PRINCETON PLASMA PHYSICS LABORATORY (PPPL)
ANNUAL SITE ENVIRONMENTAL REPORT
FOR CALENDAR YEAR 1993

by

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and

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List of Acronyms

ACO	Administrative Consent Order
AFS	Air Facility Subsystem
AGT	above ground tank
AHC	aromatic hydrocarbons
AIRS	Aerometric Information Retrieval System
ALARA	as low as reasonably achievable
ARLFRD	Air Resources Laboratories Field Research Division
BOD	biological oxygen demand
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
CICADA	Central Instrumentation , Control, and Data Aquisition
cm	centimeter
COD	chemical oxygen demand
CWA	Clean Water Act
CY	calendar year
D	deuterium
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
DEP	Department of Environmental Protection (NJ)
DEPE	Department of Environmental Protection and Energy (NJ)
DMR	discharge monitoring report
DOE	Department of Energy
DOE-EH	Department of Energy-Environment and Health
DOE-HQ	Department of Energy - Headquarters
DOE-OFE	Department of Energy - Office of Fusion Energy
DOE-PAO	Department of Energy - Princeton Area Office
DSN	discharge number
EA	Environmental Assessment
EDE	effective dose equivalent
EM-30	Waste Management - DOE
EM-40	Environmental Restoration - DOE
EML	Environmental Monitoring Laboratory
EO	Executive Order
EPA	Environmental Protection Agency (US)
ER/WM	Environmental Restoration/Waste Management
ESA	Endangered Species Act
ES&H	Environment, Safety, and Health Division
FCPC	Field Coil Power Conversion Building
FED	Facilities Engineering Division
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FSAR	Final Safety Analysis Report
GBq	Giga Bequerel
GP	General Permit (Wetlands)
HMSF	Hazardous Material Storage Facility
HRS	Hazard Ranking System
HT	tritium (elemental)
HTO	tritiated water
HVAC	heating, ventilation, and air-conditioning
ICRF	Ion Cyclotron Radio Frequency
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)
MCHD	Middlesex County Health Department
MeV	million electron volts

List of Acronyms

MG	Motor Generator
mg/l	milligram per liter
MOU	Memorandum of Understanding
mR/h	milliRoentgen per hour
MSDS	Material Safety Data Sheet
msl	mean sea level
mSv	milliSievert
MW	monitoring well
n	neutron
NAAQS	National Ambient Air Quality Standards
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
NOx	nitrous oxides
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
nSv	nanoSievert
P1, P2	piezometer 1 and 2
PBX-M	Princeton Beta Experiment - Modification
PCBs	polychlorinated biphenyls
PCE	perchloroethylene, tetrachloroethene, or tetrachloroethylene
pCi/L	picoCuries per liter
POTWs	publicly owned treatment works
ppb	parts per billion
ppm	part per million
PPPL	Princeton Plasma Physics Laboratory
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
SAD	Safety Analysis Document
SARA	Superfund Amendments and Reauthorization Act of 1986
SBRSA	Stony Brook Regional Sewerage Authority
SDWA	Safe Drinking Water Act
SPCC	Spill Prevention Control and Countermeasure
SNAP	significant new alternative s policy
S&R	shutdown and removal (TFTR)
T	tritium
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
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
UST	underground storage tanks
VOC	volatile organic compounds
χ/Q	dilution factor (NOAA)
µg/l	micrograms per liter
µSv	microSievert

1.0 EXECUTIVE SUMMARY

During Calendar Year 1993 (CY93), the Princeton Plasma Physics Laboratory's (PPPL) Tokamak Fusion Test Reactor (TFTR) set a world record of about three million watts of controlled fusion power, during the first approximately 50-50 deuterium-tritium (D-T) plasma experiment on December 9, 1993. Twenty years earlier—in December 1973—the goal of D-T experiments was presented to the Energy Research and Development Administration (ERDA), the predecessor of the Department of Energy (DOE). Hence, those twenty years of planning and designing, constructing, operating, and maintaining TFTR resulted in the success of the D-T experiments. Experiments continued through the month of December 1993 with a new record of six million watts of power set by the D-T plasma.

Earlier in 1993 in preparation for D-T operations, a small amount of tritium (<1000 Curies) was brought on-site for use in the testing of the TFTR tritium storage and cleanup systems. Later in 1993, the Operational Readiness Review or ORR was conducted by a DOE-contractor team of experts from outside PPPL who determined how well PPPL met the necessary requirements for full D-T operations. PPPL passed the ORR, and tritium was brought on-site for the scheduled December 1993 startup.

In CY93, PPPL's radiological monitoring program included on-site air monitoring, off-site air, surface water, soils, and biota analyses for radioactive baselines. Passive tritium air monitors were used in four on-site area monitors, one stack monitor, and at off-site monitor locations. Six off-site locations within 1 km of TFTR have differential atmospheric tritium samplers (DATS), which are high sensitivity monitors that are able to detect changes in the ambient levels. A tritium stack monitor was added to the TFTR stack as required by National Emission Standard for Hazardous Air Pollutants (NESHAPs) regulations, with limits set by the U.S. Environmental Protection Agency.

The results of the radiological monitoring program were: 1) Radiation exposure, via airborne and sanitary sewer effluents, have been measured in low levels; 2) The total maximum off-site dose from all sources—airborne, sanitary sewerage, and direct radiation—resulted in a total of 0.064 mrem/year, which is a fraction of the 10 mrem/year TFTR design objective and the 100 mrem/year DOE limit; and 3) The total airborne exposure at the nearest business is 0.015 mrem/year, which is well below the 10 mrem/year NESHAPs limit.

In August 1993, the Environmental Assessment (EA) for Shutdown and Removal (S&R) activities of the Tokamak Fusion Test Reactor (TFTR) and the operation of the Tokamak Physics Experiment (TPX) was submitted to DOE for its review. Comments on the Environmental Assessment were received from DOE Headquarters in December 1993, and changes were incorporated into the EA.

The EA was submitted to the NJ Department of Environmental Protection and Energy (NJDEPE) for its review in March 1994. A Finding of No Significant Impact (FONSI) for this environmental assessment is expected to be issued by the end of CY94.

The draft New Jersey Pollutant Discharge Elimination System (NJPDES) surface water discharge permit was reviewed by PPPL and DOE, and comments were submitted to the NJDEPE in November 1993. Two additional discharge numbers (DSN) were included in the new permit: DSN002—storm water discharge for the west side of C site, which does not flow to the detention basin, and DSN003—filter back wash discharge from the Delaware & Raritan Canal pump house pump. Also, PPPL is required to conduct chronic toxicity testing for DSN001—detention basin discharge. The new permit became effective on March 1, 1994.

Because the 72-acre area of PPPL includes about 11 acres of wetlands, the wetlands delineation was critical for any future development of the site. In 1993 a formal study and the delineation of the wetlands by NJDEPE were completed. The majority of wetlands found at PPPL were designated wetlands of intermediate value, which requires a 50-foot transition area at the wetlands boundary. Wetlands of ordinary value are basically storm water drainage swales, which have no transition area requirements. The 500- and 100-year floodplain delineations were also completed, and a map was drawn to present the wetland boundaries and the floodplain elevations.

PPPL continued its ground water assessment program on 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 contamination of low levels of volatile organic compounds (most probably from solvents) in three locations on-site. In February 1993, NJDEPE Bureau of State Case Management's memorandum of understanding (MOU), *i.e.*, a voluntary agreement, was signed by Princeton University. The final MOU obligates the University to investigate the James Forrestal Campus; PPPL and DOE prepared a draft work plan for a remedial investigation and remedial alternative assessment for C and D sites, which was submitted to NJDEPE for its approval. As of September 1994, NJDEP is reviewing the latest revision of the work plan, which includes ground water sampling, soil sampling, and water quality analyses for PPPL's ground water sumps.

PPPL has emphasized environment, safety, and health (ES&H) in accordance with DOE requirements at all of its facilities. The expectations are that the Laboratory will excel in ES&H as it has demonstrated in its fusion research program. The efforts are geared not only to fully comply with applicable local, state, and federal regulations, but also to achieve a level of excellence that includes state-of-the-art monitoring and best management practices.

2.0 INTRODUCTION

2.1 General

This report gives the results of the environmental activities and monitoring programs at the Princeton Plasma Physics Laboratory (PPPL) for CY93. 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, as well as environmental initiatives, assessments, and programs that were undertaken in 1993. The objective of the Annual Site Environmental Report is to document evidence that DOE facility environmental protection programs adequately protect the environment and the public health.

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 alternate energy source. In 1993, PPPL had both of its two large tokamak devices in operation; the Tokamak Fusion Test Reactor (TFTR) and the Princeton Beta Experiment-Modification (PBX-M). PBX-M completed its modifications and upgrades and resumed operation in November 1991. TFTR began the deuterium-tritium (D-T) experiments in December 1993 and set new records by producing over six million watts of energy. The engineering design phase of the Tokamak Physics Experiment (TPX), which replaced the cancelled Burning Plasma Experiment in 1992 as PPPL's next machine, began in 1993 with the planned start up set for the year 2001. In 1993, the Environmental Assessment (EA) for the TFTR Shutdown and Removal (S&R) and TPX was prepared for submittal to the regulatory agencies.

The Princeton Beta Experiment (PBX), the predecessor of PBX-M, after achieving a ratio of plasma pressure to magnetic pressure in excess of 5% in CY84 experiments, was shut down at the end of 1985 to undergo modifications permitting further examination of theoretical predictions on plasma shaping and stabilization of kink modes by means of a close-fitting conducting wall. The addition of new coils and stabilizer plates within the vessel, new power supplies, and a new control system began in 1986. The modified device, PBX-M (Fig. 1), came back into operation in October 1987. In CY88, an indentation of the plasma of 25% was achieved, an increased tokamak safety factor was obtained as measured by lower q(a) values, and high plasma stability or H-modes at lower power was attained. In CY89, the effectiveness of the passive plates in stabilizing kink modes and access to higher plasma pressure (Beta ~ 6.8%) were assessed. A Safety Assessment Document (SAD) was published for the PBX in 1984 [Fl84], which indicated that the PBX did not pose any potential environmental concerns. A new SAD published for the PBX-M in 1988 reached the same conclusion [St88a]. A third SAD was approved prior to the start-up of the upgraded PBX-M in FY91 [SAD91].

The TFTR is a toroidal magnetic fusion energy research device in which a deuterium-tritium (D-T) plasma is magnetically confined and heated to extremely high temperatures by neutral-beam injectors and radio-frequency waves. TFTR began its first full year of operation in CY83. During a seven-year period of deuterium-deuterium (D-D) operations, TFTR (Fig. 2) produced its greatest number of D-D neutrons in 1990 . The highest total neutron produced in one year occurred in 1993 with a total of 2.37×10^{19} neutrons produced from D-D and D-T operations.

TFTR Neutron Production 1987-1993

Year	*Total Neutron Production*	*Reference*
1987	3×10^{18}	He88
1988	9.04×10^{18}	He89
1989	6.4×10^{18}	Ja90a
1990	2.3×10^{19}	Ja90b
1991	1.56×10^{18}	Ja92
1992	1.53×10^{19}	Ja93
1993 (D-D)	7.2×10^{18}	Ja94
1993 (D-T)	1.65×10^{19}	Ja94

The higher neutron production has caused an increased activation level of the TFTR to the point where health physics surveys are mandatory in the TFTR test cell following an operations period and before any personnel entry is permitted for inspection, routine maintenance, or installation work. In addition, tritium from D-D reactions—which was absorbed in graphite and measured during the opening of the vessel in 1987, 1988, 1990, 1991, and 1992—posed the first known health physics contamination challenges for any tokamak operations. The experience gained from the 1987 opening was beneficial for the similar openings in 1988-89 and has helped to streamline operations for the 1990-91 and 1991-1992 openings.

A major achievement in 1986 was an increase in neutron production and fusion power by operating in what is now called the "supershot" pulse mode. Using this technique, a new record temperature of greater than 400 million degrees Celsius was achieved. Ion Cyclotron Radio Frequency (ICRF) heating became operational in 1988. The D-T operations were scheduled to begin in 1990; however, reprogramming and a budget cut announced in November 1988 resulted in a schedule delay so that D-T experiments began in December 1993. A small amount of tritium (<1000 Ci) was brought on-site in April 1993 to use in the testing of the TFTR tritium storage and cleanup systems. The safety analyses completed for this program are addressed in Safety Analysis Reports for the Project [PSAR78 and FSAR82]. In 1988, the Final Safety Analysis Report (FSAR) was being

updated to reflect operational requirements and parameters using tritium. This effort was initiated again in FY91 and was completed in 1993 [FSAR93].

Although PPPL operates C site as an unfenced site, with access controls for security purposes, it is considered to be open to the public for environmental as well as educational purposes. The D site is entirely fenced, with access controls that do not allow free access to the TFTR. This free access of C site has necessitated a thorough evaluation of the on-site discharges, as well as the potential for off-site releases of radioactive and toxic non-radioactive effluents. An extensive monitoring program, which is tailored to these needs, has been instituted and expanded over recent years. The PPPL radiological environmental monitoring program generally follows the guidance given in two DOE reports; A Guide for: Environmental Radiological Surveillance at U.S. Department of Energy Installations [Co81] and Environmental Dose Assessment Methods for Normal Operations at DOE Nuclear Sites (PNL-4410) [St82].

In the environmental monitoring program document is the requirement for adherence to the standards given in DOE Orders, in particular, DOE Order 5400.5, "Radiation Protection of the Public and the Environment" [DOE93a], which pertains to permissible dose equivalents and concentration guides and gives guidance on maintaining exposures "to as low as reasonably achievable" (ALARA). On January 1, 1990, DOE Order 5480.11, "Radiation Protection for Occupational Workers," guidelines became effective [DOE89]. While this order did not have a major impact on PPPL operations, the order did incorporate some changes in personnel monitoring requirements. DOE Order 5400.1, "General Environmental Protection Program" [DOE90], requires an environmental monitoring plan that contains meteorological, air, water, ground water, and radiological plans for PPPL [PPPL92]. This plan was completed in CY91, revised in CY92, and reviewed in CY93. Specific criteria for implementing these standards on TFTR are contained in the TFTR Technical Safety Requirements document (OPR-R-23). These criteria are shown in Table 1.

An environmental survey was conducted in June 1988 by Department of Energy Headquarters representatives (DOE-HQ) as part of an intensive evaluation at all DOE sites. No significant environmental concerns surfaced at PPPL as a result of this audit. An oil spill in 1988 by an outside vendor led to a project of incorporating the cleanup with the removal of five underground storage tanks (USTs) and the replacement of those tanks with above ground tanks. In addition, groundwater contamination became a concern, and a Petrex® soil gas survey was accomplished over the entire site in the spring of 1990 [Ne90]. A groundwater assessment program was prompted by the results of the soil gas survey, the UST issue, and New Jersey Pollutant Discharge and Elimination System (NJPDES) ground water discharge permit requirements; the results of this assessment program are discussed in detail in this report.

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. During D-T, external exposure from airborne radionuclides, such as ^{41}argon (^{41}Ar), ^{13}nitrogen (^{13}N), ^{16}nitrogen (^{16}N), and internal exposure from radionuclides, such as tritium (^{3}H) in air and water, are being monitored. Six major critical pathways are considered as appropriate (see Table 2). Prompt radiation, *i.e.*, that which is emitted immediately during operations, was also considered and is measured. The monitoring program, as envisioned by the TFTR Final Safety Analysis Report [FSAR82], was updated to reflect the current environment around TFTR (see Table 3). A tritium monitor was installed on the TFTR stack in late 1990. Approximately 30.3 Ci (1.1TBq) of tritium were released from the TFTR stack in 1993. Low-levels of tritium are detectable in pump oils.

Preliminary meteorological considerations and associated methodology, which were established at the time of the installation of PPPL's first meteorological tower, were reported in Section 2 of the TFTR FSAR. Subsequently, improved methodologies were implemented, and a new meteorological tower was erected and began operation in November 1983 (see Figs. 15-18 for comparison 1984 *versus* 1994 data) [Mc83]. The improved measurements and methodologies are included in the updated FSAR prepared for deuterium-tritium operations. Data were collected for eleven years using the monitors on the new tower (Figs. 11, 12, 13, and 14). Wind-rose plots from the data for the nine years (1984-93) are shown in Figs. 8, 9, and 10. A tracer gas-release test was conducted during the period from July to September 1988 to look at site-specific air-diffusion parameters. These tests were commissioned to determine actual site conditions *versus* model predictions in relation to future activities. The test results indicated that actual dispersion and dilution of effluents in the vicinity of PPPL are enhanced by up to a factor of 16 over that predicted by Nuclear Regulatory Commission approved standard Gaussian diffusion models [St89]. Additionally, as a result of these tracer gas-release tests, a 10-m wind speed and wind-direction sensor was added to the meteorological tower in 1990 to monitor PPPL on-site meteorology more precisely. The U.S. Environmental Protection Agency (EPA) was petitioned through the Princeton Area Office (DOE-PAO) to use the more realistic χ/Q values from these tests in the AIRDOS-EPA model used for the National Emission Standards for Hazardous Air Pollutants (NESHAPs) calculations. Approval was received in 1991.

2.2 Description of the Site

The Princeton Plasma Physics Laboratory is located at the C and D sites of the James Forrestal Research Campus of Princeton University (Figs. 4 and 6). As shown in Fig. 3, the location is in central New Jersey within Middlesex County. The site is surrounded by undisturbed areas with forest, open grass areas, corn fields, and a small brook (Bee Brook) running next to its eastern boundary. 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 Fig. 5, the municipalities of Princeton, Plainsboro, Kingston, West Windsor, and Cranbury, among others, are in the immediate vicinity of 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. The general layout of the facilities at the C and D sites of Forrestal Campus is indicated in Fig. 7; the specific location of TFTR is at D site.

A demographic study was completed in CY87 as part of the requirement for 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]. The demographic data were based on the 1980 census and show both estimated and projected data out to the year 2010 (Tables 4 to 13) in a zone from 1 mile out to 50 miles.

The PPPL site is in the center of a highly urbanized region extending from Boston, Massachusetts, to Washington, D.C., and beyond. The previous population projections for the states of New Jersey, New York, and Pennsylvania had indicated a substantial population increase within 50 miles of the PPPL site. The actual change from 1970 to 1980, as indicated by the census in these two years, was not as large as had been expected. In fact, the population in New York City and Philadelphia decreased. The Princeton area continues to experience a substantial increase in new business moving into the Route 1 corridor near the site. This increase, however, has not been as great as the projections had indicated.

3.0 1993 COMPLIANCE SUMMARY

3.1 Environmental Compliance

It is PPPL's goal to be in compliance with all applicable state, federal, and local environmental regulations. As a result of PPPL's self-assessments, DOE Chicago audits, and DOE-HQ Tiger Team action plans, PPPL continues actions to enhance its compliance efforts, especially in the area of strict documentation requirements. The status of each applicable environmental statute is listed below:

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

The PPPL is not involved with CERCLA mandated cleanup actions. As a result of the 1991 Tiger Team assessment, an action plan was developed to conduct a more comprehensive documentation for CERCLA inventory of past hazardous substances. The CERCLA inventory was completed in 1993.

In 1993, the CERCLA Inventory report was used in part to develop the work plan for a site investigation. The New Jersey Department of Environmental Protection and Energy (NJDEPE) directed Princeton University to conduct Remedial Investigations (RI) (not a CERCLA required RI) on the James Forrestal Campus (JFC). The Princeton University, DOE, and PPPL are conducting investigations on A/B and C/D sites of the JFC. The NJDEPE cited the presence of volatile organic compounds in ground water samples collected on the JFC and its proximity to potable supply wells (within 0.5 miles) as the requirement for conducting the investigation. At the end of 1993, a draft work plan for the C/D sites investigation was being prepared. The draft work plan was submitted to DEPE in 1994 for their review, comment, and approval prior to its implementation.

3.1.2 Resource Conservation and Recovery Act (RCRA)

The Laboratory is in compliance with all terms and conditions required of a hazardous waste generator. In 1993, PPPL shipped off site approximately 65 tons of waste to facilities permitted to treat, storage, or dispose of hazardous wastes. The five largest sources of waste generated at PPPL were 1) polychlorinated biphenyls (PCBs) contaminated soil removed from the detention basin, 2) purge water collected from ground water monitoring wells, 3) oil spill cleanup materials, 4) waste oil, and 5) batteries containing acid, which were sent to a recycler. [Be94] [PPPL94b]

PPPL is also in compliance with all requirements of the RCRA mandated Underground Storage Tank Program (see 3.1.6 about UST leaks).

3.1.3 National Environmental Policy Act (NEPA)

The Environmental Assessment (EA) for Shutdown and Removal (S&R) of the Tokamak Fusion Test Reactor (TFTR) and the operation of the Tokamak Physics Experiment (TPX) was submitted to DOE for their review in August 1993. Comments on the Environmental Assessment were received from DOE Headquarters in December 1993, and changes were incorporated into the EA. The EA was submitted to the NJ Department of Environmental Protection and Energy (NJDEPE) for their review in March 1994. A Finding of No Significant Impact (FONSI) for this environmental assessment is expected to be issued by the end of CY94.

Approximately 180 PPPL activities received NEPA reviews in 1993, and the vast majority of these were determined to be Categorical Exclusions according to the NEPA regulations and guidelines of the Council on Environmental Quality (CEQ) and DOE.

3.1.4 Clean Air Act (CAA)

The PPPL was in compliance with the requirements of the CAA in 1993. The 1993 Air Emission Survey was sent to NJDEPE who in turn submits the survey to the USEPA. The data are incorporated into a national database, the Aerometric Information Retrieval System (AIRS), and Air Facility Subsystem (AFS) where it will become public information.

As the result of a self-assessment by PPPL, the DOE Tiger Team assessment findings, and the Clean Air Act Amendments (CAAA) of 1990, preparation of a detailed air emission inventory was completed in May 1993. The purpose of the inventory is to estimate significant air emissions from all sources so that a manageable air control program can be established. The inventory includes air emission quantities, point and fugitive emission sources, air-producing activities, and permit applicability. The air emission inventory is updated on an annual basis and is currently under revision to reflect the NJDEPE PPPL 1993 Air Emission Statement.

The NJDEPE conducted a facility inspection on November 15, 1993. No violations were found during the inspection. During a January 12, 1994, NJDEPE inspection, PPPL and DOE were issued a Notice of Violation (NOV) for the operation of two permitted oil-fired boilers with natural gas. The PPPL and DOE had not previously prepared and submitted amendments for the installation and operation of these boilers to burn both oil and natural gas. Amendments for boilers 2, 4, and 5 were prepared and submitted to DEPE; permits were revised and reissued.

The Coil Assembly and Storage (CAS) building dust collector permit was issued by the NJDEPE on March 10, 1993. The Shop and Facilities Engineering Division (FED) dust collector permits

were issued by NJDEPE on July 23, 1993. The NJDEPE approved an amendment on March 3, 1993, to change the oil tank vent certificate from No. 6 oil to No. 4 oil. The difference between No. 6 and No. 4 fuel oil is primarily that No. 4 is refined to remove more impurities. Therefore, the amount of air contaminants emitted from the boilers is reduced, because the boilers burn cleaner.

The PPPL and DOE submitted to the NJDEPE permit applications for two above ground storage tank vents on September 27, 1993. On October 25, 1993, NJDEPE gave their permission to construct, install, or alter control apparatus of equipment for the 25,000 gallon above ground tank vents. The air certificate to operate this tank was issued by NJDEPE and received by DOE in March 1994. The PPPL and DOE have requested NJDEPE to send the second permit for the 15,000 gallon above ground storage tank.

The PPPL is currently complying with the Stratospheric Ozone Protection Program of the Clean Air Act. More specifically, PPPL currently complies with Section 608 of the Act, which prohibits the venting of ozone-depleting substances through the use of certified refrigerant recovery units. In addition, PPPL safely disposes of equipment containing ozone-depleting substances by removing the refrigerant to specified levels before disposal of the equipment.

3.1.5 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

The PPPL has added a stack sampler to the Tokamak Fusion Test Reactor (TFTR) facility for tritium releases, which has been independently verified as meeting National Emission Standard for Hazardous Air Pollutants (NESHAPs) radionuclide emission monitoring requirements. Releases of low levels of tritium may occur during TFTR tritium operations. The PPPL received EPA's concurrence on this determination in August 1993. In 1993 the effective dose equivalent to a person at the business nearest PPPL, due to radionuclide air emissions, was less than the NESHAPs standard of 10 mrem/yr. During their inspection of PPPL facilities in March 1993, representatives from EPA Region II indicated that PPPL was in compliance with NESHAPs requirements.

3.1.6 Clean Water Act (CWA)

The PPPL is in compliance with all 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 monitoring reports are submitted for the underground storage tank monitoring program as required by the NJDEPE (see Section 6.1.2 D).

3.1.7 National Pollutant Discharge Elimination System (NPDES)

During 1993, PPPL continued to operate under the conditions of expired New Jersey Pollutant Discharge Elimination System (NJPDES) surface water discharge permit (NJ0023922). The NJDEPE issued a Public Notice for the renewal of the PPPL surface water permit on October 27, 1993. PPPL and DOE submitted comments on the draft permit to the NJDEPE on November 26, 1993. The NJDEPE issued the renewed surface water permit on January 21, 1994, with an effective date of March 1, 1994 [DEP94]. The NJPDES surface water permit will expire on February 28, 1999.

In November 1993, one non-compliance was reported for an exceedance of the total suspended solid limit (TSS) (73 mg/l *versus* 50 mg/l limit) at D2 (see Table 26). After an investigation into the probable cause for the non-compliance, it was determined that the TSS level was elevated by 1) soil disturbance in the detention basin caused by excavating contaminated soils during the first week of November 1993 and/or 2) drainage of the basin prior to the sampling of D2, which would provide less time for solids to settle in the basin. The detention basin upgrades and revised sampling protocols were implemented as corrective action measures to prevent possible future TSS non-compliances.

As required in the ground water discharge permit (NJ0086029), the inflows to the detention basin are sampled twice annually, in May and August. The permit conditions list parameters and associated standards, which are not *per se* permit limits. The parameter standards are considered guidelines to be used for the purpose of comparison with the reported data. In August 1993 (see Table 37), detectable levels of tetrachloroethene were measured at both inflows 1 and 2; detectable levels of chloroform and bromodichloromethane were measured at inflow 1. Based on the NJDEPE's interpretation, no non-compliances occurred. The probable causes of these detections were cited as : 1) chlorinated canal water used in the cooling towers may have combined with organic compounds to form the routine chloroform and bromodichloromethane and/or 2) levels of the detected volatile organic compounds were also present in various ground water samples collected during August 1993.

Following the issuance of storm water regulations in 1991, PPPL and DOE/PAO requested NJDEPE to review the site's storm water runoff that does not drain to the detention basin. In addition, PPPL and DOE/PAO asked NJDEPE about the filter backwash discharge at the Delaware & Raritan Canal pump house as a possible new discharge point. As a result of these inquiries, NJDEPE directed DOE/PAO to submit a NJPDES application for these discharge points. In March 1992, the application was submitted. These two locations were incorporated in the renewed permit, effective March 1, 1994, and designated as monthly sampling points.

A Treatment Works Approval (TWA) application was submitted to the NJDEPE for several projects: 1) Detention Basin Upgrade, 2) installation of a septic holding tank at the Calibration and Services Laboratory (CASL), and 3) permitting of the existing liquid effluent collection tanks (LEC).

The TWA for upgrade of the detention basin was submitted to NJDEPE, Bureau of Industrial Discharge Permits, in August 1992 and was approved and became effective in February 1993. The project will include the installation of an impermeable liner and under drainage system for the detention basin, the construction of upgrades to the outfall of the detention basin, the re-routing of the storm drainage from the warehouse spill containment system and the southeast quadrant switchyard, and upgrading of the oil detection system at C site. The PPPL will comply with the twelve general conditions and seventeen specific provisions of the TWA permit. The permit expires on February 25, 1995.

The TWA for the septic holding tank at the CASL was submitted to the NJDEPE in June 1992. In addition, the Stony Brook Regional Sewerage Authority (SBRSA) and Plainsboro and South Brunswick Townships received the TWA, specifically for their review and endorsements. Approval of the TWA is currently awaiting endorsements and approvals by Plainsboro and South Brunswick Townships and SBRSA.

The TWA for the liquid effluent collection (LEC) tanks was submitted to the NJDEPE in October 1992. However, NJDEPE informed PPPL in October 1992 that NJDEPE does not require a TWA due to the exemption status of these tanks, based on their installation date. Wastewater collection tank systems installed before 1988 are not regulated under the TWA program. The NJDEPE informed PPPL that SBRSA will require a significant industrial user (SIU) review. Presently, PPPL is awaiting endorsements and approvals from Plainsboro and South Brunswick Townships and SBRSA.

Under the CWA and New Jersey Discharge of Petroleum and Hazardous Substances regulation (New Jersey Administrative Code Title 7, Chapter 1E), PPPL reported five releases of petroleum, petroleum products, or hazardous substances to the NJDEPE in CY 1993. Of these five releases, four releases impacted permeable surfaces (gravel and soil) and involved minor amounts of petroleum products or hazardous substances; ethylene glycol (0.5 gallon), polychlorinated biphenyls (PCBs) (167 ppm), diesel fuel oil (estimated between 2 and 10 gallons), and hydraulic oil (0.5 to 1 pint). The fifth release was a discharge of Freon® 113 to the atmosphere. It is estimated that 655 pounds of Freon® 113 were released to the interior of the Neutral Beam Power Conversion (NBPC) building on D site and eventually to the ambient air outside the building. In

addition to notifying the NJDEPE Bureau of Discharge Prevention, the NJDEPE Air Enforcement Program—Central Regional Office was also notified of the discharge.

During 1992, the SBRSA required PPPL to submit to the SBRSA a pretreatment application and sanitary sewer survey. SBRSA issued its proposed Service Rule Revisions in early 1993. Under these rule revisions, SBRSA is requiring PPPL to comply with permit requirements for a pretreatment program. On December 28, 1993, PPPL and DOE/PAO received the SBRSA Industrial Discharge Permit (22-93-NC). Prior to the permit's effective date, February 15, 1994, PPPL and DOE/PAO submitted comments to SBRSA. The PPPL and DOE/PAO requested clarification on effluent limitations and sampling location(s) as stated in the draft Industrial Discharge Permit.

Amendments to state laws, specifically the New Jersey Water Pollution Control Act and the Clean Water Enforcement Act, have expanded the enforcement authority of local publicly-owned treatment works (POTWs). Through regulations and the monitoring of user facilities, POTWs *(i.e.,* SBRSA), can ensure compliance with the facilities' effluent discharges that are regulated under not only the Clean Water Act, but also under CERCLA, RCRA, and CAA regulations.

3.1.8 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 tests incoming water. In addition, periodic testing for potential problems within the on-site drinking water distribution system is undertaken.

On a quarterly frequency, PPPL inspects and tests the back flow prevention equipment, which prevents contamination of the potable water supply via a large cross-connection. In the presence of a representative from the Middlesex County Health Department (MCHD), each quarter the system is inspected at the point where Elizabethtown Water enters C site. On an annual basis, this system is totally disassembled, inspected, and tested in the presence of both MCHD and the Elizabethtown Water Company representatives. In order to maintain an uncontaminated potable water supply, other cross-connection equipment is tested on a routine basis.

3.1.9 Superfund Amendments and Reauthorization Act (SARA) Title III.

Presently, under the requirements for SARA Title III, PPPL submits an annual inventory to be in compliance with CERCLA. This inventory reports the quantities of chemicals listed on the CERCLA regulations that are stored on site. 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 SARA Title III, PPPL provides to the applicable emergency response agencies: 1) an inventory of hazardous substances stored on the site; 2) Materials 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) to applicable emergency response agencies. The table below lists hazardous compounds at PPPL, reported under SARA Title III for 1993 [PPPL94a].

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 NJDEPE administers the SARA Title III reporting for EPA and has modified the Tier I form to include SARA Title III reporting requirements and NJDEPE reporting requirements.

Hazard Class of Chemicals at PPPL

Compound	Fire	Sudden Release of Pressure	Reactive	Acute Health Hazard	Chronic Health Hazard
Bromotrifluoromethane		✔		✔	
Carbon dioxide		✔		✔	
Chlorodifluoromethane		✔		✔	
Dichlorodifluoromethane (CFC 12)		✔		✔	
Fuel Oil	✔				
Gasoline	✔				✔
Helium		✔			
Nitrogen		✔			
Petroleum Oil	✔				
Polychlorinated Biphenyls					✔
Sulfur Hexafluoride		✔			
Sulfuric acid			✔	✔	
Trichlorotrifluoroethane (CFC 113)				✔	

Federal Agency Hazardous Waste Compliance Docket

In the February 5, 1993, *Federal Register* [FR93], the U.S. Environmental Protection Agency (USEPA) published its new and/or revised list of facilities on the Federal Agency Hazardous Waste Compliance Docket. Princeton Plasma Physics Laboratory (PPPL) was listed on the docket for the first time, due to its being a hazardous waste generator and because all federal facilities must be listed. A meeting between DOE and EPA Region II in March 1993 resulted in the DOE's submission of additional sampling data and pertinent information about PPPL [DOE93c]. In a letter to DOE, USEPA stated "...that as a docket facility, your site must be evaluated by EPA for the National Priorities List (NPL) utilizing the Hazard Ranking System (HRS)" [EPA93]. No further correspondence from USEPA has been received regarding PPPL's status.

3.1.10 Toxic Substance Control Act (TSCA)

The PPPL is in compliance with all 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 be implemented. The last PPPL polychlorinated biphenyls (PCBs) transformers were removed from the site in 1990. The 661 PCB-regulated capacitors remaining on-site at the end of 1993, are located in buildings with concrete floors and are thus protected from the weather. There are not plans at this time to remove and/or replace these capacitors.

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

The use of herbicides, pesticides, and fertilizers is done by using certified subcontractors who meet all the requirements of FIFRA. The PPPL Facilities Engineering Division (FED) monitors this subcontract.

3.1.12 Endangered Species Act (ESA)

The PPPL occupies 72 acres of the Forrestal Campus of Princeton University. In 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 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]

In the fourth quarter of 1992 and in the first quarter of 1993, the NJDEPE, Division of Parks and Forestry, Natural Heritage Data Base [Dy92], 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.

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"

The PPPL is in compliance with the EO 11988, "Floodplain Management." As a result of the Tiger Team assessment, it was suggested that the PPPL Hazardous Materials Storage Facility (HMSF) may be within the 500-year floodplain and therefore, unprotected from a 500-year storm event. Plans for upgrades to the HMSF are in progress. Having received NJDEPE and NEPA approvals, the construction of structures to protect the facility against a 500-year flood will begin in the spring of 1994.

Delineation of the 500-year floodplain and the 100-year floodplain was completed in February 1994. The 500-year and the 100-year flood plains are located at the 85-foot elevation and at the 80-foot elevation above mean sea level, respectively [NJDEPE84] (see Fig. 48).

A Stream Encroachment Permit application is required for construction within the flood hazard area and the 100-year floodplain as regulated in NJAC 7:13 *et seq.* An application was filed with the NJDEPE in August 1992 for the detention basin upgrade project, specifically, for the modifications to the discharge area. The permit was approved and became effective in November 1992 and remains in effect until November 23, 1997. The detention basin upgrade project, which includes the replacement of an existing headwall for the discharge of the detention basin, is scheduled to begin in the late summer of 1994.

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

The PPPL is in compliance with the EO 11990, "Protection of Wetlands." Formal study and delineation of the wetland boundaries within the PPPL 72-acre site are complete. Using infrared film for aerial photographs, the presence of wetland-type vegetation was found on the north and eastern boundaries of the Laboratory property. In July 1993, an "Application for a Letter of Interpretation" (LOI) for the entire 72-acre site was filed with the NJDEPE Land Use Regulation

Program. The LOI application included: US Geological Survey (USGS) topographic maps, National Wetlands Inventory maps, US Department of Agriculture (USDA) Soil Conservation maps, aerial photographs, and vegetation maps. These maps were used to prepare the delineation program and the target critical areas.

The wetland boundaries were flagged based on an analysis of the 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 wetlands delineation map that indicated the boundary, sequential flag numbers, and soil boring locations was prepared (see Fig. 48).

On December 2, 1993, NJDEPE conducted an on-site inspection to verify the wetlands boundaries, which were proposed in the LOI application. In a letter dated January 13, 1994, PPPL and DOE/PAO received formal notification from NJDEPE that the wetlands boundary lines were determined to be accurate as shown in the LOI wetlands delineation plan. In addition, the NJDEPE determined that the wetlands on the PPPL site are of "intermediate resource value" and that the standard transition area of buffer zone required to be adjacent to the wetlands is 50 feet. The exception to the 50-foot transition area and "intermediate resource value" determination is the area of C site to the west and southwest—the swales that convey storm water to the wetlands south of C site. These areas are classified as wetlands of "ordinary resource value," which have no transition area requirement, *i.e.*, there is no 50-foot transition area required next to the wetlands boundary.

The NJDEPE Land Use Regulation Program continues to be the lead agency for establishing the extent of state and federally regulated wetlands and waters. The US Army Corps of Engineers retains the right to reevaluate and modify the wetlands boundary determinations at any time.

A Statewide General Freshwater Wetlands Permit (GP 11) application was filed with the NJDEPE Land Use Regulation Program in August 1992 for the detention basin upgrade project. In July 1993, the GP 11 was approved for the construction of stormwater outfall structures and associated stormwater conveyance structures such as pipes, headwalls, rip rap, and other energy dissipation structures.

In September 1993, PPPL began the preparation of a Statewide General Freshwater Wetlands Permit (GP 1, 2, or 7) and a Transition Area Waiver application for the fire protection improvements to the Hazardous Materials Storage Facility (HMSF), the HMSF upgrade, and 26 kV line equipment and property maintenance projects. The application was submitted to NJDEPE on January 31, 1994. Approval of the application by the NJDEPE was received during the second quarter of CY94.

3.2 Current Issues and Actions

The longest, unresolved, compliance issue is the request for an adjudicatory hearing by DOE for the New Jersey Pollutant Discharge and Elimination System (NJPDES Permit No. NJ0086029) discharge to groundwater permit. The DOE protested the requirement that three monitoring wells be placed on A and B sites on the James Forrestal Campus because these locations are off-site and are on property under Princeton University's control. Since 1989, the DOE and PPPL have been waiting for a hearing date notice and have, under protest, complied with all permit-mandated activities.

The ground water discharge permit expires on December 31, 1994. The renewal application was prepared and included a report on ground water quality based on the quarterly ground water samples collected since December 1989 [Fi94]. In this application, the DOE requested that NJDEPE delete the three off-site wells from the NJPDES ground water permit.

Prior to moving to C site in 1959, PPPL occupied several locations on A and B sites since its beginning in 1951 and currently continues to occupy office space there. The A and B sites obtained their designation from the early "A" and "B" stellarators built by PPPL. Princeton University is the landowner of the approximate 300-acre James Forrestal Campus, of which DOE currently leases 72 acres, which is referred to as C and D sites. C site is named for the "C" stellarator, and D site is the location of the TFTR.

Since 1986, Princeton University has performed ground water investigations on the James Forrestal Campus, A and B sites. The PPPL and DOE/PAO have been involved in similar studies on C and D sites under the direction of NJDEPE, Bureau of Groundwater Protection since 1990. Following a review of reports, which documented the presence of volatile organic compounds (VOCs) in the ground water at James Forrestal Campus, the NJDEPE's Bureau of State Case Management, Division of Site Remediation, notified PPPL and DOE that they were drafting an Administrative Consent Order (ACO).

In early 1992, counsel for Princeton University, PPPL, and DOE met with representatives of the Bureau of State Case Management to discuss the draft ACO. Instead of an ACO, a Memorandum of Understanding (MOU) was proposed. The MOU is an agreement whereby a site is investigated and a remedial solution is proposed. In March 1992, Princeton University received a draft MOU, which stated that the VOC contamination present on the Forrestal Campus was contributing to the presence of VOCs in drinking water wells in the near vicinity (<1/2 mile downgradient from the property boundary). The final MOU for the remediation of the James Forrestal Campus was signed by Princeton University and the NJDEPE on February 5, 1993.

Within the MOU, C and D sites are separate from A and B sites and follow a different schedule due to the extended budget-approval process that DOE requires for its environmental restoration projects. Presently , the NJDEPE is reviewing all previously submitted documents. On March 21, 1994, NJDEPE, Princeton University, PPPL and DOE/PAO met to discuss the Proposed Work Plan for conducting a Remedial Investigation/Remedial Alternative Assessment (RI/RAA) at C/D sites. After review and approval of this work plan, the RI/RAA activities will commence during CY94. Following the approval of the RI/RAA results, PPPL and DOE/PAO will begin the approved remedial action, if needed.

The 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. Of these findings, 38 were related to requirements of DOE Orders, federal or state regulations, or PPPL directives or procedures. Sixteen of the findings were related to best-management practices. In addition, there were 166 safety and health concerns and 26 management concerns. 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, 85 percent have been completed as of March 1994.

From August 30 to September 3, 1993, DOE-CH, Chicago Operations Office, Environment, Safety, and Health Branch, conducted their PPPL Environmental Protection Appraisal. The DOE-CH's appraisal resulted in two findings and ten recommendations. The two findings were: 1) improper classification of a radioactive waste, *i.e.*, whether this waste is also considered a hazardous waste under RCRA regulations, 40 CFR 262.11, and 2) the apparent non-compliance with the New Jersey Administrative Code (NJAC) Title 7, Chapter 9-6.7 (c), "Groundwater Quality Criteria for Class II-A," as listed in Table 1 of the Code for volatile organics compounds in ground water. The ten recommendations largely pertained to procedures and best management practices, which were or are being implemented.

The first finding involved the analysis of tritiated vacuum pump oil for hazardous constituents. The toxic characteristic leaching procedure (TCLP) method for determining the waste hazard classification was performed on the pump oil, and the results indicated levels below the regulated maximum concentration levels for all except mercury (0.2 mg/l), which classifies it as a hazardous waste. Further investigation into the methodology revealed that the test for mercury can produce false positive results. To determine the presence or absence of mercury, a total mercury analysis was performed. The results showed that the oil does not contain mercury. Therefore, the tritiated pump oil is classified as non-hazardous, radioactive waste.

The second finding refers to the detection of low levels of volatile organic compounds in ground water samples. As previously stated above, C and D sites are included in the MOU between the NJDEPE and Princeton University, which requires a Remedial Investigation/Remedial Alternative Assessment (RI/RAA) to be conducted.

The PPPL completed the identification of wastewater streams into the Stony Brook Regional Sewerage Authority (SBRSA) system. A site sanitary survey was completed in 1993 and is currently being updated. It is estimated that approximately 3 percent of the combined sewerage flow from PPPL is classified as industrial wastewater and 97 percent as domestic wastewater.

On May 6, 1993, representatives from the SBRSA and NJDEPE conducted a site inspection of both C and D sites. The purpose of the inspection was to familiarize both groups with activities performed at PPPL and to fulfill the site audit requirements for facilities in the pretreatment permit program under the NJDEPE Pretreatment Program. As a result of the SBRSA and NJDEPE site inspection, PPPL submitted a pretreatment application and the PPPL Site Sanitary Sewer Survey to SBRSA in late 1992. In December 1993, SBRSA issued a draft industrial discharge permit to PPPL, which has not been issued as a final permit. The permit will require PPPL to sample sewerage outfalls and the liquid effluent collection tanks and report the data to SBRSA on an annual and monthly basis, respectively.

