CHAPTER 2: PHOTOCHEMICAL MODELING

2.1 INTRODUCTION

This chapter describes photochemical grid modeling conducted in support of the eight-hour ozone state implementation plan (SIP) revision for the Houston-Galveston-Brazoria (HGB) area. The modeling for the eight-hour ozone National Ambient Air Quality Standard (NAAQS) is largely an extension of the modeling for the two most recent HGB SIP revisions (Phases 1 and 2 of the Mid-Course Review) for the one-hour ozone NAAQS.

In June 2004, the HGB Consolidated Metropolitan Statistical Area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties) was classified as a moderate ozone nonattainment area for the eight-hour ozone NAAQS with an attainment date of June 15, 2010, and a SIP submittal date of June 15, 2007. Because the attainment date is early in the 2010 ozone season, the United States Environmental Protection Agency (EPA) has prescribed that the attainment test be applied to the previous ozone season. Thus, 2009 is the future year used in this modeling analysis.

On September 6, 2006, the EPA published the approval of the HGB nonattainment area's one-hour ozone attainment demonstration and associated rules (71 Federal Register 52656). Much of the modeling work is based on the work done for the HGB One-Hour Ozone Attainment Demonstration SIP that was approved by the EPA. See: http://www.tceq.state.tx.us/implementation/air/sip/dec2004hgb_mcr.html.

2.2 EPISODE SELECTION

Texas Commission on Environmental Quality (TCEQ) staff and the Southeast Texas Photochemical Modeling Technical Committee (SETPMTC) meet periodically to discuss air quality technical issues related to the photochemical modeling process, including the development of the conceptual model for ozone and evaluating episode selection criteria. When the current episode was undergoing the selection process, TCEQ staff reviewed ozone episodes between 1998 and 2000 and developed recommendations based on the current conceptual model. In considering episodes to model, the SETPMTC placed special emphasis on using the results of the Texas Air Quality Study 2000 (TexAQS 2000), because it provided extensive data on which to evaluate hypotheses and validate modeling results. This emphasis is also consistent with the EPA's eight-hour modeling guidance (EPA, Nov. 2005) for selecting episodes with extensive aerometric data bases. Although post-2000 episodes were discussed with the SETPMTC, the TCEQ could not reasonably consider post-2000 episodes for the June 15, 2007, submittal due to time and resource constraints. Figure 2-1: *Eight-Hour Peak Ozone Concentrations and Number of Monitors Recording Eight-hour Ozone Concentrations ≥ 85 ppb During TexAQS 2000* shows the maximum eight-hour ozone concentrations measured and the number of continuous monitoring stations at which concentrations reached or exceeded 85 parts per billion (ppb).

2.3 MODEL CONFIGURATION

2.3.1 Selection of Air Quality Model

The air quality model selected must be scientifically appropriate for the intended application and be accessible to all stakeholders. TCEQ and SETPMTC set the following three prerequisites for selecting the photochemical grid model to be used for SIP-related modeling. The model must:

- have a reasonably current, peer-reviewed, scientific formulation;

- be available at low cost to stakeholders; and
- not require the reformatting of available model inputs from earlier rounds of the study.

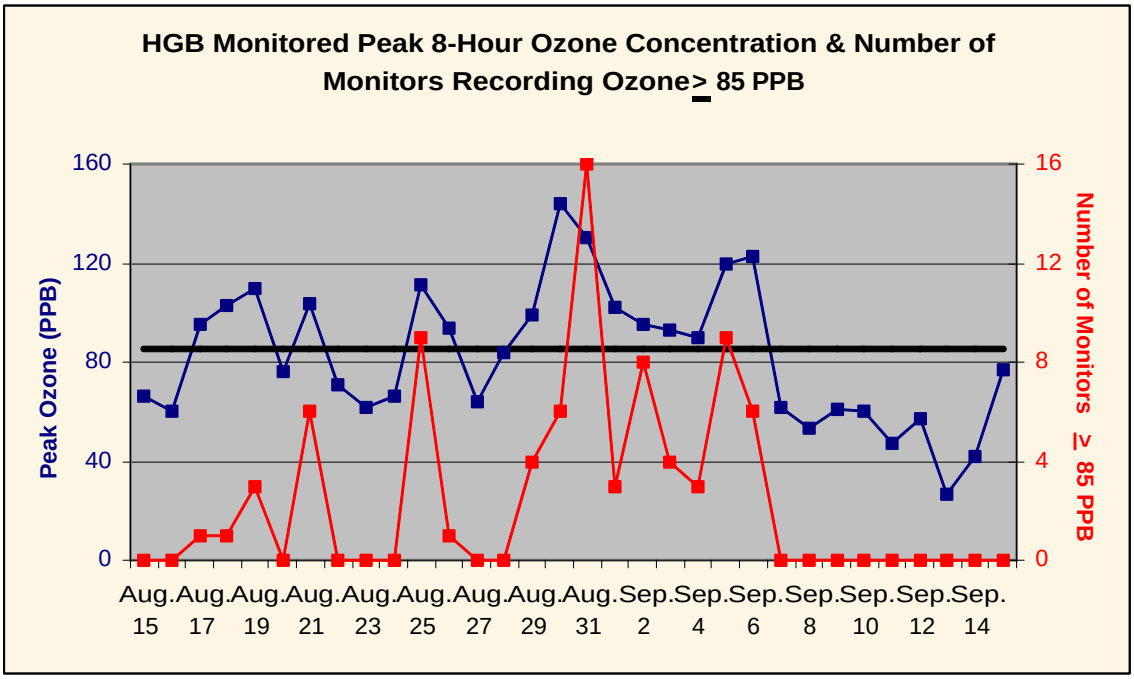


Figure 2-1: Eight-Hour Peak Ozone Concentrations and Number of Monitors Recording Eight-Hour Ozone Concentrations ≥ 85 ppb During TexAQS 2000

The only model to meet all three of these criteria is the Comprehensive Air Model with Extensions (CAMx). The model is based on well-established treatments of advection, diffusion, deposition, and chemistry. Another important feature is that nitrogen oxides (NO_X) emissions from large point sources can be treated with the plume-in-grid sub-model that helps avoid the artificial diffusion that occurs when point source emissions are inserted into a grid volume. The model software and the CAMx user's guide are publicly available at http://www.camx.com.

2.3.2 Modeling Domain, Horizontal, and Vertical Resolution

The modeling domain and the horizontal grid-cell configuration are shown in Figure 2-2: *Eight-Hour Modeling Domain and the Horizontal Grid-Cell Configuration*.

The modeling domain covers the eastern half of the United States with an outer 36 kilometer (km) x 36 km grid. The innermost sub-domain consists of a 4 km x 4 km grid encompassing the HGB and Beaumont-Port Arthur (BPA) ozone nonattainment counties (light blue box), nested within a 12 km x 12 km grid covering the eastern part of Texas (green box), which in turn is nested within the outer 36 km x 36 km grid of the eastern half of the United States (black box).

All grids are projected in a Lambert Conformal Projection with origin at 100° W. and 40° N., and aligned with EPA's National Grid, which was developed for nationwide modeling for haze and particulate matter. Using a grid system compatible with an existing large-scale grid

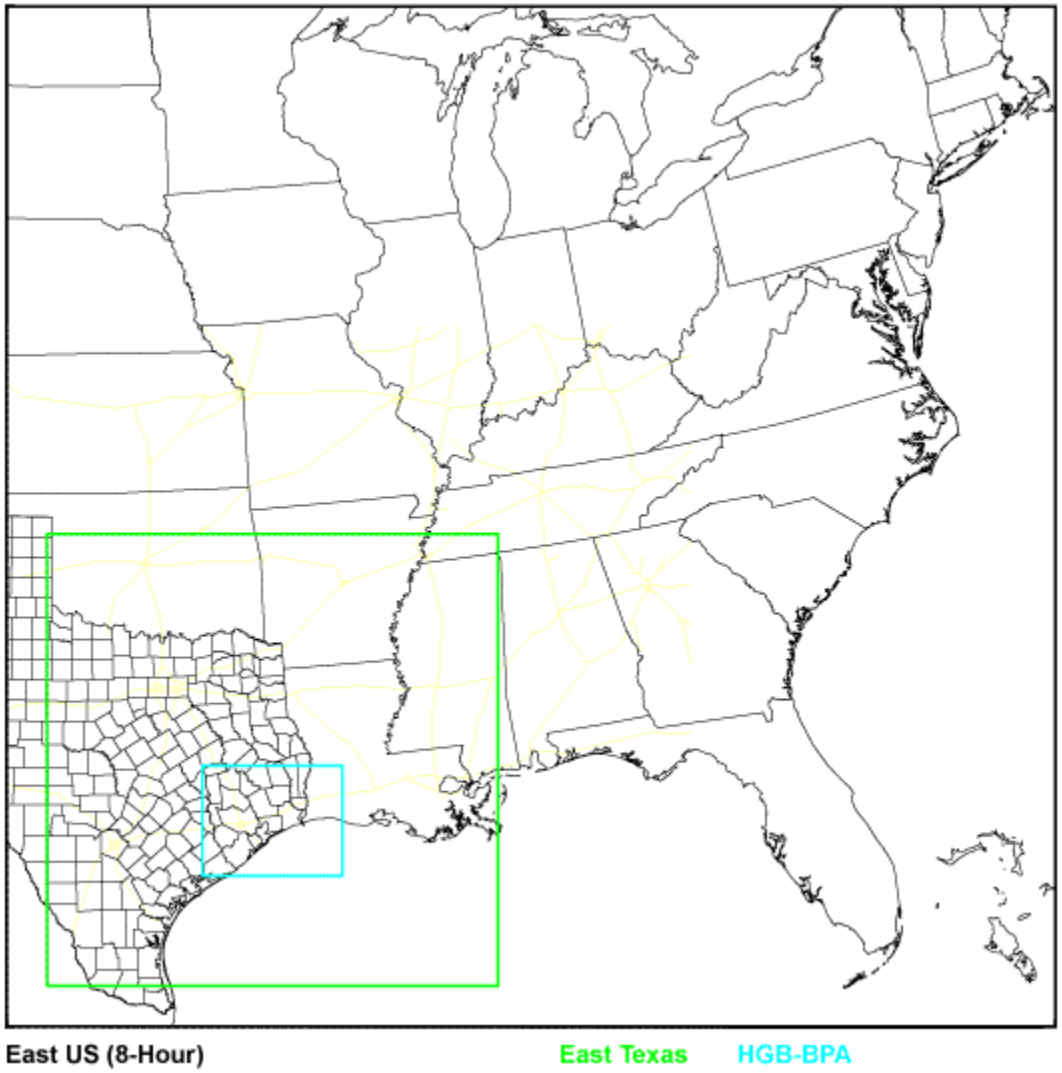


Figure 2-2: Eight-Hour Modeling Domain and the Horizontal Grid-Cell Configuration

system serves several functions, including allowing the TCEQ's modeling to be integrated into regional modeling projects and promoting consistency among various regional and urban modeling applications in the central United States.

Although the number of vertical layers and their respective layer depths vary with the horizontal grid-cell configuration, they all have a top layer that extends to a height of 15,179 meters above ground level. The unique meteorology induced by the land-sea-bay effects and the mixture of industrial sources, which release pollutants across a wide range of elevations, necessitate many vertical layers, particularly near ground level. A 28-layer structure is used within the 4 km x 4 km grid-cell configuration while a 17-layer vertical structure is used in the 12 km x 12 km and 36 km x 36 km grid-cell configurations. Figure 2-3: *Vertical Layer Structures*, presents a tabulation and graphic of the 28-layer and 17-layer vertical structuring.

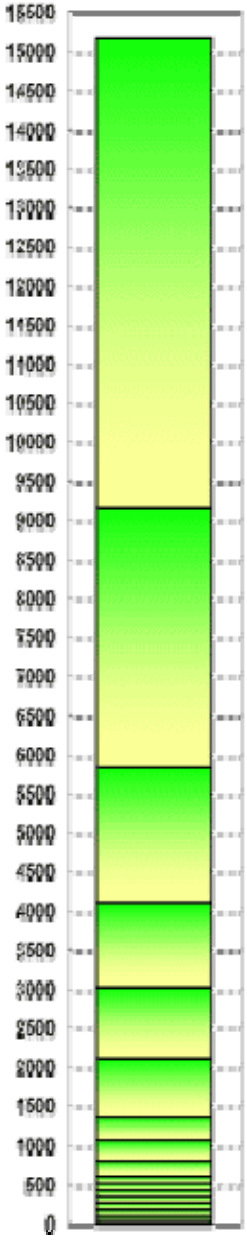
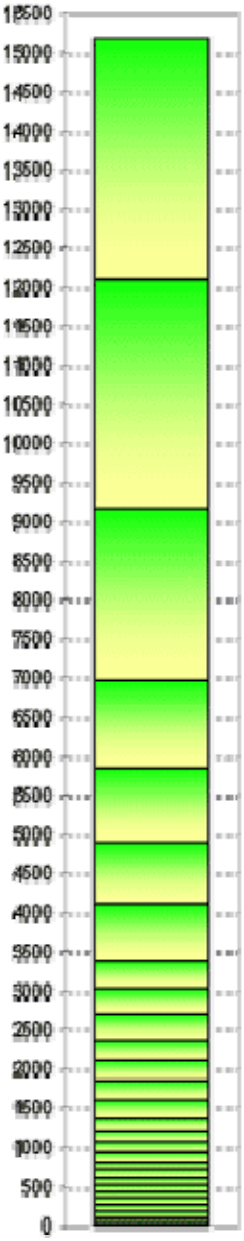
MM5 Layer	Layer Top (m AGL)	East US and East Texas Domains				HGB-BPA, HGB, and BPA Domains			
		CAMx Layer	Center (m AGL)	Thickness (m)		CAMx Layer	Center (m AGL)	Thickness (m)	
38	15179.1	**17**	12172.9	6012.5		**28**	13637.94	3082.5	
36	12096.6					**27**	10631.64	2930.0	
32	9166.6	**16**	7501.3	3330.7		**26**	8063.8	2205.7	
29	6960.9					**25**	6398.4	1125.0	
27	5835.9	**15**	4970.9	1730.0		**24**	5367.0	937.9	
25	4898.0					**23**	4502.2	791.6	
23	4106.4	**14**	3565.9	1080.0		**22**	3739.9	733.0	
21	3373.5					**21**	3199.9	347.2	
20	3026.3	**13**	2564.5	922.9		**20**	2858.3	335.9	
19	2690.4					**19**	2528.3	324.3	
18	2366.1					**18**	2234.7	262.8	
17	2103.3	**12**	1728.1	749.8		**17**	1975.2	256.2	
16	1847.2					**16**	1722.2	249.9	
15	1597.3					**15**	1475.3	243.9	
14	1353.4	**11**	1210.6	285.2		**14**	1281.6	143.6	
13	1209.8					**13**	1139.0	141.6	
12	1068.2	**10**	929.3	277.5		**12**	998.3	139.7	
11	928.5					**11**	859.5	137.8	
10	790.6	**9**	700.0	181.0		**10**	745.2	90.9	
9	699.7					**9**	654.7	90.1	
8	609.7	**8**	564.9	89.3		**8**	565.0	89.3	
7	520.3	**7**	476.0	88.5		**7**	476.1	88.5	
6	431.8	**6**	387.8	87.8		**6**	387.9	87.8	
5	344.0	**5**	300.4	87.0		**5**	300.5	87.1	
4	256.9	**4**	213.7	86.3		**4**	213.8	86.3	
3	170.6	**3**	127.7	85.6		**3**	127.8	85.6	
2	85.0	**2**	59.4	51.0		**2**	59.4	51.0	
1	33.9	**1**	16.9	33.9		**1**	17.0	33.9	

Figure 2-3: Vertical Layer Structures

The 36 km x 36 km horizontal grid-cell configuration extends to the periphery of the modeling domain so that the lateral boundary conditions do not unrealistically influence the modeling results. For the lateral boundary below 1700 meters, moderate concentrations of ozone and its precursors were used. Above 1700 meters, clean concentrations were used, per EPA guidance. The initial conditions are set at the respective lateral boundary concentration, and the top boundary conditions are set at the clean concentration level. Table 2-1: *Concentrations (ppb) Used to Define CAMx Initial and Boundary Conditions* lists the ozone and ozone precursor concentration levels for moderate and clean initial and boundary conditions.

Table 2-1: Concentrations (ppb) Used to Define CAMx Initial and Boundary Conditions

Species or Functional Group		Moderate	Clean
Ozone	O_3	40	40
Carbon Monoxide	CO	200	100
Nitric Oxide	NO	0.1	0.1
Nitrogen Dioxide	NO_2	1	1
Nitric Acid	HNO_3	3	1
Nitrous Acid	HNO_2	0.001	0.001
Other Aldehydes	ALD_2	0.555	0.05
Ethylene	ETH	0.51	0.15
Formaldehyde	HCHO	2.1	0.05
Olefins or Alkenes	OLE	0.3	0.05
Paraffins or Alkanes	PAR	14.9	7.6
Mono-substituted Aromatics	TOL	0.18	0.0786
Di-substituted Aromatics	XYL	0.0975	0.0688
Isoprene	ISOP	0.1	0.001
Peroxyacyl Nitrates	PAN	0.1	0.1
Hydrogen Peroxide	H_2O_2	3	1
Methanol	MEOH	0.001	0.001
Other Alcohols	ETOH	0.001	0.001

2.4 METEOROLOGICAL MODELING

2.4.1 MM5 Modeling Configuration

The TCEQ is using the Fifth Generation Meteorological Model (MM5, version 3.6) developed jointly by the National Center for Atmospheric Research and Pennsylvania State University. This model, supported by a broad user community including the Air Force Weather Agency, national laboratories, and academia, is currently being used extensively for regulatory air quality modeling analyses throughout the United States. For this eight-hour ozone SIP revision, MM5 was applied to the 2000 modeling episode including the dates August 15 to September 6, 2000, primarily because of the wealth of data available from TexAQS 2000 for that time period (note: the first three days of the episode are “spin-up” and are not used in the CAMx modeling).

Figure 2-4: *MM5 Domain for the HGB Area Eight-Hour Ozone Modeling Analysis* shows the MM5 modeling domain, which covers most of the North American continent, with an outer grid of 108 km x 108 km (black box). The innermost sub-domain consists of a 4 km x 4 km grid encompassing the HGB and BPA ozone nonattainment counties (red box), nested within a 12 km x 12 km grid covering the eastern part of Texas (green box), which in turn is nested within a 36 km x 36 km regional grid (blue box) encompassing the eastern part of the United States. Each of the CAMx domains shown in Figure 2-2 was embedded in the respective MM5 domains shown in Figure 2-4.

The vertical layering structure for MM5 consisted of 38-layers (see Figure 2-3), extending to a height of 15,179 meters above ground level, which is the same as the top of the CAMx domains. Unlike CAMx, the same MM5 vertical layering structure is used for all the gridded domains.

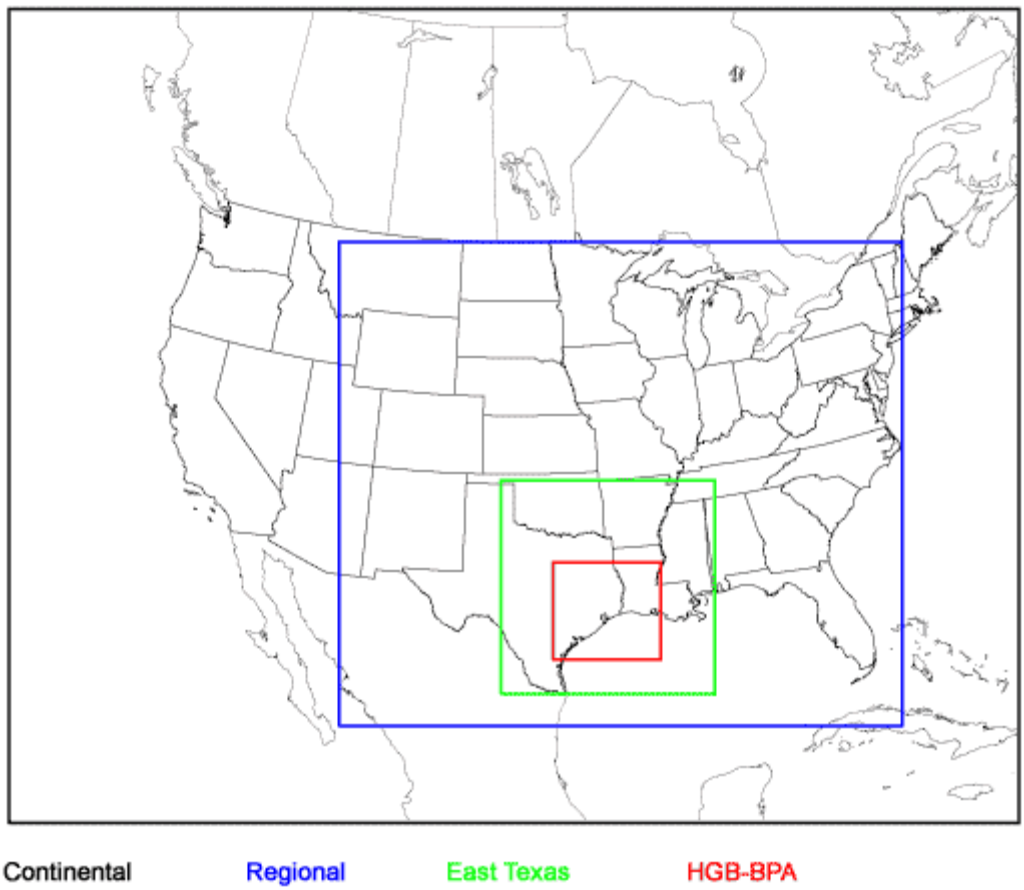


Figure 2-4: MM5 Domain for the HGB Area Eight-Hour Ozone Modeling Analysis

2.4.2 MM5 Configuration

The wind field (i.e., wind speed and direction in each horizontal and vertical grid cell) is the most important parameter predicted by the meteorological model for air quality modeling purposes because the wind field determines the proper transport and dispersion of emitted ozone precursors and their reaction products. The present MM5 modeling incorporates two different types of nudging to improve the predicted wind field. First, MM5-predicted wind fields in the 108 km, 36 km, and 12 km gridded domains are nudged towards the Eta Data Assimilation System reanalysis wind fields, which are based upon a national observational wind monitoring network. (The Eta coordinate system is a pressure-based coordinate system used in the MM5 model that allows for simpler solutions to the equations of motion in areas of widely varying topography.) Second, the MM5-predicted wind field in the 4 km gridded domain is nudged with observational radar profiler wind data, much of which was collected as a part of the TexAQS 2000 study. Each of these techniques enhances the overall predicted MM5 wind field.

The extent of vertical mixing is also an important parameter predicted by the meteorological model for air quality modeling purposes. The extent of vertical mixing establishes the volume of the atmosphere in which emitted ozone precursors and their reaction products can mix and is limited by the height of the planetary boundary layer (PBL). The height of the PBL is influenced by the turbulent kinetic energy (TKE) within the lower atmosphere. In applying MM5, there are several optional algorithms that can be selected for predicting either the PBL or the TKE. When a PBL algorithm is selected, MM5 predicts a two-dimensional meteorological field that specifies, for each horizontal grid cell, the model's vertical layer to which mixing can extend. When a TKE algorithm is selected, MM5 predicts a three-dimensional meteorological field that specifies the strength of mixing between the model's vertical layers at each horizontal grid cell.

For the present eight-hour ozone modeling the Eta-TKE scheme was selected from the optional PBL/TKE algorithms because it most accurately replicated PBL heights. With this choice, a two-dimensional PBL field can also be output for qualitative evaluation and diagnostic purposes. For evaluation purposes, the MM5 predicted PBL field can be compared to PBL estimates made from the radar profiler data. The PBL field also helps in diagnosing the photochemical model output by analyzing the chemical mixing ratios predicted at the vertical layer coincident with the PBL.

Photochemical models, such as CAMx, use vertical diffusivity coefficients (also called vertical exchange coefficients – K_vs) in the calculation of mixing between adjacent vertical CAMx model layers. The MM5CAMx program, which is the program used to convert MM5 output into CAMx input, is used to derive the K_vs input into CAMx, depending on the MM5 algorithm selected (PBL or TKE). The K_vs corresponding to the Eta-TKE scheme were determined using the Mellor-Yamada formulas (Burk & Thompson, 1989).

In addition to the meteorological parameters associated with the winds and the extent of vertical mixing discussed above, the MM5 also predicts three-dimensional fields of temperature, pressure, and water vapor content. Similar to the TKE field, all the MM5 predicted fields are processed through the MM5 CAMx program to generate proper CAMx meteorological inputs.

2.4.3 MM5 Performance

The TCEQ uses a statistical package, developed under contract with ENVIRON, to evaluate the meteorological model performance. The package is designed to interface with the MM5 model and evaluates model performance for four meteorological variables: wind speed, wind direction, temperature, and humidity. The variation between the modeled results and observations are compared to performance benchmarks. The statistical package generates standardized tables and graphs for bias, root mean square error (RMSE), and index of agreement for each meteorological variable. Figures 2-5 to 2-8 show the standardized graphs of these performance metrics for each of the four meteorological variables. The first graph in each of these groupings-of-three show the observed value compared to the modeled value for wind (Figure 2-5), wind direction (Figure 2-6), temperature (Figure 2-7), and humidity (Figure 2-8). This performance metric and the following two charts in each grouping (bias and RMSE) indicate a favorable comparison between the observed and modeled meteorological variables, and therefore these variables are suitable for use in photochemical modeling.

