State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Environmental Regulation
Division of Air Quality
P.O. Box 027
Trenton, NJ 08625-0027

JON S. CORZINE
Governor

LISA P. JACKSON
Commissioner

September 17, 2008

Ray Werner
Branch Chief, Air
United States Environmental Protection Agency – Region 2
290 Broadway- 26th Floor
New York, New York 10007-1866

Dear Mr. Werner:

In partial response to Regional Administrator Steinberg's August 14, 2008 letter, enclosed please find for your consideration documents that further substantiate the need to include Knowlton Township (Warren County) of New Jersey into a multi-state 24-hour PM2.5 National Ambient Air Quality Standard (NAAQS) nonattainment area with Pennsylvania's Northampton-Lehigh County nonattainment area. The enclosed documents are:

- "Modeling Analysis of the Sulfur Dioxide and PM2.5 Impacts Due to Emissions from the Portland Generating Station" dated April 10, 2008. This document sets forth the analysis and results of air quality modeling with CALPUFF of the impact of the coal-fired power plant, Portland Generating Station located in Northampton County, Pennsylvania, on the Township of Knowlton. Also included is a CD-ROM entitled "CALPUFF Modeling Files" that contains input and output files used for this modeling.
- "Use of CALPUFF for Near-Field Air Quality Modeling of the Portland Power Plant" dated April 10, 2008. This document justifies the use of CALPUFF for air quality modeling for the complex terrain and complex wind flow in the area of Knowlton Township and in the area of the Portland Generating Station.
- "AERMOD Modeling Analysis of the PM2.5 Impacts Due to Emissions from the Portland Generating Station" dated July 2, 2008. This document sets forth the analysis and results of air quality modeling with AERMOD of the impact of the Portland Generating Station on the Township of Knowlton.

There are three copies of each document enclosed for your convenience

The CALPUFF modeling conducted by the New Jersey Department of Environmental Protection (NJDEP) demonstrates that emissions from the Portland Generating Station—located in Northampton County, Pennsylvania within one mile of Knowlton Township—result in violations of the revised 24-hour PM2.5 NAAQS in Knowlton Township. NJDEP additionally conducted AERMOD modeling in response to the recommendation from

USEPA Region 2. Like the CALPUFF modeling performed by NJDEP to date, the AERMOD modeling further supports NJDEP's recommendation as it similarly shows violations of the 24-hour PM2.5 NAAQS in Knowlton Township due to emissions from the Portland power plant in Pennsylvania. Accordingly, based on the materials submitted herein in conjunction with the materials submitted by NJDEP to date, USEPA should reconsider its preliminary determination not to include Knowlton Township into a multi-state 24-hour PM2.5 nonattainment area with Pennsylvania's Northampton-Lehigh County nonattainment area. In addition, New Jersey intends to submit further information in support of its recommendation on New Jersey nonattainment designations for the revised 24-hour PM2.5 NAAQS by October 20, 2008 for the USEPA's consideration.

If you have any questions regarding this proposal, please contact me at (609) 984-1484.

Sincerely yours,

William O'Sullivan, P.E.
Director, Division of Air Quality

Enclosure

c: Nancy Wittenberg, Assistant Commissioner
Chris Salmi, Assistant Director
Danny Wong, BAQP
Alan Dresser, BTS
Ruth Carter, DAG

bc: Official SIP files

Division of Air Quality
Bureau of Technical Services
P.O. Box 027
Trenton, NJ 08625-0027

MEMORANDUM

TO: John Jenks, Chief
Bureau of Technical Services

FROM: Alan Dresser and Robert Huizer
Bureau of Air Quality Evaluation

DATE: April 10, 2008

SUBJECT: **Modeling Analysis of the Sulfur Dioxide and PM-2.5 Impacts due to Emissions from the Portland Generating Station**

Attached is a report that summarizes the procedures and results to date of the Bureau of Technical Services' (BTS) modeling analysis of the Portland Generating Station. The impact of this facility's emissions on sulfur dioxide (SO_2) and PM-2.5 concentrations in the vicinity were evaluated. The PM-2.5 modeling evaluated scenarios that included direct PM-2.5 emissions only and both direct and secondary PM-2.5 particulate formed from sulfur dioxide and nitrogen oxides emissions (sulfate and nitrate, respectively).

c: Ruth Carter (DAG)

Modeling Analysis of the Sulfur Dioxide and PM-2.5 Impacts due to Emissions from the Portland Generating Station

April 10, 2008

Bureau of Technical Services
Division of Air Quality
New Jersey Dept. of Environmental Protection

Addendums

The original modeling analysis was summarized in a New Jersey Department of Environmental Protection (NJDEP) December 22, 2007 memo from Alan Dresser and Robert Huizer to John Jenks. Since that time additional modeling of the Reliant Portland Generating Station has been performed. These modeling analyses incorporate additional sources of emissions from the facility and enhancements to the diagnostic meteorological model used. These changes to the modeling do not change the conclusions of the original modeling analysis. This document incorporates the changes made since the December 22, 2007 memo. The changes are listed as follows:

1. SO2, NOx, and PM-2.5 emissions from Unit 5 were included;
2. A partial accounting of fugitive particulate emissions from the coal pile and coal handling operations were included;
3. The number of vertical layers in Calmet were increased from 9 to 12 to better incorporate the MM5 data used;
4. Kinematic effects in Calmet were turned off;
5. Radius of influence of nearby terrain (TERRAD) was increased to 1.75 km;
6. Ammonia limiting method was used in the post processing of PM-2.5; and
7. Sulfate was scaled up to account for the molecular weight of ammonium sulfate;

Modeling Platform

Modeling of the Portland Generating Plant was performed with the latest EPA approved version of the CALPUFF modeling suite; CALMET/CALPUFF Version 5.8, Level 07063 and CALPOST Version 5.6394, Level 070622.

Justification for Use of Calpuff in the Near-Field

EPA's Guideline on Air Quality Models has the following discussion of complex winds in Section 8.2.8:

"In many parts of the United States, the ground is neither flat nor is the ground cover (or land use) uniform. These geographical variations can generate local winds and circulations, and modify the prevailing ambient winds and circulations. Geographic effects are most apparent when the ambient winds are light or calm. In general, these geographically induced wind circulation effects are named after the source location of the winds, e.g., lake and sea breezes, and mountain and valley winds. In very rugged hilly or mountainous terrain, along coastlines, or near large land use variations, the characterization of the winds is a balance of various forces, such that the assumptions of steady-date straight-line transport both in time and space are inappropriate. In the special cases described, the Calpuff modeling system bay be applied on a case-by-case basis for air quality estimates in such complex non-steady-state meteorological conditions. The purpose of choosing a modeling system like Calpuff is to fully treat the time and space variations of meteorology effects on transport and dispersion."

The terrain in the immediate area of the plant is complex. Terrain with elevations equal to the top of the stacks venting Units 1 and 2 (694 ft amsl) is located 1.9 km to the east and southeast of the stacks, and 2.4 km southwest of the stack. The very high terrain of 1500 ft amsl on Kittatinny Ridge is located as close as 7 km from the stacks. The non-uniform wind field in this portion of the Delaware River Valley has been verified by meteorological measurements. In the complex terrain surrounding the Portland Power Plant, the horizontally and vertically varying wind fields can only be accurately reproduced by a three-dimensional wind field. Such a wind field has been produced by the MM5 12 km data combined with the 250 meter Calmet grid spacing. A detailed justification for use of Calpuff is contained in the Bureau of Technical Services document "*Use of CALPUFF for Near-Field Air Quality Modeling of the Portland Power Plant*" (April 10, 2008)(See attachment).

Meteorology

Meteorological data from 2002 was used in the modeling. The following meteorological data sets were input into CALMET to generate the wind fields for modeling:

1. The University of Maryland created a full year meteorological data set for the year 2002 consisting of a continental scale 36-kilometer grid and a 12-kilometer scale subgrid covering the United States east of the Mississippi River (Figure 1). The 2002 Mesoscale Model Version 5 (MM5) prognostic data was obtained from the Ozone Transport Commission (OTC). This same data set was previously used in the 8-hour ozone CMAQ modeling conducted for the OTC states' ozone SIPs and is currently being used for the annual PM-2.5 SIP modeling in the Northeast U.S. The MM5 setup for generating meteorological fields was based on a modified Blackadar scheme for the boundary layer. The model was run with parameters listed below in Table 1.

2. 10 NWS ASOS hourly surface stations data listed below:

04725	725150	BINGHAMTON/EDWIN A LINK FIELD
13739	724080	PHILADELPHIA/INT'L ARPT
13781	724089	WILMINGTON/GREATER WILMINGTON DE
14734	725020	NEWARK/INT'L ARPT
14737	725170	ALLENTOWN/BETLEHEM-EASTON ARPT
14777	725130	WILKES-BARRE/WB-SCRANTON WSO
14778	725140	WILLIAMSPORT-LYCOMING /COUNTY
93721	724060	BALTIMORE/BLT-WASHNGTN INT'L ARPT
93730	724070	ATLANTIC CITY/AIRPORT NAFEC
93738	724030	WASHINGTON DC/DULLES INT'L ARPT

3. Albany NY, Brookhaven NY, and Dulles VA NWS upper air stations twice daily observations data.

4. 3 NOAA hourly buoy data (located off the coasts of Long Island NY, New Jersey, and Virginia).

Table 1. MM-5 Meteorological Model Configuration		
Science Options	**Configuration**	**Details/Comments**
Model Code		MM5 Version 3.6
Horizontal Grid Mesh		36km/12km
36-km grid		149x129 cells
12-km grid		175x175 cells
Vertical Grid Mesh		29 layers
Grid Interaction	No feedback	Two-way nesting
Initialization		Eta first guess fields/LittleR
Boundary Conditions		Eta first guess fields/LittleR
Microphysics		Simple Ice
Cumulus Scheme	Kain-Fritsch	36km/12km grids
Planetary Boundary Layer		High-resolution Blackadar PBL
Radiation		Simple cooling
Vegetation Data	USGS	24 Category Scheme
Land Surface Model		Five-Layer Soil model
Shallow Convection		None
Sea Surface Temperature		Do not update SST
Thermal Roughness		Default
Snow Cover Effects		None
4D Data Assimilation		Analysis Nudging: 36km/12km
Integration Time Step		75 seconds
Simulation Periods		2002
Platform	Linux Cluster	Done at UMD

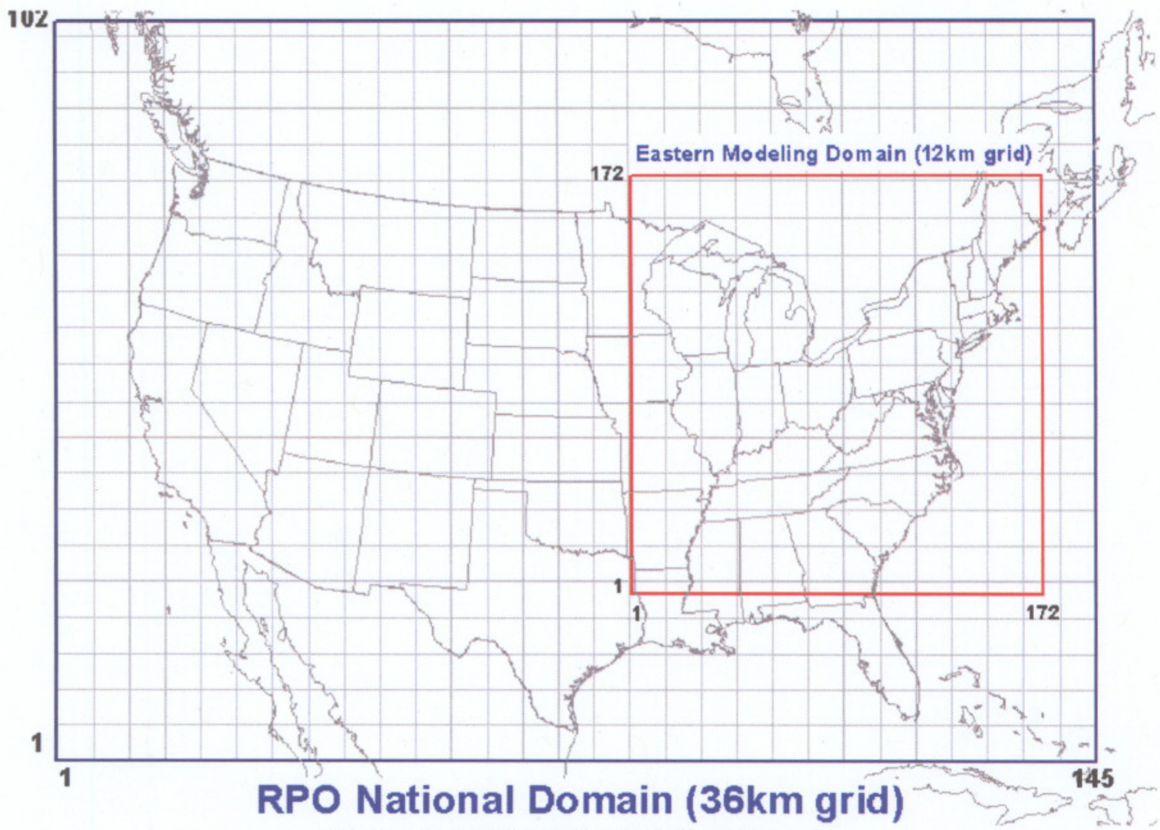


Figure 1. 2002 MM5 Modeling Domain

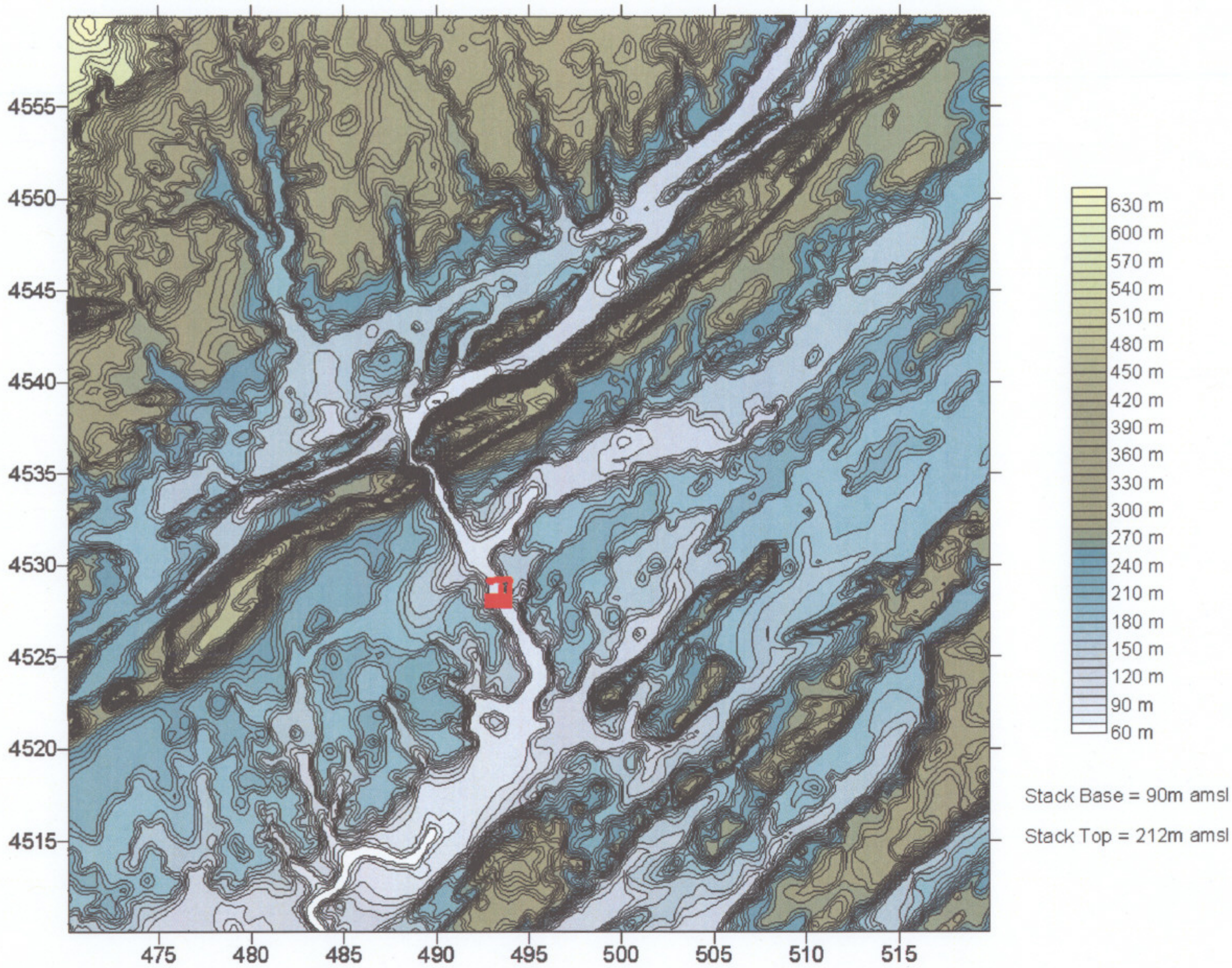
Geophysical Data / Ozone Background Data

Geophysical data used included USGS one degree digital elevation model (DEM) data and USGS Land use Land coverage files. Figure 2 shows the terrain relief input into the CALMET/CALPUFF models. 2002 hourly ozone data from all ozone monitors in New Jersey, New York, and Pennsylvania were obtained from VISTAS.

Computational Grid Size and Receptor Grids

The near-field modeling analysis has been revised to a smaller grid to provide a more precise wind field definition. The revised near-field grid used a 250 meter cell size with 200 rows and 200 columns and 12 vertical layers. A Cartesian grid with 10,000 receptors with 100 meter spacing was used. Figure 3 shows the 50 km by 50 km CALMET/ CALPUFF modeling grid and the approximately 10 km by 10 km receptor grid.

Figure 2. Calmet/Calpuff Terrain Resolution Used For Reliant Portland Generating Station Modeling Analysis



250 meter grid size with 1 degree USGS DEM data

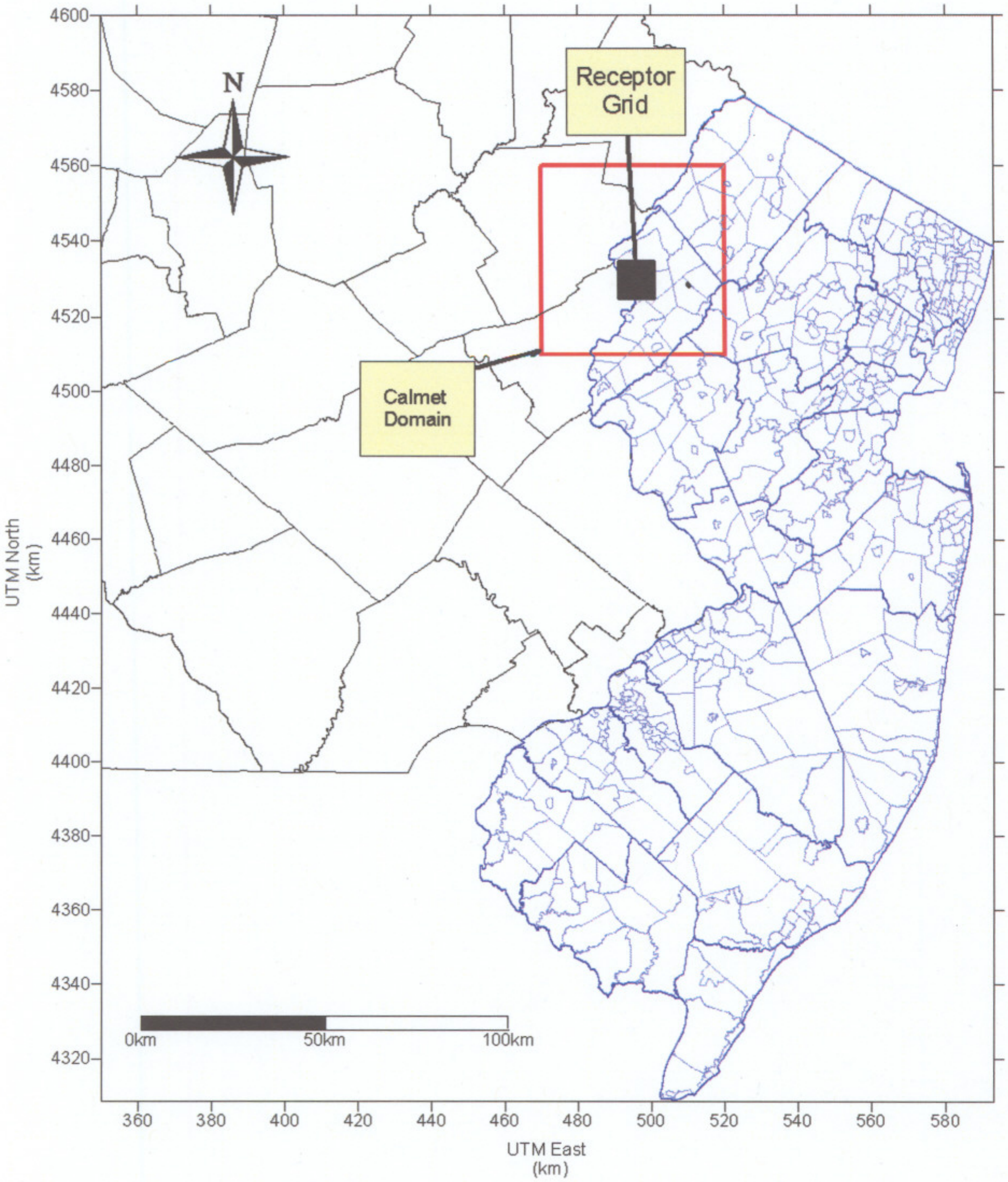


Figure 3. Calmet 250m Computational Domain and 100m Receptor Grid

CALMET Inputs

Table 2 lists the options selected when making the CALMET run to generate the wind fields.

Table 2. Important CALMET Control File Variables			
Variable	**Description**	**Default**	**Value**
NUSTA	Number of upper air stations	NA	3
NOWSTA	Number of overwater met stations	NA	3
NM3D	Number of MM4/MM5/M3D.dat files	NA	12
IBYR IBMO IBDY IBHR	Starting Date: Year Starting Date: Month Starting Date: Day Starting Date: Hour	NA NA NA NA	2002 1 2 0
IBTZ	Base Time Zone	NA	5
IRLG	Length of run (hours)	NA	8712
IRTYPE	Run type 0= compute wind fields only 1= compute wind fields and micrometeorological variables	1	1
LCALGRID	Compute special data fields required for CALGRID	T	F
ITEST	Flag to stop run after setup 1= stop 2= continue	2	2
MREG	Test options to see if they conform to regulatory values	na	1 yes
PMAP	Map projection	na	UTM
NX	No. of X grid cells	Na	200
NY	No. of Y grid cells	Na	200
DGRIDKM	Grid spacing (km)	Na	0.25
XORIGKM YORIGKM	X coordinate (km) Y coordinate (km)	Na Na	470.000 4510.000
NZ	No. Vertical layers	Na	11
ZFACE	Cell heights in grid	Na	0, 20, 80, 150, 220, 380, 620, 980, 1420, 1860, 2740, 3180,
NOOBS	No. observation mode (0 = surface, overwater and upper air)	0	0
NSSTA	No. of surface meteorological stations	Na	10
NPSTA	No. of precipitation stations (-1 to use MM5)	na	-1
ICLOUD	Gridded cloud fields (0 = not used)	0	0
IWFCOD	Model selection variable	1	1
IFRADJ	Compute Froude number adjustment? (0 = no, 1 = yes)	1	1
IKINE	Compute kinematic effects? (0 = no, 1 = yes)	0	0
IOBR	Use O'Brien procedure? (0 = no, 1 = yes)	0	0
ISLOPE	Compute slope flow effects? (0 = no, 1 = yes)	1	1
IEXTRP	Extrapolate surface wind observations to upper levels?	-4	-4
ICALM	Extrapolate surface winds even if calm? (0 = no, 1 = yes)	0	0
BIAS	Layer dependent biases modifying the weights of surface and upper air stations	NA	0,0,0,0,0,0,0,0,0,0,0
RMIN2	Minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station will be allowed (set to -1 for IEXTRP where all surface stations should be extrapolated	4	-1
IPROG	Use gridded prognostic wind field model output fields as input to the diagnostic wind field model (0 = no)	0	14
ISTEPPG	Timestep (hours) of the prognostic model input data	1	1

Table 2. Important CALMET Control File Variables			
Variable	**Description**	**Default**	**Value**
LVARY	Use varying radius of influence	F	F
RMAX1	Maximum radius of influence over land (km)	Na	10
RMAX2	Maximum radius of influence over land aloft (km)	Na	10
RMAX3	Maximum radius of influence over water (km)	Na	30
RMIN	Minimum radius of influence used in the wind field interpolation (km)	0.1	0.1
TERRAD	Radius of influence of terrain features (km)	NA	1.75
R1	Relative weighting of the first guess field and observations in the surface layer. (km)	NA	10
R2	Relative weighting of the first guess field and observations in the layers aloft. (km)	NA	10
ISURFT	No of surface stations.	NA	10

CALPUFF Inputs

Table 3 lists important options selected when making the CALPUFF runs to generate the pollutant impacts from the Portland Generating Plant.

Table 3. Important CALPUFF Control File Variables			
Variable	**Description**	**Default**	**Value**
IBYR	Starting Date: Year	NA	2002
IBMO	Starting Date: Month	NA	1
IBDY	Starting Date: Day	NA	2
IBHR	Starting Date: Hour	NA	0
IBTZ	Base Time Zone	NA	5
IRLG	Length of run (hours)	NA	8712
NSPEC	Number of chemical species	5	6
NSE	Number of chemical species emitted	3	3
METFM	Meteorological data format 1 = CALMET binary	1	1
MGAUSS	Vertical distribution used in the near field 1 = guassian	1	1
MCTADJ	Terrain adjustment method 3 = partial plume path adj.	3	3
MSLUG	Near-field puffs modeled as elongated slugs? 1 = yes	0	1
MTRANS	Transitional plume rise modeled? 1 = yes	1	1
MTIP	Stack tip downwash modeled? 1 = yes	1	1
MBDW	Method used to simulate building downwash 1 = ISC	1	1
MSHEAR	Vertical wind shear modeled above stack top? 0 = no	0	0
MSPLIT	Puff splitting allowed? 0 = no	0	0
MCHEM	Chemical mechanism flag 1 = MESOPUFF II scheme	1	1
MAQCHEM	Aqueous phase transformation 0 = not modeled	0	0
MDISP	Method used to compute dispersion coefficients 2 = dispersion coefficients from internally calculated sigma v, sigma w. 3 = PG and MP dispersion coefficients	3	2
MCTURB	Method used to compute turbulence sigma-v &sigma-w using micrometeorological variables 1 = Calpuff 2 = Aermod	1	2
MPARTL	Partial plume penetration of elevated inversion? 1= yes	1	1
MPDF	PDF dispersion under convective conditions? 1=yes	0	1
			SO2, SO4, NOX,

Table 3. Important CALPUFF Control File Variables			
Variable	Description	Default	Value
CSPEC	Chemical species modeled	na	HNO3, NO3, PM25
CSPEC	Chemical species emitted	na	SO2, NOx, PM25
MOZ	Ozone data input option 1 = read hourly ozone conc.	1	1
BCKO3	Monthly ozone concentrations (ppb) to fill missing data	12*80	20, 23, 34, 41, 39,41, 36, 36 ,23, 23, 16
BCKNH3	Monthly ammonia concentrations (ppb)	12*10	12*0.5

Stack Parameters

Stack parameters for all sources modeled are listed in Table 4. The stack parameters for Units 1, 2, and 5 were taken from data sets on a CD submitted by Reliant Energy Portland, L.L.C. entitled "Dispersion Modeling File Archive Revised NAAQS and PSD Increment for SO_2 and PM-10" (July 2001). The size of the coal pile was estimated from a 6/11/1996 map generated by United Engineers and Constructors entitled "Metropolitan Edison Company Portland Station General Arrangement - Overall Site Plan."

Table 4. Stack Parameters							
	UTM Coordinates		Stk. Base (ft amsl)			Exit	
Source	X (km)	Y (km)		Stack Height (m)	Stack Diameter (m)	Velocity (m/s)	Temp. (K)
Unit 1	493.349	4528.505	294	121.92	2.84	43.3	403.1
Unit 2	493.335	4528.554	294	121.72	3.79	36.26	405.9
Unit 5	493.008	4528.897	294	42.67	6.1	36.6	821.5
Coal Pile (volume source)	493.273	4528.186	294	4.6 (in height)	2.13 (initial sigma z)	35.5 (initial sigma y)	--

Emission Rates

The emission rates used in the modeling are listed in Table 5. Units 1 and 2's sulfur dioxide emission rates are based on their permit allowable 3-hour emission limits. Unit 1's emission rate is based on its lbs/MMBtu concentration limit (0.37 lbs/MMBtu) and a heat input of 1657.2 MMBtu/hr. Unit 2's NOx emission rate is based on its 30-day limit of 379.4 tons/month;

Units 1 and 2's direct PM-2.5 emission rates were calculated based on heat inputs of 1657.2 MMBtu/hr for Unit 1 and 2511.6 MMBtu/hr for Unit 2. The direct PM-2.5 condensable emissions are based on a stack test conducted by Alstom during normal operations on Unit 1 on June 13, 2006. A report on this stack test is available at:

www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/42306/**ALSTOM**-Hg-DOE%20Qtrly%20Sep%2006.pdf

The condensable emission rate reflects the maximum sulfur content of coal Portland could fire (2.4 percent) and still meet their sulfur dioxide emission limit. The coal sulfur content during the June 13, 2006 test was 1.9 percent. Direct PM-2.5 filterable emissions are based the unit's allowable total particulate emission rate and AP-42, Table 1.1-6, ESP particle size ratio of PM-2.5 to total particulate (0.29). These emission factors 0.029 lb/MMBtu (filterable) and 0.037 lbs/MMBtu (condensable) were applied to both units.

