2.3 METEOROLOGY

2.3.1 INTRODUCTION

This section summarizes the meteorological studies that have been conducted since the start of the engineering and design of the CCNPP. The meteorological studies performed include work in the following main categories, listed in chronological order:

a. Preliminary Data Collection
b. Initial Site Weather Data Program
c. Special Vertical Wind Standard Deviation Tests
d. Land-Sea Wind Speed Investigation
e. Extended Onsite Penetration Wind Study
f. Calculation of Incident and Routine Long-Term Relative Concentrations

2.3.2 PRELIMINARY DATA COLLECTION

Proximal long-term weather station data were used from the Patuxent NATC - PAX (now Patuxent Naval Air Station - NHK) for periods of record from 1955-1960, and 1949-1964. In addition, meteorological data from Washington National Airport (DCA); Byrd Field, Richmond, VA, (RIC); and Annapolis, MD, (ANA) were used to evaluate the frequency of various weather parameters and certain meteorological extremes, respectively. See Regional Map, Figure 2.2-1. Also, statistical data for severe weather parameters were obtained from numerous official records issued by the Environmental Science Services Administration (ESSA), Department of Commerce, Asheville, NC.

The following weather information from the above sources was evaluated and related to the Calvert Cliffs Nuclear Plant Site: Tornadoes, Freezing Precipitation, Tropical Storms, Hurricanes, and Diffusion Conditions.

2.3.2.1 Tornadoes

Five tornadoes were observed during the period 1953-1962 in the general vicinity of a single latitude-longitude square near the proposed plant site. The mean annual frequency was 0.5 tornadoes per year and the probability of a tornado striking a single point within a single latitude-longitude square near Calvert Cliffs, using a method originally derived by H.C.S. Thom of ESSA, was calculated to be 3.75×10^{-4}. The recurrence frequency was calculated to be once about every 2,700 years.

2.3.2.2 Thunderstorms

Thunderstorm day statistics indicate that about 40 thunderstorms per year can be expected in the area. Fifteen years of records at Patuxent showed 814 observations of thunderstorm activities. From these data one can calculate the average duration of a thunderstorm to be 1.356 hours for a point. A study of 10 years of records for transmission subtransmission feeders was conducted. This study showed that transmission and subtransmission feeder losses were 4 minutes and 423 minutes, respectively, due to storms in a 10-year period. The subtransmission feeders covered an area of approximately 180 square miles.

2.3.2.3 Freezing Precipitation

The Patuxent NATC records (1949-1964) list 910 hours of snow and 265 hours of frozen or freezing precipitation, other than snow, for a total of 1175 hours (or 70,500 minutes) in 15 years. Interpolating for a 10-year span yields 47,000 minutes. The outages due to snow and/or freezing precipitation were 182 minutes and 122 minutes in 10 years, for transmission and subtransmission feeders, respectively. It is interesting to note that 9 of 12 outages occurred during

a single snowstorm in March 1958. Certain design changes were made as a result of this storm and it is unlikely that outages of this magnitude would again occur.

2.3.2.4 Tropical Storms and Hurricanes

Approximately one hurricane per year poses a threat to the area, and about one hurricane every 10 years produces a significant effect. Northeasters, or extratropical storms, also can influence the area in terms of flooding of low-lying land. The detrimental effects of northeasters are considerably less than those postulated for hurricanes in the site area.

2.3.2.5 Preliminary Diffusion Climatology

The frequency of various Pasquill classes of diffusion was initially assessed through the use of the familiar Pasquill-Turner method. The proximal Patuxent NATC data were used for a five-year period of record, which yielded the following results:

Pasquill Condition	Annual Percent Occurrence
A and B	2.6
C	10.4
D (day)	35.0
D (night)	28.2
E	11.8
F	8.0
G	4.0

Since it is possible to take advantage of offshore waterways in considering a site boundary, it was considered reasonable to limit discussion interest and calculations to onshore winds at the Calvert Cliffs site.

The onshore wind directions, by sector, are as follows:

a. North
b. North-Northeast
c. Northeast
d. East-Northeast
e. East
f. East-Southeast

The frequency of all winds from these directions was documented (over a five-year period) to be:

a.	Patuxent NATC	23.0%
b.	Washington National Airport	24.0%
c.	Byrd Field, Richmond, VA	30.0%
d.	Annapolis, MD	24.0%

Based on these total wind frequency samples, it was calculated that the frequency of inversion winds associated with onshore flow was as follows:

	Station	Pasquill "E"	Pasquill "F and G"
a.	Patuxent NATC	2.04%	1.35%
b.	Annapolis	1.97%	3.40%

In order to confirm the initial conclusions drawn above and to get a first approximation of typical Pasquill "F" conditions at the site, two additional station records were examined in detail. Five years of records from RIC and DCA were examined and a computer program was written to produce the frequency of winds equal to or less than X knots for the 0100 EST hour of the day when the cloud cover was equal to or less than .4 coverage. Values for wind speeds from 10 knots to calm were documented. The results indicated that the average Pasquill wind speed for RIC was 1.88 m/sec, while that for DCA was found to be 2.02 m/sec. The frequency of these conditions with onshore wind directions was found to be 2% at RIC and 3% at DCA. Since neither of these stations had as good exposure as would be anticipated for the Calvert Cliffs site due to the unrestricted fetch over the Chesapeake Bay, it was deemed conservative to select a wind speed of 1.5 m/sec as a typical onshore Pasquill "F" site condition.