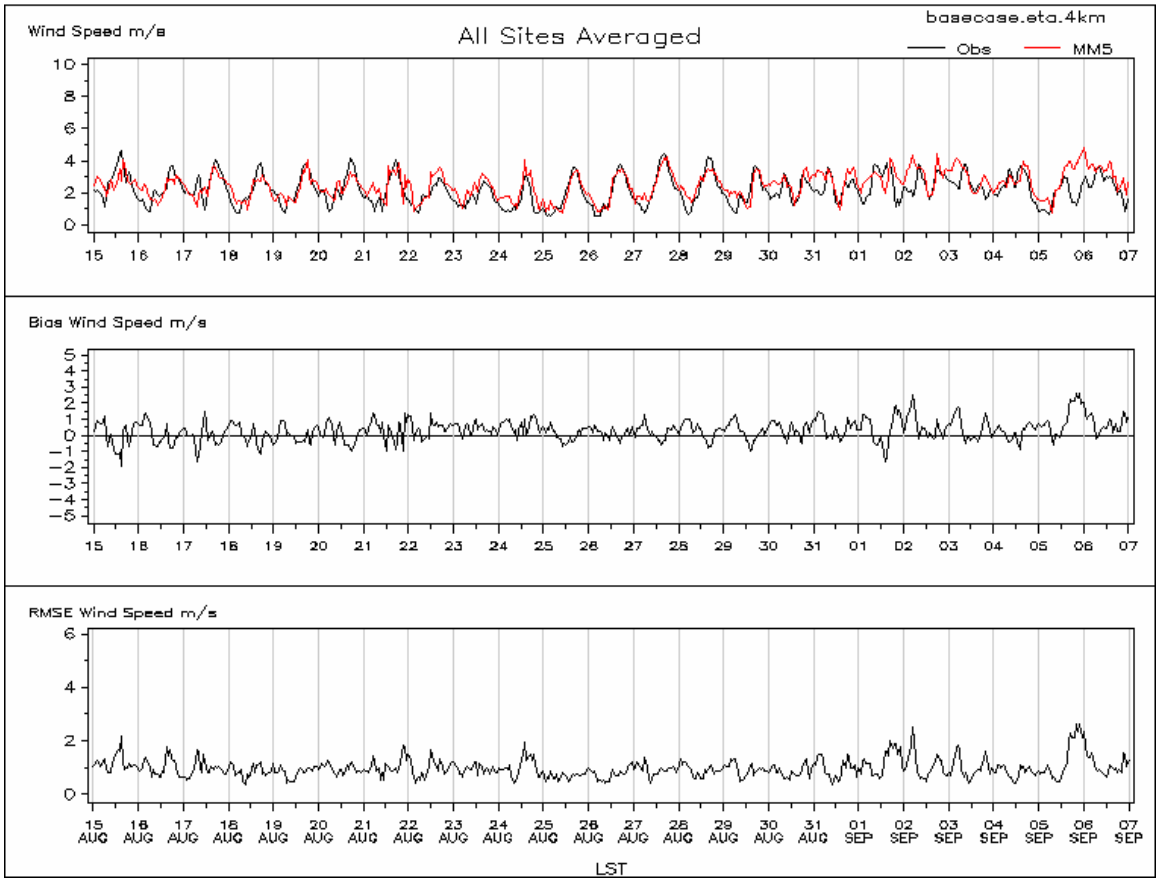


Figure 2-5: MM5 Wind Speed Performance

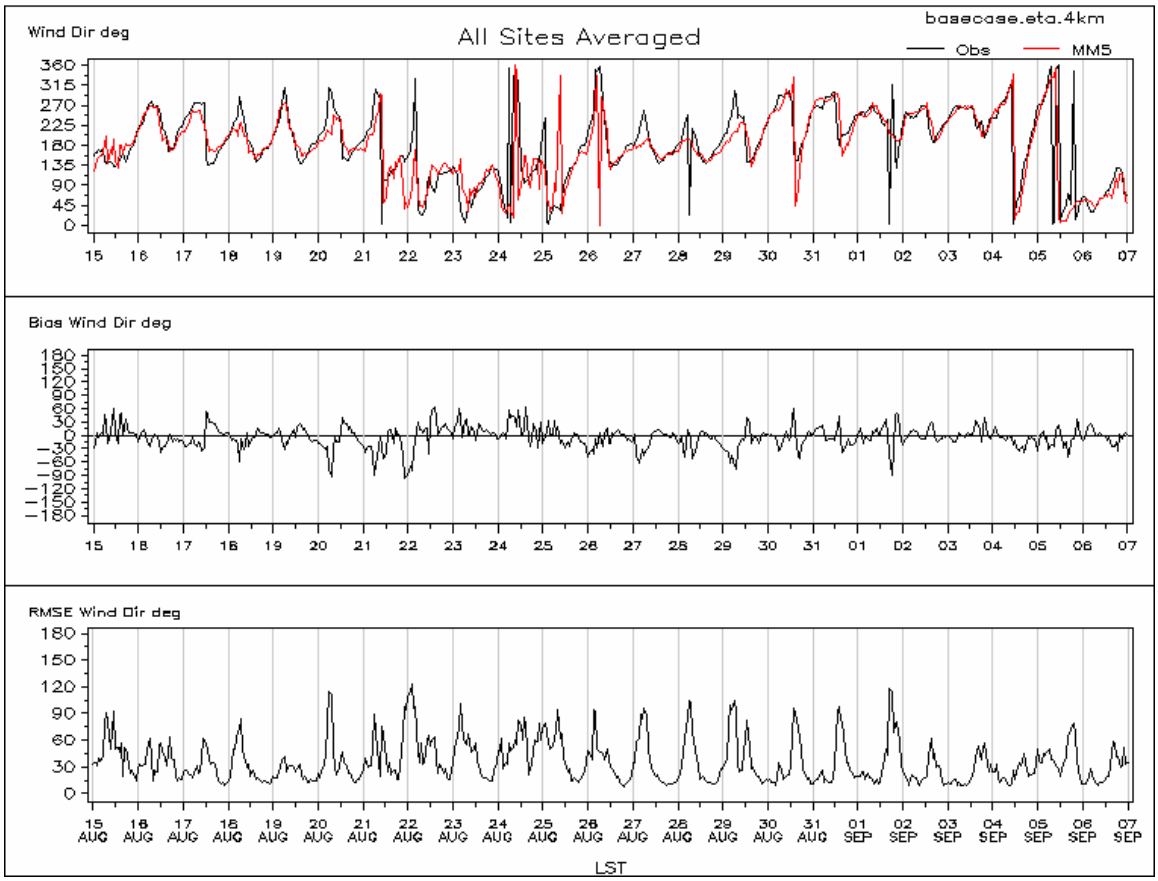


Figure 2-6: MM5 Wind Direction Performance

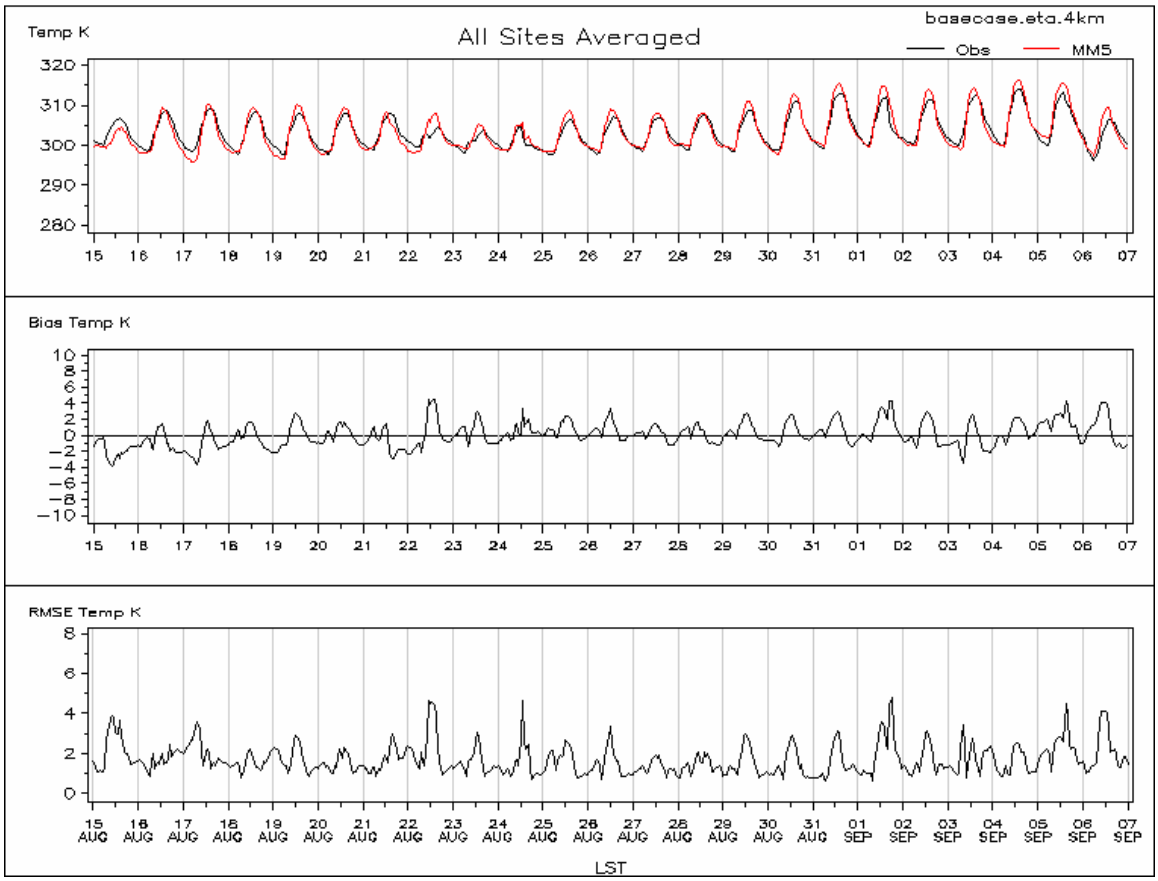


Figure 2-7: MM5 Temperature Performance

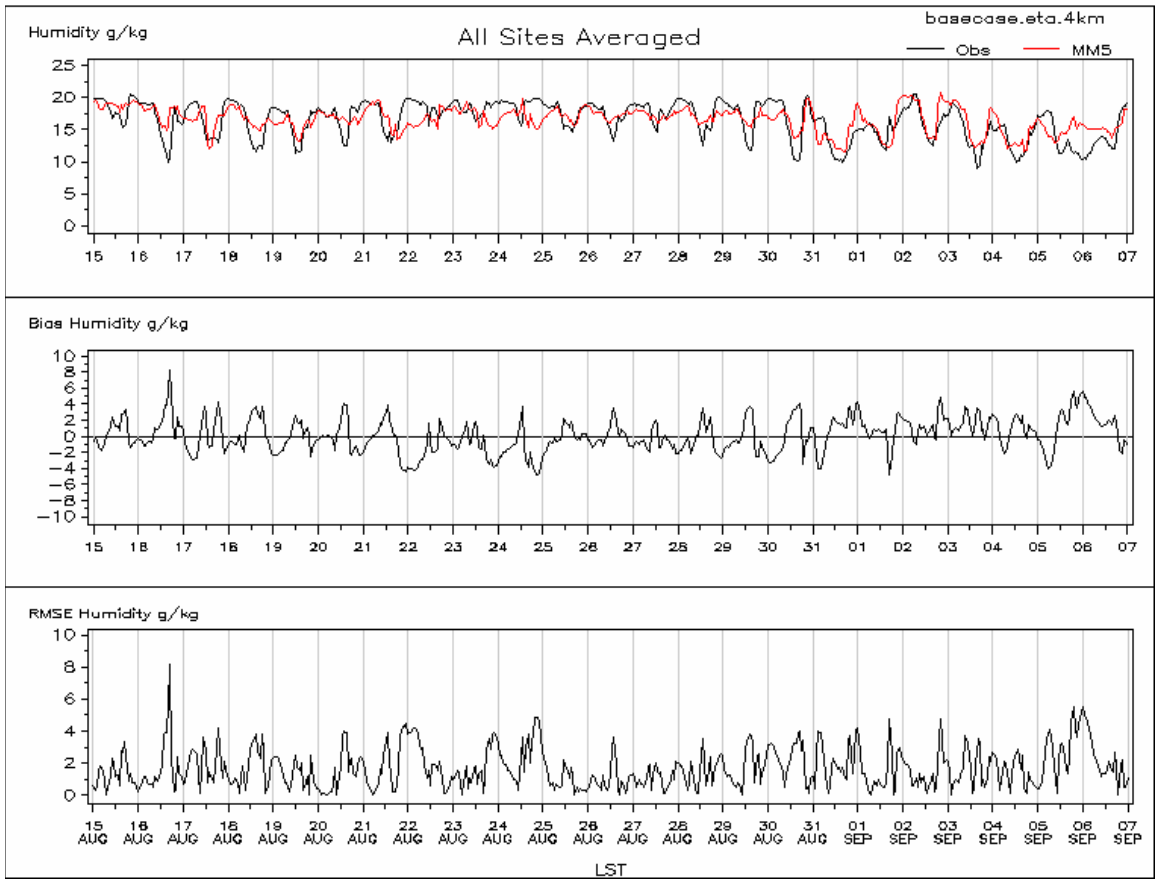


Figure 2-8: MM5 Humidity Performance

2.5 MODELING EMISSIONS DEVELOPMENT: BASE CASE, BASELINE, AND FUTURE BASELINE

2.5.1 Overview

The modeling emissions developed for the HGB eight-hour ozone SIP included three sets: one for the 2000 episode (the 2000 base case), one for a typical ozone season in 2000 (the 2000 baseline) and one for the future year (2009 baseline). The modeling emissions for the 2000 base case were developed to replicate the hourly emissions that occurred during the 2000 episode (i.e., August 18 through September 6). For example, the specific hourly temperature and humidity measurements, which influence the emissions from various sources (e.g., storage tanks, automobiles), were used in the development of the modeling emissions for the 2000 base case. Most of the background information and procedures used to develop the modeling emissions for the 2000 base case are detailed in the documentation for the 2004 HGB SIP revision. The modeling emissions for the 2000 baseline were developed to represent typical emissions that generally occurred during the 2000 ozone season. The modeling emissions for the 2000 baseline differ from the 2000 base case, generally, in that the 2000 baseline emissions are developed from reported ozone season day emissions. The modeling emissions for the 2009 baseline were developed by the application of growth and controls to the 2000 baseline.

The TCEQ uses the Emissions Processing System version 3 (EPS3), acquired from ENVIRON, as its primary emissions processing and modeling tool. A principal feature of EPS tools is that they generate emissions files in CAMx-ready format. EPS3 is faster and has better error reporting and data export capabilities compared to earlier versions of EPS. EPS3 has several advantages over other emissions processing systems including excellent reporting capabilities, stability, and ease-of-use. In addition, TCEQ staff is familiar with the software and have developed numerous scripts and programs to interface with it. The TCEQ has processed all inventory components using EPS3 except for biogenic emissions. Biogenic emissions were modeled using version 3.1 of the Global Biosphere Emissions and Interactions System (GloBEIS) model (Guenther *et al.*, 2002; Yarwood *et al.*, 2001; Yarwood *et al.*, 2000; Guenther *et al.*, 1999).

2.5.2 Biogenic Emissions

The biogenic volatile organic compounds (VOC) and NO_X emissions were developed for the 2000 base case episode using version 3.1 of the GloBEIS model. This version of GloBEIS includes several new features, including modules that vary the biogenic emissions according to changes in leaf area index, antecedent leaf temperatures, and drought, and an improved canopy energy balance model.

Because the 2000 base case episode is representative of the biogenic emissions that occurred during the ozone season, these same emissions were used in the 2000 baseline modeling emissions. Although, urban development does modify the amount, location, and type of vegetation over the years, there are large uncertainties in predicting future land use and cover type. Because there is no reliable method to predict future biogenic emissions, the 2000 base case emissions were held constant and used as the 2009 baseline modeling emissions.

Figure 2-9: *Modeled Biogenic VOC Emissions on August 30, a Typical Ozone Season Day* and Figure 2-10: *Modeled Biogenic NO_X emissions on August 30, a Typical Ozone Season Day* display the graphical distribution of biogenic VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. August 30 is used to represent a typical ozone season day for 2000. As the tables embedded in the figures indicate, for the HGB eight-county area, the modeled biogenic emissions are 1,675 tons per day (tpd) of VOC and 22 tpd of NO_X.

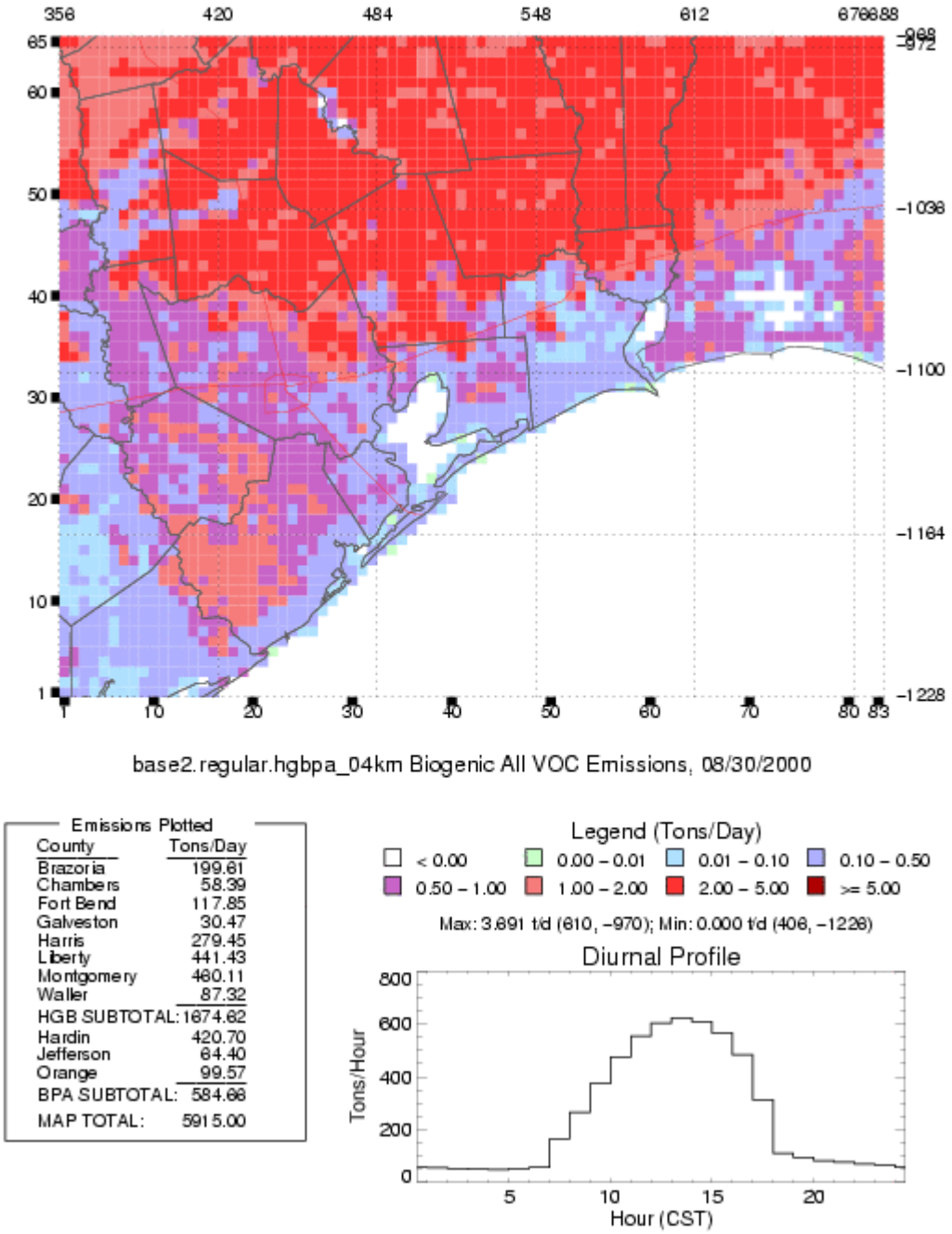


Figure 2-9: Modeled Biogenic VOC Emissions on August 30, a Typical Ozone Season Day

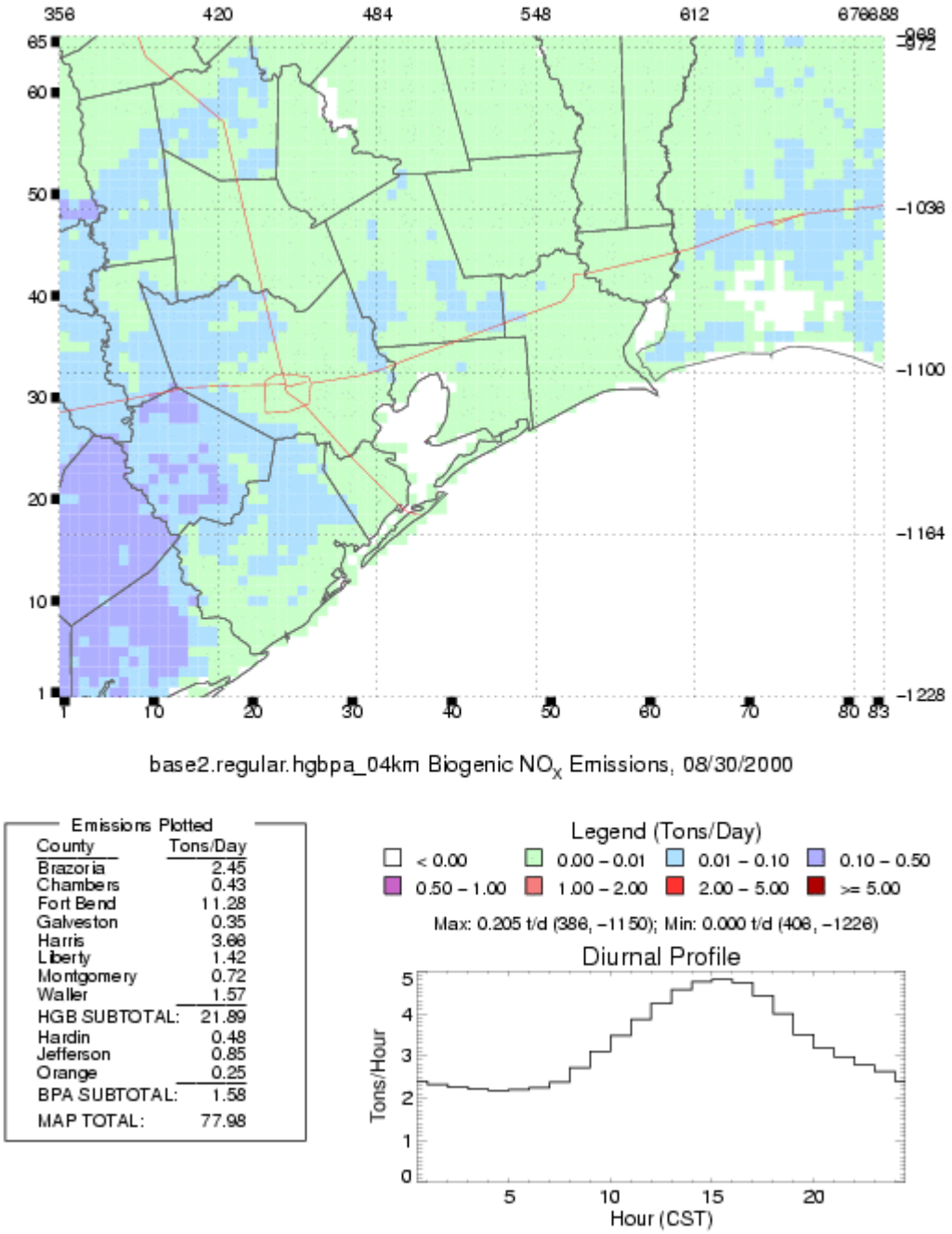


Figure 2-10: Modeled Biogenic NO_X emissions on August 30, a Typical Ozone Season Day

2.5.3 Point Sources

CAMx provides the option to model selected point source emissions with a Plume-in-Grid (PiG) algorithm, which increments the mixing of the plume emissions into the model's grid cells. The PiG sources were selected based on the magnitude of NO_X emissions (i.e., at least 5 tpd with a co-location distance of 1 meter or less). Over 300 sources from across the entire modeling domain were modeled with the PiG algorithm in the 2000 base case, the 2000 baseline, and the 2009 baseline.

2.5.3.1 2000 Base Case

Within Texas

The base case point source emissions within Texas were developed using information compiled from several databases. Emissions data from the TCEQ's Point Source Database (PSDB) reported for the year 2000 were used. The PSDB data are typically annual emissions although some sources report ozone season day emissions as well. Emissions from the PSDB were replaced with hourly emissions from the Acid Rain Program Data Base (ARPDB) where appropriate (e.g., NO_X from electric generating units (EGU)). In addition, the TCEQ's database of reported emission events was reviewed and where appropriate, these emissions were used to replace PSDB emissions. Further, during TexAQS 2000, a special emissions inventory was compiled, primarily for large emitting facilities in the HGB and BPA areas. Where appropriate, these specially compiled emissions were used to replace PSDB emissions.

As described in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP, highly-reactive volatile organic compounds (HRVOC) emissions were increased by 163 to 203 tpd, depending on episode day, in the 2000 base case inventory. This "imputation" is described in detail in the previous SIP revision and was based on observational data indicating that HRVOC emissions were under-reported in the emissions inventory (EI). For the current modeling effort, an alternative distribution was used for the petrochemical point sources within and adjacent to the Houston Ship Channel. These sources received about one-half of the added HRVOC (i.e., approximately 92 tpd). The added HRVOC were redistributed based on a more recent analysis of the hourly ambient HRVOC data collected in 2003 from six automated gas chromatograph (auto-GC) monitoring sites located within and adjacent to the Houston Ship Channel (HSC). This analysis used a triangulation technique to derive potential source contribution factors (PSCF) for the geographical region represented by the auto-GC monitors. The PSCF represent the probabilities that high HRVOC concentrations measured at the auto-GC resulted from emissions within the area.

Outside Texas

The TCEQ acquired a data file from the Louisiana Department of Environmental Quality (LDEQ) of their 2000 point source emissions inventory. As was done for point sources within Texas, hourly ARPDB emissions were substituted for the LDEQ annual emissions.

For the states in the modeling domain beyond Texas and Louisiana, the TCEQ developed regional modeling emissions using the 1999 National Emissions Inventory (NEI), version 3. Again, as was done for point sources within Texas, hourly ARPDB emissions were used. For the small portion of Ontario, Canada within the regional modeling domain, point source emissions were obtained from the EPA Clean Air Interstate Rule (CAIR) modeling website.

The TCEQ acquired 2000 emissions data from the Minerals Management Service (MMS) for platform and non-platform sources in the Gulf of Mexico offshore from Texas and Louisiana. The platform sources were represented as point sources in the model.

The TCEQ generated point source modeling emissions for the portion of Mexico within the regional modeling domain using the 1999 Big Bend Regional Aerosol and Visibility Observational Study emissions inventory.

Figure 2-11: *2000 Base Case Modeled Point Source VOC Emissions on August 30* and Figure 2-12: *2000 Base Case Modeled Point Source NO_X Emissions on August 30* show the graphical distribution of point source VOC and NO_X emissions, respectively, for the 4 km X 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area, the point source emissions are 413.7 tpd VOC and 498.6 tpd NO_X.

