US EPA ARCHIVE DOCUMENT

Eastman TNO Site-Specific Dispersion Model Application for SO2 1-Hour Compliance

Haidar Al-Rawi, TDEC/APCD
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Background

- SO2 1-hour Attainment Demonstration

  New 1-hour SO2 NAAQS of 75 ppb (196 µg/m3) in 2010

  3-km partial Sullivan County, TN, NAA centered on the Eastman facility in Kingsport, TN (August 5, 2013 Federal Register notice, 78 FR 47191)

  SO2 Monitoring basis on DV of 196 ppb (2009-2011), about 2.6 times the NAAQS of 75 ppb

- Initiation of 1-year on-site database (4/1/2012-3/31/2013) that enabled Eastman/AECOM to develop site-specific modeling approach with evaluation using concurrent meteorological, emissions, and monitoring data at multiple sites

- Major SO2 sources, Coal-fired boilers : B-83 (7, 70 m/230 ft); B-253 (5, 76 m/249 ft); B-325 (2, 114 m/374 ft)

Figure 1: EPA Final TSD Depiction of Area SO2 Sources near Kingsport, TN

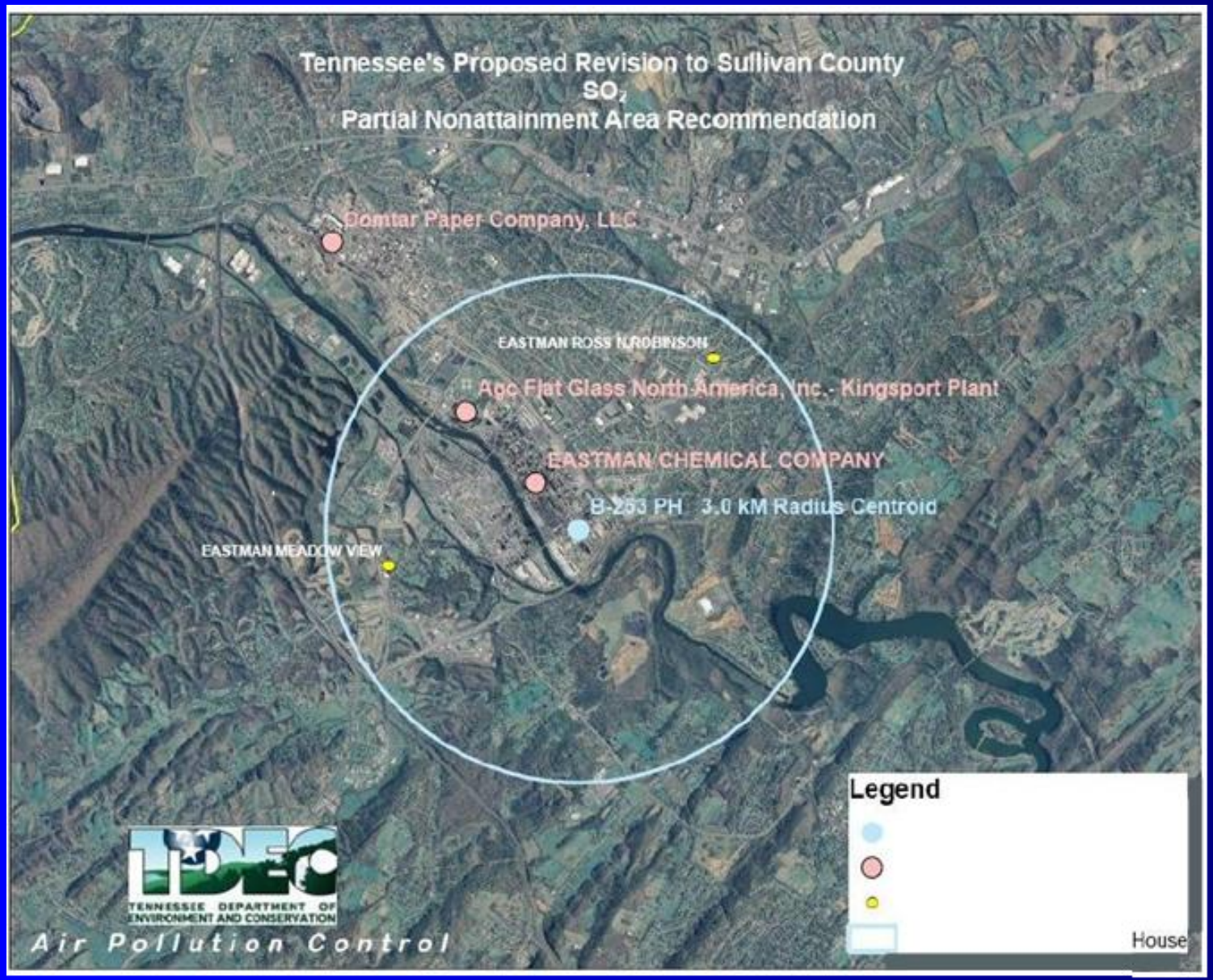


Figure 2 - Eastman Power Houses at the Kingsport, TN Complex

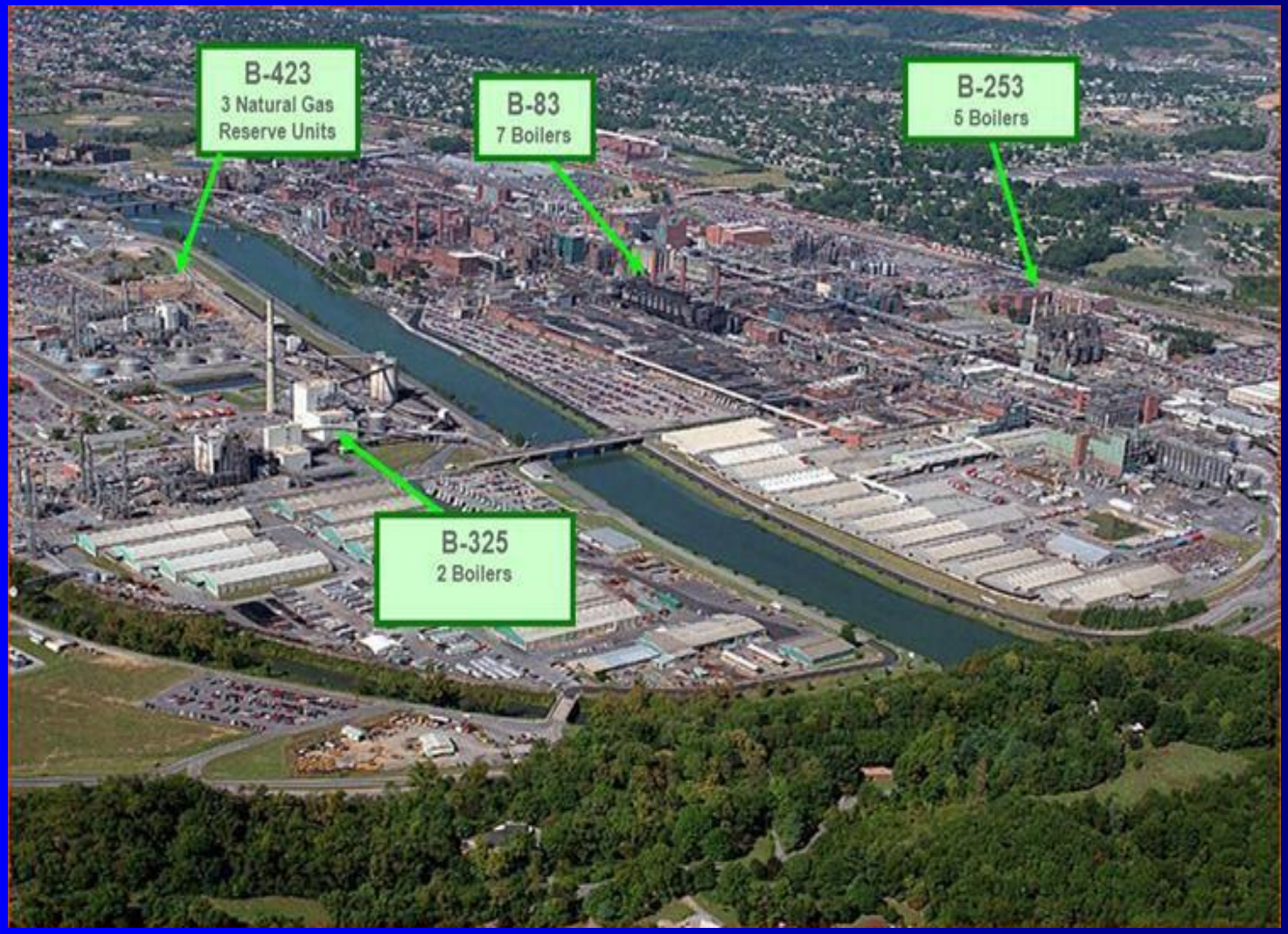


Table 1 - Eastman SO2 Sources, Emissions, and Stack Parameters

							Annually Averaged		
Powerhouse	Stack(s)	UTM-X (m)	UTM-Y (m)	Base Elev. (m)	Stack Ht. (m)	Stack Diam. (m)	Emission Rate (g/s)	Stack Temp. (K)	Exit Velocity (m/s)
83	18-22	362205.8	4042493.6	368.8	70.1	4.27	61.2	451.8	9.00
	23-24	362173.1	4042542.2	368.8	70.1	4.27	93.2	434.0	9.28
253	25	362515.1	4042333.2	373.7	76.2	2.44	83.4	397.6	17.52
	26	362530.1	4042342.0	373.7	76.2	2.44	86.1	392.6	18.41
	27	362544.7	4042351.8	373.7	76.2	2.44	86.4	406.6	17.72
	28	362557.8	4042361.0	373.7	76.2	2.44	84.7	404.7	17.43
	29	362571.5	4042370.6	373.7	76.2	2.44	85.8	408.6	18.25
325	30-31	361800.0	4042105.0	367.7	114.3	3.05	37.2	354.5	26.38

Monitoring Objective

- SO2

  Comparison of Modeling vs. Monitoring Impacts

- Pollutant Monitoring sites:

  Site 1: Meadowview Monitor – SO2, flat terrain, 1.5 km SW

  Site 3: Ross N Robinson Monitor School – SO2,
  flat terrain, 2.5 km ENE, controlling monitor for exceedance of the 1-hour SO2 NAAQS

