ANNUAL ENVIRONMENTAL MONITORING REPORT

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Radiation Physics Staff

and

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INTRODUCTION

The Stanford Linear Accelerator Center (SLAC) is located two miles west of the Stanford campus in San Mateo County, California. Its boundaries include Sand Hill Road on the north, and San Francisquito Creek on the south. The land slopes to the south toward San Francisquito Creek. The total length of the accelerator and experimental areas is approximately three miles, and is oriented almost east-west. Figures 1 and 2 locate SLAC with respect to the surrounding vicinity.

SLAC is a large research laboratory devoted to theoretical and experimental research in high energy physics and to the development of new techniques in high energy accelerator particle detectors. The main tool of the laboratory is a two mile long linear accelerator. This accelerator produces beams of electrons with energies up to 31 billion electron volts (31 GeV). It can also accelerate positrons, the "antiparticles" of the electrons, up to 20 GeV. These beams can be used directly for experiments or they can be transported into either of two storage-ring facilities — SPEAR or PEP (see Fig. 2). These storage-rings are major laboratory facilities, roughly circular in shape, in which electrons and positrons brought from the accelerator are stored and circulated continuously in opposite directions. The energies are 4.5 and 18 GeV per beam for SPEAR and PEP, giving total collision energies of 9 and 36 GeV, respectively. SPEAR has been in operation since 1972 and PEP was first filled with beam on April 13, 1980.

The operation of PEP does not pose any greater hazards than those of the laboratory as it was previously operated. A high center-of-mass energy is achieved far more efficiently by colliding particles together

than by having a single beam strike a stationary target. In a colliding beam storage-ring, the beam particles are truly 'recycled'; the same bunches of particles are brought into collision over and over again, rather than striking a target only once. For this reason, colliding beam devices produce much less radiation and residual radioactivity than do conventional accelerators. These statements are borne out by the monitoring data presented below.

The construction of PEP has necessitated the relocation of certain stations used for environmental monitoring, but the basic monitoring philosophy and techniques remain the same as in previous years. Certain monitoring stations were inoperative during 1979 and most of 1980, due to construction work at their locations.

Authorization of the project was given by the U. S. Congress in 1961. Construction of the accelerator started in 1962, and was completed in 1966. Research consisting of numerous and varied experiments has been under way since late 1966. The work is carried out under the sponsorship and financial support of the Department of Energy.

Summary

Environmental monitoring results continue to demonstrate that environmental radiological impact due to SLAC operation is not distinguishable from natural environmental sources. During 1980, the maximum measured neutron dose near the site boundary was not distinguishable from the cosmic ray neutron background. Results appear in Table 2.

There have been no measurable increases in radioactivity in ground water attributable to SLAC operations since operation began in 1966. Because of major new construction, well water samples were not collected and analyzed during 1979 and 1980. Construction activities also temporarily placed our sampling stations for the sanitary and storm sewers out of service. These were re-established as soon as construction activities permitted in September 1980. We do not plan to re-establish these wells except for W-23 and W-24 which are located near our two major beam dumps. If ground water activation did occur we would expect to find evidence at these locations long before the products migrated toward wells located at greater distances from the source. We have been sampling these and other wells scattered around the site since 1966. We have never found any evidence of radioactivity in ground water in excess of natural background radioactivity from uranium and thorium decay chains and potassium-40.

Airborne radioactivity released from SLAC continues to make only a negligible environmental impact, and results in a site boundary annual dose of less than 0.3 mrem; this represents less than 0.3% of the annual dose from the natural radiation environment, and about 0.06% of the technical standard.

MONITORING TECHNIQUES AND STANDARDS

Concentration Guides for Liquid Effluent

Because of the nature of the radionuclides produced at SLAC, the appropriate Concentration Guide (CG) for liquid effluents is 3×10^{-6} μCi/mℓ. This is true because the following isotopes are not produced at SLAC:

^{90}Sr, ^{125}I, ^{126}I, ^{129}I, ^{131}I, ^{210}Pb, ^{210}Po, ^{211}At, ^{223}Ra, ^{224}Ra, ^{226}Ra, ^{227}Ac, ^{228}Ra, ^{230}Th, ^{231}Pa, ^{232}Th, ^{248}Cm, ^{254}Cf, ^{256}Fm,

and natural thorium.[1]

(1) Sample Analysis

All water samples collected are analyzed for gross beta activity and tritium by an independent laboratory. Analysis for alpha-emitting radioelements is not performed because we do not produce nor possess in unsealed form significant quantities of this type of radioactivity at SLAC.[2] In addition to routine gross beta analysis, SLAC examines aliquots of selected specimens by gamma spectroscopy if necessary.

