	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	5.	14.	8.	0.	0.	0.	27.
NNE	2.	1.	0.	0.	0.	0.	3.
NE	3.	0.	0.	0.	0.	0.	3.
ENE	3.	0.	0.	0.	0.	0.	3.
E	3.	0.	0.	0.	0.	0.	3.
ESE	1.	0.	0.	0.	0.	0.	1.
SE	0.	0.	0.	0.	0.	0.	0.
SSE	2.	1.	0.	0.	0.	0.	3.
S	4.	5.	2.	0.	0.	0.	11.
SSW	3.	5.	0.	0.	0.	0.	8.
SW	1.	0.	0.	0.	0.	0.	1.
WSW	1.	0.	0.	0.	0.	0.	1.
W	0.	0.	1.	0.	0	0.	1.
WNW	3.	6.	6.	0.	0.	0.	15.
NW	2.	9.	8.	0.	0.	0.	19.
NNW	5.	8.	1.	0.	0.	0.	14.
TOTAL	38.	52.	26.	0.	0.	0.	113.
CALM	0.						

Table 2.6-4
(Sheet 3 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JAN-MAR 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS C

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	4.	7.	3.	0.	0.	0.	14.
NNE	7.	6.	0.	0.	0.	0.	13.
NE	3.	0.	0.	0.	0.	0.	3.
ENE	3.	0.	0.	0.	0.	0.	3.
E	1.	0.	0.	0.	0.	0.	1.
ESE	3.	0.	0.	0.	0.	0.	3.
SE	3.	2.	0.	0.	0.	0.	5.
SSE	1.	4.	0.	0.	0.	0.	5.
S	2.	2.	0.	0.	0.	0.	4.
SSW	0.	3.	0.	0.	0.	0.	3.
SW	1.	0.	0.	0.	0.	0.	1.
WSW	2.	0.	0.	0.	0.	0.	2.
W	1.	0.	1.	0.	0	0.	2.

IPEC00035021

WNW	3.	8.	3.	0.	0.	0.	14.
NW	2.	10.	13.	0.	0.	0.	25.
NNW	4.	10.	3.	0.	0.	0.	17.
TOTAL	40.	52.	23.	0.	0.	0.	115.

CALM 0.

Table 2.6-4
(Sheet 4 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JAN-MAR 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS D

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	128.	109.	40.	0.	0.	0.	277.
NNE	62.	23.	2.	0.	0.	0.	87.
NE	29.	1.	0.	0.	0.	0.	30.
ENE	17.	0.	0.	0.	0.	0.	17.
E	11.	0.	0.	0.	0.	0.	11.
ESE	7.	0.	0.	0.	0.	0.	7.
SE	11.	0.	0.	0.	0.	0.	11.
SSE	13.	12.	0.	0.	0.	0.	25.
S	17.	23.	2.	0.	0.	0.	42.
SSW	5.	3.	5.	0.	0.	0.	13.
SW	0.	0.	0.	0.	0.	0.	0.
WSW	9.	0.	0.	0.	0.	0.	9.
W	6.	9.	2.	0.	0	0.	17.
WNW	11.	31.	18.	1.	0.	0.	61.
NW	22.	81.	45.	1.	0.	0.	149.
NNW	54.	64.	30.	0.	0.	0.	148.
TOTAL	402.	356.	144.	2.	0.	0.	904.

CALM 6.

Table 2.6-4
(Sheet 5 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JAN-MAR 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS E

IPEC00035022

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	71.	13.	0.	0.	0.	0.	84.
NNE	67.	8.	0.	0.	0.	0.	75.
NE	49.	3.	0.	0.	0.	0.	52.
ENE	14.	0.	0.	0.	0.	0.	14.
E	20.	0.	0.	0.	0.	0.	20.
ESE	7.	0.	0.	0.	0.	0.	7.
SE	14.	2.	0.	0.	0.	0.	16.
SSE	12.	12.	0.	0.	0.	0.	24.
S	19.	14.	1.	0.	0.	0.	34.
SSW	7.	6.	1.	0.	0.	0.	14.
SW	5.	2.	0.	0.	0.	0.	7.
WSW	0.	0.	0.	0.	0.	0.	0.
W	9.	1.	0.	0.	0	0.	10.
WNW	16.	4.	0.	0.	0.	0.	20.
NW	13.	6.	1.	0.	0.	0.	20.
NNW	37.	5.	0.	0.	0.	0.	42.
TOTAL	360.	76.	3.	0.	0.	0.	439.
CALM	8.						

Table 2.6-4
(Sheet 6 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JAN-MAR 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS F

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	28.	1.	0.	0.	0.	0.	29.
NNE	61.	3.	0.	0.	0.	0.	64.
NE	19.	2.	0.	0.	0.	0.	21.
ENE	3.	0.	0.	0.	0.	0.	3.
E	10.	0.	0.	0.	0.	0.	10.
ESE	4.	0.	0.	0.	0.	0.	4.
SE	3.	0.	0.	0.	0.	0.	3.
SSE	9.	0.	0.	0.	0.	0.	9.
S	4.	3.	6.	0.	0.	0.	7.
SSW	1.	0.	0.	0.	0.	0.	1.

IPEC00035023

IPEC00035023

SW	1.	0.	0.	0.	0.	0.	1.
WSW	4.	0.	0.	0.	0.	0.	4.
W	1.	0.	0.	0.	0	0.	1.
WNW	2.	1.	0.	0.	0.	0.	3.
NW	0.	0.	0.	0.	0.	0.	0.
NNW	8.	0.	0.	0.	0.	0.	8.
TOTAL	158.	10.	0.	0.	0.	0.	168.

CALM 1.

Table 2.6-4
(Sheet 7 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JAN-MAR 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS G

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	5.	0.	0.	0.	0.	0.	5.
NNE	10.	1.	0.	0.	0.	0.	11.
NE	3.	2.	0.	0.	0.	0.	5.
ENE	1.	0.	0.	0.	0.	0.	1.
E	2.	0.	0.	0.	0.	0.	2.
ESE	2.	0.	0.	0.	0.	0.	2.
SE	0.	0.	0.	0.	0.	0.	0.
SSE	1.	0.	0.	0.	0.	0.	1.
S	0.	0.	0.	0.	0.	0.	0.
SSW	1.	0.	0.	0.	0.	0.	1.
SW	2.	0.	0.	0.	0.	0.	2.
WSW	1.	0.	0.	0.	0.	0.	1.
W	3	0.	0.	1.	0	0.	3.
WNW	0.	0.	0.	0.	0.	0.	0.
NW	1.	0.	0.	0.	0.	0.	1.
NNW	0.	0.	0.	0.	0.	0.	0.
TOTAL	32.	3.	0.	0.	0.	0.	35.

CALM 0.

Table 2.6-4
(Sheet 8 of 28)

JOINT FREQUENCY DISTRIBUTION

IPEC00035024

INDIAN POINT APR-JUNE 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS A

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	7.	69.	31.	2.	0.	0.	109.
NNE	2.	4.	10.	0.	0.	0.	16.
NE	0.	2.	1.	0.	0.	0.	3.
ENE	0.	2.	1.	0.	0.	0.	3.
E	0.	0.	0.	0.	0.	0.	0.
ESE	1.	0.	0.	0.	0.	0.	1.
SE	2.	4.	0.	0.	0.	0.	6.
SSE	7.	30.	2.	0.	0.	0.	39.
S	7.	43.	12.	0.	0.	0.	62.
SSW	0.	10.	6.	0.	0.	0.	16.
SW	1.	15.	1.	0.	0.	0.	17.
WSW	1.	5.	0.	0.	0.	0.	6.
W	3.	13.	0.	0.	0	0.	16.
WNW	1.	9.	2.	0.	0.	0.	12.
NW	2.	20.	16.	0.	0.	0.	38.
NNW	4.	39.	11.	0.	0.	0.	54.
TOTAL	38.	265.	93.	2.	0.	0.	398.

CALM 0.

Table 2.6-4
(Sheet 9 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT APR-JUNE 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS B

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	1.	24.	4.	2.	0.	0.	31.
NNE	1.	6.	5.	0.	0.	0.	12.
NE	1.	1.	2.	0.	0.	0.	4.
ENE	0.	2.	0.	0.	0.	0.	2.
E	1.	0.	0.	0.	0.	0.	1.
ESE	0.	0.	0.	0.	0.	0.	0.
SE	2.	1.	0.	0.	0.	0.	3.

IPEC00035025

SSE	2.	6.	0.	0.	0.	0.	8.
S	2.	11.	1.	0.	0.	0.	14.
SSW	1.	2.	1.	0.	0.	0.	4.
SW	3.	1.	0.	0.	0.	0.	4.
WSW	0.	1.	0.	0.	0.	0.	1.
W	3.	1.	0.	0.	0	0.	4.
WNW	1.	2.	2.	0.	0.	0.	5.
NW	1.	6.	2.	0.	0.	0.	9.
NNW	1.	6.	0.	0.	0.	0.	7.
TOTAL	20.	70.	17.	2.	0.	0.	109.
CALM	0.						

Table 2.6-4
(Sheet 10 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT APR-JUNE 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS C

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	6.	10.	4.	0.	0.	0.	20.
NNE	4.	7.	4.	0.	0.	0.	15.
NE	0.	2.	0.	0.	0.	0.	2.
ENE	1.	0.	0.	0.	0.	0.	1.
E	1.	0.	0.	0.	0.	0.	1.
ESE	0.	0.	0.	0.	0.	0.	0.
SE	2.	0.	0.	0.	0.	0.	2.
SSE	6.	3.	0.	0.	0.	0.	9.
S	7.	11.	0.	0.	0.	0.	18.
SSW	1.	4.	3.	0.	0.	0.	8.
SW	2.	1.	1.	0.	0.	0.	4.
WSW	0.	1.	0.	0.	0.	0.	1.
W	3.	4.	0.	0.	0	0.	7.
WNW	0.	3.	0.	0.	0.	0.	3.
NW	0.	1.	1.	0.	0.	0.	2.
NNW	3.	5.	1.	0.	0.	0.	9.
TOTAL	36.	52.	14.	0.	0.	0.	102.
CALM	0.						

Table 2.6-4
(Sheet 11 of 28)

IPEC00035026

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT APR-JUNE 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS D

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	28.	67.	20.	13.	5.	0.	133.
NNE	34.	44.	22.	0.	0.	0.	100.
NE	45.	24.	2.	0.	0.	0.	71.
ENE	32.	8.	0.	0.	0.	0.	40.
E	18.	0.	0.	0.	0.	0.	18.
ESE	14.	2.	0.	0.	0.	0.	16.
SE	23.	5.	0.	0.	0.	0.	28.
SSE	20.	41.	0.	0.	0.	0.	61.
S	24.	37.	3.	0.	0.	0.	64.
SSW	16.	11.	1.	0.	0.	0.	28.
SW	6.	3.	0.	0.	0.	0.	9.
WSW	7.	6.	0.	0.	0.	0.	13.
W	3.	4.	0.	0.	0	0.	7.
WNW	2.	18.	2.	0.	0.	0.	22.
NW	1.	15.	3.	0.	0.	0.	19.
NNW	4.	21.	10.	0.	0.	0.	35.
TOTAL	277.	306.	63.	13.	5.	0.	664.
CALM	0.						

Table 2.6-4
(Sheet 12 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT APR-JUNE 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS E

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	37.	41.	7.	0.	0.	0.	85.
NNE	44.	32.	7.	0.	0.	0.	83.
NE	72.	15.	0.	0.	0.	0.	87.
ENE	47.	3.	1.	0.	0.	0.	51.

IPEC00035027

E	15.	0.	0.	0.	0.	0.	15.
ESE	12.	0.	0.	0.	0.	0.	12.
SE	26.	2.	0.	0.	0.	0.	28.
SSE	37.	28.	0.	0.	0.	0.	65.
S	35.	39.	0.	0.	0.	0.	74.
SSW	15.	19.	1.	0.	0.	0.	35.
SW	6.	3.	0.	0.	0.	0.	9.
WSW	4.	2.	0.	0.	0.	0.	6.
W	7.	7.	1.	1.	0	0.	15.
WNW	5.	7.	0.	0.	0.	0.	12.
NW	1.	10.	0.	0.	0.	0.	11.
NNW	9.	13.	3.	0.	0.	0.	25.
TOTAL	372.	221.	20.	0.	0.	0.	613.

CALM 1.

Table 2.6-4
(Sheet 13 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT APR-JUNE1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS F

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	13.	1.	0.	0.	0.	0.	14.
NNE	48.	7.	0.	0.	0.	0.	55.
NE	59.	16.	0.	0.	0.	0.	75.
ENE	25.	0.	0.	0.	0.	0.	25.
E	18.	0.	0.	0.	0.	0.	18.
ESE	5.	0.	0.	0.	0.	0.	5.
SE	5.	1.	0.	0.	0.	0.	6.
SSE	8.	0.	0.	0.	0.	0.	8.
S	12.	3.	6.	0.	0.	0.	15.
SSW	6.	0.	0.	0.	0.	0.	6.
SW	1.	0.	0.	0.	0.	0.	1.
WSW	0.	0.	0.	0.	0.	0.	0.
W	1.	0.	0.	0.	0	0.	1.
WNW	1.	0.	0.	0.	0.	0.	1.
NW	3.	0.	0.	0.	0.	0.	3.
NNW	1.	0.	0.	0.	0.	0.	1.
TOTAL	206.	28.	0.	0.	0.	0.	234.

CALM 0.

IPEC00035028

Table 2.6-4
(Sheet 14 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT APR-JUNE 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS G

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	3.	1.	0.	0.	0.	0.	4.
NNE	13.	0.	0.	0.	0.	0.	13.
NE	12.	4.	0.	0.	0.	0.	16.
ENE	1.	0.	0.	0.	0.	0.	1.
E	3.	0.	0.	0.	0.	0.	3.
ESE	1.	0.	0.	0.	0.	0.	1.
SE	0.	0.	0.	0.	0.	0.	0.
SSE	0.	0.	0.	0.	0.	0.	0.
S	2.	0.	0.	0.	0.	0.	2.
SSW	1.	0.	0.	0.	0.	0.	1.
SW	0.	0.	0.	0.	0.	0.	0.
WSW	0.	0.	0.	0.	0.	0.	0.
W	0.	0.	0.	0.	0	0.	0.
WNW	0.	0.	0.	0.	0.	0.	0.
NW	0.	0.	0.	0.	0.	0.	0.
NNW	2.	0.	0.	0.	0.	0.	2.
TOTAL	38.	5.	0.	0.	0.	0.	43.
CALM	0.						

Table 2.6-4
(Sheet 15 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JULY-SEPT 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS A

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	4.	67.	6.	0.	0.	0.	77.

IPEC00035029

NNE	1.	9.	1.	0.	0.	0.	11.
NE	1.	4.	2.	0.	0.	0.	7.
ENE	2.	1.	0.	0.	0.	0.	3.
E	0.	0.	0.	0.	0.	0.	0.
ESE	1.	0.	0.	0.	0.	0.	1.
SE	5.	2.	0.	0.	0.	0.	7.
SSE	11.	14.	0.	0.	0.	0.	25.
S	19.	72.	3.	0.	0.	0.	94.
SSW	7.	25.	8.	0.	0.	0.	40.
SW	3.	13.	0.	0.	0.	0.	16.
WSW	1.	7.	0.	0.	0.	0.	8.
W	6.	16.	0.	0.	0	0.	22.
WNW	2.	5.	0.	0.	0.	0.	7.
NW	2.	16.	4.	0.	0.	0.	22.
NNW	5.	26.	6.	0.	0.	0.	37.
TOTAL	70.	277.	30.	0.	0.	0.	377.

CALM 0.

Table 2.6-4
(Sheet 16 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JULY-SEPT 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS B

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	4.	18.	1.	0.	0.	0.	23.
NNE	3.	9.	1.	0.	0.	0.	13.
NE	0.	1.	0.	0.	0.	0.	1.
ENE	1.	0.	0.	0.	0.	0.	1.
E	1.	0.	0.	0.	0.	0.	1.
ESE	1.	0.	0.	0.	0.	0.	1.
SE	1.	0.	0.	0.	0.	0.	1.
SSE	1.	1.	0.	0.	0.	0.	2.
S	8.	18.	1.	0.	0.	0.	27.
SSW	2.	4.	0.	0.	0.	0.	6.
SW	1.	5.	0.	0.	0.	0.	6.
WSW	1.	1.	0.	0.	0.	0.	2.
W	3.	2.	0.	0.	0	0.	5.
WNW	1.	2.	0.	0.	0.	0.	3.
NW	2.	0.	0.	0.	0.	0.	2.
NNW	1.	0.	0.	0.	0.	0.	1.

IPEC00035030

TOTAL	31.	61.	3.	0.	0.	0.	95.

CALM 0.

Table 2.6-4
(Sheet 17 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JULY-SEPT1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS C

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	3.	21.	0.	0.	0.	0.	24.
NNE	2.	2.	0.	0.	0.	0.	4.
NE	4.	4.	1.	0.	0.	0.	9.
ENE	1.	0.	0.	0.	0.	0.	1.
E	1.	1.	0.	0.	0.	0.	2.
ESE	2.	0.	0.	0.	0.	0.	2.
SE	2.	0.	0.	0.	0.	0.	2.
SSE	3.	3.	0.	0.	0.	0.	6.
S	9.	15.	0.	0.	0.	0.	24.
SSW	3.	4.	1.	0.	0.	0.	8.
SW	1.	1.	0.	0.	0.	0.	2.
WSW	0.	1.	0.	0.	0.	0.	1.
W	3.	4.	0.	0.	0	0.	7.
WNW	0.	0.	0.	0.	0.	0.	0.
NW	0.	2.	0.	0.	0.	0.	2.
NNW	4.	3.	0.	0.	0.	0.	7.
TOTAL	38.	61.	2.	0.	0.	0.	101.

CALM 0.

Table 2.6-4
(Sheet 18 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JULY-SEPT 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS D

WIND
DIRECTION WIND SPEED (MPH)

IPEC00035031

	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	11.	77.	7.	0.	0.	0.	95.
NNE	21.	36.	2.	0.	0.	0.	59.
NE	34.	22.	0.	0.	0.	0.	56.
ENE	34.	5.	0.	0.	0.	0.	39.
E	20.	6.	0.	0.	0.	0.	26.
ESE	5.	2.	0.	0.	0.	0.	7.
SE	22.	0.	0.	0.	0.	0.	22.
SSE	13.	4.	0.	0.	0.	0.	17.
S	43.	86.	5.	0.	0.	0.	134.
SSW	15.	39.	4.	0.	0.	0.	58.
SW	11.	3.	0.	0.	0.	0.	14.
WSW	12.	2.	0.	0.	0.	0.	14.
W	6.	8.	0.	0.	0	0.	14.
WNW	2.	3.	1.	0.	0.	0.	6.
NW	2.	8.	1.	0.	0.	0.	11.
NNW	5.	13.	1.	0.	0.	0.	19.
TOTAL	256.	314.	21.	0.	0.	0.	591.

CALM 0.

Table 2.6-4
(Sheet 19 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JULY-SEPT 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS E

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	31.	41.	0.	0.	0.	0.	72.
NNE	52.	49.	0.	0.	0.	0.	101.
NE	56.	38.	0.	0.	0.	0.	94.
ENE	26.	3.	0.	0.	0.	0.	29.
E	23.	2.	0.	0.	0.	0.	25.
ESE	19.	0.	0.	0.	0.	0.	19.
SE	36.	0.	0.	0.	0.	0.	36.
SSE	31.	2.	0.	0.	0.	0.	33.
S	76.	95.	2.	0.	0.	0.	173.
SSW	55.	42.	2.	0.	0.	0.	99.
SW	18.	3.	1.	0.	0.	0.	22.
WSW	9.	3.	0.	0.	0.	0.	12.
W	11.	4.	0.	0.	0	0.	15.
WNW	10.	4.	0.	0.	0.	0.	14.

IPEC00035032

NW	19.	6.	0.	0.	0.	0.	25.
NNW	14.	18.	0.	0.	0.	0.	32.
TOTAL	486.	310.	5.	0.	0.	0.	801.
CALM	14.						

Table 2.6-4
(Sheet 20 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JULY-SEPT 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS F

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	21.	2.	0.	0.	0.	0.	23.
NNE	32.	6.	0.	0.	0.	0.	38.
NE	43.	24.	1.	0.	0.	0.	68.
ENE	15.	0.	0.	0.	0.	0.	15.
E	17.	0.	0.	0.	0.	0.	17.
ESE	6.	0.	0.	0.	0.	0.	6.
SE	8.	0.	0.	0.	0.	0.	8.
SSE	12.	0.	0.	0.	0.	0.	12.
S	6.	1.	0.	0.	0.	0.	7.
SSW	4.	0.	0.	0.	0.	0.	4.
SW	2.	0.	0.	0.	0.	0.	2.
WSW	1.	0.	0.	0.	0.	0.	1.
W	2.	0.	0.	0.	0	0.	2.
WNW	2.	0.	0.	0.	0.	0.	2.
NW	5.	0.	0.	0.	0.	0.	5.
NNW	2.	0.	0.	0.	0.	0.	2.
TOTAL	178.	33.	1.	0.	0.	0.	212.
CALM	4.						

Table 2.6-4
(Sheet 21 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT JULY-SEPT 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS G

IPEC00035033

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	2.	0.	0.	0.	0.	0.	2.
NNE	1.	0.	0.	0.	0.	0.	1.
NE	3.	3.	0.	0.	0.	0.	6.
ENE	1.	0.	0.	0.	0.	0.	1.
E	0.	0.	0.	0.	0.	0.	0.
ESE	1.	0.	0.	0.	0.	0.	1.
SE	0.	0.	0.	0.	0.	0.	0.
SSE	0.	0.	0.	0.	0.	0.	0.
S	2.	0.	0.	0.	0.	0.	2.
SSW	0.	0.	0.	0.	0.	0.	0.
SW	0.	0.	0.	0.	0.	0.	0.
WSW	0.	0.	0.	0.	0.	0.	0.
W	0.	0.	0.	0.	0	0.	0.
WNW	0.	0.	0.	0.	0.	0.	0.
NW	0.	0.	0.	0.	0.	0.	0.
NNW	0.	0.	0.	0.	0.	0.	0.
TOTAL	10.	3.	0.	0.	0.	0.	13.
CALM	0.						

Table 2.6-4
(Sheet 22 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT OCT-DEC 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS A

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	1.	22.	6.	0.	0.	0.	29.
NNE	0.	0.	0.	0.	0.	0.	0.
NE	0.	0.	0.	0.	0.	0.	0.
ENE	0.	0.	0.	0.	0.	0.	0.
E	0.	0.	0.	0.	0.	0.	0.
ESE	0.	1.	0.	0.	0.	0.	1.
SE	0.	0.	0.	0.	0.	0.	0.
SSE	3.	9.	0.	0.	0.	0.	12.
S	6.	16.	4.	0.	0.	0.	26.
SSW	1.	4.	5.	0.	0.	0.	10.
SW	0.	8.	0.	0.	0.	0.	8.

IPEC00035034

IPEC00035034

WSW	0.	1.	0.	0.	0.	0.	1.
W	1.	6.	1.	0.	0	0.	8.
WNW	0.	11.	1.	0.	0.	0.	12.
NW	0.	16.	6.	0.	0.	0.	22.
NNW	1.	12.	2.	0.	0.	0.	15.
TOTAL	13.	106.	25.	0.	0.	0.	144.

CALM 0.

Table 2.6-4
(Sheet 23 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT OCT-DEC 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS B

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	0.	16.	6.	0.	0.	0.	22.
NNE	0.	1.	1.	0.	0.	0.	2.
NE	0.	0.	0.	0.	0.	0.	0.
ENE	0.	1.	0.	0.	0.	0.	1.
E	0.	0.	0.	0.	0.	0.	0.
ESE	0.	2.	0.	0.	0.	0.	2.
SE	1.	0.	0.	0.	0.	0.	1.
SSE	1.	2.	0.	0.	0.	0.	3.
S	4.	10.	1.	0.	0.	0.	15.
SSW	2.	2.	1.	0.	0.	0.	5.
SW	0.	1.	0.	0.	0.	0.	1.
WSW	2.	0.	0.	0.	0.	0.	2.
W	0.	0.	0.	0.	0	0.	0.
WNW	1.	3.	0.	0.	0.	0.	4.
NW	1.	4.	5.	1.	0.	0.	11.
NNW	2.	8.	5.	0.	0.	0.	15.
TOTAL	14.	50.	19.	1.	0.	0.	84.

CALM 0.

Table 2.6-4
(Sheet 24 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT OCT-DEC 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T

IPEC00035035

PASQUILL CLASS C

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	3.	14.	6.	1.	0.	0.	24.
NNE	1.	4.	0.	0.	0.	0.	5.
NE	0.	1.	0.	0.	0.	0.	1.
ENE	1.	1.	0.	0.	0.	0.	2.
E	0.	1.	0.	0.	0.	0.	1.
ESE	0.	0.	0.	0.	0.	0.	0.
SE	0.	0.	0.	0.	0.	0.	0.
SSE	2.	1.	0.	0.	0.	0.	3.
S	5.	3.	0.	0.	0.	0.	8.
SSW	7.	3.	1.	0.	0.	0.	11.
SW	1.	0.	0.	0.	0.	0.	1.
WSW	0.	0.	0.	0.	0.	0.	0.
W	1.	1.	1.	0.	0	0.	3.
WNW	1.	2.	3.	0.	0.	0.	6.
NW	2.	2.	3.	0.	0.	0.	7.
NNW	4.	7.	5.	0.	0.	0.	16.
TOTAL	28.	40.	19.	1.	0.	0.	88.

CALM 0.

Table 2.6-4
(Sheet 25 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT OCT-DEC1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS D

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	45.	127.	41.	8.	0.	0.	221.
NNE	29.	91.	26.	1.	0.	0.	147.
NE	19.	32.	2.	0.	0.	0.	53.
ENE	16.	13.	0.	0.	0.	0.	29.
E	8.	2.	0.	0.	0.	0.	10.
ESE	9.	0.	0.	0.	0.	0.	9.
SE	10.	3.	0.	0.	0.	0.	13.
SSE	14.	2.	0.	0.	0.	0.	16.

IPEC00035036

S	33.	48.	0.	0.	0.	0.	81.
SSW	28.	13.	1.	0.	0.	0.	42.
SW	13.	1.	0.	0.	0.	0.	14.
WSW	8.	4.	1.	0.	0.	0.	13.
W	10.	15.	5.	0.	0	0.	30.
WNW	4.	21.	7.	2.	0.	0.	34.
NW	7.	46.	28.	2.	0.	0.	83.
NNW	14.	47.	28.	4.	0.	0.	93.
TOTAL	267.	465.	139.	17.	0.	0.	888.

CALM 0.

Table 2.6-4
(Sheet 26 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT OCT-DEC1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS E

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	41.	26.	0.	0.	0.	0.	67.
NNE	59.	37.	2.	0.	0.	0.	98.
NE	58.	28.	0.	0.	0.	0.	86.
ENE	17.	4.	1.	0.	0.	0.	22.
E	17.	1.	0.	0.	0.	0.	18.
ESE	13.	1.	0.	0.	0.	0.	14.
SE	22.	0.	0.	0.	0.	0.	22.
SSE	33.	2.	0.	0.	0.	0.	35.
S	60.	55.	2.	0.	0.	0.	117.
SSW	30.	17.	0.	0.	0.	0.	47.
SW	23.	10.	0.	0.	0.	0.	33.
WSW	22	4.	1.	0.	0.	0.	27.
W	18.	32.	1.	0.	0	0.	51.
WNW	16.	19.	0.	0.	0.	0.	35.
NW	14.	19.	4.	0.	0.	0.	37.
NNW	20.	10.	4.	0.	0.	0.	34.
TOTAL	463.	265.	15.	0.	0.	0.	743.

CALM 0.

Table 2.6-4
(Sheet 27 of 28)

IPEC00035037

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT OCT-DEC 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS F

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	25.	2.	0.	0.	0.	0.	27.
NNE	47.	4.	0.	0.	0.	0.	51.
NE	46.	30.	0.	0.	0.	0.	76.
ENE	13.	2.	0.	0.	0.	0.	15.
E	9.	0.	0.	0.	0.	0.	9.
ESE	0.	0.	0.	0.	0.	0.	0.
SE	5.	0.	0.	0.	0.	0.	5.
SSE	6.	0.	0.	0.	0.	0.	6.
S	10.	2.	0.	0.	0.	0.	12.
SSW	6.	0.	0.	0.	0.	0.	6.
SW	3.	0.	0.	0.	0.	0.	3.
WSW	6.	0.	0.	0.	0.	0.	6.
W	3.	0.	0.	0.	0	0.	3.
WNW	2.	0.	0.	0.	0.	0.	2.
NW	4.	0.	0.	0.	0.	0.	4.
NNW	11.	0.	0.	0.	0.	0.	11.
TOTAL	196.	40.	0.	0.	0.	0.	236.
CALM	0.						

Table 2.6-4
(Sheet 28 of 28)

JOINT FREQUENCY DISTRIBUTION
INDIAN POINT OCT-DEC 1986
10 METER WIND SPEED & DIR. WITH 61-10 METER DELTA T
PASQUILL CLASS G

WIND DIRECTION	WIND SPEED (MPH)						
	01-03	04-07	08-12	13-18	19-24	>24	TOTAL
N	6.	0.	0.	0.	0.	0.	6.
NNE	3.	1.	0.	0.	0.	0.	4.
NE	4.	5.	0.	0.	0.	0.	9.
ENE	1.	0.	0.	0.	0.	0.	1.
E	0.	0.	0.	0.	0.	0.	0.

IPEC00035038

ESE	0.	0.	0.	0.	0.	0.	0.
SE	0.	0.	0.	0.	0.	0.	0.
SSE	1.	0.	0.	0.	0.	0.	1.
S	0.	0.	0.	0.	0.	0.	0.
SSW	1.	0.	0.	0.	0.	0.	1.
SW	0.	0.	0.	0.	0.	0.	0.
WSW	0.	0.	0.	0.	0.	0.	0.
W	0.	0.	0.	0.	0	0.	0.
WNW	1.	0.	0.	0.	0.	0.	1.
NW	0.	0.	0.	0.	0.	0.	0.
NNW	2.	0.	0.	0.	0.	0.	2.
TOTAL	19.	6.	0.	0.	0.	0.	25.
CALM	0.						

