TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
AGENDA ITEM REQUEST
for State Implementation Plan Revision Adoption

AGENDA REQUESTED: December 15, 2016

DATE OF REQUEST: November 22, 2016

INDIVIDUAL TO CONTACT REGARDING CHANGES TO THIS REQUEST, IF NEEDED: Joyce Spencer-Nelson, (512) 239-5017

CAPTION: Docket No. 2016-1243-SIP. Consideration for adoption of the Houston-Galveston-Brazoria (HGB) Attainment Demonstration State Implementation Plan (SIP) revision to meet the 2008 Eight-Hour Ozone National Ambient Air Quality Standard.

To meet Federal Clean Air Act requirements, the SIP revision includes a photochemical modeling analysis, a weight of evidence analysis, a reasonably available control technology (RACT) analysis, a reasonably available control measures analysis, a motor vehicle emissions budget for 2017, and a contingency plan. This SIP revision also includes revisions to the 30 Texas Administrative Code Chapter 115 rules to update RACT for volatile organic compound storage tanks in the HGB area. (Lola Brown, John Minter) (Non-Rule Project No. 2016-016-SIP-NR)

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Deputy Director

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Copy to CCC Secretary? NO X YES

Texas Commission on Environmental Quality
Interoffice Memorandum

To: Commissioners **Date:** November 30, 2016

Thru: Bridget C. Bohac, Chief Clerk
Richard A. Hyde, P.E., Executive Director

From: Steve Hagle, P.E., Deputy Director
Office of Air

Docket No.: 2016-1243-SIP

Subject: Commission Approval for Adoption of the Houston-Galveston-Brazoria (HGB) Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone Standard Nonattainment Area

HGB 2008 Eight-Hour Ozone AD SIP Revision
SIP Project No. 2016-016-SIP-NR

Background and reason(s) for the SIP revision:
The Federal Clean Air Act (FCAA) requires states to submit plans to demonstrate attainment of the National Ambient Air Quality Standards (NAAQS) for ozone nonattainment areas designated with a classification of moderate or higher. On May 21, 2012, the eight-county HGB area, consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, was designated a marginal nonattainment area for the 2008 eight-hour ozone NAAQS. The attainment date for the HGB marginal nonattainment area was established in the United States Environmental Protection Agency's (EPA) implementation rule for the 2008 ozone NAAQS published in the May 21, 2012 *Federal Register* (77 FR 30160) and set as December 31, 2015. Attainment of the standard (expressed as 0.075 parts per million) is achieved when an area's design value does not exceed 75 parts per billion (ppb).

As a result of a December 23, 2014 ruling by the United States Court of Appeals for the District of Columbia Circuit and the EPA's final *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements* (2008 ozone standard SIP requirements rule) published in the March 6, 2015 *Federal Register* (80 FR 12264), the attainment date for the HGB marginal ozone nonattainment area changed to July 20, 2015 and the attainment year also changed from 2015 to 2014. The HGB area did not attain the 2008 eight-hour ozone standard in 2014[1] but qualified for a one-year attainment date extension in accordance with FCAA, §181(a)(5)[2]. The EPA published final approval of the one-year attainment deadline extension on May 4, 2016, which extended the HGB area's attainment date to July 20, 2016 with a 2015 attainment

[1] The attainment year ozone season is the ozone season immediately preceding a nonattainment area's attainment date.
[2] An area that fails to attain the 2008 ozone NAAQS by its attainment date is eligible for a one-year extension if, for the attainment year, the area's 4th highest daily maximum eight-hour average is at or below the level of the standard (75 ppb); the HGB area's fourth highest daily maximum eight-hour average for 2014 was 72 ppb as measured at the Conroe Relocated monitor (C78/A321). The HGB area's design value for 2014 was 80 ppb.

year (81 FR 26697). Based on 2015 monitoring data[3], however, the HGB area did not attain the 2008 ozone NAAQS and was not eligible for a second one-year extension[4].

Because the HGB area's 2015 design value of 80 ppb exceeded this standard, the EPA published a proposed determination of nonattainment and reclassification of the HGB 2008 eight-hour ozone nonattainment area from marginal to moderate nonattainment on September 27, 2016 (81 FR 66240). The EPA proposed a January 1, 2017 deadline for the state to submit an AD SIP revision that addresses the 2008 eight-hour ozone standard moderate nonattainment area requirements, including reasonable further progress (RFP).

Scope of the SIP revision:
As a result of the EPA's final reclassification, the commission will be required to submit an AD SIP revision consistent with FCAA requirements for areas classified as moderate nonattainment for the 2008 eight-hour ozone NAAQS to the EPA by January 1, 2017. The attainment date for the HGB moderate ozone nonattainment area is July 20, 2018 with an attainment year of 2017. This memo applies to the attainment demonstration requirement under a moderate ozone nonattainment classification. A new RFP demonstration will also be required for the area; the details of which are covered in a separate memo (SIP Project No. 2016-017-SIP-NR).

A.) Summary of what the SIP revision will do:
This HGB AD SIP revision meets the requirements to demonstrate attainment of the 2008 ozone NAAQS through a photochemical modeling analysis of reductions in nitrogen oxides (NO_X) and volatile organic compounds (VOC) emissions from existing control strategies and a weight of evidence (WoE) analysis.

This HGB AD SIP revision would also incorporate revisions to the 30 Texas Administrative Code Chapter 115 rules to update reasonably available control technology (RACT) for VOC storage tanks in the HGB area (Rule Project No. 2016-039-115-AI).

This HGB AD SIP revision would be adopted in conjunction with the 2008 Eight-Hour Ozone Standard RFP SIP Revision.

B.) Scope required by federal regulations or state statutes:
This HGB AD SIP revision would be consistent with the requirements of FCAA, §182(b)(1) and the EPA's final 2008 ozone standard SIP requirements rule. The FCAA-required SIP elements include analyses for RACT and reasonably available control measures, a motor vehicle emissions budget, and a contingency plan. Consistent with EPA's draft modeling

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[3] TCEQ submitted Certification Evaluation and Concurrence Report for 2015 air monitoring data to EPA on April 25, 2015.
[4] An area is eligible for the second one-year extension if the fourth highest daily maximum eight-hour value, averaged over both the original attainment year and the first extension year, is at or below the level of the standard (75 ppb); the HGB area's fourth highest daily maximum eight-hour value averaged over 2014 and 2015 is 76 ppb as measured at the Houston Aldine monitor (C8/AF108/X150). The HGB area's 2015 design value is 80 ppb.

guidance released by the EPA in December 2014, this HGB AD SIP revision would also include a modeled attainment demonstration and a WoE analysis.

C.) Additional staff recommendations that are not required by federal rule or state statute:
None.

Statutory authority:
The authority to propose and adopt SIP revisions is derived from the following sections of Texas Health and Safety Code, Chapter 382, Texas Clean Air Act (TCAA), §382.002, which provides that the policy and purpose of the TCAA is to safeguard the state's air resources from pollution; §382.011, which authorizes the commission to control the quality of the state's air; and §382.012, which authorizes the commission to prepare and develop a general, comprehensive plan for the control of the state's air. This HGB AD SIP revision is required by FCAA, §110(a)(1) and implementing rules in 40 Code of Federal Regulations Part 51.

Effect on the:
A.) Regulated community:
The affected regulated community would be those associated with the rulemaking that is part of this HGB AD SIP revision. For further information, see the executive summary for Rule Project No. 2016-039-115-AI, VOC RACT Rules for the 2008 HGB Eight-Hour Ozone Nonattainment Area, which is scheduled to be adopted concurrently with this HGB AD SIP revision.

Affected VOC storage tanks in the HGB area that are not already at this control level would be required to increase control device efficiency from 90% to 95%, implement new inspection requirements, and maintain records of new inspection requirements.

B.) Public:
The EPA asserts that the general public in the HGB ozone nonattainment area may benefit from improved air quality as a result of lower ozone levels.

C.) Agency programs:
The Office of Compliance and Enforcement (OCE) conducts field investigations to verify compliance with the rules addressed in SIP revisions. Enforcement of any revised rules in this HGB AD SIP revision would not significantly increase the number of facilities investigated by state and local governments.

Stakeholder meetings:
The Regional Air Quality Planning Advisory Committee (RAQPAC) is appointed by the Houston-Galveston Area Council (H-GAC) Board of Directors and includes representatives of local government, public health, transportation, industry, business, environmental organizations, and citizens from the HGB eight-county nonattainment area. The committee assists and advises H-GAC, regional and local governments, transportation organizations, and other agencies on air quality issues. TCEQ SIP Team staff provide SIP revision and Air Quality Division updates at the RAQPAC monthly meetings.

The Southeast Texas Photochemical Modeling Technical Committee (SET PMTC) is an advisory group that assists the TCEQ with technical and scientific issues related to air quality modeling and analysis in the HGB and Beaumont-Port Arthur areas. Periodic SET PMTC meetings are held at H-GAC by TCEQ Air Modeling Team staff and include representatives from the public, environmental groups, industry, and government. TCEQ SIP Team staff provides SIP revision and air quality division updates at the SET PMTC meetings.

Public comment:
The public comment period opened on September 23, 2016 and closed on October 24, 2016. The commission conducted a public hearing in Houston on October 24, 2016, at 2:00 p.m. During the comment period, staff received comments from Air Alliance Houston (Air Alliance).

Generally, the Air Alliance comments focused on the adverse health effects of ozone, control techniques guidelines, use of federal emission factors, enforcement and inspections in the HGB area, and the Texas Emissions Reduction Plan. A summary of the comments and TCEQ responses are included as part of the HGB AD SIP revision.

Significant changes from proposal:
Due to the compressed schedule required for this HGB AD SIP revision, the proposal included preliminary modeling emissions estimates for some source categories that have been updated for the adoption. For the 2012 base case, both the area and on-road source categories were updated from proposal to adoption. For the 2017 future case, modeling emissions estimates were updated for the area, marine, oil and gas production, on-road, and point source categories. As was noted in the proposal, the motor vehicle emissions budgets were revised for adoption based on updated 2017 on-road emission inventories. Also as a result of the updated emissions inventories, the projected ozone design value in 2017 at the Manvel Croix Park monitor site went from 78 ppb to 79 ppb. A few of the other monitor sites in the HGB nonattainment area also had changes in the projected 2017 ozone design value but none over 75 ppb.

Potential controversial concerns and legislative interest:
This SIP revision is scheduled to be adopted before the EPA has taken final action to reclassify the HGB area to moderate. While this means that the SIP revision is not legally required at this time, if staff waits to adopt this SIP revision until the EPA's final reclassification is effective, there would not be enough time to complete the SIP revision before the EPA's January 1, 2017 deadline for submittal. Missing the submittal deadline could lead to the EPA issuing a finding of failure to submit, which would start sanctions and federal implementation plan (FIP) clocks.

Because the attainment year for a moderate nonattainment area is 2017 and the EPA has not finalized reclassification of the area, there would not be time to adopt and implement additional control measures needed to demonstrate attainment prior to the start of ozone season in the attainment year (January 1, 2017). The Chapter 115 rulemaking to update RACT for VOC storage tanks in the HGB area, scheduled to be adopted concurrently with this HGB AD SIP revision, contains a RACT compliance deadline of July 20, 2018.

Does this SIP revision affect any current policies or require development of new policies?
No.

What are the consequences if this SIP revision does not go forward? Are there alternatives to this SIP revision?
The commission could choose to not comply with requirements to develop and submit this HGB AD SIP revision to the EPA. If an HGB AD SIP revision is not submitted, the EPA could impose sanctions on the state and promulgate a FIP. Sanctions could include transportation funding restrictions, grant withholdings, and 200% emissions offset requirements for new construction and major modifications of stationary sources in the HGB nonattainment area. The EPA could impose such sanctions and implement a FIP until the state submitted, and the EPA approved, a replacement HGB 2008 eight-hour ozone AD SIP revision for the area.

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REVISIONS TO THE STATE OF TEXAS AIR QUALITY IMPLEMENTATION PLAN FOR THE CONTROL OF OZONE AIR POLLUTION

HOUSTON-GALVESTON-BRAZORIA 2008 EIGHT-HOUR OZONE STANDARD NONATTAINMENT AREA

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
P.O. BOX 13087
AUSTIN, TEXAS 78711-3087

HOUSTON-GALVESTON BRAZORIA ATTAINMENT DEMONSTRATION STATE IMPLEMENTATION PLAN REVISION FOR THE 2008 EIGHT-HOUR OZONE STANDARD NONATTAINMENT AREA

PROJECT NUMBER 2016-016-SIP-NR

Adoption
December 15, 2016

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EXECUTIVE SUMMARY

On May 21, 2012, the eight-county Houston-Galveston-Brazoria (HGB) area, consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, was designated a marginal nonattainment area for the 2008 eight-hour ozone National Ambient Air Quality Standard (NAAQS). The attainment date for the HGB marginal nonattainment area was established in the United States Environmental Protection Agency's (EPA) implementation rule published in the May 21, 2012 *Federal Register* (77 FR 30160) and was set as December 31, 2015. Attainment of the standard (expressed as 0.075 parts per million) is achieved when an area's design value does not exceed 75 parts per billion (ppb).

As a result of a December 23, 2014 ruling by the United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit Court) and the EPA's final *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements* (2008 ozone standard SIP requirements rule) published in the March 6, 2015 *Federal Register* (80 FR 12264), the attainment date for the HGB marginal nonattainment area changed to July 20, 2015 and the attainment year also changed from 2015 to 2014. The HGB area did not attain the 2008 eight-hour ozone standard in 2014,[1] but qualified for a one-year attainment date extension in accordance with Federal Clean Air Act (FCAA), §181(a)(5).[2] The EPA published final approval of the one-year attainment date extension on May 4, 2016, which extended the HGB area's attainment date to July 20, 2016 with a 2015 attainment year (81 FR 26697). Based on 2015 monitoring data,[3] however, the HGB area did not attain the 2008 ozone NAAQS and was not eligible for a second one-year extension.[4]

Because the HGB area's 2015 design value of 80 ppb exceeded the 2008 eight-hour ozone NAAQS, the EPA published a proposed determination of nonattainment and reclassification of the HGB 2008 eight-hour ozone nonattainment area from marginal to moderate nonattainment on September 27, 2016 (81 FR 66240). The EPA proposed a January 1, 2017 deadline for the state to submit an attainment demonstration that addresses the 2008 eight-hour ozone NAAQS moderate nonattainment area requirements, including reasonable further progress (RFP), which the Texas Commission on Environmental Quality (TCEQ) is addressing in a separate SIP revision. As indicated in the EPA's 2008 ozone standard SIP requirements rule, the attainment

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[1] The attainment year ozone season is the ozone season immediately preceding a nonattainment area's attainment date.