Unit 5 is a 150 MW simple-cycle turbine with a heat input of 1813 MMBtu/hr firing natural gas and 1880 MMBtu/hr when firing No. 2 oil. Unit 5 is permitted to emit up to 2,287.2 lbs/day (95.3 lb/hr) of sulfur dioxide and 303 lbs/hr of NOx when firing No. 2 oil. PM-2.5 emission rates were calculated using the results of a September 10, 2002 stack test for PM-2.5. The measured condensibles (0.0163 lbs/MMBtu) were all assumed PM-2.5. Half of the measured PM-10 filterables (0.00248 lbs/MMBtu) were assumed PM-2.5. The resulting PM-2.5 emission rate is 28.3 lbs/hr.

Table 5. Emission Rates

Unit	Sulfur Dioxide (lb/hr)	Nitrogen Oxides (lb/hr)	PM-2.5 (lb/hr)
1	5,820	613.2	109.4
2	8,900	1053.9	165.8
3	95.3	303	28.3

One bulldozer and two front-end loaders travel on the coal pile while conducting coal reclamation and coal pile maintenance operations. One bulldozer was assumed to be involved in operations between 7 am to 7 pm. Emissions were estimated using the equation in AP-42 Table 11.9-1, a silt content of 3.1 percent, and a moisture content of 6 percent. Based on these calculations, a bulldozer operating on the coal pile will emit 1 lb/hr of PM-2.5. One front-end loader was assumed to be involved in coal moving operations between 9 - 11 a.m. and between 3 - 5 pm. Emissions were estimated using Equation 1.a of AP-42 13.2.2.2 (vehicles traveling on unpaved surfaces in industrial areas). Based on a speed of 10 mph and weight of 55 tons, a value of 2.5 lb/hr was calculated for the front-end loader operations. The total annual PM-2.5 emissions from bulldozer and front-end activities were 4 tons/yr.

PM-2.5 emissions from material transfer points, coal conveyors and coal breaking/crushing activities were not included in the analysis.

Background Sulfur Dioxide Concentrations

Background sulfur dioxide concentrations were available from two existing monitors located at Freemansburg, PA and Chester, NJ. The average of the two monitors accurately represents background sulfur dioxide concentrations in the vicinity of the Portland Power Plant as explained in the following section discussing PM-2.5 background air quality. These values are listed in Table 6.

The sulfur dioxide results given later in the memo do include background values. The average background sulfur dioxide concentrations measured for a particular time period at the Freemansburg and Chester monitors were added to the concurrent modeled highest, second-high 3-hour and 24-hour sulfur dioxide concentrations and the highest annual concentration.

Table 6. 2002 SO_2 Monitored Concentrations

Averaging Time	Chester, NJ (ug/m^3)	Freemansburg, PA (ug/m^3)	Average (ug/m^3)
2nd Highest 3-hour	86.5	120.5	103.5
2nd Highest 24-hour	47.1	52.4	49.8
Annual	10.5	15.7	13.1

Background PM-2.5 Concentrations

Background concentrations were taken from two existing PM-2.5 monitors. One was the PADEP monitor located in Freemansburg, PA, approximately 23 miles southwest of the Portland Station. This monitor accurately represents PM-2.5 background levels being advected into the Portland area when winds are from the southwest quadrant. The meteorological conditions of concern are light to moderate winds from the southwest quadrant. Because the Freemansburg monitor is located near an urbanized area, an additional monitor was selected that was more representative of a rural location. The other monitor used was NJDEP's monitor located in Chester, NJ, approximately 21 miles east-southeast of the Portland Stations. PM-2.5 measurements taken by this monitor are among the lowest in New Jersey.

The days in July 2002 impacted by the large forest fires in Quebec, Canada were not included as background. Table 7 below lists the 98th percentile 24-hour and annual PM-2.5 background based on the average daily values of the two monitors. Because measurements are taken only once every three days at the Chester monitor, daily values between measurements were interpolated based on trends at the Freemansburg monitor and meteorological conditions. When no data was reported on a monitoring day at Chester, the measurement taken at the Morristown NJ monitor was substituted. There was no substitution for missing data from Freemansburg. On those days only the Chester monitoring data was used. In the future, data collected at the Allenstown PM-2.5 monitor may be used as a substitution for missing Freemansburg data.

Table 7. 2002 PM-2.5 Monitored Concentrations

Averaging Time	Chester, NJ (ug/m^3)	Freemansburg, PA (ug/m^3)	Average (ug/m^3)
98th Percentile 24-hour	30	41	33.3
Annual	10.5	14.1	12.3

The 98th percentile value in Table 1 was not used to determine compliance with the 24-hour PM-2.5 NAAQS. In order to more accurately represent air quality on a day-by-day basis, each day's monitored background PM-2.5 concentration was added to each day's modeled PM-2.5 impact, then compared to the 24-hour PM-2.5 NAAQS. Figure 7 illustrates the daily PM-2.5 background concentrations observed at the two background air quality monitors.

Sulfur Dioxide Modeling Results

Table 8 lists the maximum annual and highest, second-high 3-hour and 24-hour sulfur dioxide predicted impacts in New Jersey. Violations of both the 3-hour and 24-hour SO_2 NAAQS are predicted. Figure 4 shows the area surrounding the plant where the 3-hour sulfur dioxide NAAQS is violated. In Figure 5, the area surrounding the plant where the 24-hour sulfur dioxide NAAQS is violated is shown.

Without the inclusion of background SO_2, violations of the 3-hour NAAQS are predicted at 727 receptors. A single receptor is predicted to violate the 3-hour NAAQS up to 8 times during 2002.

Without the inclusion of background SO_2, violations of the 24-hour NAAQS are predicted at 279 receptors. A single receptor is predicted to violate the 24-hour NAAQS up to 3 times during 2002.

Table 8. Predicted Sulfur Dioxide Concentrations [(a)]

Averaging time	Predicted Impact[(b)] (ug/m^3)	Background (ug/m^3)	Total Impact (ug/m^3)	NAAQS (ug/m^3)
Annual	31.9	13.1	45.0	80
24-hour	426.3	10	**436.3**	365
3-hour	2,851	41	**2,892**	1300

a. Only values in New Jersey listed.
b. Values represent predicted highest, second-high 3 and 24-hour average concentration and highest annual.

$PM_{2.5}$ Modeling Results

Table 9 lists the maximum 24-hour and annual $PM_{2.5}$ impacts. In addition, the 8^{th} high 24-hour concentration is given. The $PM_{2.5}$ impacts in Table 9 only include directly emitted particulate matter, no secondary particulate (sulfate and nitrate) are included. Figure 6 shows the maximum predicted 24-hour $PM_{2.5}$ concentrations in the vicinity of the plant. As can be seen, high impacts occur along the plant property line due to emissions from the coal pile.

Table 10 also lists the maximum 24-hour, the 8^{th} high 24-hour concentration, and annual $PM_{2.5}$ impacts. However, the $PM_{2.5}$ impacts in Table 11 include both direct $PM_{2.5}$ emissions and secondary particulates formed after the plume leaves the stack.

Table 9. Predicted Concentrations due to Direct $PM_{2.5}$ Emissions

Averaging time	Predicted Impact (ug/m^3)	Background[(a)] (ug/m^3)	Total Impact (ug/m^3)	NAAQS (ug/m^3)
Annual	8.7	11.8	20.5	15
Maximum 24-hour	42.6	33.3	75.9	35
98^{th} Percentile 24-hour	30.7	33.3	64.0	35

a. Background $PM_{2.5}$ concentrations represent the average 24-hour 8^{th}-high and annual 2002 concentrations monitored at Freemansburg PA and Chester NJ.

Table 10. Predicted Concentrations due to Direct $PM_{2.5}$ Emissions and Secondary $PM_{2.5}$

Averaging time	Predicted Impact (ug/m^3)	Background[(a)] (ug/m^3)	Total Impact (ug/m^3)	NAAQS (ug/m^3)
Annual	8.8	11.8	20.6	15
Maximum 24-hour	42.6	33.3	75.9	35
98^{th} Percentile 24-hour	30.7	33.3	64.0	35

a. Background $PM_{2.5}$ concentrations represent the average 24-hour 8^{th}-high and annual 2002 concentrations monitored at Freemansburg PA and Chester NJ.

Both Tables 9 and 10 show that Portland Power Plant's emission's contribution added to existing background $PM_{2.5}$ concentrations results in violations of the 24-hour $PM_{2.5}$ NAAQS. However, as was explained in the $PM_{2.5}$ background section, the results in Table 9 and 10 were not used to determine compliance with the 24-hour PM-2.5 NAAQS. Compliance was determined by adding each day's monitored background concentration to each day's modeled PM-2.5 impact, this total concentration was then compared to the 24-hour PM-2.5 NAAQS. Figure 8 is a time-series graph which illustrates the Portland Generating Station's overall peak 24-hour PM-2.5 impact for each day and adds that impact to the corresponding average daily background concentration. Only directly emitted PM-2.5 emissions are represented in the graph. The results of this analysis showed that there were 37 days in 2002 where the total impact exceeded the NAAQS of 35 ug/m^3. Of those 37 days, seven are caused by background air qulality alone, and 30 days are new violations.

The results shown in Figure 8 are predominately caused by emissions from the coal pile and each daily peak PM-2.5 concentration can be at any of the 10,000 receptors in the grid. As a result, an additional analysis was done at a single receptor located approximately 1.5 km to the east of the facility in New Jersey. This analysis included the total of the facilities direct and secondary PM-2.5 emissions. A time series graph of each days PM-2.5 impact at this receptor during the summer was added to the corresponding day's average daily background concentration as shown in Figure 9. The results of this analysis showed that there were nine days in 2002 where the total impact exceeded the NAAQS of 35 ug/m^3. Figure 9 shows only 8 of these exceedances. One additional excceedance occurs in October. Of those nine days, seven are caused by background air quality alone, and two days are new violations.

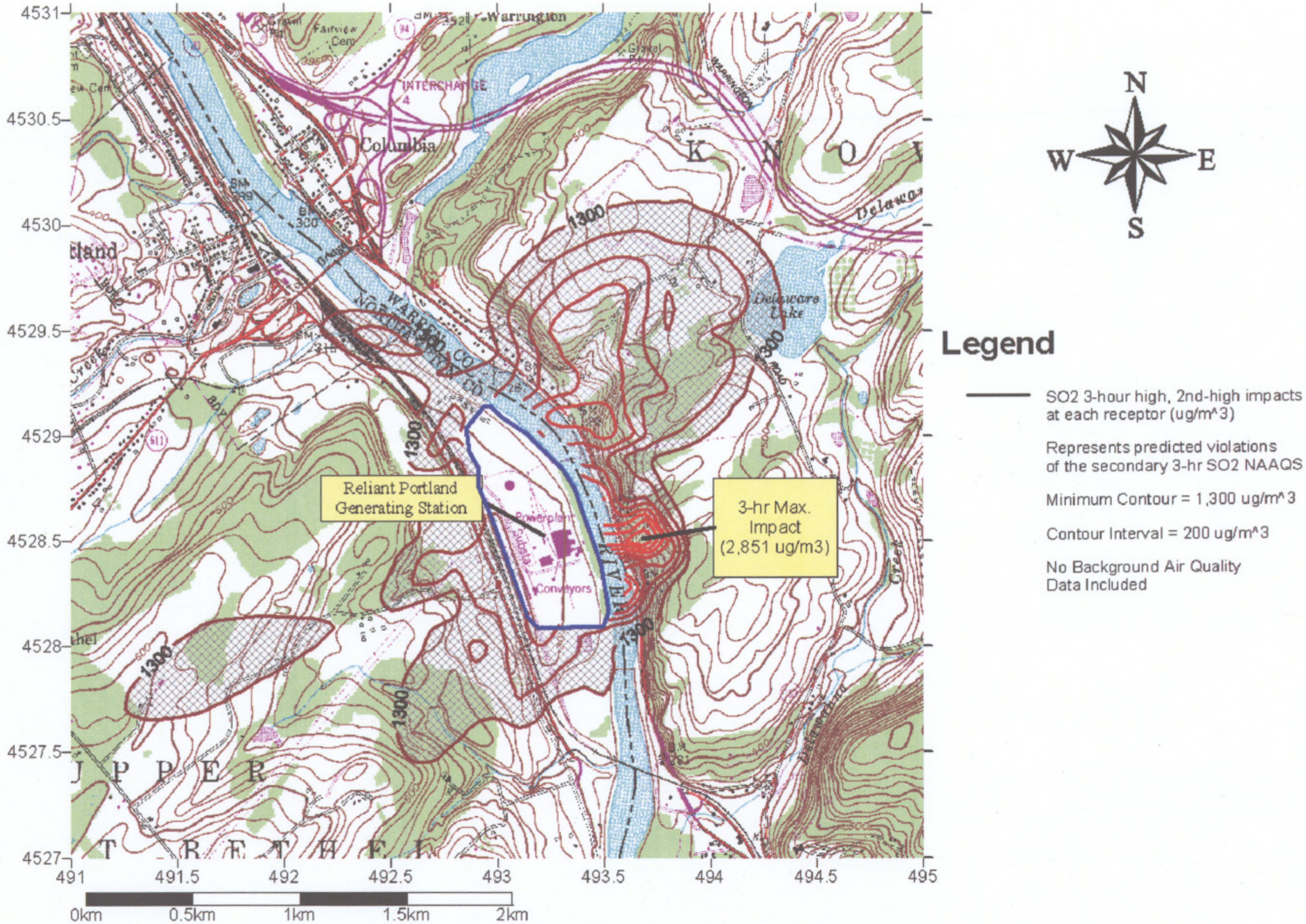


Figure 4. 3-hour SO2 Violations in the Vicinity of the Portland Generating Station

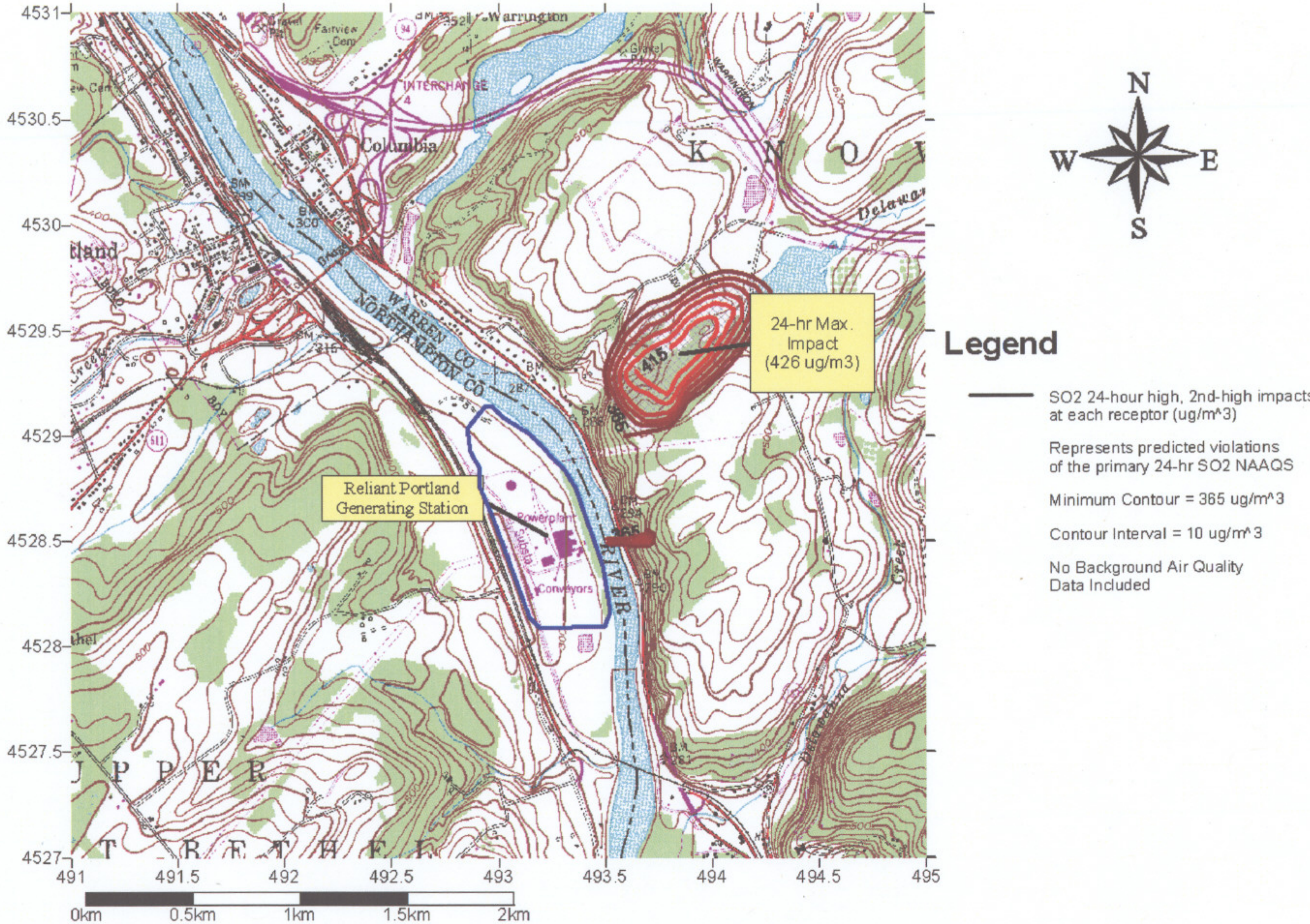


Figure 5. 24-hour SO2 Violations in the Vicinity of the Portland Generating Station

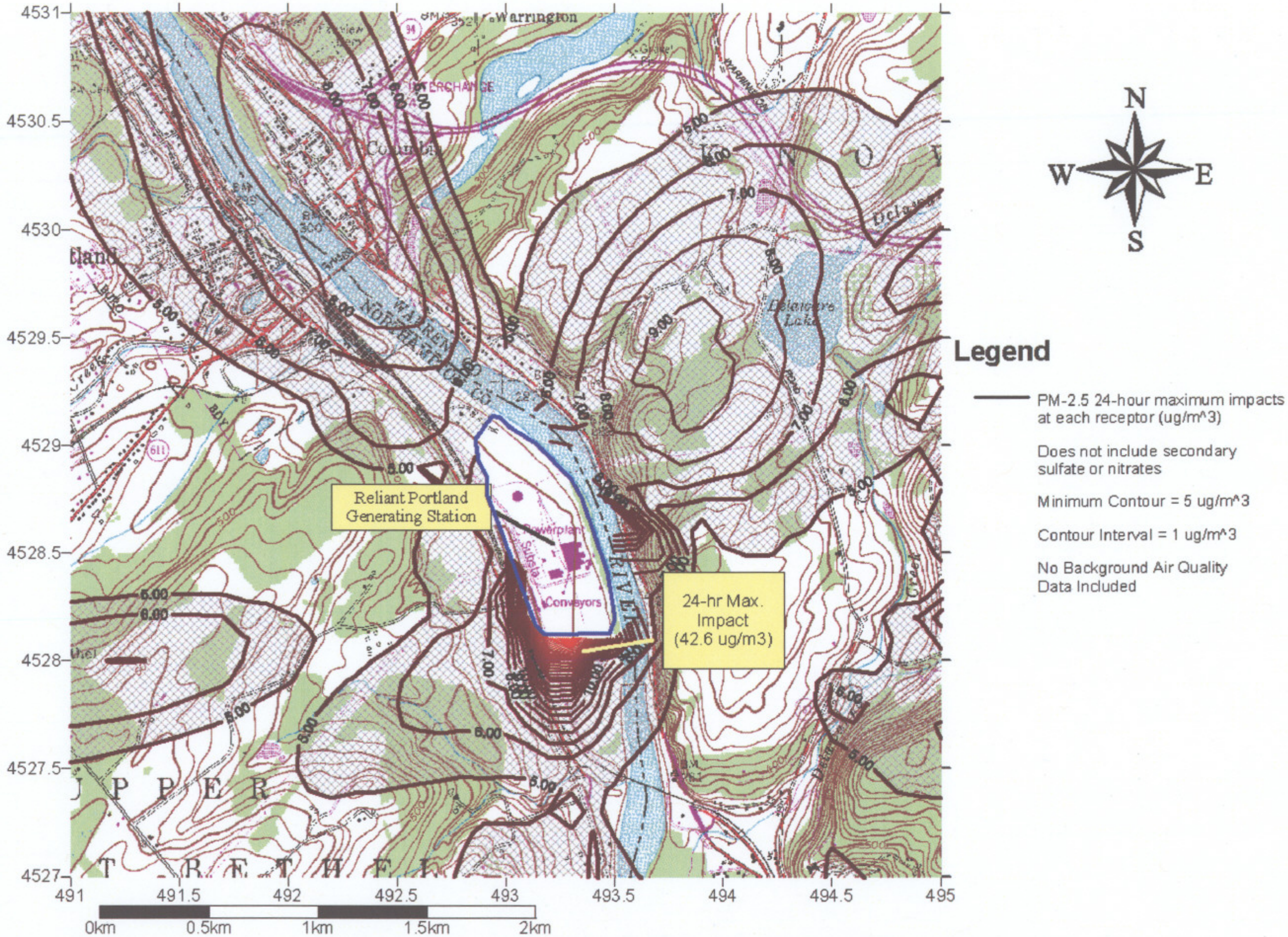


Figure 6. 24-hour Maximum PM-2.5 Impacts in the Vicinity of the Portland Generating Station

Figure 7. 2002 Daily PM2.5 Monitored Values

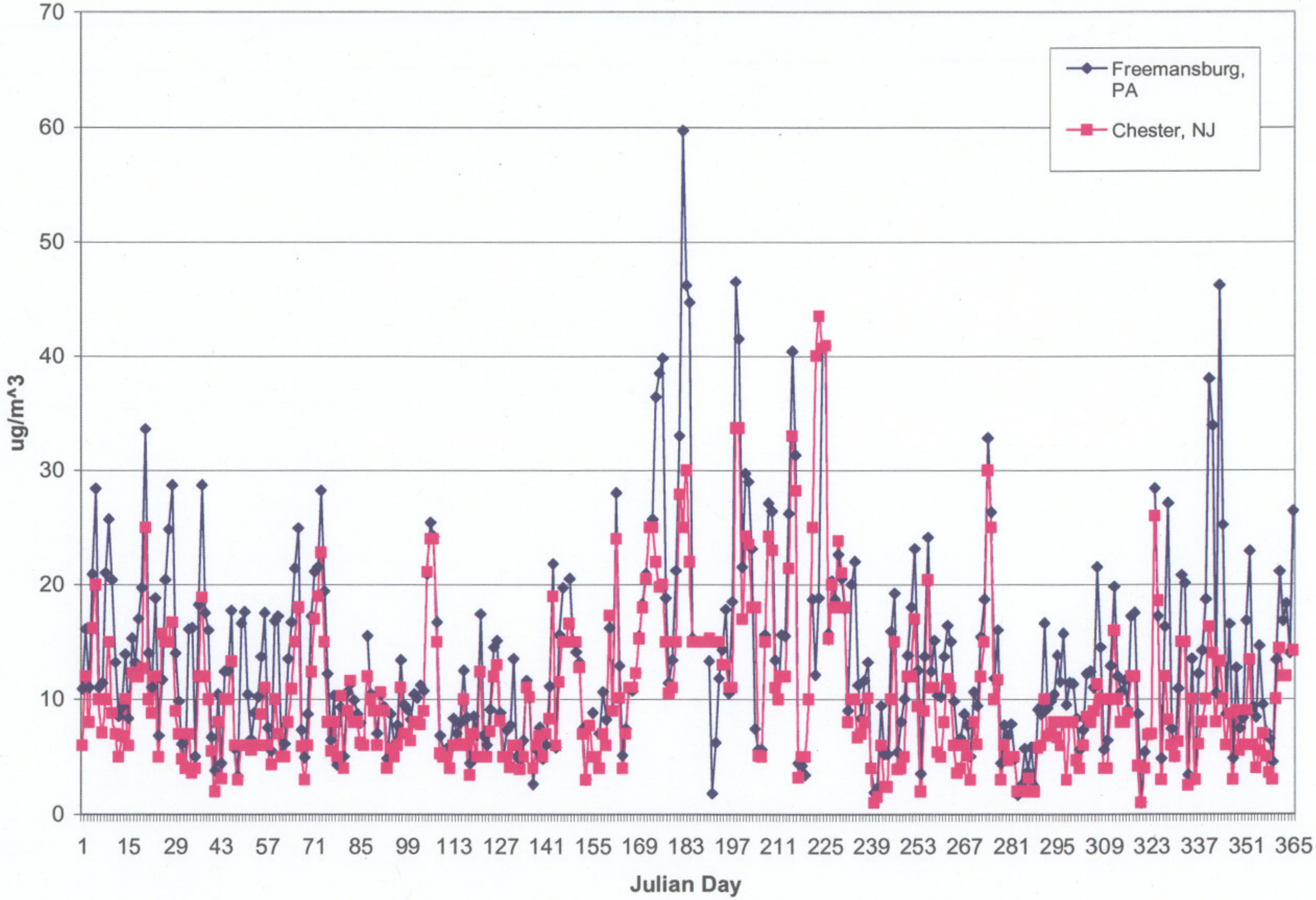


Figure 8. Portland Generating Station's Maximum Predicted Daily Direct PM-2.5 Impacts With Added Background

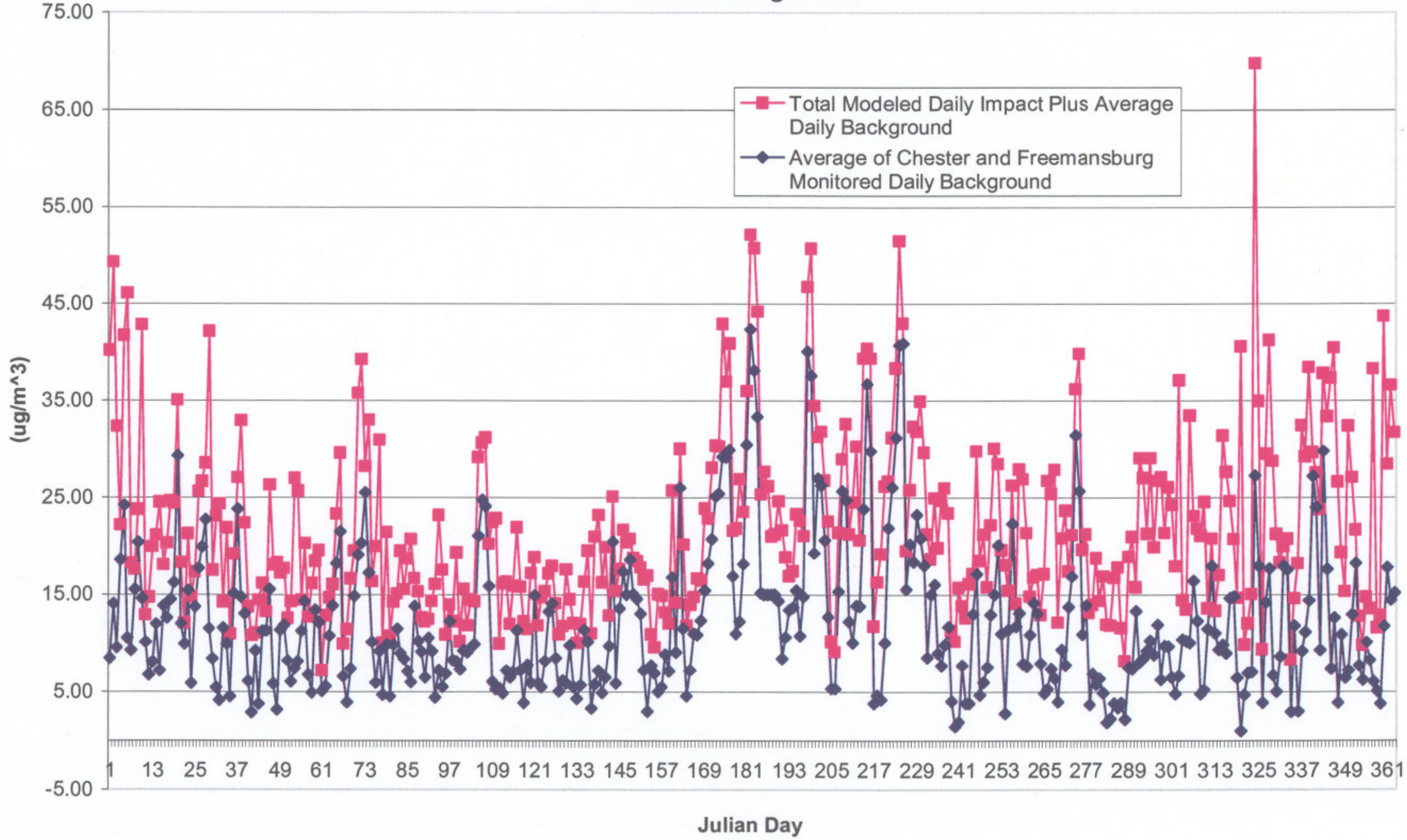
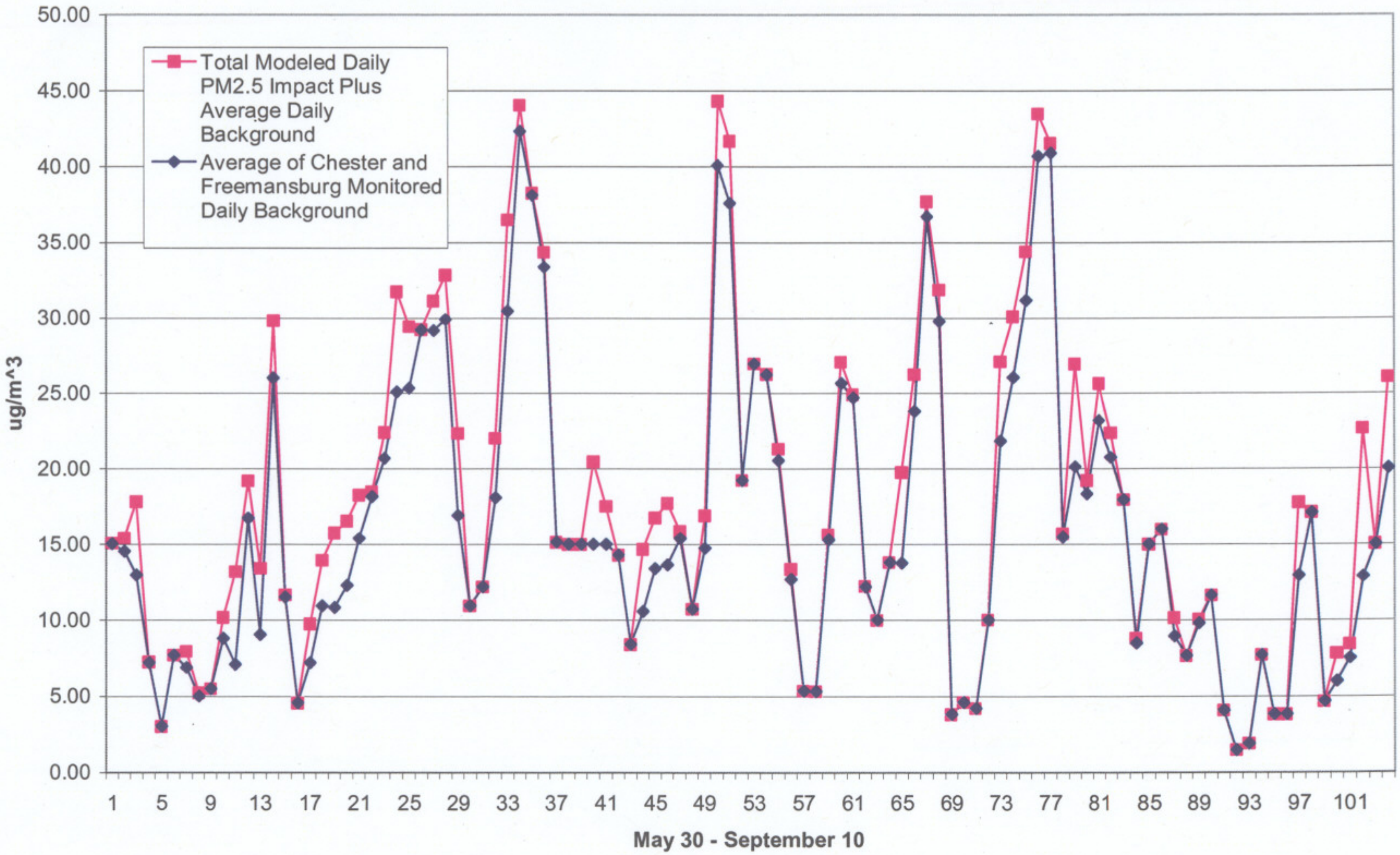


Figure 9. Portland Generating Station's Modeled Daily Direct and Secondary Particulate Impact With Added Background at a Single Receptor in NJ, Summer 2002



Use of CALPUFF for Near-Field Air Quality Modeling of the Portland Power Plant

April 10, 2008

Bureau of Technical Services
Division of Air Quality
New Jersey Dept. of Environmental Protection

Introduction

The Bureau of Technical Services is conducting an air quality dispersion modeling study of the emissions from the Portland Power Plant in Northampton County, Pennsylvania. This document justifies the use of the CALPUFF model to quantify impacts in the near-field area within 50 km of the source. The report is divided into the following section:

Section I. Existence of a Complex Wind Field at the Portland Power Plant Site

Section 1.1 Terrain Features

In Figure 1 the elevation of the terrain in the immediate vicinity of the plant is shown. Terrain with elevations equal to the top of the 400 ft stacks venting Units 1 and 2 (694 ft amsl) is located as close as 1.9 km to the east and southeast of the stacks, and 2.4 km southwest of the stack. In addition, the very high terrain on Kittatinny Ridge that approaches and exceeds 1500 ft amsl is located as close as 7 km from the stacks.