IPEC00035039

Table 2.6-5

(Sheet 1 of 14)
[Historical Information]

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND
DIRECTION FOR PASQUILL STABILITY CATEGORY A

Indian Point B(3) Using a delta t correction factor of 0.605

Jan 1 1970 to Dec 31 1972 (Jan-July), Nov-Dec. 1970, Aug 1971, Sept-Oct 1972)

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0001	.0031	.0039	.0008	.0001	.0000	.0000	.0080
12-33	NNE	.0000	.0011	.0007	.0002	.0000	.0000	.0000	.0021
34-56	NE	.0000	.0003	.0003	.0000	.0000	.0000	.0000	.0007
57-78	ENE	.0000	.0005	.0000	.0001	.0001	.0000	.0000	.0007
79-101	E	.0000	.0000	.0000	.0001	.0000	.0000	.0000	.0001
102-123	ESE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
124-146	SE	.0000	.0002	.0002	.0010	.0002	.0000	.0000	.0017
147-168	SSE	.0001	.0011	.0056	.0037	.0002	.0000	.0000	.0107
169-191	S	.0000	.0026	.0026	.0010	.0000	.0000	.0000	.0063
192-213	SSW	.0001	.0019	.0015	.0001	.0000	.0000	.0000	.0037
214-236	SW	.0000	.0015	.0009	.0001	.0000	.0000	.0000	.0025
237-258	WSW	.0002	.0008	.0008	.0000	.0000	.0000	.0000	.0018
259-281	W	.0002	.0014	.0016	.0001	.0001	.0000	.0001	.0035
282-303	WNW	.0001	.0002	.0015	.0023	.0009	.0000	.0008	.0058
304-326	NW	.0000	.0009	.0022	.0026	.0019	.0001	.0003	.0081
327-348	NNW	.0000	.0018	.0027	.0021	.0006	.0000	.0000	.0072
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0000	.0000		.0016
TOTAL		.0009	.0176	.0246	.0143	.0042	.0001	.0029	.0646

IPEC00035040

Percentage of hours of temperature difference present in this stability category = 6.5 Numbers of hours in this stability category = 565

Table 2.6-5 (Sheet 2 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY B

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION WIND SPEED (MPH)

		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0002	.0010	.0014	.0005	.0001	.0000	.0000	.0032
12-33	NNE	.0001	.0006	.0006	.0003	.0000	.0000	.0000	.0016
34-56	NE	.0000	.0005	.0001	.0000	.0000	.0000	.0000	.0006
57-78	ENE	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
79-101	E	.0000	.0003	.0001	.0001	.0000	.0000	.0000	.0006
102-123	ESE	.0000	.0000	.0001	.0000	.0000	.0000	.0000	.0001
124-146	SE	.0000	.0002	.0002	.0001	.0000	.0000	.0000	.0006
147-168	SSE	.0000	.0008	.0017	.0014	.0000	.0000	.0000	.0039
169-191	S	.0002	.0017	.0014	.0002	.0000	.0000	.0000	.0035
192-213	SSW	.0001	.0010	.0006	.0000	.0000	.0000	.0000	.0017
214-236	SW	.0002	.0003	.0005	.0001	.0000	.0000	.0000	.0011
237-258	WSW	.0002	.0000	.0003	.0000	.0000	.0000	.0001	.0007
259-281	W	.0001	.0003	.0005	.0005	.0000	.0000	.0001	.0015
282-303	WNW	.0001	.0003	.0003	.0002	.0000	.0000	.0002	.0015
304-326	NW	.0001	.0002	.0003	.0008	.0002	.0001	.0001	.0018
327-348	NNW	.0000	.0006	.0014	.0005	.0003	.0001	.0000	.0029
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0000	.0000		.0002
TOTAL		.0015	.0080	.0095	.0047	.0009	.0002	.0007	.0255

Percentage of hours of temperature difference present in this stability category = 2.5 Numbers of hours in this stability category = 223

IPEC00035041

Table 2.6-5 (Sheet 3 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY C

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0005	.0008	.0010	.0005	.0000	.0000	.0001	.0025
12-33	NNE	.0001	.0003	.0008	.0002	.0000	.0000	.0000	.0015
34-56	NE	.0002	.0003	.0001	.0000	.0000	.0000	.0000	.0007
57-78	ENE	.0001	.0000	.0000	.0000	.0001	.0000	.0000	.0002
79-101	E	.0000	.0000	.0001	.0000	.0000	.0000	.0000	.0001
102-123	ESE	.0000	.0002	.0000	.0001	.0000	.0000	.0000	.0003
124-146	SE	.0000	.0000	.0002	.0001	.0000	.0000	.0000	.0003
147-168	SSE	.0000	.0014	.0013	.0007	.0001	.0000	.0000	.0034
169-191	S	.0000	.0013	.0010	.0001	.0000	.0000	.0000	.0024
192-213	SSW	.0000	.0008	.0003	.0000	.0000	.0000	.0000	.0011
214-236	SW	.0001	.0002	.0001	.0000	.0000	.0000	.0000	.0005
237-258	WSW	.0001	.0002	.0003	.0000	.0000	.0000	.0000	.0007
259-281	W	.0002	.0000	.0010	.0002	.0001	.0000	.0000	.0016
282-303	WNW	.0001	.0000	.0005	.0005	.0002	.0002	.0000	.0015
304-326	NW	.0003	.0002	.0005	.0007	.0006	.0003	.0000	.0026
327-348	NNW	.0001	.0006	.0007	.0007	.0002	.0000	.0000	.0023
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0000	.0000		.0001
TOTAL		.0019	.0064	.0080	.0038	.0014	.0006	.0002	.0223

Percentage of hours of temperature difference present in this stability category = 2.2 Numbers of hours in this stability category = 195

IPEC00035042

Table 2.6-5 (Sheet 4 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY D

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0022	.0152	.0159	.0068	.0005	.0001	.0009	.0414
12-33	NNE	.0033	.0163	.0110	.0029	.0007	.0001	.0007	.0350
34-56	NE	.0027	.0072	.0019	.0006	.0002	.0000	.0006	.0133
57-78	ENE	.0023	.0018	.0005	.0002	.0000	.0000	.0005	.0053
79-101	E	.0026	.0013	.0009	.0001	.0000	.0000	.0001	.0056
102-123	ESE	.0022	.0021	.0014	.0005	.0000	.0000	.0002	.0063
124-146	SE	.0027	.0056	.0061	.0009	.0000	.0000	.0001	.0154
147-168	SSE	.0025	.0130	.0138	.0054	.0001	.0000	.0002	.0351
169-191	S	.0037	.0136	.0072	.0021	.0000	.0000	.0003	.0269
192-213	SSW	.0024	.0055	.0039	.0013	.0000	.0000	.0001	.0131
214-236	SW	.0026	.0025	.0009	.0010	.0001	.0000	.0003	.0075
237-258	WSW	.0018	.0019	.0009	.0015	.0000	.0000	.0001	.0063
259-281	W	.0011	.0021	.0037	.0030	.0009	.0002	.0007	.0117
282-303	WNW	.0018	.0014	.0053	.0119	.0071	.0019	.0003	.0297
304-326	NW	.0015	.0017	.0056	.0103	.0087	.0033	.0002	.0313
327-348	NNW	.0022	.0054	.0077	.0087	.0024	.0003	.0001	.0267
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0005	.0001		.0015
TOTAL		.0377	.0971	.0865	.0568	.0211	.0062	.0065	.3119

Percentage of hours of temperature difference present in this stability category = 31.2 Numbers of hours in this stability category = 2730

IPEC00035043

Table 2.6-5 (Sheet 5 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND
DIRECTION FOR PASQUILL STABILITY CATEGORY E

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0065	.0143	.0149	.0046	.0009	.0000	.0007	.0418
12-33	NNE	.0063	.0281	.0183	.0035	.0011	.0001	.0014	.0594
34-56	NE	.0059	.0123	.0043	.0006	.0005	.0000	.0014	.0250
57-78	ENE	.0031	.0032	.0008	.0000	.0000	.0000	.0002	.0073
79-101	E	.0025	.0041	.0018	.0001	.0001	.0000	.0001	.0088
102-123	ESE	.0029	.0041	.0021	.0001	.0000	.0000	.0002	.0094
124-146	SE	.0043	.0062	.0027	.0003	.0006	.0000	.0001	.0143
147-168	SSE	.0038	.0114	.0089	.0023	.0007	.0002	.0001	.0274
169-191	S	.0041	.0162	.0102	.0014	.0003	.0003	.0001	.0327
192-213	SSW	.0049	.0101	.0077	.0008	.0000	.0000	.0000	.0234
214-236	SW	.0042	.0078	.0038	.0007	.0001	.0001	.0001	.0168
237-258	WSW	.0030	.0038	.0029	.0013	.0007	.0002	.0001	.0119
259-281	W	.0023	.0025	.0055	.0019	.0015	.0005	.0007	.0149
282-303	WNW	.0022	.0017	.0072	.0079	.0059	.0016	.0007	.0272
304-326	NW	.0013	.0030	.0098	.0120	.0043	.0010	.0009	.0323
327-348	NNW	.0024	.0071	.0089	.0070	.0010	.0000	.0022	.0286
CALM		.0000							.0001
MISS		.0009	.0009	.0010	.0008	.0013	.0000		.0062
TOTAL		.0606	.1375	.1107	.0452	.0191	.0041	.0103	.3875

Percentage of hours of temperature difference present in this stability category = 38.7 Numbers of hours in this stability category = 3391

IPEC00035044

Table 2.6-5 (Sheet 6 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY F

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0043	.0033	.0007	.0000	.0000	.0000	.0000	.0083
12-33	NNE	.0053	.0143	.0051	.0005	.0000	.0000	.0001	.0253
34-56	NE	.0050	.0094	.0008	.0000	.0000	.0000	.0001	.0153
57-78	ENE	.0031	.0014	.0000	.0000	.0000	.0000	.0000	.0045
79-101	E	.0011	.0006	.0000	.0000	.0000	.0000	.0000	.0017
102-123	ESE	.0009	.0008	.0000	.0000	.0000	.0000	.0000	.0017
124-146	SE	.0016	.0016	.0001	.0000	.0000	.0000	.0000	.0033
147-168	SSE	.0029	.0041	.0005	.0001	.0000	.0000	.0000	.0075
169-191	S	.0022	.0043	.0007	.0000	.0000	.0000	.0000	.0072
192-213	SSW	.0031	.0058	.0006	.0000	.0000	.0000	.0001	.0096
214-236	SW	.0033	.0041	.0007	.0000	.0000	.0000	.0001	.0082
237-258	WSW	.0019	.0013	.0003	.0000	.0000	.0000	.0005	.0040
259-281	W	.0021	.0009	.0007	.0000	.0001	.0000	.0001	.0039
282-303	WNW	.0016	.0005	.0008	.0001	.0000	.0000	.0001	.0031
304-326	NW	.0017	.0006	.0007	.0002	.0000	.0000	.0000	.0032
327-348	NNW	.0024	.0015	.0006	.0001	.0000	.0000	.0000	.0046
CALM		.0000							.0000
MISS		.0002	.0000	.0000	.0000	.0000	.0000		.0011
TOTAL		.0427	.00544	.0122	.0010	.0001	.0000	.0021	.1125

Percentage of hours of temperature difference present in this stability category = 11.3 Numbers of hours in this stability category = 985

IPEC00035045

Table 2.6-5 (Sheet 7 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY G

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH) 01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0010	.0005	.0001	.0000	.0000	.0000	.0000	.0016
12-33	NNE	.0015	.0042	.0001	.0000	.0000	.0000	.0000	.0058
34-56	NE	.0018	.0034	.0000	.0000	.0000	.0000	.0000	.0053
57-78	ENE	.0008	.0001	.0000	.0000	.0000	.0000	.0000	.0009
79-101	E	.0010	.0002	.0000	.0000	.0000	.0000	.0000	.0013
102-123	ESE	.0005	.0002	.0000	.0000	.0000	.0000	.0000	.0007
124-146	SE	.0014	.0001	.0000	.0000	.0000	.0000	.0000	.0015
147-168	SSE	.0007	.0005	.0000	.0000	.0000	.0000	.0000	.0011
169-191	S	.0009	.0008	.0000	.0000	.0000	.0000	.0000	.0017
192-213	SSW	.0013	.0016	.0001	.0000	.0000	.0000	.0001	.0031
214-236	SW	.0016	.0005	.0000	.0000	.0000	.0000	.0000	.0021
237-258	WSW	.0009	.0002	.0001	.0000	.0000	.0000	.0000	.0013
259-281	W	.0008	.0003	.0000	.0000	.0000	.0000	.0000	.0011
282-303	WNW	.0010	.0002	.0000	.0000	.0000	.0000	.0000	.0013
304-326	NW	.0011	.0002	.0000	.0000	.0000	.0000	.0000	.0014
327-348	NNW	.0010	.0003	.0000	.0001	.0000	.0000	.0000	.0015
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0000	.0000		.0001
TOTAL		.0174	.0135	.0005	.0001	.0000	.0000	.0002	.0316

Percentage of hours of temperature difference present in this stability category = 3.2 Numbers of hours in this stability category = 277

IPEC00035046

Table 2.6-5 (Sheet 8 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND
DIRECTION FOR PASQUILL STABILITY CATEGORY A

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0010	.0070	.0080	.0025	.0002	.0000	.0001	.0189
12-33	NNE	.0005	.0042	.0027	.0010	.0000	.0000	.0001	.0086
34-56	NE	.0003	.0019	.0006	.0001	.0001	.0000	.0001	.0032
57-78	ENE	.0002	.0005	.0001	.0002	.0002	.0000	.0000	.0013
79-101	E	.0002	.0005	.0002	.0002	.0000	.0000	.0000	.0011
102-123	ESE	.0001	.0002	.0005	.0002	.0000	.0000	.0000	.0010
124-146	SE	.0005	.0006	.0014	.0016	.0002	.0000	.0000	.0042
147-168	SSE	.0002	.0050	.0103	.0071	.0003	.0000	.0000	.0230
169-191	S	.0010	.0090	.0066	.0017	.0000	.0000	.0000	.0184
192-213	SSW	.0003	.0054	.0029	.0002	.0000	.0000	.0001	.0089
214-236	SW	.0007	.0024	.0017	.0003	.0000	.0000	.0000	.0051
237-258	WSW	.0007	.0013	.0016	.0002	.0000	.0000	.0002	.0040
259-281	W	.0007	.0021	.0038	.0016	.0007	.0001	.0003	.0093
282-303	WNW	.0006	.0010	.0032	.0047	.0024	.0007	.0011	.0137
304-326	NW	.0008	.0015	.0037	.0055	.0038	.0007	.0005	.0163
327-348	NNW	.0007	.0041	.0056	.0042	.0013	.0001	.0000	.0160
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0000	.0000		.0022
TOTAL		.0086	.0466	.0528	.0315	.0093	.0016	.0048	.1552

Percentage of hours of temperature difference present in this stability category = 15.5Numbers of hours in this stability category = 1358

IPEC00035047

Table 2.6-5 (Sheet 9 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND
DIRECTION FOR PASQUILL STABILITY CATEGORY B

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0002	.0007	.0005	.0001	.0000	.0000	.0000	.0015
12-33	NNE	.0001	.0005	.0005	.0000	.0000	.0000	.0000	.0010
34-56	NE	.0005	.0003	.0000	.0000	.0000	.0000	.0000	.0008
57-78	ENE	.0001	.0002	.0000	.0000	.0000	.0000	.0001	.0005
79-101	E	.0002	.0000	.0000	.0000	.0000	.0000	.0000	.0002
102-123	ESE	.0003	.0005	.0000	.0001	.0000	.0000	.0000	.0009
124-146	SE	.0000	.0003	.0006	.0000	.0000	.0000	.0000	.0009
147-168	SSE	.0002	.0005	.0010	.0007	.0001	.0000	.0000	.0025
169-191	S	.0005	.0008	.0006	.0005	.0000	.0000	.0000	.0023
192-213	SSW	.0000	.0002	.0006	.0000	.0000	.0000	.0000	.0008
214-236	SW	.0003	.0001	.0000	.0000	.0000	.0000	.0000	.0005
237-258	WSW	.0006	.0002	.0000	.0001	.0000	.0000	.0000	.0009
259-281	W	.0000	.0000	.0007	.0001	.0000	.0000	.0000	.0008
282-303	WNW	.0002	.0000	.0000	.0005	.0003	.0000	.0000	.0010
304-326	NW	.0001	.0002	.0003	.0002	.0003	.0003	.0000	.0016
327-348	NNW	.0001	.0001	.0006	.0002	.0000	.0001	.0000	.0011
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0000	.0000		.0000
TOTAL		.0035	.0047	.0053	.0025	.0008	.0005	.0001	.0174

Percentage of hours of temperature difference present in this stability category = 1.7 Numbers of hours in this stability category = 152

IPEC00035048

Table 2.6-5 (Sheet 10 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND
DIRECTION FOR PASQUILL STABILITY CATEGORY C

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH) 01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0000	.0009	.0009	.0008	.0000	.0000	.0000	.0026
12-33	NNE	.0001	.0007	.0008	.0003	.0001	.0000	.0000	.0021
34-56	NE	.0002	.0005	.0001	.0001	.0000	.0000	.0000	.0009
57-78	ENE	.0001	.0000	.0002	.0000	.0000	.0000	.0000	.0003
79-101	E	.0000	.0001	.0000	.0001	.0000	.0000	.0000	.0002
102-123	ESE	.0000	.0001	.0000	.0000	.0000	.0000	.0000	.0001
124-146	SE	.0002	.0005	.0007	.0001	.0000	.0000	.0000	.0015
147-168	SSE	.0003	.0013	.0018	.0008	.0000	.0000	.0000	.0042
169-191	S	.0001	.0016	.0006	.0001	.0000	.0000	.0000	.0024
192-213	SSW	.0001	.0006	.0003	.0001	.0000	.0000	.0000	.0011
214-236	SW	.0003	.0005	.0002	.0003	.0000	.0000	.0000	.0014
237-258	WSW	.0001	.0000	.0002	.0003	.0000	.0000	.0000	.0007
259-281	W	.0000	.0002	.0005	.0008	.0001	.0000	.0000	.0016
282-303	WNW	.0005	.0002	.0002	.0013	.0011	.0005	.0000	.0038
304-326	NW	.0000	.0001	.0001	.0001	.0009	.0006	.0000	.0018
327-348	NNW	.0003	.0007	.0005	.0008	.0006	.0000	.0000	.0029
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0002	.0001		.0006
TOTAL		.0025	.0079	.0072	.0062	.0031	.0011	.0002	.0282

Percentage of hours of temperature difference present in this stability category = 2.8 Numbers of hours in this stability category = 247

IPEC00035049

Table 2.6-5 (Sheet 11 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY D

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0023	.0149	.0182	.0066	.0008	.0001	.0014	.0442
12-33	NNE	.0037	.0166	.0120	.0035	.0006	.0001	.0014	.0378
34-56	NE	.0030	.0066	.0026	.0003	.0003	.0000	.0006	.0135
57-78	ENE	.0022	.0016	.0001	.0001	.0000	.0000	.0006	.0046
79-101	E	.0024	.0019	.0010	.0000	.0000	.0000	.0002	.0056
102-123	ESE	.0023	.0016	.0013	.0002	.0000	.0000	.0003	.0057
124-146	SE	.0025	.0055	.0047	.0006	.0002	.0000	.0001	.0136
147-168	SSE	.0022	.0114	.0103	.0032	.0000	.0000	.0003	.0274
169-191	S	.0026	.0101	.0056	.0013	.0000	.0000	.0003	.0199
192-213	SSW	.0030	.0035	.0029	.0011	.0000	.0000	.0000	.0105
214-236	SW	.0021	.0019	.0009	.0006	.0001	.0000	.0003	.0059
237-258	WSW	.0011	.0018	.0008	.0011	.0000	.0000	.0000	.0049
259-281	W	.0013	.0018	.0022	.0017	.0008	.0001	.0006	.0085
282-303	WNW	.0015	.0010	.0050	.0097	.0063	.0011	.0002	.0249
304-326	NW	.0011	.0019	.0059	.0117	.0078	.0026	.0001	.0312
327-348	NNW	.0011	.0057	.0071	.0079	.0022	.0002	.0002	.0245
CALM		.0000							.0000
MISS		.0000	.0001	.0000	.0001	.0005	.0000		.0011
TOTAL		.0343	.0881	.0806	.0498	.0195	.0043	.0072	.2838

Percentage of hours of temperature difference present in this stability category = 28.4 Numbers of hours in this stability category = 2484

IPEC00035050

Table 2.6-5 (Sheet 12 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY E

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0046	.0096	.0073	.0022	.0006	.0000	.0002	.0243
12-33	NNE	.0035	.0178	.0117	.0019	.0009	.0001	.0006	.0366
34-56	NE	.0034	.0070	.0026	.0006	.0002	.0000	.0009	.0147
57-78	ENE	.0023	.0026	.0006	.0000	.0000	.0000	.0000	.0055
79-101	E	.0014	.0035	.0016	.0001	.0001	.0000	.0000	.0067
102-123	ESE	.0015	.0034	.0018	.0001	.0000	.0000	.0001	.0070
124-146	SE	.0035	.0043	.0021	.0002	.0003	.0000	.0001	.0106
147-168	SSE	.0025	.0078	.0066	.0016	.0005	.0002	.0000	.0192
169-191	S	.0026	.0093	.0064	.0010	.0003	.0003	.0001	.0201
192-213	SSW	.0031	.0074	.0063	.0007	.0000	.0000	.0000	.0175
214-236	SW	.0025	.0045	.0029	.0007	.0001	.0001	.0000	.0107
237-258	WSW	.0019	.0029	.0018	.0009	.0007	.0002	.0000	.0085
259-281	W	.0014	.0018	.0046	.0014	.0008	.0005	.0001	.0105
282-303	WNW	.0010	.0009	.0048	.0058	.0041	.0014	.0002	.0183
304-326	NW	.0008	.0019	.0069	.0085	.0021	.0006	.0005	.0211
327-348	NNW	.0019	.0042	.0057	.0042	.0005	.0000	.0013	.0178
CALM		.0000							.0000
MISS		.0005	.0007	.0010	.0007	.0010	.0000		.0049
TOTAL		.0385	.0897	.0746	.0306	.0122	.0034	.0051	.2542

Percentage of hours of temperature difference present in this stability category = 25.4 Numbers of hours in this stability category = 2225

IPEC00035051

Table 2.6-5
(Sheet 13 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND
DIRECTION FOR PASQUILL STABILITY CATEGORY F

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH) 01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0040	.0026	.0026	.0007	.0000	.0000	.0000	.0099
12-33	NNE	.0040	.0134	.0075	.0008	.0002	.0000	.0000	.0259
34-56	NE	.0031	.0082	.0017	.0000	.0000	.0000	.0005	.0135
57-78	ENE	.0016	.0013	.0002	.0000	.0000	.0000	.0000	.0031
79-101	E	.0013	.0003	.0001	.0000	.0000	.0000	.0000	.0017
102-123	ESE	.0013	.0007	.0000	.0000	.0000	.0000	.0000	.0019
124-146	SE	.0009	.0014	.0002	.0000	.0000	.0000	.0000	.0025
147-168	SSE	.0022	.0041	.0015	.0001	.0002	.0000	.0000	.0081
169-191	S	.0022	.0071	.0029	.0002	.0000	.0000	.0000	.0123
192-213	SSW	.0021	.0056	.0014	.0000	.0000	.0000	.0000	.0090
214-236	SW	.0027	.0049	.0009	.0000	.0000	.0000	.0001	.0087
237-258	WSW	.0021	.0013	.0009	.0000	.0000	.0000	.0005	.0047
259-281	W	.0011	.0010	.0011	.0001	.0003	.0000	.0007	.0045
282-303	WNW	.0010	.0008	.0022	.0009	.0001	.0001	.0006	.0057
304-326	NW	.0011	.0007	.0022	.0006	.0009	.0001	.0005	.0061
327-348	NNW	.0013	.0016	.0024	.0016	.0001	.0000	.0008	.0078
CALM		.0000							.0001
MISS		.0007	.0001	.0000	.0000	.0000	.0000		.0013
TOTAL		.0326	.0552	.0279	.0050	.0019	.0002	.0040	.1268

Percentage of hours of temperature difference present in this stability category = 12.7 Numbers of hours in this stability category = 1110

IPEC00035052

Table 2.6-5 (Sheet 14 of 14)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION FOR PASQUILL STABILITY CATEGORY G

Indian Point B(3) Using a delta t correction factor of 0.605

JAN. 1 1970 1 DEC. 31 1972

WIND DIRECTION		WIND SPEED (MPH)							
		01-03	04-07	08-12	13-18	19-24	Greater than 24	MISS	TOTAL
349-11	N	.0027	.0025	.0003	.0000	.0000	.0000	.0000	.0056
12-33	NNE	.0047	.0125	.0014	.0000	.0000	.0000	.0001	.0186
34-56	NE	.0053	.0089	.0000	.0000	.0000	.0000	.0000	.0142
57-78	ENE	.0029	.0008	.0000	.0000	.0000	.0000	.0000	.0037
79-101	E	.0018	.0007	.0000	.0000	.0000	.0000	.0000	.0025
102-123	ESE	.0009	.0009	.0000	.0000	.0000	.0000	.0000	.0018
124-146	SE	.0024	.0014	.0000	.0000	.0000	.0000	.0000	.0038
147-168	SSE	.0023	.0023	.0002	.0000	.0000	.0000	.0000	.0048
169-191	S	.0021	.0027	.0005	.0000	.0000	.0000	.0000	.0053
192-213	SSW	.0033	.0040	.0003	.0000	.0000	.0000	.0002	.0079
214-236	SW	.0034	.0026	.0002	.0000	.0000	.0000	.0001	.0064
237-258	WSW	.0017	.0008	.0003	.0000	.0000	.0000	.0001	.0030
259-281	W	.0024	.0006	.0001	.0000	.0000	.0000	.0000	.0031
282-303	WNW	.0022	.0003	.0001	.0000	.0000	.0000	.0000	.0026
304-326	NW	.0021	.0005	.0000	.0001	.0000	.0000	.0000	.0026
327-348	NNW	.0026	.0008	.0001	.0001	.0000	.0000	.0000	.0037
CALM		.0000							.0000
MISS		.0000	.0000	.0000	.0000	.0000	.0000		.0008
TOTAL		.0427	.0423	.0037	.0002	.0000	.0000	.0014	.0903

Percentage of hours of temperature difference present in this stability category = 9.0 Numbers of hours in this stability category = 790

IPEC00035053

2.7 GEOLOGY [Historical Information]

Indian Point 3 is located approximately two miles southwest of the city of Peekskill, Westchester County New York, on the east bank of the Hudson River. Geologically, it is located in the central part of the Peekskill Quadrangle. The complete geologic description is divided into two broad sections:regional geology, physiography and tectonics; and geology of the area surrounding the site.

2.7.1 Regional Geology, Physiography and Tectonics

The general landscape of the region (see Figure 2.7-1 consists of bedrock-supported ridges following generally northeasterly structural trends and rather steep and broad swampy valleys. The highest elevation in the region is 1,000 ft, and elevations range from 50 to 300 ft above mean sea level in low-lying areas. At the plant site the ground is level, about 15 feet above sea level and is covered with fill. The surface is artificially leveled and bedrock lies very close to the surface.

The eastern part of the United States has gone through tectonism since the Precambrian age (Figure 2.7-2 and is known as the Appalachian Orogen. The plant is situated within the Manhattan Prong of the Appalachian Mountains. It is estimated that the earliest tectonic activity in the Appalachian Orogen was in Precambrian age and was a result of continental rifting and associated intrusive activity. A striking characteristic of the region is the high degree of metamorphism exhibited by the rocks. This has resulted from their long and complex history (Precambrian through the mid- Ordovician time) which included extensive thrust faulting, folding, instrusion, etc. The Taconic Orogeny was intense in the Manhattan Prong region and produced most of the structures evident in the map today. Essentially, the rocks in the plant site area belong to three tectonic provinces, e.g., the Hudson Highlands, the Manhattan Prong and the Newark Basin. The geology of these provinces follows:

<u>The Hudson Highlands</u>

The Hudson Highlands are a part of the much larger Blue Ridge - New Jersey Highlands Province. Here the northeast trending ridges are underlain by complexly folded granitoid gneisses and schists. These also involve granodioritic intrusives. Prevailing dips in the entire region are steep towards the southeast. The bulk of the Highland rocks represent a sequence of Precambrian aged miogeosynclinal and engeosynclinal deposits, however those in the areas of concern are in faulted and in-folded strata of Cambro - Ordovician age.

Helenock and Mose[(2)] recognized a mappable sequence of five rock units in the Lake Carmel, New York, area of the Highlands. These rocks were metamorphosed to granulite facies, and were multiply deformed in the Greenville Orogeny. There was recrystallization to amphibolite facies accompanied by folding during the Taconic Orogeny (mid-Ordovician).

The Ramapo Fault Zone (Section 2.8) separates the Highlands from the Manhattan Prong and the Newark Basin.

<u>The Manhattan Prong</u>

The Manhattan Prong is bounded on the east by Cameron's line, on the west by the Newark Basin border fault and the Hudson River. It covers the geographic areas of New York City (Manhattan), Westchester County, New York and parts of Fairfield County, Connecticut.

IPEC00035054

The uppermost formation of sedimentary origin is called a Phyllite or Schist known as the Manhattan Schist. This is the most recent geologic formation. In order of increasing age and depth are the Inwood Marble, the Lowerre Quartzite, the Yonkers-Pound Ridge Granite and the Fordham Gneiss. Due to the extremely complicated nature of the region's geology this stratigraphy varies with location.

The Manhattan Formation was deposited in a miogeosyncline. It was metamorphosed, deformed and intruded during the Taconic and the Acadian episodes(3).
The Inwood Marble, consisting of dolomite and calcite marbles with interlayed calc - silicate schists, were deposited during the Cambrian - Ordovician period. It is widespread in the Appalachian Orogen.

The Lowerre Quartzite underlies the Inwood Marble. It is a relatively thin, discontinuous unit representing an arkosic sandstone. The Lowerre consists mainly of quartz with potassium feldspar and biotite. It is always found underlying the Cambro-Ordovician aged rocks.

The Yonkers and Fordham formations are Precambrian in age and are separated from the Lowerre. Inwood and Manhattan formations are joined by an angular unconformity.The Fordham formation was deformed and metamorphosed to granulite facies during the Greenville Orogeny. The Yonkers - Pound Ridge Granite, emplaced during the opening of the Proto-Atlantic in late Precambrian age, is mostly a metamorphosed rhyolite.

The Newark Basin

The Newark Basin formation, west of the Hudson River, extends from York County, Pennsylvania to Rockland County, New York. The northern tip of this basin very closely approaches the Indian Point Site on the opposite side of the Hudson River near Stony Point. This is an assemblage of conglomerates, sandstones and shales with their intercalated beds of basaltic lava and the well known intrusive sill of the "Palisades". Deposition was continuous from the late Triassic through the upper Jurassic ages(4). The boundary fault between this basin and older crystalline rocks is the well known Ramapo Fault.

2.7.2 Geology of the Area Surrounding the Site

The geology of the area surrounding the site is shown in Figure 2.7-3. The Ramapo Fault System passes through the area surrounding the site. The Ramapo is a series of N - NE trending faults, with minimum age for movement being Greenville (5). The faults surrounding the plant site have been studied utilizing radiometric age determination, cross-cutting lighologic relationships and textural evidences, by Ratcliff (5); Dames & Moore(4) studied age based on geothermometry of fluid inclusions in calcite.

The most prominent faults that separate the Manhattan Prong from Hudson Highlands are the Thiells fault, the Annsville fault, the Peekskill fault and the Croton Falls fault. These are all believed to be of Paleozoic age. The N-S faults at Tomkins Cove across the Hudson River from Indian Point are the youngest in the area, presumably of Masezoic age. Dames & Moore (4) mapped a group of faults at the Indian Point site with displacements no more than a few feet. They are filled with undeformed euthedral calcite crystals (Figure 2.7-4)

Radiometric age determination of these, and the lack of fault related deformation of Pleistocene deposits and surface features, prove that the faults surrounding the site have not moved in the

IPEC00035055

last 2 million years, although predominant movements took place in Precambrian time. Examination of recent core drills in the area indicate that the dip is consistently to the S-E and that the dominant latest motion in the fault was right oblique normal faulting.

References

1) Van Eysing, F. W. B, 1978 Geologic Time Scale

2) Heleneck, H. L. & Mose, D. G. 1978, Geology and Geochronology of Precambrian Rocks in the Lake Carmel Region Hudson Highlands, N. Y., Geological Society of America, V. 10. No. 2.

3) a) Brock, P.W.G and Mose, D. G., 1979, Taconic and Younger Deformations in the Croton Falls Area, S-Eastern N.Y., Bulletin of Geo. Soc of Am. Pt II V. 90.
b) Mose, D G. and Hall, L. M., 1979, Rb - Sr Whole-Rock Age Determination of Member C of the Manhattan Schist and its Bearing on Allochthony in the Manhattan Prong, SE New York Geo. Soc. of Am, Abstracts with Programs, V. II No. 1.

4) Dames & Moore, 1977, Geotechnical Investigation of the Ramapo Fault System in the Region of the Indian Point Generating Station.

5) Ratcliffe, N. M., 1976, Final Report on Major Fault Systems in the Vicinity of Tomkins Cove - Buchanan, N. Y. Report for Consolidated Edison Company, Inc. of N. Y.

6) Dames & Moore, Nov. 1975. Supplemental Geological Investigation of the Indian Point Generating Station for Consolidated Edison Co. of N. Y. Inc.

2.8 SEISMOLOGY [Historical Information]

2.8.1 Background and Seismic Design Bases

Geographic areas of the continental United States have been subdivided into regions of known or assigned seismic probability or risk and this has served as a useful basis for generating code provisions for earthquake - resistant structures. The Seismic Risk Map adopted by the International Conference of Building Officials for inclusion in the 1970 edition of Uniform Building Code, divides the United States into four (4) major zones of seismic risk or probability. The Indian Point Site is located in Zone I of this map with intensities limited to V and VI on the Modified Mercalli Intensity Scale of 1931 (Figure 2.8-1) and only slight earthquake activity can be expected.

However, the Indian Point 3 facility was actually built per requirements of Zone 2 of the Uniform Building Code i.e., corresponding to an intensity VII of the Modified Mercalli Scale. The range of expected horizontal acceleration of ground motion for earthquakes of this intensity is 70-150 cm/sec2 near the epicenter or about 0.15 g max. At a distance of 100 miles from the epicenter, the acceleration drops to 50%. The nearest event larger than intensity VII occurred near Cape Ann, Massachusetts, a distance of more than 200 miles from the site, in 1755. This event was classified as intensity VIII on the Modified Mercalli Scale. It was believed, therefore, that the plant's structural design, allowing for safe shutdown in the event of an earthquake of intensity VII on the Modified Mercalli Scale, was adequate. A list of known earthquakes which have occurred in the vicinity of the plant having intensities of V through VII on the modified Mercalli Scale is provided by Table 2.8-1.

IPEC00035056

The Reverend Joseph Lynch, S. J., while Director of the Fordham University Seismic Observatory stated:

> ".... that the probability of a serious shock occurring in this area for the next several hundred years is practically nil. The area therefore would certainly seem to be as safe as any area at present known."

Captain Elliott B. Roberts, while Chief of the Geophysics Division of the Department of Commerce, substantially agreed with the conclusions of Rev. Lynch.

Rev. Lynch also stated that the "estimated maximum ground acceleration of 0.03 g is reasonably conservative for the area." This has been established as the basis for design of the plant. Rev. Lynch stated further that the "safety factor for a horizontal stress of 0.1 g is therefore.... more than adequate. "For earthquakes having a horizontal acceleration of 0.1 g and a vertical acceleration of 0.05 g acting simultaneously at zero period, the plant is designed to have no loss of function of systems important to safety, although in some cases, the stresses may reach or slightly exceed yield points.

2.8.2 Public Concerns and Resolutions

Subsequent to the plant's construction, public concerns were raised on the following issues:

1) A series of N-NE trending faults pass through the area surrounding the site - collectively known as the Ramapo Fault System (Section 2.7). The concern raised was whether the Ramapo Fault is "capable" of causing an earthquake at the site.(1)
2) Because of the lack of historical records of earthquakes (Table 2.8-1) in the plant area - older than the Cape Ann earthquake, concerns were raised whether the safe shutdown earthquake (SSE) for the plant's design should be greater than intensity VII on the Modified Mercalli Scale.
3) As stated earlier, the plant was designed for 0.15 g max base shear for safe shutdown. Concern was that, if the SSE ground acceleration be raised from intensity VII to VIII on the Modified Mercalli Scale, would the 0.15 g base shear still be adequate?
4) An extended micro-monitoring system for measuring magnitude, accurately determining the location and even focal mechanism behavior of small magnitude earthquake near the plant and Ramapo Fault Zone was required by condition 2.C.4(c) of Amendment No. 2 to the Operating License of the plant. Concern was raised whether this extended micro-seismic-measuring instrumentation was considered as a licensing requirement.

An 18 month proceeding was held on the above concerns before a U.S. Nuclear Regulatory Commission (NRC) Atomic Safety and Licensing Board. Also, there have been numerous extensive studies on these concerns. The findings by the board and these studies may be summarized as follows:

1) In testimony before the board, Charles F. Richter, who developed the Richter Scale, stated that the earthquakes in the Ramapo region are "of minor magnitude and relatively trivial". Radiometric age determination of undeformed minerals that have grown within fault zones was studied by Ratcliffe(2) and fault related deformation of Pleistocene deposits and surface features by Dames & Moore(3) and Ratcliffe(5). Both prove that the faults in the Indian Point area have not moved in at least the last 2 million years. The Ramapo Fault, therefore, is considered to be old, inactive and not a "capable" fault under Appendix A to 10 CFR 100.

2) The unanimous ruling by the board was - "In accordance with Appendix A to 10 CFR 100, neither the Cape Ann earthquake nor any other historic event requires the

IPEC00035057

assumption of a safe shutdown earthquake for the Indian Point Site of greater than a Modified Mercalli intensity of VII(6)". Hearings were also held before the Advisory Committee on Reactor Safeguards. Despite some controversy over appropriate tectonic divisions, the Committee, scientists in the TERA Corp.(8)(9) and Dames & Moore(4) concluded that an event of intensity VII on the Modified Mercalli Scale is adequate as the design earthquake for the Indian Point Site.