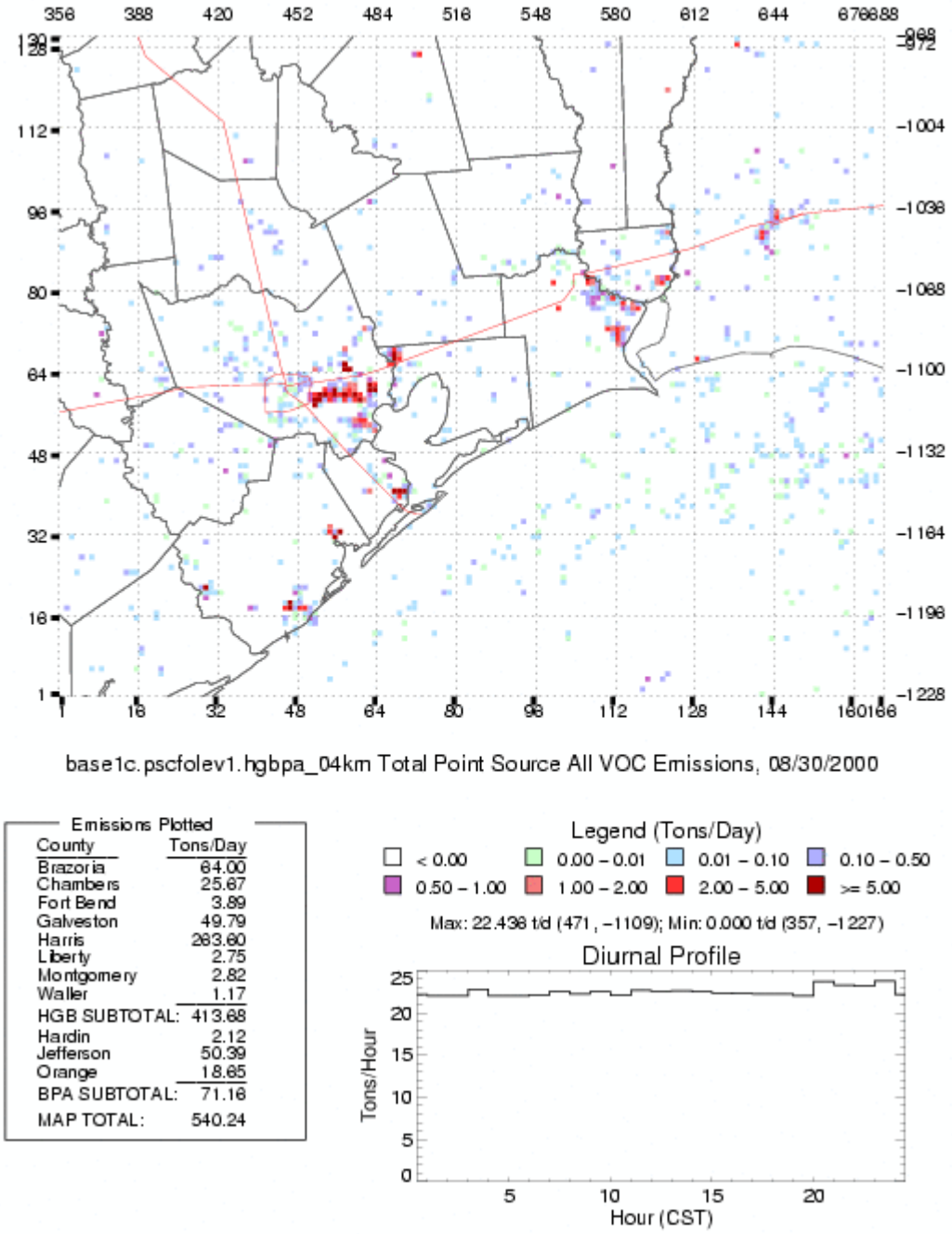


Figure 2-11: 2000 Base Case Modeled Point Source VOC Emissions on August 30

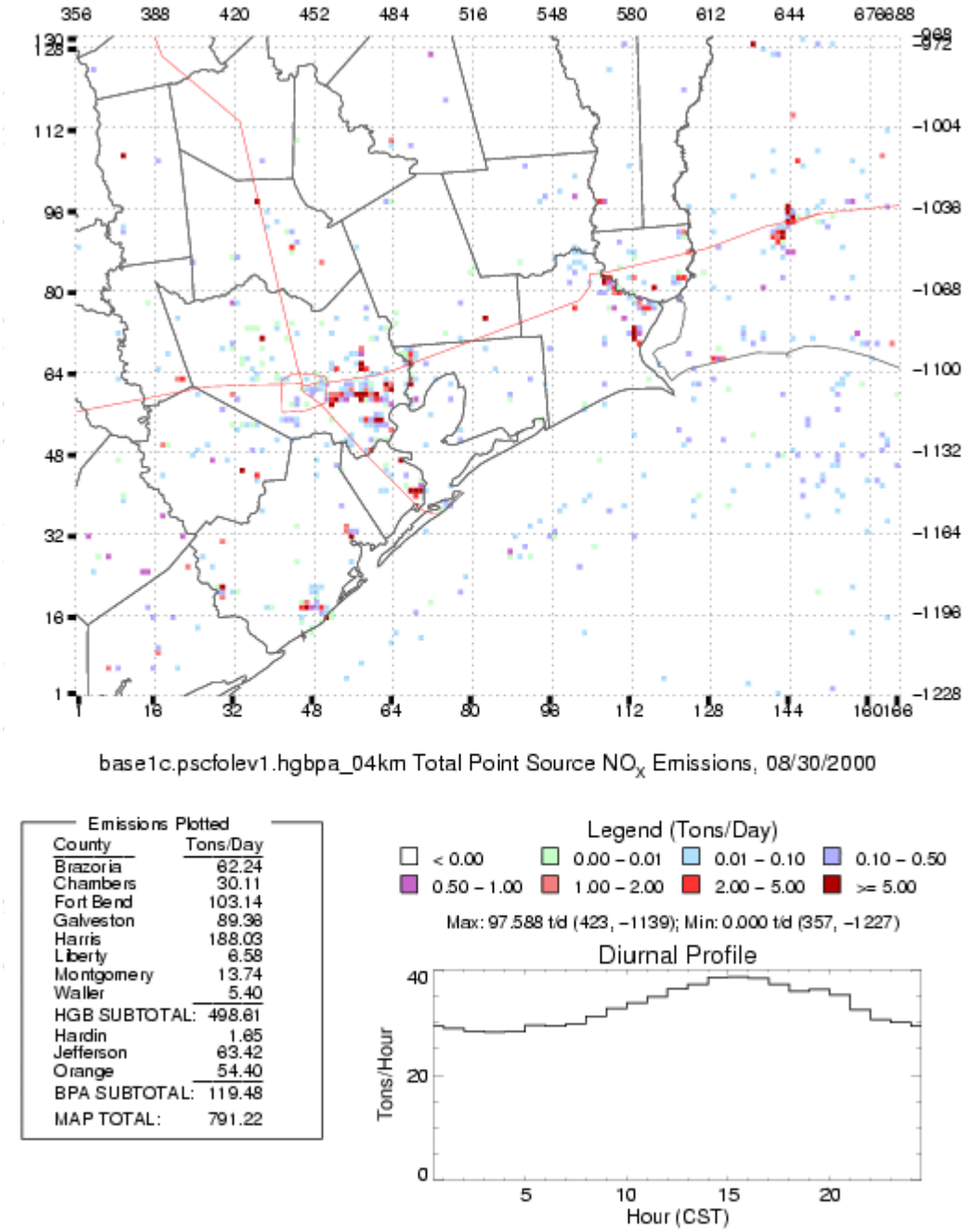


Figure 2-12: 2000 Base Case Modeled Point Source NO_X Emissions on August 30

2.5.3.2 2000 Baseline

Within Texas

The major changes in the point source modeling emissions from the 2000 base case to the 2000 baseline were the episode-specific emissions developed from the ARPDB, the emission events database, and the TexAQS 2000 special inventory. For the 2000 baseline, the episode-specific ARPDB emissions were averaged over the episode period of August 16 through September 6, 2000, for each hour of the day to maintain the temporal profile. The resulting generic day was used for each modeled day in the 2000 baseline. Any base case emissions that had been developed from the emission events database were replaced with the appropriate emissions from the PSDB. Similar to the procedure used for ARPDB emissions, any emissions developed from the TexAQS 2000 special inventory were averaged over the episode period for each hour of the day to maintain the temporal profile. The additional HRVOC added to the 2000 base case were retained in the 2000 baseline.

Outside Texas

For the point source modeling emissions in Louisiana developed from the ARPDB, again a generic episode day was developed by averaging over the episode period for each hour of the day to maintain the temporal profile. For all the other point sources outside Texas, the point source modeling emissions from the 2000 base case were used for the 2000 baseline.

These changes resulted in only minor differences in the point source modeled emissions between the base case and baseline scenarios. For example, within the eight-county HGB area the 2000 baseline point source modeled NO_X emissions are approximately 23 tpd less than the 2000 base case, which is less than a 5 percent difference. The difference in modeled VOC emissions is even smaller at approximately 5 tpd.

2.5.3.3 2009 Baseline

Within Texas

For the 2009 baseline EGU emissions at existing facilities within Texas, data from the ARPDB for the third quarter of 2005 (‘05Q3) were used, unless the facility was retired or shutdown, in which case its emissions were not included in the modeling emissions. The ‘05Q3 data were used, where available, because they include all of the EGU controls required by the TCEQ by 2009. If a non-retired facility had zero emissions for the ‘05Q3 because it was temporarily shut-down (e.g., maintenance) and the third quarter of 2004 (‘04Q3) ARPDB data were available, the ‘04Q3 data were used. However, if the facility had been mothballed, and their ARPDB ‘04Q3 data also had zero emissions, then ozone season daily emissions for 2000 were used with the appropriate reductions reflecting required controls (e.g., Senate Bill (SB) 7, 76th Texas Legislature, 30 Texas Administrative Code Chapter 117, Mass Emissions Cap and Trade (MECT) Program) applied between 2000 and 2009. For the EGU in BPA, Dallas-Fort Worth (DFW) and attainment counties of Texas that did not have ‘05Q3 data, either individual or system-average SB 7 reductions were applied, or emissions limitations in Chapter 117. For EGU within the eight-county HGB nonattainment area, the 2009 baseline modeled NO_X emissions were developed from the MECT program cap level.

The growth in EGU is accounted for via the addition of permitted new EGU that are expected to be operational between 2005 and 2009. All newly-permitted EGU within Texas that are not in the ‘05Q3 ARPDB but are expected to be operational by 2009 were included in the 2009 future baseline modeling emissions at their permitted levels. This growth should not be in excess of the electricity demand that the State requires (plus the Electric Reliability Council of Texas (ERCOT)

reliability margin). ERCOT's megawatts demand projections (as of October 2005) through 2009 were used and it was verified that the megawatt demand between 2005 and 2009 will be met with the megawatt capacity provided by the newly-permitted EGU. These newly-permitted EGU total 29 units/stacks at 10 facilities. All are gas-fired except the Sandow 5 units (lignite-fired, to be operated by TXU) at ALCOA in Milam County. As of June 2006, all 29 of these units have been issued permits and all are scheduled to be operational prior to October 2009. The newly-permitted units add approximately 19 tpd of NO_X to the 2009 inventory, none of which are in the eight-county HGB area.

For non-electric generating units (NEGU) within Texas the 2009 baseline modeling emissions were developed by applying appropriate growth and controls to the 2000 baseline. Growth factors are available from the EPA's Economic Growth Analysis System (EGAS) for various industries within Texas. However, the EPA's EGAS treats all of Texas as one economic zone. Therefore, the TCEQ commissioned the development of a Texas-specific EGAS, which provides growth factors for industries (i.e., NEGU) for each of the 44 economic zones, delineated by Source Category Codes or Standard Industrial Codes. These growth factors were used unless more recent growth factors from the Dallas Federal Reserve Bank's Texas Industrial Production Index were available. Similar to the procedure for EGU, NO_X emission reductions due to controls installed to meet the requirements of Chapter 117 were applied to NEGU in the nonattainment areas (i.e., HGB, DFW, and BPA). In addition, in the eight-county HGB area, the MECT program rule and the HGB HRVOC cap (i.e., the HRVOC Emission Cap and Trade program) were applied to appropriate NEGU.

As in previous SIP revisions, the TCEQ assumes that the only substantial growth that occurs for NEGU in the nonattainment areas occurs when facilities expand by purchasing emissions offsets from the bank during New Source Review of permit applications. It is assumed that all of the emissions in the bank can come back into the airshed, and as the worst case, it is assumed that it can happen all at once during the ozone season of 2009. The procedure for incorporating the banked emissions in the future base is unchanged from that of the previous few SIP revisions.

Outside Texas

In general, the EPA's 2010 CAIR modeling files were used for point source emissions for facilities outside of Texas. For the EGU, in particular, the EPA's October 2005 CAIR modeling files were used. No additional growth or controls were applied to these point sources between 2005 and the 2009. Because growth factors and controls are not readily available for sources in Mexico or the Gulf of Mexico the 2000 baseline emissions were used for the 2009 baseline.

Figures 2-13: *2009 Baseline Modeled Point Source VOC Emissions for August 30* and Figure 2-14: *2009 Baseline Modeled Point Source NO_X Emissions for August 30* show the graphical distribution of the 2009 baseline modeling emissions of point source VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the point source emissions are 268.6 tpd of VOC and 157.0 tpd of NO_X for the 2009 baseline.

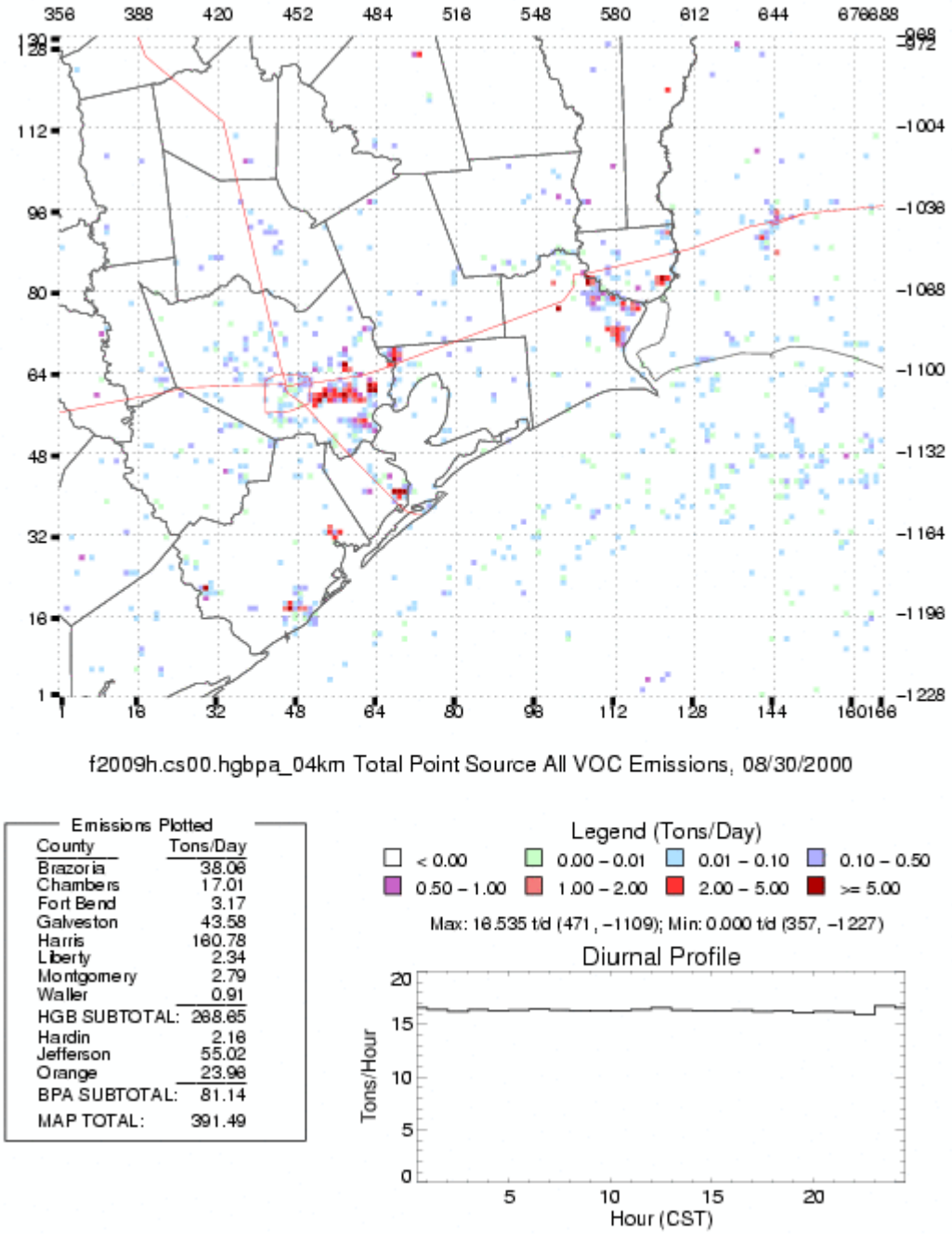


Figure 2-13: 2009 Baseline Modeled Point Source VOC Emissions for August 30

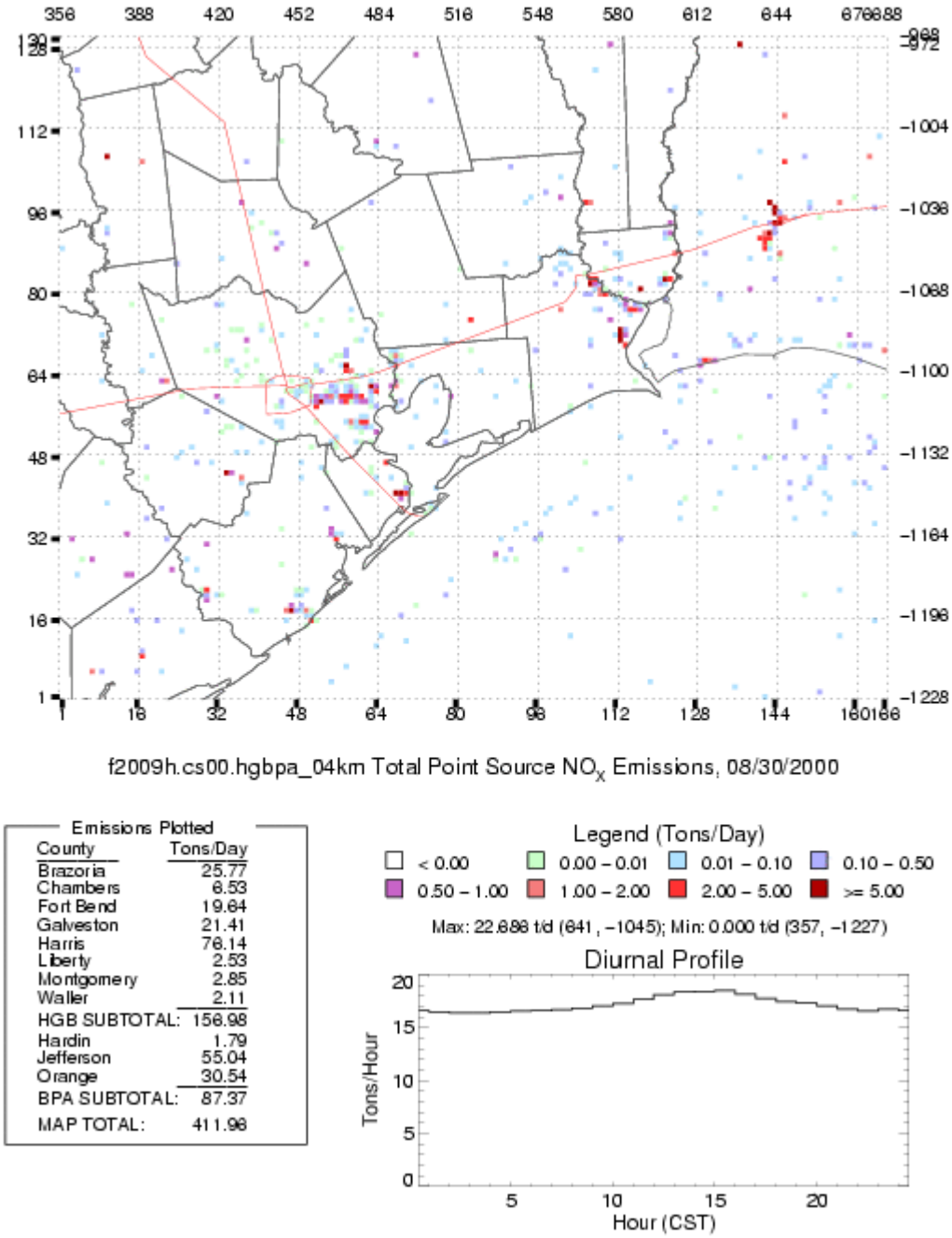


Figure 2-14: 2009 Baseline Modeled Point Source NO_X Emissions for August 30

2.5.4 Area and Non-Road Mobile Sources

2.5.4.1 2000 Base Case

The 2000 base case area and non-road mobile source modeling emissions were primarily developed from the 1999 periodic emissions inventory (PEI; area sources) and the NONROAD2004 model.

Within Texas

2000 base case area source modeling emissions within Texas for the August 18-September 6, 2000, episode were estimated by applying EGAS growth factors to the 1999 PEI emissions. EGAS is available from the EPA and provides growth factors for each area source category. For lawn and garden, recreational marine, and construction activity, more recent source survey data were collected to estimate local equipment populations. These data were used in updating the modeling emissions for area sources.

Three notable categories of non-road mobile sources are not included in the NONROAD2004 model: ships, airplanes, and locomotives. Alternate methods were used to develop the emissions included in the model for these categories. Emissions for ships were developed based on data from a contractor study (December 2000 HGB SIP Revision, Appendix C) conducted in the 1999-2000 time frame and emissions for locomotives and aircraft were developed from studies conducted by the TCEQ. Ship emissions were treated as pseudo-stacks spaced along the major waterways within the Galveston Bay region (e.g., Texas Intracoastal Waterway). Emissions for wildfires developed by the University of Texas (Allen *et al.*, 2002) were also treated as point sources.

Outside Texas

2000 base case area and non-road modeling emissions outside of Texas were obtained from ENVIRON. ENVIRON developed 1999 modeling emissions for a comparable modeling domain to use for their modeling of near-nonattainment areas in Texas. The ENVIRON modeling emissions were based on the 1999 NEI and NONROAD model. Modeling emissions for Ontario, Canada were developed using data obtained from Environment Canada's National Pollutant Release Inventory for the year 2000. Modeling emissions in the western Gulf of Mexico were developed using data obtained from the MMS's year 2000 Gulf-Wide Emissions Inventory. This inventory has emission estimates for area and non-road sources, including spatial allocation.

Details concerning the specific procedures used to develop modeling emissions can be found in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP.

Figures 2-15 through 2-20 show the graphical distribution of modeled emissions of VOC and NO_X, for area and non-road sources combined, ships and fires for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the combined emissions from these sources are 332.7 tpd of VOC and 202.3 tpd of NO_X.

