PROPOSED MODELING PROTOCOL

FOR

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE'S

MERRIMACK GENERATING STATION

BOW, NEW HAMPSHIRE

PREPARED FOR:

US EPA - REGION I

PREPARED BY:

NORTHEAST UTILITIES
SERVICE COMPANY

Prepared John W. Lewitt 4/28/94

Reviewed Paul M. Jacobson 4/28/94

SUBMITTED BY:

PUBLIC SERVICE COMPANY
OF NEW HAMPSHIRE

APRIL 29, 1994

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1.0 INTRODUCTION

This modeling protocol describes the dispersion modeling proposed by Public Service Company of New Hampshire (PSNH) for its Merrimack Generating Station in Bow, NH. Merrimack Station is a two unit, coal-fired electric generating station, with both units powered by B & W cyclone furnaces. The Unit #1 capacity is 113 MW and the Unit #2 capacity is 320 MW.

The dispersion modeling proposed for the station is part of PSNH's continuing response to a request from the United States Environmental Protection Agency - Region I under Section 114 of the Clean Air Act, initiated in April, 1991. PSNH has been asked to demonstrate through dispersion modeling that the National Ambient Air Quality Standard (NAAQS) for sulfur dioxide is not violated as a result of the emissions from Merrimack Station. Several screening modeling analyses have been performed to date, and their results indicate that more detailed modeling must be undertaken. Further details of the earlier modeling efforts and their results are presented in Section 3.0

2.0 SOURCE ENVIRONMENT DESCRIPTION

2.1 Introduction

Merrimack Station is located on River Road, in the town of Bow, Merrimack county, NH on the west bank of the Merrimack River. The site is approximately 9 km southeast of Concord, NH and 16 km north of Manchester, NH. Latitude is approximately 43° 08′ 29" North, and longitude approximately 71° 28′ 09" West. The Concord Municipal Airport, the site of the local National Weather Service (NWS) office, is approximately 7 km to the north-northwest.

2.2 Topography and Land Use

Merrimack Station is located within the Merrimack River valley, which in that section is characterized by a nearly flat, open plain on the west side of the river. This plain is some 500-800 meters in width, and the station is located near the widest point of this, on the west bank of the river at an elevation of 207 feet above mean sea level (msl). Hills rise moderately to the west beyond the edge of this plain, and to the east, beginning just beyond the river's east bank.

This is a complex terrain site, with terrain rising above the top of the Unit #1 stack (432 ft msl) across the river at a distance of about 1.1 km to the east and at 2.0 km to the southwest and 2.6 km to the west-northwest. Terrain continues to rise away from the river, reaching the height of the Unit #2 stack (524 ft msl) at approximately 2.7 km to the north-northeast, 2.9 km to the southwest, 3.6 km to the west-northwest and 4.3 km to the southeast. Within 5 km, terrain rises to over 650 feet msl in two quadrants and within 10 km terrain reaches 900-1000 feet on either side of the valley. Some 13 km to the east-northeast, Fort Mtn. rises to 1413 feet. The station location and neighboring topography are depicted in Figures 1 through 4, excerpted from the USGS Suncook (NH), Concord (NH), Goffstown (NH) and Manchester North (NH) quadrangles (7.5′ series) topographic maps, which include the station and northeast quadrant, the northwest quadrant, the southwest quadrant and the southeast quadrant of the surrounding area, respectively.

For this site, rural dispersion coefficients are applicable. Within a 10-15 km radius, industrial and commercial development is sparse and located primarily in the immediate Concord area at a distance of more than 6-7 km from the site. Population is also sparse, with the only significant community within 5 km being Suncook, population 5,214 (1990 census), whose center is approximately 2 km to the southeast. Most land within the river valley is either open or lightly forested. On the hills away from the river valley a forest cover of mixed deciduous species predominates.

Close to the station, within 1-2 km on the west side of the river, the flat plain is vegetated primarily with grasses, with some low scrub (generally less than 8 m in height) beyond about 500 m. Beyond the plain, extending westward nearly to NH route 3A at a distance of about 1.7 km, extensive sand and gravel pits extend in both north and south directions along the valley. Across the river to the east within 1-2 km the land is open or lightly wooded. Residences are mostly along or near US route 3. Pembroke Academy is also located here about 1.1 km east-northeast of the site.

2.3 Climatology

The site and its environs lie within the southern interior NH climatological region. Most of the climatology of the site should be well represented by data from the NWS office at the Concord Municipal Airport located 7 km to the north-northwest. The area is about 35 miles inland to the west-northwest of the NH seacoast, and its climate is subject to relatively little marine influence. Summers are hot and winters are cold with annual extremes of temperature typically ranging from about 95 to -20 °F. The 36.53 inches of normal annual precipitation is distributed quite evenly among the twelve months. Annual snowfall averages about 66 inches and freezing precipitation is more frequent here than in many areas of New England. An episode of heavy icing occurs every few years. Thunderstorms

Figure 1


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
SUNCOOK QUADRANGLE
NEW HAMPSHIRE – MERRIMACK CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
LOUDON
CONCORD
CHICHESTER
PEMBROKE
Pembroke Hill
North Pembroke
Pembroke
Suncook
MERRIMACK
RIVER
BEAR BROOK STATE PARK
Merrimack
Station
Mapped, edited, and published by the Geological Survey
SCALE 1:24 000
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
ROAD CLASSIFICATION
SUNCOOK, N. H.
1967