Title VI, "Stratospheric Ozone Protection," of the Clean Air Act Amendments (CAAA) of 1990 mandates the recovery of substances that deplete ozone in the upper atmosphere. Under Section 608, "National Recycling and Emission Reduction Program," class I or II substances cannot be knowingly vented to the environment, and prevention of this release is through the use of certified recovery units. The PPPL uses and maintains four recovery units for maintenance, service, and repair of appliances containing ozone-depleting substances. In addition, PPPL recovery units meet specifications of the CAAA for refrigerant recovery prior to appliance disposal. As required, PPPL and the DOE notified the EPA in August 1993 and January 1994, that PPPL possesses and uses certified recovery equipment that meets the standards of the recovery equipment for disposal of small appliances. The 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.

In the spirit of Section 613 of the CAAA, "Federal Procurement" requirements, and Executive Order 12843, "Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances," PPPL is currently developing and expanding procurement protocols. Review of safe-class I and II substance alternative substitutes, developing terms for the refrigerant recovery

regulations in new contracts, and phasing out the purchases of products containing ozone-depleting substances are in progress, to the extent economically practicable.

Several small, fundamental projects at PPPL that capture the intent of Section 612, "Significant New Alternatives Policy Program (SNAP)," are underway. Alternative refrigerants and possible retrofits for large equipment that use ozone-depleting substances are being explored. Proposed activities are planned to be part of PPPL's Waste Minimization and Pollution Prevention program. Currently, PPPL is examining substitute degreasing compounds.

Title I, "Air Pollution Prevention and Control," of the CAAA mandates the control of National Air Ambient Quality Standards (NAAQS) pollutants in non-attainment areas for ozone. Specifically, Middlesex County and its contiguous counties in New Jersey are designated as severe regions for ozone. The NJDEPE adopted a final rule, NJAC 7:27-19, "Control and Prohibition of Air Pollution from Oxides of Nitrogen (NO_X)," on November 15, 1993, which became effective on December 20, 1993.

The PPPL is exempt from the requirements of NJAC 7:27-19, including the submission to the NJDEPE of a facility-specific oxides of nitrogen control plan, despite PPPL being classified as a major source of NO_X emissions. The exemption from this requirement is based on the following, which are the only major sources of NO_X emissions: 1) the emergency diesel generators, which are restricted to run less than 500 hours during 12 consecutive months and do not have the potential to emit greater than 25 tons of NO_X per operating year; and 2) the boilers, which are classified as non-utility boilers.

Title V, "Permits," of the CAAA mandates the use of operating permits, and reporting and record keeping requirements, which will require affected facilities to submit permit applications under state-operated, federally-enforced programs. On March 15, 1993, the NJDEPE adopted the new Emission Statement rule. This rule requires PPPL to submit an annual emission statement to the NJDEPE for specific air contaminants released, at a specific threshold, directly or indirectly to the atmosphere. The PPPL has the potential to emit 25 tons of NO_X per year. In accordance with the newly-adopted volatile organic compound (VOC) definition in 1993, which excludes various ozone-depleting substances and perfluorocarbons, PPPL is no longer required to report emissions from degreasing operations which use Freon® 113. However, PPPL is not exempt from permitting these sources under NJAC 7:27-8, "Permits and Certificates," because ozone-depleting substances are considered by definition, to be air contaminants. These sources will also be included in the PPPL operating permit.

The proposed operating permit program regulations, which were published on September 7, 1993, will become effective in 1995. Due to PPPL's potential to emit 25 tons of NO_X , these regulations

will be applicable. Fugitive emissions point source emissions will be reported to the NJDEPE through the emission statement reporting requirements and the operating permit program. These emission types include volatile organic compounds, carbon monoxide, sulfur dioxide, and lead compounds. When the final regulations are promulgated, PPPL will be required to submit an operating permit application to the NJDEPE, and to the EPA 30 days after the permit is considered administratively complete.

3.3 Environmental Permits

The PPPL Environment, Safety, and Health Division maintains a status list of Environmental permits (see Table 14). A discussion of the environmental permits by the applicable statutes is listed in this table.

3.3.1 Clean Air Act (CAA)

The Laboratory maintains permits for four boiler vent stacks, one fuel oil storage tank vent, one diesel tank vent, two degreaser vents, three dust collectors, two emergency diesel generator exhaust stacks, and two above ground tank vents. All permits for these emissions are current, and all equipment under permit is operated within permit specifications. An air permitting program is presently in place; the PPPL Environment, Safety, and Health (ES&H) procedure, EN-OP-004, is used to implement compliance with the air permit program.

During a December 1993 inspection by NJDEPE, the Facility Engineering Division (FED) boiler room was visited. Originally, the boilers were designed to burn fuel oil only. In the 1980's, natural gas became more readily and economically available, and the boilers were modified to be both oil and gas-fired. Modifications to the permits had not previously been submitted to NJDEPE, but revisions to those permits are currently in progress.

3.3.2 Clean Water Act (CWA)

The Laboratory maintains two permits under the New Jersey Pollution Discharge Elimination System (NJPDES) for discharges to surface water (NJ0023922) and ground water (NJ0086029). The permits are for a detention basin, which discharges to Bee Brook, and for non-point source infiltration of the detention basin waters to ground water. The NJDEPE issued a new expiration date for the ground water discharge permit extending it from March 31, 1994, to December 31, 1994. An adjudicatory hearing had been previously requested for the ground water permit, because several of the permit conditions are contested (see Section 3.2). In the interim, however, the permit is being maintained in full compliance including those conditions being contested in the requested hearing.

In February 1994, PPPL received its renewed surface water permit from the NJDEPE. The surface water permit was modified to include two new discharge points: 1) stormwater flow from the western side of C site that does not drain to the detention basin (DSN002); and 2) the filter back wash discharge at the Delaware & Raritan Canal pump house (DSN003). Also included in the permit conditions are a requirement for chronic toxicity characteristic study (bioassays) and chronic toxicity biomonitoring of the discharge water, a toxicity reduction evaluation, and chlorine-produced oxidant analysis.

In 1993, NJDEPE inspectors audited PPPL's surface water discharges twice. The first DEPE inspection of 1993 occurred on March 1, 1993. The result of that inspection was the issuance of a Notice of Violation (NOV) for a total suspended solids exceedance (140 mg/l versus 50 mg/l limit) in November 1992. No penalty or fines were assessed. The results of a second inspection, which occurred on September 29, 1993 was an acceptable rating by the NJDEPE.

During the NJDEPE's review of the TFTR deuterium-tritium (D-T) Environmental Assessment (EA), an issue regarding the elevation of the temperature in Bee Brook was raised. The New Jersey Surface Water Quality Standards limit the temperature of the discharged water to an increase of 2.8°C (5.0°F) above ambient water temperature at any time. It has been noted that there are times in the winter when the delta t (Δt) (the difference in temperature between the discharged and surface waters) was higher than the 2.8°C limit. A suspected cause of the higher temperature is the ground water pumped to dewater various building foundations. The temperature of groundwater measures a near constant 12.8° C (55°F) all year round, while in the winter the surface water temperatures drop to as low as 0°C (32°F). At present, the estimated amount of groundwater pumped to dewater the TFTR and D site MG buildings is about 80,000 gallons per day. A study was conducted during the winter of 1993-4 to more accurately determine the cause of the temperature exceedances and to reduce the warmer water temperatures occurring during the winter. [AAC94b]

3.3.3 Resource Conservation and Recovery Act (RCRA)

The PPPL maintains EPA Identification Number (NJ1960011152), which identifies its status as a RCRA large quantity generator. The Laboratory is in compliance with all terms and conditions required of a "generator" status. The Laboratory's hazardous waste is generated from various cleaning processes, disposal of chemicals no longer needed, spill cleanup materials and contaminated soils, purge water from monitoring wells, and small miscellaneous waste streams. These wastes are stored at the Hazardous Materials Storage Facility for less than 90 days. Unlike RCRA, waste oil and other waste petroleum products are regulated as hazardous substances under New Jersey regulations, N.J.A.C. 7:26-1.1 *et seq*, "Division of Waste Management Regulations."

In March 1993, the NJDEPE, Bureau of Water and Hazardous Waste Enforcement, arrived on-site to perform an unannounced inspection. The inspectors visited the Hazardous Materials Storage Facility and five satellite accumulation areas located throughout the site. They reviewed the training program and PPPL Waste Minimization Plan. Overall, the NJDEPE inspectors noted that PPPL complied with all the hazardous waste regulations and has a good management program in place.

Mixed and radioactive waste management is the responsibility of the Health Physics Branch of the ES&H Division. Storage of these wastes are confined to the area known as the D site Boneyard, the liquid effluent collection tank area, and within controlled areas of the TFTR building.

The PPPL maintains, and is in compliance with, permits for four USTs in operation on the site. The installation of five above ground storage tanks is scheduled to begin in April 1994. The removal of all the underground storage tanks is scheduled to be completed by the end of FY94. Note that the UST program is a part of RCRA compliance activities.

3.3.4 Miscellaneous Permits

The PPPL maintains permits for medical waste generation (waste generated from the dispensary) as required by the NJDEPE and for the purchase of potable water from the Elizabethtown Water Company. An agreement is in place with the New Jersey Water Authority until the year 2009 to draw water from the Delaware and Raritan canal system for cooling-water needs and fire-fighting capabilities. PPPL is in compliance with all terms and conditions of these permits.

In October 1993, NJDEPE, Bureau of Water Allocation, directed DOE and PPPL to locate a "former supply well" and properly seal it. Records indicated that three wells were drilled on C site in 1958. Two wells, Well 4 and 5, are no longer in use as production wells. However, these wells are monitored for tritium. A third well, referred to as Well #2 in the records, was drilled and abandoned due to caving and therefore, poor water production. The records indicated that the well was located 450 feet east-northeast of Well #4. A remote sensing survey was conducted, using a magnetometer and ground penetrating radar to find the well casing. In the location indicated by the remote sensing survey, a certified well driller dug down to a depth of 11 feet below grade and in a hole the shape of a square, six feet on each side. The well casing was not located and the hole was filled in. A report was prepared and submitted to the NJDEPE on March 11, 1994, on the efforts made by PPPL and DOE to locate and seal the well. No further action is planned unless new information about the well's location is discovered or the well is found during unrelated digging.

4.0 Environmental Program Information

4.1 Summary of Radiological Monitoring Programs

Monitoring for sources of potential radiological exposures is extensive. Real-time prompt gamma/neutron environmental monitoring began on the TFTR site in 1981 to establish baselines prior to machine operation. Four air monitoring stations are located at the TFTR facility boundary, (see Figs. 20, 22, and 24). Neutron monitors and passive tritium monitors were added at these monitoring stations at the end of CY84 and CY87, respectively. One off-site baseline station was established in CY89 to monitor tritium in air for comparison with other off-site stations and with the four stations on D site. Within one km of the TFTR exhaust stack, 6 off-site stations were sited in 1991 and became operational in February 1992. These stations are referred to as remote environmental air monitoring (REAM) stations 1 through 6 (see Figs. 20, 21, and 23). Ten neutron detectors and gamma ionization detectors are part of the TFTR radiological monitoring system (RMS) for TFTR plasma operations: eight (8) at D site facility boundary (TR 1-4) and two (2) northeast (RMS-NE) and southeast (RMS-SE) property lines (Fig. 20).

On-site and off-site radiological water samples are collected at the same locations as the non-radiological water samples: B1, B2, C1, D1, D2, E1, M1, P1, and P2 (see Figs. 20 and 27-35). Biota are also analyzed for tritium in water recovered from these samples (Fig. 36). The tritium content of the biota, and in general, the soil follow the tritium content in the precipitation, which can be highly variable over the year.

The most recent and 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 region 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 detailed population distribution as a function of distance is provided in Tables 7-13.

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 0.018 mrem (0.18 μSv) for CY93 (see Table 15). Detailed person-rem calculations for the surrounding population were not performed because the value would be insignificant in comparison to the approximately 100 mrem (1 mSv) each individual receives from the natural background, exclusive of radon, in New Jersey. However, scaling or the ratio of the actual released amount of tritium *versus* the quantity cited in the EA (500 Ci) multiplied by the calculated dose was performed and indicates a value of 9.9×10^{-1} person rem (0.01 person-Sievert) out to 80 km (see Table 15).

4.2 Summary of Non-radiological Monitoring Program

The non-radiological monitoring program, which included 8 surface water sampling stations (4 off-site and 4 on-site) was established in 1979 (Figs. 19 and 20). Four ground water sampling stations (2 former production wells, W-4 and W-5, and 2 ground water monitoring wells, TW-1 and TW-10) and the potable water supply were added and monitored through November 1989. In November 1989, W-4 and W-5 were deleted from the program, and 7 new ground water monitoring wells were sampled in compliance with the New Jersey Pollutant Discharge Elimination (NJPDES) ground water permit requirements.

In 1993, under the requirements of the NJPDES surface water permit (NJ0023922), PPPL monitored the discharge of the detention basin, location designation discharge number—DSN001 or D2, once per month for temperature, pH, petroleum hydrocarbons, total suspended solids, chemical oxygen demand, and flow. Additional parameters measured are biological oxygen demand, phenols, ammonia-nitrogen, and total dissolved solids. D2 has been sampled monthly since 1984.

In January 1994, the NJPDES surface permit, No. NJ0023922, was renewed and became effective on March 1, 1994. Monthly sampling of two additional discharge points was included: DSN 002—a storm water and emergency fire protection system discharge (Fig. 19) and DSN 003—filter backwash at the Delaware and Raritan Canal pump house discharge (Fig. 20). A chronic toxicity characterization study was also required. The characterization study will establish toxicity concentrations for the detention basin effluent water, which includes chemically-treated boiler and cooling tower blowdown. Based on the study results, the NJDEP will determine the extent of permit limitations, if any, that PPPL will be required to comply with for subsequent routine chronic toxicity monitoring requirements.

For the NJPDES ground water discharge permit, No. NJ0086029, seven ground water monitoring wells were sampled quarterly in 1993 (Figs. 19 and 39). The following table presents the required parameters, wells, frequency, and permit standard. This discharge permit expires on December 31, 1994. A permit renewal application was submitted to the New Jersey Department of Environmental Protection (DEP) in July 1994 [Fi94].

An additional 10 wells were monitored for total petroleum hydrocarbons (TPHs) quarterly and annually in August for volatile organic compounds. The NJDEP required this sampling in order to determine if the ground water is being impacted from the five underground storage tanks removed in 1989. Monthly, seventeen wells were measured for water elevation, and contour maps were prepared for each month and submitted in a quarterly report [RES93a] [RES93b] [AAC94a]. Since

March 1994, this program has expanded to include a total of 30 wells that are measured for water elevation each month.

NJPDES NJ0086029
Ground Water Discharge Standards and Monitoring Requirements for Ground Water Monitoring Wells

	Standards	Feb.	May	Aug.	Nov.
Ammonia-Nitrogen	0.5 mg/l		X	X	X
Base/Neutral Extractable	Method 625			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 (TDS)	500 mg/l	X	X	X	X
Total Organic Carbon (TOC)				X	
Total Organic Halogen (TOH or TOX)				X	
Total Volatile Organics - D-11, D-12, TW-3	Method 624		X	X	
Tritium - D-11, D-12, TW-3				X	

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

In 1993, a work plan was prepared for the remedial investigation required under the Memorandum of Understanding (MOU). The proposed sampling of ground water and soil is contained in the draft work plan, which must receive NJDEPE approval prior to sampling. One round of ground water samples from 34 monitoring wells, 2 former production wells, 2 piezometers, and 6 sumps on C and D sites are proposed; analyses for volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH), pH, and conductance is planned for all ground water samples. Six of the 34 wells were selected for common ion analyses. A confirmatory round of ground water samples is planned if the results exceed the New Jersey Ground Water Quality Standards.

Soil samples are proposed for 7 locations: 1) C site cooling tower and associated reduction pits, 2) former sewage treatment plant sand/sludge drying beds, 3) CAS/RESA buildings, 4) warehouse building, 5) northeast of TFTR and Mockup buildings, 6) Radiological Environmental Monitoring Laboratory (REML), and 7) 138 kV switchyard and OH capacitor yard. The soil samples will be collected by hand auger except at the reduction pits where a hollow stem auger will be used to collect the soil samples. The following table presents the proposed analyses by location:

Proposed Soil Sampling for Site Investigation

Location	No. Samples	Analyses
C site cooling tower/former reduction pits/ background	6/6/6	Chromium - hexavalent and total
Former treatment plan sand/sludge drying beds	5	TPH, PCBs, metals
CAS/RESA buildings	2	VOCs
Warehouse building	2	VOCs
Northeast of TFTR/Mockup buildings	2	VOCs
REML	4	VOCs
138 kV switchyard/OH capacitor yard	2	PCBs

4.3 Environmental Permits

The environmental permits held by DOE/PAO for PPPL are listed in Table 14 and are discussed in Section 3.3, "Environmental Permits," of this report.

4.4 Environmental Impact Statements and Environmental Assessments

No Environmental Impact Statements were prepared in 1993.

In 1993, an Environmental Assessment (EA) was prepared for the Tokamak Fusion Test Reactor Shutdown and Removal (S&R) and the Tokamak Physics Experiment. This document was submitted to the NJDEPE for their review and to DOE/HQ for approval.

4.5 Summary of Significant Environmental Activities at PPPL

4.5.1 TFTR D-T monitoring activities

To support deuterium-tritium (D-T) operations, the radiation monitoring program performed on a routine basis during D-D operations was modified. Extensive supplemental monitoring included a combination of several, supplemental neutron and photon detection systems, Thermoluminescent Dosimeters (TLD), and increased operational health physics support. Through the use of several Pressurized Ionization Chambers (PIC) and portable neutron monitoring devices, the health physics group was able to effectively map the photon and neutron fields present during the high power D-T plasmas.

4.5.2 Waste Minimization Activities and Pollution Prevention Awareness

A Process Waste Assessment procedure was drafted and revised. The computer software for the bar-coding and chemical tracking project was designed and the hardware order placed. The management plan was drafted and is under review by senior laboratory management. TFTR personnel and ES&H Radiological Waste Management Branch are researching ways to reduce the amount of waste generated during TFTR shutdown and removal (formerly decommissioning and decontamination) (S&R) activities. The S&R schedule is not confirmed because it is solely dependent on TFTR D-T operations, which may extend into FY95.

4.5.3 Storm Water Management

PPPL received all the necessary permits for the detention basin liner installation and upgrades in 1993. The detention basin will be lined with a synthetic liner in order to prevent soil contamination from an unexpected release of chemicals, *e.g.*, oil, into the basin. It is a best management practice identified during the 1988 DOE/HQ Environmental Survey. Beneath the liner, a drainage system will be installed to drain the ground water away from the liner, which would cause it to float. Prior to the installation of the drainage system and liner, sediment/soil must be removed from the basin bottom. Sampling of the sediment occurred in June 1993; the results revealed low levels of polychlorinated biphenyls (PCBs) in one of twelve sampling grids. This soil was removed and disposed as PCB-contaminated soil. Since the liner cannot be installed in cool weather, the project was postponed until the summer of 1994.

The inventory of all storm water discharge sources and possible contaminants to storm water was developed. This inventory will serve as the basis for the Storm Water Management Plan, which, when implemented, will serve as a control of PPPL's storm water discharges.

4.5.4 Clean Air Act Amendments (CAAA) — Ozone-Depleting Substance

In addition to meeting the requirements of the CAAA for the prevention of a release of ozone-depleting substances, PPPL is actively seeking environmentally-sound substitutes and is retiring its halon fire suppression systems.

4.5.5 Storage Tanks

In 1993, a closure application for the 6 remaining underground storage tanks (UST) was submitted for DEP approval; approval was received in January 1994. These 6 tanks will be replaced with 6 above ground storage tanks (AGT). Completion of the AGT installations and UST removal is scheduled for the summer of 1994.

5.0 Environmental Radiological Program Information

5.1 Radiological Emissions and Doses

5.1.1 Penetrating Radiation

Operation of the Princeton Beta Experiment-Modification (PBX-M) results in the production of some penetrating radiation (primarily X rays and neutrons). Because the PBX-M has no roof shield, sky-shine radiation (primarily neutron) is seen at the D site Facility Boundary monitoring stations. The shielding installed for the PBX-M machine has kept the total dose equivalents in occupied areas below occupational-exposure guidelines. Sky shine radiation from the neutron production by PBX-M generally adds less than 1 mrem (0.01 mSv) to the D site environs [St91a; St91b]. PBX-M operation was limited in 1993 and thus had no impacts to the environment.

Laboratory policy states that when occupational exposures have the potential to exceed 1,000 mrem/y (10 mSv/y), the appropriate project manager must petition the PPPL Environment, Safety, and Health (ES&H) Executive Board for an exemption. This value is 20% 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 and acceptable.

The design objective for TFTR is to remain less than 10 mrem/y (0.1 mSv/y) above natural background from all sources of radiation at the PPPL site boundary. The TFTR, like other tokamaks, produces bremsstrahlung radiation from the electrons striking internal hardware at the end of a pulse. These X rays, in the range of 0 to 20 MeV, also produce photoneutrons.

Injection of deuterium neutral beams began at TFTR at the end of CY84. With these D-D runs, the neutron fluxes have increased each year as the neutral-beam heating power has increased. Additional shielding was added to the TFTR test cell walls in the middle of CY85. This added shielding has prevented the addition of any significant penetrating radiation to the environs due to TFTR operation. In 1985, the neutron production was on the order of 5×10^{16} for the entire year. This number increased to 2.4×10^{18} in CY86, to 3×10^{18} during a short run year in CY87, and to 9.04×10^{18} in CY88, and because of limited operation (also more plasma transport experiments and less supershots), the number reduced to 6.4×10^{18} in CY89. In 1990, the neutron production was 2.3×10^{19} [Ja90b], and in 1991 because of limited operations the value was 1.56×10^{18} [Ja92]. In 1992, the neutron production increased to 1.53×10^{19} [Ja93] due to increased TFTR

operations. In December 1993, D-T operations commenced. The number of neutrons produced was 7.2×10^{18} and 1.65×10^{19} [JA94] for D-D and for D-T operations, respectively.

The TFTR real-time site boundary monitors are Reuter-Stokes Sentri 1011 pressurized ionization chambers and ^{3}He-moderated neutron detectors. The electronics in the ionization chambers were modified to allow the integration of any prompt radiation resulting from a TFTR machine pulse which may be above natural background. Data are stored and processed using the Central Instrumentation, Control, and Data Acquisition (CICADA) computer system. Four of these monitoring stations are placed at the TFTR facility boundary and two are located at the PPPL property line (see Figs. 19 and 20). In addition, eight ionization chambers of lower sensitivity, paired with neutron monitors, are located nearer the TFTR device (four outside the test cell wall, three in the basement, and one on the roof). These eight detector locations are for personnel safety and are not considered environmental detectors *per se*. However, data collected from them are used to help correlate the environmental measurements. Besides the moderated ^{3}He and fission neutron detectors, Bonner-type-moderated LiI(Eu) detectors were also used for monitoring neutron dose equivalents at various locations throughout the TFTR facility. Monitors are calibrated and traceable to the National Institute of Standards and Technology (NIST).

5.1.2 Sanitary Sewage

Drainage from TFTR 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 gamma emitters. All samples for 1993 showed the effluent concentrations of radionuclides to be within the allowable limits set by New Jersey regulations (1Ci/y) and by DOE Order 5400.5 (2×10^{6} picoCuries/liter).

5.1.3 Radioactive and Mixed Waste

In CY93, low-level radioactive waste and mixed waste were stored on-site, either in the D site Boneyard or within a controlled area of TFTR. Four shipments of low-level radioactive waste were made in 1993. Part of one shipment contained approximately 15 cubic feet of mixed waste—ethanol with tritium—and was sent to Hanford for disposal. SEG received about 34,800 pounds of metals for recycling.

5.1.4 Special Radiation Surveys

A. EG&G Radiation Survey (Flyover)

In August 1980, EG&G Idaho, Inc., under DOE contract, conducted an aerial-radiological survey of PPPL and surrounding areas [St81]. The detection system used consisted of 20 sodium iodide detectors, a multichannel analyzer, and a magnetic-tape recording system. The nominal gamma-ray exposure-rate range observed was 8 to 10 mR/h. Detected radioisotopes were consistent with normal background emitters. Since conditions have not changed at C or D sites since 1980, there is no need at this time to repeat the survey.

B. National Oceanic and Atmospheric Administration (NOAA)

The Air Resources Laboratories Field Research Division (ARLFRD) of the National Oceanic and Atmospheric Administration (NOAA), Idaho Falls, Idaho, conducted atmospheric dispersion studies using tracer gases from July through September 1988. This group specializes in air quality by doing research on the physics of the lower atmosphere with emphasis on the processes contributing to atmospheric transport, dispersion, and deposition and on the development of numerical models using the results of this research. This study is being used to understand and predict human influence on the environment, especially with regard to the atmospheric transport and diffusion of toxic effluents [St89].

The Nuclear Regulatory Commission (NRC) standard-approved Gaussian models, normally used to calculate atmospheric diffusion to support radiological dose assessments, are appropriate for sites in open terrain; therefore, those models underestimate atmospheric dilution for sites like PPPL where potential sources of release are located in the midst of a complex of buildings. These buildings generate mechanical turbulence which increases atmospheric dilution and reduces dose. The field tests conducted by NOAA were performed to obtain a more realistic empirical description of actual atmospheric diffusion at PPPL in relation to TFTR. The results indicate a factor of up to approximately 16 more atmospheric dilution than that calculated by using NRC Gaussian models. The DOE-PAO petitioned EPA to utilize this real-time data for calculations using AIRDOS-EPA, a required code for annual NESHAPs calculations; AIRDOS-EPA is used to calculate the off-site dose equivalent (Table 15). As approved by EPA in 1991, the annual average dilution factor (χ/Q) derived from the NOAA tests was incorporated into the code .

C. Lawrence Livermore National Laboratory (LLNL) Seismic Study

The PPPL Environment, Safety, and Health Division (ES&H) initiated and provided technical direction for a contract with LLNL to perform a seismic hazard analysis for the PPPL site in 1989. This study, which was based on the latest methodology accepted by the NRC for seismic analysis

of Eastern U.S. nuclear power plants, indicated that the earthquake parameters applied to the TFTR project met and exceeded the current applicable DOE requirements [Sa89].

D. DOE Environmental Measurements Laboratory (EML) Radiation Measurements

A radiation measurement survey was accomplished by the EML in 1990. The measurements used high sensitivity instruments and confirmed ES&H Division Health Physics measurements, which indicate that the neutron dose equivalents during operational periods in occupied areas and at the TFTR facility boundary are much less than the original conservative code calculations. The final results were published in 1991 [Ha91].

5.1.5 Airborne Radioactivity

Radioactivation of air and the release of tritium in measurable concentrations (by EPA accepted measurement criteria) have not been expected until TFTR D-T operations. A silica-gel, environmental-tritium monitor was tested in 1986 and was placed in operation during the summer of 1987. With experience gained by a Canadian tritium release modeling experiment and in the field at PPPL, the monitor is now using a molecular sieve in place of silica gel [Gr88b]. In 1993, tritium was detected in TFTR gaseous effluent samples by a differential atmospheric tritium sampler (DATS). Data for 1993 is actual data measured at the EPA NESHAPS approved monitoring point, i.e. the TFTR exhaust stack.

In addition to the radiation monitoring program performed on a routine basis during D-D operations, an extensive supplemental monitoring program was instituted during the D-T plasma physics experiments. A combination of several, supplemental neutron and photon detection systems, Thermoluminescent Dosimeters (TLD), and increased operational health physics support were used. Through the use of several Pressurized Ionization Chambers (PIC) and portable neutron monitoring devices, the health physics group was able to effectively map the photon and neutron fields present during the high power D-T plasmas.

The projected dose equivalent at the nearest business from 16.3 Ci of tritiated water (HTO) and 14 Ci of elemental tritium (HT) and 1.78 Ci of Argon-41 (^{41}Ar) (produced by neutron activation of the test cell air during TFTR experiments) was 0.027 mrem (270 nSv), based on the use of the COMPLY Code [EPA89]. When actual NOAA χ/Q values are used, the calculated values are even smaller, approximately 0.014 mrem (140 nSv) (see Table 15). Installed in 1992, an upgraded stack sampling system provided tritium emissions data for 1993 (Table 17 and Figs. 37 and 38) for any tritium concentrations exceeding the minimal detectable levels of the DATS. Evaluations of proper laminar flow and mixing for acceptable monitoring data have been completed and the stack sampling system has been accepted by EPA for use in complying with NESHAPS. Measurements at the TFTR fence line have shown ambient levels in the range of 1 to 100 pCi/m^3 of elemental and

oxide tritium concentrations (Figs. 22 and 24). Measurements from the off-site monitoring stations are shown in Figs. 21 and 23, "Air Tritium (HT)" and "Air Tritium (HTO)," respectively. These measurements were made with the DATS [Gr88b]. ^{41}Ar is a potential air activation product from neutrons produced from D-D and D-T reactions. Its maximum production in 1993 was 1.78 Ci (65.9 GBq), with an estimated dose equivalent at the nearest off-site business of 0.002 mrem (20 nSv) using NOAA χ/Q data (see Table 15).

In November 1983, a three-level, 60-meter tower was installed for gathering meteorological data. Data have been collected and recorded for nine years. The wind-rose data for the first six years of tower operation are shown in Figs. 8, 9, and 10. Analysis indicates that the site is dominated by neutral to moderately stable conditions, with moderately unstable to extremely unstable conditions occurring less than a few percent of the time. Average surface winds are about 2.1 m/s and rise to about 4.1 m/s at 60 m [Ko86a]. Based on data from this tower and NOAA tracer-gas, release modeling, as well as effluent concentrations measured at the TFTR stack, real time dose projections will be made during the D-T operations phase to ensure compliance with applicable regulatory requirements.

5.2 Unplanned Releases

While executing the removal of pump oil from a pump in a tritium storage and delivery system (TSDS) glove box under the direction of TFTR procedure (NG-TGS-21), air from the vacuum pump cart pump exhausted to a portable ventilation duct, which released it to the TFTR exhaust stack. The high tritium alarm was set off by this release, causing the HVAC dampers for the tritium vault to automatically shut and the tritium vault cleanup system to process the vault. Within one minute, the tritium area monitor in the tritium vault sounded its caution alarm. Technicians secured the area, and all personnel evacuated the tritium vault. The tritium area monitor eventually went into the high-high alarm mode.

The tritium vault cleanup system reduced the amount of tritium to normal levels. Surveys of personnel and the tritium vault showed no evidence of surface contamination. Bioassays of personnel were also negative. The stack monitor indicated that 11 curies of elemental tritium (HT) and 0.013 curies of tritium oxide (HTO) were released. The measured site boundary dose was 0.3 nanorem (3.0×10^{-8} rem).

Investigation into the cause of the release concluded that the procedure had not adequately addressed the isolation of the primary tritium line during the oil change operation. At least one valve was not closed as part of this procedure, which allowed the pump cart to exhaust gas into the portable ventilation system connected to the tritium vault HVAC system. Corrective actions were

instituted to address the issues of the pumping systems and equipment and the procedure process—definitions, walk down process, pre-job briefings of new procedures, etc. [PPPL94b].

5.3 Environmental Monitoring

5.3.1 Waterborne Radioactivity

A. Surface Water

Surface-water samples at eight locations (four on-site and four off-site) have been analyzed for tritium and photoemitters (Table 18). Five of these locations have been monitored since CY82. Downstream sampling occurs after the mixing of effluent and ambient water is complete. Locations are indicated on Figs. 19 and 20.

Sample analysis has shown no unusual background radionuclides. Tritium analysis by liquid scintillation methods has shown tritium values to be less than 100 pCi/liter (3.7 Bq/liter) on all samples analyzed to date (Figs. 27-35), with one exception at Station D2. In July 1993, probably due to the release of tritium (see Unplanned Releases) tritium was detected above 100 pCi/liter (105.9 pCi/liter), at this station, located on C site. Tritium enrichment procedures are used on some samples to provide increased sensitivities. Rain-water samples collected and analyzed ranged from less than 24.5 to 145 pCi/liter (see Table 16 and Fig. 25), which was most similar to the 1987 range of 26 to 144 pCi/liter (see the table below). The reason for these variations can be explained as follows: HT and HTO—mainly from prior world-wide, above-ground, weapons tests,—go into the stratosphere and are returned to the troposphere by turbulence. The HT slowly converts to HTO. Furthermore, the residence time in the atmosphere is on the order of years. There is a variation of HTO in rain water as the stratosphere slowly turns over, with very little exchange between the stratosphere and troposphere in the winter months [Os88]. The peak values are slowly decreasing over the years, which is consistent with the decay of tritium with no large inventories being added.

Annual Range of Tritium in Precipitation

Year	Tritium Range
1985	45 to 160
1986	40 to 140
1987	26 to 144
1988	34 to 105
1989	7 to 90
1990	14 to 94
1991	10 to 154
1992	10 to 83.8
1993	24.5 to 145

Tritium Range measured in pCi /liter

In 1988, PPPL initiated the collection of precipitation and monitored levels starting with the second quarter. While 1988 was a dry year, 1989 and 1990 were relatively wet years with over 55 inches (140 cm) and 50.3 inches (128 cm) of precipitation in 1989 and 1990, respectively. The years 1991, 1992, and 1993 had average amounts of total precipitation: 1991 - 45 inches (114 cm), 1992 - 42 inches (107 cm), and 1993 - 42.7 inches (109 cm) (Table 17)[Ch94].

B. Ground Water

Typically, five on-site wells—D-11 and D-12 on C site, and TW-1, TW-3, and TW-10 on D site (Fig. 39)—are sampled. * As a part of continuing efforts to characterize the site, a more comprehensive ground water program was initiated in June 1985 through the USGS. This program entailed the drilling of several monitoring wells on the TFTR site in order to help profile the ground water system. The final USGS survey report was issued in 1987 [Le87]. This report indicated a cone of depression created by the TFTR sump system (Figs. 46 and 47). The samples collected from two of the wells (TW-1 and TW-10 at D site) were analyzed for tritium by PPPL. The sample results were consistent with previous testing accomplished by PPPL and the USGS and indicated tritium levels less than 100 pCi/liter (3.7 Bq/liter). These values are consistent with surface water measurements. The results for 1993 (Table 19 and Fig. 26) are also less than 100 pCi/liter (3.7 Bq/liter) averaging about 65 pCi/liter, as expected; and because the pool of water tends to average out HTO added by precipitation, the large variation noted in precipitation is not seen in the ground water.

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 (Fig. 32). In 1993, tritium measurements of potable water ranged from 21 to 69.5 pCi/liter, which are similar levels to surface (Fig. 32) and well waters (Fig. 26) with measurements indicating less than 100 pCi/liter (3.7 Bq/liter). Also, only naturally occurring, gamma-emitting radioisotopes have been detected. Radium and radon levels have not been measured in the potable water system by PPPL.

5.3.2 Foodstuffs

Foodstuffs collected and analyzed in CY93 during the growing season included zucchini, squash, tomatoes, cantaloupe, hot peppers, and pumpkin. These fruits and vegetables were collected from area farmers or gardens. The variation shown in detected HTO levels of 42 to 140 pCi/liter (see Fig. 36 and Table 20) is indicative of the variation of HTO in precipitation (24.5 to 145 pCi/liter).

5.3.3 Soil, Grass, and Vegetation

Off-site sampling locations were established in late 1985 (see Fig. 20). In 1991, some sampling points were relocated because of construction in the area in 1990 and also to be near the air-monitoring stations. Because surface soils and vegetation are among the best indicators of tritium deposition after a release [Jo74], [Mu77], [Mu82], [Mu90], baselines were established.

For those soil and grass samples collected in 1993 from off-site locations, the data are not reported as the values do not correlate to the tritium concentrations in the air or in precipitation. For tritium to been found in the soil, similar tritium concentrations would also need to be measured in the air or in the precipitation. PPPL believes that the data are inaccurate probably due to problems with analytical methodology. At the time the data was reviewed, it was not possible to reanalyze the samples, collect new samples, or verify analytical techniques for the samples analyzed in 1993.

6.0 ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

6.1 NJPDES Data

6.1.1 Surface and Storm Water

In accordance with PPPL's New Jersey Pollutant Discharge Elimination System (NJPDES) permit, NJ0023922, monthly discharge monitoring reports (DMRs) for D2 (PPPL designation) or DSN001 (permit designation) (see Table 26) were submitted to the NJDEPE in 1993 . The PPPL was well within the allowable limits for all testing parameters during CY93, except for total suspended solids (TSS). In November 1993, the TSS and permit limit of 50 mg/l was exceeded by a value of 73 mg/l. It was determined that the total suspended solid level was elevated by 1) soil disturbance in the detention basin caused by excavating contaminated soil and/or 2) drainage of the basin prior to the sampling of D2, which would provide less time for solids to settle in the basin.

Cooling-water treatment was changed from a chromate-based corrosion inhibitor to a non-chromate inhibitor in June 1983. Water analyses downstream of the detention basin in Bee Brook (see Table 21) have not indicated concentrations of any environmental pollutants, in general, above applicable codes, regulations, or standards. In previous years, there are instances when the downstream-station (B2) temperature was higher than 2.8°C or 5°F (NJ Surface Water Quality Criteria) above the upstream station (B1) ambient temperature. The difference in temperature, or Δt, is due to the Δt between ground water and surface water during the winter. The ground water temperature is relatively constant (12.8°C/55°F) in comparison to surface water temperatures, which fluctuate with the air temperature. The PPPL believes that the amount of groundwater being pumped to dewater building foundations (TFTR, D site MG, and Laboratory Office Building), is responsible for the higher temperatures observed in the winter at B1 and B2.

In early 1994, a study was conducted to confirm the source of the temperature differential and to propose methods to mitigate the differential [AAC94b]. The conclusion of the study was to alter the basin operations to a flow-through mode thereby retaining a constant level in the basin. This mode would allow for longer retention time in the basin; thus, the longer time to lower the water temperature in winter months. This solution will be implemented following the completion of the basin modifications in late 1994. PPPL will measure the temperatures in Bee Brook to determine the effectiveness of this change in the basin's operations.

Storm water and process water, which includes cooling tower and boiler blowdown, are discharged into surface waters and are governed at C and D sites by NJPDES Permit No. NJ0023922 (effective date March 1, 1994; expiration date February 28, 1999). All process water and most runoff water from C and D sites pass through a detention basin. The detention basin inflows or

influents are monitored twice each year, in May and August (see Table 25), pursuant to the PPPL NJPDES ground water discharge permit, NJ0086029. Volatile organic compounds were detected at inflow 1 and 2 in concentrations slightly above the method detection limits for volatile organic analyses. Tetrachloroethene, tetrachloroethylene, or percholorethylene (PCE) was detected in inflow 1 and 2 in concentrations of 5.7 ppb and 4.5 ppb, respectively. Inflow 1 is located on the west side of the detention basin and contributes mainly water from the C site MG basement sumps, C and D site cooling tower and boiler blowdown. Inflow 2 is located on the north side of the detention basin and contributes mainly ground water from the D site TFTR and MG basement sump pumps. In addition, chloroform and bromodichloromethane were detected in inflow 1 in concentrations of 9.1 ppb and 4.1 ppb, respectively.

Approximately 91.216 million gallons discharged through the detention basin in CY93. The storm-water discharge (DSN002) point, which does not drain into the detention basin, is included as a sampling location in the newly issued NJPDES surface water discharge permit. An upgrade to the detention basin is scheduled for completion in CY94. In March 1993, PPPL and DOE/PAO received the Treatment Works Approval (TWA) permit for the modifications to the detention basin. This project includes the installation of an under drainage system and an impermeable liner in the basin, the construction of upgrades to the basin outfall, the re-routing of the storm drainage from the warehouse spill containment system and the southeast quadrant switchyard, and the upgrading of the oil detection system at C site. Other state permits obtained prior to the project's start are: 1) Stream Encroachment permit, 2) Freshwater Wetlands general permit #11, and 3) Freehold Soil conservation District approval of the Soil and Sediment Control Plan.

6.1.2 Ground Water Assessment

In 1989, the NJDEPE required in PPPL's NJPDES ground water discharge permit the addition of two monitoring wells adjacent to the detention basin and three wells on A and B site, which are not on DOE-leased property . While DOE has requested an adjudicatory hearing on the off-site well conditions of the permit requirements, PPPL came into compliance with the NJPDES permit requirements. The permit, NJ0086029, was issued effective April 1, 1989, and expires on December 31, 1994. DOE-PAO submitted to DEP the NJPDES permit renewal application in July 1994. Included in that application was a PPPL-prepared report on ground water quality, which summarized data from 1989 to 1994 for all the ground water monitoring wells. The following sections are exerpted from that report [FI94].

A. Hydrological Studies from 1989 to 1993

In November 1989, DOE/PAO submitted a plan, prepared by PPPL, for a hydrological study to delineate and define the sources of contamination previously detected in the on-site wells, specifically in Test Well, TW-3, during the USGS study. [USGS87] [DOE89c] [PPPL89d,f] [NJDEPE90] The study included plans to delineate on-site ground water flow directions, install

additional monitoring wells, and conduct soil sampling and/or a soil gas survey to define and detect any on-site contamination.

The first study to be completed was the soil gas survey in September 1990. [Ne90] [DOE90c] [PPPL90d] The survey included the detection of three compounds and one type of compounds: tetrachloroethene (PCE), trichloroethene (TCE), trichloroethane (TCA), and aromatic hydrocarbon compounds (AHC). The three compounds—PCE, TCE, and TCA—are solvents commonly used to clean metal, and all were used at one time at PPPL. AHC are compounds that are present in petroleum products, such as gasoline.

The results of this survey showed there were localized anomalies in five areas:

1 — North and east of the Plant Maintenance and Engineering Building [now known as the Facilities and Engineering Division (FED)] and including the cooling tower area.
2 — Through the eastern half of the Receiving Warehouse Building and extending southward toward the Coil Assembly and Storage Building (CAS).
3 — Southwestern corner of the CAS Building.
4 — Northeast of the TFTR Neutral Beam Power Conversion and Mockup Buildings.
5 — West of TFTR Field Coil Power Conversion (FCPC) Building.

Summary of 1990 Soil Gas Survey Results

Area Number	PCE	TCE	AHC	TCA
1	✓	✓	✓	✓
2	✓	✓		✓
3	✓			
4	✓	✓		✓
5				✓

In the table above, the results of the soil gas survey are summarized. All four compounds were detected in only Area 1; the three chlorinated solvents were detected in both Areas 2 and 4. Only PCE was detected in Area 3, and only TCA was found in Area 5.

In May and November 1990, the NJDEPE submitted comments on the proposed plan of study for the hydrological investigation, which DOE submitted in November 1989. [DEP90a,b] In the May 1990 correspondence from the NJDEPE, the plan was approved with the following conditions [NJDEPE90a]:

- Determining the Direction of Ground Water Flow — ground water modeling must be performed.
- TFTR Cone of Influence — must identify of dewatering activities details.

- Detention Basin Impact — must monitor the impact to ground water of unlined basin.
- Contaminant Source Location — on-site historical usage of solvents/hazardous substances must be investigated.