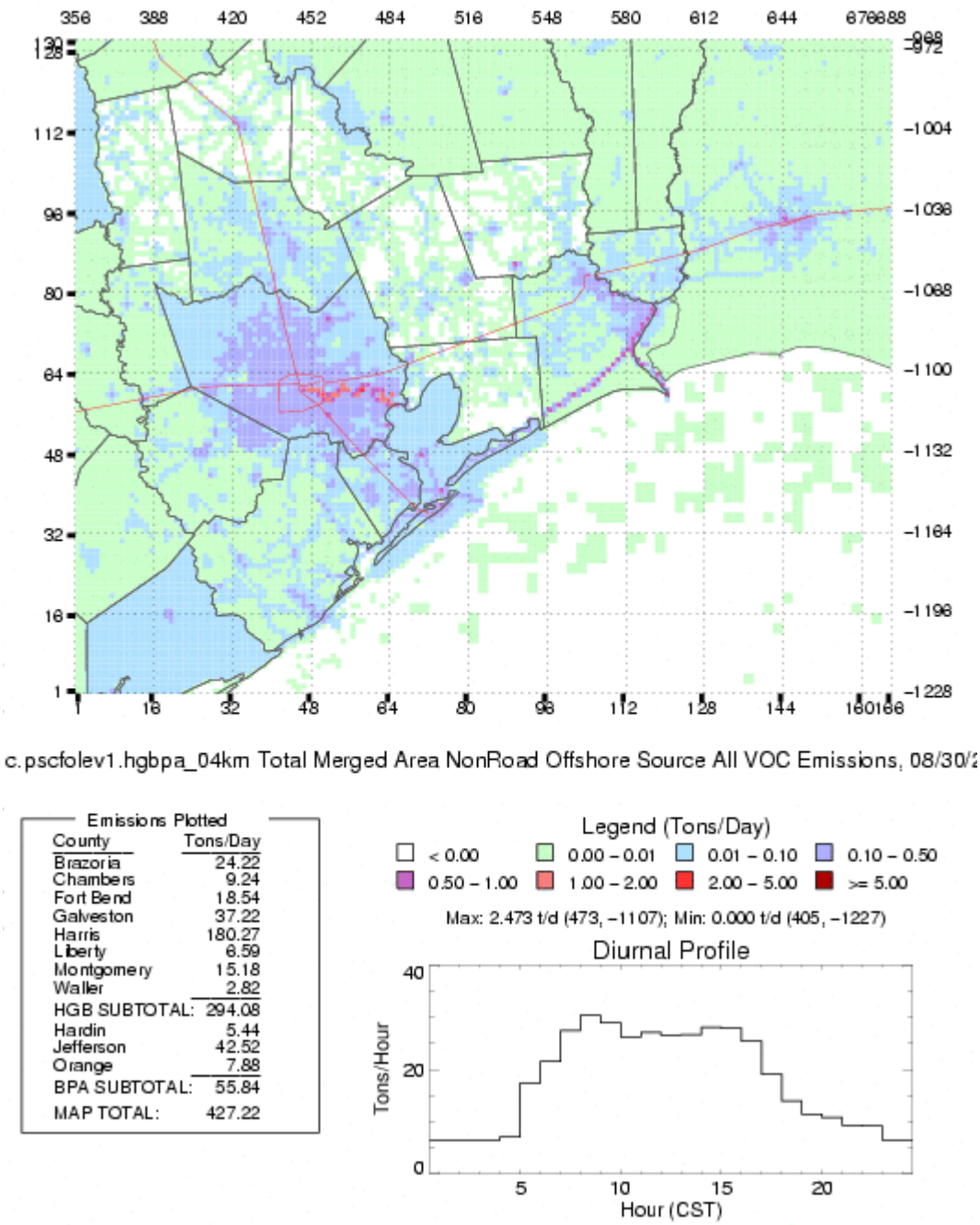


Figure 2-15: 2000 Base Case Modeled Area & Non-Road VOC Emissions for August 30

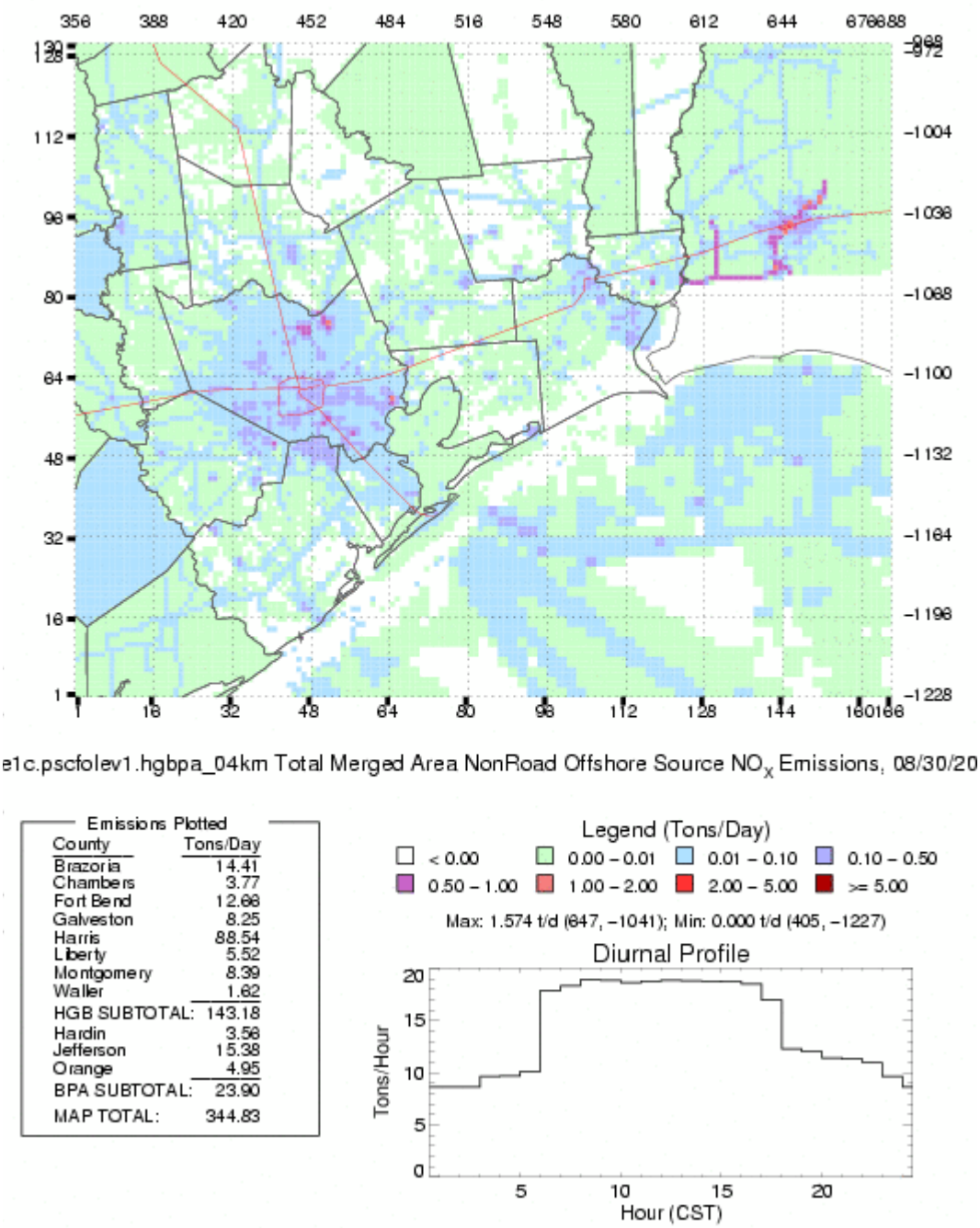


Figure 2-16: 2000 Base Case Modeled Area & Non-Road NO_X Emissions for August 30

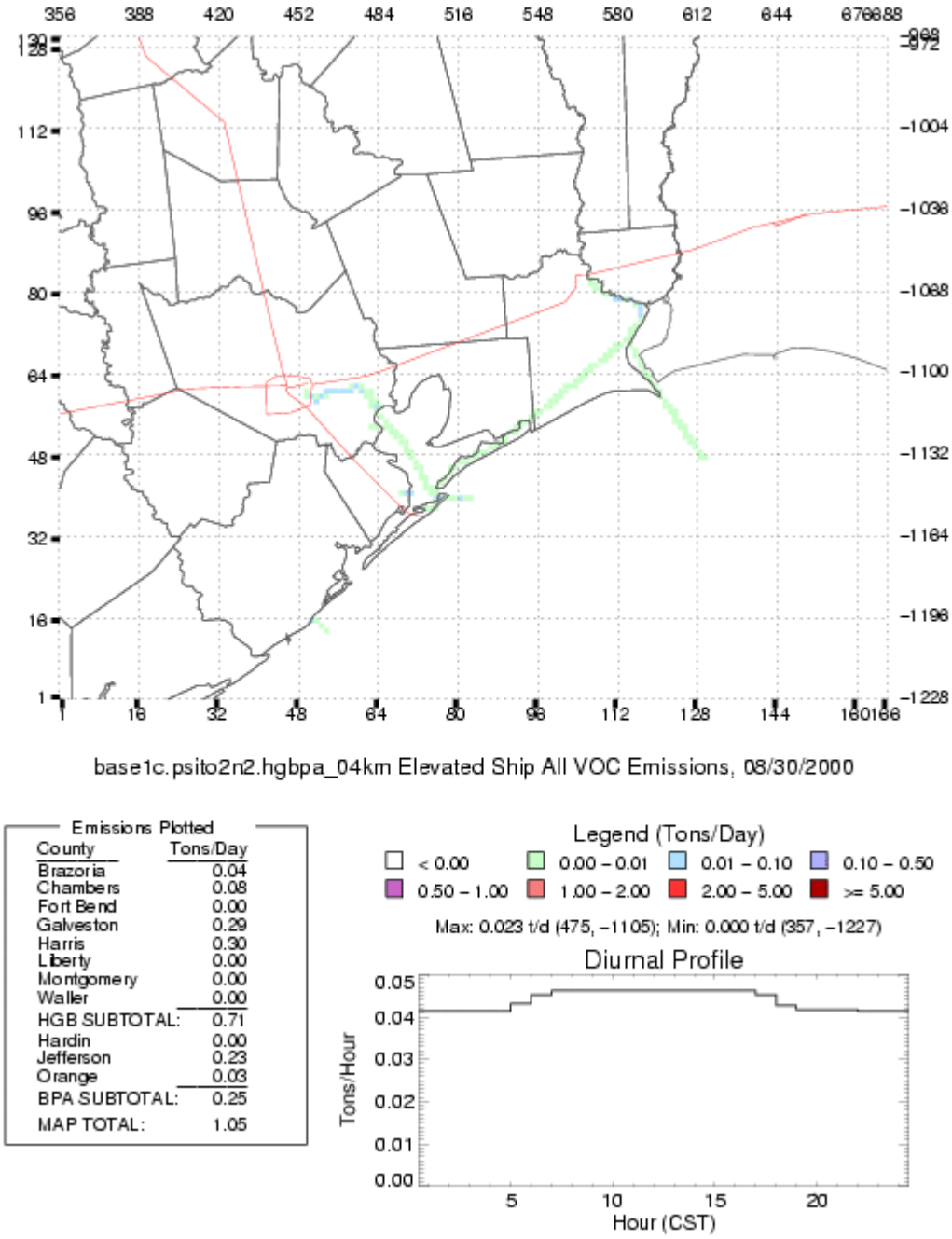


Figure 2-17: 2000 Base Case Modeled Ship VOC Emissions for August 30

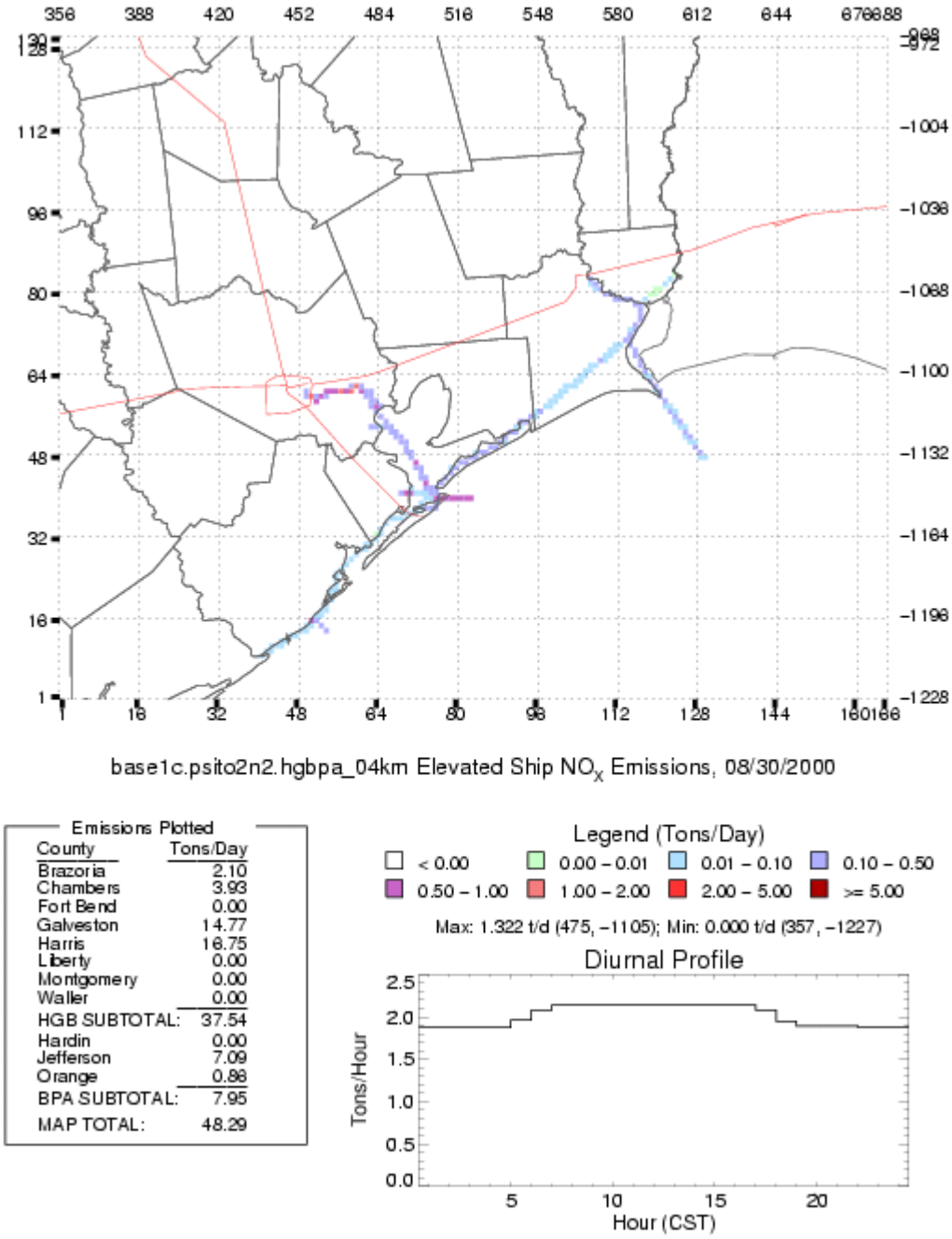


Figure 2-18: 2000 Base Case Modeled Ship NO_X Emissions for August 30

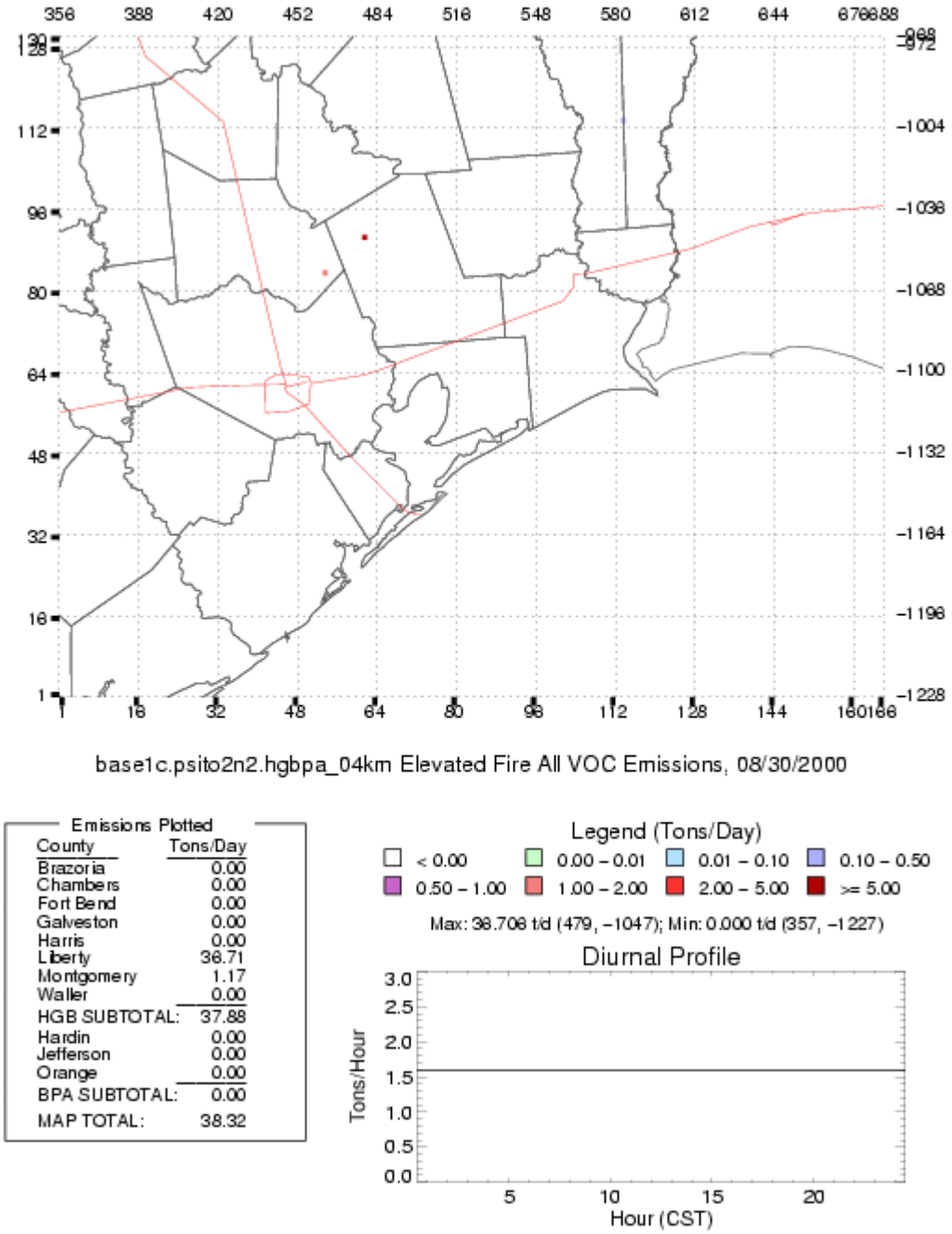


Figure 2-19: 2000 Base Case Modeled Fire VOC Emissions for August 30

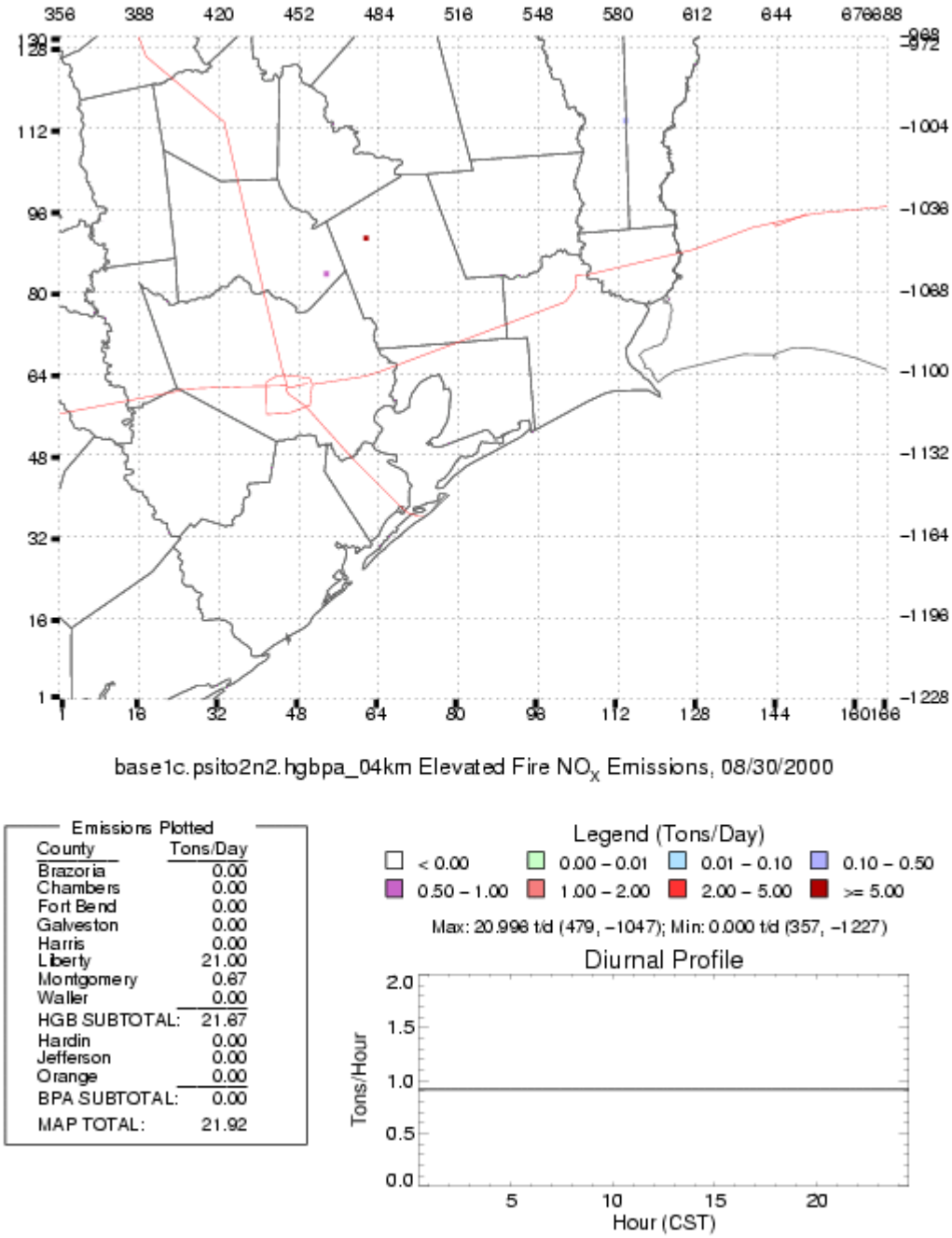


Figure 2-20: 2000 Base Case Modeled Fire NO_X Emissions for August 30

2.5.4.2 2000 Baseline

The 2000 baseline area, non-road, and ship modeling emissions are the same as the 2000 base case. Fires are not included in the 2000 baseline because they are not considered typical emissions.

2.5.4.3 2009 Baseline

Within Texas

Unless more current or locally-generated growth factors were available, area source emissions within Texas, including those from aircraft, ships, and locomotives, were grown to 2009 using the EPA's EGAS growth factors. For example, 2009 emissions for some area source categories were estimated using county-level economic or population growth projections obtained from the Texas Comptroller's Office or for particular emission source categories, using information such as oil and gas production from special studies. Emissions from liquefied natural gas (LNG) facilities (e.g., Freeport, Golden Pass) under construction in 2000 and included in the 2000 base case and 2000 baseline modeling emissions were included in the 2009 baseline at their respective construction emissions level to estimate operational emissions. The decision that LNG construction emissions were a reasonable estimate of operational emissions was based on information available at the time the inventory was developed suggesting that construction and operational emissions were similar. For non-road emissions categories, the NONROAD2004 model was used to project emissions into the future. The model accounts for both growth and federal controls on non-road sources. The control measures listed in Table 2-2: *2009 HGB 8-County Area/Non-Road Control Measures* were applied to reduce NO_X and VOC emissions from the proper area and non-road categories of the modeling inventory. The portable fuel container rule was modeled statewide using a factor applied to VOC emissions for gasoline-powered equipment in the lawn and garden category.

Table 2-2: 2009 HGB 8-County Area/Non-Road Control Measures

Control Measure	NO_X Emissions Reductions (tpd)	VOC Emissions Reductions (tpd)
Texas Emission Reduction Plan (TERP)	35.9	1.86
Texas Low Emission Diesel (TxLED)	3.1	0
Voluntary Mobile Source Emission Reduction Program (VMEP)	3.4	0.2
Minor source rule -- sources exempt from the MECT program	0.5	0
Clean portable fuel containers	0.0	2.9
Diesel engines—MECT program (0.1 tpd) plus all other diesel engine controls (0.9 tpd)	1.0	0
Total	43.9	4.96

Outside Texas

For the 2009 baseline area and non-road modeling emissions outside of Texas, the EPA emissions inventory developed for the CAIR 2010 modeling was used. Similar to the LNG facilities under

construction in Texas, the construction emissions for the LNG facility at Cheniere in Cameron Parish, Louisiana, were used to estimate the operational emissions in the 2009 baseline. Because growth factors and controls are not readily available for sources in Mexico or the Gulf of Mexico, the 2000 baseline emissions were used for the 2009 baseline. Also, similar to the 2000 baseline, fire emissions were not included in the 2009 baseline.

Figures 2-21 through 2-24 show the graphical distribution of the 2009 baseline modeling emissions of VOC and NO_X, for area and non-road sources combined and ships, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the combined emissions are 298.8 tpd of VOC and 135.2 tpd of NO_X.

2.5.5 On-Road Mobile Sources

2.5.5.1 2000 Base Case

Within Texas

For the eight-county HGB and the three-county BPA areas, on-road mobile source modeling emissions were developed from "link-based" emission inventories provided by the Texas Transportation Institute (TTI). To estimate emissions on roadway links for the 2000 episode year, TTI couples the emission factors output from the EPA's MOBILE6.2 model with the travel demand model (TDM) output of vehicle miles traveled (VMT) and speeds, provided by Houston-Galveston Area Council (H-GAC) for HGB and the Texas Department of Transportation (TxDOT) for BPA. However, prior to the coupling of the MOBILE6.2 emission factors, TTI adjusts the TDM output to make it more specific to the August 18 through September 6, 2000, episode using in-use traffic survey data, such as hourly traffic counts and the composition of VMT by vehicle type. In addition, following EPA directive, the TDM-derived VMT is adjusted to account for the difference between the TDM VMT and VMT estimated from the Highway Performance Monitoring System (HPMS) data.

For areas within Texas but outside the HGB and BPA nonattainment areas, TTI coupled the MOBILE6.2 output with county-wide HPMS-based VMT estimates adjusted for the 2000 episode to yield emission inventories by roadway type. In addition, again using traffic survey data, which show that mobile emissions vary by day of the week, hourly emissions for each county were developed for weekday (Monday-Thursday), Friday, Saturday, and Sunday day types for the various vehicle types.

The MOBILE6.2 model accounts for the effects that changes in hourly temperature and humidity have on NO_X emissions, but for only six of the 28 vehicle types. There is no temperature-humidity NO_X correction in MOBILE6.2 for the remaining 22 vehicle types, which include all 13 of the diesel-powered vehicle types and the nine heavy-duty gasoline vehicle types. Because this adjustment to the NO_X emissions can be appreciable during the ozone season in Texas, the Southwest Research Institute was commissioned to develop temperature/humidity NO_X correction equations to apply to these other vehicle types (December 2004 HGB SIP Revision, Appendix F). The temperature-humidity NO_X correction procedure allows not only for improved estimates of the total on-road NO_X emissions, but also for improved spatial and temporal allocation of those emissions.