  Site 4: Skyland Drive – SO2, high terrain, 3 km E

  Site 6: B-267 – SO2, flat terrain, near eastern plant fence line

  Site 8: Bays Mountain – SO2, high terrain, 2.5 km W
  represents high modeled concentrations

Figure 3 - Eastman Monitoring Sites Locations – Kingsport, TN

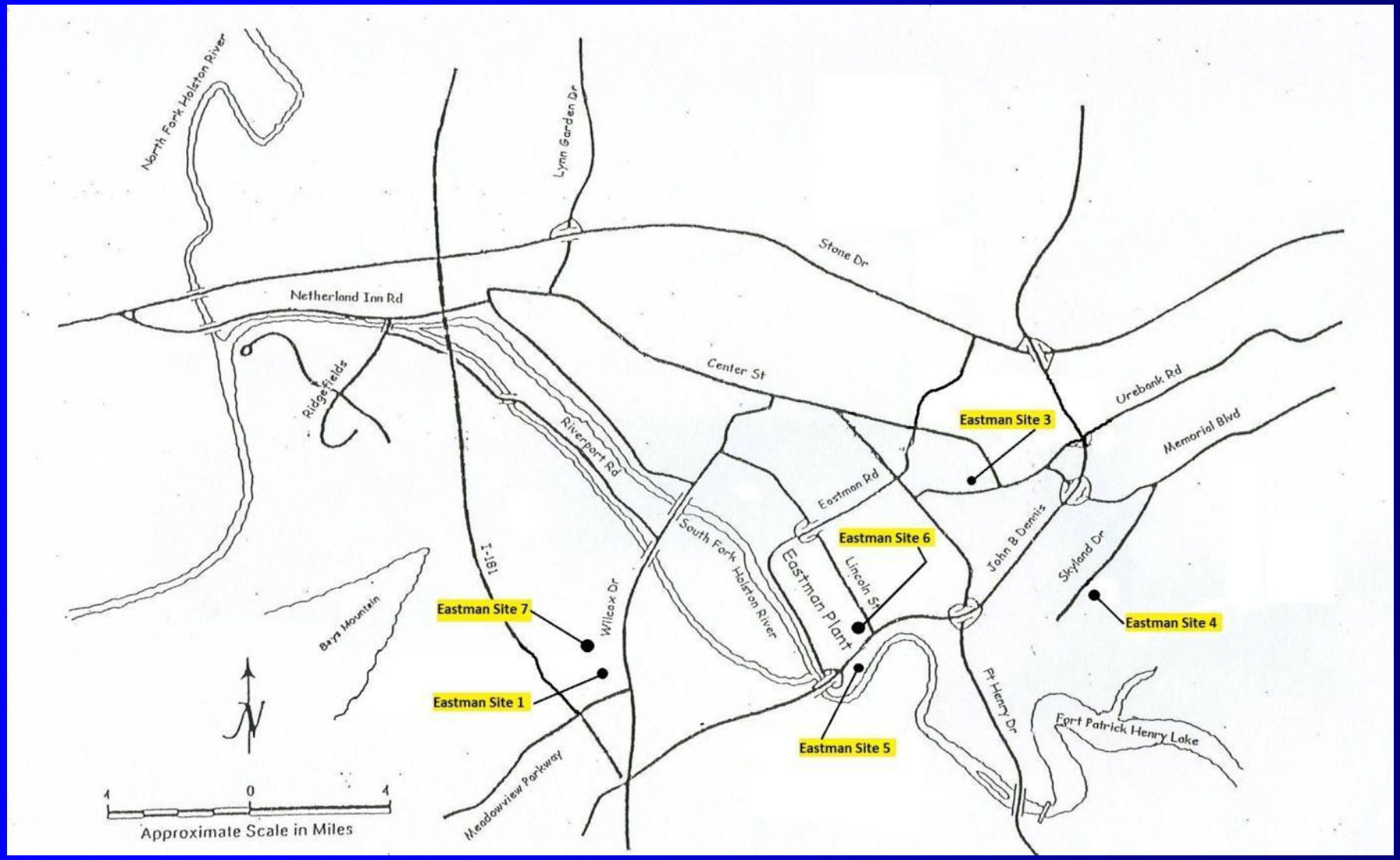
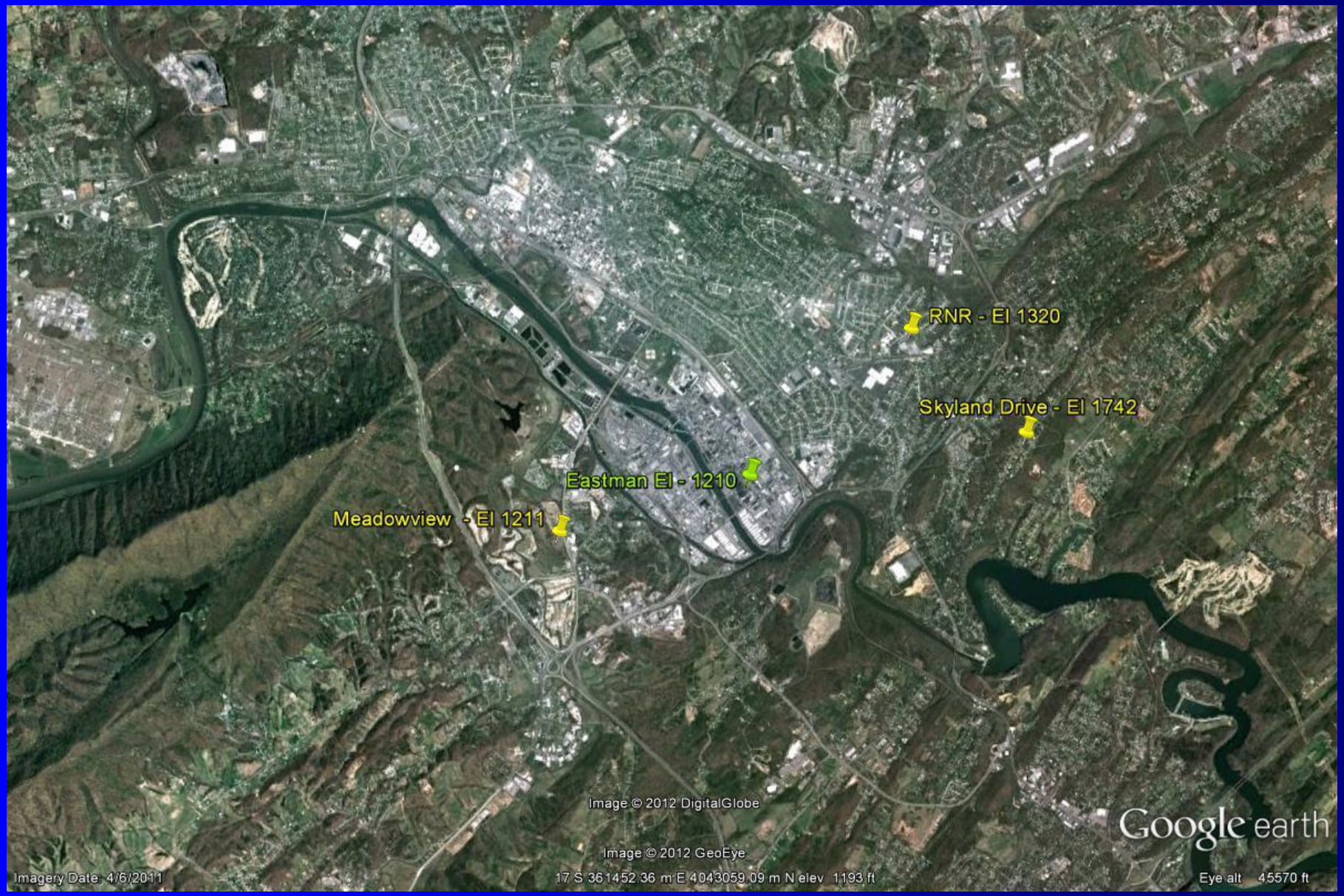


Figure 4 – Eastman Monitoring Sites Locations and Elevations



Modeling Objective

- Eastman/AECOM found that AERMOD as run in default regulatory mode resulted in substantial over-predictions at the Eastman monitors

- Eastman/AECOM proceeded with testing AERMOD using the full year of on-site data with site-specific enhancements based upon the following features
  - Use of low-wind speed options included in AERMET version 14134 (beta u* option)
  - Use of minimum sigma-v specifications using LOWWIND2 option in AERMOD
  - Accounting for partial merging of buoyancy of plumes from adjacent stacks
- Eastman/AECOM concluded that this proposed evaluation supports the use of the site-specific model that they named "Eastmod" for compliance with the 1-hour SO2 NAAQS

