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PRINCETON PLASMA PHYSICS LABORATORY (PPPL) ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

BY

J.R. STENCEL AND V.L. FINLEY

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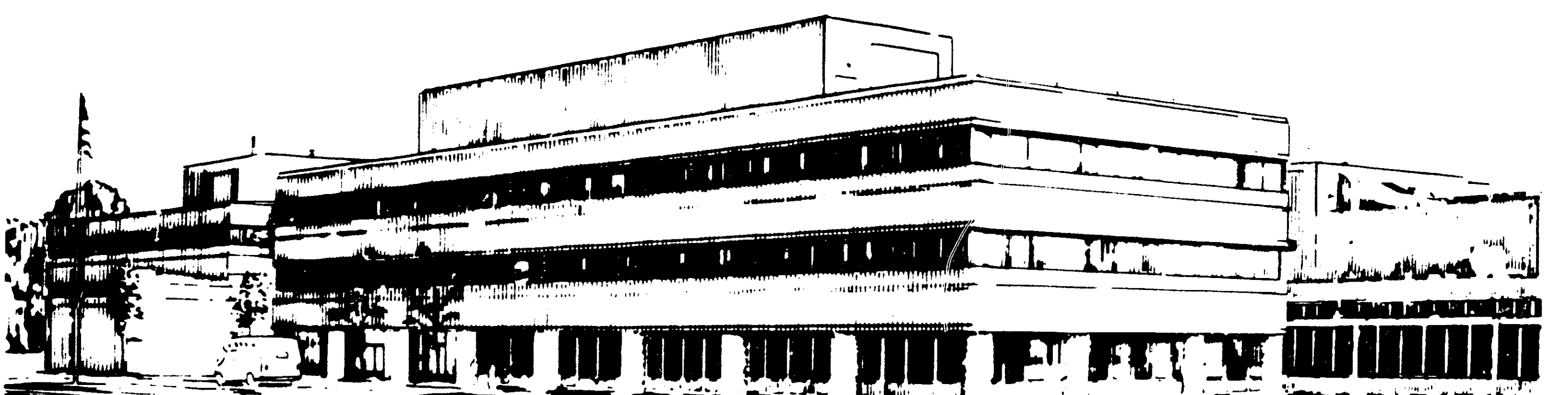
PRINCETON PLASMA PHYSICS LABORATORY



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1.0 EXECUTIVE SUMMARY

During Calendar Year 1990 (CY90), there were no accidents, incidents, or occurrences that had a significant impact on PPPL facilities, the environment, or program operations. Assessment of the cleanup of underground storage tank (UST) hydrocarbons discovered in 1988 was enhanced by doing a soil gas test over the entire 72 acres leased to the Department of Energy (DOE) by Princeton University. The Petrex soil gas evaluation [Ne90] indicated solvents in several areas at the site which are related to past practices. A groundwater assessment program was begun at the end of 1990 with the placement of 16 wells and two piezometers emplaced under the guidance of the New Jersey Department of Environmental Protection (NJDEP). The results from this assessment will clarify whether or not any groundwater cleanup will be required because of past UST leaks or solvent use practices. Lead, which was indicated in two wells during one sampling period in 1989, did not show any positive results in 1990. One other well indicated a lead level during one sampling period at the detection level. Follow-up sampling did not show any positive results.

A waste minimization review was accomplished by an outside contractor in 1990. This review recognized the many steps taken by PPPL prior to any formal DOE program and recommended some steps to further reduce the use of hazardous materials and waste disposal requirements. Several non-toxic cleaners were compared to solvent-based cleaners with surprisingly good results. In 1991, the Laboratory will do further tests in the laboratory environment for compatibility and effectiveness and then introduce these new materials for routine use.

Weed control, grass fertilization, and pesticide control was accomplished by outside certified contractors in accordance with EPA regulations. Transformers and capacitors containing Polychlorinated biphenyls (PCB) oils were removed from service and disposed of in accordance with prepared schedules and EPA regulations. At the end of 1990 there were no PCB transformers and only 661 large regulated PCB capacitors left on site.

Surface water analyses for both radioactive and nonradioactive pollutants have shown nothing above normally expected background values. Ambient tritium levels at less than 100 pCi/liter (3.7 Bq/liter) were measured in on-site well water. These data are in agreement with previous measurements by PPPL and the U.S. Geological Survey (USGS) results [St88c, St91]. Soil and vegetation samples were collected and analyzed for free water tritium as part of the continuing baseline studies. No studies have been undertaken, to date, to look at organically bound tritium (OBT).

Off-site surface water, soils, and biota continued to be analyzed for radioactive baselines in CY90. Passive tritium monitors, tested in field modeling experiments in Canada in 1987 [Gr88a], were used in four on-site area monitors, one stack monitor, and one off-site monitor. Six off-site locations within 1 km of TFTR were sited and will be presented to the local government planning board in 1991 for placement as off-site tritium air monitors. These differential atmospheric tritium samplers (DATS) are high sensitivity monitors which are able to detect changes in the ambient levels [Gr88b].

Radiation exposure, via airborne effluents into the environment, is at insignificant levels. A tritium stack monitor was added to the Tokamak Fusion Test Reactor (TFTR) stack even though it was not required by National Emission Standard for Hazardous Air Pollutants (NESHAPs) requirements. From deuterium-deuterium (D-D) fusion reactions during TFTR experimental operations, less than 1.1 Ci (41.3 GBq) of tritium was produced in 1990. This included controlled tritium releases to the air and less than .485 mCi (17.9 MBq) of tritium oxide (HTO) to the sanitary sewer. Prompt radiation is detectable at extremely low levels during high-power pulses from TFTR by using high sensitivity instrumentation. A special study was conducted in 1990 by the DOE Environmental Measurements Laboratory (DOE/EML) to verify former PPPL Health Physics (HP) Branch measurements. The EML measurements confirmed the acceptability of HP neutron dose equivalent measurements [Ku91]. The integrated dose equivalent* at the site boundary, from TFTR operations was less than 1 mrem (0.01 mSv) for CY90 for measured, prompt radiation plus calculated tritium and air activation releases [Gi91].

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

* In all cases used in this report, the whole body is the critical organ and the term dose equivalent can be considered to be synonymous with the term effective dose equivalent.

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 CY90. The report is prepared to provide the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and nonradioactive pollutants, if any, added to the environment as a result of PPPL operations, as well as environmental initiatives, assessments, and programs. 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 and in 1990 had one of its two large tokamak devices in operation: namely, the Tokamak Fusion Test Reactor (TFTR). The Princeton Beta Experiment-Modification (PBX-M) is undergoing new modifications and upgrades for future operation. A new machine, the Burning Plasma Experiment (BPX)—formerly called the Compact Ignition Tokamak (CIT)—is under conceptual design, and it is awaiting the approval of its draft Environmental Assessment (EA) report by DOE Headquarters (HQ). This report is required under the National Environmental Policy Act (NEPA). 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.

The Princeton Beta Experiment (PBX), the predecessor of PBX-M, after achieving a greater than 5% beta (ratio of plasma pressure to magnetic pressure) in CY84 experiments, was shut down at the end of 1985 to undergo modifications to permit 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, lower q(a) values obtained, and H-modes at lower power attained. In CY89, the effectiveness of the passive plates in stabilizing kink modes and access to higher plasma pressure ($\beta \sim 6.8\%$ and $\beta > 4 \times \beta_{Troyon}$) were assessed. A Safety Assessment Document (SAD) was published for the PBX in 1984 [FI84] 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 is under review and will be approved prior to the start-up of the upgraded PBX-M in FY92.

The TFTR (Fig. 2), which had its first full year of operation in CY83, had an increase in total neutron production in 1987 to a yearly total of 3×10^{18} [He88], in 1988 to a yearly total of 9.04×10^{18} [He89], in 1989 of 6.4×10^{18} [Ja90a], and in 1990 of 2.3×10^{19} [Ja90b]. The higher neutron production has increased the activation level of the machine to the point where health physics surveys are required in the test cell following a machine run 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, and 1990, 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 opening.

The TFTR is a toroidal magnetic fusion energy research device in which a deuterium-tritium (D-T) plasma will be magnetically confined and heated to extremely high temperatures by neutral-beam injectors. 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 has been 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 have resulted in a schedule delay so that D-T experiments will begin in mid 199[illegible]. 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 is expected to be completed in 1992.

Although PPPL operates as an unfenced site, with access controls for security purposes, it is considered to be open to the public for environmental purposes. This free access has necessitated a thorough evaluation of the on-site discharges as well as the potential for off-site releases of radioactive and toxic nonradioactive effluents. An extensive monitoring program, 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: namely, 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]. This includes adherence to the standards given in DOE Orders, in particular, DOE Order 5400.5 [DOE90a], 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 guidelines came into effect [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 [DOE90b] requires an environmental monitoring plan. This plan will be completed in CY91. Specific criteria for implementing these standards on TFTR are contained in a TFTR Operational Safety Requirement (OSR/TFTR/0-2F-C). The new, approved version of this OSR, which is applicable to both TFTR and BPX, is shown in Table 1.

An environmental survey was conducted in June 1988 by 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 has led to a project of incorporating its cleanup with underground storage tank leak elimination and their replacement. In addition, groundwater contamination was a concern, and a Petrex soil gas survey was accomplished over the entire site in the spring of 1990 [Ne90]. Results from the soil gas survey, the UST issue, and New Jersey Pollutant Discharge and Elimination System (NJPDES) permit requirements prompted a groundwater assessment program, which is discussed in more detail below.

The emphasis of the radiation monitoring program has been placed on exposure pathways appropriate to fusion energy projects at PPPL. These pathways include external exposure from direct penetrating radiation and, eventually, during D-T, from airborne radionuclides, such as ^{41}Ar, ^{13}N, ^{16}N, and internal exposure from radionuclides, such as ^{3}H in air and water. 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 being measured. The monitoring program, as envisioned by the TFTR Final Safety Analysis Report [FSAR82], has been updated to reflect the current environment around TFTR (see Table 3). At present, the radioactive pollutant potential to the environment by any pathway is essentially nonexistent. Small amounts of tritium are produced from D-D reactions [approximately 1.1 Ci (41.3 GBq) in 1990 if all neutrons measured are assumed to be D-D produced]. A tritium monitor was installed on the TFTR stack in late 1990.

Low levels of tritium (concentrations less than levels defined as radioactive materials by the Department of Transportation) are now detectable in pump oils. Also, tritiated water (HTO) was detected in the vacuum vessel air (outgassing from the carbon tiles) during the 1987 maintenance and upgrade period [St88b] as well as during the 1988-89 and 1990-91 opening.

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 [Mc83]. The improved measurements and methodologies are being included in the updated FSAR being prepared for tritium operations. Data have been collected for seven years using the monitors on the new tower. Wind-rose plots from the data for the first six years (1984-89) are shown in Figs. 3 and 4 [Ku89]. A tracer gas-release test was conducted during the period from July to September 1988 to look at site-specific air-diffusion parameters (also, see 5.2.2 below). 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 is 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) has been petitioned through the Princeton Area Office (DOE/PAO) to use the more realistic χ/Q values from this test in the AIRDOS-EPA model used for the National Emission Standard for Hazardous Air Pollutants (NESHAPs) calculations. Approval is expected 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. 5 and 6). As shown in Fig. 7, the location is in central New Jersey within Middlesex County. The site is surrounded by undisturbed areas with virgin forest, open grass areas, an airplane runway, 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. 8, 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. 9; 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 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 16 and Figs. 10 to 19) 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. As a summary, population data were divided into annular sectors. It was prepared in 1986 for use with several standard codes used for the determination of off-site dose equivalent due to the release of activated air radionuclides and tritium [Ko86a]. Table 16 shows data supplied by the Princeton Forrestal Center on the population within one mile of the TFTR site. The numbers indicated have been divided by four to obtain an equivalent exposure for habitation [Ko86b].

3.0 1990 ENVIRONMENTAL COMPLIANCE SELF-ASSESSMENT

3.1 Compliance Summary

It is PPPL's considered intention to be in compliance with all applicable state, federal, and local environmental regulations. As a result of self-assessments and DOE Tiger Team activities, PPPL will 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 cleanups or compliance activities. RCRA cleanup activities for underground storage tanks have a low probability of triggering a CERCLA activity. Presently, CERCLA is only invoked under the requirements for SARA Title III for which PPPL is in compliance.

Emergency Planning and Community Right to Know Act, SARA Title III.

Title III of the 1986 SARA amendments to CERCLA created a system for planning responses to emergency situations involving hazardous materials and for making information regarding the use and storage of hazardous materials available to the public. Under SARA Title III, PPPL is required to provide an inventory of hazardous substances stored on the site, Materials Safety Data Sheets (MSDS), and completed SARA Tier I forms listing each hazardous substance stored in quantities above a certain threshold planning quantity (typically 10,000 pounds, but lower for certain compounds) to applicable emergency response agencies. The table on page 9 lists hazardous compounds at PPPL, reported under SARA Title III for 1990.

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. In order to ensure compliance with such notification provisions, PPPL Procedure EP-OP-003, Spill Reporting, includes SARA Title III requirements.

The New Jersey Department of Environmental Protection (NJDEP) administers the SARA Title III reporting for EPA and has modified the Tier I form to include SARA Title III reporting requirements and NJDEP reporting requirements.

HAZARD CLASS

Compound	Fire	Sudden Release of Pressure	Reactive	Acute Health Hazard	Chronic Health Hazard
Ammonia		✔		✔	
Bromotrifluoromethane		✔		✔	
Carbon dioxide		✔		✔	
Dichlorodiflouromethane		✔		✔	
Fuel Oil	✔				
Gasoline	✔				✔
Helium		✔			
Nitrogen		✔			
Petroleum Oil	✔				
Polychlorinated Biphenyls					✔
Sulfur Hexafluoride		✔			
Sulfuric acid			✔	✔	

3.1.2 Clean Air Act (CAA)

The PPPL was in compliance with the requirements of the CAA in 1990. PPPL has added a stack sampler to the TFTR facility for tritium releases, and this will meet NESHAPs radionuclide emission requirements for upcoming operations. The monitoring system currently exceeds existing requirements as current releases produce insignificant dose equivalent to any member of the public. The need for additional air emission permits is being investigated following a self-assessment by PPPL prior to the DOE Tiger Team assessment.

3.1.3 Clean Water Act (CWA)

The PPPL is in compliance with all requirements of the CWA. An assessment of groundwater has been undertaken as part of an effort following identified leaking underground storage tanks (USTs), which contained heating oil and vehicle fuel, and a soil gas survey of the entire site was completed, which identified potential solvent contamination. Groundwater wells were placed to assess the results of the soil gas survey, the UST issue, and NJPDES requirements.

3.1.4 Endangered Species Act (ESA) and National Historic Preservation Act (NHPA)

PPPL occupies 72 acres of the Forrestal Campus. Previous environmental statements and the current draft Environmental Assessments (EAs) for the BPX and TFTR have indicated that there are no endangered species or items relating to the NHPA on site.

3.1.5 Executive Order (EO) 11988, "Floodplain Management" and 11990, "Protection of Wetlands"

The PPPL is in compliance with these EOs with the following unanswered questions. A dirt spoil pile from excavations for TFTR construction was placed in an area (1977-78) prior to wetlands determinations. While present wetlands determinations go around the spoil pile, there is some question on the need for a variance. Likewise, as a result of the Tiger Team assessment, it was determined that the PPPL HAZMAT facility has portions of the facility which are 4 inches below the 500-year floodplain and not protected, which may be a violation if the HAZMAT facility is considered a "critical" facility under 10 CFR 1022.

3.1.6 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 Plant Maintenance and Engineering (PM&E) Division monitors this subcontract.

3.1.7 National Environmental Policy Act (NEPA)

The PPPL had two major NEPA documents under consideration in 1990. An Environmental Assessment (EA) for the BPX has undergone review, and an update to the TFTR 1975 environmental statement will be addressed with an EA for the proposed deuterium-tritium (D-T) modifications and operations. Numerous categorical exclusions (CXs) were applied for in accordance with DOE Secretary of Energy Notice (SEN) 15.

3.1.8 Resource Conservation and Recovery Act (RCRA)

The Laboratory is in compliance with all terms and conditions required of a hazardous waste generator. PPPL is also in compliance with all requirements of the RCRA mandated Underground Storage Tank Program. See 3.1.3 above in relation to UST leaks.

3.1.9 Safe Drinking Water Act (SWDA)

The PPPL receives its drinking water from the Elizabethtown Water Company. While Elizabethtown is responsible for providing safe drinking water, PPPL does test incoming water. In addition, periodic testing for potential problems within the on-site drinking water distribution system is undertaken.

3.1.10 Toxic Substance Control Act (TSCA)

The PPPL is in compliance with all terms and conditions of TSCA by protecting human health and the environment by requiring that specific chemicals be controlled and regulations restricting their use be implemented. The last of PPPL's polychlorinated biphenyls (PCBs) transformers were removed from the site in 1990, and only 661 PCB-regulated capacitors were left on site at the end of 1990.

3.2 Current Issues and Actions

The sole, ongoing, environmental compliance issue is the request for an adjudicatory hearing, by DOE, under the current New Jersey Pollutant Discharge and Elimination System (NJPDES) discharge to groundwater permit. The DOE is contesting the permit requirement that monitoring wells, with a monitoring program, be placed off-site on Princeton University property, at PPPL expense, when the University volunteered to cover these requirements. The DOE and PPPL are awaiting a hearing date and have, however, come into compliance with all permit mandated activities.

The PPPL was audited by a DOE Tiger Team between 2/11/91 and 3/12/91. PPPL had identified over 70% of the Tiger Team findings in its own self-assessment. 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 (16) 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 in April 1991.

3.3 Environmental Permits

Environmental permits are maintained by PPPL (See Table 17). A discussion of the Environmental permits, by the applicable statutes, is listed below.

3.3.1 Clean Air Act (CAA)

The Laboratory maintains permits for 4 boiler vent stacks, 1 fuel oil storage tank vent, 1 diesel tank vent, 2 degreaser vents, and 2 emergency diesel generator exhaust stacks. All permits for these emissions are current, and all equipment under permit is operated within the permit specifications. Four underground storage tanks also were removed from the Laboratory in 1990, and registrations for the vent pipes for the gasoline tank, diesel tank, and one of the two fuel oil vent permits were terminated. As a result of a PPPL self-assessment prior to the Tiger Team, PPPL noted that some new permits may be required, not because of an emission limit trigger point, but because of process equipment used in the exhaust process. The Tiger Team addressed two additional sources which should be considered for the permitting process.

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 and groundwater. The permits are for a detention basin, which discharges to Bee Brook, and for non-point source infiltration of the detention basin waters to groundwater. An adjudicatory hearing was requested for the groundwater permit where several of the permit conditions are contested. In the interim, however, the permit is being maintained in full compliance including those conditions being contested in the requested hearing. The surface water permit has not been reissued by the NJDEP, and PPPL has been operating under its old permit since October 1989. The DOE/PAO has requested that storm water discharge points be added to the new permit when it is issued.

3.3.3 Resource Conservation and Recovery Act (RCRA)

The PPPL maintains EPA Number (NJ1960011152) for RCRA generator status. The Laboratory is in compliance with all terms and conditions required of a "generator" status.

The PPPL maintains and is in compliance with permits for 4 USTs in operation on the site. 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 as required by the NJDEP 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.

3.4 January 1 - April 1, 1991 Environmental Compliance Summary

The first quarter of calendar year 1991 has produced the following changes from the 1990 summary:

- An NJPDES discharge monitoring sampling point was not collected by the PPPL subcontract vendor in January 1991. This noncompliance was reported to the NJDEP, and a new procedure was set up with the vendor to ensure that this type of an oversight would not be repeated.

- The initial data from the groundwater assessment program was received. The initial results are not as severe as were expected from the 1990 soil gas survey. The data has been sent to the NJDEP with recommendations to do further sampling and to fill in the excavations from the UST soil removal project. No further action can be taken without NJDEP guidance and approval.

- The DOE Tiger Team audited ES&H programs at PPPL from February 11 through March 12, 1991. While no significant findings were identified in relation to environmental impacts and compliance issues, best management practices on the need for additional permits, sampling procedures, and timely report submittals were identified. The number of findings are noted in Section 3.2, above. An Action Plan has addressed all Tiger Team concerns.

4.0 ENVIRONMENTAL PROGRAM INFORMATION

The monitoring-program implementation has followed a phased approach commensurate with the potential hazards and the needs of an expanding program. Nonradioactive water-pollutant monitoring has been conducted for many years. A more extensive program was begun in 1979, which included eight surface water-sampling points (four on-site and four off-site). In addition, four groundwater sites (two former drinking water wells and two wells near the TFTR liquid effluent-collection tanks), along with the potable water-supply, were monitored through November 1989. In November 1989, two former wells were dropped from the program, and seven new wells were added as part of the New Jersey Pollutant Discharge and Elimination System (NJPDES) permit requirements. Current NJPDES permit requirements include one detention basin discharge point for the surface water permit, two influent surface water points for the groundwater permit, and seven (7) groundwater wells.

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 monitoring stations are located at the TFTR facility boundary (formally called the exclusion zone boundary (EZB)). Neutron monitors were added at these locations at the end of CY84. Passive tritium monitors were added in CY87. Radiological-water samples are being collected at the same locations as the nonradioactive-sample points (see Figs. 20 and 21). Soil and biota samples are also being analyzed for tritium baselines. One off-site baseline tritium air monitor was added in CY89, and six others are planned for FY91-92.

4.1 Assessment of Radiation Dose to the Public

The PPPL is located in the metropolitan region between New York City and Philadelphia. 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 distribution of population as a function of distance is given in Tables 4-16. Because of ever-increasing commercial growth in this area, a demographic update was planned for

TFTR but was completed as a requirement for the BPX Environmental Assessment [Be87a]. Also, a radiological assessment was completed for BPX [Mc89].

The overall, integrated, effective-dose equivalent 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 CY90 [Gi91] using the USEPA COMPLY code [EPA89]. This effective dose equivalent was calculated after postulating that all the tritium produced during TFTR D-D operations and Argon-41 produced from air activation was released to the environment. 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 to calculated data was done and indicates a value of only 5×10^{-2} person-rem (5×10^{-4} person-Sievert) out to 80 km (see Table 18).

4.2 <u>Assessment of Nonradioactive Pollutants</u>

There were no activities during CY90 that created problems with respect to nonradioactive pollutants. The chronic oil spill from underground tanks, which present some potential minor environmental impacts, are being addressed and are discussed below.

Polychlorinated biphenyls (PCB's) and other toxic materials continue to be disposed of in accordance with EPA requirements. Herbicides, pesticides, and fertilizers were used in very limited quantities.

4.3 <u>Pollution Prevention and Waste Minimization</u>

The PPPL has a pollution prevention and waste minimization plan as required by DOE Order 5400.1 [DOE90b]. A survey was completed in June 1990 [CEE90] and indicated that PPPL had already taken many appropriate steps in waste minimization by product substitution and volume reduction. In FY91-92, a more detailed program will be undertaken to further the testing and use of non-hazardous products such as "TPC Solvent" and "Citrikleen" in place of "Inhibisol," acetone, and alcohol. Further investigation of possible means for source reduction will begin with waste-stream identification.

4.4 Regulations and Safety Criteria

The appropriate Radiation Protection Standard for penetrating radiation was taken from DOE Order 5480.11. Specific criteria for implementing these standards are contained in PPPL Environment, Safety, and Health Directive (ESHD) 5008, Section 10, and specifically for TFTR in Operational Safety Requirements, in particular, OSR/TFTR/0-2F-C. The concentration guides, used in the analyses of surface water samples for radioactivity, were taken from DOE Order 5400.5, Chapter III. The derived concentration guides for airborne activity are taken from the same DOE Order. Tritium, for example, is listed as 1×10^{-7} µCi/ml.

Air and Water Pollution Standards for nonradioactive pollutants were taken from the New Jersey Administrative Code (NJAC), Department of Environmental Protection 7:27-1, ***et seq***, 7:14-1, ***et seq***, and 7:14A-1, ***et seq***, respectively. The appropriate regulations for PCBs and hazardous waste are found in the U.S. Code of Federal Regulations, 40 CFR 761 and 40 CFR 260-265, respectively.

4.5 Future Program Expansion

4.5.1 Meteorological

A meteorological tower was installed in November 1983. Data from this system are being used in updating dose calculations for the updated version of the TFTR FSAR. Data were also evaluated by the BPX project in relation to siting the BPX at PPPL. Several dose-assessment codes are being employed by PPPL to utilize the data from this tower in the calculation of projected doses. These codes include the required DOE standard AIRDOS-EPA, as well as PAVAN, XOQDOQ, and an Ontario Hydro version of TRITMOD. Future plans include considerations of hooking up a real-time output of the meteorological data. Instrumentation was added at 10 m in 1990 to collect wind speed and direction in addition to the present instruments at 30 and 60 m.

4.5.2 Water Quality

The initial phases of a groundwater monitoring program began in CY85. Analysis of water samples from two D-site wells was added to the monitoring program in CY86 utilizing USGS data. PPPL took over the water quality program on these two wells in December

1987. New wells were added in response to new state requirements for a groundwater discharge permit and as a result of UST spills and soil gas testing (see below). This expanded groundwater program will help to more fully understand our regional groundwater flow, surrounding area (off-site) groundwater contamination, and in anticipation of requirements for BPX.

4.5.3 Radioactive Effluents

4.5.3.1 Air, Gaseous and Particulates

Based on collected data, a decision was made in CY84 to limit the specific air and particulate real-time monitors at the EZB to a beta detector only. Particulate air sampling has been accomplished as a best management practice and not because of a particular source term. This sampling may be discontinued because of a DOE Tiger Team finding to change from our present low-volume air sampling to a high-volume air sampler.

Environmental tritium monitors tested in CY86 were deployed at the EZB in CY87. These were to be extended to off-site locations in CY88 but were delayed because of budget reductions at the end of the year. A baseline station was established off-site during 1989 at an 8-mile distance in the northwesterly direction. Six new stations are being planned off-site within 1 km of the TFTR exhaust stack.

4.5.3.2 Off-Site Radiological Water and Biota Monitoring

An off-site grab sample water-analysis program is well established. Whether more sampling points will be added in the future depends on reevaluation of the program, which is done annually. Soil and vegetation sampling is under way and will continue.

4.5.4 Nonradioactive Effluents

Air-effluent standards will continue to be met by following the guidelines of the NJDEP. Any potential toxic materials will be monitored and disposed of in accordance with applicable regulations and accepted guidelines. More permits for on-site discharge points may be requested as indicated by a PPPL self-assessment and 1991 Tiger Team assessment.

5.0 ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

5.1 Penetrating Radiation

Operation of the Princeton Beta Experiment-Modification (PBX-M) results in the production of some penetrating radiation (primarily bremsstrahlung X-rays and neutrons). Because the PBX-M has no roof shield, skyshine radiation (primarily neutron) is seen at the TFTR EZB site monitoring stations. The shielding installed for the PBX-M machine has kept the total dose equivalents in occupied areas below occupational-exposure guidelines. Skyshine radiation from the neutron production by PBX-M generally adds less than 1 mrem (0.01 mSv) to the D-site environs [St91]. PBX-M did not operate in 1990 and thus had no impacts to the environment.

It is stated Laboratory policy that when occupational exposures have the potential to exceed 1,000 mrem/y (10 mSv/y), the appropriate project manager must petition the PPPL Executive Safety Board (ESB) 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. To illustrate this point, a 1,000 mrem dose equivalent from direct radiation at the outer TFTR test cell wall will result in less than 10 mrem (0.1 mSv/y) at the facility boundary. Actual environmental measurements of the TFTR facility boundary are shown in Figures 22 and 23. Figure 22 indicates gamma background readings which range between 170-240 μR/day. Figure 23 indicates a neutron measured value of between 10-14 μrem/day.

The design objective for TFTR is to stay below 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 the end of CY84. With these D-D runs, the neutron fluxes have increased each year as the neutral-beam heating power has increased. 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]. 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. Radiation levels (mrem) were recorded for some pulses outside the test cell, with the total dose equivalent at the closest off-site receptor calculated by the COMPLY Code to be 0.018 mrem (0.18 μS) for CY90 [Gi91].

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. These 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 (see Fig. 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 for Standards and Technology (NIST)—formerly the National Bureau of Standards (NBS).

5.2 Special Radiation Surveys

5.2.1 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 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 μR/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.

5.2.2 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].

While Nuclear Regulatory Commission (NRC) standard-approved gaussian models, which are normally used to calculate atmospheric diffusion to support radiological dose assessments, are appropriate for sites in open terrain, they 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 and the future BPX. The results indicate a factor of approximately 16 less potential dose equivalent than that calculated by using NRC gaussian models. The EPA was petitioned by DOE/PAO to utilize this real-time data for use in calculations using AIRDOS-EPA, a required code for annual NESHAPs calculations. Indications are that the EPA will approve this request in 1991. In 1990, DOE authorized the use of the EPA COMPLY code for NESHAPs calculations.

5.2.3 LLNL Seismic Study

The PPPL Environment, Safety, and Health Division (ESHD) initiated and provided technical direction for a contract with Lawrence Livermore National Laboratory (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 Nuclear Regulatory Commission (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].

5.2.4 EML Radiation Measurements

A radiation measurement survey was accomplished by the DOE Environmental Measurements Laboratory (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 are expected to be published in May 1991.

5.3 Airborne Radioactivity

Radioactivation of air and the release of tritium in measurable concentrations (by EPA accepted measurement criteria) are not 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 in a Canadian tritium release modeling experiment and in the field at PPPL, the monitor is now using molecular sieve in place of silica gel [Gr88b]. Based on D-D neutron production during CY90, it is estimated that a maximum of approximately 1.1 Ci (41.3 GBq) of tritium could have been added to the environs outside the TFTR facility. Tritium was detected in TFTR effluent samples by a DATS. However, the sampling system that was in place for much of 1990 was not sufficient to quantify tritium emissions because most of the tritium was released through a vacuum line. Therefore, 1990 tritium emissions were calculated based on the number of neutrons generated. Our actual experience with the absorption and adsorption of tritium in TFTR vessel-graphite tiles in 1987 indicates that some tritium produced over the last few years by D-D reactions has been retained in the tiles [St88b]. The tiles retain approximately one-third of the tritium produce during D-D reactions. The projected dose equivalent at the nearest business from 1.1 Ci of tritium and 1.9 Ci of ^{41}Ar was 18 μrem (180 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 2.9 μrem (29 nSv) (see Table 40). An upgraded stack sampling system installed in 1990 will provide measured tritium emission for 1991 for any tritium concentrations exceeding the minimal detectable levels of the DATS. Evaluations of proper laminar flow and mixing for acceptable monitoring data are now under discussion with the EPA. An off-site monitor has shown some variation in background ambient levels, which are not attributable to PPPL operations. Measurements at the TFTR fence line have shown ambient levels in the range of 1 to 5 pCi/m^3 of elemental and oxide tritium concentrations (Figs. 24 & 25). These measurements were made with the DATS [Gr88b]. Both Figures 24 and 25 indicate a higher reading, especially at trailer position #1, during the first 20 weeks of the year. The reason for these increased readings was traced to the hydrogen used in the carrier gas of the DATS system. Whereas PPPL's carrier gas is specified as a petroleum by-product procurement, which implies deep wells and therefore little, if any, tritium contamination, the particular carrier gas was obtained from surface water electrolysis, which would have surface water tritium levels recovered in the process.

Argon-41 is a potential air activation product from neutrons produced from D-D reactions. Its maximum production in 1990 was 1.9 Ci (70.3 GBq), with an estimated dose equivalent at the nearest off-site business of 2.1 μrem (21 nSv) using NOAA χ/Q data (see Table 18).

In November 1983, a three-level, 60 meter tower was installed for gathering meteorological data. Seven years' worth of data have now been collected. The wind-rose data for the first six years of tower operation are shown in Figs. 3 and 4. 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, χ/Q values will be recalculated for the updated TFTR FSAR before D-T operations. The data were also checked for consistency by the Idaho National Engineering Laboratory (INEL) in their preparation of an Environmental Assessment (EA) for the BPX project. Data collection at 10 m were added in 1990.