3) Consistent with the above ruling, the board also ruled - "The ground acceleration value used for the design of Indian Point Units 2 and 3 should remain at 0.15 g".(6)

4) Amendment 2 to the Technical Specifications stated in Section 2(c)(4)(c) that an extended microseismic instrumentation network must be operated for at least two years following complete installation of all stations. The Atomic Safety and Licensing Appeal Board repealed this decision in hearings held on October 12, 1977(6) and the NRC issued Technical Specification Amendment 9 to reflect this. However, a network was operated from 1975-1990 and a final report(10) was published.

2.8.3 Conclusions

Microseismic activity recorded by the seismic monitoring network is evidence of minor crustal adjustments due to regional stresses. However, neither the readings from the network nor the bore-hole experiment(11) at Kent Cliffs show the evidence of any contemporary (geologic) movement along faults exposed at the surface as was suggested by Aggarwal and Sykes.(1) On the contrary, the last movement of the region (Mesozoic Period) was in a direction normal to the proposed direction.

It is therefore concluded that the seismic design criteria for structural analysis at the Indian Point site is satisfactory and that the plant is set on solid bedrock. No public hazard can be expected from the plant due to a probable earthquake in the region.

References

1) Aggarwal, Y. P. and Sykes, L. R., 1978, Earthquakes, Faults and Nuclear Power Plants in Southern New York and Northern New Jersey in "Science," V. 200.

2) Ratcliffe, N. M. 1976, Final Report on Major Fault Systems in the Vicinity of Tomkins Cove - Buchanan, New York: Report for Consolidated Edison Company of New York, Inc.

3) Dames & Moore, 1977, Geotechnical Investigation of Ramapo Fault System in the Region of the Indian Point Generating Station.

4) Dames & Moore, 1980, Seismic Ground Motion Hazard at Indian Point Nuclear Power Plant Site - A report prepared for Pickard, Lowe & Garrick, Inc.

5) Ratcliffe, N. M. 1981, Brittle Faults (Ramapo Fault) and Phyllonitic Ductile Shear Zones in the Basement Rocks of the Ramapo Seismic Zone, New York and New Jersey, and their Relationship to Current Seismicity published in: Manspeizer, W., editor, Field Studies of New Jersey Geology and Guide to Field Trips, 52nd Annual Meeting of the New York State Geological Association, Newark, New Jersey, Rutgers University.

IPEC00035058

6) United States Nuclear Regulatory Commission/Atomic Safety and Licensing Appeal Board, Farrar, M. C. - Chairman, Buck, J. H. and Quarles L. R. - Members at a Hearing cited as 6 NRC 547 (1977), ALAB -436.

7) Gutenberg, B. and Ritchter C. F. Earthquake Magnitude, Intensity, Energy and Acceleration, BSSA, 32,(3) July 1942.

8) TERA Corporation, Seismic Hazard Analysis - A Methodology for the Eastern United States, NUREG/CR-1582, 2, 1980.

9) TERA Corporation, Seismic Hazard Analysis Solicitation of Expert Opinion, NUREG/CR-1582, 3, 1980.

10) Woodward-Clyde; Scientific Results of Seismic Monitoring Network near the Indian Point Nuclear Generating Facilities, Final Report (10/27/92); R&D Project 92284

11) Woodward-Clyde, 1986: Kent Cliffs Bore-hole Research Project: A Determination of the Magnitude and Orientation of Tectonic Stress in Southeastern New York; Research Report EP 84-27, Empire State Electric Energy Research Corporation, New York, New York.

IPEC00035059

TABLE 2.8-1

LIST OF EARTHQUAKES OF INTENSITIES GREATER THAN OR EQUAL TO V ON MODIFIED MERCALLI SCALE
(SOURCE: EPRI)

DATE	TIME (HOUR)	GEOGRAPHIC COORIDINATES LATIITUDE (DEG. N)	GEOGRAPHIC COORIDINATES Longitude (Deg. W)	DEPTH (KM)	INTENSITY MODIFIED MERCALI SCALE	REMARKS
12-19-1737	04:00:00	40.80	74.00	0	VII	
11-30-1783	03:50:00	41.00	74.50	0	VI	
09-29-1847	00:00:00	40.50	74.00	0	V	Felt Over 2,000 Sq. Miles
12-11-1874	03:25:00	40.90	73.80	0	V	
10-04-1878	07:30:00	41.50	74.00	0	V	
08-10-1884	19:07:00	40.60	74.00	0	VII	Felt Over 31,000 Sq. Miles
09-01-1895	11:09:00	40.70	74.80	0	VI	
06-01-1927	12:23:00	40.30	74.00	0	Between VI and VII	
10-08-1952	21:40:00	41.70	74.00	0	V	
03-23-1957	19:02:00	40.60	74.80	0	VI	
11-17-1964	17:08:00	41.20	73.70	0	V	
11-21-1967	22:10:00	41.20	73.80	0	V	
03-11-1976	21:07:00	41.00	74.40	0	V	
04-13-1976	15:39:00	40.80	74.00	0	VI	
01-30-1979	16:30:52	40.32	74.26	5	VI	
03-10-1979	04:49:40	40.72	74.72	3	V	
12-30-1979	14:15:12	41.14	73.69	5	V	

(For location Map see Figure No. 2.7-3)

IPEC00035060

2.9 ENVIRONMENTAL MONITORING PROGRAM

2.9.1 General

A program to determine the environmental radioactivity in the vicinity of Indian Point Station was instituted in 1958, four years prior to the initial operation of Consolidated Edison's Indian Point Unit No. 1. The purpose of this survey was to determine the natural background radioactivity and to show the variations in the activities that may be expected from natural sources, fallout from bomb tests and other sources in the vicinity. This program has been continued to the present so that changes in the environment, resulting from station operations, could be accounted for. The results of these surveys are reported annually to the Nuclear Regulatory Commission.

In addition, the New York State Department of Health has conducted surveys throughout the State of New York since 1955, including extensive surveys in the vicinity of the Indian Point Station since 1958. In 1965 and 1966, they reported the findings in the vicinity of the Indian Point Station in two special reports. Since that time, their reporting has been on a statewide basis in quarterly bulletins and in annual reports.

In 1964, the New York University Medical Center began a research program on the ecology of the Hudson River. The New York University studies include the biology of the Hudson River, the distribution and abundance of fish in the river, pesticides and radio-ecological studies. The results of this program, supported by the United States Public Health Service, the New York State Department of Health, and the Consolidated Edison Company have been submitted in several program reports.

The various studies mentioned above included measurements of radioactivity in fresh water, river water, river bottom sediments, fish, aquatic vegetation, soil, vegetation and air in the vicinity of the Indian Point Station. The results of these monitoring programs have shown that the operation of the Indian Point Units 1, 2, and 3 have had no deleterious effects on the environment.

2.9.2 Survey Programs

The survey of environmental radioactivity in the vicinity of Indian Point Station provides an indication of the integrity of the in-plant radiation monitoring instrumentation and can reveal any buildup of long lived radionuclides.

By determining the activity of filterable air particulate, vegetation, drinking water and above ground gamma fields, an indirect monitoring of discharges to the atmosphere is provided by the environmental survey program.

The effect of liquid effluents on the Hudson River is monitored by measuring the activity of the cooling water inlet to and discharge from the station, discharges from the plant, activity analysis of river shoreline soils and river fish and invertebrates.

A detailed description of the media sampled in accordance with plant Environmental Monitoring Program and the ODCM is given below:

Air Particulate and Organic Iodide

IPEC00035061

IPEC00035061

Concentration of radioactive particles in the air is measured weekly from 5 stations.

Membrane filters precede charcoal impregnated filters. The particulate filters are assayed for gross beta activity and are composited for quarterly gamma spectral analysis. Charcoal filters have gamma spectral analysis for I-131 performed weekly.

Reservoir Water

Drinking water is sampled monthly from an area reservoir. The water sampled is analyzed for gross beta activity, and for other nuclides via gamma spectral analysis. A quarterly composite sample is analyzed for tritium.

Hudson River Water

Continuous flow samples of the condenser inlet cooling water and discharge water are collected and composited. Samples are taken, at a frequency specified in the ODCM, from continuous samples and composited for a monthly gamma spectroscopy analysis, and for a quarterly tritium analysis.

Hudson River Shoreline Soil

Twice a year, at least 90 days apart, samples of river shoreline soil are taken at two locations. Gamma spectral analysis is performed on each sample.

Hudson River Fish and Shellfish

Fish and invertebrates are caught seasonally (semi-annually if not seasonal) where available near the site and analyzed by gamma spectral analysis.

Vegetation

Samples of broad leaf vegetation are collected monthly, if available, in the critical wind sections within several miles of the plant. Gamma spectral and Iodine-131 analyses are performed on these samples.

Milk

Milk samples are obtained, when available, on a monthly basis (semi-monthly when animals are on pasture) from dairy farms, located within 5 miles of the site. The samples are analyzed for Iodine-131 content, and for other nuclides by gamma spectral analysis.

Direct Gamma (Continuous)

At 40 locations near the site and out to about 5 miles, the background gross gamma radiation is continuously monitored. The measuring devices consist of two sets of thermoluminescent dosimeters (TLDs). The TLDs are removed at quarterly intervals and the amount of absorbed background radioactivity is recorded.

2.9.3 Summary

IPEC00035062

The environmental monitoring program conducted by Entergy supplies sufficient data to determine the compliance of Indian Point Unit Nos. 1, 2 and 3 with the requirements of 10 CFR 20. The environmental survey program which monitors air, water, river shoreline sediments, terrestial vegetation, milk and selected aquatic biota provides an indication of the cumulative amounts of radioactivity in the environment.

Results of the environmental monitoring program are reported on an annual basis to the nuclear Regulatory Commission, who are thereby advised of the short and long-term trends in the environment. In addition, discharges of radioactive liquids and gases are reported to the Nuclear Regulatory Commission.

In the event that the Indian Point Station Environmental Monitoring Program detects increases in the background radiation levels above the reporting levels specified in the Offsite Dose Calculation Manual (ODCM), Entergy will notify the Nuclear Regulatory Commission.

Although the design of Indian Point 3 and administrative controls are such that liquid and gaseous effluents are released in accordance with the requirements of 10 CFR 20, the environmental monitoring program conducted by IP3 and IP2 provides a redundant means of insuring that the operation of this facility does not pose any undue risk to the health and safety of the public.

IPEC00035063

An Analysis

of the Con Edison and AEC-DRL

Accident Meteorology Models

as Applied to the Indian Point Site

Prepared by

James Halitsky, Ph.D.
Associate Professor of Civil Engineering
University of Massachusetts
Amherst, Massachusetts 01002

for

Consolidated Edison Company of New York, Incorporated
4 Irving Place
New York, New York 10003

January 14, 1973

2.6.L-1

IPEC00035064

TABLE OF CONTENTS

IPEC00035065

2.6 L-2

TABLE OF CONTENTS, Cont.

IPEC00035066

2.6.L-3

LIST OF TABLES

* See note on Pg 32 regarding sector notation.

2.6.L-4

LIST OF FIGURES

IPEC00035067

2.6.L-5

Summary

The conservatism of the Con Edison and AEC-DRL accident meteorology models has been investigated for the initial 0-2 hr, 0-8 hr and 0-24 hr periods following the inception of a postulated leak through the containment structure.

Values of å c / Q for each model were compared to values calculated for 15 observed wind sequences which represented the longest persistences of lightest winds under inversion conditions in a two-month period. In computing the å c / Q for each observed hour, the Con Edison system of assigning stability classifications and selecting diffusion model equations, as described in the Unit 2 FSAR, was employed.

A tabulation of the results may be found in table 7. Roughly speaking, both models gave the same results. The 0-2hr å c / Q could expected to be exceeded about 1% of the time, the 0-24 hr å c / Q would never be exceeded. Stated another way, the factor of safety at the 1% probability level was about 1 for the 0-2 hr period and 2 for the 0-24 hr period. At the 5% probability level the factors of safety were about 10 for the 0-2hr period and 3 for the 0-24 period. These values varied by about ± 25%, depending upon distance from the source.

Additional conservatism, apart from the ratios of å c / Q cited above, was found to exist in the models, but did not show up in the ratios because the same assumption was used for both the accident models and the observed sequences. This had to do with enhanced lateral diffusion within the Indian Point building complex. Wind tunnel tests were cited to show that lateral diffusion corresponding to about Pasquill C stability, coupled with restricted vertical diffusion,

2.6.L-6

would accurately predict measured concentrations in the wind tunnel. Also, bivane measurements at Indian Point under low speed inversion conditions showed that lateral turbulence increased as vertical temperature gradients increased from 0 to about 6^{o} C/100 m (3^{o} F/88 ft), while vertical turbulence was largely unaffected. A diffusion calculation based on the bivane measurements showed that the maximum value of å $\bar{u}$ / Q would occur at a vertical temperature gradient of about 1^{o} C/100 m (0.5^{o} F/88 ft), and the corresponding Pasquill stability class at that gradient would be C-D.

Therefore, it appears that the Pasquill F or Con Edison Inversion categories in the accident models should be replaced by Pasquill D or Con Edison Neutral, if the indications of the wind tunnel and field bivane measurements are to be taken as representing the true diffusion condition. Retaining the Inversion category rather than changing to the Neutral in the Con Edison model introduces a factor of safety of about 7 at the 520 m distance.

A detailed analysis of meteorological experiments conducted in 1969 and 1970 at Indian Point to assess the long term variability of annual wind statistics and the details of wind persistence and diurnal reversal of direction confirmed that the 1956 data, used as the basis for the Con Edison accident meteorology model, are still valid today.

2.6.L-7

IPEC00035068

Introduction

The report reviews and analyzes the meteorological model used in dose calculations for a postulated loss of coolant accident at the Indian Point site, with respect to questions raised by AEC staff meteorologists and consultants and by the AEC Atomic Safety and Licensing Board. Some of these questions have been answered in writing, some were answered orally during the Indian Point Unit 3 Construction permit hearings, and some could not be answered then owing to the lack of on-site experimental data, but can be answered now with data from meteorological experiments performed at Indian Point subsequent to the Unit 3 hearings.

In this report, the questions which appear to require further response are extracted from the record, and the answers are clarified or supplemented as indicated.

Because the documents in this record were filed over a 17 year period in a number of proceedings, a chronological review has been provided in Appendix A for the convenience of the reader.

Frequent reference will be made to the ConEdison and AEC-DRL accident meteorology models. These are presented in Tables 1 and 2.

2.6.L-8

1. Conservatism of the ConEdison and AEC-DRL Accident Meteorology Models As Applied to Indian Point.

1.1 General Comments on Quantification of Conservatism

The application of conservatism in the choice of an accident meteorology model involves two concepts; one is probability, the other is factor of safety.

If one anticipates that a series of events of varying severity will occur, and can estimate the probabilities of their occurrences, then one can develop a functional inverse relationship between severity and probability, select an acceptably low probability, and design for the indicated severity.

There may, however, be uncertainty about the magnitudes of various quantities which enter into the specification of the indicated severity, and it may be desirable to design for an arbitrarily greater severity to provide a reserve against this uncertainty. The ratio of the arbitrarily greater severity to the severity dictated by the specified probability may be termed the factor of safety, or often, the factor if ignorance.

The selection of this arbitarily greater severity may be based on the selection of a lower specified probability to yield a higher indicated severity, but, as frequently happens, sufficient data may not be available to allow extrapolation in this direction. One may then postulate a series of increasingly severe events, each having an intuitively or demonstrably zero probability of occurrence, and base the estimate of degree of conservatism on the magnitude of the factor of safety. This approach carries the implication that an event with the indicated severity will occur at some time, and that the arbitrarily chosen factor of safety will harden the design specifications to compensate for the inherent uncertainties in the design parameters.

2.6.L-9

2.2 Data Analysis

IPEC00035069

In the use of Con Edison and AEC-DRL accident meteorology models, it will be shown that according to past records, neither model has ever occurred in its 30-day entirety. Also, by considering the physics of fluid motions over irregular, non-isothermal terrain, it seems likely that the probability of their ever occurring is virtually zero. However, there is a finite probability that the initial stages of the models will occur. Much of the questioning on meteorology during the IP 3 Construction License hearings was directed toward ascertaining the probabilities and factors of safety during these initial stages, but the answers were inconclusive.

In the following sections, attention will be focused on the 0-2 hr, 0-8 hr, and 0-24 meteorological sequences. The contribution of the 1-30 day sequence to the total dose is so small as not to warrant a detailed investigation.

The general procedure will be to calculated from observed data a curve of the total dilution factor $\Sigma X/Q$ vs cumulative probability of occurrence for 0-2 hr, 0-8 hr and 0-24 hr meteorological sequences, and to calculated the values of $\sum X/Q$ according to the Con Edison and AEC-DRL models for the same time periods. From these computations, two estimates of conservatism will be presented:

a) the probability of occurrence of each of the model predictions,

and

b) the factor of safety of each of the model predictions, using as a reference the $\Sigma X/Q$ vale corresponding to arbitrary indicated low probability levels of 1% and 5%.

The techniques used in the calculations, and important results, are presented in the following sections.

2.21 The Con Edison Accident Diffusion Model

For each hour of the first 24 hours, the dilution factor χ/Q is given by Eq 8, Pg 14.3.5-9 of the Unit 2FSAR[1], with y = 0:

$$\frac{\chi}{Q} = \frac{2}{\pi C_y C_z (X+X_o)^{2-n}\,\bar{u}} \quad \text{(steady wind model)} \qquad (1)$$

where

$$\left.\begin{aligned} C_y &= 0.40\ m^{n/2} \\ C_z &= 0.07\ m^{n/2} \\ n &= 0.5 \end{aligned}\right\} \text{inversion stability}$$

$\bar{u}$ = 1 m/s for first 2 hours

= 2 ms for next 22 hours

X = 350 m for Unit 3 site boundary

= 520 m for Unit 2 site boundary

IPEC00035070

= 1100 m for Units 2 and 3 low population zone

$$X_o = (A/8C_yC_z)^{1/(2-n)} = 430 \text{ m when } A = 2000 \text{ m}^2$$

For each sequence in the model, the values of χ/Q for each hour calculated by Eq [(1)], may be summed to yield å X / Q for the sequence. Sequence values of å X / Q are given in Table 3.

2.22 <u>The AEC-DRL Accident Diffusion Model</u>

For each hour of the first 8 hours, the dilution factor χ/Q is given in AEC-DRS Safety Guide 4[(2)] as

$$\frac{\chi}{Q} = \frac{1}{(\pi\ \sigma_y\ \sigma_z + cA)\ \overline{u}} \quad \text{(steady wind model)} \qquad (2)$$

With the restriction that ¶ $\sigma_y \sigma_z$ + cA must not exceed 3 ¶ $\sigma_y \sigma_z$. Under conditions of F stability and cA = 1000 m^2, this restriction becomes effective at distances between 0 and 500 meters from the source.

2.6.L-11

In Eq (2),

$$(\sigma_y \sigma_z) = \left.\begin{array}{l} 83 \text{ m}^2 \text{ at } X = 350 \text{ m} \\ 165 \text{ m}^2 \text{ at } X = 520\text{m} \\ 570 \text{ m}^2 \text{ at } X = 1100\text{m} \end{array}\right\} \text{ in F stability}$$

$$\overline{u} = 1 \text{ m/s}$$

$$c = 0.5$$

$$A = 2000 \text{ m}^2$$

For the 9th through the 24th hours, the dilution factor is given by

$$\frac{X}{Q} = \frac{\sqrt{2/p}}{S_z X\ \ b} \quad \text{(meandering wind model)} \qquad (3)$$

where σz = 6.4 m at X = 350 m

IPEC00035071

8.8 m at X = 520 m

15.0 m at X = 1100 m

β = 22.5/57.3 = 0.393

Values of à c / Q are given in Table 3.

2.23 Values of Hourly Average χ/Q from Observed Data

The data used for this calculation are contained in Figs 10-11 of N.Y.U. Report TR 71-3[3].

The meteorological parameters cited therein are as follows:

© $\bar{u}$ = wind speed (m/s)

θ = wind direction (deg from N)

ΔT = T_{95}-T_7 (°F), temperature difference between the 95 and 7 ft elevations above the base of the meteorology tower IP3 whose location is shown in Fig 1 of the above report.

2.6.L-12

The calculation of x / Q or each hour was performed using Sutton Diffusion models with diffusion parameters given on Pg 14.3.5-9 of the Unit 2 FSAR. Two diffusion models are involved; one is the steady wind model described by Eq (1). The other is a meandering wind model similar to Eq (3) but written in the Sutton form and including a wide-plume factor. This wide-plume factor has not appeared in the various Con Edison submittals to the AEC-DRL. Its omission leads to illogical concentration predictions for meandering plumes, noted in the ESSA-AREL Comment on Pg 95 in Appendix C to the AEC-DRL Safety Evaluation of Unit 2[4].

The meandering wind model used in this report is that shown on Pg Q11.10-1 of the Unit 2 FSAR multiplied by the wide-plume factor. Under conditions such that the plume centerline meanders uniformily within the sector boundaries during one entire hour, the equation for the hourly average x / Q (using present notation) may be written as

$$\frac{X}{Q} = \frac{2}{\mathrm{b}\sqrt{\mathrm{p}}} \frac{W}{\bar{u} C_z X (X + X_O)^{(1-n/2)}} \tag{4}$$

where

$$W = \frac{1}{\sqrt{2\mathrm{p}}} \int_{-P}^{+P} exp\left(-p^2/2\right) dp$$

and $P = X\mathrm{b}/2\mathrm{s}_y = \mathrm{x}\mathrm{b}/\sqrt{2}\, C_y (X + X_O)^{1-n/2}$

IPEC00035072

Values of W may be found in Fig A-4 of "Workbook of Atmospheric Dispersion Estimates" by D. B. Turner[5] for corresponding values of P.

The factor W has a value of unity when the plume width is less than the sector width. For example, assuming that the plume width is equal to $5\sigma_y$,

2.6.L-13

and the sector width is equal to Xβ then P is greater than 2.5 when $5\sigma_y$ is less than Xβ. From Turner's Workbook, W is seen to have a value of .987 at P = 2.5 and to approach unity as P increases (corresponding to a narrowing plume).

When the plume is wider than the sector, P becomes less than 2.5 and W becomes increasingly smaller as the plume width increases.

The omission of W from published versions of the sector-averaged diffusion equation carries with it the implication that the plume width is smaller than the sector width. This is often true for inversions, particularly at large distances from the source, but it is generally not true for volume sources with wakes in neutral and lapse conditions.

Values of P and W for various stability and distances are given below:

X(m	350			520			1100		
Stability	I	N	L_1	I	N	L_1	I	N	L_1
X_o(m)	430	92	43	430	92	43	430	92	43
X + X_o(m)	780	449	393	950	612	563	1530	1192	1143
n	.5	.4	.2	.5	.4	.2	.5	.4	.2
C_y	.40	.47	.60	.40	.47	.60	.40	.47	.60
P	1.48	1.41	.67	1.76	1.62	.67	2.08	2.03	.81
W	.87	.85	.50	.92	.90	.50	.99	.95	.59

Inclusion of the wide plume factor in the meandering plume equation eliminates the anomaly of yielding a sector-average concentration that is greater than the steady concentration for all stabilities and wake corrections.

In applying the diffusion models to the observed data, it is necessary to translate ΔT into stability, and to specify whether the plume is steady or meandering during a given hour.
2.6.L-14

The Con Edison system for defining stability in terms of temperature gradients was defined by B. Davidson in N. Y. U. Tech. Rep. 372.3, which is included as Pgs. Q26-Q43 of Sec. 2.6 of the Unit 2 FSAR[1]. Davidson divided the temperature gradient spectrum into three parts using the isothermal (0°F/1000 ft) and adiabatic (-5.5°F/1000 ft) temperature gradients as dividers. This yielded three stability categories lapse (L), neutral (N) and inversion (I). The L category was further subdivided into a light wind lapse (L_1) for wind speeds of 1-3 m/s and a strong wind lapse (L_2) for wind speeds > 4 m/s.

IPEC00035073

For the data from the IP3 tower, reported in N.Y.U. Rep. TR71-3[3], the ΔT corresponding to an adiabatic lapse rate over a height interval of 95-7=88 ft was –0.48°F. Accordingly, observations were assigned stability categories as follows:

inversion I　　$0 < \Delta T$
neutral N　　$-0.5°F < \Delta T < 0$
lapse L_1　　$\Delta T < -0.5°F$

The L_1 lapse was assumed since most of the wind speeds of interest were less than 4 m/s.

Meander was estimated from the progression of wind directions in Fig 11 of N.Y.U. Rep. TR-71-3[3]. Each data point represents an average wind direction for an even-numbered hour. The average wind directions during the odd-numbered hours were estimated by arithmetical averaging of adjacent even-hour values. If the difference between the two odd-hour wind directions straddling a given even hour was greater than 20°, the wind was presumed to have meandered during the even hour, and the dilution factor was calculated according to Eq (4).

If the odd-hour difference was less than 20°, the wind was assumed to have been steady, and Eq (1) was used. Steady plumes occurred 75% of the time.

On several occasions, ΔT data were missing. These hours were assigned I stability if the wind speed was less than 2 m/s and the wind meandered. N stability was used for all other cases. (See Section 4 for a discussion of stability under low speed inversion conditions.)

2.24 Cumulative Probability of Observed $\bar{X}/Q$.

Cumulative probability is derived by summing the frequency distribution from the tail end, representing zero or small probability, toward the center. The small probabilities are associated with very high values of hourly χ/Q, and these in turn are associated with light winds and inversion stability.

Inasmuch as we are interested in obtaining information regarding $\bar{X}/Q$ values at very low probabilities, it is not necessary to obtain the complete frequency distribution under all wind conditions. It is sufficient to make sure that all the high $\bar{X}/Q$ hours appear in the data base.

Figs 10a-d of N.Y.U. Rep TR 71-3[3] show the wind behavior at IP 3 on all of the days in a two-month period when the geostrophic wind was virtually zero. This means that the wind-driven circulation in the valley was absent, and the resulting wind motions were due primarily to density currents originating along the valley slopes. These are the lightest winds possible in a valley system. Therefore, a cumulative frequency distribution in the low probability range, based on wind behavior during these days, should be essentially the same as a distribution which includes the days on which the wind-driven circulation is strong.

Fig 11 shows only those hours of Figs 10a-d when the wind fell into the 000°-045° sector. The joint values of speed $\bar{u}$, direction θ, and temperature difference ΔT are given in the Figure at each data point.

The data base in Fig 11 includes 15 days of light winds during the two month period of July 15-Sept 15, 1970. This period was chosen because the tests were designed to duplicate, as closely as possible, similar experiments conducted at Indian Point during Sept.-Oct. 1955 and included in Sec 2.62 of the Unit 2 FSAR[1].

An analysis which surveys only two months out of a year may be criticized as being unrepresentative. However, to quote from Pg 2.6-3 of the Unit 2 FSAR[1]: "In general, these local winds are most frequent under clear sky and relatively light prevailing wind conditions such as occur mostly in the fall of the year." Again, on Pg 2.6-6: "It is concluded that the "worst

IPEC00035074

meteorological conditions are associated with the nocturnal down-valley flow which is most frequent during September and October."

The 1955 data include 12 days in which the large scale flow was virtually zero and 35 days in which the large scale flow was less than 16 mph. It is not known whether these are overlapping statements, but it seems likely that at least 50 days were included in the sample. Thus, the frequency of occurrence for the virtually zero flow was 12/50 = 25% in 1955.

The 1970 data also show a frequency of 15/60 = 25%. Therefore, it seems likely that the 1970 tests were made in a period of high frequency of light winds, and that a sample taken throughout the year would show a lower average frequency. Consequently, use of the 1970 2-month data base is a conservative procedure.

2.6.L-17

The first step in the calculation was determine the individual values of χ/Q for each of the data points in Fig 11 of N.Y.U. Rep TR71-3[(3)], according to the diffusion models and classification procedures described in the previous section. Tables 4, 5 and 6 show the results. A zero value of χ/Q was assigned to those hours not shown as data points, since the wind was out of the critical sector during those hours.

The next step was to accumulate these single-hour values χ/Q in 2 hr, 8 hr and 24 hr sequences, starting at each of the 24 hours in a day. For the 2 hr and 8 hr sequences, values of χ/Q for the odd hours were estimated by arithmetically averaging the adjacent even hour values. Then individual sequence accumulations of χ/Q, designated S_I^{I+n-1} where I = starting hour and n= number of hours in the sequence, were calculated, and a cumulative probability distribution made based on a sample population of 24 x 60 = 1440 possible sequence accumulations in the two month period. For the 24 hr sequences, S_I^{I+n-1} was assumed equal to twice the sum of the even-hour χ/Q values for a particular day, and 24 of these equal sums appeared each day.

An element of conservatism was introduced into the above calculation by simply adding the hourly χ/Q values in each sequence. In actuality, these hourly χ/Q values occur only on the plume centerline for steady plumes, although they occur anywhere in the sector for meandering plumes. However, the plume centerlines do not lie in the same direction during each hour of the 60 day period. Therefore, a fixed sampling point at the site boundary or low population zone would experience concentrations varying from the hourly χ/Q shown in Table 3 to zero, depending upon the direction of the steady plume axis.

2.6.L-18

Examination of the 15 useful cases in Fig 11 of N.Y.U. Rep TR 71-3[(3)] shows that the mean wind direction for all data points was 026 $^{\circ}$ and the standard deviation was 4.7 $^{\circ}$. If the distribution of wind directions were normal, this would correspond to a probability of 96% that the winds would fall in a ± 10 $^{\circ}$ sector about the mean. Thus, the plume centerlines appear to have been normally distributed in a 20 $^{\circ}$ sector centered on 026 $^{\circ}$.

The reduction factor for long time plume centerline concentrations with short time centerline fluctuations may be estimated by Eq 3.120 in "Meteorology and Atomic Energy" by D. H. Slade, ed, 1968[(6)], as $Y^2/(Y^2 + D^2)$, where Y^2 may be taken as the lateral variance of the steady inversion plume and D^2 the variance of the centerline fluctuations. These quantities are given for the inversion case by:

IPEC00035075

$$\overline{Y^2} \approx \sigma_y^2 = C_y^2 (X + X_o)^{2-n} /2 = 0.08 (X + 430)^{1.5}$$

and

$$\overline{D^2} = (4.7 X/57.3)^2 = 0.0067 X^2$$

the reduction factor is tabulated below for several distances:

dist X (m)	350	520	1100
reduction factor	0.67	0.56	0.37

Figs 1 and 2 show the cumulative probability distribution of for three time periods and å c / Q three distances from the source. They represent the simple addition of plume centerline values for the steady plumes, and sector average values for the meandering plumes. Application of the centerline fluctuation factor described in the preceding paragraph would lower the å c / Q values at the

2.6.L-19

same probability levels. The amount of the reduction would be somewhat less than the values shown because only 75% of the plumes were steady.

2.3 Accident Diffusion Model Conservatism Estimates

When the Con Edison and AEX-DRL accident model å c / Q values from Table 3 are marked on the appropriate curves of Figs 1 and 2, one may estimate the probability levels and factors of safety which were described in Sec 2.1. Table 7 lists these values.

For the 0-2 hr period, the Con Edison model å c / Q is exceeded about 0.7% of the time at the average site boundary distance. The AEC-DRL model å c / Q , being lower, is exceeded about 1.1% of the time. At the low population zone, x = 1100m, both model å c / Q values are exceeded at about the 0.5% probability level.

For the 0-8 hr period at the low population zone boundary, the Con Edison model å c / Q is exceeded 0.7% of the time, whereas the AEC-DRL model is never exceeded. This is due primarily to the AEC-DRL specification of a 1 m/s wind speed during the 2-8 hr period.

For the 0-24 hr period, neither the Con Edison nor the AEC-DRL model å c / Q values are ever exceeded. This is due primarily to the omission in both models of the diurnal wind direction reversal which removes the plume from the design sector for a large part of each day. According to Fig 11 of N.Y.U. Rep. TR 71-3[3], the longest occasion of wind duration in the sector during a given day was 10 hours, with an average of 7.0 hrs and a standard deviation of 2.65 hrs. Thus the observed 10 hr maximum duration may be expected to occur 75% of the time, and a maximum duration of 14 hrs may be expected to occur 99% of the time if the durations are assumed to be normally distributed.

2.6.L-20

The factors of safety in Table 7 are defined by

$$\text{factor of safety} = \frac{\text{model } \sum\chi/Q}{\text{observed } \sum\chi/Q \text{ at specified probability level}}$$

IPEC00035076

The two models show about the same factors of safety at the 1% probability level for all distances and time periods, except that the AEC-DRL model shows more conservatism in the 0-8 hr period, due to its use of a 1 m/s wind speed in the 2-6 hr interval while the Con Edison model uses a 2 m/s speed for the same interval. Similar points of similarity and disagreement between the models occur at the 5% probability level.

At the 5% probability level, the two models show about the same agreement and disagreement with respect to factors of safety as appears at the 1% probability level. However, the factors of safety are higher by about 6-10 times for the 0-2 hr period. This reduces to about 2.5 times for the 0-8 hr period and 1.5 times for the 0-24 hr period.

It should be remembered that these factors of safety apply to χ/Q values, or to concentrations if the source strength remains constant throughout the sampling period and no decay occurs in transit from source to sample point. In theory, the source strength will be a rapidly decreasing function of time, due to operations within containment, initiated at the time of occurrence of the accident. Therefore, if the curves of Fig 2 and the corresponding data in Table 7 are to be used for predicting probabilities and factors of safety for cumulative concentration $\sum\chi$, appropriate adjustment must be made for the behavior of Q with time.

2.6.L-21

3. Building Wake Effects in Diffusion

3.1 Physical Appearance of Diffusion Model Wake Plumes

It is often useful to visualize plume behavior by determining the plume boundary in space. This is particularly helpful in wake diffusion estimates. The Con Edison and AEC-DRL accident meteorology models both incorporate wake diffusion parameters whose effect on the plume shape is not immediately seen. In this section, the wake plumes as described by the diffusion models, and as observed in wind tunnel and field tests, will be compared.

The Con Edison wake diffusion model employed a virtual displacement of the point source to a location upwind of the building. This has the effect of increasing the distance available for the plume to grow laterally and vertically before it reaches a given station downwind of the building. The increased transverse dimensions allow the matter in the plume to be distributed over a wider cross-sectional area, and the average concentration is thereby reduced at that station.

The calculation of the vertical point displacement distance for the Con Edison diffusion model is described on Pgs 14.3.5-8 and 14.3.5-9 of the Unit 2 FSAR(1). Analytically its value is given by

$$X_o = (A/8\ C_y C_Z)^{1/(2-n)} \qquad (5)$$

where A is the building area projected in the direction of the wind and C_y, C_z and n are the Sutton diffusion parameters.