In the November 1990 NJDEPE letter, the following items were further discussed [NJDEPE90b]:

- Well Locations — Wells 1, 8, and 11 not required; located wells 6 and 7 downgradient of the underground storage tank area.
- Proposed Ground Water Model — proposed model must have DEP approval prior to implementing; 72-hour pump test not required.
- TFTR Influence and Detention Basin Impact — core sediment samples are not required; synoptic water levels will be measured at all on-site monitoring wells on a monthly basis.

In December 1990, the hydrologic study began with the drilling of sixteen ground water monitoring wells and two piezometers. Samples were collected in January 1991 and analyzed for volatile organic compounds, semi-volatile organic (base/neutral) compounds, polychlorinated biphenyls (PCBs) and pesticides, metals, and total petroleum hydrocarbons. The results of this study showed a correlation between the following areas only: in Area 1— adjacent to the FED Building and the excavation where five underground storage tanks were removed—semi-volatile organics were detected correlating to the detection of aromatic hydrocarbons in the soil survey, and in Areas 1 and 3 (see Table 5), volatile organic compounds (PCE, TCE, and TCA) were detected in both the ground water samples and in the soil gas survey. [MP91a,b] [DOE91b,d,e] No relation or correlation between ground water quality and soil gas survey results were shown for Areas 2 and 5; ground water samples were not collected in Area 4, so a relationship could not be assessed.

In March 1991, the impact of the detention basin on ground water was investigated by recording the water levels in the detention basin and nearby wells (D-11, D-12, and MW-9, as the control well). [MP91c] [DEP91a] [DOE91c] The results of this study revealed that the basin does not appear to discharge to the surrounding ground water, but rather the ground water is discharging to the basin at all times except when water in the basin is at the maximum elevation. Because a mounding effect was not observed, any contamination that reaches the detention basin should not flow from the basin into the surrounding ground water except when the basin is at the maximum water elevation; at that time, the flow reverses and water then flows from the basin into the ground water. [St91]

In late 1990, a hydraulic oil spill behind the Research Equipment Storage and Assembly (RESA) Building was reported to the NJDEPE. [PPPL91] [MP91d] A new ground water monitoring well adjacent to the spill was mandated by NJDEPE [NJDEPE91]. Well MW-13 was installed in April 1991, and samples were collected in May and June 1991. The results indicated that no residual of the hydraulic oil was present in the ground water; however, the more significant finding was the

detection of tetrachloroethene (PCE) in concentrations of 200 µg/l and 140 µg/l. The 200 µg/l PCE detected in this well was the highest concentration found in any ground water sample collected to date.

There are several possible sources of the PCE in well MW-13. In 1988, a sink located in the CAS building, which is adjacent to the RESA building, was found to be discharging outside onto the ground. This situation was immediately corrected; however, the CAS building had been used since 1979. Two spill incidents were reported in the area of these buildings. Lastly, waste oil and used solvents were accumulated outside these buildings. [PPPL88] [PPPL87] [PPPL90e] From the Solvent and Hazardous Constituent Usage Survey, it is known that a large quantity of PCE (> 1,000 gallons) was stored and used in this area [MP91f] [DEP91b] [DOE91g]. This survey also documented the occurrence of petroleum hydrocarbons and solvents in most buildings at PPPL. The solvent 1,1,1-trichloroethane (TCA) was and is widely used throughout the site; substitute solvent/degreaser products are being made available and used wherever appropriate.

In January 1993, a follow-up study was conducted to re-sample those wells sampled in January 1991 and to include the remainder of the ground water monitoring wells on C and D sites, *i.e.*, the NJPDES wells (see Tables 40 and 41). [DOE93c] [MP93] This study confirmed the 1991 ground water quality analyses: the presence of chlorinated solvents and other compounds were detected in the same wells in 1993 as in the study of 1991. Dissolved contaminants have not migrated to areas previously found to be clean. In those wells where contamination was found in 1991, the concentrations have declined in the 1993 samples. Lastly, the sump pump system beneath the D site buildings continues to control the ground water movement by creating a shallow cone of depression and area of influence extending across both C and D sites; ground water movement on C and D sites moves radially toward the sump pump system (see Figures 47 and 48).

In February 1993, a Memorandum of Understanding (MOU) was signed between Princeton University, the land owner of the James Forrestal Campus, and the NJ Department of Environmental Protection and Energy (NJDEPE). In this MOU, a remedial investigation and remedial alternative assessment were required. For C and D site, PPPL's environmental subcontractor, Harding Lawson Associates (HLA) prepared a draft work plan for the remedial investigation. [HLA94] Included in this work plan is a ground water investigation. Samples from thirty-four ground water monitoring wells, two piezometers, the C and D site ground water sumps, and the former production wells will be collected. Analyses will include volatile organic compounds, total petroleum hydrocarbons, specific conductance, pH, and temperature. Selected samples will be analyzed for common ions: total dissolved solids, chloride, fluoride, nitrate (as N), sulfate, total alkalinity, hydroxide alkalinity, carbonate alkalinity, bicarbonate, bromide, calcium, magnesium, potassium, and sodium.

B. NJPDES Quarterly Ground Water Monitoring Program

In this section, the NJPDES Quarterly Ground Water Monitoring Program from 1989 to 1994 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.

Since November 1989, the wells located on A and B sites—MW-14, MW-15, and MW-16—are sampled quarterly (1993 data see Tables 34 and 39). All the results were below the permit standards with two exceptions. In May 1992, the sulfate result for MW-14 was 1,200 mg/l (standard is 250 mg/l); all other sulfate results were below 25 mg/l. The cause of this anomaly is unknown. The second occurred in November 1991— ammonia-nitrogen was detected at 0.84 mg/l in MW-16; the standard is 0.5 mg/l. All other ammonia-nitrogen concentrations have been below the detection limit. A cause for this anomaly is undetermined. No semi-volatile (base/neutral) organic compounds were detected in these wells. These wells are also sampled by Princeton University's environmental contractor, ENVIRON [EN91], and are included in the University's ground water monitoring program. In the NJPDES permit renewal application, PPPL and DOE-PAO made a formal request to DEP that these wells be removed from the ground water permit requirements.

The C and D site wells—D-11, D-12, TW-2, and TW-3—have been sampled quarterly since November 1989. For all but lead and volatile organic compounds, all the ground water results have been below the permit standards or the New Jersey Ground Water Quality Standards (1993 data see Tables 34, 35, 36, and 37). Lead and volatile organic compounds in the ground water samples are discussed in the following paragraphs.

During the November 1989 sampling event, lead (total) was detected in wells D-11 and D-12, 1.8 mg/l and 0.14 mg/l, respectively. An investigation was conducted and a preliminary report prepared, which discussed possible causes for the presence of lead in the ground water. [DOE90] [PPPL90c] In the "Preliminary Report on the Occurrence of Lead in Monitoring Wells D-11 and D-12 at Princeton Plasma Physics Laboratory," the probable source of the lead was residual "lead-free" paint that was used to paint the transformers in the Neutral Beam Power Conversion (NBPC) transformer yard on D site. [PPPL90c] The sumps which drain the transformer yard collected the residual paint and then discharged the residues and storm water to the detention basin. As shown in the 1991 Malcolm Pirnie study, "Study of Detention Basin Impact on Groundwater Elevations and Flow Direction," ground water can be impacted by the detention basin water under certain conditions. [MP91c] When the basin is at its maximum capacity, the water in the basin flows toward the ground water; otherwise, the ground water surrounding the basin discharges into the basin under "normal" conditions. Water recharging from the detention basin may have occurred when the wells D-11 and D-12 were sampled in November 1989.

Since 1989, lead has been detected three times in excess of 0.05 mg/l (permit standard): D-11, November 1992 — 0.12 mg/l; TW-2, August 1990 — 0.06 mg/l; and TW-3, November 1992 — 0.08 mg/l. These three occurrences may be due to the presence of sediments from the bottom of the wells that were drawn up with the ground water sample.

The detection of tetrachloroethene (PCE) in ground water monitoring wells was observed in every volatile organic compound analyses from November 1989 to August 1993, except once during May 1990. Of ten sampling events, PCE has been detected in wells D-11 and D-12 eight times or in 80 percent of the samples. In well TW-3, PCE was detected in 50 percent of the samples; however, higher concentrations of PCE were found in this well, 26 µg/l and 36 µg/l. Other VOCs have been detected either in levels below the method detection limits (J values) or sporadically, *e. g.*, 1,1-dichloroethane in well D-12.

The detention basin inflows are sampled twice annually, in May and August. Inflow 1 is located on the west slope of the basin and drains C site: cooling tower blowdown, boiler blowdown, storm drains, and building sumps, including ground water from the Laboratory Office Building (LOB). Inflow 2 is located on the north slope of the basin, and it receives flow from D site sump pump systems in TFTR and MG buildings, storm drains, and transformer yard sumps.

PCE has been found three times in Inflow 2 samples: August 1990, September 1991, and August 1993. The compound 1,1,1-trichloroethane (TCA) was detected once in Inflow 2—August 1990. The D site sump pump system was also sampled at the same time as the inflows were sampled in August 1993. The occurrence of PCE in the Inflow 2 may be attributed to the PCE being pumped by the D site sump pump system as the results for that sampling are shown below:

1993 Volatile Organic Compounds in D Site Sumps

	D site MG	TFTR
1, 1, 1, -Trichloroethane (µg/l)	3.8	7.1
Tetrachloroethene (PCE) (µg/l)	52	3.8

PCE was detected once in Inflow 1—August 1993. The source of the PCE is not known; however, it is clearly not caused by the VOCs in the D site sumps, which flows to Inflow 2 only. In addition to PCE, chloroform and bromodichloromethane were detected in Inflow 1; both chloroform and bromodichloromethane are compounds formed when chlorine combines with organics in the water. The Delaware and Raritan Canal water is chlorinated and is used in the cooling towers for make-up water; cooling tower blow-down is discharged to the detention basin. The discharge from the detention basin was sampled in September 1993 for VOCs (EPA Method 502); only chloroform was detected at 0.8 µg/l.

C. Regional Ground Water Monitoring Program

The Regional Ground Water Monitoring Program studies are discussed in Section 6.1.2, "Hydrological Studies." When those studies and the NJPDES Quarterly Ground Water Monitoring Program results are evaluated together, an overall trend appears regarding the presence of volatile organic compounds found in the ground water monitoring wells at PPPL.

In the table below, the same five VOCs were found in six wells shown below: chloroform, 1,1-dichloroethane, trichloroethane, trichloroethene, and tetrachloroethene. In well D-12, four out of the five were detected. Wells MW-9 and MW-13 have the greatest total number of compounds and the highest concentrations of VOCs found in all ground water monitoring wells.

Based on PCE concentration levels alone, wells D-12, MW-6S, MW-7S, and MW-7I are similar—16, 15, 11, and 2.3 µg/l, respectively; wells MW-8S, MW-9, and MW-13 are similar—76, 120, and 200 µg/l, respectively.

Most Commonly Occurring Volatile Organic Compounds (highest detected concentration in µg/l)

	D-12	MW-6S	MW-7S	MW-7I	MW-8S	MW-9	MW-13
Chloroform		3J	11	12	38	0.9	0.5
1,1-Dichloroethane	14	13	2	8.6	7	1.7	0.8
Trichloroethane TCA		34	4	1J	2	11	4,1
Trichloroethene TCE	5	6	10	9	37	3	3.2
Tetrachloroethene PCE	*16*	*15*	*11*	*2.3*	*76*	*120*	*200*
1,1-Dichloroethene	13	4JB	0.95		0.66		0.8
1,2-Dichloroethene		2J			33		2J
cis-1,2-Dichloroethene	1.1			3		3	1.2
Chloroethane						10	
Carbon Tetrachloride			7	2J			
Toluene							1J
Total No. Compounds	5	7	7	7	7	8	9

Wells MW-3, MW-9, and MW-13 are the wells located closest to the suspected source of the VOCs in the southern portion of the site — behind/beneath CAS/RESA building where VOCs were historically used and stored. The highest concentrations of contaminants would be expected in those wells closest to the source. As ground water is being pulled toward D site by the sump pump system, VOCs would be detected in lower concentrations in wells located between the CAS/RESA buildings and D site.

D. Underground Storage Tank (UST) Ground Water Monitoring Program

In July 1991, NJDEPE directed DOE/PAO and PPPL to install two ground water monitoring wells immediately south of the underground storage tank (UST) excavation.[DEP91] In August 1991, wells MW-8S and MW-8I were installed; samples were collected and analyzed for volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPHCs). [MP91] Once each quarter, ground water samples are collected from wells P-2, MW-4, MW-5S, MW-5I, MW-6S, MW-6I, MW-7S, MW-7I, MW-8S, and MW-8I and analyzed for TPHCs. Ground water from these wells is collected and analyzed once annually (in August) for VOCs. Once a month, ground water elevations are measured in these wells and in wells MW-1, MW-2, P-1, UST-1, MW-3, MW-9, and MW-13 (1993 data see Table 29). Beginning in March 1994, the remaining thirteen (total of thirty) ground water monitoring wells on C and D sites were added to the monthly water elevations measurement; this additional data will provide the ground water flow for the entire PPPL site.

Each quarter a report containing the analytical data and monthly contour maps is submitted to NJDEPE (1993 data see Tables 31 and 32) [MP91g,h] [MP92a,c] [RES92a,b][RES93a,b,c] [AAC94]. The results of the VOCs analyses are included in the discussion of the "Regional Ground Water Monitoring Program." The results of the TPHCs analyses are summarized in table below.

Summary of 1991-1994 Ground Water Total Petroleum Hydrocarbon (TPHC) Results in mg/l

Sampling Dates	Reference	Qtr.	MW-5I	MW-6I	MW-7I	MW-8I
January 1991	DOE91a	Initial		1.9		
August 1991	MP91g	1		1.3		
November 1991	MP91h	2				
February 1992	MP92a	3				
May 1992	MP92c	4				
August 1992	RES92a	5				
November 1992	RES92b	6			1.8	1.2
February 1993	RES93a	7				4.5
May 1993	RES93b	8				
August 1993	RES93c	9	1.2			
February 1994	AAC94a	10	4.2		0.80	0.73
May 1994	AAC94c					

Total petroleum hydrocarbons were detected in the intermediate (I) ground water zone only. In general, the immediate wells are bedrock wells open from 30 to 45 feet below grade or at elevations of 45 to 60 feet above mean sea level (msl).

When evaluating the monthly contour maps and elevation data, the average annual ground water elevations was calculated for each well. The wells are then grouped by elevation (see Table 30). Also included are the two detention basin wells, D-11 and D-12, which are located in the southern portion of the site.

The wells grouped in the 89 and 87-foot elevations, MW-1, MW-4, MW-2, P-1, and P-2 and UST-1, are uncontaminated, upgradient wells. The downgradient wells listed in the 86, 85, 84, and 83-foot elevations are all contaminated wells (except UST-1). Generally, contamination detected >10 µg/l total VOCs is found only in the shallow wells designated "S" and D-11 and D-12, which are also shallow wells. Conversely, contamination detected <10 µg/l total VOCs and detectable levels of total petroleum hydrocarbons are found only in intermediate wells (I).

By similar water elevation profiles or patterns, the wells are grouped in Figures 41 through 44: Figure 41—the upgradient wells (MW-1, MW-2, MW-4, P-1, P-2, and UST-1), Figure 42—CAS/RESA wells (MW-3, MW-9, and MW-13), Figure 43—the shallow wells (MW-5S, MW-6S, MW-7S, MW-8S), and Figure 44—the intermediate wells (MW-5I, MW-6I, MW-7I, and MW-8I). These wells also fit into the same groups when evaluating the chemical data: the upgradients are clean; the CAS/RESA wells have the highest concentration of PCE; the shallow wells have moderately high concentrations of volatile organic compounds; and the intermediate wells have lower concentrations of VOCs, but total petroleum hydrocarbons were detected as well as benzene.

6.2 Other Non-Radiological Data

6.2.1 Other Emissions Monitoring Data

A. Airborne Effluents

The PPPL has New Jersey Department of Environmental Protection and Energy (NJDEPE) air permits for its four C site boilers. The permit certificate numbers 061295 through 061299, were renewed and issued on March 31, 1992, and will expire on March 31, 1997. The original permit applications were submitted to the NJDEPE in November 1981. In March 1994, as a result of a NJDEPE site inspection by the Bureau of Air Enforcement Operations, and the subsequent issuance of a Notice of Violation (NOV), PPPL submitted alterations and amendment to the four boiler permits to the NJDEPE. In 1987. PPPL modified boilers 2, 4, and 5 to burn natural gas. Previously, boilers 2, 3, 4, and 5 burned only #6 fuel oil. In 1988, boiler #3 was modified to burn #4 fuel oil. Currently, boiler 3 burns only #4 fuel oil. The NJDEPE was notified in December 1992 that the fuel constituent of the underground storage tank , designated as E-1, changed from #6 fuel oil to #4 fuel oil. The NJDEPE, however, was not notified that 1) as of December 1987, the primary fuel for boilers 2, 4, and 5 was natural gas; 2) the boilers and associated equipment were modified to accommodate natural gas; and 3) the secondary fuel for the boilers is #4 fuel oil. As a

result, the PPPL estimated emission concentrations, as documented in the boiler permits, are not accurate nor reflective of emissions of compounds originating from the burning of natural gas. PPPL boiler emission concentrations have decreased as a result of burning natural gas as the primary fuel and burning #4 fuel oil, on rare occasion, as the secondary fuel.

Several additional permit modifications will be made for other air permitted sources at PPPL. First, in the Field Coil Power Conversion (FCPC) building, the FCPC degreaser, permit No. 090735, which used Freon® 113, was removed in 1992. Currently, the FCPC vacuum preparatory laboratory uses alconox and water solution in a hot water bath, which is located beneath a canopy hood, to degrease metal parts. Second, a vapor degreaser located in the TFTR hot cell uses Freon® 113 to degrease metal parts. Under the revised NJ air regulations, N.J.A.C. 7:27-16, ozone-depleting substances are excluded from this section by the definition of volatile organic compound, but may be considered air contaminants by definition. The NJDEPE will decide the applicability of the hot cell degreaser to the air permitting regulations.

Four additional air permits were issued to the PPPL by the NJDEPE; two permits for two aboveground storage tanks and three permits for each of three dust collectors. The aboveground storage tank permit No. 114785 was issued on October 25, 1993, and expires on October 25, 1998. The aboveground storage tank emissions are volatile organic compounds from the storage of #4 fuel oil or diesel oil. The CAS dust collector permit was issued on March 10, 1993, and expires on July 23, 1998. The FED and CAS dust collector emissions originate from general wood-working operations. The Shop building dust collector emissions originate from metal working operations.

Measurements of actual boiler emissions are not required. Emissions were initially calculated and then recalculated for the amendments and alterations to the boiler permits, using NJDEPE and AP-42 [EPA] formulas. These formulas are based on the appropriate boiler emission factors, percent sulfur content of the fuel, number of gallons of oil burned per hour in each boiler.

To optimize boiler efficiency and to reduce fuel cost in accordance with DOE Order 4330.2D, "In-House Energy Management," [DOE88b] PPPL utilizes an ENERAC POCKET 50® combustion-efficiency analyzer to indicate the boiler efficiency, oxygen content, flue-gas temperature, and carbon-dioxide content of the stack gas for both oil and natural gas fuels. Boiler operators maintain a record of this information in a log book.

For the TFTR emergency generator diesel engine and the C site emergency diesel generator , permit Nos. 092187 and 096074, respectively, emissions are calculated using formulas from the NJDEPE and AP-42. The boiler and emergency diesel generators are the largest sources of air emissions at PPPL. These sources have the potential to emit greater than 25 tons per year of nitrous oxides.

Through the Air Emissions Survey, additional sources, point and fugitive emission sources, were identified. Air emission sources at PPPL were grouped into three distinct areas that include: 1) point source emission, 2) fugitive emissions during project activities, and 3) fugitive emissions from standard operations of the facility [Wi93a].

Point sources are defined as those areas where an activity occurs, which produce air emissions from a specific source to the outside ambient air. These areas include laboratory fume hoods, welding hoods, photography and copier hoods, degreaser vents, and cooling towers. Dust collectors, stationary gas and diesel generators, boilers, and fuel storage vents discussed above are also point emission sources.

Fugitive emissions source categories are defined as those emission sources that produce emissions not captured in a specific area. At PPPL fugitive emission sources include vacuum pumps, ovens, welding, grinding and soldering activities, uncontrolled refrigerant leaks, unvented ultrasonic degreaser baths, and use of degreasers and cleaners. Fugitive emissions generated from routine standard operations of the facility include refueling of government vehicles as associated fuel storage tanks, and emergency generator test runs.

The NJDEPE Air Emission Statement for 1992 was completed and returned to NJDEPE. Under the definition of a major facility (one which emits >25 tons of nitrous oxides annually), PPPL has the potential to emit 25 tons of nitrous oxides (NO_x) per year from the four boilers.

PPPL uses and maintains four recovery units for maintenance, service, and repair of appliances containing ozone-depleting substances in order to minimize the release of these substances to the environment. Currently, PPPL is preparing environmental procedures that will address best management practices to reduce fugitive emission sources of refrigerants that contain Chlorofluorocarbons (CFCs), which are ozone depleters.

B. Drinking Water

Potable water is supplied by the public utility, Elizabethtown Water Co. The PPPL used approximately 37.8 million gallons in CY93 [Gu94]. This is a significant reduction from years prior to 1987 because of the changeover to Delaware & Raritan (D&R) Canal water for the cooling-water systems. Water-quality analysis at the input to PPPL was initiated in CY84 to measure non radioactive pollutants (Table 23, E1 location), as well as to measure potential radioactive pollutants exclusive of radium or radon.

C. Process (non potable) Water

Non potable water is pumped by PPPL 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 one million gallons of water per day for process and fire-fighting purposes for the period beginning July 1984 and ending on June 30, 2009. Renewal is expected at the end of the present contract. Filtration to remove suspended solids, chlorination, and corrosion inhibitor are the primary water treatment. The filter-backwash discharge number (DSN003) is included as a separate discharge point in the surface-water permit renewal application. In 1986, a multimedia sand filter with crushed carbon was installed to allow the source of the D site cooling tower make-up water to be changed from potable water to process-water supply. The PPPL used approximately 60.1 million gallons of canal water during CY93 [Gu94]. A sampling point (C1) was established to provide baseline data for process water coming on-site. Table 22 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. The two additional sampling locations were included in the renewed NJPDES surface water discharge permit that became effective March 1, 1994. These locations are DSN002, a storm water sampling point located in the ditch that runs along the southwest side of C site, and DSN003, the filter backwash from the D & R Canal pump house. Other sampling locations—Bee Brook, Ditch #5, Delaware & Raritan Canal, Elizabethtown Water Company, Millstone River, and Plainsboro sampling points (See Figs. 27 and 28 and Tables 21, 22, 23, and 24)—are not required by regulations, but are a part of a PPPL best-management practice.

E. SPCC

An updated Spill Prevention Control and Countermeasures (SPCC) Plan was prepared by an environmental consultant in January 1985; this plan underwent extensive review and revision in CY91 [MP92b]. The final plan was completed in May 1992; it is incorporated as a supplement to the PPPL Emergency Preparedness Plan. This last update was delayed until after the EPA issued the Final Regulations for Underground Storage Tanks (UST). PPPL is installing five, new above-ground tanks to replace all of its underground tanks by CY94.

F. Sanitary Sewage

Sanitary sewage is discharged to the publicly-owned treatment works operated by South Brunswick Township at the Stony Brook Regional Sewerage Authority (SBRSA). During 1993, PPPL's on-site metering devices were malfunctioning. As a result, an agreement is currently in effect among PPPL, South Brunswick Sewerage Authority, and the Township of Plainsboro, which determines the approximate flow rates from PPPL based on historical data. The estimated volume has been

adjusted for the interconnections with Forrestal Campus A and B sites and a private business. For CY 93, PPPL estimates a total discharge of 19.0 million gallons of sanitary sewage to the South Brunswick sewerage treatment system [Gu94].

As a result of a SBRSA and NJDEPE site inspection during CY93 and the submittal of a pretreatment application and PPPL Site Sanitary Sewer Survey in late 1992, SBRSA issued a draft industrial discharge permit to PPPL that was to become effective on February 15, 1994. DOE-PAO and PPPL submitted comments on this draft permit and is awaiting action on the draft permit and/or comments from SBRSA. The permit requires PPPL to sample sewerage outfalls and the liquid effluent collection (LEC) tanks. The data are to be contained in a report to SBRSA on a monthly and annual basis for the LEC tank data and sewerage outfalls, respectively.

During the DOE Tiger Team assessment, the lack of a treatment works approval (TWA) by NJDEPE for the PPPL Calibration and Service Laboratory building (CASL) sewage-holding tank was cited by the team. The CASL TWA application was submitted to the NJDEPE Bureau of Industrial Discharge Permits and to SBRSA in June 1992. In addition, Plainsboro Township, Plainsboro Township Health Department, and the South Brunswick Township were sent the CASL TWA application in September 1992. No response from these agencies has been received by PPPL.

In October 1992, the TWA application for the LEC tanks was submitted to the same agencies as the CASL TWA application. However, PPPL was informed by the NJDEPE that a TWA was not required due to an exemption of the LEC tanks based on the date of their installation. The NJDEPE informed PPPL that a significant indirect user (SIU) review would be required by the publicly-owned treatment works (POTW). No response from SBRSA has been received by PPPL.

A third TWA for the upgrades to the detention basin (a new project) was filed with NJDEPE in CY92 . The TWA permit was approved and became effective in February 1993, permit No. 92-7082-4N.

G. Herbicides, Fertilizer, and Pesticides [Ra92]

During CY93, the use of herbicides, pesticides, and fertilizers was managed by PPPL's Facilities Engineering Division (FED) utilizing an outside contractor. These materials are applied in accordance with state and federal regulations. Herbicides are applied by a certified applicator. Table 28 lists the quantities applied during CY93. No herbicides, pesticides, or fertilizers are stored on site; therefore, no disposal of these types of regulated chemicals is required by PPPL.

H. Polychlorinated Biphenyls (PCBs)

Beginning in CY82, PPPL started a program to dispose of PCB-containing capacitors, transformers, and other similarly contaminated items. During the early phases of the program, all stored items in a GSA (General Services Administration) Warehouse in Belle Mead, New Jersey, were discarded through approved disposal contractors. Remaining PCB items were labeled, as required by EPA regulations, and an inventory, inspection, and status report program was initiated. At the beginning of CY84, PPPL still had 15 PCB transformers and 6,005 large capacitors containing PCBs. In CY84, 375 large and 54 small PCB capacitors were disposed, as well as the oil and containers of two transformers. In 1985, an additional 1,330 large capacitors and 22 small capacitors were removed properly from the site. In 1986, a few small capacitors but no transformers were discarded. In 1987, two transformers containing 700 gallons of PCB fluid were disposed. In addition, 1,145 gallons of less than 500 ppm PCB fluid were generated from reworked and reclassification of six PCB transformers to non-PCB transformers, and 391 capacitors were disposed. In 1988, 1,696 capacitors and four small transformers were removed. In 1989, 273 capacitors were disposed while an additional 1,108 were removed from service. Eleven transformers were disposed along with one contaminated transformer containing 113 gallons of PCB fluid (186 ppm). In 1990, the remaining PCB transformers were disposed, leaving only one contaminated transformer (>50 ppm) on-site. By removing the contaminated oil, cleaning, and refilling with clean oil, this transformer became a non-contaminated transformer in 1991. At the end of 1993, PPPL was left with 661 large, regulated capacitors. PCB capacitors are being disposed as they are taken out of service. Disposal records are listed in the Annual Hazardous Waste Generators Report [La94].

I. Hazardous Wastes

Responsibility for this program rests with the PPPL Hazardous Material Branch Manager under the supervision of the Head, Office of the Environmental Restoration/Waste Management Administration (ER/WM). A facility (HAZMAT building) was set up in CY82 for temporary storage of hazardous materials. A new facility called the Hazardous Materials Storage Facility (HMSF) was built in 1986. This facility has concrete floors with containment walls, fire alarms, security surveillance, fire extinguishers, an eye-wash station, an emergency shower, and telephones. Improvements to the facility, following experience gained from operational needs, were made in CY88. A concern in 1990 was the flaking of the epoxy sealant used throughout the entire building. In 1991, the flooring in the HMSF was removed and replaced with a new coating of epoxy sealant.

A question raised during the DOE Tiger Team assessment indicated a resolution was needed for areas of the facility within the 500-year flood plain when the definition of "critical action" per 10 CFR 1022 is applied [CFR90]. Based on the determination that part of the facility is located in the 500-year flood plain, this issue was addressed by proposed modifications; design work was

finished in CY93 . Upgrades to the facility are in progress with its completion scheduled for the end of FY94.

The Hazardous Waste Generator Annual Report (EPA ID No. NJ1960011152) has been submitted for 1993 in accordance with EPA requirements [La94]. During 1993, 129,688 pounds of materials were disposed at EPA-certified treatment, storage, and disposal facilities. These totals include approximately 31,590 pounds of PCB-contaminated waste removed from the detention basin, 24,198 pounds of monitoring well purge water, and 20,347 pounds of oil spill clean-up debris [Be94].

J. U.S. Geological Survey Study

A groundwater study by the U.S. Geological Survey (USGS) began in 1985 and was completed in 1987 [Le87]. While this special study was predicated on a hypothetical spill of tritium from the liquid effluent collection (LEC) tanks, it more appropriately addresses the general groundwater quality and flow patterns in the region near the TFTR facility. Figure 45 shows the potentiometric surface of the bedrock aquifer from this report. The report also indicated that the sumps under the TFTR complex create a cone of depression (Fig. 45). These data are being used in conjunction with the present groundwater studies. In 1991, USGS continued to record groundwater elevations from two monitoring wells located north of TFTR. The USGS also presented PPPL some data developed in an unrelated study on naturally occurring radioactivity in the ground. Uranium-enriched rocks can be a source of radioactivity in groundwater [Sz87, Za87].

K. DOE/HQ Environmental Survey

A comprehensive environmental survey was conducted by DOE/HQ utilizing outside subcontractors during the month of June 1988. This survey was part of a DOE program which looked at 45 of its facilities. No significant environmental impact findings were noted at PPPL during this survey. A plan of action for findings was forwarded to DOE, and except for long-lead time items, the findings have been closed out. Soil sampling for petroleum hydrocarbons from former spills and for chromium in soils from previous use in cooling towers was accomplished in November 1988 [DOE88a]. Data from this sampling effort have not shown any significant contamination requiring any follow-up action by PPPL.

L. DOE/CH Audit/Appraisal

Normally during the month of August, DOE/CH conducts its annual audit/appraisal of the PPPL Environment, Safety, and Health (ES&H) and Environmental Restoration/Waste Management (ER/WM) Divisions. The audit/appraisal investigates the following areas: Environmental Protection, Quality Assurance, Industrial Hygiene, Safety Analysis Review System, and Health Physics. From August 30 to September 3, 1993, an appraisal that included environmental protection was conducted. As a result of the appraisal, two findings and ten recommendations were

made. The two findings were as follows: 1) PPPL had not fully characterized a radioactive waste as potentially hazardous to determine its status as a mixed waste and 2) PPPL appeared to be exceeding the New Jersey Class II ground water quality standards for volatile organic compounds. The first finding was resolved by PPPL's subcontractor laboratory retesting the waste for the potential hazardous constituent and found that the previous results had indicated a false positive. Therefore, the waste was not classified as a mixed waste. The second finding is being addressed through the site remedial investigation under the Memorandum of Understanding with NJDEP.

The ten recommendations included two in the Safe Drinking Water Act (SDWA) compliance, one in the Resource Conservation Recovery Act (RCRA) compliance, two in ground water protection, one in Superfund Amendments and Reauthorization Act (SARA) compliance, two in Clean Air Act (CAA) compliance, one in pesticide management, and one in National Environmental Policy Act (NEPA) compliance. Noteworthy observations included the inventory and labeling of "small capacitors" not required by the Toxic Substances Control Act (TSCA) and surface water surveillance monitoring of off-site locations beyond the NJPDES permit requirements. The NEPA program, the PCB program, and the surface water program were rated to be "excellent" [DOECH93].

M. Woodlands and Wetlands

The Princeton Forrestal Center's Forest Management Plan, prepared in July 1990, was approved by the NJDEPE Division of Parks and Forestry [For90]. The Princeton Forrestal Center includes a total of 233 acres for site development and 144 acres of woodlands, including PPPL's site. The purpose of the plan, which brings the property into compliance with a recent amendment to the Farmland Assessment Act of 1964, is to improve the productivity of the woodlot, to sustain the level of activity and incomes required for maintenance of farmland status, to maintain and enhance wildlife habitat, to preserve the aesthetic quality of the woodlot, and to protect soil quality.

The management plan period extends from the year 1990 to 2000. The 144 acres of woodland ranges from recently mature old fields to overmature hardwood timber. The Middlesex County Soil Survey displays the relevant soil types representative of the woodlands acreage. The Nixon loams, Nixon Variant loam, and the Downer sandy loam are representative of well-drained sites. These soils support red, white, and black oaks, poplar, and ash. The fourth soil type includes the Fallsington Variant loam that is representative of poorly drained sites. As a result, wet-site trees species such as sweetgum, red maple, blackgum, and pin and swamp white oaks are represented.

The PPPL is surrounded by wetlands on the south, east, and north of C and D sites (Fig. 48). In 1992, a wetlands delineation was performed in these areas. The 50-feet transition area was delineated as well by Normandeau, a subtier contractor [Nor92]. A total area of approximately 11 areas was identified to be wetlands. A 5.23 acre area north of C and D sites, a 0.07 acre area east

of D site, a 3.43 acre area east of the detention basin, and a 2.44 acre area south of C and D sites were identified to be wetlands.

In July 1993, an "Application for a Letter of Interpretation (LOI)" for the entire 72-acre site was filed with the NJDEPE Land Use Regulations Program. The wetlands boundary lines were determined to be accurate as shown in the LOI wetlands delineation plan and the majority of the wetlands are of "intermediate resource value." The swales, located on the C site to the west and southwest that convey storm water to the wetlands south of C site, were classified as wetlands of "ordinary resource value" and do not have a 50-foot buffer or transition area adjacent to the wetlands boundary.

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 hazardous substances, no "Continuous Release Reports" have been filed with EPA.

6.2.3 Environmental Occurrences

Five releases were reported to the NJDEP Hotline, and confirmation reports submitted in CY93 (Table 27). In accordance with reporting requirements, notifications were made to the NJDEPE, because these release events posed a potential threat to the environment. No reports to the National Response Center (NRC) were made since there were no releases which exceeded the reportable quantities (RQ) for any listed substance.

Of the five reported releases, two releases were in amounts between 0.5 to 10 gallons of petroleum product (diesel oil and hydraulic fluid) onto an unpaved surface [Wi93d and Fi93b]. Each incident was cleaned up immediately upon being reported. One similar incident was the release of 0.5 gallons of ethylene glycol onto an unpaved area. The area was cleaned up immediately [Wi93].

The other two incidents were a release of about 655 pounds of Freon ®113 from equipment located in the Neutral Beam Power Conversion (NBPC) building and the detection of PCBs (167 ppm) in the detention basin sediments [Fi93a]. For the Freon® 113 incident, it evaporated into the air and required no cleanup [Wi93c]. The equipment that leaked the Freon was repaired. The soil in the detention basin was removed and disposed of at a licensed facility; the contaminated soil was replaced with clean fill.

6.2.4 SARA Title III Reporting Requirements

The NJDEPE administers the SARA Title III reporting for EPA Region II. The modified Tier I form includes SARA Title III and NJDEPE specific reporting requirements. PPPL submitted the 1993 SARA Title III report to NJDEPE in February 1994. No significant changes from the previous year were noted.

The report included information about twelve compounds used at PPPL. Of the twelve, five compounds are in their gaseous form and are classified as sudden releases of pressure hazards, and two are also acute health hazards. There are eight liquid compounds; nitrogen is used in both gaseous and liquid forms. Fuel oil, gasoline, and petroleum oil are flammables; Bromotrifluoromethane, dichlorodifluoromethane, and sulfuric acid are acute health hazards; sulfuric acid is reactive. PCB's and gasoline are listed as chronic health hazards.

7.0 GROUNDWATER PROTECTION

The focus of PPPL's Ground Water Program is the "Groundwater Protection Management Plan" (GPMP), required by DOE Order 5400.1, "General Environmental Protection Program." The purpose of the GPMP is to provide a written plan, for use as a management tool, to ensure the protection of ground water investigations conducted at the site. Implementation of the GPMP has taken place in parallel with several ground water investigations conducted on-site. These investigations have been performed as required by NJDEP to address potential impacts from underground storage tanks (USTs) and the detention basin. In addition to NJDEP-required investigations, the U.S. Geological Survey (USGS) performed an investigation in the vicinity of TFTR to evaluate the effects of a potential spill of radioactive water. Also, PPPL conducted a soil vapor survey and installed numerous monitoring wells to evaluate potential ground water impacts from on-site activities. By the end of 1993, ground water investigations at the site have resulted in monitoring of 31 wells and two piezometers. Future investigations and remedial actions at PPPL will take place as required by the Memorandum of Understanding (MOU) oversight agreement.

The results of the investigations cited above are summarized in the following sections of this report: Section 6.1.2 (A)— "Hydrological Studies from 1989 to 1993;" Section 6.1.2 (B) —"NJPDES Quarterly Ground Water Monitoring Program;" Section 6.1.2 (C) — "Regional Ground Water Monitoring Program;" and Section 6.1.2. (D) — "Underground Storage Tank (UST) Ground Water Monitoring Program."

Generally, all the parameters measured in the above investigations meet the New Jersey Ground Water Quality Standards with the exception of, in particular wells, consistently certain volatile organic compounds, and occasionally dissolved lead. In 1990, PPPL initiated, as required by the NJPDES permit, a hydrologic investigation to characterize the ground water quality and determine ground water flow and direction. Numerous studies and tasks were performed to meet this requirement and are referenced in the above sections in this report. The ground water monitoring results showed the presence of volatile organic compounds (VOCs) —mainly, tetrachloroethene, trichloroethene, and trichloroethane—in a number of shallow wells on C site; in a number of intermediate depth wells, petroleum hydrocarbons were detected. These VOCs are commonly used or contained in solvents or metal degreasing agents, all of which have been used at PPPL. The source of the petroleum hydrocarbons are believed to have originated from underground storage tanks, which were removed when PPPL detected petroleum hydrocarbons in the surrounding soils.

The presence of dewatering sumps on D site largely influence the ground water gradient. The sumps create a shallow cone of depression, drawing the ground water, which would under normal

condition flow to the south/southeast toward Bee Brook. It appears that all the ground water on the site, except on the edges of the site, is drawn radially toward the D site sumps.

Upon formal NJDEP approval of the work plan, the regional ground water quality investigation will be performed under the conditions of the MOU. PPPL and DOE/PAO are responsible for the conduct of this investigation at C and D sites.

8.0 QUALITY ASSURANCE

Analysis of environmental samples for radioactivity was accomplished in-house by the Radiological Environmental Monitoring Laboratory (REML). The REML procedures follow the EPA HASL-300 Manual [Vo82] or other nationally recognized standards. Approved analytical techniques are documented in the REML procedures [REML90]. The PPPL participates in the EPA (Las Vegas) program as part of maintaining its certification. These programs provide blind samples for analysis and subsequent comparison to values obtained by other participants, as well as to known values.

Since CY84, PPPL initiated a program to have its REML certified by the state of New Jersey through the EPA Quality Assurance (QA) program. The REML complies with the EPA and NJDEPE QA requirements for certification. In March 1986, the REML facilities and procedures were reviewed and inspected by EPA/Las Vegas and the NJDEPE. The laboratory was certified for tritium analysis in urine and water and recertified in these areas annually since 1988. While the certification was expected to have been extended to gamma spectroscopy in 1990, as all of the EPA blind samples to date have been within expected detection limits, an official site visit has not yet been made by NJDEPE to authorize this certification.

In 1992, PPPL developed specific procedures, EN-OP-001 and EN-OP-002, "Surface Water Sampling Procedure" and "Ground Water Sampling Procedures," respectively, which provide detailed descriptions of all the NJPDES permit-required sampling and analytical methods for the collection of samples, the analyses of these samples, and the quality assurance/quality control requirements. Following these procedures are a requirement that all subcontractor laboratories and/or PPPL employees must meet. Chain-of-custody forms are required for all samples; holding times are closely checked to ensure that the analysis was performed within the established holding time 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.

Split and duplicate samples were analyzed by the subcontractor laboratory, Northeastern Analytical Corporation. The results of these samples are shown in Table 39. This laboratory participates in a state of New Jersey QA program and has quality assurance plans [NAC90].

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List of Tables

Table 1. TFTR 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. Critical Pathways

Path I.D.	Discharge Pathway		
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

Table 3. Monitoring Program Covering Critical Pathways

Type of Sample	Critical Path I.D.	Sample Point Description	Sampling Frequency	Analysis
Surface	L1,L2,L3 & A3	1) Cooling Water Discharge Drainage 2) Bee Brook Upstream & Downstream 3) D&R Canal	Monthly	Tritium and Gamma Spectroscopy
Soil & Sod	A3	Within 1 km radius		Tritium and Gamma Spectroscopy
Biota (Fruits & Vegetables)	A3	Within 3 km radius	Seasonal	Tritium & Gamma Spectroscopy
Surface Water	L1, L2	Liquid Effluent Collection Tanks	As Required by Filling	Tritium and Gamma Spectroscopy, Volume
Air	A1-A3	Test Cell	Continuous	Activated Air (Gross b) ^{3}H (HT and HTO)
Air	A1-A3	Vault	Continuous	^{3}H (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, ^{3}H (HT and HTO), Gross b for activated air & particulates with Gamma Spectroscopy, TLD
Direct & Air (off-site)		6 Locations off-site within 1 km radius	Continuous (integrated)	^{3}H (HT and HTO), TLD for air g, Gamma Spec. for particulates

Table 4*
Population of Municipalities Within 0-10 Miles of PPPL
1985-2010

Municipality	1985[1]	1995	2000	2005	2010	
Mercer County (Total)[2]	317,685	349,700	359,400	364,200	377,100	Mercer County (Total)
Mercer County (Part)	190,683	219,550	228,100	230,550	240,500	Mercer County (Part)
East Windsor Twp.	22,682	24,750	26,000	26,350	29,350	East Windsor Twp.
Hightstown Borough	4,494	5,050	5,100	5,100	5,100	Hightstown Borough
Hamilton Twp.	85,766	88,850	90,000	91,200	94,450	Hamilton Twp.
Hopewell Twp.	11,040	13,025	15,000	15,200	16,200	Hopewell Twp.
Hopewell Borough	2,013	2,075	2,100	2,100	2,100	Hopewell Borough
Pennington Borough	2,232	2,300	2,300	2,350	2,400	Pennington Borough
Lawrence Twp.	22,804	31,100	33,900	34,000	34,100	Lawrence Twp.
Princeton Twp.	14,202	14,550	14,700	14,900	15,400	Princeton Twp.
Princeton Borough	12,031	12,650	12,700	12,700	12,700	Princeton Borough
Washington Twp.	3,719	8,650	8,800	8,900	9,200	Washington Twp.
West Windsor Twp.	9,700	16,550	17,550	17,750	19,500	West Windsor Twp.
Middlesex County (Total)[2]	626,703	695,432	724,610	760,800	791,800	Middlesex County (Total)
Middlesex County (Part)	121,984	171,183	192,396	202,000	219,100	Middlesex County (Part)
Cranbury Twp.	2,145	5,695	8,033	8,450	8,800	Cranbury Twp.
East Brunswick Twp.	40,770	43,630	44,753	47,000	50,900	East Brunswick Twp.
Helmetta Borough	973	965	949	950	950	Helmetta Borough
Monroe Twp.	19,255	28,711	34,737	36,500	38,200	Monroe Twp.
Jamesburg Borough	4,402	4,723	4,805	5,050	5,050	Jamesburg Borough
North Brunswick Twp.	25,427	31,495	33,916	35,600	37,000	North Brunswick Twp.
Plainsboro Twp.	9,040	15,662	17,161	18,000	20,700	Plainsboro Twp.
South Brunswick Twp.	19,972	40,304	48,042	50,450	57,500	South Brunswick Twp.
Somerset County (Total)[2]	210,318	250,025	263,800	279,765	295,730	Somerset County (Total)
Somerset County (Part)	65,276	89,280	97,820	106,610	115,400	Somerset County (Part)
Franklin Twp.	33,952	47,945	52,790	57,790	62,790	Franklin Twp.
Hillsborough Twp	22,652	28,485	30,900	33,375	35,850	Hillsborough Twp.
Montgomery Twp.	7,970	12,145	13,420	14,725	16,030	Montgomery Twp.
Rocky Hill Borough	702	705	710	720	730	Rocky Hill Borough
Monmouth County (Total)[2]	530,913	568,100	591,600	604,300	613,450	Monmouth County
Millstone Twp.	4,234	5,617	7,000	9,286	11,571	Millstone Twp.