Figure 5 – Eastman Topographical Map

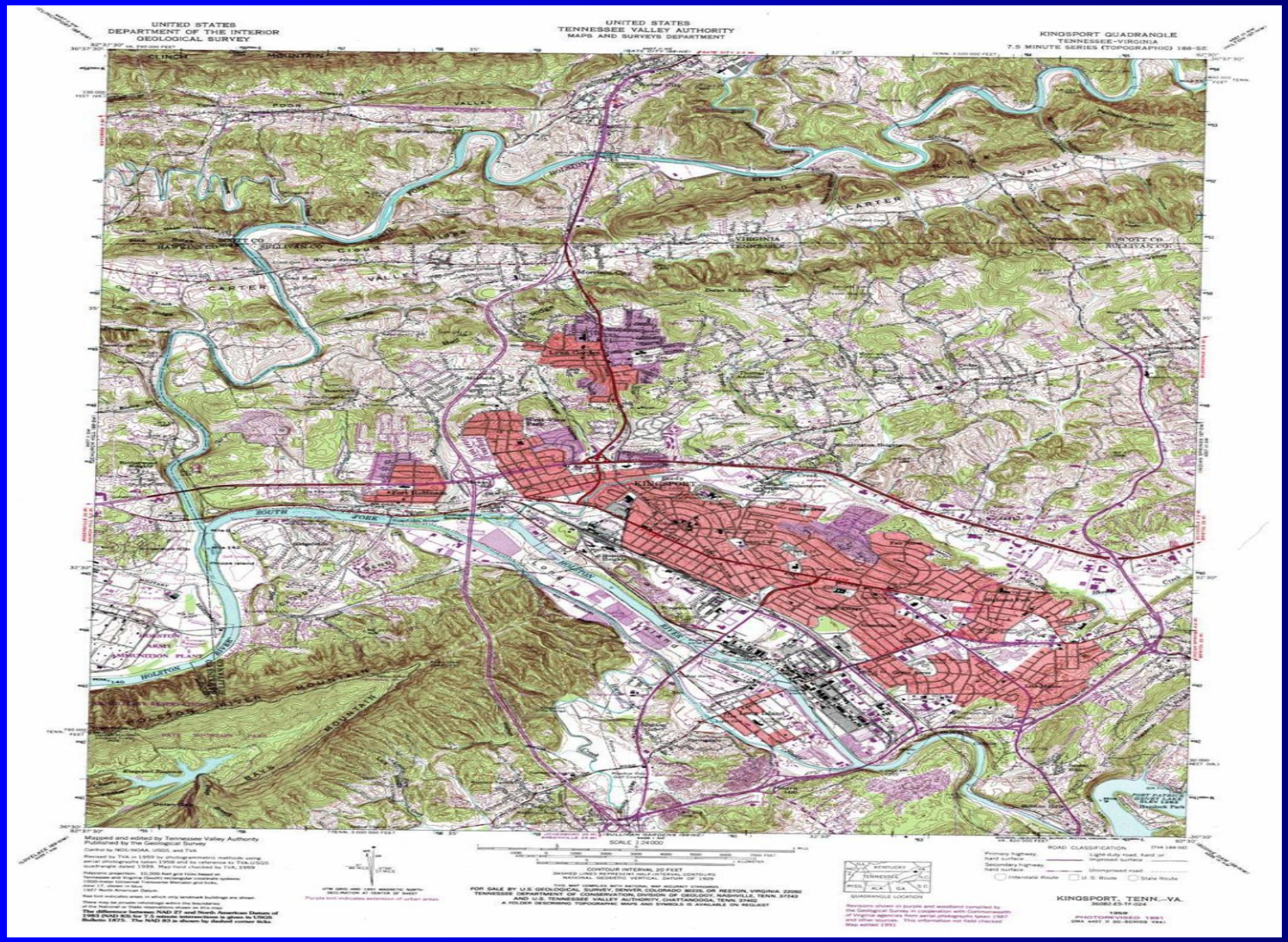
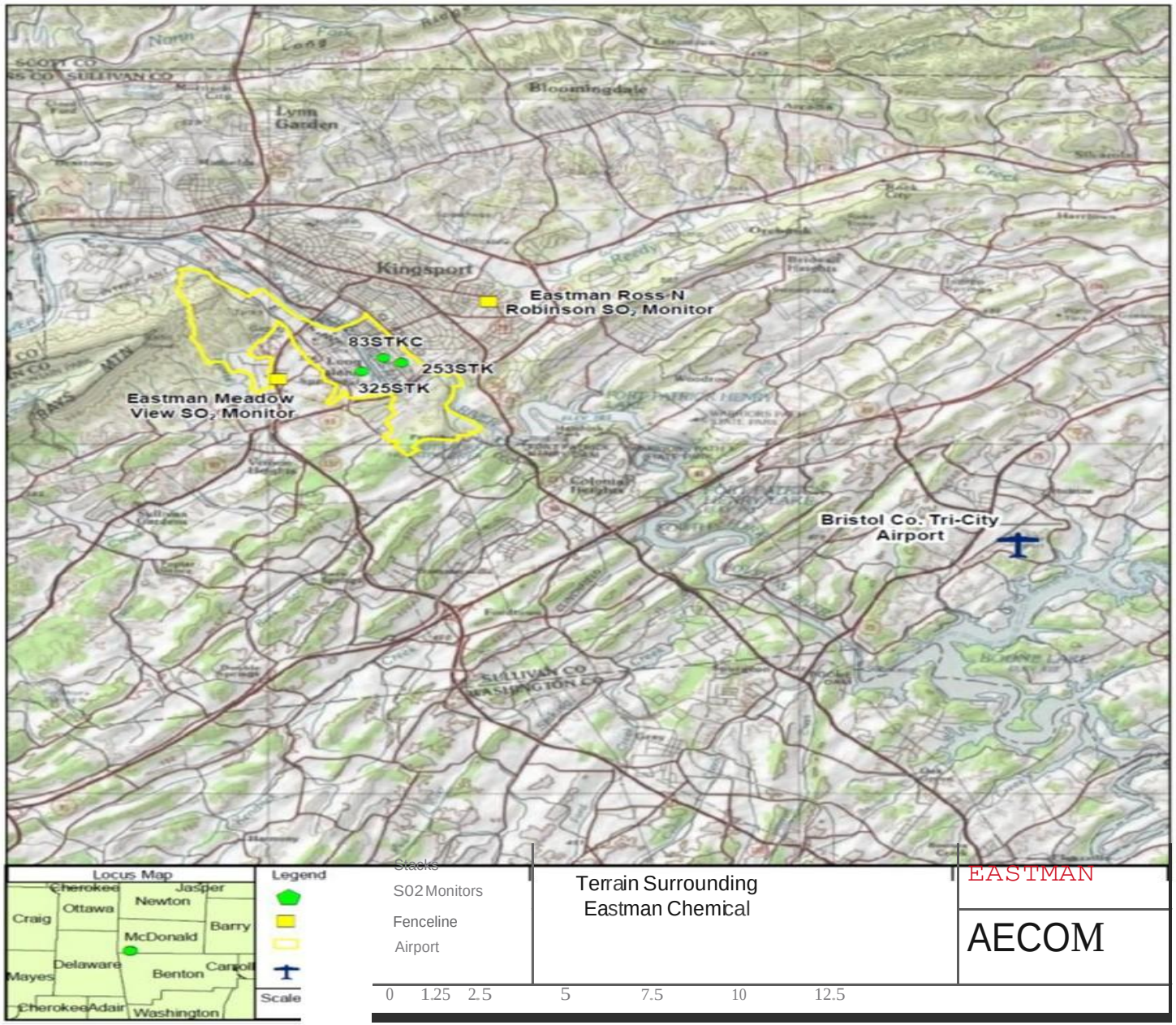


Figure 6 – Terrain Surrounding Eastman



WIND ROSE PLOT:

2005-2009 Wind Rose for Eastman Chemical
Bristol-TriCity Airport, TN Winds

DISPLAY:

Wind Speed
Direction (blowing from)

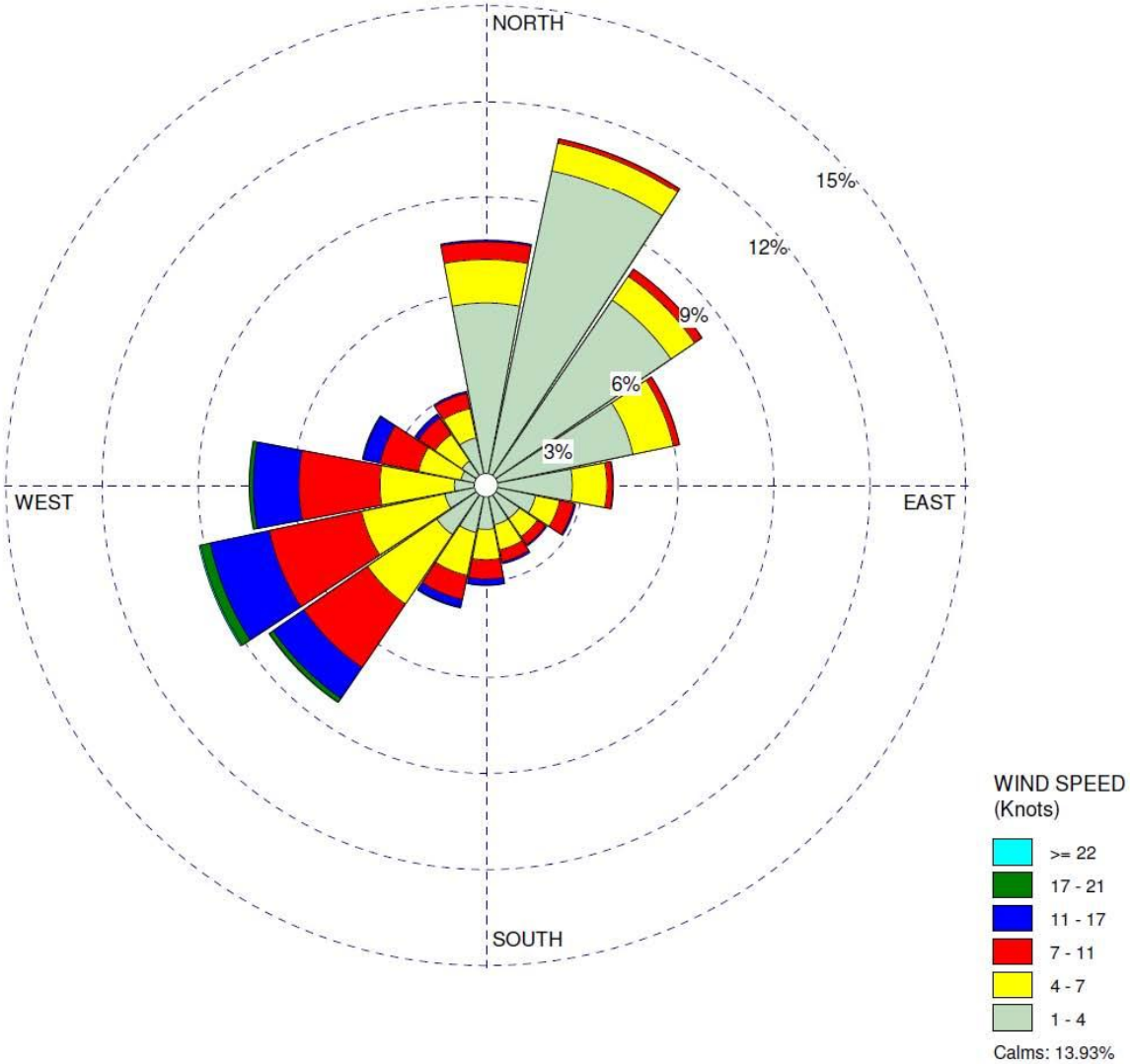


Figure 7– Eastman 2005-2009 Wind Rose Plot

Meteorological Data

- ON-Site MET Station (Site 7)

  for surface and upper-air data measurements

- And/or NWS obs site in Tri-City area

  operated by NOAA and received at the NCDC, Ashville, NC

- MET monitoring station design and QAPP

  submitted 1/5/2012 to TDAPC and EPA-R4

- On-Site MET (Site 5)