(2) Sample Preparation

When environmental water samples contain large amounts of insoluble solids, the solid fraction and filtrate activities are determined separately.

The total volume of each sample is measured and filtered. The original sample bottle is rinsed with the filtrate and the activity in each fraction is determined separately.

For the solid fraction, the filter paper and solid are dried at ~100°C and weighed after cooling. A 300 to 500 mg aliquot is counted.

The filtrate and water samples exhibiting low solid content are treated the same. A 200 cc volume is taken from each 500 cc sample and evaporated to a smaller volume in a beaker. It is then transferred to a weighed planchet with dilute acid and water rinses. The sample is evaporated gently, weighed, and counted.

(3) Gross Beta

The prepared samples are counted in a low-background proportional counter ($\leq$ 1.5 cpm). The results are normalized by comparison with the count of a known ^{137}Cs source.

Some samples may require a correction for naturally occurring ^{40}K. In that case, the total amount of potassium in the sample is determined by flame photometry. The amount of ^{40}K activity can then be calculated, based on the percent abundance of this naturally occurring radioelement and subtracted from the sample count. This correction is performed on water samples whose gross beta activity is greater than 1×10^{-7} μCi/mℓ.

(4) Tritium

To determine the tritium concentration, a 2-3 mℓ aliquot of the filtered solution from the gross beta sample preparation is accurately transferred to a liquid scintillation sample vial. The sample vial is placed in a liquid scintillation counting system. The limit of sensitivity at the 95% confidence level is $\geq 3 \times 10^{-6}$ μCi/mℓ.

Concentration Guides for Airborne Radioactivity

The Concentration Guides (CGs) for airborne radioactivity appear in Ref. 1. They were derived from dose standards which require that no individual in the general population be exposed to greater than 500 mrem in one year.

Airborne radioactivity produced as the result of operations is short-lived; i.e., the half-lives range from 2.1 minutes to 1.8 hours, and are in gaseous (not particulate) form. These isotopes include the following:

TABLE 1

Gaseous Radioactivity Released to Atmosphere

Isotope	Half-Life	CG $\mu Ci/m\ell$
^{15}O	2.1 minutes	$5 \times 10^{-8(*)}$
^{13}N	9.9 minutes	$5 \times 10^{-8(*)}$
^{11}C	20.5 minutes	$5 \times 10^{-8(*)}$
^{41}Ar	1.8 hours	4×10^{-8}

(*) Calculated from Ref. 3, assuming total submersion.

Since we do not routinely release airborne radioactivity while the beam is on, and require a waiting period before turning on the exhaustors, the only radioisotope released is ^{41}Ar. By far the greater proportion of exposure an individual may receive, under any circumstances, from the radioelements listed in Table 1 is from whole body immersion. Thus,

for an individual to receive a whole body dose of 500 mrem annually requires a continuous exposure to a large cloud of ^{41}Ar whose average concentration equals 4×10^{-8} $\mu Ci/cm^3$ (Ci/m^3) for an entire year.

Analysis Techniques for Airborne Radioactivity

The accelerator and beam switchyard (BSY) areas are vented by a total 20 fans: the discharge point is just slightly above roof elevation. The total exhaust rate for the accelerator is 60 m^3/s, and for the BSY 40 m^3/s. Venting of PEP and its Interaction Regions (IR's) is accomplished by a total of 14 exhaust fans which vent just above grade level, with a total exhaust rate of 50 m^3/s. None of these facilities are vented while the beam is on. If personnel entry has to be made during an operating cycle, the area is vented for 10 minutes prior to entry and after the primary beam has been shut off. The release of radioactivity is, therefore, infrequent, and only for brief periods of 30-60 minutes. The accelerator, SPEAR and PEP do not represent a measurable source of gaseous or particulate radioactivity due to low activating potential.

Each BSY ventilation fan is interlocked with a radioactive gas detector comprised of a Geiger-Mueller detector, power supply, rate meter, strip chart recorder and air pump. The electronics are in continuous operation, and the recorder and air pump are interlocked with the ventilation fan so that they operate only when the machine is being vented.

The gas monitors for the BSY collect particulate samples during venting and have revealed negative results. During this period, no particulate radioactivity above background was detected. This agrees with previous "grab" samples collected in the exhaust stream.

Penetrating Radiating Monitoring Techniques

Six Peripheral Monitoring Stations (PMS) provide continuously-recorded data concerning radiation levels (γ and n) near SLAC boundaries. Their positions are located in Fig. 3.