* Taken from Bender [Be87a].

[1] New Jersey Department of Labor. Population Estimates for New Jersey, July 1, 1985.

[2] See methodology in Appendix of Be87a for details on the source and derviation of County and Municipal Projections.

Table 5*
Population of Counties Within 0-50 Miles of PPPL
1985-2010

County	1985 Estimates	1995 Projections	2000 Projections	2005 Projections	2010 Projections	
New Jersey[1]	7,562,000	8,154,000	8,450,300	8,685,200	8,895,700	New Jersey
Atlantic	205,100	245,100	260,100	272,300	283,200	Atlantic
Bergen	841,200	861,800	878,700	891,900	904,000	Bergen
Burlington	380,100	437,100	467,200	494,900	521,300	Burlington
Camden	488,100	555,400	577,200	597,300	616,700	Camden
Essex	845,700	794,000	795,500	779,900	762,300	Essex
Gloucester	207,100	234,500	249,100	263,500	277,400	Gloucester
Hudson	555,900	560,100	548,100	528,500	507,300	Hudson
Hunterdon	92,800	104,500	113,000	121,900	131,000	Hunterdon
Mercer	317,700	349,700	359,400	364,200	377,100	Mercer
Middlesex	626,700	695,432	724,610	760,800	791,800	Middlesex
Monmouth	530,900	568,100	591,600	604,300	613,450	Monmouth
Morris	417,100	479,900	510,500	540,800	570,500	Morris
Ocean	380,000	449,600	484,400	515,800	545,900	Ocean
Passaic	461,400	468,600	469,100	466,500	462,000	Passaic
Somerset	210,318	250,025	263,800	279,765	295,730	Somerset
Sussex	119,600	146,100	159,600	172,900	185,700	Sussex
Union	506,700	534,500	539,700	540,900	540,000	Union
Warren	85,200	92,700	96,200	99,300	101,900	Warren
New York[2]	17,783,000	18,314,022	18,548,262	18,750,076	18,948,273	New York
Bronx	1,198,598	1,199,410	1,205,047	1,213,270	1,224,052	Bronx
Kings	2,248,139	2,228,361	2,232,835	2,242,890	2,254,228	Kings
Nassau	1,332,393	1,344,197	1,333,458	1,315,938	1,292,457	Nassau
New York	1,455,619	1,454,633	1,454,251	1,456,292	1,456,707	New York
Queens	1,917,172	1,919,057	1,925,510	1,933,829	1,953,634	Queens
Richmond	371,679	419,706	443,048	465,818	489,111	Richmond
Pennsylvania[3]	11,863,674	12,100,149	12,101,253	12,161,780	12,222,306	Pennsylvania
Bucks	512,705	576,716	601,168	636,276	673,345	Bucks
Chester	334,311	379,733	395,958	418,726	442,802	Chester
Delaware	557,180	541,442	531,068	525,279	519,554	Delaware
Lehigh	277,914	291,083	294,836	300,762	306,808	Lehigh
Monroe	78,967	104,133	117,583	134,162	153,079	Monroe
Montgomery	663,164	692,521	698,281	712,666	727,346	Montgomery
Northhampton	231,430	244,668	249,000	255,275	261,707	Northhampton
Philadelphia	1,637,434	1,599,620	1,513,674	1,472,959	1,433,333	Philadephia

* Taken from Bender [Be87a].
[1] Office of Demographic and Economic Analysis, N.J. Department of Labor and Industry, 1986.
[2] State Data Center, New York State Department of Commerce, 1985.
[3] State Data Center, Pennsylvania Department of Commerce, 1986. See methodology in Be87 Appendix for details on 2005 and 2010 projections.

Table 6*

Population of Metropolitan Areas Within 50 Miles of PPPL

Metropolitan Areas[1]	1980 Census	July 1985 Estimate	Percent Change
Allentown-Bethlehem MSA (NJ Portion)	84,429	85,200	0.9%
Jersey City, NJ PMSA	556,972	555,900	-0.2%
Monmouth-Ocean PMSA	849,211	910,900	7.3%
Middlesex-Somerset-Hunterdon PMSA	886,383	929,800	4.9%
New York, NY CMSA	8,274,961	8,410,058	1.6%
Newark, NJ PMSA	1,879,147	1,889,000	0.5%
Bergen-Passaic PMSA	1,292,970	1,302,600	0.7%
Philadelphia, PA PMSA (NJ Portion)	1,034,109	1,075,300	4.0%
Trenton, NJ PMSA	307,863	317,700	3.2%

* Taken from Bender [Be87a].

[1] MSA = Metropolitan Statistical Area
CMSA = Consolidated Metropolitan Statistical Area
PMSA = Primary Metropolitan Statistical Area

Source: State of New Jersey, Department of Labor; New York State Department of Commerce

Table 7*

1995 Population Estimates Within Annular Sectors, 0-10 Miles

Sector	0-1 Miles	1-2 Miles	2-3 Miles	3-4 Miles	4-5 Miles	5-10 Miles	Total 0-10 Miles	Sector
N	0	134	387	0	91	6,241	6,853	N
NNE	0	27	388	3,340	5,242	12,841	21,838	NNE
NE	0	0	0	486	902	21,084	22,472	NE
ENE	0	1,551	273	268	689	5,072	7,853	ENE
E	0	0	268	134	1,678	13,695	15,775	E
ESE	0	827	2,140	1,605	2,235	5,195	12,002	ESE
SE	151	1,605	291	338	493	20,928	23,806	SE
SSE	484	1,454	894	166	803	11,042	14,843	SSE
S	0	982	4,675	3,093	2,354	5,559	16,663	S
SSW	4	188	3,344	2,522	2,908	32,176	41,142	SSW
SW	0	1,077	332	544	2,796	21,450	26,199	SW
WSW	0	989	2,828	1,130	1,594	10,828	17,369	WSW
W	0	2,321	6,005	6,963	2,487	9,277	27,053	W
WNW	53	585	800	3,256	128	4,438	9,260	WNW
NW	0	1,365	898	335	468	4,716	7,782	NW
NNW	0	803	668	268	671	9,487	11,897	NNW
Totals	692	13,908	24,191	24,448	25,539	194,029	282,807	Totals

* Taken from Bender [Be87a]

Table 8*

2000 Population Estimates Within Annular Sectors, 0-10 Miles

Sector	0-1 Miles	1-2 Miles	2-3 Miles	3-4 Miles	4-5 Miles	5-10 Miles	Total 0-10 Miles	Sector
N	0	146	421	0	99	6,792	7,458	N
NNE	0	29	422	3,635	5,560	13,974	23,620	NNE
NE	0	0	0	656	1,217	22,582	24,455	NE
ENE	0	1,688	297	292	895	5,520	8,692	ENE
E	0	0	292	146	2,261	14,904	17,603	E
ESE	0	1,081	2,329	1,747	2,940	5,799	13,896	ESE
SE	164	1,747	393	368	609	21,615	24,896	SE
SSE	527	1,945	1,154	224	874	12,016	16,740	SSE
S	0	1,069	4,968	3,366	2,562	6,050	18,015	S
SSW	4	254	3,639	3,869	3,890	33,710	45,366	SSW
SW	0	1,172	252	469	4,566	22,473	28,932	SW
WSW	0	1,076	2,354	1,169	1,645	11,784	18,028	WSW
W	0	2,526	6,070	7,028	2,522	10,334	28,480	W
WNW	58	637	810	3,297	173	5,286	10,261	WNW
NW	0	1,485	909	347	509	5,132	8,382	NW
NNW	0	874	727	292	730	10,316	12,939	NNW
Totals	753	15,729	25,037	26,905	31,052	208,287	307,763	Totals

* Taken from Bender [Be87a]

Table 9*

2005 Population Estimates Within Annular Sectors, 0-10 Miles

Sector	0-1 Miles	1-2 Miles	2-3 Miles	3-4 Miles	4-5 Miles	5-10 Miles	Total 0-10 Miles	Sector
N	0	151	435	0	102	7,014	7,702	N
NNE	0	30	436	3,754	5,688	14,431	24,339	NNE
NE	0	0	0	725	1,344	23,187	25,256	NE
ENE	0	1,743	307	302	978	5,701	9,031	ENE
E	0	0	302	151	2,496	15,392	18,341	E
ESE	0	1,184	2,405	1,804	3,224	6,043	14,660	ESE
SE	169	1,804	434	380	656	21,892	25,335	SE
SSE	544	2,143	1,259	247	903	12,409	17,505	SSE
S	0	1,104	5,086	3,476	2,646	6,248	18,560	S
SSW	4	281	3,758	4,211	4,286	34,329	46,869	SSW
SW	0	1,210	277	492	5,038	22,986	30,003	SW
WSW	0	1,111	2,496	1,185	1,666	12,170	18,628	WSW
W	0	2,609	6,096	7,054	2,536	10,761	29,056	W
WNW	60	658	814	3,313	191	5,628	10,664	WNW
NW	0	1,534	913	352	526	5,300	8,625	NW
NNW	0	903	751	302	754	10,651	13,361	NNW
Totals	777	16,465	25,769	27,748	33,034	214,142	317,935	Totals

* Taken from Bender [Be87a]

Table 10*

2010 Population Estimates Within Annular Sectors, 0-10 Miles

Sector	0-1 Miles	1-2 Miles	2-3 Miles	3-4 Miles	4-5 Miles	5-10 Miles	Total 0-10 Miles	Sector
N	0	161	465	0	109	7,505	8,240	N
NNE	0	32	466	4,016	5,971	15,441	25,926	NNE
NE	0	0	0	875	1,625	24,521	27,021	NE
ENE	0	1,865	328	322	1,161	6,099	9,775	ENE
E	0	0	322	161	3,016	16,468	19,967	E
ESE	0	1,411	2,574	1,930	3,852	6,580	16,347	ESE
SE	182	1,930	525	407	749	22,503	26,306	SE
SSE	582	2,580	1,491	300	965	13,278	19,196	SSE
S	0	1,181	5,347	3,719	2,831	6,685	19,763	S
SSW	5	339	4,021	4,965	5,161	35,696	50,187	SSW
SW	0	1,295	333	542	6,080	23,797	32,047	SW
WSW	0	1,189	2,808	1,219	1,711	13,021	19,948	WSW
W	0	2,791	6,154	7,112	2,568	11,703	30,328	W
WNW	64	703	822	3,349	230	6,383	11,551	WNW
NW	0	1,641	923	363	563	5,671	9,161	NW
NNW	0	965	803	322	807	11,408	14,305	NNW
Totals	833	18,083	27,382	29,602	37,409	226,759	340,068	Totals

* Taken from Bender [Be87a]

Table 11*

1995 Population Estimates Within Annular Sectors, 10-50 Miles

Sector	10-20 Miles	20-30 Miles	30-40 Miles	40-50 Miles	Total 10-50 Miles	Sector
N	77,600	43,286	209,880	82,344	413,110	N
NNE	151,656	244,555	345,449	501,569	1,243,229	NNE
NE	189,192	466,816	1,282,528	3,531,064	5,469,602	NE
ENE	149,614	244,189	1,075,798	1,444,205	2,913,807	ENE
E	48,224	130,379	80,443	0	259,046	E
ESE	33,170	44,653	147,906	0	225,728	ESE
SE	15,551	95,456	212,796	6,924	330,726	SE
SSE	3,462	15,691	24,278	43,521	86,953	SSE
S	3,798	65,696	13,638	3,437	86,568	S
SSW	58,457	70,504	134,375	224,101	487,438	SSW
SW	254,358	385,409	1,167,023	1,035,758	2,842,548	SW
WSW	55,741	167,298	319,088	309,761	851,889	WSW
W	13,209	44,869	115,585	68,595	242,258	W
WNW	9,332	14,133	17,280	265,316	306,061	WNW
NW	15,675	21,005	72,663	91,959	201,302	NW
NNW	29,653	15,445	38,640	25,334	109,071	NNW
Totals	1,108,692	2,069,384	5,257,370	7,633,889	16,069,335	Totals

* Taken from Bender [Be87a]

Table 12*

2000 Population Estimates Within Annular Sectors, 10-50 Miles

Sector	10-20 Miles	20-30 Miles	30-40 Miles	40-50 Miles	Total 10-50 Miles	Sector
N	81,590	45,762	223,566	89,117	440,035	N
NNE	158,049	250,338	354,421	507,150	1,269,959	NNE
NE	193,977	478,786	1,286,928	3,538,387	5,498,078	NE
ENE	152,903	256,310	1,081,795	1,447,794	2,938,803	ENE
E	47,314	135,772	83,771	0	266,857	E
ESE	31,627	46,500	154,983	0	233,110	ESE
SE	16,320	102,409	229,267	7,460	355,455	SE
SSE	3,730	16,906	26,158	46,890	93,683	SSE
S	3,687	70,220	14,577	3,655	92,139	S
SSW	60,661	75,359	142,235	234,143	512,399	SSW
SW	262,872	389,374	1,137,316	1,011,964	2,801,526	SW
WSW	57,234	172,994	316,136	311,387	857,751	WSW
W	13,585	46,771	118,755	69,700	248,812	W
WNW	10,091	15,112	18,138	269,393	312,733	WNW
NW	16,950	22,713	75,734	93,637	209,035	NW
NNW	31,170	16,701	40,885	26,602	115,358	NNW
Totals	1,141,761	2,142,027	5,304,664	7,657,280	16,245,732	Totals

* Taken from Bender [Be87a]

Table 13*

2010 Population Estimates Within Annular Sectors, 10-50 Miles

Sector	10-20 Miles	20-30 Miles	30-40 Miles	40-50 Miles	Total 10-50 Miles	Sector
N	91,018	51,262	250,373	102,263	494,916	N
NNE	172,722	258,877	362,497	510,423	1,304,520	NNE
NE	209,861	499,736	1,260,255	3,552,301	5,522,153	NE
ENE	164,784	277,228	1,099,303	1,464,153	3,005,468	ENE
E	47,676	140,787	86,865	0	275,327	E
ESE	30,472	48,217	163,289	0	241,978	ESE
SE	17,263	114,276	258,374	8,407	398,321	SE
SSE	4,203	19,052	29,479	52,843	105,577	SSE
S	4,009	78,351	16,265	4,007	102,632	S
SSW	65,172	84,086	156,390	252,607	558,255	SSW
SW	284,516	410,918	1,123,253	998,753	2,817,440	SW
WSW	61,714	190,521	321,293	322,263	895,791	WSW
W	15,337	52,386	128,998	73,884	270,605	W
WNW	11,698	17,340	20,389	281,867	331,295	WNW
NW	19,650	26,331	81,471	98,437	225,889	NW
NNW	34,761	19,362	45,199	28,849	128,171	NNW
Totals	1,234,856	2,288,731	5,403,694	7,751,059	16,678,339	Totals

* Taken from Bender [Be87a]

Table 14. Summary of Environmental Permits for 1993

NJDEPE Permit No.	Permit Type	Issue Date	Expiration Date	Status
0086029	NJPDES Groundwater	4/1/89	12/31/94	In compliance. Adjudicatory hearing pending, relating to wells placed at B-site. Renewal application in progress.
0023922	NJPDES Surface water	1/21/94 Effective 3/01/94	02/28/99	Received final permit renewal. Stormwater and D&R pumphouse filter backwash sampling requirements —new. Toxicity testing req'd.
092187	TFTR Diesel Exhaust	10/24/89	10/24/94	Current. NJ Air Plant Id. No. 15952.
096074	C-site Diesel Exhaust	6/28/90	6/28/95	Current.
094831	Hot Cell Degreaser Vent	3/30/90	6/16/97	Current. Permit modifications in progress.
090735	FCPC Building Degreaser Vent	6/6/89	5/31/95	Current. Permit modifications in progress.
826	Elizabethtown Water Physical Connection	4/1/94	3/31/95	Current.
148539	UST Registration	4/1/93	3/31/94	Received renewal application from DEPE.
089962	Diesel Tank E8 Vent	11/22/88	11/22/93	Renewal notice sent to DOE 8/2/93.; due 8/24/93; sent copy of cancelled check to DEPE 12/10/93.
061295	Boiler #2 Stack Vent	3/31/82	3/31/97	Current. DEPE rec'd permti amendments 4/25/94.
061296	Boiler #3 Stack Vent	3/31/82	3/31/97	Current. DEPE rec'd permti amendments 4/25/94.
061297	Boiler #4 Stack Vent	3/31/82	3/31/97	Current. DEPE rec'd permti amendments 4/25/94. .
061299	Boiler #5 Stack Vent	3/31/82	3/31/97	Current. DEPE rec'd permti amendments 4/25/94.
061298	Oil Storage Tank Vent No. 2	3/31/82	3/31/97	Current.
0128306	Medical Waste Generator	7/22/91	7/21/94	Current.
DR-18A	D&R Canal Water Use Agreement	7/1/84	6/30/2009	Current.
12471	REML LabCertification	7/1/91	6/30/94	Current.
111580	CAS Dust Collector	3/10/93	3/10/98	Current.
113444	FED Dust Collector	7/23/93	7/23/98	Current.
113445	Shop Dust Collector	7/23/93	7/23/98	Current.
92-7082-4N	TWA - Detention Basin	2/26/93	2/25/95	Construction permit.
1218-92-0003.2	Freshwater Wetlands General Permit 11	7/15/93	3/16/97	Construction of stormwater outfall structures—detention basin mod.
separate list	Well Permits			Actively used wells are maintained.
114785	Air Permit - AGT I	10/25/93	10/25/98	Current-25,000 gal.# 4 15,000 gal. diesel
1218-92-0002.3SE	Stream Encroachment	11/23/92	11/23/9	Current. Replace headwall.
22-93-NC	SBRSA Industrial Discharge Permit			Permit still draft; final permit not expected until 1995.
1218-91-0001.5 1218-91-0001.3	Wetlands Permits (GP1)(GP7)	4/6/94	3/16/97	Rec'd permits and waiver - HMSF trans.area waiver; sprinkler mod GP 7; and AC Power line maint GP1.
1218-91-0001.2	Wetlands—Letter of Interpretation	1/13/94	1/13/99	DEPE delineated wetlands boundaries and transition area 72 acre PPPL site.
92-0363	Freehold Soil Conservation District	6/16/93	12/16/96	Soil erosion and sediment control for detention basin modifications.

Table 15. Summary of 1993 Emissions and Doses From TFTR

RADIO-NUCLIDE & PATHWAY	QUANTITY RELEASED IN 1993[1]	EDE AT THE SITE BOUNDARY	EDE AT THE NEAREST BUSINESS[2]	POPULATION DOSE WITHIN 80 km[3]
Tritium (air)	16.3 Ci HTO[4], 14 Ci HT	4.3×10^{-2} mrem[5]	1.2×10^{-2} mrem[6]	9.8×10^{-1} person-rem[7]
Ar-41 (air)	1.78 Ci[4]	7.1×10^{-3} mrem[8]	2.0×10^{-3} mrem[6]	1.0×10^{-2} person-rem[9]
N-13 (air)	0.87 Ci[4]	2.4×10^{-3} mrem[8]	6.7×10^{-4} mrem[6]	3.0×10^{-4} person-rem[9]
N-16 (air)	0.07 Ci[4]	4.7×10^{-6} mrem[8]	1.3×10^{-6} mrem[6]	Negligible
Cl-40 (air)	0.11 Ci[4]	9.0×10^{-4} mrem[8]	2.5×10^{-4} mrem[6]	Negligible
S-37 (air)	0.11 Ci[4]	1.2×10^{-3} mrem[8]	3.4×10^{-4} mrem[6]	Negligible
Direct & Scattered Neutrons and Gamma Radiation	----------	9.3×10^{-3} mrem[10]	2.3×10^{-3} mrem[11]	Negligible
Tritium (HTO) (water)	5.2×10^{-3} Ci[12]	1.0×10^{-4} mrem[13]	----------	1.0×10^{-4} person-rem[14]
Total	----------	6.4×10^{-2} mrem	1.8×10^{-2} mrem	9.9×10^{-1} person-rem
Background	----------	600 mrem[15]	600 mrem[15]	1.6×10^{6} person-rem

EDE - effective dose equivalent
Ar-41 - Argon-41
N-13 - Nitrogen-13
N-16 - Nitrogen-16
Cl-40 - Chlorine-40
S-37 - Sulfur-37
HTO - Tritium in water
HT - Tritium
Ci - Curies
mrem - milli radiation equivalent man
Kkm- kilometer

Table 15. Summary of 1993 Emissions and Doses from TFTR Footnotes

[1]Tritium (HTO and HT) quantities are as measured by the TFTR passive stack monitor; Ar-41, N-13, N-16, Cl-40, and S-37 quantities are based on production of 7.2 E18 D-D neutrons, and 1.65 E19 D-T neutrons in 1993, using methodology of JL-542, Rev.1, 2/5/93 for releases during D-T operation.

[2]At Princeton Bank Building, 351 meters east of TFTR stack.

[3]Based on year 1995 population figures as utilized for TFTR D-T EA. See Table 4 of Bentz and Bender, 1987.

[4]Measured for tritium (see footnote #1); per PPPL memorandum, D. Jassby to V. Finley, 3/4/94 for other air emissions.

[5]Based on NOAA X/Q [Start, 1989] and JL-457, 7/2/92, Table 1 (1% of HT releases are assumed to convert to HTO); (16.3 Ci x 2.6 E-03 mrem/Ci) + (0.14 Ci x 2.6 E-03 mrem/Ci) + (13.86 Ci x 1.05 E-07 mrem/Ci).

[6]Based on 28% of the NOAA X/Q at the site boundary [Start, 1989].

[7]Scaling from values used for the TFTR D-T EA, we get (30.3 Ci/500 Ci) x 16.2 person-rem = 9.8×10^{-1} person-rem.

[8]Based on NOAA X/Q [Start, 1989] and JL-457, 7/2/92, Table 1; Ar-41: 1.78 Ci x 4.0 E-03 mrem/Ci. N-13: 0.87 Ci x 2.8 E-03 mrem/Ci. N-16: 0.07 Ci x 6.71 E-05 mrem/Ci. Cl-40: 0.11 Ci x 8.2 E-03 mrem/Ci. S-37: 0.11 Ci x 1.08 E-02 mrem/Ci.

[9]Scaling from values used for the TFTR D-T EA, we get for Ar-41: (1.78 Ci/115 Ci) x 0.67 person-rem = 1.0 E-02 person-rem; for N-13: (0.87 Ci/434 Ci) x 0.149 person-rem = 3.0 E-04 person-rem.

[10]As measured in field.

[11]Based on inverse square decrease between site boundary (176 meters) and nearest business (351 meters).

[12] Released from Liquid Effluent Collection Tanks (LECT) to Stony Brook Sewer Authority treatment facility via PPPL sanitary sewer system.

[13] Based on usage of 1 E10 liters/yr for Stony Brook treatment facility, as per TFTR D-T EA, the dose to a person who drank all his/her water from the waterway (Millstone River) into which the treatment facility discharged in 1993 would be [(5.2 E-03 Ci/yr)(/1 E10 l/yr)] x [(4 mrem)/(2 E-08 Ci/l)] = 1.0 E-04 mrem

[14] Based on use of Millstone River as drinking water source for 500,000 people for 1 day per year (estimate by Elizabethtown Water Company of actual use is a few hours once every several years).

[15] Based on 100 mrem annual background dose exclusive of radon, plus dose due to exposure to average radonconcentration in Plainsboro homes (Memo, J. Greco to J. Levine, 11/13/90, "Radon Dose Equivalent," JMG-160).

Table 16. 1993 Precipitation and Tritium in Precipitation at PPPL

Week Start Dates	Period	Precipitation in Inches	Total Precipitaion per month	Cumulative Total Precipitation	Tritium Concentration
1/4/93	1	1.100		1.100	
1/1/93	2	0.500		1.600	
1/18/93	3	0.650		2.250	
1/25/93	4	0.000	2.250 Jan	2.250	
2/1/93	5	0.100		2.350	
2/8/93	6	1.425		3.775	
2/15/93	7	0.950		4.725	
2/22/93	8	0.000	4.725 Feb	4.725	
3/1/93	9	1.900		6.625	
3/8/93	10*	0.450		7.075	
3/15/93	11	1.050		8.125	
3/22/93	12	2.300		10.425	
3/29/93	13	2.275	7.975 Mar	12.700	
4/5/93	14	0.250		12.950	
4/12/93	15	1.350		14.300	
4/19/93	16	1.200		15.500	
4/26/93	17	0.700	3.500 April	16.200	81.67
5/3/93	18	0.225		16.425	
5/10/93	19	0.150		16.575	
5/17/93	20	0.450		17.025	55.99
5/24/93	21	1.950		18.975	52.24
5/31/93	22	0.050	2.285 May	19.025	55.35
6/5/93	23	0.150		19.175	
6/14/93	24	0.550		19,725	
6/21/93	25	0.250		19.975	53.76
6/28/93	26	0.950	1.900 June	20.925	37.67

Tritium concentration measured in pCi/l or picoCuries per liter.

*Due to high winds and icy conditions measured precipitation does not reflect the actual amount, which is estimated to be 1.2 inches.

Table 16. (cont.) 1993 Precipitation and Tritium in Precipitation at PPPL

Week Start Dates	Period	Precipitation in inches	Total Precipitaion per month	Cumulative Total Precipitation	Tritium Concentration
7/5/93	27	0.000		20.925	
7/12/93	28	2.150		23.075	
7/19/93	29	0.00		23.075	
7/27/93	30	0.050	2.200 July	23. 125	52.35
8/2/93	31	0.700		23.825	
8/9/93	32	0.000		23.825	57
8/16/93	33	1.450		25.275	93.06
8/23/93	34	0.500		25.775	
8/30/93	35	0.100	2.750 Aug	25.875	37.54
9/6/93	36	1.500		27.375	78
9/13/93	37	1.125		28.500	
9/20/93	38	2.375		30.875	87
9/28/93	39	0.900	5.900 Sept	31.775	45
10/4/93	40	0.000		31.775	
10/11/93	41	2.000		33.775	64.44
10/18/93	42	1.450		35.225	
10/25/93	43	1.000	4.450 Oct	36.625	36.91
11/1/93	44	0.430		36.655	31.31
11/8/93	45	0100		36.755	71.01
11/15/93	46	0.050		36.805	
11/22/93	47	2.100		36.905	145.00
11/29/93	48	2.150	4.830 Nov	41.055	24.52
12/6/93	49	0.400		41.455	37.77
12/13/93	50	0.125		41.580	
12/20/93	51	1.051		42.631	
12/27/93	52	0.100	1.676 Dec	42.731	
Total for 1993				**42.731**	

Tritium concentration measured in pCi/l or picoCuries per liter.

Table 17. Tritium Concentrations from the TFTR Stack for 1993

Sample Start Date/Time	Sample Stop Date/Time	Total Stack Volume Release (m3)	HTO Activity (pCi/m3)	HT Activity (pCi/m3)	Total Stack HTO Release (pCi)	Total Stack HT Release (pCi)
7/1/93	7/8/93	6.42E+06	5.15E+01	2.32E+03	3.31E+08	1.49E+10
7/8/93	7/15/93	6.42E+06	1.64E+02	4.64E+03	1.06E+09	2.98E+10
7/15/93	7/19/93	3.61E+06	7.29E+02	1.16E+05	2.63E+09	4.17E+11
7/15/93	7/19/93	5.43E+05	2.53E+04	2.56E+06	1.37E+10	1.39E+12
7/19/93	7/22/93	2.26E+06	5.50E+02	1.85E+04	1.24E+09	4.17E+10
7/22/93	7/29/93	2.84E+06	4.79E+02	5.49E+02	1.36E+09	1.56E+09
7/22/93	7/29/93	3.60E+06	3.88E+02	1.29E+04	1.39E+09	4.62E+10
7/29/93	8/5/93	6.38E+06	4.44E+02	1.32E+04	2.84E+09	8.46E+10
8/5/93	8/12/93	6.44E+06	5.15E+02	1.72E+03	3.32E+09	1.11E+10
8/12/93	8/19/93	5.54E+06	3.46E+02	8.26E+03	1.91E+09	4.57E+10
8/12/93	8/19/93	8.68E+05	2.67E+02	8.18E+03	2.32E+08	7.1E+09
8/19/93	8/26/93	6.40E+06	2.92E+02	8.29E+03	1.87E+09	5.31E+10
8/26/93	9/2/93	5.54E+06	2.66E+02	4.28E+03	1.47E+09	2.37E+10
8/26/93	9/2/93	8.95E+05	2.12E+02	2.85E+03	1.90E+08	2.55E+09
9/2/93	9/9/93	2.49E+06	2.16E+02	2.38E+03	5.38E+08	5.94E+09
9/2/93	9/9/93	3.92E+06	1.86E+02	4.02E+03	7.29E+08	1.58E+10
9/9/93	9/16/93	6.44E+06	1.80E+02	2.67E+03	1.16E+09	1.72E+10
9/16/93	9/23/93	3.45E+06	1.47E+02	2.31E+03	5.06E+08	7.98E+09
9/16/93	9/23/93	2.96E+06	1.42E+02	2.45E+03	4.19E+08	7.23E+09
9/23/93	9/30/93	3.78E+06	2.03E+02	2.01E+03	7.68E+08	7.6E+09
9/23/93	9/30/93	2.66E+06	0.00E+00	3.09E+00	0.00E+00	8232692
9/30/93	10/7/93	3.56E+06	2.15E+02	2.92E+03	7.66E+08	1.04E+10
9/30/93	10/7/93	2.87E+06	1.76E+02	1.92E+03	5.03E+08	5.5E+09
10/7/93	10/14/93	6.38E+06	7.65E+02	4.24E+03	4.88E+09	2.71E+10
10/14/93	10/15/93	1.19E+06	3.53E+02	1.26E+03	4.18E+08	1.49E+09
10/15/94	10/21/93	2.83E+06	2.55E+02	3.98E+02	7.22E+08	1.13E+09
10/15/94	10/21/93	2.41E+06	3.05E+02	1.63E+03	7.34E+08	3.92E+09
10/21/93	10/28/93	3.59E+06	4.17E+02	3.64E+02	1.50E+09	1.31E+09
10/21/93	10/28/93	2.87E+06	2.54E+02	5.68E+02	7.29E+08	1.63E+09
10/28/93	11/4/94	2.87E+06	3.54E+02	8.36E+02	1.01E+09	2.4E+09
10/28/93	11/4/94	3.59E+06	3.80E+02	2.58E+03	1.37E+09	9.29E+09
11/4/93	11/11/93	3.56E+06	2.40E+02	1.37E+02	8.53E+08	4.85E+08
11/4/93	11/11/93	2.81E+06	2.54E+04	5.29E+03	7.14E+10	1.49E+10
11/11/93	11/18/93	2.79E+06	8.89E+04	8.04E+02	2.48E+11	2.24E+09
11/11/93	11/18/93	3.63E+06	7.17E+02	5.46E+03	2.60E+09	1.98E+10
11/18/93	11/24/93	3.61E+06	5.79E+04	1.64E+02	2.09E+11	5.91E+08
11/18/93	11/24/93	1.89E+06	5.47E+03	3.08E+03	1.03E+10	5.83E+09
11/24/93	12/2/93	1.34E+06	1.65E+03	8.06E+02	2.21E+09	1.08E+09
11/24/93	12/2/93	6.00E+06	4.59E+02	4.93E+03	2.76E+09	2.96E+10
12/2/93	12/9/93	2.77E+06	5.32E+04	8.26E+02	1.47E+11	2.29E+09
12/2/93	12/9/93	3.65E+06	2.11E+04	1.26E+04	7.69E+10	4.61E+10
12/9/93	12/16/93	2.83E+06	3.57E+05	4.74E+03	1.01E+12	1.34E+10
12/9/93	12/16/93	3.59E+06	8.96E+04	9.30E+04	3.22E+11	3.34E+11
12/16/93	12/20/93	3.56E+06	6.22E+05	2.11E+04	2.21E+12	7.49E+10
12/16/93	12/20/93	1.15E+05	1.13E+05	4.51E+05	1.29E+10	5.17E+10
12/20/93	12/23/93	2.70E+06	2.53E+06	1.17E+06	6.85E+12	3.16E+12
12/23/93	12/30/93	6.51E+06	3.19E+05	1.06E+06	2.07E+12	6.89E+12
12/30/93	1/6/94	6.35E+06	4.78E+05	1.65E+05	3.03E+12	1.05E+12
TOTAL					1.63E+13	1.4E+13

Table 18. Tritium Concentrations in Surface Water for 1993

Collection Date	B 1	B 2	C 1	D 1	D 2	Baseline
January			27.41		35.28	
February	47.3	51.18	70.46	40.1	57.18	64.41
March						
April	41.37	49.26	53.85	58.34	38.22	43.86
May	36.98	37.46	50.14	43.36	39.23	49
June	40.74	28.61	41.75	57	41.6	40.63
July	48.33	47.72	52.05	59.5	73.06	73.93
August	53.65	41.9	38.75	37.1	69.55	31.8
September						
October	49.46	52.87	48.26	58.11	51.57	60.7
November	39.13	56.79	57.32	75.37	62.02	46.62
December	42.71	54.74	45.96	51.01	40.98	67.41

Collection Date	E 1	M 1	P 1	P 2	Baseline
January	69.54	69.55	48.36	50.35	
February		63.68	39.61	59.46	64.41
March					
April	56.73	65.63	56	38.86	43.86
May	44.86	45.66	34.23	78.25	49
June	57.92	55.36	53.84	28.8	40.63
July	21.02	44.48	55.7	52.89	73.93
August	40.29	48.03	53.66	30.1	31.8
September					
October	49.85	42.54	54.41	54.39	60.7
November	53.29	52.33	61.1	44.11	46.62
December	37.55	48.89	32.77	42.4	67.41

All measurement values are in pCi/Liter.
Blank indicate sample not collected.

Table 19. Tritium Concentrations in Ground Water for 1993

Collection Date	D11	D12	TW1	TW10	TW3
February			59.12	65	
May			52.17	55.91	
August	38.28	42.29	55.7		53.68
November			56.96	51.98	

All measurement values are in pCi/Liter.
Blanks indicate that no sample was collected.

Table 20. Tritium Concentrations in Biota Moisture for 1993

Collection Date	Zucchini	Squash	Tomato	Cantaloupe	Hot Pepper	Pumpkin
July	51.8					
August		42.14	80.68	63.86		
September					139.63	
October						46.09

All measurement values are in pCi/Liter.
Blanks indicate that no sample was collected.

Table 21. 1993 Surface Water Analysis for Bee Brook, Locations B1 and B2

Parameters, Units	B1 5/13/93	B1 8/17/93	B2 5/13/93	B2 8/17/93
Chromium, mg/l	<0.01	<0.01	<0.01	<0.01
pH, units	6.50	6.10	6.90	6.44
Phenolics as phenol, mg/1	<0.05	<0.05	<0.05	<0.05
Chemical Oxygen Demand, mg/1[1]	27.0	22.0	24.0	20.0
Biochemical Oxygen Demand, 5-day total, mg/1	7.8	<4.0	7.0	4.2
Temperature, °C	16.0	21.0	16.0	21.0
Petroleum Hydrocarbons by IR, mg/1	<1.0	<1.0	<1.0	<1.0
Ammonia-N, mg/1	<0.50	<0.50	<0.50	<0.50
Total Suspended Solids, mg/1	7.0	<5.0	6.0	<5.0
Total Dissolved Solids, mg/1	110.0	72.0	190.0	120.0
Flow, Approximate GPM	No reading[2]	126	2,749	2,828

Table 22. 1993 Surface Water Analysis for D&R Canal, C1, and Ditch #5, D1

Parameters, Units	C1 5/13/93	C1 8/17/93	D1 5/13/93	D1 8/17/93
Chromium, mg/l			<0.01	<0.01
pH, units	7.23	7.11	6.90	7.14
Phenolics as phenol, mg/1	<0.05	<0.05	<0.05	<0.05
Chemical Oxygen Demand, mg/1[1]	<20.0	8.6	24.0	5.9
Biochemical Oxygen Demand, 5-day total, mg/1	<4.0	<4.0	4.4	<4.0
Temperature, °C	21.0	25.0	17.0	25.0
Petroleum Hydrocarbons by IR, mg/1	<1.0	<1.0	<1.0	<1.0
Ammonia-N, mg/1	<0.50	<0.50	<0.50	<0.50
Total Suspended Solids, mg/1	13.0	10.0	8.8	<5.0
Total Dissolved Solids, mg/1	95.0	170.0	150.0	240.0
Flow, Approximate GPM			317	317

[1]The method detection limit for chemical oxygen demand was 20.0 mg/l during January to May 1993 and 5.0 mg/l during June to December 1993.
[2]No reading is available due to meter unable to measure low flow.

Table 23. 1993 Surface Water Analysis for Potable Water Supply, E1, and Millstone River, M1

Parameters, Units	E1 5/13/93	E1 8/17/93	M1 5/13/93	M1 8/17/93
pH, units	6.78	6.78	6.70	6.69
Phenolics as phenol, mg/l	<0.05	<0.05	<0.05	<0.05
Chemical Oxygen Demand, mg/l[1]	<20.0	5.2	21.0	13.0
Biochemical Oxygen Demand, 5-day total, mg/l	<4.0	<4.0	16.0	9.6
Temperature, °C	16.0	23.0	20.0	24.0
Petroleum Hydrocarbons by IR, mg/l	<1.0	1.3	<1.0	<1.0
Ammonia-N, mg/l	<0.50	<0.50	<0.50	<0.50
Total Suspended Solids, mg/l	<5.0	<5.0	10.0	9.7
Total Dissolved Solids, mg/l	180.0	250.0	120.0	150.0

Table 24. 1993 Surface Water Analysis for Plainsboro, Locations P1 and P2

Parameters, Units	P1 5/13/93	P1 8/17/93	P2 5/13/93	P2 8/17/93
pH, units	6.30	5.96	6.73	6.48
Phenolics as phenol, mg/l	<0.05	<0.05	<0.05	<0.05
Chemical Oxygen Demand, mg/l[1]	27.0	67.0	29.0	18.0
Biochemical Oxygen Demand, 5-day total, mg/l	4.0	<4.0	6.8	<4.0
Temperature, °C	15.0	21.0	21.0	24.5
Petroleum Hydrocarbons by IR, mg/l	<1.0	1.2	<1.0	<1.0
Ammonia-N, mg/l	<0.50	<0.50	<0.50	<0.50
Total Suspended Solids, mg/l	<5.0	12.0	29.0	5.7
Total Dissolved Solids, mg/l	93.0	120.0	100.0	120.0

Table 25. 1993 Detention Basin Influents Analysis (NJPDES NJ0086029)

Parameters, Units	Inflow 1 5/13/93	Inflow 1 8/17/93	Inflow 2 5/13/93	Inflow 2 8/17/93
pH, units	6.66	7.00	7.04	7.06
Phenolics as phenol, mg/l	<0.05	<0.05	<0.05	<0.05
Chemical Oxygen Demand, mg/l[1]	<20.0	9.3	<20.0	<5.0
Biochemical Oxygen Demand, 5-day total, mg/l	<4.0	<4.0	<4.0	<4.0
Petroleum Hydrocarbons by IR, mg/l	<1.0		<1.0	
Ammonia-N, mg/l	<0.50	<0.50	<0.50	<0.50
Settleable Solids, %	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids, mg/l	140.0	150.0	280.0	260.0
Chromium, mg/l	<0.01	<0.01	<0.01	<0.01

[1]The method detection limit for chemical oxygen demand was 20.0 mg/l during January to May 1993 and 5.0 mg/l during June to December 1993.

Table 26. 1993 Monthly Surface Water Analysis for Ditch #5, Location D2 (NJPDES NJ0023922-DSN001)

Permit Limit	Parameters, Units	1/12	2/11	3/10	4/13	5/13	6/8
NA	Chromium total, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
6.0 - 9.0	pH, units	6.25		7.00	7.20	6.90	7.50
NA	Phenolics Phenol, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
50 mg/l	Chemical Oxygen Demand, mg/l[1]	<20	<20	<20	<20	<20	7.7
NA	Biochemical Oxygen Demand, 5-day total, mg/l	4.9	4.2	5.5	<4.0	6.4	<4.0
10 mg/l	Petroleum Hydrocarbons by IR, mg/l	<1	<1	<1	<1	<1	<1
NA	Ammonia-N, mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
50 mg/l	Total Suspended Solids, mg/l	25.0	11.0	6.1	<5.0	5.5	6.3
NA	Total Dissolved Solids, mg/l	420	200	280	250	180	200
30°C max.	Temperature °C	9	5	10	13	16	20
NA	Flow, GPM	5,144	5,636	10,182	5,689	8,205	6,461

Permit Limit	Parameters, Units	7/12	8/17	9/14	10/11	11/9	12/14
NA	Chromium total, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
6.0 - 9.0	pH, units	7.50	6.88	7.50	7.40	7.20	7.20
NA	Phenolics Phenol, mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
50 mg/l	Chemical Oxygen Demand, mg/l[1]	12.0	11.0	14.0	7.5	7.7	6.4
NA	Biochemical Oxygen Demand, 5-day total, mg/l	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
10 mg/l	Petroleum Hydrocarbons by IR, mg/l	<1	<1	<1	<1	<1	<1
NA	Ammonia-N, mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
50 mg/l	Total Suspended Solids, mg/l	7.2	6.8	23	7.4	**73.0**[2]	<5.0
NA	Total Dissolved Solids, mg/l	230	190	280	150	170	170
30°C max.	Temperature °C	25	23	23	15.0	13.0	10.0
NA	Flow, GPM	4,829	3,167	9,659	6,765	1,832	7,403

[1] The method detection limit for chemical oxygen demand was 20.0 mg/l from January to May 1993. The method detection limit was 5.0 mg/l from June to December 1993.