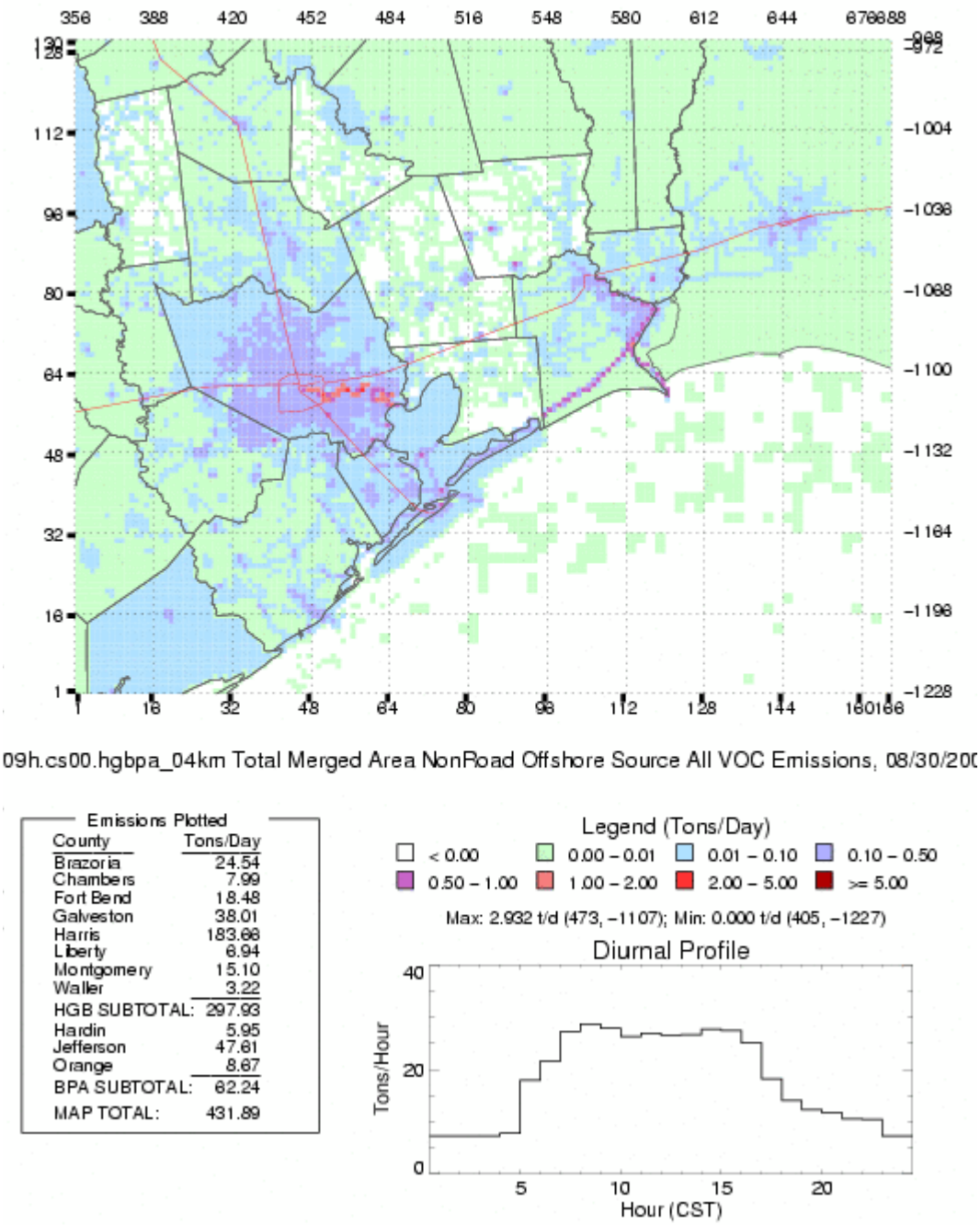


Figure 2-21: 2009 Baseline Modeled Area & Non-Road VOC Emissions for August 30

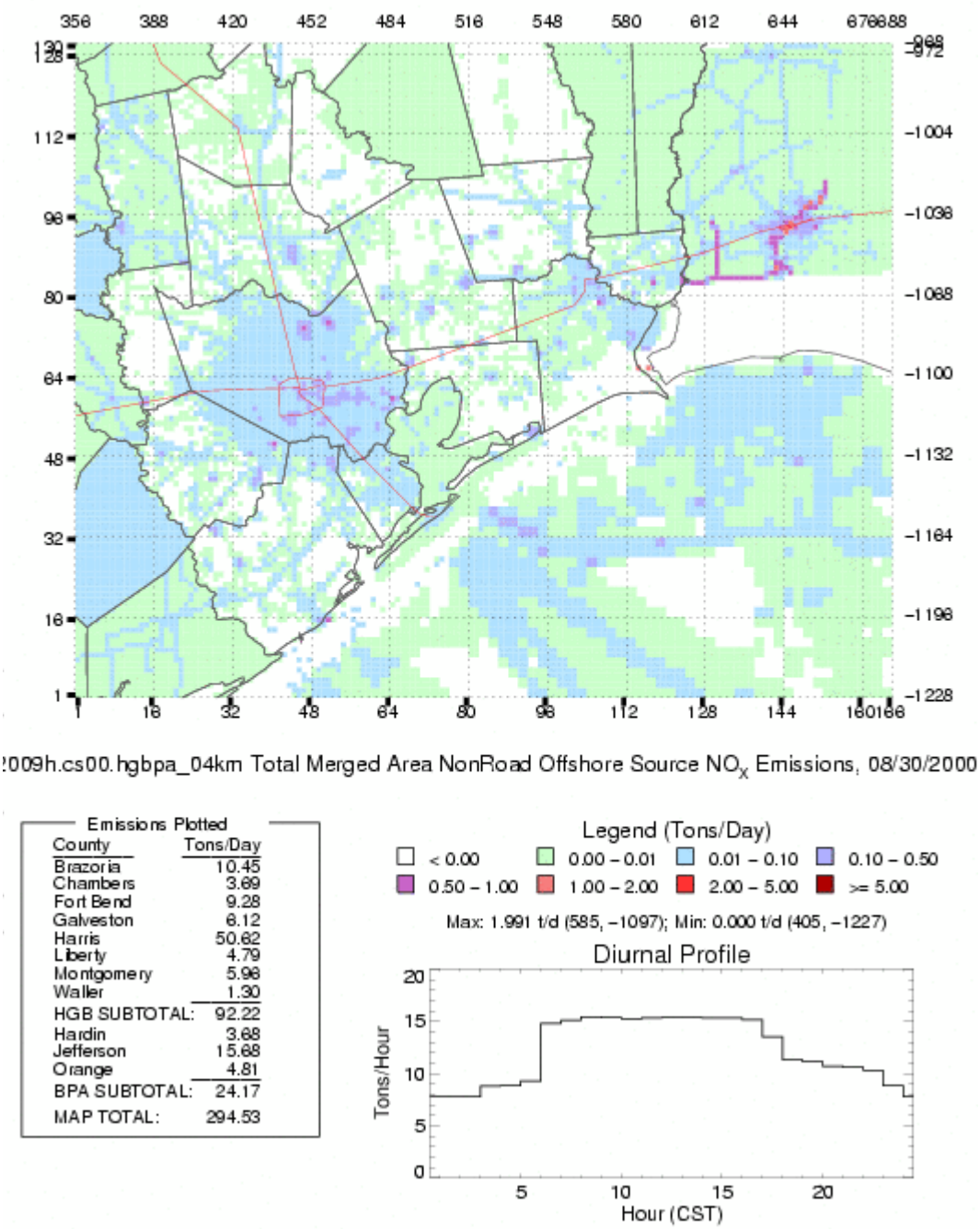


Figure 2-22: 2009 Baseline Modeled Area & Non-Road Source NO_X Emissions for August 30

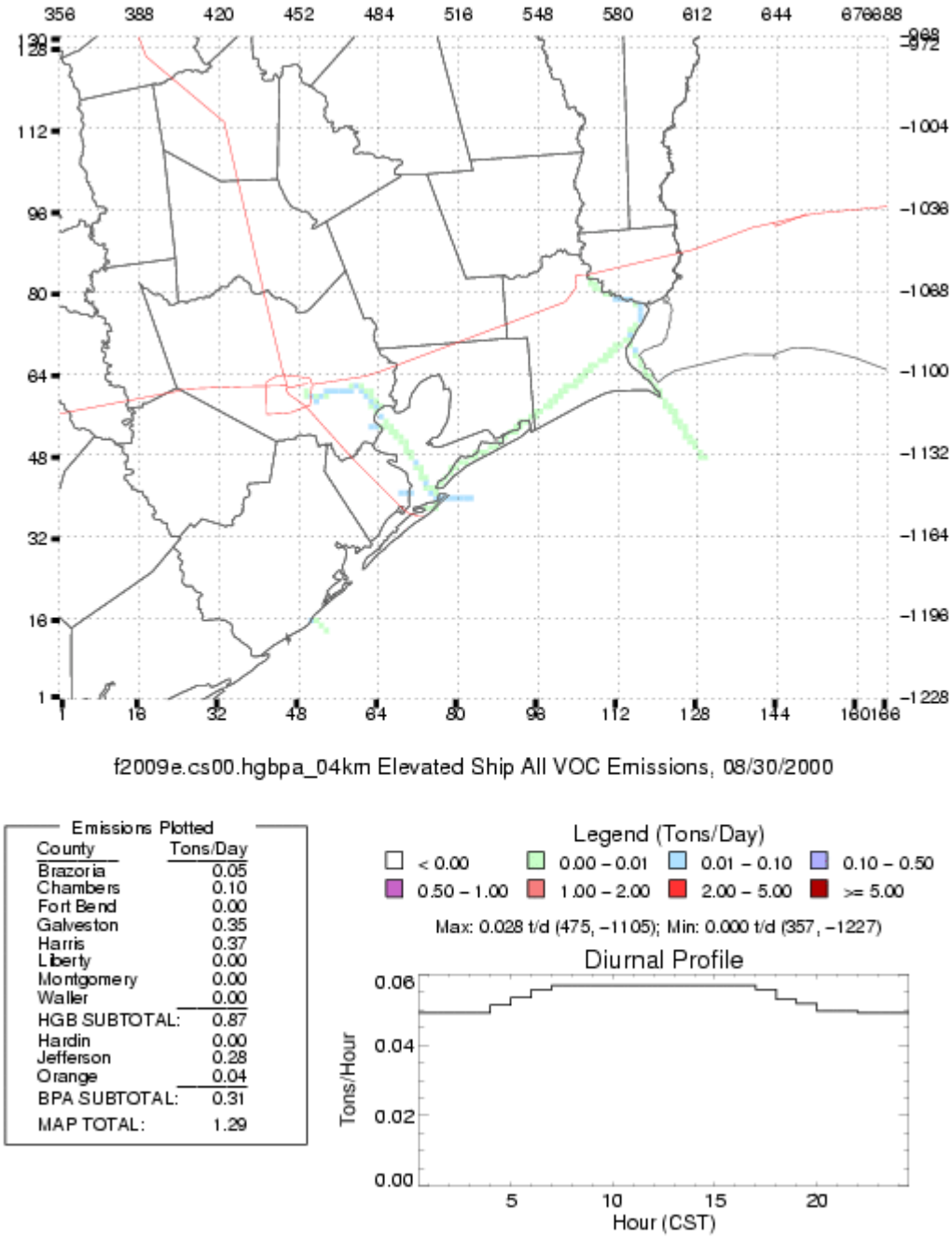


Figure 2-23: 2009 Baseline Modeled Ship VOC Emissions for August 30

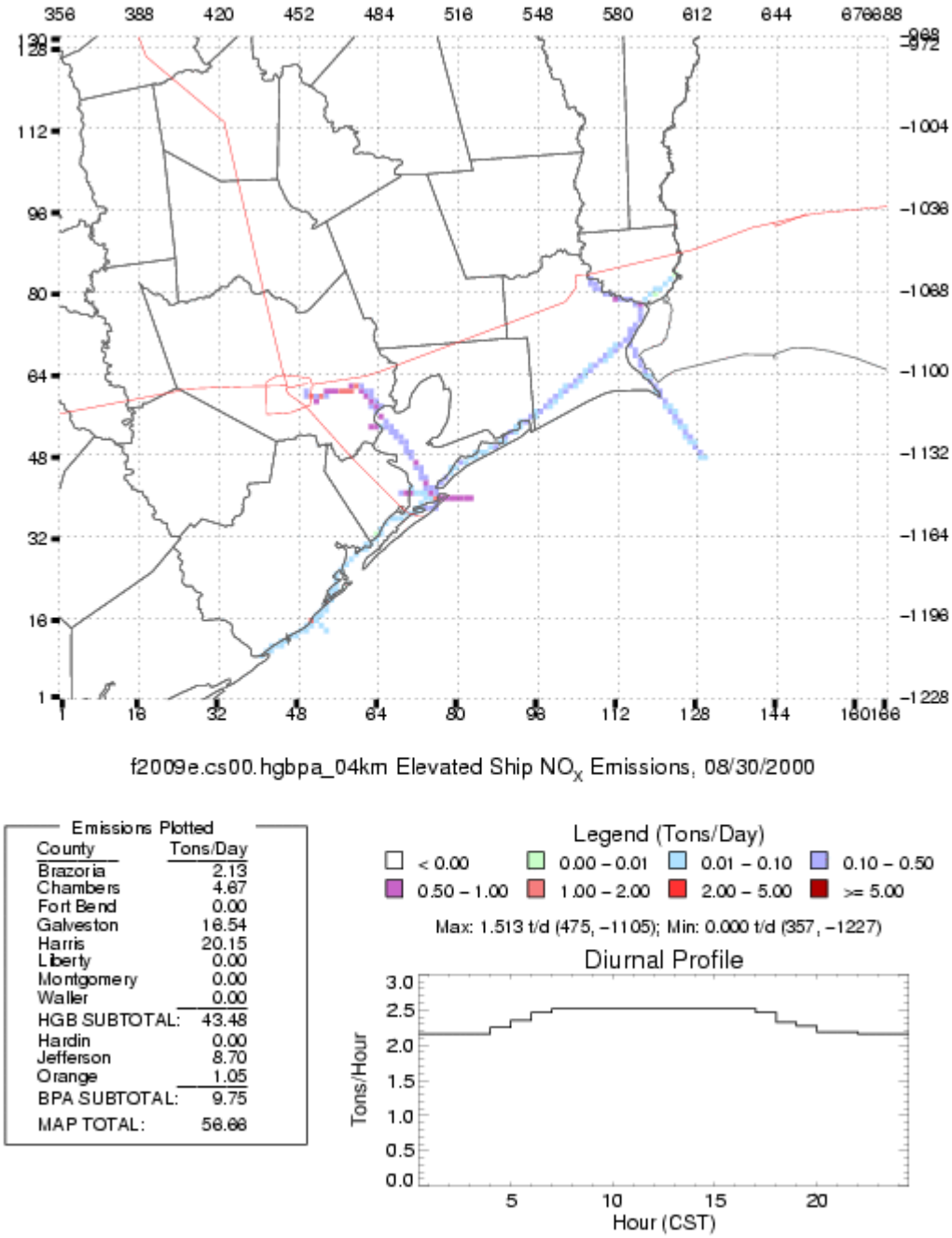


Figure 2-24: 2009 Baseline Modeled Ship NO_X Emissions for August 30

Outside Texas
On-road modeling emissions for areas outside of Texas were developed from the on-road portion of the 1999 NEI. For the 2000 base case, the 1999 on-road NEI emissions were adjusted by the relative fleetwide emission factor differences between MOBILE6.2 model runs for 1999 and 2000 and the relative state-by-state differences in VMT between 1999 and 2000. The VMT adjustment was based on the *Highway Statistics* series published by the Federal Highway Administration (FHWA) of the U.S. Department of Transportation.

Details concerning the development of the on-road modeling emissions can be found in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP.

Figure 2-25: *2000 Base Case Modeling On-Road Mobile Source VOC Emissions for August 30* and Figure 2-26: *2000 Base Case Modeling On-Road Mobile Source NO_X Emissions for August 30* show the graphical distribution of the 2000 base case on-road modeling emissions of VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, the combined emissions for the HGB eight-county area are 166.2 tpd of VOC and 342.6 tpd of NO_X.

2.5.5.2 2000 Baseline
The 2000 baseline on-road modeling emissions are the same as the 2000 base case.

2.5.5.3 2009 Baseline
Within Texas
Similar to the 2000 base case on-road modeling emissions, TTI in cooperation with H-GAC and TxDOT provided a link-based inventory for the HGB and BPA nonattainment areas, and a county-wide inventory for the remainder of Texas. The main differences from the 2000 base case are that the MOBILE6.2 outputs for 2009 were coupled with 2009 TDM outputs for HGB and BPA, and 2009 estimated county-wide VMT for the remainder of Texas. The 2009 TDM runs for HGB and BPA were based on best available future projections of population growth, demographic patterns, and roadway network changes. 2009 county-wide VMT projections for the areas in Texas outside the HGB and BPA nonattainment areas were made based upon vehicle and population trends.

The MOBILE6.2 runs for 2009 used the same meteorological inputs as the base case (temperatures, humidity, etc.), but other inputs, such as emission standards and the vehicle age distribution, were changed to reflect a 2009 fleet. For example, a 2009 vehicle fleet will be more heavily populated with newer lower-emitting vehicles. To account for existing control strategies in the HGB nonattainment area, the 2009 MOBILE6.2 was run with a maximum speed of 65 mph, rather than 70 mph, and the vehicle inspection and maintenance (I/M) program was expanded to include Brazoria, Fort Bend, Galveston and Montgomery Counties. In addition, the TTI-provided inventory for the HGB on-road emissions was reduced to reflect the benefits from transportation control measures (TCM), the TERP, and the VMEP. Further, as appropriate to many counties in Texas, the 2009 on-road emissions include the benefits of TxLED. The controls listed in Table 2-3: *2009 HGB Eight-County On-Road Controls* were applied to reduce NO_X and VOC emissions from the respective vehicle types.

Outside Texas
The 2009 on-road modeling emissions for areas outside of Texas were developed by applying appropriate growth and controls to the on-road portion of the 2002 NEI. For the 2009 baseline,

the 2002 on-road NEI emissions were adjusted by the relative fleetwide emission factor differences between MOBILE6.2 model runs for 2002 and 2009 and the relative state-by-state differences in VMT between 2002 and 2009. For the emission factor adjustment, MOBILE6.2 was run with the EPA default inputs for 2002 and 2009. The VMT adjustment was based on a growth analysis published by the FHWA in the *Highway Statistics* series.

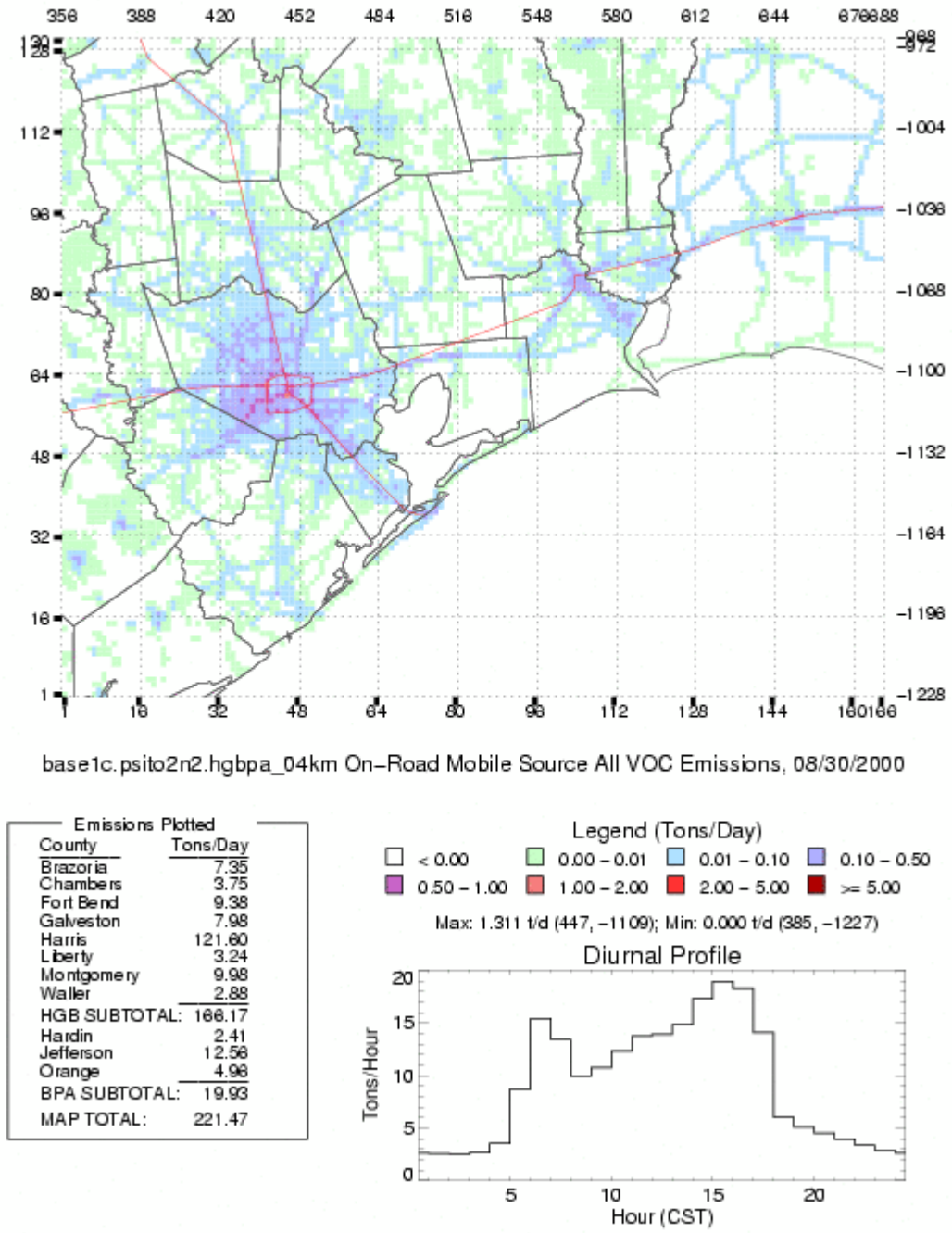


Figure 2-25: 2000 Base Case Modeling On-Road Mobile Source VOC Emissions for August 30

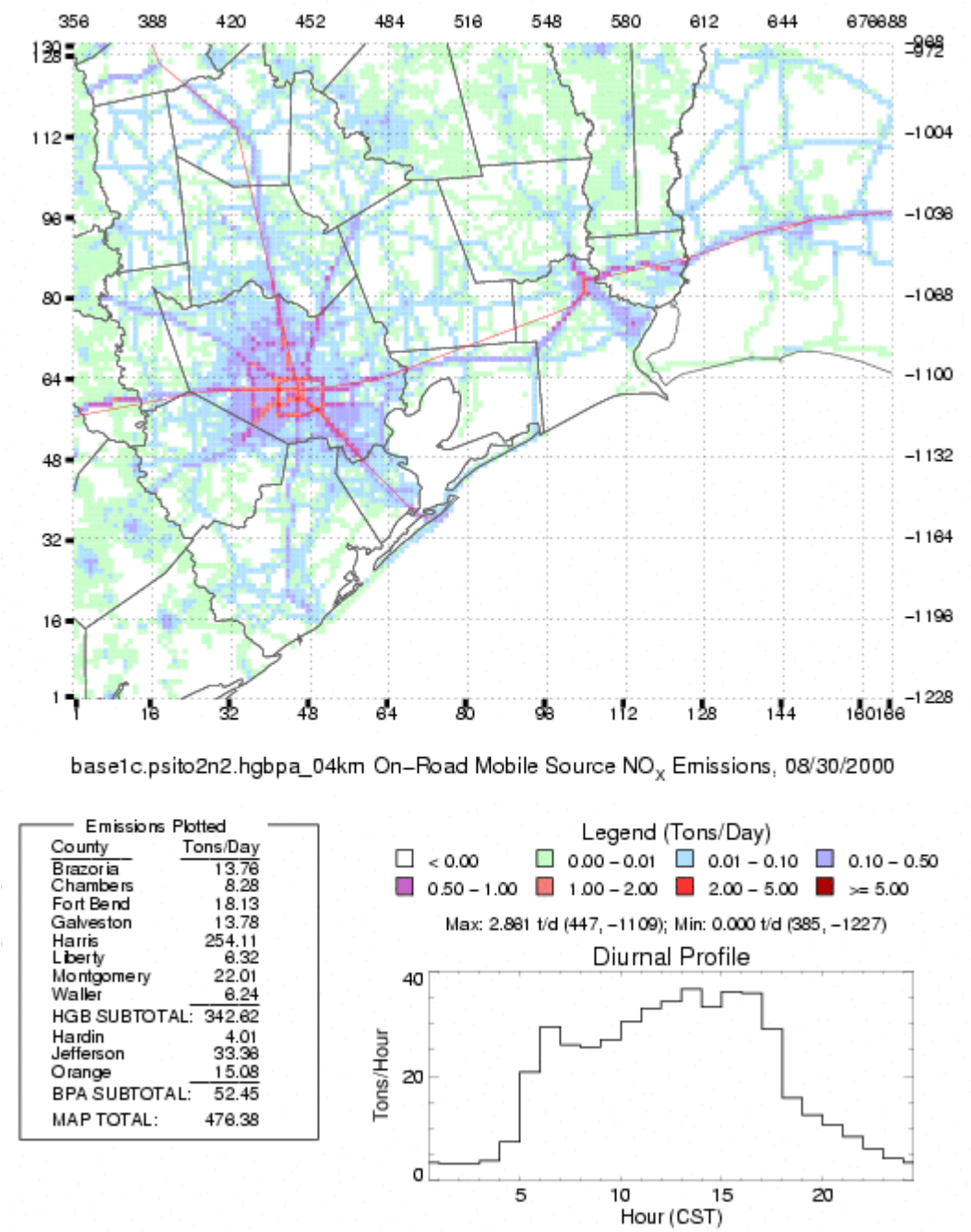


Figure 2-26: 2000 Base Case Modeling On-Road Mobile Source NO_X Emissions for August 30

Table 2-3: 2009 HGB Eight-County On-Road Controls

Control Measure	NO_X Emissions Reductions (tpd)	VOC Emissions Reductions (tpd)
TERP	3.00	0
TCM	0.85	0.52
VMEP	3.60	0.60
TxLED*	5.94	0
Total	13.39	1.12

* a NO_X reduction of 4.8 percent is applied to 2002-and-newer diesel vehicles, while a 6.2 percent NO_X benefit is applied to 2001-and-older diesel vehicles.

Figure 2-27: *2009 Baseline Modeling On-Road Mobile Source VOC Emissions for August 30* and Figure 2-28: *2009 Baseline Modeling On-Road Mobile Source NO_X Emissions for August 30* show the graphical distribution of the 2009 baseline on-road modeling emissions of VOC and NO_X, respectively, for the 4 km x 4 km modeling domain for August 30. As the tables embedded in the figures indicate, for the HGB eight-county area the combined emissions are 85.6 tpd of VOC and 152.7 tpd of NO_X.

2.5.6 Modeling Emissions Summary

Table 2-4: *HGB 2000 Base Case, 2000 Baseline & 2009 Baseline Modeling Emissions by Source Category* summarizes the modeling emissions for the eight-county HGB nonattainment area.

