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A STUDY OF ATMOSPHERIC DIFFUSION CONDITION PROBABILITIES USING THE COMPOSITE YEAR OF INDIAN POINT SITE WEATHER DATA [Historical Information]

by:

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2.6.M-1

Introduction

A study is presented below which compares atmospheric diffusion condition probabilities for the Indian Point site computed using various models. Several of these models realistically take into account characteristics of the Indian Point site. The cases studied account for the following: (1) effect of allowing diffusion for the distance to the nearest land not owned or controlled by Consolidated Edison in each direction (i.e., the effluent is assumed to diffuse for the real distance to the boundary, not just to the minimum site boundary radius), (2) effect of using the "split sigma" model to account for lateral wind meander, and (3) effect of averaging diffusion conditions over a two-hour period. Use of these realistic assumptions result in significant reductions in diffusion estimates.

Background

Meteorological data have been taken on a 100 ft tower at the Indian Point site for several years. To provide the most representative one-year period of data, a "composite year" was constructed using the most complete month from the total period of record available. Following is a summary of the data used.

Parameter	Measured Height	Percent Data Recovery
Wind Speed	100 ft	97.6
Wind Direction	100 ft	98.8
Temperature Difference	95 ft-7 ft	95.5

Basis Diffusion Model

From these data, centerline values of X/Q were computed for each hour of data using the following relationship:

$$Q / X = \frac{1}{\bar{u}(\pi \sigma y \sigma z + cA)}$$

where:

X = concentration ($\mu Ci / m^3$)

Q = release rate ($uCi / \sec$)

$\bar{u}$• = average wind speed for the hour measured at 100 ft and extrapolated to 33 ft (m/sec)

s y = horizontal diffusion coefficient (m)

s z = vertical diffusion coefficient (m)

cA = building wake factor (assumed to be c = 0.5, A = 2000 m^3).

The building wake effect is limited such that no more than a factor of 3.0 reduction in dilution is obtained for any condition. The wind speed is extrapolated to the 33 ft level in accordance with recent AEC practice. The method of extrapolation is according to the following relationship:

$$\bar{u}_{33} = \bar{u}_{100} \left(\frac{h_{33}}{h_{100}} \right)^n$$

where:

$\bar{u}_{33}$ = extrapolated wind speed (m/sec)

$\bar{u}_{100}$ = measured speed (m/sec)

h_{33} = height extrapolated to (ft)

h_{100} = measured height (ft)

n = exponent based on diffusion as follows

Pasquill Diffusion Group	Value of n

A	0.25
B	0.25
C	0.25
D	0.33
E	0.5
F	0.5
G	0.5

Since ground effects influenced the lower sensor at 7 ft, measured values of ΔT are multiplied by a factor as suggested by AEC. The method used to determine this factor assumes an exponential relationship between temperature and height such that measured temperature difference between any two heights can be represented as a temperature difference between two other heights according to the following relationship:

$$f(\Delta T \text{ correction factor} = \frac{\ln\left(\frac{h_{ue}}{h_{le}}\right)}{\ln\left(\frac{h_{um}}{h_{1m}}\right)}$$

where:

h_{ue} = height of upper extrapolated temperature (ft)

h_{le} = height of lower extrapolated temperature (ft)

h_{um} = height of upper measured temperature (ft)

h_{lm} = height of lower measured temperature (ft)

For Indian Point the factor is computed as follows: $f = \dfrac{\ln \frac{150}{33}}{\ln \frac{95}{7}} = \dfrac{1.51}{2.60} = 0.58$

Thus, all vertical temperature difference values are multiplied by this factor.

In this study, either vertical temperature difference (ΔT) is used or wind direction range (R) is used to determine values of s in the diffusion equations. The following table gives the values assumed for each Pasquill Diffusion Category.

Pasquill Category	(1) AEC ΔT Model* (°F/100')	(2) Wind Direction Range (s)
A	ΔT< -1.0	135 < R
B	-1.0 ≤ ΔT< -0.9	135 ³ R > 105
C	-0.9 ≤ ΔT< -0.8	105 ³ R > 75
D	-0.8 ≤ ΔT< -0.3	75 ³ R > 45
E	-0.3 ≤ ΔT< -0.8	45 ³ R > 22
F	0.8 ≤ ΔT< 2.2	22 ³ R > 12
G	2.2 ≤ ΔT	12 ³ R

*In conversion from °C/100 m (Safety Guide 23) to °F/100 ft, values were rounded to nearest tenth of a degree.