[2] Exceeded permit limit of 50.0 mg/l maximum daily limit.

Table 27. 1993 Release Reports

NJDEPE CASE #	PPPL #	TITLE	TYPE of RELEASE
93-2-2-0930-16	ER93-01	Ethylene Glycol Accidental Discharge	1/2 gallon of ethylene glycol discharged on gravel area
93-5-1-1657-52	ER93-02	FREON 113 Discharge	655 pounds of Freon 113 discharged to atmosphere
93-8-5-1452-57	ER93-03	PCBs in Detention Basin Incident	Presence of polychlorinated biphenyls in detention basin sediment
93-10-18-1648-00	ER93-04	Diesel Fuel Oil Accidental Discharge	2 to 10 gallons of diesel fuel discharged on gravel area
93-12-20-1539-54	ER93-05	Oil Leak Incident	1/2 to 1 pint of hydraulic oil discharged on gravel area

Table 28. 1993 Fertilizer, Pesticide, and Herbicide Applications

Application	Chemical or Trade Name	Total Quantities
Fertilizer	10-6-4 fertilizer	2,178 lbs.
Fertilizer	Lime	17,500 lbs.
Fertilizer	Turf Food 25-3-9 Team	1120 lbs.
Herbicide	Surflan ®	130 oz.
Herbicide	Princep	50 oz.
Herbicide	Roundup®	300 oz.
Pesticide	2,4-D + MCPP	196 oz.
Pesticide	Cynoff E. C.	1.8 gal.
Pesticide	Dursban L. O.	1.95 gal.
Pesticide	Dursban Granules	0.8 lbs.
Pesticide	Baiter	1
Pesticide	Maki Bait	10 oz.
Pesticide	Roach Rooter	8 oz.
Pesticide	Conquer E. C.	2.73 gal.
Pesticide	Ficam +	2.33 gal.
Pesticide	PT-230-Tri Die	30 oz.
Pesticide	Diazenon 4.E. E. C.	1.05 gal.
Pesticide	Drione Dust	22 oz.
Pesticide	GenTrol E. C.	52 oz.
Pesticide	Wasp Freeze	1.13 gal.
Pesticide	CB-40	51 oz.
Pesticide	BP-100 - fogging chemical	16 oz.
Pesticide	Sevin Dust	8 oz.

Table 29. 1993 Ground Water Elevations in the Underground Storage Tanks Monitoring Wells (in feet above MSL)

CY1993	MW-1
January	90.08
February	
March	90.61
April	90.83
May	90.41
June	88.98
July	87.05
August	85.57
Annual Avg.	*89.08*

MW-4	MW-2	P-1	P-2
87.78	88.93	88.93	87.77
88.48	89.25	89.27	88.39
89.85	91.22	91.22	90.06
89.57	90.89	90.88	89.47
88.28	89.23	89.22	88.14
86.11	85.16	85.11	85.94
84.13	81.47	81.47	83.82
83.47	80.50	80.45	83.00
87.21	*87.08*	*87.07*	*87.07*

CY1993	UST-1	MW-3	MW-7S	MW-6S	MW-13
January	88.70	86.94	86.28	86.84	86.55
February	89.11	87.47	86.78	87.36	87.21
March	91.00	87.43	88.04	89.52	87.54
April	90.65	87.86	87.64	88.40	87.49
May	89.01	86.78	86.66	87.02	86.47
June	84.83	85.78	85.85	85.16	85.57
July	81.63	84.29	85.08	83.49	84.30
August	80.28	83.78	83.89	81.93	83.90
Annual Avg.	*86.90*	*86.29*	*86.28*	*86.22*	*86.13*

CY1993	MW-6I	MW-8I	MW-8S
January	86.44	86.35	85.23
February	87.09	86.92	85.50
March	88.54	88.02	86.22
April	88.09	88.33	86.82
May	86.82	86.75	86.02
June	84.80	84.76	84.81
July	82.78	82.79	83.59
August	82.05	82.11	82.75
Annual Avg.	*85.83*	*85.75*	*85.12*

MW-9
85.62
85.99
86.28
85.91
85.42
84.95
83.86
80.77
84.85

MW-5I	MW-7I	MW-5S
85.00	83.70	84.67
85.25	84.27	84.89
87.22	85.38	87.47
86.53	85.05	86.41
85.17	84.19	84.77
82.62	83.05	81.88
80.00	82.15	78.81
79.29	81.63	78.14
83.89	*83.68*	*83.38*

MSL - mean sea level
MW - monitoring well
S - shallow depth well
I - intermediate depth well
P - piezometer
UST - underground storage tank well
D - detention basin well

Note: No well elevations were measured from September through December 1993.
Annual average is based on the eight months of measurement data.
MW-1 is based on seven months, because it was covered by ice in February 1993.

Table 30. Average Ground Water Elevation by Well Group (In feet above MSL)

8 9	8 7	8 6	8 5	8 4	8 3
MW-1	MW-4	UST-1	MW-6I	D-11	MW-5I
	MW-2	MW-3	MW-8I	MW-9	MW-7I
	P-1	MW-7S	MW-8S		MW-5S
	P-2	MW-6S			D-12
		MW-13			

MSL - mean sea level
MW - monitoring well
S - shallow depth well
I - intermediate depth well
P - piezometer
UST - underground storage tank well
D - detention basin well

Table 31. 1993 Total Petroleum Hydrocarbons Results from Underground Storage Tank Monitoring Wells (In mg/l)

Well Number	2/23/94	5/18/93	8/24/93
MW-4	0.61U	0.59U	0.57U
MW-5S	NS	NS	NS
MW-5I	NS	NS	1.2
MW-6S	0.53U	0.67U	0.57U
MW-6I	0.54U	0.6U	0.57U
MW-7S	0.54U	0.56U	0.57U
MW-7I	0.54U	0.54U	0.61U
MW-8S	0.56 U	0.63U	0.56U
MW-8I	4.5	0.6U	0.56U

U - Indicates a compound was analyzed for but not detected. for results marked with a "U," the numerical value is the compound method detection limit.

NS - Indicates well was not sampled.

Table 32. Underground Storage Tank Monitoring Program Results
August 1993 (in µg/l)

Parameter	MW-4 8/24/93	MW-5I 8/24/93	MW-6S 8/24/93	MW-6I 8/24/93	MW-7S 8/24/93
Target VOC					
Methyl Chloride	5UJ	10U	23U	4J*	5U
1,1-Dichloroethane	5U	5U	5U	5U	3J
Total 1,2-Dichloroethene	5U	5U	5U	5U	5U
Chloroform	5U	5U	5U	5U	5
1,1,1-Trichloroethane	5UJ	5UJ	5U	5UJ	4J
Trichloroethene	5U	5J	5U	5U	5U
Benzene	5U	5U	5U	3J	5U
Tetrachloroethene	5U	3J	5U	5U	8
Total Target VOC	0	8	0	7	20
Non-Target VOC					
Methoxy Methyl Propane	ND	11	ND	15	ND

Parameter	MW-7I 8/24/93	MW-8S 8/24/93	MW-8I 8/24/93	Trip Blank	Field Blank
Target VOC					
Methyl Chloride	17U	9U	5U	10B	9B
1,1-Dichloroethane	8	5U	5U	5U	5U
Total 1,2-Dichloroethene	5U	5J	5U	5U	5U
Chloroform	5U	6	5U	5U	5U
1,1,1-Trichloroethane	5UJ	5U	5U	5U	5U
Trichloroethene	5U	9	5U	5U	5U
Benzene	5U	5U	5U	5U	5U
Tetrachloroethene	5U	39	5U	5U	5U
Total Target VOC	8	59	0	0	0
Non-Target VOC					
Methoxy Methyl Propane	19	ND	ND	ND	ND

VOC - volatile organic compounds, 40 CFR Method 624
ND - compound not detected
U - Indicates a compound was analyzed but not detected. For results marked "U," the numerical value is the compound detection limit.
J - A "J" is used by the laboratory to designate a concentration of a compound that is below the analytical method quantitation limit. The resulting value is interpreted by the laboratory to be qualitatively valid. This value is added to the total VOCs.
* - This compound is not flagged with B since it was not found in the corresponding method blank. However, this compound is commonly found as a laboratory contaminant.
B - Indicates that the analyte was found in the method blank as well as the sample. It indicates possible/probable blank contamination.

Tables 33. 1993 Ground Water Analysis for Wells MW-14, MW-15, and MW-16

Parameters, Units	MW-14 2/10	MW-14 5/11	MW-14 8/10	MW-14 11/9
Chromium, mg/l			<0.025	<0.025
Lead, dissolved, mg/l			<0.005	<0.005
pH, units	5.70	5.70	5.40	5.70
Phenolics as phenol, mg/1			<0.05	<0.05
Nitrate-N, mg/1			1.8	1.4
Total Organic Carbon, mg/1			1.7	
Total Organic Halides, mg/l			0.11	
Petroleum Hydrocarbon by IR, mg/1			<1	
Ammonia-N, mg/1		<0.5	<0.5	<0.5
Chloride, mg/1			5.0	<2.0
Total Dissolved Solids, mg/1	79	67	94	58
Sulfate, mg/1	18	22	13	19
Conductivity, µmhos/cm^2	70	65	100	85

Parameters, Units	MW-15 2/10	MW-15 5/11	MW-15 8/10	MW-15 11/9
Chromium, mg/l			<0.025	<0.025
Lead, dissolved, mg/l			<0.005	<0.005
pH, units	5.80	5.80	5.50	5.60
Phenolics as phenol, mg/1			<0.05	<0.05
Nitrate-N, mg/1			0.43	0.58
Total Organic Carbon, mg/1			1.7	
Total Organic Halides, mg/l			<0.01	
Petroleum Hydrocarbon by IR, mg/1			<1	
Ammonia-N, mg/1		<0.5	<0.5	<0.5
Chloride, mg/1			4.0	3.0
Total Dissolved Solids, mg/1	69	44	78	42
Sulfate, mg/1	8.1	9.1	12.0	11.0
Conductivity, µmhos/cm^2	60	55	90	70

Parameters, Units	MW-16 2/10	MW-16 5/11	MW-16 8/10	MW-16 11/9
Chromium, mg/l			<0.025	
Lead, dissolved, mg/l			<0.005	
pH, units	6.50	6.30	6.30	6.50
Phenolics as phenol, mg/1			<0.05	<0.05
Nitrate-N, mg/1			1.1	0.93
Total Organic Carbon, mg/1			3.2	
Total Organic Halides, mg/l			0.14	
Petroleum Hydrocarbon by IR, mg/1			<1	
Ammonia-N, mg/1		<0.5	<0.5	<0.5
Chloride, mg/1			5.0	9.0
Total Dissolved Solids, mg/1	180	160	180	350
Sulfate, mg/1	43	41	36	160
Conductivity, µmhos/cm^2	220	185	270	490

Blank indicates no measurement.

Table 34. 1993 Ground Water Analysis for Wells D-11 and D-12

Parameters, Units	D-11 2/10	D-11 5/11	D-11 8/10	D-11 11/9	D-12 2/10	D-12 5/11	D-12 8/10	D-12 11/9
Chromium, mg/l							<0.025	<0.025
Lead, dissolved,mg/l			<0.005	<0.005			<0.005	<0.005
pH, units	6.40	6.60	6.10	6.20	5.60	5.80	5.40	5.60
Phenolics as phenol, mg/1			<0.05	<0.05			<0.05	<0.05
Nitrate-N, mg/1			0.96	0.75			<0.05	<0.04
Total Organic Carbon, mg/1			2.1				2.4	
Total Organic Halides, mg/1			12				0.026	
Petroleum Hydrocarbons by IR, mg/1			<1				<1	
Ammonia-N, mg/1		<0.5	<0.5	<0.5		<0.5	<0.5	<0.5
Chloride, mg/1			37	30			22	20
Total Dissolved Solids, mg/1	180	220	200	130	130	130	120	110
Sulfate, mg/1	23	34	34	28	34	36	30	45
Conductivity, µmhos/cm^2	210	260	280	225	140	140	150	175

Blank indicates no measurement.

Table 35. 1993 Ground Water Analysis for Wells TW-2 and TW-3

Parameters, Units	TW-2 2/10	TW-2 5/11	TW-2 8/10	TW-2 11/9	TW-3 2/10	TW-3 5/11	TW-3 8/10	TW-3 11/9
Chromium, mg/l				<0.025				
Lead, dissolved,mg/l			<0.005	0.0072			<0.005	<0.005
pH, units	7.30	7.40	7.10		7.50	7.20	7.10	7.00
Phenolics as phenol, mg/1			<0.05	<0.05			<0.05	<0.05
Nitrate-N, mg/1			<0.05	<0.05			<0.05	<0.04
Total Organic Carbon, mg/1			2.4				2.5	
Total Organic Halides, mg/1			0.019				<0.01	
Petroleum Hydrocarbons by IR, mg/1			<1				<1	
Ammonia-N, mg/1		<0.5	<0.5	<0.5		<0.5	<0.5	<0.5
Chloride, mg/1			14	13			17	13
Total Dissolved Solids, mg/1	190	190	230	130	240	270	230	160
Sulfate, mg/1	14	14	23	6	22	36	24	<5.0
Conductivity, µmhos/cm^2	290	295	290	295	330	380	350	340

Blank indicates no measurement.

Table 36. Ground Water Volatile Organics Analytical Results from Wells D-11, D-12, and TW-3 — May 1993 (in µg/l)

Parameter	D-11 5/11/93	D-12 5/11/93	TW-3 5/11/93
Chloromethane	<10	<10	<10
Bromomethane	<10	<10	<10
Vinyl Chloride	<10	<10	<10
Chloroethane	<10	<10	<10
Methylene Chloride	<5	<5	<5
Acrolein	<20	<20	<20
Acrylonitrile	<20	<20	<20
Trichlorofluoromethane	<5	<5	<5
1,1-Dichloroethene	<5	<5	<5
1,1-Dichloroethane	<5	<5	<5
Trans-1,2-Dichloroethene	<5	<5	<5
Chloroform	<5	<5	<5
1,2-Dichloroethane	<5	<5	<5
1,1,1-Trichloroethane	4 J	<5	<5
Carbon Tetrachloride	<5	<5	<5
Bromodichloromethane	<5	<5	<5
1,2-Dichloropropane	<5	<5	<5
cis-1,3-Dichloropropane	<5	<5	<5
Trichloroethene	<5	<5	<5
Dibromochloromethane	<5	<5	<5
1,1,2-Trichloroethane	<5	<5	<5
Benzene	<5	<5	<5
trans-1,3-Dichloropropene	<5	<5	<5
2-Chloroethylvinylether	<10	<10	<10
Bromoform	<5	<5	<5
Tetrachloroethene	6	16	6
1,1,2,2-Tetrachloroethane	<5	<5	<5
Toluene	<5	<5	<5
Chlorobenzene	<5	<5	<5
Ethylbenzene	<5	<5	<5
1,3-Dichlorobenzene	<5	<5	<5
1,2 & 1,4-Dichlorobenzenes			

J indicates a value below the reliable limit of detection.

Table 37. Volatile Organics Analytical Results from Wells D-11 and D-12, D Site Sumps, and Detention Basin Inflow— August 1993 (in µg/l)

Parameter	D-11 8/10/93	D-12 8/10/93	DSP-402 8/10/93	8/10/DSP-10493	TW-3 8/10/93	Inflow 1 8/17/93	Inflow 2 8/17/93
Chloromethane	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7
Bromomethane	<6.1	<6.1	<6.1	<6.1	<6.1	<6.1	<6.1
Vinyl Chloride	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5
Chloroethane	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2
Methylene Chloride	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1
Acrolein	<20	<20	<20	<20	<20	<20	<20
Acrylonitrile	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4	<9.4
Trichlorofluoromethane	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1
1,1-Dichloroethene	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
1,1-Dichloroethane	<2.2	2.9	<2.2	<2.2	<2.2	<2.2	<2.2
Trans-1,2-Dichloroethene	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Chloroform	<2.6	<2.6	<2.6	<2.6	<2.6	9.1	<2.6
1,2-Dichloroethane	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9
1,1,1-Trichloroethane	<3.8	<3.8	3.8	7.1	<3.8	<3.8	<3.8
Carbon Tetrachloride	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7
Bromodichloromethane	<3.4	<3.4	<3.4	<3.4	<3.4	4.1	<3.4
1,2-Dichloropropane	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4
cis-1,3-Dichloropropene	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
Trichloroethene	<8.1	<8.1	<8.1	<8.1	<8.1	<8.1	<8.1
Dibromochloromethane	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9
1,1,2-Trichloroethane	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5
Benzene	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
trans-1,3-Dichloropropene	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
2-Chloroethylvinylether	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7
Bromoform	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Tetrachloroethene	4.2	16	52	3.8	<2.1	5.7	4.5
1,1,2,2-Tetrachloroethane	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7
Toluene	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Chlorobenzene	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3
Ethylbenzene	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8

DSP-402 is a sump located in the basement of D site MG building.
DSP-104 is a sump located in the basement of TFTR, east of the Test Cell Basement.

Table 38. NJPDES Wells Ground Water Base Neutrals Analytical Results
August 1993 (In µg/l)

Parameter	D-11 8/10/93	D-12 8/10/93	8/1MW-140/93	MW-15 8/10/93	MW-16 8/10/93	TW-2 8/10/93	TW-3 8/10/93
N-nitrosodimethylamine	<10	<10	<10	<10	<10	<10	<10
bis(2-Chloroethyl)ether	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
1,3-Dichlorobenzene	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
1,4-Dichlorobenzene	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7
1,2-Dichlorobenzene	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
bis(2-Chloroisopropyl)ether	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9
N-Nitroso-di-n-propylamine	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Hexachloroethane	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3
Nitrobenzene	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3
Isophorone	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
bis(2-Chloroethoxy)Methane	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
1,2,4-Trichlorobenzene	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Naphthalene	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9
Hexachlorobutadiene	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Hexachlorocyclopentadiene	<10	<10	<10	<10	<10	<10	<10
2-Chloronaphthalene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Dimethylphthalate	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Acenaphthylene	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4
Acenaphthene	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7
2,4-Dinitrotoluene	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1
2,6-Dinitrotoluene	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Diethylphthalate	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
4-Chlorophenyl-phenylether	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Fluorene	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
N-Nitrosodiphenylamine	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
1,2-diphenylhydrazine	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2
4-Bromophenyl-phenylether	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Hexachlorobenzene	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1
Phenathrene	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1
Anthracene	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9
Di-n-Butylphthalate	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Fluoranthene	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Benzidine	<10	<10	<10	<10	<10	<10	<10
Pyrene	<5.9	<5.9	<5.9	<5.9	<5.9	<5.9	<5.9
Butylbenzylphthalate	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5
3,3'-Dichlorobenzidine	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Benzo (a) Anthracene	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Bis(2-ethylhexyl)Phthalate	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4
Chrysene	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9
Di-n-octylphthalate	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8
Benzo (b) Fluoranthene	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9
Benzo (k) Fluoranthene	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Benzo (a) Pyrene	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Indeno (1,2,3-cd) Pyrene	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7	<3.7
Dibenzo (a,h) Anthracene	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Benzo (g,h,i) Perylene	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5

Table 39. Summary of Chemical Analyses of Ground Water on C and D Sites January 1993 (in µg/l)

Parameters	Limit	MW-1	MW-2	MW-3	MW-4	MW-5I	MW-5S	MW-6I
Total VOCs		0	0.88 B	47.1	0	2.9	3.1	9.5
Chloroform	6							
Trichloro-fluoromethane				8.9				
1,1,1 Trichloroethane	30			2.2				
Carbon Tetrachloride	0.4						3.1	
Trichloroethene	1					1.6		
Methylene Chloride	30		0.88 B	1.2B				
1,1 Dichloroethene	1							
1,1 Dichloroethane	70							4.5
Benzene	0.2							3.7
Tetrachloroethene	0.4			36		1.3		
1,2,4 Trichlorobenzene	9							1.3
Cis-1,2-dichloroethene								

Parameters	Limit	MW-6S	MW-7I	MW-7S	MW-8I	MW-8S	MW-9	MW-10I
Total VOCs		25.36	15.1	23.22	0	82.36	141.6	0.8
Chloroform	6			6.6		13	0.9	
Trichloro-fluoromethane							3	
1,1,1 Trichloroethane	30	14		4		2	10	
Carbon Tetrachloride	0.4			0.77				
Trichloroethene	1		1.2			9.6	3	
Methylene Chloride	30					0.57B		
1,1 Dichloroethene	1	0.76		0.95		0.66		
1,1 Dichloroethane	70	9.3	8.6	2		3.3	1.7	
Benzene	0.2							
Tetrachloroethene	0.4	1.3	2.3	8.9		46	120	0.8
1,2,4 Trichlorobenzene	9							
Cis-1,2-dichloroethene			3			7.8	3	

Parameters	Limit	MW-12I	MW-12S	MW-13	MW-13D	P-1	P-2	UST-1
Total VOCs		2.4B	0.83B	190.6	191.6	0.88B	0.54B	1.44,2 B
Chloroform	6			0.5	0.6			0.6
Trichloro-fluoromethane								
1,1,1 Trichloroethane	30			4.1	4.5			0.84
Carbon Tetrachloride	0.4					0.88B	0.54B	2B
Trichloroethene	1			3.2	3.4			
Methylene Chloride	30	2.4 B	0.83 B					
1,1 Dichloroethene	1			0.8	0.9			
1,1 Dichloroethane	70			0.8	0.8			
Benzene	0.2							
Tetrachloroethene	0.4			180	180			
1,2,4 Trichlorobenzene	9							
Cis-1,2-dichloroethene				1.2	1.4			

VOC -Volatile Organic Compounds
D - duplicate
Limit - NJDEPE Cleanup Standard for Class II Groundwater
B - also detected in blank

Table 39. (continued) Summary of Chemical Analyses of Ground Water on C and D Sites — January 1993 (In mg/l)

Parameters,	Limit	MW-1	MW-2	MW-3	MW-4	MW-5I	MW-5S	MW-6I
Conductivity, µmhos/cm^2		260	130	190	320	250	245	355
pH, units		6.17	6.06	6.19	6.6	7.55	6.51	6.65
Ammonia-N	0.5							
Chloride	250	68	37	11	31	43	60	41
Total Dissolved Solids	500	210	110	180	240	310	200	270
Sulfate	250	18		25	5.4	14	11	1.9
Nitrate-N	10	1.3	94	71				
Total Organic Carbon	no limit			7.9	0.2			2
Total Organic Halides	no limit	0.014	0.040	0.027	0.018	0.037	0.031	0.053
Petroleum Hydrocarbon	none detected					**1.9**		

Parameters,	Limit	MW-6S	MW-7I	MW-7S	MW-8I	MW-8S	MW-9	MW-10I
Conductivity, µmhos/cm^2		180	360	580	310	600	115	160
pH, units .		6.71	6.88	7.02	7.12	6.14	6.51	6.88
Ammonia-N	0.5		0.84B	1.5B				
Chloride	250	4.2	42	70	210	**300**	6	14
Total Dissolved Solids	500	270	290	460	**520**	280	120	170
Sulfate	250	3.5	4.3	78	15	8.3	22	11
Nitrate-N	10	2.6		2.2	0.76		0.25	
Total Organic Carbon	no limit							
Total Organic Halides	no limit	0.023	0.027	0.021	0.037	0.021	0.022	0.040
Petroleum Hydrocarbon	none detected							**2.1**

Parameters	Limit	MW-12I	MW-12S	MW-13	MW-13D	P-1	P-2	UST-1
Conductivity, µmhos/cm^2		225	240	175	NS	260	520	600
pH, units		7.21	6.7	6.23	NS	5.6	6.2	5.31
Ammonia-N	0.5							
Chloride	250	5.9	40	8	8	93	130	46
Total Dissolved Solids	500	180	170	190	170	130	410	79
Sulfate	250	15	15	15	12	13	170	27
Nitrate-N	10	1.3	1.1			1.7	0.62	0.91
Total Organic Carbon	no limit	1.3	1.7	2.0	2.9	2.0	1.8	2.8
Total Organic Halides	no limit	0.012	0.028	0.020	0.030	0.030	0.29	0.36
Petroleum Hydrocarbon	none detected							

Limit NJDEPE Cleanup Standard for Class II Groundwater
B - also detected in blank
NS - not sampled

Table 40. Ground Water Results for Wells TW-1, TW-3, TW-10. D-11, and D-12 January 1993

	TW-1	TW-3	TW-10	D-11	D-12	Field	Trip
Volatile Organic Compounds (µg/l)							
1,1,1-Trichloroethane	<0.5	<0.5	<0.5	**0.7**	<0.5	<0.5	<0.5
1,3-Dichloropropane	<0.5	<0.5	<0.5	**4**	<0.5	<0.5	<0.5
Chloroform	<0.5	<0.5	<0.5	**1 B**	<0.5	**1 B**	**1 B**
Methylene chloride	<0.5	**0.6**	**0.6**	<0.5	<0.5	<0.5	**0.8**
Tetrachloroethene	<0.5	**4.3**	**1.1**	**4**	**8.7**	<0.5	<0.5
Trichloroethene	<0.5	<0.5	<0.5	<0.5	**1.4**	<0.5	<0.5
cis -1,2-Dichloroethene	<0.5	<0.5	<0.5	<0.5	**1.1**	<0.5	<0.5
Other Parameters							
Lead (mg/l)	0.012	<0.005	<0.005	<0.005	0.007	<0.005	
pH (SU)	7.31	7.41	7.51	6.38	5.76	5.6	
Specific conductance µmhos/cm^2	300	320	290	210	150	<2	

Note: Volatile Organic Compounds analyzed by EPA Method 502.2. Only those compounds detected are listed; all other compounds were below the detection limit.
B - also detected in blank.
SU - standard units

Table 41. 1993 NJPDES Program Quality Assurance Data

PARAMETER	Analytical Laboratory SAMPLE ID#	Analytical Laboratory RESULT	ERA CERTIFIED VALUE[1]	ERA ADVISORY RANGE[2]	ERA MEAN RECOVERY
TPH-89					
Total Petroleum Hydrocarbons (Infrared)	930467-001	120 mg/l	124 mg/l	74-155 mg/l	None
OIL & GREASE					
Oil & Grease (Gravimetric)	930467-002	35 mg/l	45 mg/bottle	33-56 mg/bottle	42.5 mg/bottle
HARDNESS					
Total Suspended Solids	930467-003	81.4 mg/l	84 mg/l	68-97 mg/l	80.2 mg/l
MINERALS					
Alkalinity	930467-004	140 mg/l	142 mg/l	110-171 mg/l	141 mg/l
Chloride	930467-004	160 mg/l	157 mg/l	143-168 mg/l	156 mg/l
pH	930467-004	9.36 SU	9.1 SU	8.9-9.3 SU	9.08 SU
Specific Conductance	930467-004	1100 umhos/cm^2	1038 umhos	882-1260 umhos	1085 umhos
Sulfate	930467-004	110 mg/l	113 mg/l	85-138 mg/l	112 mg/l
Total Dissolved Solids	930467-004	770 mg/l	818 mg/l	711-925 mg/l	799 mg/l
CYANIDE & PHENOL					
Phenol, Total	930467-005	0.23 mg/l	0.233 mg/l	0.16-0.28 mg/l	0.219 mg/l
NUTRIENTS					
Ammonia as N	930467-006	14 mg/l	15 mg/l	12-18 mg/l	14.2 mg/l
Nitrate plus Nitrite as N	930467-006	11 mg/l	11.1 mg/l	9.8-13 mg/l	11.0 mg/l
DEMAND					
BOD, 5 day total	930467-007	79 mg/l	79.9 mg/l	47-104 mg/l	78.4 mg/l
COD	930467-007	130 mg/l	133 mg/l	111-153 mg/l	130 mg/l
TOC	930467-007	51 mg/l	52.7 mg/l	43-63 mg/l	53.3 mg/l
TRACE METALS					
Aluminum	930467-008	0.47 mg/l	0.45 mg/l	0.37-0.53 mg/l	0.457 mg/l
Cadmium	930467-008	0.09 mg/l	0.0913 mg/l	0.074-0.108 mg/l	0.0897 mg/l
Chromium	930467-008	0.67 mg/l	0.650 mg/l	0.533-0.767 mg/l	0.668 mg/l
Cobalt	930467-008	0.12 mg/l	0.110 mg/l	0.090-0.130 mg/l	0.116 mg/l
Copper	930467-008	0.16 mg/l	0.159 mg/l	0.130-0.202 mg/l	0.173 mg/l
Iron	930467-008	0.54 mg/l	0.525 mg/l	0.430-0.620 mg/l	0.520 mg/l
Lead	930467-008	0.18 mg/l	0.145 mg/l	0.116-0.174 mg/l	0.148 mg/l
Manganese	930467-008	0.11 mg/l	0.101 mg/l	0.083-0.119 mg/l	0.101 mg/l
Nickel	930467-008	0.16 mg/l	0.163 mg/l	0.130-0.196 mg/l	0.160 mg/l
Silver	930467-008	0.096 mg/l	0.0954 mg/l	0.078-0.113 mg/l	0.0915 mg/l
Zinc	930467-008	0.19 mg/l	0.175 mg/l	0.143-0.216 mg/l	0.181 mg/l
RESIDUAL CHLORINE					
Chlorine, residual	930467-009	0.86 mg/l	0.882 mg/l	0.60-1.2 mg/l	0.882 mg/l

[1]Certified values are equal to 100% of the parameter in the indicated standard (theoretical value).

[2]Advisory ranges are listed as guidelines for acceptable recoveries given the limitations of the EPA methodologies commonly used to determine these parameters. The range closely approximates the 95% confidence interval for the parameter based upon experimental data generated by ERA and from the USEPA WP, WS and CLP interlaboratory performance evaluation programs.

List of Figures

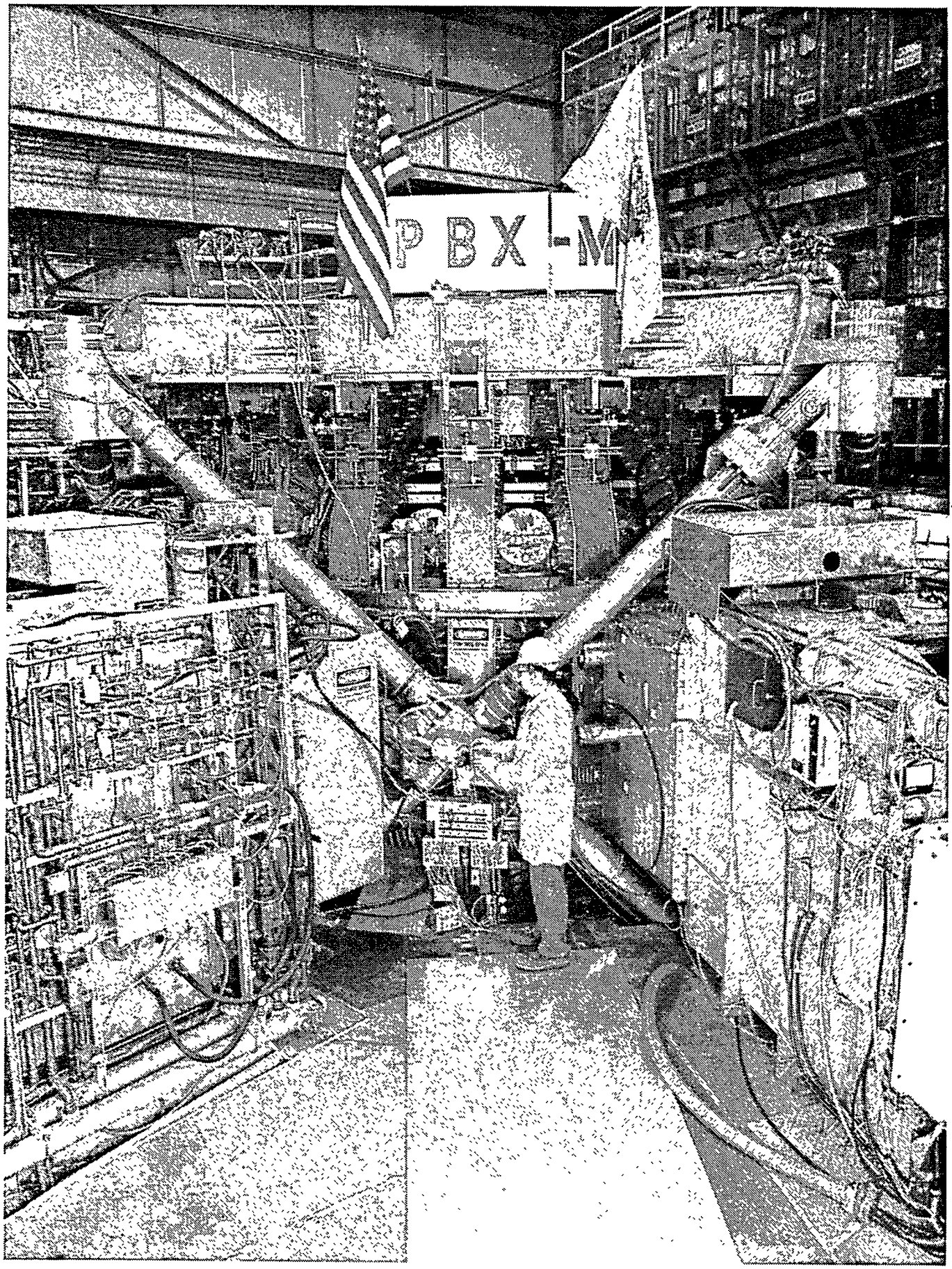

Figure 1. The Princeton Beta Experiment-Modification (PBX-M)

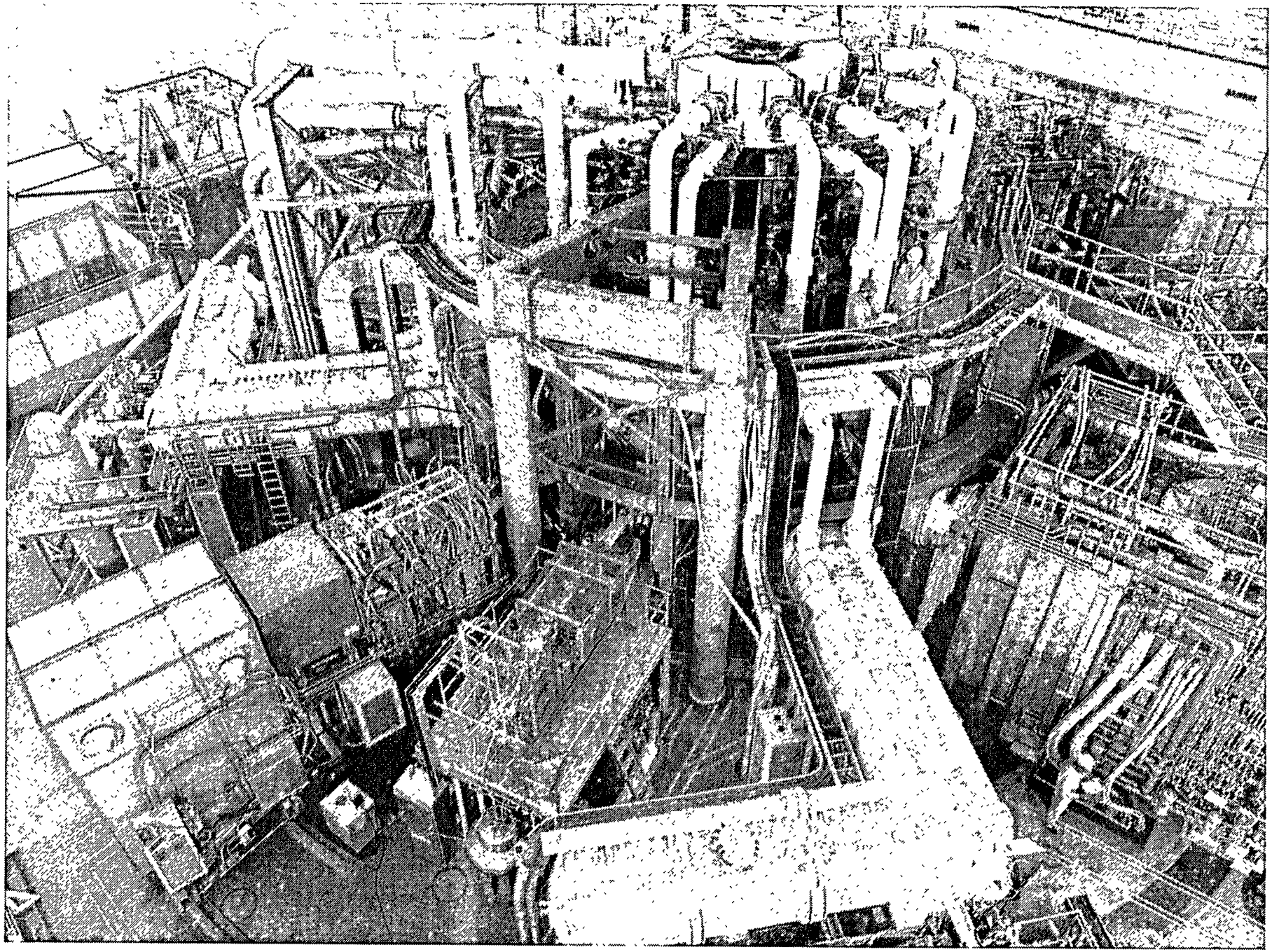

Figure 2. The Tokamak Fusion Test Reactor (TFTR)

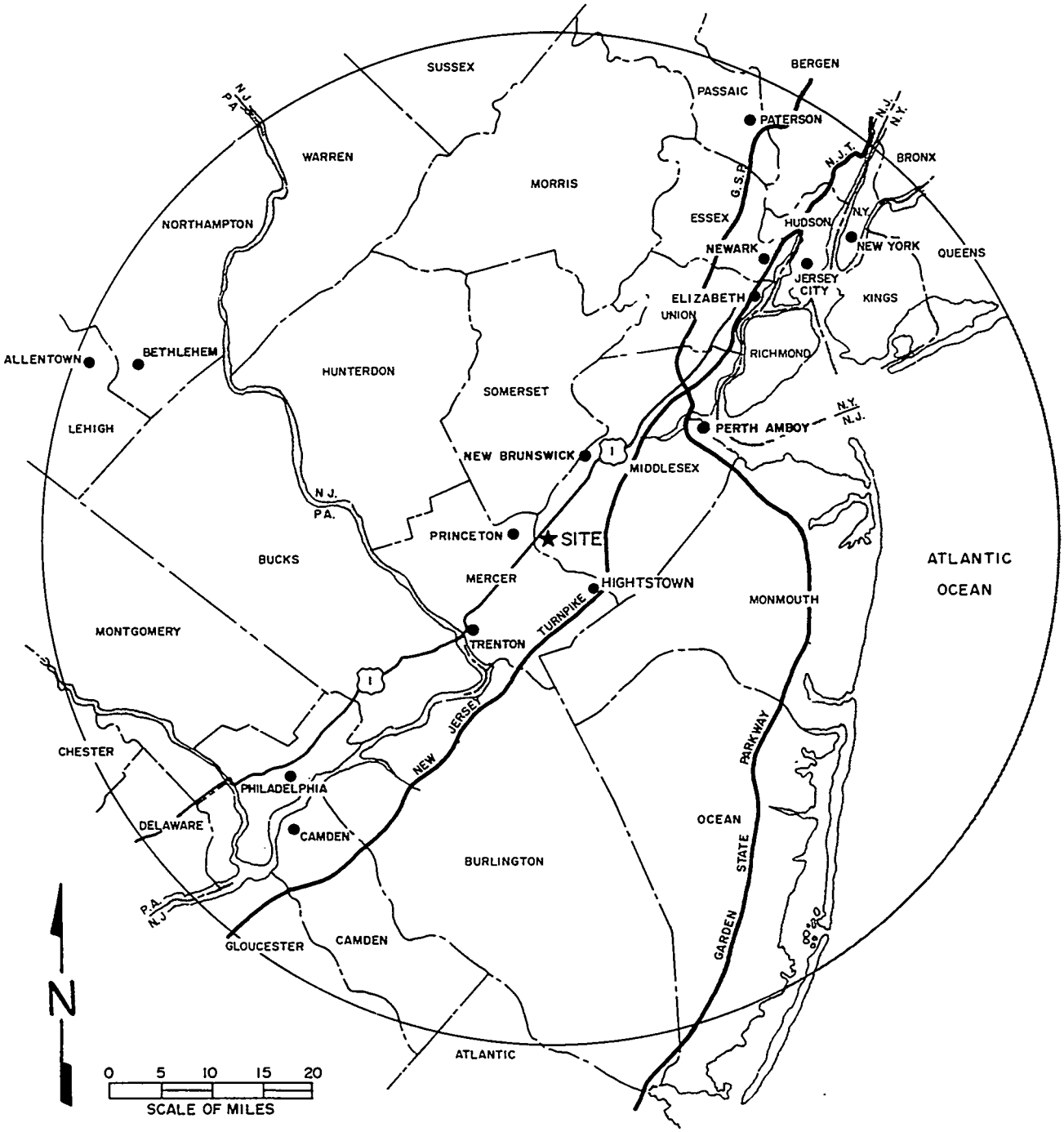

Figure 3. Region Surrounding the TFTR Site (50-mile radius shown)

Figure 4. Aerial View of the James Forrestal Campus

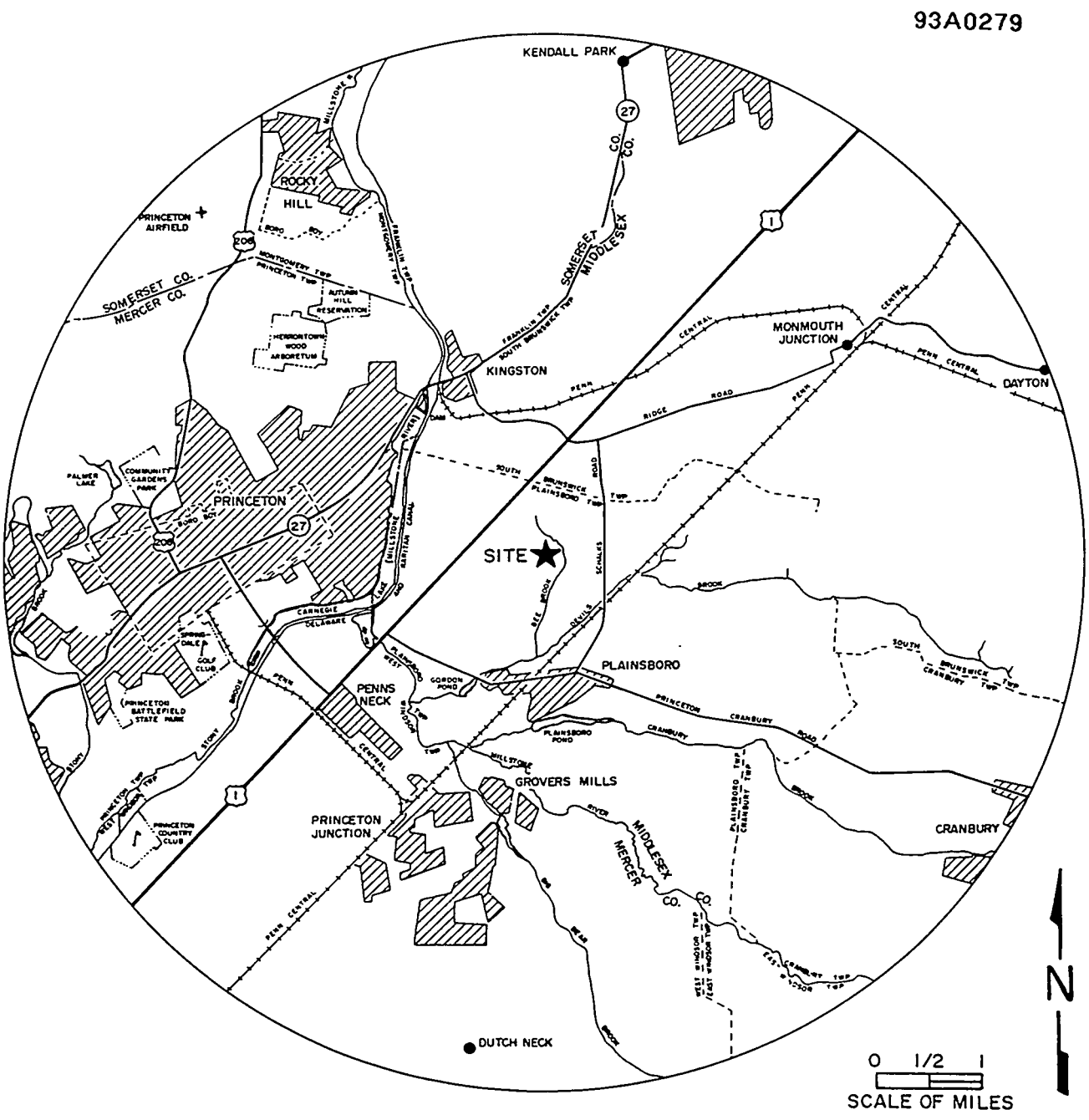

Figure 5. Immediate Site Vicinity (5 Mile Radius)