  Ws and Wd data collection

Figure 8 – Location of Eastman Site relative to Tri-Cities Airport

SO2 Control Measures

- Powerhouse B-253 BART scrubber project
  - •Spray dryer absorber/fabric filter (~90% control)
  - •Will reduce Eastman SO2 emissions by ~65 percent
  - Anticipate monitored attainment
  - •Background SO2 expected to be minor
  - •196 ppb x 0.35 = 69 ppb < 75 ppb
- Or, Powerhouse B-253 fuel switch from coal-firing to N.G.-firing
  - •Background SO2 expected to be minor
  - •Total Plant SO2 reductions to 1/3 of the current levels
  - •Current monitored DV is less than 3 times the NAAQS
- Question:
  - •Will these planned controls be enough to make an attainment demonstration?
  - •Common sense and available monitoring data says yes;
  - •AERMOD using airport data says no

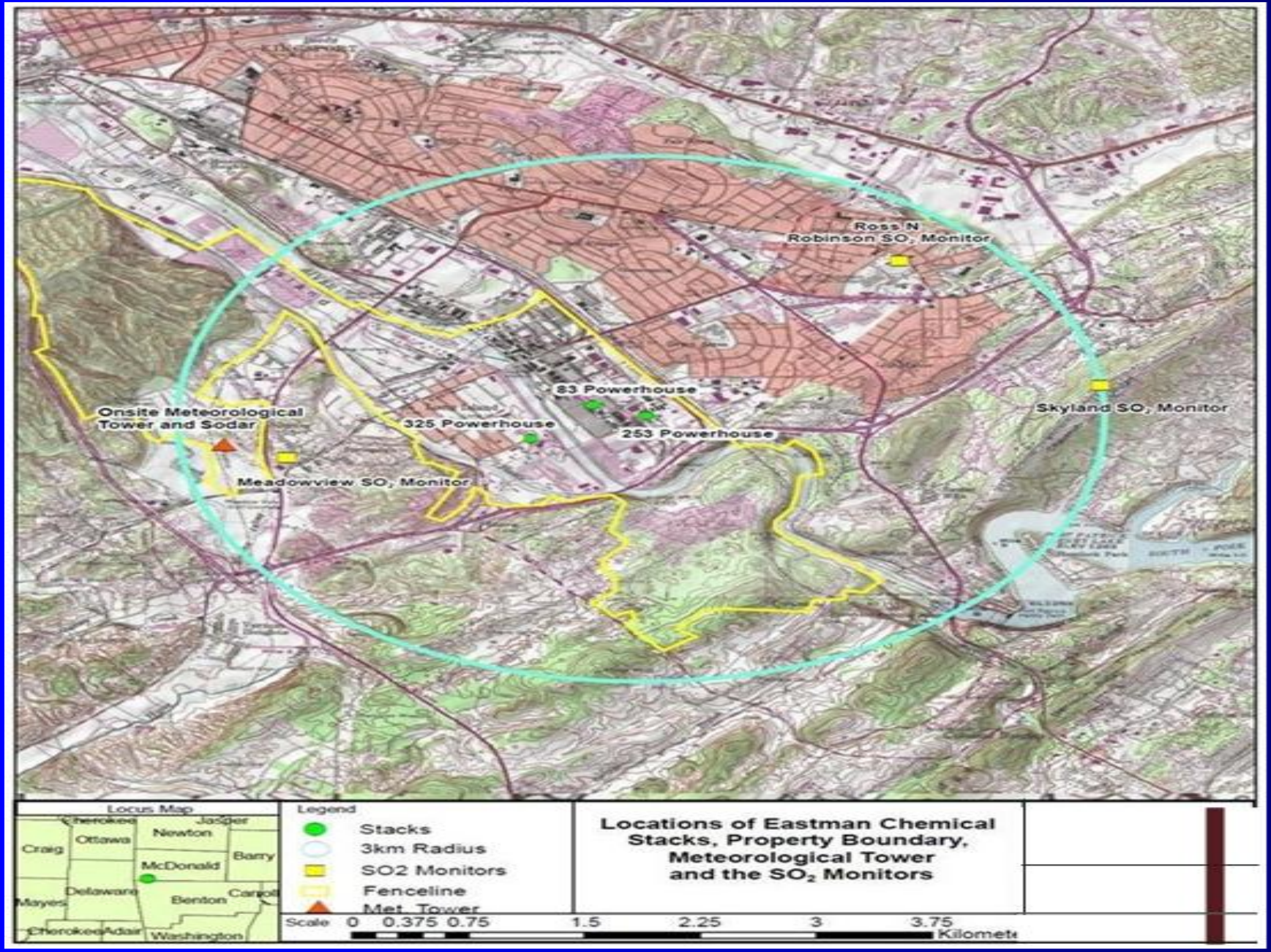
Eastman Plan for Attainment Demonstration

- Install on-site tall (100m) met tower and co-located SODAR
- Collect one-year of on-site met data
- Collect, in parallel, ambient SO2 data at four sites
  - Downwind valley (“RNR”)
  - Upwind valley (“Meadowview”)
  - Downwind high elevation “hot spot” (“Skyline Drive”)
  - Downwash zone “hot spot”
- Track hourly SO2 emissions
- Evaluate Performance of AERMOD and/or CTDMPlus
- Propose modeling approach using results as guidance

Figure 9 – Pictures of Met Tower, SODAR and SO2 Monitor

Figure 10 – Picture of the 100-meter Met Tower

Figure 11 – Location of Met Tower and SO2 Monitors



Planned SO2 Monitoring Program

- Would include the four monitors shown in the previous slide:
  - •Meadow View (to the west of the plant)
  - •Ross N Robinson (to the northeast of the plant)
  - •Skyland Drive (in high terrain to the southeast of the plant)
  - •Downwash Zone
- These monitors would be used for two purposes:
  - •Provide some information for evaluating the accuracy of the modeling approach
- •Provide concurrent hourly regional background information (the lowest monitored value would be assumed to represent hourly regional background

Use of Meteorological Data by EPA Models

- AERMOD and CTDMPLUS are guideline dispersion models supported by US EPA
- A key component of the model's ability to accurately predict concentrations in terrain is meteorological data:
  - •Vertical temperature difference near stack height – affects plume rise and interaction with terrain features
  - •Direct turbulence measurements – affects plume dispersion
- AERMOD is designed to be conservative (but still provide predictions) in the absence of these measurements
- CTDMPLUS requires these measurements to run at all

Design of Meteorological Measurement Program

- Obtain temperature difference measurements to the top of a 100-m tower
- Tower wind measurement heights would be 10, 50, and 100 m
- SODAR measurement heights would start at 50 m and use 25-m increments
- Overlap between tower and SODAR at 50 and 100 m would provide continuous SODAR Q/A
- Instruments will meet specifications stipulated in EPA's "Meteorological Monitoring Guidance for Regulatory Modeling Applications" (EPA-454/R-99-005)
- Obtain wind measurements to at least 200 meters (supplement a tower with SODAR)

Meteorological Measurement Program (continued)

- Wind measurements would include wind direction, wind speed, sigma-theta (for horizontal wind fluctuation), sigma-w (for vertical wind fluctuation), and sigma-u (alongwind standard deviation for possible roughness calculations)
- Temperature difference would be measured relative to 10 m at 2 m, 50 m, and 100 m
- Surface measurements would also include solar radiation, pressure, and precipitation (for SODAR QA)

Full-Year Field Study to Support Site-Specific Model

- Met Monitoring Network Design
  - AERMOD- First Choice to consider based on sources, topography and EPA regulatory guidance
  - Complex Terrain – Acquire multiple-level met data for input into AERMOD based upon previous sensitivity studies in terrain settings & EPA's use of site-specific data in its evaluation of AERMOD
  - Installation of a 100-m met tower w/multiple levels of met sensors (at 2, 10, 50, and 100 m)
  - Installation of a SOund Detection And Ranging (SODAR) wind profiler system (w/measurements starting at 50 m and extending upward in 50-m increments to 500 m)
  - Monitoring program relied on EPA GAQM (40 CFR 51, Appendix W) and EPA's Met Monitoring Guidance for Regulatory Modeling Application (EPA 454/R 99 005, February 2000) for sensor and parameter selection and siting of the met tower and SODAR

Full-Year Field Study to Support Site-Specific Model - Continued

- SO2 Monitoring
  - April 1, 2012 –March 31, 2013 Met Measurement Program
  - Three Eastman Monitors operated for this period (RNR, Meadowview and Skyland Drive – Historical Sites)
  - Two new sites operated for a portion of this period (B-267 Parking Lot and Bays Mountain) as shown in Figure 11
- Met Tower Data Capture Summary
  - Above 90% for each month of the monitoring program
- SODAR Data Capture Summary
  - Above 90% or greater up to around 400 m
  - Data from the 50-m and 100-m levels were not used in the modeling, but were used in the performance testing of the SODAR against the met tower

Table 2 – Data Capture for the Met Tower – April 2012 – March, 2013

Tower Level	Parameter	1-Apr	May	Jun	2nd Qtr	Jul	Aug	Sep	3rd Qtr	Oct	Nov	Dec	4th Qtr	Jan	Feb	Mar	1st Qtr	Cum Avg.
2 Meter	2M- Temp WSP	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	2M-Tot Solar	100	94	100	98	100	100	100	100	100	100	100	100	100	100	100	100	100
	2M- RH	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	2M-Bar Press	100	100	100	100	100	100	98	99	99	100	100	100	100	100	100	100	100
	2M- Precip	100	100	100	100	68	79	100	82	92	98	87	92	100	100	100	100	94
10 Meter	10M-HWS	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	10M-HWD SD1	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	10M-HWD	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	10M-HWS SU	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	10M-VWS	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	10M- VWS Std	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	10M-Temp	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	Delta T 2-10M	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
50 Meter	50M-HWS	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	50M-HWD	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	50M-HWD SD1	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	50M-HWS SU	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	50M-VWS	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	50M-VWS STD	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	50M-Temp	99	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100
	Delta T 10-50M	100	100	100	100	100	100	99	100	100	100	100	100	100	100	100	100	100