The shape of the plume boundary between the virtual source and the building is irrelevant since the plume is non-existent in this region. The shape of the boundary at large distances downwind of the building is that of a simple plume from a ground level continuous point source, i.e. elliptical in cross-section with the horizontal axis at the ground surface. At the building location

IPEC00035077

the real plume boundary must be that of the building wake. Between the building and some distance downwind, the plume boundary changes shape gradually from that of the building wake to that of the undisturbed plume.

The virtual source displacement method does not define the plume boundary at the building, and its characterization of the boundary shape takes on increasing reality with distance downwind from the building. However, it is interesting to compare the hypothetical elliptical plume dimensions with the building dimensions at the building location.

Although the Con Edison diffusion model utilizes the Sutton equations, the concentration distribution in any cross-section is bi-gaussian, and the Sutton parameters are related to the gaussian plume parameters by

$$\sigma_y = C_y X^{(2-n)/2} \quad /\sqrt{2} \tag{6}$$

and

$$\sigma_z = C_z X^{(2-n)/2} \quad /\sqrt{2}$$

Eq (5) derives from Eq (6) when the assumption

$$4\sigma_y = 4\sigma_z = \sqrt{A} \tag{7}$$

is made. However, the equality of σ_y and σ_z implied by (7) indicates that the plume boundary at the building is a circle, as a special case of an ellipse. Since no specification is made of the building shape, one may assume that the projected cross-section of the building is an approximate semi-circle, with radius R_B equal to the building height. This leads to $A = \pi R_B^2/2$ and

$\sqrt{}$

$\sigma_y = \sigma_z = \;\; A/4 = 0.31R_B$. Now assuming as is commonly done, that a gaussian plume boundary lies at 2.5 , the plume boundary radius becomes $R_P = 2.5\ (0.3/R_B) \cong 0.08R_B$.

This result is not far from reality for a hemispherical building, as may be seen by examining the photographs in Fig 5.23 of Meteorology and Atomic Energy. [6] For rounded building surfaces, the wake seems to form downwind of the building centerline, especially so for high Reynolds Numbers, and the effective wake radius is smaller than the building radius.

For sharp-edged buildings, however, the wake boundary is larger than the building radius. For example, Fig 5.18 of Meteorology and Atomic Energy shows the cavity and wake downwind of a sharp-edged square plate with the cavity boundary at about 2 plate half-widths above the plate half-widths above the plate centerline. Other experiments described in the same chapter of Meteorology and Atomic Energy[6] show that the wake boundary for a sharp edged building is about 1.5 building heights above the ground. If considerable roughness exists around the base of the building so that flow is retarded in the lower layers near the ground, the wake height is reduced.

IPEC00035078

Therefore, it seems that the virtual point source displacement calculation given by Eq (1) is realistic for rounded buildings and conservative for sharp-edged buildings, with respect to replication of the plume dimensions at the building.

The AEC-DRL[2] wake model sets $\sigma_y \sigma_z = cA/\pi$ at the building. If A =

$\pi R_B^2/2$ and $\sigma_y = \sigma_z$ as before, $\sigma_y = \sigma_z = \sqrt{c/2}\, R_B^2$ and $R_p = 2.5\sqrt{c/2}\, R_B = 1.77\sqrt{c}\, R_B$.

Using the AEC- DRL [2] shape c = 0.5, we obtain $R_P = 1.25\, R_B$.

Therefore, the AEC-DRL wake plume boundary at the building appears to be less conservative but more realistic than the Con Edison wake plume boundary at the same location.

The greatest element of conservatism in both wake models is the use of the cross-sectional area of the reactor building alone as the numerical value of A. At a real site, the reactor building may have contiguous auxiliary buildings and lie in a complex of other buildings. Matter released into the atmosphere from the reactor building will diffuse into the composite wake of the reactor and auxiliary buildings, and may disperse laterally and even upwind into the wakes of other buildings in the complex. Therefore, the effective cross-sectional area which characterizes the wake at the building should be based on the probable plume boundary dimensions near the reactor building rather than the area of the building alone. Unfortunately, no systematic study of this aspect is available as a basis for formulating a more liberal rule.

3.2 Wind Tunnel Test of Diffusion in the Indian Point Complex.

Some information regarding the behavior of gas released in a building complex with restricted vertical diffusion potential was obtained in a wind tunnel test of a topographical model of the Indian Point reactor complex. The study was reported in

"Wind Tunnel Test of Gas Dispersion From Indian Point Unit 1" by James Halitsky, June 29, 1971,[7]

and was submitted to the AEC-DRL in connection with a safety analysis of the Unit 1 stack under tornado wind loadings.

In this test, the model was oriented in the 020 $^{\circ}$ wind direction, the tunnel wind stream was isothermal, and had low turbulence (<1%) and uniform mean velocity everywhere except in the floor, ceiling and wall boundary layers. Tests were conducted at prototype wind speeds of 6.7 and 11.1 m/s which, with

Froude Number scaling and model linear scale of 1:360, mandated tunnel velocities of 0.35 m/s and 0.58 m/s, respectively. $S0_2$ tracer gas was released at ground level just downwind of the Unit 1 reactor shell, and sampled on the tunnel centerline at prototype downwind distances of 305m, 610m, and 1100m from the Unit 1 Stack, and at prototype elevations of 2m, 16m, 30 m, 45m, 74m, 103m, 131m, and 160m above local ground at each downwind location.

From the vertical concentration traverses (fig 18 of the reference) it was found that the gas had diffused upward through the entire surface boundary layer by the time it reached the first longitudinal station (305m), and did not diffuse farther vertically with additional distance downwind. The boundary layer height (and plume depth) was about 90m above local ground. Suppression of further upward diffusion was caused by the existence of very low turbulence (equivalent to Pasquill Type E stability) in the free stream.

IPEC00035079

The lateral plume boundary distance may be calculated from knowledge of the measured value of $\chi \bar{u}/Q$ at the ground and the value of σ_Z, which may be assumed to have been 90/2.5 = 36m since the vertical concentration profiles were approximately gaussian in shape. The observed data for the test, and the corresponding σ_y values, calculated with

$$\chi u/Q = [\pi \sigma_y \sigma_Z]^{-1} \qquad (8)$$

are shown below:

distance (m)	305	610	1100
$\chi\bar{u}/Q$ (m^{-2}) (observed)	2.2×10^{-4}	1.0×10^{-4}	0.8×10^{-4}
σ_z (= 90/2.5)m (observed)	36	36	36
σ_y (m) calculated	39	38	111

2.6.L-26

The above observed values may be replicated by calculation with fair accuracy by using Eq (8) with a fixed σ_Z, and assuming a Pasquill stability class slightly more unstable than C, for σ_y. The following table shows the calculated values:

distance (m)	305	610	1100
$X\bar{u}/Q(m^{-2})$(calculated)	2.3×10^{-4}	1.2×10^{-4}	0.7×10^{-4}
σ_Z (m) (assumed)	36	36	36
σ_y (m) (assumed C^+)	39	73	130

The plume behavior in this test is an example of the mixed type of diffusion process which takes place in the atmosphere when vertical diffusion is suppressed by inversion temperature gradients while horizontal diffusion is uninhibited and, in fact, may be augmented by slope density currents and mechanical turbulence generated by wind passage between buildings and other structures in a reactor complex.

Attempts were made to fit the Con Edison and AEC-DRL wake models to the observed tunnel plume behavior, but were unsuccessful. It appears that neither the vertical source displacement nor the volume wake correction, which work well for discrete buildings, is applicable to diffusion in building complexes.

2.6.L-27

4. Turbulence Characteristics Under Low Wind Speed Inversion Conditions.

4.1 Observations at the IP 2 Tower in 1969

IPEC00035080

From September 1968 to May 1969, wind data were measured at three locations in the Hudson River Valley at and near Indian Point, to aid in selection of a site for proposed new nuclear power units. A report of this investigation is contained in NYU Report TR 70-3[8].

The locations of the three towers, designated by the symbols IP2, MP and BP respectively, are shown in Figs 1-5 or TR 70-3. Of particular significance to the present study is an analysis, contained in TR 70-3, of the wind behavior at the IP 2 tower during periods of upper air stagnation.

The IP2 tower was located 305m southwest of Unit 3 on a cleared strip of ground which sloped down in a westerly direction to the Hudson River. The base of the 100 ft tower was at el 60 ft above river elevation. The tower was equipped with sensitive wind speed and direction sensors at 100 ft above local ground, and temperature difference sensors at 95 ft and 5 ft above local ground.

Figs 11-13 of TR 70-3 show simultaneous measurements of hourly mean wind speed, wind direction, temperature difference and wind direction range/4.3 for three periods of upper air stagnation during April and May 1969. During seven nights of these periods, the wind behavior approached the type assumed in both the Con Edison and AEC-DRL 2-hr accident meteorology models, exhibiting low wind speed and temperature inversion, but did not exhibit directional steadiness either within an hour or from hour to hour.

Directional steadiness within an hour is usually identified by a

IPEC00035081

small standard deviation of 15-sec average directional angles about the hourly mean direction. It has been observed by Slade in "Meteorology and Atomic Energy, 1968", Sec. 3-3.4.1, [6] that the Pasquill stability categories may be associated with typical numerical values of the standard deviation as follows:

Pasquill Stability Class	Std. Deviation σ_θ
A	25°
B	20°
C	15°
D	10°
E	5°
F	2.5°

Applying Slade's classification system to observations of direction range/ 4.3 . σ_θ) during the seven night periods under consideration, it was found that the observed hourly stabilities varied from A to F, with an average of about C or D, even though a temperature inversion was always present. Thus, on the average, a considerable amount of unsteadiness was present during an average hour.

The effect of wind unsteadiness (high σ_θ) on dispersion is to reduce concentrations to values below those which would occur under steady conditions (low σ_θ). For example, using Slade's Fig A.2, it is readily seen that a change from F stability to D stability would increase σ_y by a factor of 2 at a distance of 1100 m and thereby decrease,
$\chi\bar{u}/Q = \left[\pi\sigma_y\sigma_z\right]^{-1}$ a factor of 2, even

if σ_Z should remain unchanged. By comparing σ_Z values in F and D stabilities, it is seen that an additional reduction in concentration by a factor of 2 would occur if the vertical unsteadiness changed in proportion to the lateral unsteadiness.

Thus, it is important in evaluating conservatism to establish realistic stability classifications in both the vertical and horizontal directions.

4.2 Observations at the IP 3 Tower in 1970
4.3

When the Indian Point meteorology tower was moved from the IP 2 location to the IP 3 location in late 1969, a bivane was added at IP 3 to provide additional data on low speed inversion stability characteristics. Data were reported in NYU Report TR 71-10[9].

The bivane was equipped with a switching device which allowed the strip chart recorder to run at 3 in/min for 10 minutes each hour, and at 3 in/hr during the remainder of the hour. The recorder was operated at various intervals from May to December 1970. The intervals, which were 30 hours long, were determined according to the expectation of low wind speeds and by the availability of personnel. A total of 153 hours for which concurrent speed, direction and vertical temperature difference were available, and the speed was less than 2 m/s, formed the data base.

The most important conclusions of the study were:

IPEC00035082

a) Under inversion conditions, the standard deviation of azimuth angles (σ_θ) increased with wind speed to 1.4 m/s and then decreased, with the following values of σ_θ and equivalent Pasquill stability class according to Slade's system: (from Fig 1 of TR 71-10):

2.6.L-30

No. of Observ.	Speed Range (m/s)	5-Sec Smoothing σ_θ(deg)	5-Sec Smoothing Stability	200-Sec Smoothing σ_θ(deg)	200-Sec Smoothing Stability
3	0-0.4	9	D	7	DE
5	0.4-0.8	12	CD	10	D
12	0.8-1.2	16	C	15	C
17	1.2-1.6	18	BC	13	CD
17	1.6-2.0	9	D	4	E

The 5-sec smoothing period better approximates Slade's procedure than the 200 sec smoothing period.

b) Under the same inversion and speed categories as above, the standard deviation of elevation angles, σ_θ, remained about constant at 6-7° over the entire range of speeds.

c) A breakdown of the above according to wind direction sectors showed a minimum σ_θ of 8° (DE stability) to occur in the 340° - 040° wind sector, with a corresponding σ_ϕ of 6°, for 5 sec smoothing.

d) Under inversion conditions, both σ_θ and s_f increased with $\Delta T = T_{95}$-T_5 (°F) in the 340° - 040° wind sector as follows:

No. of Observ.	ΔT Range (°F)	σ_θ (deg)	5-Sec Smoothing Stability Class	5-Sec Smoothing σ_ϕ (deg)
10	0-1	8	DE	6
7	1-2	9	D	7

IPEC00035083

6	2-3	20	B	9

e) A calculation of $\chi \bar{u}/Q$ by the method of Hay and Pasquill in Advances in Geophysics (6) Academic Press pp 345-365[10], using data for the 340° - 040° wind sector, shows the following at a distance of 1100 m and $\bar{u}$ = 1.85 m/s:

	Values of $10^4 \chi \bar{u}/Q$	
$\Delta T(^{\circ}F)$	Steady	Meander
0	0.7	0.4
0.5	0.8	0.4
1.0	0.7	0.4
1.5	0.4	0.3
2.0	0.2	0.2

A concentration maximum occurs at a ΔT of 0.5 $^{\circ}$ F.

4.4 Interpretation of Bivane Observations

The behavior of the bivane can be attributed to the development of katabatic winds, or down-slope currents, under inversion conditions. These currents are caused by cooling of slope air near the ground. This air becomes more dense than air over the floor of the valley, resulting in local pressure differences which cause drainage of air down the slopes.

Over irregular terrain, non-parallel descending currents impinge on one another, creating irregular motions in both the horizontal and vertical directions. However, the horizontal motions are unconstrained, while the vertical motions are suppressed by the inversion. Therefore the effects of the slope currents show up strongly in enhanced horizontal turbulence (σ_θ) but have only a small effect on vertical turbulence (σ_ϕ).

IPEC00035084

The bivane observations show that, in the 340° - 040° sector, maximum turbulence levels of $\sigma_{\phi} \approx 18^{\circ}$ and $\sigma_{\phi} \approx 9^{\circ}$ occur with wind speeds near 1.4 m/s and vertical temperature differences of about 2.5 $^{\circ}$F. Turbulence levels fall off at wind speeds above and below 1.4 m/s. The temperature difference accompanying speeds greater than 1.4 m/s must have been equal to or less than 2.5 $^{\circ}$F since Table IV of TR 71-10 shows no observations >3.0 $^{\circ}$F in this sector. This may indicate the existence of extra-valley influences in creating higher wind speeds that are not thermally-generated.

The high turbulence level at a wind speed of 1.4 m/s and $\Delta T = 2.5\,^{\circ}$ produces a $\chi \bar{u}/Q$ equivalent to a Pasquill type A-B stability (See Table XI).

As ΔT reduces, $\bar{u}$, σ_{θ} and σ_{ϕ} also reduce, causing an increase in $\chi \bar{u}/Q$ to a maximum at $\Delta T = 0.5\,^{\circ}$ where the equivalent Pasquill stability is C-D.

Thus, the bivane data confirm the applicability of the Pasquill C-D stability class at near-neutral temperature stratification, even in irregular terrain. However, the customary increase of stability class with increasing temperature gradient, which is valid for level ground, is not valid at this site. On the contrary, the effective stability decreases with increasing temperature gradient at least up to a $\Delta T = 3\,^{\circ}$F. Similar behavior was observed at the IP 2 tower during the previous year.

It appears that the assignment of I stability to those hours which exhibited inversion temperature stratification in the calculation of hourly average χ/Q from observed data in Sec 2.23 in extremely conservative, and that a more realistic rule would be to use N stability instead.

2.6.L-33

5. Wind Persistence

Wind persistence is a measure of steadiness of wind direction with increasing time. It is important in accident meteorology because invariance of wind direction exposes a stationary subject on the plume centerline to the highest concentration for the longest period, under given conditions of source strength and wind speed.

Both the Con Edison and AEC-DRL accident meteorology models postulate that the hypothetical accident occurs at the onset of a 24-hr period of strong wind persistence. Both models assume a steady hourly mean wind direction for the first 8 hours. For the next 16 hours, the Con Edison model retains steadiness, while the AEC-DRL model permits uniform direction meander within a 22½ $^{\circ}$ wind sector. Although the Con Edison model is more stringent with respect to direction in the latter period, it also assumes a higher wind speed, thereby making the hourly average χ/Q values about the same for both models.

It is generally recognized that a correlation exists between strong wind speeds and long periods of persistence. [15] However, the accident models assume light wind speeds (<2 m/s) and inversion conditions during the 0-24 hr period. The probability of occurrence of long periods of persistence under these conditions is examined in the following sections.

5.1 Persistence Data Taken in 1955

On Pg 2.6-4 of the Unit 2 FSAR, experiments are cited to show that " ... a consecutive 24 hour down-valley flow with light wind speeds and inversion conditions is extremely improbable ...", that the " ... duration of the down-valley flow is about 12 hours rather than 24 hours, ..." and

IPEC00035085

that "... it must be concluded that the safety analysis for the first 24 hours is conservative to within a factor of about two ...", since the average speeds assumed in the model are about the same as those observed at the site.

2.6.L-34

The experiments referred to above were measurements taken in Sept.-Oct. 1955 with an Aerovane mounted 70 ft above the Hudson River on the mast of a ship, the Jones, whose location is shown in Figs 1-3 of NYU Rep TR 71-3[3] at the point marked J. The data taken during the experiments were presented in Figs 2.6-1, 2.6-2 and 2.6-3 of the Unit 2 FSAR.

Figs 2.6-1 and 2.6-2 are wind hodographs, or polar coordinate representations of the behavior of the wind velocity vector during a 24 hour diurnal cycle. Fig 2.6-3 is a graph of wind steadiness, defined as the ratio (mean vector wind speed)/(mean scalar wind speed) vs time of day.

All three Figures present the averages of measurements taken on 12 days and 35 days during the test period. The procedure of basing the accident meteorology model on the average condition rather than on some less frequent but more severe condition has been criticized as not being sufficiently conservative (see Appendix C to the AEC-DRL Safety Evaluation for the Unit 2 Operational License hearing, and Appendix C to the AEC-DRL Safety Evaluation for the Unit 3 Construction License Hearing).[11]

Also somewhat misleading is the placement of the coordinate center for the hodographs in Figs 2.6-1 and 2.6-2 at the Unit 2 reactor building, rather than at the Jones, which was located about a mile to the north.

The questions regarding individual, rather than average, wind characteristics, and possible differences between characteristics at the Jones and at the plant site, could not be resolved because the original data were no longer available.

2.6.L-35

5.2 Persistence Data Taken in 1970

5.21 Hodographs

In 1970, experiments were undertaken to duplicate as closely as possible the 1955 experiments at the Jones and to obtain concurrent data for the ship and plant locations. Results were presented in NYU Report TR 71-3.[3]

An Aerovane was mounted on the Cape Charles, which was anchored about 350 m SW of the former location of the Jones (at point CC in Figs 2-4 of Report TR 71-3). A sensitive Climet cup and vane anenometer was mounted on the IP 3 tower.

It was found that the average wind hodograph at the ships, separated by 14 years in time, were very similar, exhibiting the same diurnal reversal pattern and the same 2.5 m/sec nighttime downvalley speed in both years. It seems clear that the diurnal reversal of direction is a characteristic of the site and can be expected to occur every year.

The average wind hodograph at IP 3 showed a similar pattern of diurnal reversal, but the average nighttime downvalley speed was somewhat less than 2 m/s.

All sixteen daily wind hodographs at IP 3 showed the diurnal reversal, and exhibited considerable variability in speed and direction from day to day through a complete cycle. The

IPEC00035086

longest period of direction persistence was 8 hrs, occurring on each of 5 nights, and the average wind speed during each period was least 2 m/s.

Further analysis of wind behavior during these and other low speed inversion days is presented in Sections 2.23 and 4.2 of this report.

2.6.L-36

5.22 numeration of Occurrences of Persistence

Also presented in Report TR 71-3 is a listing of 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 data of Table 1 of Report TR 71-3, showing persistence under inversion conditions for the 002° - 022° and 022° - 042° sectors* taken separately, are shown combined in Table 8 of this report. Also shown are comparable data taken during 12 months of calendar year 1971 (previously unpublished).

The two sets of data show that:

a) persistence increases with wind speed,

b) the probability of finding 2 consecutive hours when the wind speed is 1 m/s or less in the 40° wide sector under inversion conditions is extremely small (2 hours in 5989 or 0.03% during 1969-70 and 0 in 1971),

c) the probability of finding 2 consecutive hours when the wind speed is 2 m/s or less under the same conditions as above was 7 hours in 5989 or 0.11% during 1969-70, and 60 hours in 5560 or 1.1% in 1971,

d) no persistences longer than 7 consecutive hours occurred in either year, for wind speeds less than 3 m/s.

The above figures are based on occurrences of wind direction somewhere in a 40 ° sector. It is likely that a more stringent definition of steadiness would reduce the probabilities even further.

*Wind direction sectors are identified in this report by the wind angles at the sector boundaries; the difference between these boundary angles is the sector width of 20 °. In the Unit 2 FSAR and early NYU reports, sectors are identified according to the range of wind observations as read to the nearest 5 ° from wind charts. Thus, wind sector 002° - 022° in this report corresponds to wind sector 005°-020° in FSAR.

IPEC00035087

2.6.L-37

6. Recurrence of Annual Wind Statistics

Fig 3 shows the annual distribution of wind direction for 1956, 1957 (from NYU Report 372.4, Pg R-6 of Sec 2.6 of the Unit 2 FSAR) and for 1970 and 1971 (unpublished).

The bi-modal character of the distribution occurs in each of the years, and the fraction of time that the wind is in the critical 002 ° - 022° sector remains relatively constant in all four years.

The most noticeable change is a re-distribution of some southerly (160° - 200°) and north-westerly (290° - 360°) winds to the easterly and westerly sectors. Neither of these changes is a matter for concern since easterly winds carry releases over the river and westerly winds carry them toward a more distant site boundary.

Fig 4 shows the wind direction distribution in each temperature gradient class for 1956, 1970 and 1971. The 1956 curves represent data in Table 3.3 of NYU Rep. 372.3, (Pgs Q-39 and 40 of Sec 2.6 of the Unit 2 FSAR). The 1970 and 1971 data have not been published as yet. The 1956 wind statistics appear to be representative of a typical year. Therefore the stability mix used in the 1-30 day period of the accident model, which was selected on the basis of the 1956 statistics, is still valid.

Fig 5 shows a small decrease in the frequency of light wind speeds (02- m/s) in the critical sector. The shift of southerly winds toward the southeast seems to be accompanied by an increase in wind speed.

2.6.L-38

7. Plume Behavior Beyond the Site Boundary

7.1 Steady Wind

Material released as a leak at the surface of a building under non-zero wind speed conditions will diffuse initially around the building surfaces in a complicated pattern determined by the building shape and the location of the leak. Typical dispersion pattern around a wind tunnel model of a reactor building having rounded surfaces are shown in Figs 5.29a-c of Meteorology and Atomic Energy[6].

It is seen that concentrations decrease rapidly with distance from the release point, although the direction of the minimum rate of decrease is not always readily foreseen. This results in irregular, non-gaussian concentration distributions in planes normal to the mean wind direction at stations within several building diameters downwind from the building.

However, at about 5 building diameters downwind, the concentration profiles become more-or-less regular in that a concentration maximum occurs at the ground on the building centerline and concentrations decrease radially outward in the y-z plane to zero at the wake boundary. With increasing distance downwind, atmospheric turbulence acts to further smooth the profiles in an asymptotic approach to the familiar bi-gaussian distribution.

IPEC00035088

A non-dimensional distance of 5 diameters is equivalent to 5 x 43 = 215 meters for the Unit No. 2 reactor building. Since the site boundary distance is 350 m from Unit No 2, it seems reasonable to assume that the maximum concentration in a plane normal to the wind at the site boundary will indeed be at the ground. If this is so, then ground level concentrations beyond the

2.6.L-39

site boundary will always be lower than at the boundary by virtue of continued plume expansion with distance downwind.

7.2 Wind Reversal

If the wind should reverse 180° after a steady plume has been established, the time history of concentration at the former downwind site boundary after reversal will be a continued reduction of concentration with time because successively more diffuse portions of the plume will cross the boundary as the plume "backs up."

If the wind reversal persists long enough, the backed-up plume will become the ambient environment within which a new plume has formed in the opposite direction from the original. The total plume concentrations will then be the sum of the residual old plume concentrations plus the new plume concentrations. The critical site boundary will be located 180° from the previous one.

At the Indian Point site, 180° wind reversals occur occasionally during periods of upper air stagnation, between about 1000 and 1200 hours and between 2000 and 2200 hours (see individual hodographs in Figs 10a-d of NYU Report TR 71-3[3]).

In the daytime reversal, the wind has been in the downvalley direction with inversion conditions, but the change to the upvalley direction is accompanied by a change to a lapse temperature gradient. Therefore both the newly-established plume and the residual old plume have light concentrations compared to those assumed in the accident model.

In the nighttime reversal, the accident meteorology must be assumed to occur at some time prior to the reversal in order to create the residual old plume. This old plume is generated under lapse conditions during the period of greatest source strength. After reversal, these concentrations pass over the downvalley site boundary, but the source strength is now weaker. Therefore the

2.6.L-40

sum of the new and residual concentrations is probably not greater than obtained with the accident model.

2.6.L-41

List of References

1. Con Edison Final Facility Description and Safety Analysis Report (FSAR), as Amended, for Indian Point Nuclear Generating Unit No 2 (U.S.A.E.C. Docket 50-247).

2. U.S.A.E.C.-D.R.S. (1970): Safety Guides for Water Cooled Nuclear Power Plants.

3. Halitsky, J., E. J. Kaplin and J. Laznow (1971): Wind Observations at Indian Point, 26 November 1969-1 October 1970. N.Y.U. Dept of Met. and Ocean. GLS Report TR 71-3.

IPEC00035089

4. U.S.A.E.C.-D.R.L. (1970): Safety Evaluation of Con Edison Indian Point Nuclear Generating Unit No. 2 (Docket 50-247), with Appendix C prepared by Air Resources Environmental Laboratory, Environmental Science Services Administration, Nov. 29, 1968 and Feb. 17, 1970.

5. Turner, D. B. (1969): Workbook of Atmospheric Dispersion Estimates, Air Resources Field Research Office, ESSA.

6. Slade, D. H., ed. (1968): Meteorology and Atomic Energy. U.S.A.E.C. Div. Of Tech. Inform. CFST1 TID-24190.

7. Halitsky, J. (1971): Wind Tunnel Test of Gas Dispersion from Indian Point Unit 1. Unpublished report prepared for Con Ed dated June 29, 1971.

8. Halitsky, J., J. Laznow and D. M. Leahey (1970): Wind Observations at Indian Point, Montrose and Bowline Point, 31 Aug 1968-30 June 1969. NYU Dept. of Met. and Ocean. GSL Report TR 70-3.

9. Leahey, D. M. and J. Halitsky (1971): Low Wind Speed Turbulence and Related Diffusion Estimates for Indian Point, N. Y. N.Y.U. Dept. of Met. and Ocean. GSL Report TR 71-10. Also Atmospheric Environment Vol. 7 page 49-61 January, 1973.

10. Hay, J.S. and F. Pasquill (1959): Diffusion from a Continuous Source in Relation to the Spectrum and Scale of Turbulence. Advances in Geophysics 6. Academic Press pp. 345-365.

11. U.S.A.E.C.-D.R.L. (1969): Safety Evaluation of the Con Edison Indian Point Nuclear Generating Unit No. 3 (Docket No. 50-286), with Appendix C prepared by Air Resources Environmental Laboratory, ESSA January 2, 1968.

12. DiNunno, J. J., R. E. Baker, F. D. Anderson and R. L. Waterfield (1962): Calculation of Distance Factors for Power and Test Reactor Sites, U.S.A.E.C. DTI document TID-14844.

13. Con Edison PSAR for Indian Point Nuclear Generating Unit No. 1 (U.S.A.E.C. Docket 50-3).

IPEC00035090

14. U.S.A.E.C.- Atomic Safety and Licensing Board (1969): Transcript of Testimony in the Matter of Con Edison Application for a Construction License for Indian Point Nuclear Generating Unit No. 3.

15. Van der Hoven, I. (1969): Wind Persistence Probability ESSA Tech. Mem. ERLTM-ARL 10.

2.6.L-43

Table 1. The Con Edison Meteorological Model

Period	Wind Speed ©	Wind Direction U: Variability in 20° Sector	Wind Direction U: Frequency in 20° Sector	Stability*: Class	Stability*: Frequency	Building** Wake Effect
0-2 hrs	1 m/s	steady	100%	Inversion, I	100%	yes
2-24 hrs	2 m/s	steady	100%	Inversion, I	100%	yes
1-30 days	1.74 m/s			Lapse, L_1	13.7%	
	5.23 m/s			Lapse, L_2	6.1%	
	2.79 m/s			Neutral, N	37.8%	
	2.03 m/s			Inversion, I	42.4%	
	all	meander	35%	all	100%	no

*Sutton parameters C_y, C_z and n for stability classes L_1, L_2 and N were derived from site meteorological experiments. For stability class I, the model adopted the Inversion parameters from USAEC TID-14844 "Calculation of Distance Factors for Power and Test Reactor Sites" by J. J. di Nunno, F. D. Anderson, R. E. Baker and R. L. Waterford, dated March 23, 1962.[12]

**Employs virtual point source displacement $X_o = (A/8\ C_y\ C_z)^{1/(2-n)}$ where A = building area of 2,000 m^2 for periods 0-2 hrs and 1-30 days.

2.6.L-44

IPEC00035091

Table 2. The AEC-DRL Meteorological Model

for Pressurized Water Reactors

Period	Wind Speed ©	Wind Direction, U: Variability in 22.5 ° Sector	Wind Direction, U: Frequency in 22.5 ° Sector	Stability*: Class	Stability*: Frequency	Building** Wake Effect
0-8 hrs	1 m/s	steady	100%	Pasquill F	100%	yes
8-24 hrs	1 m/s	meander	100%	Pasquill F	100%	no
1-4 days	3 m/s			Pasquill D	40%	
	2 m/s			Pasquill F	60%	
	all	meander	100%	all	100%	no
4-30 days	3 m/s			Pasquill C	33.3%	
	3 m/s			Pasquill D	33.3%	
	2 m/s			Pasquill F	33.3%	
	all	meander	33.3%	all	100%	no

*Volumetric building wake correction as defined in Section 3-3.5.2 of AEC TID-24190 Meteorology and Atomic Energy 1968[6] with shape factor c = 0.5 and minimum across sectional area of reactor building only.

IPEC00035092

Table 3. Values of 10^4 $\sum\chi/Q$ (sec/m^3)

According to the Con Edison and AEC-DRL Models
for Various Time Periods and Distances

	Con Edison			AEC-DRL		
Distance from Source (m)	350	520	1100	350	520	1100
Time Period						
0-2 hr	20.8	15.8	7.6	25.6	13.2	7.2
2-8 hr	--	--	11.4	--	--	21.6
8-24 hrs	--	--	30.4	--	--	19.6
0-8 hrs	--	--	19.0	--	--	28.8
0-24 hrs	--	--	49.4	--	--	48.4

Values of $\sum\chi/Q$ for sequences longer than 2 hours at x = 350 and 520 are not given because standards at the site boundary are specified for the 0-2 hr period only.

IPEC00035093

Table 4. Values of Hourly Average 10^4 χ/Q at 350 m from the Source

During 15 Selected Light Wind Days, July 15 – Sept 15, 1970

	Hour					
Date	22	24	02	04	06	08
7/23-24		3.5	4.7	0.6		
7/24-25		21.7	13.5	1.5	0.3	
7/25-26	0.7	1.2	0.3	1.0	0.4	
7/26-27				1.0		
7/27-28		9.8	8.3		0.5	
7/28-29			0.8	1.0	0.3	
8/8-9	5.1	1.1	1.0	0.7	0.6	
8/13-14	5.9	7.2	2.9	0.4	0.9	
8/14-15		2.4	21.7	5.2	0.6	
8/15-16		12.8	4.7		1.0	6.4
8/25-26	5.5	0.9	.8			
8/26-27				15.4	10.8	
8/27-28		5.5	0.9	0.6		
9/12-13	3.7	7.2	6.8	7.7	0.5	
9/13-14	15.4	9.9	0.7	0.4	0.8	

IPEC00035094

Table 5. Values of Hourly Average 10^4 χ/Q at 520 m from the Source

During 15 Selected Light Wind Days, July 15 – Sept 15, 1970

	Hour					
Date	22	24	02	04	06	08
7/23-24		2.2	3.4	0.4		
7/24-25		15.7	9.8	0.9	0.1	
7/25-26	0.3	0.7	0.1	0.6	0.2	
7/26-27				0.6		
7/27-28		7.1	6.1		0.2	
7/28-29			0.4	0.6	0.2	
8/8-9	3.2	0.6	0.6	0.4	0.3	
8/13-14	3.6	5.2	2.1	2.5	0.5	
8/14-15		1.5	15.2	3.7	0.3	
8/15-16		7.9	3.4		0.6	4.6
8/25-26	3.4	0.5	0.5			
8/26-27				9.5	7.9	
8/27-28		3.4	0.5	0.4		
9/12-13	2.3	5.2	4.9	0.5	0.3	
9/13-14	9.5	7.1	0.4	0.3	0.5	

IPEC00035095

Table 6 Values of Hourly Average $10^4\ \chi/Q$ at 1100 m from the Source

During 15 Selected Light Wind Days, July 15 – Sept 15, 1970

	Hour					
Date	22	24	02	04	06	08
7/23-24		0.8	1.7	0.1		
7/24-25		7.8	4.8	0.3	0	
7/25-26	0.1	0.3	0	0.2	0.1	
7/26-27				0.2		
7/27-28		3.5	3.0		0.1	
7/28-29			0.1	0.2	0	
8/8-9	1.1	0.2	0.2	0.2	0.1	
8/13-14	1.3	2.6	1.1	0.1	0.2	
8/14-15		0.5	7.8	1.9	0.1	
8/15-16		2.8	1.7		0.2	2.3
8/25-26	1.2	0.2	0.2			
8/26-27				3.4	3.9	
8/27-28		1.2	0.2	0.1		
9/12-13	0.8	2.6	2.4	0.2	0.1	
9/13-14	3.4	3.5	0.1	0.1	0.2	

IPEC00035096

Table 7. Probabilities and Safety Factors in the Con Edison and AEC-DRL Accident Meteorology Models

	Con Edison Model			AEC-DRL Model		
	350m	520m	1100 m	350m	520m	1100m
% Probability of Exceeding Accident Model $\sum\chi/Q$						
0-2 hr	0.8	068	0.4	1.3	1.0	0.5
0-8 hr	-	-	0.7	-	-	0
0-24 hr	-	-	0	-	-	0
Factor of Safety at 1% Probability Level						
0-2 hr	1.1	1.2	1.3	1.3	1.0	1.2
0-8 hr	-	-	1.2	-	-	1.8
0-24 hr	-	-	2.0	-	-	1.9
Factor of Safety at 5% Probability Level						
0-2 hr	7.0	7.9	12.6	8.5	6.6	12.0
0-8 hr	-	-	3.2	-	-	4.8
0-24 hr	-	-	3.1	-	-	3.0

Note

350m = distance from Unit 3 to site boundary

520m = distance from Unit 2 to site boundary

1100m = distance from Units 2 and 3 to low population zone.