Two basic models are used. One is referred to as the "AEC ΔT Model" which utilizes the Safety Guide ΔT values to determine Pasquill category for use in determining both s y and s z. The "Split Sigma Model" determines the diffusion coefficients in the diffusion equation based on both ΔT and wind direction range. In this model the X/Q values are computed assuming that s_z (controlling vertical diffusion) is related to ΔT as before, however, s y (the horizontal diffusion coefficient) is determined using the wind direction range categories given above. The validity of decoupling s_y and s_z has been demonstrated in diffusion tests at Three Mile Island, Pennsylvania (Amendment 24 to FSAR) Docket No. 50-289).

As mentioned previously, one of the models used for this study ("Site Shape") assumes that the site boundary is not circular. Consolidated Edison owns or controls land in certain directions out to a distance significantly greater than the minimum assumed radius of 330 m. Additionally, for bodies of water where there are no permanent residents, it is reasonable to assume that when winds blow toward these directions the X/Q values can be computed for a distance corresponding to that of the opposite shore. The following table lists the distances used for each direction in the "Site Shape" model calculations.

Direction	Assumed Distance (meters)
N	1775
NNE	2375
NE	825
ENE	575
E	1195
ESE	585
SE	1165
SSE	1165
S	1285
SSW	1685
SW	330
WSW	1575
W	1575
WNW	1275
NW	1275
NNW	1275

Calculational Technique

Probability distributions of the X/Q values computed as described above are constructed by connecting all hours which have X/Q values equal to or greater than a selected value. The numbers of hours so obtained are then divided by the total hours in the year of data to obtain the probability that the selected X/Q value would be equaled or exceeded. This procedure is repeated for a number X/Q values which are then plotted to form a probability distribution.

For AEC licensing it is customary to pick the 5% probable hourly (0-1 hr) X/Q for use in the 0-2 hour period of loss-of-coolant accident evaluations. However, in reality, if the wind direction or diffusion conditions change during the two-hour period, a stationary receptor would not receive a dose at the same rate for the full two-hour period. To account for this effect, probability distributions have also been made using two-hour averaging of the X/Q values.

The method of averaging over longer periods is as follows. Starting with each hour of data, the computed X/Q values are added in each of 16 assumed direction sectors for the duration of the release time period being evaluated (2 hours). The maximum integrated value of all the 16 directions is stored and a new integration period is started spaced one hour later. Again, the maximum value for this next integration period is stored regardless of the direction sector in which it occurred, and so on. After processing all hours of data, cumulative probability plots are made for each release time period considered, 2 hours in this case.

Results

Four cases were run using the composite year of Indian Point data. Each case was run to obtain probability distributions using hourly data (0-1 hr) and using the two-hour averaging technique. Figure 1 attached shows the probability distributions for the one-hour cases and Figure 2 shows the results for the two-hour averaging cases. The following table gives the assumptions and results for each case.

Case #	Model	Site Boundary	5% Probable X/Q (sec/m^3)* (1 hr only)	5% Probable X/Q (sec/m^3)* (2 hr averaging)
1	AEC ΔT	Circular	1.8×10^{-3}	1.3×10^{-3}
2	AEC ΔT	Site Shape	6.8×10^{-4}	5.0×10^{-4}
3	Split s	Circular	9.5×10^{-4}	6.5×10^{-4}
4	Split s	Site Shape	3.7×10^{-4}	2.9×10^{-4}

*Note: For Pasquill F and 1 m/sec wind at 330 m, X/Q = 1.3×10^{-3} sec/m^3.

Evaluation

Case 1 (1 hour only) is the typical model used by the AEC for the two-hour portion of the LOCA. As shown, the X/Q value is 1.8×10^{-3} sec/m^3. If the actual distance to the site boundary is used as in Case 2, the value reduces to a X/Q of 6.8×10^{-4} sec/ m^3 resulting in a factor of reduction of 2.65. If the lateral meander is accounted for as in the "Split Sigma" Case 3 for a circular site, a X/Q value of 9.5×10^{-4} results. Another meaningful comparison is between the one-hour and two-hour averaging results for Case 1. Here there is a factor of 1.4 reduction for this effect alone.

There are many combinations which can be compared using this table, however, the thrust of this study is to demonstrate that the typical AEC model (Case 1) is not appropriate for this particular site, since it does not account for inherent site characteristics.

Department of Meteorology and Oceanography

NEW YORK UNIVERSITY

COLLEGE OF ENGINEERING

RESEARCH DIVISION

SUMMARY OF CLIMATOLOGICAL DATA AT BUCHANAN, NEW YORK

1956-1957

By

Ben Davidson

Technical Report No. 372.4

Prepared for

Consolidated Edison Co. of N. Y., Inc.