Table 2 – Data Capture for the Met Tower – Continued
April 2012 – March, 2013

Tower Level	Parameter	1-Apr	May	Jun	2nd Qtr	Jul	Aug	Sep	3rd Qtr	Oct	Nov	Dec	4th Qtr	Jan	Feb	Mar	1st Qtr	Cum Avg.
100 Meter	100M-HWS	99	100	100	**100**	100	100	99	**100**	100	100	100	**100**	100	100	100	**100**	**100**
	100M-HWD	99	100	100	**100**	100	100	99	**100**	100	100	100	**100**	100	100	100	**100**	**100**
	100M-HWD SD1	99	100	100	**100**	100	100	99	**100**	100	100	100	**100**	100	100	100	**100**	**100**
	100M-HWS SU	99	100	100	**100**	100	100	99	**100**	100	100	100	**100**	100	100	100	**100**	**100**
	100M-VWS	99	100	100	**100**	100	100	99	**100**	100	100	100	**100**	95	93	100	**96**	**99**
	100M-VWS STD	99	100	100	**100**	100	100	99	**100**	100	100	100	**100**	95	93	100	**96**	**99**
	100M-Temp	99	100	100	**100**	100	100	99	**100**	100	100	100	**100**	100	100	100	**100**	**100**
	Delta T 10-100M	100	100	100	**100**	100	100	99	**100**	100	100	100	**100**	100	100	100	**100**	**100**

Table 3 – Data Capture for the SODAR – April 2012 – March, 2013

SODAR Level	Parameter	1-Apr	May	Jun	2nd Qtr	Jul	Aug	Sep	3rd Qtr	Oct	Nov	Dec	4th Qtr	Jan	Feb	Mar	1st Qtr	Cum Avg.
50 Meter	50M-WSP	87	99	100	**95**	98	99	97	**98**	91	91	98	**93**	85	40	89	**71**	**90**
	50M-WDR	87	99	100	**95**	99	99	97	**98**	91	91	98	**93**	85	41	89	**72**	**90**
	50M-SD1	84	98	99	**94**	98	98	95	**97**	88	88	94	**90**	81	37	85	**68**	**87**
	50M-VWS	86	99	100	**95**	99	99	97	**98**	91	92	98	**94**	85	42	89	**72**	**90**
	50M- SIG W	84	98	99	**94**	98	98	98	**97**	88	89	94	**90**	81	38	86	**68**	**87**
100 Meter	100M-WSP	87	98	100	**95**	97	99	98	**98**	91	91	98	**93**	85	40	89	**71**	**89**
	100M-WDR	88	98	100	**95**	97	99	98	**98**	93	84	98	**94**	85	42	89	**72**	**90**
	100M-SD1	83	97	99	**93**	97	98	97	**97**	89	82	95	**91**	83	38	86	**69**	**88**
	100M-VWS	84	98	100	**94**	97	99	98	**98**	93	83	98	**94**	86	42	90	**73**	**90**
	100M- SIG W	83	97	99	**93**	97	98	97	**97**	91	82	95	**92**	83	39	87	**70**	**88**
150 Meter	150M-WSP	86	99	100	**98**	95	99	98	**98**	91	82	98	**93**	85	37	88	**70**	**89**

Table 3 – Data Capture for the SODAR – Continued
April 2012 – March, 2013

SODAR Level	Parameter	1-Apr	May	Jun	2nd Qtr	Jul	Aug	Sep	3rd Qtr	Oct	Nov	Dec	4th Qtr	Jan	Feb	Mar	1st Qtr	Cum Avg.
150 Meter	150M-WDR	86	99	100	**95**	98	99	98	**98**	90	91	98	**93**	85	38	88	**70**	**89**
	150M-SD1	71	98	100	**90**	98	98	96	**97**	90	89	94	**91**	83	27	83	**64**	**86**
	150M-VWS	73	99	100	**91**	98	99	98	**98**	91	92	97	**93**	85	35	87	**69**	**88**
	150M- SIG W	71	98	100	**90**	98	99	97	**98**	90	90	94	**91**	83	29	84	**65**	**86**
200 Meter	200M-WSP	83	99	99	**94**	98	98	97	**98**	90	90	96	**92**	85	30	85	**67**	**88**
	200M-WDR	83	99	99	**94**	98	98	97	**98**	90	90	96	**92**	85	31	85	**67**	**88**
	200M-SD1	65	98	99	**87**	97	98	96	**97**	90	88	93	**90**	83	21	81	**62**	**84**
	200M-VWS	67	99	99	**88**	98	98	98	**98**	90	91	96	**92**	84	27	83	**65**	**86**
	200M- SIG W	65	98	99	**87**	97	98	97	**97**	90	90	93	**91**	83	22	81	**62**	**84**
250 Meter	250M-WSP	80	98	99	**92**	97	98	97	**97**	90	85	95	**90**	84	24	84	**64**	**86**
	250M-WDR	80	98	99	**92**	97	98	97	**97**	90	85	95	**90**	84	26	84	**65**	**86**
	250M-SD1	60	98	99	**86**	97	98	96	**97**	89	84	91	**88**	82	17	78	**59**	**82**
	250M-VWS	62	98	99	**86**	97	98	97	**97**	90	85	94	**90**	84	23	82	**63**	**84**
	250M- SIG W	60	98	99	**86**	97	98	96	**97**	90	84	91	**88**	82	18	78	**59**	**83**
300 Meter	300M-WSP	79	98	99	**92**	96	98	96	**97**	89	84	95	**89**	84	19	77	**60**	**85**
	300M-WDR	79	98	99	**92**	96	98	97	**97**	90	84	95	**90**	84	21	77	**61**	**85**
	300M-SD1	58	97	99	**85**	95	98	95	**96**	88	82	90	**87**	81	12	67	**53**	**80**
	300M-VWS	59	98	99	**85**	96	98	97	**97**	89	83	92	**88**	83	17	70	**57**	**82**
	300M- SIG W	58	97	99	**85**	95	98	96	**96**	89	82	90	**87**	81	13	67	**54**	**80**
350 Meter	350M-WSP	75	97	98	**90**	95	98	96	**96**	89	82	93	**88**	83	18	72	**58**	**83**

Table 3 – Data Capture for the SODAR – Continued
April 2012 – March, 2013

SODAR Level	Parameter	1-Apr	May	Jun	2nd Qtr	Jul	Aug	Sep	3rd Qtr	Oct	Nov	Dec	4th Qtr	Jan	Feb	Mar	1st Qtr	Cum Avg.
	350M-WDR	75	97	98	**90**	95	98	96	**96**	90	82	93	**88**	83	18	72	**58**	**83**
	350M-SD1	55	97	98	**83**	95	97	95	**96**	87	80	89	**85**	79	9	59	**49**	**78**
	350M-VWS	56	97	98	**84**	95	98	96	**96**	88	81	91	**87**	82	14	62	**53**	**80**
	350M- SIG W	55	97	98	**83**	95	97	95	**96**	88	80	89	**86**	79	9	60	**49**	**79**
400 Meter	400M-WSP	63	97	99	**86**	95	98	95	**96**	88	80	90	**86**	83	15	69	**56**	**81**
	400M-WDR	63	97	99	**86**	95	98	96	**96**	89	80	90	**86**	83	16	69	**56**	**81**
	400M-SD1	52	97	98	**82**	93	97	94	**95**	87	78	87	**84**	77	8	53	**46**	**77**
	400M-VWS	53	97	98	**83**	94	97	95	**95**	88	79	89	**85**	80	11	57	**49**	**78**
	400M- SIG W	52	97	98	**82**	93	97	95	**95**	87	78	87	**84**	77	8	53	**46**	**77**
450 Meter	450M-WSP	52	97	99	**83**	94	97	93	**95**	86	73	88	**82**	80	14	63	**52**	**78**
	450M-WDR	52	97	99	**83**	94	97	95	**95**	88	80	88	**85**	80	14	63	**52**	**79**
	450M-SD1	46	97	98	**80**	92	95	92	**93**	84	69	83	**79**	76	6	42	**41**	**73**
	450M-VWS	47	97	98	**81**	93	96	93	**94**	85	71	86	**81**	78	11	44	**44**	**75**
	450M- SIG W	46	97	98	**80**	92	95	92	**93**	84	69	83	**79**	76	7	41	**41**	**73**
500 Meter	500M-WSP	52	96	98	**82**	92	95	90	**92**	78	74	82	**78**	76	9	42	**42**	**74**
	500M-WDR	52	96	98	**82**	92	95	92	**93**	85	74	82	**80**	76	8	42	**42**	**74**
	500M-SD1	45	95	98	**79**	90	93	87	**90**	75	71	77	**74**	72	3	28	**34**	**70**
	500M-VWS	46	95	98	**80**	91	94	89	**91**	77	75	80	**77**	73	6	29	**36**	**71**
	500M- SIG W	45	95	98	**79**	90	93	88	**90**	76	73	77	**75**	72	3	27	**34**	**70**

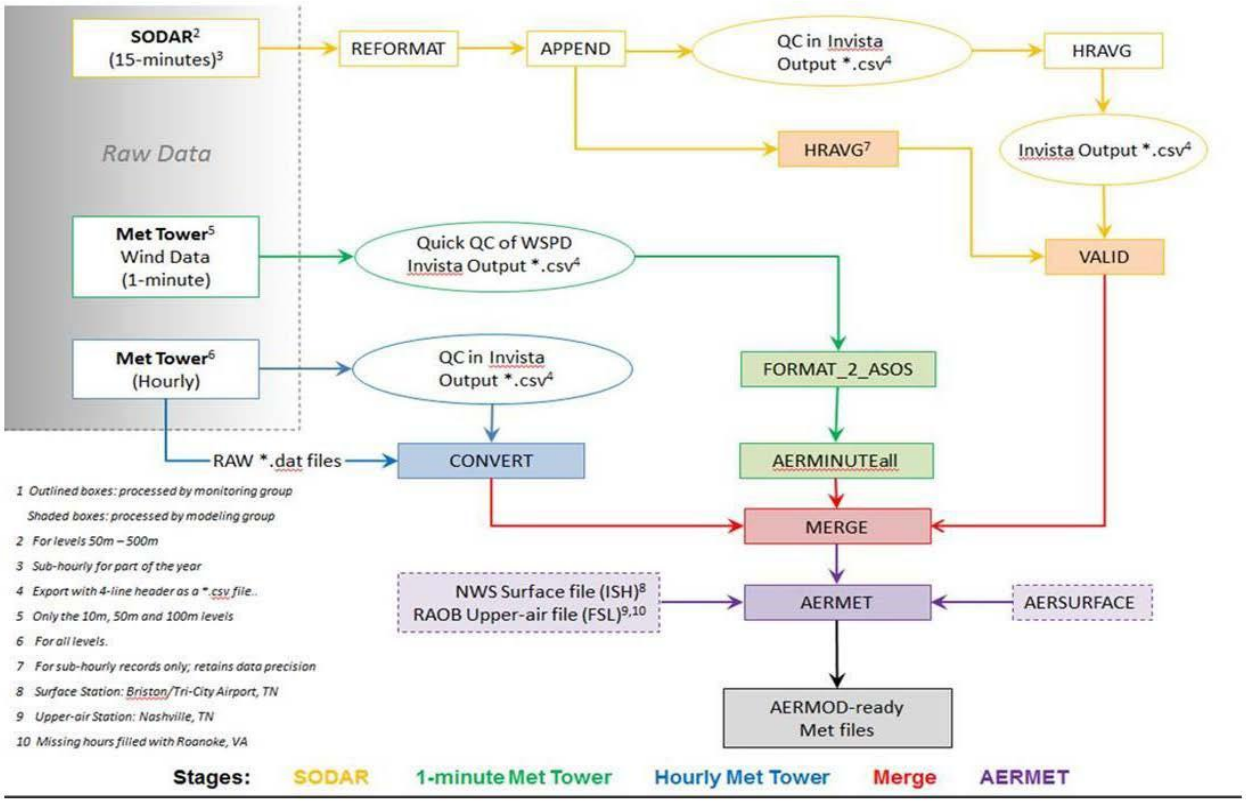
Processing of Site-Specific Met Data for AERMET