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Figure 2

CONCORD QUADRANGLE
NEW HAMPSHIRE–MERRIMACK CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

Mapped, edited, and published by the Geological Survey
Control by USGS, USC&GS, and New Hampshire Geodetic Survey
Topography by photogrammetric methods from aerial photographs taken 1967. Field checked 1967
Polyconic projection. 1927 North American datum
10,000-foot grid based on New Hampshire coordinate system
1000 meter Universal Transverse Mercator grid ticks, zone 19, shown in blue
Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked
Red tint indicates areas in which only landmark buildings are shown

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

ROAD CLASSIFICATION

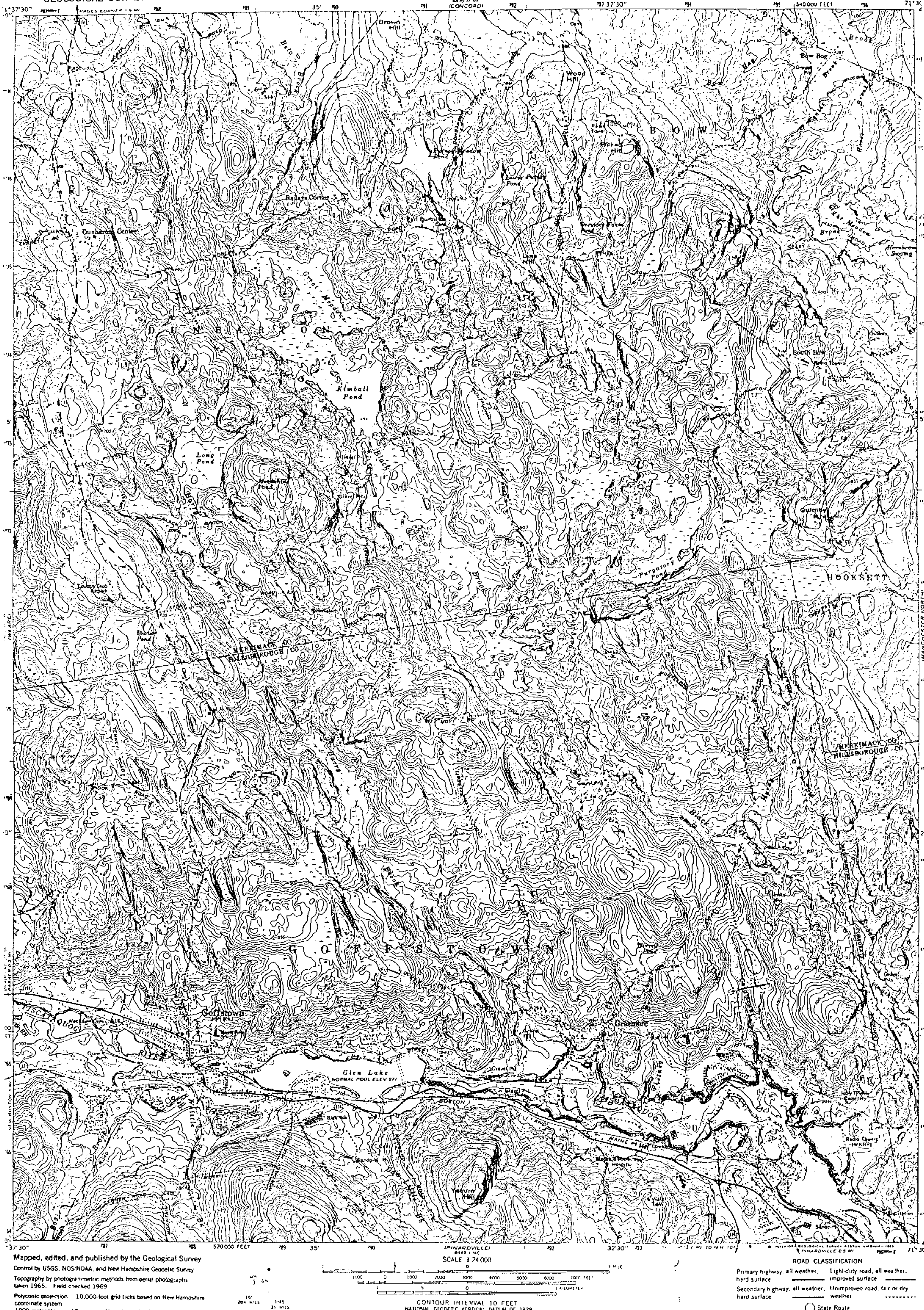
Primary highway, all weather, hard surface
Light-duty road, all weather, improved surface
Secondary highway, all weather, hard surface
Unimproved road, fair or dry weather
Interstate Route | U S Route | State Route