[2] An area that fails to attain the 2008 ozone NAAQS by its attainment date is eligible for a one-year extension if, for the attainment year, the area's 4th highest daily maximum eight-hour average is at or below the level of the standard (75 ppb); the HGB area's fourth highest daily maximum eight-hour average for 2014 was 72 ppb as measured at the Conroe Relocated monitor (C78/A321). The HGB area's design value for 2014 was 80 ppb.

[3] TCEQ submitted Certification Evaluation and Concurrence Report for 2015 air monitoring data to EPA on April 25, 2015.

[4] An area is eligible for the second one-year extension if the fourth highest daily maximum eight-hour value, averaged over both the original attainment year and the first extension year, is at or below the level of the standard (75 ppb); the HGB area's fourth highest daily maximum eight-hour value averaged over 2014 and 2015 is 76 ppb as measured at the Houston Aldine monitor (C8/AF108/X150). The HGB area's 2015 design value is 80 ppb.

deadline for nonattainment areas with a moderate classification is July 20, 2018 with an attainment year of 2017.

This HGB AD SIP revision includes the following SIP elements: a modeled attainment demonstration, a reasonably available control technology (RACT) analysis, a reasonably available control measures (RACM) analysis, a weight of evidence (WoE), a contingency plan, and a motor vehicle emissions budget (MVEB).

This HGB AD SIP revision meets the requirements to demonstrate attainment of the 2008 ozone NAAQS through photochemical modeling and corroborative analysis. The ozone design value in 2017 for the HGB nonattainment area is projected to be 75 ppb at all sites except the Manvel Croix Park site (79 ppb) using draft modeling guidance released by the EPA in December 2014. The preliminary 2016 eight-hour ozone design value for the site is 75 ppb and the HGB area preliminary design value is 79 ppb.

This HGB AD SIP revision includes base case modeling of an eight-hour ozone episode that occurred during May through September 2012. These time periods were chosen because they are representative of the times of the year that eight-hour ozone levels above 75 ppb have historically been monitored within the HGB nonattainment area. The model performance evaluation of the 2012 base case indicates the modeling is suitable for use in conducting the modeling attainment test. The modeling attainment test was applied by modeling a 2012 baseline year and 2017 future year to project 2017 eight-hour ozone design values.

Table ES-1: Summary of 2012 Baseline and 2017 Future Year Anthropogenic Modeling Emissions for HGB lists the August average anthropogenic modeling emissions in tons per day (tpd) by source category for the 2012 baseline and 2017 future year for nitrogen oxides (NO_X) and volatile organic compounds (VOC) ozone precursors. The differences in modeling emissions between the 2012 baseline and the 2017 future year reflect the net of growth and reductions from existing controls. The existing controls include both state and federal measures that have already been promulgated. The electric generating unit (EGU) emissions for the 2012 ozone season are monthly averages of actual emission measurements, while the 2017 electric utility emission projections are based on the maximum ozone season caps required under the Cross-State Air Pollution Rule (CSAPR).[5] Due to the compressed schedule required for this HGB AD SIP revision, the proposal included preliminary modeling emissions estimates for some source categories that have been updated for the adoption. For the 2012 base case, both the area and on-road source categories were updated from proposal to adoption. For the 2017 future case, modeling emissions estimates were updated for the area, marine, oil and gas production, on-road, and point source categories. The

[5] On July 28, 2015, the D.C. Circuit Court found that the CSAPR 2014 SO_2 and ozone season NO_X budgets for Texas and certain other states were invalid because the budgets required more emission reductions than were necessary. The court remanded the rule without vacatur to the EPA for reconsideration of the emission budgets. The EPA provided a plan to address the remanded SO_2 budgets in a June 27, 2016 memorandum and finalized new ozone season NO_X budgets in its September 7, 2016 final CSAPR Update Rule to address interstate transport with respect to the 2008 eight-hour ozone NAAQS. CSAPR budgets may be subject to change in the future based on any additional rulemaking to address remanded budgets or changes resulting from further appeals.

emission inputs in Table ES-1 were based on the latest available information at the time development work was done for this SIP adoption.

Table ES-1: Summary of 2012 Baseline and 2017 Future Year Anthropogenic Modeling Emissions for HGB

HGB Emission Source Type	2012 NO_X (tpd)	2017 NO_X (tpd)	2012 VOC (tpd)	2017 VOC (tpd)
On-Road	157.09	95.56	73.60	54.40
Non-Road	50.78	34.97	40.11	29.57
Non-Road Oil and Gas - Drilling	0.81	0.57	0.06	0.07
Off-Road - Airports	6.44	6.84	2.12	2.24
Off-Road - Locomotives	15.35	13.08	0.99	0.74
Off-Road - Marine	27.74	23.88	1.35	1.38
Area (Non-Oil and Gas)	19.28	19.21	277.97	264.62
Area - Oil and Gas Production	2.09	1.96	66.60	47.92
Point - EGUs (August Average)	36.49	41.95	3.91	2.15
Point - Non-EGUs (Ozone Season Average)	69.76	103.88	130.68	135.72
Total	385.83	341.90	597.39	538.81

Table ES 2: *Summary of Modeled 2012 Baseline and 2017 Future Year Eight-Hour Ozone Design Values for HGB Monitors* lists the eight-hour ozone design values in ppb for the 2012 baseline year design value (DV_B) and 2017 future year design value (DV_F) for the regulatory ozone monitors in the HGB nonattainment area. In accordance with the EPA's 2014 *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze* (draft modeling guidance),[6] the 2017 DV_F figures presented have been rounded to one decimal place and then truncated. Table ES-2 includes the DV_F figures using the 10 days from the baseline episode with the highest modeled ozone as described in the attainment test from the 2014 draft modeling guidance. The Manvel Croix Park monitor is the only regulatory monitor with a predicted future design value greater than the 2008 eight-hour ozone standard. Since the modeling cannot provide an absolute prediction of future year ozone design values, additional information from corroborative analyses are used in assessing whether the area will attain the ozone standard by July 20, 2018.

[6] https://www3.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf

Table ES-2: Summary of Modeled 2012 Baseline and 2017 Future Year Eight-Hour Ozone Design Values for HGB Monitors

Name	Site Code	2012 DV_B (ppb)	Relative Response Factor	2017 DV_F (ppb)
Manvel Croix Park C84	MACP	85.00	0.93	79
Deer Park C35	DRPK	78.33	0.96	74
Houston East C1	HOEA	78.00	0.96	75
Park Place C416	PRKP	77.33	0.96	73
Houston Northwest C26	HNWA	80.00	0.93	74
Bayland Park C53	BAYP	78.67	0.94	74
Croquet C409	HCQA	78.67	0.93	73
Houston Monroe C406	HSMA	76.67	0.96	73
Seabrook Friendship Park C45	SBFP	76.33	0.95	72
Houston Texas Ave C411	HTCA	75.00	0.96	72
Houston Aldine C8	HALC	76.67	0.95	72
Conroe Relocated C78	CNR2	78.00	0.94	73
Clinton Drive C403	CLTN	74.67	0.97	72
Houston Westhollow C410	SHWH	77.67	0.92	71
Lang C408	HLAA	76.33	0.93	71
Galveston C1034	GALV	75.33	0.94	71
Channelview C15	HCHV	73.00	0.96	70
North Wayside C405	HWAA	73.67	0.95	70
Lynchburg Ferry C1015	LYNF	71.00	0.96	67
Lake Jackson C1016	LKJK	69.33	0.94	64

This HGB AD SIP revision also includes the following FCAA-required SIP elements: RACM analysis, RACT analysis, MVEB, and contingency plan. The MVEB can be found in Table 4-2: *2017 Attainment Demonstration MVEB for the Eight-County HGB Area*.

The future year on-road mobile source emission inventories for this HGB AD SIP revision were updated from proposal to adoption using the 2014a version of the Motor Vehicle Emission Simulator (MOVES2014a) model and vehicle miles traveled (VMT) activity estimates from the HGB travel demand model managed by the Houston-Galveston Area Council. The MVEB must be used in transportation conformity analyses. Areas must demonstrate that the estimated emissions from transportation plans, programs, and projects do not exceed the MVEB. The attainment MVEB represents the updated future year on-road mobile source emissions that have been modeled for the attainment demonstration, and includes all of the on-road control measures. MOVES2014a includes impacts of the more stringent Tier 3 emission standards that begin with the 2017 model year, and gasoline with a reduced sulfur content that results in lower emissions of NO_x, VOC, and carbon monoxide.

This HGB AD SIP revision also incorporates a rulemaking (Rule Project No. 2016-039-115-AI), which is scheduled to be adopted concurrently with this SIP revision, to update control techniques guidelines (CTG) and non-CTG major source RACT requirements for VOC storage tanks in the HGB area as required by FCAA, §172(c)(1) and §182(b)(2). The rule revises 30 Texas Administrative Code Chapter 115, Subchapter B, Division 1, to increase the control efficiency for control devices, other than vapor recovery units or flares, from 90% to 95%; enhances inspection, repair, and recordkeeping requirements for fixed roof condensate and crude oil storage tanks with uncontrolled VOC emissions of more than 25 tons per year; and expands the rule applicability to include the aggregate of fixed roof condensate and crude oil storage tanks at pipeline breakout stations in the HGB area.

The TCEQ is committed to developing and applying the best science and technology towards addressing and reducing ozone formation as required in the HGB and other ozone nonattainment areas in Texas. This HGB AD SIP revision also includes a description of how the TCEQ continues to use new technology and investigate possible emission reduction strategies and other practical methods to make progress in air quality improvement.

SECTION V-A: LEGAL AUTHORITY

General

The Texas Commission on Environmental Quality (TCEQ) has the legal authority to implement, maintain, and enforce the National Ambient Air Quality Standards (NAAQS) and to control the quality of the state's air, including maintaining adequate visibility.

The first air pollution control act, known as the Clean Air Act of Texas, was passed by the Texas Legislature in 1965. In 1967, the Clean Air Act of Texas was superseded by a more comprehensive statute, the Texas Clean Air Act (TCAA), found in Article 4477-5, Vernon's Texas Civil Statutes. The legislature amended the TCAA in 1969, 1971, 1973, 1979, 1985, 1987, 1989, 1991, 1993, 1995, 1997, 1999, 2001, 2003, 2005, 2007, 2009, 2011, 2013, and 2015. In 1989, the TCAA was codified as Chapter 382 of the Texas Health and Safety Code.

Originally, the TCAA stated that the Texas Air Control Board (TACB) is the state air pollution control agency and is the principal authority in the state on matters relating to the quality of air resources. In 1991, the legislature abolished the TACB effective September 1, 1993, and its powers, duties, responsibilities, and functions were transferred to the Texas Natural Resource Conservation Commission (TNRCC). With the creation of the TNRCC, the authority over air quality is found in both the Texas Water Code and the TCAA. Specifically, the authority of the TNRCC is found in Chapters 5 and 7. Chapter 5, Subchapters A - F, H - J, and L, include the general provisions, organization, and general powers and duties of the TNRCC, and the responsibilities and authority of the executive director. Chapter 5 also authorizes the TNRCC to implement action when emergency conditions arise and to conduct hearings. Chapter 7 gives the TNRCC enforcement authority. In 2001, the 77th Texas Legislature continued the existence of the TNRCC until September 1, 2013, and changed the name of the TNRCC to the TCEQ. In 2009, the 81st Texas Legislature, during a special session, amended section 5.014 of the Texas Water Code, changing the expiration date of the TCEQ to September 1, 2011, unless continued in existence by the Texas Sunset Act. In 2011, the 82nd Texas Legislature continued the existence of the TCEQ until 2023.

The TCAA specifically authorizes the TCEQ to establish the level of quality to be maintained in the state's air and to control the quality of the state's air by preparing and developing a general, comprehensive plan. The TCAA, Subchapters A - D, also authorize the TCEQ to collect information to enable the commission to develop an inventory of emissions; to conduct research and investigations; to enter property and examine records; to prescribe monitoring requirements; to institute enforcement proceedings; to enter into contracts and execute instruments; to formulate rules; to issue orders taking into consideration factors bearing upon health, welfare, social and economic factors, and practicability and reasonableness; to conduct hearings; to establish air quality control regions; to encourage cooperation with citizens' groups and other agencies and political subdivisions of the state as well as with industries and the federal government; and to establish and operate a system of permits for construction or modification of facilities.

Local government authority is found in Subchapter E of the TCAA. Local governments have the same power as the TCEQ to enter property and make inspections. They also may make recommendations to the commission concerning any action of the TCEQ that affects their territorial jurisdiction, may bring enforcement actions, and may execute cooperative agreements with the TCEQ or other local governments. In addition, a city or town may enact and enforce ordinances for the control and abatement of air pollution not inconsistent with the provisions of the TCAA and the rules or orders of the commission.

Subchapters G and H of the TCAA authorize the TCEQ to establish vehicle inspection and maintenance programs in certain areas of the state, consistent with the requirements of the Federal Clean Air Act; coordinate with federal, state, and local transportation planning agencies to develop and implement transportation programs and measures necessary to attain and maintain the NAAQS; establish gasoline volatility and low emission diesel standards; and fund and authorize participating counties to implement vehicle repair assistance, retrofit, and accelerated vehicle retirement programs.

<u>Applicable Law</u>
The following statutes and rules provide necessary authority to adopt and implement the state implementation plan (SIP). The rules listed below have previously been submitted as part of the SIP.

<u>Statutes</u>
All sections of each subchapter are included, unless otherwise noted.