IPEC00035097

Table 8. Wind Persistence at IP 3 under Inversion Conditions

In Combined Sectors 002^{o} - 022^{o} - 042^{o}**
(The body of the table shows number of hourly occurrences of the designated duration and speed class)

Number of Consec. Hours	Maximum Speed in Sequence (m/s)*					
	0.3	0.5	1.0	1.5	2.0	3.0
During 10 months (26 Nov 1969 – 1 Oct 1970)						
1	1	2	38	83	139	270
2			2	5	7	23
3				3	1	4
4				1	0	2
7						1
During 12 months (1 Jan 1971 – 31 Dec 1971)						
1	1	6	66	115	217	431
2				18	60	181
3				2	23	89
4					4	39
5					2	19
6					1	5
7						1

*mph notation for speed in Table 1 of Rep TR 71-3[3] should be m/s.

**see note on page 32 regarding sector notations.

IPEC00035098

Appendix A

Chronological Review of Events Relating to the Accident Meteorology Models

The Con Edison meteorological model was developed by Dr. Ben Davidson of New York University, using meteorological data collected at Indian Point during the period 1955-1957. That meteorological investigation, conducted in support of the licensing application for Indian Point Unit No. 1, yielded three reports which contained not only the meteorological summaries, but various dose calculations for postulated releases at stack height and at ground level. These reports we submitted to the AEC in their entirety as Exhibits L-1, L-5 and L-6 of Docket 50-3, Indian Pont Unit No. 1[(3)]

Exh. L-1: N.Y.U. Tech. Rep. 372.1 "A Micrometeorological Survey of the Buchanan, N.Y. Area", dated Nov. 1955,

Exh. L-5: N.Y.U. Techn. Rep. 372-3 " Evaluation of Potential Radiation Hazard Resulting from Assumed Release of Radioactive Wastes to the Atmosphere from Proposed Buchanan Nuclear Power Plant", dated April 1957, and

Exh. L-6: N.Y.U. Tech. Rep. 372.4 "Summary of Climatological Data at Buchanan, N.Y., 1956-1957", dated March 1958.

The meteorological data acquired during the foregoing study were synthesized into the Con Edison meteorological model which first appeared in the PSAR for Indian Point Unit No. 2 (Docket No. 50-247). The supporting documentation for the model included:

IPEC00035099

Exhibits L-1 and L-6 (described above) in their entirety,

Meteorology Sections 2 and 3 of Exhibit L-5 (described above),

U.S.W.B. Tech. Paper No. 15: Maximum Station Precipitation for 1, 2, 3, 6, 12 and 24 Hours, Part X: New York, dated Dec. 1954, and

Additional meteorological data concerning wind behavior at an elevation of 70 ft above the Hudson River near the Indian Point site when the wind speed above the valley ridge lines fell into two classes; virtually zero and less than 16 mph. Those data had been collected during 1955, and had been used in generating the dose calculations in Exhibit L-5, but had not been presented previously in this form (low speed hodographs).

The Con Edison meteorological model postulated the sequence of wind condition shown in Table 1, beginning at the time of the postulated accident. The AEC did not comment directly as to the acceptability of the Con Edison model. It did request justification for the inversion frequency used in the 1-30 day period (question No. 16 in letter to Applicant dated Feb 28, 1966). This was provided in the First Supplement to the PSAR for I.P. 2 (Docket No. 50-247, Exhibit B-1).

The Con Edison meteorological model was used again in the PSAR for Indian Point Unit No. 3 (Docket 50-286). During evaluation of the dose calculations, the AEC-DRL made known its own meteorological model which has subsequently been published formerly in Safety Guide No. 4 of:

U.S. A.E.C.-D.R.S.: "Safety Guides for Water Cooled Nuclear Power Plants", dated Nov. 2, 1970.

The meteorological sequence in the AEC-DRL model is shown in Table 2.

IPEC00035100

When the AEC-DRL model became known to Con Edison, the latter compared the two models for comparable time periods, and it was found that the Con Edison model yielded higher χ/Q values than did the AEC-DRL model in all periods except 2-8 hrs after the postulated accident. However, in a submittal to the AEC in the Fifth Supplement to the I.P. 3 PSAR, it was argued in Item 8 that the AEC-DRL assumption of a 1 m/s wind speed during this six-hour period did not in fact occur, and that the Con Edison assumption of 2 m/s for the same period was adequately conservative. This factor of 2 on wind speed, if applied with the AEC-DRL model in the 2-8 hr period, would reduce the AEC-DRL value of χ/Q for the period to below the Con Edison value, thereby rendering the Con Edison model more conservative in all categories. The argument also called upon experimental evidence to show that the wind meandered during the 2-8 hr period, following a directional pattern of wind rotation. The omission of wind meander in both the AEC and Con Edison models during this period introduces conservatism into each model.

In preparation for the I.P. 3 Construction Permit hearings, Con Edison submitted to the AEC Licensing Board:

(1) Summary of Application (Docket 50-286) dated Feb. 20, 1969, and the AEC-DRL Technical Staff submitted:

(2) AEC-DRL Safety Evaluation dated Feb. 20, 1969,

(3) Appendix C to AEC-DRL Safety Evaluation: Comments on PSAR and Fifth Supplement for I.P.3, dated May 24, 1968 and Jan. 2, 1969 (included as Pgs. 75 and 76 of (2) above).

(4) AEC-DRL Summary Statement dated March 20, 1969.

IPEC00035101

During the pre-hearing conference for I.P. 3 on March 11, 1969, Board Member Pigford requested clarification from both AEC-DRL and Con Edison regarding (a) the statement in Document 2 (above) that Con Edison did not have long-term data on stability-speed-direction persistence, and (b) the differences between the Con Edison and AEC-DRL meteorological models (transcript pgs. 70-71).

During the I.P. 3 Construction Permit hearings, on March 27, 1969, oral testimony was given by both Con Edison and AEC-DRL representatives in response to Dr. Pigford's questions. It was established that "the absence of long-term data" referred to the fact that the original experimental data, taken in 1955, 1956 and 1957, were no longer available (transcript pg. 170), leaving only the statistical summaries in the various reports and submittals previously cited. The details of the Con Edison and AEC-DRL accident meteorologies, shown in Table 1 and 2, were also enumerated, and major points of discrepancy between the models were discussed.

Of particular interest to the Board was the rationale behind the AEC-DRL statement that the 0-8 hr meteorology used in the AEC model was conservative (pg. 660). This led to an extended discussion of the low wind speed hodographs shown in Figs. 2.6-1 and 2.6-2 of Section 2 of the Unit 3 PSAR, which provide the justification for both the Con Edison and AEC-DRL 0-8 hr meteorology models.

These hodographs show the progression of wind speed and direction during a typical day when the wind speed above ridge elevation is zero or small. The hodographs were constructed by averaging the measurements taken on 12 days (zero wind speed) and 35 days (small wind speed) during September and October, 1955.

The Con Edison positions was that the combination of average hodographs plus conservative assumptions regarding the persistence of wind speed, direction and

IPEC00035102

stability provide adequate conservatism in its 0-24 hr meteorology model.

The AEC-DRL position was that an average hodograph implied the existence of some individual hodographs which might exhibit longer persistence of lower speed winds in the critical direction with strong stability, and that a more conservative model was called for in the absence of evidence to the contrary. In its Safety Evaluation, Document (2) above, the AEC-DRL stated that its standard meteorological model, given in Table 2, "conservatively characterizes the meteorology of the Indian Point site" in the absence of long-term data "on the specific joint frequency of stability-wind speed-wind direction persistence." The AEC-DRL consultant (ESSA Air Resources Environmental Laboratory) concurred in Document (3) above that the 1-8 hr meteorology in the AEC-DRL model was a " --reasonably conservative meteorological assumption..." in view of the absence of join-frequency data.

Board member Pigford then attempted to obtain a numerical estimate of the probability of occurrence of the Con Edison and AEC-DRL 0-8 hr models in the critical wind direction sector by questioning AEC-DRL staff meteorologist Spickler and Con Edison consultant Halitsky. Mr. Spickler reasoned that it would probably be less than 1%, since the combination of inversion stability and 1 m/s wind speed occurred approximately 5% of the time for all directions combined. However, in view of the lack of persistence data for individual cases, Mr. Spickler characterized his estimate of 1% as an "educated guess" (page 67).

Dr. Pigford then requested that Dr. Halitsky estimate the probability of occurrence of the 0-8 hr meteorological sequences as defined by AEC-DRL and Con Edison (pgs. 675-676). Dr. Halitsky requested some time to consider his reply. Further questioning was directed toward the validity of diffusion coefficients

IPEC00035103

(pg 677), the need for diffusion testing to validate the Sutton diffusion model (pg 678ff and 745ff), plans for continued meteorological testing to generate the data needed to clarify the 0-8 hr assumptions (pg 682ff) and topographical effects on diffusion (pgs 749ff).

Prior to adjournment the Board posed several questions of a meteorological nature to both Con Edison and the AEC-DRL staff (pg 1671). Those were responded to at a resumption of the hearings on 13 May 1969. Mr. Spickler placed into the record the AEC-DRL standard meteorological model as shown in Table 2 (pg 1756). Two questions were directed to Dr. Halitsky (pgs. 1671 and 1672):

a) Present a technical justification for the conclusion that the frequency spectrum of wind speeds and the range of air and low wind speeds is now and will continue to be the same as that measured in 1956.

b) Present a technical justification for the meteorological conditions used in the applicant's accident analysis indicating the estimated probability of occurrence of these conditions.

Question (a) was answered by reviewing the substance of NYU Report 372.4 which compared 1956 and 1957 meteorological data. Question b) was answered in part, but the discussion veered toward temperature gradients and plume rise, not returning to probabilities that day. Mr. Jensch raised the question again of conducting diffusion tests. Dr. Halitsky recommended against such test as being unnecessary.

On the following day Dr. Halitsky continued his reply to Question b) pgs. 1795ff). He stated that the Con Edison 30-day meteorology was conservative because inversions were assumed to occur twice as frequently as the average for

IPEC00035104

the year, and the meander was assumed to occur in a 20^{o} sector whereas the actual meander angle was more like 40^{o}. The combination of those two effects introduced a factor of about 4 in the χ/Q calculation.

Turning to the first day meteorology, considerable discussions then ensued regarding the interpretation of the hodographs in Figs. 2.6-1 and 2.6-2, particularly with respect to lapse rates during different hours of the day. Dr. Halitsky pointed out that the Con Edison model ignored meander and reversal during the first day, each of which would introduce a factor of 2 for a total of 4 on the calculated χ/Q. Furthermore, the increase of wind speed from 1 m/s to 2 m/s during the 2-24 hr period appeared justified according to the average hodograph.

Dr. Pigford then brought the questioning back to the probability of occurrence of the Con Edison assumed meteorology (pg 1815). Dr. Halitsky offered an opinion of the probabilities of the first-day meteorology specified in the AEC-DRL and Con Edison models, based on Mr. Spickler's previous estimate (pg 670) of "probably less than 1%" and Dr. Halitsky's estimate of two orders of magnitude less than Mr. Spickler's for the same model; i.e., assuming that the average hodograph occurs 100 days/yr, the AEC-DRL "anomalous" hodographs would occur .01x100 = 1 day/yr according to Spickler and 1 day/100yrs according to Halitsky. The Con Edison "anomalous" hodograph, which is not as severe as the AEC-DRL version, would have an intermediate frequency, say 1 day/10yrs.

Dr. Pigford then requested a statement of probability for each of the three time periods in the Con Edison model. Dr. Halitsky was unable to furnish this information.

Dr. Pigford subsequently questioned Mr. Grob regarding the possibility of return flows over the site causing an accumulation of concentrations (pg 1846),

IPEC00035105

the possibility of accumulation of concentrations due to simultaneous operation of Units 1, 2 and 3 (pg 184) and the possibility of plumes leaving the Unit 1 stack and/or the tops of the Units 2 and 3 containment structures and impinging upon a local rise in terrain beyond the site boundary (pg 1853). Mr. Grob and Dr. Halitsky responded by giving qualitative descriptions of plume behavior and concluding that the postulated conditions would not yield higher concentrations than in the assumed accident meteorology.

Mr. Jensch then queried Mr. Spickler on wake effects with cylindrical structures at low wind speeds (pg 1862). Mr. Spickler cited various references, none of which reported tests in wind speeds as low as 1 m/s. Mr. Spickler concurred with Mr. Jensch as to the desirability of having wake concentration data at low wind speeds to justify inclusion of the wake factor in the meteorological model (pg 1864).

Dr. Halitsky completed his statement on the probability of occurrence of the Con Edison meteorological model by specifying a substantially zero probability since the first two periods in the model do not provide for wind meander which always occurs (pg 1914).

After conclusion of the hearings, both Con Edison and the AEC-DRL submitted written answers to the questions posed by Dr. Pigford at the pre-hearing conference. Con Edison concurred that data were lacking to prove that 8 hr wind persistence under low speed conditions could not occur. It also showed that the AEC-DRL value of $X\bar{u}/Q$ during the 2-8 hr period, while twice as high as the Con Edison value for the same period, would produce only a 20% increase in dose. The AEC-DRL contended that relaxation of their long-term model is not justified until joint probability of persistence with speed and stability can be examined. It

IPEC00035106

also stated that their model showed a 40% increase in dose over the Con Edison model.

The AEC-DRL also provided written comments on Dr. Halitsky's hearing testimony, i.e.: (a) they agreed with his testimony, (b) they believe that the Sutton equations are valid for this type of terrain and that smoke photography and wind measurements are adequate experimental techniques in lieu of direct concentration measurements, and (c) they believe that year to year variations in meteorology will be small and that accident meteorological assumptions would still be quite conservative.

In its Initial Decision granting a Construction Permit (Aug 13, 1969) the Board took note that Con Edison had undertaken a new meteorological program in the Indian Point area, and had stated that the new data would be used in connection with the proposed operations for Unit No. 3. The Board strongly urged that

a) Definitive criteria should be developed for judging the adequacy of the meteorological program (pg 12),

b) the present continuing study should be made as comprehensive as possible (pg 13), and

c) the possibility that ground concentrations higher than those at the site boundary might occur beyond the site boundary should be given detailed consideration (pg 16).

In response to the Board's recommendations, Con Edison revised its ongoing meteorological program in the Fall of 1969 to serve two functions; one was to acquire data which could be used for the scheduling of operational releases, the other was to acquire data which would help to resolve the unanswered questions, which arose during the hearings, regarding the 0-8 hr accident meteorology models.

IPEC00035107

The portion of the revised program relating to accident meteorology included experiments to obtain data on:

a) annual wind statistics

b) low wind speed hodographs

c) turbulence characteristics under low wind speed inversion conditions

d) persistence statistics

e) building wake effects on diffusion

The results of experiments in the above categories were submitted to Con Edison in three reports. These are

1) N.Y.U. Tech. Rep. TR 71-3 "Wind Observations at Indian Point, 26 November 1969 – 1 October 1970" by J. Halitsky, E.J. Kaplin, and J. Laznow 17 May 1971.

2) N.Y.U. Tech. Rep. TR 71-10 "Low Wind Speed Turbulence Statistics and Related Diffusion Estimates for Indian Point, N.Y/" by D. M. Leahey and J. Halitsky 15 September 1971.

3) "Wind Test of Gas Dispersion from Indian Point Unit 1", by J. Halitsky 29 June 1971.

Item 1) was submitted to the AEC-DRL in Supplement 1, pgs Y-1 to Y-32 of the Unit No. 3 FSAR.

Item 3) was submitted to the AEC-DRL in support of an application to reduce the stack height of Unit No. 1 to meet structural safety requirements under tornado loadings. In preparation for the I.P.2. Operational Permit hearings, Con Edison submitted to the AEC Licensing Board:

IPEC00035108

(1) Summary of Application (Docket 50-247) dated Nov. 12, 1970, and the AEC-DRL Technical Staff submitted:

(2) AEC-DRL Safety Evaluation dated Nov. 16, 1970,

(3) Appendix C to AEC-DRL Safety Evaluation; Comments on FSAR and Amendments 12 and 14 for I.P.2., dated Nov. 29, 1969 and Feb. 17, 1970 (included as Pgs 93, 94 and 95 of (2) above).

In Item (2) pg 9, the AEC-DRL stated that the two years of (new) meteorological data presented by the applicant provide an adequate basis for selecting the meteorological parameters for both routine and accident meteorology calculations.

In Item (3), ESSA-AREL acknowledged the existence of the diurnal reversal of valley winds at the site but stated that in the absence of joint frequency data, an appropriately conservative assumption would be a steady wind of 1 m/s speed for the first 8 hrs followed by a 22½$^{\circ}$ meandering wind of 1 m/s speed for the next 16 hrs in the same sector. ESSA characterized the latter assumption as "very conservative". It also stated that the Con Edison correction for building wake effect agreed well with the AEC-DRL method, but disagreed with the Con Edison procedure of including a virtual source displacement in the long term average diffusion model.

IPEC00035109

February 1973

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

by:

Keith Woodard

Pickard, Lowe and Associates, Inc.
1200 18th Street, N.W., Washington, D. C. 20036

2.6.M-1

IPEC00035110

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

IPEC00035111

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

2.6.M-3

Pasquill Diffusion Group	Value of n

IPEC00035112

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:

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

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: $f = \frac{\ln\frac{150}{33}}{\ln\frac{95}{7}} = \frac{1.51}{2.60} = 0.58$

IPEC00035113

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,

IPEC00035114

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

IPEC00035115

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.

IPEC00035116

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,

IPEC00035117

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.

IPEC00035118

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

IPEC00035119

RESEARCH DIVISION

COLLEGE OF ENGINEERING

NEW YORK UNIVERSITY

Department of Meteorology and Oceanography

Technical Report No. 372.4

SUMMARY OF CLIMATOLOGICAL DATA AT BUCHANAN, NEW YORK

1956-1957

Prepared by

Ben Davidson

Project Director

Prepared for

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

March 1958

R-2

IPEC00035120

Table of Contents

List of Figures

IPEC00035121

1

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.

IPEC00035122

2

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,

R-5

3

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

IPEC00035123

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.

R-6

IPEC00035124

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

IPEC00035125

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.

R-8

IPEC00035126

6

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.

R-9

IPEC00035127

8

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.

IPEC00035128

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

IPEC00035129

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

IPEC00035130

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

JOB NO. 6729

SURFACE WIND SPEEDS VERSUS
DIRECTION WHEN SOME
FORM OF PRECIPITATION

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

IPEC00035131

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

IPEC00035132

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

James Halitsky, Project Director
Edward J. Kaplin
Joseph Laznow

for

Consolidated Edison Co. of N. Y., Inc.
4 Irving Place, New York, N. Y. 10003

17 May 1971

Y-1

IPEC00035133

ii

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.

Y-2

IPEC00035134

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.

IPEC00035135

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.

IPEC00035136

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

IPEC00035137

4

3. Annual Average Wind Statistics at the I P 1 and I P 3 Stations

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.

IPEC00035138

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.

IPEC00035139

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.

IPEC00035140

7

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

IPEC00035141

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 nightime 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

IPEC00035142

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.

IPEC00035143

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 ΔT = 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.

Y-15

IPEC00035144

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	No. of	Maximum speed in sequence (mph)							
Sector	Consec. Hrs.	0.3	0.5	1.0	1.5	2.0	3.0	4.0	6.0
005º-020º	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
005º-020º	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.

IPEC00035145

12

References

Davidson, B. and J. Halitsky (1957): Evaluation of Potential Radiation Hazard Resulting from Assumed Release of Radioactive Wastes to Atmosphere from Proposed Buchanan Nuclear Power Plant. N. Y. University Dep't. of Meteorology and Oceanography Tech. Rep't. No 372.3

Halitsky, J., J. Laznow and D. Leahey 91970): Wind Observations at Indian Point, Montrose and Bowline Point. 31 August 1968 to 30 June 1969. N. Y. University Dep't. of Meteorology and Oceanography Tech. Rep't. TR-70-3.

FSAR: Final Facility Description and Safety Analysis Report. Consolidated Edison Co. of N. Y., Inc. Nuclear Generating Unit No. 2. Exhibit B-8.

IPEC00035146

[Historical Information]

New York University
School of Engineering and Science
Department of Meteorology and Oceanography
Geophysical Sciences Laboratory
Technical Report No. TR-73-1

Meteorological Observations at Indian Point, Trap Rock, Montrose Point and Cape Charles
1 January 1970-31 December 1971

Prepared by

Joseph Laznow
Edward J. Kaplin, Project Director

for

Consolidated Edison Company of New York, Inc.
4 Irving Place, New York, N.Y. 10003

15 December 1972

IPEC00035147

Z-1

IPEC00035148

Summary

Meteorological data collected at Indian Point 3, Trap Rock, Montrose Point and the Cape Charles in 1970 and 1971 were analyzed annually, seasonally and diurnally. The results were compared with observations made by Davidson in 1955-57 at similar installations.

Results

A) Comparison between two years of Indian Point 3 (1970 and 1971) data with Indian Point 1 (1956) confirm the findings of Halitsky, et al. (1970) that any apparent meteorological differences during the intervening years are such that they favor an increase in the diffusion potential at the Indian Point site. Improvements include: a) a substantial decrease of the occurrence of inversions and b) a decrease in the probability of low wind speeds in the critical quadrant during inversion conditions.

B) A shift of the secondary maximum direction to a more southeasterly orientation was found in the annual direction frequency density distribution.

C) Seasonal differences included a binodal distribution of the summer wind directions with SSE and NNE peaks. The winter curve is tri-nodal with N, WNW-NW and SSE peaks in descending order of magnitude. The percentage of low wind speeds is highest during the summer when neutral and lapse conditions are most prevalent.

D) The seasonal variation of the diurnal mean wind direction and speed is clearly defined. A direction shift occurs during the summer with upvalley winds during the day and downvalley winds at night. The IP3 diurnal curves can be expected to rotate through 360°.

E) The seasonal diurnal persistence of the wind is maximum at night and minimum during the day. The winter

IPEC00035149

persistence values are approximately twice those of the summer.

The winter has a single minimum occurring between 1800-2100 while the summer minimum is binodal: 1000-1300 and 1900-2000.

The winter maximum persistence occurs between 0500-0900 while the summer maximum generally occurs between 0500-0600.

IPEC00035150

Z-3

IPEC00035151

Table of Contents

IPEC00035152

Z-4

Table of Contents (continued)

IPEC00035153

Z-5

List of Tables

IPEC00035154

IPEC00035155

List of Tables (continued)

IPEC00035156

List of Figures

IPEC00035157

List of Figures (continued)

IPEC00035158

Acknowledgment

Appreciation is expressed to those people who helped in the development and preparation of this report:: Assistant Research Scientists – Mitchell M. Wurmbrand, Jack Kirschner, Michael Kozenko and Michael Bono; Research Technician – Mark J. Makower; Drafting – Charles Tessmer; and Patricia Twomey, Secretary.

IPEC00035159

1.

1. Introduction

This is the third of three progress reports covering the continuous meteorological data collection program in the Hudson River Valley at Consolidated Edison's Indian Point nuclear generating complex in Buchanan, New York (Figure 1).

The first report (Halitsky, Laznow and Leahey (1970)) covered wind observations at the Indian Point 2 (IP2), Montrose Point (MP) and Bowline Point (BP) meteorological tower sites, and temperature difference observations at Indian Point 2 and Bowline Point for the period 31 August 1968-30 June 1969.

The second report (Halitsky, Kaplin and Laznow (1970)) covered wind and temperature difference observations at Indian Point 3 (IP3) for the period 26 November 1969-1 October 1970, and wind observations from the U.S.S. Cape Charles for the period 16 March 1970-18 September 1970. The data were compared with similar measurements taken in 1955-1957 by Davidson ((Davidson and Halitsky (1957) and FSAR)) at approximately the same locations. The analysis was made to determine if significant changes had occurred in onsite meteorology during the intervening years.

The function of the present study was to provide meteorological data to support analyses for nuclear units at Indian point as specified by the following items:

a) Turbulence analysis at Indian Point;
b) Analysis of spatial variability of winds between Indian Point 3, Trap Rock (TR) and Montrose Point;
c) Acquisition of wind statistics at Indian Point 3 and Trap Rock; and
d) Additional instrumentation at Trap Rock to develop annual wind statistics and turbulence measurements comparable to those being collected at Indian Point 3.

Item (a) was satisfied, in part by Leahey and Halitsky (1971) whose study developed the techniques and procedures for the analysis of diffusion parameters at Indian Point and

IPEC00035160

provided initial results.

Items (b) and (c) are covered in this report. Seasonal, diurnal and annual analyses are provided and the comparison with the 1955-57 data has been extended through December 1971.

The instrumentation required to satisfy item (d) was obtained but due to de-emphasis of the Verplank site (TR) it was never installed.

2. Instrumentation Characteristics

Meteorological station locations, tower base elevations and information pertaining to instrumentation, parameter of measurement, elevation of sensor above tower base and period of record are presented in Table 1.

2.1 Sensors

a) Climet Wind Speed: threshold, 0.6 MPH; accuracy, ± % or ± 0.15 MPH; distance constant, 5 feet. (Distance constant is defined as the feet of air required to pass through the transmitter to give 63% of a sharp change.)

b) Climet Wind Direction: threshold, < 1 MPH; damping ratio, 0.4; accuracy, ± 3°.

c) Aerovane Wind Speed: threshold, 2.5 MPH; distance constanct, 15 feet.

d) Aerovane Wind Direction: distance constant, 34 feet.

e) Net Exchange Thermal Radiometer: temperature compensation to an accuracy of ± 1% over a range of –20 to ±160° F.

f) R. M. Young-Gill Bivane: threshold, 0.3-0.5 MPH for both azimuth and eletion.

g) Honeywell-Brown Resistance Bulb: when placed in specially designed wells, the time constant is about 3 minutes in a wind of 20 fps, the bulbs are in shielded gold leafed cylinders and aspirated at

IPEC00035161

Z-12

4.

about 20 fps (Davidson and Halitsky (1955)).

h) Rosemount Nickel Resistance Bulb (Temperature Difference): response time 63% < 90 sec. With 15 fps air flow; accuracy, ± 0.5% at icepoint, linear to 0.05% of full scale; overall accuracy, < ± 0.1° F.

i) Rosemount Nickel Resistance Bulb (Ambient Temperature): same as (h) except overall accuracy, ± 0.1° F.

j) Foxboro Dewcel: if ambient temperature ∃ 32° F, dew point accuracy, ± 0.5° F; if ambient temperature ∃0° F < 32° F, dew point accuracy, ± 1.0° F; if ambient temperature < 0° F, dew point accuracy, ± 1.5° F.

Items (h), (i), and (j) are mounted in Climet aspirated shields.

IPEC00035162

Table 1. Instrumentation Data

Meteorological Station Location	Base Elev. (ft) Above River	Operating Period	Parameter	Instruments	Elev. (ft) Above Base
Indian Point 3 (IP3)	120	1 Jan 70-Present	Wind Speed	Climet	100
			Wind Direction	Climet	100
		1 Jan 70-20 July 71 & 24 July 72-Present	Wind Speed	Aerovane	100
			Wind Direction	Aerovane	100
		14 Aug 70-Present	Net Radiation	Thermal Radiometer	30
		May 70-Dec 70 (Intermittent)	Turbulence	Bivane	100
		1 Jan 70-25 Oct 71	Temperature Difference	Honeywell-Brown Resistance Bulb	95-7
		14 Aug 72-Present	Temperature Difference	Rosemount	10-100
				Nickle Resistance Bulb	10-30
			Ambient Temperature	Rosemount Nickle Resistance Bulb	30
			Dew Point	Foxboro Dew-cel	100, 30, 10
Trap Rock (TR)	90	1 Jan 70-27 July 72	Wind Speed	Climet	100
			Wind Direction	Climet	100
Montrose Point (MP)	60	1 Jan 70-7 June 71	Wind Speed	Climet	100
			Wind Direction	Climet	100

IPEC00035163

Cape Charles (CC)	0	16 Mar 70-18 Sept 70	Wind Speed	Aerovane	100
			Wind Direction	Aerovane	100

3.

Table 4. Indian Point 3 Frequency Distribution of Wind Speed and Direction at 100 ft Tower Level According to Temperature Gradient Class-January 1, 1970-December 31, 1970

		Wind Speed (m/s)											
Wind Direction	Temp. Grad.	0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
349- 11	I	.0016	.0031	.0046	.0042	.0038	.0019	.0002	.0005	.0000	.0000	.0001	.0200
	N	.0009	.0010	.0018	.0063	.0093	.0086	.0063	.0045	.0006	.0001	.0015	.0408
	L	.0000	.0007	.0010	.0056	.0104	.0071	.0043	.0050	.0003	.0000	.0001	.0346
	M	.0003	.0008	.0007	.0021	.0040	.0047	.0029	.0019	.0002	.0000	.0000	.0176
	T	.0029	.0056	.0081	.0182	.0274	.0223	.0137	.0119	.0011	.0001	.0017	.1131
12- 33	I	.0003	.0022	.0047	.0125	.0102	.0050	.0013	.0002	.0000	.0000	.0002	.0366
	N	.0002	.0016	.0033	.0091	.0131	.0085	.0021	.0022	.0008	.0001	.0018	.0429
	L	.0001	.0006	.0015	.0067	.0073	.0034	.0018	.0025	.0000	.0000	.0001	.0241
	M	.0001	.0010	.0018	.0080	.0085	.0049	.0022	.0006	.0000	.0000	.0000	.0271
	T	.0008	.0054	.0113	.0364	.0391	.0218	.0073	.0055	.0008	.0001	.0022	.1307
34-56	I	.0007	.0031	.0050	.0090	.0041	.0010	.0003	.0000	.0000	.0000	.0006	.0239
	N	.0002	.0006	.0023	.0043	.0032	.0011	.0003	.0003	.0005	.0000	.0011	.0141
	L	.0002	.0009	.0016	.0048	.0043	.0009	.0006	.0007	.0001	.0000	.0002	.0144
	M	.0002	.0009	.0015	.0051	.0048	.0018	.0007	.0001	.0000	.0000	.0000	.0152
	T	.0014	.0055	.0104	.0233	.0165	.0049	.0019	.0011	.0006	.0000	.0019	.0676
57-78	I	.0009	.0017	.0022	.0019	.0007	.0001	.0001	.0000	.0000	.0000	.0000	.0077
	N	.0003	.0006	.0016	.0011	.0007	.0002	.0000	.0001	.0000	.0000	.0005	.0051
	L	.0001	.0005	.0007	.0014	.0003	.0003	.0000	.0005	.0001	.0000	.0002	.0041
	M	.0001	.0001	.0010	.0018	.0013	.0007	.0005	.0000	.0000	.0000	.0000	.0055
	T	.0015	.0029	.0055	.0063	.0030	.0014	.0006	.0006	.0001	.0000	.0007	.0224
79-101	I	.0001	.0013	.0011	.0016	.0007	.0001	.0000	.0002	.0000	.0000	.0000	.0051
	N	.0002	.0005	.0014	.0016	.0011	.0009	.0006	.0000	.0000	.0000	.0002	.0065
	L	.0000	.0006	.0007	.0008	.0005	.0001	.0000	.0003	.0000	.0000	.0000	.0030
	M	.0000	.0005	.0005	.0018	.0007	.0001	.0003	.0001	.0000	.0000	.0000	.0040

Z-23

13.