Photo 1 is a recent aerial photo of the site showing the plant in the foreground and the surrounding terrain looking in a northwesterly direction. Kittatinny Ridge can be seen as well as the higher terrain immediately to the east of the Portland Power Plant across the river in New Jersey. The curvature of the Delaware River Valley is also apparent. Another aerial photo (Photo 2) shows the view to the south of the plant. The elevated terrain to the east of the site and the various hills and ridges to the south are visible in this photo.

Section 1.2 Meteorological Measurements Collected Near the Portland Site

While not capturing the full three-dimensional local terrain and mesoscale wind fields, wind measurements taken at one location near the Portland site can be of use in demonstrating the existence of non-uniform vertical wind fields in and near Portland and the Delaware River Valley. From July 1993 through June 1994, meteorological data was collected near the Portland Generating Station. This monitoring program consisted of a collocated 100-meter tower and Doppler sodar. Tower measurements of wind direction and wind speed are available at 30 and 100 meters. The sodar provided wind direction and wind speed for modeling purposes at 30-meter increment levels from 120 meters up to 510 meters. The monitoring program is described in detail in Appendix A.

The measurement site was located 2.3 km west of the plant above the river valley at an elevation of 610 ft amsl (see Figure 3-1 in Appendix A). Wind roses were generated from wind measurements taken at three heights. Figure 2a shows the 30 meter wind rose, Figure 2b shows the 150 meter wind rose, and Figure 2c shows the 300 meter wind rose. When examining these figures, the expected difference in wind speeds at the three levels is evident. However, there are also some obvious differences in wind direction that occur at the three levels. The lower 30-meter level data clearly shows a much greater frequency of winds from the north/north-northeast and south than that which occurs at the 150 and 300 meter levels. However, these predominate 30 meter winds do not align with the axis of the river valley at that location (northwest to southeast) and possibly reflect some other local terrain influences. At 150 meters, the winds reflect the occurrence of westerly synoptic winds and with an additional peak wind direction out of the northeast. In the 300 meter wind rose the synoptic winds out to the south-southwest through north-northwest are even more evident.

As will be discussed later, the modeling results have shown one of the principal meteorological conditions of concern at the site is the near stagnation condition that accompanies wind flow reversals near mid-days, especially in the summertime. An example of a vertical wind profile during such an occurrence is given in Table 1. The table shows the extreme variation in wind direction with height that occurred at these times. There is roughly a 180 degree wind shift moving from the lower levels of the atmosphere to the higher levels during both hours. These vertical wind profiles and the wind roses in Figures 2a, 2b, and 2c show a complex and variable vertical wind field that would not be reproducible with a steady-state model.

Section II. Ability of CALPUFF to Model Near-Field Impacts

In this application, CALPUFF is used because it has the ability to treat certain important complex flow and dispersion conditions in a more refined way than other regulatory models. In the near-field, CALPUFF contains three important features that allow a refined treatment of impacts. One is the ability of CALPUFF to account for spatial variability in meteorological conditions such as wind speed and direction, stability, and temperature gradient variations over the domain. In complex terrain, winds often change dramatically over short distances. When performing near-field analyses in such conditions, the use of a model such as CALPUFF provides advantages due to its ability to represent complex spatially varying flow conditions with variable and curved plume trajectories. Steady-state (straight-line) plume models such as Aermod cannot represent the spatial variability in the meteorological fields due to the nature of the steady-state assumption.

The second important feature of the CALPUFF approach is its ability to track emissions during stagnation and light wind speed conditions. In valley situations, nocturnal temperature inversions often develop that can trap pollutants released over several hours. CALPUFF allows pollutants emitted under such conditions to be tracked, and after the

Photo 1. View of Portland Power Plant Looking Northwest

Photo 2. View of Portland Power Plant Looking South

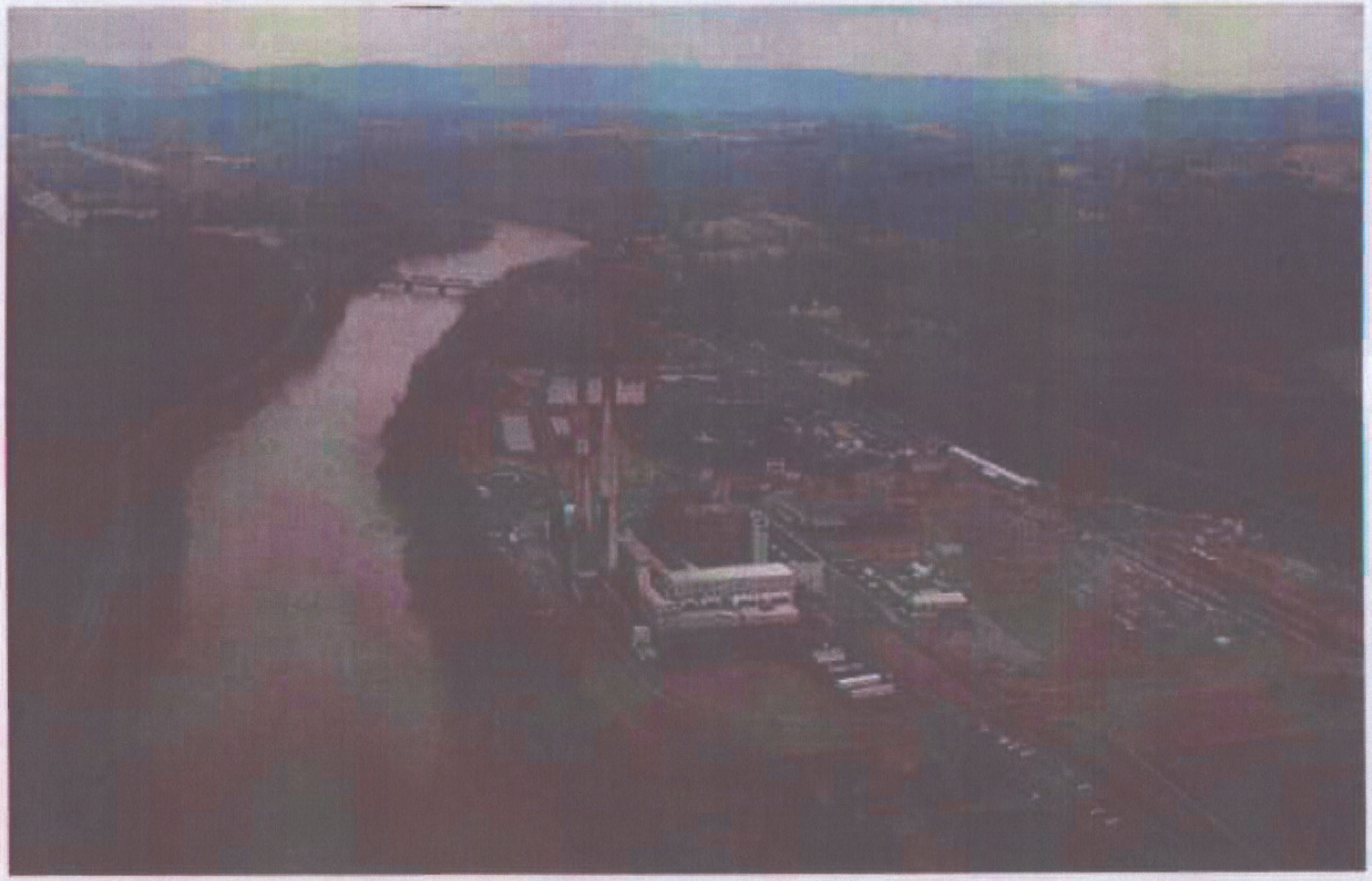


Table 1. Example of Profile Wind Direction/Speed Data Collected at the Portland Site (Hours 11 and 12, July 18, 1993)

Hour	Height of Measurement above ground (m)	Portland Site [a]	
		Wind Direction (deg.)	Wind Speed (m/s)
11	10	ND	ND
	30	274	1.74
	90	291	1.61
	120	257	0.77
	150	247	0.68
	180	253	0.50
	210	284	0.24
	240	328	0.32
	270	336	0.33
	300	35	0.49
	330	47	0.82
	360	46	1.15
	390	52	1.21
	420	63	1.25
	450	58	1.24
	480	45	1.15
	510	36	1.06
12	10	ND	ND
	30	213	1.65
	90	217	1.56
	120	295	0.63
	150	312	0.76
	180	327	0.79
	210	343	0.82
	240	5	0.75
	270	17	0.61
	300	26	0.48
	330	33	0.38
	360	16	0.34
	390	31	0.38
	420	35	0.41
	450	43	0.52
	480	40	0.45
	510	45	0.58

a. Measurement site on valley ridge 610 ft amsl.

ND = No data

inversion breaks up in the morning heating period, for this material to be subject to transport into the valley. Steady-state models do not allow for emissions during periods other than the current hour to be considered in the calculation of concentrations.

Third, CALPUFF contains detailed algorithms consistent with regulatory procedures to evaluate impacts at source-receptor distances of a few meters up to several hundred kilometers. Algorithms important in the near field that are part of the CALPUFF model include the PRIME building downwash algorithm, stack tip downwash, transitional plume rise, rain cap effects, and other near-field factors.

In the evaluation of compliance with the PM-2.5 and sulfur dioxide NAAQS, the impacts of stacks at several different heights were included. Emission release heights varied from ground-level to 400 ft. The need to simulate the potential plume impacts from a variety of sources in a vertically varying complex flow field is best done within the framework of a non-steady-state model such as CALPUFF. The ability to treat stagnation and inversion breakup conditions, drainage valley winds, flow reversals and pollutant recirculation are all non-steady-state features that are important in this application. Use of a steady-state model such as Aermod would be inappropriate in this situation.

Section 2.1 CALMET Wind Fields at Portland Power Plant

CALMET is a diagnostic meteorological model that produces three-dimensional wind fields for CALPUFF based on parameterized treatments of terrain effects such as slope flows and terrain blocking effects. In this analysis, the three-dimensional wind fields in a 50 km by 50 km centered grid centered on the Portland Power Plant were generated with the following inputs:

- One year of meteorological data (2002) from the Mesoscale Model Version 5 (MM5) with 12km grid spacing. Therefore, there were at least 16 MM-5 data points in the modeling grid. This same data set was previously used in the 8-hour ozone CMAQ modeling conducted for the OTC states' ozone SIPs and is currently being used for the annual PM-2.5 SIP modeling in the Northeast U.S.

- 10 nearby NWS ASOS hourly surface stations data

- Albany NY, Brookhaven NY, and Dulles VA NWS upper air stations twice daily observations data.

- 3 NOAA hourly buoy data (located off the coasts of Long Island NY, New Jersey, and Virginia.

- Geophysical data from the USGS 1 degree digital elevation model (DEM) and USGS Land use Land coverage files.

CALMET used the above data to generate wind fields with a 250 meter grid spacing. This small grid cell size provided a very precise definition of the wind fields. The 250 meter grid extended for 200 rows and 200 columns throughout the entire 50 km by 50 km modeling grid. The atmosphere was divided into 12 layers in the vertical.

Section 2.2 Comparison of CALMET and Meteorological Data Measured Near Portland Power Plant during Meteorological Conditions of Concern

CALMET winds can be compared against the meteorological measurements collected near the Portland site that were described earlier. Some differences are expected because of the following:

- The two meteorological data sets represent different time periods, July 1993 – June 1994 for the SODAR measurements and 2002 CALMET winds,

- The SODAR wind measurements represent a specific level of the atmosphere while the CALMET winds represent the average winds through a given depth of the atmosphere.

However, a qualitative comparison of the general wind patterns is possible. Figure 3a shows the wind rose at 10 meters above ground (average winds in the surface to 20 meter layer of the atmosphere) that was calculated by CALMET at the location of the Unit 1 and 2 stacks. The low wind speeds and alignment of drainage winds with the valley axis shown in Figure 3a is what would be expected of winds at the bottom of the Delaware River Valley. Though some of the difference between Figure 2a and Figure 3a are due to the different time periods represented by the wind roses, it is clear that Figure 3a is a better representation of low-level winds at the Portland Power Plant site than the winds collected at the Portland meteorological site on the ridge. Figure 3b shows the wind rose at 185 meters above ground (average winds in the 150 meter to 220 meter layer of the atmosphere) that were calculated by CALMET at the location of the Unit 1 and 2 stacks. This wind rose accurately depicts the reduced influence of the river valley on winds with at higher levels above the valley floor. At this height, winds reflect more of the synoptic flow in the free atmosphere above the valley similar to what is seen in Figure 2b. Figure 3c shows the wind rose at 300 meters above ground (average winds in the 220 meter to 380 meter layer of the atmosphere) that were calculated by CALMET at the location of the Unit 1 and 2 stacks.

Comparisons with the measured meteorological data also suggest that CALMET is accurately predicting the frequency of the low wind speed, stagnant conditions at the site. Table 2 compares the frequency of low wind speeds and average wind speed measured at the Portland meteorological station with those predicted by CALMET at the Portland Power Plant site. In this case, low wind speeds are defined as 2.0 m/s or less (4 kts or less). The comparison is done at four levels, 120 m, 180 m, 300 m, and 500 m. These levels were chosen because they represent the heights above ground where the CALMET and SODAR measurements most closely match.

Table 2. Comparison between CALMET and SODAR Wind Measurements

Approx. Height Above Ground	CALMET Winds (2002)		SODAR Winds(July 93-June 94)	
	2.0 m/s or less	Avg. Wind Speed	2.0 m/s or less	Avg. Wind Speed
120 meters [a]	12.1 %	5.0 m/s	15.7 %	4.9 m/s
180 meters [b]	9.3 %	5.9 m/s	9.8 %	5.9 m/s
300 meters [c]	7.2 %	6.8 m/s	5.3 %	7.4 m/s
5000 meters [d]	5.3 %	8.1 m/s	4.1 %	9.1 m/s

a. SODAR 120 meter level, CALMET 115 meter level (avg. between 80 – 150 meters).
b. SODAR 180 meter level, CALMET 185 meter level (avg. between 150 – 220 meters).
c. SODAR 300 meter level, CALMET 300 meter level (avg. between 220 – 380 meters).
d. SODAR 510 meter level, CALMET 500 meter level (avg. between 380 – 620 meters).

The table shows fairly good agreement between the two in the time of stagnant winds (2 m/s or less) and the average wind speed in light of the difference in time periods compared (2002 vs. July 1993 thru June 1994) and the fact that CALMET winds represent the average winds through a given depth of the atmosphere, not a specific level as represented by the SODAR wind measurements.

The three wind roses in Figures 3a thru 3c and Table 2 support the conclusion that the CALMET generated wind fields in the vicinity of the Portland Power Plant accurately reflect the actual wind fields.

Section 2.3 CALMET Wind Fields during Meteorological Conditions of Concern

As mentioned in the previous section, stagnation conditions and wind flow reversals near mid-day are meteorological conditions of concern. The wind fields during these meteorological conditions of concern have been evaluated by two methods. One analysis looked at the wind field throughout the entire grid that was generated by CALMET at two different levels. This was done for two periods of the highest and high, second-high 3-hour SO_2 concentrations. The other analysis examined the entire vertical profile of the CALMET generated winds at one site, the location of the Portland Power Plant. This was done for the seven episodes that produced the highest 3 and 24-hour violations of the NAAQS.

Section 2.3.1 Entire CALMET Wind Field

The following examines the two cases where these meteorological conditions resulted in the high and high, second-highest 3-hour sulfur dioxide predictions.
(Note: in the figures surface winds represent the average winds between the ground and 20 meters and 150 meter winds represent the average winds between 150 and 220 meters). The first example of this meteorological condition occurred on September 18, 2002, hours 12 -14. The CALMET wind speed and wind direction output for these hours, as well as the two preceding hours have been plotted at both the surface level and 150 meters above the surface. Figures 4 thru 13 show the winds at these two levels for hours 10 – 14. As can be seen in Figures 4 and 5, initially at hour 10 winds at both levels are

fairly uniformly out of the northeast. Hour 11 (Figures 6 and 7) shows the winds decreasing. By hour 12 (Figures 8 and 9), the first hour of high impacts, winds at both levels have stagnated everywhere in the river valley. These conditions continue through hour 13 (Figures 10 and 11). By hour 14 (Figures 12 and 13), winds at the 150 meter have begun to increase in velocity and are generally in a south/southwest direction. The higher 150 meter level winds seen on the Pocono Plateau (the northwest corner of the figure) are expected due to the high elevation in that region.

Another example of a flow reversal/stagnation condition occurred on July 19, 2002, hours 9 – 11. Figures 14 thru 23 show the CALMET output for these hours, as well as the previous and following hours. The wind flows during these hours are similar to those of the September 18 case. On hour 8 (Figures 14 and 15), winds are from the northeast. Hour 9 (Figures 16 and 17) and hour 10 (Figures 18 and 19) show stagnation conditions at both levels. By hour 11 (Figures 20 and 21), winds have begun to shift and are now from the southwest. In hour 12 (Figures 22 and 23) the southwest wind flow continues but with higher velocities. This horizontal and vertical wind variability clearly meets the criteria in Section 7.2.8 of the GAQM describing inhomogeneous flow and confirms the need for use of a non-steady state model such as CALPUFF.

Section 2.3.2 CALMET Wind Profiles

The CALMET generated winds at the site of the Portland Power Plant have been examined for time periods that produced the highest 3 and 24-hour violations of the NAAQS. Unlike Figures 4 through 23, the entire vertical profile at a single location was evaluated. The days with the two highest sulfur dioxide 24-hour average concentrations and the days with the seven highest 3-hour averages were evaluated. The wind speeds have been rounded to the nearest tenth of a meter per second.

Table 2 shows the wind profile of hours 11 through 18 on July 18th, 2002, the day when both the highest 3-hour and highest 24-hour sulfur dioxide impacts were predicted to occur. Up through the lowest 600 meters of the atmosphere winds are near stagnant (less than 1.0 m/s) from hours 13 through 17. The winds in this layer move from northeast (hours 11-12), to northwest (hour 13), to west (hours 14 and 15), to southwest (hours 16 and 17), to south-southeast (hour 18) at the end of the period.

Table 3 shows the wind profile of hours 11 through 18 on October 24th, 2002, a day of high 3-hour impacts and the highest, second-high 24-hour sulfur dioxide impact. While winds are generally light throughout the time period, they are near stagnant up through the lowest 600 meters of the atmosphere winds from hours 12 through 15. Winds in this layer start from the east (hour 11) but swing around to the southwest by hour 14.

Table 4 shows the wind profile of hours 8 through 12 on July 19th, 2002, the day of the highest, second-high 3-hour impact. Though there is some wind shift during this time period from north to southwest, the principal characteristic of this episode are the very low wind speeds. The wind speeds in hours 10 and 11 in the lower 600 meters of the atmosphere are especially low.

Table 5 shows the wind profile of hours 12 through 15 on March 14th, 2002, a day of high 3-hour impacts. The wind characteristics of this episode are similar to that in the previous episode (Table 4). There is a modest wind shift (this time from north to west) and very low wind speeds, especially in hours 14 and 15.

Table 6 shows the wind profile of hours 9 through 13 on July 15th, 2002, a day of high 3-hour impacts. The wind characteristics of this episode show a wind shift from the east-northeast (hours 9 and 10), through southeast (hour 12), to south (hour 13). There are also very low wind speed, stagnant conditions in hours 10 through 13.

Table 7 shows the wind profile of hours 12 through 17 on September 6th, 2002, a day of high 3-hour impacts. The wind characteristics of this episode show a wind shift from northeast (hours 12 and 13), to northwest (hours 14-15), to west-northwest (hour 13). Low wind speeds less than 1 m/s occur in hours 14 through 17.

Table 8 shows the wind profile of hours 10 through 14 on September 7th, 2002, a day of high 3-hour impacts. For almost all hours and all levels below 600 meters, winds are less than 0.5 m/s. Due to the light winds the wind direction is extremely variable throughout the entire.

Table 3. September 18 / Julian Day 261
Highest 3-Hour (Hours 12-14) and Highest 24-Hour (Hours 0 - 23) SO_2 Impacts

Height Above Ground (m)	Hour	Wind Speed (m/s)	Wind Direction (deg.)	Hour	Wind Speed (m/s)	Wind Direction (deg.)
10	11	1.4	59	12	0.8	58
50		1.4	48		0.9	39
115		1.5	47		1.0	40
185		1.5	47		1.0	41
300		1.9	62		1.0	45
500		3.2	88		1.2	61
800		2.3	101		1.3	82
1200		2.2	49		2.4	54
1640		6.0	39		6.0	47
2300		8.8	36		9.0	45
2960		9.1	37		8.9	45
10	13	0.1	355	14	0.1	236
50		0.4	342		0.6	287
115		0.4	345		0.6	286
185		0.4	351		0.6	286
300		0.4	3		0.5	284
500		0.3	36		0.4	279
800		0.6	81		0.1	212
1200		2.7	72		1.7	97
1640		6.0	55		5.7	66
2300		8.7	51		8.6	58
2960		8.3	52		7.8	61
10	15	0.1	229	16	0.3	227
50		0.6	275		0.6	258
115		0.6	274		0.6	255
185		0.6	272		0.6	251
300		0.5	269		0.6	243
500		0.5	260		0.6	226
800		0.3	225		0.7	189
1200		1.3	128		2.0	146
1640		5.1	79		4.8	91
2300		8.2	65		7.7	75
2960		7.1	68		6.2	78
10	17	0.6	209	18	0.4	194
50		0.7	243		0.8	175
115		0.7	239		1.3	153
185		0.7	232		1.7	146
300		0.7	223		1.7	146
500		0.8	203		1.8	147
800		1.2	176		1.8	148
1200		2.8	156		1.9	149
1640		4.5	101		3.5	100
2300		7.4	86		7.0	95
2960		5.5	90		5.3	100

Table 4. October 24 / Julian Day 297

High 3-Hr (Hours 12-14) and Highest, 2nd-High 24-Hr (Hours 0 - 23) SO_2 Impacts

Ht. Above Ground (m)	Hour	Wind Speed (m/s)	Wind Direction (deg.)	Hour	Wind Speed (m/s)	Wind Direction (deg.)
10	11	0.9	100	12	0.7	128
50		0.9	105		0.7	142
115		1.0	107		0.8	140
185		1.3	93		0.8	139
300		1.7	74		0.9	133
500		1.4	62		1.1	111
800		2.0	12		1.2	25
1200		4.9	316		4.6	309
1640		8.6	298		8.4	294
2300		14.4	292		14.0	290
2960		18.7	288		18.3	285
10	13	0.4	171	14	0.4	211
50		0.6	187		0.8	221
115		0.6	184		0.7	220
185		0.6	181		0.7	219
300		0.6	173		0.7	215
500		0.7	144		0.5	191
800		0.8	59		0.3	99
1200		4.3	301		3.8	294
1640		8.2	289		8.0	284
2300		13.5	287		12.9	285
2960		18.0	283		17.7	280
10	15	0.6	227	16	0.9	222
50		1.0	227		1.2	226
115		0.9	226		1.1	225
185		0.9	224		1.1	223
300		0.8	221		1.0	219
500		0.6	204		0.7	199
800		0.3	150		0.5	146
1200		3.5	291		4.1	293
1640		8.1	282		8.3	284
2300		12.8	282		13.1	279
2960		17.8	278		18.5	275
10	17	1.0	210	18	1.1	204
50		1.1	216		1.3	215
115		1.1	219		1.2	217
185		1.0	223		1.1	223
300		0.8	237		0.7	236
500		0.6	296		0.5	315
800		1.9	316		2.2	322
1200		5.3	296		5.5	302
1640		8.7	286		9.2	283
2300		14.0	271		14.9	267
2960		19.0	272		19.3	270

Table 5. July 19 / Julian Day 200
Highest 2nd-High 3-Hour (Hours 9 – 11) SO_2 Impacts

Height Above Ground (m)	Hour	Wind Speed (m/s)	Wind Direction (deg.)	Hour	Wind Speed (m/s)	Wind Direction (deg.)
10	8	0.5	354	9	0.5	15
50		1.5	24		0.6	14
115		2.6	360		0.6	17
185		2.6	340		1.0	9
300		2.4	334		2.1	334
500		2.3	312		2.3	303
800		2.7	303		2.7	295
1200		3.5	303		3.5	298
1640		4.7	300		4.6	299
2300		6.4	290		6.3	291
2960		7.2	279		7.3	282
10	10	0.1	356	11	0.1	314
50		0.3	3		0.2	341
115		0.3	4		0.1	336
185		0.3	6		0.1	339
300		0.4	355		0.1	331
500		1.7	304		0.3	287
800		2.7	288		1.9	284
1200		3.5	290		3.3	282
1640		4.4	293		4.0	286
2300		6.1	289		5.6	287
2960		7.2	283		7.1	283
10	12	0.6	260			
50		0.6	264			
115		0.6	262			
185		0.5	257			
300		0.6	245			
500		0.7	234			
800		1.2	248			
1200		3.1	273			
1640		4.0	275			
2300		5.4	280			
2960		7.0	280			

Table 6. March 14 (Julian Day 73)
High 3-Hour (Hours 12-14) SO_2 Impacts

Height Above Ground (m)	Hour	Wind Speed (m/s)	Wind Direction (deg.)	Hour	Wind Speed (m/s)	Wind Direction (deg.)
10	12	2.7	4	13	1.4	5
50		2.6	3		1.3	5
115		2.6	3		1.3	5
185		2.6	3		1.2	5
300		2.7	3		1.3	5
500		4.8	4		1.6	9
800		9.7	348		7.2	353
1200		12.6	322		10.4	323
1640		15.9	300		14.4	298
2300		20.1	291		19.1	286
2960		22.4	287		21.7	281
10	14	0.2	353	15	0.4	224
50		0.2	347		0.6	230
115		0.4	346		0.6	228
185		0.3	347		0.7	225
300		0.3	345		0.7	222
500		0.3	350		0.8	218
800		2.7	357		0.8	324
1200		8.5	327		6.8	325
1640		12.8	296		11.3	291
2300		18.4	281		17.5	275
2900		21.4	275		21.0	270

Table 7. June 15 / Julian Day 166
High 3-Hour (Hours 9 – 11) SO_2 Impacts

Height Above Ground (m)	Hour	Wind Speed (m/s)	Wind Direction (deg.)	Hour	Wind Speed (m/s)	Wind Direction (deg.)
10	9	1.3	66	10	0.7	75
50		1.3	60		0.8	69
115		1.3	59		0.8	69
185		1.2	55		0.8	67
300		1.9	73		0.8	68
500		4.7	102		2.9	117
800		2.2	148		1.8	205
1200		2.8	265		3.7	269
1640		4.4	258		4.7	249
2200		10.0	244		10.0	241
2960		14.6	240		14.7	240
10	11	0.1	11	12	0.1	165
50		0.3	68		0.1	160
115		0.3	69		0.1	143
185		0.3	72		0.1	146
300		0.4	71		0.2	148
500		1.9	132		0.9	167
800		2.2	243		3.0	258
1200		4.5	274		5.3	269
1640		5.0	242		6.1	241
2300		9.9	238		10.3	237
2960		14.7	238		14.6	238
10	13	0.1	182			
50		0.2	178			
115		0.3	174			
185		0.3	174			
300		0.4	172			
500		0.9	191			
800		3.6	255			
1200		6.1	262			
1640		7.3	244			
2300		10.6	238			
2960		14.5	239			

Table 8. September 6 / Julian Day 249
High 3-Hour (Hours 15 – 17) SO_2 Impacts

Height Above Ground (m)	Hour	Wind Speed (m/s)	Wind Direction (deg.)	Hour	Wind Speed (m/s)	Wind Direction (deg.)
10	12	1.6	43	13	0.8	32
50		1.5	37		1.1	18
115		1.5	38		1.1	19
185		1.5	39		1.1	21
300		1.6	41		1.1	24
500		1.6	47		1.1	31
800		2.4	53		1.4	46
1200		5.6	27		5.3	39
1640		6.2	22		6.0	29
2300		5.1	15		4.5	14
2960		5.0	1		4.1	57
10	14	0.4	14	15	0.3	3
50		0.7	340		0.7	310
115		0.7	342		0.7	310
185		0.7	344		0.7	311
300		0.6	349		0.7	313
500		0.6	359		0.6	318
800		0.7	30		0.5	345
1200		4.6	50		2.8	59
1640		5.9	35		5.7	42
2300		3.9	13		3.6	9
2960		3.3	350		3.1	342
10	16	0.2	326	17	0.2	299
50		0.7	296		0.7	287
115		0.7	296		0.6	286
185		0.6	296		0.6	286
300		0.6	297		0.5	287
500		0.6	303		0.4	292
800		0.5	333		0.3	341
1200		1.6	72		1.5	91
1640		5.2	50		4.6	56
2300		3.5	5		3.6	0
2960		3.3	336		3.7	333

Table 9. September 7 / Julian Day 250
High 3-Hour (Hours 12 – 14) SO_2 Impacts

Height Above Ground (m)	Hour	Wind Speed (m/s)	Wind Direction (deg.)	Hour	Wind Speed (m/s)	Wind Direction (deg.)
10	10	0.0	349	11	0.1	68
50		0.1	5		0.1	59
115		0.1	8		0.1	55
185		2.7	61		0.2	53
300		2.1	72		1.3	81
500		1.6	92		1.7	95
800		1.4	96		1.8	91
1200		2.7	81		3.2	83
1640		3.5	85		3.9	86
2300		3.0	70		3.6	70
2960		3.2	41		3.9	50
10	12	0.0	139	13	0.1	174
50		0.1	201		0.3	216
115		0.1	204		0.3	211
185		0.1	202		0.3	208
300		0.1	142		0.3	197
500		0.6	113		0.4	171
800		1.8	99		1.2	123
1200		3.2	87		3.2	100
1640		3.9	88		3.6	92
2300		3.9	72		3.9	74
2960		4.1	56		3.9	61
10	14	0.2	178			
50		0.5	223			
115		0.5	220			
185		0.5	216			
300		0.5	209			
500		0.5	192			
800		0.8	152			
1200		3.4	114			
1640		3.6	99			
2300		3.8	76			
2960		3.6	66			

Section 2.4 Previous Examples of Use of CALPUFF in the Near-Field

The CALPUFF model has been used in a number of near-field regulatory applications where complex flow or dispersion conditions were considered important. A partial list of near-field regulatory modeling studies with CALPUFF includes the following:

1) Proposed coal fired power plant (Dominion Virginia Power Hybrid Energy Center, Wise County, Virginia): CALPUFF with MM5 data used for both the near-field analysis and Class I analyses. Use of CALPUFF for the near-field modeling was approved by Virginia DEQ and EPA Region III.