In general, the site's low-level winds under a temperature inversion drain toward the Chesapeake Bay. It would not be possible for a ground-released effluent to get to the minimum site boundary under these conditions, and highly improbable that the ground release could get to the other inland boundaries due to terrain slope and other effects.

Wind persistence maxima for all wind sectors based on five-year record summaries at Annapolis, MD were as follows:

1 Sector	3 Sectors	5 Sectors
48 hrs	140 hrs	220 hrs

Washington National, Byrd Field, and Patuxent showed less persistent winds

MAXIMUM WIND PERSISTENCE FOR ONSHORE WINDS IN A SINGLE SECTOR (5 YEARS OF RECORD)

Station	Pasquill Condition	Maximum Persistence
DCA	1-3 knots winds	6 hrs
RIC	1-3 knots winds	6 hrs
PAX	"E" and "F"	12 hrs
ANA	"E" and "F"	12 hrs
PAX	All Speeds	27 hrs
ANA	All Speeds	37 hrs

Onsite low-level diffusion measurements were made at two primarily coastal locations during the periods from September 14, 1967, through November 9, 1968 at site N1W; and November 9, 1967 and through November 9, 1968, at site S1W. See Figure 2.3-1, Figure 2.3-2, and Table 2-10 for station locations and the description of meteorological instrumentation, respectively. In addition, temperature gradient approximations were made using two inland ground-level thermograph stations at the site at locations approximately 120' above mean sea level (MSL) and 40' MSL. These data also extended from November 9, 1967 to November 9, 1968.

The two coastal sites were selected initially because they:

a. offered good to excellent exposure to onshore winds; and
b. offered the only initial long-term exposure to winds unmodified by terrain and extensive tree cover.

The results of these onsite data comparison evaluations indicated the following:

a. Frequency of inversions derived from

1.	onsite data	31%
2.	long-term data	24%

b. Air drainage was toward the Bay under inversion conditions.

c. Average wind speed during inversion conditions was 2.6 MPS.

d. Standard deviation of horizontal wind direction (σ_θ) during worst, single-season wind sector inversion conditions averaged 6.6°.

e. When wind speed decreased, σ_θ increased, in general.

f. For on/or along-shore winds, the average value of $\sigma_\theta\bar{\mu}$ was 0.209 rad meters/sec.

g. χ/Q values at the 0.5% level of all conditions was 1.17x10^{-4} sec/m^3 for the 1150 meter minimum site boundary.

2.3.3 SPECIAL VERTICAL WIND STANDARD DEVIATION TESTS

2.3.3.1 General

Two sets of special diffusion tests were conducted at the Calvert Cliffs site. In both cases, both horizontal and vertical standard deviations of the wind conditions were measured.

2.3.3.2 Test Set 1 (October 17 to November 1, 1968)

In order to simulate actual reactor site location data, a standard anemometer was set up on a 40' bluff at Camp Conoy - just south of the reactor site. The anemometer permitted recording of wind direction and wind horizontal direction and its deviation. In addition, an σ_e meter was installed to evaluate the vertical standard deviations during this period.

The wind sensors were about 10' above the cliff area and about 40' inland. Results of σ_e Test Set 1 were as follows:

	Onshore Inversion Wind σ_e	Offshore Inversion Wind σ_e	"Neutral" Winds σ_e
Cases	16	122	157
$\bar{\sigma}_e$	13°	8°	14.3°
Lowest σ_e	1°	1°	1°
Cases <5°	1	35	9

2.3.3.3 Test Set 2 (February 11 through 20, 1969)

A second set of readings was taken during this period at Station 2 (about 2000' from the coastline). The companion statistics for Test Set 2 were follows:

	Onshore Inversion Wind σ_e	Offshore Inversion Wind σ_e	"Neutral" Winds σ_e
Cases	36	28	104
$\bar{\sigma}_e$	10°	13°	6°
Lowest σ_e	6°	2°	4°
Cases <5°	0	5	1

These readings were also taken about 10 to 12' above the ground, but with an unobstructed trajectory from an onshore viewpoint.

2.3.3.4 <u>Conclusions</u>

The sigma e values measured during these two test series both indicated that

a. Onshore inversion winds tend to produce near-neutral (Pasquill "D") σ_e values.
b. Offshore inversion winds tend to produce lower standard deviations than onshore cases near the coast, but somewhat larger inland.
c. Only one case in the total showed σ_e values as low as Pasquill "F".

2.3.4 LAND-SEA WIND SPEED INVESTIGATION

There was some concern expressed that the wind speed for onshore flow at the Station 4 (S1W) site was not representative for inland locations because the anemometer was in an area that is subject to a "Venturi" effect when the wind direction is onshore. In order to explore this possibility, this study compared the wind speed and diffusion values at the Station 4 (S1W) site to those on a raft anchored about one mile offshore.

For approximately one month of data, the diffusion parameter ($\sigma_\theta \bar{\mu}$) (STUB) was compared at each site where simultaneous onshore flow occurred at the sites. The average wind speeds at the two sites were also compared. Table 2-11 gives the results of the 256 simultaneous onshore winds and compares them to the classical Pasquill inversion classification values. The data indicated the following:

a. Only 1 observation of 256 at S1W gave $\sigma_\theta \bar{\mu}$ value equivalent to Pasquill "F".
b. Wind speeds were generally lower at S1W than at the raft, but wind deviations were larger.
c. The only possible Venturi effect noted at S1W was when the wind was onshore and the speeds were 3 mph or less.