IPEC00035164

	T	.0003	.0027	.0037	.0058	.0030	.0013	.0009	.0007	.0000	.0000	.0002	.0186

Table 4 (continued)

		Wind Speed (m/s)											
Wind Direction	Temp. Grad.	0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
102-123	I	.0005	.0008	.0011	.0011	.0011	.0000	.0001	.0000	.0000	.0000	.0001	.0049
	N	.0005	.0015	.0009	.0014	.0015	.0007	.0006	.0003	.0000	.0000	.0003	.0077
	L	.0001	.0005	.0006	.0018	.0002	.0008	.0002	.0002	.0000	.0000	.0000	.0045
	M	.0003	.0006	.0007	.0006	.0010	.0006	.0008	.0001	.0000	.0000	.0000	.0047
	T	.0014	.0033	.0033	.0049	.0039	.0021	.0017	.0007	.0000	.0000	.0005	.0217
124-146	I	.0003	.0014	.0023	.0019	.0014	.0006	.0000	.0000	.0001	.0000	.0001	.0081
	N	.0003	.0010	.0014	.0032	.0027	.0018	.0006	.0006	.0003	.0000	.0001	.0121
	L	.0001	.0006	.0016	.0018	.0015	.0026	.0009	.0017	.0002	.0000	.0000	.0111
	M	.0003	.0009	.0005	.0015	.0022	.0007	.0001	.0002	.0000	.0000	.0000	.0064
	T	.0011	.0039	.0057	.0085	.0078	.0057	.0016	.0025	.0007	.0000	.0002	.0377
147-168	I	.0007	.0015	.0027	.0047	.0040	.0014	.0002	.0002	.0003	.0001	.0000	.0159
	N	.0002	.0008	.0011	.0039	.0064	.0037	.0022	.0035	.0003	.0000	.0002	.0224
	L	.0003	.0003	.0022	.0050	.0098	.0081	.0080	.0110	.0001	.0000	.0001	.0450
	M	.0001	.0005	.0011	.0043	.0057	.0027	.0015	.0003	.0000	.0000	.0000	.0163
	T	.0014	.0031	.0072	.0179	.0260	.0159	.0119	.0151	.0008	.0001	.0003	.0997
169-191	I	.0003	.0013	.0021	.0058	.0047	.0014	.0010	.0002	.0002	.0003	.0000	.0174
	N	.0001	.0005	.0013	.0043	.0049	.0026	.0014	.0005	.0000	.0000	.0001	.0157
	L	.0002	.0010	.0022	.0106	.0101	.0046	.0046	.0027	.0000	.0000	.0003	.0364
	M	.0002	.0005	.0014	.0037	.0065	.0034	.0009	.0007	.0000	.0000	.0000	.0173
	T	.0009	.0032	.0069	.0245	.0262	.0120	.0079	.0041	.0002	.0003	.0005	.0867
192-213	I	.0002	.0021	.0032	.0071	.0040	.0022	.0011	.0002	.0000	.0000	.0002	.0203
	N	.0003	.0006	.0016	.0025	.0013	.0013	.0013	.0008	.0000	.0000	.0000	.0096
	L	.0001	.0002	.0022	.0065	.0039	.0023	.0019	.0008	.0000	.0000	.0001	.0181
	M	.0001	.0003	.0007	.0041	.0032	.0021	.0003	.0002	.0000	.0000	.0000	.0111
	T	.0008	.0032	.0077	.0202	0123	.0078	.0047	.0021	.0000	.0000	.0003	.0591

IPEC00035165

Table 4 (continued)

Wind Direction	Temp. Grad.	Wind Speed (m/s) 0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
214-236	I	.0011	.0022	.0027	.0062	.0032	.0009	.0008	.0005	.0001	.0000	.0002	.0179
	N	.0002	.0010	.0008	.0014	.0009	.0007	.0003	.0002	.0001	.0001	.0001	.0059
	L	.0000	.0014	.0010	.0042	.0010	.0007	.0010	.0014	.0000	.0000	.0002	.0110
	M	.0001	.0002	.0011	.0031	.0015	.0003	.0002	.0002	.0000	.0000	.0000	.0069
	T	.0015	.0048	.0057	.0149	.0066	.0026	.0024	.0023	.0002	.0001	.0006	.0417
237-258	I	.0007	.0018	.0021	.0021	.0017	.0008	.0013	.0006	.0006	.0000	.0002	.0118
	N	.0000	.0003	.0005	.0010	.0010	.0003	.0003	.0008	.0002	.0001	.0000	.0047
	L	.0003	.0011	.0010	.0014	.0006	.0007	.0007	.0009	.0000	.0000	.0001	.0069
	M	.0000	.0005	.0005	.0007	.0006	.0002	.0001	.0007	.0000	.0000	.0000	.0032
	T	.0010	.0038	.0040	.0051	.0039	.0021	.0024	.0030	.0008	.0001	.0003	.0265
259-281	I	.0009	.0017	.0013	.0008	.0015	.0014	.0006	.0008	.0007	.0003	.0001	.0101
	N	.0001	.0009	.0005	.0008	.0009	.0016	.0009	.0021	.0010	.0002	.0000	.0090
	L	.0001	.0003	.0007	.0017	.0016	.0023	.0018	.0027	.0006	.0001	.0007	.0127
	M	.0000	.0005	.0005	.0006	.0007	.0005	.0008	.0007	.0001	.0000	.0000	.0042
	T	.0011	.0034	.0029	.0039	.0047	.0057	.0041	.0063	.0024	.0007	.0008	.0360
282-303	I	.0005	.0013	.0011	.0003	.0005	.0009	.0014	.0022	.0016	.0010	.0000	.0107
	N	.0001	.0003	.0006	.0003	.0010	.0019	.0033	.0114	.0070	.0011	.0000	.0272
	L	.0006	.0006	.0002	.0011	.0014	.0029	.0015	.0101	.0042	.0017	.0011	.0254
	M	.0000	.0003	.0001	.0005	.0010	.0006	.0009	.0023	.0002	.0003	.0000	.0063
	T	.0011	.0025	.0021	.0023	.0039	.0063	.0071	.0260	.0130	.0042	.0011	.0696
304-326	I	.0005	.0014	.0009	.0006	.0009	.0008	.0007	.0018	.0006	.0002	.0000	.0083
	N	.0003	.0006	.0001	.0010	.0022	.0026	.0047	.0162	.0048	.0016	.0001	.0343
	L	.0001	.0002	.0006	.0010	.0014	.0030	.0033	.0088	.0064	.0025	.0005	.0278
	M	.0000	.0005	.0002	.0010	.0006	.0007	.0026	.0056	.0015	.0003	.0000	.0130
	T	.0009	.0026	.0018	.0037	.0050	.0071	.0113	.0325	.0133	.0047	.0006	.0835

Z-25

15

IPEC00035166

IPEC00035166

Table 4 (continued)

Wind Direction	Temp. Grad.	Wind Speed (m/s) 0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
327-348	I	.0009	.0015	.0015	.0016	.0011	.0009	.0006	.0010	.0000	.0000	.0001	.0093
	N	.0001	.0005	.0008	.0034	.0033	.0034	.0049	.0083	.0015	.0000	.0002	.0265
	L	.0002	.0005	.0005	.0026	.0043	.0027	.0031	.0077	.0016	.0002	.0000	.0234
	M	.0000	.0005	.0008	.0008	.0011	.0022	.0027	.0053	.0009	.0001	.0000	.0144
	T	.0013	.0029	.0035	.0085	.0099	.0093	.0113	.0223	.0040	.0003	.0003	.0736
Calm	I	.0000										.0000	.0000
	N	.0000										.0000	.0000
	L	.0000										.0000	.0000
	M	.0000										.0000	.0000
	T	.0000										.0000	.0000
Miss	I	.0001	.0003	.0007	.0005	.0003	.0002	.0001	.0003	.0000	.0000	.0017	.0043
	N	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0010	.0009	.0000	.0010	.0035
	L	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0001	.0024	.0027
	M	.0000	.0000	.0001	.0000	.0006	.0002	.0002	.0000	.0000	.0000		.0011
	T	.0001	.0003	.0008	.0005	.0009	.0006	.0008	.0014	.0011	.0001	.0051	.0118
Total	I	.0104	.0285	.0393	.0620	.0439	.0197	.0098	.0088	.0042	.0021	.0038	.2324
	N	.0043	.0122	.0199	.0458	.0536	.0401	.0302	.0529	.0181	.0034	.0074	.2881
	L	.0027	.0099	.0182	.0573	.0586	.0425	.0338	.0570	.0139	.0047	.0063	.3051
	M	.0021	.0085	.0131	.0397	.0439	.0264	.0178	.0191	.0030	.0009	.0000	.1743
	T	.0195	.0591	.0905	.2048	.2001	.1287	.0917	.1379	.0392	.0110	.0175	1.0000

IPEC00035167

Table 5. Indian Point 3 Frequency Distribution of Wind Speed and Direction at 100 ft Tower Level According to Temperature Gradient Class-January 1, 1971-December 31, 1971

Wind Direction	Temp. Grad.	Wind Speed (m/s) 0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
349- 11	I	.0007	.0023	.0041	.0071	.0063	.0041	.0013	.0019	.0003	.0007	.0000	.0288
	N	.0001	.0005	.0009	.0041	.0065	.0050	.0018	.0046	.0008	.0002	.0002	.0248
	L	.0000	.0005	.0010	.0050	.0067	.0047	.0033	.0037	.0011	.0000	.0001	.0262
	M	.0002	.0021	.0031	.0078	.0121	.0074	.0067	.0031	.0000	.0006	.0008	.0439
	T	.0010	.0053	.0091	.0240	.0317	.0213	.0132	.0133	.0023	.0015	.0011	.1237
12- 33	I	.0005	.0033	.0039	.0150	.0169	.0053	.0016	.0018	.0000	.0000	.0000	.0483
	N	.0001	.0011	.0010	.0037	.0070	.0047	.0032	.0016	.0001	.0000	.0000	.0225
	L	.0001	.0002	.0007	.0045	.0043	.0021	.0003	.0007	.0000	.0000	.0001	.0130
	M	.0002	.0023	.0041	.0136	.0145	.0096	.0040	.0022	.0006	.0000	.0002	.0513
	T	.0009	.0070	.0097	.0367	.0428	.0216	.0091	.0063	.0007	.0000	.0003	.1352
34- 56	I	.0002	.0030	.0051	.0070	.0045	.0008	.0001	.0000	.0000	.0000	.0000	.0207
	N	.0001	.0010	.0017	.0025	.0023	.0010	.0001	.0006	.0001	.0000	.0010	.0105
	L	.0001	.0005	.0013	.0022	.0009	.0008	.0001	.0000	.0000	.0000	.0001	.0059
	M	.0002	.0018	.0048	.0096	.0080	.0024	.0009	.0003	.0002	.0000	.0000	.0284
	T	.0007	.0063	.0129	.0213	.0157	.0050	.0013	.0009	.0003	.0000	.0011	.0655
57- 78	I	.0001	.0017	.0027	.0023	.0005	.0003	.0001	.0000	.0000	.0000	.0000	.0078
	N	.0001	.0005	.0006	.0010	.0007	.0016	.0002	.0001	.0000	.0000	.0002	.0050
	L	.0002	.0003	.0001	.0009	.0001	.0002	.0006	.0002	.0000	.0000	.0000	.0027
	M	.0002	.0017	.0022	.0035	.0032	.0006	.0000	.0000	.0000	.0000	.0000	.0114
	T	.0007	.0042	.0056	.0078	.0045	.0027	.0009	.0003	.0000	.0000	.0002	.0270
79-101	I	.0002	.0009	.0017	.0016	.0002	.0000	.0000	.0000	.0000	.0000	.0000	.0047
	N	.0001	.0005	.0009	.0013	.0008	.0005	.0001	.0000	.0000	.0000	.0000	.0041
	L	.0000	.0003	.0002	.0000	.0005	.0007	.0001	.0000	.0000	.0000	.0000	.0018
	M	.0003	.0021	.0016	.0024	.0013	.0003	.0000	.0000	.0000	.0000	.0000	.0080
	T	.0007	.0038	.0045	.0053	.0027	.0015	.0002	.0000	.0000	.0000	.0000	.0186

17.

Table 5 (continued)

IPEC00035168

Wind Direction	Temp. Grad.	Wind Speed (m/s) 0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
102-123	I	.0002	.0015	.0016	.0024	.0008	.0001	.0000	.0000	.0000	.0000	.0000	.0066
	N	.0000	.0008	.0002	.0010	.0011	.0001	.0001	.0000	.0000	.0000	.0000	.0034
	L	.0001	.0003	.0003	.0010	.0003	.0003	.0003	.0002	.0000	.0000	.0000	.0031
	M	.0000	.0011	.0021	.0019	.0009	.0001	.0000	.0001	.0000	.0000.	.0000	.0063
	T	.0003	.0038	.0042	.0064	.0032	.0007	.0005	.0003	.0000	.0000	.0000	.0194
124-146	I	.0003	.0021	.0015	.0046	.0030	.0007	.0000	.0001	.0000	.0000	.0000	.0122
	N	.0000	.0008	.0005	.0015	.0030	.0011	.0008	.0008	.0000	.0000	.0000	.0085
	L	.0000	.0002	.0005	.0011	.0009	.0021	.0015	.0022	.0001	.0000	.0000	.0086
	M	.0001	.0011	.0007	.0029	.0023	.0017	.0014	.0015	.0002	.0002	.0000	.0121
	T	.0005	.0042	.0031	.0101	.0091	.0056	.0037	.0046	.0003	.0002	.0000	.0414
147-168	I	.0005	.0010	.0026	.0051	.0047	.0025	.0007	.0005	.0000	.0000	.0000	.0176
	N	.0000	.0006	.0005	.0032	.0018	.0019	.0022	.0017	.0000	.0000	.0000	.0119
	L	.0000	.0003	.0011	.0047	.0053	.0051	.0048	.0024	.0003	.0000	.0000	.0241
	M	.0000	.0015	.0021	.0071	.0088	.0046	.0022	.0027	.0000	.0002	.0000	.0292
	T	.0005	.0034	.0063	.0201	.0206	.0142	.0098	.0073	.0003	.0002	.0000	.0828
169-191	I	.0002	.0016	.0038	.0070	.0055	.0017	.0001	.0006	.0001	.0000	.0000	.0206
	N	.0000	.0003	.0005	.0018	.0017	.0014	.0006	.0011	.0000	.0000	.0000	.0074
	L	.0000	.0005	.0015	.0055	.0045	.0023	.0019	.0013	.0000	.0000	.0000	.0174
	M	.0001	.0019	.0027	.0090	.0079	.0034	.0030	.0022	.0000	.0000	.0000	.0303
	T	.0003	.0043	.0085	.0233	.0196	.0088	.0056	.0051	.0001	.0000	.0000	.0757
192-213	I	.0005	.0017	.0034	.0051	.0042	.0021	.0007	.0003	.0002	.0000	.0000	.0183
	N	.0001	.0002	.0005	.0010	.0007	.0006	.0006	.0006	.0001	.0000	.0000	.0043
	L	.0000	.0003	.0008	.0032	.0017	.0009	.0014	.0009	.0000	.0000	.0000	.0093
	M	.0000	.0015	.0031	.0061	.0061	.0039	.0013	.0006	.0000	.0000	.0002	.0226
	T	.0006	.0038	.0078	.0154	.0127	.0074	.0039	.0024	.0003	.0000	.0002	.0545

Table 5 (continued)

Wind Speed (m/s)

IPEC00035169

Wind Direction	Temp. Grad.	0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
214-236	I	.0001	.0014	.0023	.0033	.0024	.0010	.0003	.0011	.0001	.0000	.0000	.0121
	N	.0000	.0006	.0005	.0007	.0002	.0009	.0005	.0017	.0002	.0001	.0000	.0054
	L	.0001	.0006	.0010	.0018	.0006	.0007	.0002	.0014	.0001	.0000	.0000	.0065
	M	.0002	.0013	.0025	.0046	.0025	.0010	.0008	.0007	.0000	.0000	.0003	.0140
	T	.0005	.0038	.0063	.0104	.0057	.0037	.0018	.0049	.0005	.0001	.0003	.0380
237-258	I	.0005	.0021	.0019	.0024	.0018	.0021	.0007	.0013	.0007	.0002	.0000	.0136
	N	.0001	.0003	.0005	.0002	.0009	.0014	.0013	.0016	.0006	.0001	.0000	.0070
	L	.0000	.0002	.0003	.0018	.0007	.0007	.0011	.0035	.0014	.0006	.0000	.0104
	M	.0002	.0014	.0013	.0015	.0021	.0006	.0006	.0006	.0000	.0000	.0001	.0082
	T	.0008	.0040	.0040	.0059	.0055	.0047	.0037	.0070	.0026	.0009	.0001	.0392
259-281	I	.0003	.0016	.0013	.0017	.0016	.0019	.0016	.0013	.0007	.0001	.0000	.0121
	N	.0001	.0002	.0000	.0000	.0009	.0013	.0024	.0053	.0013	.0001	.0000	.0115
	L	.0000	.0003	.0003	.0005	.0015	.0027	.0021	.0038	.0023	.0003	.0000	.0138
	M	.0005	.0013	.0014	.0016	.0022	.0023	.0016	.0030	.0014	.0000	.0001	.0152
	T	.0009	.0034	.0030	.0038	.0062	.0082	.0077	.0133	.0056	.0006	.0001	.0527
282-303	I	.0008	.0014	.0009	.0010	.0014	.0017	.0024	.0029	.0008	.0001	.0001	.0135
	N	.0001	.0002	.0003	.0002	.0008	.0023	.0030	.0069	.0024	.0013	.0013	.0188
	L	.0001	.0001	.0009	.0009	.0008	.0023	.0035	.0090	.0041	.0010	.0000	.0229
	M	.0006	.0008	.0014	.0014	.0024	.0025	.0030	.0080	.0024	.0009	.0001	.0234
	T	.0016	.0025	.0035	.0035	.0054	.0088	.0119	.0268	.0097	.0033	.0015	.0786
304-326	I	.0001	.0017	.0005	.0010	.0013	.0019	.0023	.0029	.0003	.0001	.0000	.0121
	N	.0000	.0002	.0002	.0003	.0003	.0015	.0032	.0072	.0011	.0003	.0002	.0148
	L	.0001	.0010	.0006	.0007	.0018	.0023	.0015	.0079	.0041	.0005	.0000	.0205
	M	.0005	.0008	.0010	.0006	.0025	.0030	.0040	.0113	.0056	.0008	.0000	.0301
	T	.0007	.0038	.0023	.0026	.0059	.0087	.0110	.0293	.0112	.0017	.0002	.0774

z-29

19.

Table 5 (continued)

		Wind Speed (m/s)								
Wind	Temp.	0.0-	>0.5-	>1.0-	>1.5-	>2.5-	>3.5-	>4.5-	>5.5-	>8.5-

IPEC00035170

IPEC00035170

Direction	Grad.	0.5	1.0	1.5	2.5	3.5	4.5	5.5	8.5	11.0	>11.0	Miss	Total
327-348	I	.0006	.0021	.0011	.0017	.0018	.0010	.0014	.0015	.0002	.0000	.0000	.0114
	N	.0001	.0002	.0002	.0003	.0017	.0017	.0023	.0040	.0003	.0001	.0001	.0112
	L	.0000	.0000	.0003	.0017	.0035	.0040	.0019	.0053	.0005	.0002	.0000	.0175
	M	.0000	.0010	.0014	.0025	.0031	.0042	.0039	.0095	.0032	.0003	.0006	.0297
	T	.0007	.0033	.0031	.0063	.0102	.0110	.0095	.0202	.0042	.0007	.0007	.0699
Calm	I	.0000										.0000	.0000
	N	.0000										.0000	.0000
	L	.0000										.0000	.0000
	M	.0000										.0000	.0000
	T	.0000										.0000	.0000
Miss	I	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	N	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0001
	L	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0002
	M	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	T	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0003	.0003
Total	I	.0058	.0293	.0385	.0684	.0568	.0273	.0133	.0161	.0035	.0013	.0001	.2605
	N	.0011	.0081	.0089	.0230	.0305	.0270	.0223	.0377	.0071	.0023	.0032	.1713
	L	.0009	.0058	.0111	.0356	.0342	.0319	.0248	.0424	.0141	.0026	.0006	.2040
	M	.0034	.0237	.0353	.0760	.0798	.0477	.0333	.0457	.0136	.0031	.0025	.3642
	T	.0113	.0669	.0939	.2030	.2014	.1339	.0937	.1420	.0383	.0093	.0064	1.0000

Z-30

20.

Table 6. Trap Rock Frequency Distribution of Wind Speed and Direction
January 1, 1970-December 31, 1970.

IPEC00035171

Wind Direction		Wind Speed (m/s) 0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
349- 11	N	.0049	.0113	.0146	.0247	.0203	.0155	.0117	.0170	.0030	.0013	.0029	.1271
12- 33	NNE	.0024	.0101	.0137	.0244	.0215	.0087	.0051	.0034	.0007	.0002	.0022	.0925
34- 56	NE	.0035	.0088	.0105	.0118	.0086	.0024	.0005	.0009	.0005	.0000	.0007	.0481
57- 78	ENE	.0021	.0047	.0058	.0052	.0015	.0003	.0001	.0008	.0000	.0000	.0002	.0208
79-101	E	.0012	.0028	.0036	.0056	.0028	.0012	.0003	.0003	.0000	.0000	.0001	.0178
102-123	ESE	.0020	.0038	.0039	.0058	.0046	.0022	.0009	.0007	.0001	.0000	.0000	.0241
124-146	SE	.0012	.0044	.0058	.0146	.0152	.0130	.0081	.0133	.0027	.0002	.0002	.0786
147-168	SSE	.0019	.0057	.0109	.0210	.0208	.0126	.0075	.0111	.0010	.0007	.0003	.0935
169-191	S	.0012	.0072	.0084	.0178	.0141	.0084	.0050	.0041	.0001	.0000	.0008	.0671
192-213	SSW	.0021	.0057	.0088	.0130	.0091	.0036	.0027	.0023	.0002	.0001	.0007	.0483
214-236	SW	.0029	.0064	.0065	.0075	.0031	.0024	.0013	.0029	.0001	.0005	.0002	.0338
237-258	WSW	.0028	.0041	.0025	.0045	.0038	.0029	.0028	.0024	.0005	.0005	.0000	.0267
259-281	W	.0023	.0038	.0027	.0034	.0043	.0051	.0042	.0083	.0030	.0012	.0001	.0383
282-303	WNW	.0022	.0038	.0031	.0065	.0073	.0089	.0079	.0204	.0091	.0056	.0010	.0758
304-326	NW	.0023	.0047	.0049	.0081	.0109	.0131	.0087	.0306	.0191	.0076	.0030	.1130
327-348	NNW	.0038	.0087	.0079	.0145	.0139	.0114	.0076	.0139	.0031	.0030	.0020	.0898
Calm		.0000											.0000
Miss		.0000	.0003	.0005	.0023	.0012	.0001	.0000	.0001	.0001	.0000		.0046
Total		.0385	.0963	.1140	.1905	.1630	.1117	.0743	.1326	.0434	.0208	.0146	1.0000

Z-33

23.

Table 7. Trap Rock Frequency Distribution of Wind Speed and Direction
January 1, 1971-December 31, 1971.

Wind Speed (m/s)

IPEC00035172

Wind Direction		0.0-0.5	>0.5-1.0	>1.0-1.5	>1.5-2.5	>2.5-3.5	>3.5-4.5	>4.5-5.5	>5.5-8.5	>8.5-11.0	>11.0	Miss	Total
349- 11	N	.0011	.0105	.0123	.0240	.0217	.0166	.0126	.0266	.0041	.0030	.0002	.1328
12- 33	NNE	.0015	.0061	.0159	.0375	.0281	.0145	.0046	.0037	.0002	.0001	.0008	.1130
34- 56	NE	.0012	.0070	.0078	.0231	.0120	.0044	.0013	.0013	.0001	.0000	.0007	.0590
57- 78	ENE	.0007	.0033	.0055	.0069	.0032	.0012	.0004	.0001	.0001	.0000	.0001	.0214
79-101	E	.0008	.0033	.0033	.0040	.0025	.0009	.0004	.0000	.0000	.0000	.0001	.0152
102-123	ESE	.0011	.0027	.0027	.0071	.0046	.0013	.0009	.0002	.0000	.0000	.0001	.0207
124-146	SE	.0006	.0019	.0036	.0091	.0139	.0099	.0079	.0084	.0007	.0001	.0002	.0565
147-168	SSE	.0007	.0040	.0084	.0179	.0188	.0122	.0086	.0081	.0009	.0001	.0000	.0797
169-191	S	.0015	.0033	.0078	.0161	.0124	.0067	.0041	.0043	.0002	.0001	.0001	.0567
192-213	SSW	.0012	.0047	.0079	.0145	.0099	.0061	.0033	.0027	.0000	.0000	.0008	.0511
214-236	SW	.0012	.0047	.0068	.0120	.0058	.0029	.0025	.0037	.0000	.0002	.0008	.0407
237-258	WSW	.0018	.0053	.0044	.0040	.0047	.0033	.0037	.0071	.0027	.0009	.0008	.0387
259-281	W	.0013	.0040	.0029	.0044	.0053	.0047	.0057	.0106	.0042	.0009	.0016	.0457
282-303	WNW	.0013	.0044	.0029	.0042	.0088	.0111	.0118	.0261	.0085	.0034	.0027	.0852
304-326	NW	.0013	.0057	.0037	.0047	.0071	.0129	.0117	.0360	.0161	.0037	.0022	.1052
327-348	NNW	.0014	.0083	.0077	.0090	.0094	.0113	.0092	.0139	.0026	.0007	.0013	.0748
Calm		.0000											.0000
Miss		.0000	.0000	.0005	.0012	.0005	.0005	.0004	.0005	.0001	.0002		.0037
Total		.0185	.0790	.1043	.1997	.1685	.1204	.0891	.1535	.0407	.0137	.0127	1.0000

Z-34

24.

Table 8. Montrose Frequency Distribution of Wind Speed and Direction
January 1, 1970-December 31, 1970.

	Wind Speed (m/s)								
Wind	0.0-	>0.5-	>1.0-	>1.5-	>2.5-	>3.5-	>4.5-	>5.5-	>8.5-

IPEC00035173

Direction		0.5	1.0	1.5	2.5	3.5	4.5	5.5	8.5	11.0	>11.0	Miss	Total
349- 11	N	.0038	.0072	.0054	.0084	.0143	.0099	.0050	.0067	.0010	.0003	.0123	.0743
12- 33	NNE	.0033	.0064	.0125	.0294	.0200	.0102	.0077	.0078	.0011	.0000	.0241	.1224
34- 56	NE	.0024	.0065	.0092	.0203	.0146	.0054	.0016	.0010	.0001	.0000	.0223	.0834
57- 78	ENE	.0016	.0037	.0052	.0038	.0033	.0009	.0001	.0013	.0001	.0000	.0078	.0278
79-101	E	.0010	.0027	.0014	.0044	.0009	.0004	.0009	.0007	.0004	.0000	.0065	.0193
102-123	ESE	.0016	.0028	.0023	.0043	.0021	.0007	.0001	.0006	.0000	.0000	.0047	.0191
124-146	SE	.0013	.0035	.0060	.0102	.0094	.0054	.0020	.0010	.0000	.0000	.0098	.0485
147-168	SSE	.0007	.0026	.0082	.0271	.0240	.0184	.0081	.0070	.0001	.0001	.0160	.1123
169-191	S	.0009	.0030	.0075	.0153	.0133	.0079	.0026	.0011	.0003	.0006	.0140	.0665
192-213	SSW	.0017	.0037	.0051	.0108	.0092	.0058	.0026	.0016	.0001	.0001	.0148	.0555
214-236	SW	.0023	.0045	.0072	.0082	.0044	.0033	.0020	.0026	.0006	.0003	.0099	.0452
237-258	WSW	.0021	.0037	.0045	.0052	.0024	.0013	.0016	.0023	.0007	.0003	.0071	.0312
259-281	W	.0023	.0028	.0030	.0034	.0035	.0038	.0031	.0058	.0011	.0011	.0070	.0370
282-303	WNW	.0017	.0026	.0021	.0030	.0047	.0044	.0051	.0148	.0079	.0028	.0068	.0559
304-326	NW	.0018	.0024	.0020	.0045	.0058	.0067	.0084	.0262	.0148	.0050	.0135	.0911
327-348	NNW	.0040	.0034	.0031	.0045	.0071	.0065	.0081	.0200	.0047	.0007	.0119	.0740
Calm		.0000											.0000
Miss		.0054	.0060	.0070	.0085	.0058	.0021	.0010	.0003	.0003	.0000		.0363
Total		.0377	.0675	.0918	.1712	.1448	.0932	.0597	.1006	.0335	.0113	.1885	1.000

Z-35

25.

IPEC00035174

2.2 Recorders

All instruments produce ink trace records on strip chart analog recorders. Items (a) and (b) use Esterline Angus continuous trace recorders at chart speed of 3 in./hr. Items (c) and (d) use a Bendix-Friez continuous trace recorder at chart speed of 3 in./hr. Item (e) uses a continuous trace recorder at chart speed of 1 in./hr. Item (f) uses a Texas Instrument dual channel continuous trace recorder for elevation and azimuth readings at chart speeds of either 3 in./hr. or 3 in./min. Item (g) uses a 6 channel Honeywell-Brown dot print recorder with a three minute recording cycle. Items (h), (i) and (j) use a common 8 point Bristol recorder which dot prints every 30 seconds at a chart speed of 3 in./hr.

3. Data Log

A monthly tabulation of days in which 12 or more hours of missing data occurred during the period of data collection

Z-14

5.

from January 1970-December 1971 is presented in Table 2. Data collected beyond this period is indicated as well as instrumentation activation and termination dates.

Data recovery information is given in Table 3. Most data loss occurred when instruments were out of service for repair or when data were deemed erroneous due to improper functioning of instruments. Major instrumentation difficulties included: for the Climet wind system, speed head bearing failures and hypersensitivity of the directional module; and for the Honeywell-Brown Temperature Difference system, aspirator failures due to corroded connections and loss of calibration due to unobserved deterioration of recorder components.

IPEC00035175

Complete breakdowns due to lightning strikes on the Montrose Point and Trap Rock towers were another source of data loss.

A special reference must be made to the Honeywell-Brown temperature difference system. One of the initial purposes for data collection at Indian Point was to determine if any climatic changes had occurred since 1955-57 that could be detrimental to the Indian Point accident model. It was felt that the utilization of the exact instruments used in 1955-57 would facilitate the evaluation. The original Honeywell-Brown system was rehabilitated and placed in operation. Because of age factors it became difficult to maintain temperature difference data recovery at greater than 70-80% after July 1970. The amount of valid data output, however, was considered sufficient to meet its original function. As it became apparent that a reliable, continuously operating temperature difference system was a necessity, and with the complete breakdown of the aging system on 25 October 1971, a new system was acquired and subsequently installed on 14 August 1972.

4. Analytical Procedure

4.1 Wind Direction

To facilitate the development of the statistical

IPEC00035176

7.

Table 3. Record of Data Recovery

Station	Parameter	Period	Hours of Valid Data	Total Hours in Period	% Recovery
IP3	Wind Direction (Climet)	Annual 1970	8644	8760	98.68
		Summer 1970	5072	5136	98.75
		Winter 1970	3572	3624	98.57
		Annual 1971	8742	8760	99.80
		Summer 1971	4406	4416	99.77
		Winter 1971	4336	4344	99.82
	Wind Speed (Climet)	Annual 1970	8594	8760	98.11
		Summer 1970	5019	5136	97.72
		Winter 1970	3575	3624	98.65
		Annual 1971	8689	8760	99.19
		Summer 1971	4381	4416	99.21
		Winter 1971	4308	4344	99.17
	Wind Direction (Aerovane)	Summer 1970 (Partial: until Sept. 18)	4003	4104	97.54
	Wind Speed (Aerovane)	Summer 1970 (Partial: until Sept. 18)	4001	4104	97.49
	Temperature Difference	Annual 1970	7222	8760	82.44
		Annual 1971	5560	8760	63.47
TR	Wind Direction	Annual 1970	8600	8760	98.17
		Summer 1970	4983	5136	97.02
		Winter 1970	3617	3624	99.81
		Annual 1971	8524	8760	97.31
		Summer 1971	4242	4416	96.06
		Winter 1971	4282	4344	98.57
	Wind Speed	Annual 1970	8514	8760	97.19
		Summer 1970	5018	5136	97.70
		Winter 1970	3496	3624	96.47
		Annual 1971	8447	8760	96.43

IPEC00035177

	Summer 1971	4243	4416	96.08
Winter 1971	4204	4344	96.78	

Z-17

IPEC00035178

8.

Table 3 (continued)

Station	Parameter	Hours of Valid Period	Total Hours in Data	% Period	Recovery
MP	Wind Direction	Annual 1970	6794	8760	77.56
		Summer	4045	5136	78.76
	Wind Speed	Annual 1970	5721	8760	65.31
		Summer	3140	5136	61.14
CC	Wind Direction	Summer 1970	4093	4104	99.73
	Wind Speed	Summer 1970	4091	4104	99.68

IP1 No recovery information indicated.

IPEC00035179

Z-18

9.

analysis, the parameter categories were standardized on the basis of sixteen compass point (22 1/2° sectors) as opposed to eighteen 20° sectors from 002 1/2° as used by Davidson.

The frequency density for each wind quadrant is determined by:

$$f = \frac{n}{(N-m)\theta}$$

where:

f	=	frequency density
n	=	number of data hours in a specified category
N	=	total number of hours possible for a selected time period
m	=	number of hours for which <u>no</u> data was available
u	=	sector interval (Note: 20.0° for 1955-1957 data and 22.5° for 1970-1971 data.)

The sum of the sector frequency densities is equal to 1. Calm and missing data are assumed to be equally distributed throughout the compass and are divided by a sector width of 360°.

4.2 <u>Wind Speed</u>

Wind speeds are presented in m/s. (For conversion to mph, multiply by 2.237) The number of speed categories were increased at low end to provide more detailing of the speed distribution in this critical range.

IPEC00035180

For wind speeds, the frequency is defined by

$$F_x = \frac{n_x}{(N - m)}$$

where:

F_x = frequency in a class interval

n_x = number of data hours within a specified interval

N = total number of hours possible for a selected time period

Z-19

10.

m = number of hours for which no data was available

The percent probability is defined by

$$P_x = \left[\frac{n_x}{(N - m) + 1}\right] x100$$

The cumulative percent probability is defined by

$$CP = \sum_{i=1}^{i=x} P_i$$

where:

i = number of class intervals.

When CP is plotted, a point on the curve is read as the percent time that the wind speed # indicated value.

4.3 Stability Categories

4.31 Atmospheric Stability Categories Defined in Terms of Temperature Difference

IPEC00035181

	Class	IP1 – 1955-57 (300 ft tower)	IP3 – 1970-71 (100 ft tower)
I =	Inversion (“stable”)	$T_{150} - T_7 \geq 0$	$T_{95} - T_7 \geq 0$
N =	Isothermal-Adiabatic (“neutral”)	$0 > T_{150} - T_7 \geq -0.98$	$0 > T_{95} - T_7 \geq -0.58F$
L =	Lapse (“unstable”)	$-0.98F > T_{150} - T_7$	$-0.58F > T_{95} - T_7$

4.32 Classification of Atmospheric Stability According to U. S. A. E. C. Safety Guide 23

Stablity Classification	Pasquill Categories	Temperature Change with Height (8C/100m)	(°F/88 ft) (IP3)
Extremely Unstable	A	< -1.9	< -0.9
Moderately Unstable	B	-1.9 to –1.7	-0.9 to < -0.8
Slightly Unstable	C	-1.7 to –1.5	-0.8 to < -0.7
Neutral	D	-1.5 to –0.5	-0.7 to < -0.2
Slightly Stable	E	-0.5 to 1.5	-0.2 to < +0.7
Moderately Stable	F	1.5 to 4.0	+0.7 to <1.9
Extremely Stable	G	>4.0	$1.9

IPEC00035182

11.

4.4 Seasonal Distributions

After careful examination of individual monthly frequency distributions it was determined that a definite seasonal effect existed. Two distinct seasons emerge: summer and winter, with no distinctive transition months. November-March are always "winter" months and May-September always "summer" months. April and October distribution patterns may appropriately fit either a winter or summer season. There was no means of predicting, in advance, what season was appropriate for these two months until the actual data was analyzed. The seasonal breakdown, as used, is as follows:

	Winter	Summer
1970	January-March, November-December (5 months)	April-October (7 months)
1971	January-April, November-December (6 months)	May-October (6 months)

4.5 Diurnal Analysis

The hourly diurnal mean wind direction and speed were determined by resolving each individual data point into its N-S and E-W components, summing the components within each hourly category and calculating a mean wind direction and speed. When plotting the diurnal direction curve it is assumed that the rotation of the mean between two points will circumvent the smallest arc.