CONCORD, N. H.
NE/4 CONCORD 15' QUADRANGLE
N4307.5—W7130/7.5
1967
AMS 6470 II NE—SERIES V812

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Figure 3

GOFFSTOWN QUADRANGLE
NEW HAMPSHIRE
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey
Control by USGS, NOS/NOAA, and New Hampshire Geodetic Survey
Topography by photogrammetric methods from aerial photographs taken 1965. Field checked 1969
Polyconic projection. 10,000-foot grid ticks based on New Hampshire coordinate system
1000-meter Universal Transverse Mercator grid ticks, zone 19, shown in blue
1927 North American Datum
To place on the predicted North American Datum 1983 move the projection lines 5 meters south and 40 meters west as shown by dashed corner ticks
Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

UTM GRID AND 1985 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY
DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

QUADRANGLE LOCATION

Revisions shown in purple and woodland compiled from aerial photographs taken 1982 and other sources
This information not field checked. Map edited 1985

ROAD CLASSIFICATION

Primary highway, all weather, hard surface	Light-duty road, all weather, improved surface
Secondary highway, all weather, hard surface	Unimproved road, fair or dry weather

State Route

GOFFSTOWN, N. H.
SE/4 CONCORD 15' QUADRANGLE
43071-A5-TF-024
1969
PHOTOREVISED 1985

Figure 4


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
MANCHESTER NORTH QUADRANGLE
NEW HAMPSHIRE
7.5 MINUTE SERIES (TOPOGRAPHIC)
ALLENSTOWN
BEAR BROOK STATE PARK
BOW
Suncook
Hooksett
MERRIMACK
RIVER
HOOKSETT
Clay Pond
Campbell Hill
Martins Corner
South Hooksett
AUBURN
CANDIA
MANCHESTER
MASSABESIC LAKE
MERRIMACK CO
HILLSBOROUGH CO
ROCKINGHAM CO
SCALE 1:24 000
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
Mapped, edited, and published by the Geological Survey
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225
ROAD CLASSIFICATION
MANCHESTER NORTH, N. H.
1968

occur on an average of 20 days per year, and heavy fog with visibility less than 1/4 mile develops on 50 days per year.

Southern interior NH is influenced by the prevailing westerlies, with regular frontal passages and air mass changes. These events are often more frequent and bring sharper changes in the weather during the autumn, winter and spring months, but do occur throughout the year. Consequently, wind direction may be expected to shift periodically during all seasons, although the prevailing wind direction is from the northwest during all months of the year. The location of the airport within the Merrimack valley is responsible for a fairly large percentage of calm wind hours in the airport data, cautiously estimated at perhaps 15% of the total hours, and these are heavily concentrated during the period from late evening until just after sunrise. The mean wind speed at the airport, at approximately the 12 meter level, averages 6.7 mph (3.0 m/s) for the year, with monthly mean wind speeds varying from a maximum of 8.2 mph (3.7 m/s) for March to a minimum of 5.4 mph (2.4 m/s) for August.

Despite the proximity of the site to the airport, local topography and exposure may be expected to produce differences in wind direction and wind speed under certain conditions. As indicated previously, Merrimack Station is located on the west bank of the Merrimack River at a surface elevation of 207 feet msl, with hills rising gradually from the east bank of the river and from the edge of the plain less than 1 km to the west. Merrimack Station is located near a bend in the river valley. The valley is oriented northwest-southeast for about 5 km to the northwest of the site, and oriented north-south for about 8 km to the south. In contrast, the airport is located about 1.5 km east of the river, between the Merrimack River and its tributary, the Soucook River, at 342 feet msl. In this area the valley broadens and the low hills defining the sides of the valley are some 5-6 km apart. For these reasons, valley channelling of the wind should produce differences in wind direction and speed between the airport and the site under certain meteorological regimes.

Furthermore, given the relatively high incidence of calm winds in the airport data at the 12 m anemometer height, on-site data observed near stack-top should significantly reduce the incidence of calm and low wind speeds and show a reduction in valley channelling effects. These on-site stack-top observations should better represent initial plume transport.

3.0 HISTORY OF AIR QUALITY MONITORING AND DISPERSION MODELING STUDIES OF MERRIMACK STATION PERFORMED TO DATE

During the 1980's ambient monitoring of sulfur dioxide was performed for PSNH by the New Hampshire Air Resources Division (NHARD) over a period of years at three locations surrounding the station. No violations of the NAAQS are known to have been observed, and in January 1991 PSNH petitioned to discontinue the ambient monitoring program. Subsequent to the granting of this petition and the aforementioned EPA request in April 1991 to demonstrate that the NAAQS for sulfur dioxide is not violated, PSNH undertook a series of several preliminary dispersion modeling analyses which are described below.

Initially, in an effort to assess the station's impact upon terrain above stack height, the Complex-1 model was used with the Valley option. This was done in screening mode, using pre-established meteorological parameter inputs. This screening modeling could not confirm modeled SO_2 concentrations (plus background concentration estimates) in compliance with the NAAQS for receptors above stack height.

Also, in an effort to establish the impact in simple terrain, below stack height, the ISCST model was run using meteorological data from the nearest NWS site. These data were from the period 1986-1990 and consisted of surface data from the Concord, NH NWS (which is only about 7 km from Merrimack Station) combined with upper air data from Portland, ME. ISCST contains algorithms for assessing aerodynamic building downwash, a condition which may exist when stack height is below Good Engineering Practice (GEP) height, which, in this case, is 2.5 times the height of the dominant structure. At Merrimack Station, the dominant structure is the Unit 2 boiler, at approximately 173.5 feet, while the stack heights are 225 feet for Unit 1 and 317 feet for Unit 2, both well below the GEP height of approximately 433 feet. Therefore, it was expected that ISCST would model elevated sulfur dioxide impact in the near field, below stack height, due to downwash conditions. Indeed, this did occur, and the modeling results contained predicted concentrations above permissible levels some 500-1200 meters downwind of the station. These results were submitted to EPA Region I and NHARD in January 1992.