Table 2-4: HGB 2000 Base Case, 2000 Baseline & 2009 Baseline Modeling Emissions by Source Category

Source Category	2000 Base Case		2000 Baseline		2009 Baseline	
	NO_X (tpd)	VOC (tpd)	NO_X (tpd)	VOC (tpd)	NO_X (tpd)	VOC (tpd)
Points	498.6	413.7	475.3	409.1	157.0	268.6
Area & Non-Road	143.2	294.1	143.2	294.1	92.2	297.9
Ships	37.5	0.7	37.5	0.7	43.5	0.9
Fires	21.7	37.9	NA	NA	NA	NA
On-Road	342.6	166.2	342.6	166.2	152.7	85.6
Sub-total	1043.6	912.6	998.6	870.1	445.4	653.0
Biogenic	21.9	1674.6	21.9	1674.6	21.9	1674.6
Total	1065.5	2587.2	1020.5	2544.7	467.3	2327.6

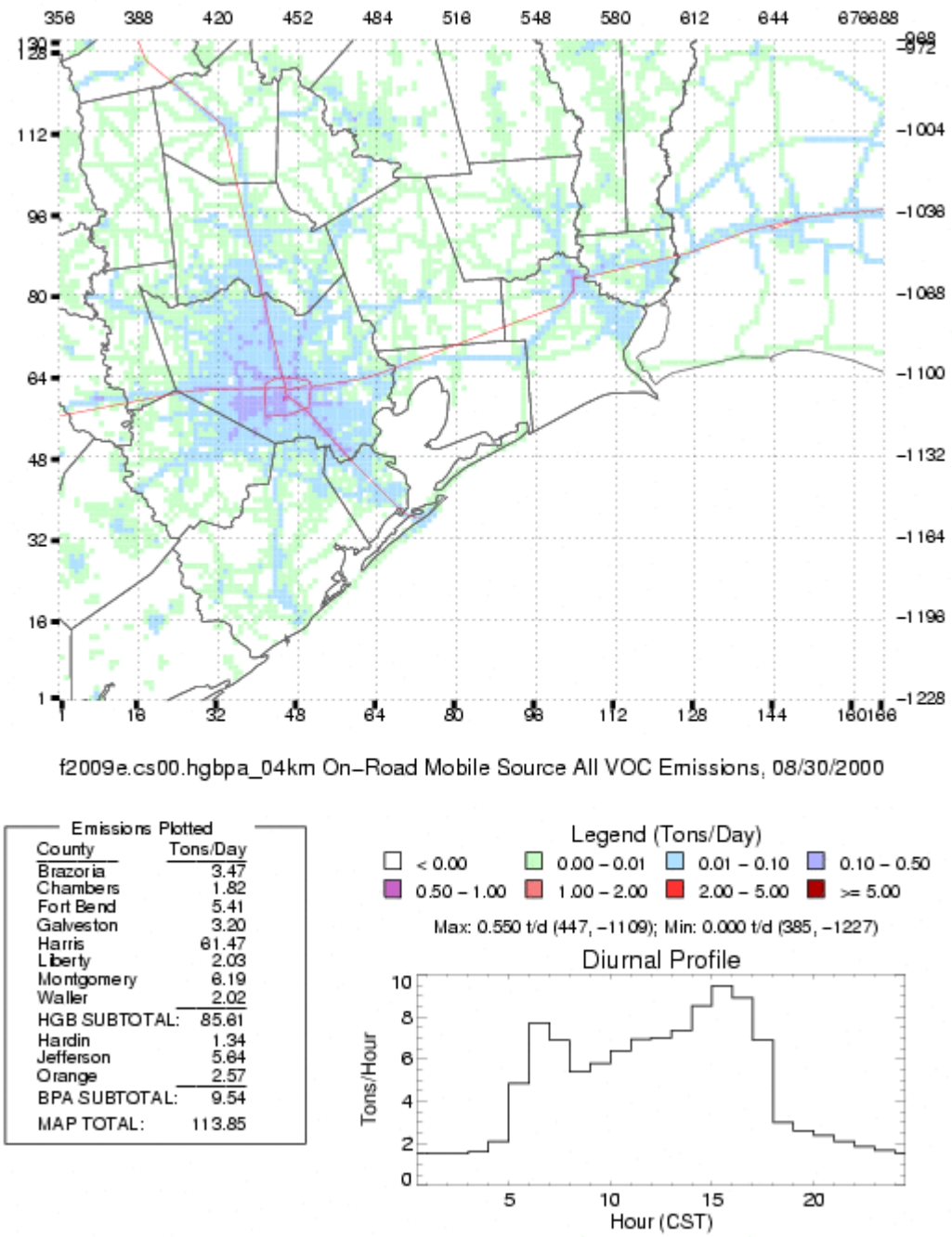


Figure 2-27: 2009 Baseline Modeling On-Road Mobile Source VOC Emissions for August 30

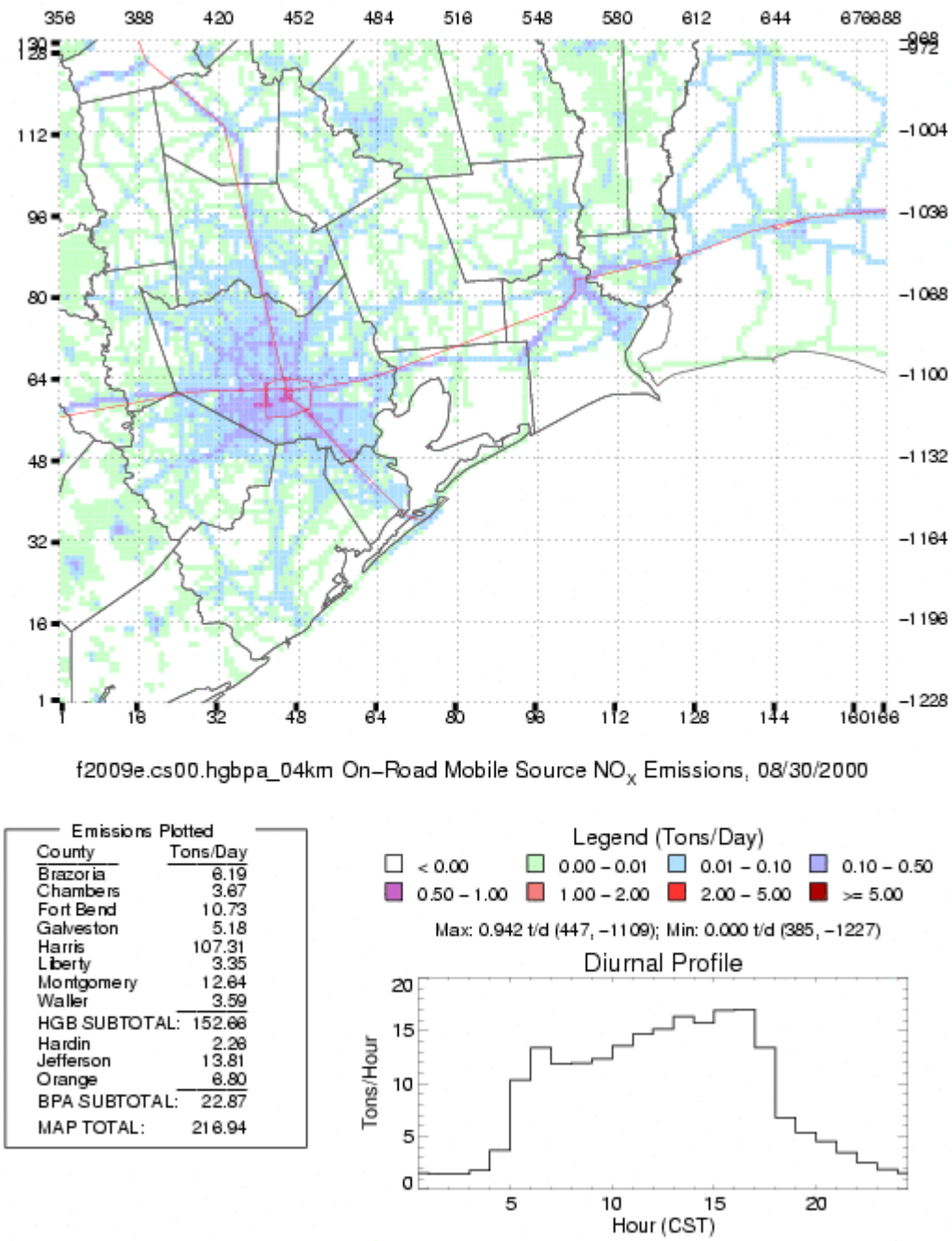


Figure 2-28: 2009 Baseline Modeling On-Road Mobile Source NO_X Emissions for August 30

2.6 BASE CASE MODEL PERFORMANCE EVALUATION

The performance of the base case modeling is evaluated to determine whether the model is adequately simulating the formation of ozone. The model must show reasonable performance for the base case episode before the future case is modeled and control measures are tested. The evaluation of the modeling is primarily conducted by comparing modeled predictions with monitored data. However, the model predicts a volumetric one-hour average throughout an entire grid cell, while hourly monitoring data provide a measure of air quality at a specific point in space. Therefore, modeled and monitored comparisons can only provide insight into model prediction trends but do not provide precise measures of model performance.

Additional information on specific performance evaluation procedures can be found in the *Guideline for Regulatory Application of the Urban Airshed Model* (EPA, 1991) and in the new *Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS* (EPA, 2005). These documents recommend performance evaluation of both quantitative (i.e., statistical) and qualitative (i.e., graphical) measures. The localized small-scale (i.e., high resolution) meteorological and emissions features characteristic of the HGB nonattainment area require model evaluation be performed at the highest resolution possible to evaluate whether or not the model is producing the right answer for the right reasons. Therefore, the performance evaluation focuses on comparisons of hourly modeled and monitored concentrations. This section also indicates how model performance has been improved since the 2004 HGB SIP Revision.

2.6.1 Statistical Performance Evaluations

The most commonly used measures of statistical performance are the three statistics; Unpaired Peak Accuracy, Normalized Bias, and Gross Error, which compare modeled and monitored ozone concentrations. These statistics are calculated separately for each episode day. Figures 2-29 through 2-31 show the classic performance statistics recommended in the EPA's 1992 Guidance for the current modeling. Also shown for comparison are the corresponding statistics from the modeling used in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP. Because August 16 and 17 were modeling initialization days, they should not be considered in the evaluation of performance. Further, the period from August 18 through August 21 was not modeled as part of the previous one-hour ozone SIP revision.

The Unpaired Peak Accuracy measures the model's ability to replicate the highest ozone observed on each day of the episode. A negative value of Unpaired Peak Accuracy is a clear indication that the model is not generating high enough peak ozone, but a positive value does not necessarily signal that the model is generating a peak that is too high, because the actual peak concentration may not occur at a monitoring location. Figure 2-29: *Comparison of Monitored Peak Ozone with Eight-Hour (current) and One-Hour Modeling* compares the modeled and monitored peak ozone concentrations on the various episode days. Although the Unpaired Peak Accuracy target statistic is not shown, the error bars represent the EPA's recommended $\pm$ 20 percent tolerance. Peaks that lie within this tolerance range meet the Unpaired Peak Accuracy performance criterion. For 16 of the 20 episode days, the modeled peak ozone is within this range.

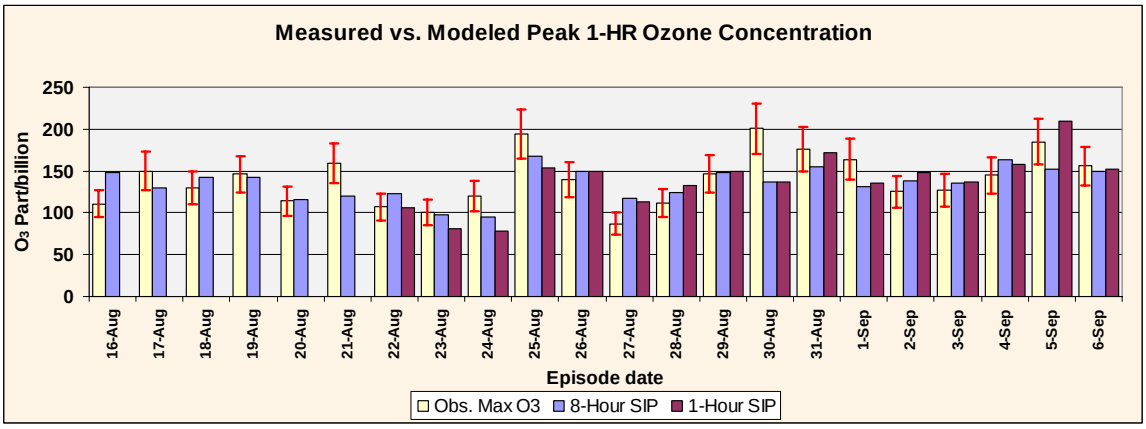


Figure 2-29: Comparison of Monitored Peak Ozone with Eight-Hour (current) and One-Hour Modeling

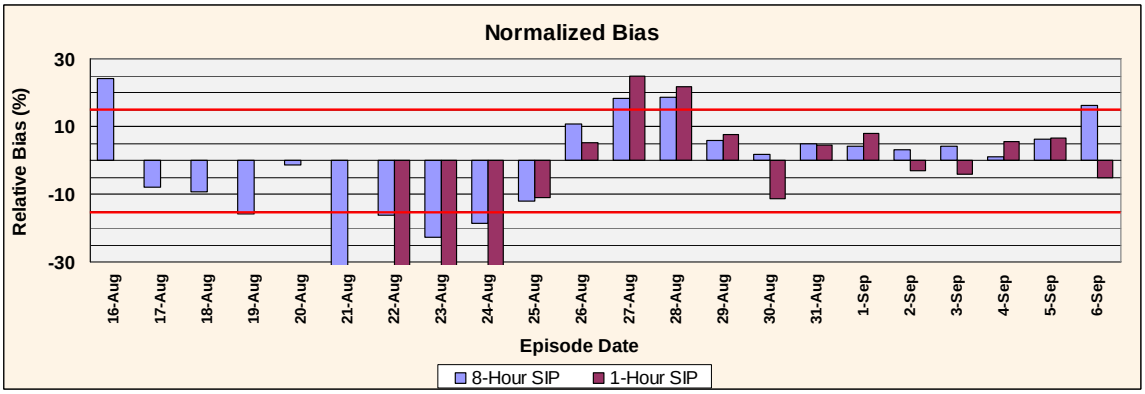


Figure 2-30: Comparison of Model Bias for Eight-Hour (Current) and One-Hour Modeling

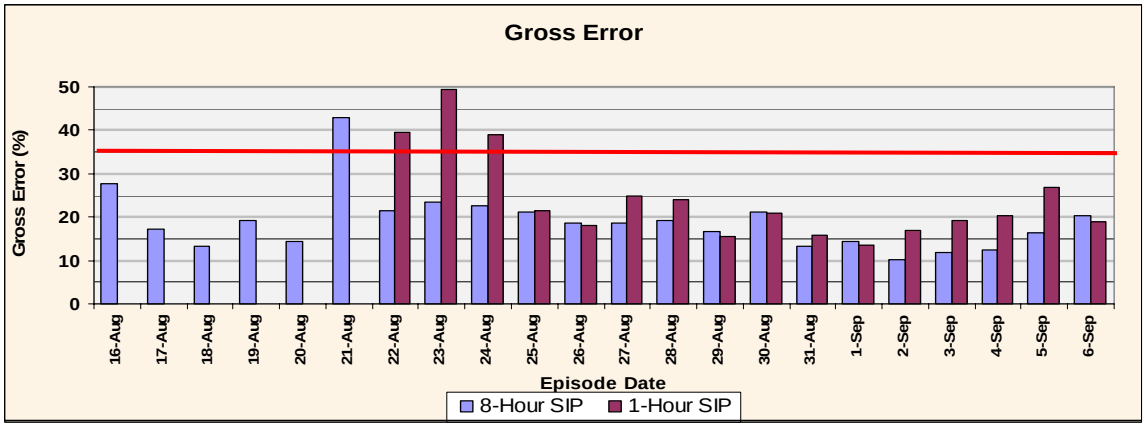


Figure 2-31: Comparison of Model Gross Error for Eight-Hour (Current) and One-Hour Modeling

The Normalized Bias measures the model's overall accuracy. A positive bias indicates the model's tendency to over-predict ozone concentrations and a negative bias indicates the model's tendency to under-predict ozone concentrations. Because this statistic can magnify small differences between monitored and modeled concentrations, it was calculated for monitored and modeled pairs where the monitored ozone was at least 60 ppb. Figure 2-30: *Comparison of Model Bias for Eight-Hour (Current) and One-Hour Modeling,* displays this statistic for the current modeling as well as for the modeling used in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP. The red lines indicate the EPA's recommended tolerance of ±15 percent. The results for the current modeling are somewhat improved over the previous modeling. The model bias is within the EPA-recommended range of ±15 percent on 12 of the 20 episode days.

The Gross Error measures the model's overall precision and represents the absolute deviation of the monitored and modeled pairs. Similar to the Normalized Bias, this statistic was calculated for monitored and modeled pairs where the monitored ozone was at least 60 ppb. Figure 2-31: *Comparison of Model Gross Error for Eight-Hour (Current) and One-Hour Modeling* displays this statistic for the current modeling and the modeling used in the 2004 HGB One-Hour Ozone Attainment Demonstration SIP. The red line indicates the EPA's recommended tolerance of 35 percent. Only one episode day, August 21, has gross error outside the EPA-recommended range of 35 percent.

While one-hour ozone statistics use every hour of the day (subject to measured concentrations being at least 60 ppb), the nature of the eight-hour standard limits most analyses to consider only the daily peak eight-hour concentrations. Table 2-5: *Eight-Hour Ozone Statistics (Across Monitors) for August 18-September 6, 2000*, provides some summary eight-hour statistics, which quantify how well the model replicates daily maximum monitored eight-hour ozone concentrations (averaged across all monitors reporting on each given day). The table shows that for the episode, eight-hour model predictions have a small bias (+2.4 ppb, approximately +8 percent). Mean relative (gross) error (approximately 20 percent) is strongly influenced by the under-prediction on August 21 and by the over-prediction on August 27, but overall is considered acceptably small. Root mean square error is related to mean relative (gross) error, but is expressed in the original units of the data (ppb) instead of as a percentage.

Overall the statistical performance for the current modeling is acceptable and shows notable improvement over that used in the 2004 HGB SIP revision modeling.

2.6.2 Graphical Performance Evaluations

Graphical analysis of the modeling output was used to qualitatively evaluate the model's performance. These graphical analyses include contour plots of simulated ozone concentrations and animations showing the development of ozone throughout the episode. Time series plots were generated for various monitoring sites and for relevant constituents, such as nitrous acid, hydrogen peroxide, nitric acid, and formaldehyde, as well as ozone, all of which were monitored during the TexAQS 2000. In addition, scatter plots for eight-hour ozone concentrations and relevant constituents were developed for each monitoring site and separately for each episode day.

Figure 2-32: *Time Series of Modeled and Measured Ozone Concentrations at Three Monitoring Locations*, shows selected time series plots of ozone at various monitoring locations. The green boxes are the monitored observations, the red trace shows the previous one-hour modeling results, and the blue trace shows the current modeling results.

Table 2-5: Eight-Hour Ozone Statistics (Across Monitors) for August 18-September 6, 2000

Episode Day	Bias (ppb)	Relative Bias (%)	Mean Relative Error (%)	RMS Error (ppb)	Average Modeled Eight-hr. Conc. (ppb)	Average Monitored Eight-hr. Conc. (ppb)
Aug. 18	-3.66	-10.82%	13.70%	10.60	59.68	67.00
Aug. 19	-6.22	-16.10%	18.64%	15.42	62.61	75.04
Aug. 20	4.07	18.52%	18.65%	10.05	59.30	51.17
Aug. 21	-13.67	-33.45%	34.64%	31.94	47.95	75.29
Aug. 22	0.52	3.20%	14.52%	10.94	58.95	57.90
Aug. 23	-0.10	2.24%	19.02%	10.15	47.40	47.60
Aug. 24	0.24	4.89%	18.50%	10.42	49.29	48.81
Aug. 25	-3.15	-3.48%	19.99%	15.59	68.04	74.35
Aug. 26	6.66	27.57%	28.64%	15.40	69.32	56.00
Aug. 27	7.14	35.50%	35.50%	15.42	56.36	42.09
Aug. 28	5.80	29.85%	29.85%	12.84	56.23	44.64
Aug. 29	5.14	24.09%	27.61%	15.47	69.09	58.82
Aug. 30	-0.50	3.48%	17.15%	19.95	79.38	80.38
Aug. 31	1.67	5.02%	9.88%	10.48	95.57	92.22
Sept. 1	2.91	13.28%	18.37%	12.60	77.00	71.17
Sept. 2	1.50	4.65%	8.38%	9.52	79.78	76.78
Sept. 3	3.75	15.17%	16.76%	12.21	77.18	69.68
Sept. 4	0.80	2.83%	8.88%	8.57	77.27	75.68
Sept. 5	3.15	9.21%	13.56%	14.57	90.13	83.83
Sept. 6	7.52	23.68%	24.46%	18.75	91.76	76.71
Episode	**2.40**	**8.02%**	**19.74%**	**14.87**	**68.87**	**66.46**

At Bayland Park on most episode days, the current modeling (blue trace) better replicates observations than does the 2004 HGB SIP revision modeling. At Deer Park, there is no clear preference for either the current or previous modeling. At Aldine the current and previous modeling are comparable on most days, although the current modeling corrects a large over-estimate seen previously on September 5 (red trace).

Figure 2-33: *Six Selected Time Series Plots of Relevant Constituents and Ozone Precursor Concentrations* shows time series plots of some relevant constituents and important ozone precursors at four sites.

The top two panels in Figure 2-33: *Six Selected Time Series Plots of Relevant Constituents and Ozone Precursor Concentrations* show modeled and monitored concentrations of NO and NO_2, respectively, at Bayland Park. At this location, the model appears to reproduce monitored concentrations of NO well; however, the model notably over-estimates NO_2. These patterns are seen for both the current and previous modeling, and are generally true at most monitoring sites

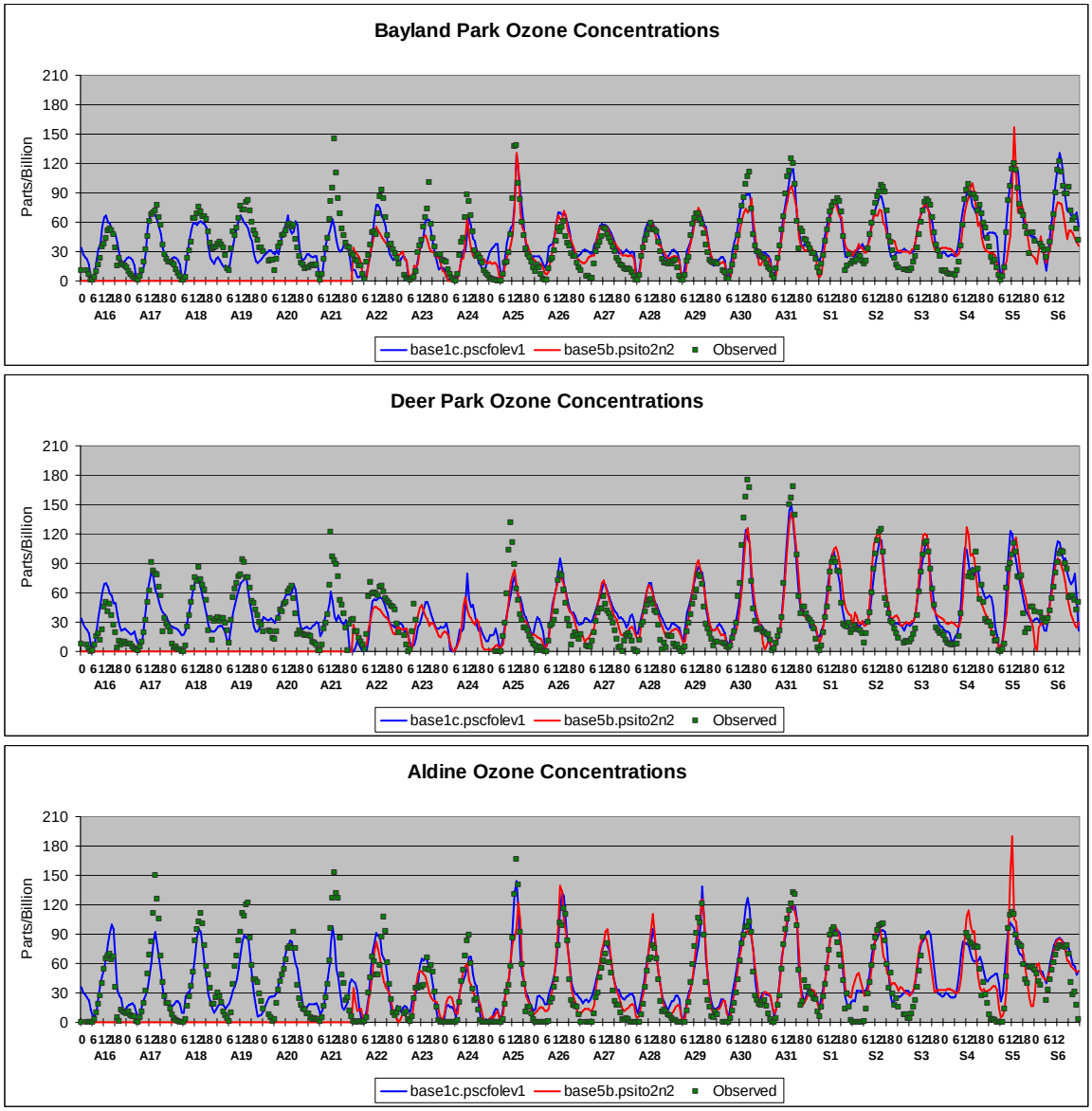
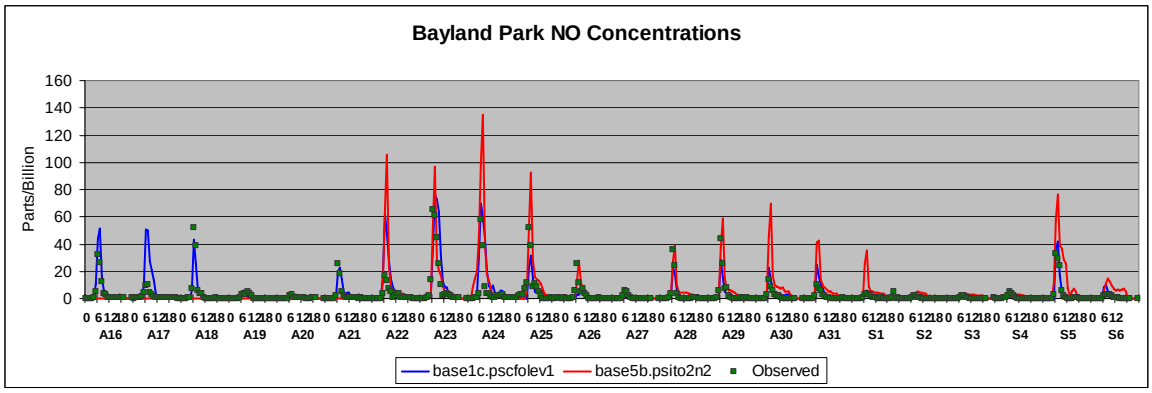


Figure 2-32: Time Series of Modeled and Measured Ozone Concentrations at Three Monitoring Locations