Persistence is defined as,

$$P = \frac{\text{Vector Average Speed}\left(\left|\overline{\vec{V}}\right|\right)}{\text{Magnitude of Scalar Average Speed}\left(\left|\overline{V}\right|\right)}$$

4.6 Spatial Variation

IPEC00035183

The spatial relationship of wind direction and speed between two tower sites was determined by selecting the category range at one station as the independent variable and calculating a frequency distribution and mean value at the

Z-21

12.

second station for each of the independent variable's categories. This method assumes a gaussian distribution around the mean value at the independent station.

5. Discussion of Data

5.1 Joint Frequency Distribution of Wind Direction, Wind Speed and Temperature Difference

5.1.1 Inversion – Neutral – Lapse Temperature Difference Classification

Annual frequency distributions of wind speed and direction according to temperature gradient class at Indian Point 3 for 1970 and 1971 are given in Tables 4 and 5, respectively.

5.1.2 Pasquill Stability Classification

Annual joint frequency distributions of wind direction and speed according to the Pasquill stability categories, as established by the U. S. A. E. C. Safety Guide 23, at Indian Point 3 for 1970 and 1971 are given in Appendix Table 1 and 2, respectively.

5.2 Joint Frequency Distribution of Wind Direction and Temperature Difference

5.2.1 Monthly Distribution of Temperature Difference

IPEC00035184

A monthly distribution of temperature difference at IP3 for 1970 and 1971 is given in Figure 2. The distribution for missing hours of temperature difference data is also presented so that a measure of reliability can be determined.

The frequency of inversions remain relatively constant throughout the year. Neutral conditions are more frequent during the winter months while lapse conditions reach their peak during the summer months. These features seem most apparent during those time periods, in both years, when data collection efficiency was greater than 80%.

IPEC00035185

21.

5.2.2 Annual Joint Frequency Distribution

The annual frequency distributions of wind direction according to temperature difference category for IP1 (1956) and IP3 (1970 and 1971) are presented in Figure 3.

For inversion conditions, a marked discrepancy is observed between the 1956 and 1970-71 data. Substantial decreases are observed in the frequency of observed inversions during 1970-71 in all quadrants except those between 050 to 160°. The reduction is by a factor of 0.50 in some sectors. The cause of this deviation may be due to one, or more of the following: a) different tower locations; b) different measurement height intervals ((150-7 ft (1956) and 95-7 ft (1970-71)); c) change in the surrounding environs (the area is now more developed); or d) a calibration error ((only 0.9°F (1956) and 0.5°F (1970-71)) separate inversions from lapse conditions).

The distribution for neutral and lapse conditions between 1956 and 1970-71 are generally similar. The neutral maxima are from the same quadrant (NNE) as the inversion for all years. Under lapse conditions, maximums are observed of approximately equal magnitude for winds from the N and SSE quadrants.

Major discrepancies between the 1970 and 1971 data occur in the neutral category from 300° -030° and in the lapse category from 140° -200°. These can be attributed to periods of missing data. The decrease in frequency of neutral condition northerly winds in 1971 may be due to missing data during October-December. A strong northwesterly wind persists during these months resulting in dominating neutral atmospheric conditions. The decrease in frequency of lapse conditions for southerly winds in 1971 may be due to data loss during May-July. These are the months in which lapse conditions normally prevail.

IPEC00035186

In general, throughout 1970-71 most specific descrepancies are associated with periods of maximum data losses.

Z-31

IPEC00035187

22.

5.3 Joint Frequency Distribution of Wind Direction and Wind Speed

The annual joint frequency distribution of wind direction and wind speed for Trap Rock (TR) 1970 and 1971, and Montrose Point (MP) 1970 are given in Tables 6, 7, and 8, respectively.

Wind direction distributions for various speed categories are presented in Figure 4. Discrepancies between 1956 and 1970-71 are less apparent than when classified by temperature difference. The 1970 and 1971 distributions are almost a duplicate of each other.

Halitsky, et al. (1971) found that there was a significant increase in the frequency of occurrence of low speed winds from the critical sector, 000° -040°, for 10 months of 1970 data compared to 1956. With 1970 and 1971 data, the frequencies are nearly the same. The remaining small discrepancy may be due to alteration of quadrant angles. The improvement can be attributed to the extension of 1970 data to a complete year and the difference in category range, 0.0-1.5 m/s in this report versus 0.4-2.0 m/s in the 1971 report. The generally slight increase of frequency in 1970 through most directions is due to a change in instrumentation. A Climet speed unit (threshold: 0.6 MPH) was used in 1970-71 while an aerovane (threshold: 2.5 MPH) was used in 1956. Thus, data points which were measured as calm by the aerovane in 1956 would now be present within the distribution with speed between 0.27-1.2 m/s (0.6-2.5 MPH) when measured with the Climet.

Figure 4 also indicates a general backing into the NW of the maximum frequency direction as wind speeds increase for all years.

IPEC00035188

26.

5.4 Frequency Distribution of Wind Direction

5.4.1 Annual

Annual frequency distributions of wind direction for the various meteorological tower sites are given in Figure 5. Obvious differences that exist between IP1 (1956) and IP3 (1970-71) are: a) decrease in magnitude of the maximum direction; and b) shifting of the secondary maximum from 172° backing to 156° in 1970-71.

Comparison between IP3 and TR for the same years show differences which are no doubt caused by local topographical effects. The IP3 NNE maximum has backed to the N at Trap Rock. There is also a marked increase in both NW and SE winds at Trap Rock with the NW direction now becoming the secondary maximum.

The frequency density distribution at Montrose Point closely resembles that at IP3.

5.4.2 Seasonal

A definite seasonal pattern was observed during the analysis of monthly data at each station. The seasonal frequency distributions for IP3, Trap Rock and Montrose Point are given in Figures 6, 7 and 8, respectively.

The winter season wind direction frequency distribution at IP3 is tri-nodal. The primary maximum appears with winds from N-NNE. The secondary maximum appears for winds from WNW-NW. This second maximum is of the same order of frequency of the primary. The binodal maximum for winds from these northern quadrants may be attributed to the effect of blockage by the Dunderberg Mountain (Figure 1). The winds, as is seen, preferentially go around it rather than over its top. The tertiary maximum during the winter season is for winds from SSE at half the frequency of the north-quadrant maxima.

IPEC00035189

During the summer season the direction frequency distributions are binodal with two well defined peaked regions,

Z-36

IPEC00035190

27.

one northerly (NNE) and the other southerly (SSE). Over the 1970-71 seasons, the maxima are approximately equal in frequency. The winter season secondary peak (WNW-NW) is completely lacking during the summer.

Seasonal differences can be attributed to the influence or lack of influence of the atmospheric geostrophic wind. A persistent and strong NW winter geostrophic wind is responsible for the W-N quadrant peaks at the valley stations. The summer distributions reflect the diurnal wind pattern which flows along the valley axis: upvalley during the day and downvalley at night. The diurnal winds dominate the valley flow system during calm and nearly zero atmospheric pressure gradient conditions, which occur primarily during the summer months and account for the increased frequency of SSE-SSW winds.

Comparison between IP3 (Figure 6) and TR (Figure 7) shows that during the winter TR has the same tri-nodal distribution as IP3. At TR, however, the maximum frequency density is for winds from NNW quadrant without a significant change in frequency of NNE or SSE winds. During the summer the IP3 NNE maximum has backed to N at TR as occurs with the annual distribution and becomes binodal. The previously mentioned sharp increase of annual SE winds at TR is seen to occur almost entirely during the summer season. The annual NW increase is divided between the two seasons.

Based on limited data, the seasonal distributions at Montrose Point (Figure 8) are similar to those of IP3 except for a semblance of retention of the tri-nodal aspect during the summer season.

5.4.3 Comparison Between IP3 and Cape Charles for a Summer Season

IPEC00035191

On 16 March 1970, an aerovane was installed aboard the U.S.S. Cape Charles. The intent of this station was to obtain comparable data to that collected by Davidson in September-

28.

October 1955 aboard the U.S. S. Jones in order to produce diurnal hodographs of the mean vector wind for virtually zero and weak pressure gradient conditions. Data retrieval over a lengthy time span could not be achieved because of the “mothball” fleet’s disposal operations. However, a hodograph was constructed for July-September 1970 for comparative purposes ((Halitsky, et al. (1971)).

Frequency distributions of wind direction for Cape Charles and IP3 aerovanes are given in Figure 9. For the record period, SSE winds are most frequent at IP3 and SW at Cape Charles. This variation is related to the dominant valley terrain features that influence each station (Figure 1). The proximity of the Cape Charles to the Dunderberg Mountain is the controlling feature. The prevailing SSE valley wind, as measured at IP3, is forced to veer and flow parallel to the face of Dunderberg Mountain giving the Cape Charles its SW flow. The lack of NW and NNW winds at the Cape Charles as compared to IP3 is further indication of the blocking action of the Dunderberg.

Both stations compare relatively well during northerly quadrant winds. The IP3 sharp peak at NNE is spread out at the Cape Charles almost uniformly over the N, NNE and NE quadrants. This dispersion probability reflects the vortex generated as the air is deflected by the eastern tip of Dunderberg. In particular the NE peak could also represent nocturnal drainage flow from the Annsville Creek, Sprout Brook and Peekskill Hollow Brook valley complexes.

IPEC00035192

It should be cautioned that the Cape Charles aerovane was exposed at an elevation of approximately 100 ft MSL while the IP3 aerovane measured at an elevation of 220 ft MSL and some variations may be due to this difference in exposure elevations.

IPEC00035193

29.

5.5 Cumulative Probability Distribution for Wind Speed

5.5.1 Annual

The annual cumulative probability curves for wind speed are presented for IP1, IP3, Trap Rock and Montrose Point in Figures 10-13. A summary of annual and seasonal median wind speeds is given in Table 9.

Table 9. Annual and Seasonal Median Wind Speeds

Station	Period	Median Wind (m/s)
Indian Point 1	1956 - Annual	3.0
Indian Point 3	1970 - Annual	3.0
	-Winter	3.4
	-Summer	2.9
	1971 - Annual	3.1
	-Winter	3.7
	-Summer	2.7
Trap Rock	1970 - Annual	2.8
	-Winter	3.3
	-Summer	2.5
	1971 - Annual	3.0
	-Winter	3.6
	-Summer	2.7
Montrose Point	1970 - Annual	2.7
	-Winter	3.3
	-Summer	2.3
Cape Charles	1970 - Summer	2.8

IPEC00035194

Indian Point 3 (Aerovane)	1970	-	Summer	2.3

Figure 10 is a comparison of data collected at IP3 in 1970 and 1971. It shows the relationship between the two years for all wind speed data and as functions of temperature gradient categories. When all wind speed data is considered at each of the stations, there is less than 1% probability deviation between the two annual curves. The maximum deviation is observed at 0.5 m/s where the probability of speeds

IPEC00035195

0.5 m/s is about 2.0% and 1.1% for 1970 and 1971, respectively.

Before discussing the curves in terms of temperature gradient categories, it should be borne in mind that the annual curve contains all hours for which wind speed data was available. The speed data recovery was 98.1% in 1970 and 99.2% in 1971 (Table 3). The curves now to be considered were constructed from those data hours in which both wind speed and temperature gradient were available: 82% in 1970 and 63.5% in 1971.

In the total inversion category, the two years are nearly identical in the speed range 1.0-2.5 m/s with 1970 having the greater probability of low wind speeds at 0.5 m/s, and 1971 the greater probability of low wind speeds > 2.5 m/s with a spread of approximately 4%. From 3 m/s to 11 m/s the probability of lower speeds is increased from 16.5% to 23.0% in 1970, and from 17.5% to 26.0% in 1971.

In 1970 the neutral and lapse probabilities curves were quite similar. Below 2.4 m/s there were more neutral occurrences and above 2.4 m/s more lapse observations. The neutral-lapse conditions were, as can be anticipated, more frequent at wind speeds greater than 5.5 m/s and less frequent at speeds below 5.5 m/s. This is consistent with their normal association as being high speed phenomena while inversions are associated with low wind speeds. In 1971, however, the neutral-lapse curves were significantly lower than in 1970 and did not approach the probability of the 1971 annual inversion curve. These discrepancies may be, in part, real but most probably the explanation lies in the fact that there was about 20% less valid data available in 1971 compared to 1970. These excess losses are distributed as follows (from Table 2) in terms of missing days:

IPEC00035196

Z-40

IPEC00035197

IPEC00035197

31.

	J	F	M	A	M	J	J	A	S	O	N	D
1970	0	3	3	0	0	3	0	13	17	20	4	0
1971	0	12	2	1	16	11	13	2	7	5	30	31
1971-1970	0	9	-1	1	16	8	13	-11	-10	-15	26	31

The losses during the summer may account for the lack of lapse data and the excessive winter losses can account for the decrease in neutral data since these are the seasons when such gradients normally prevail.

A comparison of the probability curves between IP1 (1956) and IP3 (1970 and 1971) on an annual basis, for total inversions and inversions in the critical sector, is shown in Figure 11. For all available wind speeds, IP3 is nearly identical to IP1 until 4 m/s after which IP1 indicates a higher probability of lower wind speeds. For all inversion data IP1 indicates a significantly higher probability of low winds speeds. When the analysis of inversion data is restricted to the critical quadrants (002.5° -22.5° in 1956, and 011.5°-033.5° in 1970-71), the 1956 curve always indicates a higher probability of low wind speeds than does IP3 (1970 and 1971).

A comparison between IP3 and Trap Rock (figure 12) shows that a greater percent probability of low wind speeds are observed at TR until about 5.5 m/s in 1970 and 3.5 m/s in 1971 after which TR has greater probability of higher wind speeds.

The low wind speed conditions occur mostly as part of the valley diurnal system. Here, where atmospheric influences are negligible the driving force to a crossvalley or diagonal wind is the gravitational drainage of the valley slopes. The IP3 location is more influenced by such a drainage pattern and will therefore exhibit higher wind speeds at the lower range than over leveler terrain as surrounds Trap Rock.

IPEC00035198

The Montrose Point cumulative probability resembles that of Trap Rock. It has been found previously that the Montrose Point direction distribution most resembles IP3.

Z-41

32.

The variations merely emphasize the dominant effects of strictly local terrain.

5.5.2 Seasonal

Seasonal cumulative frequency distributions of wind speed for Montrose Point, IP3 and Trap Rock are given in Figures 13, 14 and 15, respectively. The winter curves show a greater probability of high speeds at all stations than during the summer with but two exceptions: at IP3 in 1970 the winter curve shows a greater probability for wind speeds below 0.68 m/s and Trap Rock in 1971 below 0.87 m/s. Overall, however, the probability of low wind speeds is generally greatest during the summer season.

The summer cumulative frequency speed curves for the Cape Charles and IP3 aerovanes are given in Figure 16. The Cape Charles exhibits a greater percentage of higher wind speeds up to 8.8 m/s after which the IP3 percentage is greater. Higher wind speeds exist at Cape Charles because there are fewer local effects and less frictional loss over water than over land. The deviation at the high speed winds is generally associated with strong W-N geostrophic flow and the Cape Charles is shielded from these by the Dunderberg and Buckberg Mountains.

5.6 Diurnal Variation of the Mean Wind Direction

A primary analysis for data collected in a valley is to determine the extent of the diurnal wind pattern. This pattern is generally ignored in diffusion meteorology models used for nuclear generating sites. The models used are based on air flow over level and unobstructed

IPEC00035199

terrain. The diurnal wind direction fluctuations and the ever present motion of air (zero frequency of calms) in the valley is a definite positive affect on the diffusion potential.

Seasonal diurnal variations of the mean wind direction

Z-42

IPEC00035200

33.

for IP3, TR, MP and CC are presented in Figures 17-20, respectively.

The seasonal differences are clearly evident. The winter means fluctuate over shorter ranges exhibiting only a slight diurnal variation between the night and day hours. The winter mean at IP3 ranges from 352°-302° in 1970, and from 332°-305° in 1971. The TR mean ranges from 341°-308° in 1970, and from 332°-305° in 1971. The winter range at MP for 1970 was 357°-319°.

On a point by point basis, during the night, TR's mean direction tends to be west of that at IP3 while MP is about the same as IP3. During the day, IP3 and TR are similar while MP holds more to the north.

The summer diurnal curves at IP3 shows the direction rotating through a complete circle, being downvalley at night and upvalley during the day. From 2300-0800 the means hold from 20°-40°. Thereafter the wind direction backs; rapidly during the transition hours of 1000-1100 and 2000-2200, and slower during the intervening hours at a rate of approximately 8 degrees per hour.

The TR summer diurnal wind pattern is similar to that at IP3. From 2300-1000 a downvalley wind exists ranging from 006°-034°. Both transition periods are sharp, occurring at 1000-1100 and 2000-2100. In 1970 the wind backed into the upvalley direction during the day and veered into the downvalley direction at night. This pattern was reversed in 1971.

MP (Figure 19) shows a similar diurnal summer pattern for 1970 but unlike TR it veered into an upvalley flow during the transition hours.

The question of backing or veering during transition hours may be somewhat more complex than is nominally indicated. Referring it back to original analog records during the transition period one can find <u>either</u> the backing <u>or</u> the veering on any particular day. The

IPEC00035201

diurnal wind itself, however, is related not only to a primary valley circulation (katabatic-anabatic)

Z-43

IPEC00035202

34.

but a locally induced land-sea breeze. It is the strength of this latter feature that will ultimately determine the backing or veering nature of the diurnal wind during transition hours.

The preceding diurnal analyses indicate that there is small likelihood of a wind persisting in the same direction for as much as 24 hours. The valley structure seems to have a built-in natural mechanism which would prevent such a wind condition from existing particularly at low wind speeds.

5.7 Diurnal Variation of the Mean Wind Speed

Seasonal diurnal variations of mean wind speeds for the various stations are given in Figure 21. The curves indicate that the winter mean speeds are greater than the summer speeds for all the stations throughout the day with both winter and summer maximum speeds occurring between 1300-1500 hours.

5.8 Diurnal Variation of Wind Persistence

The wind persistence is used as a measure of the constancy of a wind direction with time. If a wind always blows from the same direction, the persistence is equal to 1. If the wind is equally likely to blow from all directions or blows half the time from one sector and half the time from the opposite sector, the persistence will be zero.

The seasonal diurnal variation of wind persistence for the various stations is given in Figures 22 and 23. It is clearly evident that the higher persistence values are associated with the winter season. This result is however due to atmospheric conditions which enhance the diffusion, mainly high wind speeds.

Both seasons show a diurnal shift with the summer being more pronounced. Maximum persistence occurs between 04-0600 EST. The times of occurrence of the maximum

IPEC00035203

values of persistence correspond to those times at which the nocturnal downvalley flow is a maximum and the daytime upvalley flow

Z-44

IPEC00035204

35.

reaches its peak. At CC it almost equals the magnitude of the nighttime maximum. The summer minimums occur between 1100-1200 and 1900-2100 which are about the times of the diurnal wind direction transition periods.

5.9 Spatial Variability of Wind Velocity Between Tower Sites

The annual and seasonal spatial variabilities of wind direction and speed between selected stations are presented in Tables 10 through 17.

Table 10. Annual Spatial Variability of Wind Direction Between Indian Point 3 and Trap Rock.

IP3 1970	TR 1970	TR 1970	IP3 1970	IP3 1971	TR 1971	TR 1971	IP3 1971
000.0	354	000.0	012	000.0	358	000.0	008
022.5	010	022.5	025	022.5	017	022.5	024
045.0	024	045.0	041	045.0	033	045.0	043
067.5	048	067.5	070	067.5	047	067.5	065
090.0	078	090.0	094	090.0	076	090.0	091
112.5	107	112.5	126	112.5	104	112.5	118
135.0	129	135.0	154	135.0	134	135.0	146
157.5	147	157.5	171	157.5	154	157.5	167
180.0	168	180.0	188	180.0	177	180.0	182
202.5	190	202.5	206	202.5	200	202.5	199
225.0	212	225.0	224	225.0	224	225.0	219
247.5	239	247.5	256	247.5	250	247.5	244
270.0	270	270.0	285	270.0	277	270.0	271
292.5	295	292.5	301	292.5	296	292.5	293
315.0	308	315.0	321	315.0	313	315.0	318
337.5	330	337.5	353	337.5	333	337.5	346

IPEC00035205

Z-45

IPEC00035206

36.

Table 11. Seasonal Spatial Variability of Wind Direction Between Indian Point 3 and Trap Rock (1970).

IP3 1970 Wntr	TR 1970 Wntr	TR 1970 Wntr	IP3 1970 Wntr	IP3 1970 Smmr	TR 1970 Smmr	TR 1970 Smmr	IP3 1970 Smmr
000.0	358	000.0	008	000.0	350	000.0	016
022.5	013	022.5	019	022.5	008	022.5	030
045.0	029	045.0	034	045.0	022	045.0	047
067.5	059	067.5	066	067.5	043	067.5	072
090.0	085	090.0	080	090.0	074	090.0	100
112.5	116	112.5	120	112.5	103	112.5	129
135.0	138	135.0	146	135.0	126	135.0	155
157.5	158	157.5	166	157.5	145	157.5	173
180.0	176	180.0	184	180.0	166	180.0	190
202.5	194	202.5	201	202.5	188	202.5	209
225.0	216	225.0	219	225.0	210	225.0	228
247.5	244	247.5	252	247.5	233	247.5	261
270.0	275	270.0	281	270.0	261	270.0	290
292.5	299	292.5	298	292.5	284	292.5	306
315.0	310	315.0	315	315.0	306	315.0	330
337.5	335	337.5	346	337.5	325	337.5	359

Table 12. Seasonal Spatial Variability of Wind Direction Between Indian Point 3 and Trap Rock (1971).

IP3	TR	TR	IP3	IP3	TR	TR	IP3
1971	1971	1971	1971	1971	1971	1971	1971

IPEC00035207

Wntr	Wntr	Wntr	Wntr	Smmr	Smmr	Smmr	Smmr
000.0	359	000.0	007	000.0	358	000.0	009
022.5	014	022.5	022	022.5	018	022.5	025
045.0	030	045.0	048	045.0	034	045.0	040
067.5	046	067.5	070	067.5	049	067.5	062
090.0	076	090.0	091	090.0	076	090.0	091
112.5	109	112.5	112	112.5	102	112.5	119
135.0	136	135.0	143	135.0	132	135.0	148
157.5	157	157.5	165	157.5	152	157.5	168
180.0	178	180.0	181	180.0	176	180.0	183
202.5	203	202.5	201	202.5	198	202.5	198
225.0	226	225.0	222	225.0	222	225.0	215
247.5	250	247.5	243	247.5	249	247.5	246
270.0	277	270.0	272	270.0	275	270.0	268
292.5	296	292.5	292	292.5	296	292.5	296
315.0	313	315.0	317	315.0	312	315.0	322
337.5	331	337.5	345	337.5	335	337.5	348

Z-46

IPEC00035208

37.

Table 13. Annual Spatial Variability of Wind Speed (m/s) Between Indian Point 3 and Trap Rock.

IP3 1970	TR 1970	TR 1970	IP3 1970	IP3 1971	TR 1971	TR 1971	IP3 1971
0.25	0.6	0.25	1.0	0.25	0.7	0.25	0.9
0.75	0.9	0.75	1.4	0.75	0.9	0.75	1.1
1.25	1.2	1.25	1.8	1.25	1.3	1.25	1.6
2.0	1.9	2.0	2.5	2.0	2.0	2.0	2.2
3.0	2.8	3.0	3.3	3.0	3.0	3.0	3.1
4.0	3.9	4.0	4.1	4.0	4.0	4.0	4.0
5.0	4.9	5.0	4.9	5.0	5.1	5.0	4.9
7.0	6.8	7.0	6.2	7.0	6.9	7.0	6.5
9.75	9.9	9.75	8.4	9.75	9.7	9.75	9.0

Table 14. Seasonal Spatial Variability of Wind Speed (m/s) Between Indian Point 3 and Trap Rock.

IP3 1970 Wntr	TR 1970 Wntr	TR 1970 Wntr	IP3 1970 Wntr	IP3 1970 Smmr	TR 1970 Smmr	TR 1970 Smmr	IP3 1970 Smmr
0.25	0.5	0.25	0.8	0.25	0.6	0.25	1.1
0.75	0.8	0.75	1.3	0.75	0.9	0.75	1.4
1.25	1.3	1.25	1.8	1.25	1.2	1.25	1.9
2.0	2.0	2.0	2.4	2.0	1.8	2.0	2.6
3.0	3.0	3.0	3.3	3.0	2.8	3.0	3.4
4.0	4.1	4.0	4.1	4.0	3.8	4.0	4.2
5.0	5.1	5.0	5.0	5.0	4.7	5.0	4.8
7.0	7.2	7.0	6.4	7.0	6.4	7.0	6.0
9.75	10.0	9.75	8.5	9.75	9.3	9.75	8.1

IPEC00035209

IP3	TR	TR	IP3	IP3	TR	TR	IP3
1971	1971	1971	1971	1971	1971	1971	1971
Wntr	Wntr	Wntr	Wntr	Summr	Summr	Summr	Summr
0.25	0.6	0.25	1.0	0.25	0.7	0.25	0.7
0.75	0.8	0.75	1.1	0.75	1.0	0.75	1.1
1.25	1.2	1.25	1.7	1.25	1.3	1.25	1.5
2.0	1.9	2.0	2.4	2.0	2.1	2.0	2.2
3.0	2.9	3.0	3.3	3.0	3.0	3.0	3.0
4.0	3.9	4.0	4.2	4.0	4.1	4.0	3.8
5.0	5.1	5.0	5.1	5.0	5.2	5.0	4.6
7.0	6.9	7.0	6.8	7.0	6.8	7.0	6.0
9.75	9.6	9.75	9.1	9.75	9.9	9.75	8.5

IPEC00035210

38.

Table 15. Annual Spatial Variability of Wind Direction and Speed (m/s) Between Montrose Point and Trap Rock.

Wind Direction				Wind Speed			
MP 1970	TR 1970	TR 1970	MP 1970	MP 1970	TR 1970	TR 1970	MP 1970
000.0	351	000.0	018	0.25	0.8	0.25	0.7
022.5	009	022.5	033	0.75	1.2	0.75	1.0
045.0	023	045.0	049	1.25	1.7	1.25	1.4
067.5	035	067.5	069	2.0	2.5	2.0	1.9
090.0	054	090.0	096	3.0	3.7	3.0	2.7
112.5	089	112.5	127	4.0	4.9	4.0	3.4
135.0	135	135.0	150	5.0	5.7	5.0	4.1
157.5	151	157.5	166	7.0	7.4	7.0	5.6
180.0	173	180.0	189	9.75	10.0	9.75	8.0
202.5	191	202.5	207				
225.0	214	225.0	229				
247.5	236	247.5	253				
270.0	269	270.0	277				
292.5	289	292.5	302				
315.0	309	315.0	324				
337.5	323	337.5	356				

Table 16. Annual Spatial Variability of Wind Direction and Speed (m/s) Between Indian Point 3 and Montrose Point.

Wind Direction				Wind Speed			
IP3	MP	MP	IP3	IP3	MP	MP	IP3

IPEC00035211

1970	1970	1970	1970	1970	1970	1970	1970
000.0	011	000.0	358	0.25	0.6	0.25	0.9
022.5	029	022.5	015	0.75	0.8	0.75	1.3
045.0	043	045.0	027	1.25	1.2	1.25	1.8
067.5	067	067.5	040	2.0	1.8	2.0	2.6
090.0	088	090.0	070	3.0	2.6	3.0	3.5
112.5	123	112.5	108	4.0	3.5	4.0	4.5
135.0	142	135.0	153	5.0	4.4	5.0	5.3
157.5	158	157.5	167	7.0	6.2	7.0	6.9
180.0	175	180.0	183	9.75	9.1	9.75	9.1
202.5	198	202.5	198				
225.0	216	225.0	220				
247.5	238	247.5	244				
270.0	272	270.0	275				
292.5	304	292.5	297				
315.0	320	315.0	315				
337.5	338	337.5	330				

IPEC00035212

39.

Table 17. Summer (1970) Spatial Variability of Wind Direction and Speed (m/s) Between Cape Charles and Indian Point 3.

CC 1970 Smmr	IP3 1970 Smmr	IP3 1970 Smmr	CC 1970 Smmr	CC 1970 Smmr	IP3 1970 Smmr	IP3 1970 Smmr	CC 1970 Smmr
000.0	001	000.0	007	0.25	0.9	0.25	1.1
022.5	017	022.5	022	0.75	1.1	0.75	1.4
045.0	031	045.0	028	1.25	1.5	1.25	1.9
067.5	049	067.5	044	2.0	1.8	2.0	2.5
090.0	088	090.0	069	3.0	2.5	3.0	3.4
112.5	102	112.5	107	4.0	3.4	4.0	4.5
135.0	122	135.0	153	5.0	4.4	5.0	5.3
157.5	146	157.5	187	7.0	5.4	7.0	6.0
180.0	163	180.0	212	9.75	7.2	9.75	7.3
202.5	180	202.5	221				
225.0	196	225.0	234				
247.5	216	247.5	247				
270.0	285	270.0	268				
292.5	301	292.5	286				
315.0	321	315.0	317				
337.5	346	337.5	355				

The station listed first in each tabular set is the independent variable. When the role of independent and dependent stations are reversed, the relationships between the mean values are not, a priori, similarly inverted. This discrepancy may be attributed, in part, to the effects of local topography as well as to a reaction time lag engendered by the spatial distance between stations.

IPEC00035213

The significance of any degree of change in magnitude of speed or wind direciton angle between stations are arbitrary. An angular change of $ 6 10° and speed change of $ 6 0.5 m/s may be considered.

The spatial variability analysis indicated:

1) A general backing of wind direction between IP3 and TR, with TR having a lower speed at the low range and a higher speed at the high range. Seasonal analysis showed the greatest variations occurring during the "summer" months.

Z-49

IPEC00035214

40.

2) A general backing of wind direction between MP and TR with speeds being greater at TR.

3) Based on the comparable data available (1970), the wind directions at IP3 and MP were similar to each other and in the relationship to TR. The magnitude of the wind speeds were similar at IP3 and TR, with each being generally stronger than at MP.

IPEC00035215

41.

References

Halitsky, J., J. Laznow and D. Leahey (1970): Wind Observations at Indian Point, Montrose and Bowline Point. 31 August 1968 to 30 June 1969. New York University, Department of Meteorology and Oceanography Technical Report TR-70-3.

Halitsky, J., E. J. Kaplin and J. Laznow (1971): Wind Observations at Indian Point 26 November 1969-1 October 1970. New York University Department of Meteorology and Oceanography Technical Report TR-71-3.

Leahey, D. M. and J. Halitsky (1971): Low Wind Speed Turbulence Statistics and Related Diffusion Estimates for Indian Point, N.Y. New York University Department of Meteorology and Oceanography Technical Report TR-71-10.

FSAR: Final Facility Description and Safety Analysis Report. Consolidated Edison Company of New York, Inc. Nuclear Generating Unit No. 2. Exhibit B-8.

Davidson, B. and J. Halitsky (1955): A Micrometeorological Survey of the Buchanan, New York Area, Summary of Program to 1 December 1955. New York University Department of Meteorology and Oceanography Technical Report 372.1.

Davidson, B. and J. Halitsky (1957): Evaluation of Potential Radiation Hazard Resulting from Assumed Release of Radioactive Wastes to Atmosphere from Proposed Buchanan Nuclear Power Plant. New York University Department of Meteorology and Oceanography Technical Report 372.3.

U. S. Atomic Energy Commission Safety Guide 23 – Onsite Meteorological Programs, February 17, 1972.

IPEC00035216

65.

Appendix Table 1. Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category A – January 1, 1970-December 31, 1970.

Wind Direction		Wind Speed (mph) 01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0010	.0086	.0097	.0025	.0002	.0000	.0001	.0222
12- 33	NNE	.0008	.0059	.0031	.0010	.0000	.0000	.0001	.0110
34- 56	NE	.0015	.0041	.0008	.0005	.0001	.0000	.0001	.0071
57- 78	ENE	.0005	0006	.0000	.0003	.0002	0000	.0000	.0016
79-101	E	.0003	.0005	.0002	.0002	.0000	0000	.0000	.0013
102-123	ESE	.0005	.0005	.0003	.0002	.0000	.0000	.0000	.0015
124-146	SE	.0013	.0010	.0010	.0016	.0002	.0000	.0000	.0051
147-168	SSE	.0016	.0074	.0109	.0078	.0003	.0000	.0000	.0280
169-191	S	.0016	.0122	.0081	.0015	.0000	0000	.0000	.0234
192-213	SSW	.0010	.0071	.0033	.0002	.0000	.0000	.0001	.0118
214-236	SW	.0009	.0034	.0016	.0006	.0000	0000	.0000	.0065
237-258	WSW	.0010	.0010	.0011	.0002	.0000	.0000	.0001	.0035
259-281	W	.0009	.0022	.0030	.0013	.0007	.0001	.0001	.0082
282-303	WNW	.0005	.0014	.0031	.0053	.0024	.0008	.0010	.0144
304-326	NW	.0005	.0016	.0042	.0054	.0035	.0007	.0005	.0163
327-348	NNW	.0007	.0039	.0049	.0041	.0011	.0001	.0000	.0149
Calm			.0000						.0000
Miss			0000	.0000	.0000	.0000	.0000	.0000	.0022
Total		.0145	.0614	.0554	.0327	.0089	.0017.	0043.	1790

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category B – January 1, 1970-December 31, 1970.

Wind Direction		Wind Speed (mph) 01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0002	.0007	.0006	.0001	.0000	.0000	.0000	.0016
12- 33	NNE	.0001	.0009	.0006	.0000	.0000	.0000	.0000	.0016
34- 56	NE	.0005	.0008	.0002	.0000	.0000	0000	.0000	.0015
57- 78	ENE	.0001	.0003	.0000	.0000	.0000	0000	.0001	.0006
79-101	E	.0002	.0000	.0000	.0000	.0000	0000	.0000	.0002
102-123	ESE	.0003	.0007	.0000	.0000	.0000	0000	.0000	.0010
124-146	SE	.0000	.0003	.0001	.0000	.0000	.0000	.0000	.0005
147-168	SSE	.0001	.0002	.0008	.0008	.0001	.0000	.0000	.0021
169-191	S	.0003	.0010	.0005	.0005	.0000	0000	.0000	.0023
192-213	SSW	.0000	.0005	.0003	.0002	.0000	0000	.0000	.0010
214-236	SW	.0002	.0001	.0000	.0000	.0000	0000	.0000	.0003
237-258	WSW	.0007	.0002	.0000	.0001	.0000	.0000	.0000	.0010
259-281	W	.0000	.0000	.0002	.0001	.0000	.0000	.0000	.0003
282-303	WNW	.0001	.0000	.0001	.0003	.0003	.0001	.0000	.0010
304-326	NW	.0001	.0001	.0007	.0007	.0003	.0003	.0000	.0023

IPEC00035217

IPEC00035217

327-348	NNW	.0000	.0001	.0005	.0001	.0000	.0001	.0000	.0008
Calm			.0000						.0000
Miss			.0000	.0000	.0000	.0000	.0000	.0000	.0000
Total		.0031	.0061	.0046	.0030	.0008	.0006	.0001	.0182

Z-75

66.