At about the same time, in order to obtain an estimate of model prediction of SO_2 impact in complex terrain under a wider range of meteorological conditions, PSNH ran the Complex-1 model with these same five years of NWS meteorological data. It is understood that regulatory applications of Complex-1 require on-site data. However, it was believed that this might provide a reliable approximation of what results would be obtained using Complex-1 if an on-site data collection program were to be undertaken. Modeled concentrations from Complex-1 with NWS data were sufficiently high to warrant pursuit of more advanced modeling options.

To further understand the station's impact upon the nearby complex terrain, PSNH obtained the CTDMPLUS model, which had been approved for use on a case-by-case base by other EPA Regions and which was awaiting approval for inclusion under the Guideline on Air Quality Modeling (GAQM). PSNH processed the digitized terrain inputs for 21 hills within approximately a 13 km radius, and ran CTSCREEN, the screening version of CTDMPLUS. The results indicated that further modeling of the complex terrain with CTDMPLUS would be advisable.

By early 1992, after the preliminary modeling analyses had been completed, it was evident that a compliance demonstration would likely have to be based upon both changes in station operation and station configuration (stack height). PSNH had decided to undertake an on-site meteorological data collection program, and was ascertaining what dispersion models such a program should be designed to support. Toward this end, in June 1992, representatives of PSNH, NHARD and EPA Region I met to discuss this matter, and in August 1992 a Draft Monitoring Protocol was submitted detailing meteorological data collection at five levels on a 100 meter tower, which was to be supplemented by a Doppler Acoustic Sounder (SODAR). This system would collect stack top data for input to ISCST (now the newly-released ISCST2) and data from the surface to plume height and above (up to 500 meters) to support CTDMPLUS.

The meteorological tower was erected during the fall of 1992, and, after final approval of the Monitoring Protocol was secured in October 1993, the tower was instrumented and the SODAR installed in December 1993. Data collection commenced January 1, 1994.

4.0 MODEL SELECTION

Many of the factors to be considered in the model selection process have been described in the previous sections addressing topography and the preliminary dispersion modeling which was performed.

4.1 Topographical Considerations

Topographical considerations, with the presence of terrain above the level of the shorter stack at a distance of 1.1 km, establish the need for complex terrain modeling to be performed.

4.2 Building Induced Downwash

Similarly, the relative stack and building dimensions were analyzed to determine the possible effects of building wake-effect induced downwash. There are two downwash algorithms approved by EPA for use in evaluating the magnitude of downwash when stack heights are sub-GEP: the Huber-Snyder and the Schulman-Scire. The Huber-Snyder algorithm applies in the more general case of:

$H_{gep} = H_b + 1.5\ L$, where
H_{gep} = GEP stack height
H_b = Height of dominant nearby structure
L = Lesser of height or projected width of nearby structure

The Schulman-Scire algorithm applies under the more limited condition where the following occurs:

$H_{geps} = H_b + 0.5\ L$, where
H_{geps} = GEP stack height for Schulman-Scire downwash
H_b = Height of dominant nearby structure
L = Lesser of height or projected width of nearby structure

These algorithms can evaluate the downwash according to the wind direction specific dimensions which are applicable for each of 36 wind directions. These building dimensions have been calculated according to the EPA guideline procedures.

4.3 Proposed Models

All models to be used in this analysis will be EPA-approved dispersion models. The procedures used in implementing and executing these models will follow those outlined in EPA's <u>Guidelines on Air Quality Models (Revised</u>) (1993).

Based upon the findings in the previous subsections, two models are proposed to simulate the variety of dispersion scenarios found near Merrimack Station:

- o The Industrial Source Complex Short-Term Model (revised) - ISCST2
- o Complex Terrain Dispersion Model Plus Algorithms for Unstable Situations (CTDMPLUS)

4.4 Model Objectives

The ISCST2 model will be used to predict air quality impacts at receptors below the lowest stack height (base elevation 207 ft + Unit #1 stack height 225 ft = 432 ft msl). The ISCST2 model, which contains both the Huber-Snyder and the Schulman-Scire downwash algorithms, will also be used to predict the near-field impacts due to building wake-effect induced downwash.

CTDMPLUS will be used to predict air quality impacts at all receptors above the lowest stack height of 432 ft msl (i.e. where complex terrain is defined by EPA).

There are sound technical reasons why ISCST2 will not be used to model impacts above the lowest stack top, and CTDMPLUS will be used exclusively in this area. These reasons include:

- ISCST2, as with its predecessor ISCST, is designed to calculate concentrations at receptor elevations no greater than stack top. Although concentrations can be calculated for receptors above stack top, the ISC User's Guide (EPA, 1987) cautions that "concentrations at these receptors may not be valid."

- ISCST2 uses the same terrain adjustment technique for all stability regimes (i.e no terrain adjustment). This simplistic approach was first proposed by Turner (EPA, 1970), and since then a better understanding of wind flow over terrain has been developed.