Radiation information is obtained with a Geiger tube for gamma detection, and a paraffin-moderated BF_3 neutron detector calibrated with a Pu-Be neutron source. The resultant sensitivities are such that an γ dose of 1 mR from a radioactive ^{60}Co source would be recorded as $\sim 10^4$ counts on the Geiger tube channel, and a neutron dose-equivalent of 1 mrem would be recorded as $\sim 10^5$ counts on the BF_3 channel. The hourly printout cycle of the Sodeco register is programmed by two clock motors with cam actuated switches and associated electronic circuitry. This programmer automatically interrupts data acquisition, generates a print command, resets the digits in parallel, and reverts to the normal condition of serial counting of incoming data pulses. Dead time per printout cycle is less than 20 seconds per hour.

In connection with the pulse pair resolution limitation of the Sodeco register mentioned above, an important feature of this system involves the pulser which drives the register. It is of the non-paralyzable type. This means that if the maximum instantaneous counting rate (20 counts/sec) is ever exceeded, the register will merely not count the pulses in excess of its maximum rate. It can count at this maximum rate continuously (72,000 counts/hr.).

MONITORING RESULTS

Penetrating Radiation Monitoring

The measured annual dose to the general population from accelerator operations is almost entirely from fast neutrons and is characterized as skyshine from SLAC's research area. Estimates of individual and general population whole body dose can be calculated from the PMS data, based on estimates of distance and population density near SLAC. During January through July, 1980, only two stations were operated due to construction activities. PMS-5 (which has been renumbered as PMS-1) is located at the most sensitive location. Historically this station has always been used to calculate population dose since it records the maximum dose at our site boundary. All stations were reestablished in July, 1980. They have been renumbered (see Fig. 3).

From this population estimate and the measured radiation dose near the site boundary, we can estimate both the average individual dose and the population dose from SLAC operations. From 1974 data, we arrive at a population of 2040 persons who are included in the pool exposed to 1 mrem or more for the calendar year 1980. The man-rem dose was not distinguishable from natural background radiation. A shift in the experimental program to low intensity experiments, including storage ring activities, is the primary reason for the decrease in site boundary dose.

Monitoring for Airborne Radioactivity

During 1980, 0.25 Ci of short-lived gaseous radioactivity was released into the atmosphere from SLAC. Particulate samplers continue

to demonstrate that radioactivity in particulate form is not released from SLAC. When corrected for dilution, this resulted in an average off-site concentration of 3.5×10^{-12} Ci/m^3. This concentration is compared to the CG for ^{41}Ar, which is 4×10^{-8} Ci/m^3.

We emphasize that the model used to calculate off-site concentration applies to the plume centerline, and is not corrected for vertical and horizontal plume spread. Also, the model is not corrected for wind direction or velocity. The estimate of off-site concentration is, therefore, conservative and overestimates the actual concentration at the site boundary by factors of 2-10.

NONRADIOACTIVE EFFLUENT

Waste Water

Waste water from SLAC is discharged in basically three directions:

(1) Sanitary sewer.

(2) Storm sewer effluent is released to natural open ditches. The ditches conduct this water to San Francisquito Creek by surface flow or by seepage. Both these liquid effluents (1) and (2) eventually reach San Francisco Bay, about six miles to the east.

(3) About 40% of the water leaves the site as water vapor via the four cooling towers.

Typical amounts are 7×10^4 m^3/year to the sanitary sewer; 1.5×10^5 m^3/year to the storm drains, and 1.5×10^5 m^3/year evaporated, for a total of 3.7×10^5 m^3/year. In addition, an average of 9×10^5 m^3/year fall as rain on the 472 acre site, also flowing to the creek.

Thus, the SLAC effluent to the creek is diluted by an average factor of 6 by natural run-off.

The turn on of PEP in April, 1980, has not changed these figures from those of previous reporting periods. This is because, as the PEP facility came into operation, other experimental programs were somewhat reduced so that there was no significant net change in water usage.

Because of PEP construction the sampling stations for both the sanitary sewer and storm drains have been relocated (see Fig. 3). These became operational in September, 1980. The sanitary sewer sampling station is now at Manhole No. 1, northeast of the PEP Interaction Region 12 (IR-12). All SLAC sanitary sewage flows through this point.* A pump continuously samples the effluent at the rate of 5 mℓ per minute, which is stored in drums at that point. At the end of each calendar quarter, the contents of the drums are mixed, and 1 liter samples are removed for chemical-radiological analysis.

It should be noted that the sampling rate is constant at all times regardless of the flow rate, and thus tends to give relatively greater weight to the effluent at lower flow rates when concentrations are likely to be higher. Therefore, this method of sampling is likely to lead to an overestimate rather than an underestimate of concentration.