2) Proposed coal fired power plant (Desert Rock 1500 MW Energy Facility, San Juan County, New Mexico): CALPUFF with MM5 data used for both the near-field analysis and Class I analyses. Use of CALPUFF for the near-field modeling was approved by EPA Region IX (the site is located on tribal land and hence is subject to Region IX approval.) The near-field analysis included emissions from roads and mining activities as well as point source emissions.

3) Near-field PM10 modeling of the Holcim Lee Island facility in St. Genevieve County Missouri: PSD modeling of PM_{10} emissions from roads and point sources in the near-field of a cement plant, including at the property-line. Use of CALPUFF was approved by EPA Region VII and the Missouri Department of Natural Resources.

4) Mt. Holly Aluminum Facility, Goose Creek, South Carolina: CALPUFF was used for Class I and Class II (near-field) PSD analyses of PM_{10}, NO_x, and toxic pollutant modeling. The modeling was approved by the South Carolina Department of Health and Environmental Control.

5) Badin, North Carolina: Near-field toxic pollutant modeling of an aluminum smelter in support of a permit application of two new sources at the facility. Use of CALPUFF for the near-field analysis was approved by the North Carolina department of environment and Natural Resources.

6) Warrick Power Plant, SIGECO Power Plant and Warrick smelter (Warrick, Indiana): Near-field CO modeling analysis of these and background CO sources were used in a regulatory cumulative CO modeling analysis. Use of CALPUFF for near-field analysis was approved by the Indiana Department of Environmental Management.

7) PSD Class II analyses for an expansion of a facility in Ferndale, Washington: CALPUFF was used in support of both Class I and Class II PSD analyses to evaluate the impacts of PM_{10}, CO, HF, and NO_x for a PSD permit. Use of CALPUFF for both the near-field and far-field analyses was approved by EPA Region X and the Washington State Department of Ecology.

8) Alcoa Massena East aluminum plant: Toxic pollutant modeling of emissions of HF, COS, and PAHs in the near-field of the facility. Use of CALPUFF approved by the New York State Department of Environmental Conservation.

9) HF modeling of a smelter in complex terrain, Malaga, Washington: The use of CALPUFF for near-field HF modeling analysis of an industrial facility in Wenatchee, Washington was approved by the Washington State Department of Ecology. The site is located in complex terrain in the Columbia River Valley.

Section III. Inability of AERMOD to Model Near-Field Impacts

AERMOD is EPA's recommended refined model for traditional point sources. As noted earlier, AERMOD is a steady-state (straight-line) plume model. A critical limitation of a steady-state model is its inability to respond to terrain-induced spatial variability in wind fields or to changes in dispersion conditions resulting from changes in surface characteristics. When transporting and dispersing a plume from a stack, AERMOD uses a spatially invariant wind field (the entire modeling grid is assumed to have one wind direction in both vertically and horizontally). The straight-line plume transport used by AERMOD is based on the wind observations from a single location. Unlike CALPUFF, a variable or curved trajectory by the plume is not possible. Therefore, as a steady-state model, AERMOD cannot represent the three-dimensional variability in the meteorological fields, will not treat stagnation, will not track plume (puff) transport over time, and cannot assess the impact of wind reversals. Accordingly, AERMOD is not appropriate for modeling impacts from Portland's emissions.

Section 3.1 Inability of AERMOD to Model Meteorological Conditions of Concern

The stagnation conditions and wind flow reversals near mid-day are meteorological conditions of concern. AERMOD will have very limited capabilities in modeling stagnation conditions with very low wind speeds and variable wind directions. EPA's *Guideline on Air Quality Models* states in Section 8.3.4.2(b):

"Stagnant conditions that include extended periods of calms often produce high concentrations over wide areas for relatively long averaging periods. The standard steady-steady Gaussian plume models are often not applicable to such situations. When stagnation conditions are of concern, other modeling techniques should be considered on a case-by-case basis (see also subsection 7.2.8)."

AERMOD will not account for the time required for the plume to reach a receptor and will not track the plume over several hours. Therefore, wind reversals that bring the previously emitted plume back into an area of concern as well as puffs that linger in the vicinity of the plant over several hours during stagnation conditions would be ignored. In an hours travel time the plume will only be transported 2 km from the stack when wind speeds are 0.6 m/s, and only 1 km from the stack when the wind speed is 0.3 m/s.

Section 3.2 Available Meteorological Data for Use in AERMOD

An important secondary reason for not using AERMOD to quantify the impacts from the Portland Power Plant is the lack of a representative meteorological data set needed for such modeling. The only meteorological data measurements taken near the Portland Generating Station were collected from July 1993 to June 1994. The meteorological site was designed to collect data for the CTDMPlus model.

Guidance on the requirements of meteorological data used in AERMOD is given in Appendix A. Section 8.3.c of the Guideline on Air Quality Models. It states:

> "Of paramount importance is the requirement that all meteorological data used as input to AERMOD must be both laterally and vertically representative of the transport and dispersion within the analysis domain."

Measurements of the meteorological conditions taken at a single point will not reflect the three-dimensional local terrain and mesoscale winds, temperature, and stability variations in the modeling grid near the Portland site. The 1993-94 meteorological data that would be used in the AERMOD model runs does not accurately represent the horizontal varying turbulence and dispersion rates, as well as the vertical wind shear and differential advection at the Portland site. An additional potential problem with use of this meteorological data in AERMOD is the sigma-w (σ_w) measurements. Measured at both 30 m and 100 m level on the meteorological tower, the reported values of σ_w below 0.05 m/s were set to 0.05 m/s due to limitations in the vertical wind propeller. As discussed in Section 7.3.5 (Measured Turbulence) of the document *AERMOD: Description of Model Formulation*, a reasonable minimum of σ_w values which is used by AERMOD is 0.02 m/s.

Section IV. EPA's Guideline on Air Quality Models

The Guideline on Air Quality Models (GAQM) discusses the use of preferred and alternative models in various situations. The CALPUFF model is recommended as a preferred model in Appendix A of the GAQM for situations involving long range transport and on a case-by-case basis for near-field applications involving complex flows. In Appendix A, Section A.4.a (Recommendations for Regulatory Use) the following is stated concerning use of CALPUFF in the near field:

> *CALPUFF may also be used on a case-by-case basis if it can be demonstrated using the criteria in Section 3.2 that the model is more appropriate for the specific application. The purpose of choosing a modeling system like CALPUFF is to full treat stagnation, wind reversals, and time and space variations of meteorological conditions on transport and dispersion, as discussed in paragraph 7.2.8(a).*

In Section 7.2.8(a) (Complex Winds) of the GAQM, the use of CALPUFF for near-field analyses is discussed:

> *Inhomogeneous Local Winds. In many parts of the United States, the ground is neither flat nor is the ground cover (or land use) uniform. These geographical variations can generate local winds and circulations, and modify the prevailing ambient wind and circulations. Geographic effects are most apparent when the ambient winds and light or calm. In general these geographically induced wind circulation effects are named after the source location of the winds, e.g., lake and sea breezes, and mountain and valley winds. In very rugged hilly or mountainous terrain, along coastlines, or near large land use variations, the characterization of the winds is a balance of various forces, such that the assumptions of steady-state straight-line transport both in time an space are inappropriate. In the special cases described, the CALPUFF modeling system (described in Appendix A) may be applied on a case-by-case basis for air quality estimates in such complex non-steady state meteorological conditions. The purpose of choosing a modeling system like CALPUFF is to fully treat the time and space variations of meteorology effects on transport and dispersion.*

Later in this section, the GAQM states "*setup and application of the model should be determined in consultation with the appropriate reviewing authority (paragraph 3.0(b)) consistent with the limitations in paragraph 3.2.2(e)*". In this case, New Jersey DEP is the reviewing authority. U.S. EPA Region II was also informed of NJDEP's use of MM5/CALMET/CALPUFF modeling approach that is being used.

Section 3.2.2(e) of the GAQM lists the following criteria for the use of an alternative refined model:

i. The model has received a scientific peer review;
ii. The model can be demonstrated to be applicable to the problem on a theoretical basis;
iii. The data bases which are necessary to perform the analysis are available and adequate;
iv. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and
v. A protocol on methods and procedures to be followed has been established.

Each of these items is discussed below. Much of this discussion was taken directly from the document *Use of CALPUFF for the Near-Field Class II Air Quality Modeling of a Proposed Coal-Fired Power Plant in Southwest Virginia*, prepared for Dominion Energy, prepared by TRC Environmental Corp., June 27, 2007. Approval for use of CALPUFF in this instance was given both by Virginia DEQ and EPA Region 3.

(1) The model has received a scientific peer review.

CALPUFF has received extensive peer review as part of the process resulting in its acceptance as a Guideline Model. In particular, the U.S. EPA commissioned a study entitled "Peer Review of CALMET/CALPUFF Modeling System" (Allwine et al., 1998). This document is available from the U.S. EPA modeling web site (http://www.epa.gov/scram001/7thconf/calpuff/calpeer.pdf).

In addition, the modeling system was one of the major subjects of the U.S. EPA's *7th Conference on Air Quality Modeling,* held on June 28-29, 2000 in Washington, D.C. The main purpose of the Conference was to receive comments on EPA's proposal to add several new modeling techniques, including CALPLUFF, to Appendix W of 40 CFR Part 51. An EPA document entitled "Summary of Public Comments and EPA Responses, 7th Conference on Air Quality Modeling, Washington, DC, June 28-29, 2000 is available from the U.S. EPA web site:

http://www.epa.gov/scram001/guidance/guide/response.pdf

The CALPUFF model was a focus of a specialty conference sponsored by the Air & Waste Management Association (A&WMA) entitled *"Guideline on Air Quality Models: The Path Forward"* which was held in Mystic, Connecticut on October 22-24, 2003. A second specialty conference entitled *"Guideline on Air Quality Models: Applications and FLAG Developments"* was organized by the A&WMA in Denver, Colorado on April 26-28, 2006.

(2) The model can be demonstrated to be applicable to the problem on a theoretical basis.

The CALPUFF model was found to be appropriate on a theoretical basis to this type of application by the U.S. EPA-sponsored peer review study (Allwine et al., 1998) and in the public review process associated with the 7th Conference on Air Quality Modeling.

The Allwine et al. (1998) study concluded "the CALMET/CALPUFF modeling system is scientifically sound and represents a significant advancement in regulatory air quality modeling". Regarding the model formulation, the EPA-sponsored peer review study concluded:

> *The CALMET/CALPUFF modeling system represents the state-of the-practice insofar as dispersion models are concerned. The explicit integration of mesoscale meteorological models such as MM4/5 and CSUMM with a diagnostic, mass-consistent wind model in CALMET is an important and welcome advance in dispersion modeling. The model should serve as a flexible and robust system for a wide range of applications both in the near field and the far field. CALMET provides the ability to stimulate a number of important local effects, such as: slope flows, kinematic terrain effects, terrain blocking, and sea breeze circulations.*

Note the conclusion of the applicability of the model formulation includes the near-field. The result of scientific review of the model formulation conclusion resulted in CALPUFF being recommended by the U.S. EPA in Section 7.2.8 of the GAQM: *"CALPUFF modeling system (described in Appendix A) may be applied on a case-by-case basis for air quality estimates in such complex non-steady-state meteorological conditions. The purpose of choosing a modeling system like CALPUFF is to fully treat the time and space variations of meteorology effects on transport and dispersion."*

(3) The data bases which are necessary to perform the analysis are available and adequate.

The data base used in the Portland study were more than sufficient for this purpose. A fine-resolution prognostic meteorological model simulation with the MM5 model was conducted in the area that provided high quality, three-dimensional meteorological fields to use as input into the CALMET meteorological model. MM5 was run for 2002 with a 12 km resolution. CALMET was run with a grid resolution of 250 meters using MM5 fields along with meteorological observations from 10 NWS surface stations, 3 upper air stations (Albany NY, Brookhaven NY, and Dulles VA), and 3 NOAA ocean buoys to develop three-dimensions, spatially-varying wind fields.

(4) Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates.

The CALPUFF model has been extensively evaluated for use in both near-field and far-field applications. The GAQM refers to nine different model evaluation studies of CALPUFF and its meteorological model CALMET:

Berman, S., J.Y. Ku, J. Zhang and S.T. Rao, 1977. Uncertainties in estimating the mixing depth - Comparing three mixing depth models with profiler measurements, *Atmospheric Environment*, 31: 3023-3039.

Chang, J.C., P. Franzese, K. Chayantrakom and S.R. Hanna, 2001, Evaluations of CALPUFF, HPAC and VLSTRACK with Two Mesoscale Field Datasets. *Journal of Applied Meteorology*, 42(4): 453-466.

Environmental Protection Agency, 1998. Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long-Range Transport Impacts. EPA Publication No. EPA-454/R-98-019. Office of Air Quality Planning & Standards, Research Triangle Park, NC.

Irwin, J.S., 1997. A Comparison of CALPUFF Modeling Results with 1997 INEL Field Data Results. In Air Pollution Modeling and its Application, XII. Edited by S.E. Gyrning and N. Chaumerlia. Plenum Press, New York, NY.

Irwin, J.S., J.S. Scire and D.G. Strimaitis, 1996. A Comparison of CALPUFF Modeling Results with CAPTEX Field Data Results. In *Air Pollution Modeling and its Application, XI*. Edited by S.E. Gyrning and F.A. Schiermeier. Plenum Press, New York, NY.

Morrison, K, Z-X Wu, J.S. Scire, J. Chenier and T. Jeffs-Schonewille, 2003. CALPUFF-Based Predictive and Reactive Emission Control System. 96th A&WMA Annual Conference & Exhibition, 22-26 June 2003; San Diego, CA.

Schulman, L.L., D.G. Strimaitis and J.S. Scire, 2000. Development and Evaluation of the PRIME Plume Rise and Building Downwash Model. JAWMA, 50: 378-390.

Scire, J.S., Z-X Wu, D.G. Strimaitis and G.E. Moore, 2001. The Southwest Wyoming Regional CALPUFF Air Quality Modeling Study-Volume I. Prepared for the Wyoming Dept. of Environmental Quality. Available from TRC at http://www.src.com.

Strimaitis, D.G., J.S. Scire and J.C. Change, 1998. Evaluation of the CALPUFF Dispersion Model with Two Power Plant Data Sets. Tenth Joint Conference on the Application of Air Pollution Meteorology, Phoenix, Arizona. American Meteorological Society, Boston, MA. January 11-16, 1998.

Note that this list of model evaluation studies includes a near-field dataset for a power plant in complex terrain and a second dataset involving tall stack dispersion from a second power plant (Strimaitis et al., 1998). In addition, Morrison et al. (2003) is an evaluation with near-field monitors. This collection of model evaluation studies show that the model is not biased toward underprediction.

(5) A protocol on methods and procedures to be followed has been established.

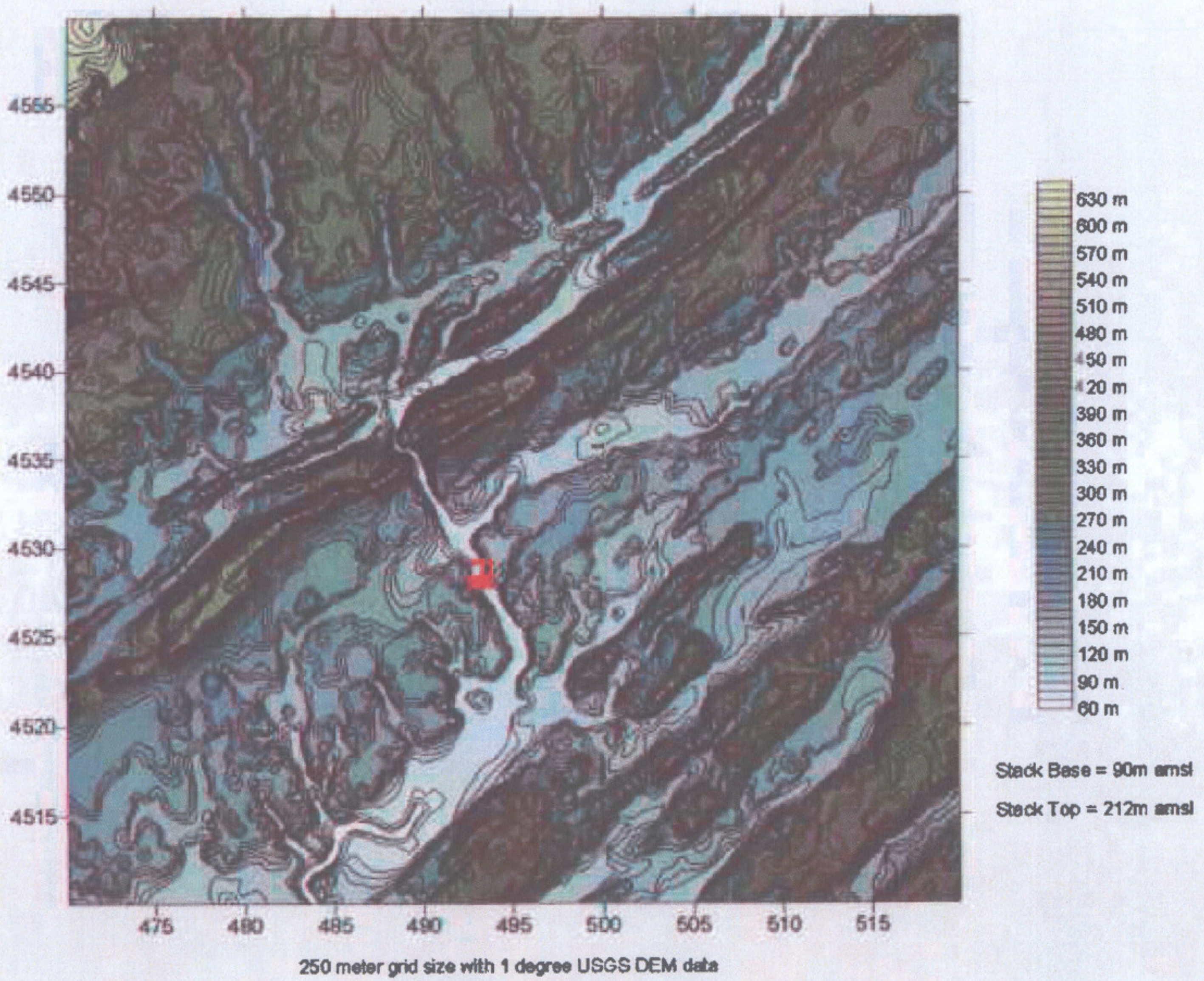
A memo describing the procedures and techniques used was prepared by BTS and shared with Region 2 EPA prior to the modeling. The memo describes the CALMET and CALPUFF model inputs. The CALMET input file was also e-mailed to EPA Region 2.

The conclusion from this analysis is that the CALPUFF model is recognized by the U.S. EPA as a suitable model for use in near-field, complex flow situations and that it meets all of the five criteria specified in Section 3.2.2(c) of the GAQM for this application.

References

Allwine, K.J. and C.D. Whiteman, 1985: MELSAR: A mesoscale air quality model for complex terrain: Volume 1-Overview, technical description and user's guide. Pacific Northwest Laboratory, Richland, Washington.

Figure 1. Calmet/Calpuff Terrain Resolution Used For Reliant Portland Generating Station Modeling Analysis



WIND ROSE PLOT:

30 meter Meteorological Tower Data
Portland Meteorological Site

DISPLAY:

Wind Speed
Direction (blowing from)

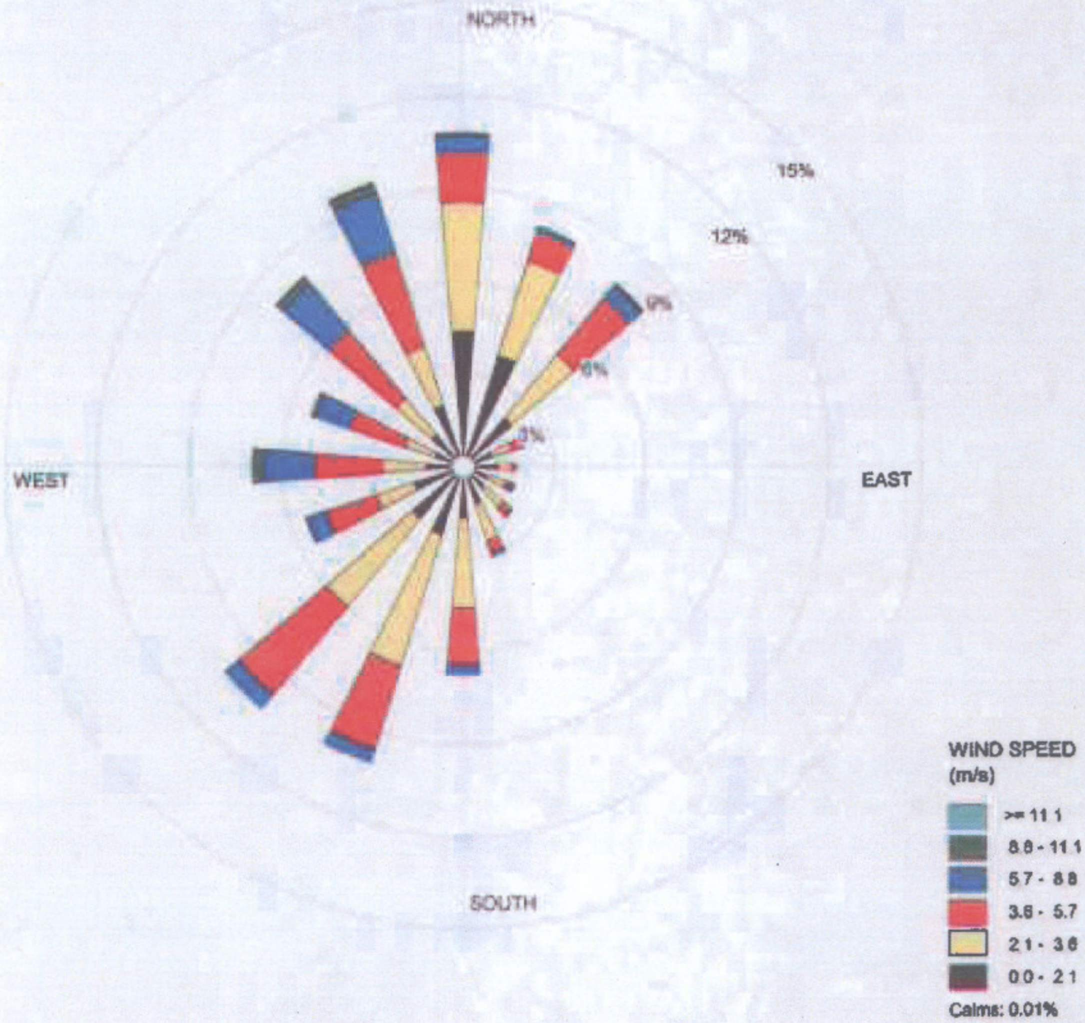


FIGURE 2a

CALM WINDS: 0.01%	TOTAL COUNT: 8760 hrs.
AVG. WIND SPEED: 3.41 m/s	DATE: 3/26/2008
PROJECT NO.:	

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

300 meter SODAR Data (July 1993 - June 1994)
Portland Meteorological Site

DISPLAY:
Wind Speed
Direction (blowing from)

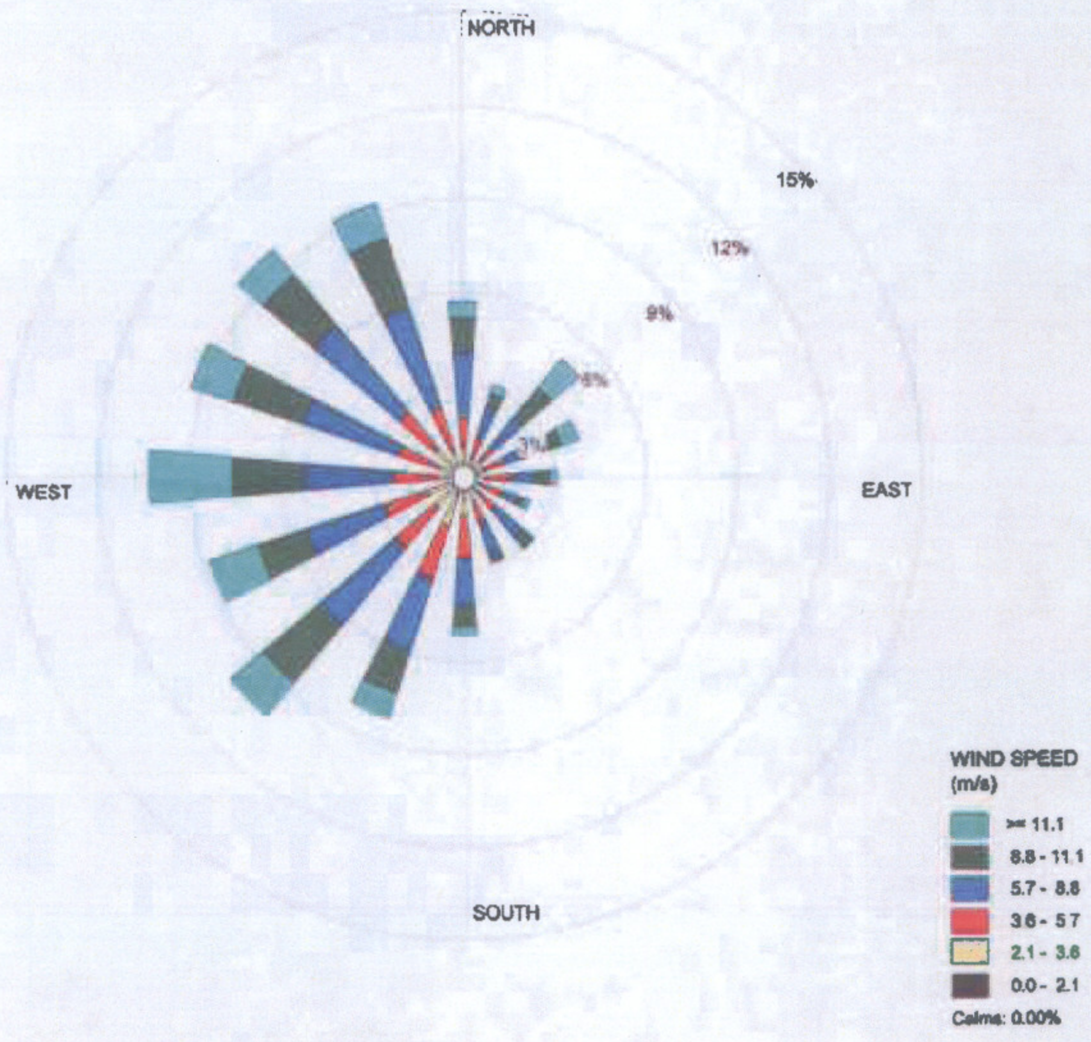


FIGURE 2c

CALM WINDS: 0.00%	TOTAL COUNT: 8015 hrs.
AVG. WIND SPEED: 7.35 m/s	DATE: 4/10/2008

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

10 meter CALMET 2002 Data (surface to 20 m above ground)
Portland Power Plant Site

