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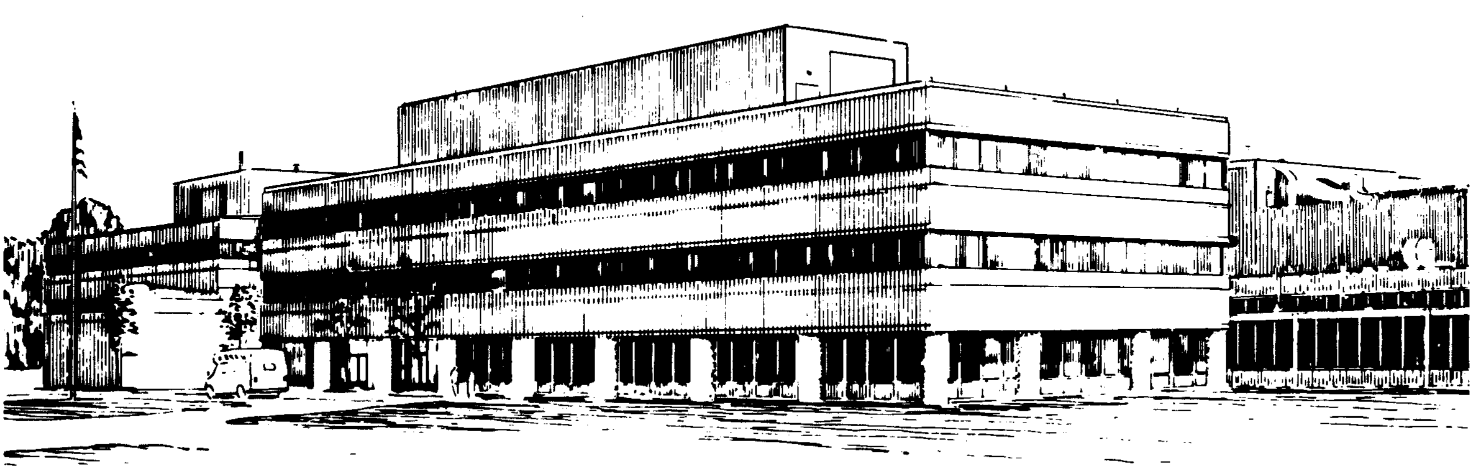
Princeton Plasma Physics Laboratory Annual Site Environmental Report for Calendar Year 1998

by

Virginia L. Finley

March 2000

PPPL PRINCETON PLASMA PHYSICS LABORATORY



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Princeton Plasma Physics Laboratory (PPPL)
Certification of Monitoring Data for
Annual Site Environmental Report for 1998

Contained in the following report are data for radioactivity in the environment collected and analyzed by Princeton Plasma Physics Laboratory's Radiological Environmental Monitoring Laboratory (REML). The REML is located on-site and is certified for analyzing radiological parameters through the New Jersey Department of Environmental Protection's Laboratory Certification Program, Certification Number 12471. Non-radiological surface and ground water and soil samples are analyzed by NJDEP certified subcontractor laboratories – QC, Inc., Reliance Laboratory, or Core Laboratory, subcontractor to Harding Lawson Associates. To the best of our knowledge, these data, as contained in the "Annual Site Environmental Report for 1998," are documented and certified to be correct.

Signed:

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Princeton Plasma Physics Laboratory

Annual Site Environmental Report

For Calendar Year 1998 – Abstract

The results of the 1998 environmental surveillance and monitoring program for the Princeton Plasma Physics Laboratory (PPPL) are presented and discussed. The purpose of this report is to provide the U.S. Department of Energy and the public with information on the level of radioactive and non-radioactive pollutants, if any, that are added to the environment as a result of PPPL's operations. The report also summarizes environmental initiatives, assessments, and programs that were undertaken in 1998. One significant initiative is the Integrated Safety Management (ISM) program that embraces environment, safety, and health principles as one.

The Princeton Plasma Physics Laboratory has engaged in fusion energy research since 1951. The long-range goal of the U.S. Magnetic Fusion Energy Research Program is to develop and demonstrate the practical application of fusion power as an alternative energy source. 1998 was the transitional year between the operation of the Tokamak Fusion Test Reactor (TFTR) and the National Spherical Torus Experiment (NSTX).

Groundbreaking ceremonies for National Spherical Torus Experiment (NSTX) were held in May 1998. The NSTX construction project is a national collaboration with PPPL, the Oak Ridge National Laboratory, Columbia University, and the University of Washington (Seattle). The NSTX is a major element in the US Fusion Energy Sciences Program. It has been designed to test the physics principles of spherical torus (ST) plasmas. The ST concept could play an important role in the development of smaller, more economical fusion reactors. First plasma was performed in early 1999.

The 1998 performance of the Princeton Plasma Physics Laboratory was rated "outstanding" by the U.S. Department of Energy in the Laboratory Appraisal report issued early in 1998. The report cited the Laboratory's consistently excellent scientific and technological achievements, its successful management practices, and included high marks in a host of other areas including environmental management, employee health and safety, human resources administration, science education, and communications.

Ground-water investigations continued under a voluntary agreement with the New Jersey Department of Environmental Protection. PPPL monitored for the presence of non-radiological contaminants, mainly volatile organic compounds (components of degreasing solvents). Monitoring revealed the presence of low levels of volatile organic compounds in an area adjacent to PPPL.

Virginia L. Finley, author

Also, PPPL's radiological monitoring program characterized the ambient, background levels of tritium in the environment and from the TFTR stack; the data are presented in this report.

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List of Acronyms

AFS	Air Facility Subsystem
AGT	above ground tank
AHC	aromatic hydrocarbons
AIRS	Aerometric Information Retrieval System
AIRDOS-EPA	Air Model for USEPA
ALARA	as low as reasonably achievable
APEC	area of potential environmental concern
AR or AR-41	Argon, Argon-41
BOD	biological oxygen demand
BN	base neutral priority pollutant organic compounds
BPX	Burning Plasma Experiment
Bq	Becquerel
BTEX	Benzene, toluene, ethylbenzene, and xylenes
C_4	C site of James Forrestal Campus, part of PPPL site
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CAS	Coil Assembly and Storage Building
CASL	Calibration and Service Laboratory
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFCs	chlorofluorocarbons
CFR	Code of Federal Regulations
Ci	Curie (3.7 ^{E10} Becquerel)
CICADA	Central Instrumentation, Control, and Data Aquisition
Cl or Cl-40	Chlorine, Chlorine-40
cm	centimeter
COD	chemical oxygen demand
CS	C site stellarator (PPPL)
CWA	Clean Water Act
CY	calendar year
D	deuterium
D&D	decontamination and decommissioning
D-D	deuterium-deuterium
D-T	deuterium-tritium
D-11, D-12	detention basin monitoring wells number 11 and 12
DATS	differential atmospheric tritium sampler
DeCon	Decontamination (Room)
DMR	discharge monitoring report
DOE	Department of Energy
DOE-CH	Department of Energy - Chicago Operations Office
DOE-EH	Department of Energy – Environment, Safety and Health
DOE-EM	Department of Energy – Environmental Management
DOE-HQ	Department of Energy - Headquarters
DOE-OFES	Department of Energy - Office of Fusion Energy Sciences
DOE-PG	Department of Energy - Princeton Group
D&R	Delaware & Raritan (Canal)
DRCC	Delaware & Raritan Canal Commission
DSN	discharge serial number
EA	Environmental Assessment
EDE	effective dose equivalent
EHS	Environment, Health & Safety
EM-30	Waste Management - DOE
EM-40	Environmental Restoration - DOE
EML	Environmental Monitoring Laboratory (DOE)
EO	Executive Order
EPA	Environmental Protection Agency (US)
EPCRA	Emergency Planning and Community Right to Know Act
ERDA	Energy Research and Development Agency, DOE predecessor agency
ER/WM	Environmental Restoration/Waste Management (PPPL)
ESA	Endangered Species Act
ES&H	Environment, Safety, and Health
F&EM	Facilities and Environmental Management Division (PPPL)
FCPC	Field Coil Power Conversion Building
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FSAR	Final Safety Analysis Report

List of Acronyms

FSCD	Freehold Soil Conservation District (Middlesex and Monmouth Counties)
g	gram
GBq	giga Becquerel or 10^9Bq
GP	General Permit (Wetlands)
GPMP	Groundwater Protection and Monitoring Program
GWPP	Ground Water Protection Plan
GW	ground water
H-3	tritium
HAPs	Hazardous Air Pollutants
HMSF	Hazardous Material Storage Facility
HQ	Headquarters
HRS	Hazard Ranking System
HT	tritium (elemental)
HTO	tritiated water
HVAC	heating, ventilation, and air-conditioning
ICRF	Ion Cyclotron Radio Frequency
IC_{25}	inhibition concentration 25 percent
JFC	James Forrestal Campus
km	kilometer
kV	kilovolt (thousand volts)
LEC	liquid effluent collection (tanks)
LEPC	Local Emergency Planning Committee
LLNL	Lawrence Livermore National Laboratory
LOB	Laboratory Office Building
LOI	Letter of Interpretation (Wetlands)
LLW	Low level waste (radiological waste)
m	meter
MCHD	Middlesex County Health Department
MeV	million electron volts
MG	Motor Generator (Building)
mg/L	milligram per liter
MOU	Memorandum of Understanding
mrem	milli radiation equivalent man
mR/h	milliRoentgen per hour
MSDS	Material Safety Data Sheet
m/s	meters per second
msl	mean sea level
mSv	milliSievert
MW	monitoring well
n	neutron
N or N-	Nitrogen
NAAQS	National Ambient Air Quality Standards
NB	Neutral beam
NBPC	Neutral Beam Power Conversion Building
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic and Preservation Act
NIST	National Institute of Standards and Technology
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection (prior to 1991 and after July 1994)
NJDEPE	New Jersey Department of Environmental Protection and Energy (1991 to June 1994)
NJPDES	New Jersey Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
NOEC	no observable effect concentration
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NRC	National Response Center
NSTX	National Spherical Torus Experiment
nSv	nanoSievert
OH	ohmic heating
OSHA	Occupational Safety and Health Agency
P1, P2	piezometer 1 and 2
PBX-M	Princeton Beta Experiment - Modification
PCAST	Presidential Committee Science and Technology
PCBs	polychlorinated biphenyls

List of Acronyms

PCE	perchloroethylene, tetrachloroethene, or tetrachloroethylene
pCi/L	picoCuries per liter
PFC	Princeton Forrestal Center
PLT	Princeton Large Torus
POTWs	publicly owned treatment works
ppb	parts per billion
ppm	part per million
PPPL	Princeton Plasma Physics Laboratory
PSTP	Proposed Sie Treatment Plan for the Federal Facility Compliance Act
RAA	Remedial Alternative Assessment
RACT	reasonably achieveable control technology
RCRA	Resource Conservation and Recovery Act
REAM	remote environmental atmospheric monitoring (station)
REML	Radiological Environmental Monitoring Laboratory
RESA	Research Equipment Storage and Assembly Building
RI	Remedial Investigation
RMS	Remote Monitoring Station
RQ	reportable quantity
S or S-	Sulfur
SAD	Safety Assessment Document
SARA	Superfund Amendments and Reauthorization Act of 1986
SBRSA	Stony Brook Regional Sewerage Authority
SDWA	Safe Drinking Water Act
SF_6	sulfur hexafluoride
SPCC	Spill Prevention Control and Countermeasure
SNAP	significant new alternatives policy
S&R	shutdown and removal (TFTR)
T	tritium
TBq	tera Becquerel or 10^{12}Bq
TCA	trichloroethane
TCE	trichloroethene or trichloroethylene
TCLP	toxic characteristic leaching procedure (RCRA)
TDS	total dissolved solids
TFTR	Tokamak Fusion Test Reactor
TPH	total petroleum hydrocarbons
TR	trailer atmospheric monitors
TRI	Toxic Reduction Inventory (CERCLA)
TPX	Tokamak Physics Experiment
TSCA	Toxic Substance Control Act
TSDS	tritium storage and delivery system
TSS	total suspended solids
TW	test wells
TWA	treatment works approval
USDA	US Department of Agriculture
USGS	US Geological Survey
USEPA	US Environmental Protection Agency
UST	underground storage tanks
VOCs	volatile organic compounds
c/Q	atmospheric dilution factor (NOAA)
µg/L	micrograms per liter
µSv	microSievert

List of Exhibits Contained in the Text

NOTE: Data tables are located in Section 11.0 beginning on page 46.

Chapter 1

Princeton Plasma Physics Laboratory

Annual Site Environmental Report for Calendar Year 1998

Executive Summary

This report presents the results of environmental activities and monitoring programs at the Princeton Plasma Physics Laboratory (PPPL) for Calendar Year 1998. The report is prepared to provide the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants, if any, added to the environment as a result of PPPL operations. The report also summarizes environmental initiatives, assessments, and programs that were undertaken in 1998. One significant initiative is the Integrated Safety Management (ISM) program that embraces environment, safety, and health principles as one. The objective of the Annual Site Environmental Report is to document evidence that PPPL's environmental protection programs protect the public health and the environment.

The Princeton Plasma Physics Laboratory has engaged in fusion energy research since 1951 (Fig. 1). The long-range goal of the U.S. Magnetic Fusion Energy Research Program is to develop and demonstrate the practical application of fusion power as an alternative energy source. 1998 was the transitional year between the operation of the Tokamak Fusion Test Reactor (TFTR) and the National Spherical Torus Experiment (NSTX).

After fifteen years of operation, 1982-1997, PPPL maintained this large tokamak device, TFTR, in a safe shut-down mode (Fig. 2). This marked the end of its era, during which many milestones were achieved. Milestones included achieving approximately 10.7 million watts of controlled fusion power during the deuterium-tritium (D-T) plasma experiments in November 1994 (a world record), and more than 700 tritium experiments conducted, thereby, generating approximately 5.6 x 10^{20} neutrons and 1.6 gigajoules of fusion energy. These achievements represent major steps forward toward the reality of a commercial fusion reactor in the twenty-first century.

During groundbreaking ceremonies in May 1998, the new device, the National Spherical Torus Experiment (NSTX) was dedicated in the former TFTR Hot Cell of D-site (Fig. 3). The NSTX program is a national collaboration with the Oak Ridge National Laboratory, Columbia University, and the University of Washington (Seattle). It is a major effort to produce a smaller and more economical tokamak fusion reactor or volumetric neutron source. First plasma was scheduled for early 1999.

The 1998 performance of the Princeton Plasma Physics Laboratory was rated "outstanding" by the U.S. Department of Energy in the Laboratory Appraisal report issued early in 1998 [DOE98]. The report cited the Laboratory's consistently excellent scientific and technological achievements, its successful management practices, and included high marks in a host of other areas including environmental management, employee health and safety, human resources administration, science education, and communications.

To strengthen the idea that fusion will provide an environmentally attractive and economically viable energy option for the next century, PPPL continued its environmental monitoring programs. In 1998, PPPL's radiological monitoring program measured on-site and off-site tritium in air, making comparisons with baseline data. Capable of detecting small changes in the ambient levels of tritium in the air, highly sensitive monitors are located at six off-site stations within 1 km of TFTR and at a baseline location. On-site tritium levels are monitored by four air monitoring stations, located on the perimeter of D site, and by one tritium monitor in the D site stack (formerly the TFTR stack) and in the Radioactive Waste Handling Facility. These monitoring stations are required by National Emission Standard for Hazardous Air Pollutants (NESHAPs) regulations with limits set by the U.S. Environmental Protection Agency. Also included in PPPL's radiological environmental monitoring program is precipitation and surface, ground, and wastewater monitoring.

The results of the radiological monitoring program for 1998 were as follows: 1) Radiation exposure, via airborne and sanitary sewer effluents, was measured at low levels; 2) Total maximum off-site dose from all sources—airborne, sanitary sewerage, and direct radiation—was 0.67 mrem/year, which is a small fraction of the 10 mrem/year TFTR design objective and the 100-mrem/year DOE limit; and 3) Total airborne exposure at the nearest business was 0.08 mrem/year, which is well below the 10 mrem/year NESHAPs limit.

PPPL's non-radiological environmental monitoring program demonstrates compliance with applicable environmental requirements, which includes monthly surface water monitoring for New Jersey Pollutant Discharge Elimination System (NJPDES) discharge permit, NJ0023922. Two discharge locations are identified by Discharge Serial Numbers (DSN): DSN001—the outfall at an on-site detention basin, and DSN003—a filter back wash discharge from the Delaware & Raritan Canal pump house. Also, PPPL is required to conduct quarterly chronic toxicity testing at DSN001. As required by the NJPDES ground water (GW) permit, NJ0086029, PPPL collects quarterly ground-water samples from seven monitoring wells and twice-annual samples from the detention basin inflows.

In 1998, PPPL continued its remedial investigation and remedial alternative assessment for C and D sites of the James Forrestal Campus, which is leased to the Department of Energy (DOE) by Princeton University. Since 1989, ground-water data has revealed volatile organic compound contamination (most likely from solvents) at low levels in three locations on-site. In February 1993, Princeton University signed a voluntary agreement, or Memorandum of Understanding (MOU), with the New Jersey Department of Environmental Protection. PPPL's work plan included ground-water sampling, soil sampling, and soil removal from two locations, which exceeded the New Jersey Soil Cleanup Standards.

PPPL has and continues to emphasize environment, safety, and health (ES&H) in accordance with DOE requirements at the facility. The expectations are that the Laboratory will continue to excel in ES&H as it has in its fusion research program. Efforts are geared not only to full compliance with applicable local, state, and federal regulations, but also to achieve a level of excellence. PPPL employs state-of-the-art monitoring and best management practices, and is an institution that serves other research facilities and the nation with valuable information gathered from its fusion program.

To view current activities and news about PPPL, visit http://www.pppl.gov

Chapter 2

Introduction

2.1 General

The U.S. Department of Energy's Princeton Plasma Physics Laboratory is a Collaborative National Center for plasma and fusion science. Its primary mission is to develop the scientific understanding and the key innovations leading to an attractive fusion energy source. Associated missions include conducting world-class research along the broad frontier of plasma science and providing the highest quality of scientific education.

At PPPL, the National Spherical Torus Experiment (NSTX) is a collaboration project with Oak Ridge National Laboratory, Columbia University, and the University of Washington (Seattle). Also located at PPPL, are smaller experimental devices, such as the Magnetic Reconnection Experiment (MRX) and the CDX-U, which investigates plasma physics phenomenon.

As a part of off-site collaborative projects, PPPL scientists assisted other fusion programs both in the United States and world-wide. Particularly, PPPL collaborated with the Koreans in their K-Star program and with the European community at the Joint European Torus (JET) facility located in the United Kingdom.

In May 1998, in conjunction with the ground-breaking ceremony for NSTX, the Laboratory honored its founder, Lyman Spitzer, Jr., by naming the Laboratory Office Building for him. In the early 1950's, Dr. Spitzer's vision for plasma physics culminated in the Project Matterhorn, which gained approval of the U.S. Atomic Energy Commission. Its mission was to contain and harness the nuclear burning of hydrogen at temperatures exceeding those found in the sun. Dr. Spitzer was the father of the "Stellarator" and PPPL Director until 1961. A, B, and C sites on the James Forrestal Campus are named for the A, B, and C stellarators that were built at these locations. A model of a stellarator is on display at PPPL.

2.2 Description of the Site

The Princeton Plasma Physics Laboratory site is in the center of a highly urbanized region extending from Boston, Massachusetts, to Washington, D.C., and beyond. The closest urban centers are New Brunswick, 14 miles to the northeast, and Trenton, 12 miles to the southwest. Major metropolitan areas, including New York City, Philadelphia, and Newark, are within 50 miles of the site. As shown in Figure 4, the site is in central New Jersey within Middlesex County, with the municipalities of Princeton, Plainsboro, Kingston, West Windsor, and Cranbury in the immediate vicinity. The Princeton area continues to experience a substantial increase in new business moving into the Route 1 corridor near the site. Also, the main campus of Princeton University, located primarily within the Borough of Princeton, is approximately three miles to the west of the site.

A demographic study or population study of the surrounding 50 kilometers was completed in 1987 as part of the Environmental Assessment for the former Burning Plasma Experiment (BPX) [Be87a]. Other information gathered and updated from previous TFTR studies included socioeconomic information [Be87b] and an ecological survey [En87].

PPPL is located on the C and D sites of the James Forrestal Research Campus of Princeton University (Fig. 5). The site is surrounded by undisturbed areas with upland forest, wetlands, and a minor stream (Bee Brook) flowing along its eastern boundary and by open, grassy areas and cultivated fields on the west. In an aerial photo (Fig. 1), the general layout of the facilities at the C and D sites of Forrestal Campus is viewed; the specific location of TFTR, is at D site (on the left side of photo).

The D site is completely surrounded with a chain-linked fence for controlled access. As an unfenced site with access controls for security reasons, PPPL openly operates C site, allowing the public access for educational purposes. This free access to C site warranted a thorough evaluation of on-site discharges, as well as the potential for off-site releases of radioactive and toxic non-radioactive effluents. To maintain free access to C site, PPPL instituted an extensive monitoring program that was expanded over recent years. The PPPL radiological environmental monitoring program generally follows the guidance given in two DOE reports; <u>A Guide for: Environmental Radiological Surveillance at U.S. Department of Energy Installations</u> [Co81] and <u>Environmental Dose Assessment Methods for Normal Operations at DOE Nuclear Sites (PNL-4410)</u> [St82].

The environmental monitoring program is documented in PPPL's Environmental Monitoring Plan **[**PPPL99]**;** its contents meets the requirement stated in DOE Orders, in particular, DOE Order 5400.5, "Radiation Protection of the Public and the Environment" [DOE93a]. That order pertains to permissible dose equivalents and concentration guides and gives guidance on maintaining exposures "to as low as reasonably achievable" (ALARA). When 10 CFR 835 became effective, PPPL made operational changes reflected in personnel monitoring requirements. Specific criteria for implementing the requirements on TFTR are contained in the TFTR Technical Safety Requirements document (OPR-R-23). These criteria are shown in Table 1 (page 47).

Exhibit 2-1. Critical Pathways

Path	Identification
A1	Atmospheric ---> Whole Body Exposure
A2	Atmospheric ---> Inhalation Exposure
A3	Atmospheric ---> Deposition on Soil & Vegetation Ingestion, Whole Body Exposure
L1	Liquid Water Way ---> Drinking Water Supply --> Man
L2	Liquid Water Way ---> External Exposure
L3	Liquid Water Way ---> Fish ---> Man

The emphasis of the radiation monitoring program was placed on exposure pathways appropriate to fusion energy projects at PPPL. These pathways include external exposure from direct penetrating radiation. Following the end of TFTR D-T experiments, internal exposure from radionuclides, such as tritium (H-3) in air and water was monitored. Tritium releases continue to be measured following TFTR shut down. Six major critical pathways are considered as appropriate (see Exhibit 2-1). The radiation monitoring program, described in the TFTR Final Safety Analysis Report [FSAR82], was updated to reflect the current environment around TFTR (see Exhibit 2-2). A tritium monitor was installed on the TFTR stack in late 1990; 74.849 Curies (Ci) (45.867 Ci of HTO and 28.982 Ci of HT), 2.8.0 TBq of tritium, were released from the stack in 1998. Monitoring continued for post-operational and pre-dismantlement and de-construction (D&D) of TFTR activities.

Preliminary meteorological data and its associated methodology were reported in Section 2 of the 1982 TFTR FSAR. Subsequently, improved methodologies were implemented. A meteorological tower was erected and began operation in November 1983 (note: previous reports included the meteorological data; this compilation was discontinued. However, the data is still being collected and saved.) [Mc83, Ku95] Improved measurements and methodologies are included in the amended FSAR, which is updated annually.

DOE Order 5400.1, "General Environmental Protection Program" [DOE90], requires PPPL to have an environmental radiological and non-radiological monitoring plan that contains meteorological, air, water, ground water, and radiological plans [PPPL92]. This Environmental Monitoring Plan was completed in 1991, with revisions made in 1992 and 1995. Further revisions were also made for 1999.

Exhibit 2-2. Radiation Monitoring Program Covering Critical Pathways

Type of Sample	Critical Path I.D.	Sample Point Description	Sampling Frequency	Analysis
Surface Water	L1,L2,L3 & A3	1) Cooling Water Discharge Drainage 2) Bee Brook upstream & downstream 3) D&R Canal	Monthly	Tritium & Gamma Spectroscopy
Rain Water	L1, L2, & L3	1) Within 250 and 500 ft radius from D site stack 2) Within 1 km radius	Monthly	Tritium
Ground Water	L1, L2, & L3	1) Ground water monitoring wells 2) D site sumps	Monthly	Tritium
Sanitary Waste Water	L1, L2	Liquid Effluent Collection Tanks	As Required by Rate of Filling	Tritium & Gamma Spectroscopy, Volume
Air	A1-A3	Test Cell	Continuous	Activated Air (Gross b H-3) (HT and HTO)
Air	A1-A3	Vault	Continuous	H-3 (HT and HTO)
Air	A1-A3	HVAC Discharge (Stack)	Continuous	Activated Air (Gross b) HT and HTO, Particulates, Volume
Direct & Air (on-site)		4 Locations at TFTR Facility Boundary	Continuous	g, n, H-3 (HT and HTO), Gross b for activated air
Direct & Air (off-site)		6 locations off site with 1 km radius	Continuous integrated)	H-3 (HT and HTO)

H-3 = tritium
HT = elemental tritium
HTO = tritiated water

Gross b = Gross beta
g = gamma
n = neutron

2.3 Environmental Setting

The climate of central New Jersey is classified as mid-latitude, rainy climate with mild winters, hot summers, and no dry season. Temperatures range from below zero to above 100 degrees Fahrenheit (F) occurring once every five years. Approximately half the year, or from late April until mid-October, the days are freeze-free. Normally, the climate is fairly humid with a total average precipitation of 46.5 inches evenly distributed throughout the year. Droughts occur about once every 15 years [PSAR78].

The PPPL is situated on the eastern edge of the Piedmont Physiographic Province, approximately one-half mile from the western edge of the Atlantic Coastal Plain Province. The site is underlain largely by gently dipping and faulted sedimentary rock of the Newark Basin. The Newark Basin is one of several rift basins that were filled with sedimentary material during the Triassic Period. At PPPL, bedrock is part of the Stockton Formation, which is reportedly more than 500 feet thick and consists of fractured red siltstone and sandstone [Lew87]. The formation strikes approximately north 65 degrees east, and dips approximately 8 degrees to the northwest. The occurrence of limited amounts of clean sand near the surface indicates the presence of the Pennsauken Formation. This alluvial material was probably deposited during the Aftonian Interglacial period of the Pleistocene Ice Age.

Within 25 miles, there are a number of documented faults; the closest of which is the Hopewell fault located about 8 miles from the site. The Flemington Fault and Ramapo Faults are located within 20 miles. None of these faults are considered to be “active” by the U.S. Geological Survey. This area of the country (eastern central US) is not earthquake-prone, with the occurrence of minor earthquakes that have caused little or no damage.

The Millstone River and its supporting tributaries geographically dominate the region. The well-watered soils of the area have provided a wealth of natural resources including good agricultural lands from prehistoric times to the present. Land use was characterized by several small early centers of historic settlement and dispersed farmland. It has now been developed into housing developments, industrial parks, apartment complexes and shopping centers [Gr 77].

The topography of the site is relatively flat and open with elevations ranging from 110 feet in the northwestern corner to 80 feet above mean sea level along the southern boundary. The low-lying typography of the Millstone River drainage reflects the glacial origins of the surface soils; sandy loams with varying percents of clay predominate.

Two soil series are recognized for the immediate environs of the site. Each reflects differences in drainage and subsurface water tables. Along the low-lying banks of stream tributaries, Bee Brook, the soils are classified Nixon-Nixon Variant and Fallsington Variant Association and Urban Land [Lew87]. This series is characterized by nearly level to gently sloping upland soils, deep, moderate to well drained, with a loamy subsoil and substratum. The yellowish-white sands contain patches of mottled coloring caused by prolonged wetness. Here, the water table fluctuates between 1.5 and 2.5 feet below the surface in wet periods and drops below 5 feet during drier months.

In the slightly higher elevations (above 70 feet), the sandy loams are better drained and belong to the Sassafras series. The extensive farmlands and nurseries of the area indicate this soil provided a good environment for agricultural purposes, both today and in the past.

An upland forest type with Oak forest dominant characterizes vegetation of the site. Associated with the various oaks are Red maple, Hickories, Sweetgums, Beech, Scarlet oak, and Ash. Red, white, and black oaks are isolated in the lower poorly drained areas. Along the damp borders of Bee Brook, a bank of Sweetgum, Hickory, Beech, and Red maple define the watercourse. The forest throughout most of the site has been removed either for farmland during the last century or recently for the construction of new facilities. Grass has replaced much of the open areas.

The understory of the wooded areas is fairly open with isolated patches of shrubs, vines, and saplings occurring mostly in the uplands area. The more poorly drained areas have a low ground cover of ferns, grasses, and leaf litter.

An archaeological survey was conducted in 1978 as part of the TFTR site environmental assessment study. From historical records, personal interviews, and field investigations, one projectile point and a stone cistern were found. The site apparently had limited occupation during prehistoric time and has only in recent times been actively used for farming. There are examples of prehistoric occupation in those areas nearer the Millstone River, which are within a mile of the site.