TEXAS HEALTH & SAFETY CODE, Chapter 382	September 1, 2015
TEXAS WATER CODE	September 1, 2015

Chapter 5: Texas Natural Resource Conservation Commission
- Subchapter A: General Provisions
- Subchapter B: Organization of the Texas Natural Resource Conservation Commission
- Subchapter C: Texas Natural Resource Conservation Commission
- Subchapter D: General Powers and Duties of the Commission
- Subchapter E: Administrative Provisions for Commission
- Subchapter F: Executive Director (except §§5.225, 5.226, 5.227, 5.2275, 5.231, 5.232, and 5.236)
- Subchapter H: Delegation of Hearings
- Subchapter I: Judicial Review
- Subchapter J: Consolidated Permit Processing
- Subchapter L: Emergency and Temporary Orders (§§5.514, 5.5145, and 5.515 only)
- Subchapter M: Environmental Permitting Procedures (§5.558 only)

Chapter 7: Enforcement
- Subchapter A: General Provisions (§§7.001, 7.002, 7.0025, 7.004, and 7.005 only)
- Subchapter B: Corrective Action and Injunctive Relief (§7.032 only)
- Subchapter C: Administrative Penalties
- Subchapter D: Civil Penalties (except §7.109)
- Subchapter E: Criminal Offenses and Penalties: §§7.177, 7.179-7.183

Rules

All of the following rules are found in 30 Texas Administrative Code, as of the following latest effective dates:

Chapter 7: Memoranda of Understanding, §§7.110 and 7.119 December 13, 1996 and May 2, 2002

Chapter 19: Electronic Reporting March 15, 2007

Chapter 35: Subchapters A-C, K: Emergency and Temporary Orders and Permits; Temporary Suspension or Amendment of Permit Conditions July 20, 2006

Chapter 39: Public Notice, §§39.402(a)(1) - (6), (8), and (10) - (12), 39.405(f)(3) and (g), (h)(1)(A) - (4), (6), (8) - (11), (i) and (j), 39.407, 39.409, 39.411(a), (e)(1) - (4)(A)(i) and (iii), (4)(B), (5)(A) and (B), and (6) - (10), (11)(A)(i) and (iii) and (iv), (11)(B) - (F), (13) and (15), and (f)(1) - (8), (g) and (h), 39.418(a), (b)(2)(A), (b)(3), and (c), 39.419(e), 39.420 (c)(1)(A) - (D)(i)(I) and (II), (D)(ii), (c)(2), (d) - (e), and (h), and 39.601 - 39.605 December 31, 2015

Chapter 55: Requests for Reconsideration and Contested Case Hearings; Public Comment, §§55.150, 55.152(a)(1), (2), (5), and (6) and (b), 55.154(a), (b), (c)(1) - (3), and (5), and (d) - (g), and 55.156(a), (b), (c)(1), (e), and (g) December 31, 2015

Chapter 101: General Air Quality Rules November 24, 2016

Chapter 106: Permits by Rule, Subchapter A April 17, 2014

Chapter 111: Control of Air Pollution from Visible Emissions and Particulate Matter February 6, 2014

Chapter 112: Control of Air Pollution from Sulfur Compounds July 16, 1997

Chapter 113: Standards of Performance for Hazardous Air Pollutants and for Designated Facilities and Pollutants May 14, 2009

Chapter 114: Control of Air Pollution from Motor Vehicles August 25, 2016

Chapter 115: Control of Air Pollution from Volatile Organic Compounds June 25, 2015

Chapter 116: Permits for New Construction or Modification November 24, 2016

Chapter 117: Control of Air Pollution from Nitrogen Compounds June 25, 2015

Chapter 118: Control of Air Pollution Episodes March 5, 2000

Chapter 122: §122.122: Potential to Emit April 17, 2014

Chapter 122: §122.215: Minor Permit Revisions	June 3, 2001
Chapter 122: §122.216: Applications for Minor Permit Revisions	June 3, 2001
Chapter 122: §122.217: Procedures for Minor Permit Revisions	December 11, 2002
Chapter 122: §122.218: Minor Permit Revision Procedures for Permit Revisions Involving the Use of Economic Incentives, Marketable Permits, and Emissions Trading	June 3, 2001

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LIST OF ACRONYMS

ABY	adjusted base year
ACT	alternative control techniques
AD	attainment demonstration
AEDT	Aviation Environmental Design Tool
AMPD	Air Markets Program Database
APU	auxiliary power unit
AQRP	Air Quality Research Program
auto-GC	automated gas chromatographs
AWO	American Waterways Operators
BACT	best available control technology
BEIS	Biogenic Emission Inventory System
BMP	best management practices
CAIR	Clean Air Interstate Rule
CAMx	Comprehensive Air Quality Model with Extensions
CEMS	continuous emissions monitoring systems
CFR	Code of Federal Regulations
CMV	commercial marine vessel
CSAPR	Cross-State Air Pollution Rule
CTG	control techniques guidelines
D.C.	District of Columbia
DERC	Discrete Emissions Reduction Credit
DERI	Diesel Emissions Reduction Incentive Program
DPS	Texas Department of Public Safety
DTIP	Drayage Truck Incentive Program
DV	design value
DV_B	baseline year design value
DV_F	future year design value
EBT	Emissions Banking and Trading Programs
EDMS	Emissions and Dispersion Modeling System
EE	energy efficiency
EGU	electric generating unit
EI	emissions inventory

EIQ	emissions inventory questionnaires
EOF	empirical orthogonal function
EPA	United States Environmental Protection Agency
EPS3	Emissions Processing System
ERC	Emission Reduction Credit
ERG	Eastern Research Group
FAA	Federal Aviation Administration
FCAA	Federal Clean Air Act
FINN	Fire Inventory of NCAR
FR	*Federal Register*
FY	fiscal year
HB	House Bill
GDF	gasoline dispensing facility
GSE	ground support equipment
HECT	Highly Reactive Volatile Organic Compounds Emissions Cap and Trade
H-GAC	Houston-Galveston Area Council
HGB	Houston-Galveston-Brazoria
HPMS	Highway Performance Monitoring System
HRVOC	highly reactive volatile organic compounds
H-GAC	Houston-Galveston Area Council
I/M	inspection and maintenance
ITAC	Independent Technical Advisory Committee
Kv	vertical diffusity
LAI	leaf area index
LCC	Lambert Conformal Conic
LDEQ	Louisiana Department of Environmental Quality
LIP	Local Initiatives Projects Program
LIRAP	Low Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program
LST	local standard time
m	meter
MACT	maximum achievable control technology
MATS	Modeled Attainment Test Software
MCR	mid-course review

MDA8	maximum daily average eight-hour ozone
MDERC	Mobile Discrete Emission Reduction Credits
MECT	Mass Emissions Cap and Trade
MODIS	Moderate-Resolution Imaging Spectroradiometer
MOS	mineral oil scrubber
MOVES	Motor Vehicle Emissions Simulator
MPE	model performance evaluation
MPO	metropolitan planning organization
MVEB	motor vehicle emissions budget
MW	megawatt
MWh	megawatt-hours
NAAQS	National Ambient Air Quality Standard
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NEI	National Emissions Inventory
NLCD	National Land Cover Dataset
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NMIM	National Mobile Inventory Model
NSR	New Source Review
NO	nitric oxide
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
NSPS	New Source Performance Standards
NSR	new source review
OMI	Ozone Monitoring Instrument
ORVR	Onboard Refueling Vapor Recovery systems
PEI	periodic emissions inventory
PHA	Port of Houston Authority
PBL	planetary boundary layer
PiG	Plume-in-Grid
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers
ppb	parts per billion

ppbC	parts per billion by carbon
ppbV	parts per billion by volume
ppm	parts per million
psia	pounds per square inch absolute
PTE	potential to emit
RACM	reasonably available control measures
RACT	reasonably available control technology
RAQPAC	Regional Air Quality Planning Advisory Committee
RE	renewable energy
RFP	reasonable further progress
ROP	rate of progress
RRC	Texas Railroad Commission
RRF	relative response factor
SB	Senate Bill
SETPMTC	Southeast Texas Photochemical Modeling Technical Committee
SIC	Standard Industrial Classification
SIP	state implementation plan
SMOKE	Sparse Matrix Operation Kernel Emissions
SO_2	sulfur dioxide
SOF	solar occultation flux
STARS	State of Texas Air Reporting System
TexAER	Texas Air Emissions Repository
TexN	Texas NONROAD model
TAC	Texas Administrative Code
TACB	Texas Air Control Board
TATU	TCEQ Attainment Test for Unmonitored areas
TCAA	Texas Clean Air Act
TCEQ	Texas Commission on Environmental Quality (commission)
TCFP	Texas Clean Fleet Program
TDM	travel demand model
TERP	Texas Emissions Reduction Plan
TMC	Texas Motorist's Choice Program
TNGVGP	Texas Natural Gas Vehicle Grant Program
TNRCC	Texas Natural Resource Conservation Commission

tpd	tons per day
tpy	tons per year
TTI	Texas Transportation Institute
TNMHC	total non-methane hydrocarbon
TxDMV	Texas Department of Motor Vehicles
TxLED	Texas Low Emission Diesel
UMA	unmonitored area
U.S.	United States
VMEP	Voluntary Mobile Source Emissions Reduction Program
VMT	vehicle miles traveled
VOC	volatile organic compounds
WoE	weight of evidence
WPS	Weather Research and Forecasting Model Processing System
WRF	Weather Research and Forecasting Model

LIST OF PREVIOUS STATE IMPLEMENTATION PLAN (SIP) REVISIONS AND REPORTS

The following list references SIP revisions and reports that were previously adopted by the commission and submitted to the United States Environmental Protection Agency (EPA). The list identifies how these SIP revisions are referenced in this document and contains the project number, adoption date, full title, and a hyperlink for each SIP revision or report.

2010 HGB 1997 Eight-Hour Ozone AD SIP Revision (TCEQ Project No. 2009-017-SIP-NR, adopted March 10, 2010) Houston-Galveston-Brazoria Attainment Demonstration State Implementation Plan Revision for the 1997 Eight-Hour Ozone Standard (http://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/hgb_sip_2009/09017SIP_completeNarr_ado.pdf)

2010 HGB 1997 Eight-Hour Ozone RFP SIP Revision (TCEQ Project No. 2009-018-SIP-NR, adopted March 10, 2010) Houston-Galveston-Brazoria Reasonable Further Progress State Implementation Plan Revision for the 1997 Eight-Hour Ozone Standard (http://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/hgb_sip_2009/09018SIP_ado.pdf)

2011 HGB 1997 Eight-Hour Ozone RACT Update SIP Revision (TCEQ Project No. 2010-028-SIP-NR, adopted December 7, 2011) Houston-Galveston-Brazoria Reasonably Available Control Technology Analysis Update State Implementation Plan for the 1997 Eight-Hour Ozone Standard (http://www.tceq.texas.gov/airquality/sip/HGB_eight_hour.html)

2013 HGB 1997 Eight-Hour Ozone MVEB SIP Revision (TCEQ Project Number 2012-002-SIP-NR, adopted April 23, 2013) Houston-Galveston-Brazoria Motor Vehicle Emissions Budgets Update for the 1997 Eight-Hour Ozone Standard (https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/hgb_mveb_2012/12002SIP_ado_complete.pdf)

2014 HGB One-Hour Ozone RS Report (Submitted to the EPA on July 22, 2014) Houston-Galveston-Brazoria Redesignation Substitute Report for the One-Hour Ozone Standard (https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/HGB_1Hr_Ozone_RS_Report.pdf)

2015 HGB 1997 Eight-Hour Ozone RS Report (Submitted to the EPA on August 18, 2015) Houston-Galveston-Brazoria Redesignation Substitute Report for the 1997 Eight-Hour Ozone Standard (https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/1997ozone_RS_Report/HGB_RS_1997_8Hr_report.pdf)

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CHAPTER 1: GENERAL

1.1 BACKGROUND

The *History of the Texas State Implementation Plan*, a comprehensive overview of the state implementation plan (SIP) revisions submitted to the United States Environmental Protection Agency (EPA) by the State of Texas, is available on the Introduction to the SIP Web page (http://www.tceq.texas.gov/airquality/sip/sipintro.html#what-is-the-history) on the Texas Commission on Environmental Quality's (TCEQ) Web site (http://www.tceq.texas.gov/).

1.2 INTRODUCTION

The following history of the one-hour and eight-hour ozone standards and summaries of the Houston-Galveston-Brazoria (HGB) area one-hour and eight-hour ozone SIP revisions are provided to give context and greater understanding of the complex issues involved in the area's ozone challenge.

1.2.1 One-Hour Ozone National Ambient Air Quality Standard (NAAQS) History

The EPA established the one-hour ozone NAAQS of 0.08 parts per million (ppm) in the April 30, 1971 *Federal Register* (36 FR 8186). The EPA revised the one-hour ozone standard to 0.12 ppm (124 ppb) on February 8, 1979 (44 FR 4202). The HGB one-hour ozone nonattainment area (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties) was designated nonattainment in 1991 and classified as Severe-17 in accordance with the1990 Federal Clean Air Act (FCAA) Amendments (56 FR 56694). As a Severe-17 nonattainment area, the HGB area was required to demonstrate attainment of the one-hour ozone NAAQS by November 15, 2007. The one-hour ozone NAAQS was revoked in the June 15, 2005 *Federal Register* (69 FR 23951).

1.2.1.1 December 2000

The HGB One-Hour Ozone Attainment Demonstration and Post-1999 Rate of Progress (ROP) SIP Revision was adopted on December 6, 2000. The attainment demonstration portion of the submittal contained numerous air pollution control measures resulting in an overall 90% reduction in point source nitrogen oxides (NO_x) emissions. Despite this reduction, a modeling analysis included in the SIP revision indicated a shortfall in NO_x emissions reductions necessary for an approvable attainment demonstration. To address this shortfall, the SIP revision also contained enforceable commitments to implement further measures in support of the attainment demonstration and to submit a mid-course review (MCR) to the EPA. The ROP plan portion of the December 2000 SIP revision submittal provided emissions inventories, ROP analyses for milestone years 2002, 2005, and 2007, and motor vehicle emissions budgets (MVEB) for NO_x and volatile organic compounds (VOC). On November 14, 2001, the EPA published approval of both the December 2000 and September 2001 SIP revisions (66 FR 57159).

1.2.1.2 September 2001

On September 26, 2001, the Follow-Up One-Hour Ozone Attainment Demonstration and ROP SIP Revision was adopted. This revision incorporated changes to several control strategies and detailed the MCR process, which described how the state would fulfill the commitment to obtain the additional emission reductions necessary to address the remainder of the emission reductions shortfall and demonstrate attainment of the one-hour ozone standard in the HGB area. On November 14, 2001, the EPA published approval of both the December 2000 and September 2001 SIP revisions (66 FR 57159).

1.2.1.3 December 2002

The Business Coalition for Clean Air Appeal Group and several regulated companies challenged the December 2000 HGB SIP Revision and the 90% NO_X reduction requirement from stationary sources. In 2001, the Texas Natural Resource Conservation Commission, now the TCEQ, was required to perform an independent and thorough analysis of the causes of rapid ozone formation events and to identify potential mitigating measures not yet included in the HGB attainment demonstration.