Sanitary Sewer Effluents

About 20% of SLAC's domestic water supply is released to the sanitary sewer; the remaining 80% leaves the site by evaporation or

* There is a second sewer connection serving only PEP IR-4, 6 and 8. No cooling or process water is released via this connection which carries only small amounts of ordinary human wastes.

via storm drains to San Francisquito Creek. The sanitary sewer outlet at the northeast corner of the site is connected to the Menlo Park Sanitary District. The releases are ordinary sanitary wastes, and the Menlo Park treatment plant discharges its treated wastes directly into San Francisco Bay.

The quantity of discharge for 1980 was 8.2×10^4 m^3. This amount is not unusual for a facility employing about 1300 people, and does not constitute a burden on the Menlo Park Sanitary District. The amount is rather constant the year around, and relatively insensitive to the accelerator operating cycle.

Storm Drain Effluents

Water effluent discharged into the storm sewer is a combination of (1) cooling tower blowdown, (2) water run-off from SLAC landscaping irrigation, (3) rainwater run-off during the winter, and (4) miscellaneous uses, mainly once-through cooling of various small systems.

The largest potential source of chemical effluents discharged to San Francisquito Creek is cooling tower blowdown water, discharged to three natural open ditches. There are four towers of the induced-draft counterflow type. The primary system in all cases is a closed-loop, low-conductivity system. Tower 101 is located at the Central Utility Building, and provides cooling for laboratories and shops of the Campus Area. Tower 1201 is adjacent to the accelerator, and is meant to cool the injector, positron source, and the first accelerator mile. Tower 1202, also adjacent to the accelerator, cools the second mile, while Tower 1701, near the Beam Switchyard and Research Area, provides cooling for these areas and for PEP.

The cooling tower water is chemically treated with silica and organic algaecides. The blowdown water is basically source water whose solutes are concentrated by a factor of 4-6.

The cooling tower effluents are subject to control by the State of California, California Regional Water Quality Control Board, NPDES No. CA0028398, order No. 78-73, October 1, 1978. The discharge permit states the maximum permissible concentrations of settlable solids, oil and grease, chlorine residuals, as well as maximum temperature and permissible range of pH. It sets forth a monitoring schedule describing the types of sampling and minimum frequency of analysis. Each tower's effluent is analyzed separately, except that effluent of tower 101 is combined with that of 1701.

MONITORING RESULTS

Sanitary Sewer

Concentrations of various elements found in analyses of sanitary sewer effluents are shown in Table 4. These are compared to an applicable standard, namely General Regulation No. 56 of the Menlo Park Sanitary District, Menlo Park, CA, as amended November 10, 1975.

Storm Drains

Results of cooling tower blowdown monitoring for 1980 appear in Table 5. These results show continued progress in meeting standards specified by the State of California NPDES Permit No. CA0028398.

APPENDIX A

ATMOSPHERIC DISPERSION MODEL

In 1966, an independent evaluation of meterological regimes at SLAC was performed.[4] From this study, an empirical mathematical model was developed. The model that is used predicts the centerline concentration very well, but overestimates the total dosage values.

$$\frac{\chi_P}{Q} = \frac{G}{u}\left(\frac{X}{X_0}\right)^{-1.75+[b(1-C)/u]}$$

where χ_P = centerline concentration (Ci/m^3)

Q = source strength (Ci/s)

$G = 8\ m^{-2}$

u = mean wind speed (m/s)

X = distance from source (m)

$X_0 = 2$ m

C = fraction of sky covered by low clouds

$b = 0.5$ m/s (day) ; $b = -1.2$ m/s (night) .

Figure 5 summarizes peak concentration per unit source strength as a function of wind speed and atmospheric stability at a fixed distance of 400 meters (roughly the distance from the source to SLAC's boundaries). To characterize atmospheric stability, the degree of cloud cover is indicated for day and night time regimes. This method is based upon Pasquill's data for cloud expansion for various stability categories.

For a wind speed of 2 m/s atmospheric dilution factors — for determining centerline concentrations — range between 2×10^{-5} and

1.5×10^{-3}. For purposes of estimating radiation dose at the site boundary, neutral conditions are assumed, and a generally conservative dilution factor of 4.5×10^{-4} s/m^3 is used in calculation of average concentration at the site boundary (see Fig. 5, curve 1.0).