5.4 Waterborne Radioactivity

5.4.1 Surface Water

Surface water samples at eight locations (four on-site and four off-site) have been analyzed for tritium and photon emitters. 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. 20, 21, and 31.

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 (Fig. 26). Tritium enrichment procedures are used on some samples to provide increased sensitivities. Rain water samples collected and analyzed ranged from less than 14 to 94 pCi/liter (see Table 19 and Fig. 27), which was similar to the 1985 range of 45 to 160 pCi/liter, the 1986 range of 40 to 140 pCi/liter, the 1987 range of 26 to 144 pCi/liter, the 1988 range of 34 to 105 pCi/liter, and the 1989 range of 7 to 90 pCi/liter. The reason for this variation 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.

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) of precipitation in 1989 and 50.3 inches (128 cm) of precipitation in 1990 (see Fig. 28 and Table 20) [Ch91].

5.4.2 Groundwater

Seven existing on-site wells—W4, W5, D11, and D12 on C-site (Fig. 20), and TW1, TW3, and TW10 on D-site—were sampled (see Table 21). As a part of continuing efforts to characterize the site, a more comprehensive groundwater 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 groundwater system. The final USGS survey report was issued in 1987 [Le87]. This report indicates a cone of depression created by the TFTR sump system (Fig. 29 & 30). The samples collected from two of the wells (TW1 and TW10 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 1990 are also less than 100 pCi/liter (3.7 Bq/liter).

5.4.3 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, Fig. 20) to provide baseline data for water coming onto the site. Radiological analysis has included gamma spectroscopy and tritium-level determination. Tritium levels are similar to surface and well waters 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.

5.5 Foodstuffs

Because there are so few dairy farms in this area, milk is not a viable analysis medium around the site. Also, the fish population is very scarce to nonexistent in Ditch 5 and Bee Brook, which carry the runoff from the site. The DOE agreed in 1986 that a substitute of vegetables and other biota from the surrounding area can be used for reference data. A corn sample taken on September 18, 1990, indicated a value of 61 pCi/L. Distillation techniques were unsuccessful for strawberries, peas, and pumpkins [Gi91]. The measured level is indicative of tritium in the environment (see water results).

5.6 Soil, Grass, and Vegetation

Off-site sampling locations were established in late 1985 (see Fig. 31). In 1991, some sampling points will be relocated because of construction in the area and also to be near proposed air-monitoring stations. Soil and grass samples collected on-site and off-site in 1990 indicated tritium levels below 100 pCi/liter (3.7 Bq/liter) (see Fig. 32 and Table 22). Sample location S14 was not done in 1990 due to overpass and road construction. Laboratory techniques for doing these analyses were perfected in CY84 [Gr85], and the techniques are documented in the Radiological Environmental Monitoring Laboratory Handbook [REML90]. These baselines are being established because surface soils and vegetation are among the best indicators of tritium deposition after a release [Jo74], [Mu77], [Mu82], [Mu90]. The present, measured concentrations are consistent with those of tritium in the environment.

6.0 ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

6.1. Airborne Effluents [Ki91]

The PPPL has a New Jersey Department of Environmental Protection (NJDEP) permit for its four C-site boilers and one fuel tank vent. The five permit certificates, numbered 061295 through 061299, were renewed in 1987 and will next expire on March 31, 1992. New air permits applied for and received include the TFTR Mockup Building degreaser, the Field Coil and Power Conversion (FCPC) building degreaser, the TFTR emergency generator diesel engine, the C-site emergency generator diesel engine, and a 15,000 gallon diesel tank vent (E#8).

Measurements of actual boiler emissions are not required. Emissions were initially calculated using formulas supplied by the NJDEP [Ki88]. These formulas are based solely on the percent sulfur and the number of gallons of oil burned per hour in each boiler. In the last quarter of CY87, PPPL purchased an ENERAC POCKET 50 combustion-efficiency analyzer. This device indicates boiler efficiency, oxygen content, flue-gas temperature, and carbon-dioxide content of the stack gas for both oil and natural-gas fuels. This information is recorded and entered into a log book by the boiler operators. This is done to optimize boiler efficiency and to reduce fuel costs in accordance with DOE Order 4330.2C [DOE88b].

6.2 Water Utilization [Ki91]

6.2.1 Drinking Water

Potable water is supplied by the public utility, Elizabethtown Water Co. The PPPL used approximately 24.1 million gallons in CY90. 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 nonradioactive pollutants (Table 29, E-1 location), as well as to measure potential radioactive pollutants exclusive of radium or radon.

6.2.2 Process (nonpotable) Water

Nonpotable 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 is the primary treatment. In 1986, a multimedia sand filter 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 49.3 million gallons of canal water during CY90. The sampling point (C-1) was established to provide baseline data for process water coming on-site. Table 25 indicates results of water quality analysis at the canal.

6.2.3 Storm Water

Storm water, which includes cooling tower and boiler blowdown, is discharged into surface waters and is governed at C- and D-sites by NPDES Permit No. NJ0023922 (effective date November 1, 1984—expiration date October 31, 1989). This permit is still in effect while NJDEP reviews the new application request. All process water and most runoff water from C- and D-sites now pass through a detention basin. Approximately 7.3 million gallons discharged through the detention basin in CY90. Discharge points which do not run into the detention basin are included in the surface water renewal permit application. Upgrades to the detention basin, including an oil-spill detection and alarm system, were completed in 1986. As a result of minor problems following the transformer-oil leak in 1988 [St88d] and the 1988 DOE Environmental Survey (see 6.7.2), another analysis of this system determined that the best long-term, best management practice, environmental solution is to line the detention basin and to find more reliable oil sensors. This project is expected to be funded in CY91. Quarterly water-chemistry reports, compiled from the data of Table 22, were submitted to the state of New Jersey in 1990 in accordance with NJDEP requirements. The PPPL was well within the allowable limits for all testing parameters during CY90.

Cooling-water treatment was changed from a chromate-based corrosion inhibitor to a nonchromate inhibitor in June 1983. Water analyses downstream and groundwater tests (see Tables 23-46) have not indicated concentrations of any environmental pollutants, in general, above applicable codes, regulations, or standards. One cooling tower discharges to the storm water and the second to the sanitary sewers. The Stony Brook Sewage Authority has requested that the second cooling tower also discharge to the surface water. This change is authorized under our current permits per discussions with the NJDEP. The changeover is expected in CY91. Two shallow wells (D11 and D12), next to the detention basin, indicated some lead in CY89. Subsequent monitoring of these wells has not shown any detectable lead levels. After the application for the the groundwater permit, which was filed in 1986, the NJDEP proposed the addition of monitoring wells around the detention basin and three wells off of DOE-leased property. While DOE has requested a hearing on the off-site well aspects of the permit requirements, PPPL came into compliance with the existing permit requirements in November 1989. Monitoring of the off-site wells (MW14, 15, and 16—see Fig. 31) has not shown any contaminants and, therefore, closure of the wells or turnover to Princeton University will be requested of the NJDEP in 1991.

An updated Spill Prevention Control and Countermeasures (SPCC) Plan was received from an environmental consultant in January 1985 and is currently scheduled for an upgrade completion in early CY91. The final update was delayed until after the EPA issued the Final Regulations for Underground Storage Tanks (UST). With the experience of the underground storage tank leakage, PPPL will eliminate all of its underground tanks by CY92.

6.2.4 Sanitary Sewage

Sanitary sewage is discharged to the publicly-owned treatment works operated by South Brunswick Township at the Stony Brook Regional Authority. Flow rates are measured by the PPPL sanitary-sewage metering station and indicated a total volume discharge of approximately 19 million gallons in CY90. Sampling of PPPL discharges, performed by the publicly-owned treatment works in the past, had determined that pretreatment is unnecessary. Therefore, PPPL is in compliance with the EPA Pretreatment Standard, 40 CFR Part 403. However, new sampling requirements are expected in CY91. When these regulations are promulgated, PPPL will implement the requirements.

6.2.5 Surface Water

Surface water is monitored for potential nonradioactive pollutants both on-site and at surface-water discharge pathways (upstream and downstream) off-site in addition to the one location (D2) required by the NJPDES permit (See Figs. 20, 21, and 31, and Tables 23-32). These extra sampling locations are not required by regulations, but are a part of a PPPL best management practice.

6.3 Spills

Several spills were recorded in CY90. Those which posed a potential threat to the environment were reported to the NJDEP in accordance with their reporting requirements. A chromium sand pile was discovered, which was a result of the former decommissioning of a sand filter for the C-site cooling tower (NJDEP ID #90-03-23-1551) [Tu90]. Sampling of the sand and discussions with the NJDEP determined that the sand could be classified as "non-RCRA hazardous." A second spill (NJDEP ID #90-08-09-1320), which was entirely internal to a room within a building, involved the mixing of a few quarts of nitric acid with acetone. Because of the potential explosive nature, the incident was reported to the NJDEP as a spill [St90]. A third spill was identified during the annual leak tightness test for USTs. A 1,000 gallon diesel fuel tank was found to have a leak in a connection in a supply line. The spill was reported (NJDEP ID #90-10-22-1141), a well was emplaced, and a discharge investigation corrective action report (DICAR) was generated. It is expected that this issue will be closed in CY91. In addition, this UST will be removed as part of the PPPL program to remove all of its USTs and replace them, where needed, with above-ground tanks. A fourth spill involved the leaking of hydraulic oil from the pumping system for a vertical bore milling machine. Soil was removed and a report was generated [Fi91]. Subsequently, the NJDEP has requested the emplacement of a well next to the excavated area for groundwater monitoring. Two wells within approximately 60 m of the spill were deemed to be too far removed from the spill site by NJDEP. Other miscellaneous spills within facilities did not require notification of the NJDEP or the National Response Center. All spills are responded to immediately by an in-house Emergency Services Unit (ESU), who acts as first responders. Outside consultants are under contract to provide clean-up services if it is required. Because of the prompt internal response and vigilance by employees, the 1990 spills resulted in no significant impacts to the environment.

6.4 Herbicides, Fertilizer, and Pesticides [Ra91]

During CY90, the use of herbicides, pesticides, and fertilizers was managed by PPPL Plant Maintenance and Engineering utilizing an outside contractor. These materials are applied in accordance with state and federal regulations. Herbicides are applied by a certified applicator. Table 47 lists the quantities applied during CY90.

6.5 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 of, 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. This transformer will become a noncontaminated transformer in 1991. At the end of 1990, PPPL was left with only 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 [La91].

6.6 Hazardous Wastes

Responsibility for this program rests with the PPPL Hazardous Material Manager under the Materiel Control Office. A facility was set up in CY82 for temporary storage of hazardous materials. A new area 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 on the outside asphalt loading and unloading area. A question brought out during the DOE Tiger Team assessment indicates a resolution is needed on some areas of the facility being within the 500-year flood plain when the definition of "critical facility" per 10 CFR 1022 is applied [CFR90]. This issue will be addressed in CY91.

The Hazardous Waste Generator Annual Report (EPA ID number NJ1960011152) has been submitted for 1990 in accordance with EPA requirements [La91]. During 1990, 6,731,436 pounds of solid materials and 12,970 gallons of liquid waste were disposed at EPA-certified treatment, storage, and disposal facilities. These totals included 380,463 pounds of PCBs (oil plus containers). These numbers reflect actual waste, plus containers and packing materials. It should be noted that a significant fraction of the waste was oil-contaminated soil from oil-spill cleanups (6,336,000 pounds). Outside of oil contaminated soil and PCB disposal, less than 15,000 pounds of other hazardous waste (including containers) was shipped for disposal.

6.7 Special Non-Radiological Program Surveys

6.7.1 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 spill of tritium from the liquid effluent collection tanks (LECTs), it more appropriately addresses the general ground water quality and flow patterns in the region near the TFTR facility. Figure 29 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. 30). These data are being used in conjunction with the present groundwater studies. 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].

6.7.2 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 a part of a DOE program which looked at 45 of their 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.

6.7.3 Soil Gas Survey

As a need to further characterize potential contamination on the site based on the UST spill results and low-levels of solvent contamination seen in four monitoring wells (TW-1, TW-3, TW-10, and D-11), plus requirements of the PPPL NJPDES permit, a Petrex passive soil gas test was conducted during the months of April-May 1990 over the entire site [Ne90]. The PPPL decided to take a proactive approach to look for any potentially unknown chemical contamination over the entire site.

The data were generated by conducting a survey which produced identification for tetrachloroethene (PCE), trichloroethene (TCE), aromatic hydrocarbons compounds (AHC), and trichloroethane (TCA). The survey indicated that localized anomalies had been detected and delineated at five locations. They were (1) north and east of the excavation pit for the former UST locations including the eastern half of the Plant Maintenance and Engineering Building and the TFTR Cooling Tower Buildings (PCE,TCE,AHC, and TCA); (2) through the eastern half of the Receiving Warehouse Building (PCE, TCE, and TCA) extending south into; (3) the southwestern corner of the CAS Building (PCE); (4) northeast of the TFTR Neutral Beam Power Conversion and Mockup Buildings (PCE, TCE, and TCA); and (5) west of the TFTR Field Coil Power Conversion Building (TCA) (see Fig.33-37).

It appeared that the source of tetrachloroethene (PCE) was localized within the "hot spot" areas and not a part of a large regional contamination plume.

6.7.4 Groundwater Assessment

As a result of the the soil gas survey (see 6.7.3), UST issues, and NJPDES permit requirements, a groundwater assessment was initiated in November 1990. The objective of the assessment was two-fold: (1) determine the impact of the underground storage tanks on groundwater and (2) correlate the soil-gas survey results with groundwater quality.

Sixteen wells and two piezometers were installed in December 1990 and sampled in January 1991. The initial results indicate that potential groundwater contamination is less severe than the soil gas survey indicated; however, it must be remembered that the soil gas survey is qualitative and not quantitative. The results of this study will be reported in the 1991 Annual Site Environmental Report.

7.0 GROUNDWATER PROTECTION

As part of our NJPDES permit, groundwater sampling was begun at the end of 1989 on seven additional wells (D-11, D-12, MW-14, MW-15, MW-16, TW2, and TW3). The data are indicated in Tables 34-40. The permit number is the same as the surface water, NJ0023922, with an effective date of May 1, 1989, and an expiration date of May 1, 1994. In addition, two former production wells, W4 and W5 (see Table 41), were monitored.

Other monitoring data included base neutrals and volatile organics (Tables 42-44), some miscellaneous data (Table 45), and general chemistry (Table 46). The solvents PCE, TCE, and TCA were all found in trace amounts in either wells D-11 or D-12 or in the inflow from D-site during the August 1990 sampling; but they were not indicated in the May 1990 sampling.

Groundwater assessment (see 6.7.4) initiated in 1990 will continue into 1991-92 to further characterize groundwater quality and the direction of flow.

8.0 QUALITY ASSURANCE

Analysis of water samples for radioactivity was accomplished in-house. In general, in-house procedures follow the HASL-300 Manual [Vo82]. In-house procedures adopt accepted techniques and are documented in the Radiological Environmental Monitoring Laboratory (REML) manual [REML90]. PPPL participates in the EPA (Las Vegas) program and the DOE Environmental Measurements Laboratory (EML) in New York City. These programs provide blind samples for analysis and subsequent comparison to values obtained by other participants, as well as to known values. Results are shown in Table 48.

In CY84, PPPL initiated a program to have its radiation-counting laboratory certified by the State of New Jersey through the EPA Quality Assurance (QA) program. In March 1986, the REML facilities and procedures were reviewed and inspected by EPA/Las Vegas and the NJDEP. The laboratory was certified for tritium analysis in urine and water and recertified in these areas in 1988, 1989, and 1990. While the certification was expected to have been extended to gamma spectroscopy in 1990, as all of the blind samples to date have been within expected detection limits (see Table 48 and Figs. 38 and 39), an official site visit has not been made by NJDEP to authorize this certification.

Two different vendors were used for nonradioactive water quality analysis in 1990. They participate in a state of New Jersey QA program and have quality assurance plans [A185], [NAC90]. A blind split-sample was also sent for analysis (Table 49).

9.0 ACKNOWLEDGEMENTS

D. Hwang, M. Lewis, J. Greco, and J. Gilbert compiled the data for radiation analysis. O. Griesbach and R. Leuenberger performed in-house radiation analyses, and R. Frankenfield, K. Chase, and J. Lehner worked on instrument installation and calibration. These individuals are staff members of the PPPL ES&H Division, Health Physics Branch. W. Slavin, the PPPL Industrial Hygienist, and V. Finley, the PPPL Environmental Engineer, reviewed nonradioactive pollutant analysis data. C. Kircher is responsible for all water-utilization information and V. Finley, the environmental engineer, is now responsible for the preparation of relevant data to DOE for environmental protection permits. J. Levine, the Nuclear/Environmental Engineer, provided NESHAPs calculations. S. Larson is responsible for hazardous-waste disposal. Various other PPPL individuals have reviewed the manuscript.

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Table 1. TFTR/BPX Radiological Design Objectives and Regulatory Limits[a]

CONDITION		PUBLIC EXPOSURE[b]		OCCUPATIONAL EXPOSURE	
		REGULATORY LIMIT	DESIGN OBJECTIVE	REGULATORY LIMIT	DESIGN OBJECTIVE
<u>ROUTINE OPERATION</u> 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		
<u>ACCIDENTS</u> 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 β) ^3H (HT and HTO)
Air	A1-A3	Vault	Continuous	^3H (HT and HTO)
Air	A1-A3	HVAC Discharge (Stack)	Continuous	Activated Air (Gross β) HT and HTO, Particulates, Volume
Direct & Air (on-site)		4 Locations at TFTR Facility Boundary	Continuous	γ, n, ^3H (HT and HTO), Gross β for activated air & particulates with Gamma Spectroscopy, TLD
Direct & Air (off-site)		6 Locations off-site within 1 km radius	Continuous (integrated)	^3H (HT and HTO), TLD for air γ, 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	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*

1985 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	100	289	0	68	4,666	5,123	N
NNE	0	20	290	2,497	4,334	9,600	16,741	NNE
NE	0	0	0	0	0	16,799	16,799	NE
ENE	0	1,160	204	200	100	3,792	5,456	ENE
E	0	0	200	100	10	10,238	10,548	E
ESE	0	100	1,600	1,200	219	3,469	6,588	ESE
SE	113	1,200	0	253	161	18,964	20,691	SE
SSE	362	50	150	0	600	8,255	9,417	SSE
S	0	734	3,837	2,312	1,760	4,156	12,799	S
SSW	3	0	2,500	600	100	27,788	30,991	SSW
SW	0	805	10	250	50	18,525	19,640	SW
WSW	0	739	1,000	1,019	1,449	8,095	12,302	WSW
W	0	1,735	5,820	6,777	2,386	6,253	22,971	W
WNW	40	437	772	3,139	0	2,013	6,401	WNW
NW	0	1,020	866	300	350	3,526	6,062	NW
NNW	0	600	499	200	502	7,093	8,894	NNW
Totals	518	8,700	18,037	18,847	12,089	153,232	211,423	Totals

* Taken from Bender [Be87a]

Table 8*

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 9*

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 10*

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 11*

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 12*

1985 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	66,118	36,704	181,881	68,882	353,586	N
NNE	134,838	226,290	341,211	488,415	1,190,754	NNE
NE	178,403	431,968	1,293,973	3,522,231	5,426,575	NE
ENE	142,397	220,455	1,076,490	1,449,544	2,888,886	ENE
E	52,020	121,842	75,175	0	249,037	E
ESE	38,489	41,729	135,843	0	216,061	ESE
SE	14,219	81,760	179,854	5,852	281,685	SE
SSE	2,926	13,262	20,520	36,784	73,492	SSE
S	5,446	57,129	11,859	2,908	77,342	S
SSW	54,390	61,310	117,286	196,892	429,878	SSW
SW	230,879	361,455	1,147,177	1,032,046	2,771,556	SW
WSW	52,379	151,542	311,433	299,453	814,807	WSW
W	13,955	39,888	106,238	64,611	224,693	W
WNW	8,287	12,555	15,439	252,047	288,328	WNW
NW	13,920	18,653	66,682	86,917	186,172	NW
NNW	26,092	13,716	34,241	22,704	96,753	NNW
Totals	1,034,758	1,890,257	5,115,303	7,529,287	15,569,605	Total

* Taken from Bender [Be87a]

Table 13*

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 14*

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 15*

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 16. (Ku86b)

Sectorized Population Data To 1 Mile

		radial distances (m)*				
		50	125	375	1105	2416
S	n	0	0	0	377	486
E	nnw	0	0	63	0	469
C	nw	0	0	0	20	416
T	wnw	0	0	0	800	830
O	w	0	0	103	0	1587
R	wsw	0	0	116	192	749
	sw	0	0	116	317	12
	ssw	0	0	0	950	247
	s	0	0	317	317	820
	sse	0	0	0	0	3848
	se	0	0	18	0	64
	ese	0	0	73	0	60
	e	0	0	73	0	30
	ene	0	0	18	34	17
	ne	0	0	0	250	66
	nne	0	0	0	186	25

* The radii shown are midpoints of the sector radial boundaries.

Table 17. Environmental Permits

	NJDEP Permit No.	Type	Issue Date	Expiration Date	Status
1	0023922	NJPDES Groundwater	4/1/89	5/1/94	In compliance. Adjudicatory hearing pending in relation to wells placed at B-site. Regional groundwater study as part of permit requirements submitted to NJDEP on 3/1/91. Submitted to NJDEP, items required by inspection report (1/31/91).
2	0023922	NJPDES Surface water	9/28/84	10/31/89	Still awaiting NJDEP approval of new permit; requested review of stormwater discharges, NJDEP reviewing now. NAC developed tables for monthly sampling, to be incorporated into a procedure.
3	092187	TFTR Diesel Exhaust	10/24/89	10/24/94	Current
4	096074	C-site Diesel Exhaust	6/28/90	6/28/95	Current
5	094831	Hot Cell	3/30/90	6/22/91	NJDEP updates expiration date on a three month basis while we await for their inspection.
6	090735	FCPC Building Degreaser Vent	6/6/89	5/31/95	Current. Awaiting NJDEP inspection.
7	826	Elizabethtown Water	4/30/90	3/31/91	Renewal application submitted to NJDEP.
8	148539	Underground Storage Tank Registration	4/1/90	3/31/91	Registration for E1, E5, E8, & E9 received. Contacted NJDEP 10/10/90 (PL-JRS-96 &97) to reinstate tanks E9 and A10. Note: this is a registration only. Registration renewals not yet received from NJDEP.
9	089962	Diesel Tank E8 Vent	12/13/88	12/13/93	Current
10	061295	Boiler #2 Stack Vent	3/31/82	3/31/92	Current
11	061296	Boiler #3 Stack Vent	3/31/82	3/31/92	Current
12	061297	Boiler #4 Stack Vent	3/31/82	3/31/92	Current
13	061299	Boiler #5 Stack Vent	3/31/82	3/31/92	Current
14	61298	Oil Storage Tank Vent No. 2	3/31/82	3/31/92	Current
15	0128306	Medical Waste Generator	7/22/90	7/21/91	Current
16	DR-18A	Delaware and Raritan Canal Water Use Agreement	7/1/84	6/30/2009	Current
17	12471	REML Laboratory Certification	7/1/90	6/30/91	Current for Tritium in Water; Expanding to Gamma Spectrosopy

Table 18. Summary of 1990 Airborne Emissions and Doses from TFTR

Radionuclide & Pathway	Quantity Realeased in 1989[1]	EDE at the Site Boundary	EDE at the Nearest Business[2]	Population Dose Within 80 km[3]
Tritium (HTO) [air]	1.1 Ci[4]	3×10^{-3}mrem[5]	8×10^{-4} mrem[6]	4×10^{-2}person-rem [7]
^{41}Ar	1.9 Ci[4]	2×10^{-3} mrem[8]	2.1×10^{-3} mrem[6]	1×10^{-2}person-rem[9]
Direct & Scattered Neutrons and Gamma radiation	--------------	Background[10]	Background[10]	Background[10]
Tritium (HTO) [water]	4.9×10^{-4}Ci[11]	1×10^{-5}mrem[12]	-------------	1×10^{-5} person-rem[13]
Total	---------------	1.1×10^{-2}mrem	2.9×10^{-3}mrem	5×10^{-2}person-rem
Background	---------------	600 mrem[14]	600 mrem[14]	1.6×10^{6}person-rem

Footnotes:

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[1] Tritium & ^{41}Ar quantities are based on production of 2.31×10^{19} neutrons in 1990.

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

[3] Based on year 1995 population figures as utilized for Draft TFTR D-T EA. See Tables 4 [Be87a].

[4] As per letter Stencel, PPPL, to Mix, DOE, on 4/15/91, "Calendar Year (CY) 1990 Air Emissions Annual Report to the Environmental Protection Agency (EPA)," JRS-2053.

[5] Based on NOAA χ/Q [St89]; $1.1 \text{ Ci} \times 2.6 \times 10^{-3}$ mrem/Ci.

[6] Based on 28% of the NOAA χ/Q at the site boundary [St89].

[7] Scaling from values used for the Draft TFTR D-T EA, we get (1.1 Ci/500 Ci) × 16.2 person-rem = 3.6×10^{-2} person-rem.

[8] Based on NOAA χ/Q [St89]; $1.9 \text{ Ci} \times 4.0 \times 10^{-3}$ mrem/Ci.

[9] Scaling from values used for the Draft TFTR D-T EA, we get (1.9 Ci/115 Ci) × 0.67 person-rem = 1.0×10^{-2} person-rem.

[10] As per "PPPL Ionizing Radiation Report for Calendar Year 1990," [Gi91].

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

[12] Based on usage of 1×10^{10} liters/y for Stony Brook treatment facility, as per Draft TFTR D-T EA, the dose to a person who drank all his/her water from the waterway (Milstone River) into which the treatment facility discharged in 1990 would be $[(4.9 \times 10^{-4}\text{ Ci/y})/(1 \times 10^{10}\text{ liters/y})] \times [(4\text{ mrem})/(2 \times 10^{-8}\text{ Ci/liter})] = 1 \times 10^{-5}$mrem.

[13] 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).

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

Table 19. Tritium in Precipitation for 1990

Precipitation Collection Dates	Period	^3H Concentration pCi/liter
Jan. 1-8	1	No Analysis
Jan. 8-15	2	44
Jan 15-22	3	47
Jan 22 - 29	4	54
Jan 29 - Feb 2	5	21
Feb 2 - 13	6	47
Feb 13 - 19	7	No Analysis
Feb 19 - 26	8	41
Feb 26 - Mar 5	9	No Analysis
Mar 5 - 12	10	No Analysis
Mar 12 - 19	11	19
Mar 19 - 26	12	34
Mar 26 - Apr 2	13	29
Apr 2 - 9	14	45
Apr 9 - 16	15	23
Apr 16 - 23	16	48
Apr 23 - 30	17	38
Apr 30 - May 7	18	49
May 7 - 14	19	21
May 14 - 21	20	59
May 21 - 29	21	50
May 29 - Jun 4	22	34
Jun 4 - 11	23	38
Jun 11 - 18	24	53
Jun 18 - 25	25	43
Jun 25 - Jul 16	26	No Analysis
Jul 16 - 23	27	37
Jul 23 - 30	28	37
Jul 30 - Aug 6	29	94
Aug 6 - 13	30	65
Aug 13 - 20	31	No Analysis
Aug 20 - 27	32	21
Sep 4 - 10	33	No Rain
Sep 10 - 17	34	92
Sep 17 - 24	35	54
Sep 24 - Oct 1	36	60
Oct 1 - 8	37	45
Oct 8 - 15	38	28
Oct 15 - 22	39	25
Oct 22 - 29	40	14
Oct 29 - Nov 5	41	No Rain
Nov 5 - 12	42	No Analysis
Nov 12 - 19	43	85
Nov 19 - 26	44	91
Nov 26 - Dec 3	45	No Rain
Dec 3 - Jan 2 1991	46	No Analysis

Table 20. Precipitation at PPPL for 1990

Week	Start Date	Inches	Inch/Month	Month	Accumulation
1	1-Jan	0.000			0.000
2	6-Jan	0.950			0.950
3	15-Jan	0.600			1.550
4	22-Jan	1.450			3.000
5	29-Jan	1.500	4.500	Jan	4.500
6	5-Feb	0.800			5.300
7	12-Feb	0.050			5.350
8	19-Feb	0.550			5.900
9	26-Feb	0.000	1.400	Feb	5.900
10	5-Mar	0.140			6.040
11	12-Mar	1.000			7.040
12	19-Mar	0.550			7.590
13	26-Mar	0.590	2.280	Mar	8.180
14	2-Apr	1.350			9.530
15	9-Apr	1.505			11.035
16	16-Apr	0.340			11.375
17	23-Apr	0.315	3.510	Apr	11.690
18	7-May	1.470			13.160
19	14-May	1.995			15.155
20	21-May	2.125			17.280
21	28-May	0.700	6.290	May	17.980
22	4-June	2.580			20.560
23	11-June	1.100			21.660
24	18-June	0.500			22.160
25	25-June	2.250	6.430	June	24.410
26	2-July	0.680			25.090
27	9-July	0.450			25.540
28	16-July	2.235			27.775
29	23-July	0.810			28.585
30	30-July	0.450	4.625	July	29.035
31	6-Aug	2.750			31.785
32	13-Aug	3.650			35.435
33	20-Aug	0.550			35.985
34	27-Aug	0.525	7.475	Aug	36.510
35	3-Sept	0.725			37.235
36	10-Sept	0.000			37.235
37	17-Sept	0.725			37.960
38	24-Sept	1.000	2.450	Sept	38.960
39	1-Oct	0.675			39.635
40	8-Oct	0.250			39.885
41	15-Oct	0.900			40.785
42	22-Oct	1.175			41.960
43	29-Oct	0.850	3.850	Oct	42.810
44	5-Nov	0.000			42.810
45	12-Nov	1.450			44.260
46	19-Nov	0.300			44.560
47	26-Nov	0.225	1.975	Nov	44.785
48	3-Dec	0.000			44.785
49	10-Dec	1.575			46.360
50	17-Dec	1.075			47.435
51	24-Dec	1.850			49.285
52	31-Dec	1.050	5.550	Dec	50.335

Table 21. Tritium Concentrations in Surface Water and Groundwater for 1990*

Surface Water (See Fig. 31 for Location)

Location-> Collection Date	B1	B2	C1	D1	D2	E1	M1	P1	P2
1/9/90	38	40	frozen	35	39	52	50	53	51
2/1/90	51	48	50	50	54	49	44	43	39
2/20/90	49	49	55	49	47	48	49	53	54
3/13/90	48	50	52	51	50	50	58	57	55
4/9/90	44	45	46	48	49	48	46	64	57
5/2/90	54	53	62	62	60	56	56	59	54
5/31/90	No Analysis	No Analysis	41	53	51	47	36	38	35
6/22/90	51	52	52	55	53	56	55	62	49
7/11/90	53	46	56	55	62	57	52	52	52
8/1/90	57	53	61	52	No Analysis	60	49	55	53
8/31/90	52	52	72	57	55	55	49	66	54
9/11/90	51	57	62	63	62	61	57	57	60
10/8/90	50	55	61	57	61	61	51	60	63
11/6/90	42	46	61	56	52	54	47	61	49
11/28/90	38	48	50	53	54	55	46	62	50

Groundwater Wells (See Fig. 20 for Locations)

Location-> Collection Date	TW1	TW10	TW3	D11	D12	#W4	#W5		
3/13/90	56	63	No Sample	No Sample	No Sample	No Sample	No Sample		
5/2/90	52	56	46	49	53	No Sample	No Sample		
5/31/90	50	53	48	No Sample	No Sample	50	53		
8/31/90	No Sample	No Sample	57	56	53	No Sample	No Sample		

Table 22. Tritium Concentrations in Soil/Sod Moisture for 1990

Location--> Collection Date	S11	S12	S13	S14	S15	S16	S17	S18	S19
3/27/90	45	41	44	**	41	47	49	47	47
6/26/90	46	49	45	**		47	48	44	49
9/5/90	69	72	67	**	72	63	73	65	68
10/10/90	73	65	68	**	60	66	70	No Analysis	No Analysis

** = Sample not taken; soil disruption due to road construction.

* All measurement values are in pCi/liter.