On December 13, 2002, the commission adopted the One-Hour Ozone Attainment Demonstration Follow-Up SIP Revision that addressed the agreements contained in the June 8, 2001 consent order. This SIP revision also incorporated energy efficiency measures and the Texas Emissions Reduction Plan (TERP) protocol. The December 2002 SIP Revision replaced 10% of industrial point source NO_X emissions reductions with industrial source, highly reactive volatile organic compounds (HRVOC) controls. The result was an industrial source ozone control strategy that relied on an 80% reduction in NO_X emissions through 30 Texas Administrative Code (TAC) Chapter 117 and the Mass Emissions Cap and Trade (MECT) Program, and HRVOC rules in 30 TAC Chapter 115 that better quantified and reduced emissions of HRVOC from four key industrial sources: fugitives, flares, process vents, and cooling tower heat exchange systems.

This December 2002 One-Hour Ozone Attainment Demonstration Follow-Up SIP Revision is included in the EPA's September 6, 2006 approval of the HGB area's one-hour ozone attainment demonstration (71 FR 52670).

1.2.1.4 October 2004

On October 27, 2004, the commission adopted the HGB One-Hour Ozone Post-1999 ROP SIP Revision. This revision provided updated emissions inventories and ROP analyses for milestone years 2002, 2005, and 2007 and revised MVEB for the HGB area based on new models for estimating on-road and non-road mobile emissions sources. This SIP revision replaced the previous versions of the Post-1999 ROP that the EPA approved in November 2001. On February 14, 2005, the EPA published approval of this SIP revision (70 FR 7407).

1.2.1.5 December 2004

On December 1, 2004, the commission adopted the HGB One-Hour Ozone Attainment Demonstration MCR SIP Revision reflecting a strategy based on reducing NO_X and point source HRVOC rather than NO_X alone. This SIP revision changed a number of NO_X control strategies and added the HRVOC emission reduction requirements. The results of photochemical modeling and technical documentation included in this SIP revision demonstrated attainment of the one-hour ozone standard by the November 15, 2007 deadline. The one-hour ozone SIP revision commitments addressed in this revision included: completion of a one-hour ozone MCR; adoption of measures sufficient to address the shortfall in NO_X reductions; adoption of measures sufficient to demonstrate attainment; MVEB updates using EPA's MOBILE6 model; and changes to voluntary mobile emissions reduction program measures.

On September 6, 2006, the EPA published approval of the HGB area's one-hour ozone attainment demonstration and associated rules (71 FR 52656). The approval was published in six parts covering the rules for the control of HRVOC, the one-hour ozone attainment plan, the Highly Reactive Volatile Organic Compounds Emissions Cap and Trade (HECT) Program for HRVOC, the MECT Program for NO_X, the Emissions Credit Banking and Trading Program, and the Discrete Emissions Credit Banking and Trading Program.

1.2.1.6 Redesignation Substitute for the One-Hour Ozone NAAQS

The HGB area failed to attain the one-hour ozone standard by the November 15, 2007 attainment deadline, and the EPA published a failure-to-attain determination on June 19, 2012 based on air quality monitoring data for 2005 through 2007 (77 FR 36400).

Although the EPA revoked the one-hour ozone NAAQS in June 2005, states must continue to meet the one-hour ozone anti-backsliding requirements in 40 Code of Federal Regulations (CFR) §51.905(a).[7] The anti-backsliding requirements that apply to the HGB severe one-hour ozone nonattainment area are: contingency measures,[8] nonattainment new source review (NSR) permitting requirements for severe nonattainment areas;[9] and a penalty fee provision.

In 1997, the one-hour ozone NAAQS was replaced by the eight-hour ozone NAAQS. As part of the transition to the 1997 eight-hour ozone standard, the EPA created a submittal termed a termination determination to address anti-backsliding requirements for the one-hour ozone standard. In May 2010, the TCEQ requested a determination regarding termination of the one-hour ozone anti-backsliding obligations associated with the transition from the one-hour ozone standard to the 1997 eight-hour ozone standard. As a result of court action, the EPA was unable to propose approval of the request.[10] Consequently, on May 22, 2013, the commission adopted the Severe Ozone Nonattainment Area Failure to Attain Fees rulemaking to implement the §185 penalty fee.

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[7] South Coast v. EPA, 472 F.3d 882 (D.C. Cir. 2006), directed the EPA to provide one-hour ozone NAAQS anti-backsliding requirements for nonattainment NSR, §185 fees, and §172(c)(9) and §182(c)(9) contingency measures for failure to attain the one-hour ozone NAAQS by the applicable attainment date or to make reasonable further progress toward attainment of that standard.

[8] The EPA-approved one-hour ozone attainment demonstration and Rate of Progress SIP revisions included contingency measures (71 FR 52670, 70 FR 7407, 66 FR 57195, and 66 FR 20750).

[9] According to the EPA's *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements; Final Rule* (80 FR 12264), areas designated nonattainment for the 2008 eight-hour ozone NAAQS must continue to implement the most stringent NSR requirement that applied to the area (whether under the one-hour standard, the 1997 eight-hour standard, or the 2008 eight-hour standard) to which the area is still subject.

[10] On July 1, 2011, the District Court of Columbia Circuit Court of Appeals vacated EPA's memorandum "Guidance on Developing Fee Programs Required by Clean Air Act Section 185 for the one-hour ozone NAAQS," ruling that the EPA's suggested alternative relating to attainment of the eight-hour ozone standard was not consistent with the FCAA.

The EPA's *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements; Final Rule* (2008 ozone standard SIP requirements rule), published in the March 6, 2015 *Federal Register* (80 FR 12264), includes a mechanism for lifting anti-backsliding obligations for the revoked 1997 eight-hour or one-hour ozone NAAQS. States can provide a showing, termed a redesignation substitute, based on FCAA, §107(d)(3)(E) redesignation criteria to demonstrate that an area qualifies for lifting anti-backsliding obligations under a revoked standard consistent with the EPA's 2008 ozone standard SIP requirements rule. The EPA's 2008 ozone standard SIP requirements rule indicates that approval of the redesignation substitute has the same effect on the area's nonattainment anti-backsliding obligations as would a redesignation to attainment for the revoked standard.

The HGB area began monitoring attainment of the one-hour ozone NAAQS in 2013. On July 22, 2014, the TCEQ submitted the Redesignation Substitute Report for the HGB One-Hour Ozone Standard Nonattainment Area to the EPA. Based on certain FCAA redesignation criteria, this report included: monitoring data showing attainment of the revoked one-hour ozone NAAQS; a showing that attainment was due to permanent and enforceable emissions reductions; and a demonstration that the area can maintain the standard through 2026 via emissions inventory trends and future emission projections. The EPA published its final rule approving the redesignation substitute report in the October 20, 2015 *Federal Register* (80 FR 63429).

1.2.2 1997 Eight-Hour Ozone NAAQS History

On July 18, 1997, the EPA published the revised NAAQS for ground-level ozone in the *Federal Register* (62 FR 38856), and it became effective on September 16, 1997. The EPA revoked and replaced the previous one-hour ozone NAAQS with an eight-hour NAAQS set at 0.08 ppm (84 ppb) based on the three-year average of the annual fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area.

Effective June 15, 2004, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties were designated nonattainment in the first phase of the EPA's implementation rule for the 1997 eight-hour ozone NAAQS (69 FR 23951). The HGB area was classified moderate nonattainment for the standard, with an attainment deadline of June 15, 2010. The TCEQ was required to submit a SIP revision for the 1997 eight-hour ozone NAAQS to the EPA by June 15, 2007. The EPA addressed the control obligations that apply to areas designated nonattainment for the 1997 eight-hour ozone NAAQS in the second phase of the implementation rule (70 FR 71612).

1.2.2.1 May 2007

The commission adopted the 2007 HGB 1997 Eight-Hour Ozone Nonattainment Area SIP Revision on May 23, 2007 as the first step in addressing the 1997 eight-hour ozone NAAQS in the HGB area. The revision included additional Voluntary Mobile Source Emissions Reduction Program (VMEP) commitments, an analysis of reasonably available control technology (RACT), and the Texas 2002 Periodic Emissions Inventory for the HGB ozone nonattainment area. The SIP revision also incorporated amendments to 30 TAC Chapter 114, relating to the Texas low emission diesel (TxLED) rule for certain marine fuels and 30 TAC Chapter 115, relating to the control of emissions of VOC from storage and degassing operations in the HGB area.

On April 2, 2013, the EPA published approval of portions of the RACT analysis for certain VOC categories and the VMEP commitments (applicable through 2009) in the 2007 SIP revision (78 FR 19599). The EPA published approval of the remaining source categories that were not previously approved as meeting RACT requirements on April 15, 2014 and March 27, 2015 (79 FR 21144 and 80 FR 16291).

The commission also adopted the 2007 HGB 1997 Eight-Hour Ozone Nonattainment Area Reasonable Further Progress (RFP) SIP Revision on May 23, 2007, which demonstrated that a required 15% emissions reduction in ozone precursors (VOC and NO_X) would be met for the 2001 through 2008 RFP analysis period. On April 22, 2009, the EPA published approval of this SIP revision, the associated MVEBs, and the 2002 base year emissions inventory (74 FR 18298).

1.2.2.2 Reclassification to Severe for the 1997 Eight-Hour Ozone NAAQS

On June 15, 2007, the state requested that the HGB area be reclassified from a moderate to a severe nonattainment area for the 1997 eight-hour ozone NAAQS, with an attainment deadline of June 15, 2019. On December 31, 2007, the EPA published its proposal to grant the governor's request and took comments on a range of dates for the state to submit a revised SIP (72 FR 74252). The TCEQ provided comments to the EPA that supported the reclassification and justification for an April 2010 SIP submission date. On October 1, 2008, the EPA published approval of the governor's request to voluntarily reclassify the HGB ozone nonattainment area from a moderate to a severe nonattainment area for the 1997 ozone NAAQS (73 FR 56983) effective October 31, 2008. The EPA set April 15, 2010 as the date for the state to submit a SIP revision addressing the severe-ozone nonattainment requirements and set a new attainment deadline of June 15, 2019.

1.2.2.3 March 2010

On March 10, 2010, the commission adopted two revisions to the Texas SIP for the HGB ozone nonattainment area. The 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision included a photochemical modeling analysis and a weight of evidence analysis to demonstrate attainment of the 1997 eight-hour ozone NAAQS by the June 15, 2019 deadline. This SIP revision also included MVEBs, VOC and NO_X RACT analyses, reasonably available control measures analysis, and a contingency plan. In addition, this SIP revision incorporated revisions to 30 TAC Chapters 101 and 115, also adopted on March 10, 2010, which include the MECT Program Cap Integrity, the HECT Program Cap Reduction and Allowance Reallocation, and the VOC Control Techniques Guidelines (CTG) Update for offset lithographic printing.

On April 2, 2013, April 15, 2014, August 4, 2014, and March 27, 2015, the EPA published its approvals of the RACT analysis for all affected VOC and NO_X emissions sources in the HGB area for the 1997 eight-hour ozone NAAQS (78 FR 19599, 79 FR 21144, 79 FR 45105, and 80 FR 16291). On January 2, 2014, the EPA published its approval of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision and revisions to the MECT and HECT Programs (79 FR 57).

The 2010 HGB 1997 Eight-Hour Ozone RFP SIP Revision, as required by EPA rule, demonstrated that an 18% emissions reduction requirement will be met for the 2002 through 2008 RFP analysis period and that an average of 3% per year emissions reduction will occur between each of the milestone years 2008, 2011, 2014, 2017, and 2018. This SIP revision established baseline emission levels, calculated reduction targets, identified control strategies to meet emission target levels, and tracked actual emission reductions against established emissions growth. This revision also included an MVEB for each milestone year and a contingency plan.

On January 25, 2011, the EPA published a notice of its determination that the MVEBs in the March 10, 2010 SIP revisions, which were developed using the on-road mobile source emissions inventories based on the EPA's MOBILE 6.2 model, were adequate for transportation conformity purposes (76 FR 4342). On January 2, 2014, the EPA published approval of this RFP SIP revision (79 FR 51).

1.2.2.4 December 2011

On December 7, 2011, the commission adopted the 2011 HGB 1997 Eight-Hour Ozone RACT Update SIP Revision. This SIP revision updated the RACT analysis for VOC emission sources to include the seven CTG documents issued by the EPA from 2006 through 2008 that were not addressed in the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision. This SIP revision incorporated concurrent CTG-related rulemaking that revised 30 TAC Chapter 115, Subchapter E to implement RACT for those CTG emission source categories in the HGB area. On March 27, 2015, the EPA published its approval of this SIP revision (80 FR 16291).

1.2.2.5 April 2013

On April 23, 2013, the commission adopted the 2013 HGB 1997 Eight-Hour Ozone MVEB SIP Revision. This SIP revision updated on-road mobile source emissions inventories and MVEBs for the HGB area using the Motor Vehicle Emissions Simulator (MOVES) 2010a version of the EPA's mobile emissions estimation model. The 2013 SIP revision also met the primary obligation of the mid-course review commitment in the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision by demonstrating that the outstanding 3% contingency requirement was fulfilled. Updated on-road inventories and emissions analysis based on the EPA’s August 30, 2012 vehicle miles traveled offset guidance and a modified version of the MOVES model demonstrated compliance with FCAA requirements for transportation control measures in severe nonattainment areas.

On January 2, 2014, the EPA published approval of this 2013 HGB 1997 Eight-Hour Ozone MVEB SIP Revision along with its approval of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision (79 FR 57).

1.2.2.6 Redesignation Substitute for the 1997 Eight-Hour Ozone NAAQS

Although the EPA revoked the 1997 eight-hour ozone standard in its 2008 ozone standard SIP requirements rule, the HGB area remains subject to the 1997 nonattainment area requirements for a severe classification already approved in the SIP and must continue to meet anti-backsliding requirements described in 40 CFR §51.905(a).

The three anti-backsliding requirements that apply to the HGB severe nonattainment area for the 1997 eight-hour ozone NAAQS are contingency measures, a penalty fee provision, and NSR permitting requirements for severe nonattainment areas. The anti-backsliding requirement for contingency measures under FCAA, §172(c)(9) and §182(c)(9) have been approved by the EPA for the HGB area for the 1997 eight-hour ozone standard and, if triggered, would not require any additional action by the TCEQ to implement.[11]

The anti-backsliding requirement to implement a penalty fee program under FCAA, §182(d)(3) and §185 would only be triggered with the publication of a failure-to-attain determination by the EPA if the HGB area failed to attain the 1997 eight-hour ozone NAAQS by June 15, 2019. For NSR anti-backsliding purposes, areas like HGB that are designated nonattainment for the 2008 eight-hour ozone NAAQS must continue to implement the most stringent NSR requirement that applied to the area (whether under the one-hour standard, the 1997 eight-hour standard, or the 2008 eight-hour standard) to which the area is still subject.