Table 4 – Summary of Measured Met Parameters

Levels	**MET TOWER: Hourly**				
2 m	Pressure	Insolation	Temperature		
10, 50 and 100 m	Horiz. Wspd.	Wind Dir.	Sigma-theta	Sigma-w	Temp
Levels	**MET TOWER: Minute**				
10, 50 and 100 m	Horiz. Wspd.	Wind Dir.			
Levels	**SODAR: Sub-hourly & Hourly**				
Every 50 m from 150 – 700 m	Horiz. Wspd.	Wind Dir.	Sigma-w		

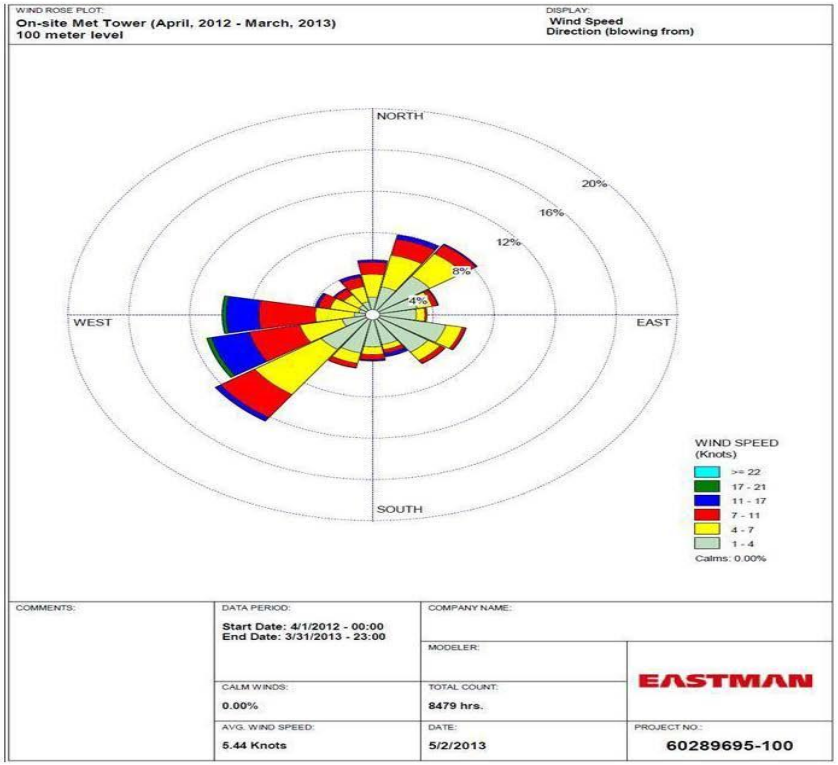
Processing of Site-Specific Met Data for AERMET

Figure 12 – Met Data Processing Flowchart



Processing of Site-Specific Met Data for AERMET

Figure 13 – Wind Rose for 100-m On-Site Met Tower



Determination of Background Concentrations

- Using Seasonal-by-hour-of-the-day ambient background value
  - Based on March 1, 2011 EPA guidance -Tier 2 approach
  - The 99th percentile (h-2-h) for each season for each hour were selected for the look-up table.
- Downwind analysis of all met levels up to 400 m to eliminate plant impacts (Wd within +/- 45°of a monitor) eliminated that monitor for the given hour
- High impacts (>30 µ/m3) at all monitors were excluded from considerations for the 99th percentile background
- The hourly values were screened for the lowest remaining obs among the valid monitor records for each hour

Determination of Background Concentrations - Continued

Figure 14: Seasonal by Hour of Day Ambient Background Values for Kingsport

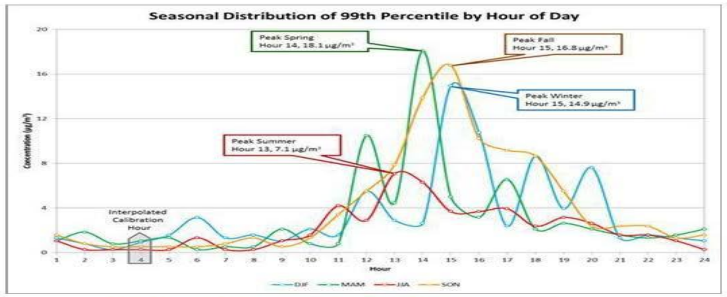


Table 5: Lookup Table for Each Season by Hour of Day

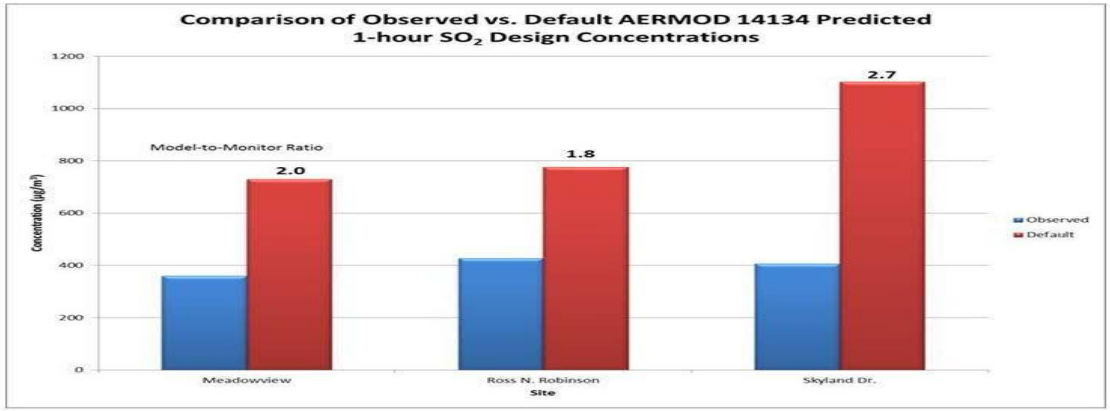
Hour	DJF/W	MAM/SP	JJA/SM	SON/F
1	1.31	1.05	1.05	1.57
2	0.79	1.83	0.26	0.79
3	0.26	0.79	0.26	0.52
4	0.92	1.05	0.26	0.52
5	1.57	1.31	0.26	0.52
6	3.14	0.26	1.31	0.52
7	1.31	0.52	0.26	0.79
8	1.57	0.52	0.26	1.31
9	1.05	2.1	1.05	0.52
10	2.1	0.79	1.57	1.31
11	1.57	0.79	4.19	3.41
12	5.5	10.48	2.88	5.5
13	2.88	4.45	7.07	7.86
14	2.62	18.08	6.29	13.89
15	14.93	4.98	3.67	16.77
16	10.74	3.14	3.67	10.22
17	2.36	6.55	3.93	9.17
18	8.65	2.1	2.36	8.65
19	3.93	2.62	3.14	5.5
20	7.6	2.1	2.62	2.36
21	1.31	1.57	1.57	2.36
22	1.57	1.31	1.57	2.36
23	1.31	1.57	1.05	1.31
24	1.05	2.1	0.26	1.57

Evaluation Results for Default AERMOD

Table 6: Comparison of 1-hour SO_2 Design Concentrations, Observed vs. Predicted (for the Default AERMET/AERMOD, version 14134)