APPENDIX B

MODEL FOR POTENTIAL DOSE ASSESSMENT

According to Chapter 0513 "Effluent and Environmental Monitoring and Reporting," an assessment of whole body man-rem dose to the general population within 50 miles (80 km) of SLAC is required. Our site boundary dose due to accelerator operation is generally detectable, and is < 20 mrem per year from penetrating radiation. Integrating a population dose of small values out to 50 miles becomes an exercise in numerical analysis that results in questionable dose estimates. This is true because assumptions must be made regarding the behavior of neutrons at large distances from the source. We have, therefore, modified the distance term to include individual annual doses down to 1 mrem, which corresponds to a distance of < 1 mile from a central point representative of the source of neutrons. The 1 mrem value is approximately 1% of the total natural background dose, and any further extrapolation is unjustified because the difference in population dose from natural background and SLAC operations cannot be reasonably determined.

There are three major pathways leading to human exposure: (1) airborne, (2) food chain, and (3) direct exposure to penetrating radiation. Of the three major pathways listed above, only direct exposure to penetrating radiation is of any measurable significance from SLAC operations. The source of this exposure is from neutrons resulting from the absorption of high energy electrons and photons in the experimental area creating energetic particles, some of which escape from the heavily shielded areas.

In order to make an accurate and realistic assessment of radiation exposure to the public at low doses, it is necessary that exposure from the natural radiation environment be known. This is true because the instruments used for this purpose respond to natural radiation sources as well as man-made sources, and the portion due to natural radiation must be subtracted from the raw results. The population exposure assessments appearing in this document are, in all cases, overstatements of the true impact. Hence, the resulting values are representative of an upper limit of the possible range.

While the annual neutron dose from accelerator operations at the site boundary has generally been measurable, it has always amounted to < 25% of the total annual individual dose from natural background radiation. According to an EPA report, the average dose from cosmic, terrestial, and internal radiation in California is 125 mrem.[5] For purposes of comparison, we have rounded this number off to 100 mrem.

Another quantity of interest is the population dose in units of man-rem. This is simply the product of the average individual dose and the total population exposed. For example, if there are 2000 people exposed to an average annual background dose of 0.1 rem (100 mrem), then the population dose is 0.1 × 2000, or 200 man-rem from natural background radiation. The annual variation of exposure to natural background radiation may vary by ±20%, largely caused by the difference of naturally occurring uranium, thorium, and potassium present in the ground and in building materials where people live and work. This value is also affected by weather conditions which may increase or decrease the amount of randon/thoron present in the atmosphere at any given time.

There are two major problems associated with this determination that affect overall accuracy of the measurement. First, the conversion of neutron flux to dose requires that the spectrum of neutrons at the measurement point be known because the quality factor Q is a function of neutron energy. Because of the very low neutron fluences at the SLAC boundary and beyond it is impossible to measure the energy spectrum. Therefore we have selected a QF of 10 as a conservative choice. We feel that this choice leads to an overestimate of the neutron dose-equivalent by a factor of approximately 2. Until a useful experiment can be performed, with neutron yields of sufficient intensity, the quality factor cannot be determined with any better precision.

A second problem with this sort of extrapolation is the behavior of neutrons at large distances. Most of the high energy accelerator laboratories have made measurements and have derived formulas for predicting this behavior.[8] Unfortunately, all such measurements are unique to each facility because of design differences, type of machine, and surrounding topography. Here, again, we have chosen a conservative formula for calculating the dose at distances other than the point of measurement. Lindebaum[6] gave a method for evaluating skyshine neutrons which was later verified by Ladu et al.[7] using Monte Carlo techniques. Lindenbaum approximated the falloff by $e^{-R/\lambda}/R$, where R is in feet, and λ = 830 feet. This equation fits the SLAC data fairly well, and is the one used to predict doses beyond our measuring station (Fig. 5). In order to derive a correction for large distances unique for SLAC, we will need a much larger intensity to determine a more precise correction for distance. We feel that the methods used and reported in this document

may overestimate the true population dose by at least a factor of 2 or greater.

The population activity close to SLAC, i.e., within 1 mile, is a mixture of commerce and residential dwellings. The occupancy factor — the proportion of time throughout the year that these structures are occupied — is assumed to be 1/4 for business activities, and 1.0 for private dwellings. The number of people is estimated for each type of structure, multiplied by the occupancy factor, and summed to estimate the total population that might be continuously present (see Fig. 4).

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TABLE 2

Annual Penetrating Radiation Dose Measured

Near SLAC Boundaries - 1980

PMS	Gamma (mrem)			Neutron (mrem)		
No.	Total	Background	Net	Total	Background	Net
1(c)	70	68	(a)	12	12	(a)
2(b)	32	31	(a)	7.5	6.2	(a)
3(b)	33	31	(a)	7.2	6.2	(a)
4(b)	54	52	(a)	8.7	7.8	(a)
5(b)	38	35	(a)	7.8	6.6	(a)
6(c)	75	70	(a)	11	13	(a)

(a) Within normal fluctuation of background radiation.