Bayland Park NO Concentrations
Parts/Billion
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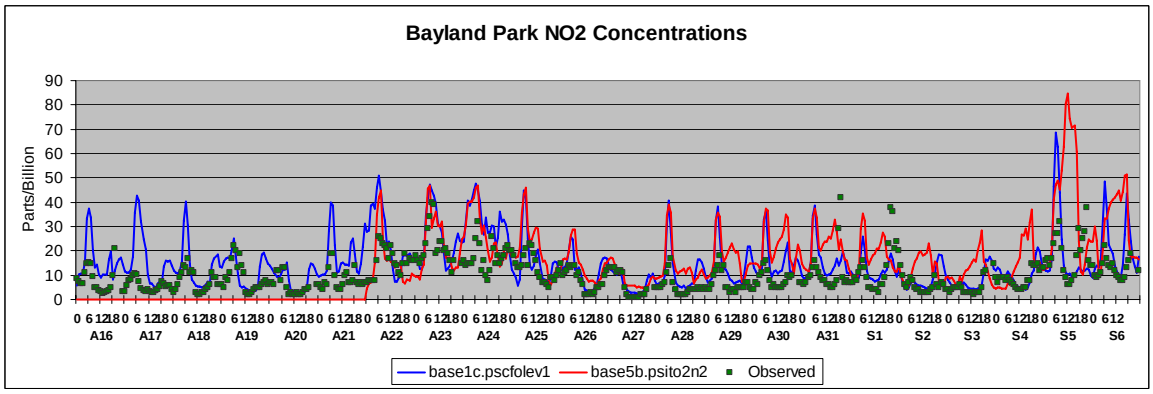
base5b.psito2n2
Observed


Bayland Park NO2 Concentrations
Parts/Billion
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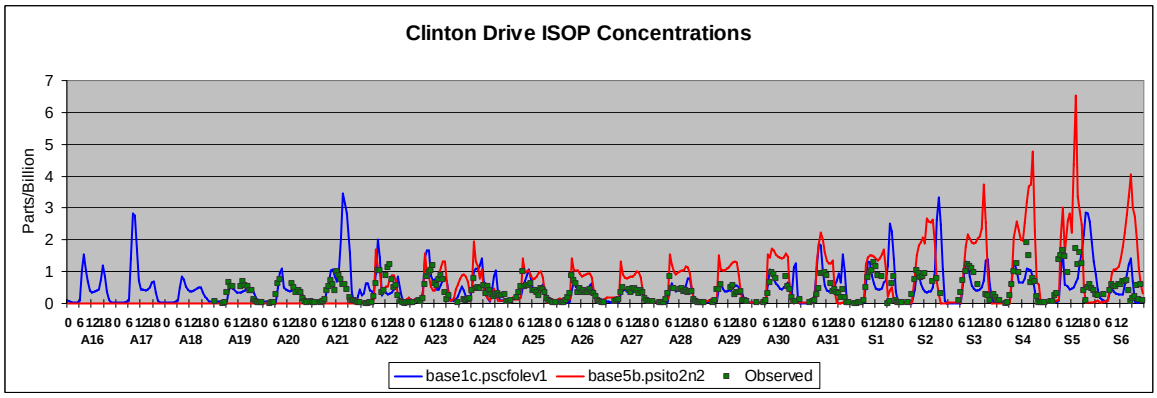
Observed


Clinton Drive ISOP Concentrations
Parts/Billion
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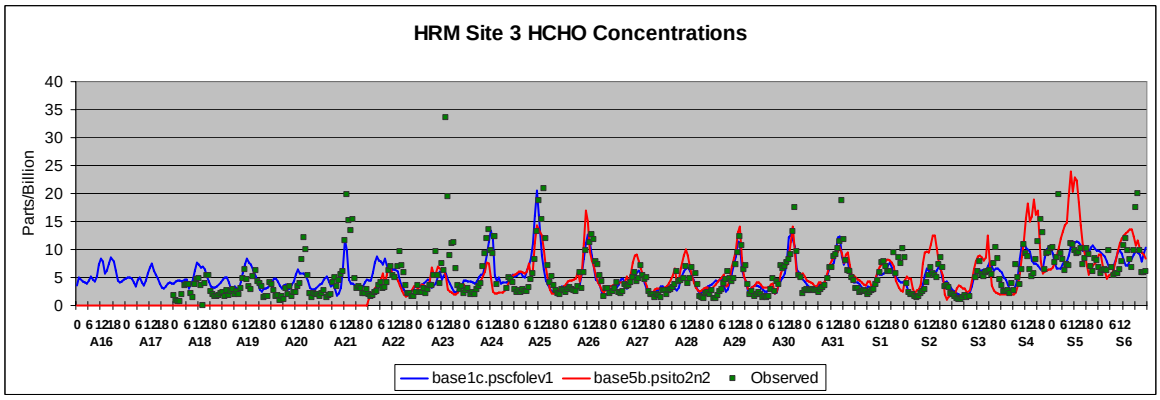
Observed


HRM Site 3 HCHO Concentrations
Parts/Billion
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base5b.psito2n2
Observed

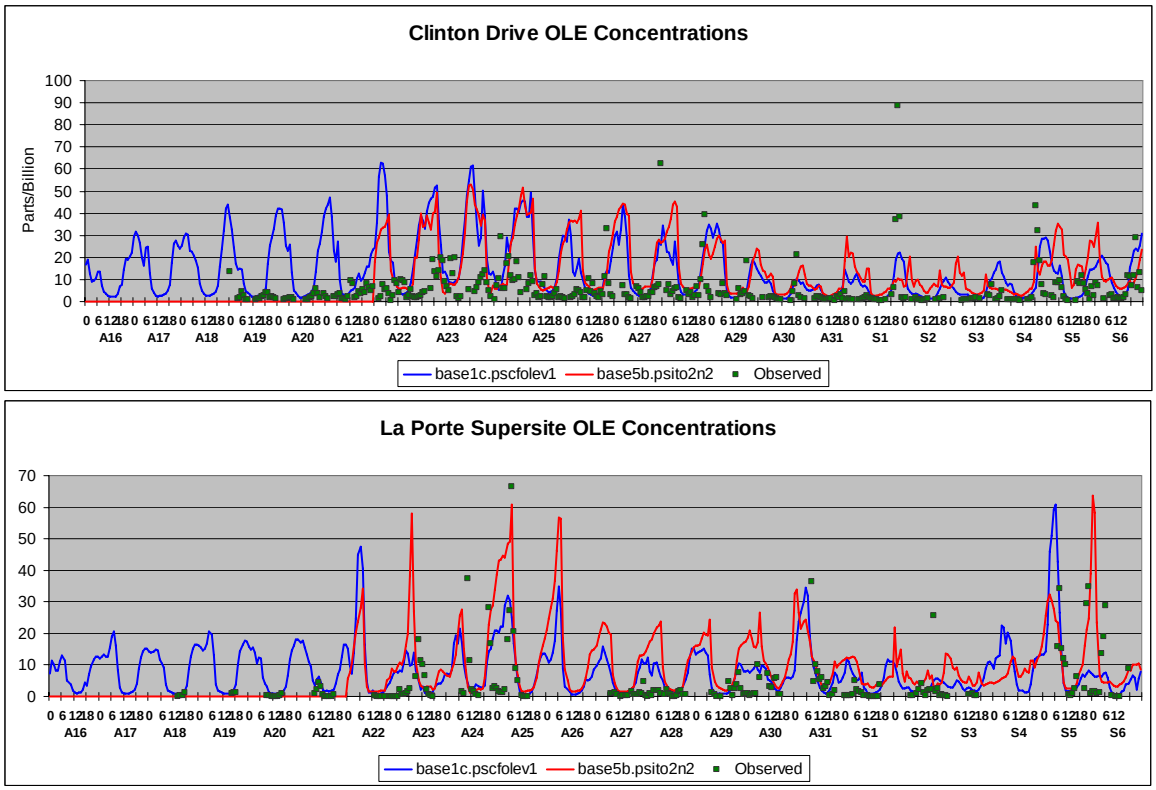

Figure 2-33: Six Selected Time Series Plots of Relevant Constituents and Ozone Precursor Concentrations (Continued From Previous Page)

in the region. This could be an indication that in the model NO is inappropriately titrating ozone and creating NO_2. The cause of this imbalance may be due to vertical mixing complexities, emissions modeled, the model's chemistry, or some combination of these. The analysis of Texas Air Quality Study II (TexAQS II) data should help elucidate the causes of the over-estimation of NO_2.

The third panel shows modeled and monitored concentrations of isoprene at Clinton Drive. The current modeling replicates the isoprene more closely than the previous modeling.

The fourth panel shows modeled and monitored concentrations of formaldehyde, a relevant constituent, at HRM3. The current modeling is somewhat better than the previous modeling, but both reproduce the monitored formaldehyde concentrations quite well. Most atmospheric formaldehyde forms as a product of the oxidation of HRVOC, hence observed concentrations of formaldehyde are related to the emissions of HRVOC. Significantly, if the model is run without imputing additional HRVOC emissions, modeled formaldehyde concentrations are too low on several days of the episode.

The final two panels of Figure 2-33 show modeled and monitored concentrations of the model species OLE at Clinton Drive and the LaPorte airport, respectively. The OLE species represents a variety of olefins excluding ethylene, but is largely composed of propylene, which is one of the HRVOC. At Clinton Drive, the model actually performs reasonably well during daylight hours. Similarly, at the LaPorte airport site, the modeled OLE concentrations are close to the monitored

concentrations except during some overnight periods. The overall agreement at LaPorte appears to be better than that at Clinton Drive, but that may be in part because LaPorte does not have as many nighttime observations as the Clinton Drive Site. The potential causes for the excessive overnight OLE concentrations are similar to those discussed earlier for NO_2, vertical mixing complexities, emissions modeled, the model's chemistry, or some combination. The TexAQS II data will help provide insight into the question of OLE overestimation.

Figure 2-34: *Eight-Hour Ozone Scatterplots by Episode Day, Monitor Location, and All Data Plotted as a Quantile-Quantile Plot*, shows three scatter plots comparing monitored and modeled eight-hour peak ozone concentrations.

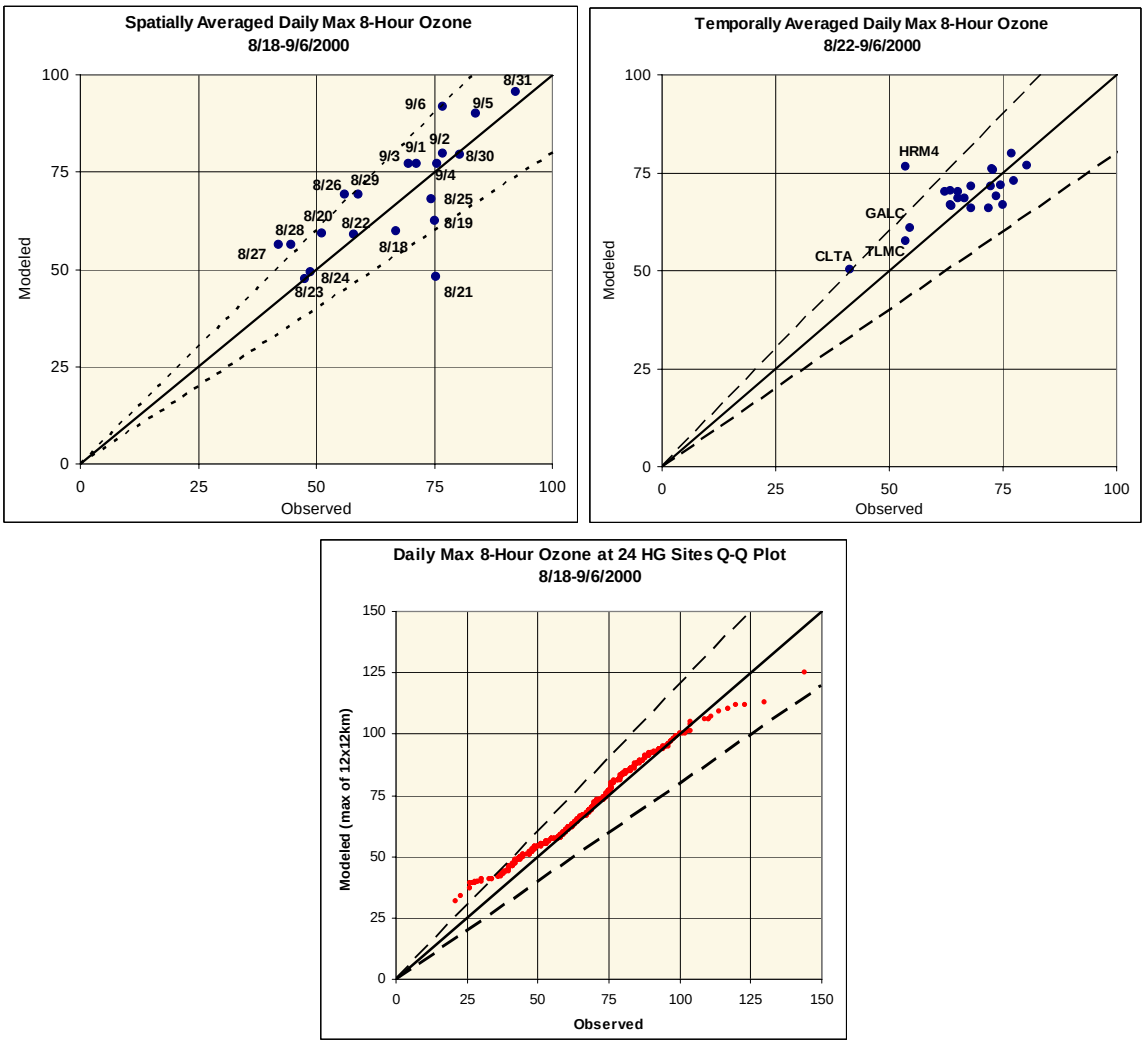

Figure 2-34: Eight-Hour Ozone Scatterplots by Episode Day, Monitor Location, and All Data Plotted as a Quantile-Quantile Plot

The upper left-hand plot shows maximum daily eight-hour ozone concentrations by day, averaged across all monitors in the eight-county HGB nonattainment area. The dashed lines represent ±20 percent deviation from monitored concentrations. On 16 of the 20 episode days the model agrees

well with the monitored maximum daily eight-hour ozone concentrations, but shows a negative bias on August 21 and over-predicts peak ozone by over 20 percent on August 26-28.

The upper right-hand plot shows maximum daily eight-hour ozone concentration by monitor, averaged across days. Most monitors are clustered around a point where both monitored and modeled maximum daily eight-hour ozone concentrations are about 70 ppb. Only monitoring sites outside of this area are individually labeled. HRM4 is notable because of the model's over-prediction of ozone. Since HRM4 is in eastern Harris County not far from other monitors with higher monitored ozone, it is likely that the site experiences NO_X titration from local sources not correctly represented in the model. Clute (labeled CLTA) also shows over-prediction of ozone by a little over 20 percent. The model replicates the average maximum daily eight-hour ozone concentrations reasonably well at the other two sites with lower monitored ozone concentrations, Galveston (GALC) and Texas City/La Marque (TLMC).

The bottom plot is a quantile-quantile plot of monitored vs. modeled maximum daily eight-hour ozone concentrations across all sites and days. Both the monitored and modeled concentrations are sorted from smallest to largest, then the sorted values are plotted against each other (smallest monitored, smallest modeled; 2nd smallest monitored, 2nd smallest modeled, etc). While this technique loses all information about time and space, it provides a comparison of the distribution of modeled versus monitored concentrations. The plot shows that the modeled distribution of maximum daily eight-hour ozone concentrations closely matches the monitored distribution where monitored ozone is between about 60 and 110 ppb.

Overall the graphical performance for the current modeling is acceptable and provides a reasonable representation of not only the observed ozone concentrations but also the fundamental physical and chemical processes which result in the formation of high levels of ozone. Therefore, the TCEQ is confident that the modeling in this proposed SIP revision provides an appropriate platform for predicting future air quality.

2.7 FUTURE CASE MODELING BASELINE AND MODELING SENSITIVITIES

2.7.1 2009 Baseline

The 2009 baseline photochemical CAMx modeling was conducted using the MM5-generated meteorological parameters for the 2000 episode and the 2009 baseline modeling emissions. As per the EPA guidance for estimating future eight-hour ozone design values, relative reduction factors (RRF) were calculated for each of the monitors with a year 2000 current design value (DVc). The RRF are calculated by taking the ratio of the daily average 2009 baseline modeling results to the daily average of the 2000 baseline modeling results. Figure 2-35: *2009 to 2000 Baseline Relative Reduction Factors by Monitor* shows the RRF calculated at each of the 20 monitors with a year 2000 DVc that exceeds the standard.

Multiplying these RRF by the appropriate monitor's DVc yields the estimated future design value (DVf). That is;

$$DVf = RRF * DVc$$

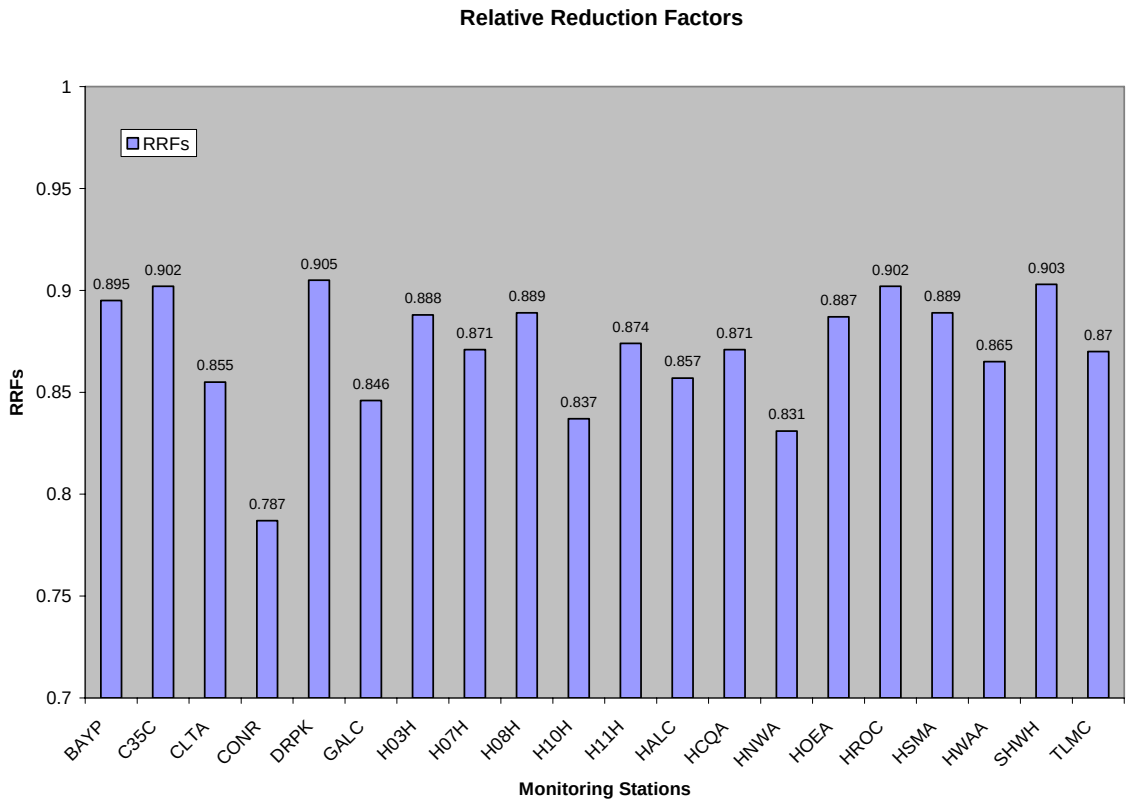

Figure 2-35: 2009 to 2000 Baseline Relative Reduction Factors by Monitor

Figure 2-36: *Current and 2009 Future Eight-Hour Ozone Design Values by Monitor*, shows the year 2000 DVc and estimated 2009 DVf for each of the 20 monitors with a year 2000 DVc of 85 ppb or greater. For the 2009 baseline, 11 of the 20 monitors are projected to move from modeling 85 ppb or greater in 2000 to modeling less than 85 ppb in 2009. Table 2-6: *Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling Attainment in 2009*, summarizes the DVc and DVf values for these 11 monitors. Nine of the 20 monitors are projected to remain at or above 85 ppb. Table 2-7: *Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling 85 ppb or Greater in 2009*, summarizes the DVc and DVf values for these nine monitors. The Deer Park monitor has the highest DVf at 97 ppb.

Additionally, the exceedance area (the area and population with projected eight-hour ozone of 85 ppb or higher) and the number of episode days with projected exceedances, are reduced in the 2009 baseline. For the 18 episode days with modeled exceedances in the 2000 baseline, on average only 20.1 percent of the exceedance area remains in the 2009 baseline. (Note: ozone exceedances were not modeled or monitored for August 23 or 24). Figure 2-37: *Modeled Area of Exceedance for the 2000 and 2009 Baselines* shows the reductions in the exceedance area for each of the exceedance days.

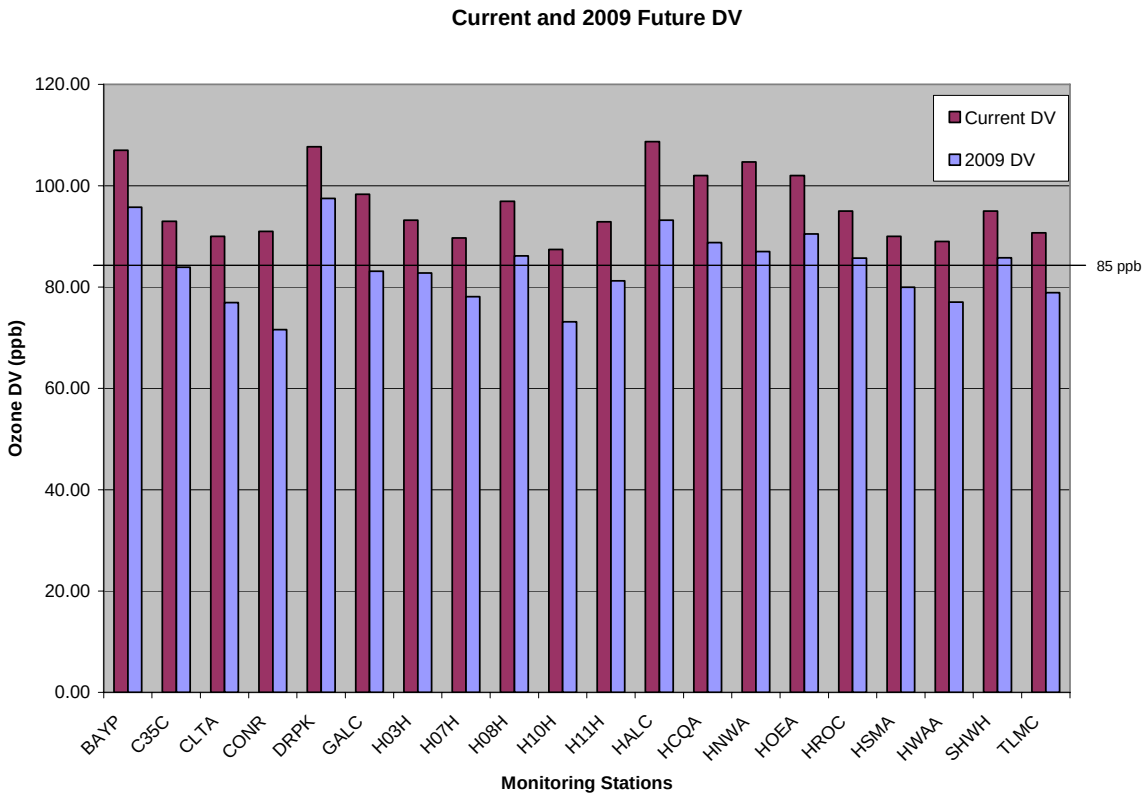

Figure 2-36: Current and 2009 Future Eight-Hour Ozone Design Values by Monitor

Table 2-6: Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling Attainment in 2009

Monitoring Site (Code)	Current 2000 and Future 2009 Design Values		Design Value Change (ppb)
	2000 DVc (ppb)	2009 DVf (ppb)	
Clinton Drive (C35C)	93.0	83.9	9.1
Clute (CLTA)	90.0	76.9	13.1
Conroe (CONR)	91.0	71.6	19.4
Galveston County (GALC)	98.3	83.1	15.2
HRM 3, Haden Road (H03H)	93.2	82.8	10.4
HRM 7, West Baytown (H07H)	89.7	78.1	11.6
HRM 10, Mont Belvieu (H10H)	87.4	73.1	14.3
HRM 11, East Baytown (H11H)	92.9	81.2	11.7
Swiss & Monroe (HSMA)	90.0	80.0	10.0
North Wayside (HWAA)	89.0	77.0	12.0
Texas City (TLMC)	90.7	78.9	11.8

Table 2-7: Current 2000 and Future 2009 Eight-Hour Ozone Design Values for Monitors Modeling 85 ppb or Greater in 2009

Monitoring Site (Code)	Current 2000 and Future 2009 Design Values		Design Value Change (ppb)
	2000 DVc (ppb)	2009 DVf (ppb)	
Bayland Park (BAYP)	107.0	95.8	11.2
Deer Park (DRPK)	107.7	97.5	10.2
HRM 8, La Porte (H08H)	96.9	86.1	10.8
Aldine (HALC)	108.7	93.2	15.5
Croquet (HCQA)	102.0	88.8	13.2
Northwest Harris (HNWA)	104.7	87.0	17.7
Houston East (HOEA)	102.0	90.5	11.5
Houston Regional Office (HROC)	95.0	85.7	9.3
Westhollow (SHWH)	95.0	85.7	9.3

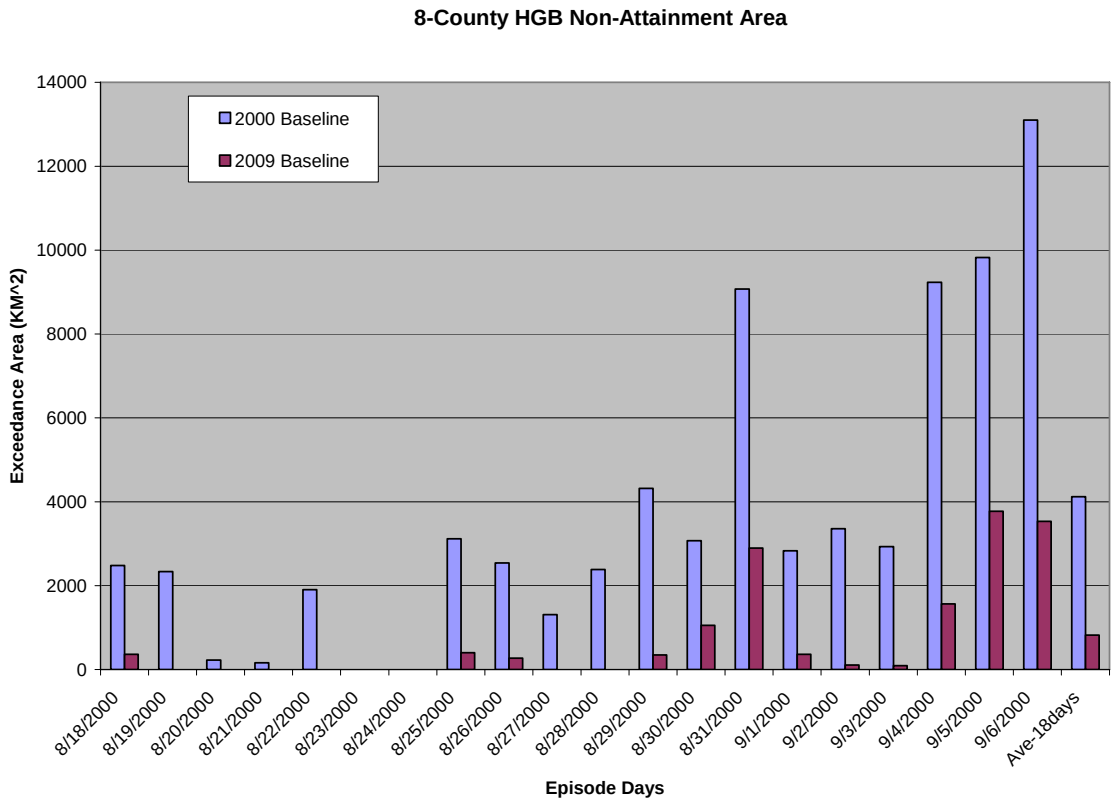

Figure 2-37: Modeled Area of Exceedance for the 2000 and 2009 Baselines

Further, of the 18 episode days with modeled ozone at 85 ppb or greater in the 2000 baseline, six episode days do not model 85 ppb or greater in the 2009 baseline, and 12 episode days continue to model exceedances in the 2009 baseline. Table 2-8: *2009 Baseline Modeling Summary* summarizes the 2009 baseline changes from the 2000 baseline.