- The ISCST model will allow a plume (assuming no plume rise) to intercept terrain at stack height elevation independent of atmospheric conditions. Such an assumption is supported neither by theory nor by observation. Field experiments indicate that as a plume approaches terrain, the plume will move over and/or around the obstacle. Hence, the air adjusts its path in the vicinity of elevated terrain. Only under severely limited conditions will a plume actually impact terrain.

- CTDMPLUS is especially designed to calculate impacts in complex terrain (i.e. terrain above the stack top), permitting a plume to either move over and around terrain or to impact it directly, dependent on hill contour and meteorological conditions.

4.5 ISCST2 Model Features and Option Selections

ISCST2 will be used to assess the impact of Merrimack Station sulfur dioxide emissions at receptors with elevations below the lower (Unit #1) stack top at 432 ft msl. Three-hour, 24-hour and average annual impacts will be calculated. ISCST2 will be run in the rural (see section 2.2) "regulatory" mode, which employs the following model option settings:

- Stack-tip downwash

- Final plume rise
- Buoyancy induced dispersion (BID)
- Vertical potential temperature gradients of 0.0, 0.0, 0.0, 0.02 and 0.035 for stability classes A through F, respectively.
- Automatic treatment of calm winds
- Wind profile exponents of 0.07, 0.07, 0.10, 0.15, 0.35 and 0.55 for stability classes A through F, respectively.
- Infinite pollutant half-life.

4.6 CTDMPLUS Model Features and Option Settings

CTDMPLUS will be used to assess the impact of Merrimack Station sulfur dioxide emissions for all stability conditions at receptors above the elevation of the lower (Unit #1) stack at 432 ft msl. The 3-hour, 24-hour and average annual impacts will be calculated.

CTDMPLUS is the first refined model approved by EPA for general use in complex terrain. It differs from the other currently available complex terrain models in the following ways:

- The three-dimensional nature of the terrain is used in the flow distortion calculations.
- Vertical variations of wind speed, wind direction and turbulence intensities are determined through either interpolation of input measurements or surface layer scaling.
- In stable/neutral conditions the structure of the two-layer flow (above/below the dividing streamline height, H_c) is explicit in the model, and plume material that straddles the interface remains in the respective layers. (The plume is not treated as if it were all in one layer or the other.) Above H_c the plume is deflected and distorted and the rate of dispersion is altered. Below H_c the stagnation streamline divides the flow, and only material that diffuses onto the stagnation streamline is able to reach the surface of the hill. The stagnation streamline and the concentration pattern wrap around the terrain. Plumes that lie to one side of the stagnation streamline pass around the terrain.

- The rate of plume growth depends on the turbulence, and, in the case of sigma-z, it also depends on the degree of stratification. Sector averaging in the lateral direction is not used.

- For plumes released into daytime convective layers, a probability density function (PDF) approach is used to describe the vertical distribution of pollutants, and convective scaling concepts are utilized to parameterize the lateral diffusion coefficient. CTDMPLUS considers the effect of terrain on pollutant trajectories and on mixed-layer height deflections.

- Partial plume penetration into elevated stable layers is considered.

CTDMPLUS will be executed using the following options:

- Model all hours in each year (IUNSTA=1). A RAWIN file is required.

- Scalar wind speed will be input.

- Sigma-theta will be used for stable/neutral crosswind turbulence measurements (ISIGV=0).

- Final plume rise.

- Buoyancy enhanced dispersion (BED).

- Observed mixing heights (processed from data imported from the nearest NWS upper air station, Portland, ME) will be used as first priority (IMIX=1).

- Minimum wind speed will be set at 1 m/s (IWSI=1).

- Wind direction will be scaled with height (IWD=1).

- Infinite pollutant half-life.

Desmond, this is what Brian is asking comment on in Item B(4) of his comments on the Protocol.

4.7 Receptor Grid Selection

4.7.1 Receptor Grid for ISCST2

The receptor grid for the ISCST2 modeling will be a polar grid extending outward sufficiently to cover those receptors below lowest stack top (432 ft msl) in the impact area. This impact area will be established in accordance with the guidance set forth in the <u>NHARD Policy and Procedure for Air Quality Impact Modeling</u> (Revised, 1991). Within the polar grid the receptors will placed on 36 azimuths ten degrees apart, at radial distance increments of 100 meters out to 5 km, at radial distance increments of 250 meters beyond 5 km, and at increments of 500 meters beyond the 10 km distance, if required. No receptors on plant property will be used.

Additional discrete receptors will be generated at closer intervals in the regions of maximum modeled impact to more closely identify the maximum predicted impact values.

4.7.2 Receptor Generation for CTDMPLUS

CTDMPLUS employs its own receptor grid generation technique which is based on a digitization of contours around each of a number of discrete "hills" within the impact area. During the previous CTSCREEN modeling of Merrimack Station, 21 "hills" were identified within approximately a 13 km radius. These "hills" represent the most significant terrain features in the vicinity of the station, and encompassed virtually all of the terrain features within line-of-sight of the stack in the expected plume height elevation range.