Tables 23. Surface Water Analysis for Bee Brook, Location B1.

	Collection Date	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	32	10	23	50		
mg/l O_2	BOD5	<1.0	2	<1.0	4.1	1.9	2.3
mg/l $CaCO_3$ eq.	Calcium Hardness	25	11	27	4.0		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.020	<0.02	<0.02
mg/l Cr	Chromium - Hexavalent	<0.02	<0.02	<0.02	<0.02		
mg/l O_2	COD	<5.0	<5.0	<5.0	<5.0	<5.0	13
mg/l Cu	Copper	<0.02	<0.02	<0.02	<0.025		
mg/l O_2	Dissolved Oxygen	9.9	13.2	11	9.6		
mg/l Cu eq.	EDTA	<0.02	0.30	0.83	1.0		
MPN/100 ml	Total Coliform Count	70	8	280	240		
ft^3/sec	Flow	0.15	0.13	0.25	0.13	0.1	0.05
mg/l Fe	Iron	0.55	0.21	0.30	0.28		
mg/l	Nitrogen, Ammonia					0.73	<0.10
mg/l N	Nitrogen, Total Kjedahl	<0.10	1.3	0.67	0.28		
mg/l N	Nitrogen, Nitrate	0.12	1.1	0.98	0.65		
mg/l	Oil & Grease	<0.50	0.9	<0.5	<0.050		
unit	pH	6.6	7.0	7.4	8.6	6.7	7.2
mg/l	Petroleum Hydrocarbons, Total					<0.5	<0.50
mg/l	Phenols, Total					<0.10	<0.10
mg/l P	Phosphate, Total	<0.1	<0.1	<0.1	<0.1		
mg/l P	Phosphate, Ortho	<0.1	<0.1	<0.1	0.4		
mg/l	Solids - Dissolved	176	124	95	139	106	113
mg/l	Solids - Setteable					<0.10	
mg/l	Solids - Suspended	1	5	7	6		5
mg/l SO_4	Sulfate	20	15	22	15		
Deg C	Temperature	5	6	12	16		
NTU	Turbidity	3.1	4.8	3.6	6.3		
mg/l Zn	Zinc	<0.02	<0.02	<0.02	<0.02		
	Clarity	Clear	Clear	Clear	Cloudy		

Table 24. Surface Water Analysis for Bee Brook, Location B2.

	Collection Date	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	22	17.2	23	37		
mg/l O2	BOD5	<1.0	<1	<1	3.5	2.4	3.7
mg/l $CaCO_3$ eq.	Calcium Hardness	30	20	28	40		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
mg/l Cr	Chromium - Hexavalent	<0.02	<0.02	<0.02	<0.02		
mg/l O_2	COD	<5.0	<5.0	10	<5.0	17	18
mg/l Cu	Copper	<0.02	<0.02	<0.02	<0.025		
mg/l O_2	Dissolved Oxygen	10.3	13	11.7	10.2		
mg/l Cu eq.	EDTA	0.23	0.8	0.77	80		
MPN/100 ml	Total Coliform Count	90	23	<1600	0.72		
ft^3/sec	Flow	0.12	0.17	0.28	0.2	0.2	0.1
mg/l Fe	Iron	0.46	0.2	0.22	0.285		
mg/l	Nitrogen, Ammonia					0.2	<0.10
mg/l N	Nitrogen, Total Kjedahl	0.87	1	1.1	0.95		
mg/l N	Nitrogen, Nitrate	0.85	1.2	1.5	0.55		
mg/l	Oil & Grease	<0.5	<0.5	<0.5	<0.5		
unit	pH	6.8	7.1	7.3	9	6.9	7.4
mg/l	Petroleum Hydrocarbons, Total					<0.50	<0.50
mg/l	Phenols, Total					<0.10	<0.10
mg/l P	Phosphate, Total	0.2	<0.1	<0.1	<0.1		
mg/l P	Phosphate, Ortho	<0.10	<0.1	<0.1	<0.1		
mg/l	Solids - Dissolved	181	78	97	136	118	119
mg/l	Solids - Setteable					<0.10	
mg/l	Solids - Suspended	2	6	6	10		2
mg/l SO_4	Sulfate	26	16	29	195		
Deg C	Temperature	6	5	11.5	16		
NTU	Turbidity	4.4	4	5.5	5		
mg/l Zn	Zinc	<0.02	<0.02	<0.02	0.022		
	Clarity	Clear	Clear	Clear	Clear		

Table 25. Surface Water Analysis for D&R Canal, Location C1.

	Collection Date	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	41	15	30	34		
mg/l O_2	BOD_5					2.1	2.4
mg/l $CaCO_3$ eq.	Calcium Hardness	40	28	33	35		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.02		
mg/l Cr	Chromium - Hexavalent	<0.02	<0.02	<0.02			
mg/l O_2	COD					<5.0	17
mg/l Cu	Copper	<0.02	<0.02	<0.02	<0.025		
mg/l Cu eq.	EDTA	<0.02	0.26	0.76	0.2		
mg/l Fe	Iron	0.28	0.5	0.29	0.26		
mg/l	Nitrogen, Ammonia					0.31	<0.10
mg/l N	Nitrogen, Nitrate	1.8	3.0	2.2	1.1		
mg/l	Oil & Grease	<0.5	0.9	<0.5	<0.5		
unit	pH	7.1	7	7	7.1	6.6	7.2
mg/l	Petroleum Hydrocarbons, Total					<0.50	<0.50
mg/l	Phenols, Total					0.1	<0.10
mg/l P	Phosphate, Total	<0.1	0.1	<0.1	<0.1		
mg/l P	Phosphate, Ortho	<0.1	<0.1	<0.1	<0.1		
mg/l	Solids - Dissolved	123	117	118	105	100	107
mg/l	Solids - Setteable					0.10	
mg/l	Solids - Suspended	<1.0	11	23	11		27
mg/l SO_4	Sulfate	20	20	31	17		
NTU	Turbidity	4.9	8.8	9.5	9.1		
mg/l Zn	Zinc	<0.02	<0.02	<0.02	<0.020		
	Clarity	Clear	Slightly Cloudy	Clear	Clear		

Table 26. Surface Water Analysis for Ditch #5, Location D1.

	Collection Date	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	34	23	31	28		
mg/l O_2	BOD_5	<1.0	<1	<1	2.9	24	7
mg/l $CaCO_3$ eq.	Calcium Hardness	40	32	50	36		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
mg/l Cr	Chromium - Hexavalent	<0.02	<0.02	< 0.02	<0.02		
mg/l O_2	COD	<5.0	<5.0	<5.0	<5.0	25	19
mg/l Cu	Copper	<0.02	<0.02	<0.02	0.025		
mg/l O_2	Dissolved Oxygen	9.6	10.9	9.9	9.1		
mg/l Cu eq.	EDTA	<0.02	0.28	0.31	0.32		
MPN/100 ml	Total Coliform Count	900	<2	<2	<2.0		
ft^3/sec	Flow	0.05	0.05	0.06	0.08	0.5	0.03
mg/l Fe	Iron	0.23	0.15	0.14	0.282		
mg/l	Nitrogen, Ammonia					0.31	<0.10
mg/l N	Nitrogen, Total Kjedahl	0.95	0.6	1.3	1.2		
mg/l N	Nitrogen, Nitrate	2.5	1.9	2.9	1.2		
mg/l	Oil & Grease	1.1	0.6	<0.5	<0.5		
unit	pH	7	6.8	7	7	6.6	7
mg/l	Petroleum Hydrocarbons, Total					<0.50	<0.50
mg/l	Phenols, Total					<0.10	<0.10
mg/l P	Phosphate, Total	0.5	0.5	<0.1	0.5		
mg/l P	Phosphate, Ortho	0.1	0.1	<0.1	0.2		
mg/l	Solids - Dissolved	135	138	157	104		1 34
mg/l	Solids - Setteable					132	<0.10
mg/l	Solids - Suspended	<1.0	3	7	4		
mg/l SO_4	Sulfate	24	18	3	19		
Deg C	Temperature	12	12	13	14		
NTU	Turbidity	3.9	2.9	0.65	7.1		
mg/l Zn	Zinc	<0.02	<0.02	<0.02	<0.020		
	Clarity	Clear	Clear	Clear	Clear		

Table 27. Surface Water Analysis for Ditch #5, Location D2 (NJPDES).

	Collection Date	1/2/90	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	6/18/90	7/16/90	8/20/90	9/19/90	10/30/90	11/26/90
Units	Parameter												
mg/l $CaCO_3$ eq.	Alkalinity		53	49	46	45							
mg/l O_2	BOD_5		<1.0	<1	<1.0	2.5	1.6		1.1	2.5	4		2.5
mg/l $CaCO_3$ eq.	Calcium Hardness		65	51	55	49							
mg/l Cr	Chromium - Total		<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02		<0.02
mg/l Cr	Chromium - Hexavalent		<0.02	<0.02	<0.02	<0.02							
mg/l O2	C O D		<5.0	<5.0	<5.0	<5.0	<5.0	12	20	<5.0	<5	<5	<5
mg/l Cu	Copper		<0.02	<0.02	<0.02	0.025							
mg/l O_2	Dissolved Oxygen		8.5	11.4	10.6	7.7							
mg/l Cu eq.	EDTA		<0.02	0.3	0.66	0.54							
MPN/100 ml	Total Coliform Count		140	7	34	240							
ft^3/sec	Flow		0.02	0.02	0.03	0.02	0.2	0.02	0.01	0.03	0.15	0.01	0.01
mg/l Fe	Iron		0.2	0.12	0.15	0.173							
mg/l	Nitrogen, Ammonia						0.25		0.2	<0.10	<0.10		<0.10
mg/l N	Nitrogen, Total Kjedahl		0.76	0.76	<0.1	0.31							
mg/l N	Nitrogen, Nitrate		1.8	1.3	1.6	0.87							
mg/l	Oil & Grease		<0.5	<0.5	<0.5	<0.05							
unit	pH		6.7	7	6.9	6.8	6.7	7.55	7.5	7	8	7.1	7.2
mg/l	Petroleum Hydrocarbons, Total	<0.5					<0.5	<0.5	<0.5	<0.50	<0.5	<0.5	<0.5
mg/l	Phenols, Total						<0.10		<0.10	<0.10	<0.10		<0.10
mg/l P	Phosphate, Total		0.5	0.2	0.1	0.3							
mg/l P	Phosphate, Ortho		0.4	0.1	<0.1	0.2							
mg/l	Solids - Dissolved		206	120	147	107	173		211	196	147		118
mg/l	Solids - Settleable						<0.10						
mg/l	Solids - Suspended		<1.0	4	5	2		<1.0	6	<1.0	2	11	3
mg/l SO4	Sulfate		24	19	49	33							
Deg C	Temperature		12	12	16	14		23	23			14	16
NTU	Turbidity		2.4	2.1	1.4	3.6							
mg/l Zn	Zinc		<0.02	<0.02	<0.02	0.32							
	Clarity		Clear	Clear	Clear	Clear							

Table 28. Surface Water Analysis for Ditch #5, Location D2 (NJPDES).

	Collection Date	10/26/90	11/19/90	12/14/90	Detection Limit
Units	Parameter				
mg/l	BOD_5	ND	ND	7.86	4
mg/l	Chromium, Total	ND	ND	ND	0.01
mg/l	COD	ND	ND	ND	50
gpm*	Flow	10	30		NA
mg/l	Method Blank	ND	ND		0.01
mg/l	Nitrogen, Ammonia	ND	ND	ND	0.5
mg/l	pH	7.23	7	7.86	NA
mg/l	Petroleum Hydrocarbons by IR	ND	ND	ND	1
mg/l	Phenols, Total	ND	ND	ND	0.2
mg/l	Solids - Dissolved, Total	110	91	130	5
mg/l	Solids - Suspended, Total	8.3	5.1	12	5

ND=Not Detected; NA=Not Applicable
*Analysis performed on-site at time of sampling.

Table 29. Water Analysis for Water Supply, Location E1.

	Collection Date	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	36	36	40	44		
mg/l O_2	BOD_5					1.2	1.5
mg/l O_2	COD					<5.0	<5.0
mg/l $CaCO_3$ eq.	Calcium Hardness	67	58	60	66		
mg/l Cu	Copper	<0.02	<0.02	<0.02	<0.025		
MPN/100 ml	Total Coliform Count	<2	<2	<2	<2		
mg/l Fe	Iron	0.08	0.02	0.1	0.055		
mg/l	Nitrogen, Ammonia					0.1	<0.10
mg/l N	Nitrogen, Total Kjedahl	1.2	1	0.42	0.2		
mg/l N	Nitrogen, Nitrate	1.8	1.8	2.9	0.85		
unit	pH	6.7	7.2	7	7	6.6	7
mg/l	Petroleum Hydrocarbons, Total					<0.50	<0.50
mg/l	Phenols, Total					<0.10	<1.10
mg/l P	Phosphate, Total	<0.1	<0.1	<0.1	0.1		
mg/l P	Phosphate, Ortho	<0.1	<0.1	<0.1	0.1		
mg/l	Solids - Dissolved	278	136	155	162	182	259
mg/l	Solids - Suspended						<1.0
mg/l Mn	Manganese	<0.01	<0.01	<0.01	<0.010		
mg/l Cl	Chloride	74	29	27	25		
mg/l	Solids - Setteable					<0.10	
mg/l SO_4	Sulfate	40	37	29	38		
Deg C	Temperature	5	8	10	12		
NTU	Turbidity	0.27	0.35	0.24	1.2		

Table 30. Surface Water Analysis for the Millstone River, Location M1.

	Collection Date	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	14	29	11	16		
mg/l O_2	BOD_5					2.3	3.3
mg/l O_2	COD					26	30
mg/l $CaCO_3$ eq.	Calcium Hardness	22	39	24	26		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.02		
mg/l Cr	Chromium - Hexavalent	<0.02	<0.02	<0.02	<0.02		
mg/l Cu	Copper	<0.02	<0.02	<0.02	<0.025		
mg/l Cu eq.	EDTA	<0.02	0.24	0.38	0.24		
mg/l Fe	Iron	0.66	0.12	0.58	0.75		
mg/l	Nitrogen, Ammonia					1	0.36
mg/l N	Nitrogen, Nitrate	2.6	1.9	2.9	2.2		
mg/l	Oil & Grease	<0.5	0.6	<0.5	<0.5		
unit	pH	6.5	7.1	6.8	6.6	6.5	6.6
mg/l	Petroleum Hydrocarbons, Total					<0.50	<0.50
mg/l	Phenols, Total					0.2	<0.10
mg/l P	Phosphate, Total	0.1	<0.1	0.1	<0.10		
mg/l P	Phosphate, Ortho	<0.1	<0.1	<0.1	<0.10		
mg/l	Solids - Dissolved	1 38	101	89	116	140	114
mg/l	Solids - Settleable					<0.10	
mg/l	Solids - Suspended	7	7	18	14		22
mg/l SO_4	Sulfate	23	17	19	20		
NTU	Turbidity	6.3	3.3	8.4	10		
mg/l Zn	Zinc	<0.02	<0.02	<0.02	0.023		
	Clarity	Clear	Clear	Slightly Cloudy	Clear		

Table 31. Surface Water Analysis for Plainsboro, Location P1.

	Collection Date ---------->	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	9.6	8.6	8.6	8.6		
mg/l O_2	BOD_5					2.8	3.7
mg/l O_2	COD					<5.0	20
mg/l $CaCO_3$ eq.	Calcium Hardness	22	22	22	21		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.02		
mg/l Cr	Chromium - Hexavalent	<0.02	<0.02	<0.02	<0.02		
mg/l Cu	Copper	<0.02	<0.02	<0.02	<0.025		
mg/l Cu eq.	EDTA	<0.02	0.02	0.44	0.18		
mg/l Fe	Iron	0.62	0.63	1	1.7		
mg/l	Nitrogen, Ammonia					0.95	<0.10
mg/l N	Nitrogen, Nitrate	2.5	2.5	2.4	1.3		
mg/l	Oil & Grease	<0.5	0.5	<0.5	<0.5		
unit	pH	6.2	7	6.5	6.6	6.3	6.4
mg/l	Petroleum Hydrocarbons, Total					<0.50	<0.50
mg/l	Phenols, Total					0.1	<0.1
mg/l P	Phosphate, Total	<0.1	<0.1	0.1	0.2		
mg/l P	Phosphate, Ortho	<0.1	<0.1	<0.1	<0.1		
mg/l	Solids - Dissolved	184	91	110	109	111	99
mg/l	Solids - Settleable					<0.10	
mg/l	Solids - Suspended	8	13	26	30		35
mg/l SO_4	Sulfate	26	23	19	20		
NTU	Turbidity	7.5	8.4	16	20		
mg/l Zn	Zinc	<0.02	<0.02	<0.02	<0.020		
	Clarity	Slightly Cloudy	Slightly Cloudy	Slightly Cloudy	Cloudy		

Table 32. Surface Water Analysis for Plainsboro, Location P2.

	Collection Date	1/23/90	2/20/90	3/22/90	4/24/90	5/23/90	8/20/90
Units	Parameter						
mg/l $CaCO_3$ eq.	Alkalinity	10.2	11.4	7.4	13		
mg/l O_2	BOD5					<1.0	9.4
mg/l O_2	COD					<5.0	23
mg/l $CaCO_3$ eq.	Calcium Hardness	12	15	11	14		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.020		
mg/l Cr	Chromium - Hexavalent	<0.02	<0.02	<0.02	<0.02		
mg/l Cu	Copper	<0.02	<0.02	<0.02	<0.025		
mg/l Cu eq.	EDTA	<0.02	<0.02	0.22	0.2		
mg/l Fe	Iron	0.42	0.34	0.39	0.6		
mg/l	Nitrogen, Ammonia					0.11	<0.10
	Nitrogen, Nitrate	2	3	1.9	2.5		
mg/l	Oil & Grease	<0.5	0.9	<0.5	<0.5		
unit	pH	6.2	6.8	6.9	6.6	6.3	6.5
mg/l	Petroleum Hydrocarbons, Total					<0.5	<0.50
mg/l	Phenols, Total					0.1	<0.10
mg/l P	Phosphate, Total	<0.1	<0.1	<0.1	<0.1		
mg/l P	Phosphate, Ortho	<0.1	<0.1	<0.1	<0.1		
mg/l	Solids - Dissolved	67	62	53	84	102	88
mg/l	Solids - Settleable					<0.10	
mg/l	Solids - Suspended	3	8	9	<1.0		3
mg/l SO_4	Sulfate	13	8.6	9.3	8.4		
NTU	Turbidity	2.6	3.5	0.34	3.1		
mg/l Zn	Zinc	<0.02	<0.02	<0.02	<0.020		
	Clarity	Clear	Slightly Cloudy	Clear	Clear		

Table 33. Detention Basin Influent Analysis (NJPDES)

	Collection Date	Inflow 1 5/18/90	Inflow 2 5/18/90	Inflow 1 8/13/90	Inflow 2 8/13/90
Units	Parameter				
mg/l O_2	BOD_5	1	9	1.2	2
mg/l O_2	COD	4	11	23	<5.0
mg/l	Cadmium	0.02			
mg/l	Chromium - Hexavalent	0.02	0.02		
mg/l	Chromium - Total		0.02	<0.02	<0.02
mg/l	Nitrogen, Ammonia	<0.01	<0.10	<0.10	<0.10
mg/l	Petroleum Hydrocarbons, Total	0.5	0.5		
unit	pH			7	7.4
mg/l	Phenols, Total		0.1	0.2	<0.10
mg/l	Solids - Dissolved	224	151	96	191
mg/l	Solids - Setteable	0.1	0.1	<0.10	0.1
mg/l SO_4	Sulfate	23	32		

Table 34. Groundwater Analysis for Well D-11

	Collection Date	2/12/90	5/18/90	5/18/90	8/13/90	11/21/90	Detection Limit**
Units	Parameter		(Before)	(After)			
mg/l	Barium, Dissolved		0.12	0.22			
mg/l	Chloride				17	29	3
mg/l	Lead, Dissolved		0.05	0.05	<0.05	ND	
mg/l	Nitrogen, Ammonia		0.1		<0.10	ND	0.5
mg/l	Nitrogen, Nitrate				1.2	ND	1
mg/l	Organic Carbon, Total				3		
mg/l	Organic Halides, Total				<30		
mg/l	Petroleum Hydrocarbons, Total				<0.50		
unit	pH	6	6.5			5.2*	NA
mg/l	Phenols, Distillation				<0.10	ND	0.2
mg/l	Solids - Dissolved, Total	126	47	133	110	250	5
µmho/cm	Specific Conductance 925C	170	184			140	NA
mg/l SO_4	Sulfate, Dissolved	24	30	21	30	20	5
Deg. C	Temperature		13.6			16*	NA
mg/l	Titanium		0.05	0.05			

ND=Not Detected; NA=Not Applicable
*: Analysis performed on-site at time of sampling.
** For 11/21/90 only

Table 35. Groundwater Analysis for Well D-12

	Collection Date	2/12/90	5/18/90	5/18/90	8/13/90	11/21/90	Detection Limit**
Units	Parameter		(Before)	(After)			
mg/l	Barium, Dissolved		0.08	0.07			
mg/l	Chloride				19	18	3
mg/l	Chromium - Hexavalent				<0.02		
mg/l	Lead, Dissolved		0.05	0.05	<0.05	ND	
	Nitrogen, Ammonia		0.1		<0.10	ND	0.5
mg/l	Nitrogen, Nitrate				0.21	ND	1
mg/l	Organic Carbon, Total				3		
mg/l	Organic Halides, Total				48		
mg/l	Petroleum Hydrocarbons, Total				<0.50		
unit	pH	5.2	5.6			5.2*	NA
mg/l	Phenols, Distillation				<0.10	ND	0.2
mg/l	Solids - Dissolved, Total	142	160	176	116	92	5
µmho/cm	Specific Conductance @ 25C	181	192			180	NA
mg/l SO_4	Sulfate, Dissolved	30	37	40	39	25	5
Deg. C	Temperature		13			16*	NA
mg/l	Titanium		0.05	0.05			

ND=Not Detected; NA=Not Applicable

*: Analysis performed on-site at time of sampling.

** For 11/21/90 only

Table 36. Groundwater Analysis for Well MW-14

	Collection Date ---------->	2/12/90	5/18/90	8/13/90	11/21/90	Detection Limit**
Units	Parameter					
mg/l	Chloride			7	6	3
mg/l	Chromium, Hex.			<0.02	ND	
mg/l	Lead, Dissolved			<0.05	ND	
mg/l	Nitrogen, Ammonia		0.1	<0.10	ND	0.5
mg/l	Nitrogen, Nitrate			2.9	2	1
mg/l	Organic Carbon, Total			3		
mg/l	Organic Halides, Total			31		
mg/l	Petroleum Hydrocarbons, Total			<0.50		
unit	pH	6	5.8		5.5*	NA
mg/l	Phenols, Distillation			<0.10	ND	0.2
mg/l	Solids - Dissolved, Total	61	76	70	54	5
μmho/cm	Specific Conductance @ 25C	84	110		85	NA
mg/l SO_4	Sulfate, Dissolved	2.1	14	15	10	5
Deg. C	Temperature				14*	NA

ND=Not Detected; NA=Not Applicable
*: Analysis performed on-site at time of sampling.
** For 11/21/90 only

Table 37. Groundwater Analysis for Well MW-15

	Collection Date --------->	2/12/90	5/18/90	8/13/90	11/21/90	Detection Limit**
Units	Parameter					
mg/l	Chloride			4.5	6	3
mg/l	Chromium, Hex.			<0.02	ND	
mg/l	Lead, Dissolved			<0.05	ND	
mg/l	Nitrogen, Ammonia		0.1	<0.10	ND	0.5
mg/l	Nitrogen, Nitrate			0.94	ND	1
mg/l	Organic Carbon, Total			3		
mg/l	Organic Halides, Total			30		
mg/l	Petroleum Hydrocarbons, Total			< 0.50		
unit	pH	6	6.1		5.7*	NA
mg/l	Phenols, Distillation			<0.10	ND	0.2
mg/l	Solids - Dissolved, Total	91	76	82	69	5
µmho/cm	Specific Conductance @ 25C	108	87		75	NA
mg/l SO4	Sulfate, Dissolved	14	11	18	12	5
Deg. C	Temperature				13*	NA

ND=Not Detected; NA=Not Applicable
*: Analysis performed on-site at time of sampling.
** For 11/21/90 only

Table 38. Groundwater Analysis for Well MW-16

	Collection Date --------->	2/12/90	5/18/90	8/13/90	11/21/90	Detection Limit**
Units	Parameter					
mg/l	Chloride			6.5	12	3
mg/l	Chromium - Hexavalent			<0.02	ND	
mg/l	Lead, Dissolved			<0.05	ND	NA
mg/l	Nitrogen, Ammonia		0.1	<0.10	ND	0.5
mg/l	Nitrogen, Nitrate			1.4	ND	1
mg/l	Organic Carbon, Total			6		
mg/l	Organic Halides, Total			143		
mg/l	Petroleum Hydrocarbons, Total			<0.50		
unit	pH	6.5	6.3		6.6*	NA
mg/l	Phenols, Distillation			<0.10	ND	0.2
mg/l	Solids - Dissolved, Total	166	186	285	21	5
μmho/cm	Specific Conductance @ 25C	263	330		430	NA
mg/l SO_4	Sulfate, Dissolved	30	60	52	41	5
Deg. C	Temperature				14*	NA

ND=Not Detected; NA=Not Applicable
*: Analysis performed on-site at time of sampling.
** For 11/21/90 only

Table 39. Groundwater Analysis for Well TW2

	Collection Date ---------->	2/12/90	5/18/90	8/13/90	11/21/90	Detection Limit**
Units	Parameter					
mg/l	Chloride			6.5	7	3
mg/l	Lead, Dissolved			0.06	ND	
mg/l	Nitrogen, Ammonia		0.1	<0.10	ND	0.5
mg/l	Nitrogen, Nitrate			0.92	ND	1
mg/l	Organic Carbon, Total			4		
mg/l	Organic Halides, Total			<30.0		
mg/l	Petroleum Hydrocarbons, Total			<0.5		
unit	pH	6.5	6.8		6.8*	NA
mg/l	Phenols, Distillation			<0.10	ND	0.2
mg/l	Solids - Dissolved, Total	211	233	191	190	5
μmho/cm	Specific Conductance @ 25C	294	286		260	NA
mg/l SO_4	Sulfate, Dissolved	38	29	42	12	5
Deg. C	Temperature				12*	NA

ND=Not Detected; NA=Not Applicable
*: Analysis performed on-site at time of sampling.
** For 11/21/90 only

Table 40. Groundwater Analysis for Well TW#3

	Collection Date ---------->	2/12/90	5/18/90	8/13/90	11/21/90	Detection Limit**
Units	Parameter					
mg/l	Chloride			6	26	3
mg/l	Lead, Dissolved			<0.05	ND	
mg/l	Nitrogen, Ammonia		0.1	<0.10	ND	0.5
mg/l	Nitrogen, Nitrate			0.2	ND	1
mg/l	Organic Carbon, Total			3		
mg/l	Organic Halides, Total			<30.0		
mg/l	Petroleum Hydrocarbons, Total			<0.5		
unit	pH	6.5			6.7*	NA
mg/l	Phenols, Distillation			<0.10	ND	0.2
mg/l	Solids - Dissolved, Total	222	246	218	180	5
µmho/cm	Specific Conductance @ 25C	312			310	NA
mg/l SO_4	Sulfate, Dissolved	22	23	27	20	5
Deg. C	Temperature				12*	NA

ND=Not Detected; NA=Not Applicable
*: Analysis performed on-site at time of sampling.
** For 11/21/90 only

Table 41. Groundwater Analysis for Well #W4 and #W5.

	Collection Date ---------->	3/22/90	3/22/90	5/23/90	5/23/90	8/20/90	8/20/90
Units	Parameter	W-4	W-5	W-4	W-5	W-4	W-5
mg/l	Alkalinity	1	46				
mg/l	BOD_5			<1.0	<1.0	2.5	6.4
mg/l	COD			<5.0	<5.0	20	10
mg/l	Calcium Hardness	70	34				
mg/l	Copper	<0.02	<0.02				
mg/l	Coliform Total	11	<2				
mg/l	Iron	4.5	0.33				
mg/l	Kjedahl Nitrogen Total	0.5	<0.1				
mg/l	Nitrogen, Ammonia			0.11	0.36	<0.10	<0.10
mg/l	Nitrate, Nitrogen	0.11	1.6				
mg/l	pH	7.3	6.3	6.9	6	6.9	6.1
mg/l	Petroleum Hydrocarbons, Total			<0.5	<0.5	<0.50	<0.50
mg/l	Phenols, Total			<0.10	<0.10	<0.10	<0.10
mg/l	Phosphate Total	0.2	0.2				
mg/l	Ortho Phosphate	<0.1	0.1				
mg/l	Solids, Dissolved Total	161	100	183	127	190	116
mg/l	Solids, Settleable			<0.10	<0.10		
mg/l	Solids, Suspended Total					12	4
mg/l	Manganese	0.11	<0.01				
mg/l	Chloride	10	5				
mg/l	Sulfate	10	12				
mg/l	Temperature	12	12				
mg/l	Turbidity	4.7	2.6				

Table 42. Groundwater Base Neutral Analysis

	Collection Date ------->	8/13/90							
Units	Parameter	D-11	D-12	MW-14	MW-15	MW-16	TW-2	TW-3	Field Blank
µg/l	1,2,4-Trichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	1,2-Dichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	1,3-Dichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	1,4-Dichlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	2,4-Dinitrotoluene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	2,6-Dinitrotoluene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	2-Chloronaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	2-Methylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	3,3-Dichlorobenzidine	<20	<20	<20	<20	<20	<20	<20	<20
µg/l	4-Bromophenyl-phenylether	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	4-Chlorophenyl-phenylether	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Acenaphthene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Acenaphthylene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Anthracene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Benzo (a) Anthracene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Benzo (A) pyrene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Benzo (B) fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Benzo (G,H,I) perylene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Benzo (K) fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Bis(2-chloroethoxy) methane	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Bis(2-chloroethyl) ether	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Bis(2-chloroisopropyl) ether	<10	<10	<10	<10	<10	<10	<10	<10

Table 42 (Continued). Groundwater Base Neutral Analysis

	Collection Date ------->	8/13/90							
Units	Parameter	D-11	D-12	MW-14	MW-15	MW-16	TW-2	TW-3	Field Blank
µg/l	N-nitroso-di-n-propylamine	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	N-Nitrosodimethylamine	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Naphthalene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Nitrobenzene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Nitrosodiphenylamine	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Phenanthrene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Phyrne	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Bis(2-ethylhexyl) phthalate	9.6B	3.8B	48B	52B	20B	52B	52B	20B
µg/l	Butylbenzylphthalate	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Chrysene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	D12-Perylene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Di-n-Butylphthalate	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Di-N-Octyl phthalate	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Dibenzo (A,H) anthracene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Diethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Dimethyl phthalate	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Fluorene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Hexachlorobenzene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Hexachlorobutadiene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Hexachlorocyclopentadiene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Hexachloroethane	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Indeno (1,2,3-cd) pyrene	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Isophorone	<10	<10	<10	<10	<10	<10	<10	<10

B=Compound found in blank.