Table 2-8: 2009 Baseline Modeling Summary

Emissions Changes			Results in Eight-County HGB Area			
2009 Baseline from:	NO_X (tpd)	VOC (tpd)	DVf Change @ DRPK	Change in Sites at 85 ppb or Greater	Average Change in Area at 85 ppb or Greater	Change in Days at 85 ppb or Greater
2000 Baseline	-563	-221	-10 ppb (107 to 97 ppb)	11 sites (20 to 9 sites)	- 3295 km^2 (-79.9%)	6 days (18 to 12 days)

2.7.2 H-GAC and TxLED Sensitivity Modeling

A modeling sensitivity run was conducted to determine the effect of emissions reductions including the cumulative 5.3 tpd of NO_X reductions from the H-GAC's original VMEP estimate (4.4 tpd) and the TxLED Marine Diesel Rule (0.9 tpd). (The VMEP estimate was revised to 2.82 tpd after this sensitivity run was performed.) These proposed controls (at 5.3 tpd) reduce the 2009 baseline NO_X emissions by approximately 1.2 percent.

Modeling the 5.3 tpd NO_X emissions reduction decreased the projected DVf at all nine monitors projected to be at or above 85 ppb in the 2009 baseline. The average reduction in the projected 2009 DVf for these nine sites is approximately -0.15 ppb, and there is no reduction in the number of monitors at or above 85 ppb, which remains at nine. In the 2009 baseline, the Deer Park (DRPK) monitor's DVf is the highest at 97.5 ppb. With the 5.3 tpd NO_X emissions reduction, the DRPK monitor's DVf remains the highest at 97.4 ppb, which does not decrease the DVf upon applying the EPA truncating convention for the eight-hour ozone NAAQS.

In addition, this NO_X emissions reduction decreased the exceedance area on a number of episode days. In the 2009 baseline, the average exceedance area is 809.8 km^2 and there are 12 days with projected ozone values at or above 85 ppb. With the combined 5.3 tpd NO_X emissions reduction in on- and non-road mobile sources, and ship emissions, the exceedance area is reduced by 2.5 percent and the number of days with projected ozone values at or above 85 ppb remains at 12 days.

Table 2-9: *2009 H-GAC and TxLED Sensitivity Modeling Summary* summarizes the changes from the 2009 baseline of the proposed H-GAC and TxLED controls.

Table 2-9: 2009 H-GAC and TxLED Sensitivity Modeling Summary

Emissions Changes			Results in Eight-County HGB Area			
Change from 2009 Baseline	NO_X (tpd)	VOC (tpd)	DVf Change @ DRPK	Change in Sites at 85 ppb or Greater	Average Change in Area at 85 ppb or Greater	Change in Days at 85 ppb or Greater
H-GAC On- & Non-Road Plus TxLED Marine NO_X Reduction	-5.3	0.0	-0.13 ppb (97.5 to 97.4 ppb)	0 sites (9 to 9 sites)	- 20.5 km^2 (-2.5%)	0 days (12 to 12 days)

2.7.3 Reduction Matrix Sensitivity Run--Across All Source Categories

Starting with the 2009 baseline, a matrix of hypothetical reductions of anthropogenic NO_X, VOC, and combined NO_X and VOC emissions was modeled. Across-the-board emissions reduction levels of 25, 50 and 75 percent were applied uniformly to all source categories. The purpose of this analysis was to test the effect of emissions reductions on the projected eight-hour ozone design values. Figure 2-38: *2009 Ozone DVf Response to NO_X and VOC Emissions Reductions*, shows the results of the matrix modeling, which indicates that combined NO_X and VOC emission reductions are slightly more effective than just NO_X emission reductions in reducing the projected eight-hour ozone design values. The curves indicate that combined NO_X and VOC reductions of 53 percent each or NO_X-only reductions of 58 percent may be needed to reach attainment. However, the needed emission reductions are probably over-estimated, since all source categories were reduced uniformly. Just as predicted eight-hour ozone design values respond differently to reductions of NO_X versus VOC, the DVf will likely respond differently to comparable mass emission reductions from various source categories (e.g., point sources versus on-road mobile).

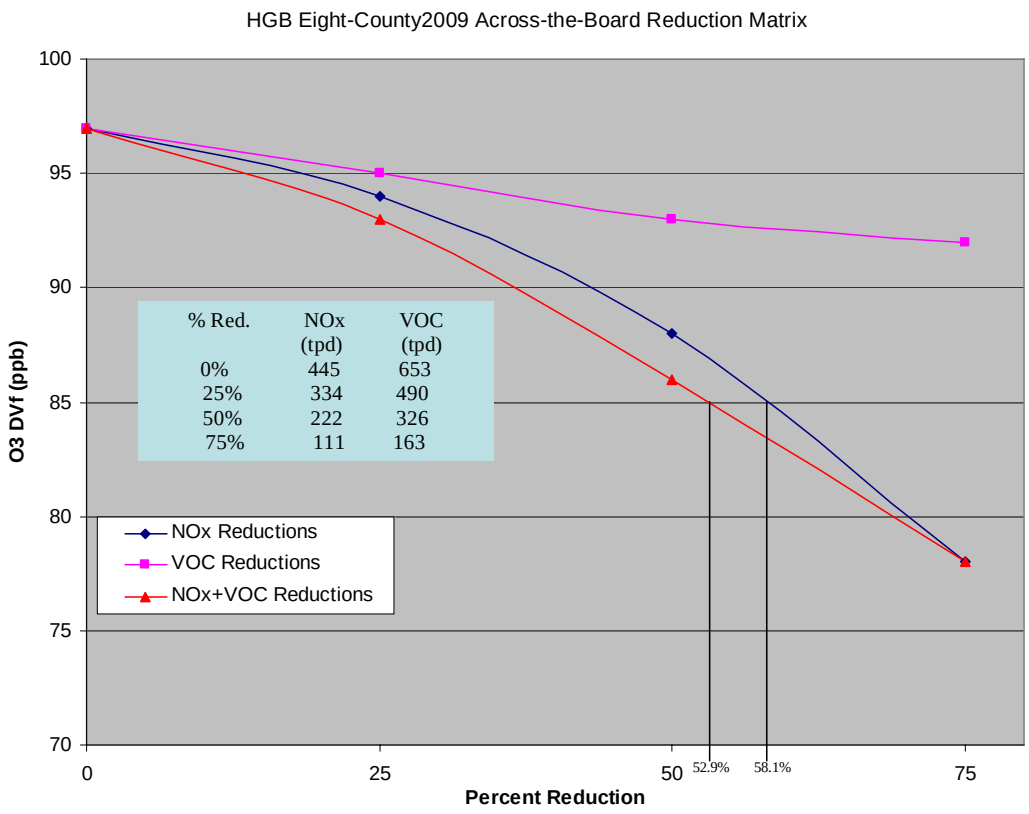

Figure 2-38: 2009 Ozone DVf Response to NO_X and VOC Emissions Reductions

2.7.4 Reduction Matrix Sensitivity Run - Point Source VOC

Starting with the 2009 baseline, a matrix of hypothetical VOC emissions reductions was applied to the point source category within the eight-county HGB area at levels of 25, 50, and 75 percent. These hypothetical VOC emissions reductions amounted to overall reductions of 65 tpd, 130 tpd and 196 tpd, respectively, from the 261 tpd of point source VOC in the 2009 baseline. The purpose of this analysis was to test the effect of emissions reductions on the projected eight-hour ozone design values. Table 2-10: *Summary of the Point Source VOC Reduction Matrix Sensitivity Run*, shows the results of the matrix modeling, indicating that VOC reductions of 25, 50, and 75 percent would reduce the design value at the monitor with the highest projected future design value by 1, 2, and 3.2 ppb, respectively, and would result in reduced exceedance areas across all three reduction values by 65, 128, and 185 km^2, respectively. The 25 percent reduction did not reduce the number of days at or above 85 ppb. However, the 50 and 75 percent reductions projected a reduction of the number of days at or above 85 ppb by 3 and 4 days, respectively.

Table 2-10: Summary of the Point Source VOC Reduction Matrix Sensitivity Run

Emissions Changes			Results In Eight-County HGB Area			
Change from 2009	NO_X (tpd)	VOC (tpd)	Average DVf change	DVf Change Max. Mon	Average Change in Area at 85 ppb or Greater	Change in Days at 85 ppb or Greater
25% Point Source VOC Reduction	0.0	-65	-0.65 ppb	-1.0 ppb (DRPK)	- 65 km^2 (-8.1%)	0 days (12 to 12 days)
50% Point Source VOC Reduction	0.0	-130	-1.35 ppb	-2.0 ppb (DRPK)	- 129 km^2 (-16.3%)	3 days (12 to 9 days)
75% Point Source VOC Reduction	0.0	-196	-2.09 ppb	-3.2 ppb (DRPK)	- 185 km^2 (-23.3%)	4 days (12 to 8 days)

2.7.5 Reduction Sensitivity Matrix Sensitivity Run - H-GAC and TxLED and Ground-Level NO_X Modeling Matrix

A modeling sensitivity was conducted to determine the effect on projected future eight-hour ozone metrics of reducing ground-level sources of NO_X emissions within the eight-county HGB nonattainment area. (Ground-level sources, as used here, includes primarily on-road mobile and non-road mobile sources; it also includes some point and area sources which may have stack height and or plume rise up to 30 meters.) In addition to the 2009 H-GAC plus TxLED marine modeling sensitivity, a matrix of hypothetical NO_X emissions reductions was applied to the ground-level source categories within the eight-county HGB area at levels of 25, 50 and 75 percent. These NO_X emissions reductions amounted to overall reductions of 62 tpd, 124 tpd, and 186 tpd, respectively, from the 248 tpd of ground-level NO_X in the 2009 H-GAC plus TxLED marine scenario.

With a 25 percent reduction in ground-level NO_X (62 tpd), the average reduction in the projected 2009 DVf for the nine sites at or above 85 ppb is approximately -2.4 ppb, and the number of monitors at or above 85 ppb is reduced to five. The DRPK monitor's DVf, which is the highest,

was reduced from 97.4 ppb to 95.8 ppb, which results in a 2 ppb reduction in the DVf after applying the EPA truncating convention for the eight-hour ozone NAAQS. With a 50 percent reduction in ground-level NO_X (124 tpd), the average reduction in the projected 2009 DVf for the nine sites at or above 85 ppb is approximately -5.5 ppb, and the number of monitors at or above 85 ppb is reduced to four. The DRPK monitor's DVf, which is the highest, was reduced from 97.4 ppb to 93.5 ppb, which reduces the DVf by 4 ppb after applying the EPA truncating convention for the eight-hour ozone NAAQS. With a 75 percent reduction in ground-level NO_X (186 tpd), the average reduction in the projected 2009 DVf for the nine sites that are projected to be 85 ppb or higher is approximately -9.8 ppb, and the number of monitors at or above 85 ppb is reduced to one. The DRPK monitor's DVf, which is the highest, was reduced from 97.4 ppb to 90.3 ppb, which reduces the DVf by 7 ppb after applying the EPA truncating convention for the eight-hour ozone NAAQS.

Table 2-11: *2009 H-GAC and TxLED and Ground-Level NO_X Modeling Matrix Summary* summarizes the changes from the 2009 baseline of the proposed H-GAC and TxLED controls.

Table 2-11: 2009 H-GAC and TxLED and Ground-Level NO_X Modeling Matrix Summary

Emissions Changes			Results in Eight-County HGB Area			
Change from 2009 H-GAC & TxLED Marine	NO_X (tpd)	VOC (tpd)	DVf Change @ DRPK	Change in Sites at 85 ppb or Greater	Average Change in Area at 85 ppb or Greater	Change in Days
25% Ground-level NO_X Reduction	-62	0	-1.6 ppb (97.4 to 95.8)	4 sites (9 to 5)	- 242 km^2 (-27.3%)	1 days (12 to 11 days)
50% Ground-level NO_X Reduction	-124	0	-3.9 ppb (97.4 to 93.5)	5 sites (9 to 4)	- 366 km^2 (-46.4%)	7 days (12 to 5 days)
75% Ground-level NO_X Reduction	-186	0	-7.1 ppb (97.4 to 90.3)	8 sites (9 to 1)	- 476 km^2 (-60.4%)	7 days (12 to 5 days)

2.7.6 Ship Channel Zero-Out Test

A modeling test was conducted to estimate the 2009 future design value assuming all of the point source emissions and shipping emissions in the HSC were removed. The HSC, for the purposes of this model run, includes sources along the main channel, primarily in Harris County, but does not include sources in the Bayport, Channelview, or Mont Belvieu areas. Figure 2-39: *Houston Ship Channel 4-km Mask, Extent of Modeling Run*, shows the HSC, as defined for this test.

From the 2009 emissions estimates, 69 tpd of NO_X and 109 tpd of VOC were removed. The subset removed represents approximately 16 percent of the total NO_X and 21 percent of the total VOC in the eight-county HGB area. Table 2-12: *Houston Ship Channel Zero-Out Test*, lists the future design values for the 2009 baseline and this modeling sensitivity.

As the table shows, even if the emissions associated with the HSC are removed, six of the nine monitors would still not model attainment and the area's design value would be 93 ppb at the

Bayland Park (BAYP) monitor. This modeling sensitivity indicates that even with a sizable decrease in emissions associated with the HSC, there are still enough ozone precursors from other sources in the HGB area for ozone levels to exceed the standard.

Figure 2-39: Houston Ship Channel 4-km Mask, Extent of Modeling Run

Table 2-12: Houston Ship Channel Zero-Out Test

Monitoring Site (Code)	Future 2009 Design Values	
	Baseline DVf (ppb)	w/o HSC DVf (ppb)
Bayland Park (BAYP)	95	93
Deer Park (DRPK)	97	91
HRM 8, La Porte (H08H)	86	80*
Aldine (HALC)	93	88
Croquet (HCQA)	88	86
Northwest Harris (HNWA)	87	85
Houston East (HOEA)	90	86
Houston Regional Office (HROC)	85	83*
Westhollow (SHWH)	85	84*

* denotes monitors below 85 ppb

2.8 2018 ANALYSIS

A technical analysis, using a limited data set, was performed for the HGB in 2018. The previously described 2009 H-GAC/TxLED sensitivity run and the Ground-Level NO_X Modeling Matrix results were used to estimate how many tons of ground-level NO_X reduction would be needed to reduce the monitors predicted to be 85 ppb or higher to below 85 ppb by 2018. See Table 2-13: *NO_X Reduction Estimated from 2009 to 2018*. Ground-level NO_X reductions were the focus of this analysis because many of the federal emissions control measures scheduled to come on-line between 2009 and 2018 are applicable to ground-level emissions sources, e.g., on-road and non-road mobile.

Table 2-13: NO_X Reduction Estimated from 2009 to 2018

Monitor Site (Code)	NO_X Reduction needed to get below 85 ppb
Deer Park (DRPK)	256 tpd
Bayland Park (BAYP)	174 tpd
Houston East (HOEA)	152 tpd
Aldine (HALC)	135 tpd
Croquet (HCQA)	82.6 tpd
HRM 8, La Porte (H08H)	45.4 tpd
Northwest Harris (HNWA)	33.5 tpd
Houston Regional Office (HROC)	19.7 tpd
Westhollow (SHWH)	14.5 tpd

In a separate effort, mobile source emissions changes anticipated by 2018 were estimated. To show long-term trends, future on-road mobile emissions were projected to 2015, 2018, 2020, 2025, 2030, and 2035. Emissions were projected by coupling on-road VMT growth (at 2 percent per year) with the reduced emission factors arising from federal vehicle and fuel requirements. The final estimates included the emissions benefit of vehicle I/M, TxLED, and reformulated gasoline, but did not include adjustments for TERP, VMEP, TCM, or the proposed eight-hour ozone control measures detailed in Chapter 4. Figure 2-40: *Future Eight-County On-Road Mobile Emissions* shows the resulting predicted weekday emissions of NO_X and VOC. A NO_X reduction of approximately 110 tpd in on-road mobile source emissions is expected between 2009 and 2018.

The National Mobile Inventory Model (NMIM) was run with default assumptions to estimate future non-road emissions reductions for the same future years. The results of this analysis are shown in Figure 2-41: *Future Eight-County Non-Road Emissions Based on NMIM Default Inputs*. A reduction of approximately 30 tpd in non-road mobile source emissions is expected between 2009 and 2018.

NMIM does not address emissions from ships, aircraft and locomotives, and growth is anticipated in these categories, although it is not explicitly accounted for in this analysis. Area sources were also not specifically accounted for in this analysis and are also anticipated to grow between now and 2018. Further, care must be taken not to double-count emissions reductions already accounted for by TERP.

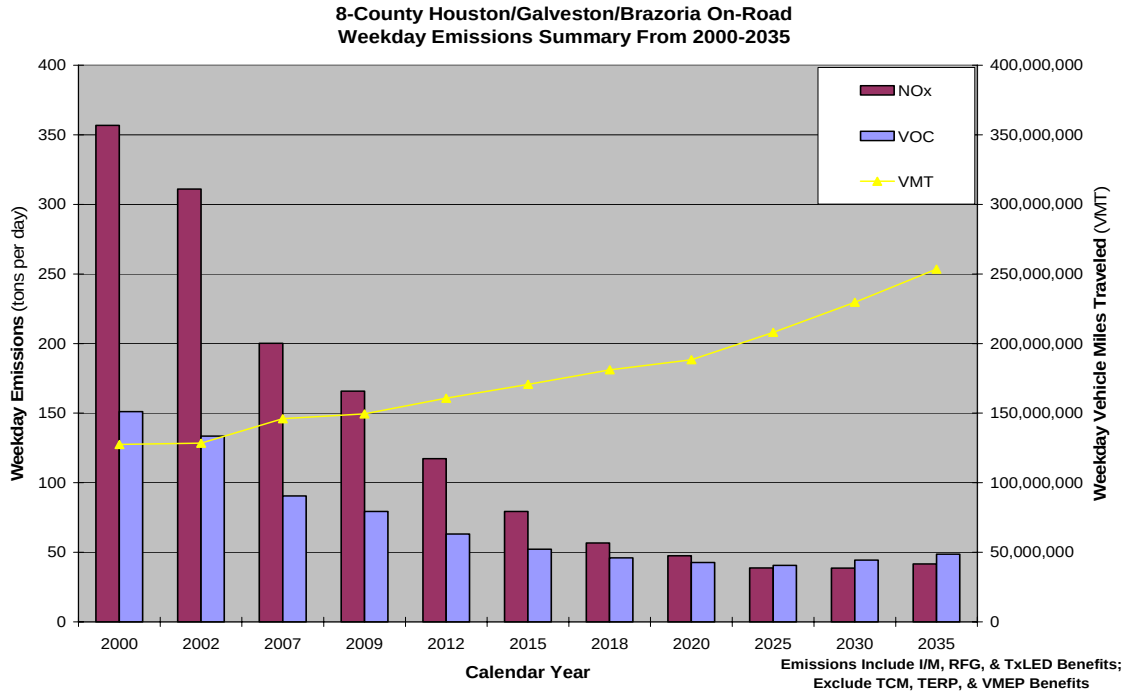

Figure 2-40: Future Eight-County On-Road Mobile Emissions

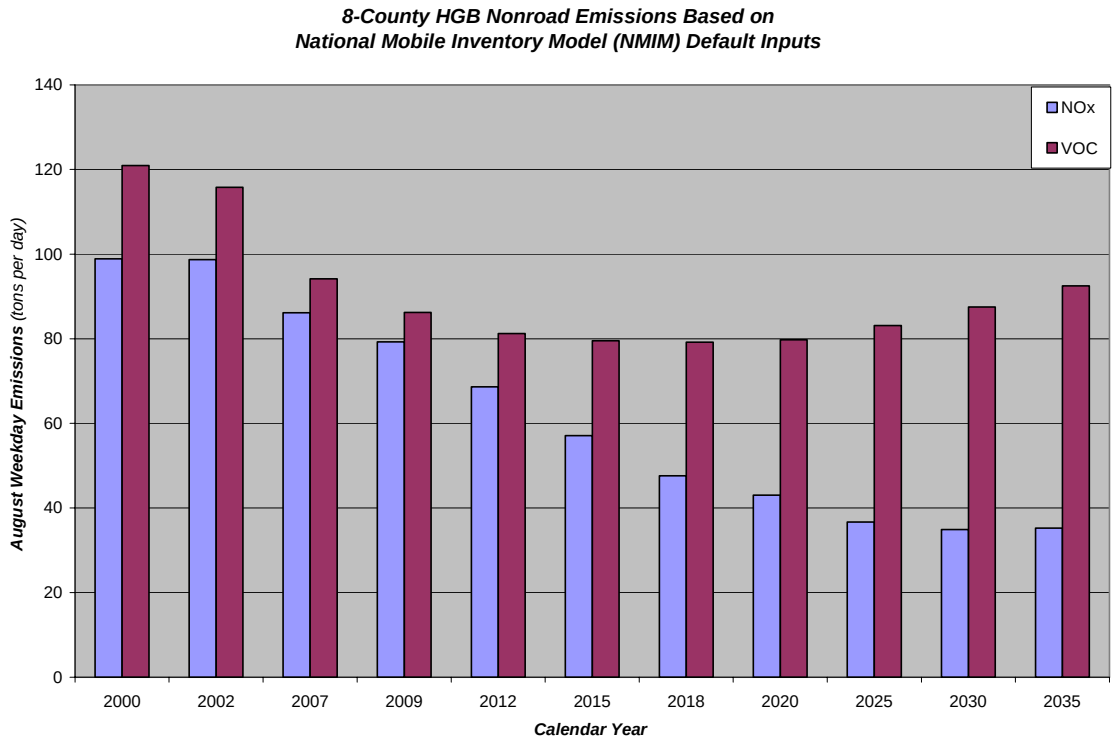

Figure 2-41: Future Eight-County Non-Road Emissions Based on NMIM Default Inputs

Finally, for this analysis, point sources were assumed to remain constant from 2009 to 2018. Although CAIR Phase II will be in place in 2018 and should result in reductions in Texas, the banking and trading component of these regulations makes it difficult to predict actual reductions resulting from the program. Based on federal nonattainment New Source Review requirements, NO_X emissions are not likely to increase in this area.

Table 2-14: *HGB Eight-County Nonattainment Area Estimated 2018 Mobile Source NO_X Emissions* summarizes the mobile source emissions changes between 2009 and 2018 because the available information for these sources is more quantitative than changes described for other emissions categories.

Table 2-14: HGB Eight-County Nonattainment Area Estimated 2018 Mobile Source NO_X Emissions

Source Category	2009	2018
On-Road Mobile	163 tpd	53 tpd
Non-Road Mobile	78 tpd	48 tpd
Total TERP + VMEP (on-road & non-road)	-42 tpd	NA
Subtotal On-Road & Non-Road	199 tpd	101 tpd
2009 to 2018 difference	NA	98 tpd

The 2009 to 2018 anticipated mobile source emissions reductions were compared with the results of the ground-level NO_X reduction matrix modeling (Table 2-13). Five of the monitors, Westhollow, Houston Regional Office, Northwest Harris, HRM8 - La Porte, and Croquet, are expected to be below 85 ppb in 2018, even factoring in the stated uncertainties and assuming net growth of no more than 10 to 20 tpd in emissions from those ground-level sources described previously as expected to grow.

Although this analysis shows that further progress will be made in air quality by 2018, there are four monitors (Deer Park, Bayland Park, Houston East, and Aldine) in the HGB area that are estimated to be 85 ppb or greater in 2018. Data collected during TexAQS II will likely provide further insight into ozone formation in HGB and guidance on potentially effective control strategies that may assist the effort to bring the HGB area into attainment by 2018.

2.9 FUTURE WORK

The next modeling effort for HGB will be to develop a new ozone episode (using days from 2005 and/or 2006) and the corresponding meteorological characterization and EI. In establishing this new base case, emphasis will be placed on replicating measured ozone and precursor concentrations. TexAQS II, as discussed in Chapter 5, will provide a wealth of new data and findings which will support model performance evaluation, and further characterization of ozone formation in the HGB area. Various external organizations have begun modeling exercises using episodic days from 2005 and 2006, and TCEQ will review and consider these other modeling efforts as work progresses.

Once the new base case is established, modeling a new future year will be the focus and the future year inventory will be developed. It will be determined what level of emissions reductions are needed for attainment demonstration. Following this determination, the TCEQ will proceed with a series of modeling runs testing the sensitivity of the future case to reductions in emissions of various source categories and the testing of potential control strategies as needed. This

technical work is expected to take between 18 and 24 months, and the TCEQ will work with stakeholders and interested parties through updates and briefings at the Southeast Texas Photochemical Modeling Committee meetings and other technical workshops as appropriate.

2.10 ACCESSING MODELING DATA

All documentation and modeling input/output files generated as part of the HGB eight-hour ozone SIP modeling have been archived. Dick Karp of the TCEQ is responsible for these products and may be reached by telephone at (512) 239-1462 or via e-mail, dkarp@tceq.state.tx.us for information regarding data access or project documentation.

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