Public Service
of New Hampshire

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The Northeast Utilities System

April 11, 1994

D07512

Mr. Brian Hennessey, Mechanical Engineer
Air Management Division
U.S. Environmental Protection Agency
Region I - New England
JFK Federal Building (MAIL CODE: AAA)
Boston, MA 02203

QA report

Dear Mr. Hennessey:

Merrimack Station
Meteorological Data Collection

As required by the Protocol for Onsite Meteorological Monitoring Program at Merrimack Station, the attached report summarizes the comparison of wind speed and wind direction data from the 100-meter and 70-meter levels of the Merrimack Station meteorological tower with the 120-meter, 90-meter and 60-meter levels of the Doppler Acoustic Sounder. Based on the results of this comparison, PSNH believes the tower and SODAR instruments are operating properly. We request your endorsement of the SODAR performance during this period.

PSNH believes that data capture for the month of January has been successful. Our next data comparison report will be submitted on April 30, for the March 1 through 31 period.

If you have any questions concerning this submittal, please contact Jeffrey B. Lander, NUSCO Production Services - New Hampshire, at (603) 634-2390.

Sincerely,

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

R. G. Chevalier
Vice President

Attachment
cc: See page 2

METEOROLOGICAL DATA COMPARISON
MERRIMACK STATION
METEOROLOGICAL TOWER vs. DOPPLER ACOUSTIC SOUNDER

1.0 INTRODUCTION

Public Service Company of New Hampshire (PSNH) specified in the Protocol for On-site Meteorological Monitoring Program at Merrimack Generating Station (August, 1993) that periodic comparisons would be made of wind speed and wind direction data from the meteorological tower and the Doppler Acoustic Sounder (SODAR) and that these comparisons would be accompanied by a SODAR data capture report.

It was originally envisioned that this comparison would be made with a SODAR system whose data were acquired beginning at the 100-meter level and extending upward to 500-meters in 50-meter increments. In this case, the comparisons would be made between the 100-meter tower anemometer and the 100-meter layer data for the SODAR. Upon selection of an AeroVironment SODAR system with greater resolution in 30-meter layers beginning at 60-meters above the surface, the data comparison concept has initially been amended and expanded to include three comparisons: data from the 100-meter tower anemometer and the 90-meter SODAR data, data from the 100-meter tower anemometer and the 120-meter SODAR data and data from the 70-meter tower anemometer and the 60-meter SODAR data.

2.0 DATA CAPTURE RATES

This submission includes data collected from the tower instrumentation and SODAR systems between January 1 and January 31, 1994. SODAR data recovery (wind speed and wind direction) was affected by power outages of approximately 16 hours duration on January 18, at which time the 100-meter wind speed was also lost due to an inoperable heater, aoof about 9 additional hours at other times through the month. Anemometer heater failures also resulted in the eight hour loss of the 100-meter wind speed on January 28, and a three hour loss of the 70-meter wind speed data on January 19. Wind direction data capture of 100% was achieved for both the 70-meter and 100-meter levels, attributable to the backup power supply for the tower instrumentation system. Data capture rates for the 70-meter and 100-meter tower wind instrumentation and for each SODAR level are presented in Table 1 along with the joint capture rates for the paired parameters subject to comparison.

SODAR data capture at the upper levels was affected not only by the power outages but also by the winter storminess, in the forms of both heavy precipitation and high wind, but nevertheless achieved a rate of 90 percent through the 210-meter level, over 75 percent through the 330-meter level, and approached 50 percent at the 500-

Table 3
WIND DIRECTION DISTRIBUTION

Wind Direction Sector/Degrees		WD60 (%)	WD70 (%)	WD90 (%)	WD100 (%)	WD120 (%)
NE	22.5-67.5	2.9	4.2	3.9	5.4	3.8
E	67.5-112.5	1.9	3.4	1.2	2.8	2.2
SE	112.5-157.5	2.9	7.1	2.5	4.3	2.1
S	157.5-202.5	15.9	9.7	15.4	9.8	11.4
SW	202.5-247.5	6.1	3.4	6.0	5.4	10.1
W	247.5-292.5	20.6	15.7	23.9	15.7	27.4
NW	292.5-337.5	41.1	46.8	40.5	46.2	36.1
N	337.5-22.5	8.4	9.8	6.7	10.3	6.9

Note: Totals may not add to 100.0% due to rounding.