Table 43. Groundwater Volatile Organics Analysis (May 90)

	Collection Date ------->	5/18/90								
Units	Parameter	D-11	D-12	MW-15	TW-3	Inflow 1	Inflow 2	Field Blank	Trip Blank	Blank
µg/l	1,1,1-Trichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,1,2,2-Tetrachloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,1,2-Trichloroethane	<5	<5	<5	<5	<5	<5	5	<5	<5
µg/l	1,1-Dichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,1-Dichloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,2-Dichlorobenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,2-Dichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,2-Dichloroethene (Total)	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,2-Dichloropropane	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,3-Dichlorobenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	1,4-Dichlorobenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	2-Butanone	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	2-Chloroethylvinylether	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	2-Hexanone	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	4-Methyl-2-Pentanone	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Acetone	<5	<5	<5	<5	<5	<5	205B*	<5	33
µg/l	Acrolein	<50	<50	<50	<50	<50	<50	<50	<50	<50
µg/l	Acrylonitrile	<50	<50	<50	<50	<50	<50	<50	<50	<50
µg/l	Benzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Bromodichloromethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Bromoform	<5	<5	<5	<5	<5	<5	<5	<5	<5

Table 43 (continued). Groundwater Volatile Organics Analysis (May 90)

	Collection Date ------->	5/18/90								
Units	Parameter	D-11	D-12	MW-15	TW-3	Inflow 1	Inflow 2	Field Blank	Trip Blank	Blank
µg/l	Bromomethane	<10	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Carbon Disulfide	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Carbon Tetrachloride	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Chlorobenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Chloroethane	<10	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Chloroform	<5	<5	<5	<5	<5	<5	5	5	<5
µg/l	Chloromethane	<10	<10	<10	<10	<10	<10	<10	<10	<10
µg/l	Cis-1,3-Dichloropropene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Dibromochloromethane	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Ethylbenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Methylene Chloride	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Styrene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Tetrachloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Toluene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Total Xylenes	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Trans-1,3-Dichloropropene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Trichloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Trichlorofluoromethane	<5	<5	<5	<5	<5	<5	<5	5	<5
µg/l	Vinyl Acetate	<5	<5	<5	<5	<5	<5	<5	<5	<5
µg/l	Vinyl Chloride	<10	<10	<10	<10	<10	<10	<10	<10	<10

*Compound found in blank.

Table 44. Groundwater Volatile Organics Analysis (August 90)

	Collection Date ------->	8/13/90					
Units	Parameter	D-11	D-12	MW-15	TW-3	Inflow 1	Inflow 2
µg/l	1,1,1-Trichloroethane	<5	<5	<5	<5	<5	<5
µg/l	1,1,2,2-Tetrachloroethane	<5	<5	<5	<5	<5	7
µg/l	1,1,2-Trichloroethane	<5	<5	<5	<5	<5	<5
µg/l	1,1-Dichloroethane	<5	14	<5	<5	<5	<5
µg/l	1,1-Dichloroethene	<5	13	<5	<5	<5	<5
µg/l	1,2-Dichlorobenzene	<5	<5	<5	<5	<5	<5
µg/l	1,2-Dichloroethane	<5	<5	<5	<5	<5	<5
µg/l	1,2-Dichloroethene (Total)	<5	<5	<5	<5	<5	<5
µg/l	1,2-Dichloropropane	<5	<5	<5	<5	<5	<5
µg/l	1,3-Dichlorobenzene	<5	<5	<5	<5	<5	<5
µg/l	1,4-Dichlorobenzene	<5	<5	<5	<5	<5	<5
µg/l	2-Butanone	<5	<5	<5	<5	<5	<5
µg/l	2-Chloroethylvinylether	<5	<5	<5	<5	<5	<5
µg/l	2-Hexanone	<5	<5	<5	<5	<5	<5
µg/l	4-Methyl-2-Pentanone	5.6	12	<5	<5	<5	6
µg/l	Acetone	17B*	<5	<5	11B*	<5	<5
µg/l	Acrolein	<50	<50	<50	<50	<50	<50
µg/l	Acrylonitrile	<50	<50	<50	<50	<50	<50
µg/l	Benzene	<5	<5	<5	<5	<5	<5
µg/l	Bromodichloromethane	<5	<5	<5	<5	<5	<5
µg/l	Bromoform	<5	<5	<5	<5	<5	<5
µg/l	Bromomethane	<10	<10	<10	<10	<10	<10
µg/l	Carbon Disulfide	<5	<5	<5	<5	<5	<5
µg/l	Carbon Tetrachloride	<5	<5	<5	<5	<5	<5
µg/l	Chlorobenzene	<5	<5	<5	<5	<5	<5
µg/l	Chloroethane	<10	<10	<10	<10	<10	<10
µg/l	Chloroform	<5	<5	<5	<5	<5	<5
µg/l	Chloromethane	<10	<10	<10	<10	<10	<10
µg/l	Cis-1,3-Dichloropropene	<5	<5	<5	<5	<5	<5
µg/l	Dibromochloromethane	<5	<5	<5	<5	<5	<5
µg/l	Ethylbenzene	<5	<5	<5	<5	<5	<5
µg/l	Methylene Chloride	5.6B*	<5	4.7JB*	6.7B*	<5	<5
µg/l	Styrene	<5	<5	<5	<5	<5	<5
µg/l	Tetrachloroethene	5.6	12	<5	<5	26	<5
µg/l	Toluene	<5	<5	<5	<5	<5	<5
µg/l	Total Xylenes	<5	<5	<5	<5	<5	<5
µg/l	Trans-1,3-Dichloropropene	<5	5	<5	<5	<5	<5
µg/l	Trichloroethene	<5	5	<5	<5	<5	<5
µg/l	Trichlorofluoromethane	<5	<5	<5	<5	<5	<5
µg/l	Vinyl Acetate	<5	<5	<5	<5	<5	<5
µg/l	Vinyl Chloride	<10	<10	<10	<10	<10	<10

B=Compound found in blank; J=Estimated value (detected below quantitation limits).

Table 45. Miscellaneous Data for Groundwater Wells

	Collection Date	11/21/90					
Units*	Parameter	TW-1	TW-10	Blank	Blan k	Blank	Limit
mg/l	Chloride	24	14	ND	ND	3	3
mg/l	Chromium - Hexavalent						25
umhos/cm*	Conductivity	280	280	0			NA
mg/l	Lead, Dissolved	ND	ND	ND			5
mg/l	Nitrogen, Ammonia	ND	ND	1.8	ND	0.5	0.5
mg/l	Nitrogen, Nitrate	ND	1.1	ND	ND	1	1
mg/l	pH	6.9	6.7	4.4			NA
mg/l	Phenols, Total	ND	ND	ND	ND	0.2	0.2
mg/l	Solids - Dissolved	180	190	ND	ND	5	5
mg/l	Sulfate	20	18	ND	ND	5	5
mg/l	Temperature	12	12	20			NA

ND=Not Detected; NA=Not Applicable
*: Analysis performed on-site at time of sampling.

Table 46. General Chemistry for Groundwater Wells

	Collection Date			1/29/90		
Units	Parameter	D-11	D-12	Sump	Field Blank	Trip Blank
mg/l	Barium	1.2	<0.10	0.25	<0.10	<0.10
mg/l	Titanium	<0.05	<0.05	<0.05	<0.05	<0.05
mg/l	Beryllium	<0.05	<0.05	<0.05	<0.05	<0.05
mg/l	Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01
mg/l	Chromium	<0.02	<0.02	<0.02	<0.02	<0.02
mg/l	Copper	0.06	<0.02	0.4	<0.02	<0.02
mg/l	Nickel	<0.04	<0.04	<0.04	<0.04	<0.04
mg/l	Lead	<0.02	<0.02	0.02	<0.02	<0.02
mg/l	Zinc	0.06	<0.02	0.5	<0.02	<0.02
mg/l	Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01
mg/l	Silver	<0.01	<0.01	<0.01	0.01	0.01
mg/l	Antimony	<0.06	<0.06	<0.06	<0.06	<0.06
mg/l	Selenium	<0.01	<0.01	<0.01	<0.01	<0.01
mg/l	Thallium	<0.01	<0.01	<0.01	<0.01	<0.01
mg/l	Mercury	<0.001	<0.001	<0.001	<0.001	<0.001
mg/l	Lead, Filtered	<0.02	<0.02	<0.02	<0.02	<0.02

Table 47

FERTILIZER, PESTICIDES, AND HERBICIDE APPLICATION [Ra91]

DATE	LOCATION	PRODUCT	AMOUNT
FERTILIZER			
4/22/90	C & D Sites	Morral 16-0-4	77 gals.
PESTICIDES			
10/26/90	C Site (Rm. 145)	2% Cynoff EC	4 oz.
10/31/90	C Site-PM&E	2% Cynoff EC	4 oz.
	C Site-Eng. Wing	2% Cynoff EC	4 oz.
	C Site Control House	Bell Block Bait	4 sqs.
11/6/90	C-Site Kitchen/Cafe.	Tempo 2	1 gal.
	C-Site QA Trailers	Baton Block Bait	4 oz.
11/15/90	C-site MOD.2 Theory Wing	Cynoff EC (.2%/gal)	12 oz
12/4/90	C-Site Kitchen/Cafe	Dursban (.5%/gal)	2 qt.
	" "	Orthene Pt 280 aerosal	5 oz.
	" "	Roach Router aerosal	3 oz.
12/5/90	C-Site-NEW Cubicle W,V,O,Y	It Works Ant Bait	6 oz.
1990	D Site	No pesticides applied	

HERBICIDES

DATE	LOCATION	PRODUCT	AMOUNT
4/22/90	C & D Sites All turfed areas	Trimec 899 Pre-M Crabgrass	1.85 gals. 8.9 gals (Total mixture) with water & fert. = 475 gals.)
6/2 & 6/16	C & D Sites Nonturfed stone areas	2% Round-Up*	8.0 gals. (Total mixture with water = 400 gals.)
9/13/90	C & D Sites All stoned areas	1% Round-Up* and Oust	4.5 gals. 3.0 lbs (Total mixturewith water = 600 gals.)

* Round-Up applications were done on selected nonturfed areas — primarily stoned parking lots and road shoulders. Round-Up applications were prohibited in the detention basin and areas surrounding it.

Table 48. PPPL REML QA/QC from EPA/Las Vegas and DOE/EML*

Radioisotope	pCi/L Known Value	pCi/L Control Limits	pCi/L PPPL Values
DATE-->	**2/9/90 - EPA Las Vegas**		
Ba-133	74	61.9 to 86.1	70.67
Co-60	15	6.3 to 23.7	17.67
Zn-65	139	114.8 to 163.2	147.67
Ru-106	139	114.8 to 163.2	134.67
Cs-134	18	9.3 to 26.7	16.67
Cs-137	18	9.3 to 26.7	18
DATE-->	**10/5/90 - EPA Las Vegas**		
Ba-133	110	90.9 to 129.1	108.33
Co-60	20	11.3 to 28.7	19.33
Zn-65	115	94.2 to 135.8	122.33
Ru-106	151	125 to 177	144
Cs-134	12	3.3 to 20.7	13
Cs-137	12	3.3 to 20.7	12.33
DATE-->	**June 1990 EML/DOE NYC**		
H-3	1960		1770
Mn-54	103		105
Co-57	198		195
Co-60	206		185
Cs-134	462		419
Cs-137	198		180
Ce-144	403		427
DATE-->	**December 1990 EML/DOE NYC**		
H-3	3900		4090
Mn-54	301		306
Co-57	1300		1410
Co-60	491		500
Cs-134	355		366
Cs-137	390		379
Ce-144	923		952
DATE	**Tritium in Water- EPA/Las Vegas**		
2/23/90	4976	4113.4 to 5838.6	4926.7
10/19/90	7203	5953.8 to 8452.2	7785.3

*
REML = PPPL Radiological Environmental Monitoring Laboratory
EPA/Las Vegas = Environmental Protection Agency's Laboratory in Las Vegas
DOE/EML = The Department of Energy's Environmental Measurements Lab in New York City

Table 49. Split Sample QA Data

	Collection Date-->	2/20/90	2/20/90	8/20/90	8/20/90
Units	Parameter	QA-1	QA-2	QA-1	QA-2
mg/l $CaCO_3$ eq.	Alkalinity	16	12		
mg/l O2	BOD5	<1	<1	2.3	2.6
mg/l $CaCO_3$ eq.	Calcium Hardness	15	15		
mg/l Cr	Chromium - Total	<0.02	<0.02	<0.02	<0.02
mg/l Cr	Chromium - Hexavalent	<0.02			
mg/l O_2	COD	<5.0	<5.0	30	20
mg/l Cu	Copper	0.02	<0.02		
mg/l O_2	Dissolved Oxygen	11	11		
mg/l Cu eq.	EDTA	0.56	0.36		
MPN/100 ml	Total Coliform Count	2	4		
ft^3/sec	Flow	NA*	NA*		
mg/l Fe	Iron	0.15	0.14		
mg/l	Nitrogen, Ammonia			0.11	<0.10
mg/l N	Nitrogen, Total Kjedahl	1	0.62		
mg/l N	Nitrogen, Nitrate	1	7.1		
mg/l	Oil & Grease	<0.5	0.5		
unit	pH	6.8	6.9	7	7.1
mg/l	Petroleum Hydrocarbons, Total			<0.50	<0.50
mg/l	Phenols, Total			<0.10	<0.10
mg/l P	Phosphate, Total	<0.1	<0.1		
mg/l P	Phosphate, Ortho	<0.1	<0.1		
mg/l	Solids - Dissolved	113	103	236	229
mg/l	Solids - Suspended	9	12	22	26
mg/l SO_4	Sulfate	6040	5460		
Deg C	Temperature	8	9		
NTU	Turbidity	4	4.2		
mg/l Zn	Zinc	0.02	<0.02		
	Clarity	Clear	Clear		

*NA=Not Applicable

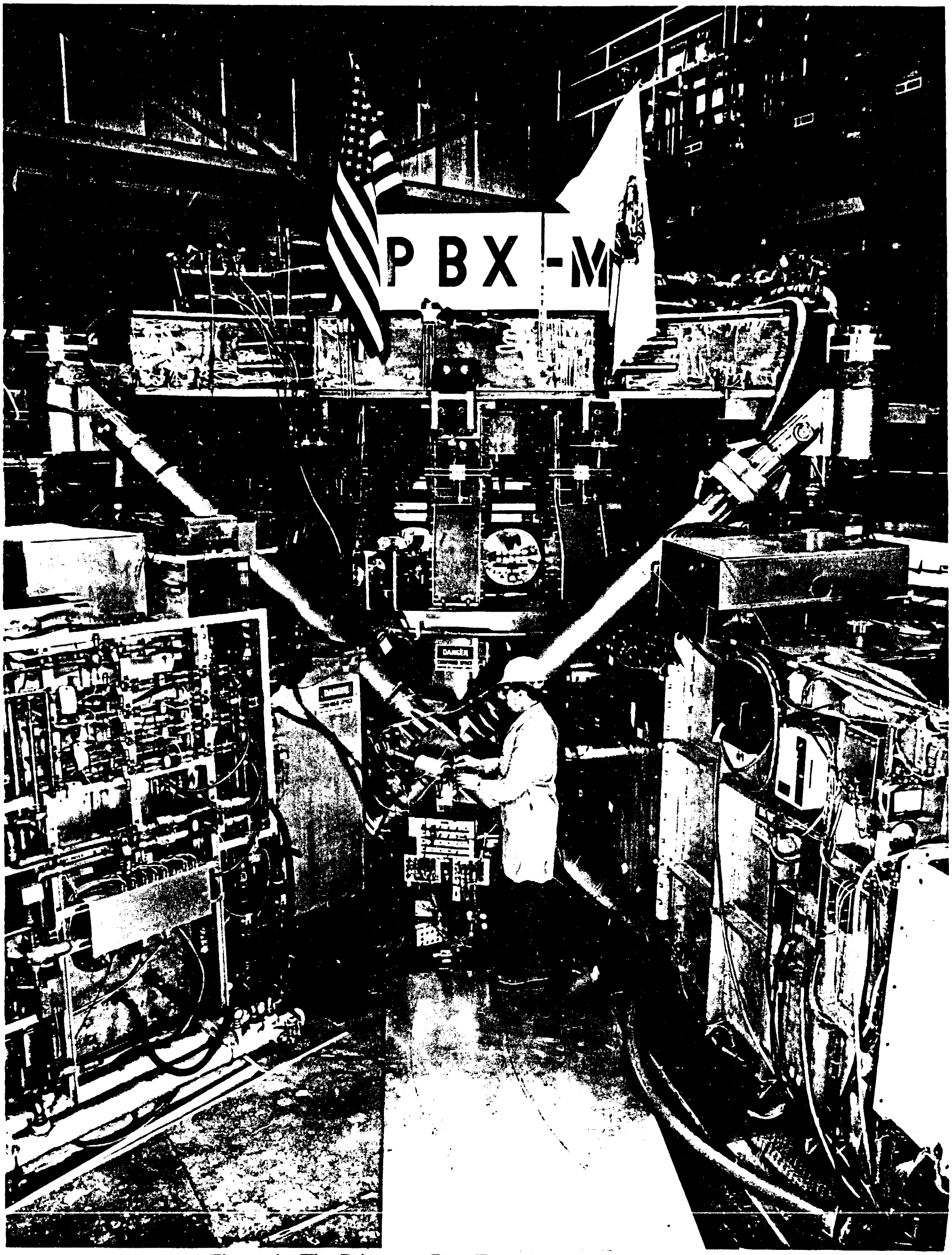


Figure 1. The Princeton Beta Experiment - Modified (PBX-M)

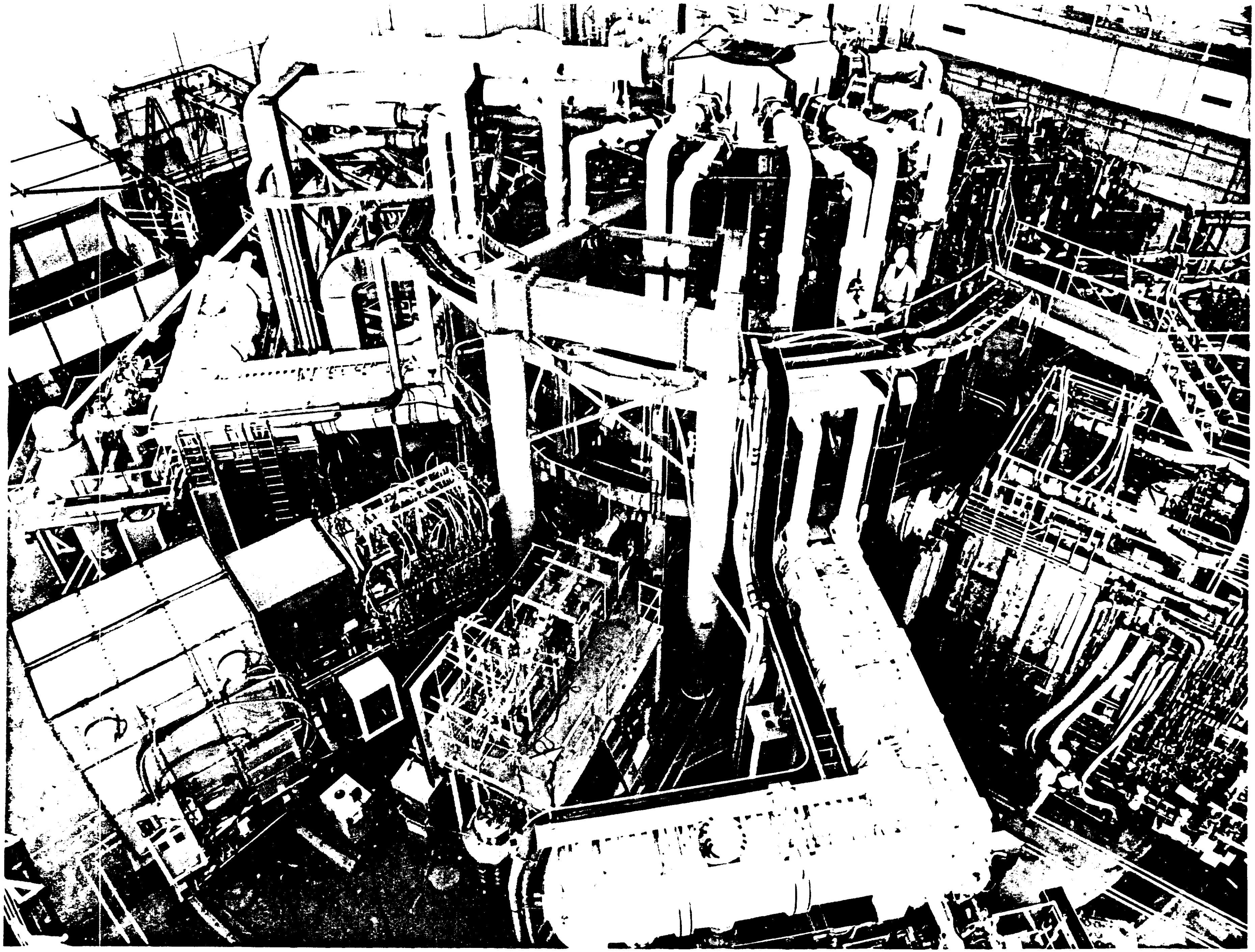


Figure 2. The Tokamak Fusion Test Reactor (TFTR)

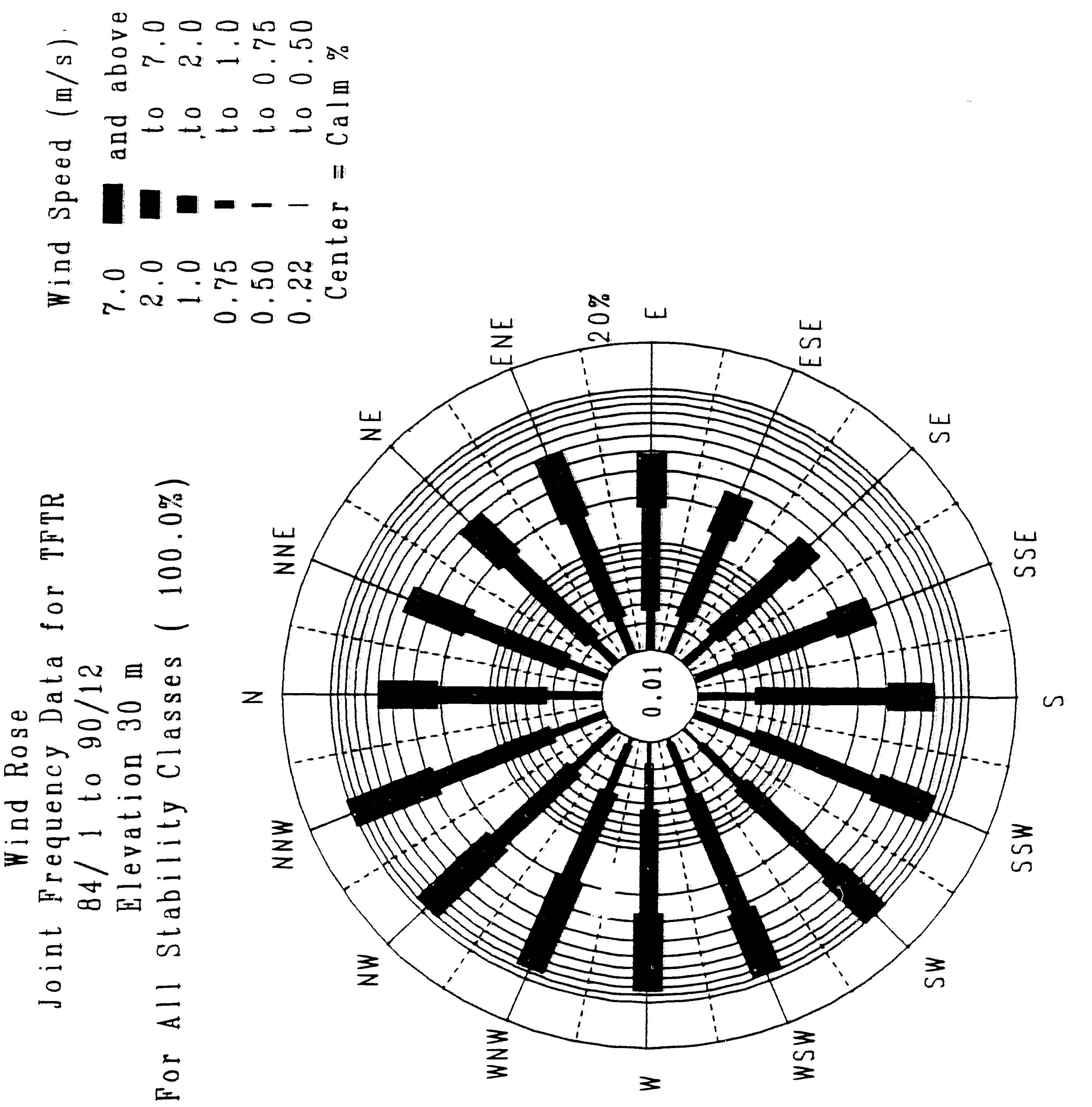


Figure 3. Wind Rose at 30 m.

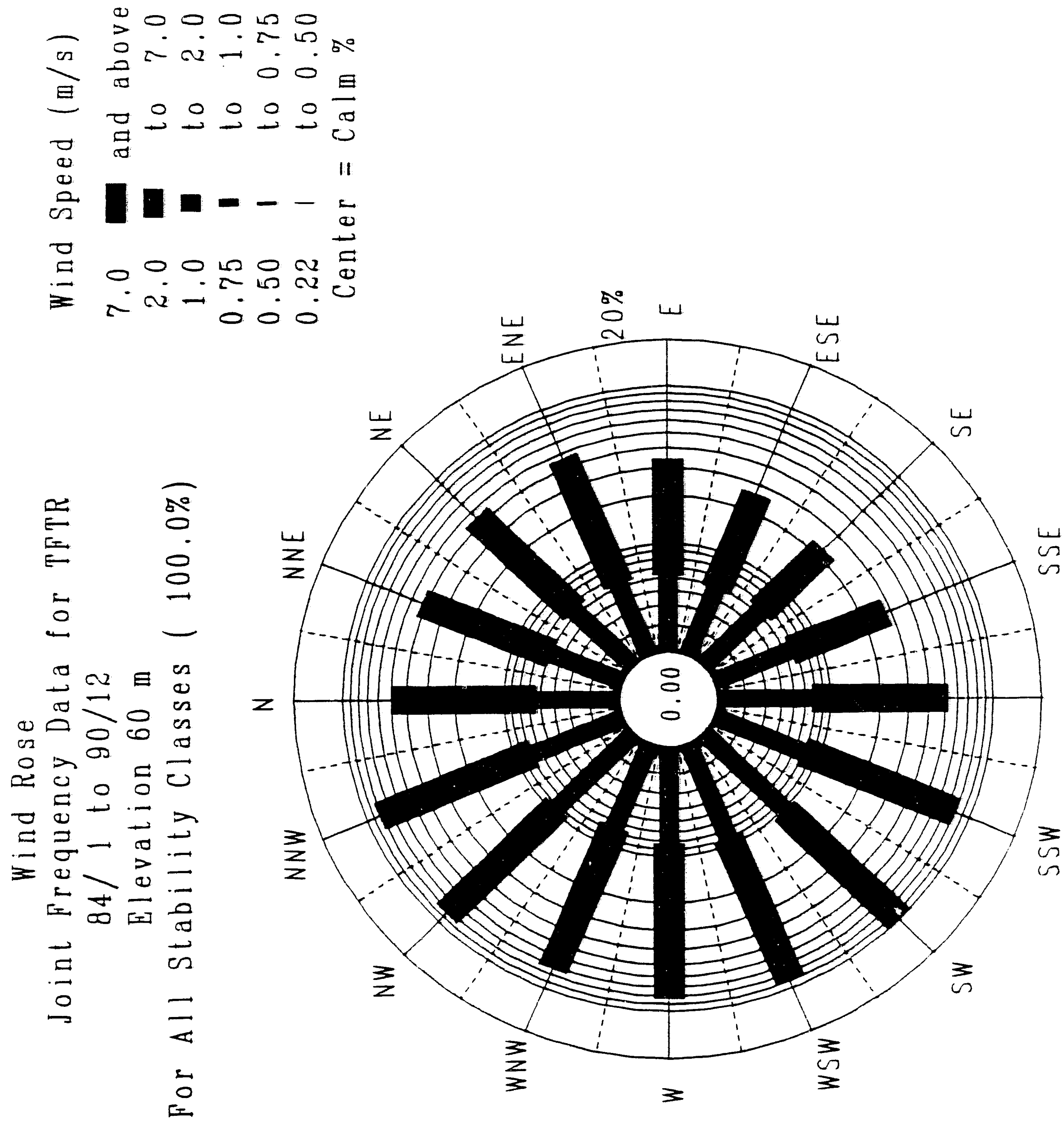


Figure 4. Wind Rose at 60 m.