March, 1958

R-1

RESEARCH DIVISION

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SUMMARY OF CLIMATOLOGICAL DATA AT BUCHANAN, NEW YORK

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R-2

Table of Contents

List of Figures

1. Introduction

A detailed summary of climatological data collected during 1956 is contained in Technical Report No. 372.3 – Evaluation of Potential Radiation Hazard, April 1957. The tower was run on a skeleton basis during 1957. Wind observations were made at 100 and 300 feet (200 and 400 feet above river level), while temperature was observed at 7, 150, and 300 feet above ground. Because of the relative infrequency of calibration and general maintenance during 1957 the 1956 data are considered far more accurate. The 300 ft 1957 data were processed in the same manner as the 1956 data. In the present report we summarize:

(a) The effect of climatological differences between 1956 and 1957 on the radiation calculations of Report 372.3

(b) The local wind rose as a function of height above river, and

(c) The combined 1956-1957 wind rose at 300 feet as a function of stability and wind speed.

2. Comparison of 1956-1957 data

In Table I the essential features of the 1956 and 1957 300 ft data are summarized as a function of stability class. All definitions remain the same as in the previous report. In particular, Inversion conditions (I) are defined to occur when $T_{300} - T_7 \geq 0$; Isothermal-adiabatic conditions (N) when $0 > T_{300} - T_7 \geq -1.8°F$; and Lapse conditions (L) when $T_{300} - T_7 < 1.8°F$.

Table I. Frequency of Inversion (I), Neutral (N), and Lapse (L) conditions with associated mean wind speeds, $\overline{V}$ (mph) for 1956 and 1957.

Summer	I	$\overline{V}$	N	$\overline{V}$	L	$\overline{V}$
1956	0.38	6.5	0.31	10.4	0.31	11.6
1957	0.35	6.2	0.33	12.8	0.32	9.7
Winter						
1956	0.25	7.6	0.54	12.6	0.20	8.5
1957	0.33	7.1	0.48	13.1	0.19	9.0
All seasons						
1956	0.315	6.9	0.425	11.8	0.255	10.4
1957	0.340	6.6	0.405	13.0	0.255	9.4

There are minor differences, but on the whole, the data seem compatible. There were slightly more inversion hours in 1957 than in 1956 with a slightly lower wind speed. The yearly frequency for each temperature gradient condition does not vary more than 10 percent whilst the mean wind speed for each class is also within 10 percent of the 1956 figure. Almost all of the radiation calculations are inversely proportional to the mean wind speed or to the harmonic mean. There is not too great a difference between the two years and for this reasons the total integrated dosage for the area should not vary too greatly, say within 10 to 20 percent,

which is well within the range of uncertainty of the original calculations.

The areal distribution of radiation contained in Figs. 1.1. and 1.2 of the earlier report depends in the mean on the distribution of wind direction. Fig. 1 is a comparison of the annual distribution of wind direction for 1956 and 1957. Again the differences are not great; the 1957 distribution seems a bit more peaked than the 1956 data. This may be due in part to systematic individual differences in reading the charts. Whatever the cause, the differences in the distribution are well within the limits of accuracy of the initial calculations.

3. Variation of wind direction with height

Some idea of the variation of wind direction with height may be gained from the 100 and 300 ft summer wind rose (Figs. 3.1 and 3.2 of the original report). To supplement this information, we compare in Fig. 2 the distribution of wind direction for the 1956 summer season at 400 ft (300 ft tower level), 200 ft (100 ft tower level) and 70 ft above river. The 70 ft data were obtained from an anemometer mounted on the "Jones," a ship anchored in mid-river. The ship site is about 0.8 mile northwest of the tower (see map in Report 372.1). It is evident that there are systematic differences in the three distributions. The most obvious is the build-up of southerly winds with height. The Jones distribution is flat from 150° to 250°, while the 100 and 300 ft tower

5

distributions peak fairly at 170°. On the down valley side of the distribution (about 020°), The Jones and 100 ft tower level distributions are fairly well matched. The 300 ft tower level distribution does not reach nearly the same frequency at 030° as do the other two distributions. Some of the essential differences in the two distributions are summarized in the following table.

Percent time indicated wind direction ranges were observed at

Direction Range	Jones	100 ft Tower	300 ft Tower
340-040	38	37	30
360-040	28	30	19
160-220	16	23	27
160-200	10	18	22

Part of the difference between the distributions can be explained by the tendency for light southerly winds to be observed at the 300 ft tower level when the nocturnal NNE winds have set in at the Jones and 100 ft tower locations. The remainder appears to be a daytime phenomenon and indicates that The Jones distribution is affected by the proximity of the valley walls in a rather complicated fashion.