The HGB area monitored attainment of the 1997 eight-hour ozone NAAQS based on 2012 through 2014 monitoring data. In February 2015, the TCEQ submitted certification of 2014 ozone data in support of the TCEQ's subsequent request for a determination of attainment, also known as a clean data determination, for the 1997 eight-hour ozone NAAQS for the HGB area, which the EPA approved in the December 30, 2015 *Federal Register* (80 FR 81466). The HGB area continues to monitor attainment of the 1997 eight-hour ozone standard with a 2015 design value of 80 ppb and a preliminary 2016 design value of 79 ppb.

A 1997 eight-hour ozone redesignation substitute demonstration for the HGB area was submitted to the EPA on August 18, 2015 in the form of a letter and report. This report fulfills the EPA's redesignation substitute requirements in its 2008 ozone standard SIP requirements rule to lift anti-backsliding obligations for the revoked 1997 eight-hour ozone NAAQS by ensuring that specific redesignation requirements are met under the revoked standard. On November 8, 2016, the EPA published its final approval of the HGB area redesignation substitute and a finding of attainment for the 1997 eight-hour ozone NAAQS (81 FR 78691).

1.2.3 2008 Eight-Hour Ozone NAAQS History

On March 12, 2008, the EPA lowered the primary and secondary eight-hour ozone NAAQS to 0.075 ppm or 75ppb (73 FR 16436).

On May 21, 2012, the EPA published in the *Federal Register* final designations for the 2008 eight-hour ozone standard of 0.075 ppm. An eight-county HGB area including Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties was designated nonattainment with a marginal classification. The EPA also published a final rule for the 2008 eight-hour ozone standard to establish classification thresholds, establish December 31 of each relevant calendar year as the

[11] The EPA-approved 1997 eight-hour ozone attainment demonstration, reasonable further progress, and motor vehicle emissions budgets update SIP revisions included contingency measures. See January 2, 2014 *Federal Register* (79 FR 51).

attainment date for each classification, and revoke the 1997 eight-hour ozone NAAQS for purposes of transportation conformity (77 FR 30160). The effective date for both rules was July 20, 2012.

On June 6, 2013, the EPA published the proposed 2008 ozone standard SIP requirements rule (78 FR 34178). The proposed rule addressed SIP requirements, the timing of SIP submissions, revocation of the 1997 eight-hour ozone NAAQS, and anti-backsliding requirements for previous ozone standards.

The United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit Court) published an opinion on December 23, 2014 agreeing with two challenges to the EPA's proposed rule implementing the 2008 ozone NAAQS published on May 21, 2012 (77 FR 30160). The court vacated the provisions of the rule relating to attainment deadlines and revocation of the 1997 ozone NAAQS for transportation conformity purposes. As part of the final 2008 ozone standard SIP requirements rule, the EPA modified 40 CFR §51.1103 consistent with the D.C. Circuit Court decision to establish attainment dates that run from the effective date of designation, i.e., July 20, 2012, and revoked the 1997 ozone NAAQS for all purposes.

As a result of the D.C. Circuit Court ruling, the attainment date for the HGB marginal nonattainment area changed from December 31, 2015 to July 20, 2015. In addition, because the attainment year ozone season is the ozone season immediately preceding a nonattainment area's attainment date, the attainment year for the HGB marginal nonattainment area changed from 2015 to 2014. The EPA published the final 2008 ozone standard SIP requirements rule on March 6, 2015 (80 FR 12264).

On July 2, 2014, the commission approved adoption of a SIP revision to satisfy FCAA, §172(c)(3) and §182(a)(1) emissions inventory reporting requirements for the HGB nonattainment area under the 2008 eight-hour ozone standard. The EPA published direct final approval of this SIP revision in the February 20, 2015 *Federal Register* (80 FR 9204).

1.2.3.1 Reclassification to Moderate for the 2008 Eight-Hour Ozone NAAQS

The HGB area did not attain the 2008 eight-hour ozone standard in 2014, but qualified for a one-year attainment date extension in accordance with FCAA, §181(a)(5). In the May 4, 2016 *Federal Register* (81 FR 26697), the EPA granted a one-year attainment deadline extension for the HGB 2008 eight-hour ozone marginal nonattainment area to July 20, 2016.

Because the HGB area's 2015 design value of 80 ppb exceeded the 2008 eight-hour ozone NAAQS, the EPA published a proposed determination of nonattainment and reclassification of the HGB area from marginal to moderate nonattainment on September 27, 2016 (81 FR 66240). The EPA proposed a January 1, 2017 deadline for the state to submit an attainment demonstration that addresses the 2008 eight-hour ozone NAAQS moderate nonattainment area requirements, including reasonable further progress (RFP). As indicated in the EPA's 2008 ozone standard SIP requirements rule, the attainment deadline for moderate classification is July 20, 2018 with an attainment year of 2017.

1.2.4 Current Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone NAAQS

This HGB AD SIP revision includes a photochemical modeling analysis of reductions in NO_x and VOC emissions from existing control strategies and a weight of evidence (WoE) analysis which meets the requirements to demonstrate attainment of the 2008 ozone NAAQS. Consistent with the requirements of FCAA, 182(b)(1) and the EPA's final 2008 ozone standard SIP requirements rule, this HGB AD SIP revision also includes the following FCAA-required SIP elements: a RACT analysis; a reasonably available control measures analysis, an MVEB; and a contingency plan. Consistent with EPA's draft guidance released by the EPA in December 2014, this HGB AD SIP revision also includes a modeled attainment demonstration and a WoE analysis. Information regarding how the HGB area meets additional FCAA requirements for ozone nonattainment areas classified as moderate is included in Chapter 4: *Control Strategies and Required Elements*, Section 4.10: *Additional FCAA Requirements*.

This HGB AD SIP revision also incorporates a rulemaking to 30 TAC Chapter 115, which is scheduled to be adopted concurrently with this SIP revision, to implement RACT for volatile organic compound storage tanks in the HGB area (Rule Project No. 2016-039-115-AI).

This HGB AD SIP revision would be adopted in conjunction with the 2008 Eight-Hour Ozone Standard RFP SIP Revision.

1.2.5 Existing Ozone Control Strategies

Existing control strategies implemented to address the one-hour and 1997 eight-hour ozone standards are expected to continue to reduce emissions of ozone precursors in the HGB nonattainment area and positively impact progress toward attainment of the 2008 eight-hour ozone NAAQS. The one-hour and eight-hour ozone design values for the HGB nonattainment area from 1991 through 2015 are illustrated in Figure 1-1: *Ozone Design Values and Population in the HGB Area*. Both design values have decreased over the past 25 years. The 2016 one-hour ozone design value was 120 ppb, representing an approximate 45% decrease from a value of 220 ppb in 1991. The preliminary 2016 eight-hour ozone design value is 79 ppb, a 34% decrease from the 1991 value of 119 ppb. These decreases occurred despite a 72% increase in area population from 1991 through 2015, as shown in Figure 1-1. Note that 2016 design values are as of November 10, 2016 and are subject to change.

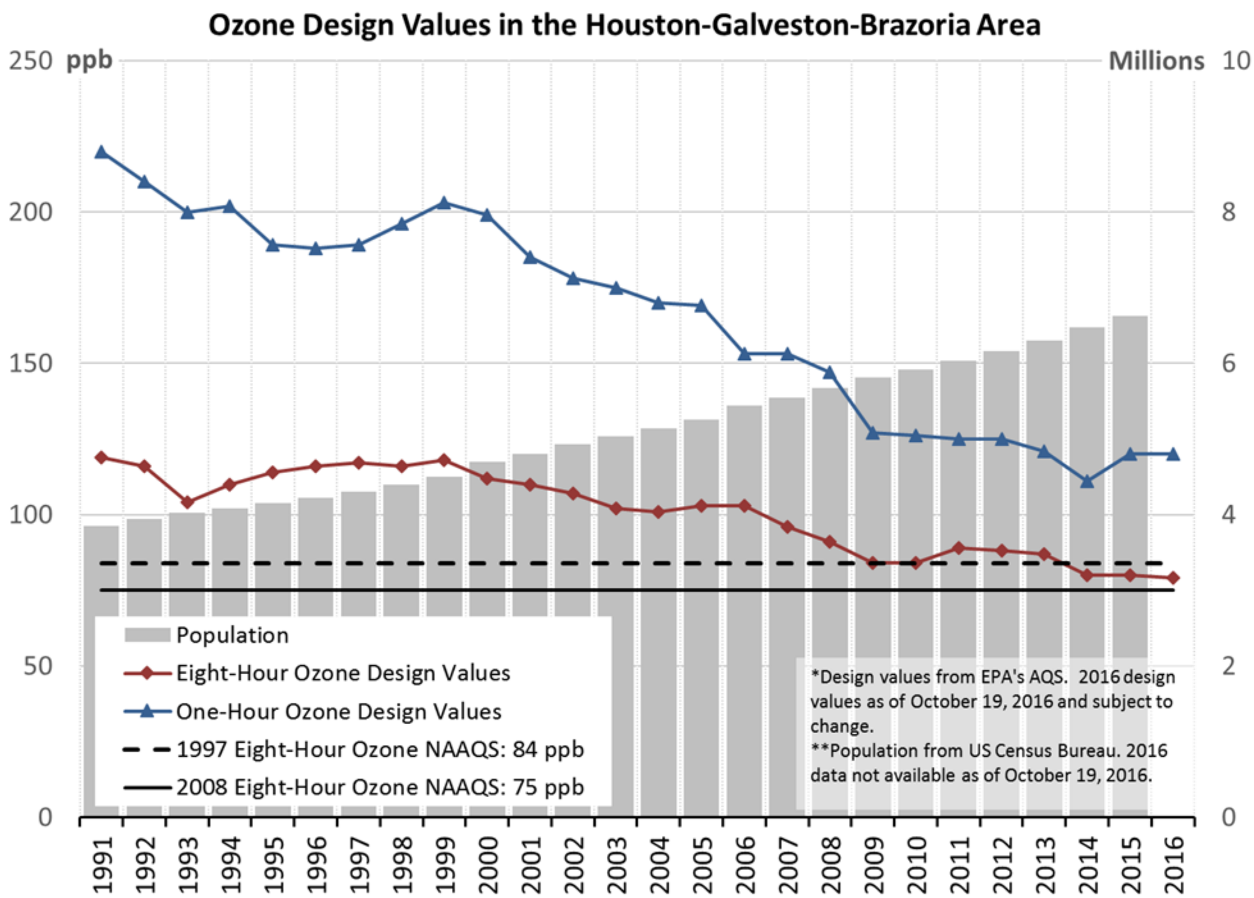


Figure 1-1: Ozone Design Values and Population in the HGB Area

1.3 HEALTH EFFECTS

In 2008, the EPA revised the primary ozone NAAQS to 0.075 ppm (75 ppb). To support the 2008 eight-hour primary ozone standard, the EPA provided information that suggested that health effects may potentially occur at levels lower than the previous 0.080 ppm (80 ppb) standard. Breathing relatively high levels of ground-level ozone can cause acute respiratory problems like cough and decreases in lung function and can aggravate the symptoms of asthma. Repeated exposures to high levels of ozone can potentially make people more susceptible to allergic responses and lung inflammation.

Children are at a relatively higher risk from exposure to ozone when compared to adults since they breathe more air per pound of body weight than adults and because children's respiratory systems are still developing. Children also spend a considerable amount of time outdoors during summer and during the start of the school year (August through October) when high ozone levels are typically recorded. Adults most at risk from exposures to elevated ozone levels are people working or exercising outdoors and individuals with preexisting respiratory diseases.

1.4 STAKEHOLDER PARTICIPATION AND PUBLIC MEETINGS

1.4.1 Regional Air Quality Planning Advisory Committee Meetings

The Regional Air Quality Planning Advisory Committee (RAQPAC) is appointed by the Houston-Galveston Area Council (H-GAC) Board of Directors and includes representatives of local government, public health, transportation, industry, business, environmental organizations, and citizens from the HGB eight-county nonattainment area. The committee assists and advises H-GAC, regional and local governments, transportation organizations and other agencies on air quality issues. TCEQ SIP Team staff provide air quality planning updates at the RAQPAC monthly meetings. More information about this committee is available on the RAQPAC Web page (http://www.h-gac.com/about/advisory-committees/raqpc/ac_raqpc.aspx).

1.4.2 Southeast Texas Photochemical Modeling Technical Committee Meetings

The Southeast Texas Photochemical Modeling Technical Committee (SETPMTC) is an advisory group that assists the TCEQ with technical and scientific issues related to air quality modeling and analysis in the HGB and Beaumont-Port Arthur areas. Periodic SETPMTC meetings are held at H-GAC by TCEQ Air Modeling Team staff and include representatives from the public, environmental groups, industry, and government. More information about this committee is available on the SET PMTC Web page (https://www.tceq.texas.gov/airquality/airmod/committee/pmtc_set.html).

1.5 PUBLIC HEARING AND COMMENT INFORMATION

The public comment period opened on September 23, 2016 and closed on October 24, 2016. Notice of the public hearing for this HGB AD SIP revision was published on September 23, 2016 in the *Austin American-Statesman*, *Houston Chronicle*, and *Fort Worth Star-Telegram* and on October 7, 2016 in the *Texas Register* (41 TexReg 8125). Written comments were accepted via mail, fax, or through the eComments (http://www1.tceq.texas.gov/rules/ecomments/index.cfm) system.

The commission conducted a public hearing in Houston on October 24, 2016 at 2:00 p.m. One commenter, Air Alliance Houston, provided oral testimony at the public hearing. No other comments were received during the public comment period. Summaries of the comments and TCEQ responses are included as part of this HGB AD SIP revision in the Response to Comments.

An electronic version of the HGB AD SIP Revision for the 2008 Ozone NAAQS and appendices can be found at the TCEQ's HGB: Latest Ozone Planning Activities Web page (https://www.tceq.texas.gov/airquality/sip/hgb/hgb-latest-ozone).

1.6 SOCIAL AND ECONOMIC CONSIDERATIONS

For a detailed explanation of the social and economic issues involved with the rule revisions (Rule Project No. 2016-039-115-AI), please refer to the preamble that precedes the rule package accompanying this HGB AD SIP revision.