(b) Six months of data operated during July - December, 1980.

(c) PMS-1 and 6 operated entire year January - December, 1980.

TABLE 3

Summary of Radiation Measurements by Pathway

During Calendar 1980

Exposure Pathway	Maximum Annual Dose mrem	Percent of Standard	Man-Rem Estimate	
			SLAC	Background
Penetrating [a]	(c)	< 0.5	(c)	204
Water	(b)		(c)	50(d)
Airborne	(c)	< 0.5	(c)	
Total	(c)	< 0.5	(c)	250

(a) Maximum measured value at PMS.

(b) Because of heavy construction, water samples were not collected (see text).

(c) Below significant levels (< 2 man-rem).

(d) 25 mrem per person for internal dose from natural radioactivity[5] or ~50 man-rem to population near SLAC.

TABLE 4

Nonradioactive Effluent Monitoring Results

for Sanitary Sewer - 1980

Analysis	Standard (mg/ℓ)	Results (mg/ℓ)
Arsenic	0.1	0.009
Cadmium	0.1	0.01
Chromium	1.0	< 0.005
Copper	1.0	0.80
Cyanide	1.0	< 0.02
Lead	0.5	0.1
Mercury	0.005	< 0.0001
Nickel	1.0	< 0.04
Phenol	1.0	< .005
Silver	5.0	< 0.007
Zinc	5.0	0.4
*TICH	0.002	< 0.002

* Total indicated chloronated hydrocarbons

TABLE 5

Nonradioactive Effluent Discharge Monitoring Report

(Cooling Tower Blowdown) - 1980

Parameter	Flow	pH	Temperature	Settlable Solids
Sample Frequency	Continuous	Continuous	Daily	Monthly
Range or MDL [a]	Meter	0.1 to 14.0	0.5	≥ 0.1
Units	Gal/d	NA [b]	°F	mg/l
Stand	NA	6.0 to 8.5	85	0.1
Cooling Tower 1201				
Minimum [c]	0	7.4	71	--
Maximum	18,400	8.5	75	0.3
Average	6004	NA	NA	< 0.05
Cooling Towers 101 & 1701				
Minimum [c]	0	7.2	51	--
Maximum	44,530	8.5	78	< 0.05
Average	13,900	NA	NA	< 0.05
Cooling Tower 1202				
Minimum [c]	0	7.4	63	--
Maximum	26,200	8.7	74	2.3
Average	6674	NA	NA	< 0.05

(a) MDL is minimum detectable level of concentration analyses.

(b) NA indicates not applicable.

(c) Cooling Tower Blowdown is activated by a conductivity controller and this is intermittent.