4. Wind rose presentation

In Fig. 3 we present wind roses based upon two years of data for inversion, neutral, and lapse conditions at the 300 ft level. The bars here are flying with the wind and pointing to the indicated meteorological wind direction. The length of the bar is proportional to the average frequency of occurrence per year of the appropriate wind direction and stability condition. For convenience in interpretation we indicate the general location of populated areas surrounding the site.

An interesting feature of the wind rose is the elongation along the axis of the valley during inversion hours. Wind trajectories towards Peekskill, the most densely populated area near the site, are relatively infrequent during neutral and lapse conditions. There is a sizeable frequency of 210° winds during inversion hours. This trajectory would just about brush the northern outskirts of Peekskill, but it is probable that terrain effects would tend to curve the trajectory so that it follows the river. In general, the inversion wind rose shows a high frequency of up and down valley wind directions.

During lapse and neutral conditions, the wind rose indicates a substantial frequency of northwest winds which are the prevailing winds over flat land in this area. Under these temperature gradient conditions, one may expect effluent concentrations on the ground. There are a substantial number of wind trajectories toward the villages of Buchanan, Montrose and Verplank during neutral and lapse conditions, and towards the village of Verplank during inversion conditions.

References

Davidson, B., and J. Halitsky, 1955: A micrometeorological survey of the Buchanan, N.Y. area. - Summary of progress to 1 December 1955. Technical Report No. 372.1, Research Division, New York University, College of Engineering.

Davidson, B., and J. Halitsky, 1957: Evaluation of potential radiation hazard resulting from assumed release of radioactive wastes to atmosphere from the proposed Buchanan nuclear power plant. Technical Report No. 372.3, Research Division, New York University, College of Engineering.

Station: BEAR MOUNTAIN, NEW YORK

Drainage basin: HUDSON **County:** ORANGE

Lat. 41° 19' N **Long.** 74° 00' W **Elev.** (ft.) 1301

Period of record: 1941-1950

Month		Duration (hours)					
		1	2	3	6	12	24
Jan.	Amt.	0.38	0.60	0.85	1.29	1.49	1.51
	Date	7/1946	31/1942	31/1942	1/1945	31/1942	5-6/1949
Feb.	Amt.	0.26	0.41	0.56	0.80	1.12	1.42
	Date	14/1944	14/1944	14/1944	14-15/1944	20-21/1947	20-21/1947
Mar.	Amt.	0.35a	0.57	0.78	0.99	1.19	1.41
	Date	21/1948	3/1942	3/1942	3/1942	6-7/1944	2-3/1947
Apr.	Amt.	0.61	0.89	1.06	1.51	1.71	2.08
	Date	30/1947	30/1947	1/1948	1/1948	1/1948	18-19/1949
May	Amt.	0.70	1.21	1.35	1.77	2.51	2.87
	Date	6/1949	20/1949	30/1948	27/1946	27/1946	27/1946
Jun.	Amt.	0.67	0.83	0.88	1.01	1.50	1.82
	Date	21/1945	21/1945	21/1945	23/1942	2/1946	1-2/1946
July	Amt.	1.57	1.72	1.85	2.47	2.74	3.98
	Date	20/1945	22/1946	22/1946	22-23/1945	22-23/1945	18-19/1945
Aug	Amt.	1.25	1.44	1.71	1.93	2.30	2.47
	Date	26/1947	16/1942	16/1942	16/1942	9/1942	24-25/1945
Sep.	Amt.	0.81	1.21	1.71	2.08	2.28	2.80
	Date	30/1946	24/1946	24/1946	24/1946	24/1946	26-27/1942
Oct.	Amt.	0.59	0.86	1.03	1.53b	2.83	3.95
	Date	10/1950	26/1943	26/1942	26/1942	26-27/1943	26-27/1943
Nov.	Amt.	1.18	1.97	2.22	3.14	3.65	3.65
	Date	8/1947	8/1947	8/1947	8/1947	8/1947	8/1947
Dec.	Amt.	0.63	1.17	1.48	1.99	2.09	3.33
	Date	25/1945	25/1945	25/1945	25/1945	25-26/1945	30-31/1948

Annual	Amt. Date	1.57 7/20/45	1.97 11/8/47	2.22 11/8/47	3.14 11/8/47	3.65 11/8/47	3.98 7/18-19/45

[a] Also 23/1949 [b] Also 26/1943.