The digitization of the contours was done from the USGS 7.5' quadrangles using a digitizing table, with contours selected at 50 foot intervals from the hilltop down to either the lowest stack top elevation (432 ft msl) or the lowest contour which could be reasonably closed about the hill. For several of the hills, not all terrain contours were closed; therefore the contours were either manually completed following (to the extent possible) the general terrain pattern, or the terrain fitting algorithm FITCON within the CTDMPLUS terrain preprocessor was allowed to complete the contour.

Within the CTDMPLUS terrain preprocessor, FITCON evaluates and edits each contour and processes the data by numerical integration to determine for each an equivalent ellipse. Next, the ellipse parameters are input to a second terrain preprocessor program, HCRIT, which determines the best-fit inverse-polynomial (vertical) profile of the hill along the major and minor axes of the hill. CTDMPLUS uses the contour representations to provide hill shape information above the critical dividing streamline height for each hour and each hill using interpolation between values specified at "critical" elevations. A third program, PLOTCON, generates screen displays of the digitized input contours and their fitted ellipses to aid in qualifying the terrain input data.

The CTDMPLUS receptor generator program, RECGEN, then displays the qualified contour and allows the user to locate receptors along the input contour (not the fitted ellipse) either at a user-supplied spacing along the contour, or as a user-specified number of receptors placed at equal intervals around the contour. For most of the hills previously processed for CTSCREEN, approximately 30-50 receptors were generated for each hill.

Additional discrete receptors will be added in areas of maximum modeled impact. This can either be done in the RECGEN program by adding receptors at closer spacing along the contours or by manually creating receptor coordinates for intermediate contours and adding these points to the receptor file.

4.8 Fluid Modeling

An additional study establishing the presence of building induced downwash could be required as part of the justification for increasing the heights of the Unit #1 and Unit #2 stacks at Merrimack Station, should that become a portion of the SO_2 attainment demonstration strategy. An ambient monitoring program comparing SO_2 concentrations within the building zone of influence with concentrations elsewhere in the vicinity might be required to establish the existence of downwash. Or, alternatively, a fluid modeling study could be used to demonstrate the presence of downwash which could be mitigated by increasing the height of the stacks.

5.0 METEOROLOGICAL DATA

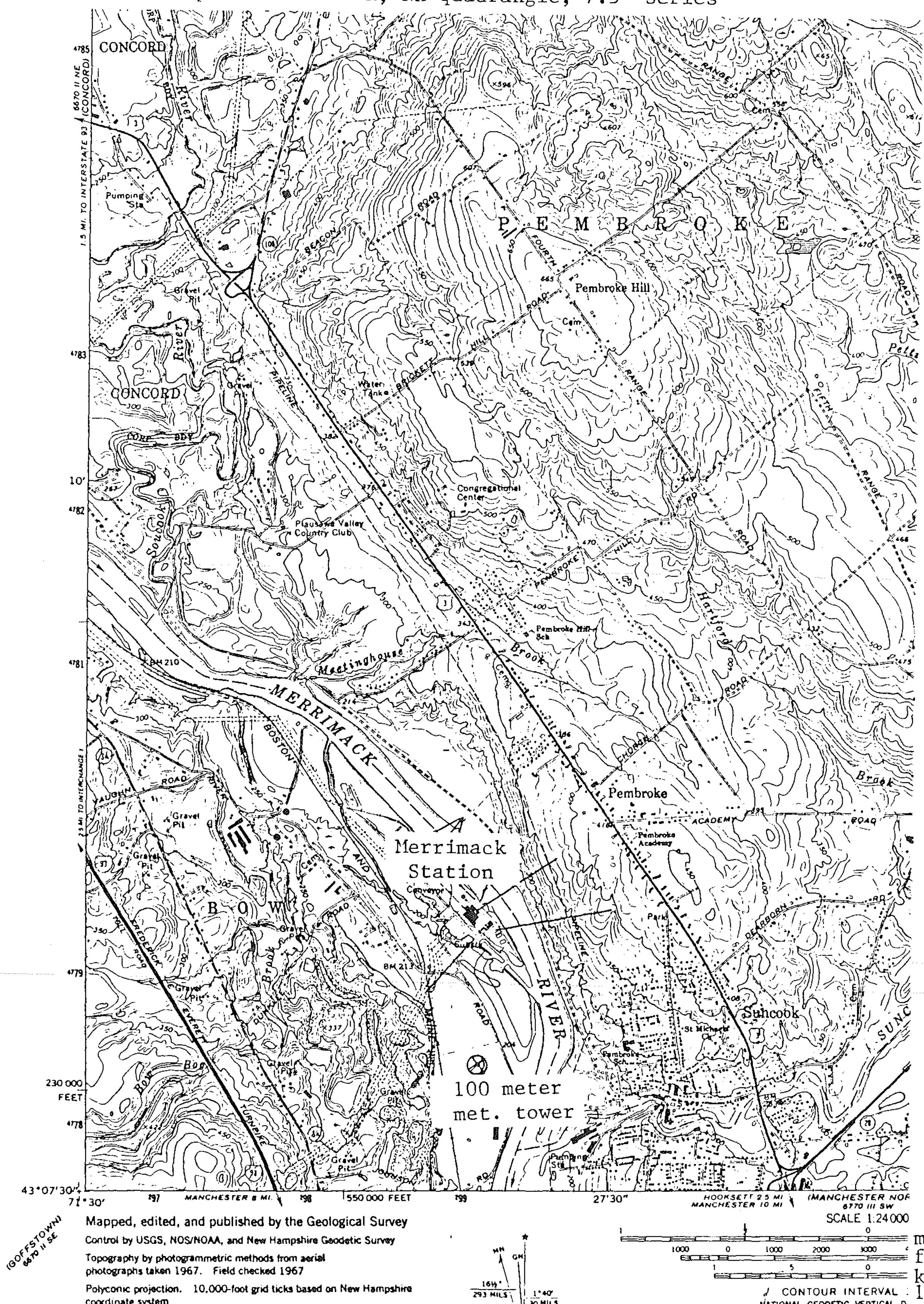
As indicated in Section 3.0, the preliminary results obtained from several dispersion modeling analyses performed between late 1991 and mid 1992 highlighted a need to perform further refined modeling of Merrimack Station using on-site meteorological data.