2.3.5 THE PENETRATION ONSHORE WIND STUDY

The primary purpose of this extended meteorological investigation at the Calvert Cliffs site was to further refine the atmospheric dispersion parameters obtained from the initial site weather data program for use in the calculation of the relative concentration, χ/Q, at the site boundary nearest the reactor. Of secondary importance was to examine any anomalous flow features detected at the site and discuss its relevance to site diffusion characteristics.

Three inland meteorological stations were set up along with Station 4 (S1W). All four stations became active January 10, 1969 at the Calvert Cliffs site. In addition, temperature gradient systems were installed at Stations 2 and 4. See Figure 2.3-1 and Table 2-12 for station locations and instrumentation. A computer program was developed to analyze the wind flow across the site using the simultaneous wind observations from the four stations as input. The wind speed at each of the four stations was conservatively read to the lowest whole mph.

Standard techniques for evaluation of short-term releases (Pasquill "F", wind direction invariant, $\bar{\mu}$ = 1 MPS), were compared with measured parameters to determine, within conservative limits, the proper values applicable to this specific location.

The low percent probability level of $\sigma_\theta \bar{\mu}$ values was considered over the area collectively. The procedure was to select only those hours when the wind at Station 1 (K) was blowing onshore and also where at least two of the stations a $\sigma_\theta \bar{\mu}$ value of $\leq$ 0.200 existed.

Results for the one year extended study showed inversion conditions for 35% of the total observations, neutral conditions for 47%, and lapse for 17%, with 1% of the observations

missing. The winds showed a definite tendency to drain offshore during inversions; for the onshore winds, nearly 18% were in the neutral category, 9% in the unstable, and less than 4% in the stable category. The cumulative frequency distribution by wind speed category of on/or along-shore inversion winds for the four stations is given in Table 2-13 in terms of the total observations.

2.3.6 CALCULATION OF INCIDENT AND ROUTINE LONG-TERM RELATIVE CONCENTRATIONS

Two types of relative concentration calculations are of interest at the Calvert Cliffs site. The first are the 0-2 hour, 2-24 hour, and 1-30 day values which are used to determine the resulting radiation exposure from all of the postulated incidents. The second type is that pertinent to routine gaseous releases at the site.

2.3.6.1 Calculation of the Zero to Two-Hour Relative Concentration

For the first two hours following a postulated "maximum hypothetical accident," the relative concentration is calculated by the Gifford wake model for a ground release:

$$\frac{\chi}{Q} = \frac{1}{\bar{\mu}\left(\pi\sigma_y\sigma_z + cA\right)}$$

where:

$\frac{\chi}{Q}$	=	relative concentration, seconds/m^3
$\bar{\mu}$	=	average wind speed, meters/sec
$\sigma_y\sigma_z$	=	standard deviations of the distributed material in the lateral and vertical directions, in meters
c	=	wake factor (dimensionless)
A	=	cross-sectional area of structure from which material is presumed to be released, square meters

From the data in Table 2-13 it was determined that 5% of the time the on/or along-shore winds at Station 1 had speeds of 3.2 MPS or less; the comparable speeds at the 5% level for Stations 2, 3, and 4 are 1.1 MPS, 1.7 MPS, and 2.1 MPS, respectively. The average of the four stations at the 5% level is 2.0 MPS. This shows that relatively strong flow is available for on/or along-shore inversion wind directions even at the 5% frequency level at the site.

The 0-2 hour relative concentration was evaluated at various frequency levels of the statistic STUB, the product of sigma theta and u-bar, using a very conservative technique. The technique was to select the average of the two lowest of the four simultaneous values of STUB observed for on/or along-shore winds, and to array these averages in the order of frequency of occurrence. Assuming that the wind speed was one meter per second, the corresponding values of were tabulated, and the corresponding values of σ_θ for a distance of 1150 meters (the distance to the nearest site boundary) were selected. A wake factor of cA = 0.5x1640 M^2 = 820 M^2, and a σ_z value of 24 meters were used. The relative concentrations are shown in Table 2-14 for the 1% through 10% frequency levels.

The value of σ_z = 24 meters was selected as being compatible with the Pasquill "E" category for the 1% STUB level, using a wind speed of one meter per second. The previously referred to measurements of σ_e showed that a selection of Pasquill "E" for the vertical fluctuations was highly conservative.

A value for the 0-2 hour χ/Q of 1.3×10^{-4} sec/m^3 was selected for the radiation exposure calculations in Chapter 14 resulting from the containment wall release pathway. Meteorological conditions resulting in this value or higher for the 0-2 hour relative concentration will occur less than 5% of the time. For releases from the plant vent stack, main steam gooseneck, and refueling water tank vent, a 0-2 hour χ/Q of 1.44×10^{-4} sec/m^3 was calculated based on a zero cross-sectional area.

2.3.6.2 Calculation of the 2-24 Hour and 1-30 Day Average Relative Concentrations

Average relative concentrations for periods of 10 hours, 12 hours, and 29 days were calculated utilizing the onsite data acquired at Calvert Cliffs. No credit was taken for the wake factor of the plant structure and a minimum site boundary of 1150 meters was assumed in all 16 sectors.