1.7 FISCAL AND MANPOWER RESOURCES

The state has determined that its fiscal and manpower resources are adequate and will not be adversely affected through the implementation of this plan.

CHAPTER 2: ANTHROPOGENIC EMISSIONS INVENTORY DESCRIPTION

2.1 INTRODUCTION

The Federal Clean Air Act Amendments of 1990 require that attainment demonstration emissions inventories (EIs) be prepared for ozone nonattainment areas (57 *Federal Register* (FR) 13498). Tropospheric ozone is produced when ozone precursors, volatile organic compounds (VOC) and nitrogen oxides (NO_x), undergo photochemical reactions in the presence of sunlight.

The Texas Commission on Environmental Quality (TCEQ) maintains an inventory of current information for sources of NO_x and VOC that identifies the types of emissions sources present in an area, the amount of each pollutant emitted, and the types of processes and control devices employed at each facility or source category. The total anthropogenic inventory of NO_x and VOC emissions for an area is derived from estimates developed for three general categories of emissions sources: point, area, and mobile (both non-road and on-road).

The EI also provides data for a variety of air quality planning tasks, including establishing baseline emissions levels, calculating reduction targets, developing control strategies to achieve emissions reductions, developing emissions inputs for air quality models, and tracking actual emissions reductions against established emissions growth and control budgets.

This chapter discusses general EI development for each of the anthropogenic source categories. Chapter 3: *Photochemical Modeling* details specific EIs and emissions inputs developed for the Houston-Galveston-Brazoria (HGB) area ozone photochemical modeling.

2.2 POINT SOURCES

Stationary point source emissions data are collected annually from sites that meet the reporting requirements of 30 Texas Administrative Code (TAC) §101.10. This EI reporting rule establishes EI reporting thresholds in ozone nonattainment areas that are currently at or less than major source thresholds in the HGB area. Therefore, some minor sources in the HGB ozone nonattainment area report to the point source emissions inventory. To collect the data, the TCEQ provides detailed reporting instructions and tools for completing and submitting EI questionnaires (EIQ). Companies submit EI data using a Web-based system called the Annual Emissions Inventory Report System. Companies are required to report emissions data and to provide sample calculations used to determine the emissions. Information characterizing the process equipment, the abatement units, and the emission points is also required. Company representatives certify that reported emissions are true, accurate, and fully represent emissions that occurred during the calendar year to the best of the representative's knowledge.

All data submitted in the EIQ are reviewed for quality assurance purposes and then stored in the State of Texas Air Reporting System (STARS) database. The TCEQ's Point Source Emissions Inventory Web page (https://www.tceq.texas.gov/airquality/point-source-ei/psei.html) contains EIQ guidance documents and historical point source emissions data. Additional information is available upon request from the TCEQ's Air Quality Division.

For this HGB Attainment Demonstration (AD) State Implementation Plan (SIP) revision, the TCEQ has designated the projection-base year for point sources as 2015 for electric generating units (EGUs) with emissions recorded in the United States Environmental Protection Agency's (EPA) Air Markets Program Data and 2014 for all other stationary point sources (non-EGUs). For more detail on the projection-base year for point sources, please see Chapter 3: *Photochemical Modeling*, Section 3.6.4.1: *Point Sources* and Appendix B: *Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard*.

The TCEQ requested regulated entities submit revisions to the 2014 or 2015 (as appropriate) point source EI by August 1, 2016. The point source emissions in this HGB AD SIP revision incorporate these updates. The TCEQ did not receive 2015 EGU emissions inventory revisions; final 2014 non-EGU point source emissions in this HGB AD SIP revision differ by less than one ton per day each of VOC and NO_x emissions from the point source emissions in the proposed version of this HGB AD SIP revision.

2.3 AREA SOURCES

Stationary emissions sources that do not meet the reporting requirements for point sources are classified as area sources. Area sources are small-scale stationary industrial, commercial, and residential sources that use materials or perform processes that generate emissions. Examples of typical sources of VOC emissions include: oil and gas production sources; printing operations; industrial coatings; degreasing solvents; house paints; gasoline service station underground tank filling; and vehicle refueling operations. Examples of typical fuel combustion sources include: oil and gas production sources; stationary source fossil fuel combustion at residences and businesses; outdoor refuse burning; structure fires; and wildfires.

Area source emissions are calculated as county-wide totals rather than as individual sources. Area source emissions are typically calculated by multiplying EPA- or TCEQ-developed emissions factor (emissions per unit of activity) by the appropriate activity or activity surrogate responsible for generating emissions. Population is one of the more commonly used activity surrogates for area source calculations. Other activity data commonly used include the amount of gasoline sold in an area, employment by industry type, and crude oil and natural gas production.

The air emissions data from the different area source categories are collected, reviewed for quality assurance, stored in the Texas Air Emissions Repository database system, and compiled to develop the statewide area source EI. This area source periodic emissions inventory (PEI) is reported every third year (triennially) to the EPA for inclusion in the National Emissions Inventory. The TCEQ submitted the most recent PEI for calendar year 2014.

2.4 NON-ROAD MOBILE SOURCES

Non-road vehicles do not normally operate on roads or highways and are often referred to as off-road or off-highway vehicles. Non-road emissions sources include, but are not limited to: agricultural equipment; commercial and industrial equipment;

construction and mining equipment; lawn and garden equipment; aircraft and airport equipment; locomotives; drilling rigs; and commercial marine vessels (CMVs).

For this HGB AD SIP revision, EIs for non-road sources were developed for the following subcategories: NONROAD model categories; airports; locomotives; CMVs; and drilling rigs used in upstream oil and gas exploration activities. The airport subcategory includes estimates for emissions from the aircraft, auxiliary power units (APUs), and ground support equipment (GSE) subcategories. The sections below describe the emissions estimates methodologies used for the non-road mobile source subcategories.

2.4.1 NONROAD Model Categories Emissions Estimation Methodology

A Texas-specific version of the EPA's latest NONROAD 2008a model, called the Texas NONROAD (TexN) model, was used to calculate emissions from all non-road mobile source equipment and recreational vehicles, with the exception of airports, locomotives, CMVs, and drilling rigs used in upstream oil and gas exploration activities. Because emissions for airports, CMVs, and locomotives are not included in either the NONROAD model or the TexN model, the emissions for these categories are estimated using other EPA-approved methods and guidance. Although emissions for drilling rigs are included in the NONROAD model, alternate emissions estimates were developed for that source category in order to develop more accurate inventories. The equipment populations for drilling rigs were set to zero in the TexN model to avoid double counting emissions from these sources.

2.4.2 Drilling Rig Diesel Engines Emissions Estimation Methodology

Drilling rig diesel engines used in upstream oil and gas exploration activities are included in the NONROAD model category "Other Oilfield Equipment," which includes various types of equipment; however, due to significant growth in the oil and gas exploration and production industry, a 2015 survey of oil and gas exploration and production companies was used to develop updated drilling rig emissions characterization profiles. The drilling rig emissions characterization profiles from this study were combined with drilling activity data obtained from the Texas Railroad Commission to develop the emissions inventory.

2.4.3 CMV and Locomotive Emissions Estimation Methodology

The locomotive EI was developed from a TCEQ-commissioned study using EPA-accepted EI development methods. The locomotive EI includes line haul and yard emissions activity data from all Class I, II, and III locomotive activity and emissions by rail segment.

The CMV EI was developed from a TCEQ-commissioned study using EPA-accepted EI development methods. The CMV EI includes at-port and underway emissions activity data from Category I, II, and III CMVs by county.

2.4.4 Airport Emissions Estimation Methodology

The airport EI was developed from a TCEQ-commissioned study using the Federal Aviation Administration's Emissions and Dispersion Modeling System model. The airport emissions categories used for this HGB AD SIP revision included aircraft (commercial air carriers, air taxis, general aviation, and military), APU, and GSE operations.

2.5 ON-ROAD MOBILE SOURCES

On-road mobile emissions sources consist of automobiles, trucks, motorcycles, and other motor vehicles traveling on public roadways. On-road mobile source ozone precursor emissions are usually categorized as combustion-related emissions or evaporative hydrocarbon emissions. Combustion-related emissions are estimated for vehicle engine exhaust. Evaporative hydrocarbon emissions are estimated for the fuel tank and other evaporative leak sources on the vehicle. To calculate emissions, both the rate of emissions per unit of activity (emission factors) and the number of units of activity must be determined.

The proposed version of this HGB SIP revision included preliminary on-road EIs developed using MOVES2014. Updated on-road EIs and emission factors for this HGB AD SIP revision were developed using the EPA's mobile emissions factor model, MOVES2014a. The MOVES2014a model may be run using national default information or the default information may be modified to simulate data specific to the HGB area, such as the control programs, driving behavior, meteorological conditions, and vehicle characteristics. Because modifications to the national default values influence the emission factors calculated by the MOVES2014a model, to the extent that local values are available, parameters that are used reflect local conditions. The localized inputs used for the on-road mobile EI development include vehicle speeds for each roadway link, vehicle populations, vehicle hours idling, temperature, humidity, vehicle age distributions for each vehicle type, percentage of miles traveled for each vehicle type, type of inspection and maintenance program, fuel control programs, and gasoline vapor pressure controls.

To estimate on-road mobile source emissions, emission factors calculated by the MOVES2014a model must be multiplied by the level of vehicle activity. On-road mobile source emissions factors are expressed in units of grams per mile, grams per vehicle (evaporative), and grams per hour (extended idle); therefore, the activity data required to complete the inventory calculation are vehicle miles traveled (VMT) in units of miles per day, vehicle populations, and source hours idling. The level of vehicle travel activity is developed using travel demand models (TDMs) run by the Texas Department of Transportation or by the local metropolitan planning organizations. The TDMs are validated against a large number of ground counts, i.e., traffic passing over counters placed in various locations throughout a county or area. For SIP inventories, VMT estimates are calibrated against outputs from the federal Highway Performance Monitoring System, a model built from a different set of traffic counters. Vehicle populations by source type are derived from the Texas Department of Motor Vehicles' registration database and, as needed, national estimates for vehicle source type population.

In addition to the number of miles traveled on each roadway link, the speed on each roadway type or segment is also needed to complete an on-road emissions inventory. Roadway speeds, required inputs for the MOVES2014a model, are calculated by using the activity volumes from the TDM and a post-processor speed model.

2.6 EI IMPROVEMENT

The TCEQ EI reflects years of emissions data improvement, including extensive point and area source inventory reconciliation with ambient emissions monitoring data. Reports detailing recent TCEQ EI improvement projects can be found at the TCEQ's Air Quality Research and Contract Projects Web page (https://www.tceq.texas.gov/airquality/airmod/project/pj.html).

CHAPTER 3: PHOTOCHEMICAL MODELING

3.1 INTRODUCTION

This chapter describes modeling conducted in support of the Houston-Galveston-Brazoria (HGB) Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone Standard. The HGB ozone nonattainment area consists of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties. The 1990 Federal Clean Air Act (FCAA) Amendments require that attainment demonstrations be based on photochemical grid modeling or any other analytical methods determined by the United States Environmental Protection Agency (EPA) to be at least as effective. The EPA's December 2014 *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone,* $PM_{2.5}$*, and Regional Haze* (EPA, 2014a; hereafter referred to as modeling guidance) recommends procedures for air quality modeling for attainment demonstrations for the eight-hour ozone National Ambient Air Quality Standard (NAAQS).

The modeling guidance recommends several qualitative methods for preparing attainment demonstrations that acknowledge the limitations and uncertainties of photochemical models when used to project ozone concentrations into future years. First, the modeling guidance recommends using model results in a relative sense and applying the model response to the observed ozone data. Second, the modeling guidance recommends using available air quality, meteorology, and emissions data to develop a conceptual model for eight-hour ozone formation and to use that analysis in episode selection. Third, the modeling guidance recommends using other analyses, i.e., weight of evidence (WoE), to supplement and corroborate the model results and support the adequacy of a proposed control strategy package.

This HGB AD SIP revision uses photochemical modeling and other analyses to meet the requirements of the EPA's final *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements* (2008 ozone standard SIP requirements rule) published in the March 6, 2015 *Federal Register* (80 FR 12264).

3.2 OVERVIEW OF THE OZONE PHOTOCHEMICAL MODELING PROCESS

The modeling system is composed of a meteorological model, several emissions processing models, and a photochemical air quality model. The meteorological and emission models provide the major inputs to the air quality model.

Ozone is a secondary pollutant; it is not generally emitted directly into the atmosphere. Ozone is created in the atmosphere by a complex set of chemical reactions between sunlight and several primary (directly emitted) pollutants. The reactions are photochemical and require ultraviolet energy from sunlight. The majority of primary pollutants directly involved in ozone formation fall into two groups, nitrogen oxides (NO_X) and volatile organic compounds (VOC). In addition, carbon monoxide (CO) is an ozone precursor, but much less effective than either NO_X or VOC in forming ozone. Because of these multiple factors, higher concentrations of ozone are most common during the summer with concentrations peaking during the day and falling during the night and early morning hours.

Ozone chemistry is complex, involving hundreds of chemical compounds and chemical reactions. As a result, ozone cannot be evaluated using simple dilution and dispersion algorithms. Due to this chemical complexity, the modeling guidance strongly recommends using photochemical computer models to simulate ozone formation and to evaluate the effectiveness of future control strategies. Computer simulations are the most effective tools to address both the chemical complexity and the future case evaluation.

3.3 OZONE MODELING PROCESS

Ozone modeling involves two major phases, the base case modeling phase and the future year modeling phase. The purpose of the base case modeling phase is to evaluate the model's ability to replicate measured ozone and ozone precursor concentrations during recent periods with high ozone concentrations. The purpose of the future year modeling is to predict attainment year design values at each monitor and to evaluate the effectiveness of controls in reaching attainment. The Texas Commission on Environmental Quality (TCEQ) developed a modeling protocol, attached as Appendix E*: Modeling Protocol for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard*, describing the modeling configuration, performance evaluation, and quality assurance process and submitted the plan to the EPA on August 10, 2016 as prescribed in the modeling guidance.

3.3.1 Base Case Modeling

Base case modeling involves several steps. First, recent ozone episodes are analyzed to determine what factors were associated with ozone formation in the area and whether those factors were consistent with the conceptual model and the EPA's episode selection criteria. Once an episode is selected, emissions and meteorological data are generated and quality assured. Then the meteorological and emissions (NO_X, VOC, and CO) data are input to the photochemical model and the ozone photochemistry is simulated, resulting in predicted ozone and ozone precursor concentrations.