Accordingly, a 100 meter meteorological tower was erected on the flat plain approximately 950 meters south (178° true) from the station (see Figure 5) at the same base elevation of 207 feet msl. The tower data were to be supplemented by a SODAR located in as close proximity to the tower as practicable (about 160 meters to the south-southeast), which would collect meteorological data to plume height for use with CTDMPLUS.

The on-site meteorological data collection program shall continue for the period required for the collection of twelve months of valid data.

Figure 5

Excerpt from Suncook, NH quadrangle, 7.5' series



5.1 Meteorological Requirements for ISCST2

ISCST2 can accept meteorological data at only one level. The modeling previously done with ISCST and Complex-1 used wind data from the Concord, NH NWS observed at the 12.2 meter level. As indicated in the discussion of climatology in section 2.3, there is a substantial incidence of calm winds, especially during the nighttime and early morning hours.

For this analysis, wind data will be collected at the 100 meter level of the tower. This is nearly coincident with the release height (317 ft agl) of the Unit #2 stack, which accounts for approximately 75% of the total SO_2 emissions from the facility. Thus, the wind data input to the model should more accurately represent plume transport, and presumably contain a significantly lower percentage of calm or light wind conditions, resulting in improved modeled dispersion. Furthermore, due to the differences in local topography between the airport and the station, on-site wind data may also more accurately reflect wind, and therefore plume transport, direction.

Ambient air temperature will also be observed at the 100 meter level. Stability class determination will be made using sigma-E (as estimated by sigma-w/ scalar mean wind speed) from the 10 meter level as referenced in <u>EPA On-Site Meteorological Program Guidance for Regulatory Modeling Applications EPA-450/4-87-013</u>, revised February 1993, p 6-21, method 2. Alternatively, 10 meter sigma-theta data will be available to support method 3, and, with the acceptance of cloud cover and ceiling height data from the Concord NWS observations as representative of the site, method 4 will be supported also. Mixing height data will either be calculated from the other observed meteorological values collected for CTDMPLUS (see section 5.2) using the CTDMPLUS meteorological preprocessor METPRO (or equivalent) or be imported from NWS rawinsonde data from Portland, ME, the nearest NWS upper air observation site.

Meteorological data will be processed using RAMMET or an equivalent meteorological preprocessing program to create the required binary meteorological input file for the ISCST2 model.

5.2 Meteorological Requirements for CTDMPLUS

The meteorological requirements for CTDMPLUS are among the most complex of any of the dispersion models except for the family of photochemical models. There are three separate input files of meteorological data which are required to drive the model, each of which will be discussed in a later portion of this text.

The following meteorological parameters are required to drive the model:

- o Ambient temperature.
- o Unit vector wind direction.
- o Scalar mean wind speed.
- o Sigma-theta, the standard deviation of the horizontal wind direction.
- o Sigma-w, the standard deviation of the vertical wind speed.
- o Solar radiation.
- o Daytime mixed-layer or nocturnal surface layer height

To accomplish this, PSNH's <u>Protocol for On-Site Meteorological Monitoring Program at Merrimack Generating Station</u> (Revised, August, 1993) has specified in detail the instrumentation to be used, their placement, the data collection procedures and the quality assurance and quality control procedures to be used. In summary, this system will observe the following data:

- o Ambient temperature - to be observed at five levels of the 100 meter meteorological tower, at approximately 2 m, 10 m, 40 m, 70 m and 100 m above the surface. The 2 m and 40 m levels are were added in order to provide a more complete temperature profile, since CTDMPLUS is especially sensitive to the observed vertical temperature profile. No ambient temperature measurements will be made above the 100 m level, in the range where data will be collected using the SODAR.
- o Unit vector wind direction - to be observed at three levels on the meteorological tower, at approximately 10 m, 70 m and 100 m. In addition, the SODAR will measure unit vector wind direction in layers 30 meters in thickness centered on 60 m, 90 m, 120 m,...at 30 meter intervals up through the 510 m level.
- o Scalar mean wind speed - will be observed at the same levels of the tower and SODAR as the wind direction, specified above.
- o Sigma-theta - will be computed for the 10 m, 70 m and 100 m levels on the tower. Data collection will archive both 15 minute and 60 minute averaging period data, with the model input to be selected according to EPA recommendation at the time model inputs are being processed. Sigma-theta data are not being collected from

the SODAR.