Figure 5. Aerial View of the Forrestal Campus

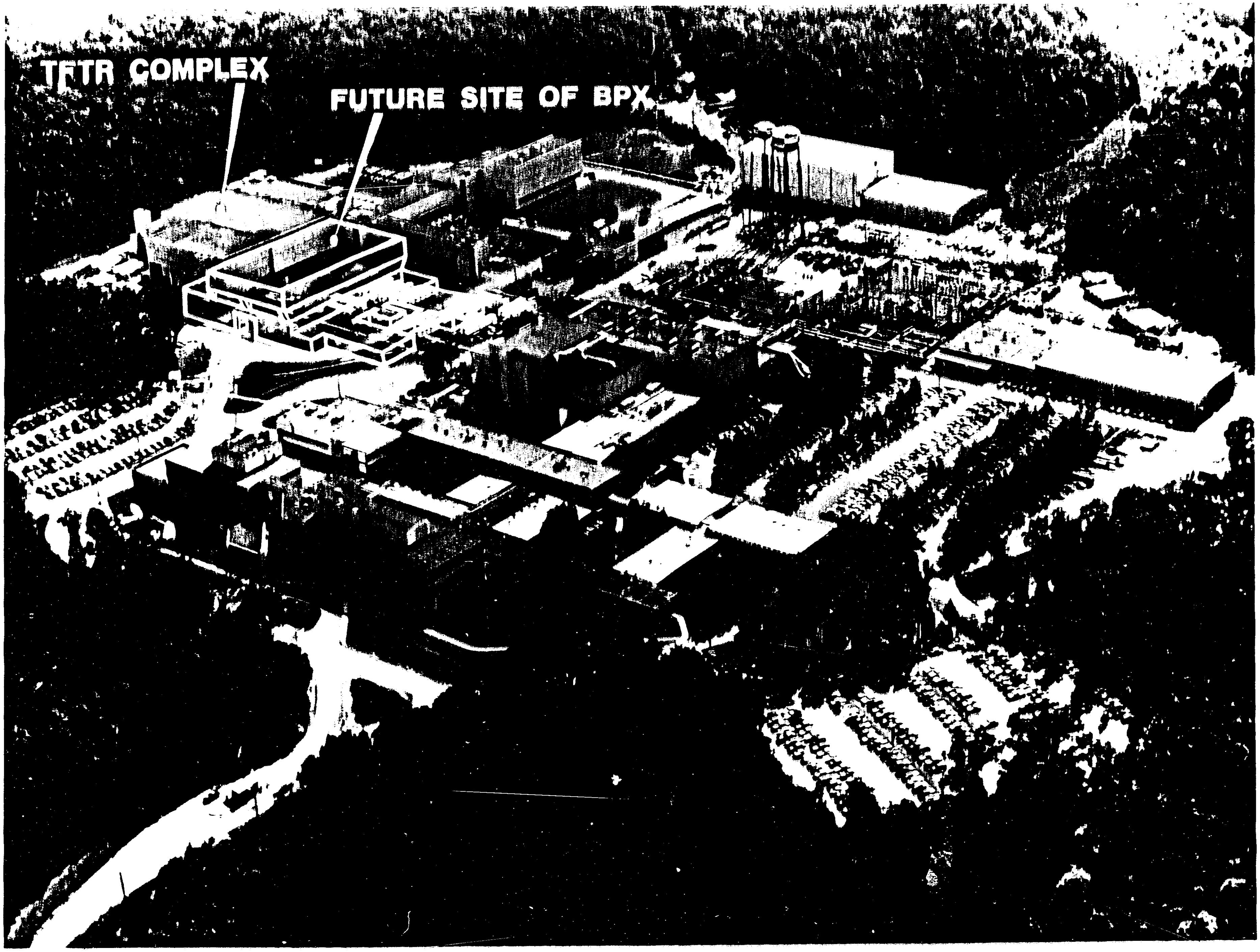


Figure 6. C- and D-Sites of the Forrestal Campus, PPPL

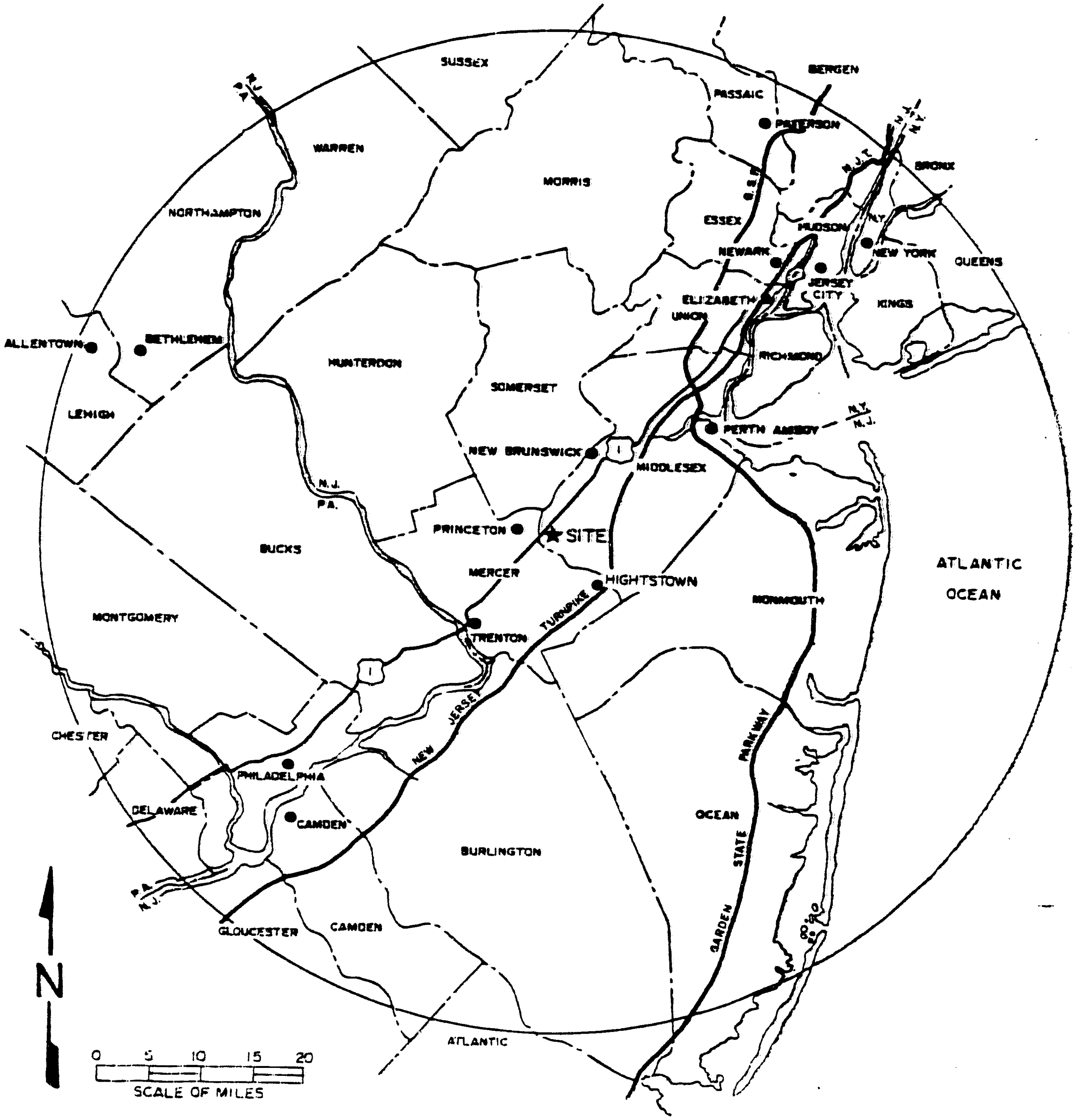


Figure 7. 80 km (50-mile) Radius of PPPL Site

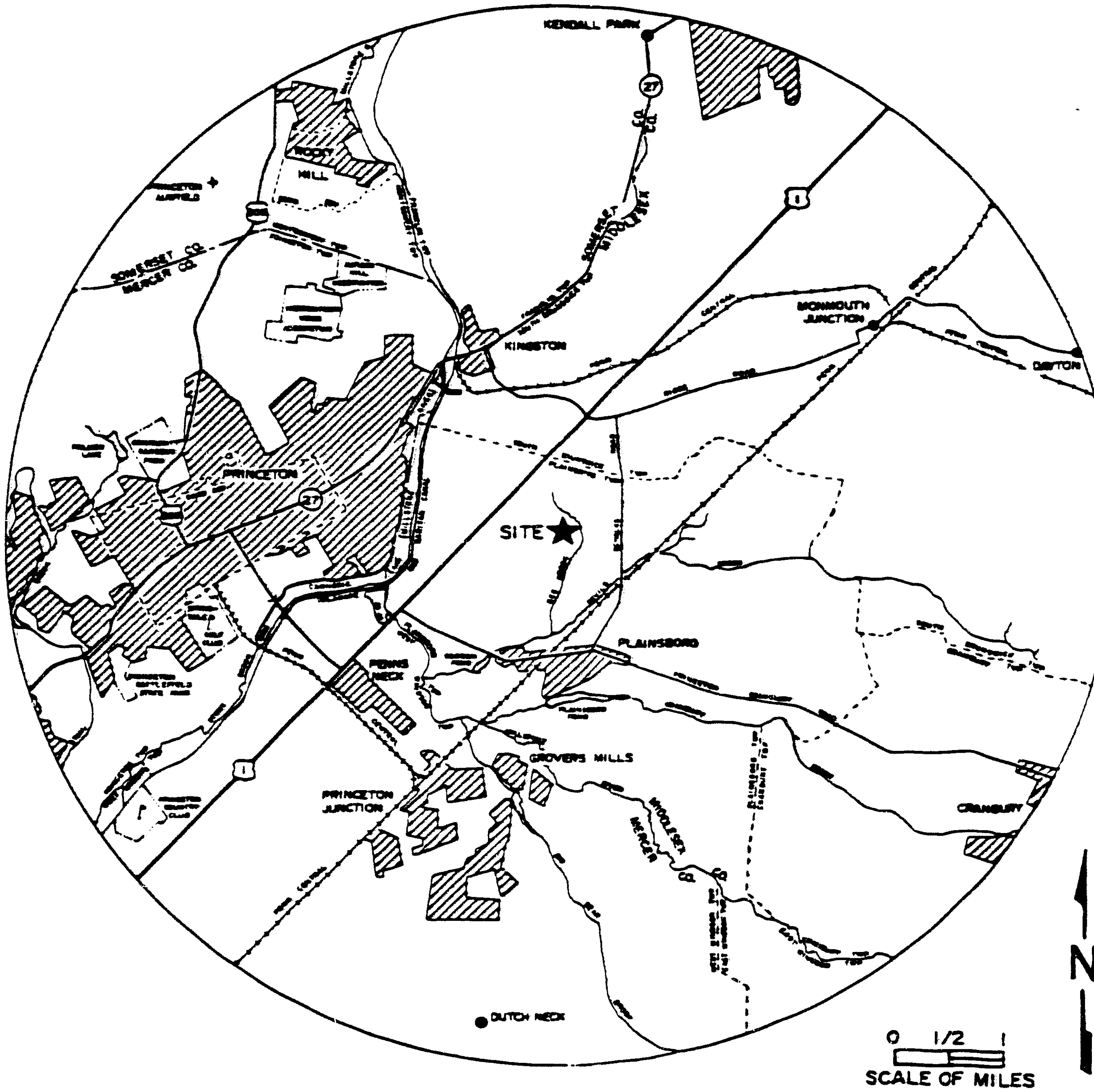


Figure 8. Immediate Site Vicinity (5-Mile Radius)

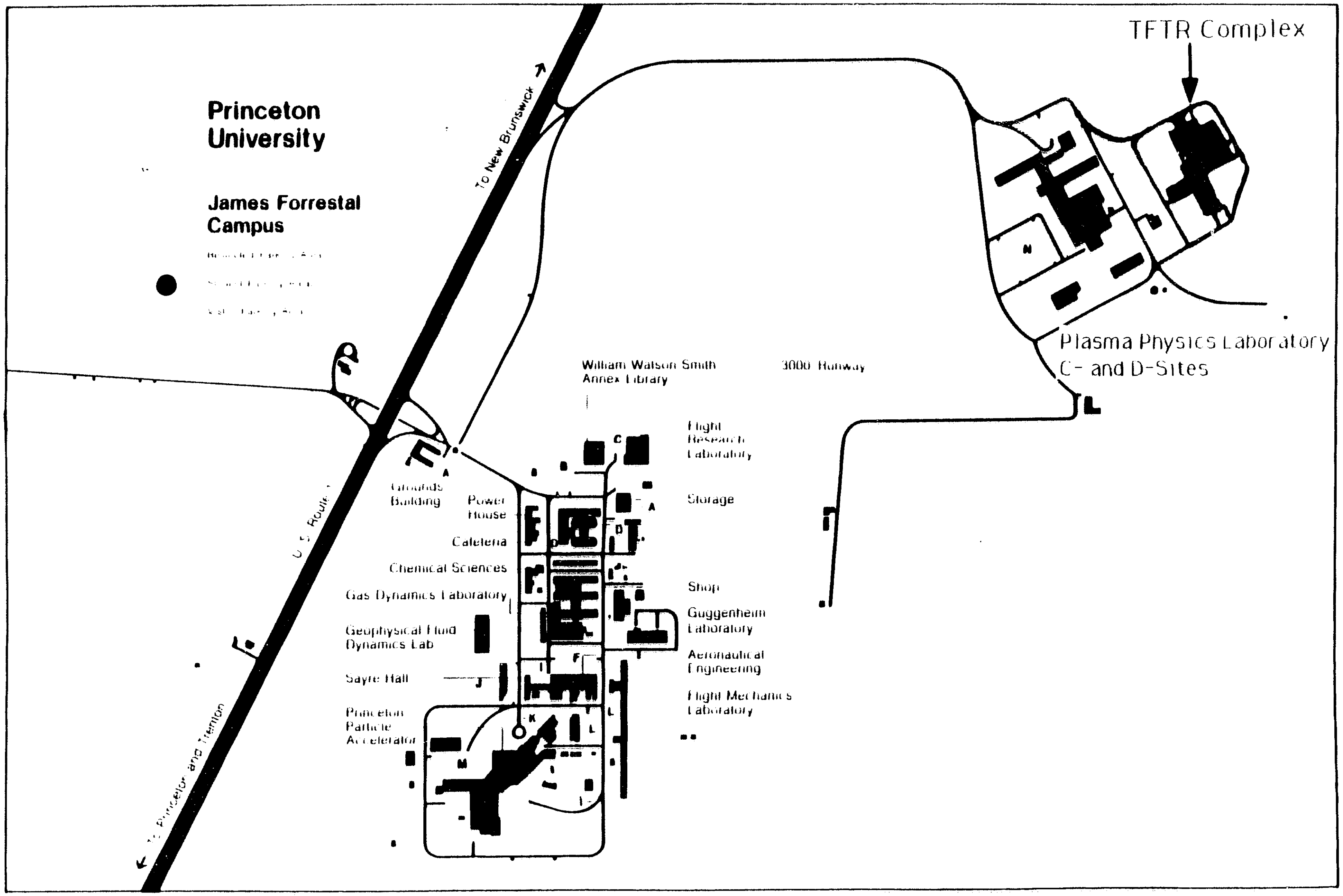
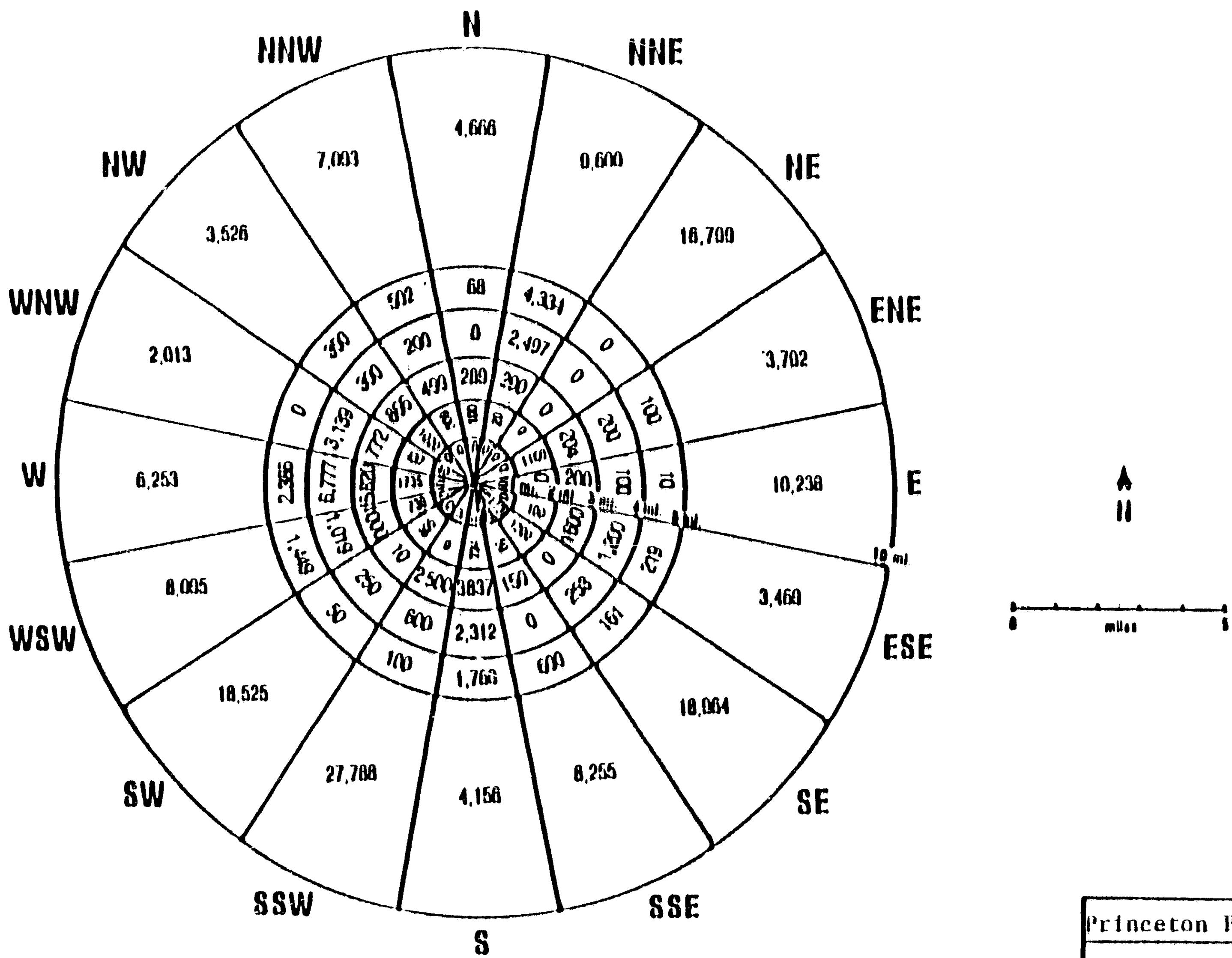


Figure 9. Layout of the James Forrestal Campus
Princeton University, Princeton, New Jersey