The meteorological station with the lowest STUB value, Station 4 (S1W), was selected for this study. No Pasquill class with more diffusion than Pasquill "C" (slightly unstable) was considered and a ground-release accident model was assumed. As was done with the 0-2 hour χ/Q, the 2-24 hour and the 1-30 day values were also selected at the 5% frequency level. The resulting values were as follows:

Time Period	5% Probability Level χ/Q at 1150 meters (sec/m^3)
2-24 hrs	9.10×10^{-6}
1-30 days	2.70×10^{-6}

The 5% values are shown as a function of distance on Figure 2.3-3 for all of the incident-related time periods.

2.3.6.3 Calculation of Routine Long-Term Concentrations

The average annual relative concentrations, χ/Q which are applicable to routine venting or other routine operational gaseous effluent releases, have been determined for the final annual data record in accordance with the following equations:

$$\frac{\chi}{Q(i,D)} = \frac{\sqrt{2}}{\sqrt{\pi}} \sum_{p=A}^{G} \frac{R(p)}{\sigma_z(p,D)} \frac{1}{DB}$$

Where $R\rho$ =

$$\sum_{k=1}^{K} \frac{0.01 f(k)}{\mu(k)}$$

$\frac{\chi}{Q(i,D)}$ = relative concentration (sec meter^{-3}); at a distance D (meters) from the effluent source; in direction sector i

p = Pasquill class (A through G)

f(k) = percent frequency wind blows toward sector i, within speed interval k, during Pasquill class condition p

$\mu(k)$ = Wind speed value representative of speed class interval, k, MPS

$\sigma_z(p,D)$ = vertical dispersion coefficient, meters, for Pasquill class p, at distance D

B = spread of wind sector, radians = $\pi/8$, for 22-1/2° sectors.

These equations and resultant calculations are appropriate for evaluating ground releases over longer time intervals. They do not include a wake factor term.

The Isopleths of the average annual concentration, shown in Figure 2.3-4 were calculated using the wind data and ΔT Pasquill class data of the final annual record. The maximum average on-shore relative concentration is 2.2×10^{-6} seconds meter^{-3} in the southeast sector at a distance of 1300 meters, which occurs as a result of the northwest winds and associated stability conditions. The site boundary in this direction is 2100 meters (Figure 1-1).

2.3.6.4 Average Annual Concentration at the Milk Samples Location

Milk samples were obtained from a location 4.2 miles southwest of the reactor site, during the period December 23, 1971 through June 5, 1976. Since this time, no samples have been available in the area.

The model used in the above section has been applied to this location. The average annual χ/Q is 7.0×10^{-8} and occurs with a northeast wind.

2.3.6.5 Continuing Studies

Additional studies were made to further refine the diffusion parameters. Included in these studies was an analysis of the data obtained at Station 2 (IS) between November 12, 1971 and November 11, 1972. This analysis showed that the diffusion characteristics specified in Section 2.3.6 are conservative.

Comparisons were made of ΔT data from the 12' to 48' system installed on the pole at Station 2 (IS) and the ΔT data from the "Sky Needle" 30' to 98' system also located at Station 2. The 12' to 48' system was continued in operation until September 1974.

A comparison study was made during the summer of 1974 to determine the correlation between meteorological data obtained from the "Sky Needle" 30' to 98' system at Station 2 and data obtained from the microwave tower system. The results of this study have been evaluated, and the remaining meteorological systems at Stations 2 and 4 were discontinued. The "Sky Needle" system was taken out-of-service August 14, 1975.

2.3.7 METEOROLOGICAL MEASUREMENT SYSTEMS

In accordance with the requirements of NUREG-0654 and Generic Letter 82-33 (Supplement 1 to NUREG-0737), a meteorological tower (Figure 1-1) was installed to provide the essential parameters used in support of dose assessment calculations for emergency preparedness. The meteorological tower and instrumentation design meets the intent of Safety Guide 23, February 1972, and Regulatory Guide 1.97, Revision 3, for primary meteorological measurements systems.

The instrumentation on the meteorological tower is described in Table 2-12. Signals from the wind and temperature sensors are transmitted to the plant Control Room where ΔT, W_s, W_d, σ_θ, and rain water level can be continuously monitored by the operator. The meteorological tower, located at the end of Road B-1, has been operational since April 1982. Subsequently, the Technical Specifications were amended to designate the new meteorological system as the "primary" meteorological system as addressed in Regulatory Guide 1.23, Revision 1, and the old microwave tower became a backup system. The meteorological instrumentation on the old microwave tower was taken out-of-service in the fall of 1993. The current primary and backup meteorological

measurement systems are described in the Emergency Response Plan and its implementing procedures.

2.3.8 INVESTIGATION OF RELATIVE CONCENTRATION FREQUENCIES USING THERMAL STABILITY PARAMETERS

During the investigation of the meteorological conditions at Calvert Cliffs, the almost universal acceptance of sigma theta to define diffusion qualities was questioned. This was in part due to the uncertainties of the sigma theta measurements in defining vertical plume growth. Also with winds at 2 to 3 mph or less, the measurement of sigma theta becomes difficult. Yet, in evaluations of the accident hazards, the periods of low wind speeds are the most critical. For these reasons the need for a Calvert Cliffs diffusion climate evaluation which does not depend upon sigma theta measurements was assessed.