Chapter

3

1998 COMPLIANCE SUMMARY

3.1 Environmental Compliance

Princeton Plasma Physics Laboratory's (PPPL) goal is to be in compliance with all applicable state, federal, and local environmental regulations. As a part of PPPL's Project Mission Statement, PPPL initiates those actions that enhance its compliance efforts and fully documents how it is meeting the requirements. The compliance status of each applicable federal environmental statute is listed below:

In February 1998, the US Environmental Protection Agency (EPA) Region II conducted a four-day multi-media inspection of PPPL. Included in the inspection were the following environmental regulations:

- ❐ Clean Air Act (CAA) including National Emissions Standards for Hazardous Air Pollutants (NESHAPs)
- ❐ Clean Water Act (CWA) including National Pollutant Discharge Elimination system (NPDES)
- ❐ Resource Conservation and Recovery Act (RCRA) including Underground Storage Tanks (USTs)
- ❐ Emergency Preparedness and Community Right-to-Know Act (EPCRA)
- ❐ Toxic Substances Control Act (TSCA) including polychlorinated biphenyls (PCBs)
- ❐ Safe Drinking Water Act (SDWA) including underground injection control (UIC)
- ❐ Spill Control and Countermeasure Plan (SPCC)
- ❐ Superfund Act Reauthorization Act (SARA)

The results of the EPA's intensive inspection were that PPPL is in compliance with CAA, CWA, EPCRA, RCRA UST, TSCA, SARA and SDWA programs. As a result of the inspection, EPA issued two notices of violations (NOVs) – one for RCRA and one for SPCC programs [EPA98]. The RCRA NOV was issued for the lack of training provided to satellite accumulation area managers; this NOV was contested on applicability grounds and was rescinded by EPA. The SPCC NOV was issued for deficiencies in the SPCC Plan and for the lack of containment at 1) the C site MG basement mineral oil tanks, 2) the vehicle refueling island, and 3) the 138 kV switchyard [EPA98]. The SPCC Plans was readily amended rendering PPPL in compliance. The installation of containment in the deficient areas will be performed.

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

PPPL is not involved nor has been involved with CERCLA-mandated cleanup actions. As a result of the 1991 DOE-HQ Tiger Team assessment, an action plan was developed to conduct a more comprehensive documentation of past CERCLA hazardous substances releases. A CERCLA inventory was completed in 1993 [Dy93], and no further CERCLA actions were warranted by the results of the inventory.

3.1.2 Resource Conservation and Recovery Act (RCRA) and Solid Waste

The Laboratory is in compliance with all the requirements of a hazardous waste generator. In 1998, PPPL shipped off site approximately 82 tons (74.4 metric tons) of waste to facilities permitted to treat, store, or dispose of hazardous wastes or to recycling facilities [EI99].

Exhibit 3-1. 1997 vs. 1998 Hazardous Waste Quantities

Hazardous Waste	1997	1998
Tons	7.8	81.98
Metric tons	7.08	74.37
1	RCRA-regulated,flammable liquids	Oil-contaminated soil (recycled)
2	Batteries containing acid (hazardous under RCRA),	Electronic and computer scrap (recycled)
3	Potassium permanganate/ sodium hydroxide from REML	Mercury from ignitrons (switches) & fluorescent lamps (recycled)

PPPL is also in compliance with the requirements of the RCRA-mandated Underground Storage Tank Program. Since 1995, PPPL has taken all underground storage tanks out-of-service. PPPL submitted a Site Assessment report as part of the Remedial Investigation and Remedial Alternative Assessment (RI/RAA) Report in March 1997 [HLA97]. Pending NJDEP's acceptance of the RI/RAA, the tank closure file remains open.

In 1998, PPPL's non-hazardous, solid waste hauler removed 110.9 metric tons of solid wastes to a sanitary landfill. Also, PPPL generated 104.3 metric tons of construction waste that was not recyclable [Kin98].

Exhibit 3-2. 1998 Waste Reduction

Landfill versus Recycled, Reused or Source Reduction

Type	Source	Amount	Fate
Hazardous	Asbestos	107.04 MT	***Landfill***
Waste	Boron Frit (concrete additive)	2.72 MT	**Reused by PPPL**
	CFC-11	0.63 MT	**Recycled**
	Oil-contaminated soil	11.47 MT	**Recycled**
	Fluorescent lamps	9.56 MT	**Recycled**
	Fluorescent lamps (non-mercury)	0.28 MT	**Source reduction**
	Electronic and computer scrap	19.80 MT	**Recycled**
	Batteries including lead acid batteries used in emergency lighting	7.00 MT	**Recycled**
	HazWaste waste reduction ratio	51.46/158.5	**32.47%**
Municipal	Front end trash	89.12 MT	***Landfill***
Solid	Construction waste	57.41 MT	***Landfill***
Waste	Paper	22.75 MT	**Recycled**
(MSW)	Cardboard	25.48 MT	**Recycled**
	Aluminum & glass	7.97 MT	**Recycled**
	Wood	3.38 MT	**Recycled**
	Concrete	18.62 MT	**Recycled**
	Scrap metals	52.98 MT	**Recycled**
	Office supplies	0.90 MT	**Recycled**
	MSW waste reduction ratio	137.08/279.61	**47.41 %**

MT = metric tons = 2,204.6 lbs.

In 1998, 19 cubic yards of asbestos waste were disposed in a secure landfill [EI99].

3.1.3 National Environmental Policy Act (NEPA)

Thirty-four (34) PPPL activities received NEPA reviews in 1998, with all of these determined to be Categorical Exclusions according to the NEPA regulations and guidelines of the Council on Environmental Quality (CEQ) and DOE, or covered in a previously approved environmental assessment (EA).

No EAs or Environmental Impact Statements (EISs) were completed or were in progress in 1998 [Lev99].

3.1.4 Clean Air Act (CAA)

PPPL was in compliance with the requirements of the CAA in 1998. Under the Title I, Nonattainment Provisions, PPPL is located in a severe 17-ozone nonattainment area (ozone attainment to be reached 15 to 17 years following date of regulations, *i.e*. 2005-2007). This classification limits the threshold potential to emit (PTE) to 25 tons per year of nitrogen oxides and 10 tons per year of volatile organic compounds (VOCs). Formed during the burning of fossil fuels in boilers, generators, vehicle engines, *etc.*, nitrogen oxides (NO_x) and VOCs are precursors to ozone formation.

At PPPL, nitrogen oxides (NO_x) are the one class of regulated air contaminant that has the potential to exceed thresholds limits. In order to meet this limit, PPPL requested that NJDEP, who has primacy for the Air programs, allow PPPL a total fuel use limit for all four boilers. NJDEP granted that request and imposed a maximum annual fuel (oil and/or natural gas) use limitation for the C site boilers rather than the per boiler fuel use limit. PPPL continues to operate successfully within the stated limitations. [NJDEP96 and Kir99].

Exhibit 3-3.1998 Fuel Use at PPPL

Fuel type	NJDEP Limit	PPPL 1998 Use
#4 fuel (in gallons)	227,370	13,470
Natural gas (in cubic feet)	88.6 million	28.9 million

As a requirement of New Jersey Administrative Code (NJAC) Title 7:27-21, “Emissions Statements,” PPPL submitted the 1994 Air Emission Survey to NJDEP, who then submitted the survey to the US Environmental Protection Agency (USEPA). The data were incorporated into a national database, the *Aerometric Information Retrieval System* (AIRS), and *the Air Facility Subsystem* (AFS) where it became public information. The 1994 Air Emission Survey was the last survey submitted to NJDEP. In March 1996, the NJDEP approved PPPL’s request for Annual Emission Statement Non-Applicability.

The CAA Title V Operating Permit program is implemented through the State of New Jersey. In August 1995, PPPL filed a negative declaration for the New Jersey Operating Permit Program; NJDEP granted approval in March 1996. The effective date, November 29, 1995, was based on a change to the TFTR emergency diesel generator permit, which reduced the operating hours from 500 to 200 hours. This reduction lowered PPPL’s potential to emit NO_x to below the 25 ton-per-year threshold.

Under CAA Title VI, “Stratospheric Ozone Depletion,” PPPL’s use of certified refrigerant recovery units and trained technicians comply with Section 608 of the Act, which prohibits the venting of ozone-depleting substances. In 1996, PPPL submitted an inventory of Class I and II ozone-depleting substances (chlorofluorocarbons or CFCs) to DOE. PPPL safely disposes of equipment containing ozone-depleting substances by removing refrigerant to specified levels before disposal of equipment. PPPL employs trained and certified technicians to service and repair equipment containing ozone-depleting substances and to operate the Laboratory’s four refrigerant recovery units.

Tracking gases that contribute to global warming, NJDEP requested that PPPL determine the amount of sulfur hexafluoride (SF_6) released annually from TFTR. Prior to 1995, the amount of SF_6 needed to maintain the SF_6 systems ranged from 28,060 pounds to 36,340 pounds per year. In 1997, 3,335 pounds of SF_6 were used to maintain the modulator regulators, the ICRF, and the NB high voltage and ion source enclosures. In 1998, no additional SF_6 was purchased due to the TFTR shutdown; the remaining inventory of SF_6 was removed from the systems and stored for future use.

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3.1.5 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

PPPL has a stack sampler at the Tokamak Fusion Test Reactor (TFTR) facility to monitor tritium releases. The monitor has been independently verified as meeting National Emission Standard for Hazardous Air Pollutants (NESHAPs) radionuclide emission monitoring requirements. In August 1993, PPPL received USEPA's concurrence on this determination. In 1998, the levels of tritium released during TFTR safe-shutdown operations were measured: 45.867 curies of tritiated water or HTO and 28.982 curies of elemental tritium or HT (see Exhibit 3-4 and Table 3) [As99].

Exhibit 3-4. Total Air Releases from D-Site (formerly TFTR) Stack from 1994 to 1998

Calendar Year	HTO (Curies)	HT (Curies)	Total Curies (HTO + HT)
1994	4.30	9.28	13.58
1995	37.031	24.87	61.901
1996	118.624	64.88	183.504
1997	124.093	63.019	187.112
1998	45.867	28.982	74.849

Annual Limit is 500 Curies.

In 1998, the effective dose equivalent (EDE) to a person at the business nearest PPPL, due to radionuclide air emissions, was 0.08 mrem (0.8 _Sv), which is significantly lower than the NESHAPs standard of 10 mrem/yr (Exhibit 3-5). During their most recent inspection of PPPL facilities in March 1998, representatives from USEPA Region II indicated that PPPL was in compliance with NESHAPs requirements [Lev99].

Exhibit 3-5. Dose from PPPL Operations from 1994 to 1998

Calendar Year	Estimated Dose Equivalent (mrem) at Site boundary	Estimated Dose Equivalent (mrem) at Nearest Business
1994	0.30	0.01
1995	0.31	0.01
1996	0.43	0.11
1997	0.51	0.12
1998	0.68	0.08

Annual Limit is 10 mrem/year.

3.1.6 Spill Prevention Control and Countermeasure (SPCC)

PPPL maintains a Spill Prevention Control and Countermeasures (SPCC) Plan as a requirement of 40 CFR 112. “Oil Pollution Prevention Regulations.” There are numerous transformers containing non-PCB mineral oil as well as fuel oil tanks (25,000 and 15,000 gallon aboveground storage tanks) for supplying fuel to the boilers and generators located on-site. Smaller tanks used for vehicle refueling and equipment oil storage tanks also contain petroleum products that are regulated under this regulation.

In June 1998, NJDEP conducted an inspection of the facility. Under New Jersey regulations, NJDEP classified PPPL as a non-major facility [NJDEP98a]. The threshold of 200,000 gallons of petroleum (not in transformers) is not exceeded. PPPL has reporting obligations under the regulations including notification of discharges and discharge confirmation reporting requirements. PPPL is considered a minor facility and therefore, the Discharge Prevention Control and Containment Plan and Discharge Cleanup Plans do not apply.

3.1.7 Clean Water Act (CWA)

PPPL is in compliance with the requirements of the CWA. An assessment of ground water has been undertaken as part of an effort that followed identification of leaking underground storage tanks (USTs) containing heating oil and vehicle fuel. Quarterly ground water monitoring for petroleum hydrocarbons and volatile organic compounds was conducted until September 1997 (see Section 6.1.3 B). The data collected for 24 quarters (6 years) were consistent: trace or no petroleum hydrocarbons were detected and the tanks were not the source of any low levels of volatile organic compounds. PPPL concluded that quarterly ground water monitoring should not continue, rather, this program was incorporated into a site-wide monitoring program.

Under the CWA and “New Jersey Discharge of Petroleum and Hazardous Substances” regulation (New Jersey Administrative Code Title 7, Chapter 1E), PPPL reported one release to the NJDEP in 1998. Oil-contaminated soil adjacent to C Site Maintenance Building was discovered during a water line excavation project. Approximately 15 cubic yards of soil from pipe and tank releases had not been previously removed due to potential structural damage to the building. The soil was excavated, remaining soil tested, and clean material replaced in the excavation [Sh99].

3.1.8 National Pollutant Discharge Elimination System (NPDES)

In 1998, PPPL operated under the requirements of New Jersey Pollutant Discharge Elimination System (NJPDES) surface water discharge permit (NJ0023922). The NJDEP issued the renewed surface water permit on January 21, 1994, with an effective date of March 1, 1994 [NJDEP94]. The NJPDES surface water permit expires on February 28, 1999. In August 1998, 180 days prior to the permit’s expiration, PPPL submitted the NJPDES renewal application to NJDEP.

In 1998, the monitoring locations in the permit are the detention basin outfall (DSN001), and the filter backwash discharge (DSN003) at the Delaware & Raritan Canal pump house. These two locations are designated as monthly sampling points. During 1998, one exceedance of the total suspended solids limit (20 mg/L) at DSN003 occurred in June (22 mg/L). The probable cause of the exceedance is the total suspended solids concentration in the Delaware & Raritan Canal.

PPPL completed the identification of wastewater streams (industrial discharge) into the Stony Brook Regional Sewerage Authority (SBRSA) system. Under the requirements of the Discharge License from SBRSA, PPPL reports the discharges each month to SBRSA.

3.1.9 Safe Drinking Water Act (SDWA)

The PPPL receives its drinking water from the Elizabethtown Water Company. While Elizabethtown is responsible for providing safe drinking water, PPPL periodically tests incoming water quality. In 1994, PPPL installed a new backflow prevention system beneath the elevated water tower. In the event of a fire or other emergency situation, PPPL can switch from Delaware & Raritan Canal water (non-potable) to potable water for its non-contact water supply**.** During 1998, when the D&R Canal supply line was being replaced due to previous line breaks, potable water was used for make-up water to the cooling towers and other water systems.

On a quarterly basis, PPPL inspects and pressure tests the back flow prevention equipment at both locations: the main potable water connection where Elizabethtown Water enters C site and the new system beneath the elevated water tower. Back flow prevention equipment prevents contamination of the potable water supply *via* a large cross-connection. On an annual basis, these systems are completely disassembled, inspected, and tested in the presence of an Elizabethtown Water Company representative. In order to maintain an uncontaminated potable water supply, other cross-connection equipment is tested annually. These inspection reports are submitted to the NJDEP annually.

3.1.10 Toxic Substance Control Act (TSCA)

PPPL is in compliance with the terms and conditions of TSCA for the protection of human health and the environment by requiring that specific chemicals be controlled and regulations restricting use are implemented. The last PPPL polychlorinated biphenyl (PCB) transformers were removed from the site in 1990.

A total of 645 capacitors were in inventory in January 1998. In September 1998, 640 capacitors were removed. By the end of 1998, there were 5 on-site PCB capacitors, which met the regulation criteria. These capacitors are located in a locked building with concrete floors and are protected from the weather [El99].

3.1.11 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Certified subcontractors who meet all the requirements of FIFRA, performed the application of herbicides, pesticides, and fertilizers. PPPL Maintenance & Operations Division (M&O) monitors this subcontract. In 1998, 1800 pounds of fertilizers were applied. The herbicides Surflan (57.8 quarts), Roundup (72.7 quarts), and Dissolve (10 pounds) were used on the PPPL site in 1998. [Kin99].

3.1.12 Endangered Species Act (ESA)

In 1998, PPPL occupied 88.5 acres of the Forrestal Campus of Princeton University. Historically, the 1975 “Final Environmental Statement for the Tokamak Fusion Test Reactor Facilities,” the approved “Environmental Assessment (EA) for the TFTR Deuterium-Tritium (D-T) Modifications,” and the approved “TFTR Decommissioning and Decontamination (D&D) and Tokamak Physics Experiment (TPX) Environmental Assessment” have indicated that there are no endangered species on-site. [ERDA75] [DOE92] [DOE93b]

As of 1993, the NJDEP, Division of Parks and Forestry, *Natural Heritage Data Base* [Dy93], reported that there are no records for rare plants, animals, or natural communities on the

PPPL site. There are records for a number of occurrences of rare species that may be on or near waterways surrounding the site. As the Natural Heritage data is based on a literature search and on individuals' observations of endangered species in the vicinity of PPPL and is not based on site-specific surveys and/or observations, the data obtained from this database are not considered definitive.

In 1997, as part of the Remedial Investigation, Amy S. Greene Environmental Consultants, Inc. conducted a baseline ecological evaluation [Am98]. The New Jersey Audubon Society has visually verified and reported a pair of Cooper's Hawk (*Accipiter cooperii*) nesting within one mile of the PPPL property [NJB97]. Cooper's hawks are presently listed as threatened in the state of New Jersey [NJDEP97]

3.1.13 National Historic Preservation Act (NHPA)

There are no identified historical or archaeological resources at PPPL. No buildings or structures have been identified as historical [Gr77].

3.1.14 Executive Orders (EO) 11988, "Floodplain Management"

In 1998, PPPL was in compliance with EO 11988, "Floodplain Management." Delineation of the 500 and the 100-year floodplains was completed in February 1994. The 500-year and the 100-year floodplains are located at the 85-foot elevation and at the 80-foot elevation above mean sea level, respectively [NJDEP84] (see Fig. 8).

In 1995, PPPL began preparing a site-wide stormwater management plan. It would have included the proposed second cell detention basin, which was in the conceptual design phase. In the process, PPPL discovered that the Princeton Forrestal Center (PFC), the management group for Princeton University's corporate office and research complex, included the PPPL site in their Stormwater Management Plan. This plan was submitted to the Delaware Raritan Canal Commission (DRCC) in 1980 and a Certificate of Approval was signed on May 20, 1980. The 88.5-acre parcel that PPPL occupies is included in PFC's stormwater management plan-Phase I. The 88.5-acre parcel is part of the Bee Brook watershed and therefore includes PPPL in the PFC stormwater plan.

One condition of the PFC Storm Water Management Plan is that the average density of development does not exceed a maximum of 60% impervious coverage in developable areas. PPPL meets the ≤60% impervious coverage limit and is in compliance with the stormwater requirements. PPPL determined that the aforementioned, second detention basin was not required. The Site-Wide Stormwater Management Plan was completed in February 1996 [SE96].

In 1997, PPPL prepared a Site-Wide Storm Water Pollution Prevention Plan. Incorporating the Storm Water Management Plan, Spill Prevention Control and Countermeasure (SPCC) Plan, and other best management practices, this plan was a culmination of activities already in practice at PPPL.

3.1.15 Executive Orders (EO) 11990, "Protection of Wetlands"

In 1998, PPPL was in compliance with the EO 11990, "Protection of Wetlands." The Land Use Regulation Program within NJDEP continues to be the lead agency for establishing the extent of state and federally regulated wetlands and waters. The U.S. Army Corps of Engineers retains the right to re-evaluate and modify wetland boundary determinations at any time.

In 1994, PPPL received a "Letter of Interpretation" (LOI) from NJDEP for defining the wetland boundaries and wetlands classification. This LOI is needed before NJDEP issues wetlands permits for a site. The LOI is valid for a five-year period with the option to renew for an additional five years. PPPL submitted a renewal application to NJDEP and was granted the five-year extension, which is valid until January 2004.

The LOI determination was based upon infrared aerial photographs, the presence of wetland-type vegetation, US Geological Survey (USGS) topographic maps, National Wetlands Inventory maps, US Department of Agriculture (USDA) Soil Conservation maps, an analysis of soil type, vegetation identification, and area hydrology, *i.e.*, depth to ground water. Soil profiles to determine soil type were conducted through soil borings, which were also analyzed for indications of seasonal high water table. A wetland delineation map that indicated the boundary, sequential flag numbers, and soil boring locations was approved (see Fig. 8).

3.1.16 Executive Order (EO)12856, "Federal Compliance with Right-to-Know and Pollution Prevention Requirements," and Superfund Amendments and Reauthorization Act (SARA) Title III, Emergency Planning and Community Right-to-Know Act (EPCRA)

Emergency Planning and Community Right-to-Know Act, Title III of the 1986 SARA amendments to CERCLA created a system for planning responses to emergency situations involving hazardous materials and for providing information to the public regarding the use and storage of hazardous materials. Under the reporting requirements of EO 12856 and SARA Title III, PPPL has complied with the following:

Exhibit 3-6. Summary of PPPL EPCRA Reporting Requirements

EPCRA 302-303: Planning Notification	YES [✓]	NO [ ]	NOT REQ. [ ]
EPCRA 304: EHS Release Notification	YES [ ]	NO [ ]	NOT REQ. [✓]
EPCRA 311-312: MSDS/Chemical Inventory	YES [✓]	NO [ ]	NOT REQ. [ ]
EPCRA 313: TRI Inventory	YES [ ]	NO [ ]	NOT REQ. [✓]

In 1998, PPPL submitted an annual chemical inventory in compliance with SARA Title III (EPCRA Section 312). This inventory reports the quantities of chemicals listed on the CERCLA regulations.

Under SARA Title III, PPPL provides the following to the applicable emergency response agencies:

1) An inventory of hazardous substances stored on-site;
2) Material Safety Data Sheets (MSDS); and
3) Completed SARA Tier I forms listing each hazardous substance stored by users above a certain threshold planning quantity (typically 10,000 pounds, but lower for certain compounds).

Exhibit 3-7 lists hazardous compounds at PPPL reported under SARA Title III for 1998 [PPPL1999a].

Exhibit 3-7. Hazard Class of Chemicals at PPPL

Compound	Fire	Sudden Release of Pressure	Acute Health Hazard	Reactive	Chronic Health Hazard
Carbon dioxide		✓		✓	

Chlorodifluoromethane (HCFC-22)		✓		✓	
Dichlorodifluoromethane (CFC 12)		✓		✓	
Fuel Oil	✓				
Gasoline	✓				✓
Helium		✓			
Nitrogen		✓			
Petroleum Oil	✓				
Polychlorinated Biphenyls					✓
Sulfur Hexafluoride		✓			
Sulfuric acid			✓	✓	
Trichlorotrifluoroethane (CFC 113)				✓	

Of the twelve, six compounds are in their gaseous form and are therefore classified as sudden release of pressure hazards; three gaseous compounds are also classified as acute health hazards: carbon dioxide, chlorodifluoromethane, and dichlorodifluoromethane (CFC-12). There are seven liquid compounds; nitrogen is used in both gaseous and liquid forms. Fuel oil, gasoline, and petroleum oil are flammables; trichlorotrifluoroethane (CFC-113) and sulfuric acid are the liquid compounds that are classified as acute health hazards; sulfuric acid is also reactive. PCBs and gasoline are listed as chronic health hazards.

Section 304 of SARA Title III requires that the Local Emergency Planning Committee (LEPC) and state emergency planning agencies be notified of accidental or unplanned releases of certain hazardous substances to the environment. To ensure compliance with such notification provisions, a Laboratory-wide procedure, ESH-013, "Non-Emergency Environmental Release—Notification and Reporting," includes SARA Title III requirements. The NJDEP administers SARA Title III reporting for the USEPA and has modified the Tier I form to include SARA Title III reporting requirements and NJDEP reporting requirements.

Because PPPL's use of chemicals listed on the Toxic Release Inventory (TRI) is below threshold amounts, PPPL is technically not required to submit the TRI. Following DOE's guidance, PPPL completed an annual submittal to DOE for 1997 that included the TRI cover page and laboratory exemption report. PPPL did not submit a TRI in 1998.

3.1.17 Federal Facility Compliance Act (FFCA)

The Federal Facility Compliance Act (FFCA) requires the Department of Energy (DOE) to prepare "Site Treatment Plans" for the treatment of mixed waste, waste containing both hazardous and radioactive components. Based on the possibility of the site generating mixed waste, which could require treatment on site, PPPL was identified on the list of DOE sites that would be included in the FFCA process [PPPL95]. In 1995, PPPL prepared its "Proposed Site Treatment Plan (PSTP) for Princeton Plasma Physics Laboratory (PPPL)."

PPPL developed an approach where any potential mixed waste would be treated in the original accumulation container within 90 days of generation of the hazardous waste. This treatment option was discussed with the State of New Jersey and USEPA Region II regulators, who were in agreement with this approach. Based on their agreement, this approach will keep PPPL in compliance with the applicable Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions. However, DOE will provide the state and USEPA with annual updates and will keep the regulators apprised of the status of activities. If mixed wastes were generated that could not be treated in original accumulation containers, PPPL would notify the regulators and provide them with a revised "Site Treatment Plan" [PPPL95].

3.1.18 Safety

PPPL's 1998 performance with respect to worker safety was as follows:

1.	Recordable injury case rate:	1.47 per 200,000 hours worked
2.	Lost Work Day case rate:	0.21 per 200,000 hours worked
3.	Lost Work day rate:	0.63 per 200,000 hours worked
4.	Number of radioactive contaminations (external):	2
5.	Number of Safety Occurrence reports: (OSHA confined space, chemical exposure and lock out/tag out incidents)	0

3.2 <u>Current Issues and Actions</u>

3.2.1 Air Issues and Actions

Through PPPL's Waste Minimization and Pollution Prevention program, PPPL selected a substitute for degreasing compounds. Specifically, the decontamination room (former Hot Cell) degreaser will operate using a non-chlorofluorocarbon solvent. The selected degreaser contains no volatile organic compounds nor hazardous air pollutants (HAPs), and the degreaser will not require an air permit.

Through tracking the fuel consumption of the four utility boilers during 1998, PPPL calculates the amount of nitrogen oxides generated. The actual NO_x emissions from PPPL permitted sources based on actual fuel consumption and operating hours during 1998 was 2.4 tons (2.17 metric tons) per year [McG99].

In April 1998, the NJDEP Air Enforcement Inspector conducted a review of PPPL's permits and records. To his satisfaction, PPPL provided all the necessary documentation and received a favorable evaluation for the NJDEP's air inspection.

In 1998, NJDEP began accepting air permit applications *via* electronic submission. The program is called RADIUS and is available on NJDEP's web site. Currently, PPPL has no new air permits pending and has submitted renewal permit applications for its aboveground storage tanks, dust collectors, and boilers.

3.2.2 NJPDES Surface Water Permit No. NJ0023922 Issues and Actions

In July 1998, the NJDEP conducted its annual inspection of the facility including record maintenance. The inspector rated PPPL "unacceptable," based on deficiencies occurring in 1997. During 1997, two non-compliances were reported: one for total suspended solids (TSS) exceedance and one for missing a parameter; both occurred at DSN003 (Delaware & Raritan Canal pump house discharge). The total suspended solid limit (27 mg/L *versus* the limit of 20 mg/L) was exceeded, likely due to high solids in the D&R Canal at the time the sample was collected and not due to PPPL operation of the pump house. The missed TSS sample was due to an error by the analytical laboratory, and could not be corrected before the end of the sampling period; no further lapses in the analytical laboratory's performance have occurred.

Under NJPDES requirements, Chronic Toxicity Testing was conducted quarterly in March, June, and September 1998 using the effluent from the basin, DSN001. Semi-annual chronic toxicity testing began the following March (1999). The test organisms, *Pimephales promelas* or fathead minnows, survived in 100 percent concentration of PPPL's detention basin discharge over the test period for all tests.

3.2.3 NJPDES Ground Water Permit No. NJ0086029 and Ground Water Issues and Actions

PPPL's ground water discharge permit (NJ0086029) expired on December 31, 1994. A renewal application was prepared and included a report on ground-water quality based on quarterly ground water samples collected from December 1989 through February 1994 [Fi94]. Since 1994, PPPL has continued to monitor quarterly seven ground water wells in compliance with the conditions of the expired permit.

In 1997, the NJDEP proposed that PPPL prepare a Ground Water Protection Plan (GWPP), in which data and recommendations are presented to reduce sampling locations, sampling frequency, and parameters. PPPL is currently working with NJDEP to develop a GWPP.

Since 1993 when Princeton University signed a Memorandum of Understanding (MOU) with Princeton University to investigate A and B sites, and PPPL and DOE-PG to investigate C and D sites, the following actions have occurred at PPPL:

1993	PPPL prepared specifications for Remedial Investigation and Remedial Alternative Assessment project (RI/RAA).
1994	Harding Lawson Associates (HLA) began RI/RAA. Sampled existing wells, sumps, and soil borings. Soil beneath the Facilities Building and adjacent to C Site Cooling Tower removed.
1995	HLA conducted additional sampling and prepared RI/RAA report. DOE and PPPL submitted report in 1996. NJDEP required further investigation.
1996	Installed four new monitoring wells south of the CAS/RESA Building to fully delineate extent of ground water contamination.
1997	New area of potential environmental concern (APEC) near the former PPPL Annex Building identified and characterized by sampling ground water from eight new wells and soil borings. Report submitted in December 1997.
1998	Phase 3 RI report submitted to NJDEP in September 1998 [HLA98].

3.2.4 Tiger Team and Self-Assessments Issues and Actions

PPPL was audited by a DOE Tiger Team between February 11, 1991, and March 12, 1991. During PPPL's own self-assessment performed in late 1990, PPPL had identified over 70 percent of the Tiger Team findings. There were 54 environmental findings; none of which represented situations that presented an immediate risk to public health or to the environment or that warranted an immediate cessation of operations. An Action Plan was finalized by PPPL in April 1991 and approved and officially released by DOE/HQ in April 1992. Of the 612 milestones addressing the 300 Tiger Team findings and concerns, no environmental actions remained open.

3.2.5 Integrated Safety Management

PPPL developed a description document outlining how the Laboratory implements Integrated Safety Management (ISM), which every PPPL Department and Project endorsed [PPPL99b]. Integrated Safety Management at PPPL is accomplished consistent with DOE policy, requirements, and guidance in a manner that applies controls and precautions tailored appropriately to the hazards of the projects and work being performed. ISM at PPPL is comprised of two components:

1. The governing policy that safety be integrated into work management and work practices at all levels.
2. The distinct policies, programs, procedures, and cultural beliefs that have been developed as the structure that PPPL workers utilize in fulfilling the Laboratory's environment, safety, and health responsibilities.

Although the term "integrated safety management" is relatively new, integrating safety into the management of work and into work practices has been the Laboratory's philosophy and practice for years. No new systems or programs are required to implement ISM at PPPL. By establishing policies, procedures and manuals that define the Laboratory's ES&H objectives, the Laboratory' implements its Integrated Safety Management Plan. These documents continue to be updated and improved.