Appendix Table 1 (continued)

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category C – January 1, 1970-December 31, 1970

Wind Direction		Wind Speed (mph)							
		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0000	.0007	.0008	.0006	.0000	.0000	.0000	.0021
12- 33	NNE	.0001	.0008	.0009	.0003	.0001	.0000	.0000	.0023
34- 56	NE	.0002	.0006	.0003	.0001	.0000	.0000	.0000	.0013
57- 78	ENE	.0002	.0000	.0003	.0000	.0000	.0000	.0000	.0006
79-101	E	.0001	.0001	.0000	.0001	.0000	.0000	.0000	.0003
102-123	ESE	.0000	.0001	.0000	.0000	.0000	.0000	.0000	.0001
124-146	SE	.0002	.0005	.0006	.0001	.0000	.0000	.0000	.0014
147-168	SSE	.0002	.0013	.0018	.0008	.0000	.0000	.0000	.0041
169-191	S	.0002	.0014	.0008	.0001	.0000	.0000	.0000	.0025
192-213	SSW	.0001	.0005	.0003	.0001	.0000	.0000	.0000	.0010
214-236	SW	.0003	.0005	.0002	.0003	.0000	.0000	.0000	.0014
237-258	WSW	.0001	.0000	.0001	.0003	.0000	.0000	.0000	.0006
259-281	W	.0000	.0002	.0003	.0008	.0001	.0000	.0000	.0015
282-303	WNW	.0003	.0005	.0002	.0015	.0010	.0005	.0000	.0040
304-326	NW	.0000	.0000	.0001	.0001	.0010	.0006	.0000	.0018
327-348	NNW	.0003	.0005	.0005	.0007	.0006	.0000	.0000	.0025
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0000	.0002	.0001		.0006
Total		.0026	.0074	.0074	.0061	.0031	.0011	.0002	.0280

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category D - January 1, 1970-December 31, 1970.

Wind Direction		Wind Speed (mph)							
		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0024	.0143	.0173	.0051	.0007	.0001	.0014	.0413
12- 33	NNE	.0042	.0178	.0122	.0029	.0006	.0001	.0014	.0392
34- 56	NE	.0031	.0078	.0026	.0003	.0003	.0000	.0006	.0147
57- 78	ENE	.0022	.0016	.0001	.0001	.0000	.0000	.0006	.0046
79-101	E	.0021	.0021	.0009	.0000	.0000	.0000	.0002	.0053
102-123	ESE	.0026	.0016	.0011	.0002	.0000	.0000	.0003	.0059
124-146	SE	.0025	.0053	.0038	.0003	.0002	.0000	.0001	.0122
147-168	SSE	.0023	.0110	.0098	.0032	.0000	.0000	.0003	.0266
169-191	S	.0025	.0098	.0053	.0010	.0000	.0000	.0003	.0190

IPEC00035218

192-213	SSW	.0030	.0038	.0021	.0008	.0000	.0000	.0000	.0096
214-236	SW	.0023	.0017	.0009	.0006	.0001	.0000	.0003	.0059
237-258	WSW	.0008	.0016	.0007	.0008	.0000	.0000	.0000	.0039
259-281	W	.0011	.0019	.0019	.0016	.0008	.0001	.0006	.0081
282-303	WNW	.0011	.0010	.0051	.0095	.0062	.0011	.0001	.0242
304-326	NW	.0010	.0019	.0061	.0109	.0074	.0026	.0000	.0300
327-348	NNW	.0009	.0054	.0069	.0079	.0022	.0002	.0002	.0237
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0001	.0005	.0000		.0010
Total		.0342	.0886	.0768	.0454	.0190	.0043	.0070	.2753

Z-76

IPEC00035219

67.

Appendix Table 1 (continued)

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category E – January 1, 1970-December 31, 1970.

Wind Direction		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0045	.0067	.0043	.0014	.0001	.0000	.0002	.0173
12- 33	NNE	.0045	.0166	.0080	.0005	.0003	.0000	.0006	.0304
34- 56	NE	.0030	.0078	.0019	.0001	.0001	.0000	.0008	.0137
57- 78	ENE	.0023	.0018	.0003	.0000	.0000	.0000	.0000	.0045
79-101	E	.0011	.0023	.0011	.0001	.0001	.0000	.0000	.0048
102-123	ESE	.0014	.0029	.0016	.0001	.0000	.0000	.0001	.0061
124-146	SE	.0027	.0035	.0017	.0001	.0003	.0000	.0001	.0086
147-168	SSE	.0022	.0053	.0041	.0016	.0005	.0002	.0000	.0138
169-191	S	.0017	.0062	.0043	.0003	.0002	.0003	.0001	.0133
192-213	SSW	.0027	.0063	.0045	.0005	.0000	.0000	.0000	.0139
214-236	SW	.0024	.0045	.0024	.0006	.0001	.0001	.0000	.0101
237-258	WSW	.0019	.0027	.0016	.0008	.0007	.0002	.0000	.0080
259-281	W	.0015	.0015	.0034	.0014	.0008	.0005	.0000	.0090
282-303	WNW	.0010	.0006	.0038	.0054	.0041	.0014	.0000	.0162
304-326	NW	.0008	.0017	.0054	.0071	.0016	.0005	.0001	.0171
327-348	NNW	.0017	.0034	.0046	.0027	.0001	.0000	.0001	.0127
Calm		.0000							.0000
Miss		.0005	.0007	.0009	.0007	.0010	.0000		.0048
Total		.0359	.0744	.0541	.0233	.0102	.0032	.0032	.2043

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category F – January 1, 1970-December 31, 1970

Wind Direction		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0047	.0022	.0008	.0001	.0000	.0000	.0000	.0078
12- 33	NNE	.0030	.0075	.0022	.0000	.0000	.0000	.0000	.0127
34- 56	NE	.0034	.0042	.0009	.0000	.0000	.0000	.0005	.0090
57- 78	ENE	.0015	.0011	.0001	.0000	.0000	.0000	.0000	.0027
79-101	E	.0011	.0005	.0000	.0000	.0000	.0000	.0000	.0016
102-123	ESE	.0010	.0006	.0000	.0000	.0000	.0000	.0000	.0016
124-146	SE	.0009	.0006	.0000	.0000	.0000	.0000	.0000	.0015
147-168	SSE	.0023	.0027	.0005	.0001	.0002	.0000	.0000	.0058
169-191	S	.0016	.0035	.0009	.0000	.0000	.0000	.0000	.0061
192-213	SSW	.0013	.0032	.0008	.0000	.0000	.0000	.0000	.0053
214-236	SW	.0024	.0040	.0006	.0000	.0000	.0000	.0001	.0071
237-258	WSW	.0018	.0009	.0009	.0000	.0000	.0000	.0001	.0038
259-281	W	.0011	.0003	.0003	.0000	.0003	.0000	.0001	.0023
282-303	WNW	.0007	.0002	.0003	.0002	.0001	.0001	.0000	.0017
304-326	NW	.0011	.0002	.0001	.0000	.0002	.0000	.0000	.0017

IPEC00035220

327-348	NNW	.0013	.0007	.0003	.0002	.0000	.0000	.0000	.0025
Calm		.0000							.0000
Miss		.0007	.0001	.0000	.0000	.0000	.0000		.0013
Total		.0300	.0327	.0088	.0007	.0009	.0001	.0013	.0744

68.

Appendix Table 1 (Continued)

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category C – January 1, 1970-December 31, 1970.

Wind Direction		Wind Speed (mph) 01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0019	.0010	.0003	.0000	.0000	.0000	.0000	.0033
12- 33	NNE	.0018	.0037	.0008	.0000	.0000	.0000	.0001	.0064
34- 56	NE	.0030	.0021	.0000	.0000	.0000	.0000	.0000	.0050
57- 78	ENE	.0018	.0006	.0000	.0000	.0000	.0000	.0000	.0024
79-101	E	.0008	.0003	.0000	.0000	.0000	.0000	.0000	.0011
102-123	ESE	.0006	.0002	.0000	.0000	.0000	.0000	.0000	.0008
124-146	SE	.0014	.0007	.0000	.0000	.0000	.0000	.0000	.0021
147-168	SSE	.0013	.0014	.0002	.0000	.0000	.0000	.0000	.0029
169-191	S	.0009	.0015	.0005	.0000	.0000	.0000	.0000	.0029
192-213	SSW	.0024	.0024	.0003	.0000	.0000	.0000	.0002	.0054
214-236	SW	.0019	.0013	.0002	.0000	.0000	.0000	.0001	.0035
237-258	WSW	.0015	.0006	.0003	.0000	.0000	.0000	.0001	.0025
259-281	W	.0018	.0005	.0000	.0000	.0000	.0000	.0000	.0023
282-303	WNW	.0015	.0002	.0000	.0000	.0000	.0000	.0000	.0017
304-326	NW	.0011	.0000	.0000	.0000	.0000	.0000	.0000	.0011
327-348	NNW	.0015	.0005	.0001	.0001	.0000	.0000	.0000	.0022
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0000	.0000	.0000		.0008
Total		.0253	.0168	.0029	.0001	.0000	.0000	.0014	.0464

IPEC00035221

69.

Appendix Table 2. Indian Point B(3) Point Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category A - January 1, 1971-December 31, 1971

Wind Direction		Wind Speed (mph)							
		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0006	.0054	.0057	.0021	.0011	.0000	.0001	.0150
12- 33	NNE	.0003	.0043	.0018	.0005	.0000	.0000	.0000	.0070
34- 56	NE	.0008	.0011	.0002	.0000	.0000	.0000	.0000	.0022
57- 78	ENE	.0001	.0008	.0000	.0000	.0000	.0000	.0000	.0009
79-101	E	.0000	.0000	.0002	.0000	.0000	.0000	.0000	.0002
102-123	ESE	.0001	.0005	.0005	.0001	.0000	.0000	.0000	.0011
124-146	SE	.0002	.0005	.0018	.0016	.0001	.0000	.0000	.0042
147-168	SSE	.0006	.0050	.0065	.0015	.0003	.0000	.0000	.0140
169-191	S	.0005	.0062	.0041	.0007	.0000	.0000	.0000	.0114
192-213	SSW	.0003	.0029	.0014	.0006	.0000	.0000	.0000	.0051
214-236	SW	.0003	.0015	.0007	.0005	.0000	.0000	.0000	.0030
237-258	WSW	.0003	.0018	.0011	.0024	.0009	.0003	.0000	.0070
259-281	W	.0003	.0009	.0039	.0022	.0017	.0002	.0000	.0093
282-303	WNW	.0008	.0008	.0042	.0050	.0027	.0009	.0000	.0145
304-326	NW	.0005	.0016	.0031	.0046	.0035	.0006	.0000	.0138
327-348	NNW	.0003	.0033	.0046	.0039	.0007	.0001	.0000	.0129
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0000	.0000	.0000		.0002
Total		.0062	.0366	.0399	.0255	.0112	.0022	.0003	.1219

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category B – January 1, 1971-December 31, 1971.

Wind Direction		Wind Speed (mph)							
		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0000	.0013	.0009	.0001	.0000	.0000	.0000	.0023
12- 33	NNE	.0000	.0008	.0000	.0000	.0000	.0000	.0000	.0008
34- 56	NE	.0002	.0001	.0001	.0000	.0000	.0000	.0000	.0005
57- 78	ENE	.0002	.0000	.0000	.0000	.0000	.0000	.0000	.0002
79-101	E	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
102-123	ESE	.0000	.0001	.0001	.0001	.0000	.0000	.0000	.0003
124-146	SE	.0000	.0001	.0003	.0002	.0000	.0000	.0000	.0007
147-168	SSE	.0002	.0008	.0014	.0001	.0001	.0000	.0000	.0026
169-191	S	.0002	.0009	.0000	.0000	.0000	.0000	.0000	.0011
192-213	SSW	.0003	.0008	.0002	.0001	.0000	.0000	.0000	.0015
214-236	SW	.0001	.0001	.0002	.0001	.0000	.0000	.0000	.0006
237-258	WSW	.0001	.0002	.0000	.0002	.0001	.0001.	0000	.0007
259-281	W	.0000	.0002	.0005	.0000	.0002	.0001	.0000	.0010
282-303	WNW	.0000	.0001	.0005	.0010	.0003	.0000	.0000	.0019
304-326	NW	.0005	.0002	.0003	.0006	.0003	.0001	.0000	.0021
327-348	NNW	.0000	.0003	.0002	.0006	.0000	.0000	.0000	.0011
Calm		.0000							.0000

IPEC00035222

Miss	.0000	.0000	.0000	.0000	.0000	.0000		.0000
Total	.0018	.0062	.0048	.0032	.0011	.0003	.0000	.0175

Z-79

70.

Appendix Table 2 (continued)

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category C – January 1, 1971- December 31, 1971.

Wind Direction		Wind Speed (mph) 01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0003	.0014	.0006	.0002	.0000	.0000	.0000	.0025
12- 33	NNE	.0001	.0006	.0006	.0001	.0000	.0000	.0001	.0015
34- 56	NE	.0001	.0003	.0001	.0000	.0000	.0000	.0000	.0006
57- 78	ENE	.0000	.0000	.0001	.0000	.0000	.0000	.0000	.0001
79-101	E	.0001	.0002	.0001	.0000	.0000	.0000	.0000	.0005
102-123	ESE	.0003	.0001	.0002	.0000	.0000	.0000	.0000	.0007
124-146	SE	.0001	.0003	.0005	.0000	.0000	.0000	.0000	.0009
147-168	SSE	.0001	.0006	.0003	.0002	.0000	.0000	.0000	.0013
169-191	S	.0005	.0011	.0005	.0002	.0000	.0000	.0000	.0023
192-213	SSW	.0000	.0005	.0001	.0000	.0000	.0000	.0000	.0006
214-236	SW	.0003	.0001	.0001	.0001	.0001	.0000	.0000	.0008
237-258	WSW	.0001	.0001	.0003	.0001	.0002	.0001	.0000	.0010
259-281	W	.0001	.0001	.0003	.0003	.0001	.0000	.0000	.0010
282-303	WNW	.0001	.0001	.0006	.0010	.0000	.0001	.0000	.0019
304-326	NW	.0003	.0002	.0002	.0005	.0003	.0000	.0000	.0016
327-348	NNW	.0000	.0007	.0007	.0001	.0001	.0000	.0000	.0016
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0000	.0000	.0000		.0000
Total		.0027	.0065	.0054	.0030	.0009	.0002	.0001	.0180

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category D – January 1, 1971- December 31, 1971.

Wind Direction		Wind Speed (mph) 01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0014	.0079	.0067	.0034	.0005	.0000	.0001	.0200
12- 33	NNE	.0023	.0066	.0050	.0015	.0000	.0000	.0000	.0154
34- 56	NE	.0029	.0026	.0014	.0005	.0000	.0000	.0001	.0074
57- 78	ENE	.0010	.0011	.0018	.0003	.0000	.0000	.0000	.0043
79-101	E	.0015	.0008	.0011	.0000	.0000	.0000	.0000	.0034
102-123	ESE	.0011	.0015	.0002	.0000	.0000	.0000	.0000	.0029
124-146	SE	.0013	.0026	.0026	.0008	.0001	.0000	.0000	.0074
147-168	SSE	.0013	.0040	.0065	.0014	.0001	.0000	.0000	.0133
169-191	S	.0015	.0030	.0014	.0009	.0001	.0000	.0000	.0069
192-213	SSW	.0009	.0017	.0018	.0006	.0000	.0001	.0000	.0051

IPEC00035223

214-236	SW	.0017	.0013	.0013	.0019	.0001	.0001	.0000	.0064
237-258	WSW	.0008	.0010	.0026	.0018	.0008	.0002	.0000	.0073
259-281	W	.0005	.0005	.0024	.0041	.0023	.0001	.0000	.0098
282-303	WNW	.0008	.0002	.0056	.0051	.0024	.0010	.0003	.0156
304-326	NW	.0009	.0002	.0031	.0055	.0014	.0000	.0001	.0112
327-348	NNW	.0003	.0010	.0039	.0019	.0008	.0001	.0001	.0082
Calm			.0000						.0000
Miss			.0000	.0000	.0000	.0000	.0000	.0000	.0001
Total		.0201	.0361	.0476	.0298	.0086	.0017	.0009	.1449

Z-80

71.

Appendix Table 2 (continued)

Indian Point B (3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category E – January 1, 1971-December 31, 1971.

Wind Direction		Wind Speed (mph)							
		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0027	.0072	.0094	.0037	.0013	.009	.0001	.0253
12- 33	NNE	.0029	.0144	.0129	.0019	.0002	.0000	.0000	.0324
34- 56	NE	.0035	.0063	.0019	.0001	.0001	.0000	.0010	.0130
57- 78	ENE	.0021	.0021	.0014	.0000	.0000	.0000	.0002	.0057
79-101	E	.0016	.0021	.0001	.0000	.0000	.0000	.0000	.0038
102-123	ESE	.0015	.0034	.0006	.0000	.0000	.0000	.0000	.0055
124-146	SE	.0019	.0063	.0024	.0002	.0000	.0000	.0000	.0109
147-168	SSE	.0016	.0061	.0058	.0009	.0000	.0000	.0000	.0144
169-191	S	.0019	.0058	.0038	.0009	.0001	.0000	.0000	.0126
192-213	SSW	.0016	.0034	.0031	.0005	.0002	.0000	.0000	.0088
214-236	SW	.0010	.0013	.0015	.0008	.0002	.0000	.0000	.0048
237-258	WSW	.0017	.0014	.0026	.0014	.0005	.0002	.0000	.0078
259-281	W	.0006	.0015	.0050	.0025	.0009	.0001	.0000	.0106
282-303	WNW	.0006	.0015	.0051	.0051	.0024	.0006	.0010	.0164
304-326	NW	.0005	.0010	.0063	.0054	.0013	.0003	.0001	.0149
327-348	NNW	.0008	.0016	.0035	.0030	.0006	.0001	.0000	.0096
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0000	.0000	.0000		.0000
Total		.0265	.0653	.0655	.0264	.0078	.0023	.0025	.1963

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category F – January 1, 1971-December 31, 1971.

Wind Direction		Wind Speed (mph)							
		01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0019	.0042	.0015	.0001	.0000	.0000	.0000	.0078
12- 33	NNE	.0026	.0113	.0029	.0000	.0000	.0000	.0000	.0168
34- 56	NE	.0024	.0046	.0008	.0000	.0000	.0000	.0000	.0078
57- 78	ENE	.0010	.0009	.0000	.0000	.0000	.0000	.0000	.0019

IPEC00035224

79-101	E	.0008	.0003	.0001	.0000	.0000	.0000	.0000	.0013
102-123	ESE	.0011	.0005	.0000	.0000	.0000	.0000	.0000	.0016
124-146	SE	.0010	.0023	.0000	.0000	.0000	.0000	.0000	.0033
147-168	SSE	.0013	.0024	.0005	.0001	.0000	.0000	.0000	.0042
169-191	S	.0014	.0040	.0002	.0001	.0000	.0000	.0000	.0057
192-213	SSW	.0016	.0030	.0006	.0001	.0000	.0000	.0000	.0053
214-236	SW	.0008	.0023	.0005	.0008	.0000	.0000	.0000	.0043
237-258	WSW	.0010	.0016	.0007	.0001	.0002	.0000	.0000	.0037
259-281	W	.0007	.0011	.0008	.0001	.0000	.0000	.0000	.0027
282-303	WNW	.0013	.0005	.0007	.0005	.0001	.0000	.0000	.0030
304-326	NW	.0006	.0008	.0003	.0000	.0000	.0001	.0000	.0018
327-348	NNW	.0010	.0014	.0006	.0001	.0000	.0000	.0000	.0031
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0000	.0000	.0000		.0000
Total		.0206	.0412	.0101	.0021	.0003	.0001	.0000	.0743

72.

Appendix Table 2 (continued)

Indian Point B(3) Joint Frequency Distribution of Wind Speed and Direction for Pasquill Stability Category G – January 1, 1971- December 31, 1971.

Wind Direction		Wind Speed (mph) 01-03	04-07	08-12	13-18	19-24	>24	Miss	Total
349- 11	N	.0031	.0034	.0005	.0000	.0000	.0000	.0000	.0070
12- 33	NNE	.0027	.0064	.0008	.0000	.0000	.0000	.0000	.0099
34- 56	NE	.0031	.0026	.0000	.0000	.0000	.0000	.0000	.0057
57- 78	ENE	.0019	.0003	.0000	.0000	.0000	.0000	.0000	.0023
79-101	E	.0009	.0006	.0000	.0000	.0000	.0000	.0000	.0015
102-123	ESE	.0009	.0001	.0000	.0000	.0000	.0000	.0000	.0010
124-146	SE	.0013	.0005	.0000	.0001	.0000	.0000	.0000	.0018
147-168	SSE	.0016	.0019	.0002	.0001	.0000	.0000	.0000	.0039
169-191	S	.0024	.0030	.0000	.0000	.0000	.0000	.0000	.0054
192-213	SSW	.0027	.0027	.0000	.0000	.0000	.0000	.0000	.0055
214-236	SW	.0022	.0016	.0003	.0000	.0000	.0000	.0000	.0041
237-258	WSW	.0019	.0013	.0002	.0001	.0000	.0000	.0000	.0035
259-281	W	.0021	.0007	.0002	.0000	.0000	.0000	.0000	.0030
282-303	WNW	.0014	.0002	.0002	.0000	.0000	.0000	.0000	.0018
304-326	NW	.0013	.0007	.0000	.0000	.0000	.0000	.0000	.0019
327-348	NNW	.0022	.0011	.0002	.0000	.0000	.0000	.0000	.0035
Calm		.0000							.0000
Miss		.0000	.0000	.0000	.0000	.0000	.0000		.0000
Total		.0317	.0272	.0027	.0003	.0000	.0000	.0000	.0620

IPEC00035225

CHAPTER 3

REACTOR

3.1 DESIGN BASIS

3.1.1 Performance Objectives

The reactor thermal power analyzed is 3216 MWt.

The fuel rod cladding was designed to maintain its integrity for the anticipated fuel assembly life. The effects of gas release, fuel dimensional changes, and corrosion-induced and irradiation-induced changes in the mechanical properties of cladding were considered in the design of the fuel assemblies.

Rod Control Clusters are employed to provide sufficient reactivity control to terminate any credible power transient prior to reaching the design minimum departure from nucleate boiling ratio (DNBR) of the applicable limit. This is accomplished by ensuring sufficient control cluster worth to shut the reactor down by at least 1.3% in the hot condition with the most reactive control cluster stuck in the fully withdrawn position.

Redundant equipment is provided to add soluble poison to the reactor coolant in the form of boric acid to maintain shutdown margin when the reactor is cooled to ambient temperatures.

In addition, the control rod worth in conjunction with the boric acid injection from the refueling water storage tank (RWST) is sufficient to prevent an unacceptable return to power level as a result of the maximum credible steam line break (one safety valve stuck fully open) even assuming that the most reactive control rod is fully withdrawn.

With the BIT functionally eliminated, the return to power following a credible steamline break accident has been evaluated showing that the event is bounded by the hypothetical steamline break. The departure from nucleate boiling (DNB) design basis is met with no consequential fuel failures predicted, and assuring that the return to power remains within the limits established for the protection of the health and safety of the public, with margin.

Plant specific analyses performed by Westinghouse for Indian point Unit 3, have shown that the Boron Injection Tank (BIT) may be bypassed, eliminated, or the concentration of its contents reduced, while continuing to meet applicable safety criteria.

The functional elimination of the BIT replaces the concentrated boric acid contained therein, with water from the Refueling Water Storage Tank (RWST); this obviates the need to maintain the BIT and its associated piping at elevated temperatures.

The lowering of the minimum required boric acid concentration in the BIT:

1) reduces the potential for degradation of carbon steel components and supports as a result of leakage;

2) eliminates the need to maintain recirculation of boric acid through BIT;

3) eliminates the need to maintain the BIT heaters and heat tracing on the associated SIS piping and recirculation lines; and

IPEC00035226

4) eliminates the need for periodic checks of BIT concentration thereby reducing radiation exposure of plant personnel.

5) Eliminates the need to maintain closed the BIT inlet and outlet isolation valves.

Experimental measurements from critical experiments or operating reactors, or both, were used to validate the methods employed in the design. During design, nuclear parameters were calculated for every phase of operation of the first core and reload cycles and, where applicable, were compared with design limits to show that an adequate margin of safety existed. In the thermal hydraulic design of the core, the maximum fuel and clad temperatures during normal reactor operation and at overpower conditions were conservatively evaluated and found to be consistent with safe operating limitations.

3.1.2 Principal Design Criteria

The General Design Criteria presented and discussed in this section are those which were in effect at the time when Indian Point 3 was designed and constructed. These general design criteria, which formed the bases for the Indian Point 3 design, were published by the Atomic Energy Commission in the Federal Register of July 11, 1967, and subsequently made a part of 10 CFR 50.

A study of compliance with 10 CFR Parts 20 and 50 in accordance with some of the provisions of the Commission's Confirmatory Order of February 11, 1980 has been completed. The detailed results of the evaluation of compliance of Indian Point 3 with the General Design Criteria presently established by the Nuclear Regulatory Commission (NRC) in 10 CFR 50 Appendix A, were submitted to the NRC on August 11, 1980, and approved by the Commission on January 19, 1982. These results are presented in Section 1.3.

Reactor Core Design

Criterion 6: The reactor with its related controls and protection systems shall be designed to function throughout its design lifetime without exceeding acceptable fuel damage limits which have been stipulated and justified. The core and related auxiliary system designs shall provide this integrity under all expected conditions of normal operation with appropriate margins for uncertainties and for specified transient situations which can be anticipated.

The reactor core, with its related control and protection system, was designed to function throughout its design lifetime without exceeding acceptable fuel damage limits. The core design, together with reliable process and decay heat removal systems, provide for this capability under all expected conditions of normal operation with appropriate margins for uncertainties and anticipated transient situations, including the effects of the loss of reactor coolant flow (Section 14.1.6), trip of the turbine generator (Section 14.1.8), loss of normal feedwater (Section 14.1.9) and loss of all offsite power (Section 14.1.12).

The Reactor Control and Protection System was designed to actuate a reactor trip for any anticipated combination of plant conditions, when necessary, to ensure a minimum Departure from Nucleate Boiling (DNB) ratio equal to or greater than the applicable limit.

The integrity of fuel cladding is ensured by preventing excessive clad heating and excessive cladding stress and strain. This is achieved by designing the fuel rods so that the following

IPEC00035227

conservative limits are not exceeded during normal operation or any anticipated transient condition:

1) Minimum DNB ratio equal to or greater than the applicable limit

2) Fuel center temperature below 4700° F

3) The internal gas pressure of the lead rod in the reactor is limited to a value below that which would cause (1) the diametral gap to increase due to outward clad creep during steady-state operation, and (2) extensive DNB propagation to occur

4) Clad stresses less than the Zircaloy or ZIRLO™ yield strength

5) Clad strain less than 1%

The ability of fuel designed and operated to these criteria to withstand postulated normal and abnormal service conditions is shown by the analyses described in Chapter 14 to satisfy the demands of plant operation well within applicable regulatory limits.

The reactor coolant pumps provided for the plant are supplied with sufficient rotational inertia to maintain an adequate flow coastdown and prevent core damage in the event of a simultaneous loss of power to all pumps.

In the unlikely event of a turbine trip from full power without an immediate reactor trip, the subsequent reactor coolant temperature increase and volume insurge to the pressurizer results in a high pressurizer pressure trip and thereby prevents fuel damage for this transient. A loss of external electrical load of 50% of full power or less is normally controlled by rod cluster insertion together with a controlled stream dump to the condenser to prevent a large temperature and pressure increase in the Reactor Coolant System and thus prevent a reactor trip. In this case, the overpower-overtemperature protection would guard against any combination of pressure, temperature, and power which could result in a DNB ratio less than the applicable limit during the transient.

In neither the turbine trip nor the loss-of-flow events do the changes in coolant conditions provoke a nuclear power excursion because of the large system thermal inertia and relatively small void fraction. Protection circuits actuated directly by the coolant conditions identified with core limits are therefore effective in preventing core damage.

Suppression of Reactor Power Oscillations

Criterion 7: The design of the reactor core with its related controls and protection systems shall ensure that power oscillations, the magnitude of which could cause damage in excess of acceptable fuel damage limits, are not possible or can be readily suppressed.

The potential for possible spatial oscillations of power distribution for this core has been reviewed. It was concluded that low frequency xenon oscillations may occur in the axial dimension, and the control rods can suppress these oscillations. The core is expected to be stable to xenon oscillations in the X-Y dimension. Excore instrumentation is provided to obtain necessary information concerning power distribution. This instrumentation is adequate to enable the operator to monitor and control xenon induced oscillations. (In-core instrumentation is used to periodically calibrate and verify the information provided by the Excore

IPEC00035228

instrumentation.) The analysis, detection and control of these oscillations is discussed in Reference 2 of Section 3.2.

Redundancy of Reactivity Control

Criterion 27: Two independent reactivity control systems, preferably of different principles, shall be provided.

Two independent reactivity control systems are provided, one involving rod cluster control (RCC) assemblies and the other involving chemical shimming.

Reactivity Hot Shutdown Capability

Criterion 28: The reactivity control systems provided shall be capable of making and holding the core subcritical from any hot standby or hot operating condition.

The reactivity control systems provided are capable of making and holding the core subcritical from any hot standby or hot operating condition, including those resulting from power changes.

The Rod Cluster Control (RCC) assemblies are divided into two categories comprising control banks, and shutdown banks. The control banks used in combination with chemical shim control provide control of the reactivity changes of the core throughout the life of the core during power operation. These banks of RCC assemblies are used to compensate for short term reactivity changes at power that might be produced due to variations in reactor power level or in coolant temperature. The chemical shim control is used to compensate for the more slowly occurring changes in reactivity throughout core life such as those due to fuel depletion and fission product buildup.

Reactivity Shutdown Capability

Criterion 29: One of the reactivity control systems provided shall be capable of making the core subcritical under any anticipated operating condition including anticipated operational transients sufficiently fast to prevent exceeding acceptable fuel damage limits. Shutdown margin should assure subcriticality with the most reactive control rod fully withdrawn.

The reactor core, together with the reactor control and protection system was designed so that the minimum allowable DNBR is at least the applicable limit and there is no fuel melting during normal operation including anticipated transients.

The shutdown groups are provided to supplement the control groups RCC assemblies to make the reactor at least 1.3% subcritical at the hot zero power condition following trip from any credible operating condition assuming the most reactive RCC assembly is in the fully withdrawn position.

Sufficient shutdown capability is also provided to prevent an unacceptable return to power level, assuming the most reactive rod to be in the fully withdrawn position for the most severe anticipated cooldown transient associated with a single active failure, e.g., accidental opening of a stream bypass, or relief valve, or safety valve stuck open. This is achieved by the combination of control rods and automatic boric acid addition via the Emergency Core Cooling System. With the BIT functionally eliminated, the return to power following a credible steamline break accident has been evaluated showing that the event is bounded by the hypothetical

IPEC00035229

steamline break. The departure from nucleate boiling (DNB) design basis is met with no consequential fuel failures predicted, and assuring that the return to power remains within the limits established for the protection of the health and safety of the public, with margin.

The minimum shutdown margin was calculated to be at least 1.3% @EOL conditions assuming the maximum worth control rod in the fully withdrawn position allowing 10% uncertainty in the control rod calculations.

Manually controlled boric acid addition is used to maintain the shutdown margin for the long term conditions of xenon decay and plant cooldown. Redundant equipment is provided to guarantee the capability of adding boric acid to the Reactor Coolant System.

Reactivity Holddown Capability

Criterion 30: The reactivity control systems provided shall be capable of making the core subcritical under credible accident conditions with appropriate margins for contingencies and limiting any subsequent return to power that there will be no undue risk to the health and safety of the public.

Normal reactivity shutdown capability is provided within 2.7 seconds following a trip signal by control rods, with boric acid injection used to compensate for the long term xenon decay transient and for plant cooldown. As discussed in response to the previous criteria, the shutdown capability prevents return to critical as a result of the cooldown associated with a safety valve stuck fully open.

Any time that the reactor is at power, the quantity of boric acid retained in the boric acid tanks and ready for injection always exceeds that quantity required for the normal cold shutdown. This quantity always exceeds the quantity of boric acid required to bring the reactor to hot shutdown and to compensate for subsequent xenon decay. Boric acid is pumped from the boric acid tanks by one of two boric acid transfer pumps to the suction of one of three charging pumps which inject boric acid into the reactor coolant. Any charging pump and either boric acid transfer pump can be operated from diesel generator power on loss of station power. Using either one of the two boric acid transfer pumps, in conjunction with any one of the three charging pumps, the RCS can be borated to hot shutdown even with the control rods fully withdrawn. Additional boration would be used to compensate for xenon decay. At a minimum CVCS design boration rate of 132 ppm/hr, the boron concentration required for cold shutdown can be reached well before xenon decays below its pre-shutdown level. The RWST is a suitable backup source for emergency boration. When two charging pumps are used to transfer borated water from the RWST to the reactor coolant, the boron concentration required for cold shutdown can be reached before xenon decays below its full power pre-shutdown level.

On the basis of the above, the injection of boric acid is shown to afford backup reactivity shutdown capability, independent of control rod clusters which normally serve this function in the short term situation. Shutdown for long term and reduced temperature conditions can be accomplished with boric acid injection using redundant components, thus achieving the measure of reliability implied by the criterion.

Alternately, boric acid solution at lower concentration can be supplied from the refueling water tank. This solution can be transferred directly by the charging pumps or alternately by the safety injection pumps. The reduced boric acid concentration lengthens the time required to achieve equivalent shutdown.

IPEC00035230