2.3.8.1 The Requirement For Additional Meteorological Evaluation at Calvert Cliffs

The Calvert Cliffs site analyses in Section 2.3.6 use sigma theta measurements to define horizontal plume growth only. The uncertainties of the relationships between these measurements and vertical plume growth do not, therefore, cloud the validity of these analyses. Further, the 5% worst weather conditions of most concern for the accident evaluations are those with on-shore winds at low speeds. With on-shore directions conservatively defined to include nine 22-1/2° sectors, NW through SE clockwise, at Station 2 (IS) at 12' above grade, on-shore winds at 3 mph or less occur 12% of the time. This 12% frequency includes the unstable and neutral as well as the stable (winds have subsequently been measured at 33' above grade. At this elevation, on-shore winds of 3 mph or less occur less than 5% of the time.) It is unlikely, therefore, that the analysis based on sigma theta measurements are significantly biased by difficulties of measuring sigma theta at low wind speeds. Nevertheless, to remove the residual uncertainties in 1969 Baltimore Gas and Electric Company began to measure and record vertical temperature gradients near the ground for use in classifying site stability characteristics into inversion, neutral, and unstable conditions.

2.3.8.2 The Weather Data for the Independent Evaluation

The vertical temperature gradient (ΔT) was measured continuously between 12 and 50' above grade at Station 2 from 1969 through September 14, 1974. Concurrently, an MRI 2040 wind instrument was installed at 33' above grade (as opposed to the prior wind instrumentation at 12' above grade) to measure wind speed and direction and values. Hourly averages of wind speed and direction, and one-an-hour 20 minute averages of were recorded. There were two sources of σ_θ data available with the MRI 2040 wind instrument, sigma meter readings and wind range measurements. The data were compared and wind range measurements, divided by six to obtain σ_θ, in accordance with the standard procedures, gave uniformly-lower values at the smaller σ_θ readings. The range measured σ_θ values were, therefore, used in this analysis because they provide more conservative estimates of the site diffusion quality.

Subsequent to the initiation of this program, it became an accepted practice to classify stability conditions into the standard Pasquill classes by the use of ΔT values in accordance with the following table of values.

PASQUILL CLASS	ΔT° C/100 meters
A	≤ -1.9
B	-1.9 to -1.7
C	-1.7 to -1.5
D	-1.5 to -0.5
E	-0.5 to +1.5
F	+1.5 to +4.0
G	≤ +4.0

To take advantage of this accepted practice, the validity, for Pasquill classification purposes, of the 12 to 50' ΔT data has been investigated by a comparison with concurrently observed 12 to 97' data, as shown in Figure 2.3-5 and Table 2-15.

For the shallower layer, 2 to 3% more of the observations fell in the critical Pasquill E, F and G classes, and 2 to 3% less in classes B, C, and D.

Because the atmospheric layer upward from 30' above grade was becoming the standard layer for determination of thermal stability Pasquill classes, the validity of the 12 to 50' layer data was further investigated by a comparison with concurrently observed 30 to 97' ΔTs at Station 2, as shown in Figure 2.3-6. On this figure, the dashed line is the line showing equal lapse rates for both layers. It is apparent that the assignment of Pasquill classes using the 12 to 50' layer ΔTs is very conservative in comparison with the use of the standard layer based at 30' above grade.

Data observed at Station 2, from November 1969 through October 1970, were selected for the Primary Year of Record. There were gaps in this record caused by equipment malfunctions. To complete the record and eliminate a potential seasonal bias, 1971 data were added to it, thereby creating the Final Annual Record. These added data are limited to dates and hours of the day which coincide with the data gaps in the Primary Year of Record.

2.3.8.3 The Zero to Two-Hour Relative Concentration Determined by ΔT and σ_θ Parameters

Relative concentrations for each hour of the final annual record have been calculated using the equations in Section 2.3.6.1 but with the uncertainties associated with σ_θ measurements eliminated. σ_y and σ_z values were fixed by the Pasquill classes, as before. However, two sets of Pasquill Classes were defined; one set based upon the ΔT measurements using the table in Section 2.3.8.2 and the other set using the measurements as recommended in Meteorology and Atomic Energy. All vertical dilution factors (σ_z), plus those horizontal dilution factors (σ_y) associated with wind speeds at 3 mph or less, were determined by the ΔT Pasquill classes. The horizontal dilution factors (σ_y) associated with winds greater than 3 mph were determined by the σ_θ Pasquill Classes. On-shore and along shore wind directions were conservatively selected to include the nine sectors NW through SE, clockwise. The hourly relative concentration values occurring with these wind direction were ranked and placed in a cumulative frequency distribution in accordance with the accepted practice at coastal sites for evaluation of accident conditions as shown in Figure 2.3-7. The relative concentration which is exceeded only 5% of the time during the year is 1.3×10^{-4}

seconds per cubic meter. In view of the very conservative nature of the 12 to 50' ΔT data, as evidenced in Figure 2.3-6, and of the conservatism of the σ_θ data as evidenced by a comparison with the concurrently observed sigma meter readings, this 5 percentile relative concentration value is conservative indeed.

It is concluded that, considering both the ΔT and σ_θ data observed at the Calvert Cliffs site, a relative concentration of 1.3×10^{-4} seconds per cubic meter is a very conservative value, and is appropriate for the 0-2 hour accident evaluations. This relative concentration is equivalent to a meteorological condition which may be defined as Pasquill E and a wind at 1.4 MPS.