3.3 <u>Environmental Permits</u>

The following table (Exhibit 3-8) presents the different regulatory requirements/permits with which PPPL must comply. It is not solely a list of environmental permits, but rather the list specifies the citation for environmental regulations, PPPL's requirement or permit, and where data reports may be found. A discussion of environmental permits required by the applicable statutes is found in Sections 3.0 and 6.0, "Environmental Non-Radiological Program Information."

Exhibit 3-8. PPPL Environmental Requirements

Media	Regulatory Citation	Requirement/Permit	Data Reported
Air	40 CFR 61 – National Emission Standards for Hazardous Air Pollutants (NESHAPs)	Monitor D site stack for tritium	Reported in the annual Site Environmental Report (ASER)
	40 CFR 82 – Protection of Stratospheric Ozone	Training & certification; Chillers, HVAC, fire suppression systems, cylinders	Ozone Depleting Substances (ODS) Inventory
	NJAC 7:27-8 – Air Pollution Control – Permits and Certificates	4 Boiler stacks; 2 Storage tank vents; 3 Dust collectors; 2 Diesel generators.	Fuel use reported in ASER; Generator hours recorded
Asbestos	29 CFR 1910.1001, 1910.1200 – OSHA General Industry Standard	Identify locations prior to removal (roofing, tiles, walls, pipes, insulation, etc.)	Reporting to EPA prior to removal; Track generated quantities
EPCRA	40 CFR 370 – Hazardous Chemical Reporting: Community Right-to-Know	SARA Title III listed substances above threshold amounts	Section 312 annual report to EPA in March; Also reported in ASER
Laboratory Certification	NJAC 7:18 - Regulations Governing Laboratory Certification and Environmental Measurements	Radiological Environmental Monitoring Laboratory (REML)	Annual application; semi-annual performance testing; results reported in ASER
Land Use - Wetlands	NJAC 7:7A – Freshwater Wetlands Protection Act Rules	Delineated wetlands – LOI; 26 kV tower maintenance, well installations	Status reported in bi-monthly updates; Also, reported in ASER
Meteorology	DOE Order 430.1A - Life Cycle Asset Management	Meteorological tower – 3 levels (10, 30, and 60 meters) Rain gauge	Wind speed & direction, air temperature, dew point, precipitation. Precipitation reported in ASER
Safe Drinking Water	40 CFR 141.16 –National Primary Drinking Water Regulations	*Best Management Practices* - Tritium analyzed in ground, surface, & rain water	20,000 pCi/L or 4 mrem/year annual dose
Soil	NJAC 7:1E – Discharge of Petroleum and Other Hazardous Substances	Reporting discharge of petroleum or hazardous substances on soil/ unpaved areas/ water	30-Day confirmation report to NJDEP; Also reported in ASER
	Standards for Soil Erosion and Sediment Control Act Chapter 251=	Projects which create soil disturbance greater than 5,000 sq. feet	Bi-monthly status reported in updates;
SPCC	NJAC 7:1E – Discharge of Petroleum and Other Hazardous Substances 40 CFR 110 – Discharge of Oil 40 CFR 112 – Oil Pollution Prevention	PPPL designated minor facility – no DPCC or DCR required; Spill Prevention, Control, and Countermeasure Plan (SPCC) required	SPCC Plan required; Inspections, records, procedures

Exhibit 3-8. Environmental Requirements (cont.)

Media	Regulatory Citation	Requirement/Permit	Data Reported
TSCA	40 CFR 761- Polychlorinated Biphenyls (PCBs)	Label, inspect, records of polychlorinated biphenyls (PCBs) in capacitors	Inventory; Disposal records; Also reported in ASER
Waste - Hazardous	40 CFR 260 –279 – Resource Conservation and Recovery Act (RCRA) NJAC 7:26-8 – Hazardous Waste Regulations	On-site 90 –day temporary storage; EPA ID #. NJ1960011152 Manifest records	Biennial report to NJDEP
Waste - Medical	NJAC 7:26-3A Regulated Medical Waste	Disposal of medical wastes generated from dispensary	Annual report to NJDEP
Waste - Sanitary	NJAC 7:28 – Bureau of Radiation Protection	Liquid effluent collection tanks (LECT) sampled for: Tritium Gross beta	Tritium concentrations not to exceed 1 Curie per year
	DOE Order 5400.5 – Radiation Protection of the Public and the Environment	LECT - Tritium Gross beta	or 2 million picoCuries/Liter per discharge
	Stony Brook Regional Sewerage Authority Industrial Discharge License (22-967-NC)	LECT sampled for: Tritium & Gross beta pH, temperature, Chemical oxygen demand (COD) Quantity released	Monthly Discharge Report – Self Reporting Form to SBRSA Also, reported in ASER
Waste - Solid	NJAC 7:26 – Solid Waste	Registered Solid waste hauler; recycling separation of materials	Recycle report for paper, cardboard, glass/aluminum, plastics, scrap metals, batteries, office waste, etc.; Also reported in ASER
Water - Ground	NJAC 7:14A – The New Jersey Pollutant Discharge Elimination System (NJPDES)	Quarterly ground water monitoring of seven wells; May & Aug. sampling two inflows	Quarterly reports to NJDEP; Also, reported in ASER
	NJAC 7:19 – Water Supply Allocation Permits	Two former production wells - quantities pumped not to exceed 100,000 gpd	Annual report to NJDEP
	NJAC 7:26E – Technical Requirements for Site Remediation	Investigation - ground water monitoring, soil assessment, soil removal	Remedial Investigation reports to NJDEP; Also , reported in ASER
Water - Potable	NJAC 7:10 – Safe Drinking Water Act	Quarterly inspection of back-flow preventors; annual internal inspection	Annual report to NJDEP, water purveyor, & County Health Officer
Water – Storm	NJAC 7:13 – Flood Hazard Area Control	Basin inspection & maintenance	Records
Water - Surface	NJAC 7:14A – The New Jersey Pollutant Discharge Elimination System (NJPDES)	Monthly surface water samples at two locations; semi-annual chronic toxicity test	Monthly discharge monitoring reports to NJDEP; annual chronic toxicity test report to NJDEP; Also, reported in ASER

Chapter 4

ENVIRONMENTAL PROGRAM INFORMATION

4.1 Summary of Radiological Monitoring Programs

Monitoring for sources of potential radiological exposures is extensive. Begun in 1981, real-time prompt gamma and/or neutron environmental monitoring on the D site established baselines prior to machine operation. In 1998, the following air stations were monitored:

Exhibit 4-1. Radiological Air Monitoring Stations

Station Name	Number/Description	Figure
Remote Environmental Air Monitoring (REAM)-off site	Stations *R 1- 6*: Tritium	6
Radiological monitoring system (RMS) on D site	8 Neutron detectors and gamma ionization detectors and passive tritium monitors at *T 1-4*:	5
Radiological monitoring system (RMS) at property line stations	2 Neutron detectors and gamma ionization detectors at Northeast (*RMS-NE*) and Southeast (*RMS-SE*)	5

Water samples are collected at the same locations for both non-radiological and radiological samples that are analyzed for tritium, HTO (Exhibit 4-2).

Exhibit 4-2. Radiological and Non-Radiological Water Monitoring Stations

Station #	Location/Figure #	Description
B1	Off-site / 5	Bee Brook Upstream of discharge from detention basin
B2	Off-site /5	Bee Brook Downstream of discharge from detention basin
C1	Off-site / 6	Delaware & Raritan Canal (Plainsboro)
D1	On-site / 5	D site Manhole-stormwater sewer
DSN001	On-site / 5	Surface Water Discharge from the detention basin
E1	On-site / 6	Elizabethtown Water Company - potable water supply
M1	Off-site / 6	Millstone River - Plainsboro & West Windsor boundary-Route 1
P1	Off-site / 6	Plainsboro Surface Water - Millstone River
P2	Off-site / 6	Plainsboro Surface Water - Devils Brook

The last comprehensive assessment of population distribution in the vicinity of PPPL was completed for the Burning Plasma Experiment (BPX) Environmental Assessment (EA) [Be87a]. PPPL is situated in the metropolitan corridor between New York City to the northeast and Philadelphia to the southwest. Census data indicate that approximately 16 million people live within 80 km (50 miles) of the site and approximately 212,000 within 16 km (10 miles) of PPPL.

The overall, integrated, effective-dose equivalent (EDE) from all sources (excluding natural background) to a hypothetical individual residing at the nearest business was calculated to be 0.68 mrem (6.8 _Sv) for 1998 (see Exhibit 5-2). Detailed person-rem calculations for the surrounding population was not performed, because the value would be insignificant in comparison to the approximately 100 mrem (1 mSv) that each individual receives from the natural background, exclusive of radon, in New Jersey.

4.2 Summary of Non-Radiological Monitoring Program

During 1998, PPPL operated under the NJPDES surface water permit, No. NJ0023922, which became effective on March 1, 1994. As stated in the permit conditions, PPPL monitored monthly the discharge of the detention basin, DSN001. Once each month, water quality at DSN001 is assessed by monitoring the following parameters:

- Temperature
- pH
- Petroleum hydrocarbon
- Total suspended solids
- Chemical oxygen demand
- Chlorine-produced oxidants, and
- Flow.

Quarterly, additional parameters are measured:

- Biological oxygen demand
- Phenols
- Ammonia-nitrogen and
- Total dissolved solids.

Monthly data exists for this location dating back to 1984. Monthly sampling continued at DSN003— a filter backwash discharge located at the Delaware and Raritan Canal pump house (Fig 6).

As a requirement of the permit, a chronic toxicity characterization study was conducted to test the DSN001 effluent with the fathead minnow (*Pimephales promelas*) as the test organism. Quarterly study results were submitted for March, June, and September 1998 tests. In 1998, PPPL and DOE-PG requested that the NJDEP reduce the quarterly frequency to annual based on successful completion of more than twelve consecutive chronic toxicity tests; NJDEP approved semi-annual testing in September 1998.

As a requirement of the NJPDES ground water permit, Discharge Permit No. NJ0086029, seven ground water monitoring wells were sampled quarterly in 1998 (Tables 19-24 and Figs. 5 & 7). Exhibit 4-3 presents the required parameters, wells, frequency, and permit standard. Under May 5, 1997-adopted NJPDES regulations, NJDEP extended expiration dates for all permits until a new ground-water discharge permit could be issued.

Exhibit 4-3. NJPDES NJ0086029 Ground Water Discharge Standards and Monitoring Requirements for Ground Water Monitoring Wells

Parameters (these wells only)	Standards	Feb.	May	Aug.	Nov.
Ammonia-Nitrogen	0.5 mg/L		X	X	X
Base/Neutral Extractable	See Note below			X	
Chloride	250 mg/L			X	X
Chromium (hex.) & compounds - (D-12, MW-14, MW-15, MW-16)	0.05 mg/L			X	X
Lead and compounds	0.05 mg/L			X	X
pH- field determined	Standard Units	X	X	X	X
Petroleum Hydrocarbons				X	
Phenols	0.3 mg/L			X	X
Specific Conductance - field determined	μmho/cm	X	X	X	X
Sulfate	250 mg/L	X	X	X	X
Total Dissolved Solids	500 mg/L	X	X	X	X
Total Organic Carbon				X	
Total Organic Halogen				X	
Total Volatile Organic -D-11,D-12,TW-3	See Note below		X	X	
Tritium - (D-11, D-12, TW-3)				X	

Elevation of top of casing, depth to water table from top of casing and from ground level reported every quarter.
All monitoring wells D-11, D-12, MW-14, MW-15, MW-16, TW-2, and TW-3 are sampled except where so noted.

Note: 40 CFR Part 136-Methods 624 and 625 shall be used to identify and monitor for the volatile organic compounds and base/neutral toxic pollutants as identified in Appendix B of the NJPDES Regulations (NJAC 7:14A-1 *et seq*.).

In 1993, Princeton University entered into an agreement called a Memorandum of Understanding (MOU) with the Department of Environmental Protection to investigate and to potentially remediate ground-water contamination. In September 1994, PPPL prepared a revised work plan for the remedial investigation required under the MOU and submitted it to NJDEP (see Sections 3.2.3, 6.1.3 B, and 7.0 for further discussion of the MOU).

In December 1996, a round of ground-water samples was performed for all monitoring wells, including the four newly installed wells on the south side of C site (Fig. 5). The results exceeded New Jersey Ground Water Quality Standards for volatile organic compounds, mainly tetrachloroethene and trichloroethene (see Tables 23 & 24). This monitoring activity lead the investigation in a new direction toward the former Annex Building. In August 1997, eight additional wells were drilled (see Fig. 5), and samples were collected in January and April 1998.

4.3 Environmental Requirements

Environmental requirements held by DOE-PG are listed in Exhibit 3-6 and are discussed in Section 3.0, "Environmental Compliance Summary" and Section 6.0, "Environmental Non-Radiological Program Information," of this report.

4.4 Environmental Impact Statements and Environmental Assessments

No Environmental Impact Statements or Environmental Assessments were prepared in 1998.

4.5 Summary of Significant Environmental Activities at PPPL

4.5.1 Regulatory Inspections/Audits

In February 1998, the US Environmental Protection Agency (EPA) Region II conducted a multi-media inspection of PPPL. It was a four-day effort covering Clean Air Act, Clean Water Act, Emergency Preparedness and Community Right-to-Know, Resource Conservation and Recovery Act, Safe Drinking Water Act, Toxic Substances Control Act, Superfund Act Reauthorization Amendments, and Spill Prevention Control and Countermeasure Act regulatory requirements. The final results of the Inspection were the issuance of two NOVs; the RCRA training NOV was later rescinded. PPPL has, in part, resolved the SPCC issues. Containment structures are being designed to complete the SPCC actions.

In April, an NJDEP Air Enforcement inspector audited the Air Compliance Program at PPPL.. The areas audited were the boiler fuel use logs, diesel generator run-time logs, the large C site chillers, which contain CFCs, and aboveground storage tanks; PPPL's exisiting permits were reviewed for compliance. PPPL received an acceptable rating based on no deficiencies in the Air Compliance Program.

In May 1998, an inspector from the NJDEP Bureau of Discharge Prevention inspected PPPL. Based on the criterion in the regulations, the inspector determined that PPPL is not a major facility [NJDEP98a]. Therefore, the requirements for the Discharge Prevention Containment and Countermeasure (DPCC) Plan and Discharge Cleanup Report (DCR) are not applicable.

In July, an NJDEP Enforcement inspector conducted the annual inspection of the discharge to Surface Water Permit (NJPDES NJ0023922 [NJDEP98b). After reviewing the records and visually inspecting the two permitted outfalls, the result was an unacceptable rating. Based on missing the total suspended solids measurement at the outfall DSN003 in October 1997, a request for an affirmative defense must be made to NJDEP. Previous to the inspection, an affirmative defense had not been made to NJDEP. PPPL and DOE requested the affirmative defense, because it was the contractor laboratory who missed the analysis; NJDEP approved. Since October 1997, the contractor laboratory's performance has been without errors.

In September 1998, PPPL conducted an internal assessment of the surface water monitoring program. One finding was issued: the surface water monitoring procedure needed to be revised (completed). One commendation was issued for PPPL taking responsibility for the sampling.

4.5.2 Tritium in the Environment

The August 1995 sample result for tritium concentration (in water) was found to be elevated above background or baseline sample for well TW-1, located north of the D site (formerly TFTR) stack. The tritium concentration was 789 picoCuries/Liter (pCi/L), which was higher than 150 pCi/L at the baseline well. As a result of this elevated level, PPPL began an investigation into the cause of the concentration increase. More wells and ground water sumps were sampled, underground utilities were tested for leaks, soil was tested, and roof drains were evaluated. In addition, ten on- and five off-site rain water sampling stations were established and sampled.

The investigation found no leaks emanating from underground utilities; soil results supported this finding. Drain samples from the LECT roof as well as soil samples next to drain spouts showed that tritium concentrations were elevated.

Exhibit 4-4. Highest Tritium Concentrations in Environmental Samples

Media	Location	Highest HTO	Date	Stack Data/Rainfall
Well	TW-1	1,288 pCi/L	March 1998	10/8/97 8.84 Ci HTO
Well	TW-5	1,441 pCi/L	March 1998	0.4 in. rainfall
Rain water	R1N duplicate	26,459 pCi/L	August 1998	8/19/98 3.81 Ci HTO
Surface water	DSN001	592 pCi/L	August 1998	1.33 in. rainfall

During March 1998, the highest concentration of tritium in the ground water was 1,441 pCi/L at TW-5 and 1,288 pCi/L at TW-1 well below the Safe Drinking Water Act tritium limit of 20,000 pCi/L. Approximately five months previously, in October 1997, HTO measured from the D site stack was 8.84 Curies, which was the third highest concentration in 1997. Ground water results showed that tritium concentrations at TW-1 declined after the first quarter from above the 1,000 pCi/L range to consistently below 1,000 pCi/L except during May when the tritium concentration was slightly above 1,000 pCi/l. (1,055 pCi/L). TW-5 remained in the above 1,000 pCi/L range until the fourth quarter of 1998 when the tritium concentrations were well below 1,000 pCi/L range. Monitoring of ground water (wells and sumps), precipitation, and the TFTR vent stack continued into 1999.

Also, in 1998, the highest tritium concentrations in rainwater occurred in August (26,4590 pCi/L), which was when the highest tritium air releases were detected (3.81 Ci during one week) (Tables 3, 8, and 9). Numerous scientific studies have documented the effects of atmospheric tritium releases and the subsequent “washout” in precipitation. Rain droplets act as a scrubber and wash tritiated water vapor (HTO) out of the plume from the stack [Mu90]. Water infiltrates into the ground, and eventually, some of the tritium reaches the ground water table and monitoring wells.

4.5.3 New Jersey Pollutant Discharge Elimination System Ground and Surface Water Permits

In 1998, PPPL prepared a renewal application for the New Jersey Pollutant Discharge Elimination System (NJPDES) surface water discharge permit (NJ0023922), which expired on February 28, 1999. The NJDEP had issued the surface water permit on January 21, 1994, effective date of March 1, 1994 [NJDEP94]. In August 1998, 180 days prior to the permit’s expiration, PPPL submitted the NJPDES renewal application to NJDEP. In December 1998, NJDEP was contacted and PPPL found that a draft permit could be expected in early 1999.

With the NJDEP’s ground water discharge program being modified, the Ground Water Pollution Plan (GWPP) offered an option to a conventional discharge permit. In order for PPPL to apply for the GWPP option, the ground water monitoring program requires revision and updating to include data collected in 1998.

4.5.4 Waste Minimization Activities and Pollution Prevention Awareness

PPPL site-wide Waste Minimization/Pollution Prevention Program accomplished the following in 1998. The hazardous waste recycling program continued with PPPL's solid waste stream reduced by the recycling of 106,325 pounds of paper and cardboard, and 17,570 pounds of aluminum cans, plastic and glass bottles [see Exhibit 3-2]. These accomplishments are attributable to the continuation of the Sanitary Waste Evaluation [PPPL98b].

In 1998, PPPL reduced the amount of hazardous waste disposal by 37.47%; municipal solid waste was reduced by 47.41% through active recycling programs. PPPL instituted a "buy recycled-content products" through its Procurement Office.

In 1998, PPPL sponsored Public Outreach Education programs: the April celebration of Earth Day with a program of invited speakers as well as activities for students (middle grades, primarily) and American Recycles Day (November 15th) with vendors exhibits and invited speakers.

4.5.5 Environmental Training and College Interns

In 1998, PPPL employees were provided with the opportunity to attend the 40-hour training "Health and Safety for Hazardous Waste Site Investigation Personnel" (HAZWOPER), the 8-hour refresher course or OSHA HAZWOPER refresher, and the 8-hour course for Supervisors of Hazardous Waste Operations. Through a grant for the Department of Energy, instructors from the Environmental and Occupational Health Sciences Institute (EOHSI) provided these training courses. EOHSI is jointly sponsored by the University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School and Rutgers, the State University of New Jersey.

In September 1998, PPPL and Drexel University (Philadelphia, PA) began a co-operative internship program at the Laboratory. Those selected students with computer, physics, engineering, or environmental studies majors spend six months at PPPL working in a department related to their major. PPPL's Environmental Restoration/Waste Management Division has provided opportunities for students to work in the environmental field while providing them guidance and instruction.

Chapter 5

ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

5.1 Radiological Emissions and Doses

5.1.1 Penetrating Radiation

The TFTR conducted high power Deuterium-Tritium operations from December 1993 to April 1997, after which TFTR went into a safe shut down mode. These operations were a potential source of neutron and gamma/x-ray exposure. The TFTR device and the Princeton Beta Experiment Modification (PBX-M) did not operate in 1998.

Laboratory policy states that when occupational exposures have the potential to exceed 1,000 mrem per year (10 mSv/y), the appropriate project manager must petition the PPPL Environment, Safety, and Health (ES&H) Executive Board for an exemption. This value (1,000 mrem per year limit) is 20 percent of the DOE legal limit for occupational exposure. In addition, the Laboratory applies the DOE ALARA (as low as reasonably achievable) policy to all its operations. This philosophy for control of occupational exposure means that environmental radiation levels, as a result of experimental device operation, are also very low.

From all operational sources of radiation, the design objective for TFTR was less than 10 mrem per year (0.1 mSv/y) above natural background at the PPPL site boundary. When TFTR last operated in 1997, D-D (2.4 MeV) and D-T (14.0 MeV) neutrons and gamma/x-rays were produced in the range of 0 to 10 MeV [Ja98].

5.1.2 Sanitary Sewage

Drainage from D site sumps is collected in the Liquid Effluent Collection (LEC) tanks; each of three tanks has a total capacity of 15,000 gallons. Prior to release of these tanks to the sanitary sewer system, *i.e.*, Stony Brook Regional Sewerage Authority (SBRSA), a sample is collected and analyzed for tritium concentration and gross beta. All samples for 1998 showed effluent quantity and concentrations of radionuclides (tritium) to be within allowable limits established in New Jersey regulations (1 Ci/y for all radionuclides) and by 40 CFR 141.16 and DOE Order 5400.5 (2×10^6 pCi/liter for tritium). As shown in Exhibit 5-1 below, the 1998 total amount of tritium released to the sanitary sewer was 0.071 Curies, about seven percent of the allowable 1.0 Curie per year.

Exhibit 5-1. Total Annual Releases to Sanitary System from 1994 to 1998

Calendar Year	Total Gallons Released	Total Activity (Curies)
1994	273,250	0.299
1995	308,930	0.496
1996	341,625	0.951
1997	139,650	0.366
1998	255,450	0.071

In April 1998, the Emergency Operations Center was called into action for the first time under actual emergency conditions. The sump pumps in the D site air shaft failed to operate and ground water began filling the air shaft basement and an adjacent mechanical equipment room. Drains in these areas sent water to the LEC tanks until these three tanks were filled to capacity, after which time, flooding of the air shaft and adjacent mechanical equipment room continued unabated. Also, a number of drums holding tritiated water (some empty, some containing water) were located in the basement area next to the air shaft. Emergency measures were employed to ensure that the tritium content and concentrations in the LEC tanks were sufficiently low for release to the sanitary sewer. In this manner, flooding conditions were relieved, the pumps were repaired, and the system was returned to normal operations. .As shown on Table 11, there were 6 LECT releases for a total of 70,800 gallons on April 14, 1998, the date of the incident.

5.1.3 Radioactive and Mixed Waste

In 1998, low-level radioactive wastes were stored on-site, either in the Radioactive Waste Handling Facility or within a controlled area of TFTR. The low-level radioactive shipments made in 1998 consisted of removed systems from TFTR and compacted solid waste, including personal protective clothing. No low-level radioactive mixed waste was generated in 1998 [El99].

Exhibit 5-2. Total Low-Level Radioactive Waste 1997 *vs*, 1998

	1997	1998
Cubic feet (ft^3)	1,997.7	533.74
Total Activity in Curies	31,903.0	204.80

5.1.4 Airborne Emission

A. Differential Atmospheric Tritium Samplers (DATS)

PPPL uses the differential atmospheric tritium sampler (DATS) to measure elemental (HT) and oxide (HTO) tritium at the D site stack and in the Radioactive Waste Handling Facility (RWHF). DATS are similarly used at eleven (11) environmental sampling stations: 4 located on D site facility boundary trailers (T1 to T4), 6 located at remote environmental air monitoring stations (R 1 to R6) and one located baseline station in Hopewell Township, NJ (Tables 3-5). All of the aforementioned sampling is performed continuously.

In previous years, the projected dose equivalent at the site boundary was based on emissions of airborne radioactivity (HTO, HT, Ar-41, N-13, N-16, Cl-40, and S-37). In 1998, TFTR did not operate and therefore, no neutrons were produced. Ar-41, N-13, N-16, Cl-40, and S-37 are air activation products from neutrons produced during TFTR experiments.

Tritium (HTO and HT) was continued to be released *via* the D site stack, which was continuously monitored (Table 3 and Fig. 13). Projected dose equivalent at the nearest off-site business from airborne emissions of tritium was 0.08mrem (0.8 μSv). Measurements at the D site facility boundary have measured in the concentrations range of 3.6 to 584.4 pCi/m^3 of oxide tritium - HTO and 6.1 to 648.1 elemental tritium - HT (Table 4 and Figs. 9 & 10). Measurements from off-site monitoring stations are shown in Table 5 and Figures 11 & 12, "Air Tritium (HT)" and "Air Tritium (HTO)," respectively.

The EDE at the site boundary was calculated based on annual tritium totals as measured at the stack and RWHF (DATS air) and water samples at the LECT and highest measurements from a well and surface water during 1998. The addition of the RWHF, which has no elevated stack, contributes more significantly to the EDE at the site boundary than to the EDE at the nearest business.

Exhibit 5-3. Summary of 1998 Emissions and Doses from D Site Operations

Radiolnuclide & Pathway	Source	Source Term (Curies)	EDE (mrem/yr) at Site Boundary	Percent of Total
Tritium (air)	D-site stack	45.867 (HTO) 28.982(HT)	0.12001	17.8
Tritium (air)	RWHF	0.074 (compactor & vial crusher est.) 2.745 (calculated est. based on RWHF air measurements)	0.5528	81.8
Tritium (water)	LECT	0.071271 (HTO)	0.0014254	0.2
Tritium (water)	Surface & ground water	419 pCi/L (Bee Brook) 1,441 pCi/L (Well TW-5)	0.00133	0.2
Total			**0.6755654**	100

EDE = effective dose equivalent
LECT = liquid effluent collection tanks
RWHF = Radioactive Waste Handling Facility
Surface water is measured at Bee Brook Station B2.
Annual limit is 10 mrem/year.

5.2 Unplanned Releases

There were no unplanned releases in 1998.

5.3 Environmental Monitoring

5.3.1 Waterborne Radioactivity

A. Surface Water

Surface-water samples at nine locations (two on-site: DSN001, and E1; and seven off-site: B1, B2, C1, DSN003, M1, P1, and P2) have been analyzed for tritium (Table 6). The locations, DSN003 (Delaware & Raritan Canal pump house) and E1 (Elizabethtown Water), replaced the baseline (Rock Brook in Montgomery Township) in November 1995. Five of these locations have been monitored since 1982. Downstream sampling occurs after mixing of effluent and ambient water is complete. Locations are indicated on Figures 5 (on-site) and 6 (off-site locations).

In August 1998, at on-site location DSN001, basin outfall, tritium was detected at 592 pCi/Liter, which was the highest in 1998 for surface water samples. As an explanation for this data, the surface water highest concentration correlates with the highest tritium releases from the D site stack and with the highest rainfall concentration both occurring in August.

Rain water samples collected and analyzed in 1998 ranged from below detection (<99 to 26,450 pCi/liter (see Tables 8, & 9 and Figs. 15 & 16), which is lower than the 1997 range of 131 to 61,660 pCi/liter (see Table 10). In the three weeks prior to collecting the highest level rainwater sample (26,450 pCi/L), D site stack released 9.04 Curies HTO; this release occurred during the removal of tiles from the TFTR vacuum vessel and RF antennae from the Test Cell. These releases account for approximately 20 percent of the annual 1998 total for HTO released to the atmosphere. Based on this data and associated literature [Mu77, Mu82, Mu90], it is believed that the observed increase in tritium concentrations in rain water is due to washout by precipitation a portion of the tritium released from the TFTR stack. Monitoring of tritium concentrations in rainwater continues.

Exhibit 5.4 - Total Rainfall in Inches (centimeters) 1988-1998

Dry: < 40"	Average: 40-50"	Wet: >50"
1988*	1991 - 45 (114 cm)	1989 – 55 (140cm)
1995 – 35.6 (90 cm)	1992 – 42 (107cm)	1990 – 50.3 (128cm)
	1993 – 42.7 (109cm)	1994 – 51 (130cm)
	1997 – 41.99 (107cm)	1996 – 61 (155cm)
	1998 – 42.96 (109 cm)	

Rainfall was not collect for a full 12 months in 1988; the estimated amount for 1988 is below 40 inches.

In April 1988, PPPL initiated the collection of precipitation. Exhibit 5-2 shows the occurrence of dry, average, and wet years (see Table 2 for 1998 rainfall by week) [Ch99].

B. Ground Water

Beginning in August 1995, more frequent ground-water monitoring and sampling of different wells began. This increase in scope of ground-water monitoring was prompted by the increase in tritium level in well TW-1. An investigation into the potential sources began in the fall of 1995. Leak tests and checks of lines and equipment in the area near TW-1 (north side of D site) were performed; none were found to be leaking tritiated water into the ground water.

In 1998, eleven on-site wells - TW-7, TW-8, MW-12S, D-11R and D-12 on C site, and TW-1, TW-2, TW-3, TW-4,TW-5, and TW-9 on D site (Fig. 14) - were sampled. Since the presence tritium at D site and the onset of D-T operations, ground water results (Table 7and Fig.14) were slightly elevated in TW-1 and TW-5; for 1998, TW-1 tritium concentrations ranged from 730 pCi/Liter to 1,288 pCi/Liter; and TW-5 tritium concentrations ranged from 595 to 1,441 pCi/L.