DISPLAY:
Wind Speed
Direction (blowing from)

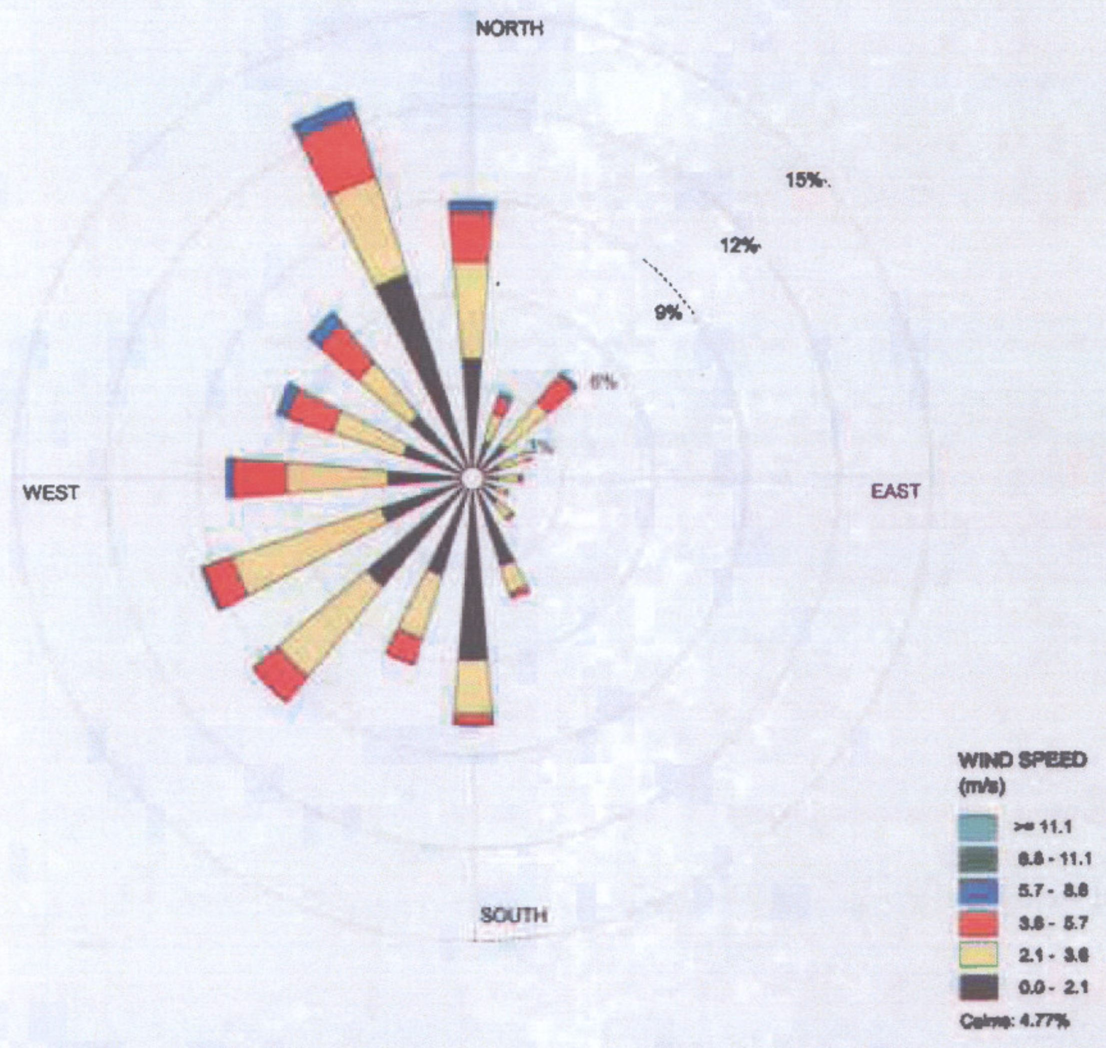


FIGURE 3a

CALM WINDS:	TOTAL COUNT:	
4.77%	8719 hrs.	
AVG. WIND SPEED:	DATE:	PROJECT NO.:
2.22 m/s	4/10/2008	

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

185 meter CALMET 2002 Data (150 to 220 m above ground)
Portland Power Plant Site

DISPLAY:
Wind Speed
Direction (blowing from)

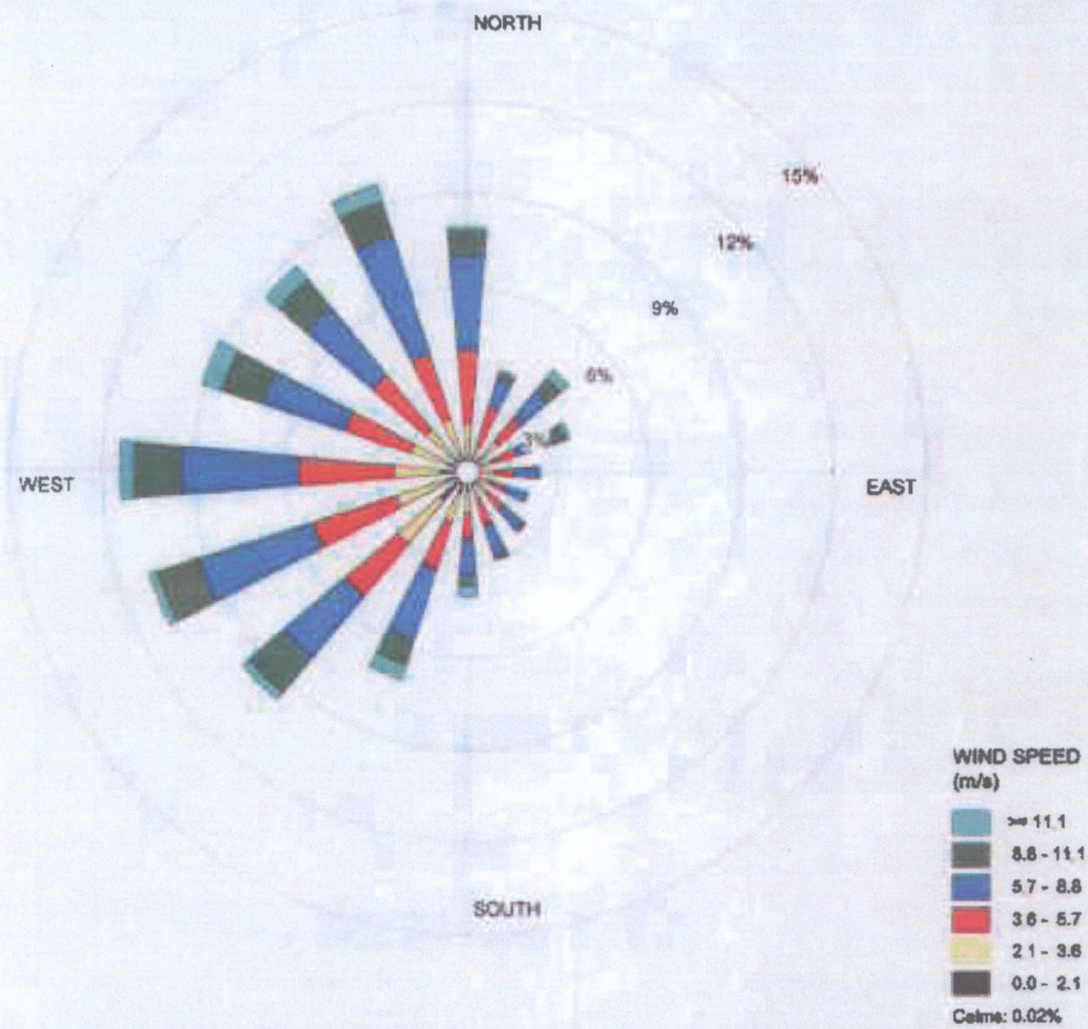


FIGURE 3b

CALM WINDS:
0.02%

TOTAL COUNT:
8719 hrs.

AVG. WIND SPEED:
5.84 m/s

DATE:
4/10/2008

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

300 meter CALMET 2002 Data (220 - 380 m above ground)
Portland Power Plant Site

DISPLAY:
Wind Speed
Direction (blowing from)

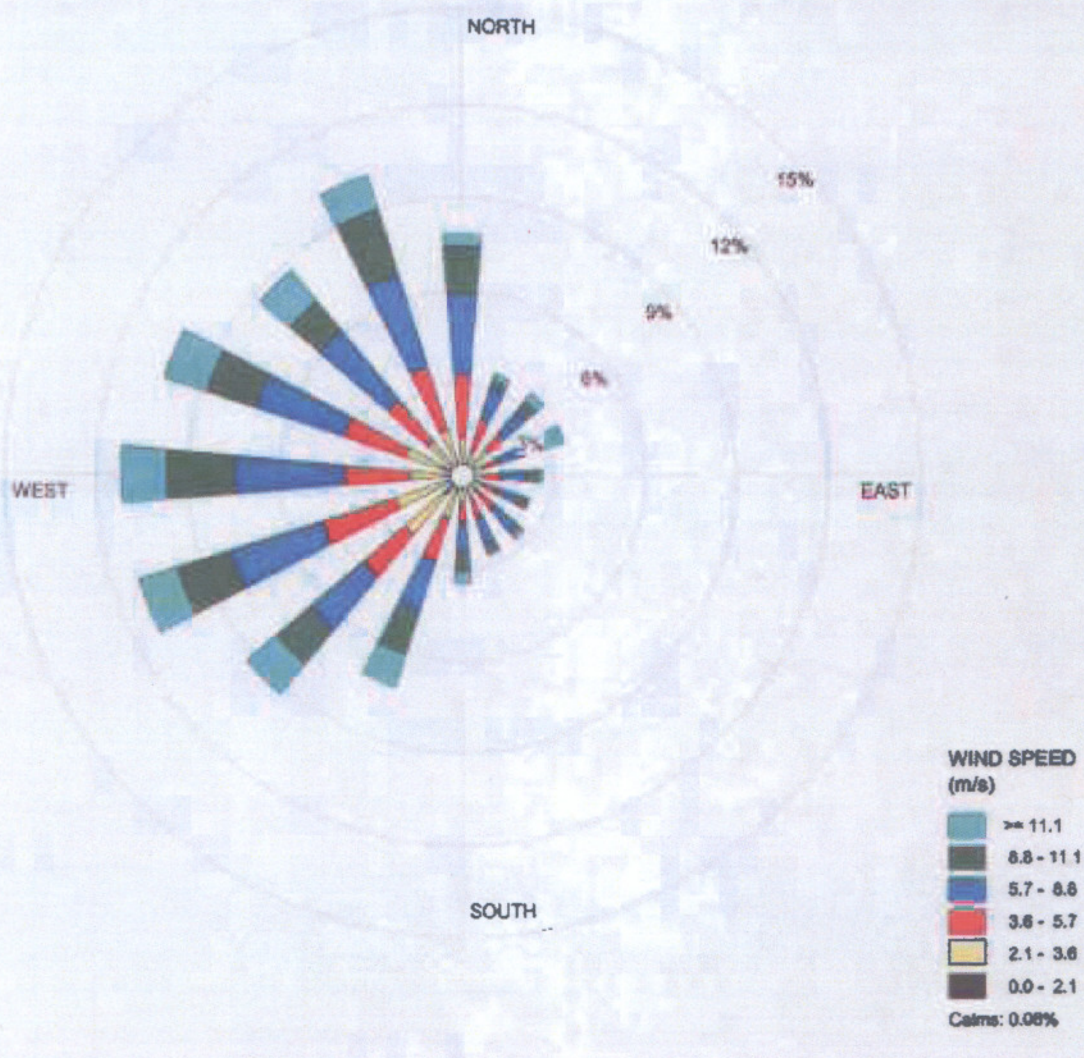
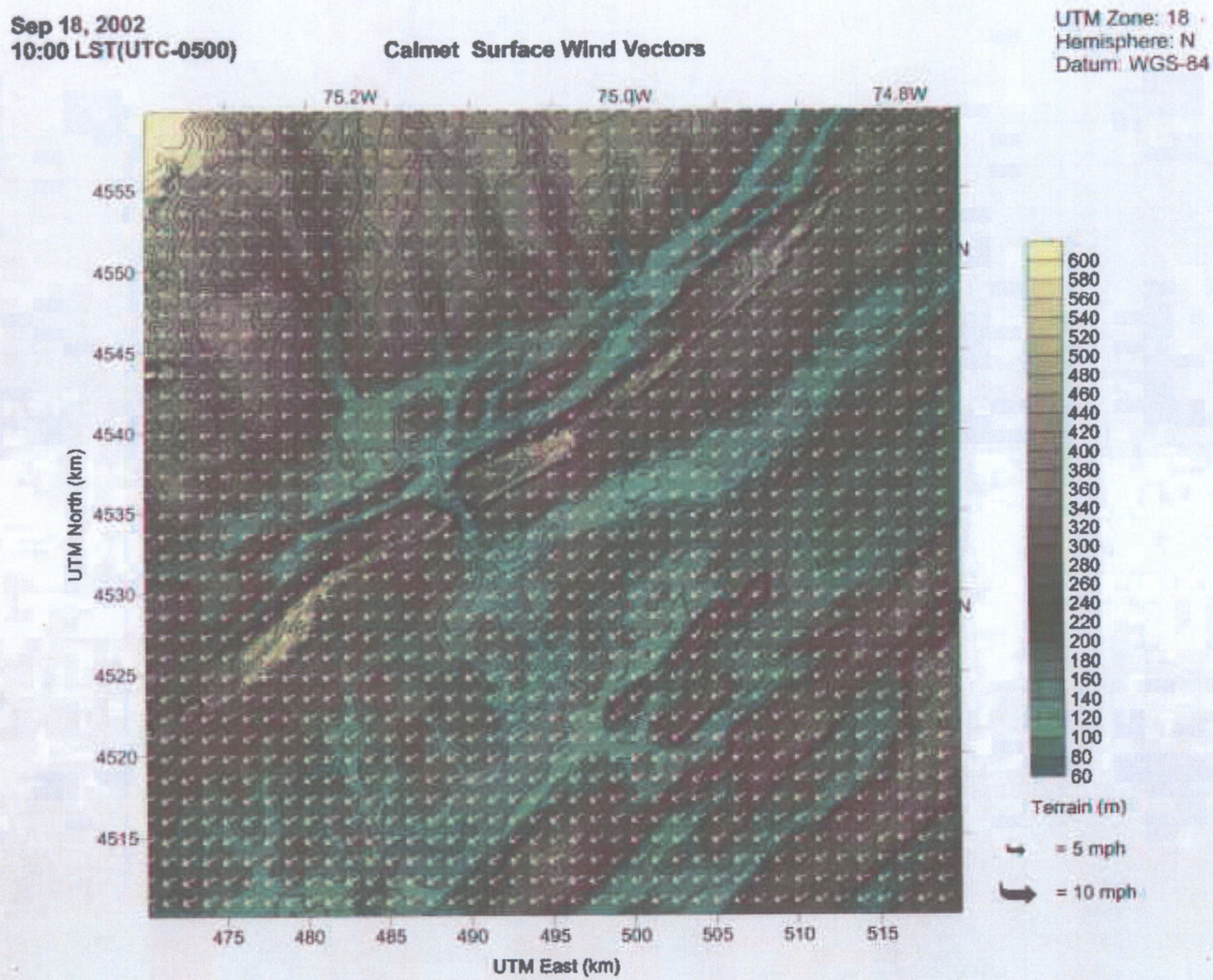


FIGURE 3c

CALM WINDS:	TOTAL COUNT:	
0.06%	8719 hrs.	
AVG. WIND SPEED:	DATE:	PROJECT NO.:
6.77 m/s	4/10/2008	

WRPLOT View - Lakes Environmental Software



Sep 18, 2002
10:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
UTM North (km)
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM East (km)
475
480
485
490
495
500
505
510
515
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 4.

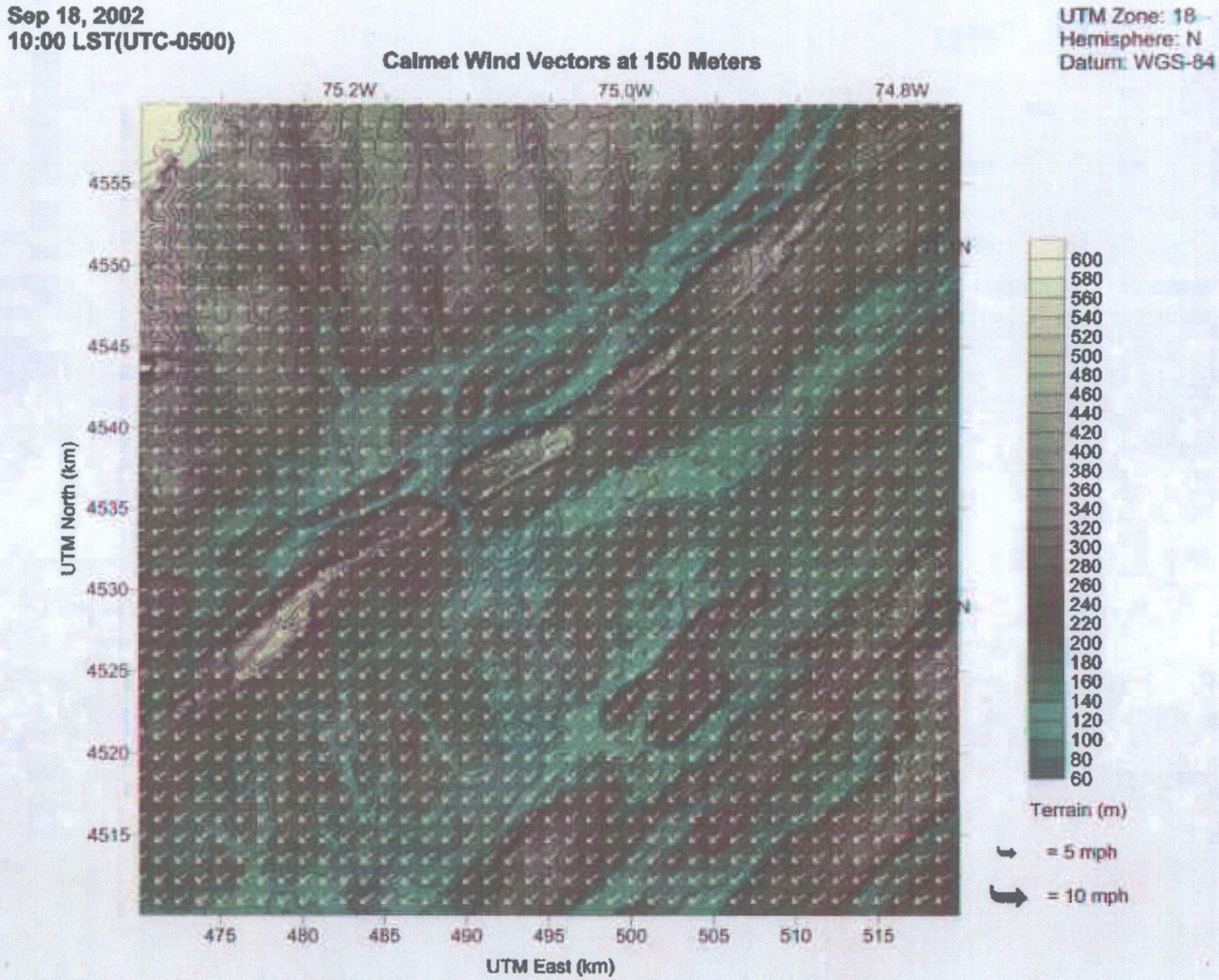

Sep 18, 2002
10:00 LST(UTC-0500)
Calmet Wind Vectors at 150 Meters
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 5

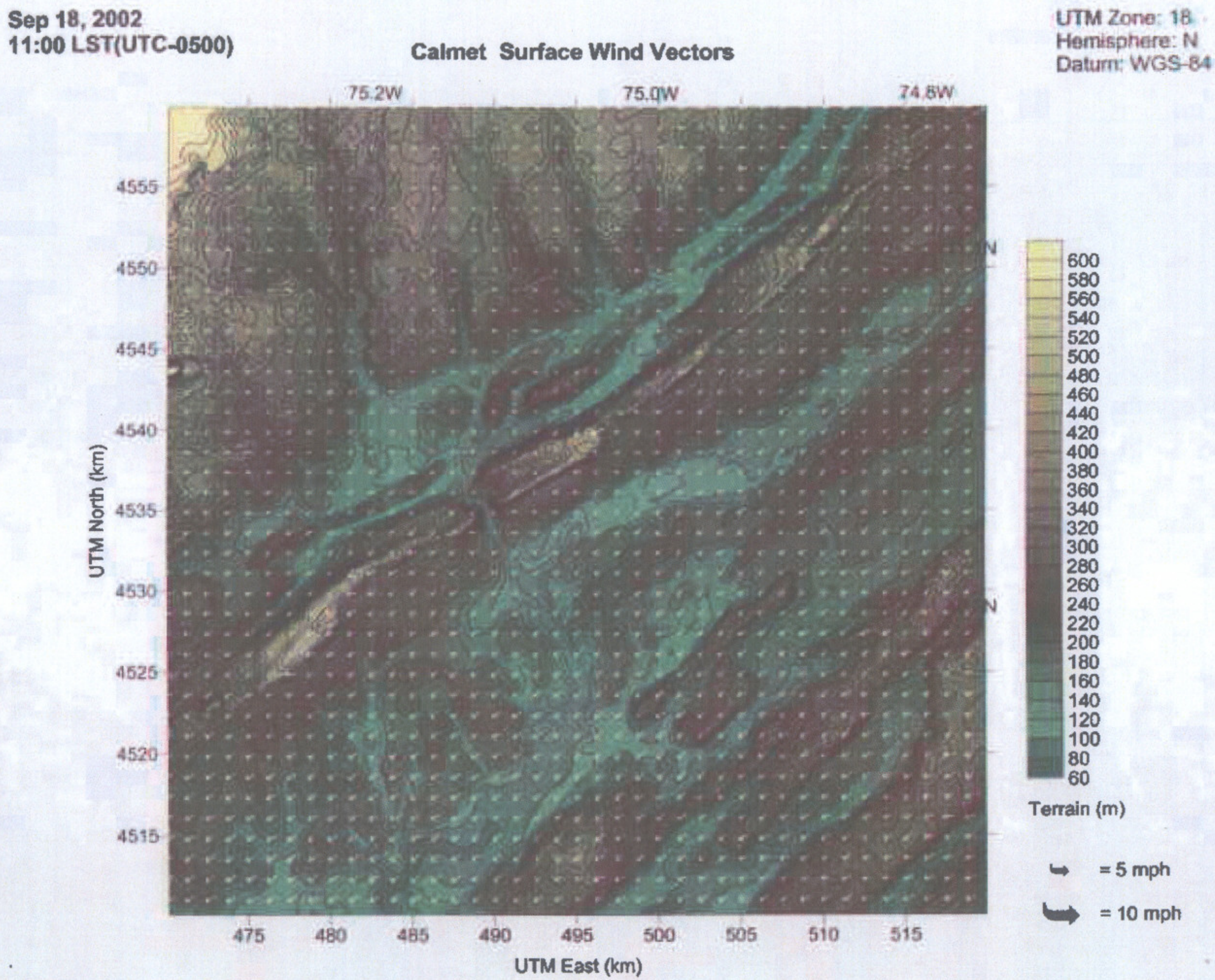

Sep 18, 2002
11:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 6

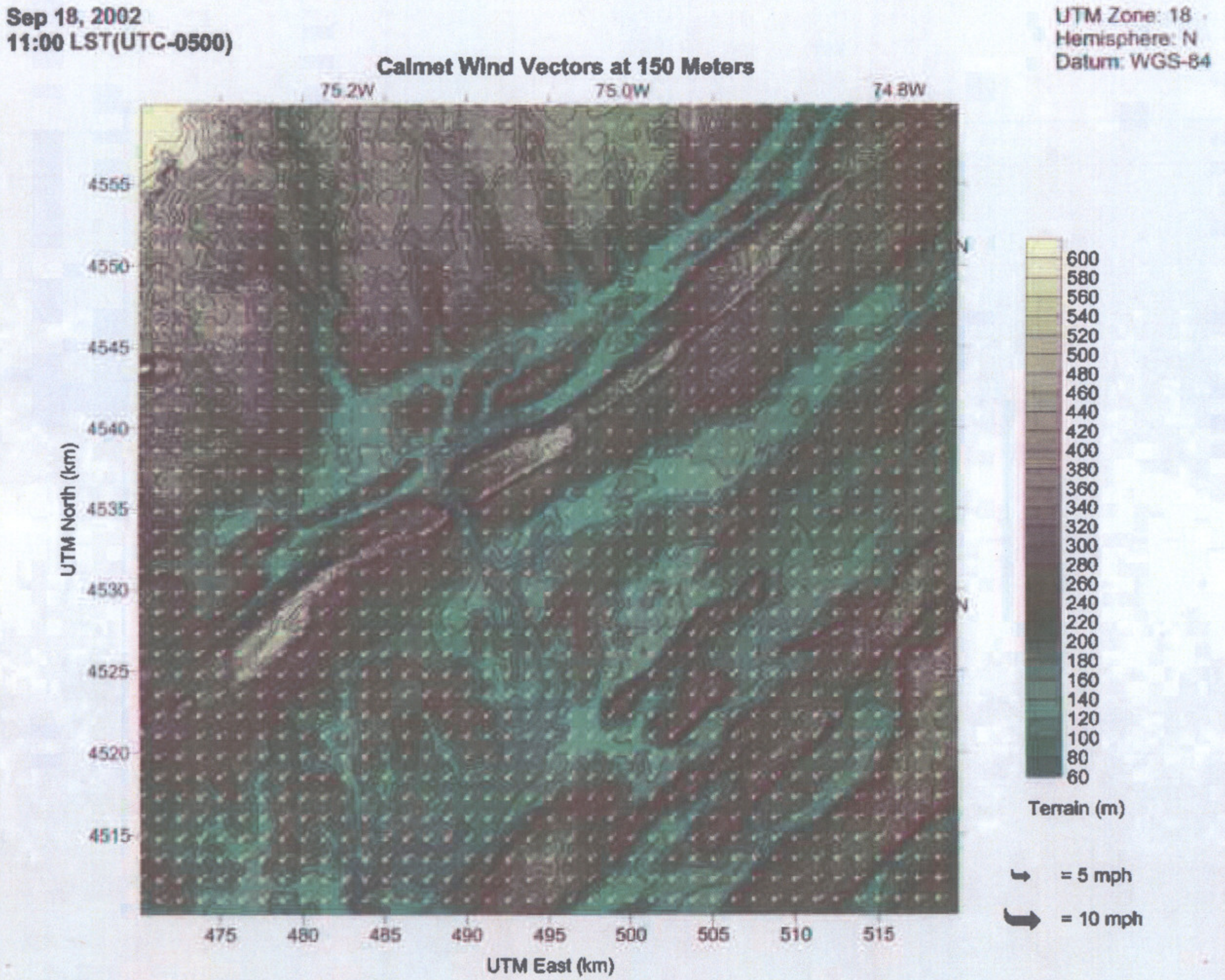

Sep 18, 2002
11:00 LST(UTC-0500)
Calmet Wind Vectors at 150 Meters
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 7