The data from Table 2 and Table 3 indicate fairly good internal continuity of the data sets with similarly shaped distributions for all of the wind speed datasets and all of the wind direction datasets. Additional detail in the form of comparisons of paired values from adjacent tower and SODAR levels for the same time period will follow in the next section.

4.0 PAIRED-VALUE COMPARISONS

For this section, comparisons have been performed using wind speed or wind direction from the 70-meter or 100-meter tower instrumentation and an adjacent level from the SODAR. For each pair of data, arithmetic differences of tower value minus SODAR value have been calculated and are defined by the SODAR data level. These are denoted by delta-u for difference in wind speed or delta-theta for difference in wind direction, and are defined as follows:

60-m delta-u = 70-m WS (tower) - 60-m WS (SODAR)
90-m delta-u = 100-m WS (tower) - 90-m WS (SODAR)
120-m delta-u = 100-m WS (tower) - 120-m WS (SODAR)

60-m delta-theta = 70-m WD (tower) - 60-m WD (SODAR)
90-m delta-theta = 100-m WD (tower) - 90-m WD (SODAR)
120-m delta-theta = 100-m WD (tower) - 120-m WD (SODAR)

Where applicable, delta-theta subtractions are corrected by adding or subtracting 360 degrees in order for the absolute value of delta theta not to exceed 180 degrees.

Additionally, many of these differences have also been converted to absolute value deviations for study, and their distributions have been tabulated for various categories of wind speed, wind direction and stability category.

Table 4 (Cont'd)

(Mean values, degrees)

Wind Speed Category		Delta-theta 90-m	Abs. delta-theta 90-m	Delta-theta 120-m	Abs. delta-theta 120-m
All	(710)	4.3	17.4	4.7	18.0
0-1 m/s	(29)	4.3	82.4	1.7	74.3
1-2 m/s	(94)	4.6	36.6	2.5	37.7
2-4 m/s	(224)	7.7	18.0	7.5	17.7
4-7 m/s	(230)	3.1	8.3	3.5	9.8
7-10 m/s	(101)	0.6	4.7	1.8	6.5
>10 m/s	(32)	0.9	3.2	3.1	5.0
<1 m/s	(29)	4.3	82.4	1.7	74.3
>1 m/s	(681)	4.3	14.7	4.4	15.6
<2 m/s	(123)	4.5	47.4	2.3	46.2
>2 m/s	(587)	4.3	11.1	4.7	12.0

Standard deviation of the 90-m delta-theta: 30.93 degrees
Standard deviation of the 120-m delta-theta: 31.67 degrees.

Note: Numbers in parentheses are category population (hours).

4.2 Paired Wind Direction Data

For this section, delta-u and delta-theta were analyzed for the entire dataset and for various categories of wind direction at the 70-meter and 100-meter levels of the tower. The 70-meter tower data were compared with the 60-meter SODAR data while the 100-meter tower data were compared with both the 90-meter and 120-meter data from the SODAR. Tabulations of absolute values of the "delta-" data are identified by "Abs. <parameter>". Wind direction categories are defined as in Table 3. Mean values by category are presented in Table 5.

4.3 Paired Data by Stability Category

In this section the dataset was divided according to stability classification, which was determined from sigma-e as detailed in the Monitoring Protocol. Again, the distributions of mean delta-u and delta-theta values and their absolute values have been tabulated according to stability class. Due to the predominance of arctic air masses and snow cover during the period, very few unstable hours are represented. Mean values by stabilitiy category are presented in Table 6.