From PPPL's environmental monitoring data and the available scientific literature [Mu77, Mu83, Mu90], the most likely source of the tritium detected in the on-site ground water samples is from the atmospheric venting of tritium from TFTR operations and the resulting "wash-out' during precipitation (Figure 15). Ground water monitoring of the wells and the foundation sump (dewatering sump for the TFTR and Motor Generator buildings) will continue.

C. Drinking Water

Potable water is supplied by the public utility, Elizabethtown Water Co. In April 1984, a sampling point at the input to PPPL was established (E1 location) to provide baseline data for water coming onto the site. Radiological analysis has included gamma spectroscopy and tritium-concentration determination. In 1998, tritium measurements of potable water ranged from <130pCi/L to 320 pCi/liter (Table 6).

5.3.2 Foodstuffs and Soil and Vegetation

There were no foodstuffs, soil, or vegetation samples gathered for analysis in 1998. In 1996, the HP Manager reviewed the requirement for soil/biota sampling. At that time, a decision was made to discontinue the sampling program. In general the decision was made because the program had "No Value Added". A heavier concentrated effort was placed on the water sampling and monitoring which produced more relevant results.

The capability to perform soil/biota analysis has been retained and is now performed using Oxidation, when necessary.

Chapter 6

ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

6.1 New Jersey Pollutant Discharge Elimination System (NJPDES) Program

6.1.1 Surface and Storm Water

To comply with permit requirements of the New Jersey Pollutant Discharge Elimination System (NJPDES) permit, NJ0023922, PPPL submitted to NJDEP monthly discharge monitoring reports (DMRs) for Discharge Serial Number (DSN)—DSN001 and DSN003 (see Tables 17 & 18). During 1998, PPPL was within allowable limits for all testing parameters at DSN001. The last exceedance at DSN001 was reported in November 1993 for total suspended solids (73 mg/L *vs.* 50 mg/L—the permit limit).

One exceedance in June 1998 occurred at DSN003 (22 mg/L for total suspended solids exceeded the monthly average limit of 20 mg/L). Previous to this exceedance, a total suspended solid concentration of 27 mg/L exceeded the permit limit of 20 mg/L in September 1997, at DSN003 (filter back wash for the pumps at the Delaware & Raritan Canal).

In August 1998, PPPL and DOE submitted to NJDEP the renewal permit application for the NJPDES permit, 180 days prior to the expiration date, February 28, 1999. NJDEP had assigned a permit writer, and a draft permit was prepared in early 1999 for internal review.

6.1.2 Chronic Toxicity Characterization Study

In 1998, chronic toxicity testing for DSN001 effluent continued. In all chronic toxicity tests, *Pimephales promelas* (fathead minnow) was the only test species required [NJDEP95]. NJDEP chose the fathead minnow as the more sensitive species for the Chronic Toxicity Biomonitoring requirements. For all tests in 1998, the survival rate, as defined by the NJ Surface Water Quality Standards, was 100 percent no observable effect concentration (NOEC), and the inhibition concentration 25 (IC_{25}) was greater than one hundred percent. The last unsuccessful test occurred in March 1995, the fathead minnows survived in the 50 percent dilution, *i.e.*, mortality was observed in the 100 percent effluent test.

In September 1998, NJDEP granted PPPL and DOE's request for reduced testing frequency based on the successful completion of 15 consecutive tests. Frequency was reduced from quarterly to semi-annually; September 1998 chronic toxicity test was the last quarterly test and March 1999 the first semi-annual test.

6.1.3 Ground Water

Since 1989, PPPL has monitored ground-water quality in seven wells in compliance with the NJPDES ground-water discharge permit, NJ0086029; four of the seven wells are located on PPPL C and D sites, and three wells are located on A and B sites. The wells on A & B sites are not on DOE-leased property, but are on the adjacent James Forrestal Campus property. The two inflows to the on-site basin are included in the monitoring requirements.

The permit was issued effective April 1, 1989, and the expiration date was extended to December 31, 1996. In July 1994, DOE-PG submitted to NJDEP the NJPDES permit renewal application. Included in that application was the "Ground Water Quality Report for the NJPDES Permit Renewal Application Permit No. NJ0086029," which summarized data from 1989 to 1994 [Fi94]. PPPL is preparing the Ground Water Pollution Prevention Plan (GWPPP), which will replace the standard NJPDES permit.

A. NJPDES Quarterly Ground Water Monitoring Program in 1998

In this section, the NJPDES Quarterly Ground Water Monitoring Program is discussed in three parts: A and B site wells (MW-14, MW-15, and MW-16); C and D site wells (D-11, D-12, TW-2, and TW-3); and the detention basin Inflows 1 and 2.

Three A and B site wells—MW-14, MW-15, and MW-16—were sampled quarterly (see Tables 19 & 24). All results were below permit standards with two exceptions: in August 1998, Bis(2-ethylhexyl)phthalate (base/neutral compound) was detected at 1.21 µg/l for MW-14and 2.21 µg/l at MW-16, which are below the detection limit. Bis(2-ethylhexyl)phthalate is a commonly detected compound usually resulting from the plastic gloves worn when collecting samples.

The C and D site wells—D-11R, D-12, TW-2, and TW-3—1998, were sampled quarterly (Tables 20 and 21). Tetrachloroethene (PCE) was detected (May and August samples); these PCE results were above the Ground Water Quality Standards (GWQS) (Exhibit 6-1). Also, detected above the GWQS was trichloroethene (TCE) in wells D-12 and TW-3. Detected in concentrations well below the GWQS were the compounds and toluene (70 µg/L and 1,000 µg/L, respectively) (Tables 22 & 23).

Exhibit 6-1. Volatile Organics in Ground Water

Volatile Organics in µg/L	D-11R		D-12		TW-3		*GWQS*
	May	Aug.	May	Aug.	May	Aug.	
Tetrachloroethene (PCE)	4.90	7.13	4.73	10.4	2.59	10.1	*0.4*
Trichloroethene (TCE)	<1	<1	1.9	2.82	<1	1.05	*1.0*
1,1-dichloroethane	<5	<5	1.66 J	1.91 J	<5	<5	*70*

Detention basin inflows or influents were monitored twice each year, in May and August (see Tables 16 & 23), pursuant to PPPL NJPDES ground water discharge permit, NJ0086029. Volatile organic compounds were detected at Inflow 2 in concentrations above the GWQS for tetrachloroethene (1.69 µg/L), and chloroform (2.60 µg/L). Located on the north side of the detention basin, Inflow 2 receives ground water from the D site TFTR and MG basement sump pumps and storm water from the transformer yard sumps.

Located on the west side of the detention basin, Inflow 1 receives water from the C site MG, LOB, and CS basement sumps, C and D site cooling tower and boiler blow down, and non-contact heat exchanger cooling water, as well as storm water. At Inflow 1, volatile organic compounds were detected: chloroform at 1.98 µg/L. Both water from the D&R Canal and the cooling tower are chlorinated to prevent fouling.

Based on 12 months of flow data, greater than 161 million gallons of water were discharged from the detention basin in 1998. The lined detention basin operates with a permanent oil boom, oil sensors that are capable of sending an alarm signal to Security, an outfall exit valve mechanism, and a fence around the perimeter of the basin. Presently, the detention basin is operated in a flow-through mode.

B. Regional Ground Water Monitoring Program

In 1993, a Memorandum of Understanding (MOU) was signed between Princeton University, the landowner of the James Forrestal Campus, and the NJ Department of Environmental Protection (NJDEP). A remedial investigation and remedial alternative assessment were required in this MOU. For C and D sites, a Remedial Investigation is discussed in Section 3.2.3 and is fully documented in the Remedial Investigation Report prepared by Harding Lawson Associates and submitted to NJDEP in early 1997 [HLA97].

In 1998, soil and ground water monitoring activities were continued in the area of potential environmental concern (APEC) near the location of the former PPPL Annex Building in the wooded are southwest of CAS/RESA. (Tables 25 & 26).

The C and D sites sump pump systems (TFTR-S1, LOB-S3, MG-S2, MG-S4, MG-S5, MG-S6, and CS-S7) were also sampled at the same time wells were sampled in June 1994, March and May 1995, December 1996, February and September 1997, and January and April 1998 (Tables 25 & 26). Occurrence of PCE in all the sumps except MG-S5 can be attributed to the PCE present in the ground water.

6.2 Non-Radiological Programs

The following sections briefly describe PPPL's environmental programs required by federal, state, or local agencies. The programs were developed to comply with regulations governing air, water, wastewater, soil, land use, and hazardous materials, as well as with DOE orders or programs.

6.2.1 Non-Radiological Emissions Monitoring Programs

A. Airborne Effluents

PPPL maintains New Jersey Department of Environmental Protection (NJDEP) air permits for its four boilers located on C site. The permit certificate numbers 061295 through 061299 were issued as 90-day temporary certificates; however, in 1997, NJDEP stopped issuing the temporary certificates. The boiler permits were part of NJDEP's inspection of the facility; the facility was determined to be in compliance of the air regulations and permit requirements. In 1998, PPPL operated all boilers with natural gas as the primary fuel; the boilers were shutdown for the entire summer months for maintenance and repairs.

Measurements of actual boiler emissions are not required. To optimize boiler efficiency and to reduce fuel cost in accordance with DOE Order 4330.2D, "In-House Energy Management," [DOE88b] PPPL utilizes an outside contractor to tune all the boilers on an annual basis and provide a report for each boiler. The report includes the boiler efficiency, oxygen content, flue-gas temperature and carbon dioxide content of the stack gas for both oil and natural gas fuels. The PPPL boiler operations Chief Engineer maintains a record of this information on file [Kir99].

Five additional air permits are maintained by PPPL: two permits for two above ground storage tanks and three permits for three dust collectors. The aboveground storage tanks (25,000 and 15,000 -gallon capacities) emit volatile organic compounds that originate from #4 fuel oil and #1 diesel oil, respectively. The FED and CAS dust collector emissions originate from general wood working operations. The Shop building dust collector emissions originate from metal working operations.

B. Drinking Water

Potable water is supplied by the public utility, Elizabethtown Water Co. The PPPL used approximately 27.115 million gallons in 1998 [Kir00]. In 1994, a cross-connection was installed beneath the water tower to provide potable water to the tower for the fire-protection system and other systems. 1998 potable water usage is close to the previous two years (1997 and 1996 - 24.56 and 27.82 million gallons, respectively).

C. Process (non-potable) Water

In 1986, a multimedia sand filter with crushed carbon was installed to allow the D site cooling tower make-up water to be changed from potable water to process-water (non-potable) supply. In 1987, PPPL made a changeover from potable water to Delaware & Raritan (D&R) Canal non-potable water for the cooling-water systems. Non-potable water is pumped from the D&R Canal as authorized by a permit agreement with the New Jersey Water Supply Authority. The present agreement gives PPPL the right to draw up to half a million gallons of water per day for process and fire-fighting purposes.

Filtration to remove solids, chlorination, and corrosion inhibitor is the primary water treatment at the canal pump house. Located at the canal pump house, the filter-backwash, discharge number (DSN003), is a separate discharge point in the NJPDES surface-water permit and is monitored monthly (Table 18). PPPL used approximately 30.9 million gallons of canal water during 1998 [Kir00]; this compares to 32.8 million gallons (1997), 96.2 million gallons of canal water (1996) [An97] and 67.2 million gallons (1995). A sampling point (C1) was established to provide baseline data for process water coming on-site. Table 13 indicates results of water quality analysis at the canal.

D. Surface Water

Surface water is monitored for potential non-radioactive pollutants both on-site and at surface-water discharge pathways (upstream and downstream) off-site. Other sampling locations—Bee Brook (B1 & B2), D site Ditch #5 (D1), Delaware & Raritan Canal (C1), Millstone River (M1), and Plainsboro (P1 & P2) sampling points (Tables 12-16)—are not required by regulation, but are a part of PPPL's environmental monitoring program.

E. Sanitary Sewage

Sanitary sewage is discharged to the publicly owned treatment works (POTW) operated by South Brunswick Township, which is part of the Stony Brook Regional Sewerage Authority (SBRSA). During 1994, due to malfunctioning metering devices, PPPL, South Brunswick Sewerage Authority, and the Township of Plainsboro agreed upon an estimated volume. The estimated volume was based on historical data of approximate flow rates from PPPL. This volume was adjusted for the interconnections with Forrestal Campus A and B sites and a private business. For 1998, PPPL estimates a total discharge of 6.00 million gallons of sanitary sewage to the South Brunswick sewerage treatment system [Kir00**]**.

In 1994, Stony Brook Regional Sewerage Authority (SBRSA) issues an Industrial Discharge Permit (22-93-NC) to PPPL and DOE-PG. In 1996, the SBRSA permit was changed to a license and required monthly measurement of radioactivity, flow, pH and temperature at the LEC tanks (designated compliance and sampling location) and annual sampling for chemical oxygen demand. During 1998, PPPL performed monthly radiological and non-radiological analyses to meet these license requirements (see Table 11).

F. Spill Prevention Control and Countermeasure

PPPL maintains a Spill Prevention Control and Countermeasure Plan (SPCC), which was revised in 1998 [VNH98]. The SPCC Plan is incorporated as a supplement to the PPPL Emergency Preparedness Plan.

G. Herbicides and Fertilizers

During 1998, PPPL's Facilities Management Division managed the use of herbicides by outside contractors. These materials are applied in accordance with state and federal regulations. Chemicals are applied by certified applicators. In 1998, 1800 pounds of fertilizers were applied to the PPPL site, though no fertilizers were needed during 1997.

The quantities applied during 1998 were as follows 1800 pounds of fertilizers; the herbicides - Surflan (57.8 quarts), Roundup (72.7 quarts), and Dissolve (10 pounds) [Ki99]. No herbicides or fertilizers are stored on site; therefore, no disposal of these types of regulated chemicals is required by PPPL [Kin99].

H. Polychlorinated Biphenyls (PCBs)

At the end of 1998, PPPL's inventory of equipment containing polychlorinated biphenyls (PCBs) was 5 large, regulated capacitors. 648 regulated-PCB capacitors were removed in 1998. However, as they are taken out of service, the disposal records are listed in the Annual Hazardous Waste Generators Report [PPPL98b].

I. Hazardous Wastes

The last Hazardous Waste Generator Annual Report (EPA ID No. NJ1960011152) was submitted for 1998 in accordance with EPA requirements. A description of Resource Conservation and Recovery Act (RCRA) compliance is found in Section 3.1.2 of this report. The 1996-1997 Hazardous Waste Generator Annual Report was submitted in early 1998. 1998 will be included in the 1998-1999 Biennial Hazardous Waste Generator Report in early 2000.

6.2.2 Continuous Release Reporting

Under CERCLA's reporting requirement for the release of a listed hazardous substance in quantities equal to or greater than its reportable quantity, the National Response Center is notified and the facility is required to report annually to EPA. Because PPPL has not released any CERCLA-regulated hazardous substances, no "Continuous Release Reports" have been filed with EPA.

6.2.3 Environmental Occurrences

One report (Case No. 98-09-22-1035-23) was made to the New Jersey Department of Environmental Protection when it was discovered it required notification to NJDEP; the oil released did not exceeded reportable quantities (RQ) and was not reported to the National Response Center [Sh98].

Oil-contaminated soil was discovered adjacent to the Facilities Building foundation during the installation of a new potable water line connecting to the boilers. This discovery was called in the NJDEP Hotline on September 22, 1998 [RS98]. In 1988, underground storage tanks (USTs) and associated piping were determined to have leaked No. 4 and No. 6 fuel oil. Subsequently, these tanks, pipes, and contaminated soil were removed; however, the soil immediately adjacent to the foundation could not be excavated without compromising the building's integrity. Approximately 15 cubic yards of soil were removed and shipped to an asphalt paving plant. Clean soil was then placed in the excavation, and the area was cap with asphalt.

6.2.4 SARA Title III Reporting Requirements

NJDEP administers the Superfund Amendments and Reauthorization Act (SARA) Title III (also known as the Emergency Reporting and Community Right-to-Know Act) reporting for EPA Region II. The modified Tier I form includes SARA Title III and NJDEP-specific reporting requirements. PPPL submitted the SARA Title III Report to NJDEP in March 1998 [PPPL98a]. No significant changes from the previous year were noted. The SARA Title III reports included information about twelve compounds used at PPPL as listed in Exhibit 3-7.

Though PPPL does not exceed threshold amounts for chemicals listed on the Toxic Release Inventory (TRI), PPPL completed the TRI cover page and laboratory exemptions report for 1996, and submitted these documents to DOE. Since PPPL did not exceed the threshold amounts, no TRI submittal was completed for 1998.

6.3 Safety

PPPL's 1998 performance with respect to worker safety was as follows:

1. Recordable injury case rate:	1.47 per 100 employees
2. Lost Work Day case rate:	0.21 per 100 employees
3. Lost Work day rate:	0.63 per 100 employees
4. Number of radioactive contaminations (external):	2
5. Number of Safety Occurrence reports: (OSHA confined space, chemical exposure, and lock out/tag out incidents)	0

Chapter 7

GROUND WATER PROTECTION

PPPL's Ground Water Program focus is the "Groundwater Protection Management Plan" (GPMP), required by DOE Order 5400.1, "General Environmental Protection Program." The GPMP is a written plan that PPPL uses as a management tool, to ensure protection of ground water. The GPMP was implemented in parallel with two ground-water investigations; an investigation of volatile organic compounds, which are consistently found —tetrachloroethene (PCE) and trichloroethene (TCE), and petroleum hydrocarbons, and an investigation regarding tritium.

As required by NJDEP, PPPL performed ground water investigations to address potential impacts from former underground storage tanks (USTs), a formerly unlined detention basin, and areas where spills occurred or may have occurred. In all, PPPL has installed 44 wells to monitor ground-water quality. Remedial investigations and remedial alternative assessment studies at PPPL are ongoing as required by conditions of the Memorandum of Understanding (MOU).

Generally, all parameters measured meet the New Jersey Ground Water Quality Standards. Ground-water monitoring results showed that PCE, TCE, and their natural degradation products are present in a number of shallow and intermediate-depth wells on C site. These VOCs are commonly contained in solvents or metal degreasing agents. In a couple wells, low levels of petroleum hydrocarbons were also detected. The source of the petroleum hydrocarbons is believed to have originated from former underground storage tanks that were removed.

By mid-1995, the remaining USTs were removed with the exception of one tank that was abandoned in-place with NJDEP's approval. PPPL replaced all USTs with above ground storage tanks. PPPL determined that the hazard of digging up one tank, buried next to a high-voltage electrical transformer yard, was too great a risk. The tank passed a tightness-test; soil borings around the tank showed no indications of any leakage from the tank or its associated piping. It was then emptied, cleaned, and filled with concrete in accordance with to NJDEP regulations.

Foundation de-watering sumps located on D site largely influence the ground-water gradient. The sumps create a shallow cone of depression drawing ground water toward them. Under natural conditions, ground-water flow is to the south/southeast toward Bee Brook; it appears that all ground water (except in the northwestern corner) is drawn radially toward the D site sumps).

In the winter and spring months of 1998, the sump pump flow was the highest (averaging over 477,000 gallons per day in May 1998) due to heavy rainfalls in those months (Table 27. During the summer and into the fall, little to no rain fell so that ground water recharge was minimal as shown during December 1998, which is the all-time low flow (averaging only 67,700 gallons per day).

During Phase 1 and 2 of the Remedial Investigation, samples from wells and other ground water characterization activities lead to the identification of a new area of potential environmental concern (APEC) near the Former Annex Building Area (FABA). This finding expanded the site boundaries by 16.5 acres for a total of 88.5 acres (see Figure 20). Characterization of soil and ground water in the former Annex Building area was conducted during 1997 and 1998 (Figures 17 & 18) [HLA98].

The Phase 3 activities were conducted to:

- Fulfill Baseline Ecological Evaluation (NJAC 7:26E) requirements;
- Investigate soil and ground water quality at the Former Annex Building Area (FABA);
- Further assess PCE and other VOC concentrations and distribution in ground water;
- Evaluate potential for natural attenuation.

Based on the investigation results, HLA proposed that continuing hydraulic control *via* the foundation de-watering by the D site sumps (TFTR and D site MG sumps) be the remediation action for PCE and TCE. Natural attenutation (natural reduction of these VOCs) was proposed for those areas beyond the influence of the sumps as evidenced that off-site migration is not present [HLA98].

The second investigation began in the August 1995, when the tritium concentration from well TW-1, located north of the TFTR stack, was found to be above the background or baseline concentration, 789 *versus* 150 picoCuries/Liter (pCi/L), respectively. As a result of this finding, PPPL began looking into the cause of the concentration increase. More wells and ground water sumps were sampled, underground utilities were tested for leaks, soil was tested, and roof drains were sampled. In addition, rainwater-sampling stations were established and sampled.

The results of this program were that no leaks were found emanating from underground utilities, and soil results supported this finding. Drain samples from the liquid effluent collection tank roof showed that tritium concentrations were elevated as well as soil samples next to drain spouts. Rain water samples showed elevated levels of tritium during August 1998 (26,450 pCi/L at station R1North duplicate) when atmospheric releases were elevated (Table 3 and Figure 9). A number of documents have described the effect of tritium releases and rain. Rain droplets act as a scrubber and wash tritiated water vapor (HTO) out of the plume from the stack [Mu90]. The water infiltrates into the ground, and eventually, some of the tritium reaches the ground water table and the monitoring wells.

The highest concentrations of tritium in the ground water in March 1998 were 1,441 pCi/L at TW-5, and 1,288 pCi/L at TW-1 (compared to the Drinking Water standard of 20,000 pCi/L). The ground water results showed that the tritium concentrations fluctuate over time. PPPL believes that tritium concentrations in the atmosphere, amount of precipitation (rainfall), and time of year all have an effect on the concentration in the ground water monitoring.

Chapter

8

QUALITY ASSURANCE

Analysis of environmental samples for radioactivity was accomplished on-site by the Radiological Environmental Monitoring Laboratory (REML). REML procedures follow DOE's Environmental Measurements Laboratory's EML HASL-300 Manual [Vo82] or other nationally recognized standards. Approved analytical techniques are documented in REML procedures [REML90]. PPPL participates in the EPA Laboratory Performance Evaluation (Las Vegas) program as part of maintaining its radiological certification. For non-radiological parameters, PPPL receives proficiency evaluation samples from EPA (Cincinnati, OH). These programs provide blind samples for analysis and subsequent comparison to values obtained by other participants, as well as to known values.

In 1984, PPPL initiated a program to have its REML certified by the State of New Jersey through the EPA Quality Assurance (QA) program. REML complies with EPA and NJDEP QA requirements for certification. In March 1986, REML facilities and procedures were reviewed and inspected by EPA/Las Vegas and NJDEP. The laboratory was certified for tritium analysis in urine (bioassays) and water and has been recertified in these areas annually since 1988.

In 1998, REML performed EPA semi-annual performance evaluation tests for radionuclides in water. REML passed all tests for tritium and gamma in water (Table 28).

In 1998, PPPL followed its internal procedures, EN-OP-001—"Surface Water Sampling Procedure," EN-OP-002—"Ground Water Sampling Procedures," and EN-OP-008—"Stormwater Sampling Procedures." These procedures provide in detail descriptions of all NJPDES permit-required sampling and analytical methods for collection of samples, analyses of these samples, and quality assurance/quality control requirements. All subcontractor laboratories and/or PPPL employees are required to follow these procedures. Chain-of-custody forms are required for all samples; holding times are closely checked to ensure that the analysis was performed within established holding times and that the data is valid. Field blanks are required for all ground water sampling, and trip blanks are required for all volatile organic compound analyses. Subcontractor laboratories used by PPPL are certified by NJDEP and participate in the state's QA program; the subcontractor laboratories must also follow their own internal quality assurance plans [QC96].

Chapter

9

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Chapter

10

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Chapter

11

TABLES

Table 1. PPPL Radiological Design Objectives and Regulatory Limits[a]

CONDITION		PUBLIC	EXPOSURE[b]	OCCUPATIONAL	EXPOSURE
		REGULATORY LIMIT	DESIGN OBJECTIVE	REGULATORY LIMIT	DESIGN OBJECTIVE
ROUTINE OPERATION Dose equivalent to an individual from routine operations (rem per year, unless otherwise indicated)	NORMAL OPERATIONS	0.1 Total, 0.01[c] Airborne, 0.004 Drinking Water	0.01 Total	5	1
	ANTICIPATED EVENTS $(1 > P \geq 10^{-2})$	0.5 Total (including normal operation)	0.05 per event		
ACCIDENTS Dose equivalent to an individual from an accidental release (rem per event)	UNLIKELY EVENTS $10^{-2} > P \geq 10^{-4}$	2.5	0.5	(e)	(e)
	EXTREMELY UNLIKELY EVENTS $10^{-4} > P \geq 10^{-6}$	25	5[d]	(e)	(e)
	INCREDIBLE EVENTS $10^{-6} > P$	NA	NA	NA	NA

P = Probability of occurrence in a year.

[a] All operations must be planned to incorporate the radiation safety guidelines, practices and procedures included in PPPL ESHD 5008, Section 10.

[b] Evaluated at the PPPL site boundary.

[c] Compliance with this limit is to be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business or office.

[d] For design basis accidents (DBAs), i.e., postulated accidents or natural forces and resulting conditions for which the confinement structure, systems, components and equipment must meet their functional goals, the design objective is 0.5 rem.

(e) See PPPL ESHD-5008, Section 10, Chapter 12 for emergency personnel exposure limits.

Table 2. 1998 Precipitation Data

START DATE	WEEK	INCH	INCH/MONTH	MONTH	ACCUMULATION
5-Jan-98	1	0.950			0.950
12-Jan-98	2	0.850			1.800
19-Jan-98	3	2.475			4.275
26-Jan-98	4	0.015	4.290	January	4.290
2-Feb-98	5	0.700			4.990
9-Feb-98	6	0.750			5.740
16-Feb-98	7	1.050			6.790
23-Feb-98	8	1.975	4.475	February	8.765
2-Mar-98	9	1.700			10.465
9-Mar-98	10	0.175			10.640
16-Mar-98	11	3.000			13.640
23-Mar-98	12	0.000			13.640
30-Mar-98	13	1.200	6.075	March	14.840
6-Apr-98	14	2.375			17.215
13-Apr-98	15	0.800			18.015
20-Apr-98	16	1.300			19.315
27-Apr-98	17	0.750	5.225	April	20.065
4-May-98	18	3.500			23.565
11-May-98	19	0.900			24.465
18-May-98	20	0.650			25.115
25-May-98	21	1.450	6.500	May	26.565
1-Jun-98	22	0.000			26.565
8-Jun-98	23	3.300			29.865
15-Jun-98	24	0.045			29.910
22-Jun-98	25	0.000			29.910
29-Jun-98	26	1.050	4.395	June	30.960
6-Jul-98	27	0.450			31.410
13-Jul-98	28	0.000			31.410
20-Jul-98	29	0.000			31.410
27-Jul-98	30	0.425	0.875	July	31.835
3-Aug-98	31	0.000			31.835
10-Aug-98	32	0.550			32.385
17-Aug-98	33	1.325			33.710
24-Aug-98	34	0.150			33.860
31-Aug-98	35	0.700	2.725	August	34.560
7-Sep-98	36	0.975			35.535
14-Sep-98	37	0.150			35.685
21-Sep-98	38	1.000			36.685
29-Sep-97	39	0.350	2.475	Sepember	37.035
5-Oct-98	40	2.150			39.185
12-Oct-98	41	0.500			39.685
19-Oct-98	42	0.750			40.435
26-Oct-98	43	0.175	3.575	October	40.610
2-Nov-98	44	0.000			40.610
9-Nov-98	45	0.450			41.060
16-Nov-98	46	0.150			41.210
23-Nov-98	47	0.650			41.860
30-Nov-98	48	0.000	1.250	November	41.860
7-Dec-98	49	0.300			42.160
14-Dec-98	50	0.050			42.210
21-Dec-98	51	0.100			42.310
28-Dec-98	52	0.550	1.000	December	42.860

Table 3. 1998 D-Site Tritium Stack Releases in Curies

Week Ending	HTO (Ci)	HT (Ci)	WeeklyTotal (Ci)	AnnualTotal (Ci)
Baseline 1/1/98	0.000	0.000	0.000	0.000
January 7, 1998	0.332	0.081	0.413	0.413
January 14, 1998	0.347	0.101	0.448	0.861
January 21, 1998	0.837	0.215	1.052	1.913
January 28, 1998	0.442	0.863	1.305	3.218
February 4, 1998	0.514	1.894	2.408	5.626
February 11, 1998	0.370	0.536	0.906	6.532
February 18, 1998	0.330	0.171	0.501	7.033
February 26, 1998	0.410	0.160	0.570	7.603
March 4, 1998	0.233	0.099	0.332	7.935
March 11, 1998	0.837	1.284	2.121	10.056
March 18, 1998	0.322	0.095	0.417	10.473
March 25, 1998	0.734	0.057	0.791	11.264
April 1, 1998	0.870	0.250	1.120	12.384
April 8, 1998	0.634	0.532	1.166	13.550
April 15, 1998	0.633	0.428	1.061	14.611
April 22, 1998	0.185	0.109	0.294	14.905
April 29, 1998	0.319	0.076	0.395	15.300
May 6, 1998	0.308	0.122	0.430	15.730
May 13, 1998	1.189	0.102	1.291	17.021
May 20, 1998	2.554	0.507	3.061	20.082
May 27, 1998	0.599	0.589	1.188	21.270
June 3, 1998	0.616	0.134	0.750	22.020
June 10, 1998	0.361	0.035	0.396	22.416
June 17, 1998	0.315	0.056	0.371	22.787
June 24, 1998	0.034	0.793	0.827	23.613
July 1, 1998	0.931	0.318	1.249	24.862
July 8, 1998	0.982	0.306	1.288	26.150
July 16, 1998	0.766	1.130	1.896	28.046
July 22, 1998	3.910	9.410	13.320	41.366
July 29, 1998	0.599	0.093	0.692	42.058
August 3, 1998	2.750	0.506	3.256	45.314
August 12, 1998	3.430	3.430	6.860	52.174
August 19, 1998	3.810	0.589	4.399	56.573
August 26, 1998	2.860	0.148	3.008	59.581
September 2, 1998	0.425	0.015	0.440	60.022
September 9, 1998	0.336	0.039	0.375	60.396
September 16, 1998	0.322	0.033	0.355	60.751
September 23, 1998	0.303	0.038	0.341	61.092
September 30, 1998	0.246	0.091	0.337	61.429
October 7, 1998	0.243	0.047	0.290	61.719
October 14, 1998	0.233	0.078	0.311	62.030
October 21, 1998	0.320	0.092	0.412	62.441
October 28, 1998	0.373	0.103	0.476	62.917
November 4, 1998	2.750	2.290	5.040	67.957
November 11, 1998	3.800	0.645	4.445	72.402
November 18, 1998	0.287	0.033	0.320	72.722
November 25, 1998	0.333	0.055	0.388	73.110
December 2, 1998	0.219	0.014	0.233	73.343
December 9, 1998	0.255	0.028	0.283	73.625
December 16, 1998	0.238	0.012	0.250	73.875
December 23, 1998	0.204	0.086	0.290	74.165
December 31, 1998	0.618	0.066	0.684	74.849
1998 Totals	**45.867**	**28.982**		**74.849**