R-13 14

U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

Station, Bear Mountain County, Orange State, New York

Latitude, 41.19 Longitude, 74.00 Elevation, 1300 feet.

Data, Precipitation, Monthly and Annuals

Year	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1939	3.81	3.62	3.16	5.90	1.30	5.32	3.04	3.36	3.04	4.20	1.69	3.39	41.83
1940	5.58	3.87	5.72	6.68	6.53	3.12	3.68	4.05	2.82	3.38	4.48	3.87	53.78
1941	2.77	2.87	2.22	2.00	1.79	4.46	6.31	3.33	0.25	2.35	3.18	4.47	36.00
1942	3.98	1.85	5.67	0.92	3.20	3.80	5.79	5.51	4.44	3.61	4.79	4.62	48.18
1943	2.36	1.19	2.00	3.47	4.56	3.80	3.73	2.56	2.99	12.64	4.18	[a] 1.01	44.49
1944	1.93	2.05	5.60	5.30	2.54	3.06	2.03	2.42	5.99	2.12	5.09	2.37	40.50
1945	2.97	2.46	1.79	3.79	7.18	4.28	16.87	4.73	5.36	2.13	6.53	4.46	62.55
1946	1.79	1.65	2.97	1.97	8.91	3.11	8.10	4.93	6.24	2.13	1.03	2.48	45.31
1947	2.85	3.39	3.48	4.76	9.49	6.55	7.38	2.78	[a] 1.90	2.69	8.51	3.68	57.46
1948	3.05	1.21	3.29	5.28	7.30	4.84	3.52	2.76	0.68	1.92	4.90	6.14	44.89
1949	5.08	2.27	1.88	5.47	6.53	0.96	3.45	2.94	5.60	2.52	1.91	2.79	41.40
1950	2.81	4.46	3.40	2.97	6.02	3.77	5.16	2.94	2.26	2.45	5.39	6.24	47.87
1951	4.60	4.14	8.40	2.94	4.11	3.87	5.07	5.19	2.06	5.13	7.55	5.96	59.02
1952	4.53	3.22	5.46	8.54	5.29	5.92	5.13	8.13	5.01	0.52	4.48	5.84	62.07
1953	6.75	1.89	5.71	4.72									
Sums													
Means													

REMARKS

R-14

U. S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
NATIONAL WEATHER RECORDS CENTER

JOB NO. 6729

SURFACE WIND SPEEDS VERSUS DIRECTION WHEN SOME FORM OF PRECIPITATION IS OCCURRING

STATION: BEAR MOUNTAIN, NEW YORK

PERIOD: JANUARY 1944 – DECEMBER 1948

Sponsored by: Consolidated Edison Company of New York,

Date October 28, 1965

FEDERAL BUILDING
ASHEVILLE, N.C.

Book 2 of 2

USCOMM. WB-ASHVILLE

R-15

U. S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
NATIONAL WEATHER RECORDS CENTER

JOB NO. 6729

OCCURRENCE OF WIND SPEED AND DIRECTION DURING THUNDERSTORMS

STATION: BEAR MOUNTAIN, NEW YORK

PERIOD: JANUARY 1944 – DECEMBER 1948

Sponsored by: Consolidated Edison Company of New York,

Date October 28, 1965

FEDERAL BUILDING
ASHEVILLE, N.C.

Book 1 of 2

USCOMM. WB-ASHVILLE

R-18

New York University
School of Engineering and Science
Department of Meteorology and Oceanography
Geophysical Sciences laboratory
Technical Report No. TR 71-3

Wind Observations at Indian Point
26 November 1969-1 October 1970

Prepared by

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for

Consolidated Edison Co. of N. Y., Inc.
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17 May 1971

Summary

Wind observations made at a 100 ft meteorological tower at Indian Point and at a ship anchored in the Hudson River northwest of Indian Point in 1969-70 were compared with observations made at similar installations in 1955-56. It was found that

1) Annual average statistics of wind speed, direction and vertical temperature difference were substantially the same for 1956 and 1970. Points of difference were increased frequencies of lapses and low wind speeds and a shift in the southerly frequency maximum to the southeast in 1969-70. The low-speed inversion frequency was unchanged.

2) Average wind hodographs at the ships exhibited the same diurnal reversal pattern and the same 2.5 m/sec nighttime downvalley speed in both years. The average wind hodograph at the tower showed a similar pattern of reversal but the nighttime downvalley speed was about 2m/sec.

3) All sixteen daily wind hodographs used for calculating the aver age hodograph at the tower showed the diurnal reversal and exhibited considerable variability in speed and direction from day to day through a complete cycle.