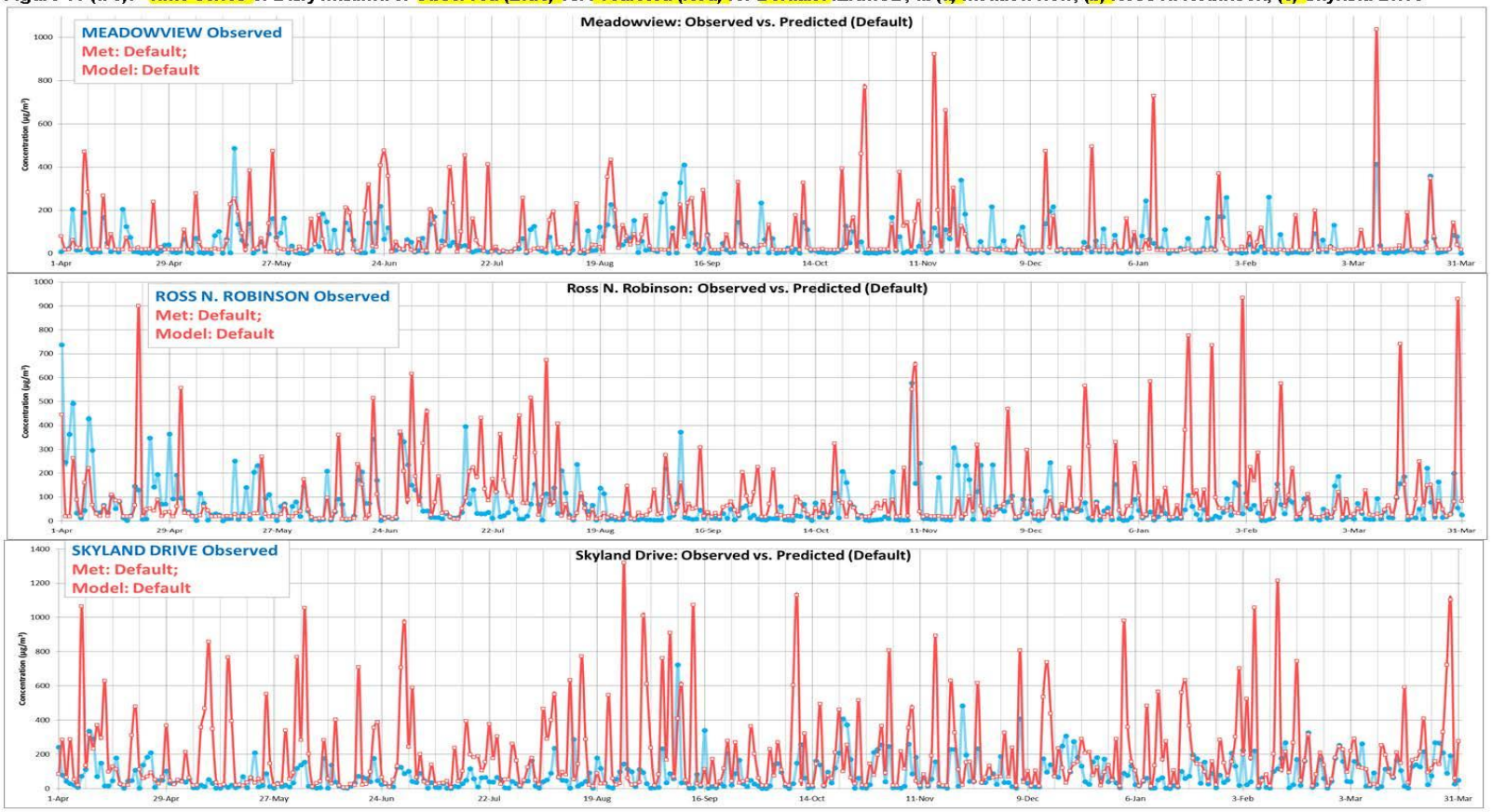
April, 2012 – March, 2013	H4H Concentrations ($\mu g/m^3$)	
Monitor	**Observed**	**Predicted (Default)**
Meadowview	359.5	730.5
Ross N. Robinson	428.1	776.0
Skyland Dr.	406.6	1102.8

Figure 15: Comparison of Observed vs. Predicted 1-hour SO2 Design Concentrations for the Default AERMET/AERMOD, version 14134



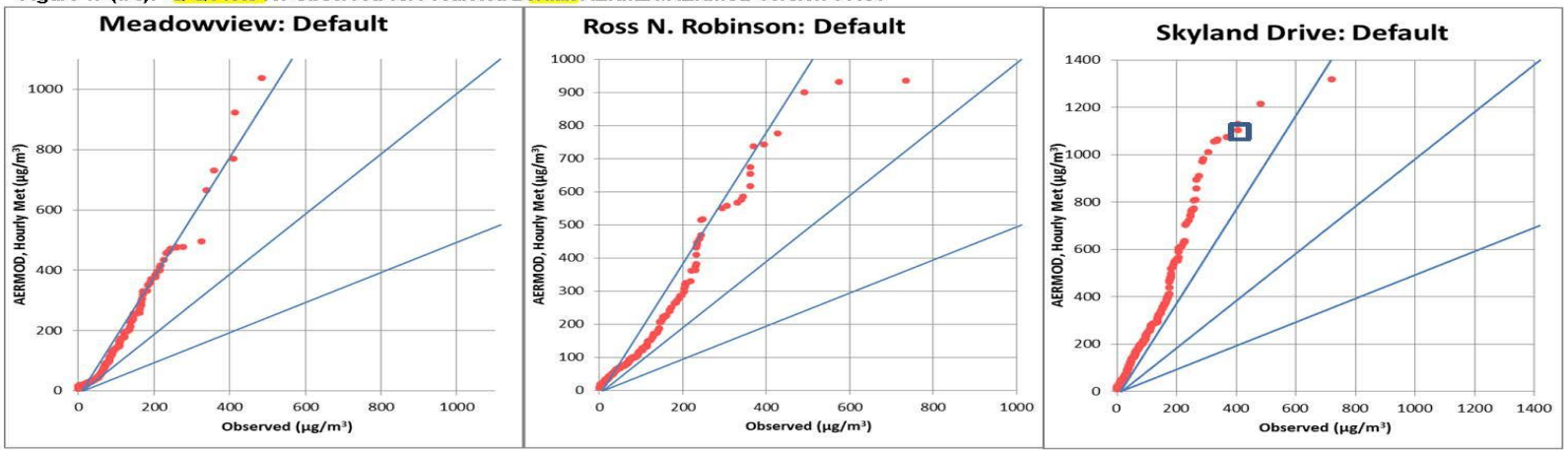
Evaluation Results for Default AERMOD - Continued

Figure 16 (a-c): Time series of Daily Maxima of Observed (Blue) vs. Predicted (Red) for Default AERMOD, at (a) Meadowview, (b) Ross N. Robinson, (c) Skyland Drive



Evaluation Results for Default AERMOD - Continued

Figure 17 (a-c): Q-Q Plots for Observed vs. Predicted Default AERMET/AERMOD version 14134



(a) (b) (c)

Notes:

[1] *The upper diagonal shows the two-fold model over-prediction and the lower diagonal, the two-fold under-prediction. The central diagonal is the 1:1 correlation line.*

[2] *The predicted model concentrations include the seasonal by hour-of-day background value.*

[3] *The boxed value represents the design concentration (i.e. the High-4th-High)*

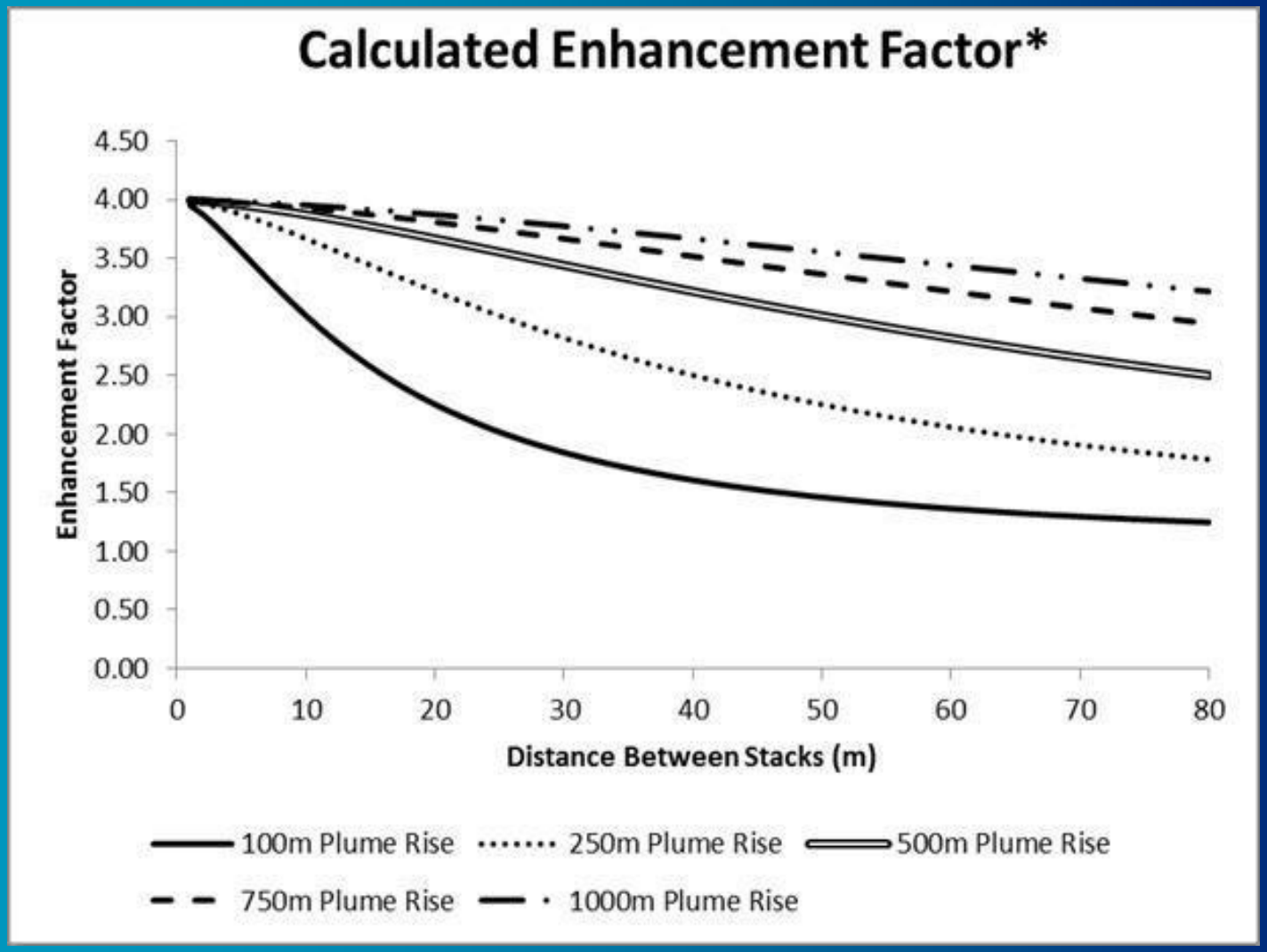
Areas of Enhancement Incorporated Into EASTMOD

- Low Wind Speed Enhancements
  - Peak Conc occur in light wind speeds obs at the 3 monitors in the evaluation (AERMOD over-predicting under low wind speed stable conditions)
  - Low wind speed already implemented as beta options in AERMOD version 14134
  - Plume merging from nearby stacks probably occurring at Eastman in light wind conditions
  - AERMET version 14134 with the beta (u*- friction velocity) option is used
  - AERMOD with LOWWIND2 option deployed with a minimum sigma-v 0.5 m/s with (0.6/0.4 split for stable/unstable conditions) – required minor code change to AERMOD version 14134

Areas of Enhancement Incorporated Into EASTMOD - Continued

- Plume Merging Enhancements
  - Plumes from adjacent, aligned stacks tend to combine, resulting in a buoyant plume rise greater than that from any one of the individual sources
  - MPE improves by implementing this concept as a post-processor to the initial AERMOD run to determine effective hourly stack exhaust characteristics that accounts for partial plume buoyancy merging
  - Tendency of adjacent stacks plumes to merge is a function of
    - The separation between the stacks
    - The angle of the wind relative to the stack alignment
    - The plume rise for individual stack plumes (associated with stack buoyancy flux and met variables such as stack-top wind speed)
  - Briggs Plume Rise equation merger parameter S value between 2.3 (good enhancement) and 3.3 (no enhancement) and Anfossi study (5 to 10 factor range)
  - Using DISTANCE-DEBUG option in modified AERMOD (ver. 14134) with AERLIFT post-processor for merging calculations