Table 4. On-Site and Baseline Tritium Concentrations in Air for 1998 (in picoCuries/meter^3)

HTO	T1	T2	T3	T4	Baseline
January	30.3	50.7	123.2	30.5	13.2
February	26.6	36.7	80.5	37.5	7.6
March	36.5	72.8	102.0	30.4	13.6
April	24.3	34.6	118.6	30.8	10.2
May	30.3	67.2	69.7	35.0	15.4
June	50.8	88.2	104.5	37.7	21.2
July	40.3	78.2	118.2	14.9	2.4
August	82.4	159.0	584.4	93.0	9.0
September	22.5	51.2	33.2	8.6	4.9
October	17.3	47.0	59.0	7.7	1.9
November	17.2	35.7	442.2	20.0	0.5
December	5.6	21.2	31.8	3.6	3.3
Total	**384.3**	**742.4**	**1,867.5**	**349.7**	**103.1**

HT	T1	T2	T3	T4	Baseline
January	44.4	217.2	32.3	67.6	56.9
February	51.6	193.5	57.0	70.9	36.8
March	29.8	648.1	38.5	44.7	52.3
April	16.8	51.8	24.2	17.5	29.2
May	12.0	41.7	16.8	20.7	17.7
June	37.8	127.6	41.7	67.8	48.4
July	31.9	289.8	61.0	27.0	5.1
August	16.7	389.5	114.2	36.9	8.1
September	21.6	56.1	49.9	11.2	4.3
October	14.6	83.1	61.1	5.3	2.8
November	11.7	36.9	100.8	7.6	16.3
December	7.2	13.7	10.8	6.1	1.6
Total	**296.1**	**2,149.0**	**608.3**	**383.4**	**279.5**

Table 5. Off-Site and Baseline Tritium Concentrations in Air for 1998 (in picoCuries/meter^3)

HTO	R1	R2	R3	R4	R5	R6	Baseline
January	19.1	18.0	28.6	19.6	18.6	16.0	13.2
February	27.4	24.5	13.0	16.3	24.3	18.7	7.6
March	33.8	28.6	20.2	24.8	26.4	25.7	13.6
April	10.3	11.2	18.6	14.0	10.2	18.1	10.3
May	9.6	10.0	9.2	10.7	17.0	22.5	15.4
June	22.0	28.6	17.9	21.4	30.8	24.0	21.2
July	172.6	7.7	10.6	13.8	16.3	99.3	2.4
August	18.7	10.8	22.3	29.3	36.7	35.3	9.0
September	7.3	4.1	13.8	7.2	7.1	20.0	4.9
October	6.4	8.5	6.4	6.9	8.2	8.2	1.9
November	7.0	4.9	4.4	6.8	8.1	7.0	0.5
December	1.3	2.8	1.8	3.8	1.9	5.2	3.3
Total	**335.5**	**159.6**	**166.8**	**174.7**	**205.6**	**300.0**	**103.1**

HT	R1	R2	R3	R4	R5	R6	Baseline
January	49.9	79.7	1,133.9	53.9	39.9	35.1	56.9
February	86.7	45.5	49.5	24.6	68.1	23.5	36.8
March	728.3	31.0	31.5	25.5	88.5	65.8	52.3
April	14.9	13.5	10.7	14.9	129.3	10.6	29.2
May	12.4	10.6	15.7	11.0	11.3	59.6	17.7
June	48.7	58.4	17.3	15.6	23.0	575.3	48.4
July	8.2	10.9	24.5	10.5	13.1	18.8	5.1
August	10.3	12.8	15.7	11.8	20.5	19.7	8.1
September	5.5	8.6	7.4	9.1	7.7	10.1	4.3
October	7.5	7.0	6.8	7.9	6.4	7.3	2.8
November	16.8	8.6	6.0	7.0	9.6	10.2	16.3
December	5.1	1.8	2.8	4.0	3.5	10.8	1.6
Total	**994.4**	**288.4**	**1,321.8**	**195.8**	**421.0**	**846.7**	**279.5**

Table 6. Surface Water Tritium Concentrations for 1998
(in picoCuries/Liter)

	Bee Brook (B1)	Bee Brook (B2)	Bee Brook (B3)	PPPL Basin (DSN001)	D&R Canal (DSN003)
January	266	<133	<137	275	<188
February					297
March	144	243	239	369	329
April				311 297	<143
May	<136	146		353	<132
June				243	<151
July				441	221
August	482	419		592	153
September				216	<99
October				230	<117
November	414	257		333	<185
December				<264	<264

	Potable Water (E1)	D&R Canal (C1)	Millstone River (M1)	Cranbury Brook (P1)	Devil's Brook (P2)
January	<140		<140	<140	<140
February					
March	320		212	176	158
April					
May	178		<132	376	<132
June					
July					
August	<130	195	<130	141	211
September					
October					
November	<185	<185	<185	<185	<185
December					

Table 7. Ground Water Tritium Concentrations for 1998 (in picoCuries/liter)

	TFTR Sump	D-site MG Sump	Well TW-1	Well TW-2	Well TW-3	Well TW-4	Well TW-5	Well TW-7
January	399	322	1,126				988	156
February	371	255	1,144				1,095	
March	<139	415	1,288				1,441	
April	473 1,851 293	207	946				1,329	
May	486	332	1,055	596	468		1,318	
June	171	<145	734				1,097	
July	464	401	895				1,175	
August	378	342	838	502	360		1,005	
September	239		730				842	
October	293	225 207	802				793	
November	766	644 <126	689	293	234	<124	595	<124
December	257	194						

	Well TW-8	Well D-11R	Well D-12	Well MW-12S	Well MW-14	Well MW-15	Well MW-16
January	<140		<140	153			
February	563	<139	<131	<131	<131	<131	<131
March	883		158	198			
April	847		<143	<143			
May	733	<136	<136	<151	<135	<150	<135
June	746		<151	<151			
July	858		347	232			
August	739	<128	212	140	210		239
September	604		167				
October	527		207				
November		<182 <124	<182		<182	<182	<182
December					<123	<123	126

Table 8. On-Site Tritium Concentrations in Rain Water for 1998 (in picoCuries/liter)

	Date	R1E (East)	R1W (West)	R1S (South)	R1N (North)	R1ND (Duplicate)
January	12	378	387	558	196	221
	29	171	1,005	640	<135	<135
February	27	<143	<143	501	<143	<143
March	2	<138				
	9			267	196	257
	9			145		
	24	<147		153	<147	<147
April	7	414	<147	257	<147	<147
	29	<160	<160	451	<160	<160
May	13	<151	<151	311	<151	<151
June	8	203	<153	<153	<153	<153
	17	563	251	<145	<145	<145
July	30	907	531	450	739	805
August	19	1,324	1,266	3,910	20,200	26,450
September	11	689	144	437	518	640
	23		<108	203	153	203
October	15	487	122	275	189	176
November	13	572	<118	671	<118	
December	9	171	198	198	<155	<155

	Date	R2E (East)	R2W (West)	R2S (South)	R2N (North)	R3N (Far field)
January	12	140	288	302	<133	<133
	29	<135	1,311	176	140	563
February	20					<94
	27	<143	196	<135	<143	<138
March	9		293	<139		
	10					162
	24	<147	315	<147	149	<138
April	7	<147	<159	<147	<147	<159
	29	<135	162	212	<135	<135
May	13	<151	135	167	324	<129
June	8	804	<141	<141	<141	<141
	17	374	<145	<145	<145	<145
July	30	549	267	239	408	264
August	19	396	923		22,640	428
September	11	252	140	230	806	
	23	<108	<108	<108	189	
October	15	230	<111	171		<111
November	13		<118	<118	122	<118
December	9	<155	<155	<155	<155	<155

Table 9. Off-Site Tritium Concentrations in Rain Water for 1998
(in picoCuries/liter)

	Date	R1	R2	R4	R5	R6
January	5	150	152	132	139	<189
	26	139	136		219	<94
February	17	<140	<140	<140	<140	
March	2	<138	<138		<138	
	10		<139		<139	
	23	176	185	261	<148	<147
April	7				<147	
	13	<159	<159	<159	<159	<159
	20				<143	
	27		<160		<160	
	28					<160
May	4	<135				
	12	<129	<129		158	<129
	20			176		
	26				<153	
June	8		578		<153	<153
	15	500	<151	<151	<151	<151
July	6				<141	
	20			629		
August	3				264	184
	24		<99	<99	<99	
September	8	<99		<99	<99	<99
	28		<111			
October	12	<115	<115	<115	<115	153
	15				<111	
November	16				185	162
	30				158	
December	9			<195	<195	

Table 10. Annual Range of Tritium Concentration at PPPL in Precipitation from 1985 to 1998

Year	Tritium Range picoCuries/Liter	Precipitation inches	Difference from Middlesex County Avg. Precipitation of 46.5 inches/yr
1985	40 to 160		
1986	40 to 140		
1987	26 to 144		
1988	34 to 105		
1989	7 to 90	55.35	+8.8
1990	14 to 94	50.33	+3.8
1991	10 to 154	45.08	-1.5
1992	10 to 838	41.86	-4.6
1993	25 to 145	42.73	-3.8
1994	32 to 1,130	51.26	+4.8
1995	<19 to 2,561	35.63	-10.9
1996	<100 to 21, 140	61.04	+14.5
1997	131 to 61,660	41.99	-4.5
1998	<108 to 26,450	42.86	-3.6

Table 11. 1998 Liquid Effluent Collection Tank Release Data

Sample Date	Tank #	Gallons Released	Tritium Sample LLD (pCi/L)	Tritium Sample Activity (pCi/L)	Total Tank Activity (Ci)	Annual Cumulative Activity (Ci)	Gross Beta Sample LLD (pCi/L)	Gross Beta Sample Activity (pCi/L)
1/16/98	3	10,800	316	115,000	0.00469	0.00469	195	531
2/12/98	3	10,800	323	32,700	0.00133	0.00602	195	118
3/25/98	3	10,200	314	300,000	0.0116	0.0176	195	985
4/14/98	3	13,800	337	16,900	0.00088	0.0185	195	19.5
4/14/98	2	12,900	332	52,800	0.00258	0.0211	195	215
4/14/98	3	13,050	333	24,800	0.00123	0.0223	195	105
4/14/98	2	10,800	332	50,900	0.00208	0.0244	195	216
4/14/98	2	7,500	331	19,400	0.000551	0.0249	195	<BKG
4/14/98	3	12,750	330	18,800	0.000908	0.0258	195	40.8
4/16/98	3	11,100	333	23,200	0.000976	0.0268	195	147
5/12/98	3	10,650	299	168,000	0.00679	0.0336	195	460
6/16/98	3	12,600	336	241,000	0.0115	0.0451	195	858
6/29/98	3	12,750	320	55,500	0.00268	0.0478	196	165
7/13/98	3	11,850	329	43,400	0.00195	0.0497	196	<BKG
7/23/98	3	12,600	305	44,000	0.00210	0.0518	196	<BKG
8/7/98	3	11,250	327	70,000	0.00298	0.0548	195	434
8/18/98	3	10,050	306	69,100	0.00263	0.0574	195	51.0
8/25/98	3	12,000	306	161,000	0.00731	0.0647	195	170
9/10/98	3	11,700	326	62,000	0.00275	0.0675	195	<BKG
9/28/98	3	12,750	321	24,700	0.00119	0.0687	195	90.5
11/17/98	3	11,550	317	22,300	0.000976	0.0697	195	85.1
12/17/98	3	12,000	317	35,500	0.00161	0.0713	195	<BKG

Ci = Curies
LLD =lower limit of detection
pCi/L = picoCuries per Liter
<BKG = below background

Table 12. 1998 Surface Water Analysis for Bee Brook, B1 and B2

Parameters/Units	*B1 5/7/98*	*B1 8/3/98*	*B1 11/4/98*	*B2 5/7/98*	*B2 8/3/98*	*B2 11/4/98*
Ammonia-N, mg/L	<0.100	<0.0100	<0.100	<0.100	<0.100	<0.100
Biochemical Oxygen Demand, 5-day total, mg/L	<2.90	<2.20	40.9	<2.90	<2.70	<2.70
Chemical Oxygen Demand, mg/L	50.3	13.5	124	34.5	8.00	8.80
Chromium, mg/L		<0.010	<0.010		<0.010	<0.010
Petroleum hydrocarbons, mg/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
pH, standard units	6.32	6.92	6.08	6.73	7.47	7.95
Phenolics, as phenol, mg/L	0.006	<0.005	0.0350	<0.005	<0.005	<0.005
Temperature, ^{o}C	13.3	20.9	7.4	14.2	22.6	10.7
Total Dissolved Solids, mg/L	114	124	108	134	122	234
Total Suspended Solids, mg/L	14.0	2.0	26.0	20.0	9.0	3.0

Location B1 = Bee Brook upsteam of PPPL basin discharge
Location B2 = Bee Brook downstream of PPPL basin discharge
See Figure 6.

Table 13. 1998 Surface Water Analysis for Delaware & Raritan Canal, C1, and Millstone River, M1

Parameters/Units	C1 5/7/98	C1 8/3/98	C1 11/4/98	M1 5/7/98	M1 8/3/98	M1 11/4/98
Ammonia-N, mg/L		<0.100	<0.100	0.150	0.270	<0.100
Biochemical Oxygen Demand, 5-day total, mg/L		<2.20	<2.70	<2.90	2.90	<2.70
Chemical Oxygen Demand, mg/L		8.00	6.40	16.6	13.5	7.40
Chromium, total, mg/L			<0.010			<0.010
Petroleum hydrocarbons, mg/L		<0.500	<0.500	<0.500	<0.500	<0.500
pH, standard units		7.16	7.62	6.66	6.85	7.28
Phenolics, as phenol, mg/L		<0.005	<0.005	<0.005	<0.005	<0.005
Temperature, $^{\circ}$C		26.0	10.8	18.4	24.7	10.3
Total Dissolved Solids, mg/L		208	120	102	132	144
Total Suspended Solids, mg/L		6.0	4.00	12.0	8.00	4.00

Location C1 = Delaware & Raritan Canal State Park at Mapleton Avenue, Plainsboro midway on pedestrian bridge
Location M1 = Millstone River at Route 1 bridge mid-span on northbound side
See Figure 6 for locations.

Table 14. 1998 Surface Water Analysis for Elizabethtown Water, E1

Parameters/Units	E1 5/8/98	E1 8/3/98	E1 11/4/98
Ammonia-N, mg/L	0.120	0.180	0.200
Biochemical Oxygen Demand, 5-day total, mg/L	<2.90	<2.20	<2.70
Chemical Oxygen Demand, mg/L	5.50	5.50	3.70
Chromium, mg/L		<0.010	<0.010
Petroleum hydrocarbons, mg/L	<0.500	<0.500	<0.500
pH, standard units		6.78	
Phenolics, as phenol, mg/L	<0.005	<0.005	<0.005
Temperature, ^{o}C		23.3	
Total Dissolved Solids, mg/L	154	198	234
Total Suspended Solids, mg/L	<2.0	<2.0	<2.0

Location E1 = Elizabethtown Water (potable) collected at Main Gate Security Booth
See Figure 5 for locations.

Table 15. 1998 Surface Water Analysis for Plainsboro, P1 and P2

Parameters/Units	*P1 5/7/98*	*P1 8/3/98*	*P1 11/4/98*	*P2 5/7/98*	*P2 8/3/98*	*P2 11/4/98*
Ammonia-N, mg/L	0.210	0.130	<0.100	<0.100	<0.100	<0.100
Biochemical Oxygen Demand, 5-day total, mg/L	<2.90	<2.20	3.90	<2.90	<2.20	<2.70
Chemical Oxygen Demand, mg/L	16.6	11.0	15.6	30.2	5.50	6.40
Chromium, total, mg/L			<0.010			<0.010
Petroleum hydrocarbons, mg/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
pH, standard units	6.40	6.38	7.16	6.47	6.42	6.84
Phenolics, as phenol, mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Temperature, ^{o}C	18.5	23.0	10.4	17.3	17.9	8.80
Total Dissolved Solids, mg/L	80.0	104	88.0	64.0	106	108
Total Suspended Solids, mg/L	12.0	4.00	8.00	5.0	2.00	5.00

Location P1 = Cranbury Brook at George Davison Road, Plainsboro mid-span on bridge southbound
Location P2 = Devil's Brook at Schalks Road overpass, adjacent to Amtrak railroad tracks
See Figure 6 for locations.

Table 16. 1998 Detention Basin Influents Analysis (NJPDES NJ0086029)

Parameters/Units	*Inflow 1 5/7/98*	*Inflow 1 8/3/98*	*Inflow 2 5/7/98*	*Inflow 2 8/3/98*
Ammonia-N, mg/L	<0.100	<0.100	<0.100	<0.100
Biochemical Oxygen Demand, 5-day total, mg/L	<2.90	2.90	<2.90	<2.20
Chemical Oxygen Demand, mg/L	6.00	38.4	6.50	3.60
Chromium, mg/L	<0.010	<0.010	<0.010	<0.010
Petroleum hydrocarbons, mg/L	<0.500	<0.500	<0.500	<0.500
pH, standard units	6.46		6.87	
Phenolics, as phenol, mg/L	<0.005	<0.005	<0.005	<0.005
Settleable solids, %	<0.200	1.80	0.200	0.200
Temperature, ^{o}C	16.5		16.7	
Total Dissolved Solids, mg/L	152	334	184	194
Total Volatile Organics (GC/MS), μg/L		see Table 23		see Table 23

Inflow 1 = Detention basin influent located on western side of basin
Inflow 2 = Detention basin influent located on northern side of basin

Table 17. Detention Basin Outfall Surface Water Results for 1998 at DSN001(NJPDES NJ0023922)

Permit Limit	Units	Parameters	1/7	2/4	3/6	4/1	5/6	6/10
NA	mg/L	Ammonia-N		<0.100			<0.100	
NA	mg/L	Biochemical Oxygen Demand, 5-day total		<2.00			<2.90	
50 mg/L	mg/L	Chemical Oxygen Demand	10.2	5.80	7.80	6.60	8.50	4.60
NL	mg/L	Chlorine Produced Oxidants as chlorine, free		0.12			0.17	
160 μg/L	mg/L	Chromium, total		<0.010				
100	percent	Chronic Toxicity Test NOEC (% effluent) IC_{25} (% effluent) *Pimephales promelas*			 100 >100			 100 >100
NA	gpm	Flow	496.801	404.0	365.5	343.9	139.9	138.1
10 mg/L	mg/L	Petroleum Hydrocarbons	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
6.0-9.0	S.U.	pH	7.1	7.5	7.44	7.95	6.63	7.24
NA	mg/L	Phenolics, as phenol		<0.005			<0.005	
30 °C max.	°C	Temperature	13.3	10.8	11.8	17.5	16.3	18.5
500 mg/L	mg/L	Total Dissolved Solids		220			194	
50 mg/L	mg/L	Total Suspended Solids	31.0	2.00	<2.00	2.00	<2.0	2.00

Permit Limit	Units	Parameters	7/8	8/3	9/9	10/8	11/4	12/3
NA	mg/L	Ammonia-N	<0.100	<0.100			<0.100	
NA	mg/L	Biochemical Oxygen Demand, 5-day total	<2.80	<2.20			<2.70	
50 mg/L	mg/L	Chemical Oxygen Demand	14.5	7.50	6.50	8.00	6.00	7.50
NL	mg/L	Chlorine Produced Oxidants as chlorine, free	0.080	0.43			0.005, 0.01	
160 μg/L	mg/L	Chromium, total		<0.010			<0.010	
100	percent	Chronic Toxicity Test NOEC (% effluent) IC_{25} (% effluent) *Pimephales promelas*			100			
NA	gpm	Flow	242.7	137.0	152.1	547.9	570.5	139.8
10 mg/L	mg/L	Petroleum Hydrocarbons	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
6.0-9.0	S.U.	pH	7.39	7.58	8.09	8.14	8.39	8.19
NA	mg/L	Phenolics, as phenol		<0.005			<0.005	
30 °C max.	°C	Temperature	21.1 20.3	23.6	18.5	18.4	12.4	13.7
500 mg/L	mg/L	Total Dissolved Solids		226			258	
50 mg/L	mg/L	Total Suspended Solids	3.00	5.00	3.00	3.00	5.00	<2.00
0.1 mg/L	mg/L	Total Phosphate	0.073					
NA	mg/L	Total Organic Carbon	3.16					

Italics indicates the NJ Surface Water Quality Criteria
Blank indicates no measurement
NA = not applicable
NL = no limit

Table 18. D&R Canal Pump House - DSN003
Surface Water Results for 1998 (NJPDES NJ0023922)

Permit Monthly Avg.	Limit Daily Max.	Units	Parameters	1/7	2/4	3/6	4/22	5/7	6/10
NA	NA	mg/L	Ammonia-N		<0.100			<0.100	
NA	NA	mg/L	Biochemical Oxygen Demand		<2.00			<2.90	
NL	NL	mg/L	Chlorine Produced Oxidants		0.12			1.37	
160 µg/L	*160 µg/L*	mg/L	Chromium		<0.010			<0.010	
10 mg/L	15 mg/L	mg/L	Petroleum Hydrocarbons	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
NA	6.0-9.0	S.U.	pH	6.7	7.5	8.14	7.21	6.64	7.07
NA	NA	mg/L	Phenolics, as phenol		<0.005			0.008	
NA	NA	°C	Temperature					16.7	
500 mg/L	*500 mg/L*	mg/L	Total Dissolved Solids		132			104	
20 mg/L	60 mg/L	mg/L	Total Suspended Solids	15.0	3.0	3.0	12.0	13.0	**22.0**

Permit Monthly Avg.	Limit Daily Max.	Units	Parameters	7/8	8/3	9/9	10/8	11/4	12/3
NA	NA	mg/L	Ammonia-N	<0.100	<0.100			<0.100	
NA	NA	mg/L	Biochemical Oxygen Demand	<2.80	<2.20			<2.70	
NL	NL	mg/L	Chlorine Produced Oxidants	0.06	0.13			<0.05	
160 µg/L	*160 µg/L*	mg/L	Chromium		<0.010			<0.010	
10 mg/L	15 mg/L	mg/L	Petroleum Hydrocarbons	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
NA	6.0-9.0	S.U.	pH	7.02	6.98, 7.16	7.77	7.60	7.73	7.90
NA	NA	mg/L	Phenolics, as phenol		<0.005			<0.005	
NA	NA	°C	Temperature	23.0	24.2	22.8	16.8	10.4	9.5
500 mg/L	*500 mg/L*	mg/L	Total Dissolved Solids		132			138	
20 mg/L	60 mg/L	mg/L	Total Suspended Solids	16.0	7.0	8.0	6.0	4.0	<2.0
NA	NA	mg/L	Chemical Oxygen Demand	7.10				9.70	
0.1 mg/L	*0.1 mg/L*	mg/L	Total Phosphate	0.137					
NA	NA	mg/L	Total Organic Carbon	3.17					

Flow = 250 gallons per minute X 2 minutes per cycle X 15 cycles per day = 7,500 gallons per day
Italics indicate the NJ Surface Water Quality Criteria
Blank indicates no measurement
NA = not applicable
NL = no limit

Table 19. Ground Water Analysis for Wells MW-14, MW-15, and MW-16 for 1998

Parameters Units	NJPDES Permit Std	MW-14 2/19/98	MW-14 5/6/98	MW-14 8/4/98	MW-14 11/5/98
Ammonia-Nitrogen, mg/L	*0.5*		<0.100	<0.100	<0.100
Chloride, mg/L	*250*			3.40	7.00
Chromium,dissolved, hexavalent,mg/L	*0.05*			<0.010	<0.010
Conductivity, μmhos/cm^2		96.3	38.6	89.7	0
Lead, total, mg/L	*0.05*			<0.005	<0.005
Nitrate-Nitrogen, mg/L	*10*			<0.400	2.28
Petroleum Hydrocarbon by IR, mg/L				<0.500	
pH, units		6.33	5.48	5.54	5.73
Phenolics as phenol, mg/L	*0.3*			<0.005	<0.005
Sulfate, mg/L	*250*	17.8	17.1	17.8	9.30
Total Dissolved Solids, mg/L	*500*	78.0	78.0	86.0	62.0
Total Organic Carbon, mg/L				<1.0	
Total Organic Halides, mg/L				0.0125	

Parameters Units	NJPDES Permit Std	MW-15 2/19/98	MW-15 5/6/98	MW-15 8/4/98	MW-15 11/5/98
Ammonia-Nitrogen, mg/L	*0.5*		<0.100	<0.100	<0.100
Chloride, mg/L	*250*			3.40	4.40
Chromium, dissolved,hexavalent,mg/L	*0.05*			<0.010	<0.010
Conductivity, μmhos/cm^2		101	48.2	68	91.1
Lead, total, mg/L	*0.05*			<0.005	<0.005
Nitrate-Nitrogen, mg/L	*10*			<0.400	0.99
Petroleum Hydrocarbon by IR, mg/L				<0.500	
pH, units		6.29	6.48	5.14	5.98
Phenolics as phenol, mg/L	*0.3*			<0.005	<0.005
Sulfate, mg/L	*250*	8.80	9.20	8.50	9.20
Total Dissolved Solids, mg/L	*500*	68.0	68.0	76.0	36.0
Total Organic Carbon, mg/L				<1.00	
Total Organic Halides, mg/L				<0.005	

Parameters Units	NJPDES Permit Std	MW-16 2/19/98	MW-16 5/6/98	MW-16 8/4/98	MW-16 11/5/98
Ammonia-Nitrogen, mg/L	*0.5*		<0.100	<0.100	<0.100
Chloride, mg/L	*250*			4.90	5.20
Chromium, dissolved,hexavalent,mg/L	*0.05*			<0.010	<0.010
Conductivity, μmhos/cm^2		373	270	318	471
Lead, total, mg/L	*0.05*			<0.005	<0.005
Nitrate-Nitrogen, mg/L	*10*			<0.400	0.540
Petroleum Hydrocarbon by IR, mg/L				<0.500	
pH, units		6.67	6.01	6.34	6.28
Phenolics as phenol, mg/L	*0.3*			<0.005	<0.005
Sulfate, mg/L	*250*	62.9	45.1	33.2	54.8
Total Dissolved Solids, mg/L	*500*	242	180	192	264
Total Organic Carbon, mg/L				1.89	
Total Organic Halides, mg/L				0.0801	

Blank indicates no measurement.

Table 20.   Ground Water Analysis for Wells D-11R and D-12 for 1998

Parameters Units	*NJPDES Permit Std*	D-11R 2/19/98	D-11R 5/6/98	D-11R 8/4/98	D-11R 11/5/98
Ammonia-Nitrogen, mg/L	*0.5*		<0.100	<0.100	<0.100
Chloride, mg/L	*250*			15.7	17.1
Chromium,dissolved, hexavalent,mg/L	*0.05*				
Conductivity, μmhos/cm^2		289	300		
Lead, total, mg/L	*0.05*			<0.005	0.005
Nitrate-Nitrogen, mg/L	*10*		<0.400	<0.400	<0.400
Petroleum Hydrocarbon by IR, mg/L				<0.500	
pH, units		7.03	6.68	6.45	6.34
Phenolics as phenol, mg/L	*0.3*			<0.005	<0.005
Sulfate, mg/L	*250*	12.8	8.50	15.8	16.7
Total Dissolved Solids, mg/L	*500*	174	196	190	124
Total Organic Carbon, mg/L				<1.0	
Total Organic Halides, mg/L				25.9	
Tritium, pCi/L					

Parameters Units	*NJPDES Permit Std*	D-12 2/19/98	D-12 5/6/98	D-12 8/4/98	D-12 11/5/98
Ammonia-Nitrogen, mg/L	*0.5*		<0.100	<0.100	<0.100
Chloride, mg/L	*250*			16.6	20.5
Chromium, dissolved,hexavalent,mg/L	*0.05*			<0.010	<0.010
Conductivity, μmhos/cm^2		222	229		
Lead, total, mg/L	*0.05*			<0.005	<0.005
Nitrate-Nitrogen, mg/L	*10*			<0.400	<0.400
Petroleum Hydrocarbon by IR, mg/L				<0.500	
pH, units		6.32	5.24		5.22
Phenolics as phenol, mg/L	*0.3*			<0.005	<0.005
Sulfate, mg/L	*250*	35.4	35.8	37.4	29.7
Total Dissolved Solids, mg/L	*500*	142	144	122	52.0
Total Organic Carbon, mg/L				1.67	
Total Organic Halides, mg/L				30.7	
Tritium, pCi/L					

Blank indicates no measurement.