4) Maximum persistences of low-speed inversion winds in the critical 005° - 020° sector were 2 hrs, 4 hrs and 3 hrs for 1, 1.5 and 2 m/s speeds, respectively, during the entire 10-month data record.

1. Introduction

This is the second of two progress reports covering meteorological investigations in the Hudson River valley near Indian Point from August 1968 to the present.

The first report [Halitsky, Laznow and Leahev (1970)] described wind measurements at Indian Point, Bowline Point and Montrose until 30 June 1969, and provided details of changes in tower location and instrumentation introduced during the period July-November 1969.

This report presents an analysis of measurements taken at the present tower at Indian Point (IP 3) and at a ship, the Cape Charles (CC) anchored in the Hudson River, and compares them with similar measurements taken in 1955-1957 at approximately the same locations. The focus of this report is to evaluate whether site meteorology has changed significantly during the intervening years, and to elucidate aspects of the meteorology not reported previously.

In order to clarify the various tower locations and periods of operation, the following nomenclature was established in the first report and will be continued.

Date Period	Station Symbol	Station Location
1955	J	Ship "Jones" in Hudson River
1956-1957	I P 1	Indian Point, southeast of plant
1968-1969	I P 2	Indian Point, southwest of plant
1968-	B P	Bowline Point
1968-	M P	Montrose Point
1969-	I P 3	Indian Point (close to I P 1)
1970	C C	Cape Charles (close to J)

Figs 1, 2 and 3 show the station locations and local topography.

2. Data Log

Fig 4 shows the periods of data acquisition for all of the stations which were in operation in 1970. Station 3 P is included, even though its operation is now being funded by Orange and Rockland Utilities, Inc., order to show the total store of data for the region. The net radiometer (R) and ambient temperature (T) at I P 3, and the Aerovane (A) at the Cape Charles are supplementary instruments provided by N. Y. University.

All of the instruments except the bivane produced continuous records on slow-speed strip charts 91 inch, 2 inch or 3 inch per hour). The bivane chart drive was modified to run 50 minutes at 3 inch per hour followed by 10 minutes at 3 inches per minute and repeat. Thus, each chart (indicated by a dot in Fig 3) contained a 36-hr record of fast-and slow-speed data for each hour.

The statistical data presented in this report represent periods when simultaneous wind speed, wind direction and temperature difference were available at I P 3. The overall period selected for analysis was 26 November 1969-1 October 1970. The degree of completeness of record is as follows:

	Hours all data present	Total Hours in period	% completeness
Climet	5989	7440	80.5
Aerovane	6164	7440	82.8

4

3. <u>Annual Average Wind Statistics at the I P 1 and I P 3 Stations</u>

The annual average wind statistics at I P 3 for the 10-month measurement period in 1969-1970 are shown in graphical form in Figs 5 (a-h), 6 and 7. Also included in these figures, for comparison purposes, are the equivalent I P 1 statistics originally reported by Davidson and Halitsky (9157), Table 3.3 and subsequently incorporated into Se 2.6 of the Unit 2 FSAR.

The two sets of Aerovane statistics represent observations taken about 13 years apart with similar or identical instruments at almost the same locations. As seen in Fig 1, the two towers are about 200 ft apart, and the base of the I P e tower is about 15 ft lower in elevation. The present site topography has fewer trees, more pavement, and new steel and concrete structures in the quadrant northwest of the tower.

Wind speed and direction were measured at the 100 ft elevation on each tower; therefore the absolute elevation of the I P e instrument is about 15 ft lower than that of the I P 1 instruments.

Temperature differences were measured between 95 ft and 7 ft on the 100 ft high I P 3 tower whereas 150 ft and 7 ft were used on the 310 ft high I P 1 tower. However, the isothermal and adiabatic lapse rates were used to separate the lapse, neutral and inversion categories in both cases. This was accomplished by using an adiabatic ΔT of – 0.5 F for I P 3 in place of the – 0.9 F used for I P 1.

Fig 5 shows the frequency distribution of wind directions as measured by the Aerovanes in 1956 and 1970.

Y-9

Fig 5a represents all winds irrespective of speed and temperature gradient class. The shapes of the curves are quite similar, the most important difference being a shift of the 1956 southerly maximum toward the southeast in 1970.

Fig 5 (b0d) shows the dependence on temperature gradient class. No major change is apparent in the neutral class, but the 1970 data show more frequent lapses and less frequent inversions in all directions.

Fig 5 (e-h) shows the dependence on speed class. The southeasterly shift observed in Fig 5a is seen to occur in the 5-8 mph and 9-13 mph speed classes. Low-speed winds in the 1-4 mph class were more frequent in 1970, especially for the 000°-045° direction range.