Table 5 (Cont'd)

(Mean values, degrees)

Wind Direction Category		Delta-theta 90-m	Abs. delta-theta 90-m	Delta-theta 120-m	Abs. delta-theta 120-m
All	(721)	4.3	17.8	4.7	18.3
N	(76)	28.1	29.7	26.7	29.5
NE	(40)	1.7	35.5	3.3	34.4
E	(20)	46.9	59.5	-42.3	51.5
SE	(31)	32.2	35.4	-39.2	39.3
S	(73)	-6.4	11.3	-12.1	12.4
SW	(40)	9.2	16.0	-7.0	7.7
W	(113)	2.8	10.2	4.9	7.7
NW	(328)	8.0	13.0	12.0	15.8

Wind Direction Category		Delta-theta 60-m	Abs. delta-theta 60-m
All	(722)	1.8	19.8
N	(77)	22.2	27.8
NE	(40)	15.9	34.6
E	(21)	-58.2	59.4
SE	(32)	-37.4	37.7
S	(73)	-13.8	16.3
SW	(40)	5.2	24.2
W	(113)	2.3	12.8
NW	(326)	6.0	14.5

Note: Numbers in parentheses are population size (hours).

Table 6 (Cont'd)

(Mean values, degrees)

Stability Category		Delta-theta 90-m	Abs. delta-theta 90-m	Delta-theta 120-m	Abs. delta-theta 120-m
All	(721)	4.3	17.8	4.7	18.3
A	(3)	-29.8	29.8	-25.5	25.5
B	(8)	0.3	5.6	-0.8	8.5
C	(42)	-7.7	21.2	-3.5	22.6
D	(419)	3.4	13.5	4.4	15.8
E	(143)	9.3	22.0	11.7	24.0
F	(106)	7.0	28.6	0.8	18.9

Stability Category		Delta-theta 60-m	Abs. delta-theta 60-m
All	(722)	1.8	19.8
A	(3)	-32.4	32.4
B	(8)	-1.9	4.7
C	(42)	-1.7	23.0
D	(419)	3.2	15.7
E	(145)	6.6	21.0
F	(105)	-7.4	34.0

Note: Numbers in parentheses are population size (hours).

5.0 ACCEPTANCE CRITERIA

As indicated in the Monitoring Protocol, acceptance criteria for SODAR vs. tower data comparisons have not been established. PSNH has obtained data from AeroVironment, Inc., the manufacturer of the SODAR, on comparisons which have been performed between the same generation of SODARs and tethersonde instrumentation. In this context, the audit criteria used, which had been established from past SODAR/tethersonde comparions, were average differences of +/- 3 m/s for wind speed and +/-50 degrees for wind direction for paired data.

Although PSNH does not propose usage of these criteria as a formal measurement of performance, they should be useful for establishing the order of magnitude of our expectations. The comparisons presented above go far beyond the criteria presented in the previous paragraph. Rather, they cover a broad range of combinations of wind speed and wind direction and are supplemented

Review of the more detailed comparison breakdowns reveals what PSNH believes to be the expected results in almost all cases. Please note in Tables 4 through 6 that many of the categories have quite small populations and that the statistical significance of those data is reduced.

For wind speed, deviations (expressed as a percentage) are fairly constant across all speed ranges after light wind conditions (less than 2 m/s, and especially less than 1 m/s) are removed (see Table 4). Wind speed deviations distributed by wind direction sector (Table 5) are fairly uniform and generally related to mean wind speeds for the sector. The wind speed deviation distribution by stability category (Table 6) is likewise fairy uniform across categories, rising slightly, as might be expected, for the more stable E and F categories where mean wind speeds are lower. Average differences and mean absolute value deviations are substantially less than 3 m/s for every category.

For the wind direction data, deviations are strongly and inversely related to wind speed. Considering the fact that the paired instruments are not sampling the same volume of air, this would be an expected result, since under light wind conditions the scale of motion of the atmosphere decreases while at higher speeds larger scales of motion become more dominant. This tendency was demonstrated dramatically, for across the 5 wind speed categories below 10 m/s, the mean absolute value wind direction deviations decreased by approximnately a factor of two across every category as wind speeds increased (see Table 4). These absolute values of delta-theta were below the 50 degree criterion for every category except wind speeds less than 1 m/s, which will be treated in dispersion modeling as "calms." Delta-theta values by wind direction sector (Table 5) and stability category (Table 6) likewise showed distributions which were strongly influenced by the mean wind speeds for the category.

PSNH concludes, based on these data, that the two instrumentation systems are properly measuring the same medium, and that the differences between paired data over the 744-hour sample are acceptable and of a nature which might be meteorologically expected. Accordingly, PSNH requests endorsement of the SODAR performance during this period, and shall submit data for the next comparison period (March 1-31) on April 30.