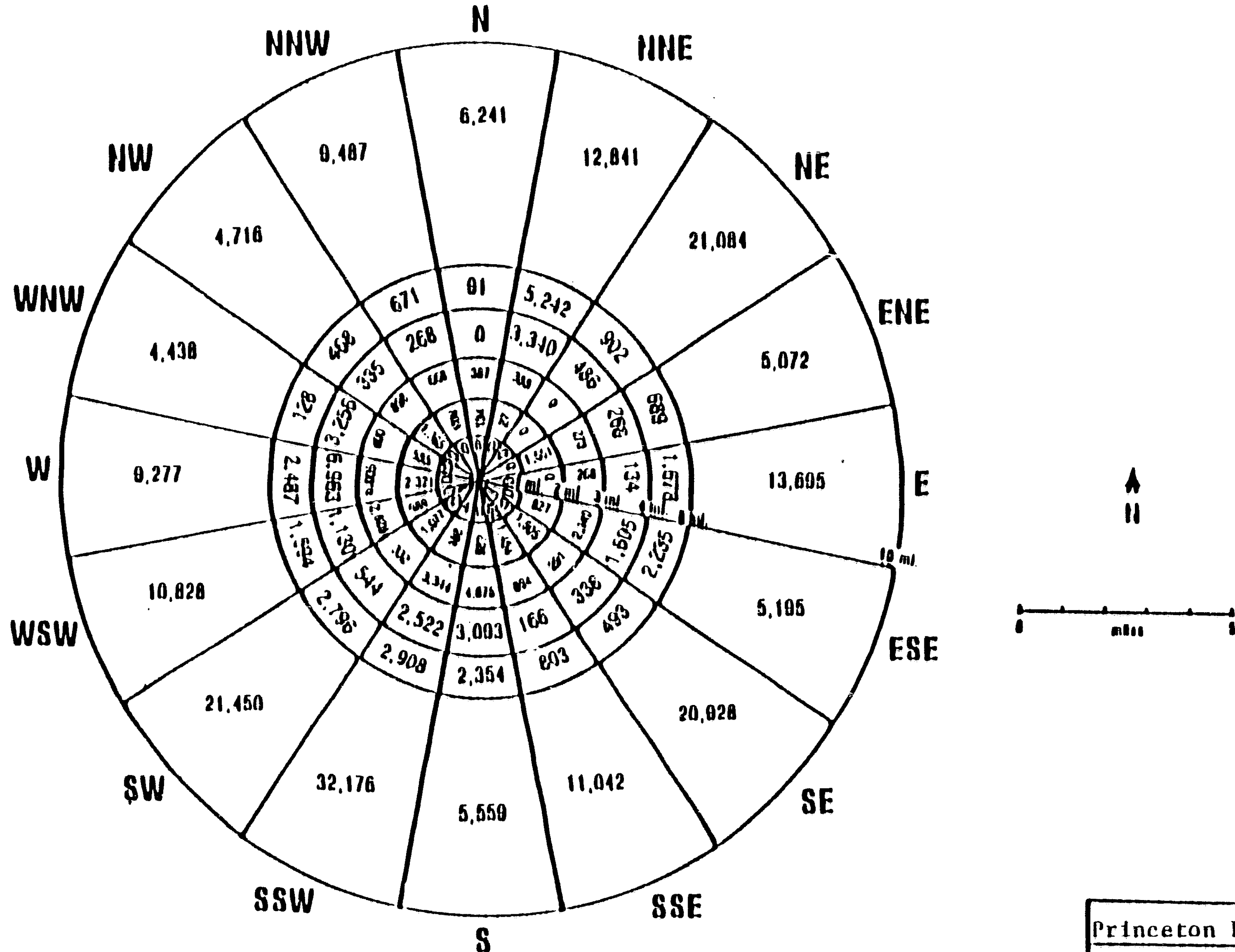


Princeton Plasma Physics

1985 POPULATION ESTIMATES
WITHIN ANNULAR SECTORS
0 - 10 MILES

Figure 10

*Taken from Be87a

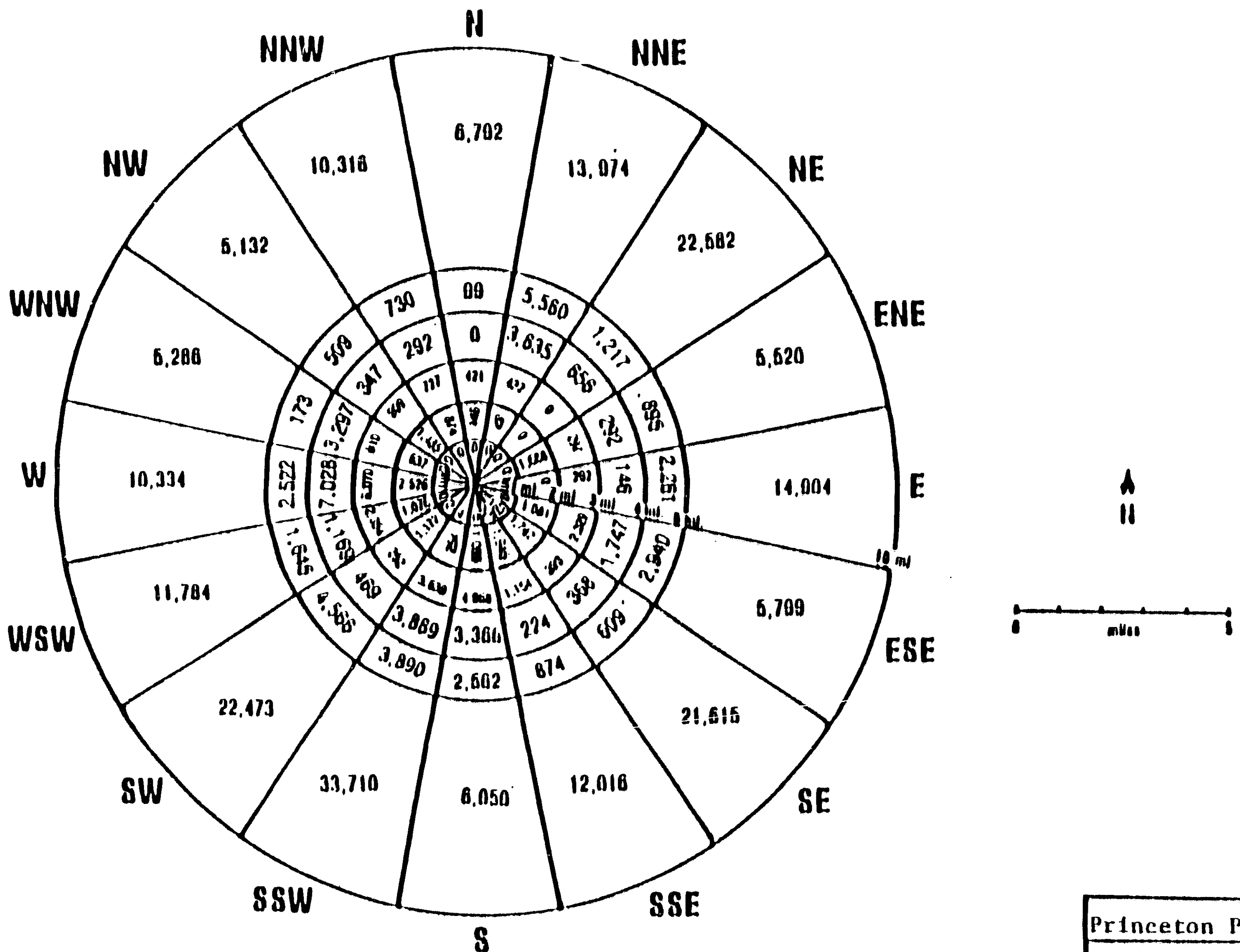


Princeton Plasma Physics

1995 POPULATION PROJECTIONS
WITHIN ANNULAR SECTORS
0 - 10 MILES

Figure 11

*Taken from Be87a

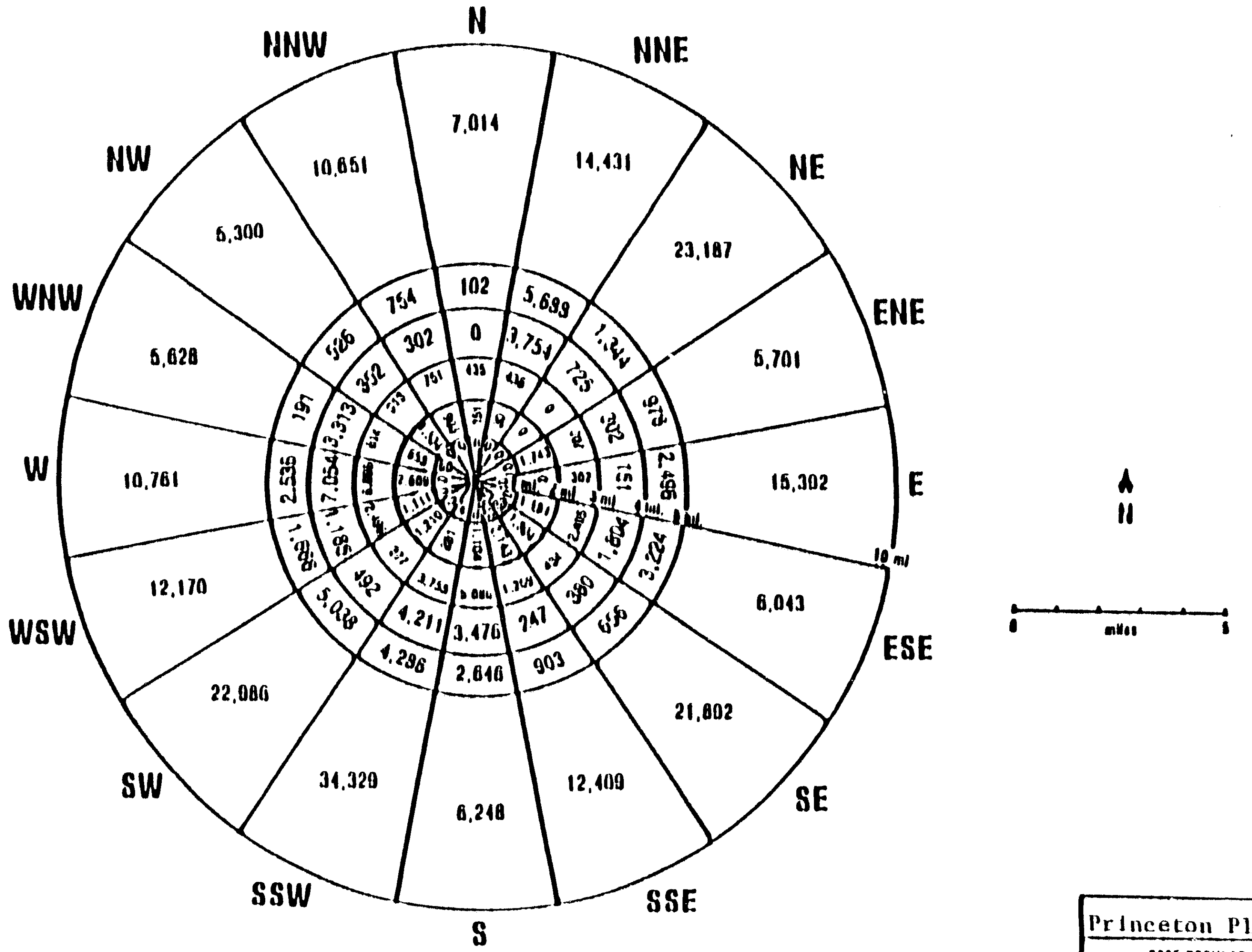


Princeton Plasma Physics

2000 POPULATION PROJECTIONS
WITHIN ANNULAR SECTORS
0 - 10 MILES

Figure 12

*Taken from Be87a

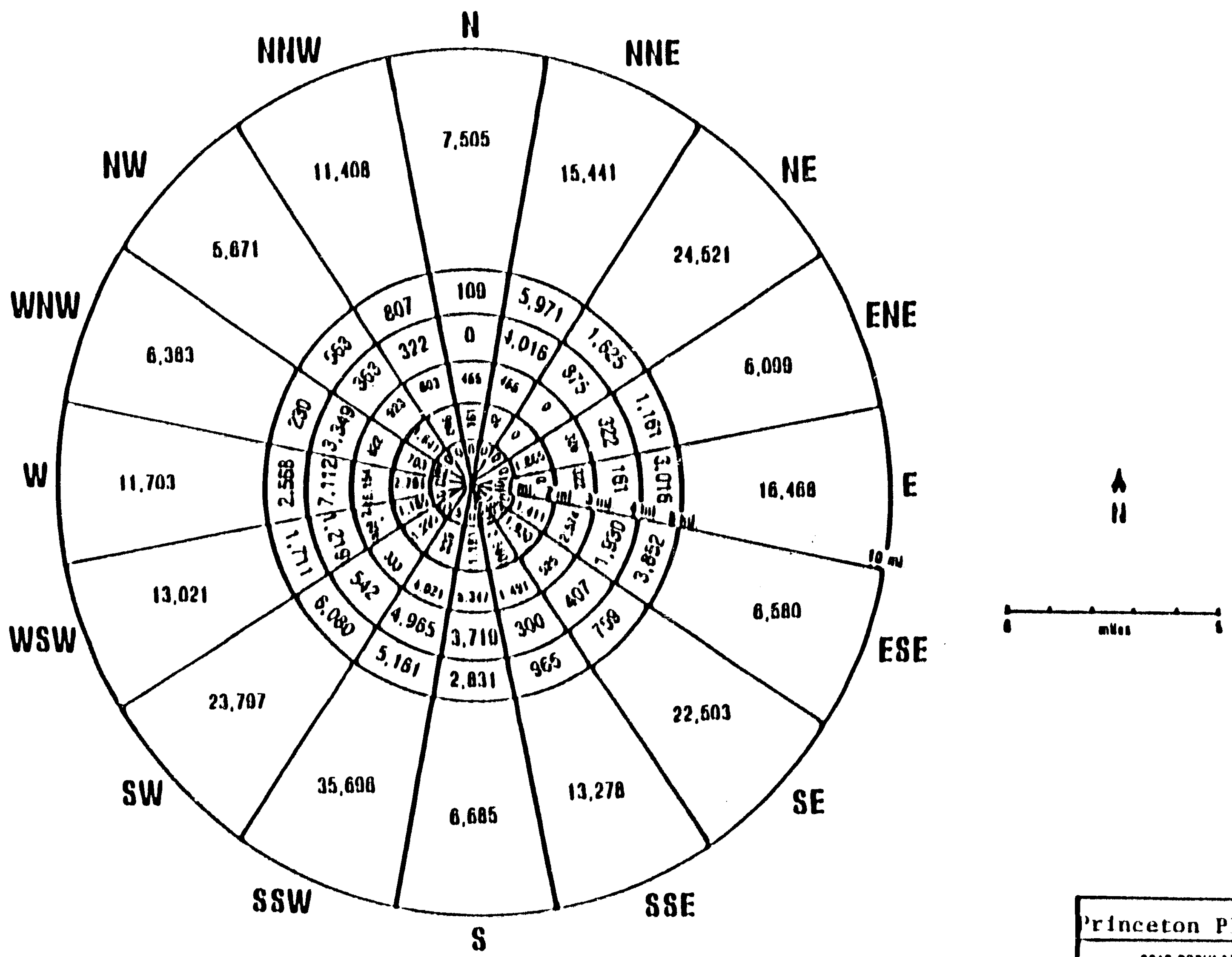


Princeton Plasma Physics

2005 POPULATION PROJECTIONS WITHIN ANNULAR SECTORS 0 - 10 MILES

Figure 13

*Taken from Be87a

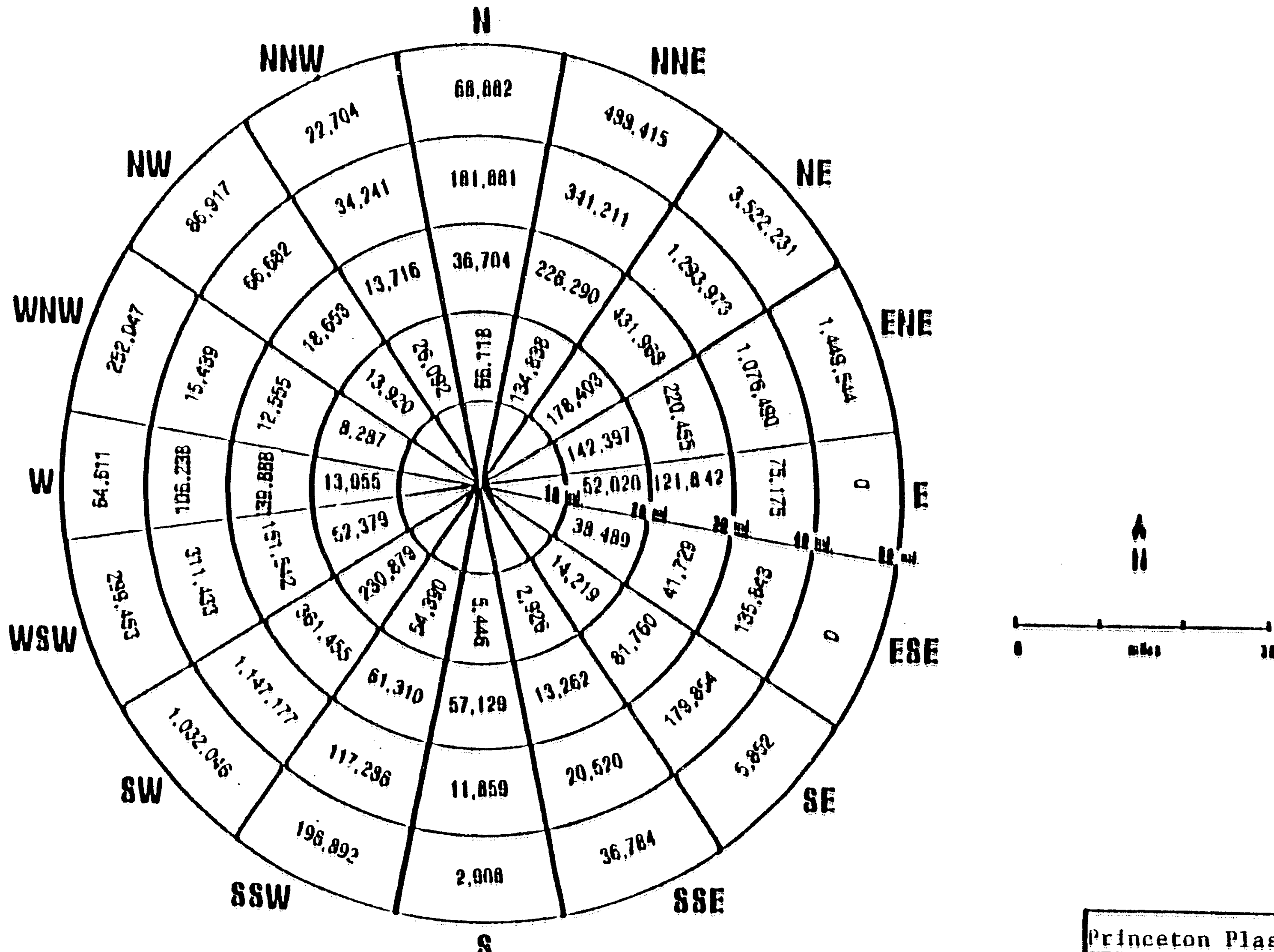


Princeton Plasma Physics

2010 POPULATION PROJECTIONS
WITHIN ANNULAR SECTIONS
0 - 10 MILES

Figure 14

*Taken from Be87a

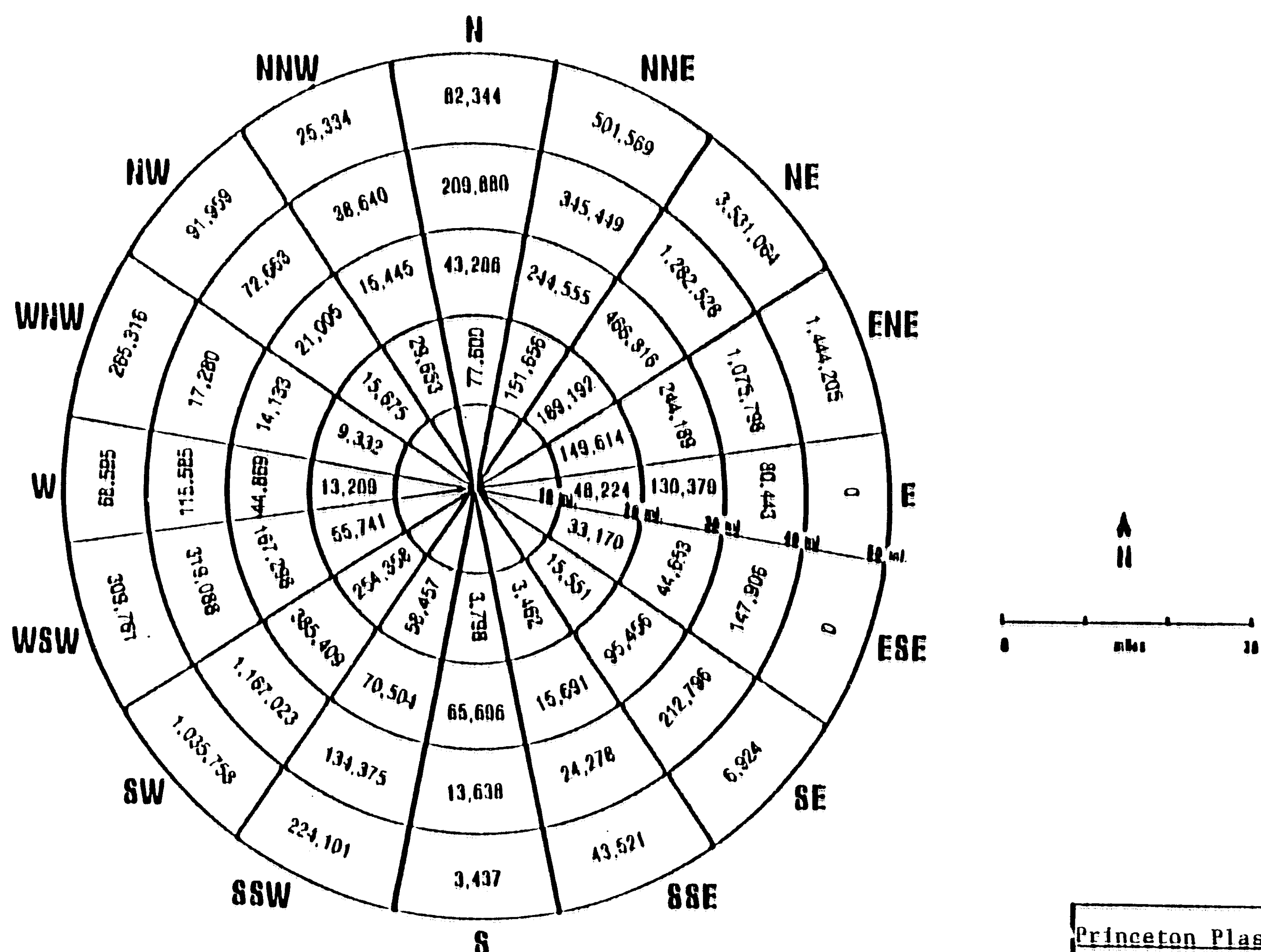


Princeton Plasma Physics

1988 POPULATION ESTIMATES WITHIN ANNULAR SECTORS 10 - 50 MILES

Figure 15

*Taken from Be87a

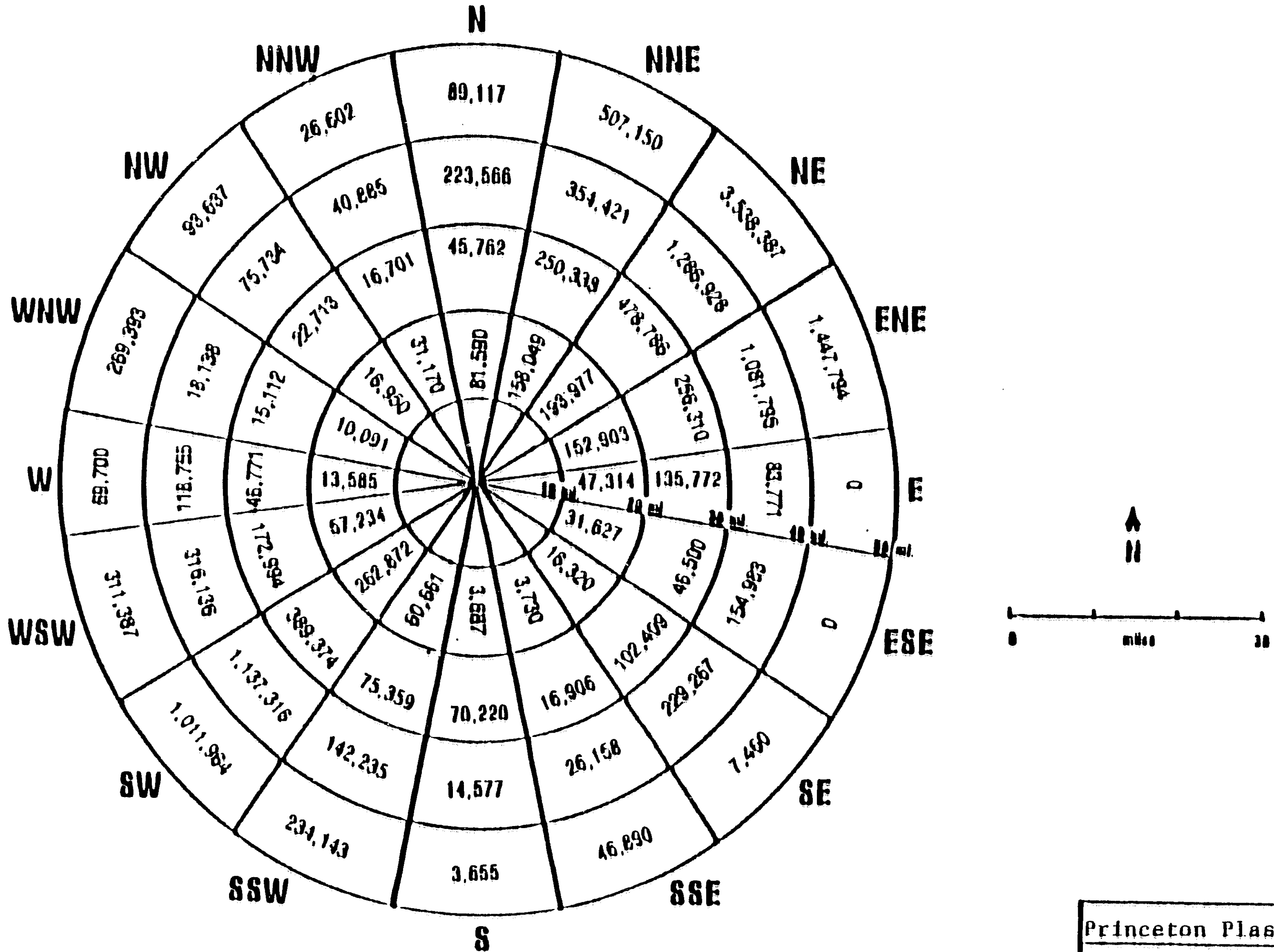


*Taken from Be87a

Princeton Plasma Physics

1995 POPULATION ESTIMATES
WITHIN ANNULAR SECTORS
10 - 50 MILES

Figure 16



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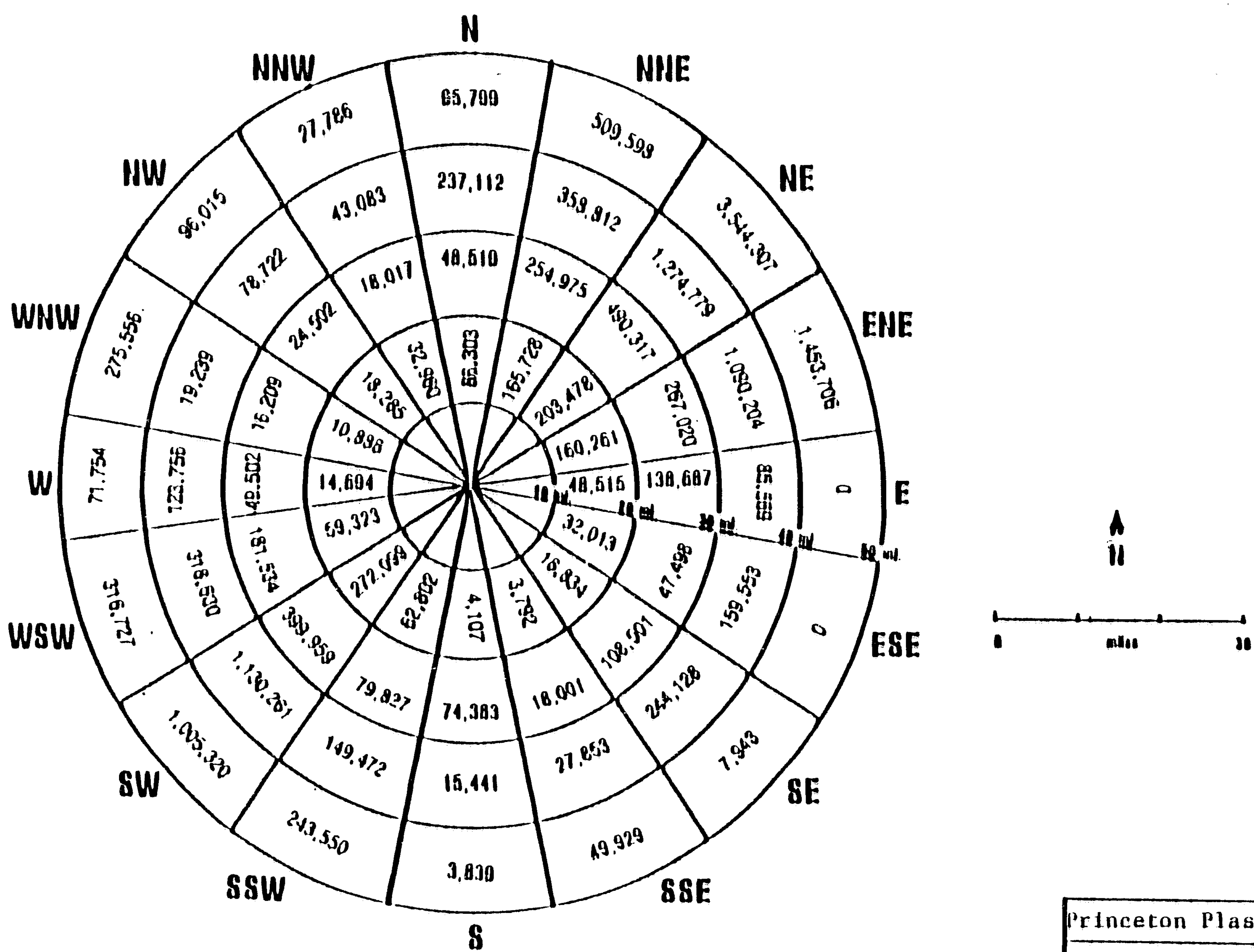
2000 POPULATION ESTIMATES WITHIN ANNULAR SECTORS 10 - 50 MILES