None of the above differences are sufficiently large to invalidate the 1956 wind statistics reported in Davidson and Halitsky (1957). Of the three noticeable differences, the decrease in frequency of inversions and the increase in southeasterly winds both contribute to reducing the concentrations in inhabited regions contiguous to the site. However, the increase frequency of low-speed winds from the northeasterly sector bears further examination.

Fig 6 shows a comparison of cumulative frequencies of wind speed for the two years. The 1956 curves can not be extended below 2 m/s because the published data show only two categories below that speed, i.e., calm and 1-4 mph, covering speeds from 0 – 4.5 mph. The cumulative frequency shown at a speed of 2 m/s is the sum of these two categories. The 1970 data were classified in finer groupings and yielded well-defined curves in the low speed range. The 1970 data in Fig 6 were uncorrected for speed calibration. It is not known if corrections were applied to the 1956 data.

The upper curves, representing all temperature gradients and directions, show good agreement for the two years. The inversion curves show good agreement during calms and near 2-3/m/s, but the 1970 inversion frequencies were smaller than the 1956 frequencies at the higher speeds. This discrepancy in high speed inversions is in the direction of enhancing the atmospheric diffusion potential over that which was postulated on the basis of the 1956 data. It is not known how much of the difference between the two years is due to the absence of October and November data in 1970.

Because of the high starting speed of the Aerovane, the curves of Fig 6 show spuriously high frequencies of low wind speeds. When the 1970 data are corrected for speed calibration (see Fig 6 of Halitsky et al (1970)], the data appear as in Fig 7.

In order to check the Aerovane data, we have included in Fig 7 the corresponding curves obtained from the more sensitive Climet instrument at the same location during the same period, corrected for speed calibration.

The difference between the Aerovane and Climet curves may be attributed to the poor behavior of the aerovane at low speeds. A true speed of 1 m/s is near the starting threshold of the Aerovane. The corresponding indicated speed may be anything in the range 0-2 mph or one division of the chart. At the same time, a one-division indication may be simply a zero setting error. For these reasons, it is believed that the Climet data should be regarded as more reliable.

4. Valley Wind Hodographs During Virtually-Zero Pressure Gradient Conditions

4.1 Average Hodographs

Average wind hodographs taken during the months of September and October 1955 are presented in FSAR Sec 2.6, Figs 2.6-1 and 2.6-2, to demonstrate that the wind reverses diurnally when the upper air (geostrophic) wind is zero or weak, thereby precluding the occurrence of protracted periods of calm or light wind.

The 1955 data were taken with an Aerovane mounted 70 ft above river elevation on the mast of a ship, the Jones, anchored in the Hudson River about one mile northwest of the tower (see Fig 2). Thirty-five days, during which weak pressure gradient conditions existed over the area, were selected for study. Of these 35 days, 12 days had virtually zero pressure gradient. The two Figures represent the average of wind vectors over the 12 or 35 day period, for each even-numbered hour during the day.

Both of the 1955 hodographs show a well-defined steady flow toward the SSW (030° winds) during the night 92000-0800 hrs), and a somewhat less steady flow toward the NNE (210° winds) during the day (1200-1600). During the transition hours (1000 and 1800 hrs) the flow was weak and variable. The average wind speeds during the night were about 2.5 m/s.

On the basis of these data, it was concluded that the accident meteorology model calling for a wind sequence of 1 m/s steady for two hours followed by 2 m/s steady in the same direction for 24 hours was conservative since the hodograph showed a wind reversal after 12 hours. However, it has been pointed out that individual hodographs for each of the days may have exhibited lower wind speeds and may have failed to show the diurnal reversal.

Y-12

8

To explore this aspect, an Aerovane was installed 100 ft above river level on the mast of another ship, the Cape Charles, anchored in the Hudson River close to the former location of the Jones. The instrument was in operation from March 17, 1970 to Sept. 17, 1970. It had been hoped that the period could be extended to the end of October to gather test data for the same months that were used in the 1955 study, but the instrument had to be removed prematurely because the ship was being prepared for removal.

Using the available record, we selected the two-month period July 15-Sept. 15 as having the closest seasonal correspondence to the 1955 study, and found 17 days during which virtually-zero pressure gradient conditions existed, as determined frm surface weather maps for 0700 EST. The hourly wind velocity vector was determined for each even-numbered hour and a vector average was taken over the 17 days for those hours. The average hodograph is shown in Fig 8, together with the 1955 Jones hodograph.