Details of the concurrent values of wind speed and direction and ΔT and σ_θ Pasquill Classes for the Final Annual Record are presented in Figure 2.3-10, Sheets 1 through 14. The same data are presented in Figure 2.3-10, Sheets 13 through 28 except that the 1971 data observed after the Primary Year of Record have been omitted.

2.3.8.4 A Critique of the Data Record for the Independent Evaluation

A calendar of data availability is presented in Table 2-30. It can be seen from this table that the Primary Year of Record, November 1969 through October 1970, provides the most complete 12-consecutive-month data record during the November 1969 through October 1971 period.

To fill in the data gaps which might be the cause of a seasonal bias in the Primary Year of Record, 1971 data coincident with the dates and times-of-day of the data gaps have been added in this Final Annual Record used in the analysis. A calendar of data in this Final Annual Record is presented in Figure 2.3-8, which shows the dates for which no data is available from November 1969 through October 1971. The sequence of overall data availability is presented in Figures 2.3-8 and 2.3-9.

The Final Annual Record data is quite complete with less than 10% missing observations; 8% occurring in consecutive-day lots, and 2% in periods of less than a day duration. The consecutive-day lots range from four to six days duration, occurring in January, April, August, and November. Because of the distribution of this missing data, it is very unlikely that it has contributed a seasonal or diurnal bias to the data record.

The data added to the Primary Year of Record to fill in its gaps, thereby producing the Final Annual Record, were added to ensure that a potential seasonal bias in the data record was eliminated. Data were added only to replace data lost because of equipment malfunctions, and they were only added to the extent that 1971 data, coincident with the dates and times-of-the-day of the equipment malfunction, were available. Although added data constitute 20% of the Final Annual Record, they could not create a bias in the record.

2.3.9 RECENT DATA COLLECTION

The following sections summarize the meteorological studies that were conducted to obtain information for use in the design of the Diesel Generator Building for Diesel Generator 1A.

2.3.9.1 Strong Winds

As illustrated in Reference 2, the average velocity for CCNPP's "fastest mile" of wind with a mean return period of 100 years is 100 mph. Reference 2 used

records of the fastest mile as published by the United States Weather Bureau from data obtained at airport stations.

2.3.9.2 Snow Storms

Monthly snowfall depth data from the weather stations at Baltimore, Maryland (1958 to 1989) and the Patuxent River Naval Air Station, Lexington Park, Maryland (1976 to 1992) were used to estimate the 100-year ground snow pack level at the CCNPP site. Frequency analyses were performed on the monthly snowfall records for the months of December, January, February, March, and the combined snowfall total for the months of January and February. The snowfall total for the combined months of January and February, 59", was chosen to represent the 100-year snow pack on the ground.

2.3.10 REFERENCES

1. Meteorology and Atomic Energy 1968, USAEC Division of Technical Information
2. S. C. Hullister, The Engineering Interpretation of Weather Bureau Records for Wind Loading on Structures, Cornell University, Ithaca, NY

TABLE 2-10

FIRST YEAR ONSITE METEOROLOGICAL STATIONS AND INSTRUMENTATION CALVERT CLIFFS NUCLEAR POWER PLANT

DESIGNATION	LOCATION	ELEVATION	PERIOD	INSTRUMENTATION
Station 1[(a)] "N1W" North	N11,916 E10,403	100' MSL +10' Mast	09/14/67-11/11/68	Packard Bell (Beckman-Whitley, Inc.) Model K-100 with Quick-D Vane Wind System
			09/14/67-11/15/67	Cassella Thermograph
			12/14/67-11/11/68	Standard US Weather Bureau Rain and Snow Gauge
Station 4 "S1W" Conoy South	N8,400 E1,060,000	90' MSL +50' Mast	11/09/67 Use Discontinued, Date Unknown	Packard Bell Electronics Corporation (Beckman-Whitley, Inc.) Model K-101 with Quick-D Vane Wind System
Station UT1 Upper	N10,000 E8,162	120' MSL +4' Shelter	11/15/67 to 12/31/68	Cassella Thermograph installed in standard US Weather Bureau Cotton-Region type shelter
Station LT1 Lower	N8,642 E9,590	40' MSL +4' Shelter	11/15/67 to 12/31/68	Same as Station UT1
Test Site Camp Conoy	N7,600 E1,055,000 N7,625 E1,000,000	40' MSL +12' Masts 60' MSL	10/17/68 11/01/68	Meteorology Research, Inc. (MRI) Mechanical Weather Station Model 1072 with rain gauge; (2) MRI vector vane Sigma Meter Model 1053 and (3) MRI Mechanical Weather Station Model 1071

(a) Temporary Location

TABLE 2-11

RESULTS OF 256 SIMULTANEOUS ONSHORE WINDS IN RAFT STUDY AS COMPARED TO CLASSICAL PASQUILL INVERSION CLASS VALUES

SITE PASQUILL CLASS	AVG. $\sigma_\theta \bar{\mu}$ (rad m/sec)	Ave. $\bar{\mu}$ (m/sec)	AVERAGE (degrees)
Raft	0.434	4.23 (9.5 mph)	7.2
Station 4 (S1W)	0.492	3.41 (7.6 mph)	8.3
Classical "F"	0.044	1.00 (2.2 mph)	2.5
Classical "E"	0.175	2.00 (4.5 mph)	5.0