Table 21. Ground Water Analysis for Wells TW-2 and TW-3 for 1998

Parameters Units	***NJPDES Permit Standards***	**TW-2 2/19/98**	**TW-2 5/6/98**	**TW-2 8/4/98**	**TW-2 11/5/98**
Ammonia-Nitrogen, mg/L	*0.5*		<0.100	<0.100	<0.100
Chloride, mg/L	*250*			12.7	16.6
Conductivity, _mhos/cm^2		379	396		
Lead,total, mg/L	*0.05*			<0.005	<0.005
Nitrate-Nitrogen, mg/L	*10*			<0.400	<0.400
Petroleum Hydrocarbon by IR, mg/L				<0.500	
pH, units		6.57	7.45		7.36
Phenolics as phenol, mg/L	*0.3*			<0.005	<0.005
Sulfate, mg/L	*250*	22.9	23.5	19.8	14.9
Total Dissolved Solids, mg/L	*500*	246	242	222	12.0
Total Organic Carbon, mg/L				<1.0	
Total Organic Halides, mg/L				<5.0	

Parameters Units	***NJPDES Permit Standards***	**TW-3 2/19/98**	**TW-3 5/6/98**	**TW-3 8/4/98**	**TW-3 11/5/98**
Ammonia-Nitrogen, mg/L	*0.5*		<0.100	<0.100	<0.100
Chloride, mg/L	*250*			21.5	8.30
Conductivity, _hos/cm^2		336	229		
Lead, dissolved, mg/L	*0.05*			<0.005	<0.005
Nitrate-Nitrogen, mg/L	*10*			<0.400	<0.400
Petroleum Hydrocarbon by IR, mg/L				<0.500	
pH, units		6.63	5.24		7.33
Phenolics as phenol, mg/L	*0.3*			<0.005	<0.005
Sulfate, mg/L	*250*	20.9	21.7	24.2	12.6
Total Dissolved Solids, mg/L	*500*	226	236	256	198
Total Organic Carbon, mg/L				1.02	
Total Organic Halides, mg/L				10.5	
Tritium, pCi/L					

Blank indicates no measurement.

Table 22. May 1998 Volatile Organics Results from Detention Basin Discharge DSN001 and Wells (D-11R, D-12, and TW-3 in μg/L)

Parameter	*DEP GW Quality Criteria*	D-11R 5/6	D-12 5/6	Trip Blar 5/6	TW-3 5/6	Trip Blank 5/6
Chloromethane	*30*	<10	<10	<10	<10	<10
Bromomethane	*10*	<10	<10	<10	<10	<10
Vinyl Chloride	*0.08*	<5	<5	<5	<5	<5
Chloroethane	*NL*	<10	<10	<10	<10	<10
Methylene Chloride	*400*	<2	<2	<2	<2	<2
Acrolein	*NA*	<10	<10	<10	<10	<10
Acrylonitrile	*0.06*	<5	<5	<5	<5	<5
1,1-Dichloroethane	*70*	<5	**1.66J**	<5	<5	<5
1,2-Dichloroethane	*0.3*	<2	<2	<2	<2	<2
1,1-Dichloroethene	*1*	<1	<1	<2	<2	<2
1,2-trans-Dichloroethene	*100*	<2	<2	<2	<2	<2
1,2-Dichloropropane	*0.5*	<1	<1	<1	<1	<1
1,3-trans-Dichloropropene	*0.2*	<5	<2	<5	<5	<5
Chloroform	*6*	<1	<1	<1	<1	<1
1,1,1-Trichloroethane	*30*	<1	<1	<1	<1	<1
1,1,2-Trichloroethane	*3*	<2	<5	<2	<2	<2
Trichloroethene	*1*	<1	**1.90**	<1	<1	<1
Carbon Tetrachloride	*0.4*	<2	<1	<2	<2	<2
Bromodichloromethane	*0.3*	<2	<1	<1	<1	<1
Chlorodibromomethane	*10*	<1		<1	<1	<1
Benzene	*0.2*	<1	<1	<1	<1	<1
2-Chloroethyl Vinyl Ether	*NL*	<10	<10	<10	<10	<10
Bromoform	*4*	<1	<1	<1	<1	<1
Tetrachloroethene	*0.4*	**4.90**	**4.73**	<1	**2.59**	<1
1,1,2,2-Tetrachloroethane	*2*	<1	<1	<1	<1	<1
Toluene	*1,000*	<5	<5	<5	<5	<5
Chlorobenzene	*4*	<2	<2	<2	<2	<2
Ethylbenzene	*700*	<5	<1	<5	<5	<5
1,3-Dichlorobenzene	*600*	<5	<5	<5	<5	<5
1,4-Dichlorobenzene	*75*	<5	<5	<5	<5	<5
1,2-Dichlorobenzene	*600*	<5	<5	<5	<5	<5

NA Not available
NL Not Listed on NJDEP's Ground water (GW) Quality Criteria.
T Value reported is less than criteria of detection.

Table 23. August 1998 Volatile Organics Results for Wells (TW-3, D-11R, D-12) and Detention Basin Inflows (1 and 2 in µg/L)

Parameter	*DEP GW Quality Criteria*	TW-3	D-11R	D-12	Inflow 1	Inflow 2	Trip Blank
Methyl Chloride (Chloromethane)	*30*	<10	<10	<10	<10	<10	<10
Methyl Bromide (Bromomethane)	*10*	<5	<10	<10	<10	<10	<10
Vinyl Chloride	*0.08*	<5	<5	<5	<5	<5	<5
Chloroethane	*NL*	<10	<10	<10	<10	<10	<10
Methylene Chloride	*400*	<2	**1.01 J**	<2	<2	<2	**1.21 J**
Acrolein	*NA*	<50	<50	<50	<50	<50	<50
Acrylonitrile	*0.06*	<25	<25	<25	<50	<50	<25
1,1-Dichloroethane	*70*	<5	<5	**1.91 J**	<5	<5	<5
1,2-Dichloroethane	*0.3*	<2	<2	<2	<2	<2	<2
1,1-Dichloroethene	*1*	<2	<2	<2	<2	<2	<2
1,2-trans-Dichloroethene	*100*	<5	<5	<5	<5	<5	<5
1,2-Dichloropropane	*0.5*	<1	<1	<1	<1	<1	<1
1,3-trans-Dichloropropene	*0.2*	<5	<5	<5	<5	<5	<5
Chloroform	*6*	<1	<1	<1	**1.98**	**2.60**	<1
1,1,1-Trichloroethane	*30*	<1	<1	<1	<1	<1	<1
1,1,2-Trichloroethane	*3*	<2	<2	<2	<2	<2	<2
Trichloroethene	*1*	**1.05**	<1	**2.82**	<1	<1	<1
Carbon Tetrachloride	*0.4*	<2	<2	<2	<2	<2	<2
Chlorodibromomethane	*0.3*	<1	<1	<1	<1	<1	<1
Bromodichloromethane		<1	<1	<1	<1	<1	<1
Benzene	*0.2*	<1	<1	<1	<1	<1	<1
2-Chloroethyl Vinyl Ether	*NL*	<10	<10	<10	<10	<10	<10
Bromoform	*4*	<1	<1	<1	<1	<1	<1
Tetrachloroethene	*0.4*	**10.1**	**7.13**	**10.4**	<1	**1.69**	<1
1,1,2,2-Tetrachloroethane	*2*	<1	<1	<1	<1	<1	<1
Toluene	*1,000*	**2.28 J**	<5	**2.02 J**	<5	<5	<5
Chlorobenzene	*4*	<2	<2	<2	<5	<5	<2
Ethylbenzene	*700*	<5	<5	<5	<1	<1	<5
cis-1,3-Dichloropropene	*NA*	<5	<5	<5	<5	<5	<5
1,2-Dichlorobenzene	*600*	<5	<5	<5	<5	<5	<5
1,3-Dichlorobenzene	*600*	<5	<5	<5	<5	<5	<5
1,4-Dichlorobenzene	*75*	<5	<5	<5	<5	<5	<5
Trichlorofluoromethane	*NL*	<5	<5	<5	<5	<5	<5

NA Not available
NL Not listed on NJDEP Ground Water Quality Criteria.
T Value reported is less than criteria of detection.

Table 24. August 1998 Base Neutrals Results for NJPDES Wells (in µg/L)

Parameter	***D-11R***	***D-12***	***MW-14***	***MW-15***	***MW-16***	***TW-2***	***TW-3***
Acenaphthene	<2	<2	<2	<2	<2	<2	<2
Acenaphthylene	<2	<2	<2	<2	<2	<2	<2
Anthracene	<2	<2	<2	<2	<2	<2	<2
Benzidine	<20	<20	<20	<20	<20	<20	<20
Benzo (a)anthracene	<2	<2	<2	<2	<2	<2	<2
Benzo (a)pyrene	<2	<2	<2	<2	<2	<2	<2
Benzo (b)fluoranthene	<2	<2	<2	<2	<2	<2	<2
Benzo (k)fluoranthene	<2	<2	<2	<2	<2	<2	<2
Benzo (g,h,i)perylene	<2	<2	<2	<2	<2	<2	<2
bis(2-Chloroethoxy)methane	<10	<10	<10	<10	<10	<10	<10
bis(2-Chloroethyl)ether	<5	<5	<5	<5	<5	<5	<5
bis(2-Chloroisopropyl)ether	<5	<5	<5	<5	<5	<5	<5
Bis(2-Ethylhexyl)phthalate	**1.14 J**	<5.00	**1.21J**	<5.00	**2.21 J**	<5.00	<5.00
4-Bromophenyl-phenylether	<5	<5	<5	<5	<5	<5	<5
N-Butylbenzylphthalate	<5	<5	<5	<5	<5	<5	<5
2-Chloronaphthalene	<5	<5	<5	<5	<5	<5	<5
4-Chlorophenyl-phenylether	<5	<5	<5	<5	<5	<5	<5
Chrysene	<2	<2	<2	<2	<2	<2	<2
1.2,5,6 Dibenzanthracene	<2	<2	<2	<2	<2	<2	<2
1,2-Dichlorobenzene	<5	<5	<5	<5	<5	<5	<5
1,3-Dichlorobenzene	<5	<5	<5	<5	<5	<5	<5
1,4-Dichlorobenzene	<5	<5	<5	<5	<5	<5	<5
3,3-Dichlorobenzidine	<5	<5	<5	<5	<5	<5	<5
Diethylphthalate	<10	<10	<10	<10	<10	<10	<10
Dimethylphthalate	<10	<10	<10	<10	<10	<10	<10
Di-n-butylphthalate	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
2,4-Dinitrotoluene	<5	<5	<5	<5	<5	<5	<5
2,6-Dinitrotoluene	<5	<5	<5	<5	<5	<5	<5
Di-n-octylphthalate	<10	<10	<10	<10	<10	<10	<10
1,2-Diphenylhydrazine	<5	<5	<5	<5	<5	<5	<5
Fluoranthene	<5	<5	<5	<5	<5	<5	<5
Fluorene	<2	<2	<2	<2	<2	<2	<2
Hexachlorobenzene	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	<5	<5	<5	<5	<5	<5	<5
Hexachlorocyclopentadiene	<5	<5	<5	<5	<5	<5	<5
Hexachloroethane	<5	<5	<5	<5	<5	<5	<5
Indeno (1,2,3-cd)pyrene	<2	<2	<2	<2	<2	<2	<2
Isophorone	<5	<5	<5	<5	<5	<5	<5
Naphthalene	<2	<2	<2	<2	<2	<2	<2
Nitrobenzene	<5	<5	<5	<5	<5	<5	<5
N-nitrosodimethylamine	<10	<10	<10	<10	<10	<10	<10
N-Nitroso-di-n-propylamine	<10	<10	<10	<10	<10	<10	<10
N-Nitrosodiphenylamine	<10	<10	<10	<10	<10	<10	<10
Phenathrene	<2	<2	<2	<2	<2	<2	<2
Pyrene	<5	<5	<5	<5	<5	<5	<5
1,2,4-Trichlorobenzene	<5	<5	<5	<5	<5	<5	<5

B Found in method blank.
T Value reported is less than criteria of detection.

Table 25. Tetrachloroethene Results Exceeding NJDEP Ground Water Quality Standard for Class II-A Aquifers - June 1994 through April 1998 (in μg/L)

Date	6/94	3/95	5/95	12/96	2/97	9/97	1/98	4/98
D-11 /11R	**1.9**	**4.62**	**1.35**	**5.36 TN**	**5.18**	**4.53**	**6.92**	**4.13**
D-12	**11**	**9.87**	**10.6**	**5.53 TN**	**3.87**	**8.81**	**6.05**	**2.94**
TFTR-S1	**3**	**5.37**	**4.16**	**4.2 TN**	**3.73**	**3.8**	**3.3**	**2.83**
DMG-S2	**30**	**39.3**	**58.7**	**42.8 TN**	**50.1**	**54.8**	**84.4**	**35.4**
LOB-S3	**2.3**	**2.14**	**2.01**	**1.01 TN**	0.998	**4.37**	**3.08**	**1.07**
C MG-S4	**2.3**	**9.5**	**4.44**	**2.05 TN**	**2.39**	**1.82**	<0.46	**4.12**
C-MG-S5	<1	<1	<1	0.304 TN	<0,23	0.24	<0.08	<0.08
C-MG-S6	**11**	**20.9**	**8.66**	**19 TN**	**14.4**		**14.5**	**12.3**
CS-S7	NS	NS	NS	NS	NS	0.252	<0.486	0.726
MW-1	<1	<1	<1	<0.23	<0.23	<0.08	<0.492	0.242
MW-2	<1	<1	<1	<0.23	<0.23	<1.12	0.366	0.292
MW-2 dup								0.24
MW-3	**25**	**14.7**	**15.4**	**5.83 TN**	**4.93**	0.68	**8.09 TN**	**9.41**
MW-5S				0.838 TN	0.944		NS	**1.63**
MW-5I	**3.6**	**5.53**	<1	**2.11 TN**	**1.73**	0.404	**1.21 TN**	0.548
MW-6S	**2.8**	NS	**13.1**	**36.7 TN**	**7.93**	**19.80**	**5.2**	**6.71**
MW-6S dup						**17.4**		
MW-7I	**7.4**	**6.87**	**2.79**	0.246 TN	<0.23	<0.08	0.28	0.234
MW-7S	**12**	**13.8**	**17.2**	**7.54 TN**	**10.4**	**5.57**	**11.31**	**5.78**
MW-8S	**14**	**9.23**	**7.48**	**7.43 TN**	**12.1**	**6.85**	**8.45**	**5.2**
MW-8I								0.394
MW-9	**78**	**89.9**	**79.8**	**113 TN**	**93.9**	**63.6**	**54.6**	**45.1**
MW-9 dup								**52.8**
MW-9I							**1.06**	0.348
MW-9I dup						<1.12	0.954	
MW-10I								<0.085
MW-13	**120**	**126**	**111**	**111 TN**	**123**	**74.9**	**86.8**	**63**
MW-13I						**19**	**31.7 TN**	**2.82**
MW-17				**2.55 TN**	0.59	**37.1/40**	**61.4**	**4**
MW-18				0.722 TN	0.762	**1.05**	**1.07**	0.61
MW-19S						**150**	**269**	**60.9**
MW-19I						<1.12	<1.43	0.314
MW-20S							**22.8 TN**	**13.8**
MW-21S						**22**	**27.7**	**27.7**
MW-21I						<1.12	<0.325	0.374
MW-22						<1.12	0.274	0.402
MW-23S						<1.12	<2.55	0.468
MW-24S						<1.12	0.238	<0.08
TW-1	**1.7**	<1	**1.57**	0.932 TN	0.51	<1.12	0.548	0.58
TW-2	**2.2**	<1	<1	0.638 TN	0.46	<1.12	0.694	0.498
TW-3	**14**	<1	**5.15**	<0.23	**1.77**	**8**	**5.2**	**3.92**
TW-3 dup							**5.48**	**3.86**
TW-4	<1	<1	<1	**13.5 TN**	**11.8**	<1.12	**10.7**	**4.12**
TW-7	**30**	**3.75**	**21.7**	<0.23	<0.23	<1.12	**2.41**	**8.01**
TW-8							0.23	
TW-10	<1	**1.34**	<1	0.576 N	0.472	<1.12	0.5	0.5
P-2							<0.08	<0.1

Bold is used for all concentrations above the 1.0 ug/L ground water standard.
Blank space indicates no sample analyzed.
T = Estimated value
N = Tentatively Identified Compound (TIC) was presumptively present

Table 26. Trichloroethene Results Exceeding NJDEP Ground Water Quality Standard for Class II-A Aquifers - June 1994 through April 1998 (in μg/L)

Date	6/94	3/95	5/95	12/96	2/97	12/97	1/98	4/98
D-11 /11R	<1	<1	<1	**2.22 TN**	0.354	0.428	<0.684	0.454
D-12	**1.7**	**5.16**	**5.43**	0.262 JN	**1.97**	**3.69**	**1.84**	**1.22**
TFTR-S1	<1	<1	<1	0.266 JN	0.186	0.192	0.252	0.2
DMG-S2	**2.1**	**4.96**	<10	**3.71 TN**	**4.36**	**5.57**	**7**	**3.73**
LOB-S3	<1	<1	<1	<0.15	<0.15	<0.10	<0.1	<0.1
C MG-S4	**2.1**	**1.08**	**4.89**	0.382 JN	0.24	**3.40**	0.428	**1.21**
C-MG-S5	<1	<1	<1	<0.15	<0.15	<0.10	<0.1	<0.1
C-MG-S6	<1	**1.8**	<1	**1.44 TN**	0.87	NS	**1.03**	0.952
CS-S7						<0.10	<0.1	0.166
MW-1	<1	<1	<1			<0.10	<0.1	<0.1
MW-2	<1	<1	<1	<0.15	<0.15	<1.04	<0.1	<0.1
MW-2 dup								<0.1
MW-3	<1	<1	<1	<0.15	<0.15	0.214	0.1 TN	<0.1
MW-5S	<1	<1	<1	<0.15	<0.15			<0.1
MW-5I	**5.2**	**8.1**	**5.8**	**9.87 TN**	**9.84**	**2.05**	**11.5 TN**	**6.6**
MW-6S	<1	**8.15**	**25.1**	**9.82 TN**	**1.89**	**4.86**	**1.23**	**1.56**
MW-6 dup						**4.15**		
MW-6I							0.195	<0.1
MW-6I dup							<0.1	
MW-7I	**3**	**4.13**	**2.21**	0.264 JN	<0.15	0.216	0.314	<0.1
MW-7S	**2**	**3.48**	**4.5**	**1.45 TN**	**2.23**	0.948	**2.4 TN**	**1.32**
MW-8S	**1.6**	**1.62**	**1.38**	0.892 JN	**1.25**	0.696	**1.03**	0.594
MW-8I							<0.1	<0.1
MW-9	**1.7**	<5	<10	<3	<0.15	**1.57**	**2.04 TN**	**1.32**
MW-9I						<0.10	<0.1	<0.1
MW-9I dup							<0.1	**1.34**
MW-10I						<1.04	<0.1	<0.1
MW-13	**1.8**	<10	<10	<3	**1.71**	**3.02**	**3**	**1.89**
MW-13I						0.22	0.595	<0.1
MW-17				<0.15	<0.15	**1.18**	**1.57**	<0.1
MW-17 dup						**1.10**		
MW-18				0.146 TN	0.161	0.616	0.464	0.167
MW-19S						<1.04		
MW-19I						<1.04	<5.35	**2.32**
MW-20S							0.5 TN	0.167
MW-21S						<1.04	<0.5	<0.25
MW-21I						<1.04	<0.202	<0.1
MW-21I dup						<1.04		
MW-22						<1.04	<0.1	<0.1
MW-23S						<1.04	<0.214	<0.1
MW-24S						<1.04	<0.1	<0.1
TW-1	<1	<1	<1	<0.15	<0.15	<1.04	<0.1	<0.1
TW-2	<1	<1	<1	<0.15	<0.15	<1.04	0.1	<0.1
TW-3	<1	<1	<1	<0.15	<0.15	<1.04	0.44	<0.344
TW-3 dup							0.434	0.33
TW-4	<1	**1.07**	**1.12**	**1.16 TN**	**1.04**	<1.04	**1.24**	0.754
TW-7	**1.3**	<1	<2.5	0.282 TN	0.268	<1.04	**1.92**	0.948
TW-8							<0.1	<0.1
TW-10	<1	<1	<1	0.358 TN	0.304	<1.04	0.512	0.308
P-2							<0.1	<0.1

Bold is used for all concentrations above the 1.0 ug/L ground water standard.
Blank indicates no sample analyzed.
N = Tentatively Identified Compound (TIC) was presumptively present *T = Estimated value*

Table 27. 1998 Summary of Ground Water Pumped at PPPL (in gallons per day)

Date	TFTR Sump	D Site MG Sump	LOB Basement	CS Basement	Daily Avg. Flow Sum	Cum. Daily Avg. Flow
Jan.	279,540	105,014	18,966	118	403,638	
Feb.	129,150	132,384	60,803	485	322,822	363,230
March	155,448	121,248	126,757	3,842	407,295	377,918
April		187,166		13,478		
May	213,237	108,672	143,177	11,940	477,026	402,695
June	149,923	83,520	138,340	12,412	384,195	398,995
July	116,827	15,812	97,532	1,281	231,452	291,567
Aug.	87,276	12,882	66,818	715	167,691	287,132
Sept.	69,520	13,100	2,564	323	85,507	281,022
Oct.	64,055	13,488	1,589	434	79,566	265,722
Nov.	55,938	13,133	166	346	69,583	254,327
Dec.	55,397	12,190	0	124	67,711	237,902

Table 28. 1998 Quality Assurance Data for Radiological and Non-Radiological Samples

Laboratory, Program, and Parameter	Reported Value	Actual Value	Acceptance Range
PPPL EPA (ESD-LV, Mar. 98) Tritium in water (picoCuries/Liter)	1759.33	2155	± 348
PPPL EPA (ESD-LV, Aug. 98) Tritium in water (picoCuries/Liter)	17,602	17,996	± 1,800
PPPL EPA (July 98) Gamma in water (pCi/L)			
Cobalt 60	12.24	12.0	± 5
Zinc 65	106.37	104.0	± 10
Cesium 134	27.6	31.0	± 5
Cesium 137	34.55	35.0	± 5
Barium 133	40.07	40.0	± 5
PPPL EPA (WP040)			
pH	8.38	8.6	8.31-8.92
Total residual chlorine (mg/L)	1.15	0.93	0.811-1.32
Nitrate as N (mg/L)	14.2	12.0	10.1-13.4
Orthophosphate as P (mg/L)	0.63	0.58	0.496-0.669
Conductivity	669	525	471-544

Chapter

12

FIGURES

Figure 1. Aerial View of PPPL

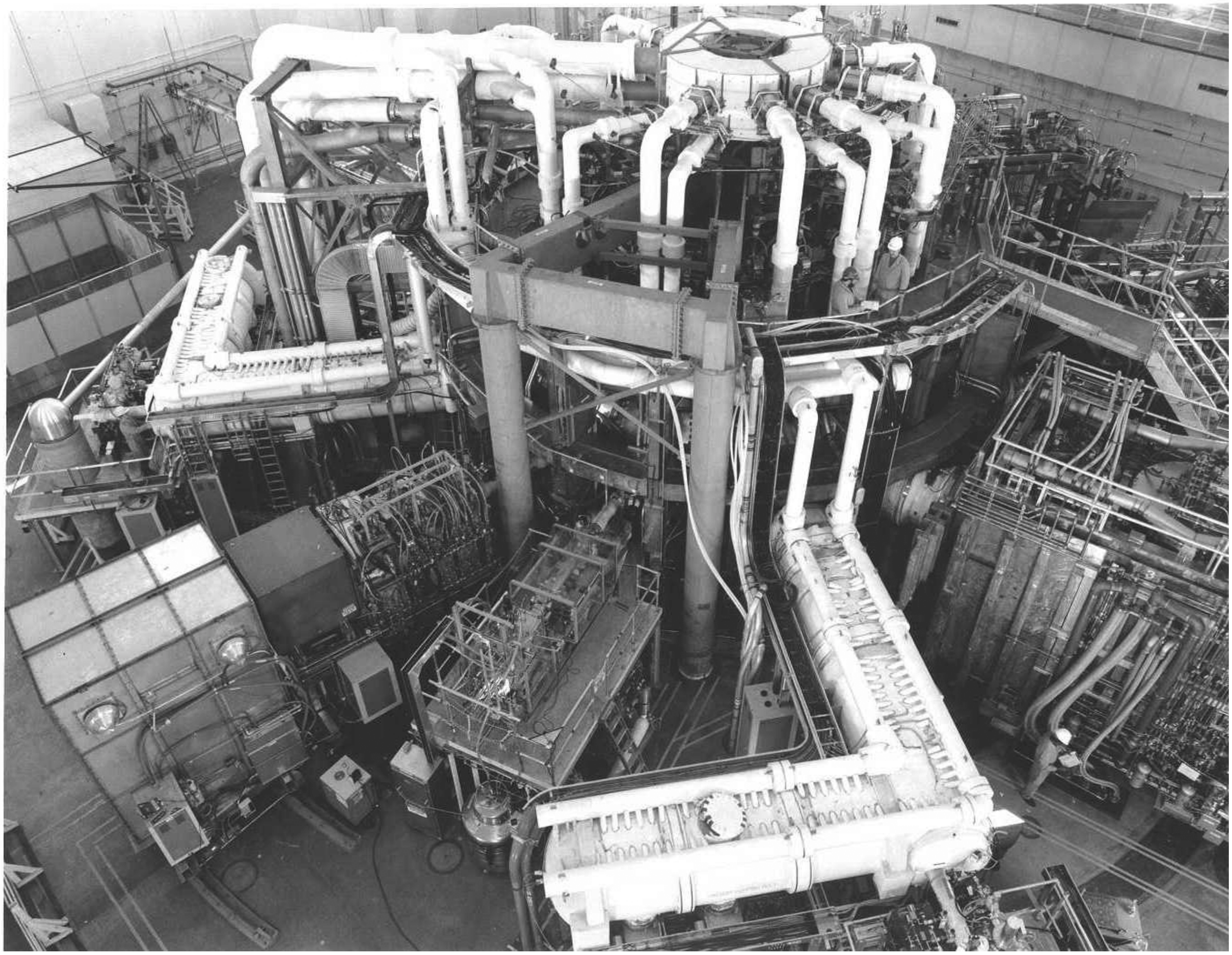


Figure 2. Tokamak Fusion Test Reactor (TFTR)

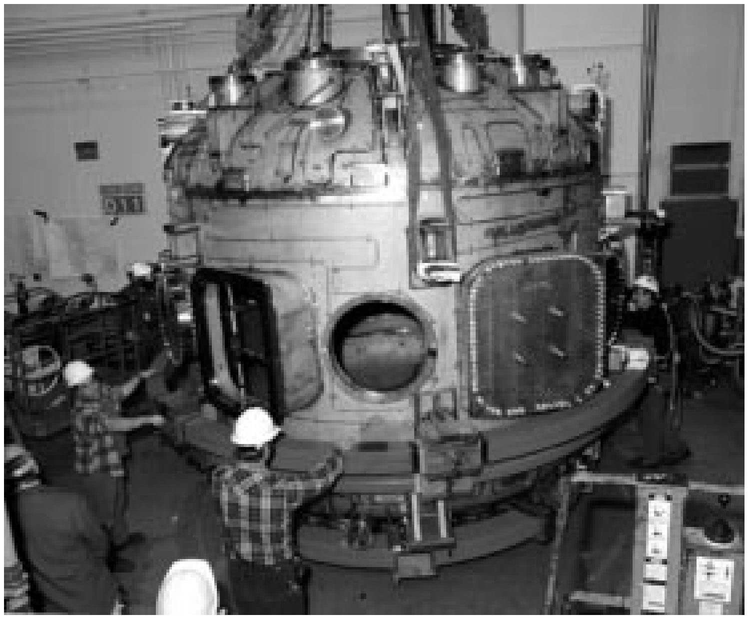
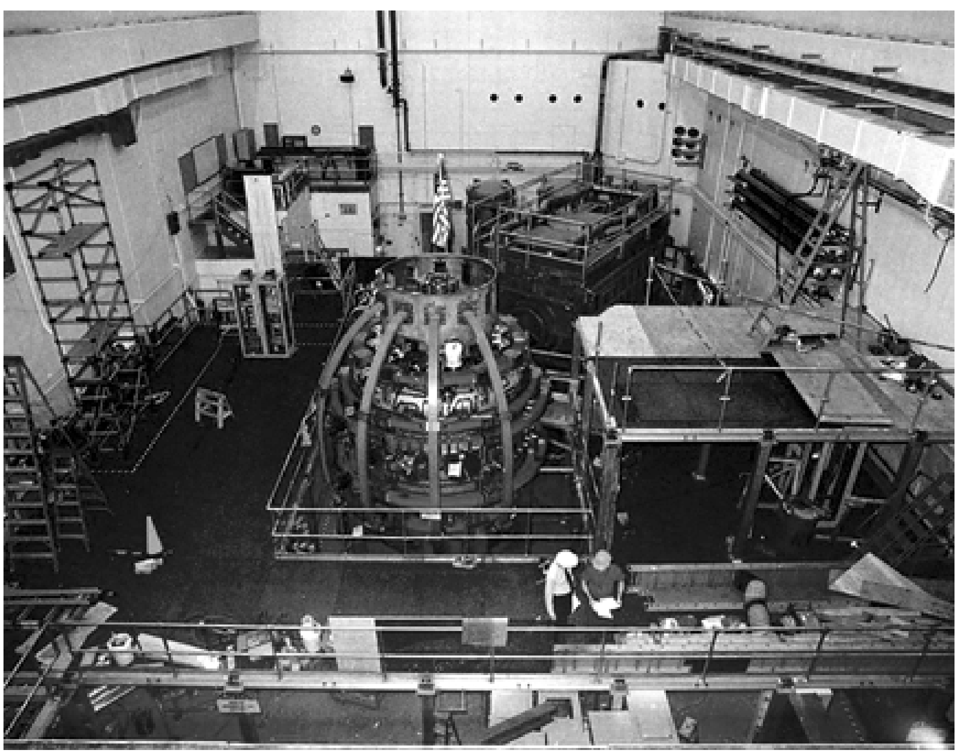


Figure 2. National Spherical Torus Experiment (NSTX) under construction (1998)