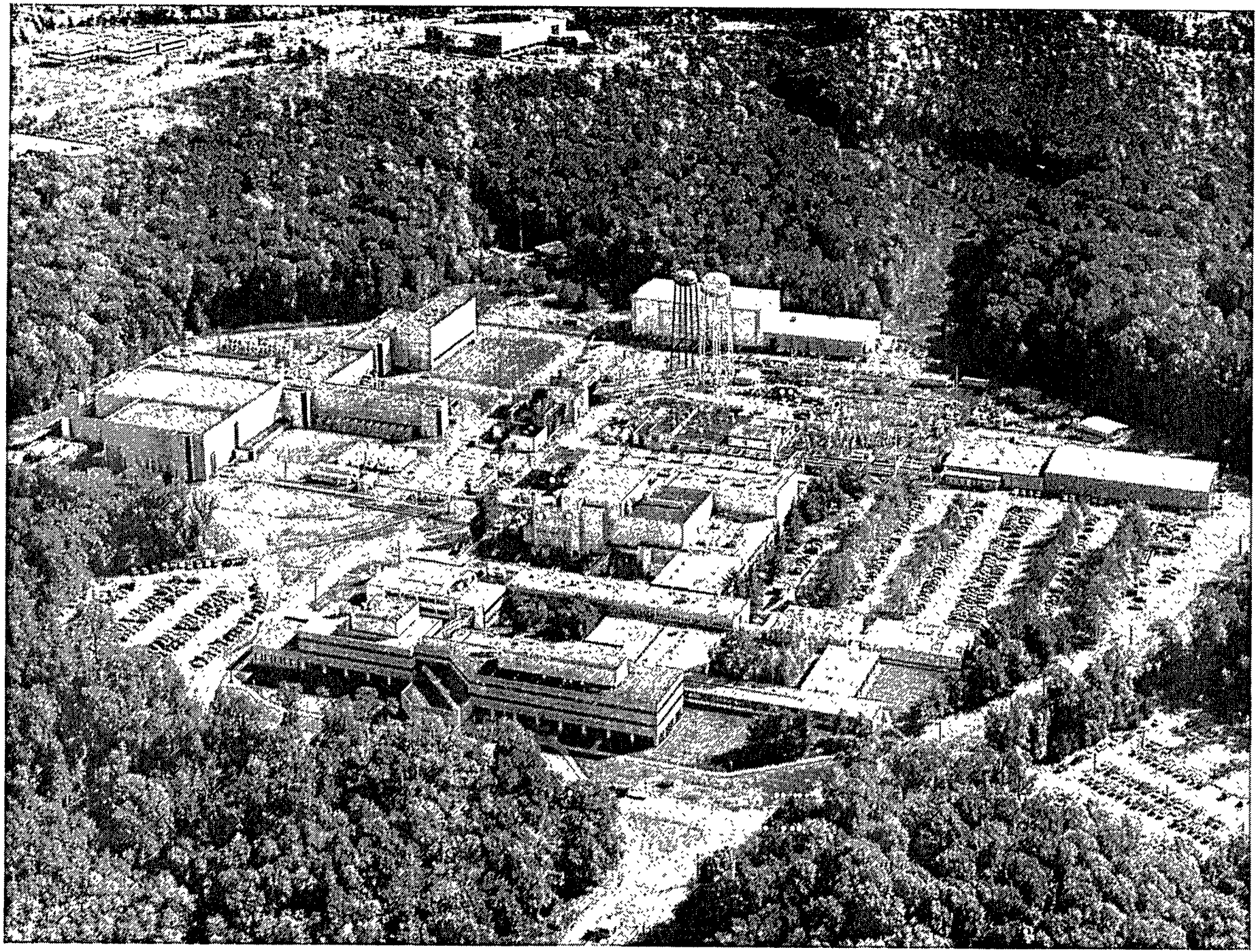

Figure 6. PPPL C and D Sites of the James Forrestal Campus

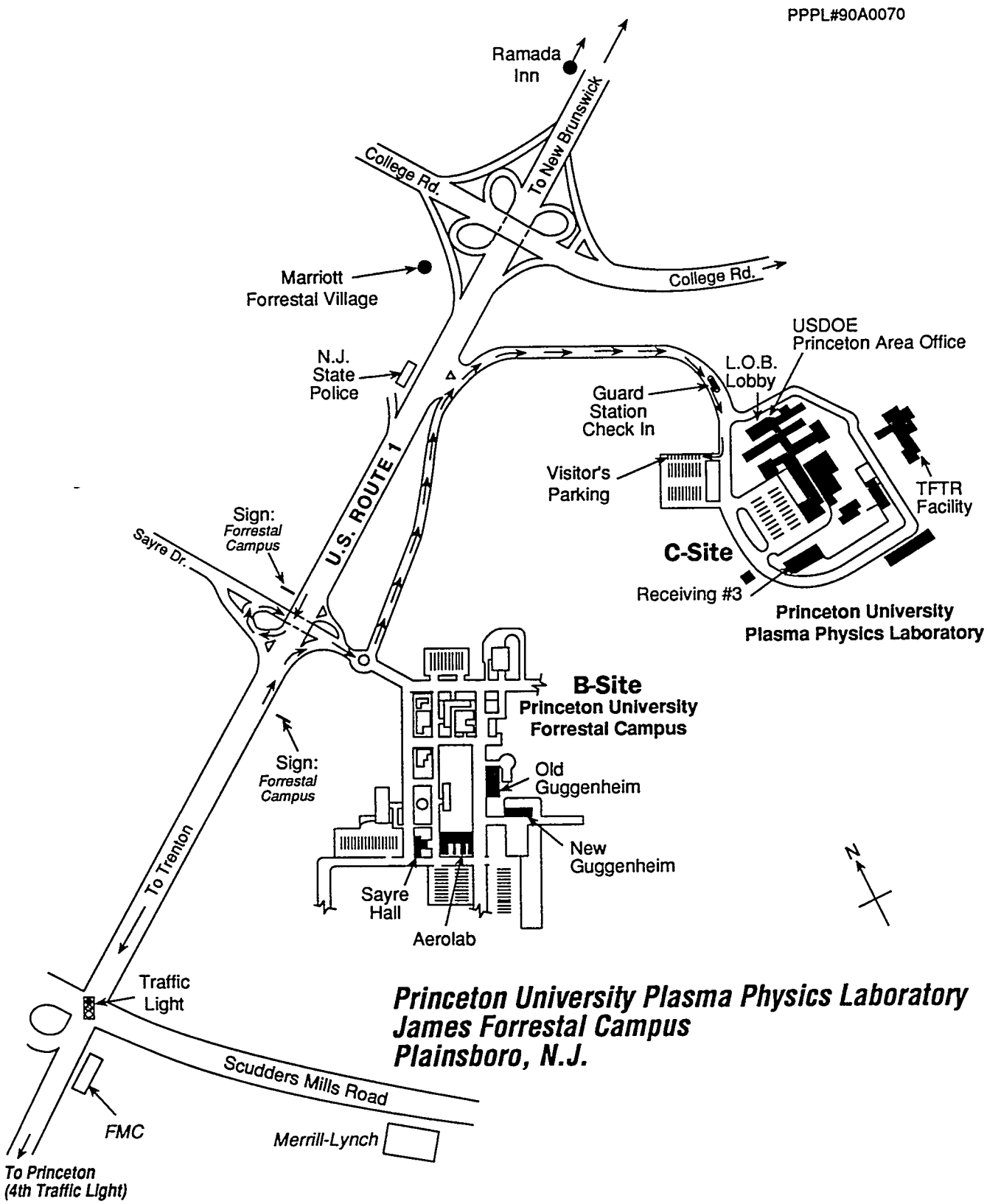

Figure 7. Layout of James Forrestal Campus

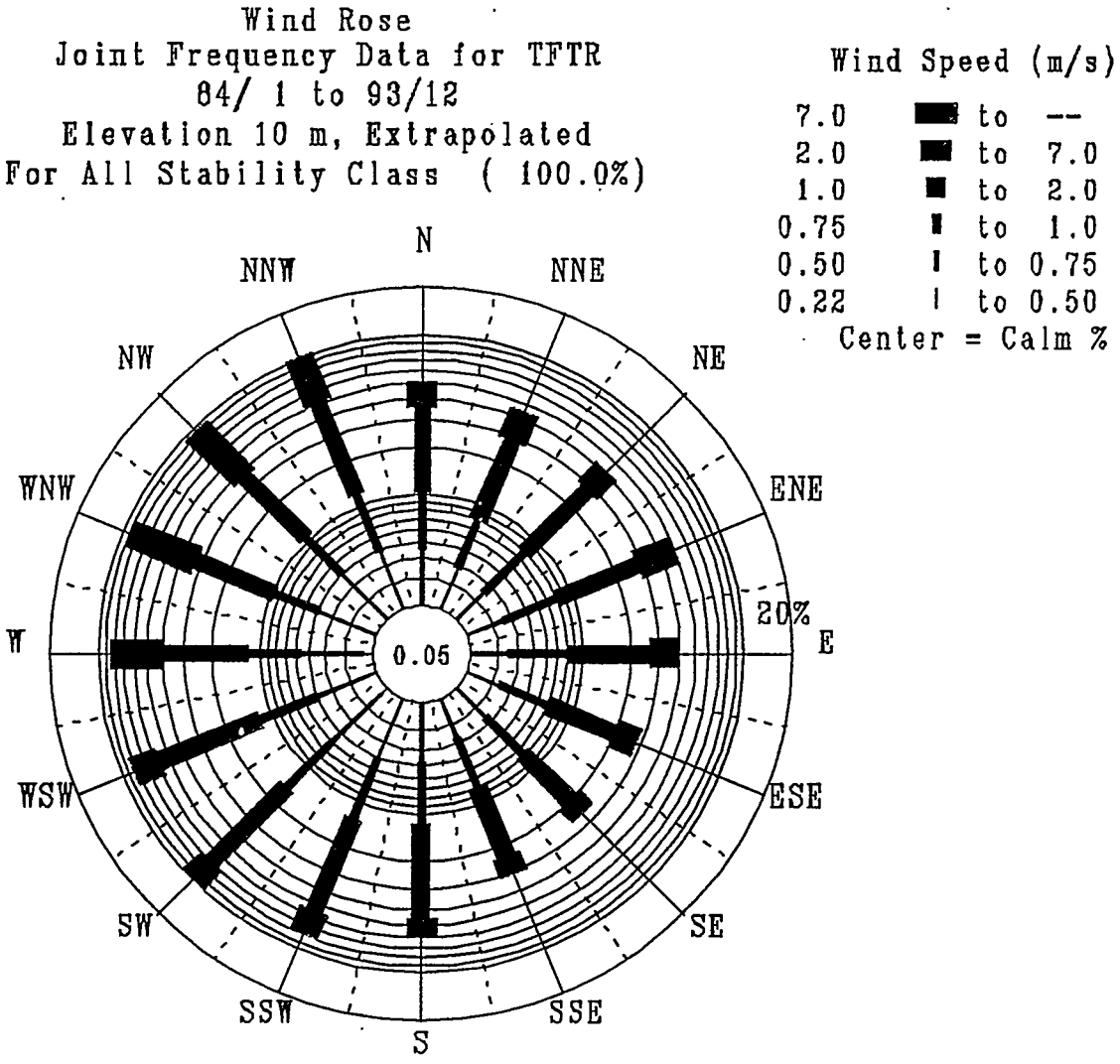

Figure 8. Wind Rose Joint Frequency Data for TFTR at 10 m, 1984-1993

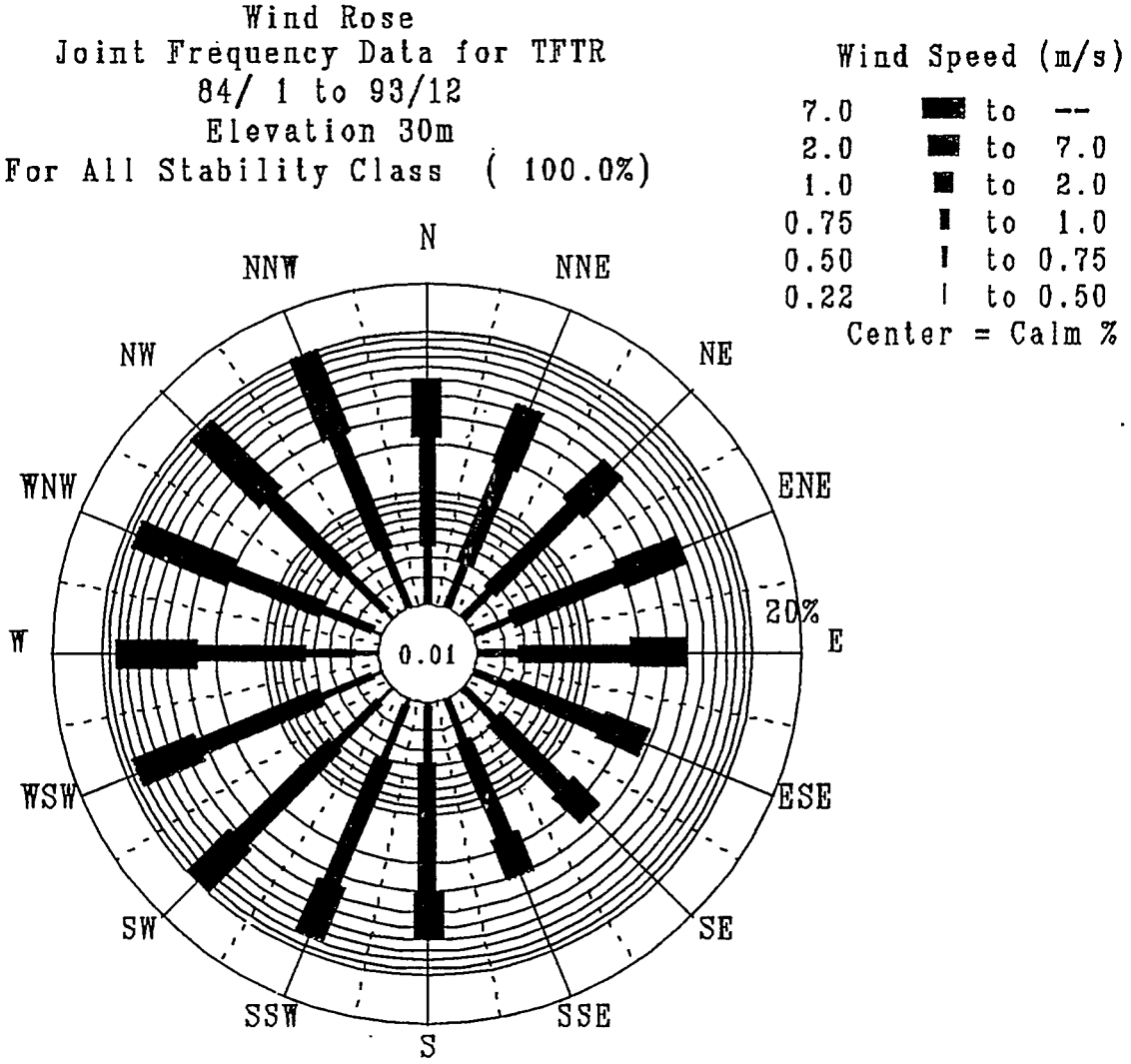

Figure 9. Wind Rose Joint Frequency Data for TFTR at 30 m, 1984-1993

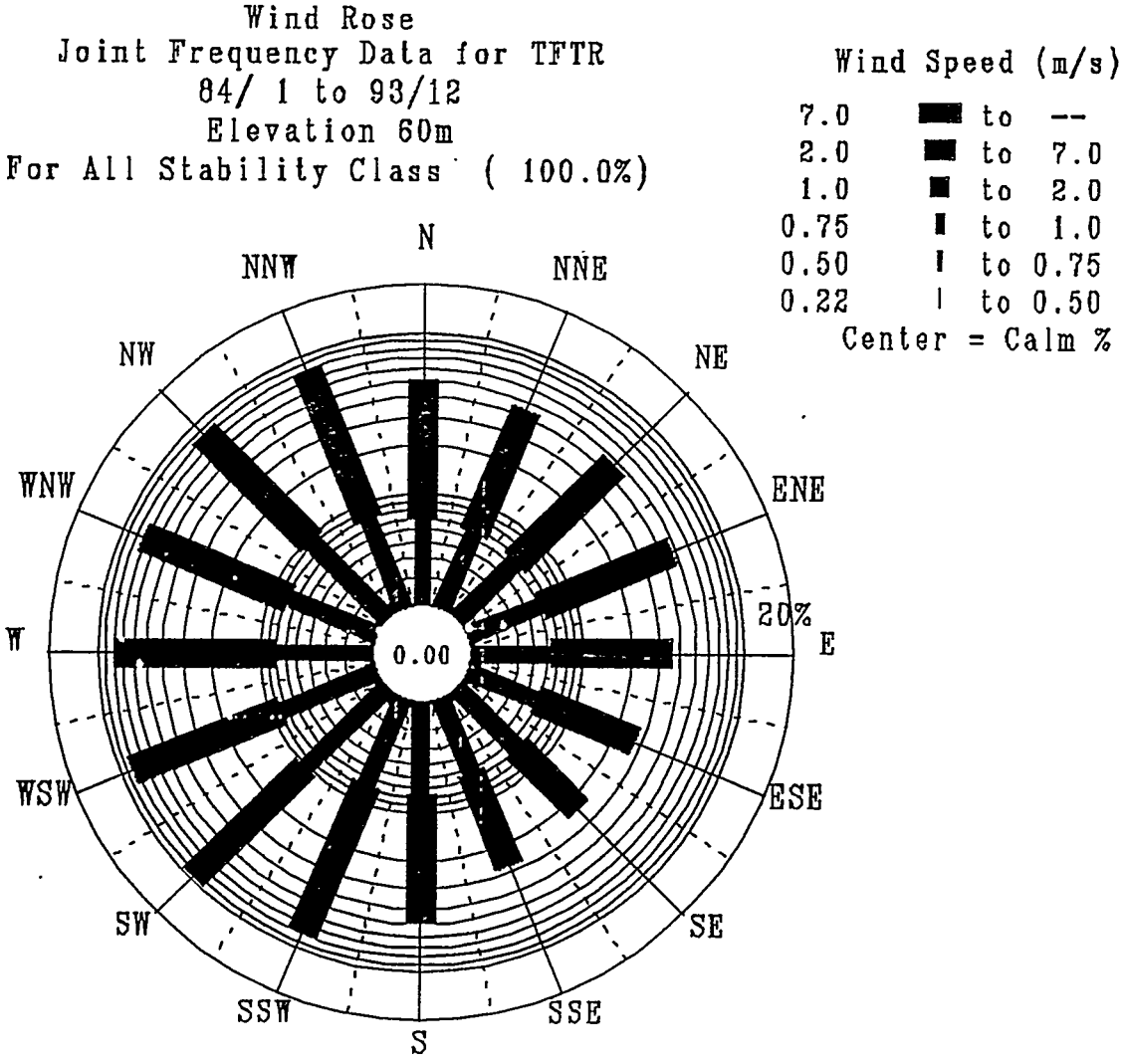

Figure 10. Wind Rose Joint Frequency Data for TFTR at 60 m, 1984-1993

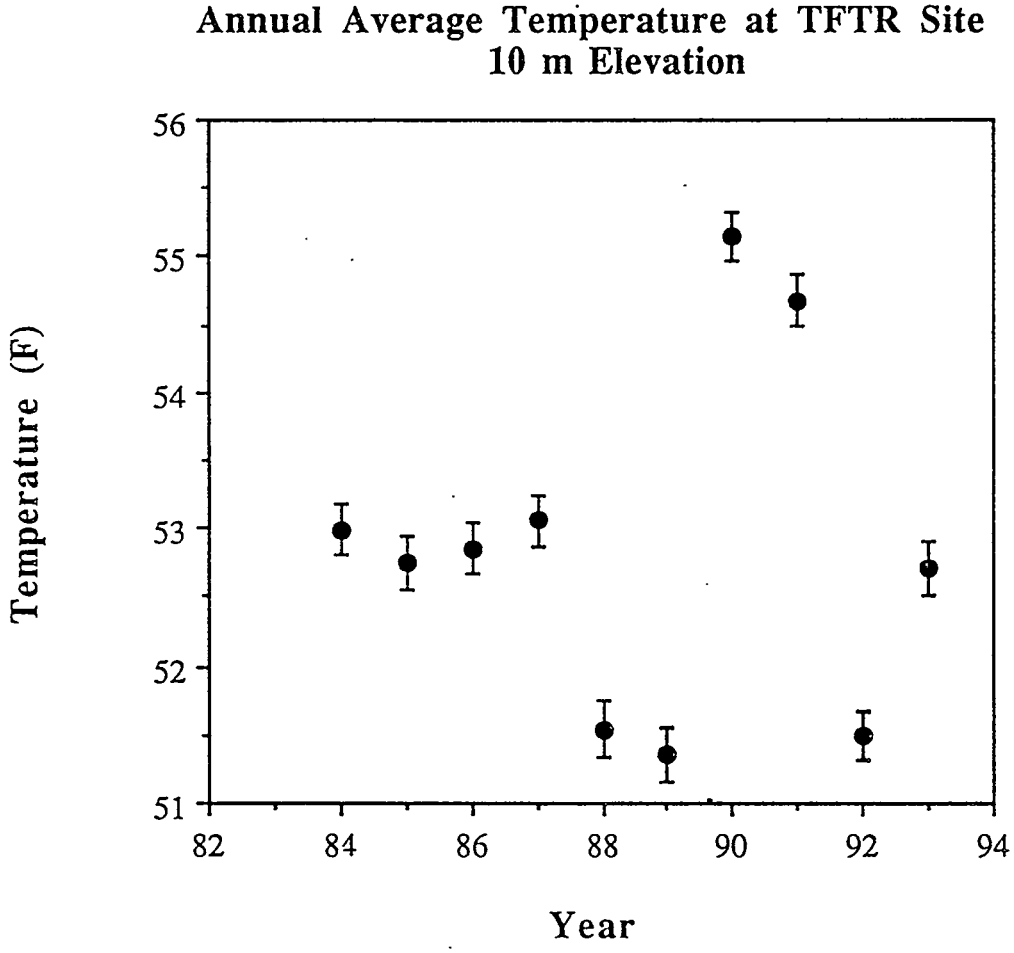

Figure 11. Annual Average Temperature at TFTR, 1984-1993

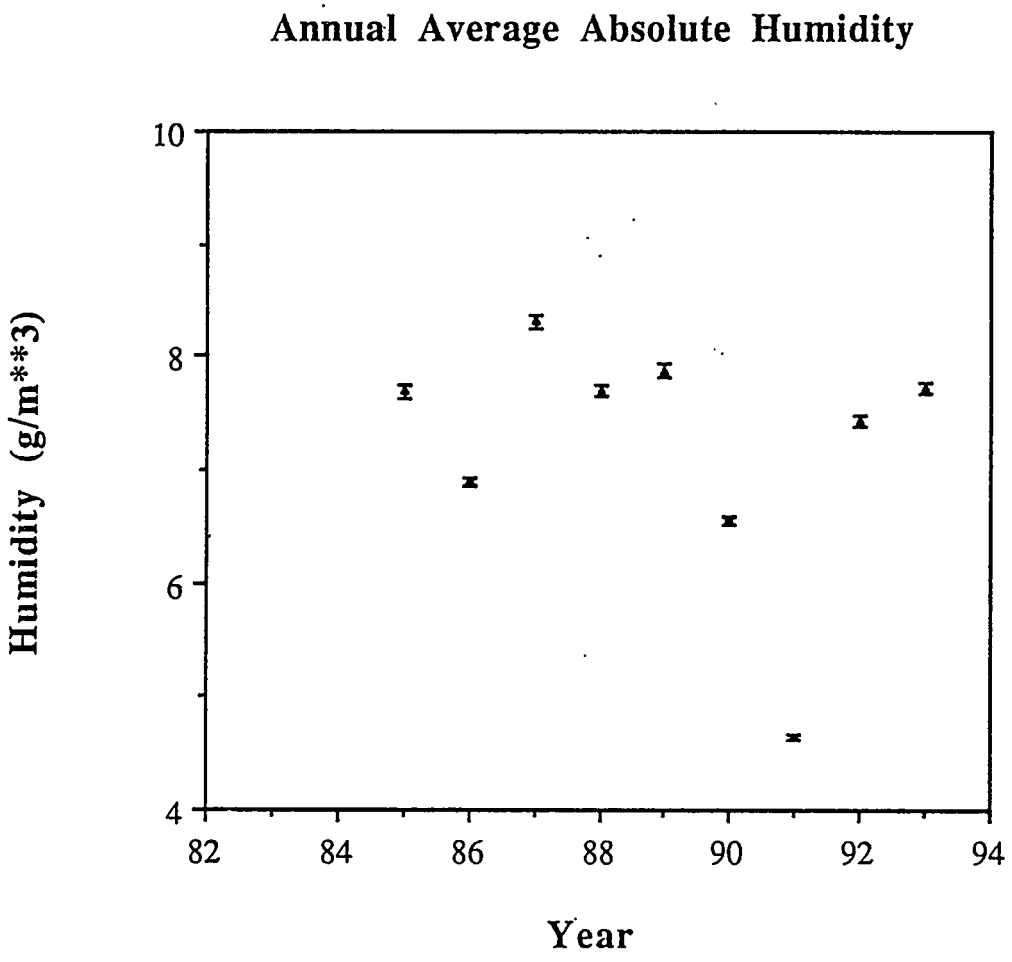

Figure 12. Annual Average Absolute Humidity at TFTR Site, 1984-1993

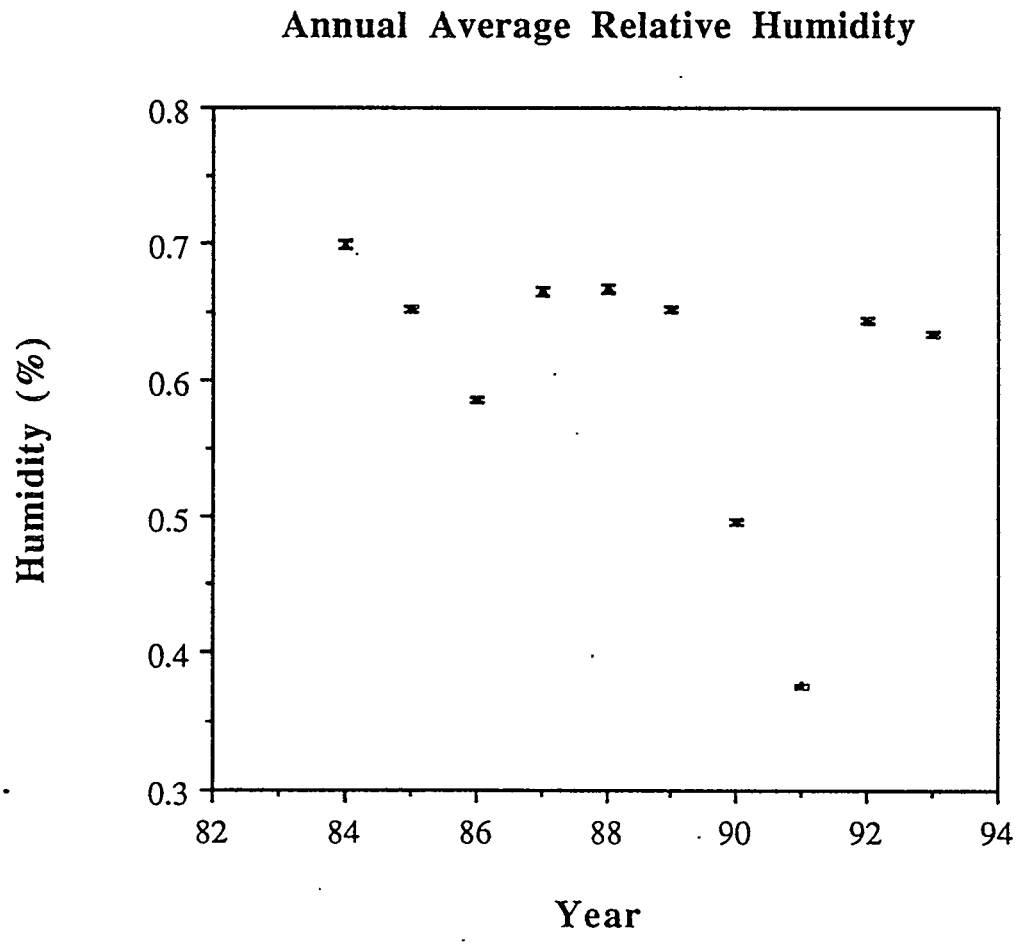

Figure 13. Annual Average Relative Humidity at TFTR Site, 1984-1993

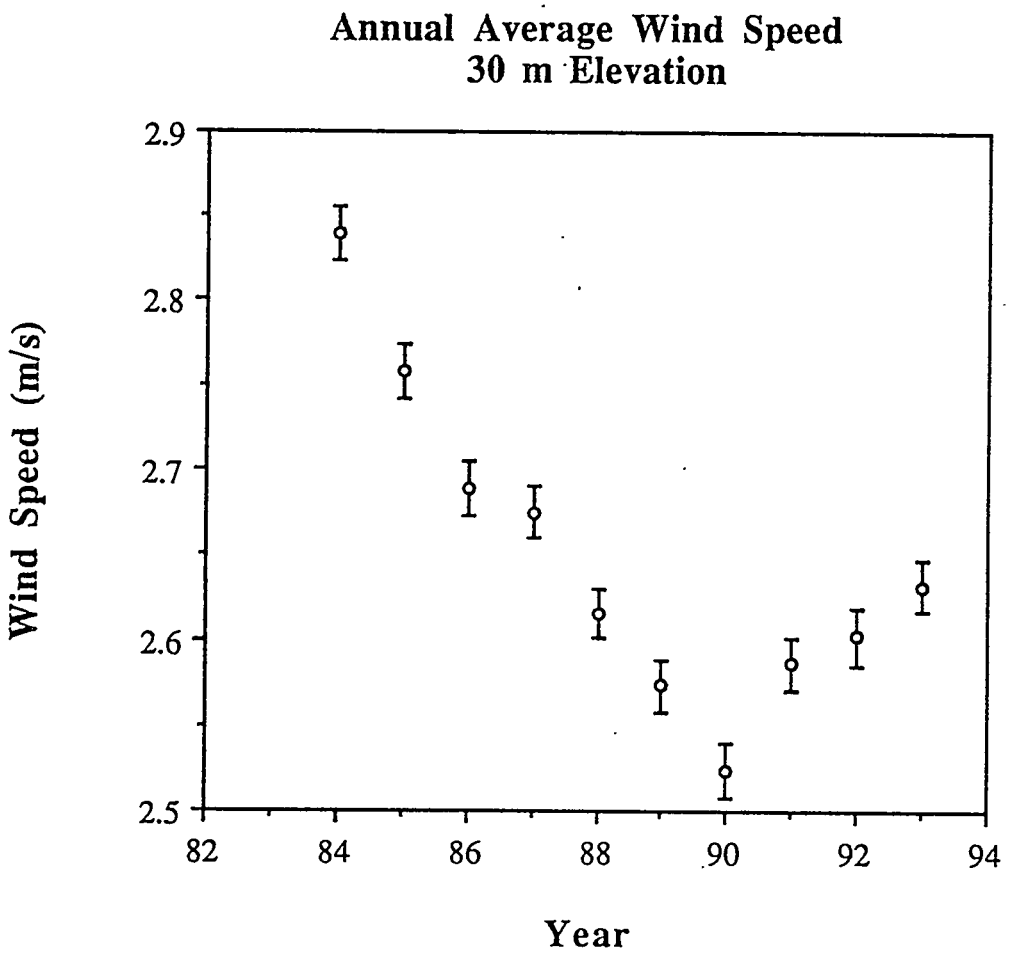

Figure 14. Annual Average Wind Speed at 30 m, 1984-1993

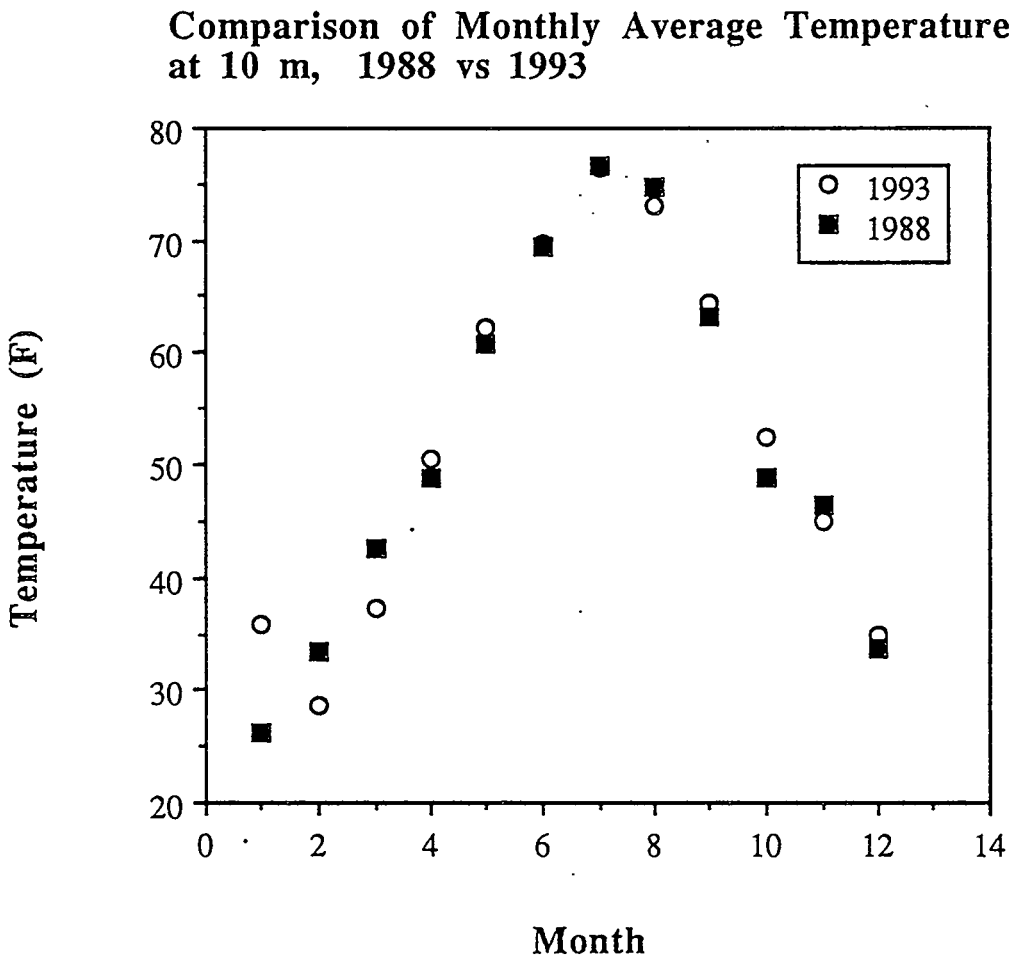

Figure 15. Comparison of Monthly Average Temperature at 10 m, 1984 vs. 1993

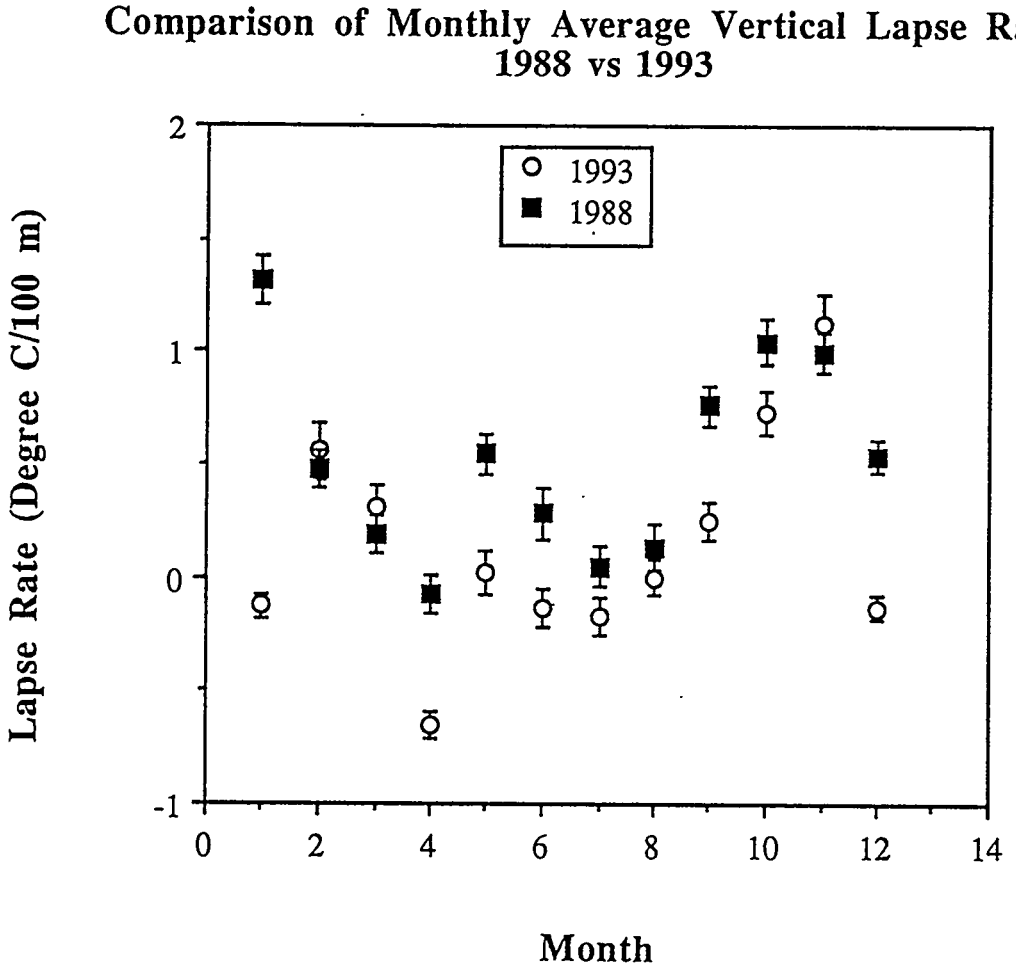

Figure 16. Comparison of Monthly Average Vertical Lapse Rate, 1988 vs. 1993

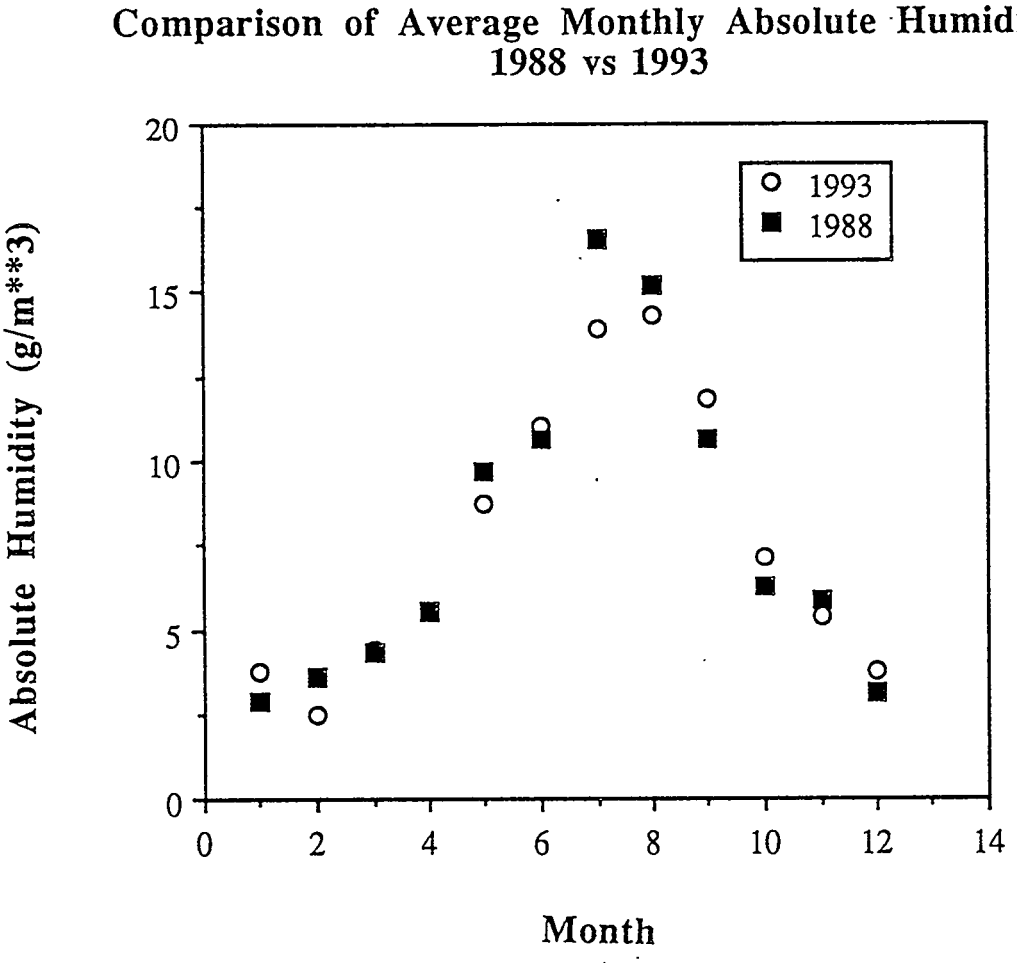

Figure 17. Comparison of Monthly Absolute Humidity, 1988 vs. 1993

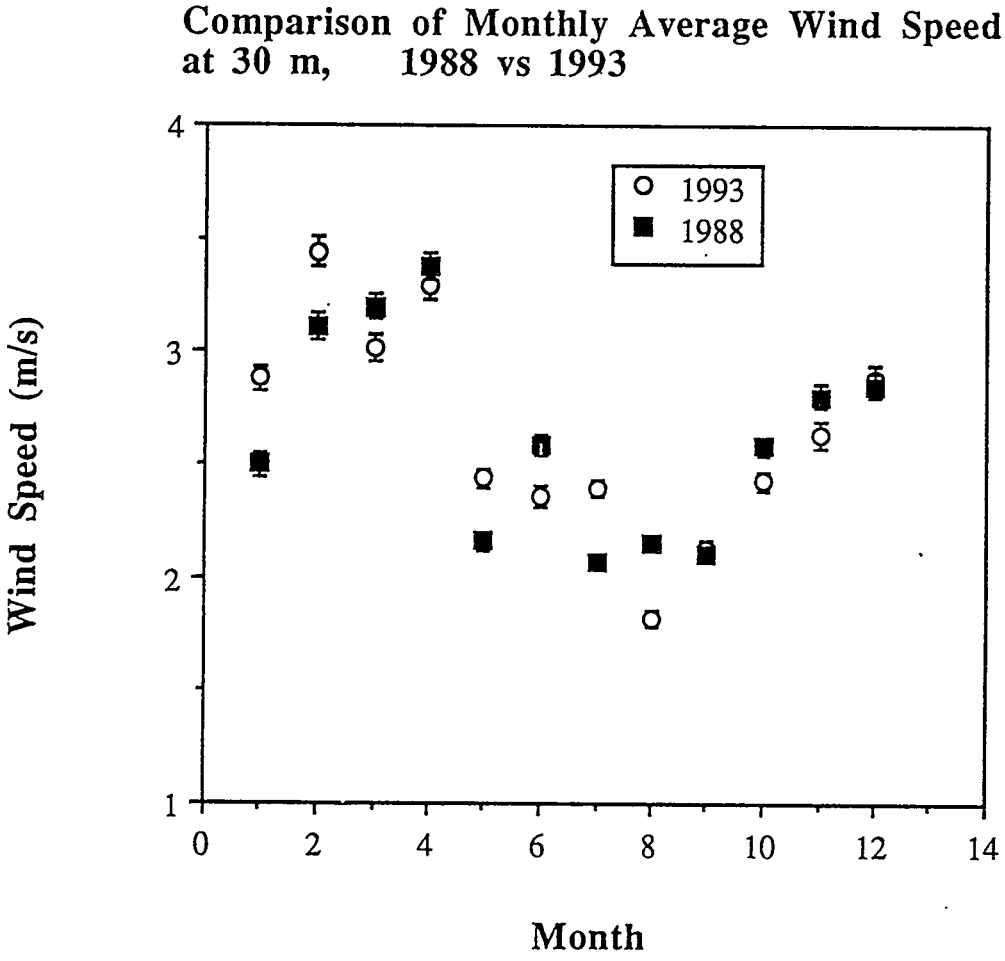

Figure 18. Comparison of Monthly Average Wind Speed at 30 m, 1984 vs. 1993

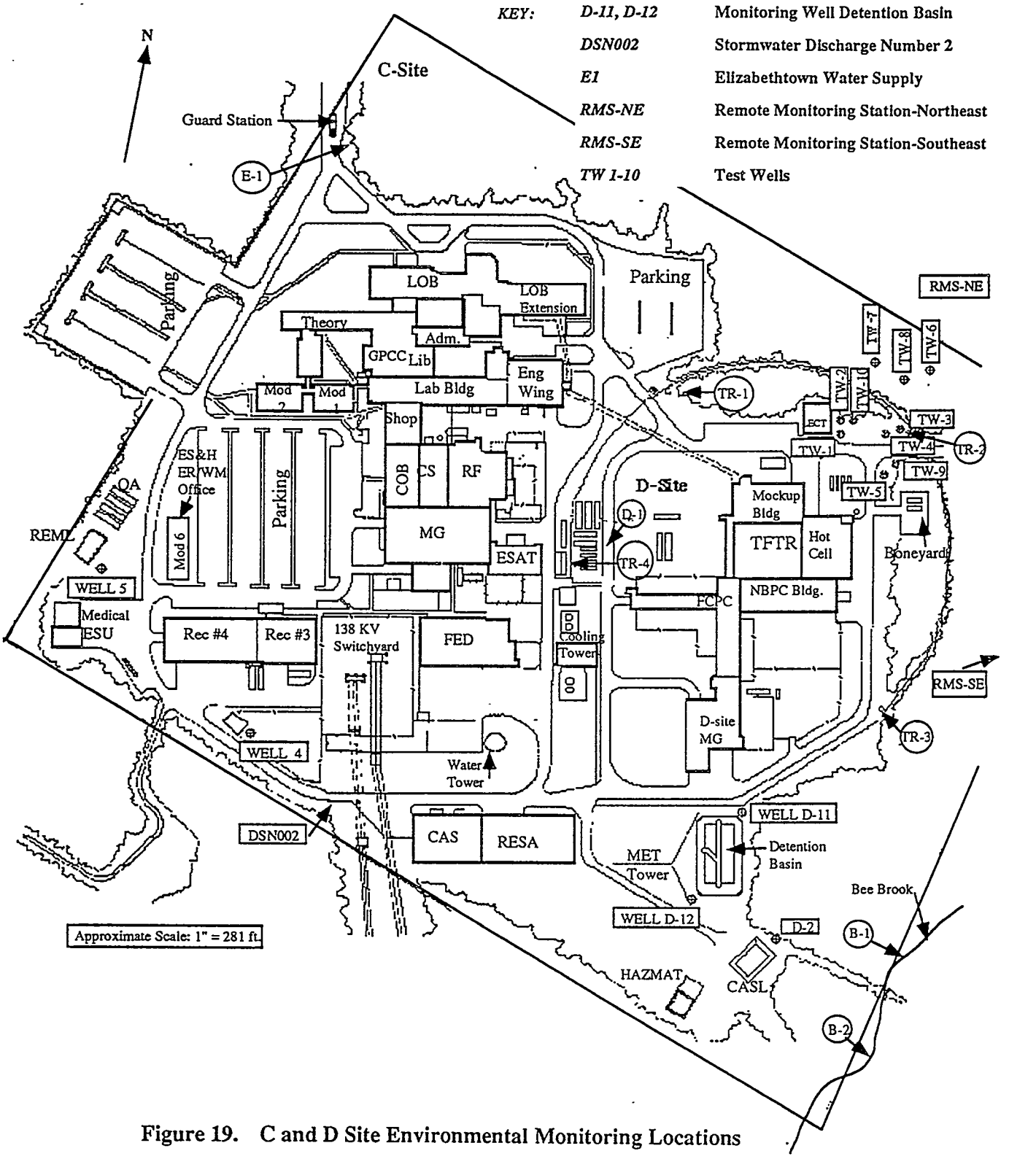

Figure 19. C and D Site Environmental Monitoring Locations

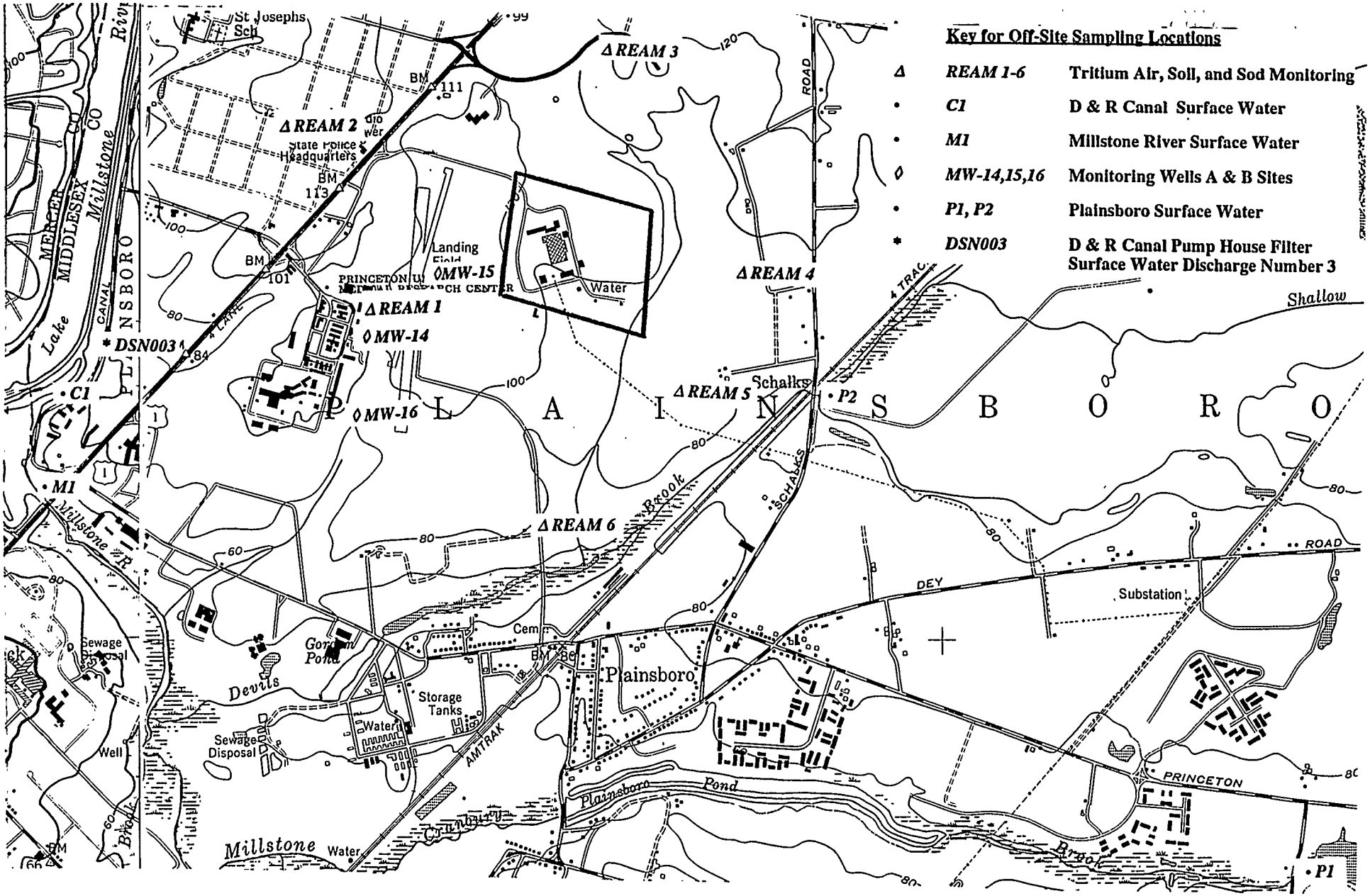

Figure 20. Offsite Monitoring Locations

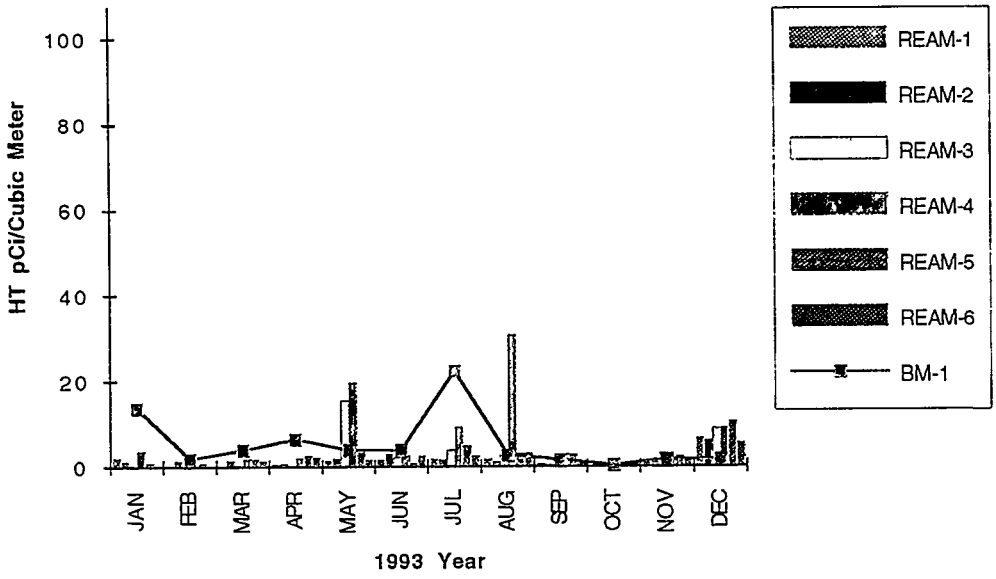

Figure 21. 1993 Air Tritium (HT) - REAM-1 to REAM-6

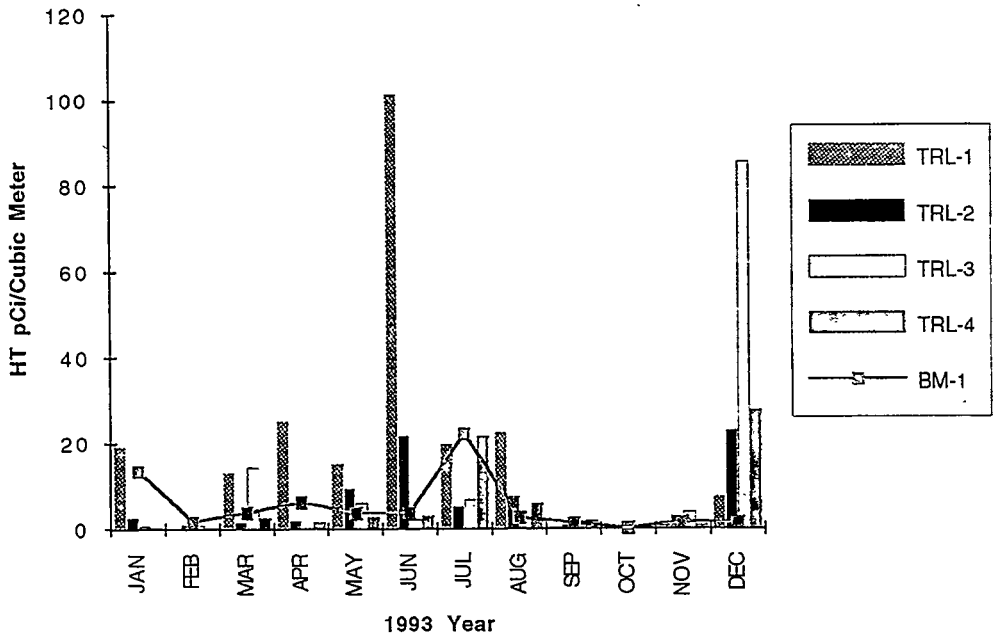

Figure 22. 1993 Air Tritium (HT) - TRL-1 to TRL-4

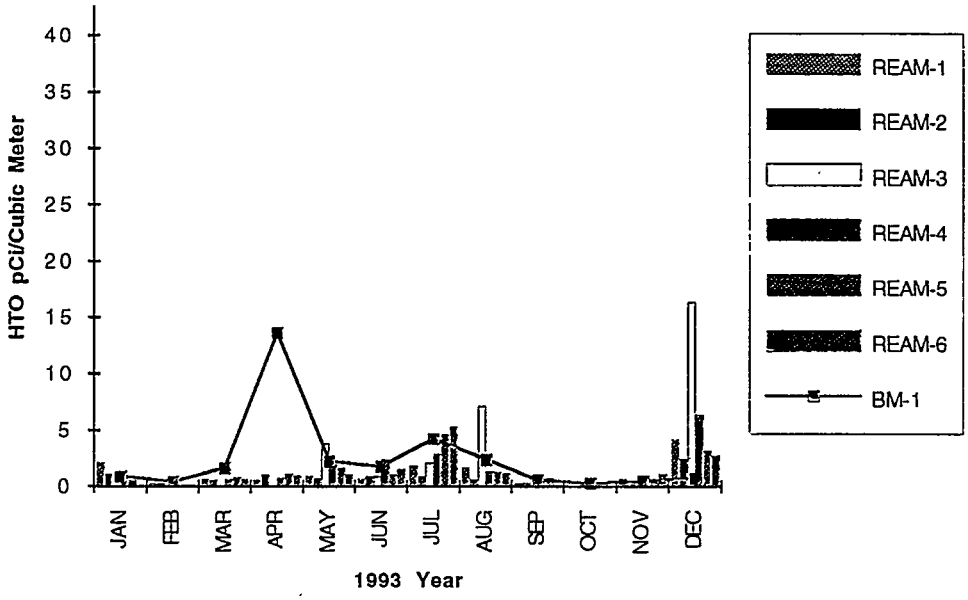

Figure 23. 1993 Air Tritium (HTO) - REAM-1 to REAM-6

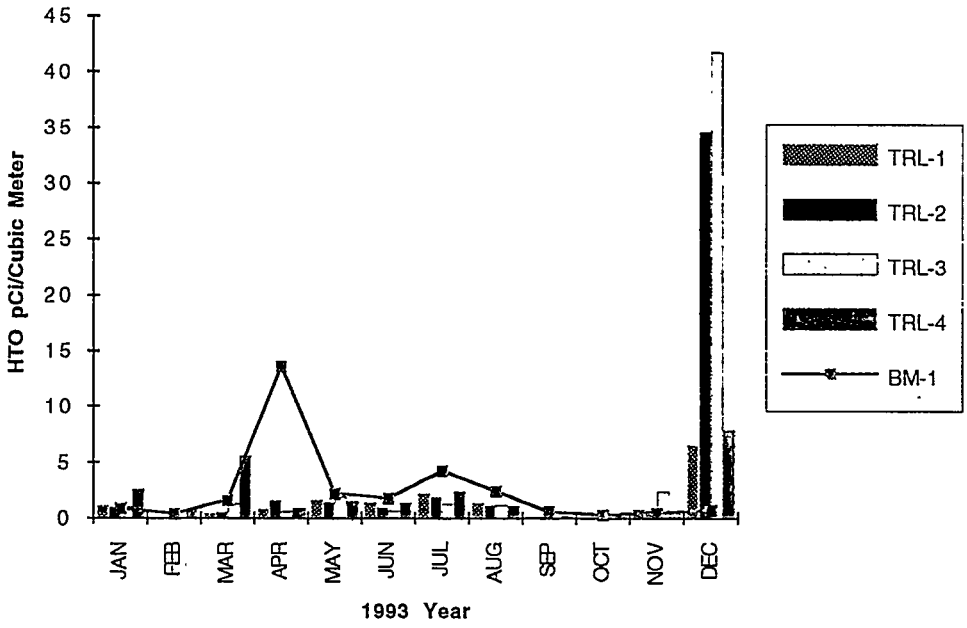

Figure 24. 1993 Air Tritium (HTO) - TRL-1 to TRL-4

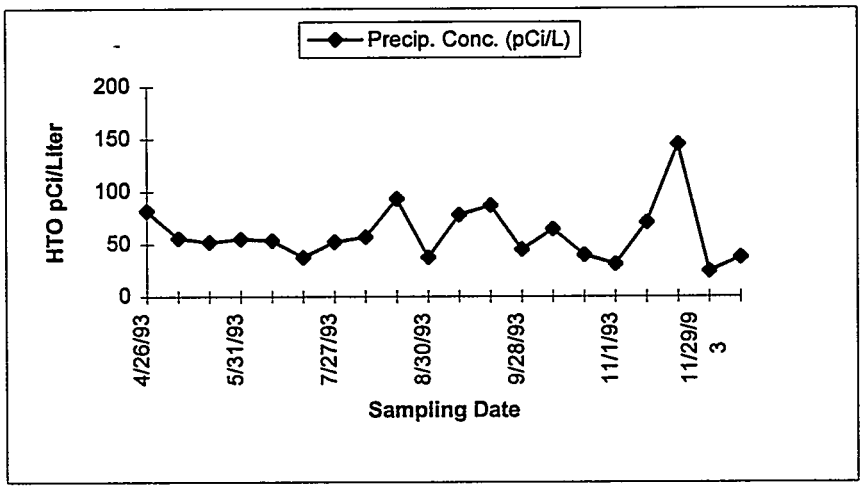

Figure 25. 1993 Tritium (HTO) in Rain Water

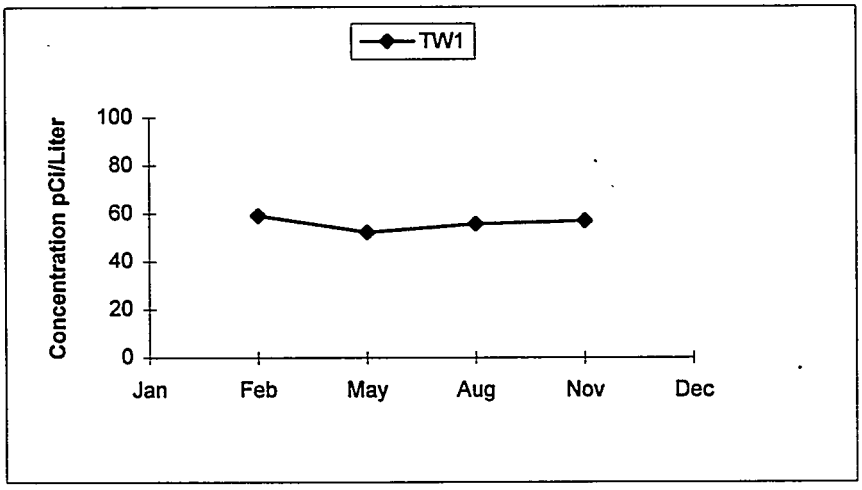

Figure 26. 1993 Tritium (HTO) in Ground Water

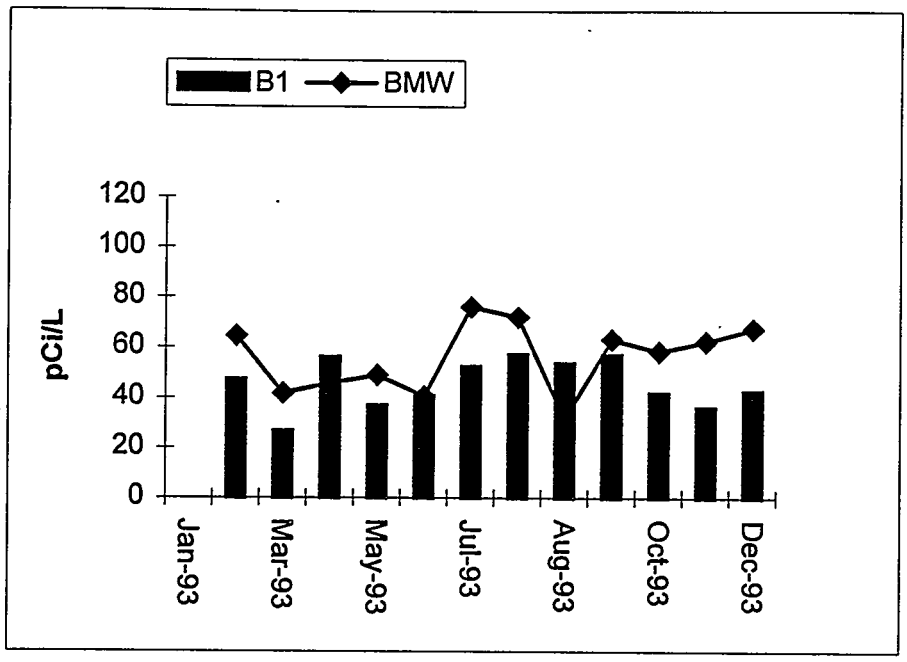