Figure 17

*Taken from Be87a

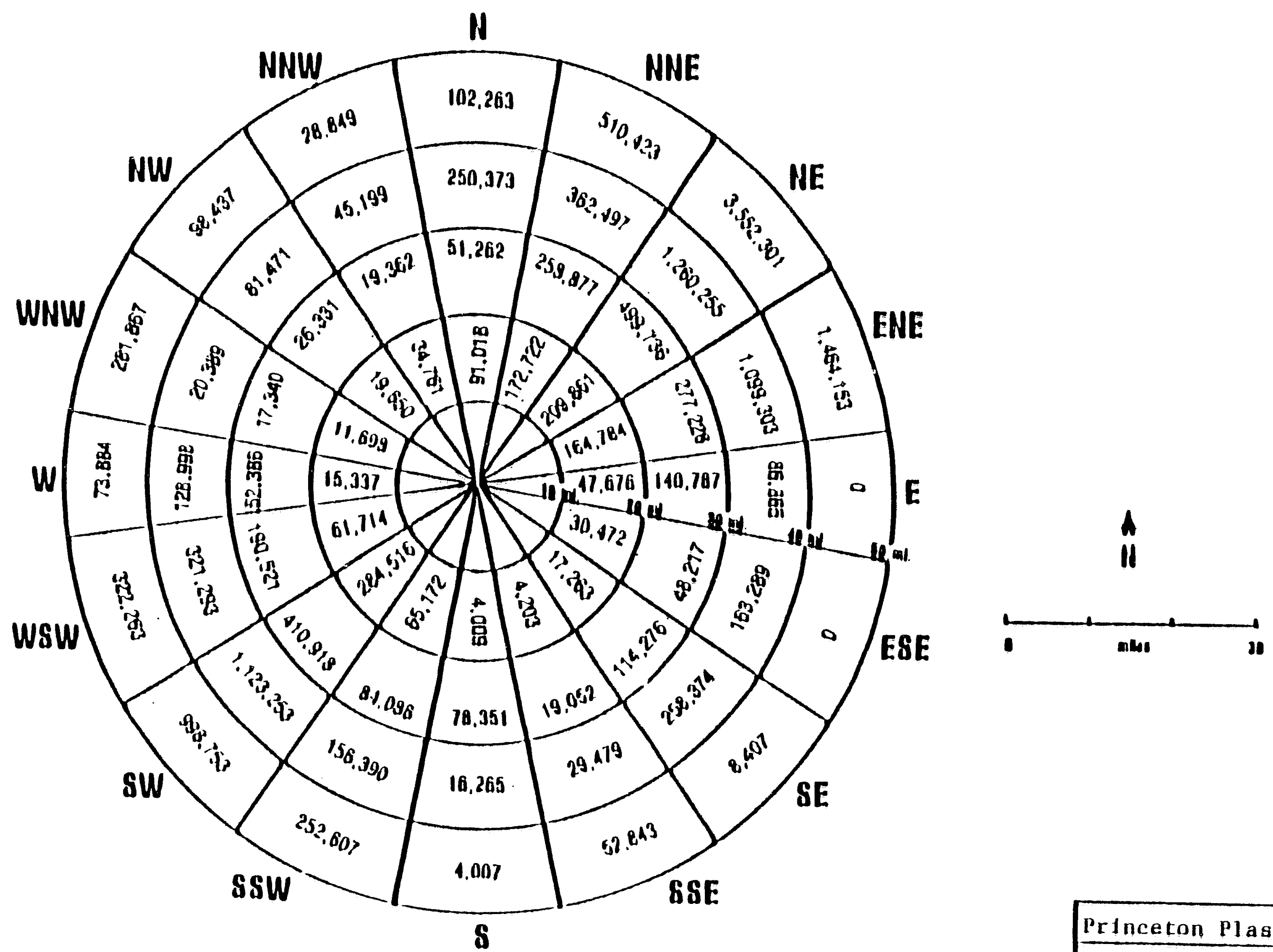


Princeton Plasma Physics

2005 POPULATION ESTIMATES
WITHIN ANNULAR SECTORS
10 - 50 MILES

Figure 18

*Taken from Be87a



*Taken from Be87a

Princeton Plasma Physics

2010 POPULATION ESTIMATES
WITHIN ANNULAR SECTORS
10 - 50 MILES

Figure 19

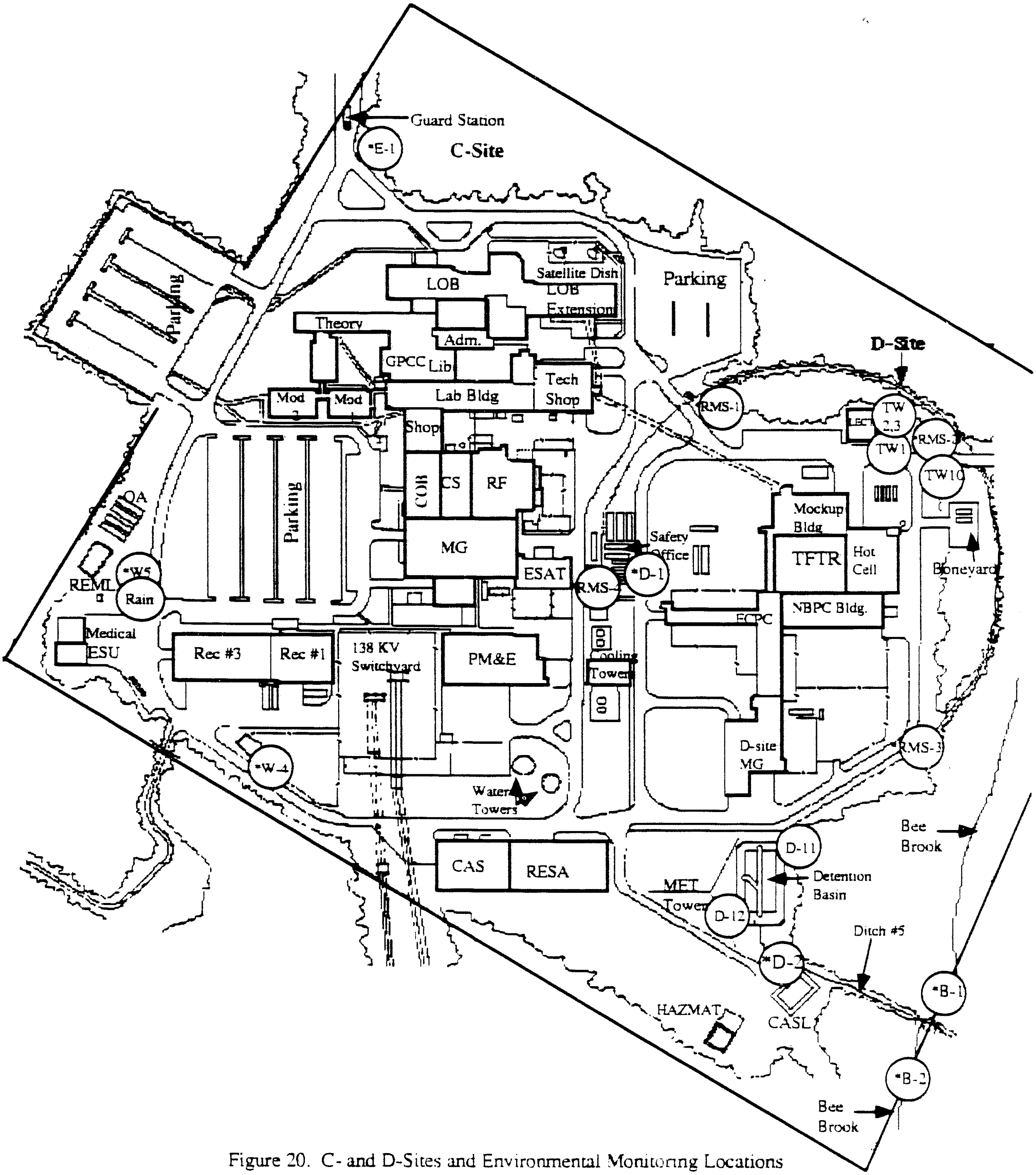


Figure 20. C- and D-Sites and Environmental Monitoring Locations

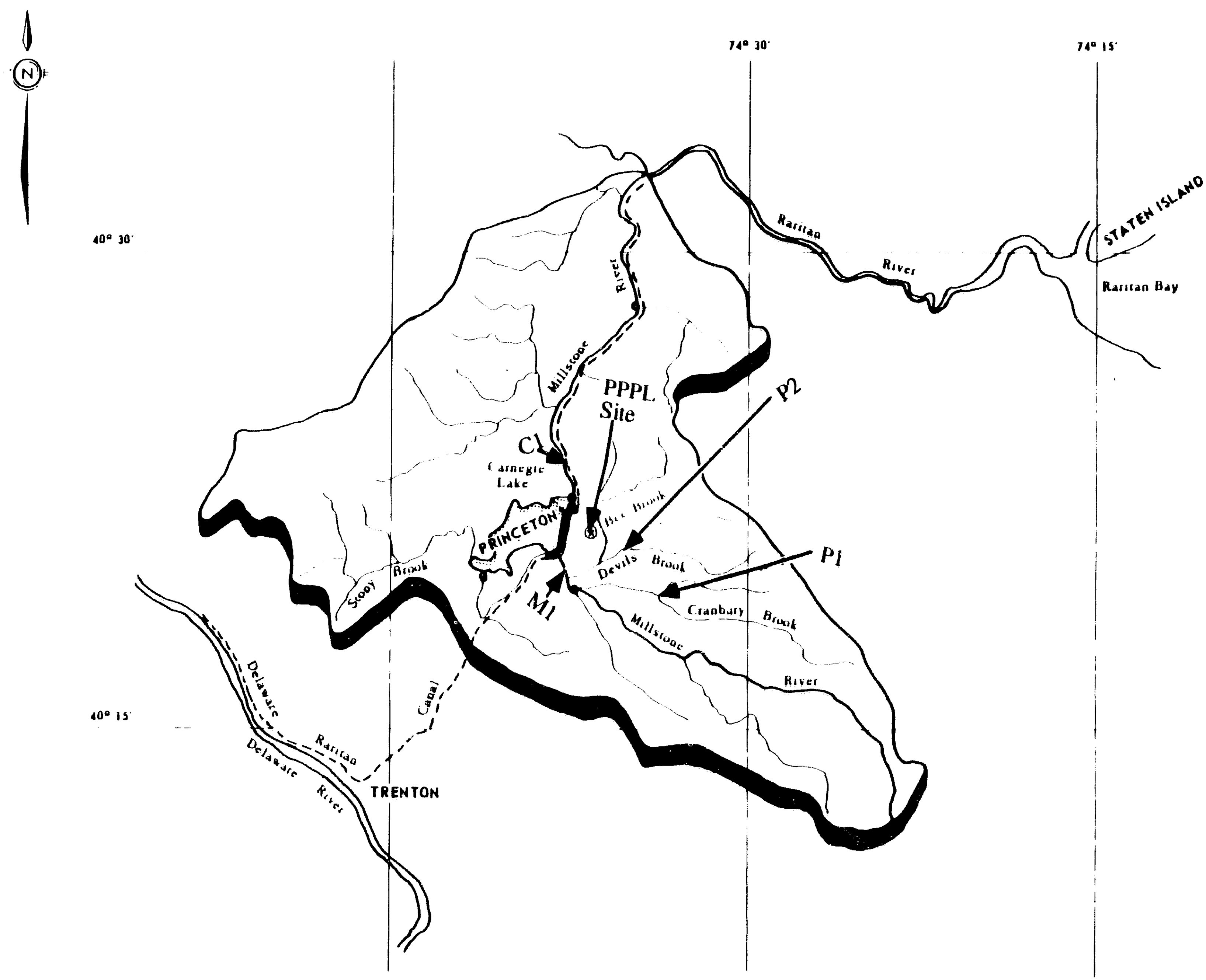


Figure 21. Millstone River Basin Offsite Water Sample Locations

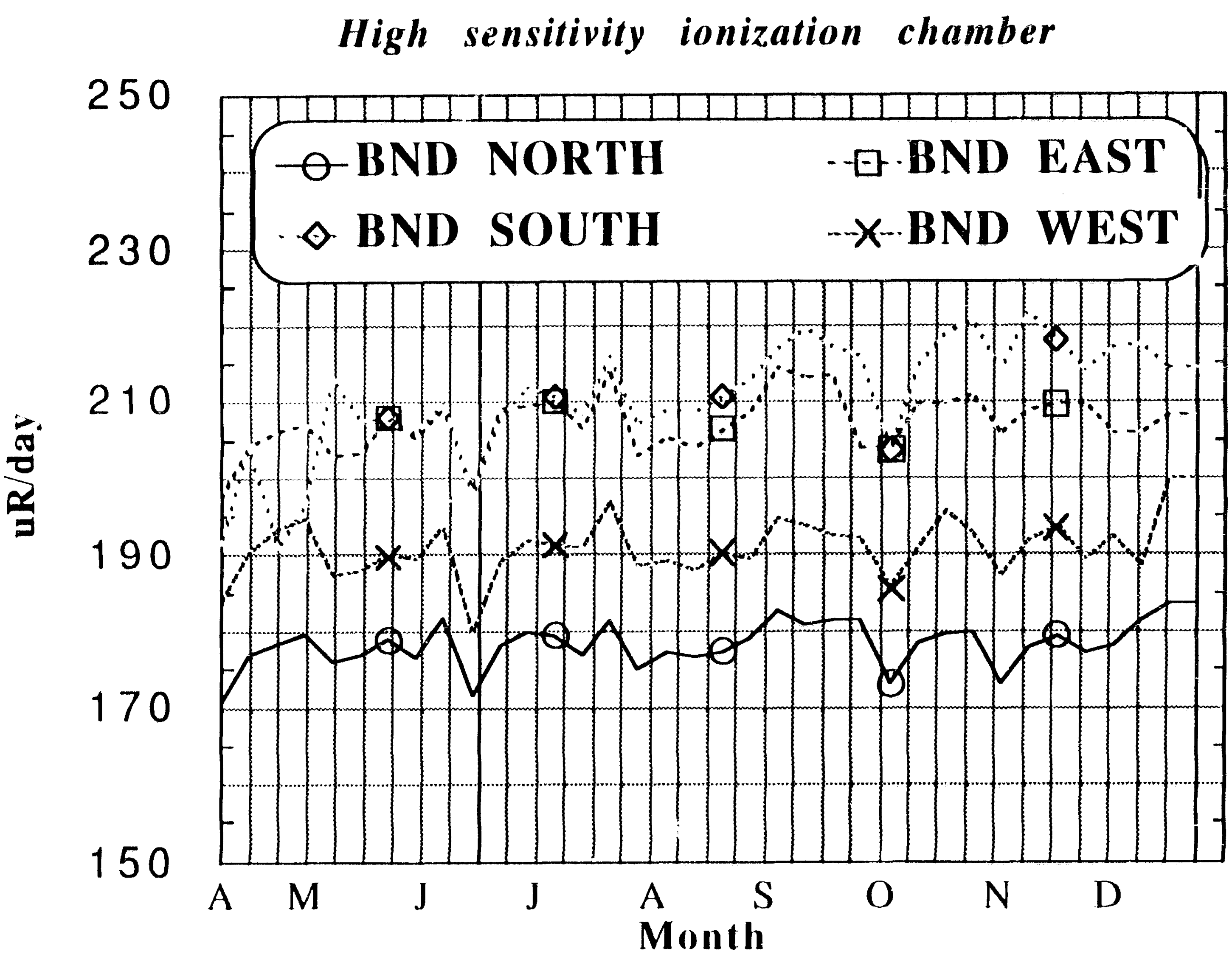


Figure 22. TFTR Facility Boundary Gamma Results - 1990

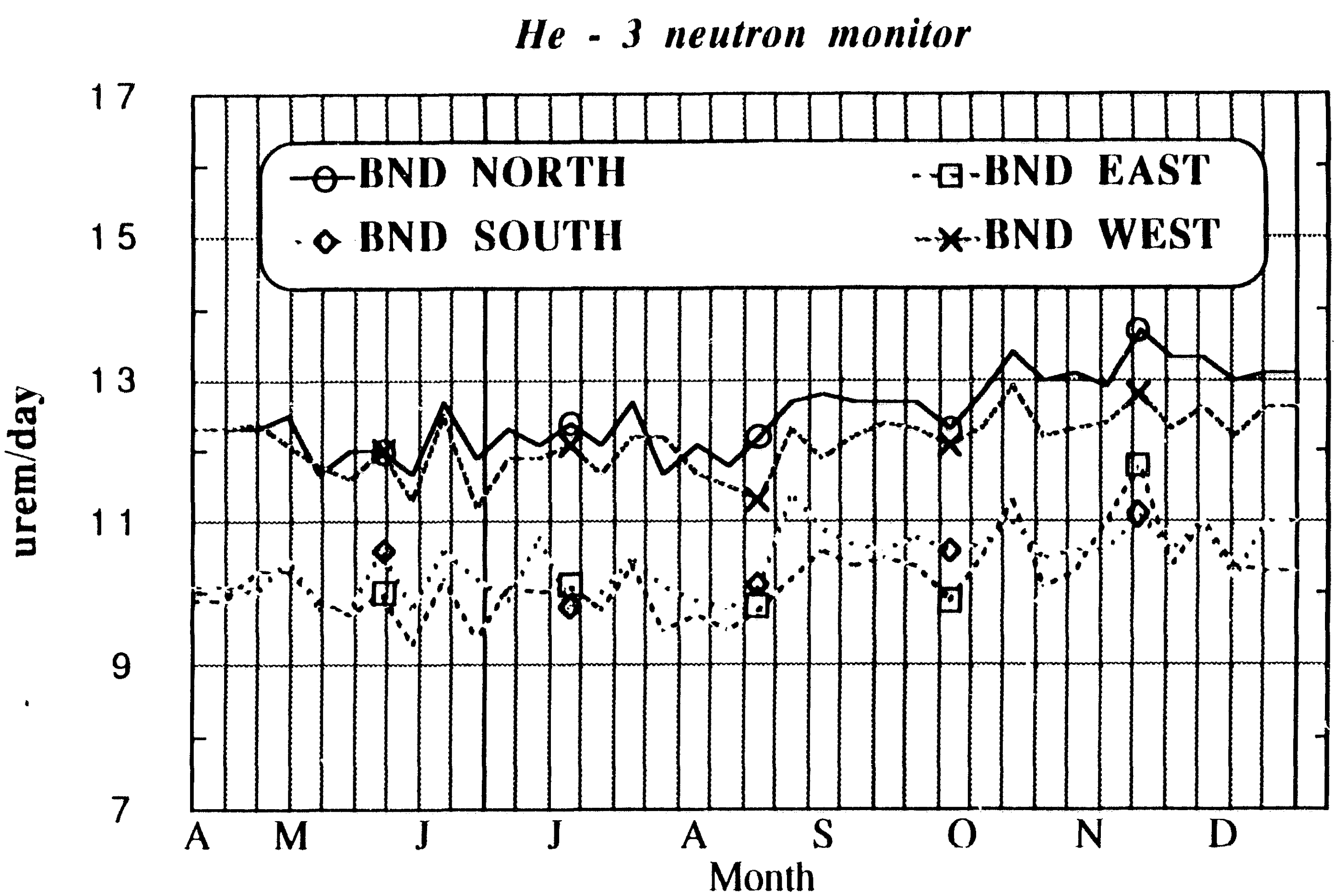


Figure 23. TFTR Facility Boundary Neutron Results - 1990

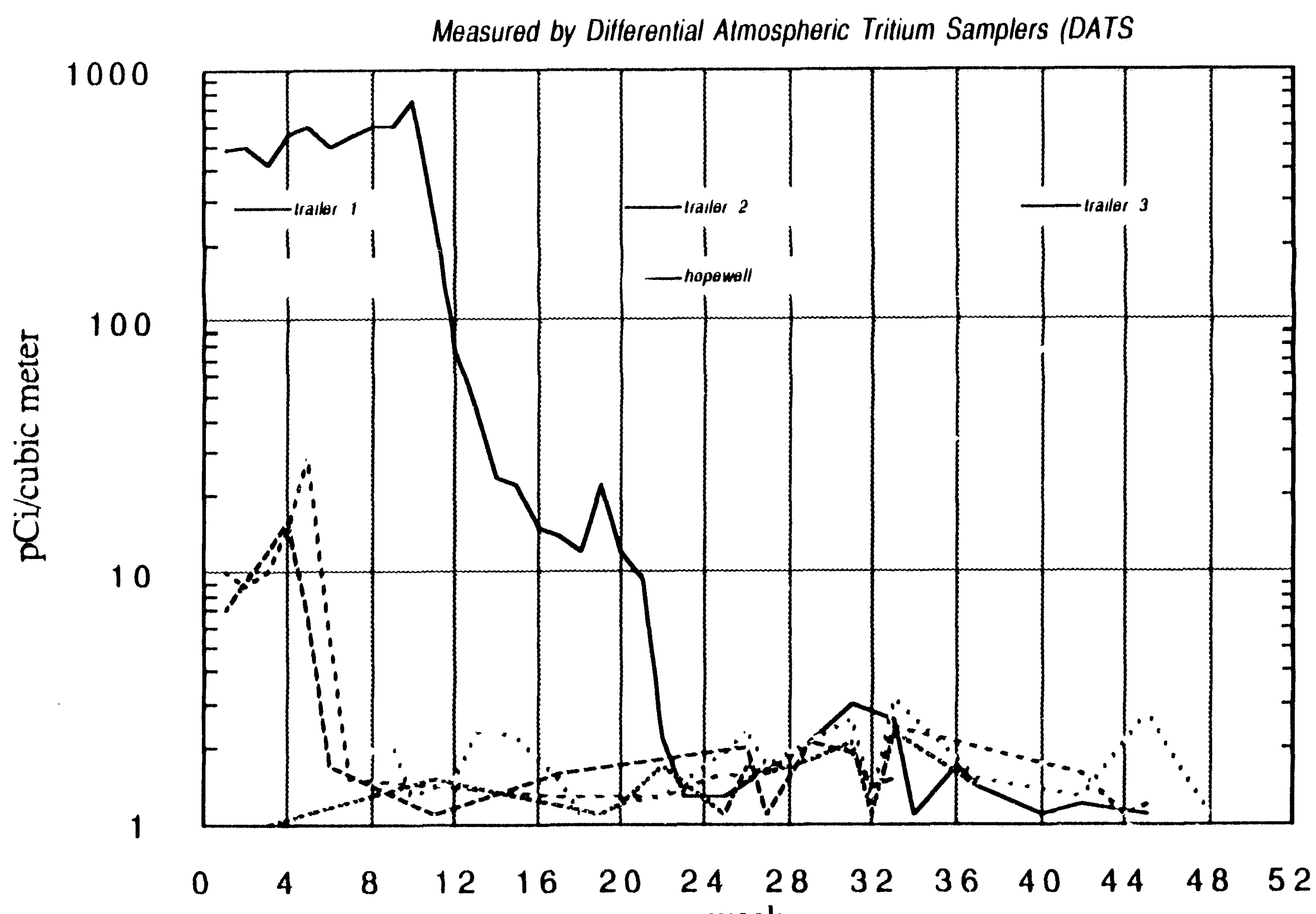


Figure 24. Tritium Oxide (HTO) in Air - 1990

Measured by Differential Atmospheric Tritium Samplers (DATS)

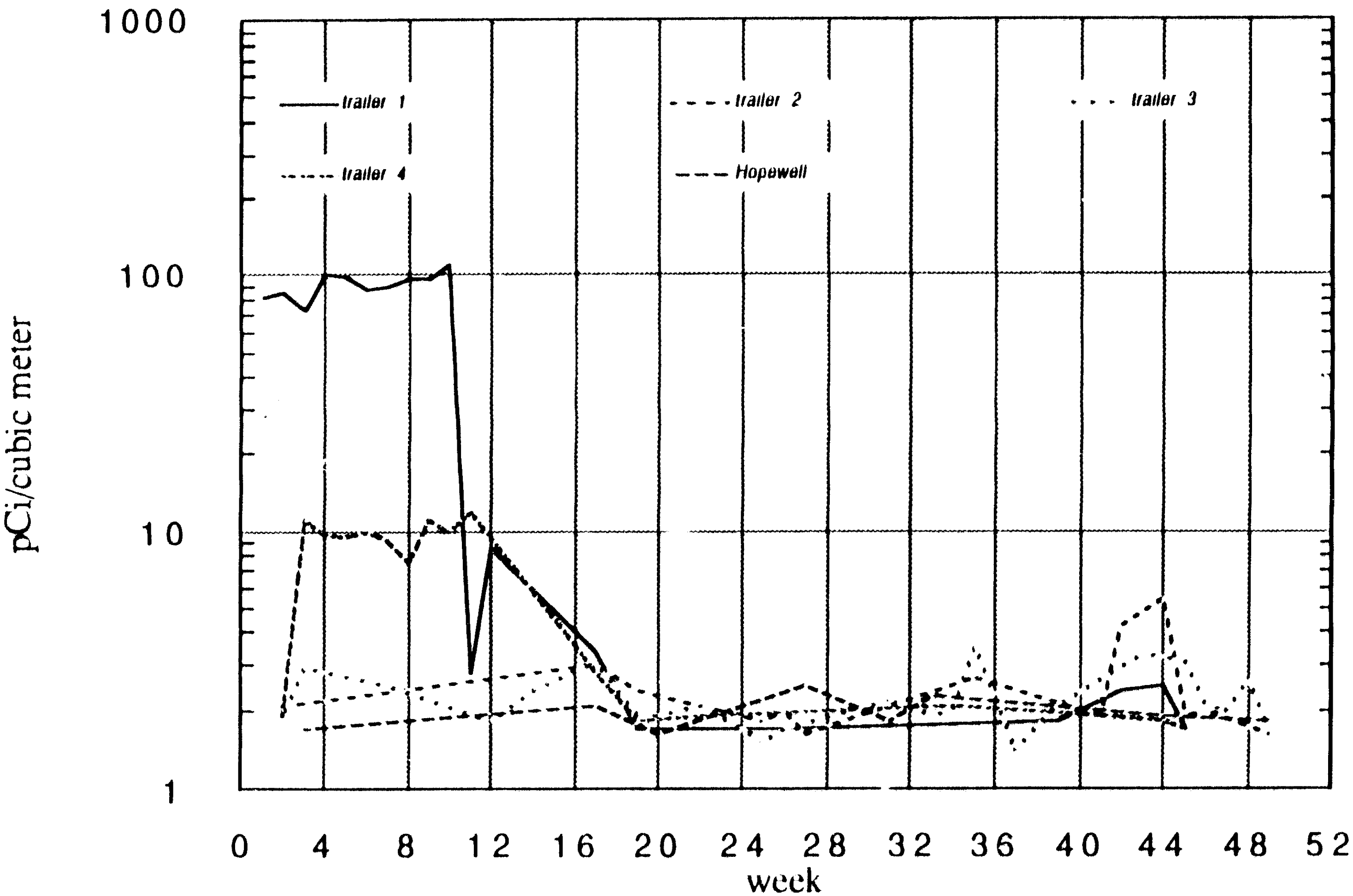


Figure 25. Tritium (HT) in Air - 1990

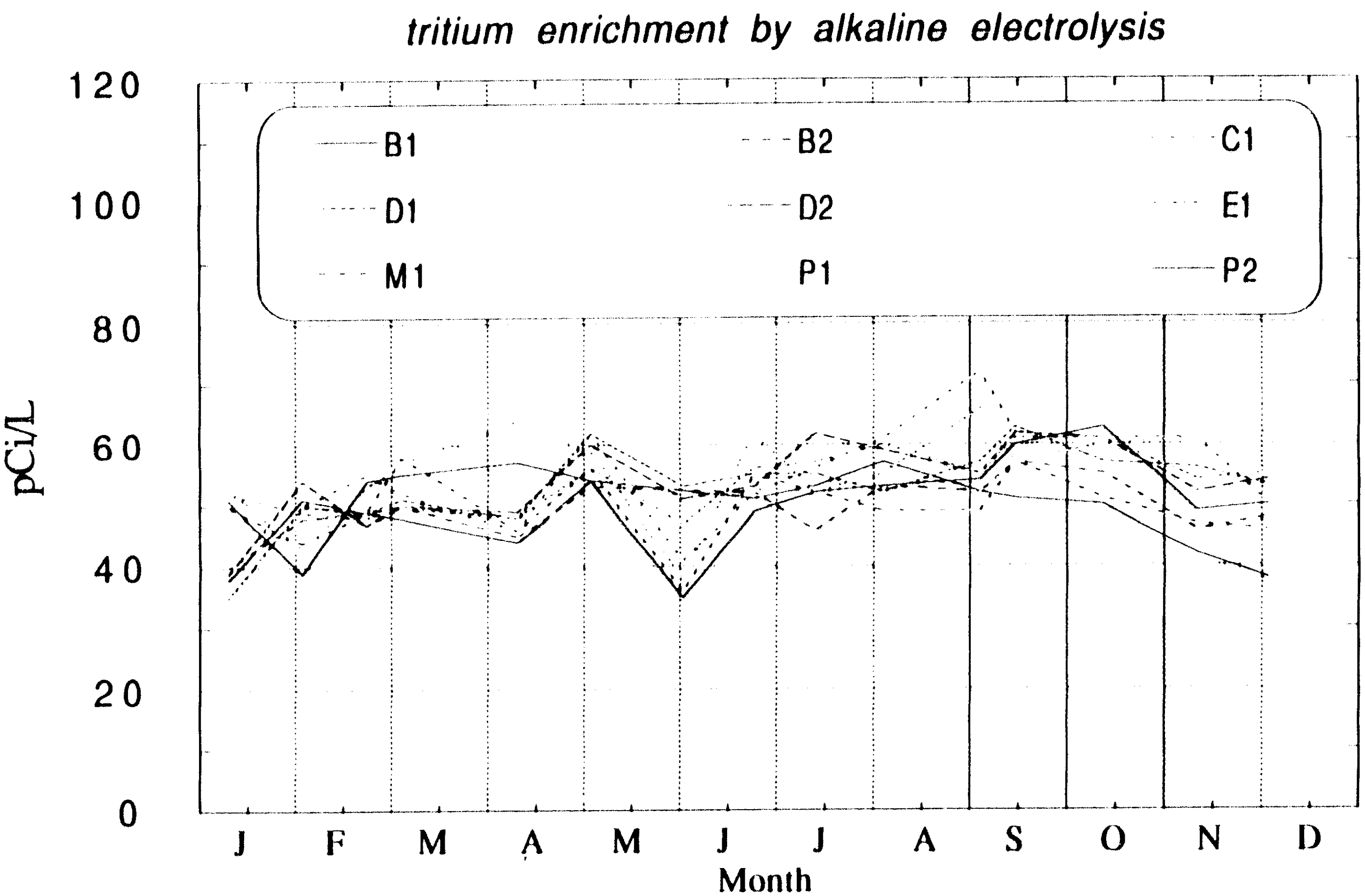


Figure 26. Tritium Concentrations in Off-Site Surface Water

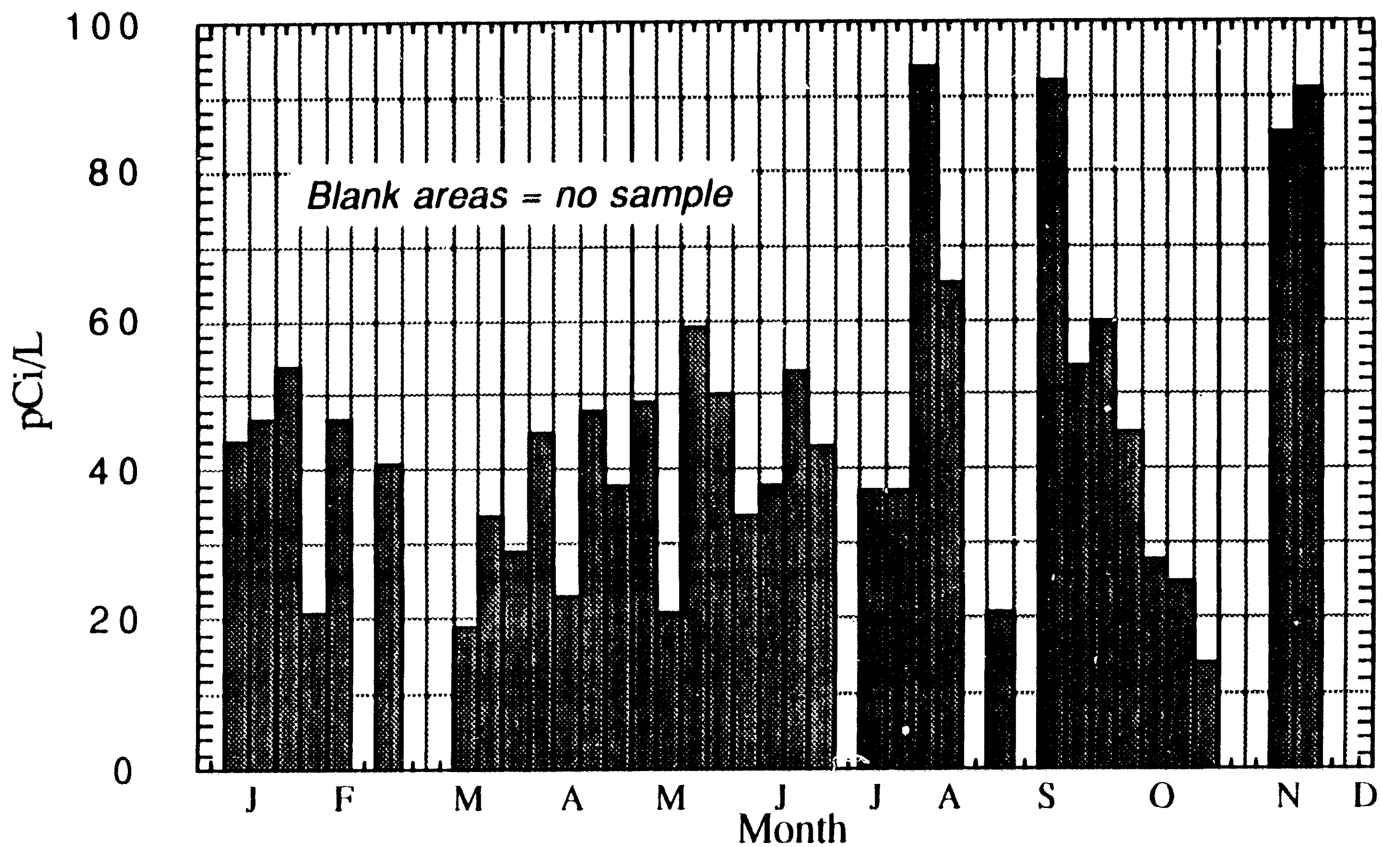


Figure 27. Tritium Concentrations in Precipitation - 1990

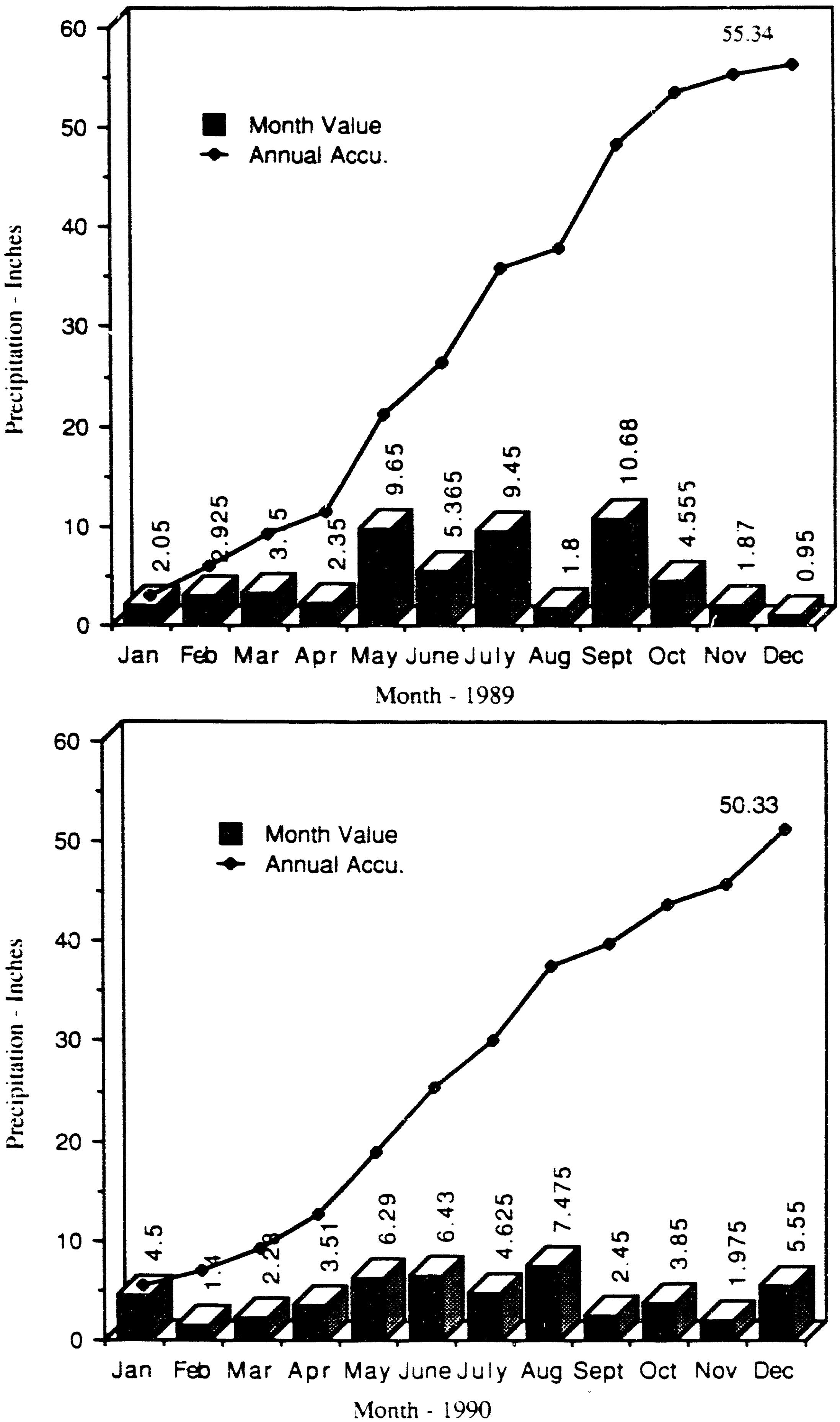


Figure 28. Precipitation at PPPL

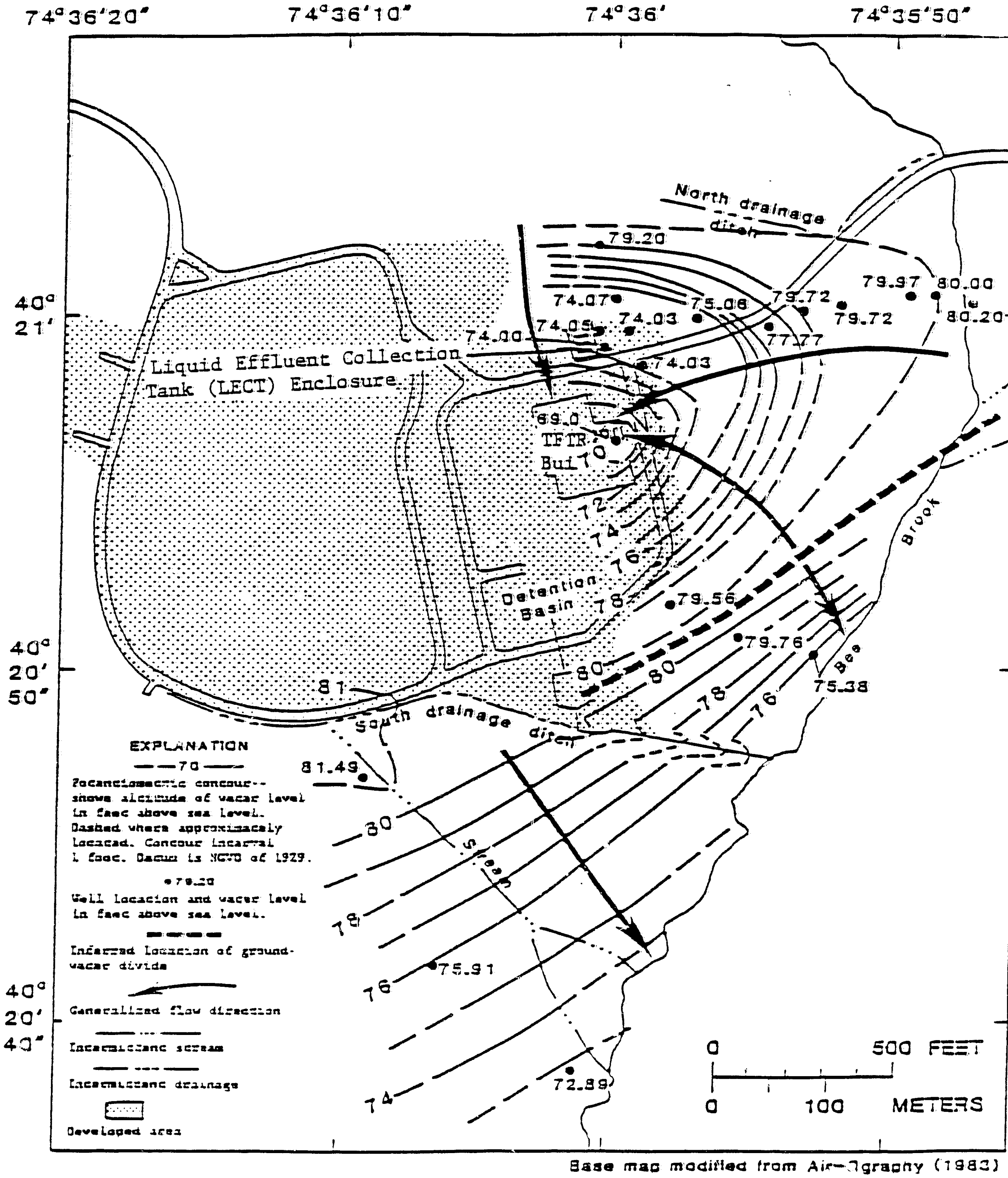


Figure 29. Potentiometric surface of the bedrock aquifer, October 30, 1986. (Taken from Le87)

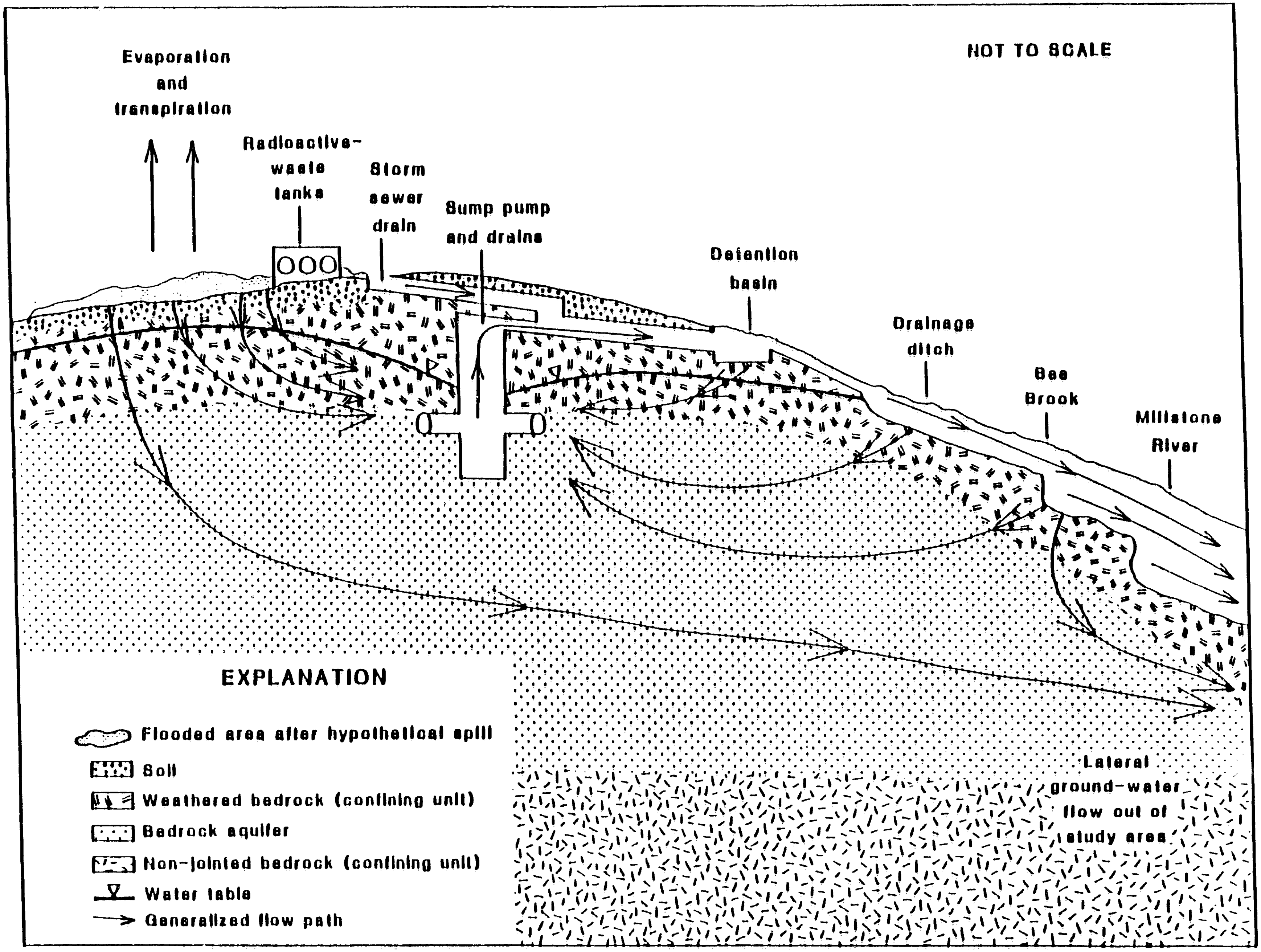


Figure 30. Schematic representation of hydrogeologic framework and potential flow paths of spilled water. (Taken from Le87).