TABLE 2-12

ONSITE METEOROLOGICAL SYSTEMS AND INSTRUMENTATION CALVERT CLIFFS NUCLEAR POWER PLANT

DESIGNATION	LOCATION	ELEVATION	PERIOD	INSTRUMENTATION
Microwave Tower	N9,770 E8,809	75' MSL +40' & 125' & 220'	8/8/73 - Fall 1993	125' & 200' MRI 2040 Wind Diffusion System
			8/8/73 - Fall 1993	40', 125' & 200' Weathermeasure Corporation Aspirated Radiation Shields with Rosemount Sensors (Temperature Gradient System)
			8/23/73 - Fall 1993	125' Weathermeasure Corporation Dewpoint System
Meteorological Towers				
a. Primary Tower	N10,560 E7,710	110' MSL +33' & 197'	1982 - Current	197' & 33' Wind Sensors
			1982 - Current	197' & 33' Temperature Sensors
			1982 - Fall 1995	33' Dewpoint Sensor
b. Backup Tower	N10,422 E7,709	110' MSL +33'	1982 - Current	0' Rain Gauge
			2005 - Current	33' Wind Sensor
			2005 - Current	33' Temperature Sensor
Station 1 "K" Knoll	N10,895 E10,435	48' MSL +12' Mast	1/3/69 to 11/4/70	Meteorology Research, Inc. (MRI) Mechanical Weather Station, Model 1072 Wind System with Precipitation Gauge
Station 2 "IS" Inner South	N9,530 E8,720	48' MSL +12' Mast	1/9/69 to 1/12/70	MRI Mechanical Weather Station, Model 1071
			2/11/69 to 2/20/69	MRI Vector Vane Sigma Meter Model 1053
		48' MSL +12' & 49.5'	5/15/69 to 9/4/74	Temperature Gradient System, Packard Bell Corp. (Beckman-Whitley) Model 327 Aspirated Radiation Shields
		48' MSL +12' Mast	6/1/69 to 8/7/69	MRI 2040 Wind Diffusion System
		48' MSL +33'	8/7/69 to 5/15/71	MRI 2040 Wind Diffusion System

TABLE 2-12

ONSITE METEOROLOGICAL SYSTEMS AND INSTRUMENTATION CALVERT CLIFFS NUCLEAR POWER PLANT

DESIGNATION	LOCATION	ELEVATION	PERIOD	INSTRUMENTATION
		48' MSL +33' & 97'	5/15/71 - 8/14/75 9/29/71 - 8/14/75 7/17/71 - 8/14/75	MRI 2040 Wind Diffusion System Temperature Gradient System. Weathermeasure Corp. Aspirated Radiation Shields with Rosemount Sensors Beckman-Whitley Model WS-101 Quick Vane Wind System
			3/13/72 - 1/11/74	Gill Anemometer Bivane
Station 3 "BW" Boundary West	N12,375 E6,735	115' MSL +10' Mast	1/9/69 to 1/11/70	MRI Mechanical Weather Station Model 1071
Station 4 "S1W" Conoy South	N8,500 E10,550	90' MSL +50' Mast +12' & 49' Mast	1/10/69 to 5/13/75 This station was shut down for reworking during the summer of 1971. It was reactiviated 9/1/71.	Beckman-Whitley Model WS101 Wind System Packard Bell (Beckman-Whitley) Model 327 Aspirated Radiation Shields

TABLE 2-13

CUMULATIVE FREQUENCY DISTRIBUTION, PERCENT OF TOTAL OBSERVATIONS, FOR ON/ALONG-SHORE INVERSION WINDS

		STATION		
SPEED CLASS meters/sec	**1 (K)**	**2 (IS)**	**3 (BW)**	**4 (S1W)**
0.01 - 0.50	0.30%	2.52%	1.40%	0.55%
0.51 - 1.00	0.82	4.92	2.92	1.54
1.01 - 2.00	2.46	7.66	6.11	4.91
2.01 - 3.00	4.28	9.66	7.94	8.53
3.01 - 4.00	5.78	10.67	8.55	11.01
4.01 - 5.00	7.44	11.23	8.68	12.59
5.01 - 6.00	8.01	11.36	8.71	13.02
6.01 - 8.00	8.57	11.37	8.71	14.14
8.01 -10.00	8.87	11.37	8.71	14.17
10.01	8.98	11.37	8.71	14.17
	8291[a]	8386[a]	8399[a]	6743[a]

[a] Number of valid observations in each record.