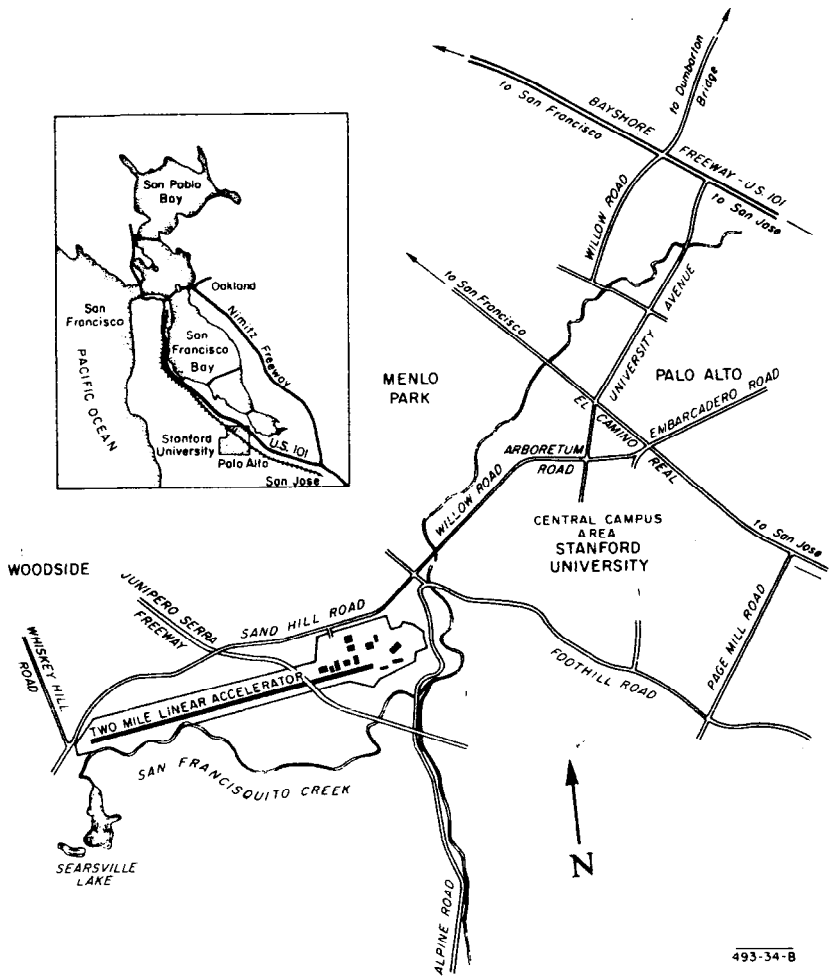

Fig. 1. Site location relative to Stanford University and surrounding communities.

Fig. 2. Air view of SLAC site showing the two mile accelerator, the research facility, and the principal laboratories and shops. In the foreground the PEP Interaction Regions can be seen, connected by the circumferential road.

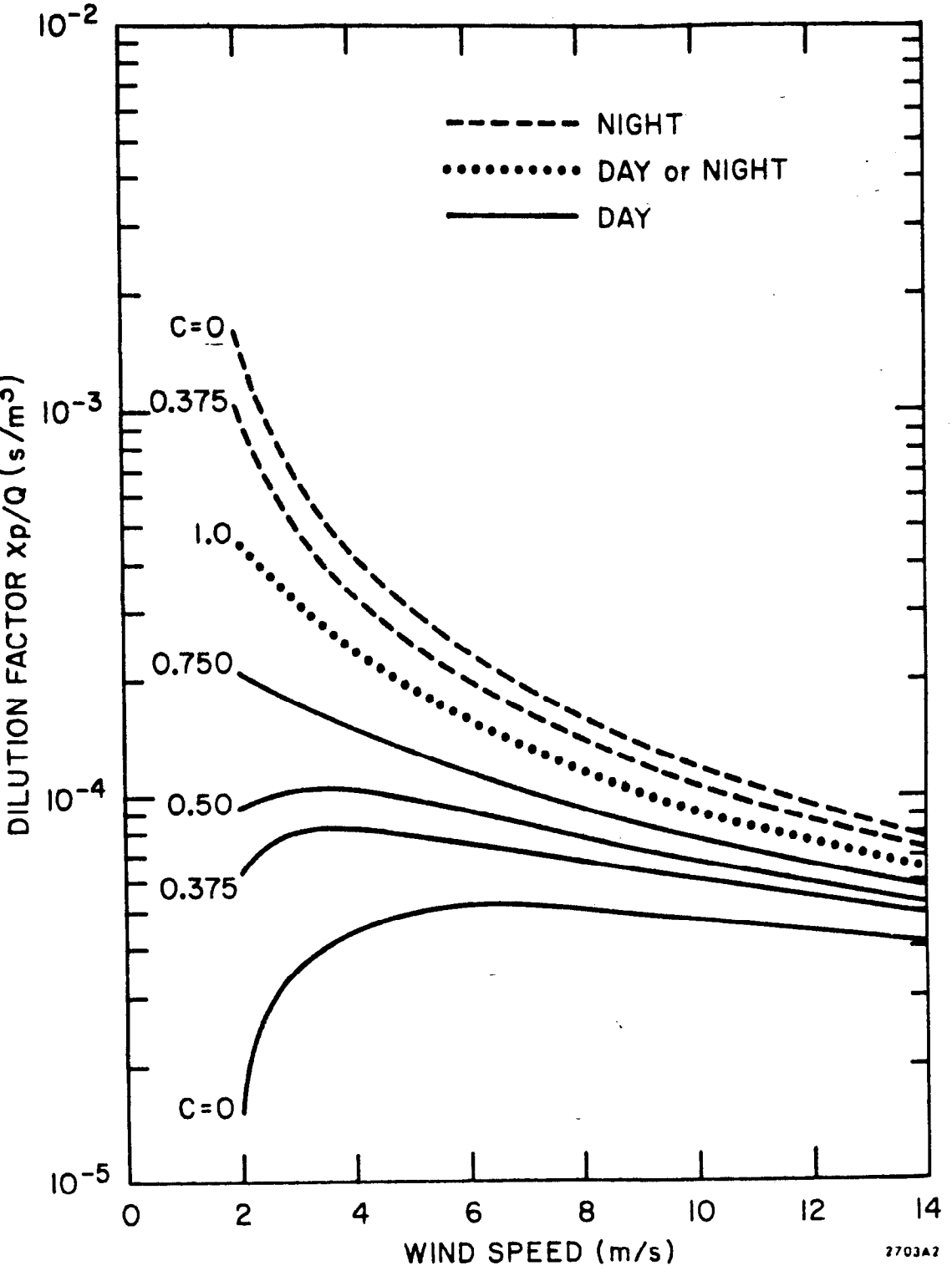

Fig. 4. Centerline dilution factor for various atmospheric conditions as a function of wind speed.