Figure 27. 1993 Tritium (HTO) Concentrations in Surface Water - B1

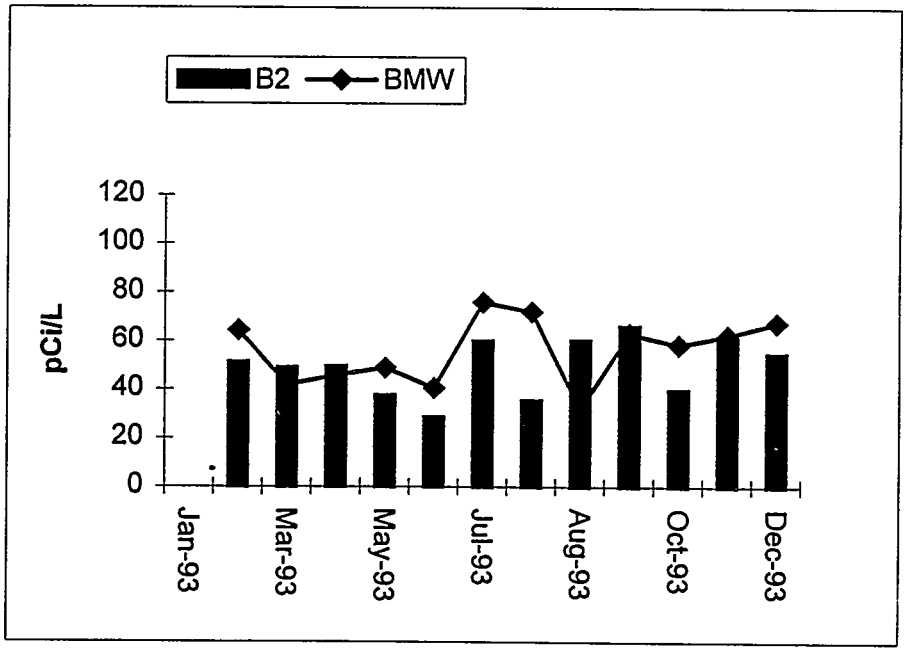

Figure 28. 1993 Tritium (HTO) Concentrations in Surface Water - B2

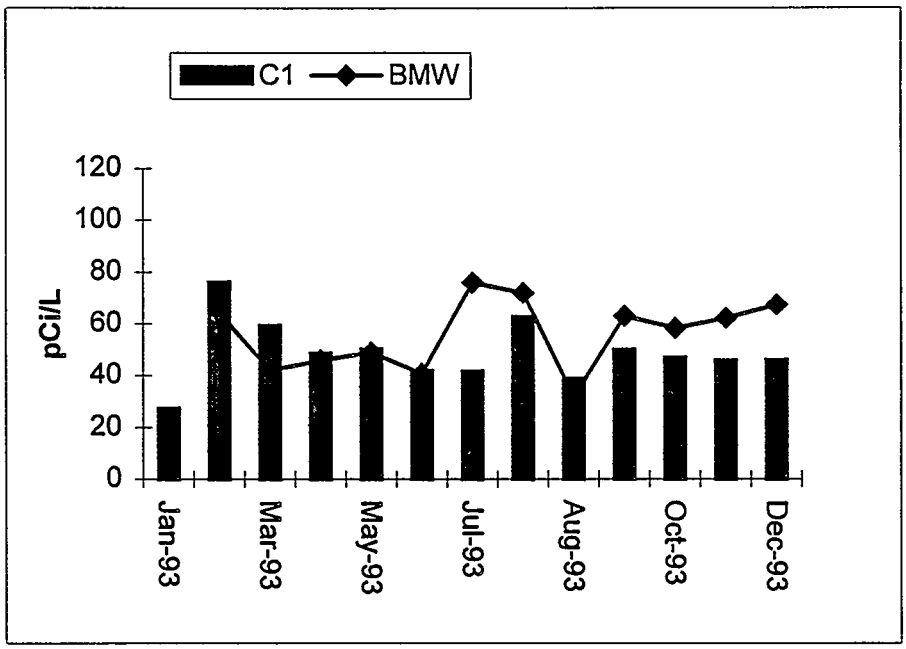

Figure 29. 1993 Tritium (HTO) Concentrations in Surface Water - C1

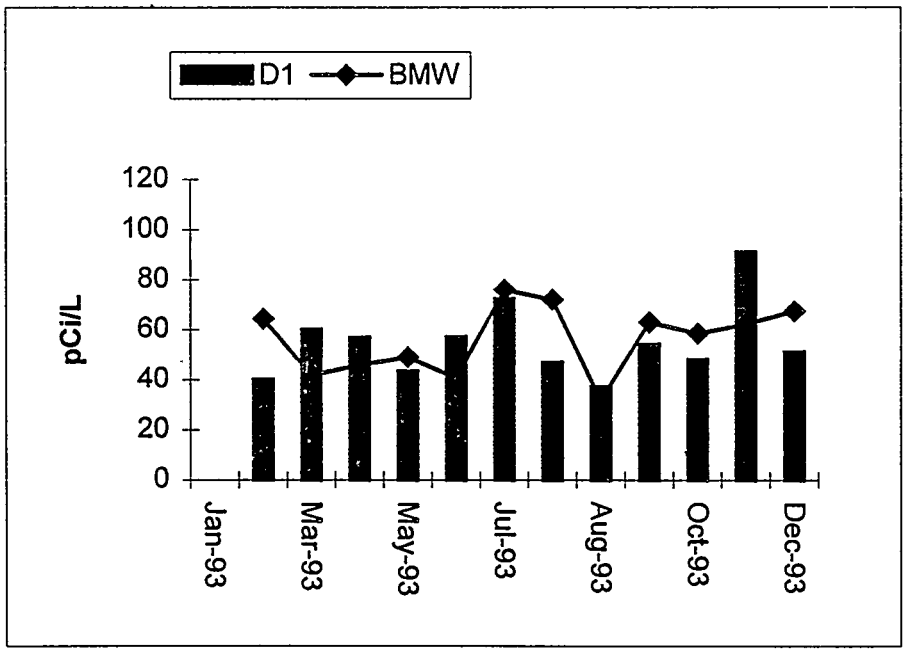

Figure 30. 1993 Tritium (HTO) Concentrations in Surface Water - D1

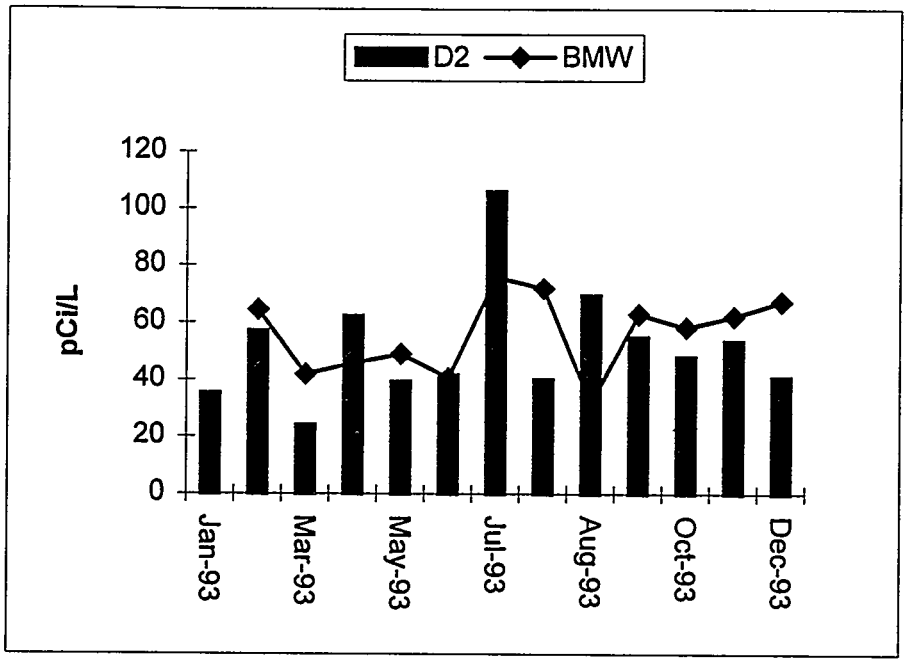

Figure 31. 1993 Tritium (HTO) Concentrations in Surface Water - D2

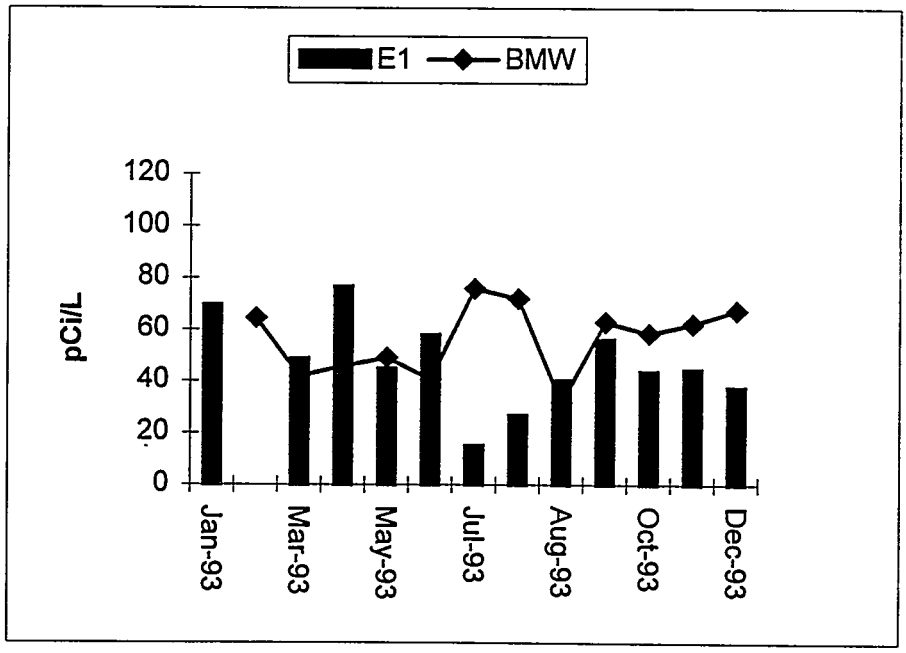

Figure 32. 1993 Tritium (HTO) Concentrations in Surface Water - E1

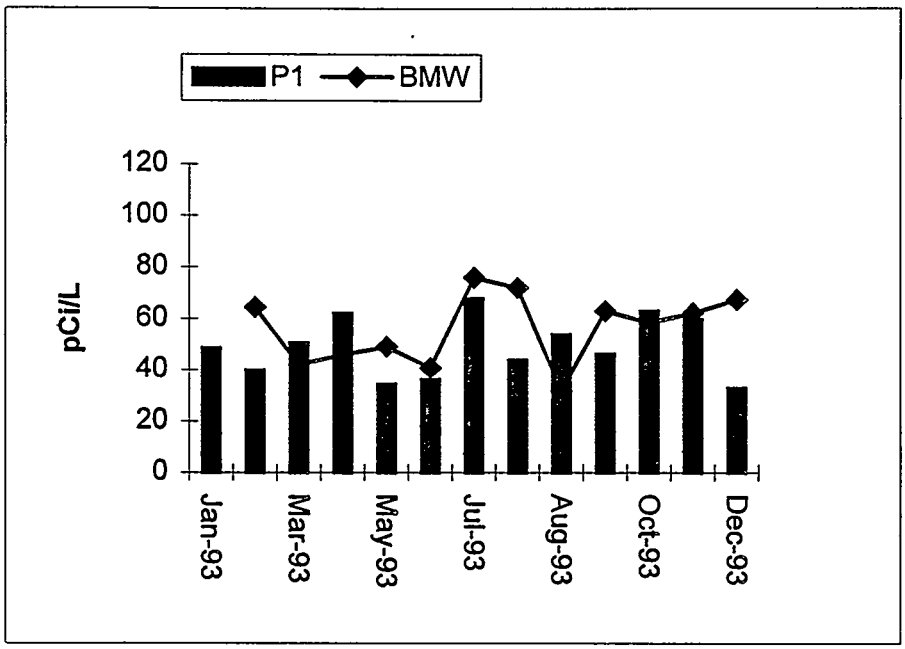

Figure 33. 1993 Tritium (HTO) Concentrations in Surface Water - P1

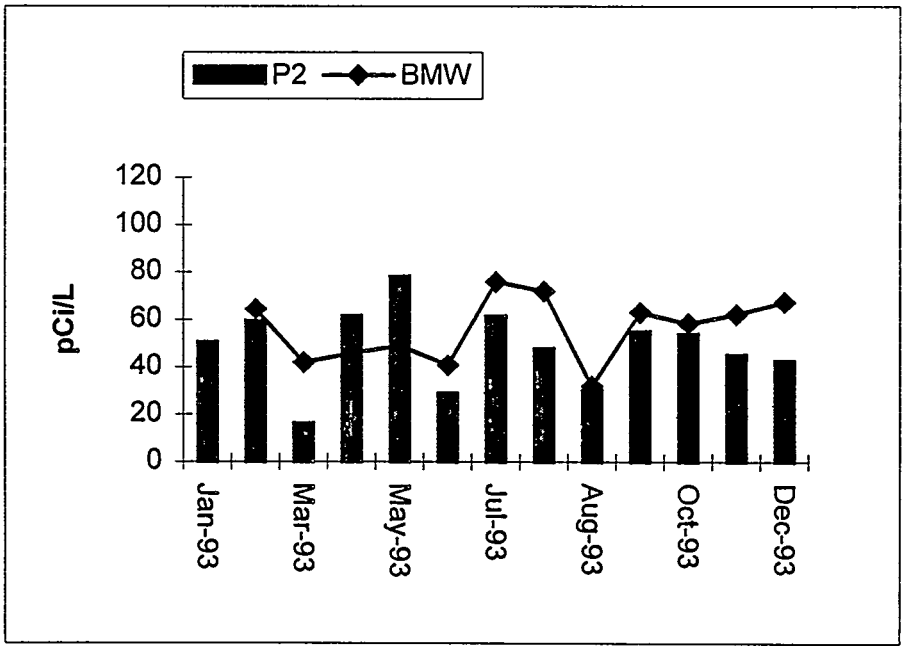

Figure 34. 1993 Tritium (HTO) Concentrations in Surface Water - P2

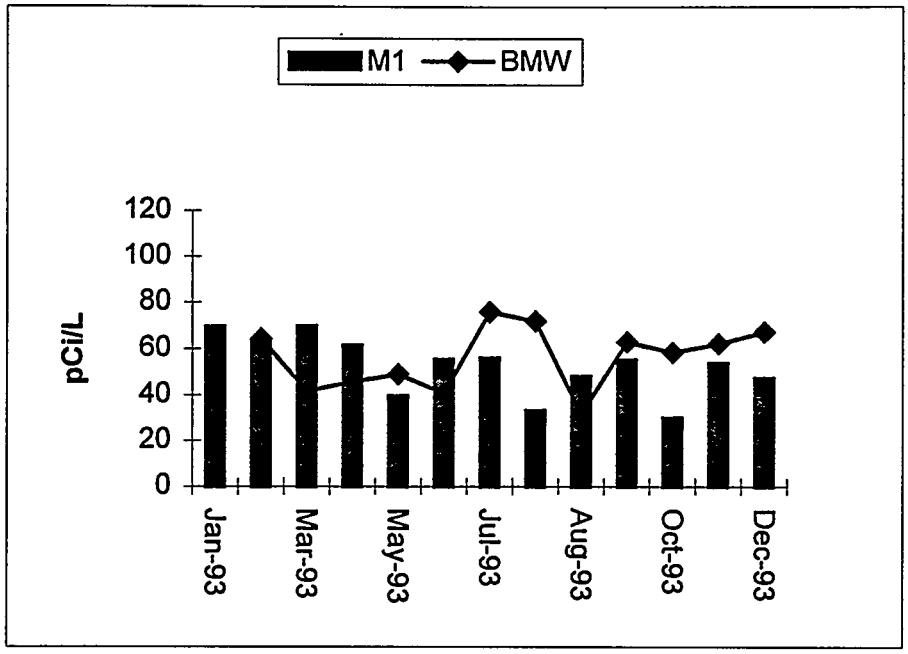

Figure 35. 1993 Tritium (HTO) Concentrations in Surface Water - M1

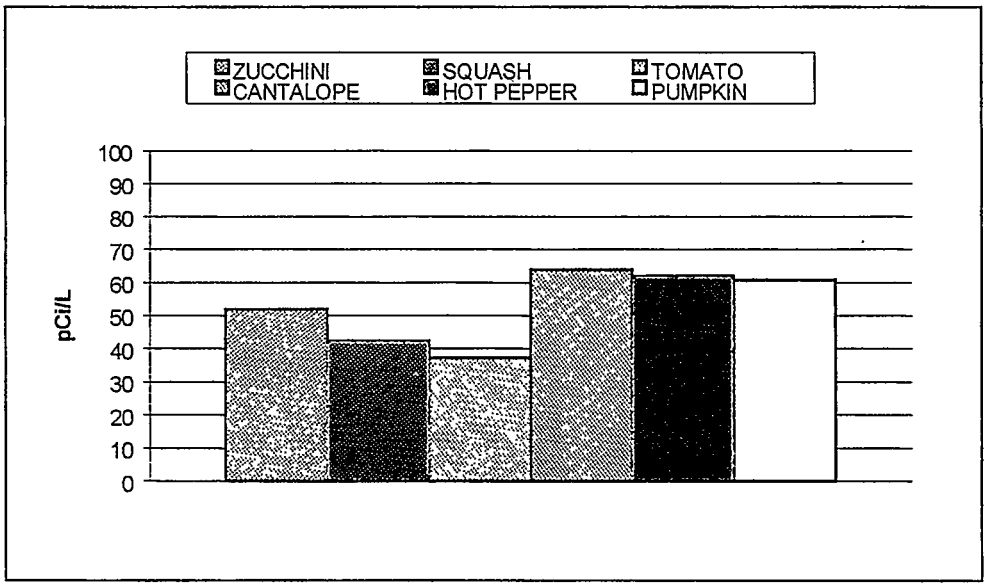

Figure 36. 1993 Tritium (HTO) in Biota

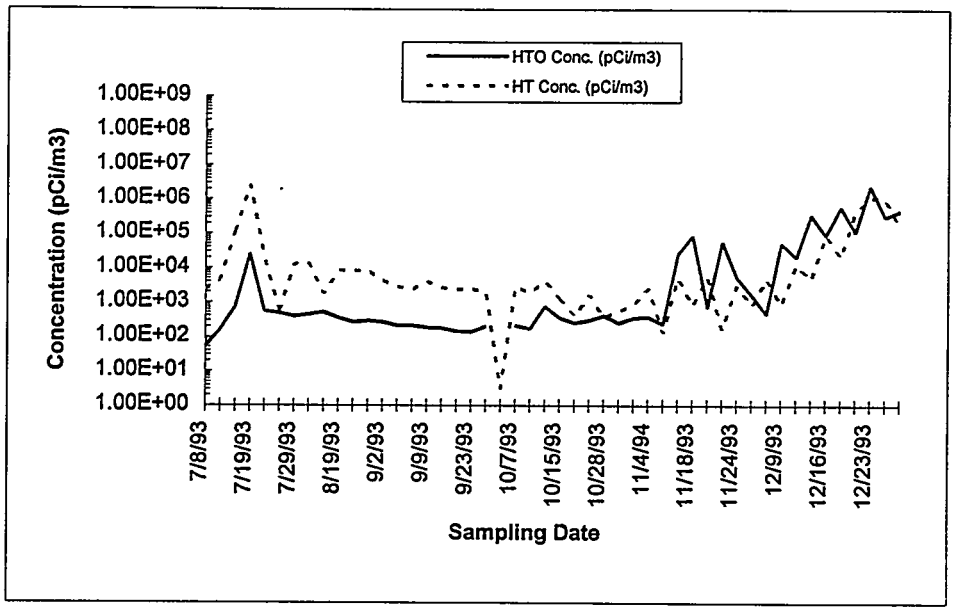

Figure 37. TFTR Total Stack Tritium (HT/HTO) Release for Activities 1993

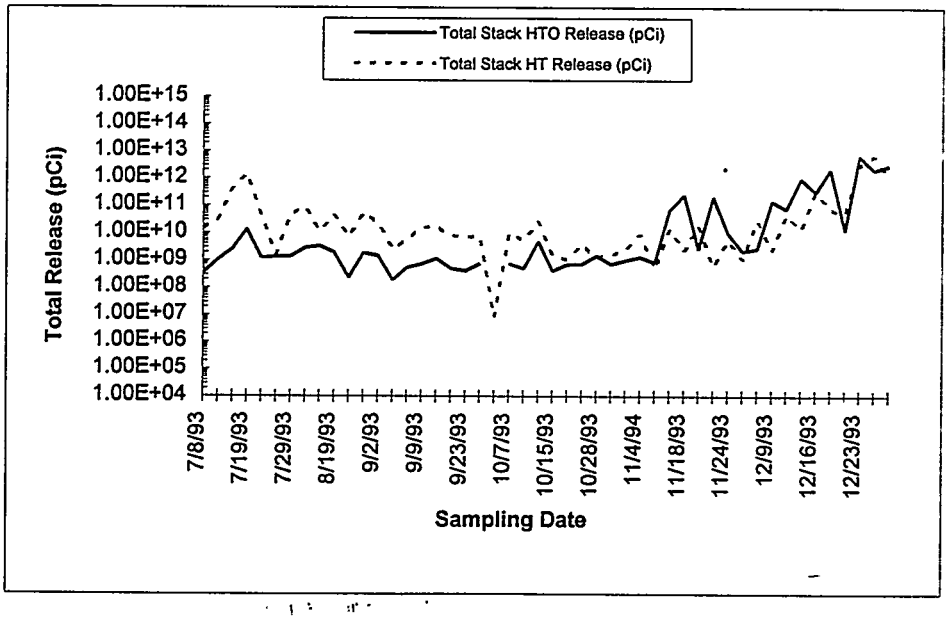

Figure 38. TFTR Stack Tritium (HT/HTO) Concentrations for 1993

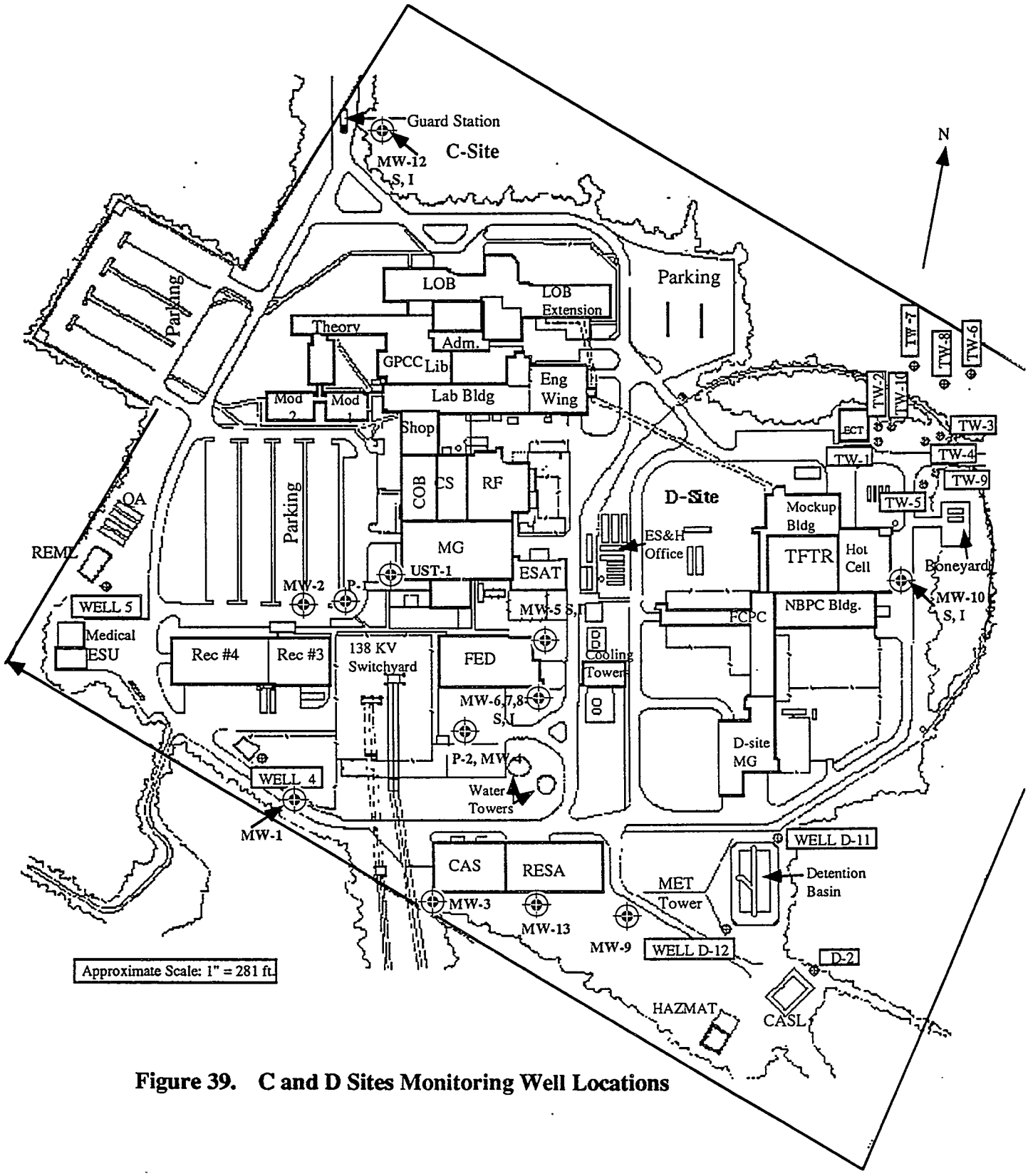

Figure 39. C and D Sites Monitoring Well Locations

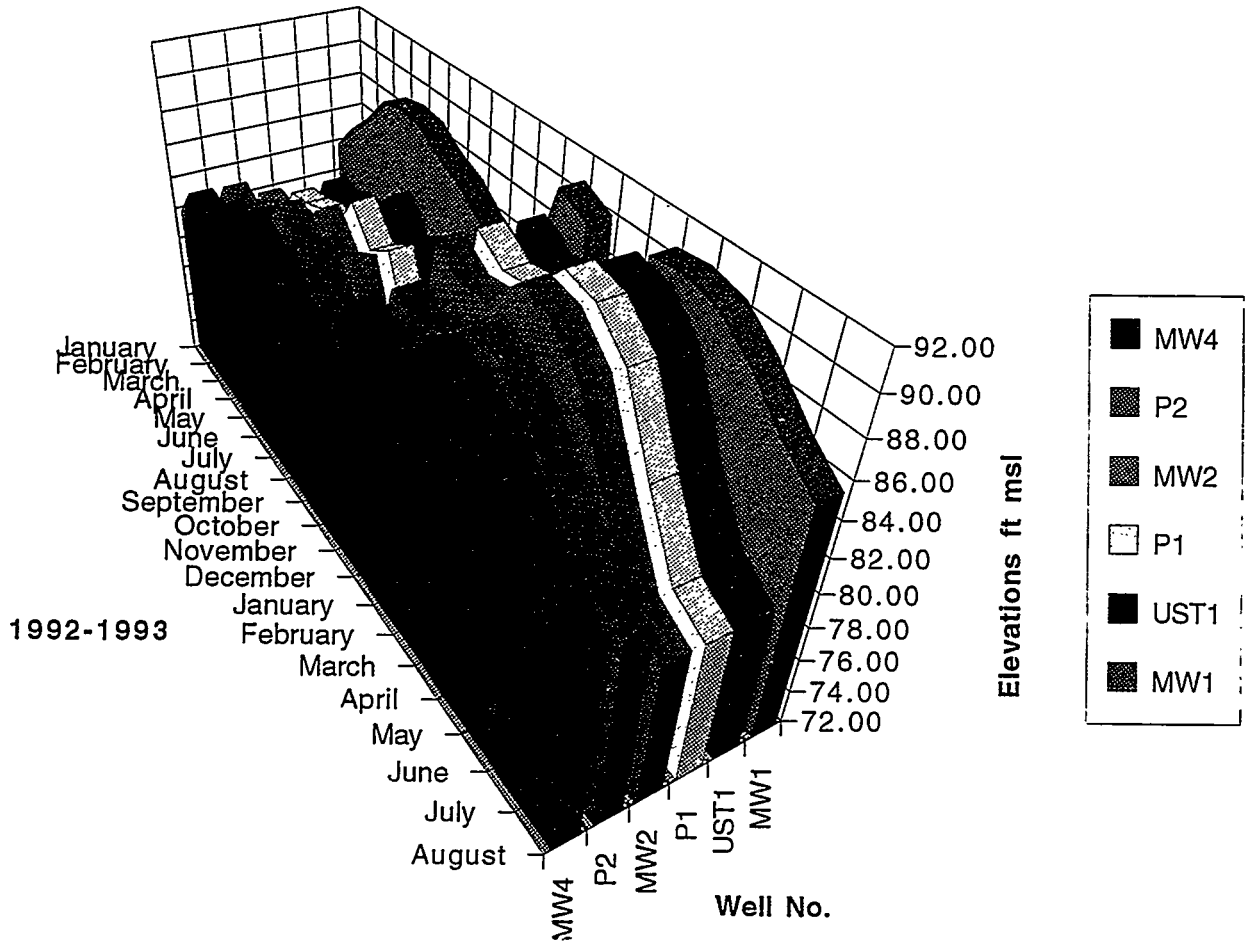

Figure 40. Monthly Water Elevations Upgradient Wells (1,2,4, UST1, P-1, and P-2)

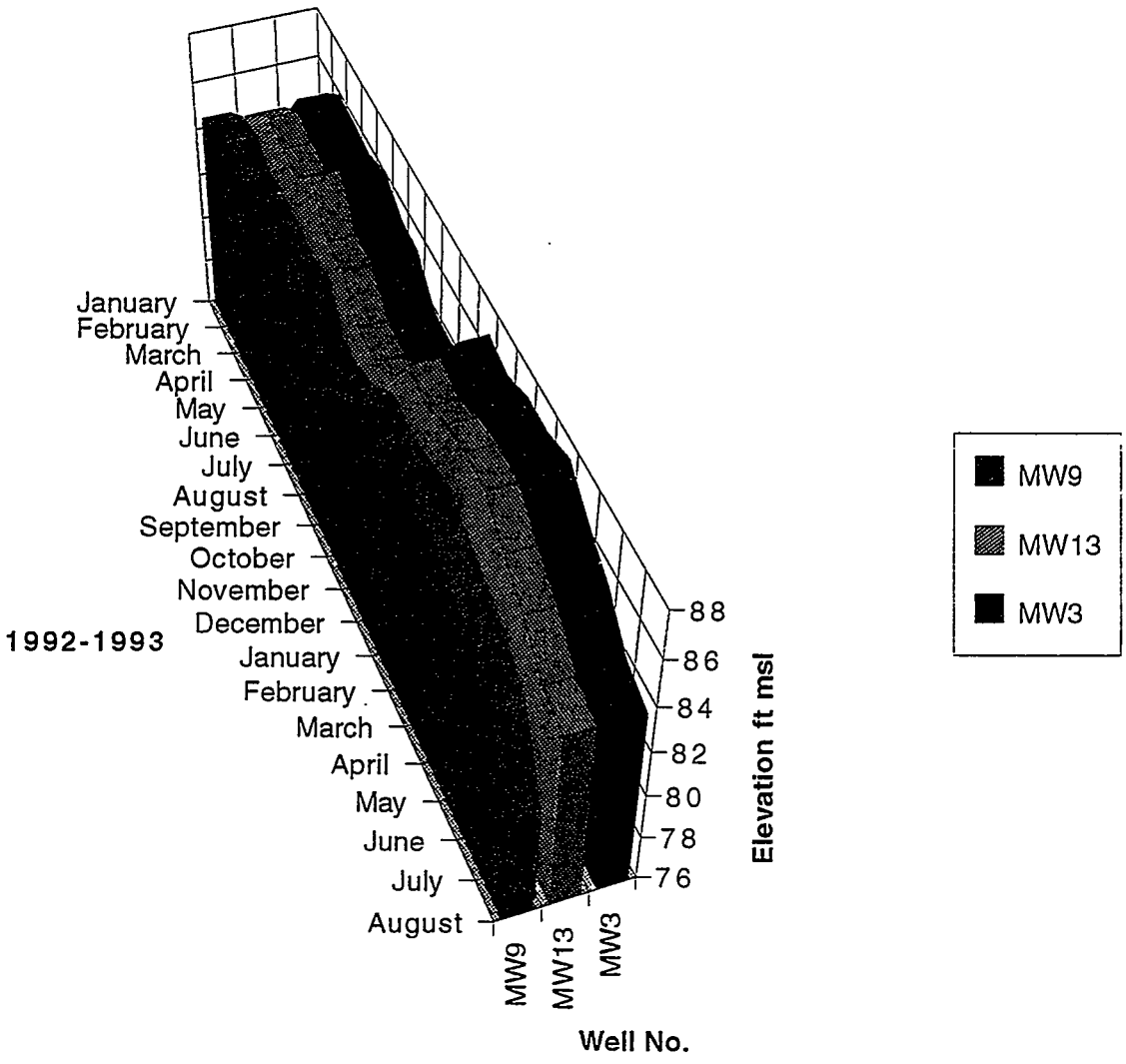

Figure 41. Monthly Water Elevations for Monitoring Wells 3, 9, and 13

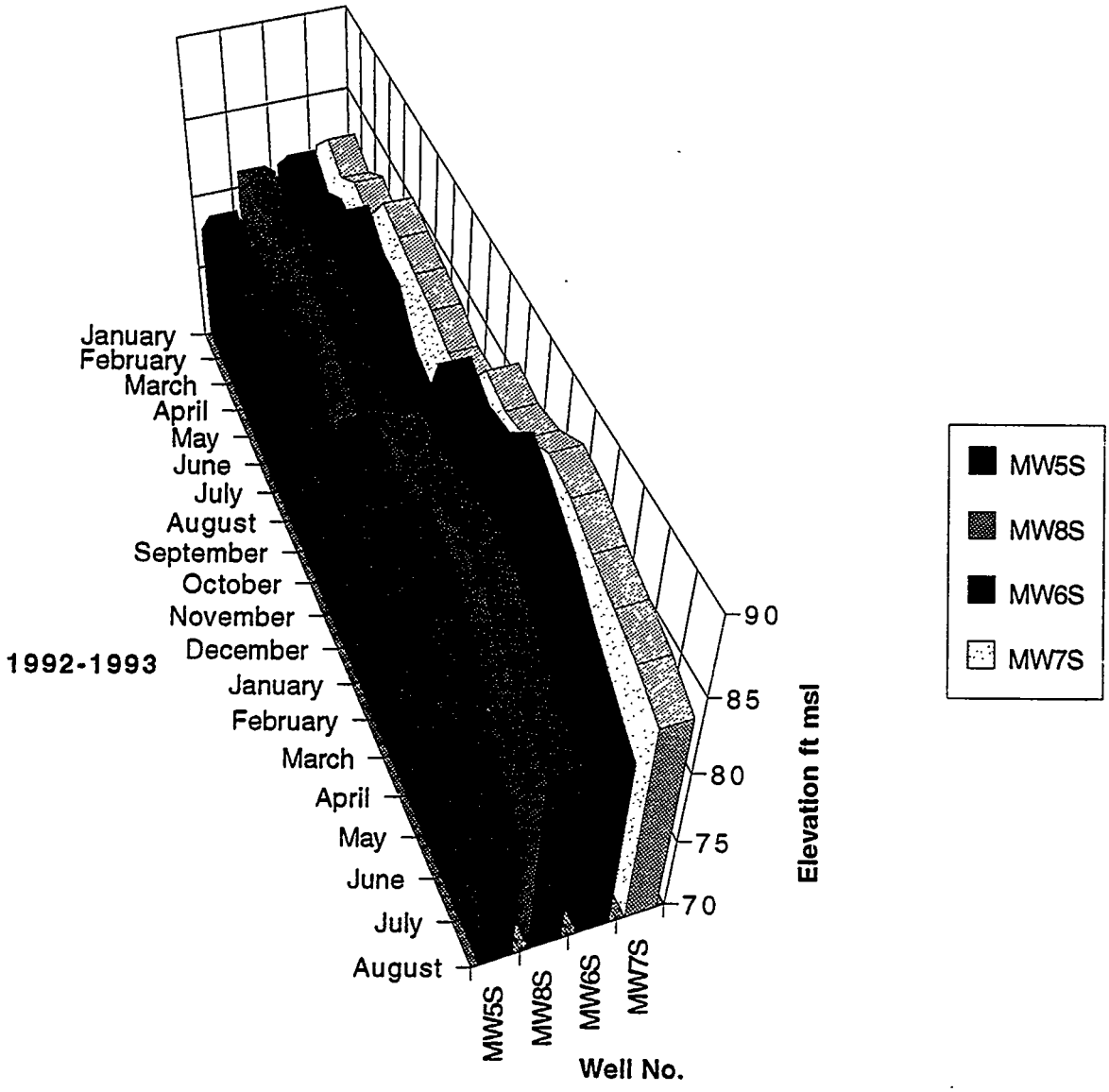

Figure 42. Monthly Water Elevations Shallow Wells (5S, 6S, 7S, 8S)

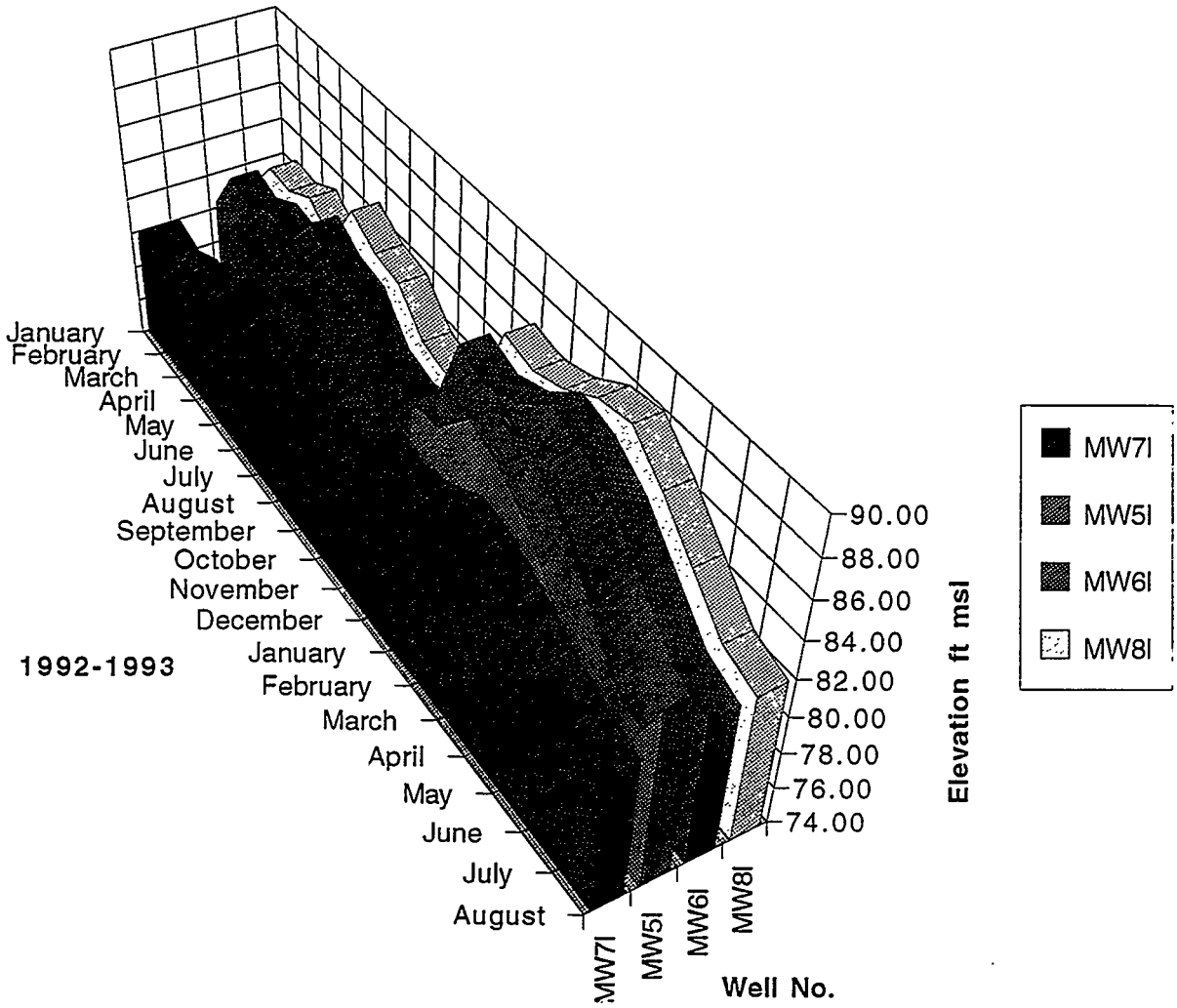

Figure 43. Monthly Water Elevations Intermediate Wells (5I, 6I, 7I, and 8I)

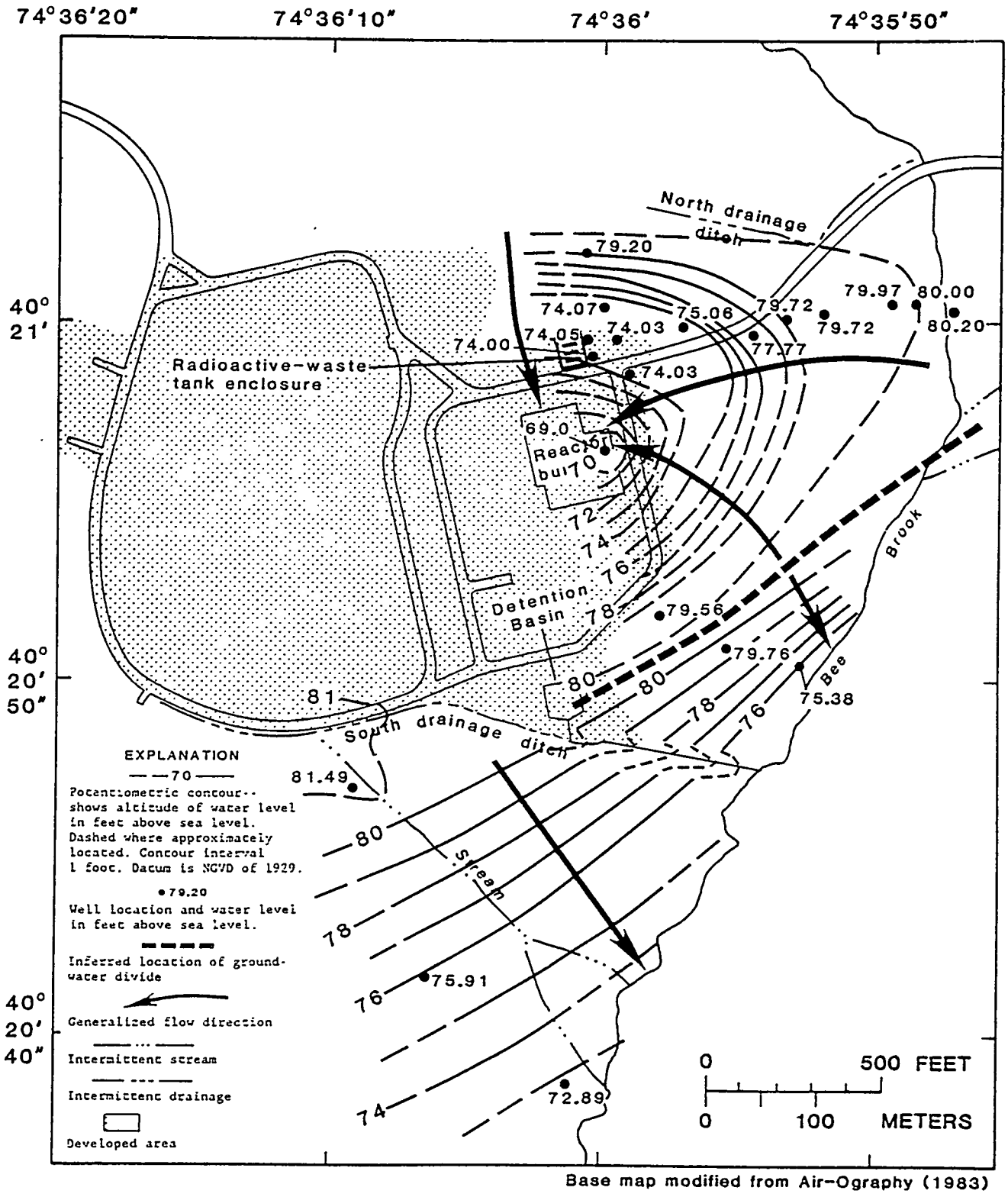

Figure 44. Potentiometric Surface of the Bedrock Aquifer at PPPL, October 30, 1986

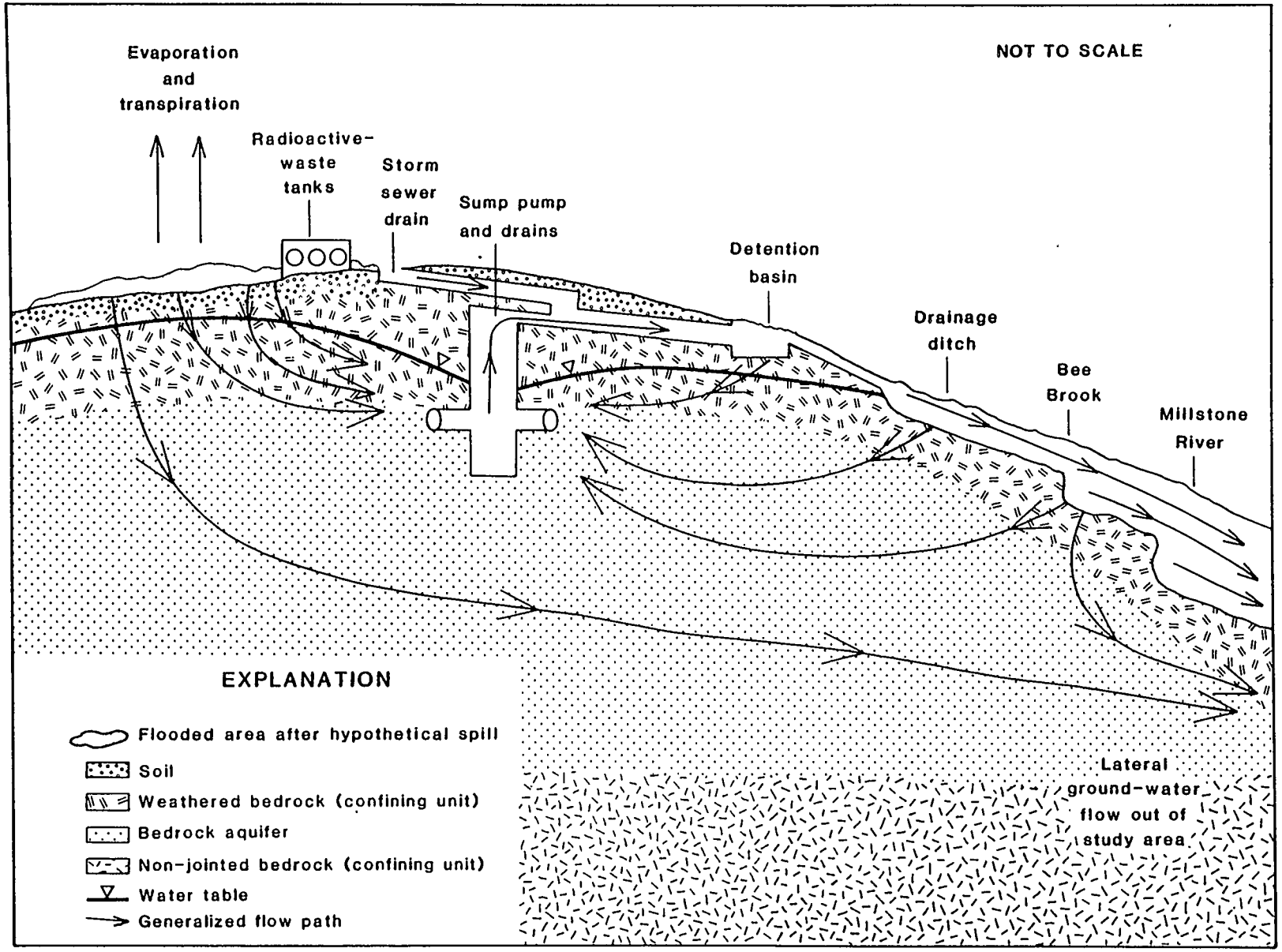

Figure 45. Hydrogeologic Framework and Potential Flow Paths of Spilled Water

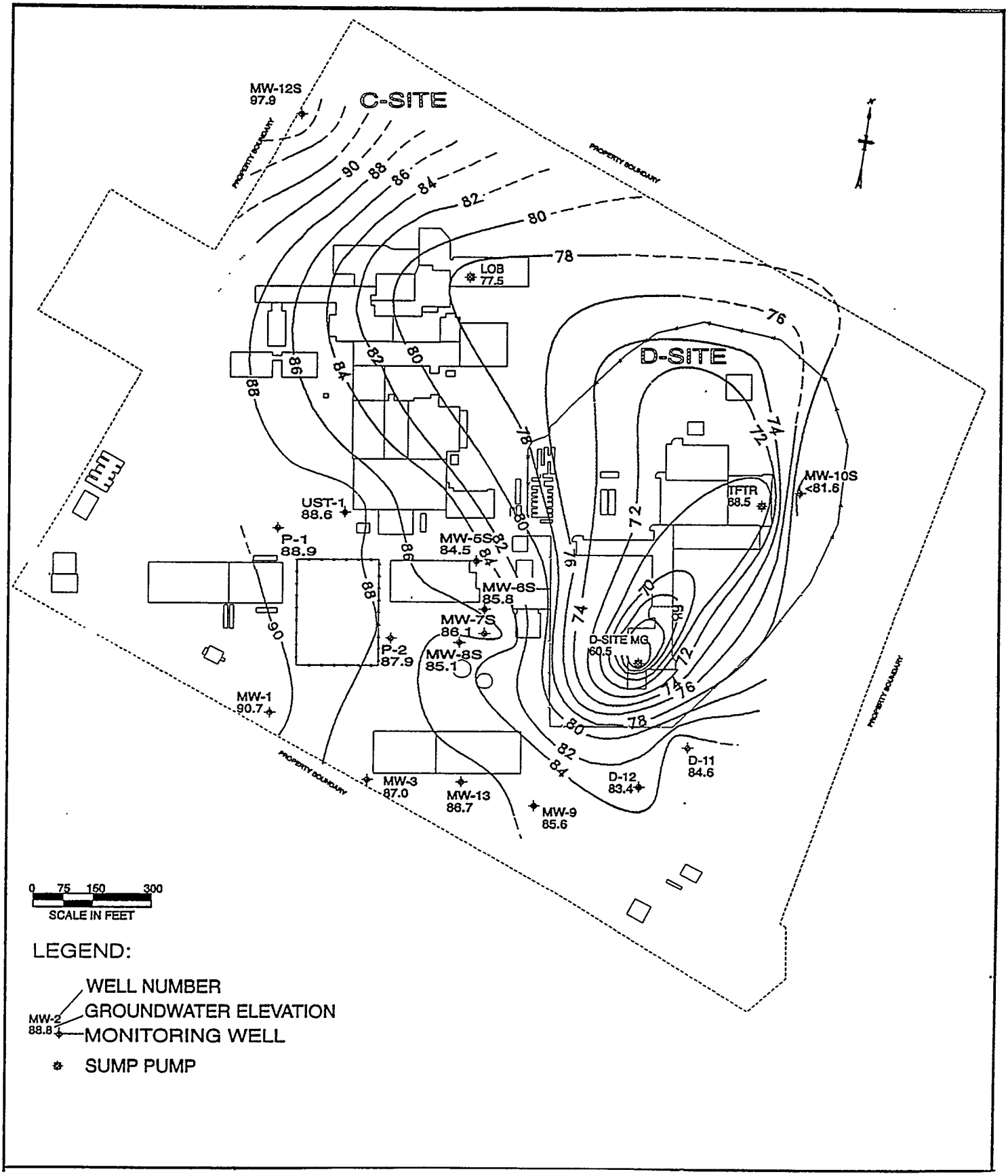

Figure 46. Shallow Groundwater Potentiometer Contour Map, January 11, 1993