TABLE 2-14

LOW-FREQUENCY χ/Q VALUES FOR ON-ALONG SHORE INVERSION WINDS AT CALVERT CLIFFS NUCLEAR STATION

% LEVEL OF OCCURRENCE	STUB (radian-M/sec)	σ_y (M)(1150M)	σ_z (M)(1150M)	χ/Q (0-2 hrs) (sec/m^3)
1	.097	59	24	1.89×10^{-4}
2	.130	66	24	1.72×10^{-4}
3	.158	74	24	1.56×10^{-4}
4	.185	83	24	1.41×10^{-4}
5	.208	92	24	1.29×10^{-4}
6	.228	103	24	1.17×10^{-4}
7	.243	110	24	1.09×10^{-4}
8	.258	116	24	1.045×10^{-4}
9	.273	124	24	9.85×10^{-5}
10	.287	133	24	9.20×10^{-5}

TABLE 2-15

THE FREQUENCY OF CONCURRENTLY OBSERVED ΔT VALUES FROM THE 50-12 FT AND 97-12 FT LEVELS ABOVE GRADE

97-12 ft	50-12 ft ΔT														
ΔT	≤0.5	-0.4	-0.3	-0.2	-0.1	0	+0.1	0.2	0.3	0.4	0.5	0.6	0.7	+0.8	≥0.9
≤0.9	924	52	41	61	46	68	20	39	20	10	7	9	3	1	15
-0.8	12	8	5	5	3	3	0	1	0	0	0	2	1	1	0
-0.7	11	4	6	4	3	0	1	0	1	0	1	0	1	0	1
-0.6	19	6	9	8	1	3	0	1	1	2	1	3	0	2	6
-0.5	16	12	9	9	2	16	2	0	0	0	0	0	2	2	2
-0.4	14	16	11	8	3	21	6	4	2	0	1	0	2	1	3
-0.3	6	12	11	13	5	34	8	3	2	0	0	0	0	1	1
-0.2	4	4	3	9	2	12	6	2	1	0	0	1	1	0	2
-0.1	4	2	5	9	4	9	2	3	1	1	0	0	0	0	2
0	4	3	4	1	3	9	3	4	2	0	0	0	0	0	4
+0.1	3	1	5	1	1	4	1	6	2	0	1	1	1	0	3
0.2	0	0	0	4	0	3	2	2	2	0	1	0	1	0	5
0.3	0	0	0	1	0	0	2	1	3	1	1	0	0	1	6
0.4	0	0	0	0	0	3	0	2	1	2	1	1	0	0	2
0.5	1	1	0	0	0	0	1	3	1	1	1	1	0	0	6
0.6	1	0	1	3	1	3	1	2	2	0	2	1	1	1	10
0.7	0	0	1	0	0	2	1	1	0	0	0	0	0	0	6
0.8	1	0	0	0	0	0	0	0	1	0	0	5	0	2	5
0.9	0	0	0	0	0	1	2	1	1	3	1	0	1	1	5
1.0	0	0	0	1	0	0	0	0	0	1	3	0	1	1	7
1.1	0	0	1	0	0	1	0	1	0	0	0	1	2	0	9
1.2	0	0	0	0	0	0	0	1	1	0	0	0	1	2	5
1.3	0	0	0	0	0	0	0	1	0	2	0	0	0	2	8
1.4	0	0	0	0	0	0	0	0	0	1	1	1	0	0	5
1.5	0	0	0	1	0	0	0	0	0	0	1	0	0	0	6
1.6	0	0	0	0	0	0	0	1	0	0	2	2	1	0	7
1.7	0	0	0	0	0	0	0	0	0	0	1	0	0	1	8
1.8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6
≥1.9	0	0	1	2	1	5	3	1	3	0	7	4	12	7	215

Observations were made between May 14, 1971 and September 29, 1971.
Tables 2-16 through 2-29 were deleted, see Figure 2.3-10.

TABLE 2-30

CALENDAR OF METEOROLOGICAL DATA AT STATION 2 FROM NOVEMBER 1969 THROUGH OCTOBER OF 1971

Number of Days with 12 or more hours of valid data.

PARAMETER	NOV 69	DEC 69	JAN 70	FEB 70	MAR 70	APR 70	MAY 70	JUN 70	JUL 70	AUG 70	SEP 70	OCT 70
ΔT	23	30	24	28	31	14	20	30	31	28	30	28
Wind Dir	27	31	31	28	31	30	31	26	31	27	8	0
Sigma Theta	27	31	31	28	31	30	31	26	31	27	8	0
Wind Speed	30	31	31	27	31	30	31	26	31	27	15	4
All	23	30	24	27	31	14	20	26	31	24	8	0
Running 12-Month Totals												
ΔT	--	--	--	--	--	--	--	--	--	--	--	317
Wind Dir	--	--	--	--	--	--	--	--	--	--	--	301
Sigma Theta	--	--	--	--	--	--	--	--	--	--	--	301
Wind Speed	--	--	--	--	--	--	--	--	--	--	--	314
All	--	--	--	--	--	--	--	--	--	--	--	258

PARAMETER	NOV 70	DEC 70	JAN 71	FEB 71	MAR 71	APR 71	MAY[a] 71	JUN 71	JUL 71	AUG 71	SEP 71	OCT 71
ΔT	30	27	30	28	30	30	31	20	30	24	30	29
Wind Dir	14	14	26	28	20	19	28	20	26	25	30	29
Sigma Theta	14	14	26	28	20	19	28	20	26	25	30	29
Wind Speed	21	31	22	26	20	19	28	28	29	24	27	29
All	8	12	16	26	19	19	28	17	25	16	27	29
Running 12-Month Totals												
ΔT	324	321	327	327	326	343	354	344	343	339	339	340
Wind Dir	288	271	266	266	255	244	241	235	230	228	250	279
Sigma Theta	288	271	266	266	255	244	241	235	230	228	250	279
Wind Speed	305	305	296	295	284	273	270	272	270	267	279	304
All	243	225	217	216	204	209	217	208	202	194	213	242

[a] Much of the wind data from May through September 1971 was observed at 100' above grade.