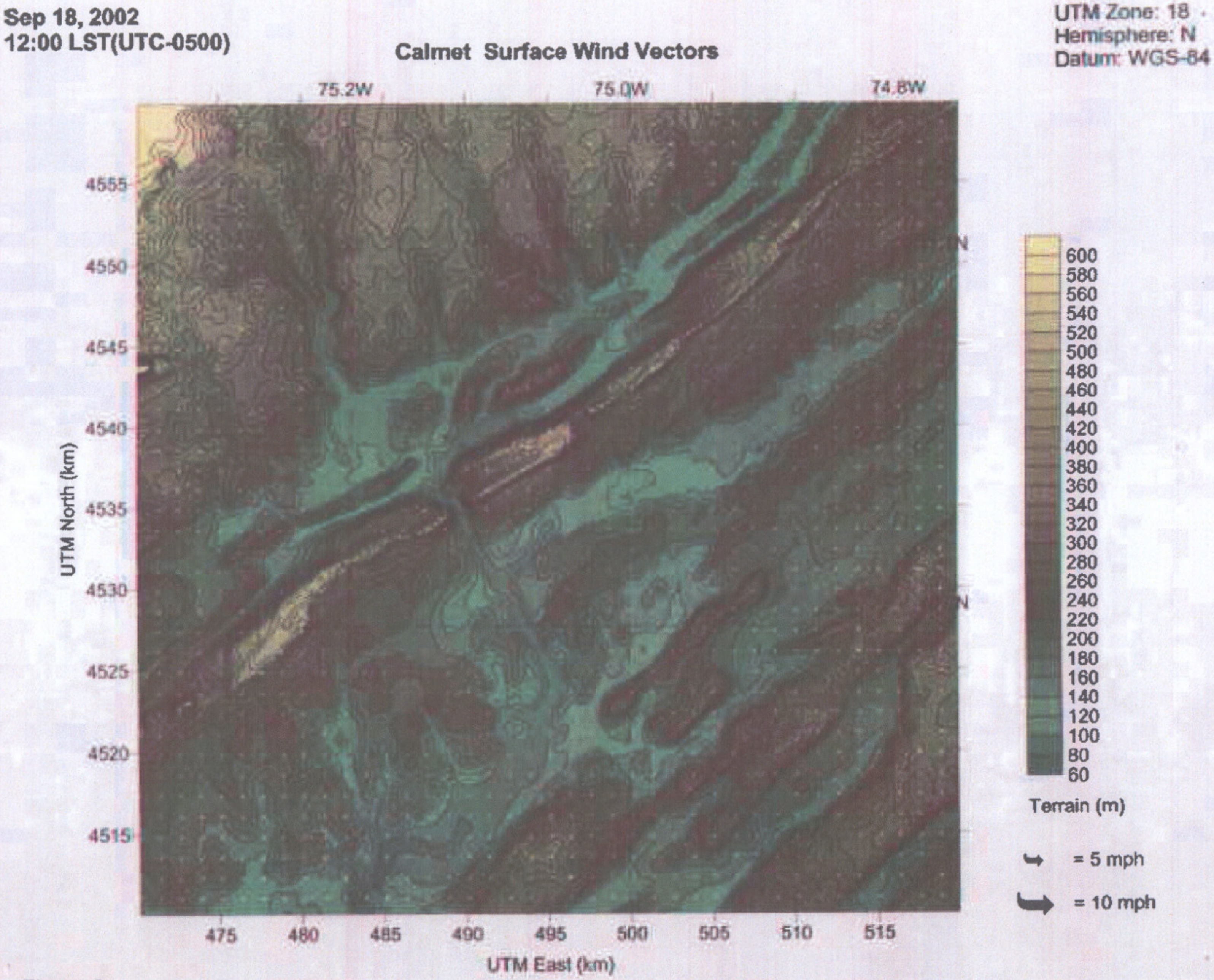

Sep 18, 2002
12:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 8

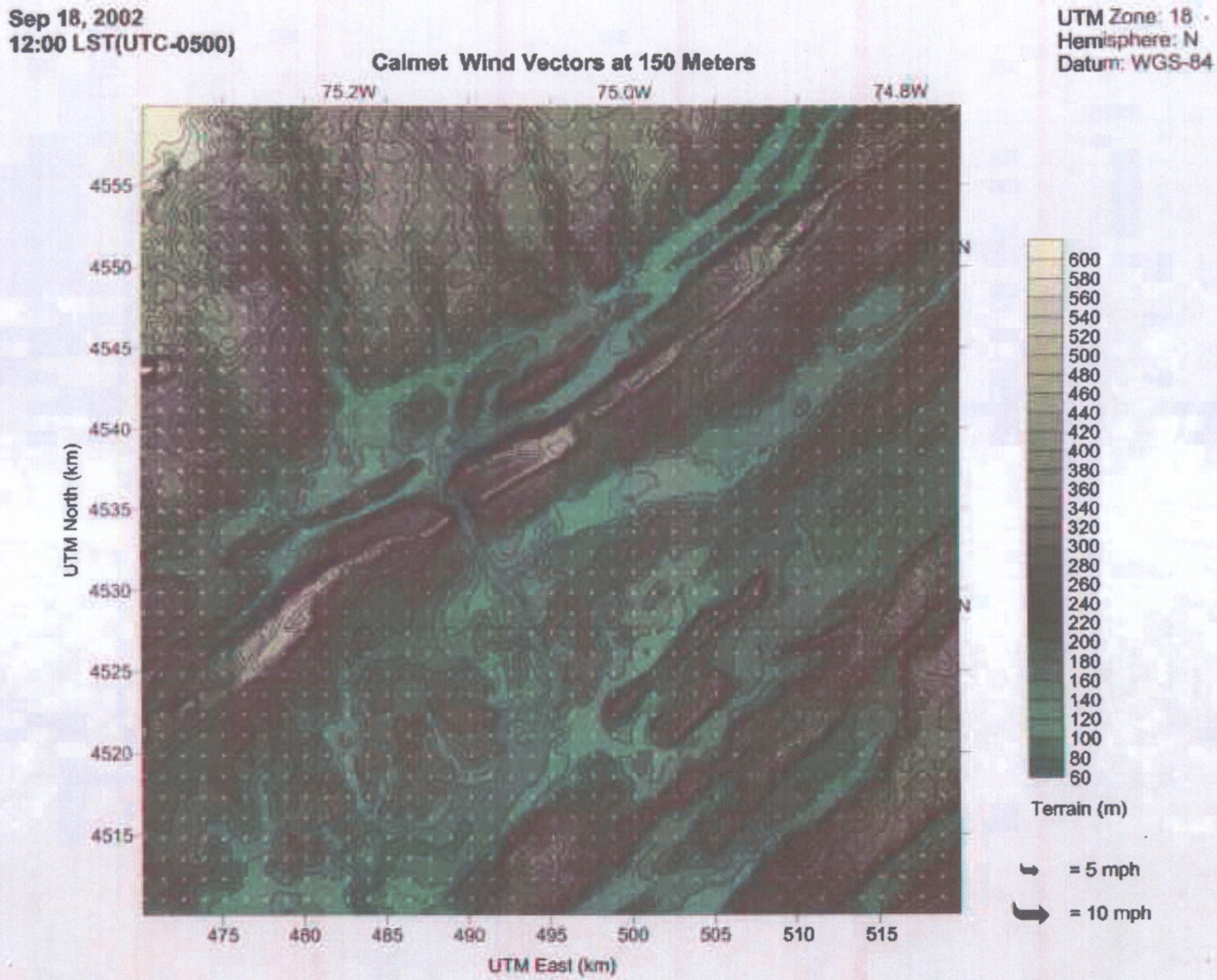

Sep 18, 2002
12:00 LST(UTC-0500)
Calmet Wind Vectors at 150 Meters
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 9

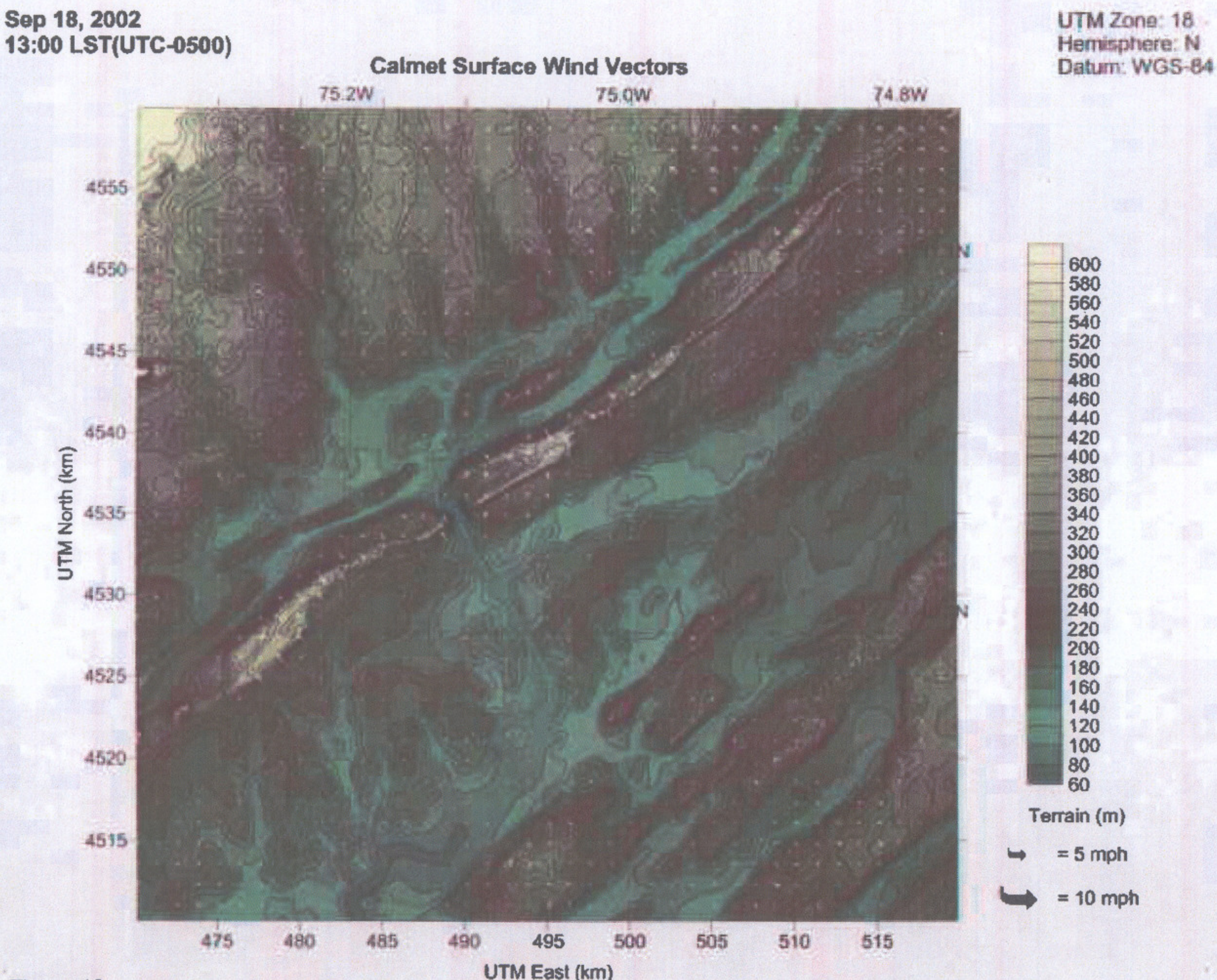

Sep 18, 2002
13:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 10

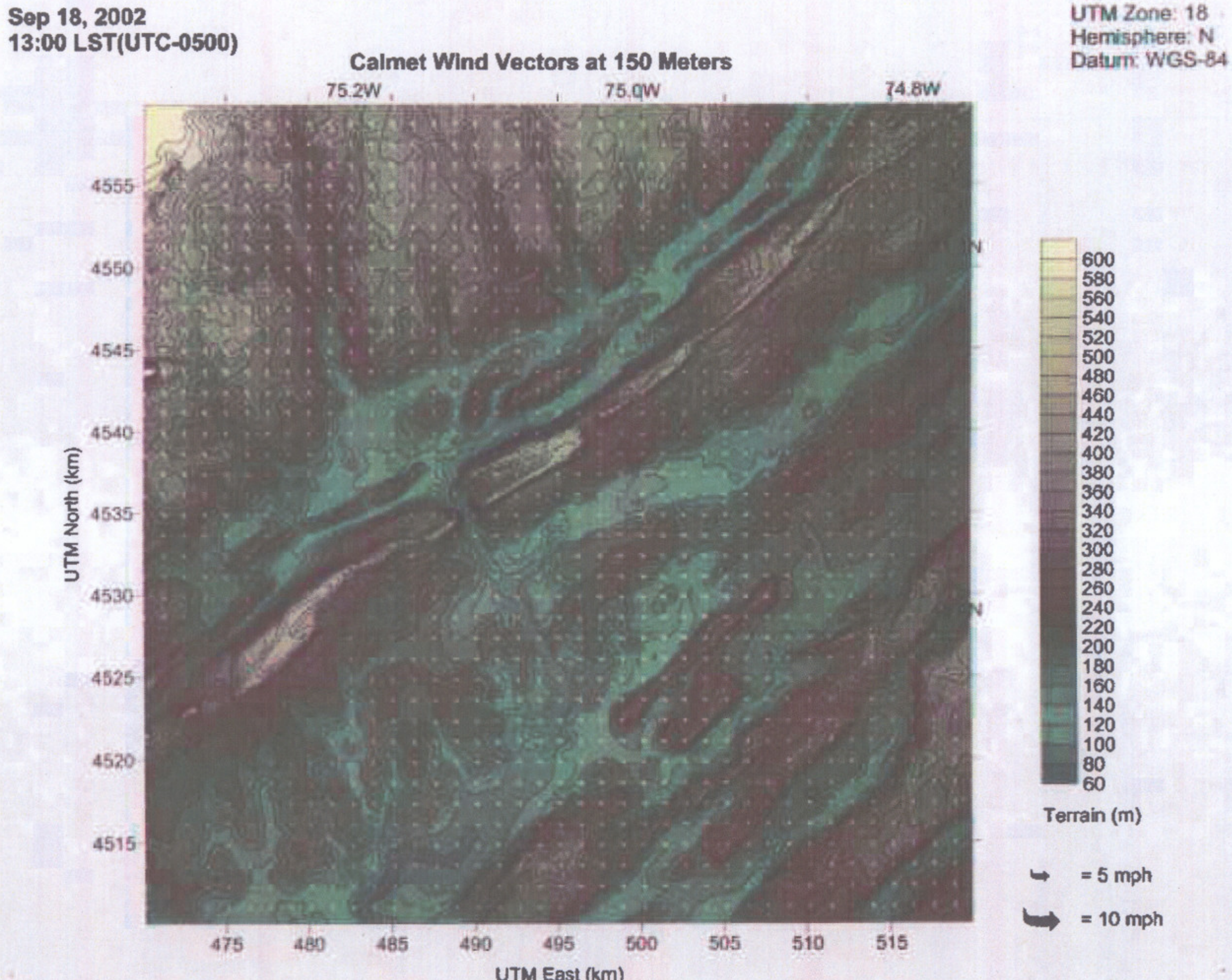

Sep 18, 2002
13:00 LST(UTC-0500)
Calmet Wind Vectors at 150 Meters
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 11

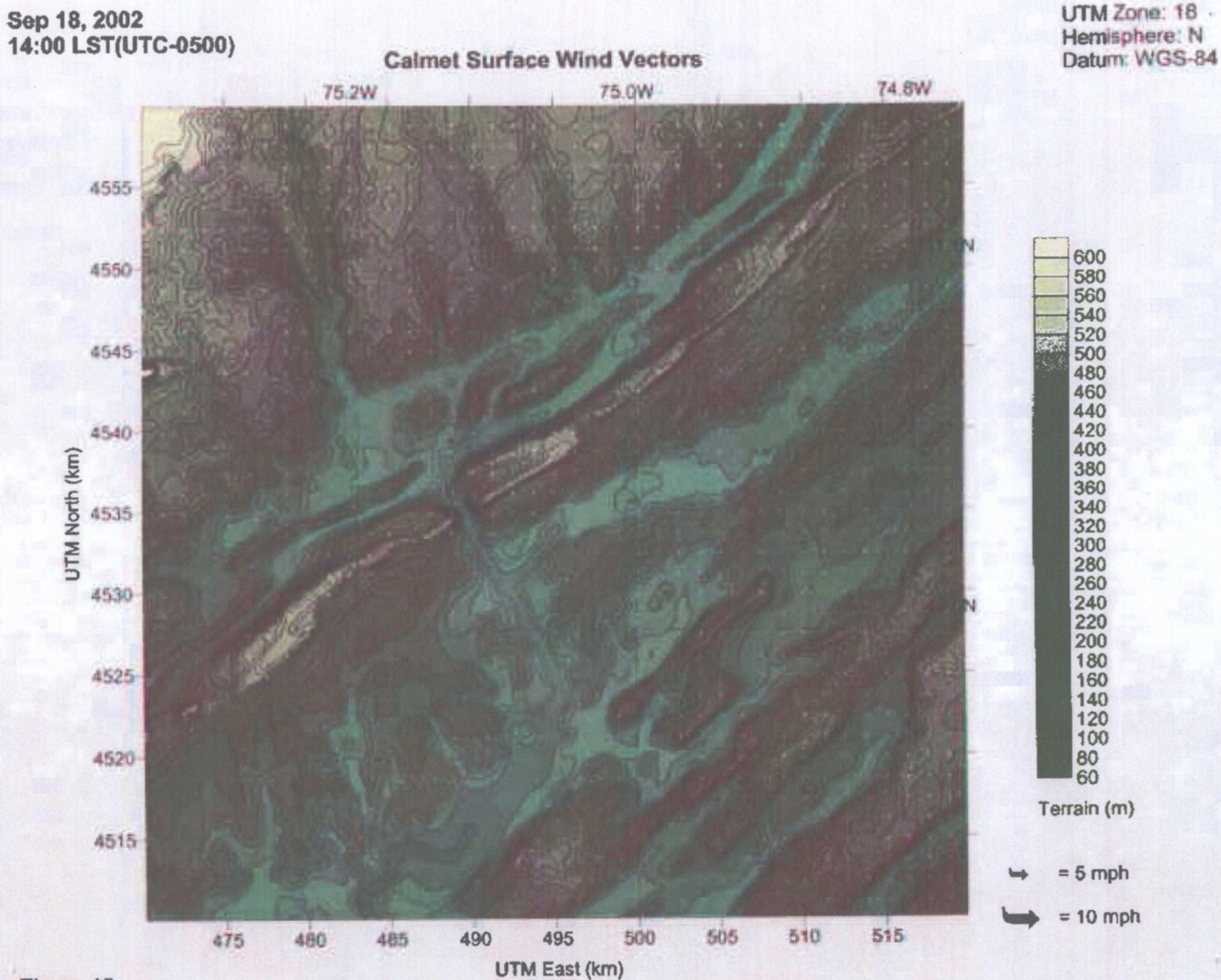

Sep 18, 2002
14:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
UTM North (km)
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM East (km)
475
480
485
490
495
500
505
510
515
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 12

Sep 18, 2002
14:00 LST(UTC-0500)

UTM Zone: 18
Hemisphere: N
Datum: WGS-84

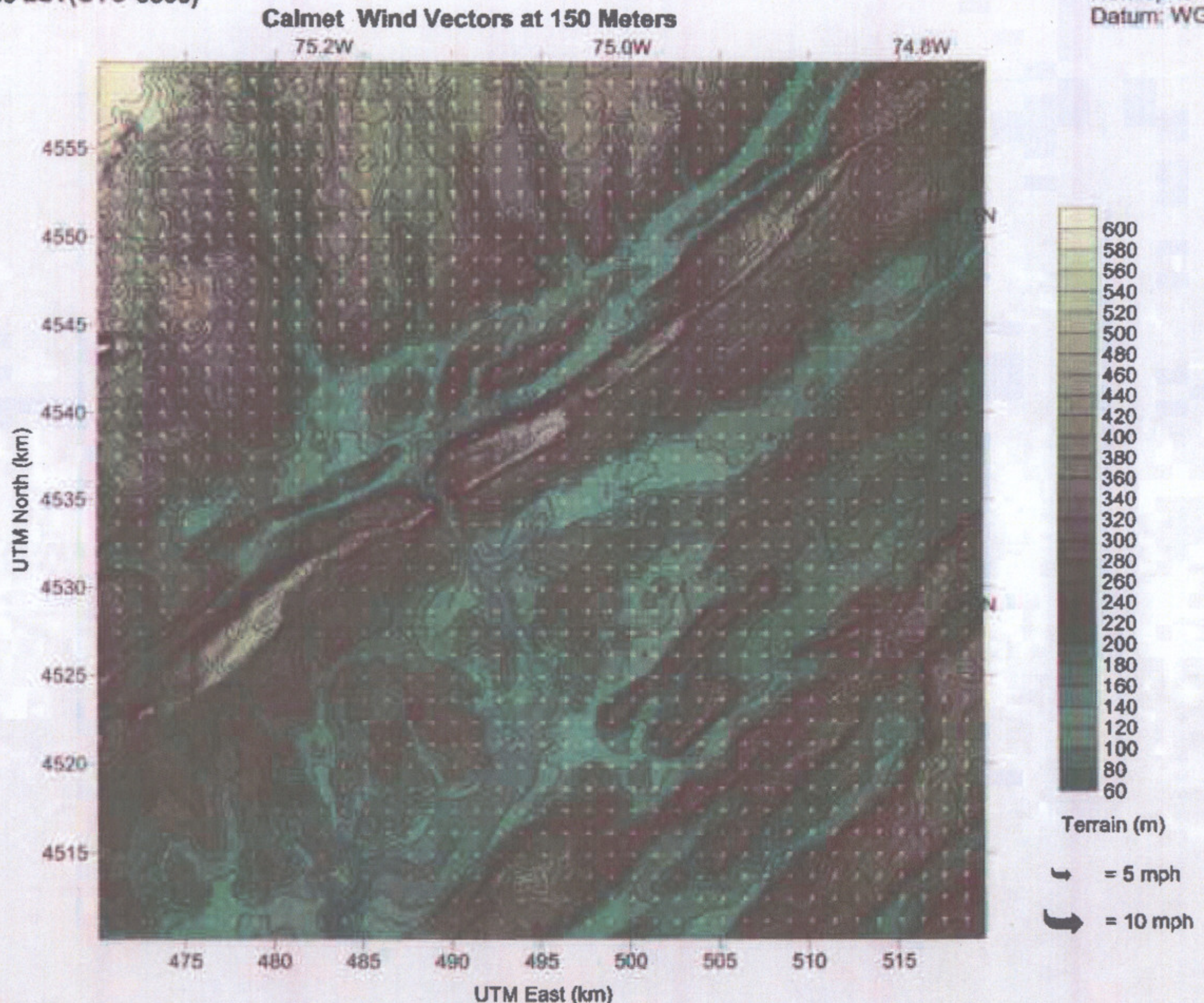


Figure 13

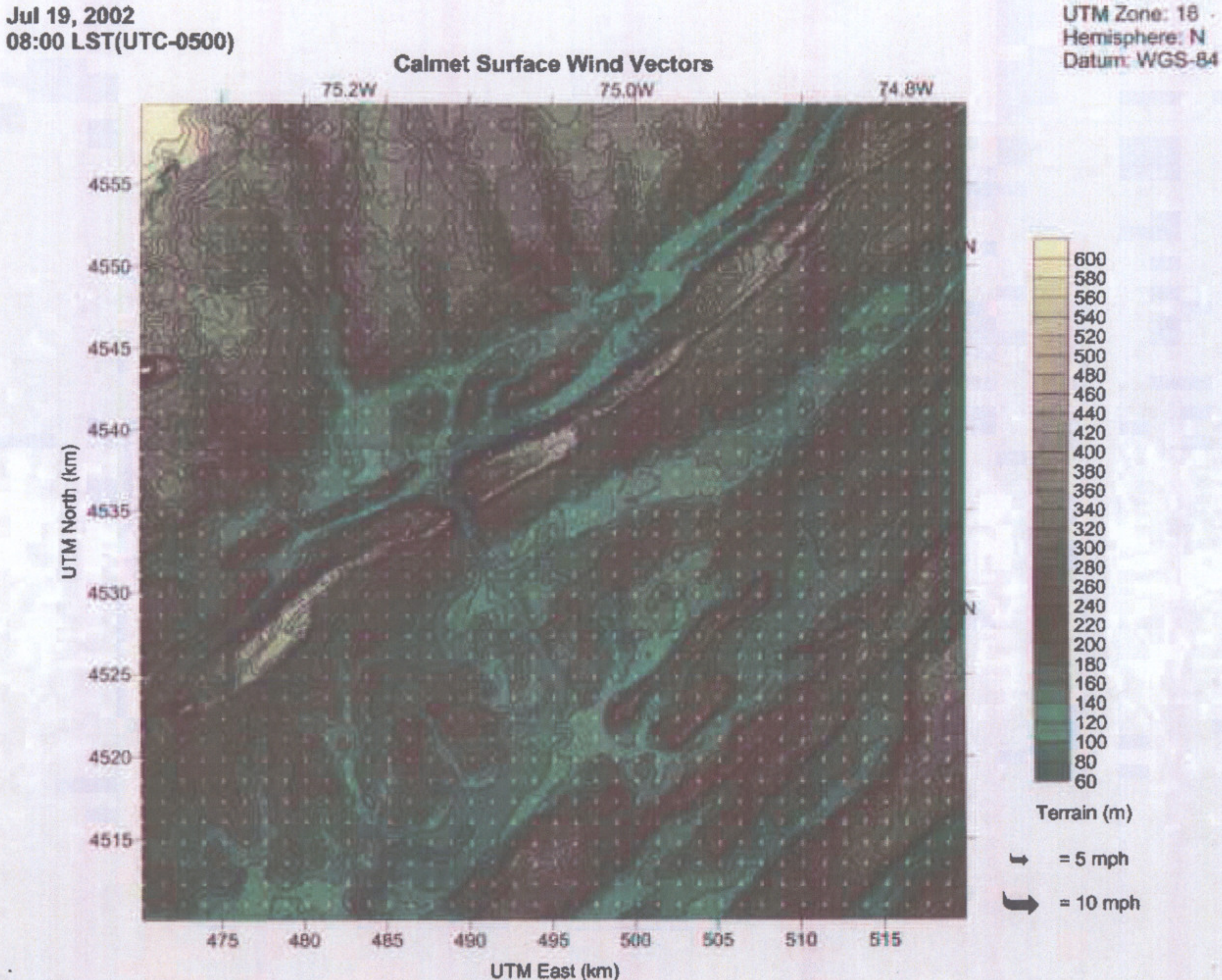
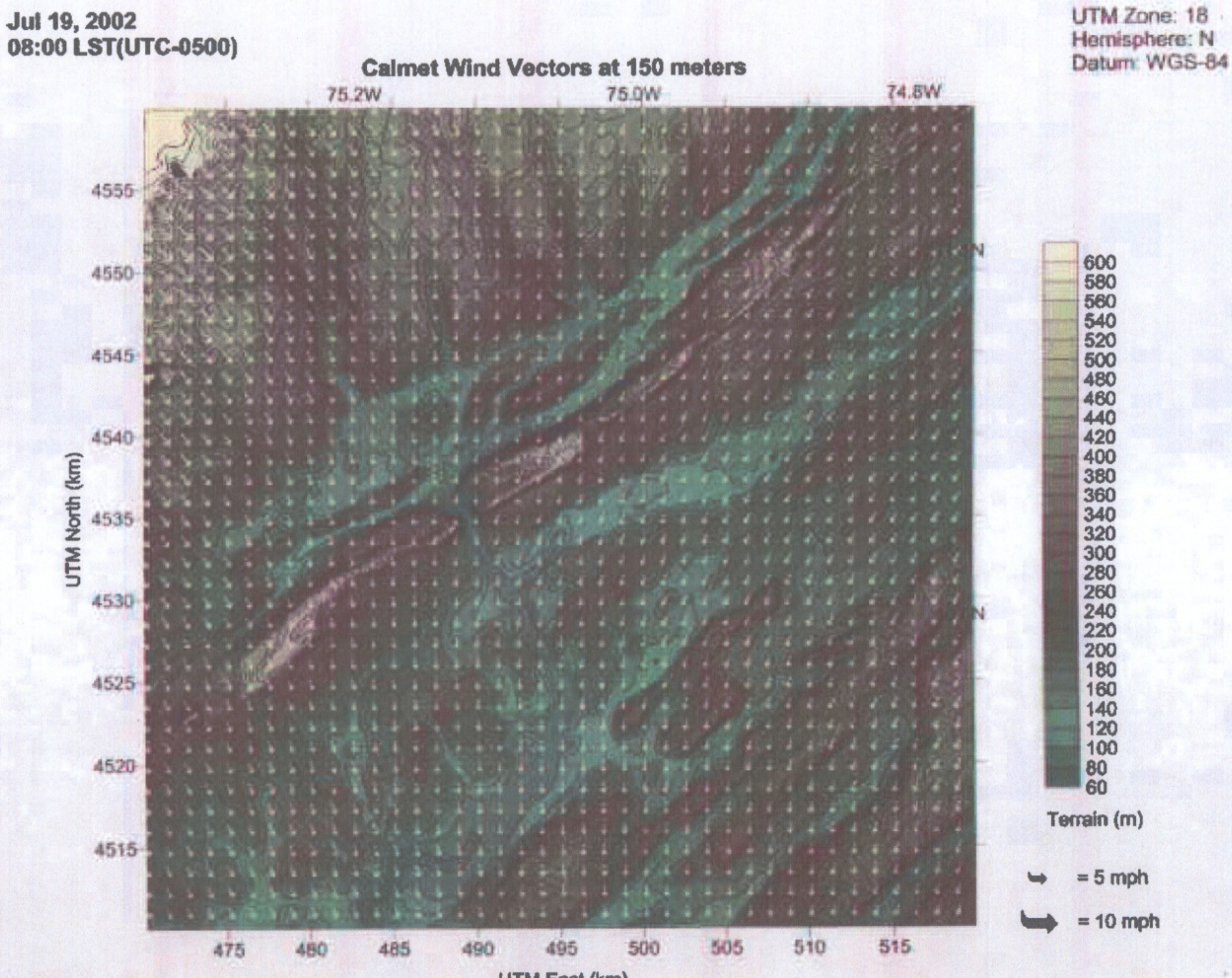

Jul 19, 2002
08:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
UTM North (km)
4555
4550
4545
4540
4535
4530
4525
4520
4515
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 14



Jul 19, 2002
08:00 LST(UTC-0500)
Calmet Wind Vectors at 150 meters
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
UTM North (km)
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM East (km)
475
480
485
490
495
500
505
510
515
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 15

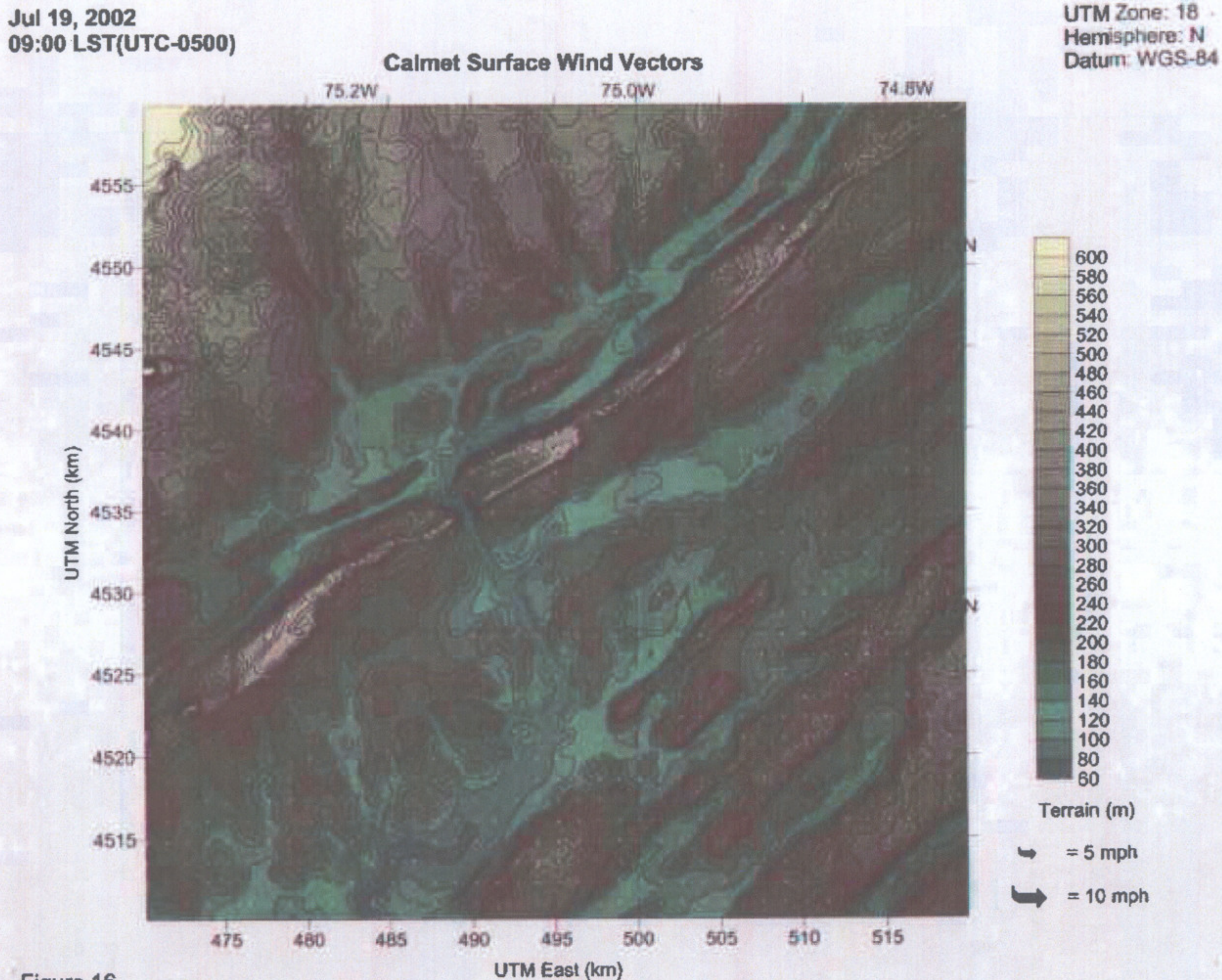

Jul 19, 2002
09:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
UTM North (km)
4555
4550
4545
4540
4535
4530
4525
4520
4515
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 16