Base case modeling results are evaluated by comparing them to the observed measurements of ozone and ozone precursors. This step is an iterative process incorporating feedback from successive evaluations to ensure that the model is adequately replicating observations throughout the modeling episode. The adequacy of the model in replicating observations is assessed statistically and graphically as recommended in the modeling guidance. Additional analyses using special study data are included when available. Satisfactory performance of the base case modeling provides a degree of certainty that the model can be used to predict future year ozone concentrations (future year design value or DV_F), as well as to evaluate the effectiveness of possible control measures.

3.3.2 Future Year Modeling

Future year modeling involves several steps. The procedure for predicting a DV_F, called an attainment test, involves determining the ratio of the future year to the baseline year modeled ozone concentrations. This ratio is called the relative response factor (RRF). Whereas the emissions data for the base case modeling are episode-specific, the emissions data for the baseline year are based on typical ozone season emissions. Similarly, the emissions data for the future year are developed applying growth and control factors to the baseline year emissions. The growth and control factors are developed based on the projected growth in the demand for goods and services, along with the reduction in emissions expected from state, local, and federal control programs.

Both the baseline and future years are modeled using their respective ozone season emissions and the base case episode meteorological data as inputs. The same meteorological data are used for modeling both the baseline and future years, and thus, the ratio of future year modeled ozone concentrations to the baseline year concentrations provides a measure of the response of ozone concentrations to the change in emissions from projected growth and controls.

A DV_F is calculated by multiplying the RRF by a baseline year design value (DV_B). The DV_B is the average of the regulatory design values for the three consecutive years containing the baseline year, as shown in Figure 3-1: *Example Baseline Design Value Calculation*. A calculated DV_F of less than or equal to 75 parts per billion (ppb) signifies modeled attainment. When the calculated DV_F is greater than 75 ppb, additional controls may be needed and the model can be used to test the effectiveness of various control measures in developing a control strategy.

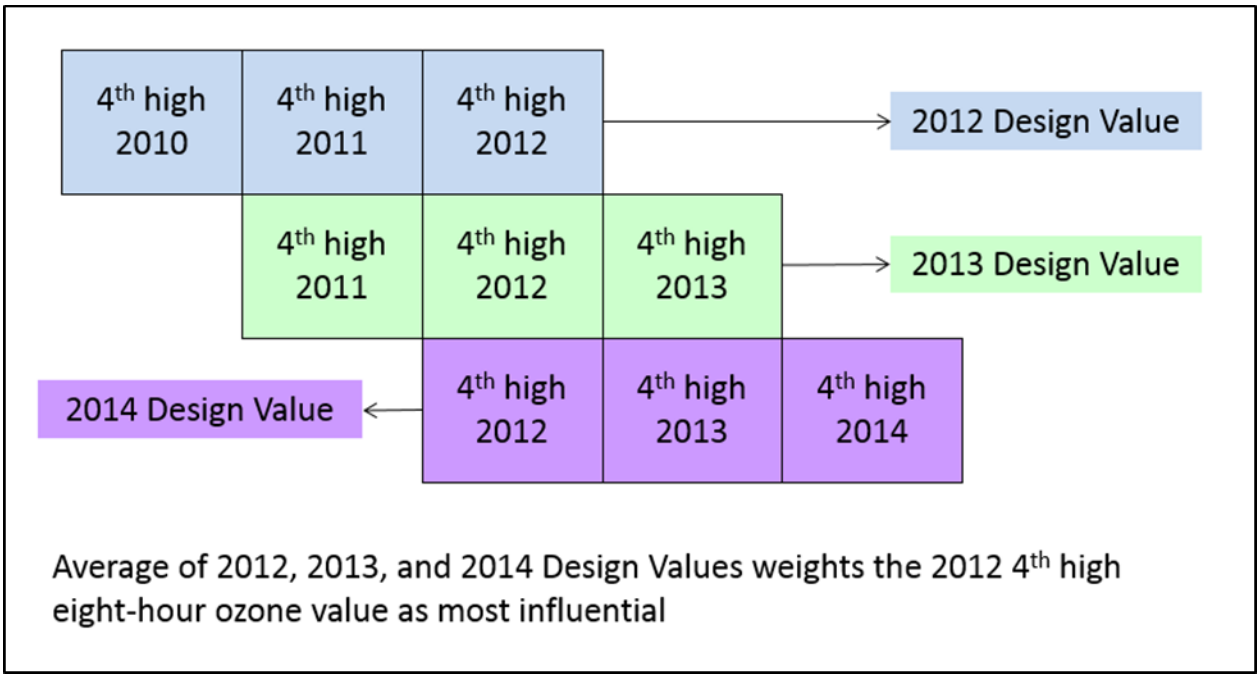


Figure 3-1: Example Baseline Design Value Calculation

3.4 EPISODE SELECTION

3.4.1 Modeling Guidance for Episode Selection

The primary criteria for selecting ozone episodes for eight-hour ozone attainment demonstration modeling are set forth in the modeling guidance and shown below.

- Consider a modeling period near a National Emissions Inventory (NEI) year or where extensive air quality and/or meteorological data sets exist.

- Select periods reflecting a variety of meteorological conditions that frequently correspond to observed eight-hour daily maximum ozone concentrations greater than 75 ppb at different monitoring sites.
- Select periods during which observed eight-hour ozone concentrations are close to the eight-hour ozone design values at monitors with a DV_B greater than or equal to 75 ppb.
- Model periods before, during, and after observed elevated ozone concentrations to ensure the photochemical model characterizes conditions leading to and following pollution events.
- Model a sufficient number of days so that the modeled attainment test can be applied at all of the ozone monitoring sites that are in violation of the NAAQS.

3.4.2 Episode Selection Process

An episode selection analysis was performed to identify time periods with elevated eight-hour ozone concentrations that complied with the primary selection criteria and were representative of historical periods with high ozone. Entire ozone seasons were the focus, as many recent years did not have individual months where HGB area monitors observed 10 days above the NAAQS necessary for a robust attainment test, reflective of the continuing improvement in measured ozone in the HGB area. Modeling an ozone season also allows the attainment demonstration to reflect the historical bi-modal pattern of elevated eight-hour ozone concentrations as shown in Figure 3-2: *HGB Eight-Hour Ozone Exceedance Days by Month from 1990 through 2015*.

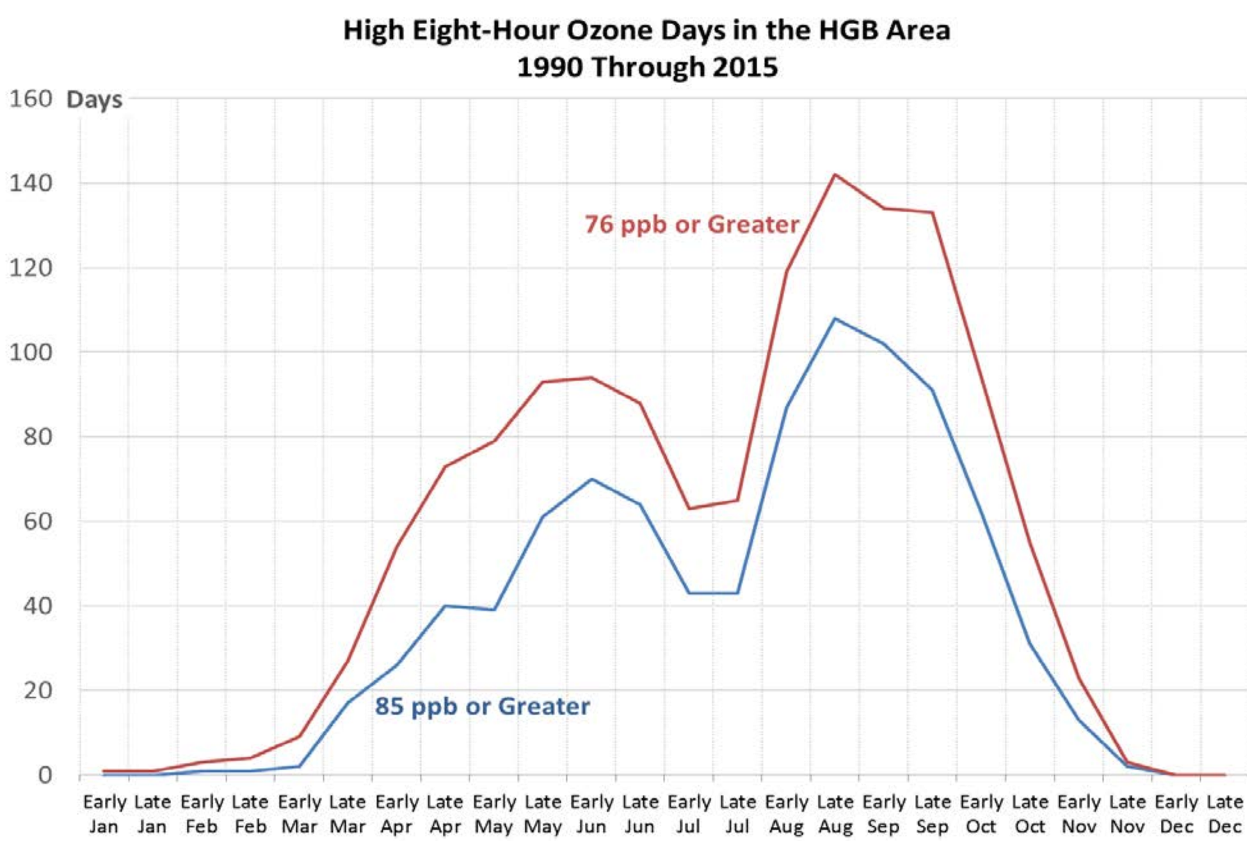


Figure 3-2: HGB Eight-Hour Ozone Exceedance Days by Month from 1990 through 2015

As discussed previously, as ozone and precursor concentrations have declined, it was important to evaluate recent ozone seasons in order to have enough high ozone days to evaluate. Years 2011 through 2013 were reviewed because DV_Bs could be calculated using official monitoring data. The number of days the HGB area measured maximum daily average eight-hour ozone (MDA8) above 75 ppb was the initial metric used to evaluate the seasons as shown in Figure 3-3: *HGB Number of Days Maximum Daily Average Eight-Hour Ozone Greater than 75 ppb*. The year 2013 stands out from 2011 and 2012 as having fewer days above the eight-hour ozone NAAQS.

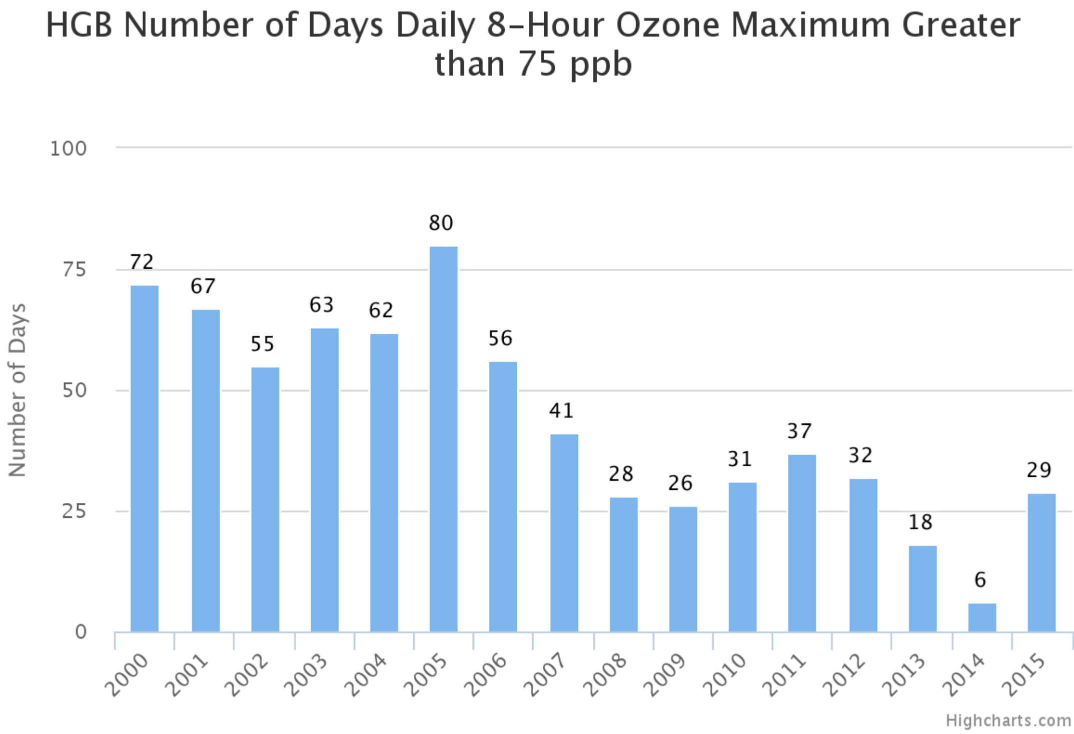


Figure 3-3: HGB Number of Days Maximum Daily Average Eight-Hour Ozone Greater than 75 ppb

June, typically a month with multiple exceedances (see Figure 3-2), only had two days in 2013 with regulatory monitored values greater than 75 ppb as shown in Table 3-1: *HGB 75 ppb Ozone Exceedance Days by Month from 2011 through 2013*. July 2013 had four exceedances, which is unusual compared to typical July trends.

Table 3-1: HGB 75 ppb Ozone Exceedance Days by Month from 2011 through 2013

Month	2011	2012	2013
January	0	0	0
February	0	0	0
March	1	3	0
April	2	5	0
May	5	6	3
June	6	6	2
July	1	0	4
August	6	4	5
September	12	7	2
October	4	1	2
November	0	0	0
December	0	0	0
Annual Total	37	32	18
June/August-September Total	24	19	9

In addition, two of the monitors that typically observe the highest ozone concentrations, Manvel Croix Park (C84) and Bayland Park (C53), only measured MDA8 greater than 75 ppb on seven days as shown in Figure 3-4: *2013 HGB Number of Days Maximum Daily Average Eight-Hour Ozone Greater than 75 ppb by Monitor*. Four of those exceedance days at the Manvel Croix Park (C84) monitor and three at Bayland Park (C53) monitor were observed in July, atypical of HGB ozone seasons. Because high ozone did not follow the historical bi-modal pattern and it was not measured at the typical monitors, 2013 was not considered for ozone season modeling.