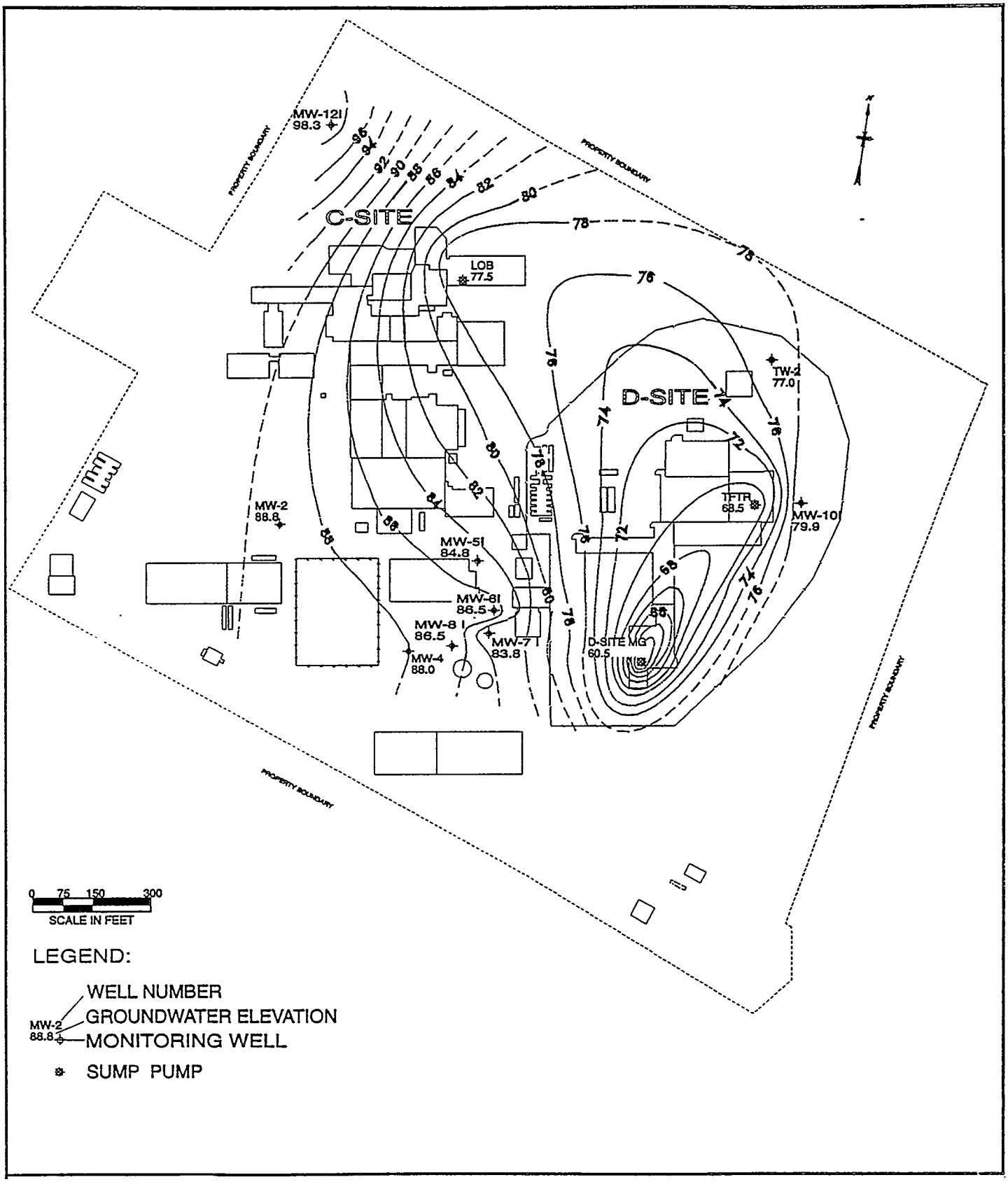

Figure 47. Intermediate Groundwater Potentiometer Contour Map, January 11, 1993

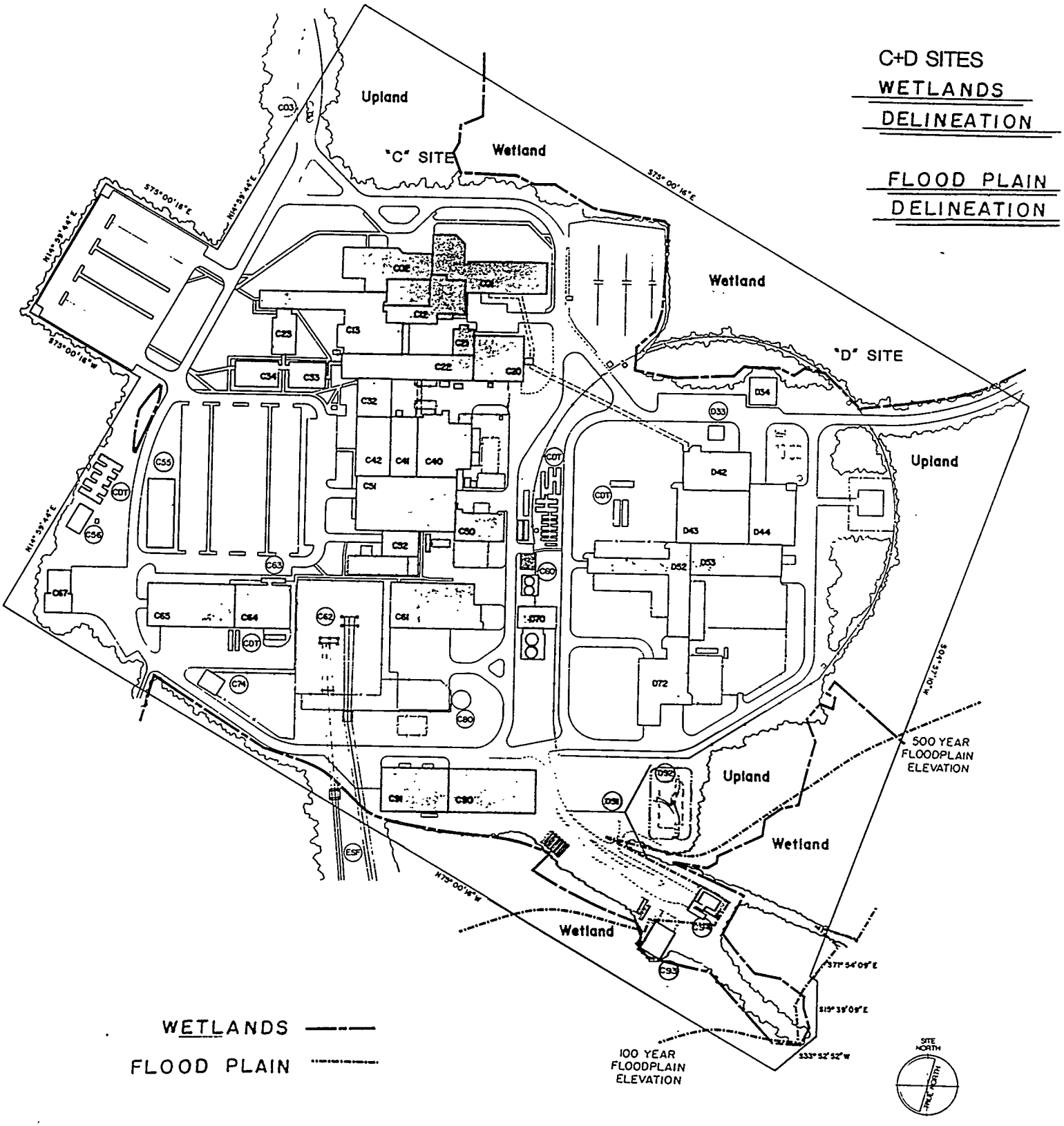

Figure 48. 1993 PPPL Flood Plain and Wetlands Boundaries

Other Distribution

Argonne National Laboratory (R. Kolzow)
Battelle Pacific Northwest Laboratory (E. Eckert Hickey)
Brookhaven National Laboratory (J. Naidu)
CEBAF (C. Ficklen)
Congress (Sen. W. Bradley, Sen. F. Lautenberg, Rep. C. Smith)
Congressional Information Service (Joy Haftel)
DOE Chicago Field Operations [10]
DOE Environmental Audit, EH-24 [2]
DOE Office of Environmental Guidance and Compliance, EH-23 [5]
DOE Office of Fusion Energy, ER-55
DOE Office of NEPA Project Assistance, EH-25 [2]
DOE Princeton Area Office (J. Balodis) [10]
EPA/HQ (William Gunther)
EPA/Region II
Fermilab (J. Don Cossairt)
Forrestal Development Center (R. Wolf)
General Atomics (R. Savercool)
Lawrence Livermore National Laboratory (E. B. Hooper, Henry Bell)
Los Alamos National Laboratory (W. E. Quinn)
Idaho National Engineering Laboratory (L. Calwallader, G. Lonhurst, P. Ritter)
Massachusetts Institute of Technology (C. Fiore)
Middlesex County Health Department
NJDEP, Bureau of Environmental Radiation (G. Nicolls)
NJDEP, Bureau of Hazardous Waste Management
NJDEP, Bureau of Planning and Site Assessment (L. Adams)
NJDEP, Bureau of Groundwater Pollution Abatement (G. Nicholas)
NJDEP, Bureau of Central Enforcement (G. Schussler)
NJOEM, Division of Law & Public Safety (C. Williams)
NUS Savannah River (J. Fulmer)
Oak Ridge National Laboratory (J. Glowenika)
Plainsboro Township (Glenn Carter) [2]
The Princeton Packet (W. Plump)
SAIC (M. McKenzie-Carter)
SSC (L. Coulson)
PPPL/Princeton University:

J. W. Anderson
K. Buttolph
J. Caruso
R. C. Davidson
J. De Looper
A. R. De Meo
H. Ende
V. Finley
G. Gettelfinger
J. D. Gilbert
C. Gillars
S. M. Goldfeld [5]
R. Hawryluk
R. D. Holt
S. M. Iverson
C. Kircher
S. B. Larson
J. D. Levine
R. Kaeser
J. Malsbury
D. M. Meade
T. O'Connor
R. Ortego
P. H. Rutherford
N. Sauthoff
J. A. Schmidt
J. Scott
R. Sheneman
E. D. Simon
J. Sinnis
R. Shoe
W. Slavin
C. Smith
D. Speed
J. R. Stencel
M. Viola
J. Wheeler
A. White
M. Wieczorek
M. Williams
E. H. Winkler