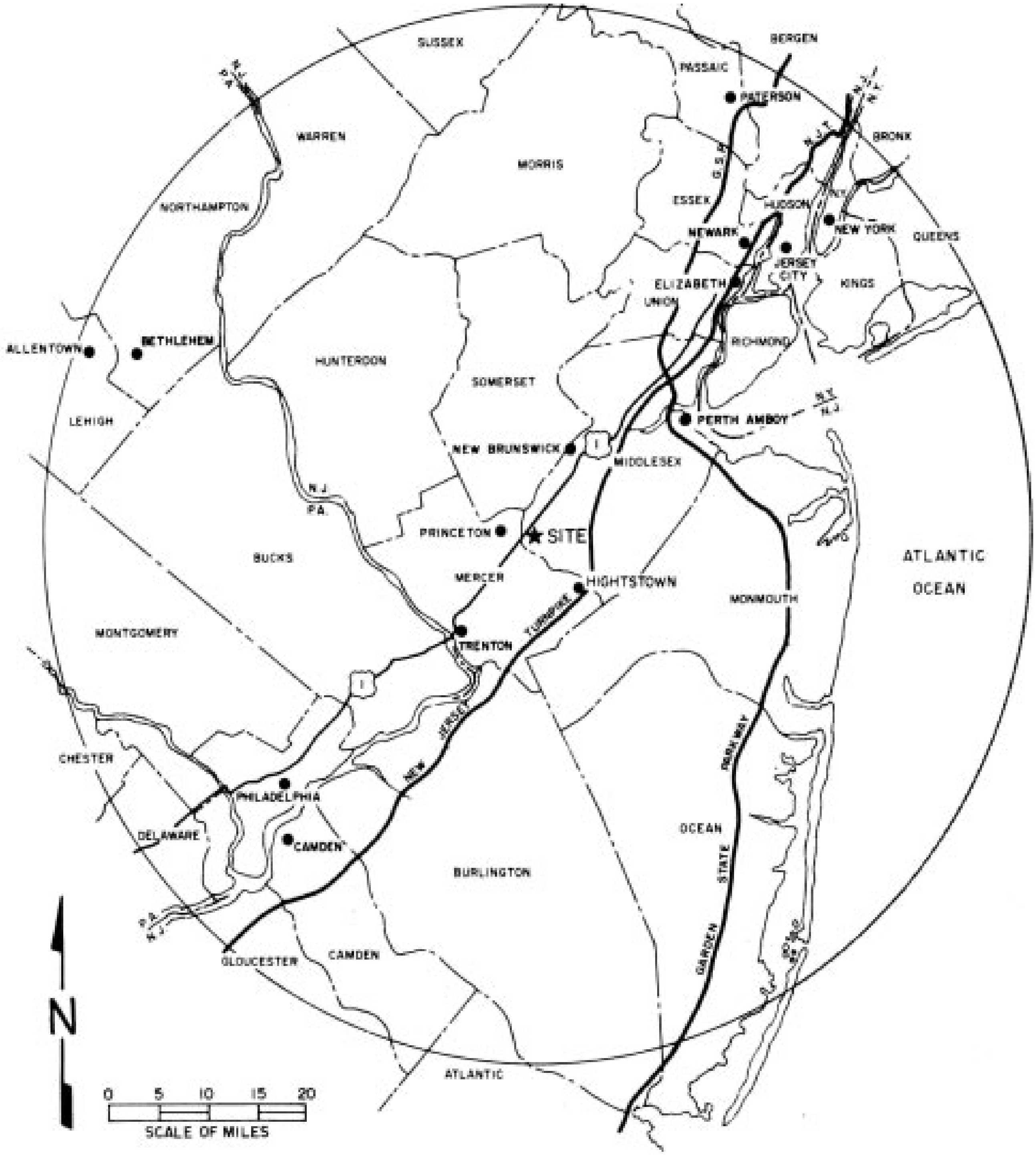


Figure 4. Region Surrounding PPPL (50-mile radius shown)

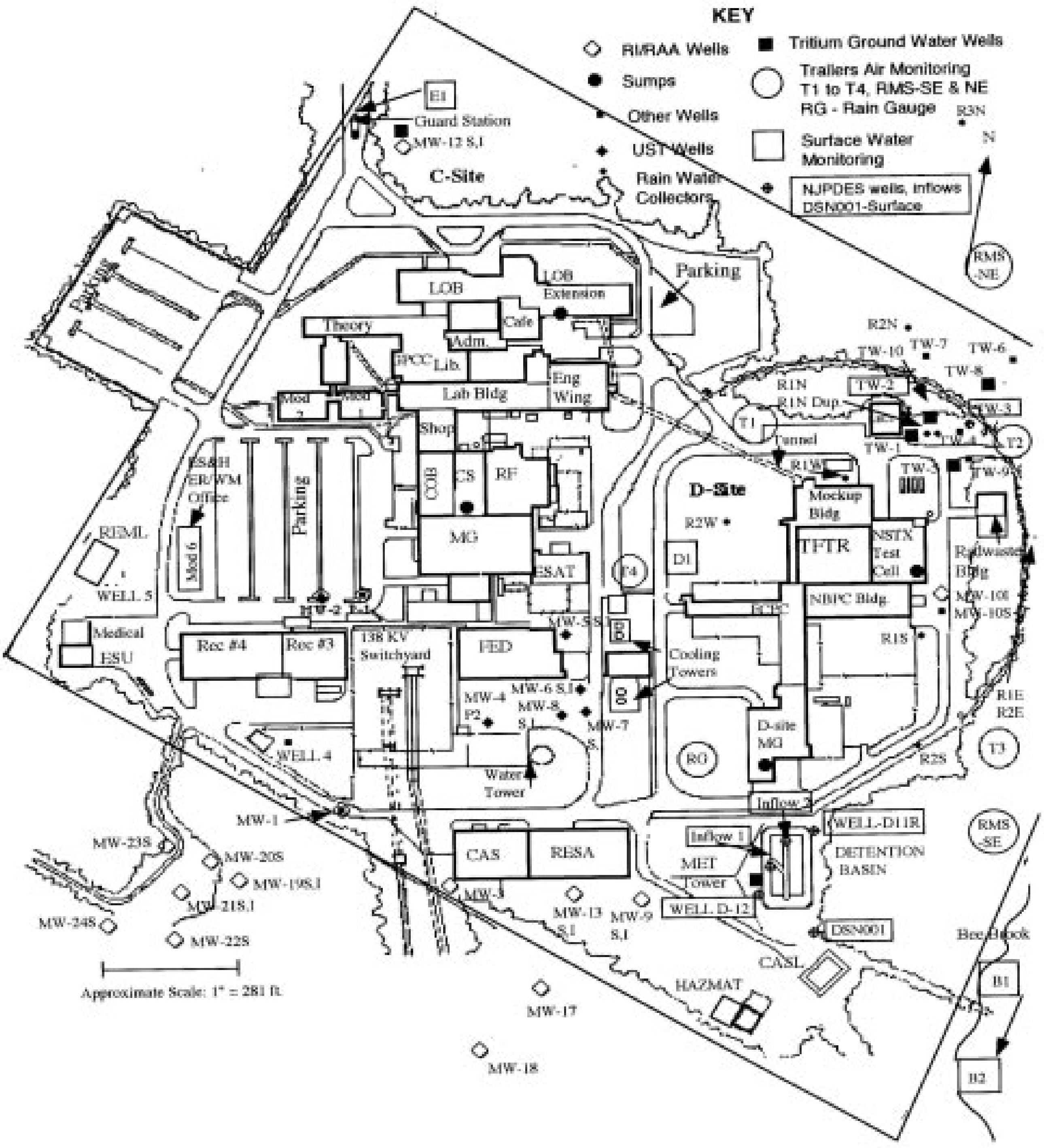


Figure 5. PPPL C and D Sites for the James Forrestal Campus

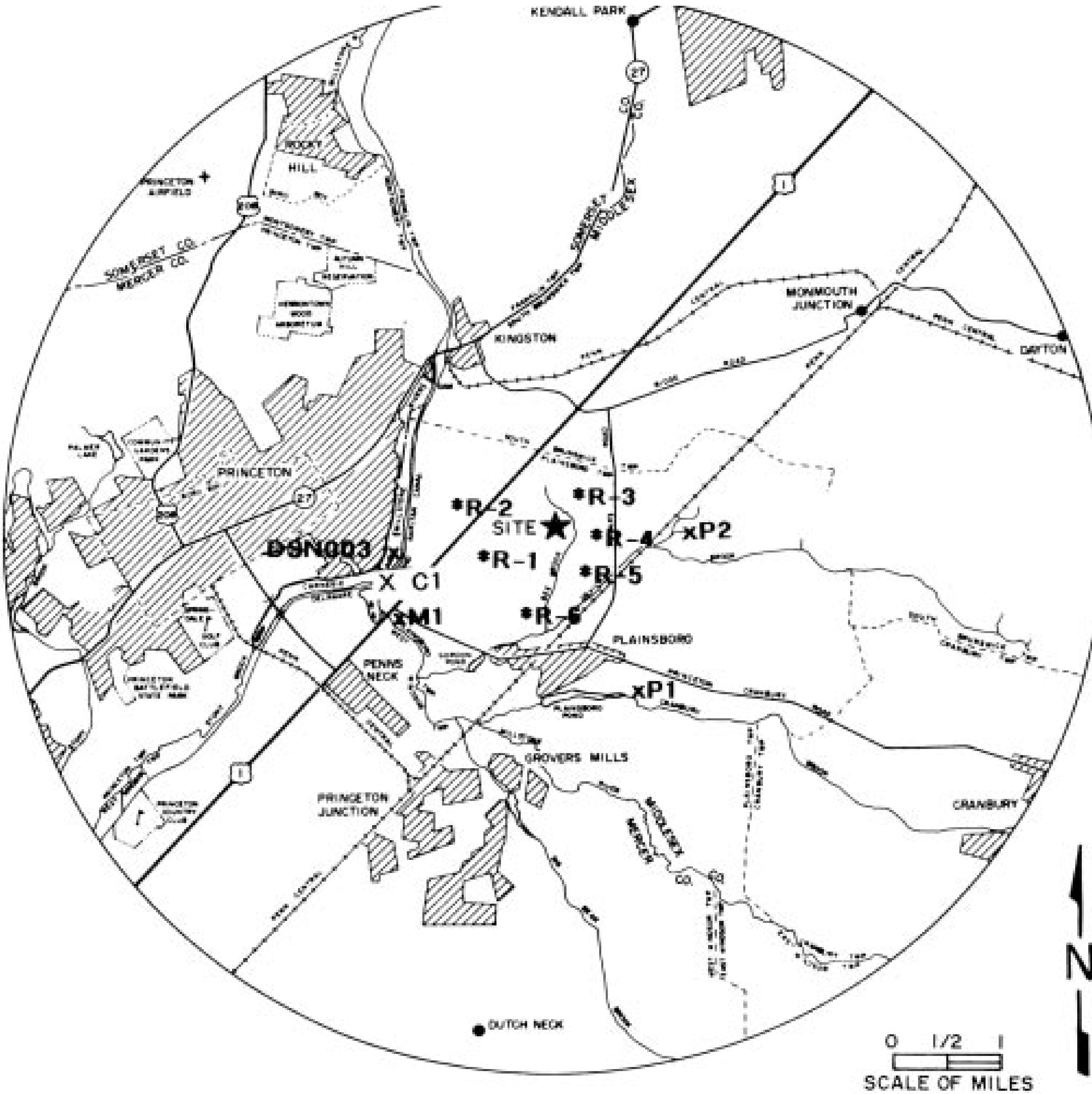


Figure 6. Off-Site Monitoring Locations

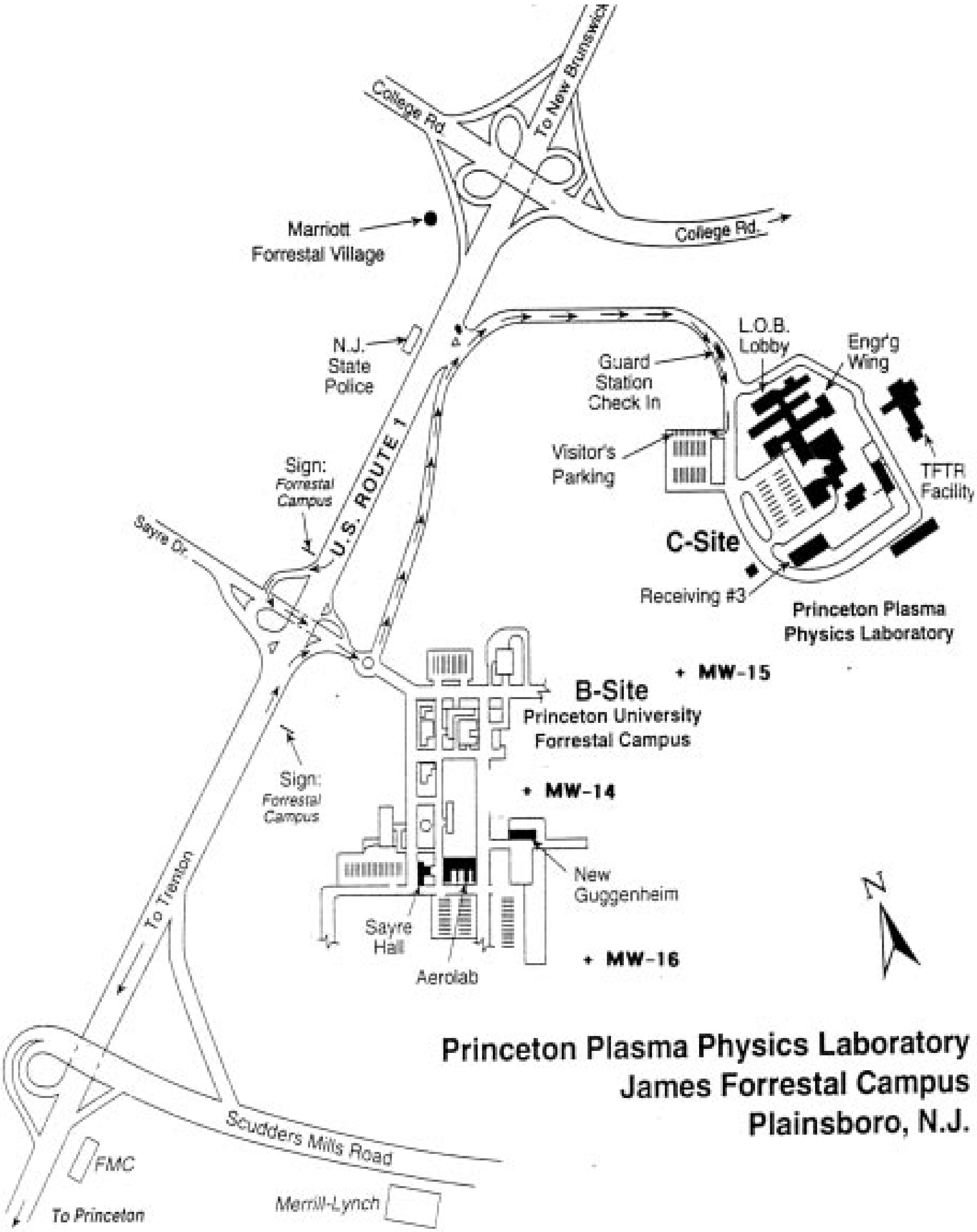


Figure 7. PPPL James Forrestal Campus A and B Site Well Locations

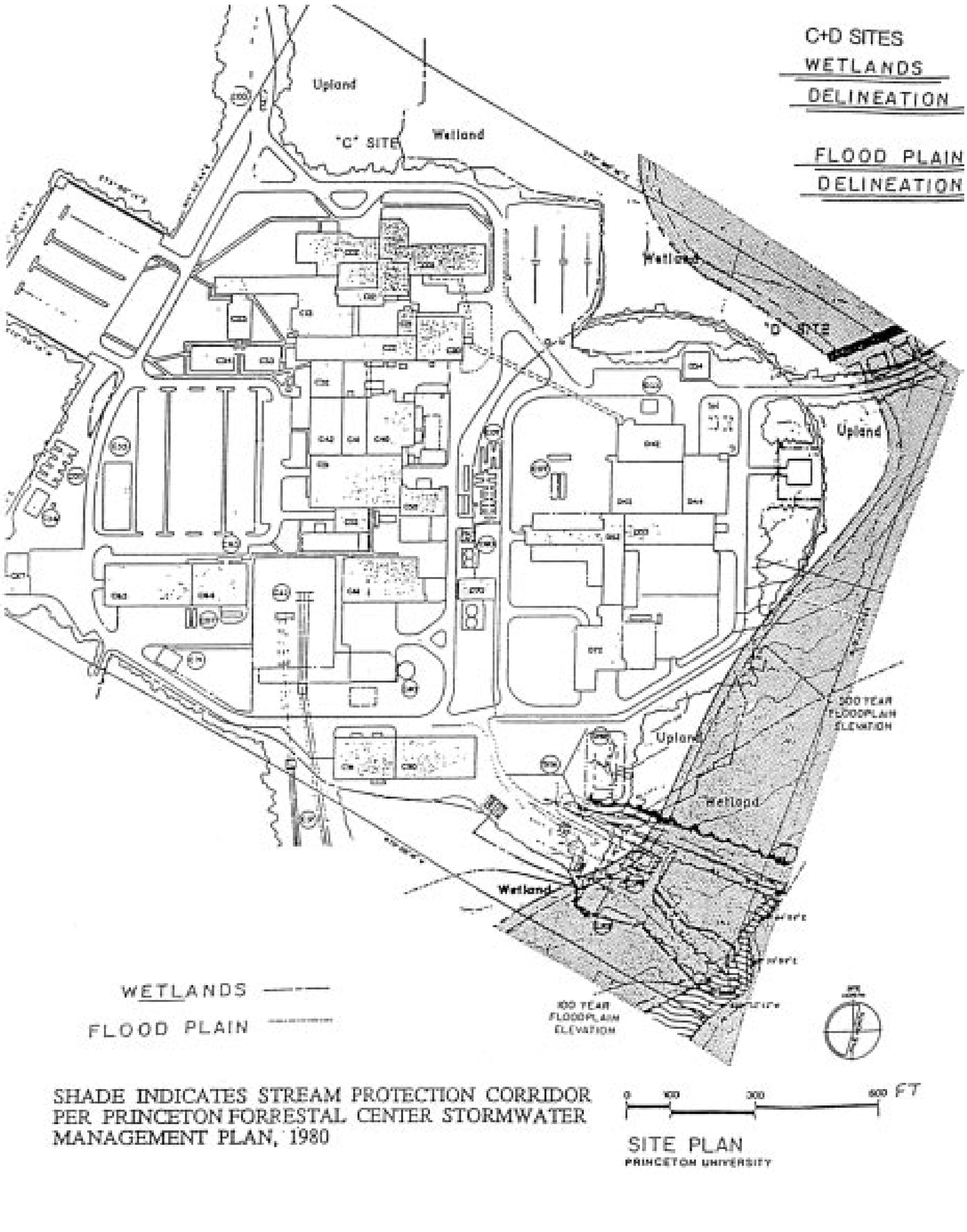


Figure 8. PPPL Site Map – Floodplain and Wetland Boundaries

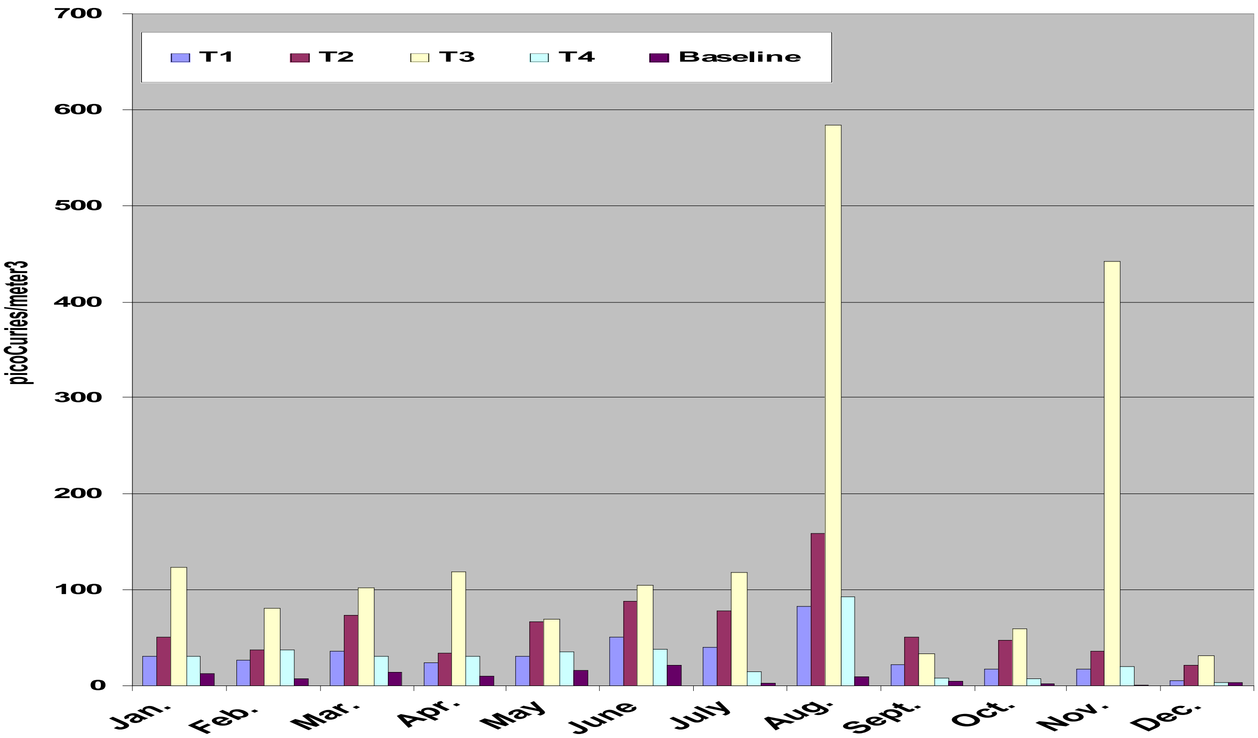


Figure 9. Tritium in Air (T1-T4 and Baseline) for 1998 (HTO)

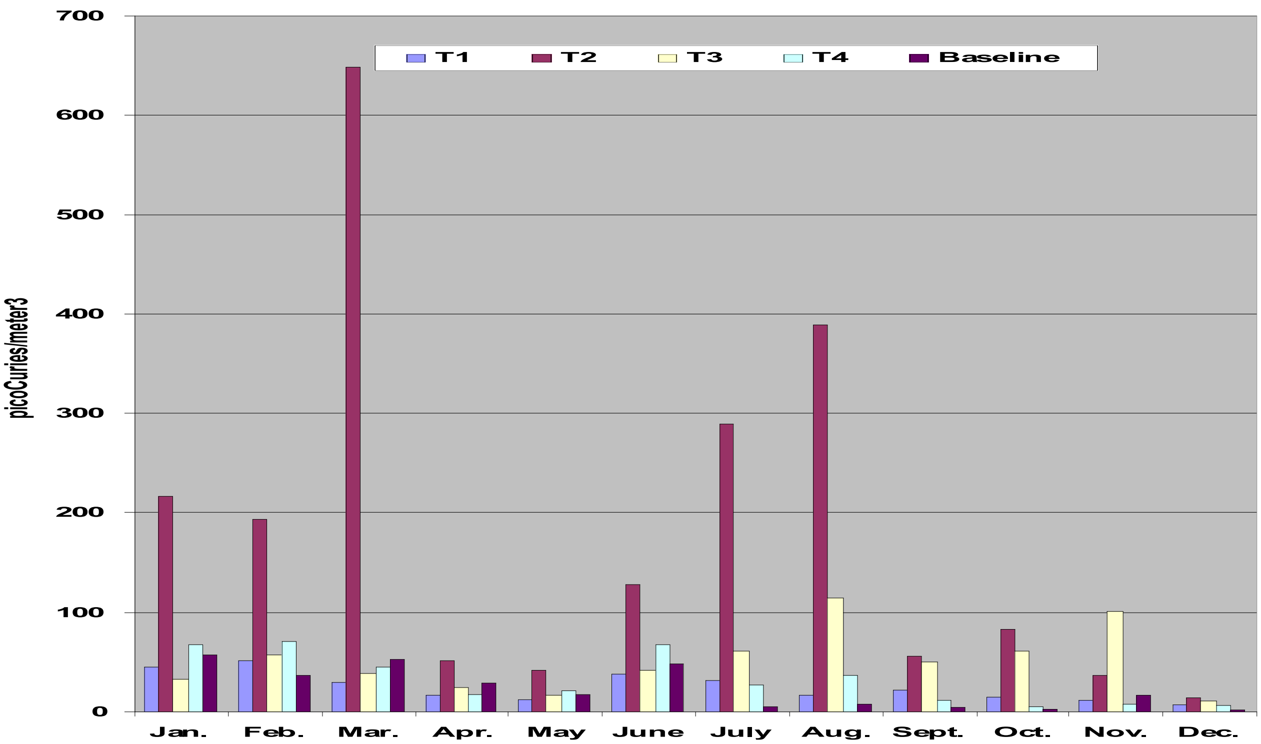


Figure 10. Tritium in Air (T1-T4) for 1998 (HT)

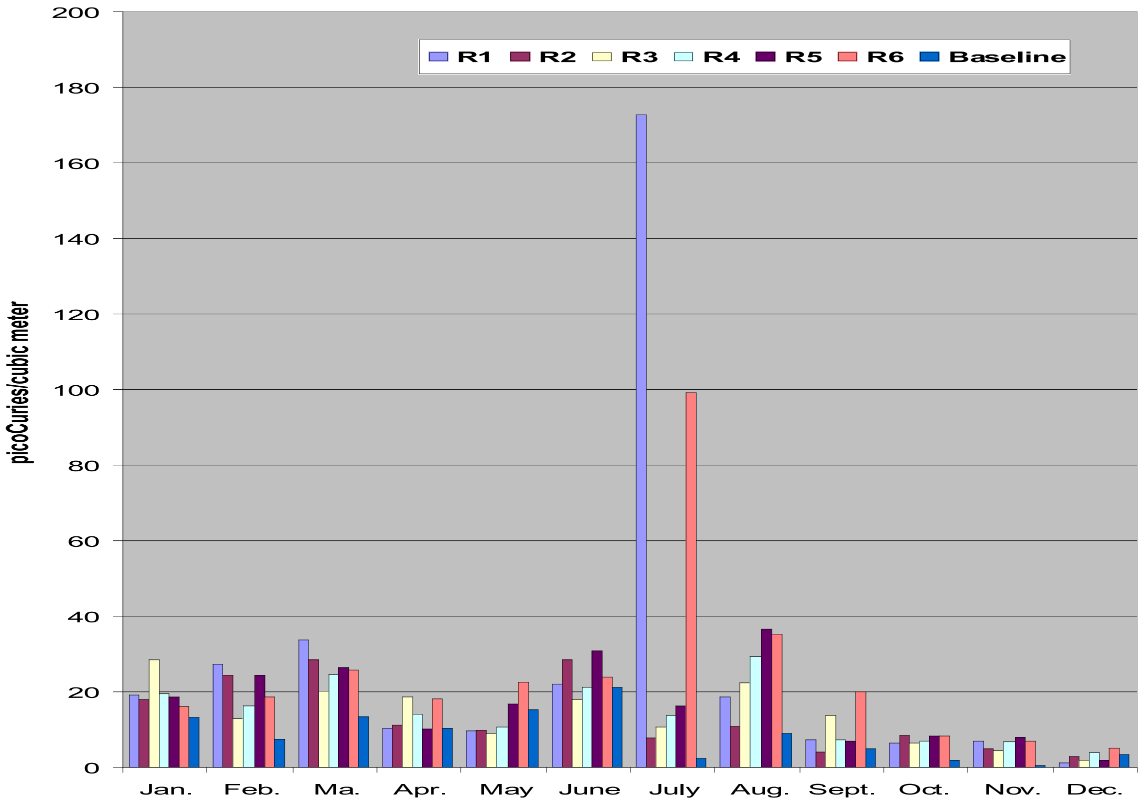


Figure 11. Tritium in Air (R1-R6 and Baseline) for 1998 (HTO)

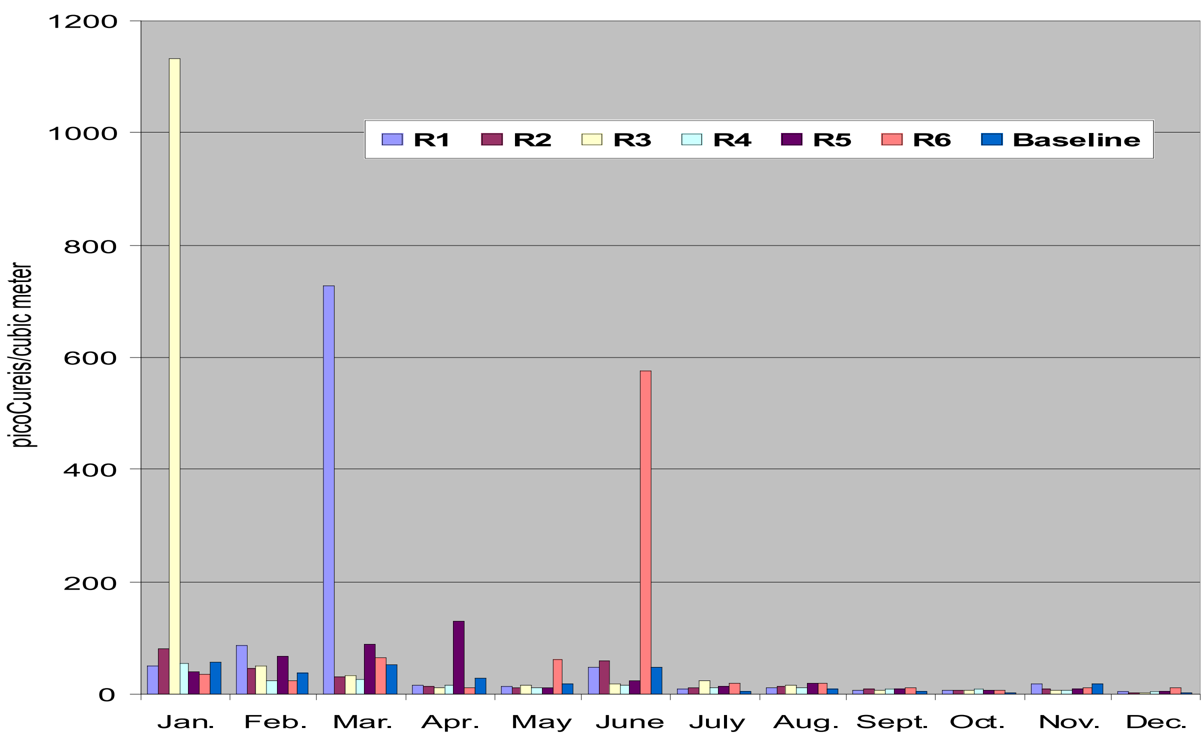


Figure 12. Tritium in Air (R1-R6 and Baseline) for 1998 (HT)