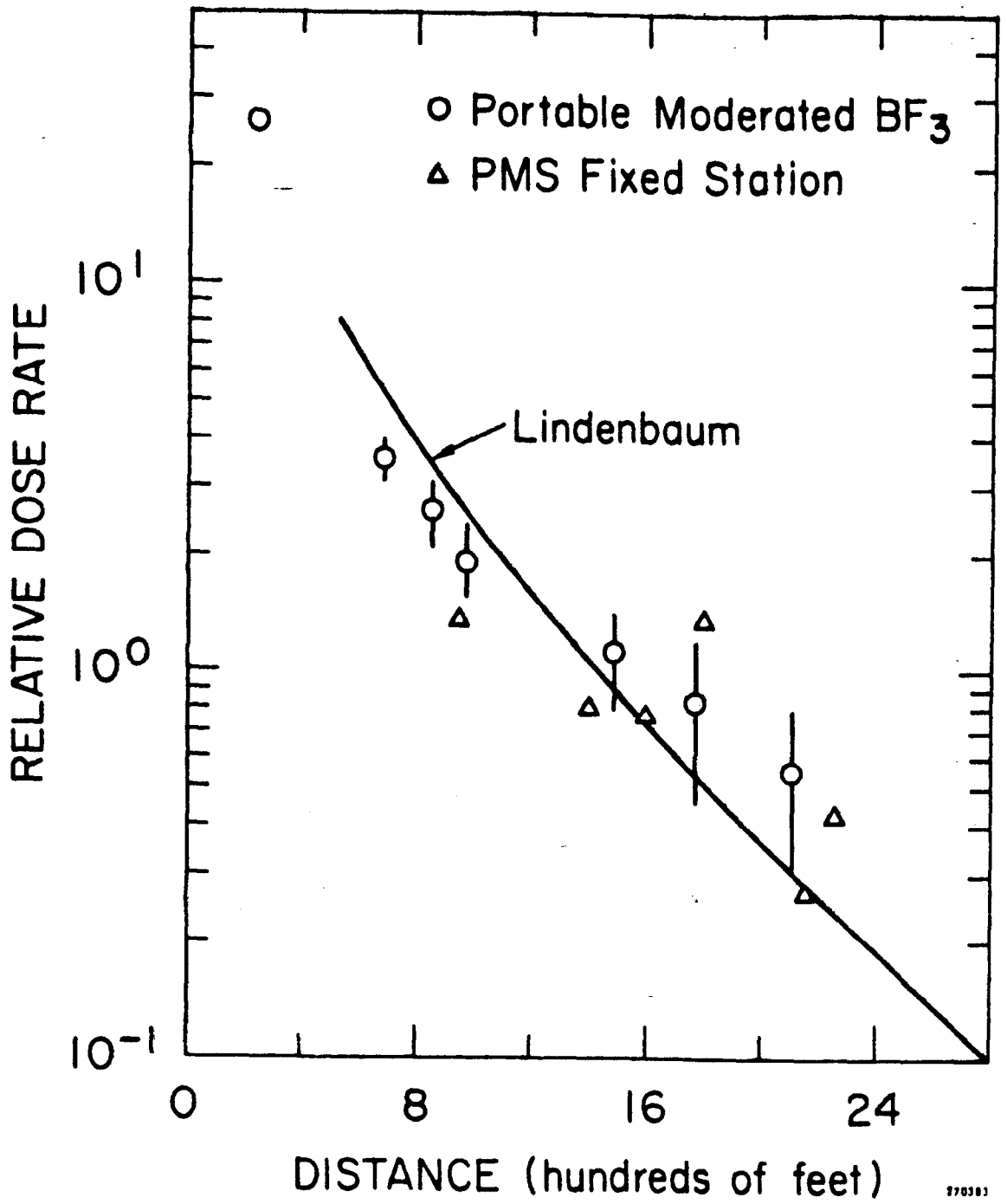

Fig. 5. Measurements made along a line between ESA and site boundary.