Jul 19, 2002
09:00 LST(UTC-0500)

Calmet Wind Vectors at 150 meters

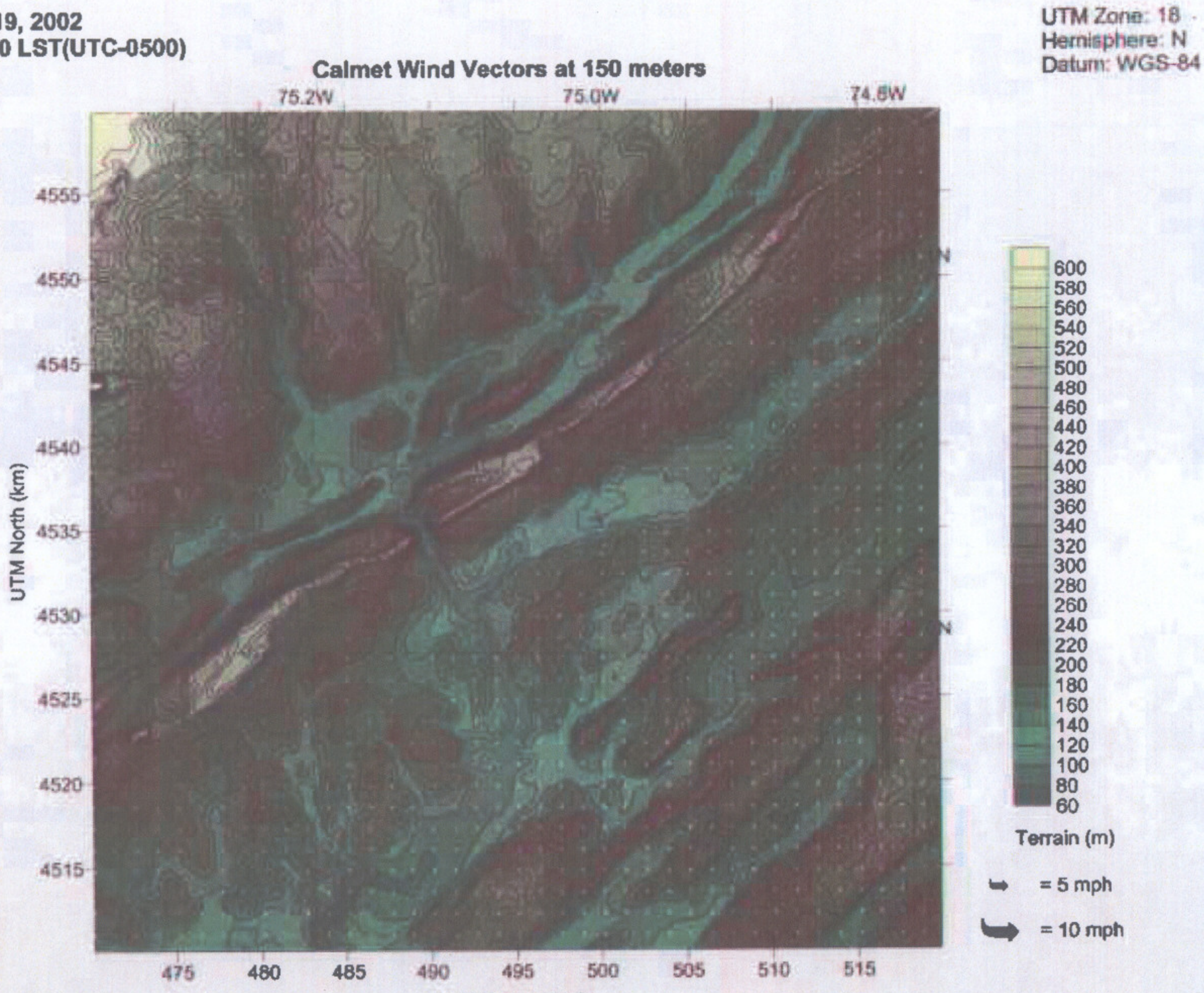


Figure 17

Jul 19, 2002
10:00 LST(UTC-0500)

UTM Zone: 18
Hemisphere: N
Datum: WGS-84

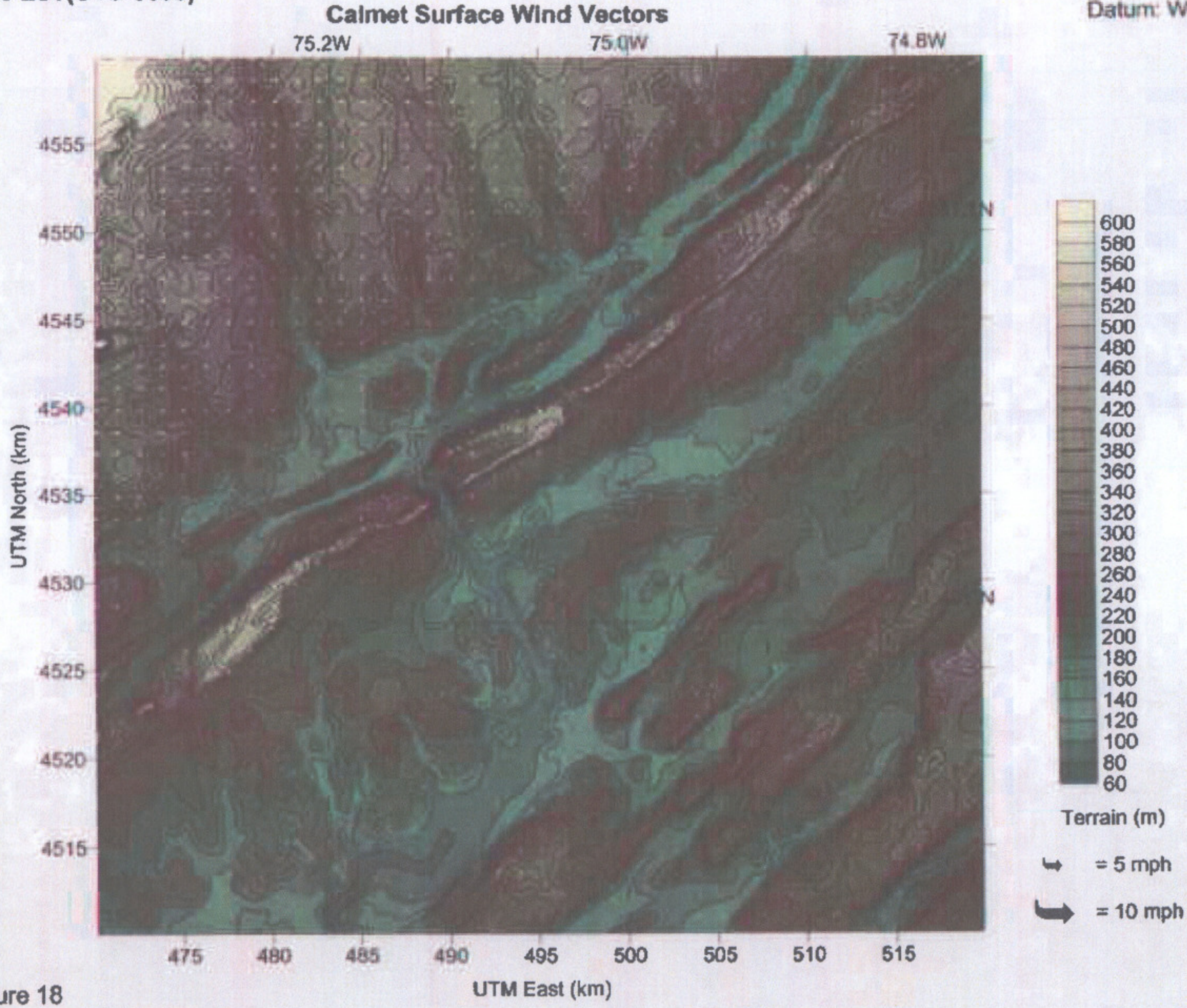


Figure 18

Jul 19, 2002
10:00 LST(UTC-0500)

UTM Zone: 18
Hemisphere: N
Datum: WGS-84

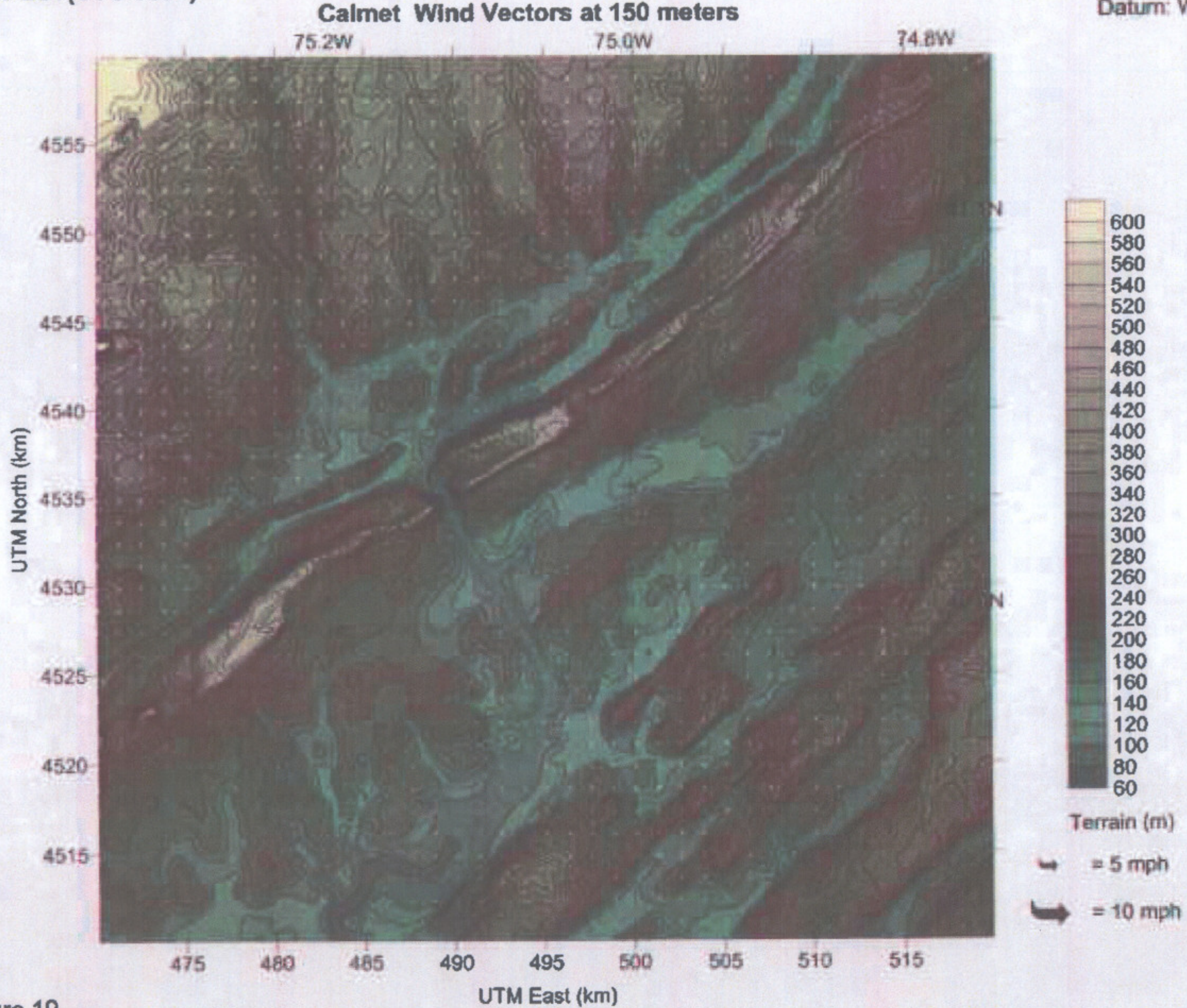
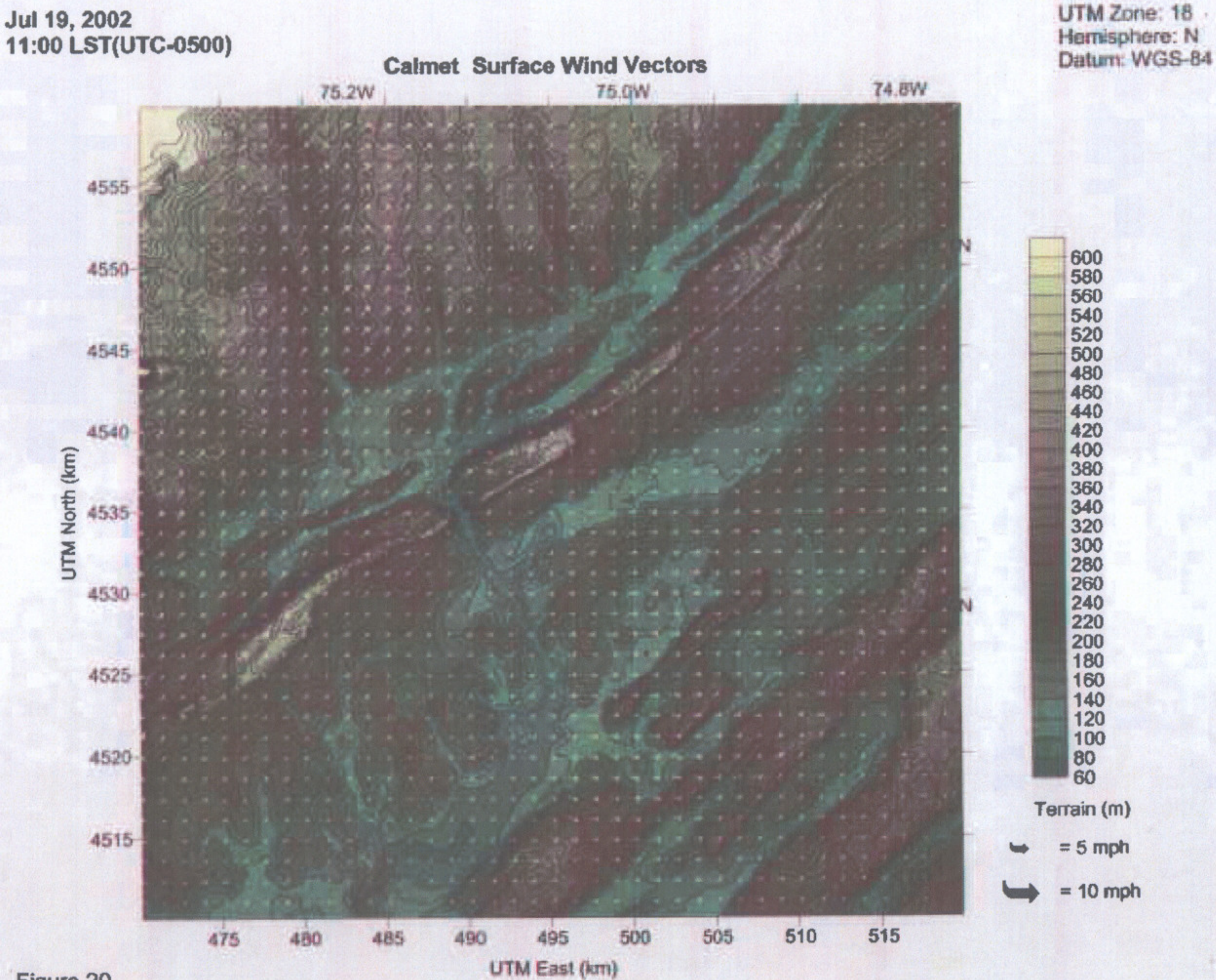
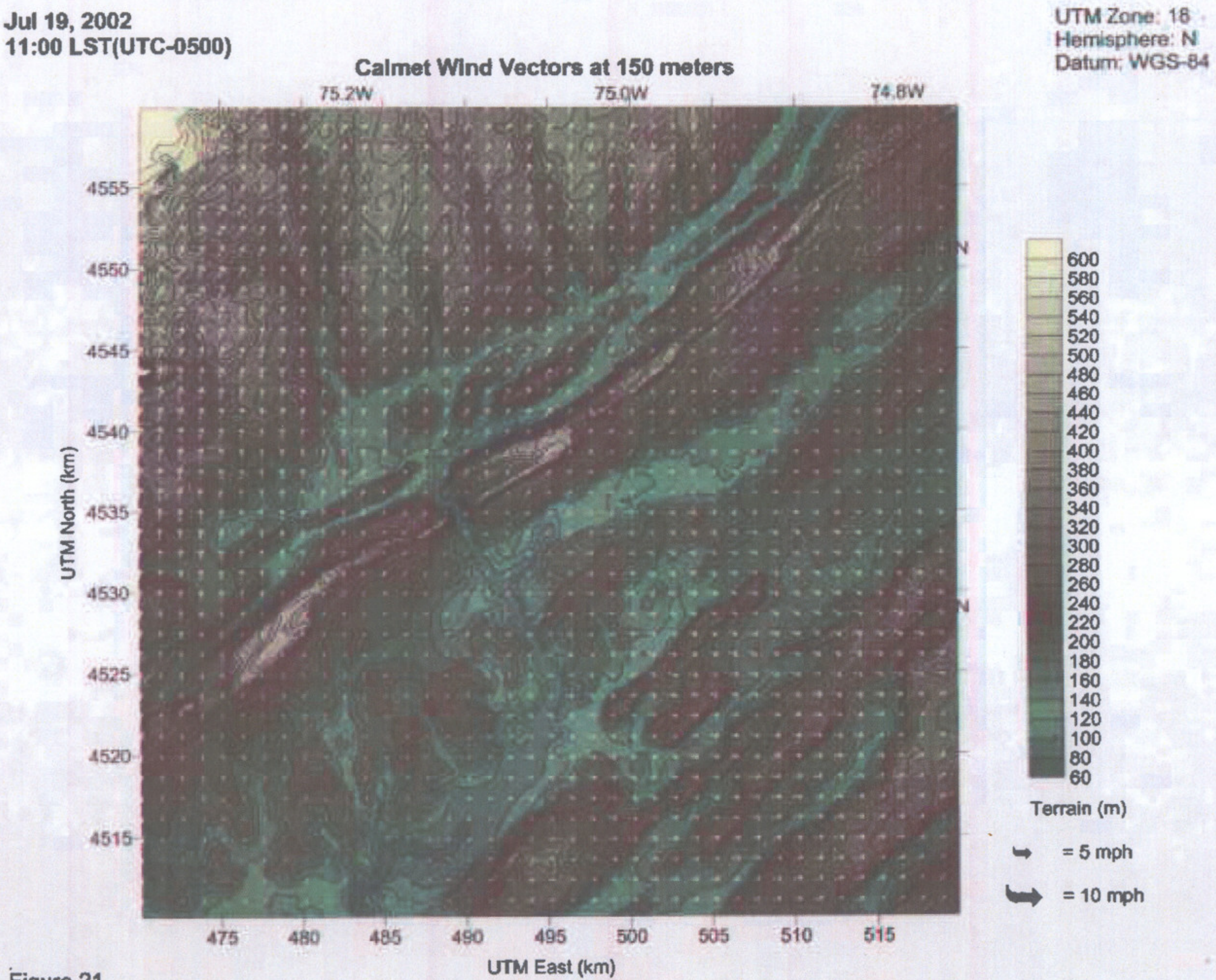


Figure 19



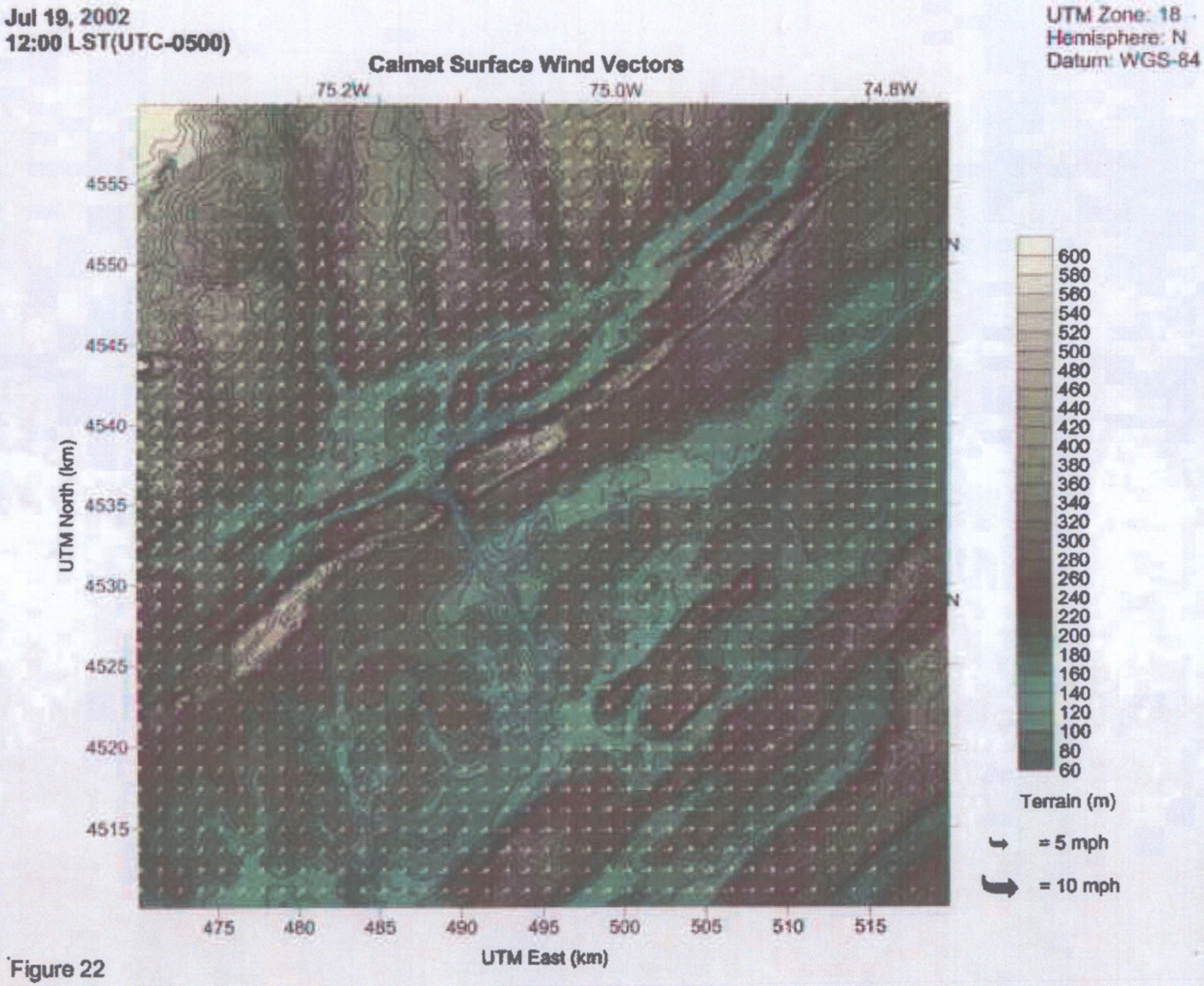
Jul 19, 2002
11:00 LST(UTC-0500)
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
Calmet Surface Wind Vectors
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 20



Jul 19, 2002
11:00 LST(UTC-0500)
Calmet Wind Vectors at 150 meters
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 21



Jul 19, 2002
12:00 LST(UTC-0500)
Calmet Surface Wind Vectors
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 22

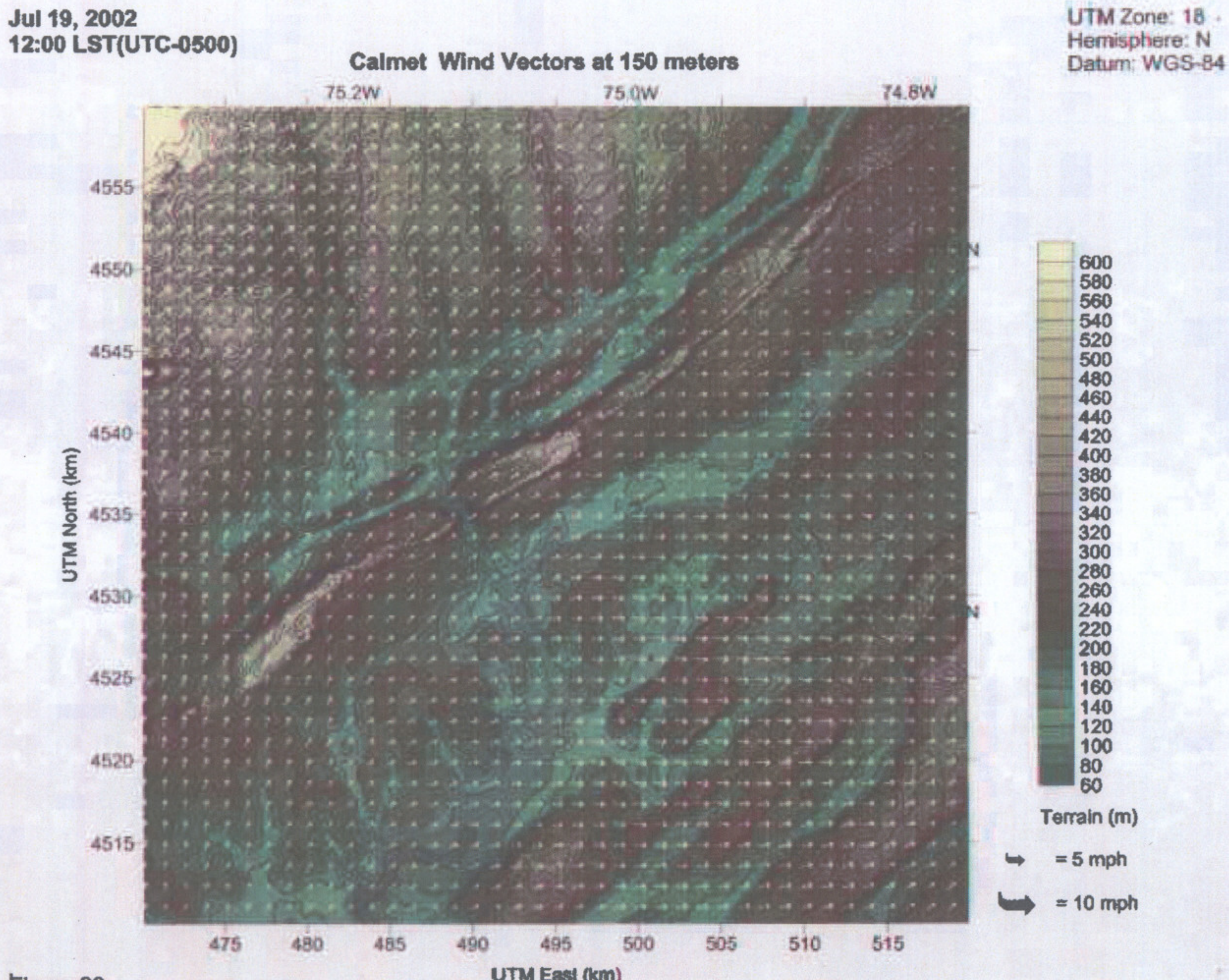

Jul 19, 2002
12:00 LST(UTC-0500)
Calmet Wind Vectors at 150 meters
UTM Zone: 18
Hemisphere: N
Datum: WGS-84
75.2W
75.0W
74.8W
4555
4550
4545
4540
4535
4530
4525
4520
4515
UTM North (km)
475
480
485
490
495
500
505
510
515
UTM East (km)
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
Terrain (m)
= 5 mph
= 10 mph

Figure 23

APPENDIX A

Description of Portland Power Plant's Meteorological Data

The following description of the meteorological data collected near the Portland Power Plant was taken directly from Section 2 document of the document: *SO_2 NAAQS Compliance Modeling Protocol for GPU's Portland Generating Station*, prepared for GPU Genco, prepared by ENSR Corporation, April 1999. The location of the meteorological site relative to Portland Power Plant is shown in Figure 4-2 shows the location of the GPU meteorological site.

2.0 GPU'S METEOROLOGICAL MONITORING PROGRAM

A meteorological monitoring program was conducted at the GPU/Metropolitan Edison Portland Generating Station which consisted of a collocated 100-meter tower and Doppler sodar. The tower was instrumental at multiple levels to measure wind directions, wind speed, sigma-theta (σ_θ), vertical wind speed, sigma-w (σ_w), solar radiation and temperature (See Table 2.1). The sodar provided wind direction, wind speed and turbulence at 30-meter increment levels from 90 meters up to 600 meters. For modeling purposes, the tower data up to 100 meters and the sodar data from 120 meters to 510 meters will be used. From the information collected, a high quality 1-year database suitable for AERMOD applications has been developed.

Prior to the installation of the meteorological network, the search for a meteorological measurement monitoring location focused on available property west and south of the Portland Power Generating Station. These areas were generally undeveloped land with portions being sued for growing cattle feed and vegetables. The following siting criteria were considered in all the site evaluations:

- Proximity to the power generating station,
- Site exposure, relative to spacing from obstructions, and roads,
- Site accessibility including proximity to a maintained roadway,
- Property ownership,
- Site grading/preparation requirements,
- Proximity to electric power and telephone services, and
- Potential for vandalism.