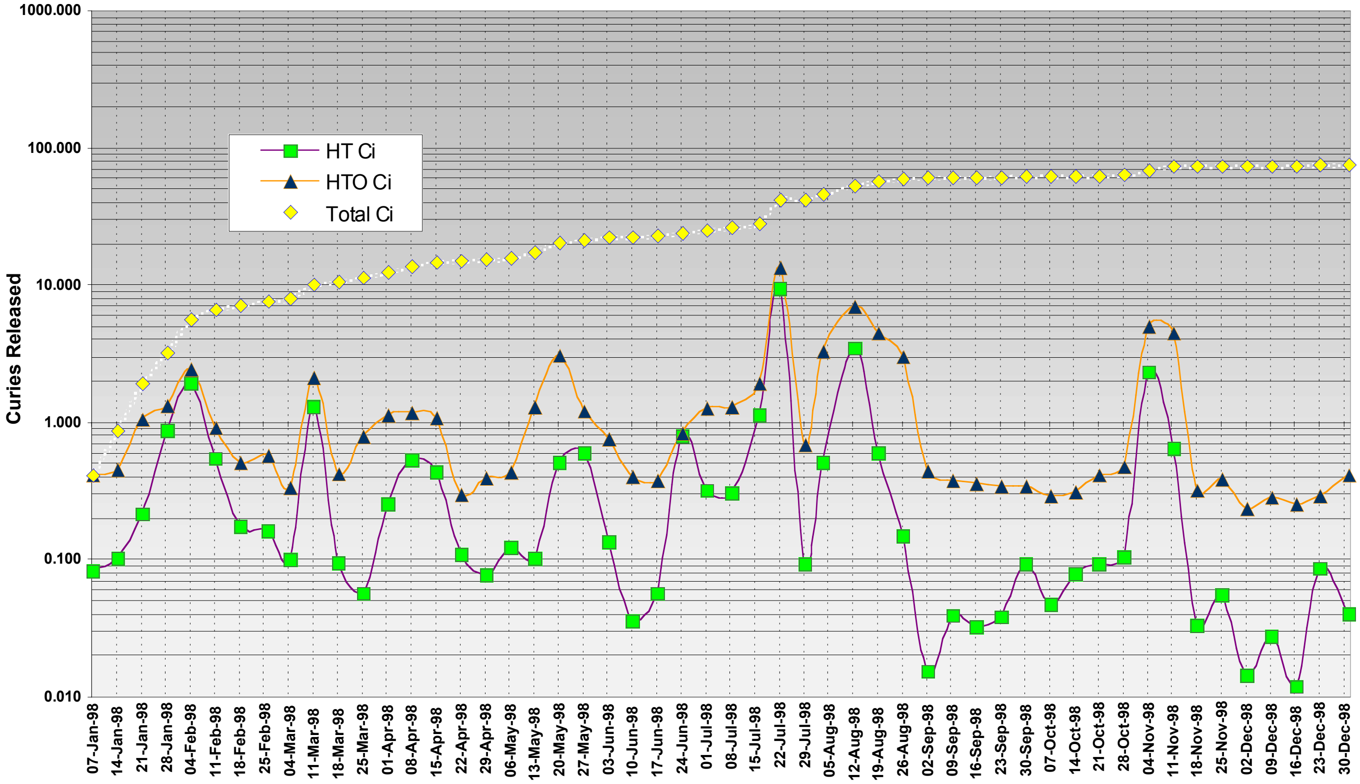


Figure 13. 1998 Monthly Tritium Released

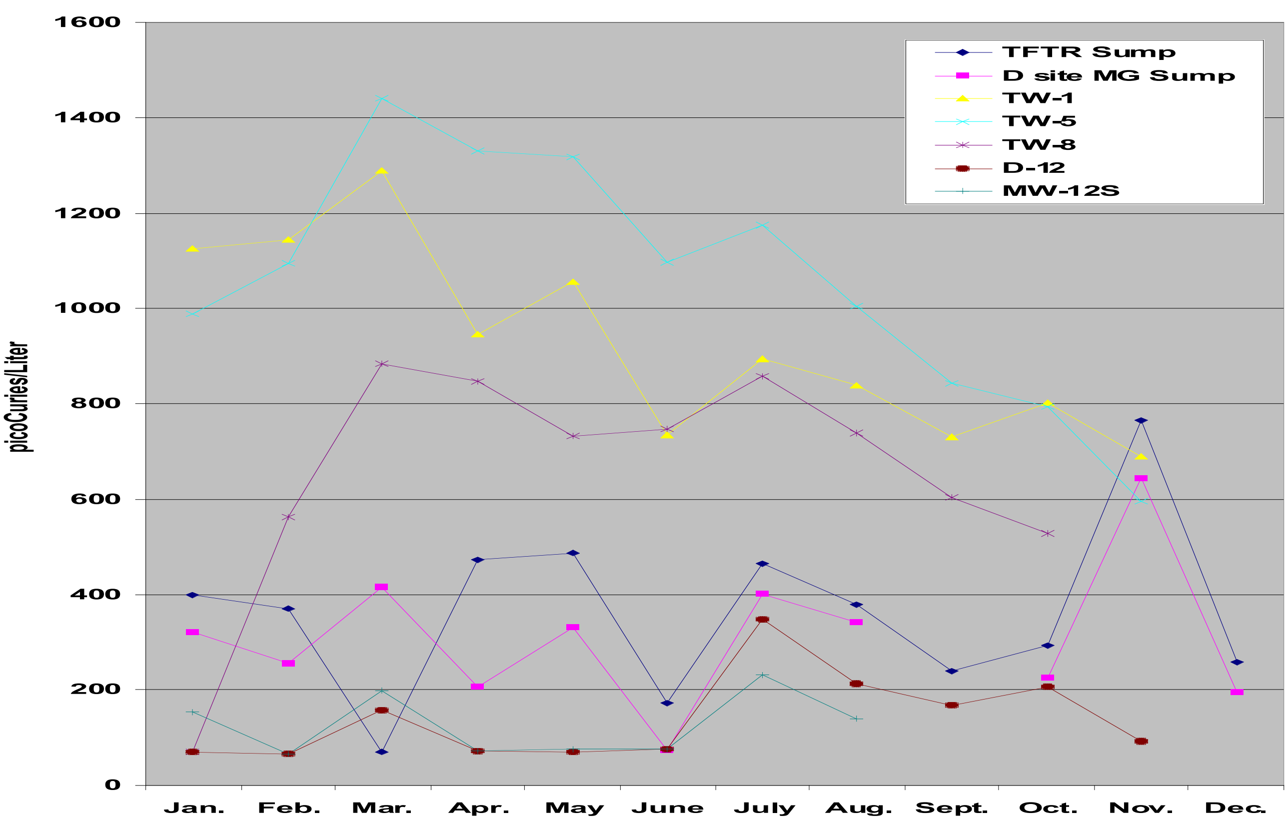


Figure 14. 1998 Tritium (HTO) Concentrations in Ground Water

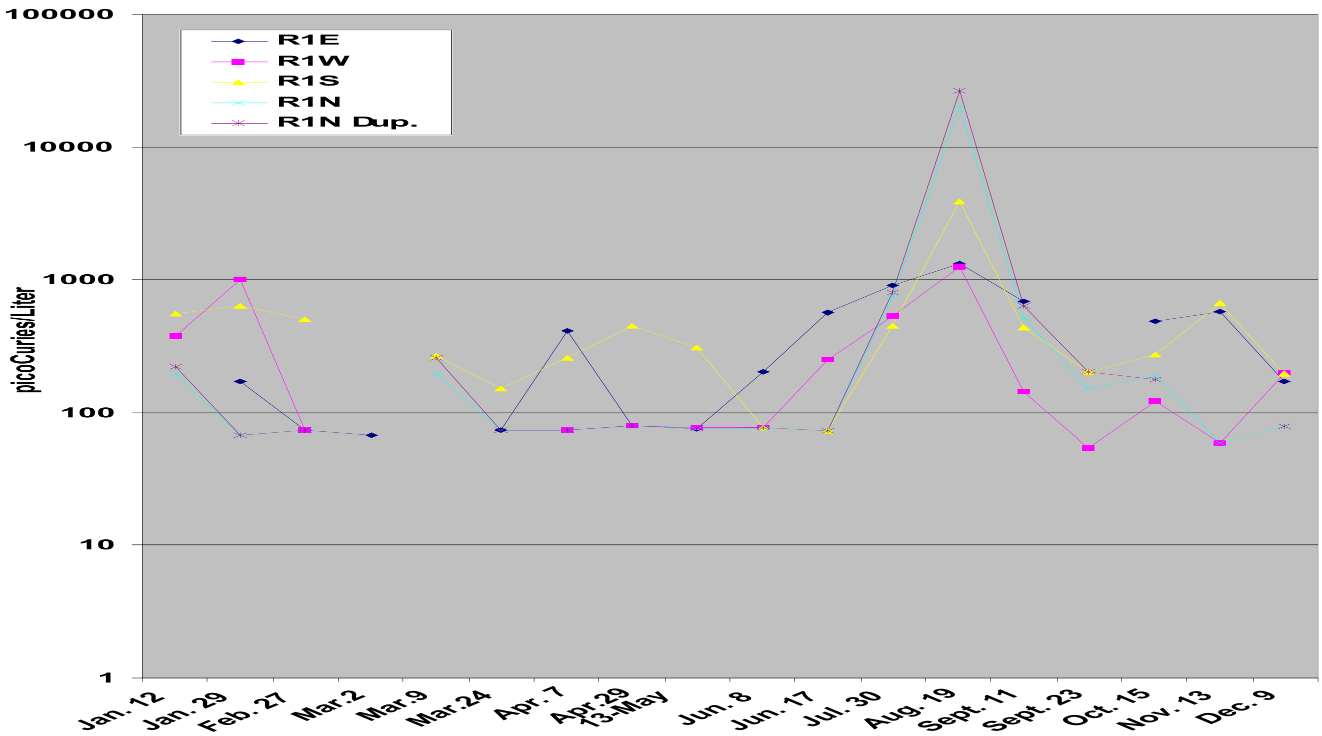


Figure 15. 1998 Tritium (HTO) in Rain Water (R1 Stations)

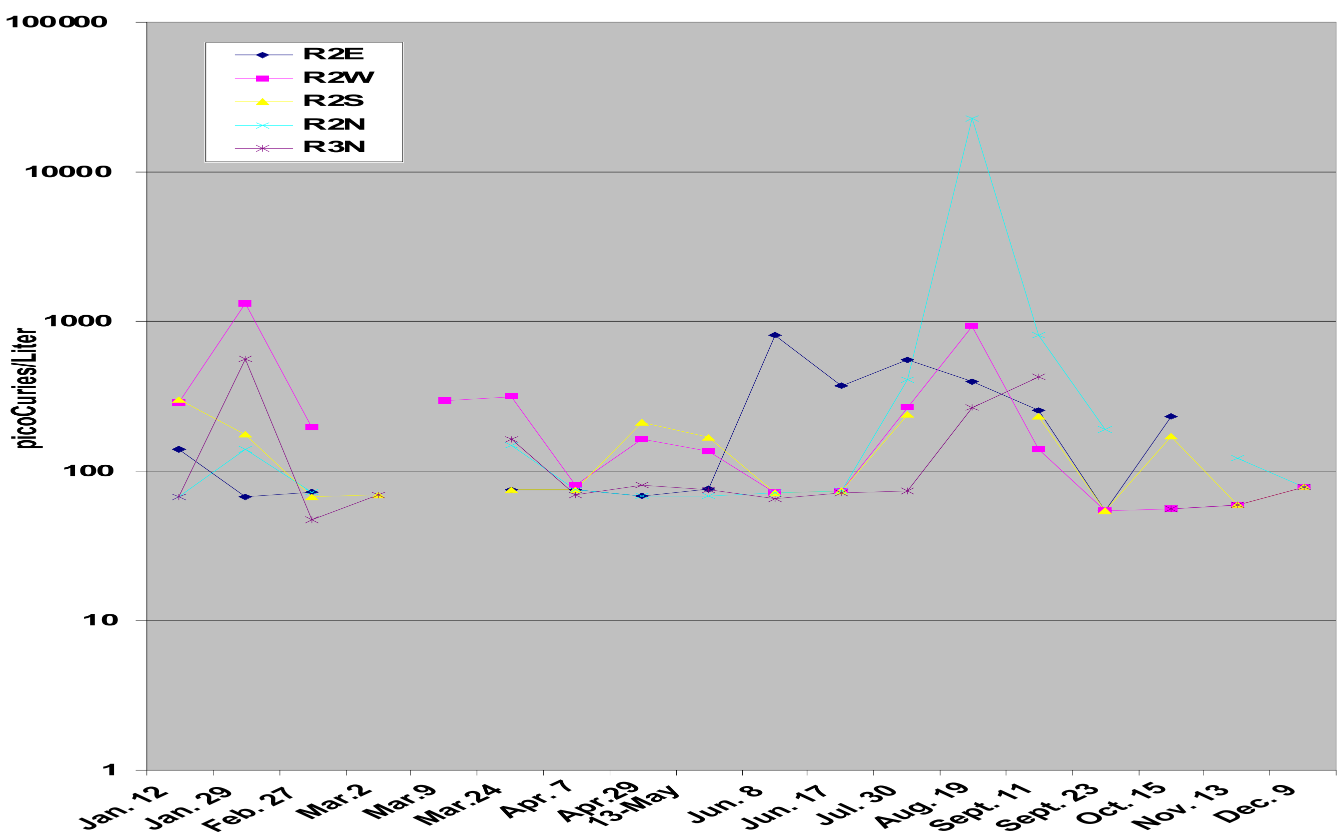


Figure 16. 1998 Tritium (HTO) in Rain Water (R2 Stations)

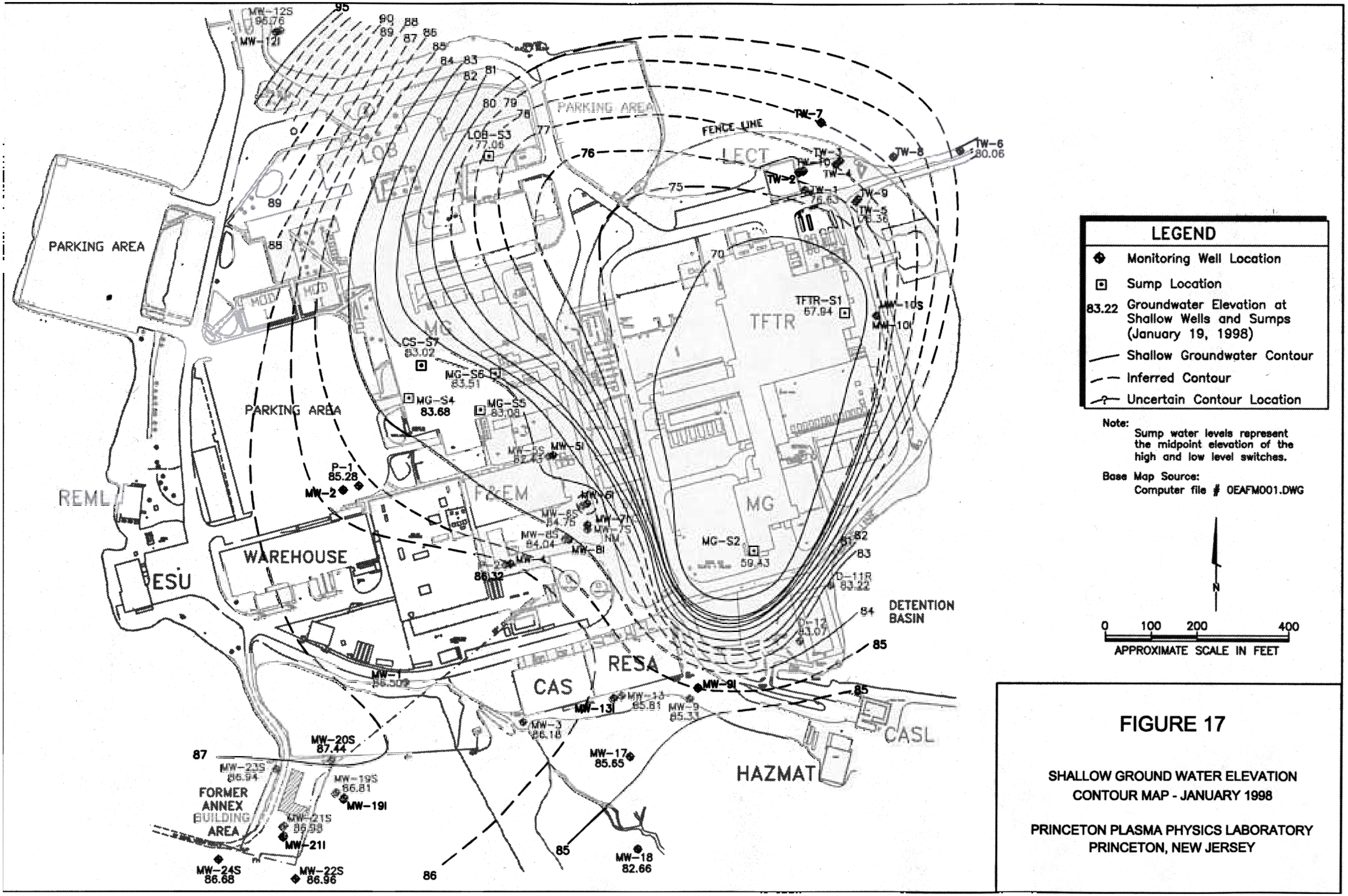


FIGURE 17

SHALLOW GROUND WATER ELEVATION CONTOUR MAP - JANUARY 1998

PRINCETON PLASMA PHYSICS LABORATORY
PRINCETON, NEW JERSEY

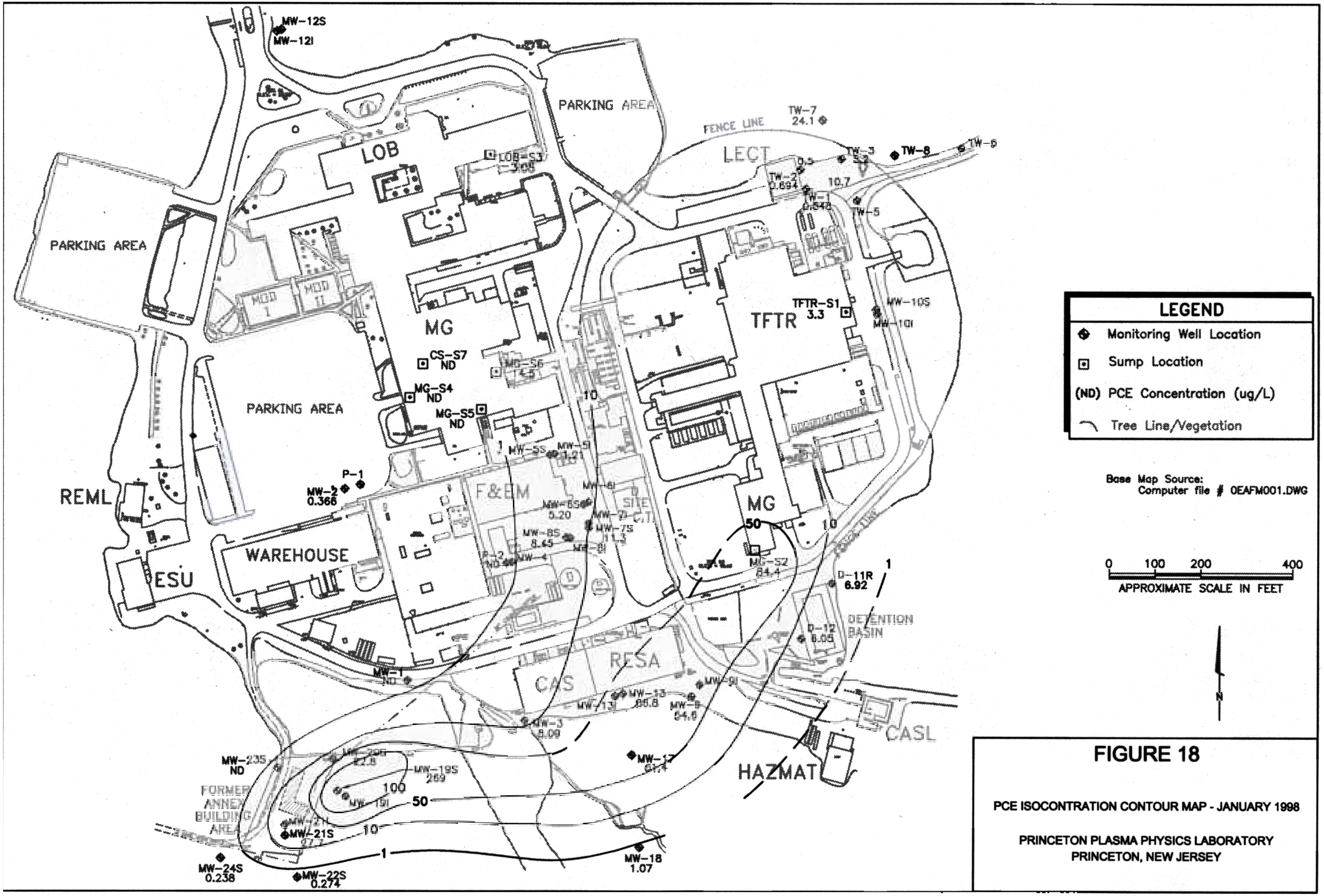
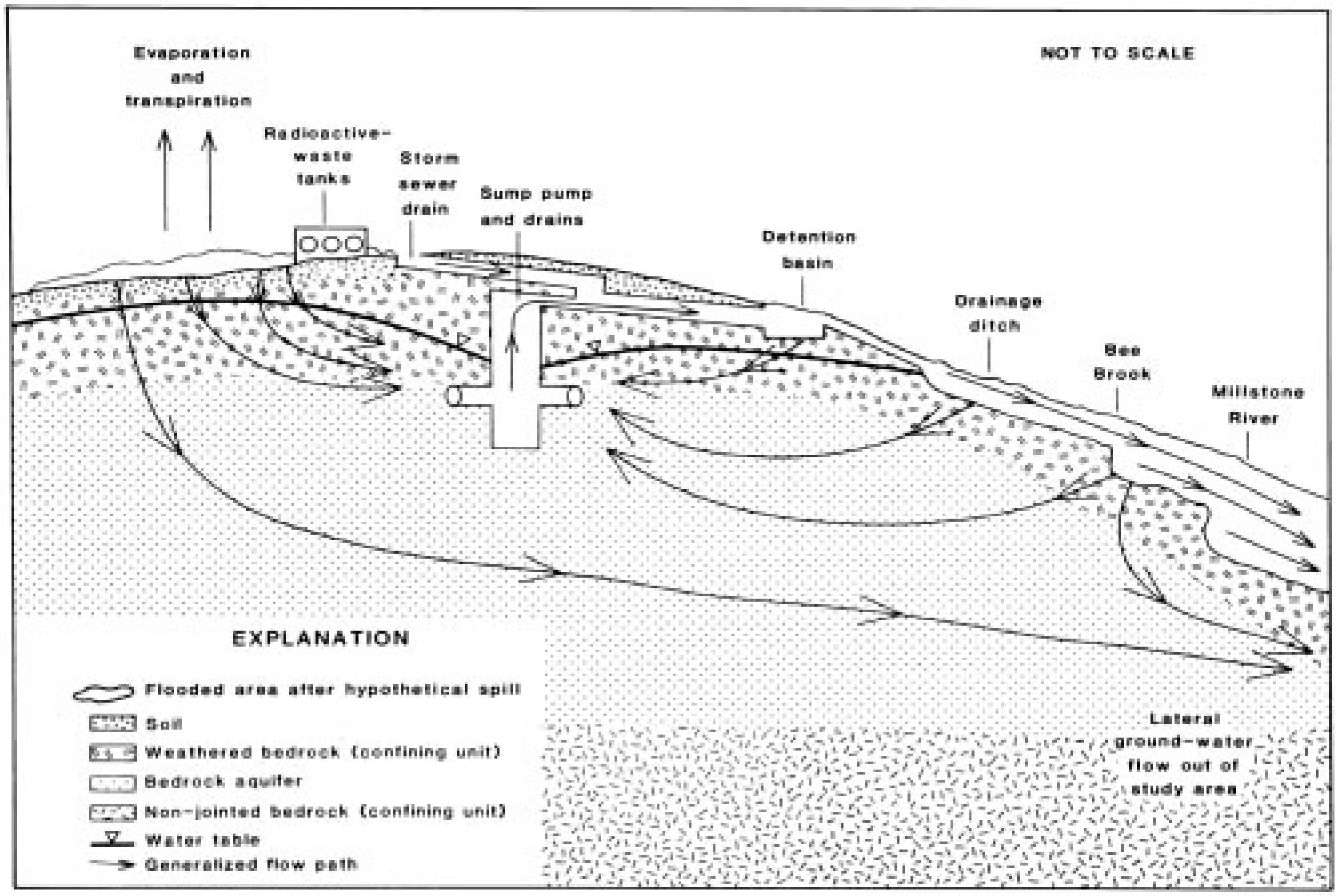


FIGURE 18

PCE ISOCONTRATION CONTOUR MAP - JANUARY 1998

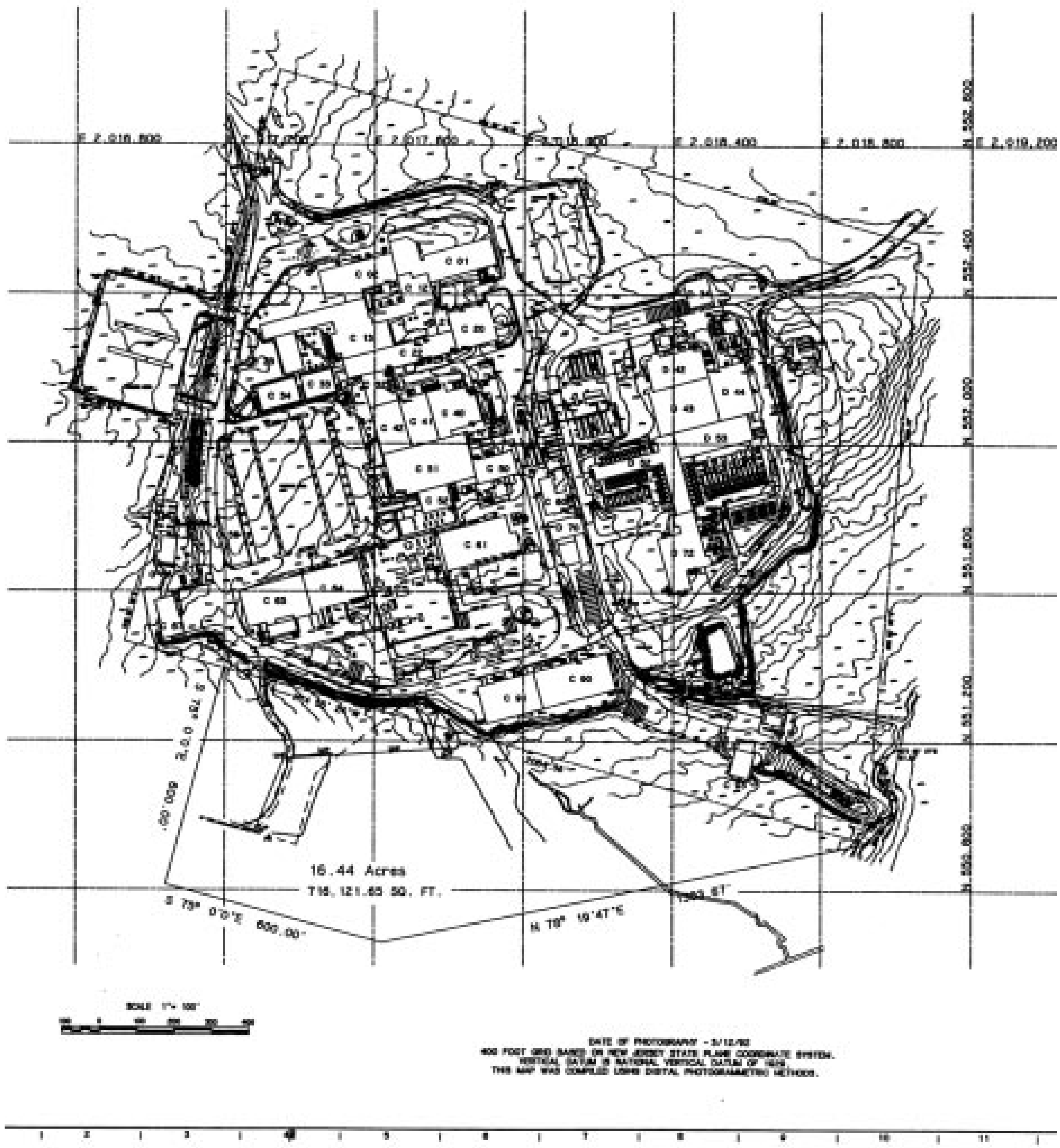
PRINCETON PLASMA PHYSICS LABORATORY
PRINCETON, NEW JERSEY

Figure 19. Potentiometric Surface of the Bedrock Aquifer at PPPL
[from Le87]



-Schematic representation of hydrogeologic framework and potential flow paths of spilled water.

Figure 20. PPPL Expanded Boundaries



Chapter

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