The important characteristics of the 1955 hodograph were confirmed by the 1970 data. A predominant, diurnally-reversing circulation exists along the 030°-210° axis. The nighttime down-valley flow was slightly weaker (~ 2.0 m/s vs ~ 2.4 m/s) and began about an hour later (2100 vs 2000 hrs) in 1970 but both terminated at ~ 0900 hrs. The up-valley daytime flow was also somewhat weaker (~ 1.5 m/s vs ~ 2 m/s), and did not show the strong southerly wind at 1400 and 1600 hrs. The latter effect may be due to the more northerly locations of the Jones, near the nose of Dunderberg Mtn., where the flow direction changes rapidly (see Fig 2).

Y-13

9

Before analyzing the individual hodographs for each day, it should be noted that the Jones and Cape Charles are located very close to the steep southerly side of Dunderberg Mtn. (peak el. 1120 ft), and are therefore exposed to air currents which tend to flow parallel to the hillside. This topographic influence is not present at the plant site.

To determine what differences, if any, exist between the winds at the ships and the plant site, an average hodographs for 16 of the 17 days was calculated from the records of the Climet speed and direction instrument at the 100 ft elevation on the I P 3 tower (Fig 9). The Climet instrument was inoperative on 1 of the 17 days). The most significant change from the Cape Charles hodograph is the appearance of a southeasterly wind component during the afternoon and evening hours. This component also appeared at the Jones in 1955. Apparently this is an integral part of the valley circulation, causing the hodograph vector to rotate counterclockwise with increasing time, and was not experienced at the Cape Charles due to the deflecting influence of the hillside. A northwesterly down-slope wind may also have been present during the afternoon and evening at the Cape Charles, since the hillside is in shadow at that time.

4.2 Daily Hodographs

Fig 10 (a-d) shows the 16 daily hodographs from which the average hodograph at the I P 3 tower, shown in Fig 9, was calculated. The nighttime down-valley flow appears in all 16 cases. The daytime up-valley flow is quite variable in both speed and direction, and is characterized by generally higher wind speeds and wider direction swings.

10

5. Persistence of Low-Speed Winds

Fig 11 contains a time history of each of the wind conditions during the night hours of the days corresponding to the hodographs of Fig 10 (a-d). The graphs are the variation of the wind speed with time for those hours when the wind direction was between 000° and 045°. We shall assume that the wind direction was steady if it remained in this 45° sector. (This is quite conservative, since a wind which meanders uniformly in a 45° sector of 500 m radius under inversion conditions produces an average concentration about 8 times smaller than the steady wind axial concentration.)

The observed wind angle • and temperature differences $\Delta T = T_{95} - T_7$ are noted under each observation. Positive values of ΔT indicate inversions. ΔT values between – 0.5 and 0 indicate neutral. ΔT values smaller than – 0.5 designate lapses.

The longest period of direction persistence was 8 hrs, occurring on July 25-26, Aug. 8-9, Aug. 13-14, Sept. 12-13 and Sept. 13-14. The average winds speed in each case was at least 2 m/s. ΔT was recorded only 3 of these days, and an inversion occurred only during the first two hours of one of the days.

The period of poorest dispersion potential occurred on July 24-25. It lasted 6 hours with a gradual increase of wind speed from 0.2 to 2.0 m/s, a gradual decrease of temperature gradient from $\Delta T = 1.7$ to $- 0.8$, and a gradual direction change from 007° to 043°. The occurrence of the strongest inversion during the early part of the night and its subsequent weakening and change to neutral or lapse beyond 0200 hrs seems to be a common phenomenon at the site.

11

Wind persistence may also be examined by listing the number of occurrences that wind of specified characteristics persisted for a specified number of consecutive hours during the entire 10 month test period in 1969-70. The following talbe shows these data for inversion condition only.

Table 1. Wind Persistence at I P 3 Under Inversion Conditions 91969-1970)

Wind Sector	No. of Consec. Hrs.	Maximum speed in sequence (mph) 0.3	0.5	1.0	1.5	2.0	3.0	4.0	6.0
005°-020°	1	1	2	22	41	64	115	141	151
	2			1	3	2	7	5	2
	3				3		2	2	3
4				1					
	10								1
005°-020°	1			16	42	75	155	189	198
	2			1	2	5	16	7	3
	3					1	2	2	1
	4						2	3	
	5							2	1
	6							1	
	7						1		

It is seen that very light winds do not persist beyond one hour, and high persistences begin to appear at about 3 m/s. For both sectors combined, the longest persistences for 1l.0, 1.5 and 2.0 m/s winds were 2 hrs, 4 hrs and 3 hrs, respectively.

12

References

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