Figure 18-Illustration of Buoyancy Enhancement of Adjacent Stacks



Evaluation Tests Using EASTMOD

- AERMET and AERMOD Enhancements
  - METHOD STABLEBL_ADJ_U* and LOWWIND2
- Testing has shown that minimum values of 0.4 m/s for unstable and 0.6 m/s for stable conditions best approached obs at both the flat and elevated terrain monitors
- the default values for the min wind speed (0.2828 m/s) and the meander fraction (0.95) were retained.
  - CO LOW_WIND 0.4 0.2828 0.95 0.6
- DISTANCE-DEBUG
  - CO DEBUGOPT DISTAN specified output file name
- AERLIFT Post – Processing for Plume Merging Calculations
  - Uses hourly, source-specific plume data from the DISTANCE-DEBUG output
  - Also requires hourly ambient temp (via AERMET SFC file) as well as hourly stack temperatures and exit velocities (in the hourly emission file)
  - Calculates the alignment angle of the stacks (for each powerhouse separately)
  - Then proceeds thru the hourly data by assessing if Wd at plume height is conductive to plume merging (from 0-90° governs) and 5/10 factor assessment. Then enhancement is applied to the hourly stack temp and exit velocity

Figure 19-Example of Hourly Data from DIST-DEBUG

```
OBSERVED MET CONDITIONS FOR:   USTAR   WSTAR   OBULEN   URB_OBULEN   ZIMECH   ZICONV   ZI_URB     SFCZ0    THSTAR
YYMMDDHH: 12040102             (m/s)   (m/s)    (m)       (m)         (m)      (m)      (m)        (m)      (K)
                                0.13   -9.00    12.90       N.A.    103.00  -999.00     N.A.     0.4280    0.090
-----------------------------------------------------------------------------------------------------------------

 POINT SOURCES:
    SOURCE          RCPT    FINAL   DIST.   WDIR  Effect. <------ DISTANCE -----> MEAND.   PART.   EFFECT. EFFECT.   HOURLY
POT.
    ID              NO.     PLUME   FINAL   FINAL WSPD    3600*       TO      PLUME FRAC.   PEN.    SIGMA_V SIGMA_W   CONC.       AERVAL COHERENT   PANCAKE  GAMFACT
PRMVAL      TEMP.
                            HT.     PL.HT   HT.           ueff        RECEPT TYPE           FRAC.
GRAD.
                            (m)     (m)     (deg) (m/s)   (m/s)       (m)                           (m/s)   (m/s)     (µg/m3)     (µg/m3)   (µg/m3)    (µg/m3)
(µg/m3)   (K/m)
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------
--------------
 P MERGE001         329  153.1   269.4  273.   2.669   9610.1     3242.0 GAU   0.025   0.000   0.200   0.052     35.017      0.000      0.000      0.000  PLUME OUT
OF WAKE  0.01637
   MERGEN01     <--- Source is not emitting during this hour
 P POINT002        1130   31.5   172.3  273.   1.347   4848.7 <   9157.9 GAU   0.090   0.000   0.200   0.074      2.209      2.209      2.422      0.066  PLUME OUT
OF WAKE  0.01637
 P POINT003         329   14.4   158.4  273.   1.347   4848.7     3202.3 GAU   0.073   0.000   0.200   0.074     13.187     13.019     14.021      0.330   1.000
13.187  0.01278
 P POINT004        1099   30.6   172.3  273.   1.347   4848.7 <   8260.8 GAU   0.085   0.000   0.200   0.074      2.880      2.880      3.141      0.055   0.000
6.682  0.01278
 P POINT005         325   16.2   158.4  273.   1.347   4848.7     2779.5 GAU   0.070   0.000   0.200   0.074     15.001     15.001     16.095      0.397   0.000
39.017  0.01278
 P POINT006         332   14.6   158.4  273.   1.347   4848.7     3637.3 GAU   0.077   0.000   0.200   0.074     14.365     14.365     15.528      0.358   0.000
24.576  0.01278
 P POINT007         333   15.6   158.4  273.   1.347   4848.7     3690.4 GAU   0.077   0.000   0.200   0.074     14.284     14.284     15.448      0.354   0.000
23.986  0.00781
```

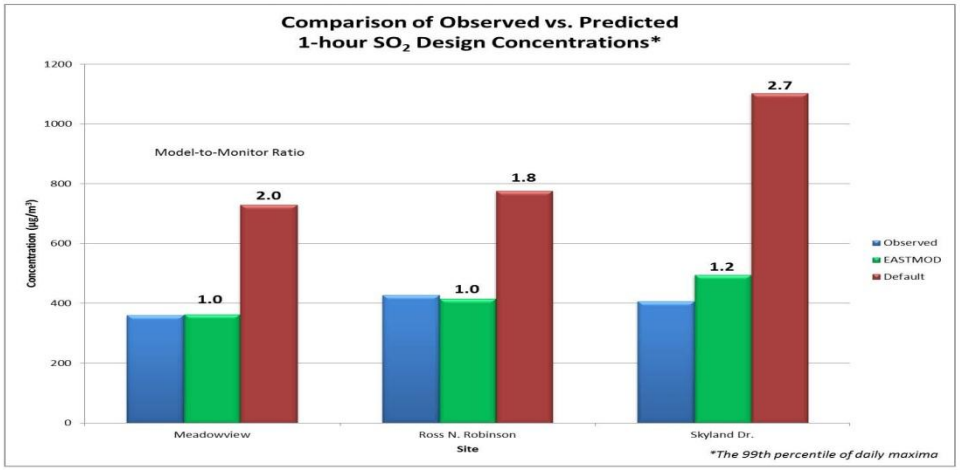
Evaluation Results for EASTMOD

Table 7: Comparison of 1-hour SO_2 Design Concentrations, Observed vs. Predicted (for Default AERMOD and Site-Specific EASTMOD)

Site	H4H Concentrations (µg/m³)		
	Observed	Predicted	
		Default	EASTMOD
Meadowview	359.50	730.50	363.20
Ross N. Robinson	428.10	776.00	415.70
Skyland Dr.	406.60	1102.80	495.20

April, 2012 - March, 2013

Figure 20: Comparison of Observed vs. Predicted 1-hour SO_2 Design Concentration

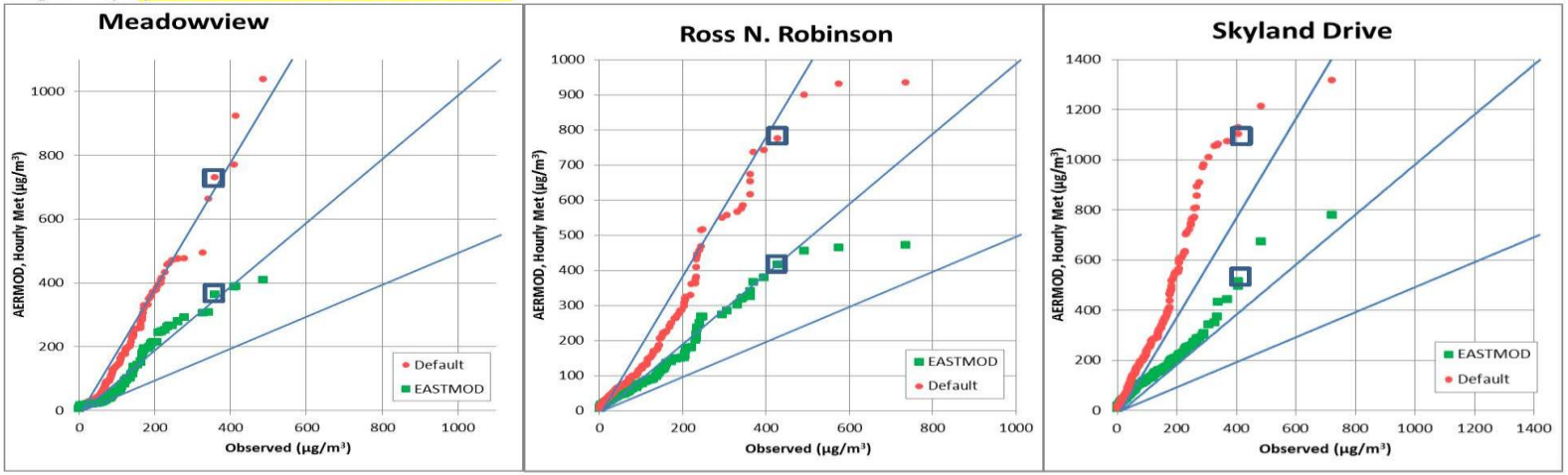


Evaluation Results for Default EASTMOD - Continued

Figure 21 (a-c): Time Series of Daily Maxima of Observed (Blue) vs. Predicted (Red) for EASTMOD, at (a) Meadowview, (b) Ross N. Robinson, and (c) Skyland Drive

Evaluation Results for Default EASTMOD - Continued

Figure 22 (a-c): Q-Q Plots for Observed vs. Predicted



(a) (b) (c)

Notes:

[1] *The upper diagonal shows the two-fold model over-prediction and the lower diagonal, the two-fold under-prediction. The central diagonal is the 1:1 correlation line.*

[2] *The predicted model concentrations include the seasonal by hour-of-day background value.*

[3] *The boxed values represent the design concentrations (i.e. the High-4th-High)*

Study Conclusions

- AERMOD (default) and EASTMOD comparisons
  - EASTMOD MPE indicates an unbiased or over-predicting estimates of AQ concentrations at the 3 monitoring sites
  - EASTMOD is expected to be protective of AQ in the Kingsport area.
  - EASTMOD formulation is based on EPA-approved AERMOD model, but with scientifically justifiable enhancements, including:
    - Improvements in the u-formulation in the AERMOD met pre-processor
    - Use of a minimum sigma-v averaging 0.5 m/s in AERMOD, consistent with findings from other investigators and usage in other models such as SCICHEM
    - Accounting for partial merging of plumes from nearby stacks as computed on a n hourly basis using algorithms reported in peer-reviewed technical publications
  - Based on these findings, TDEC/EPA recommendations ?

Questions ?

Haidar Al-Rawi
615-532-0578
Haidar.Alrawi@tn.gov