- o Sigma-w - will be computed from vertical wind speed data collected at the 10 m, 70 m and 100 m levels on the tower. Sigma-w data are not being collected from the SODAR.

- o Solar radiation - data are being collected at the 1 m level near the base of the tower.

- o Daytime mixed-layer or nocturnal surface layer height - data will either be calculated from the other observed meteorological values using the meteorological preprocessor METPRO (or equivalent) or be imported from the NWS rawinsonde data from Portland, ME, the nearest upper air observation site.

These observed data, with the exceptions of solar radiation and mixed layer height, will be processed into the meteorological input file PROFILE, which may be used to input meteorological variables at up to fifty levels. PROFILE also requires the vector wind speed, which may be calculated from the scalar mean wind speed according to the method of Yamartino (1984). For the overlapping range of tower and SODAR, the election may be made to input data from both measurement systems (since the levels do not coincide), or to select one system or the other based on the assessment of SODAR performance detailed in the monitoring protocol. PROFILE does not require data at all of the same observation levels for each time period; therefore, at those times when SODAR does not capture data at all levels, missing data codes may be inserted at those levels where data is not available.

A second meteorological input file required for CTDMPLUS is the file SURFACE. This file contains the derived surface boundary layer parameters such as the Monin-Obukhov length, the friction velocity, the surface roughness length and the mixed layer height. These inputs are calculated from the observed meteorological data file using CTDMPLUS's meteorological preprocessor METPRO, or equivalent software.

METPRO allows adjustment of surface roughness by direction sector and season when executed in mode 3. Analysis of the land use types in the vicinity of the station indicates that input of uniform values for all direction sectors is appropriate. However, seasonal adjustment factors may be used. Based on land use, the surface roughness values for "deciduous forest" are deemed most representative, with the winter values used for the months of December through March, spring values for April and May, summer values for June through September, and autumn values for October and November. Seasonal adjustments may also be made for albedo and Bowen ratio.

Another meteorological input file, RAWIN, is required if CTDMPLUS is being run for unstable hours. This file consists of rawinsonde data created from a National Climatic Data Center TD6201 file using the READ62 preprocessor, or equivalent. This file will be created using the NWS rawinsonde data observed at Portland, ME. CTDMPLUS uses the hourly pressure and surface temperature data from this file to calculate daytime mixing height, and the RAWIN file data serve as the basis for determining stability above the mixed layer during daytime conditions.

Two additional meteorological data files which may be used in conjunction with the METPRO meteorological preprocessor are SURF1, which will contain solar radiation data base on on-site measurement, and SURF2, which will contain cloud cover data from the Concord, NH NWS

5.3 Missing Data Periods

Missing data values will be created for the 100 m data to be input to ISCST and also for the 10 m data which is the basis for some of the CTDMPLUS SURFACE file calculations. In accordance with EPA On-Site Meteorological Program Guidance for Regulatory Modeling Applications (revised, February 1993) p. 6-34, the following methods will be used:

- wind direction and ambient temperature - direct substitution will be made from the closest available level. If on-site data is not available, linear interpolation will be used for gaps of fewer than three hours. Otherwise, Concord NWS observed wind direction will be substituted.

- wind speed - will be scaled from the closest available level. If on-site data is not available, linear interpolation will be used for gaps of fewer than three hours. Otherwise, Concord NWS observed wind speed will be substituted directly for 10 m and scaled for the 100 m level.

- stability class - if the basis for alternate calculation from on-site data is available, such alternate calculation will be made. Otherwise, stability class will be determined from Concord NWS data based on cloud cover, wind speed, the time of day and date.

- mixing height - handled in accordance with the READ62 rawinsonde data preprocessor (or equivalent mixing height determination program) procedures.

It is recognized that a data loss period which is too lengthy might render these methods inappropriate and require a restart of the data collection period. Such a decision would only be reached in consultation with NHARD and EPA Region I.

6.0 SOURCE DATA

The dispersion modeling is proposed to address emissions from Merrimack Station only. Discussions with NHARD during the preliminary phase of modeling had concluded that there were no other major sources nearby which would need to be modeled as interactive sources. However, this issue will again be assessed when the impact area for the station is established, and should other sources be identified at that time as interactive, they will be included in the modeling.

No scaling of emissions will be used in the modeling. Each source will be modeled for its permitted emissions. However, since the compliance demonstration may require modifications, either of operation, such as restrictions on fuel sulfur content, or physical changes, such as an increase in stack height, it is not appropriate to specify source input characteristics at this time.

7.0 SCHEDULE

PSNH is currently collecting on-site meteorological data. This data collection began on January 1, 1994, and it is anticipated that the collection of twelve months of valid data should be complete by March 31, 1995.

It is anticipated that upper air data and the on-site meteorological data could be quality assured and preprocessed for model input by June 30, 1995. Initial modeling results should be available by August 31, 1995. However, the possible complexity of attainment demonstration strategies and the completion of a fluid modeling study could necessitate additional time. PSNH anticipates that the demonstration of attainment of the NAAQS for SO_2 for Merrimack Station should be complete by the end of 1995.

operation, such as restrictions on fuel sulfur [illegible]

[illegible] anticipated that upper air data and the on-site