A final decision on the use of this site was made in consultation with the Pennsylvania Department of Environmental Resources (Mr. Robert Simonson). The site offered good exposure (meeting PSD siting criteria) in all directions, except initially to the east where there was an area of several trees and thick brush growth. Metropolitan Edison Company removed these trees and brush prior to installation/commencement of monitoring activities.

The site was located west of the plant at a direction of approximately 250 degrees and a distance of 2,300 m from the PGS (491.2 UTME, 4527.7 UTMN, 610 feet in elevation; (see Figure 3.1). After the removal of the trees and brush obstructions east of the tower location, all other possible obstacles in other directions were more than 10 times the obstacle height from the tower location. The relatively uniform and shallow grade averaging 2.4 degrees between the meteorological site and the PGS source allowed the data from the meteorological site to be considered as being representative of conditions at the PGS site.

Configuration, siting, operation, data processing and quality assurance/quality control practices for the GP measurement program conformed to the provisions of EPA's Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) (EPA-450/4-87-007, May 1987) and EPA's On-Site Meteorological Program Guidance for Regulatory Modeling Applications (EPA-450/4-87-013, June 1987).

The ENSR monitoring and quality control/quality assurance plan required that the validation of continuous meteorological data be governed by strict standard operating procedures. For data to be considered valid, they needed to be accurate and precise within prescribed limits, represent factual conditions, be obtained from a calibrated, well-functioning instrument and from air sampled without interference or obstructions, and be thoroughly documented as to traceability to recognized primary standards.

The validation process began in the field with the on-site field operations technician's assessment of data during each site visit. Charts were scanned for anomalous results and any faulty instrument performance. Events affecting validity were documented on Field Station Log forms. The field technician kept a record of validity for each continuous parameter on the Field Data Assessment Report. Concurrently with the field assessment, the data were checked daily by the ENSR field operations manager and/or a meteorologist via the real-time management summary report. At the end of the month, the complete FDAR was signed and turned in along with all other site documentation and strip charts to the field operations manager for quality control review. The reviewed and signed data and document package were then turned over to the ENSR Data Reduction and Analysis department for processing and final validation.

Periods of data labeled "suspect" by the field technician were subsequently deemed valid or invalid by either the ENSR field engineering and operations manager of a meteorologist, depending on the expertise required. Changes to the validation categories were initiated and the reasons were documented on the FDAR.

A collocated Aerovironment Doppler acoustic sodar system was supplied and operated by Aerovironment. On a monthly basis, an ENSR meteorologist compared the sodar data to the tower data for the 30 and 100 m levels. The checks included use of reasonability checking software tools in addition to the manual checks each month.

All data was managed using ENSR's IBM PC-based data processing system. Once a day, the computer at the ENSR Wilmington, Massachusetts facility connected through a dial-up phone line with the site's data acquisition systems to obtain the latest data. During each work day, these data were screened for gross errors and corrected for any communications problems. Data were then checked and converted into internal format and stored automatically in the data base to be ready for any prescribed interactive applications, including data editing, validation and reporting.

Monitored data was presented in monthly validated data reports within 45 days after the end of each monitoring month. These records contained monthly summaries of continuous meteorological parameters. In addition, the following items were presented in each monthly report:

1) Summary of missing data for each parameter with explanations for all missing data values.

2) Graphic data presentations of the data (i.e., wind roses).

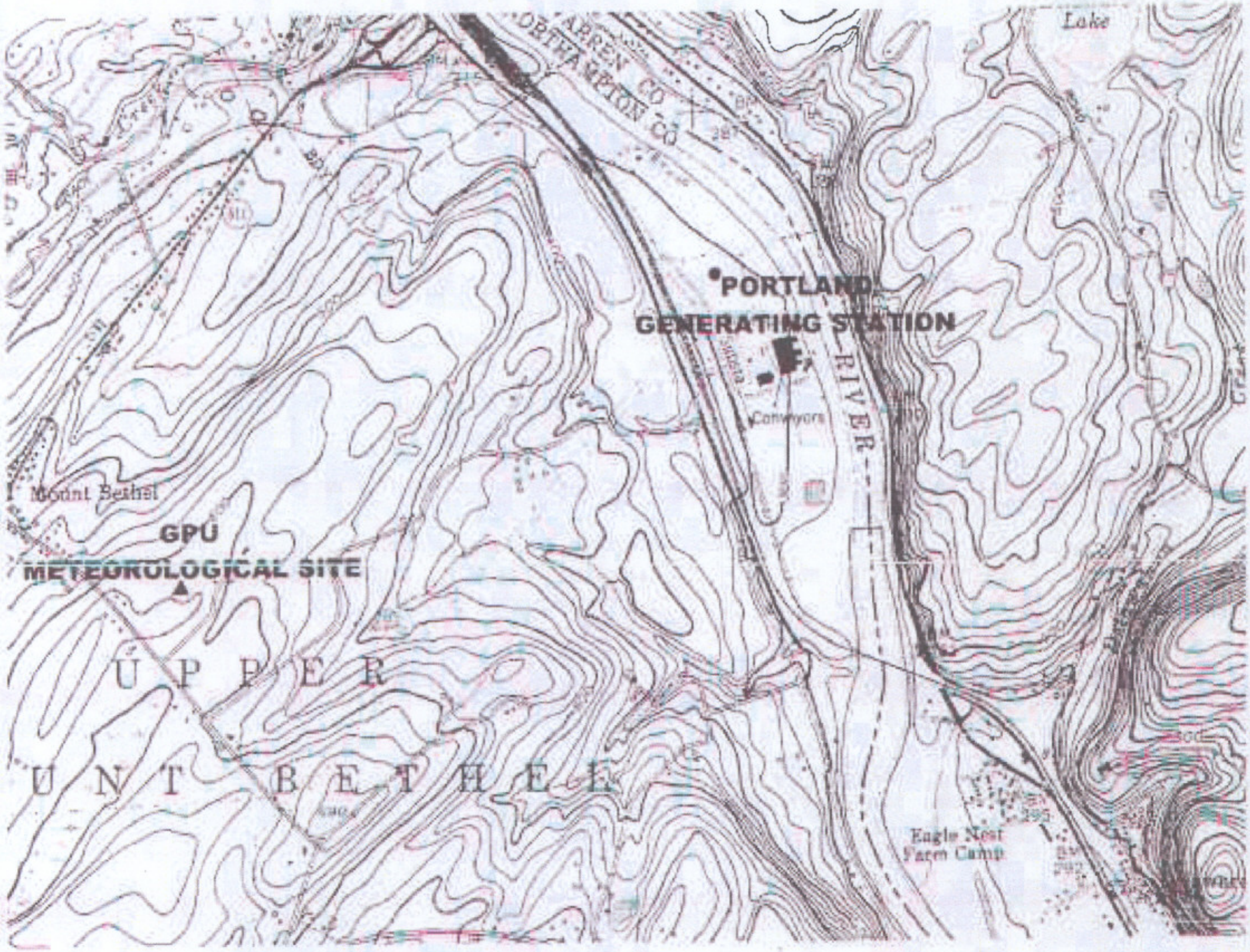
The data capture for all parameters on the tower exceeded 98.6% for all levels (see Table 2-1). Furthermore the collective data capture on the sodar was about 97% (more discussion of data capture is provided in Section 3). With the multitude of available levels of wind data from the tower and sodar data, there was a substantial amount of redundant data that could be used by a dispersion model to compensate for any levels of missing data for a particular hour.

On-site data for the July 1, 1993 to June 30, 1994 period was selected for use in the AERMOD modeling.

Table 2-1 Meteorological Data from GPU's Sodar and 100-m Tower

Parameter	Instrumentation	Tower Level	Data Capture
Radiation	Climatronics/Eppley Pyranometer	2 meters	99%
Wind Speed	Climatronics F460	10 meters	99%
		30 meters	99%
		100 meters	99%
Wind Direction	Climatronics F460	10 meters	N/A
		30 meters	99%
		100 meters	99%
Sigma-Theta	Odessa DSM 3260	10 meters	N/A
		30 meters	99%
		100 meters	98%
Temperature	Climatronics 100093	2, 10, 30, 70, and 100 meters	99%
Delta-T	Climatronics 100093	1-10 meters	99%
		10-70 meters	99%
		10-100 meters	99%
Sigma-w	Odessa DSM 3260	30 and 100 meters	98%
Sodar WS, WD, & sigma-w 120-510 meters	AeroVironment Model 8000 Doppler Acoustic Sounder	**	97%*

*The sodar data capture is based on obtaining at least three levels of valid data per EPA on-site data recommendations.



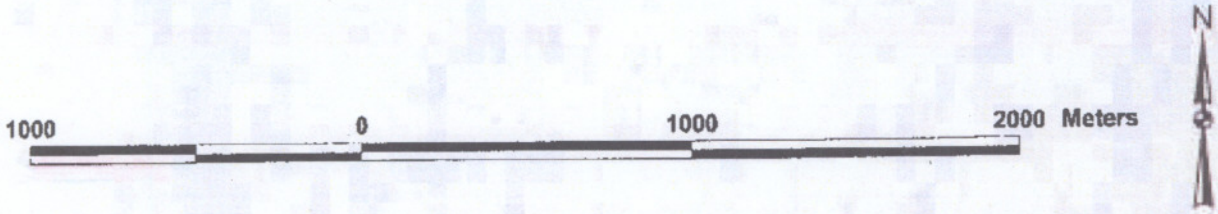


FIGURE 3-1
Location of the GPU Meteorological Site
Relative to the Portland Generating Station

AERMOD Modeling Analysis of the PM-2.5 Impacts Due to Emissions from the Portland Generating Station

July 2, 2008

Bureau of Technical Services
Division of Air Quality
New Jersey Dept. of Environmental Protection

Modeling Platform

In response to comments from EPA, the New Jersey Department of Environmental Protection, Bureau of Technical Services (BTS) performed modeling of the Portland Generating Plant with the latest EPA approved version of the AERMOD modeling suite; AERMOD (version 06341), AERMAP (version 06341), and AERMET (version 06341).

Use of AERMOD in Complex Winds

EPA's Guideline on Air Quality Models provides in Section 7.2.8, Appendix W, 40 C.F.R. Part 51, that CALPUFF is a dispersion model for complex wind situations. Complex winds are described as:

"In many parts of the United States, the ground is neither flat nor is the ground cover (or land use) uniform. These geographical variations can generate local winds and circulations, and modify the prevailing ambient winds and circulations. Geographic effects are most apparent when the ambient winds are light or calm. In general, these geographically induced wind circulation effects are named after the source location of the winds, e.g., lake and sea breezes, and mountain and valley winds. In very rugged hilly or mountainous terrain, along coastlines, or near large land use variations, the characterization of the winds is a balance of various forces, such that the assumptions of steady-date straight-line transport both in time and space are inappropriate…."[Id.]

The terrain in the immediate area of the Portland plant is complex. Terrain with elevations equal to the top of the stacks venting Units 1 and 2 (694 ft amsl) is located 1.9 km to the east and southeast of the stacks, and 2.4 km southwest of the stacks. The very high terrain of 1500 ft amsl on Kittatinny Ridge is located as close as 7 km from the stacks. The non-uniform wind field in this portion of the Delaware River Valley has been verified by meteorological measurements. In the complex terrain surrounding the Portland Power Plant, the horizontally and vertically varying wind fields can only be accurately reproduced by a three-dimensional wind field. Accordingly, the immediate area of the plant exhibits complex winds as described in Section 7.2.8 of the regulations, and therefore, CALPUFF is a more suitable model than AERMOD here. A detailed description of the complex wind field is contained in the Bureau of Technical Services document "*Use of CALPUFF for Near-Field Air Quality Modeling of the Portland Power Plant*" (April 10, 2008). This document has been sent to EPA.

BTS is also concerned that the only available meteorological data in the vicinity of the plant was collected for use in CTDMPlus. Use of this data in AERMOD in previous air quality analyses performed for the Portland Generating Station may not be representative (see below). Nevertheless, in response to USEPA Region 2 comments, BTS has performed an air quality impact analysis using AERMOD.

Meteorology

The meteorological data set that was used in this analysis is the only meteorological data available for use in AERMOD to evaluate the Portland Generating Station. However, there are a few issues with this meteorological data. The meteorological data used was collected by Metropolitan Edison (previous owner of the Portland Power Plant) at a site located 2.3 km west-southwest of Units 1 and 2 at an elevation 316 ft higher than Unit 1 and 2's stack base elevation. Paine and Gendron[1] report in their paper describing the use of on-site tower and SODAR data in modeling analyses that "[i]n some cases, applicants attempt to "gain elevation" and save money by placing a tower and/or sodar on a hill, while the source of interest is located at lower elevations in a valley. The problem with this strategy is that the tower/sodar is displaced some distance away from the actual source. The unique valley winds and temperature structure that is present at the source location are often not adequately represented at the alternate location…" Paine concludes "[t]he use of tower and sodar data in elevated areas away from stacks (e.g., located in a valley) is also not recommended due to likely misrepresentation of the vertical temperature structure and the turbulence (as well as horizontal wind) profiles in adjacent hilly areas." This type of data, however, was collected by Metropolitan Edison. Another concern with the meteorological data is the high frequency of low sigma w values. This suggests problems with the instrumentation used to measure the sigma w at the 30 m and 100 m levels.

Measurements were taken at a 100 meter tower and with SODAR from July 1993 thru June 1994. Measurements collected consisted of hourly values of solar radiation, multiple levels of wind direction, wind speed, and temperature. In addition, turbulence measurements of sigma-theta (30m and 100m) and sigma-w (30m and 100m) were collected.

Site characteristics such as surface roughness, albedo, and Bowen ratio in the original analysis were recalculated using the Aersurface program. Albedo and Bowen ratios (average precipitation) were based on land use in an area 10 km by 10 km around the site. Surface roughness was calculated for 12 sectors extending out 2 km from the meteorological tower. The default radius for surface roughness of 1 km was not used because the lowest height of wind speed input (30 m) was well above the 10 meter height used as the basis for the 1 km recommendation (AERMOD Implementation Guide, Section 3.1.2). Based on review of aerial photos, the amount of low density land use in the USGS land use data was increased modestly in two of the sectors.

Terrain Data

Terrain data for use in AERMAP included USGS 30-meter digital elevation model (DEM) data. These data were obtained from the CD entitled "Computer Modeling Archive – SO2 NAAQS Compliance Modeling for GPU's Portland Generating Station" (ENSR Corp., May 1999). Figure 1 shows the terrain relief in the vicinity of the Portland Generating Station.

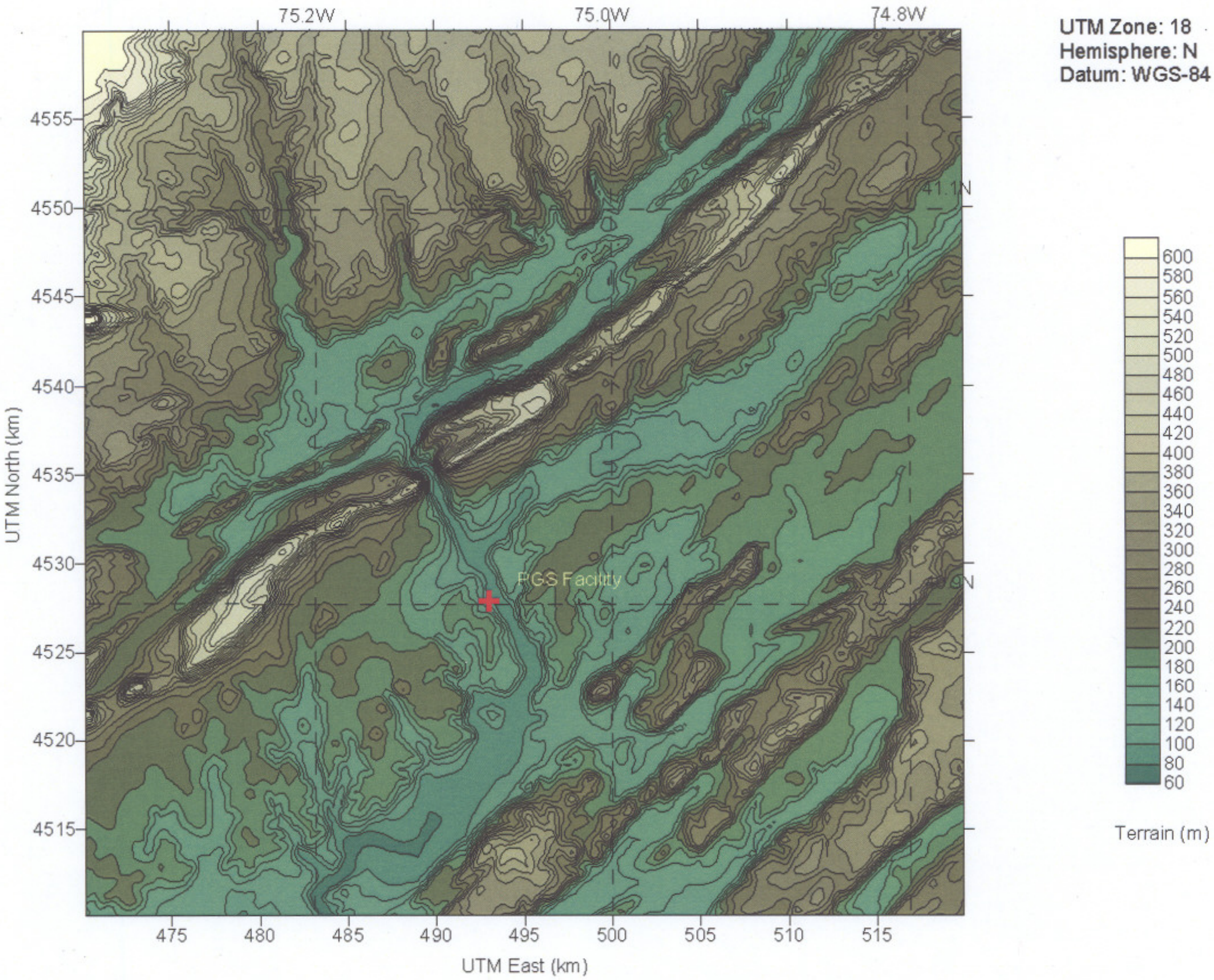


Figure 1 Terrain in the vicinity of the Portland Generating Station

Receptor Grids

Figure 2 shows the receptor grids used in the analysis. As was the case for the terrain data, receptor data was also taken from the above referenced CD.

The receptor grid consisted of the following 250 meter grids:

- a diagonal area of elevated terrain encompassing the Kittatinny Ridge areas in both Pennsylvania and New Jersey
- a square area 6 km on a side, centered at the PGS site,
- a diagonal area of elevated terrain to the northeast of the Jenny Jump terrain.

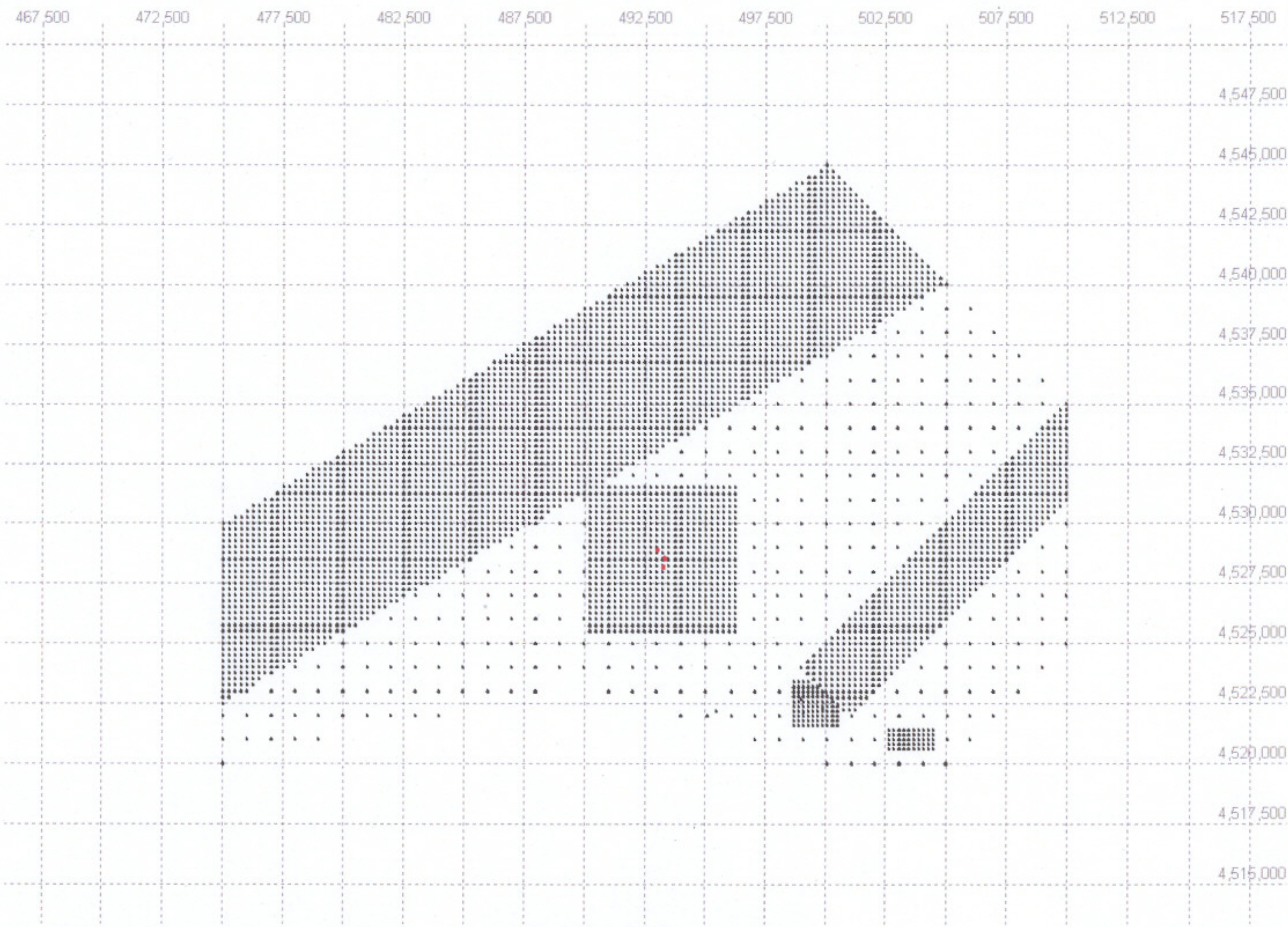


Figure 2 Receptor Locations

Stack Parameters

Stack parameters for all sources modeled are listed in Table 2. The stack parameters for Units 1, 2, and 5 were taken from data sets on a CD submitted by Reliant Energy Portland, L.L.C. entitled "Dispersion Modeling File Archive Revised NAAQS and PSD Increment for SO_2 and PM-10" (July 2001). The size of the coal pile was estimated from a 6/11/1996 map generated by United Engineers and Constructors entitled "Metropolitan Edison Company Portland Station General Arrangement - Overall Site Plan."

Table 2. Stack Parameters

Source	UTM Coordinates		Stk. Base (ft amsl)	Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Temp. (K)
	X (km)	Y (km)					
Unit 1	493.349	4528.505	294	121.92	2.84	43.3	403.1
Unit 2	493.335	4528.554	294	121.72	3.79	36.26	405.9
Unit 5	493.008	4528.897	294	42.67	6.1	36.6	821.5
Coal Pile (volume source)	493.273	4528.186	294	4.6 (in height)	2.13 (initial sigma z)	35.5 (initial sigma y)	--

Emission Rates

The emission rates used in the modeling are listed in Table 3. Units 1 and 2's direct PM-2.5 emission rates were calculated based on heat inputs of 1657.2 MMBtu/hr for Unit 1 and 2511.6 MMBtu/hr for Unit 2. The direct PM-2.5 condensable emissions are based on a stack test conducted by Alstom during normal operations of Unit 1 on June 13, 2006. A report on this stack test is available at:

www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/42306/**ALSTOM**-Hg-DOE%20Qtrly%20Sep%2006.pdf

The condensable emission rate reflects the maximum sulfur content of coal Portland could fire (2.4 percent) and still meet the sulfur dioxide emission limits. The coal sulfur content during the June 13, 2006 test was 1.9 percent. Direct PM-2.5 filterable emissions are based the unit's allowable total particulate emission rate and AP-42, Table 1.1-6, ESP particle size ratio of PM-2.5 to total particulate (0.29). These emission factors--0.029 lb/MMBtu (filterable) and 0.037 lbs/MMBtu (condensable)--were applied to both units.

Unit 5 is a 150 MW simple-cycle turbine with a heat input of 1813 MMBtu/hr firing natural gas and 1880 MMBtu/hr when firing No. 2 oil. PM-2.5 emission rates were calculated using the results of a September 10, 2002 stack test for PM-2.5. The measured condensable (0.0163 lbs/MMBtu) was all assumed PM-2.5. Half of the measured PM-10 filterable (0.00248 lbs/MMBtu) was assumed PM-2.5. The resulting PM-2.5 emission rate is 28.3 lbs/hr.

Table 3. PM-2.5 Emission Rates	
Unit	**lb/hr**
1	109.4
2	165.8
5	28.3

One bulldozer and two front-end loaders travel on the coal pile while conducting coal reclamation and coal pile maintenance operations. One bulldozer was assumed to be involved in operations between 7 am to 7 pm. Emissions were estimated using the equation in AP-42 Table 11.9-1, a silt content of 3.1 percent, and a moisture content of 6 percent. Based on these calculations, a bulldozer operating on the coal pile will emit 1 lb/hr of PM-2.5. One front-end loader was assumed to be involved in coal moving operations between 9 - 11 a.m. and between 3 - 5 pm. Emissions were estimated using Equation 1.a of AP-42 13.2.2.2 (vehicles traveling on unpaved surfaces in industrial areas). Based on a speed of 10 mph and weight of 55 tons, a value of 2.5 lb/hr was calculated for the front-end loader operations. The total annual PM-2.5 emissions from bulldozer and front-end activities were 4 tons/yr.

PM-2.5 emissions from material transfer points, coal conveyors and coal breaking/crushing activities were not included in the analysis.

Background PM-2.5 Concentrations

Background concentrations were taken from two existing PM-2.5 monitors. One was the PADEP monitor located in Freemansburg, PA, approximately 23 miles southwest of the Portland Station. This monitor accurately represents PM-2.5 background levels being advected into the Portland area when winds are from the southwest quadrant. The meteorological conditions of concern are light to moderate winds from the southwest quadrant. Because the Freemansburg monitor is located near an urbanized area, an additional monitor was selected that was more representative of a rural location. The other monitor used was NJDEP's monitor located in Chester, NJ, approximately 21 miles east-southeast of the Portland Stations. PM-2.5 measurements taken by this monitor are among the lowest in New Jersey.

Table 4 below lists the 98th percentile 24-hour and annual PM-2.5 background based on the average of the 3 most recent years (2005 – 2007) of data.

Table 4. 2005 -2007 PM-2.5 Monitored Concentrations

Averaging Time	Chester, NJ (ug/m^3)	Freemansburg, PA (ug/m^3)	Average (ug/m^3)
98th Percentile 24-hour	37.3	30.7	34.0
Annual	10.1	13.4	11.8

The 98th percentile value in Table 4 was used to determine compliance with the 24-hour PM-2.5 NAAQS.

$PM_{2.5}$ Modeling Results

AERMOD was run with the regulatory default options to evaluate the impacts of the Portland Generating Station's emissions of $PM_{2.5}$ on New Jersey ambient air quality. Table 5 lists the maximum 24-hour and annual $PM_{2.5}$ impacts. In addition, the 8th highest 24-hour concentration is given. The $PM_{2.5}$ impacts in Table 5 only include directly emitted particulate matter, no secondary particulate (sulfate and nitrate) are included. The maximum 24-hour concentration from all sources at the facility in New Jersey was approximately 8 ug/m^3 along the Delaware River. The maximum 8th highest 24-hour concentration from all sources in New Jersey was approximately 5 ug/m^3 located along the Delaware River.

Table 6 lists the maximum 24-hour, annual $PM_{2.5}$ impacts, and the 8th highest 24-hour concentrations in New Jersey from the stacks only. The maximum 24-hour concentration from the stacks in New Jersey was approximately 5 ug/m^3 located along the Kittatinny Ridge. The maximum 8th highest 24-hour concentration from the stacks in New Jersey was approximately 2 ug/m^3 located approximately 1.5 km southeast of the facility.

Table 5 Total Facility Predicted Concentrations in NJ Due to Direct $PM_{2.5}$ Emissions

Averaging time	Predicted Impact (ug/m^3)	Background[(a)] (ug/m^3)	Total Impact (ug/m^3)	NAAQS (ug/m^3)
Annual	1.1	11.8	12.9	15
Maximum 24-hour	8.1	34.0	42.1	35
98th Percentile 24-hour	4.7	34.0	38.7	35

a. Background $PM_{2.5}$ concentration, represent the average 24-hour 8th-highest and annual 2005-2007 concentrations monitored at Freemansburg PA and Chester NJ.

Table 6 Predicted Concentrations in NJ Due to Direct $PM_{2.5}$ Emissions from the Stacks

Averaging time	Predicted Impact (ug/m^3)	Background[(a)] (ug/m^3)	Total Impact (ug/m^3)	NAAQS (ug/m^3)
Annual	0.25	11.8	12.05	15
Maximum 24-hour	4.8	34.0	38.8	35
98th Percentile 24-hour	1.7	34.0	35.7	35

a. Background $PM_{2.5}$ concentrations represent the average 24-hour 8th-highest and annual 2005-2007 concentrations monitored at Freemansburg PA and Chester NJ.

Both Tables 5 and 6 indicate that when Portland Power Plant's 8th highest 24-hour predicted concentrations are added to existing background $PM_{2.5}$ concentrations, violations of the 24-hour $PM_{2.5}$ NAAQS occur. Because only one year of representative meteorological data (1993-1994) was available and the fact that $PM_{2.5}$ was not monitored at that time, it was not possible to compare impacts and monitored data on a more robust day by day basis.

References

Paine, R.J, L.J. Gendron, ENSR Corporation, Acton, MA, Experience in Modeling Applications Using On-site Tower and Sodar Data. Paper 11.4, presented at the 11th Conference on Air Pollution Meteorology, American Meteorological Society