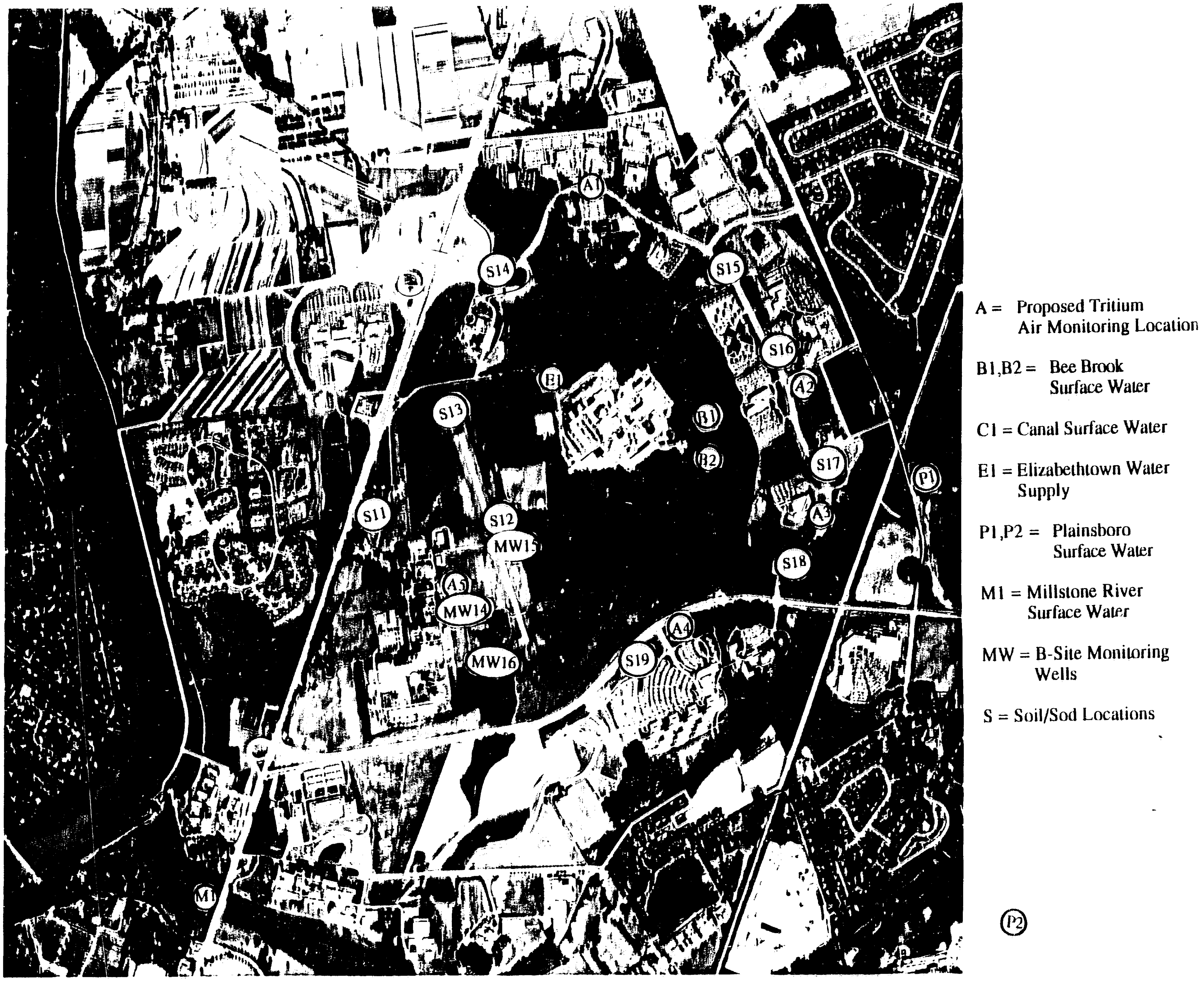


Figure 31. Off-Site Monitoring Locations

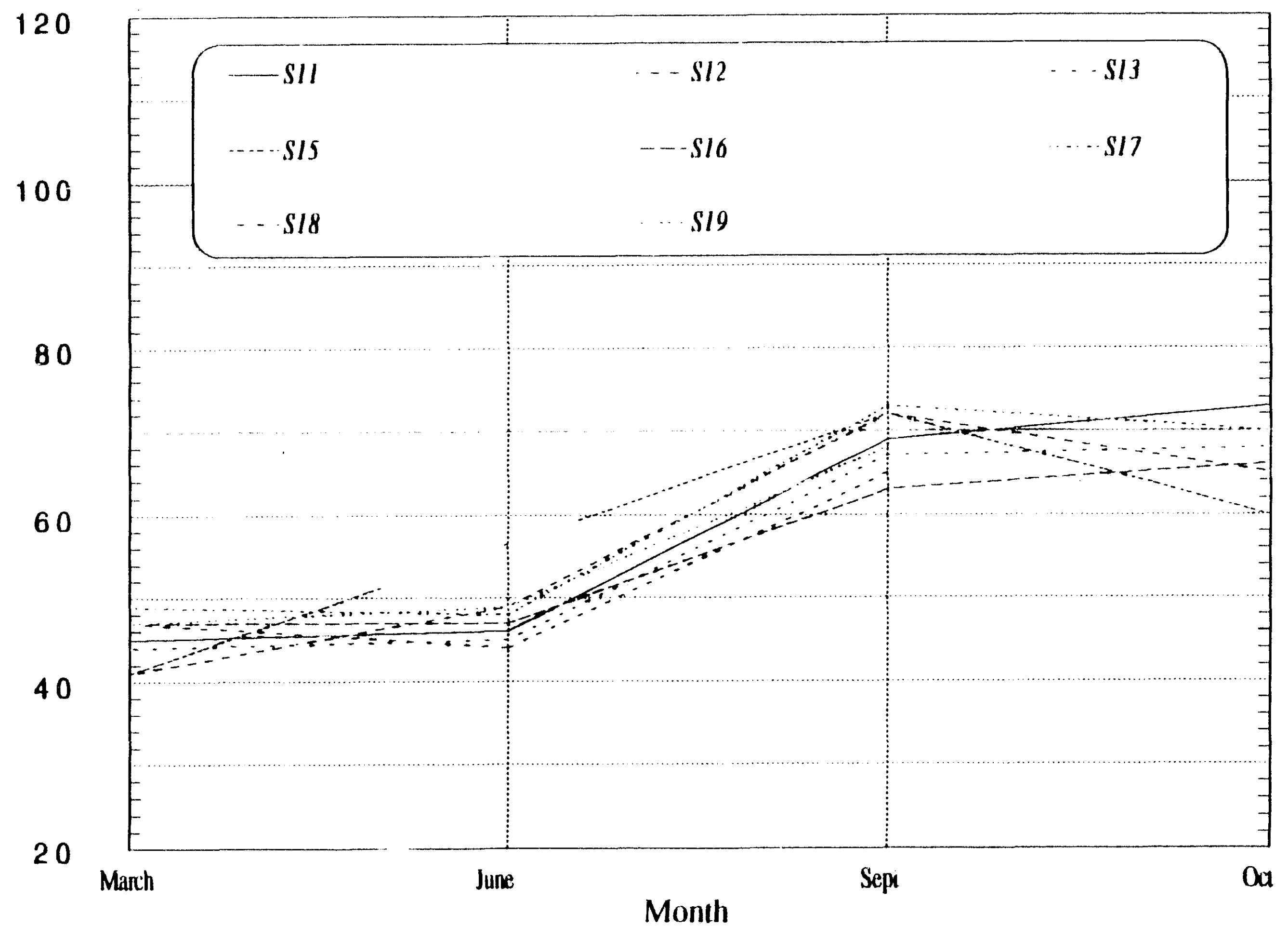


Figure 32. Tritium in Soil/Sod Moisture - 1990

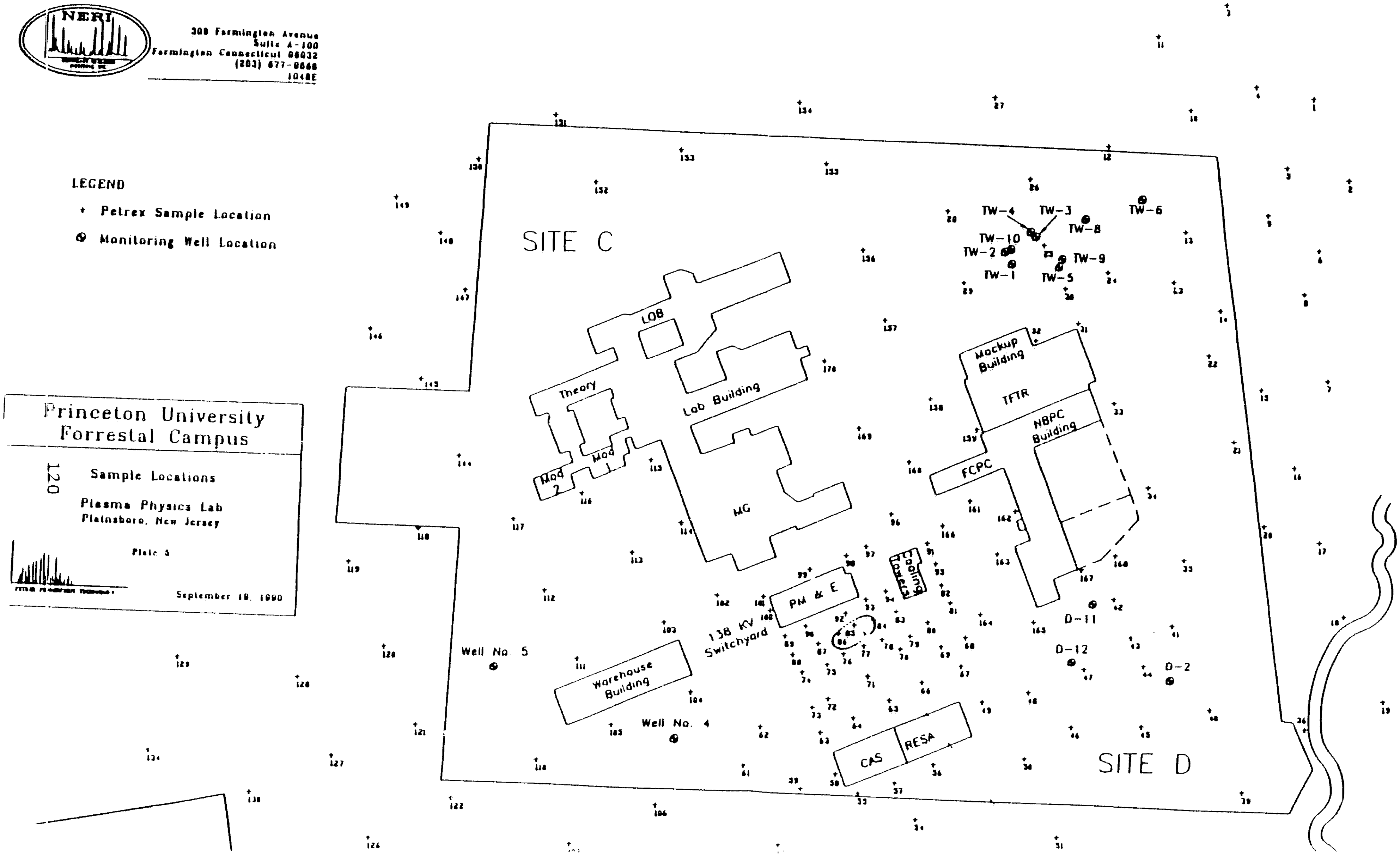
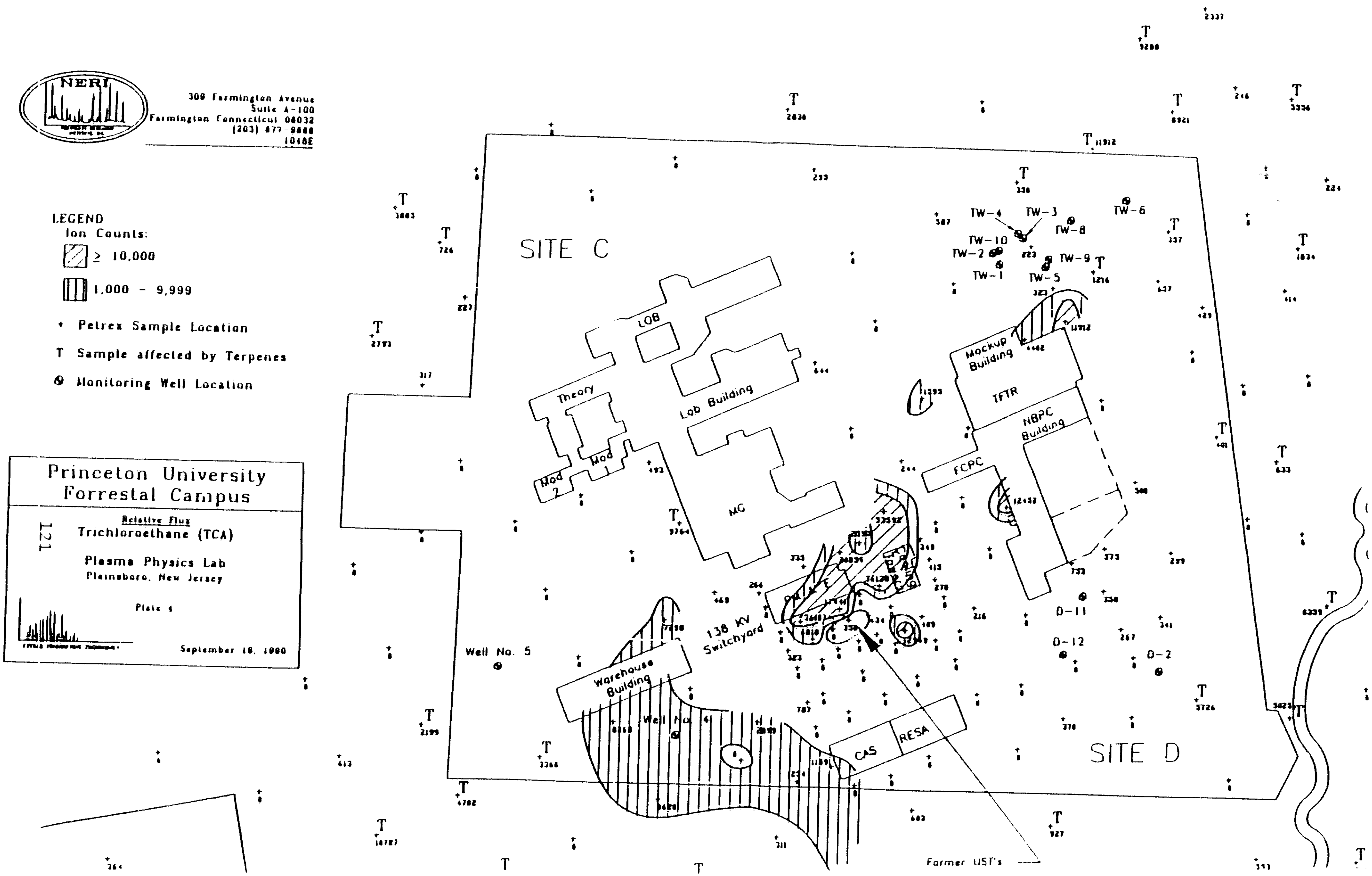


Figure 33. Petrex Soil Gas Survey Sample Points(Ne90)

120



121

Figure 34. Petrex Soil Gas Survey TCA Indications (Ne90)

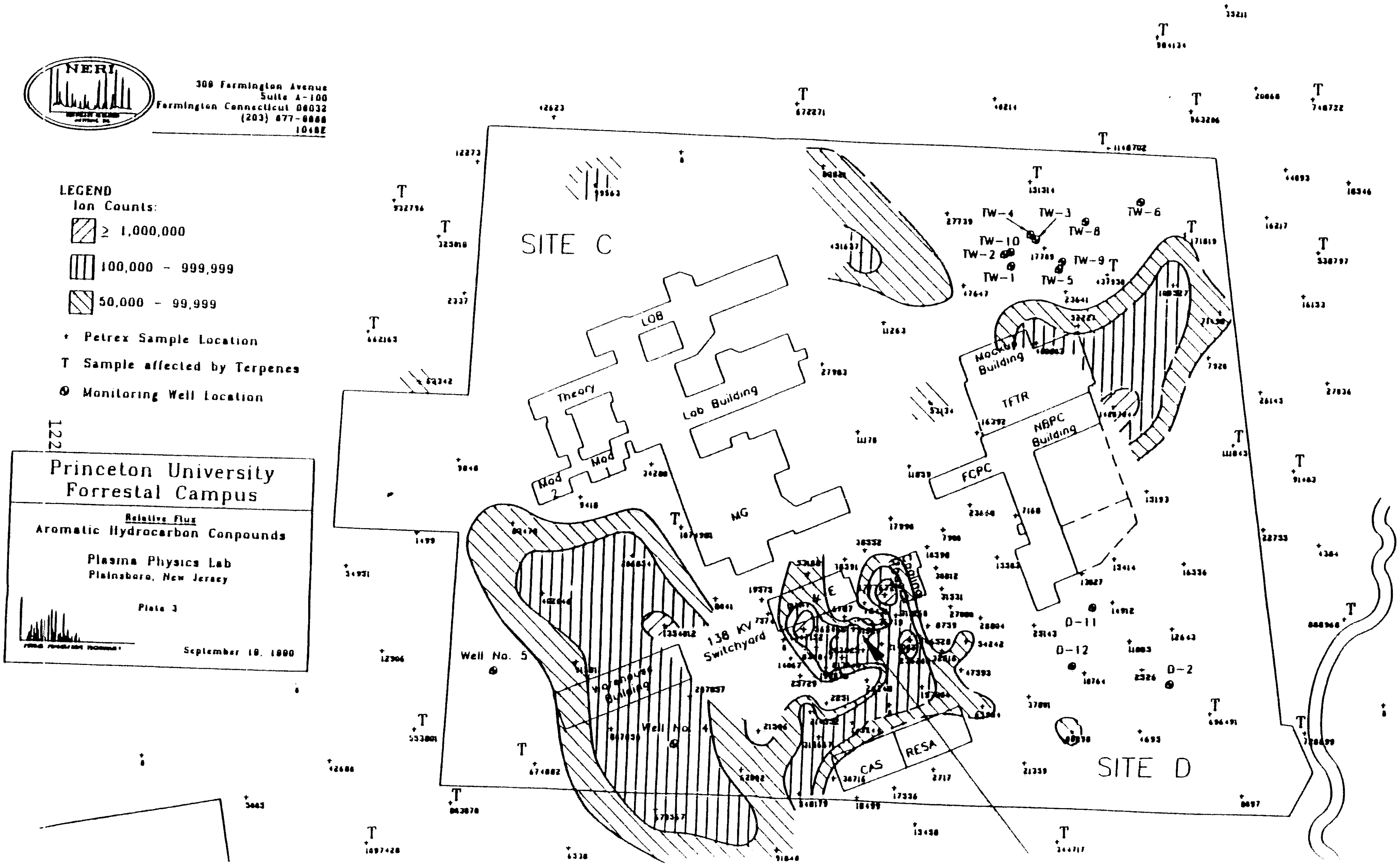


Figure 35. Petrex Soil Gas Survey Hydrocarbon Indications (Ne90)

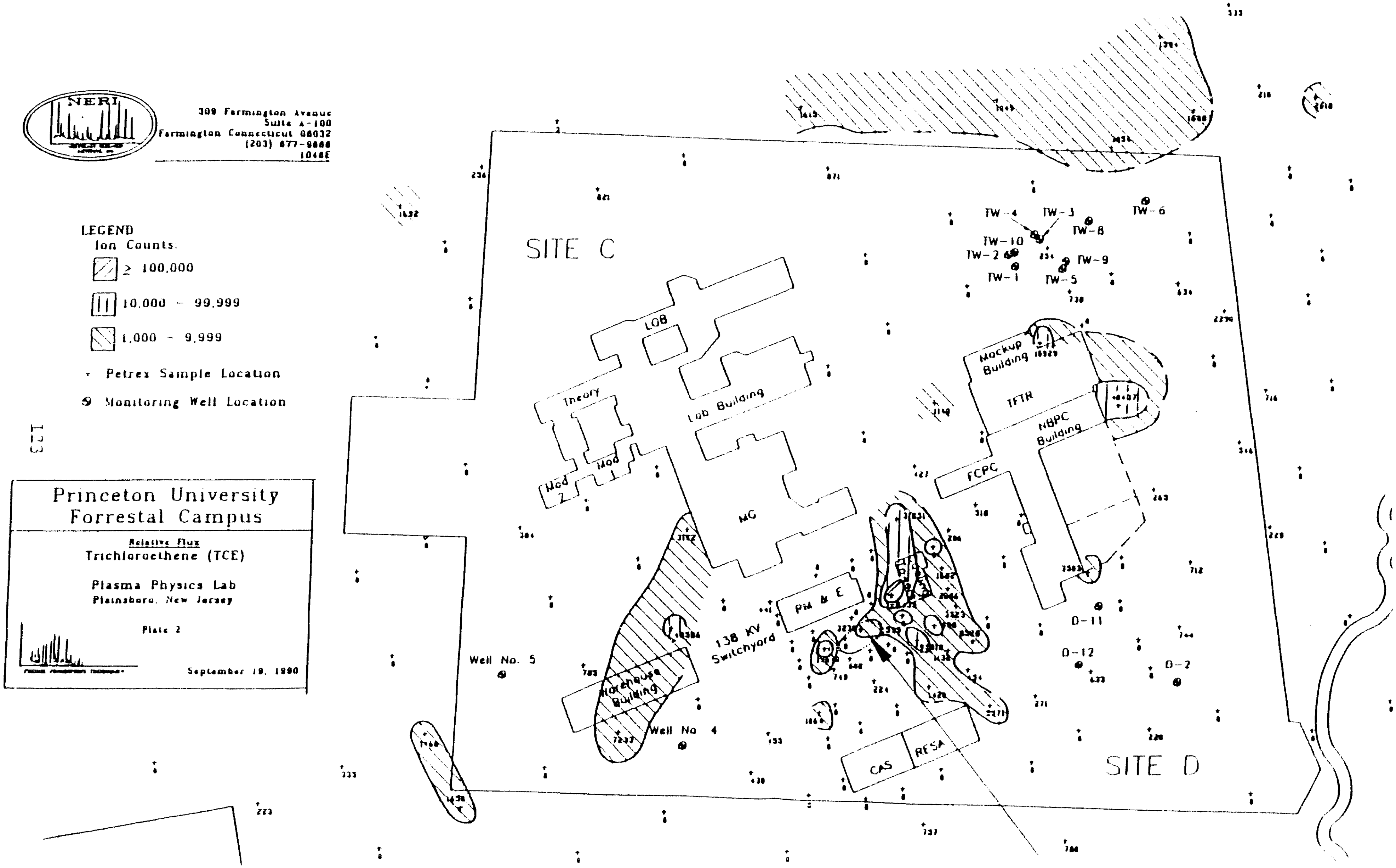


Figure 36. Petrex Soil Gas Survey TCE Indications (Ne90)

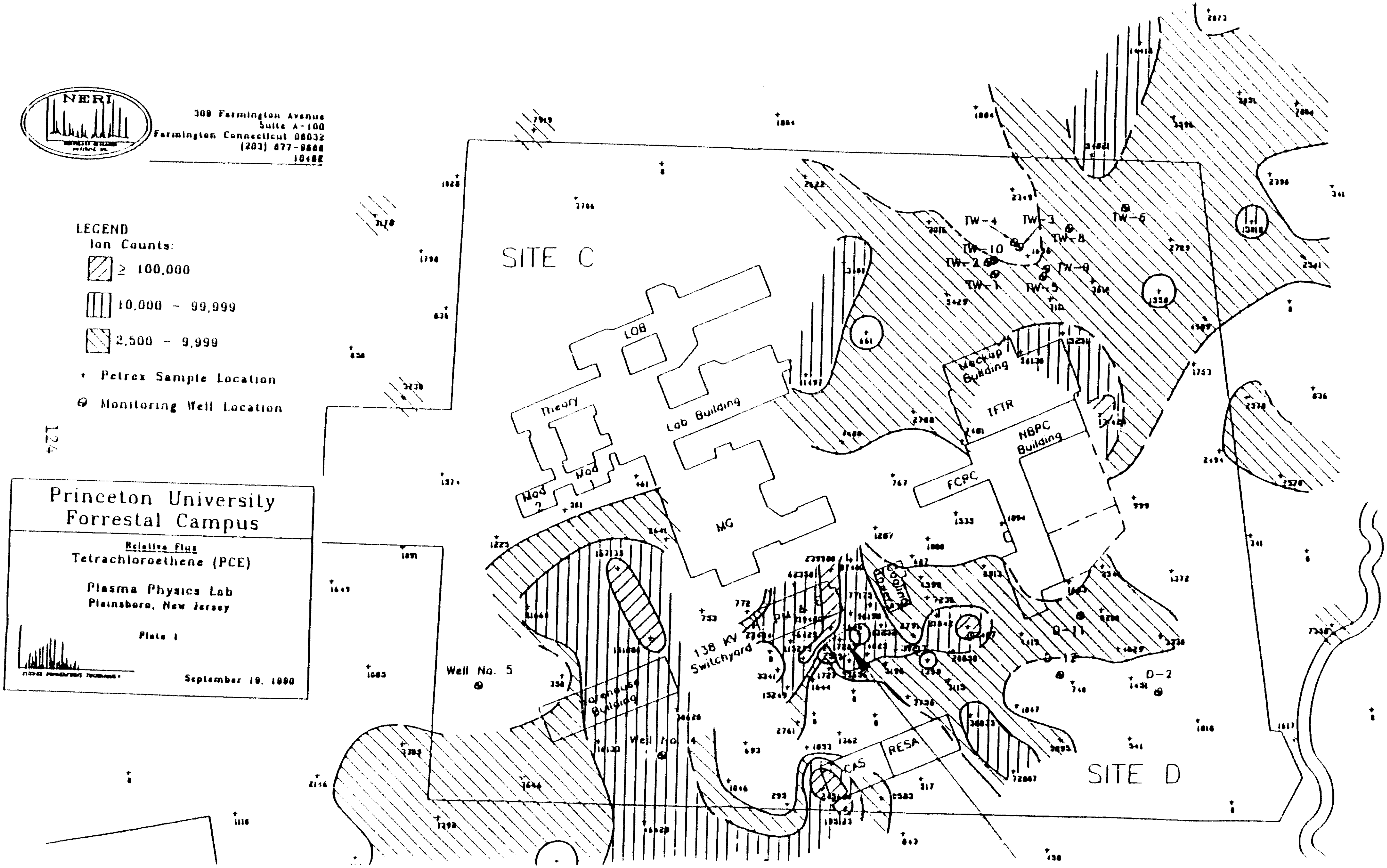


Figure 37. Petrex Soil Gas Survey PCE Indications (Ne90)

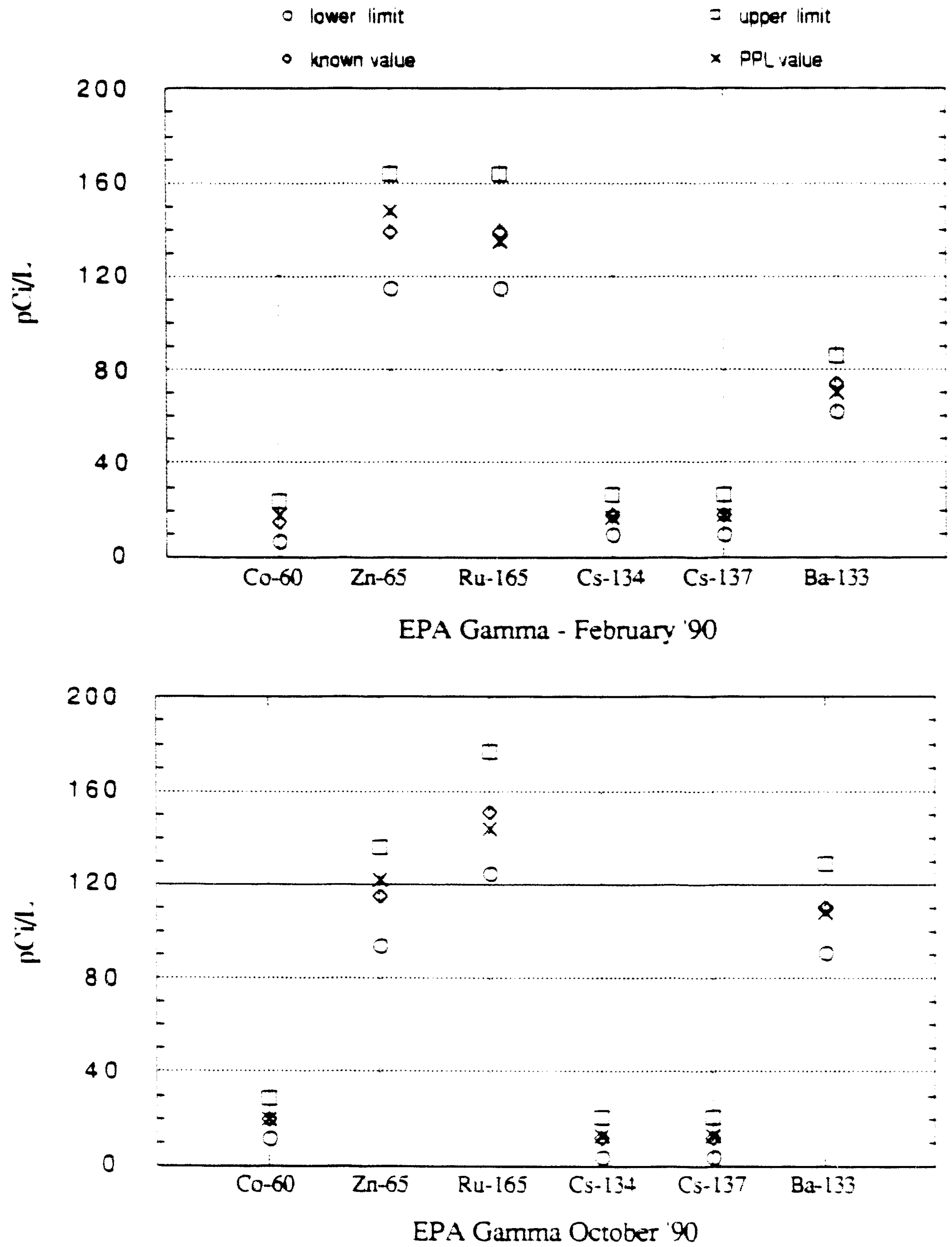


Figure 38. EPA-Las Vegas QA/QCWater Samples for Gamrna

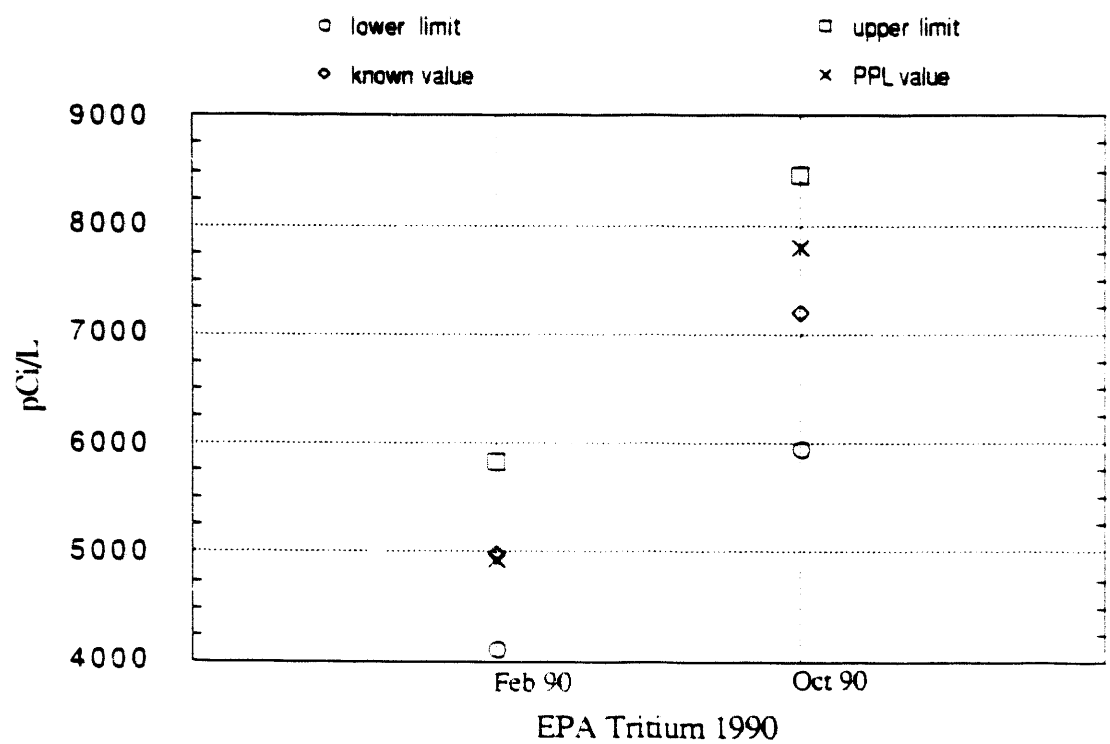


Figure 39. EPA-Las Vegas QA/QC Water Samples for Tritium

Other Distribution

Argonne National Laboratory (R. Kolzow)
Brookhaven National Laboratory (J. Naidu)
CEBAF (G. Stapleton)
Congress (Sen. W. Bradley, Sen. F. Lautenberg, Cong. C. Smith)
DOE Chicago Operations (B. Fritz) [3]
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 (H. Hix) [3]
EPA/HQ (William Gunther)
EPA/Region II
Fermilab (J. Don Cossairt)
Forrestal Development Center (R. Wolf)
General Atomics (R. Savercool)
Lawrence Livermoore National Laboratory (E. B. Hooper, S. F. Eccles)
Los Alamos National Laboratory (W. E. Quinn)
Idaho National Engineering Laboratory (L. Cadwallader, D. Holland)
Massachusetts Institute of Technology (C. Fiore)
Middlesex Health Department
NJDEP, Bureau of Environmental Radiation (G. Nicholls) [2]
NJDEP, Bureau of Hazardous Waste Management
NJDEP, Bureau of Planning & Site Assessment (L. Adams)
NJDEP, Division of Water Resources, Bureau of Aquifer Protection (G. Nichollas)
NJOEM, Division of Law & Public Safety (C. Williams)
ORNL (J. Glowenika)
Omni-Environmental (M. Dimino)
Plainsboro Township (Glenn Carter) [2]
The Princeton Packet (W. Plump)
SAIC (M. McKenzie-Carter)
SSC (L. Coulson)
PPPL:

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