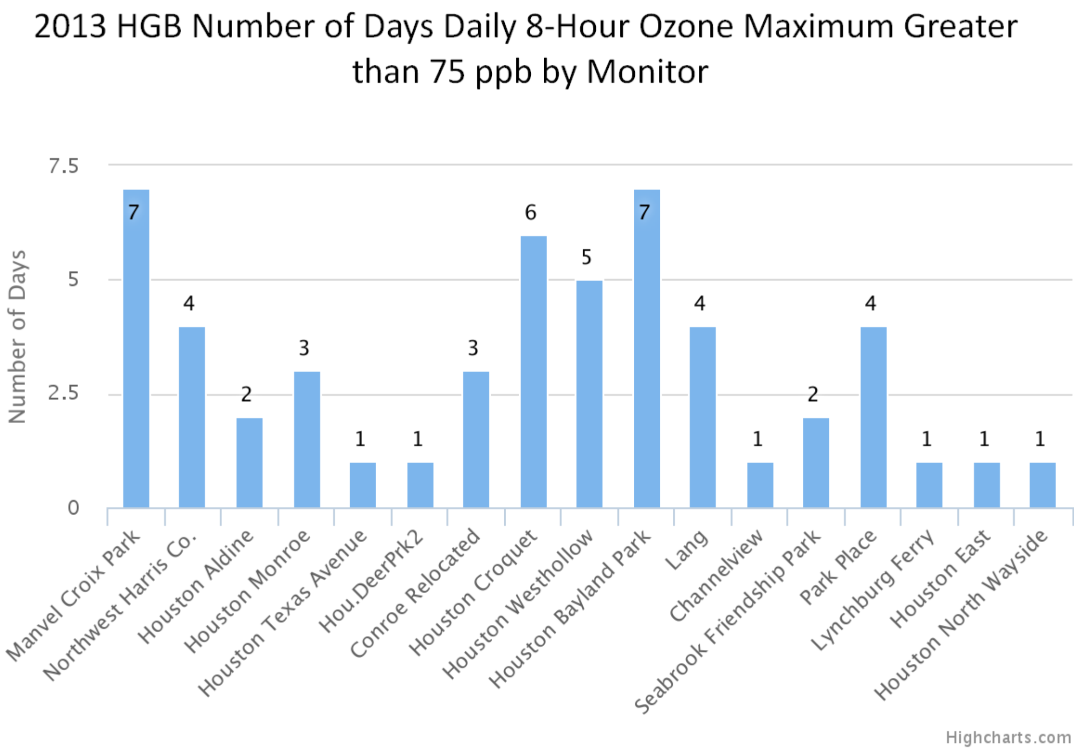


Figure 3-4: 2013 HGB Number of Days Maximum Daily Average Eight-Hour Ozone Greater than 75 ppb by Monitor

For 2011, an NEI year, the HGB nonattainment area monitors recorded many days above 75 ppb. However, 2011 was an anomalous year as it was the hottest year on record and the single-worst drought year recorded in Texas since 1895. *Figure 3-5: August 9, 2011 U.S. Drought Monitor Map of Texas* shows the extent of the drought across the state. Temperatures were much above normal and annual precipitation was the lowest in recorded history (Nielsen-Gammon, 2011) due to high pressure dominating the synoptic meteorological conditions. The unusually extended period of high pressure in 2011 decreased wind speeds, limited cloud formation, and reduced soil moisture; all are conditions conducive to ozone formation. Because 2011 was atypical of recent ozone seasons, it was not considered for ozone season modeling.

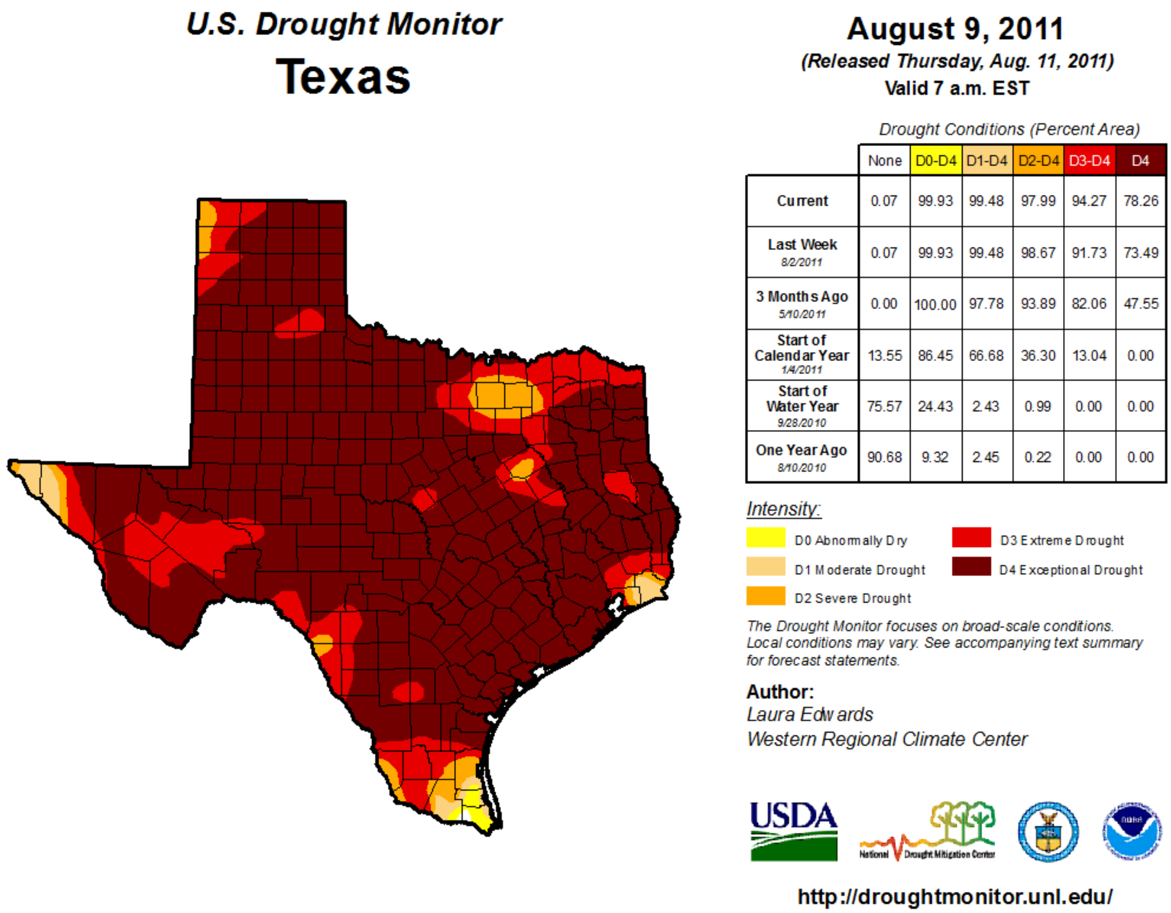


Figure 3-5: August 9, 2011 U.S. Drought Monitor Map of Texas

In 2012, the HGB nonattainment area observed ozone concentrations above 75 ppb during most of the ozone season, especially during the typical months of June, August, and September as shown in Table 3-1. All regulatory monitors experienced elevated ozone concentrations, including those at Manvel Croix Park (C84) and Bayland Park (C53), as shown in Figure 3-6: 2012 *HGB Number of Days Maximum Daily Average Eight-Hour Ozone Greater than 75 ppb by Monitor*.

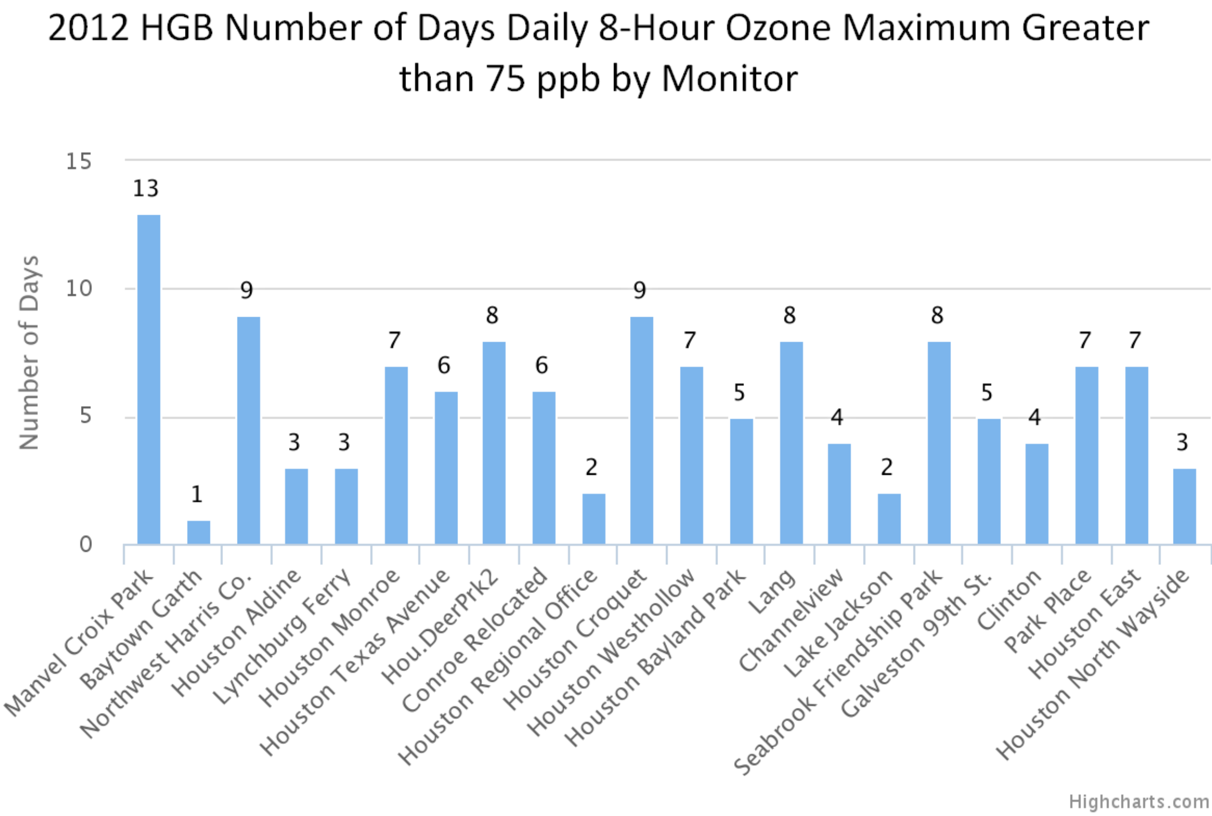


Figure 3-6: 2012 HGB Number of Days Maximum Daily Average Eight-Hour Ozone Greater than 75 ppb by Monitor

Texas drought conditions in 2012 were typical of previous years, with the exception of 2011, as depicted in Figure 3-7: *August 7, 2012 U.S. Drought Monitor Map of Texas*. The HGB area was not in a drought for most of the 2012 ozone season. The episode selection analysis identified 2012 as a representative year, with the May through September period monitoring the majority of elevated ozone, and suitable for ozone season modeling.

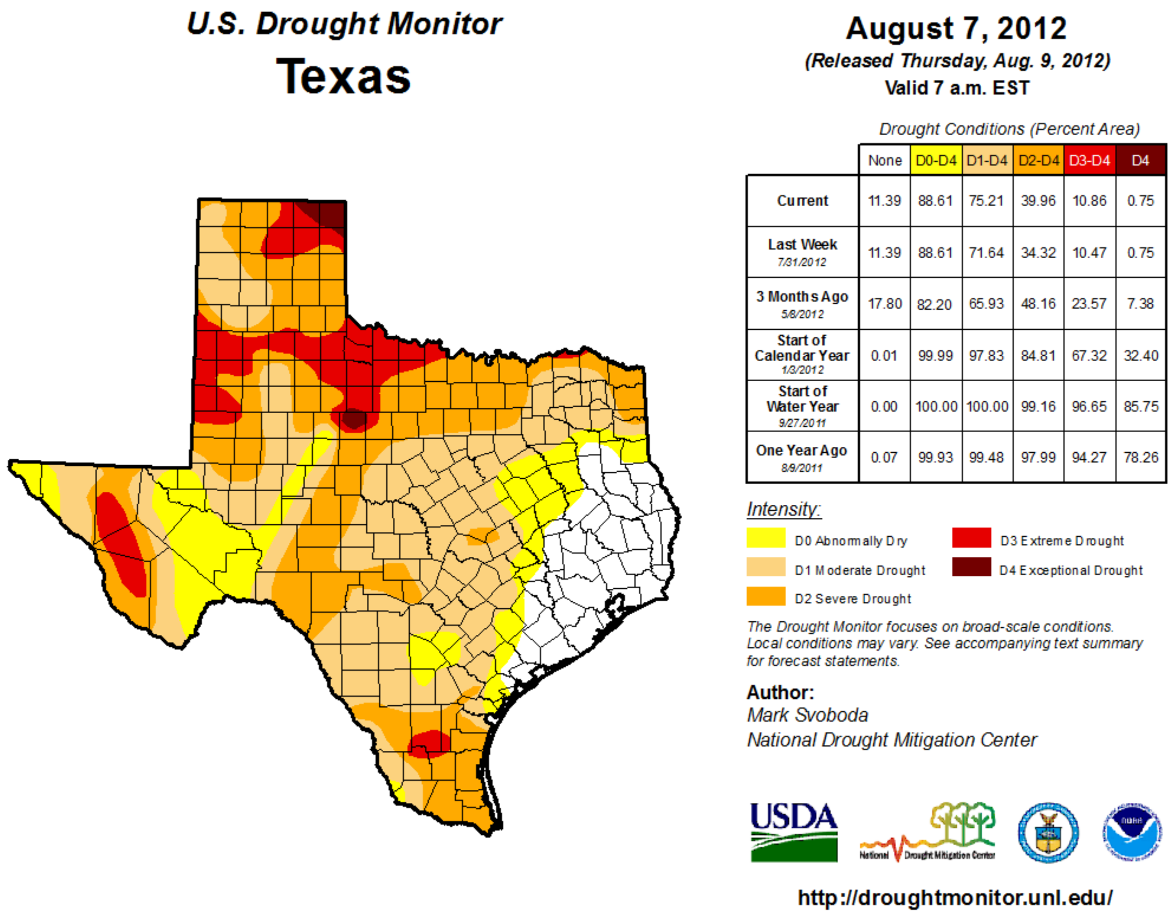


Figure 3-7: August 7, 2012 U.S. Drought Monitor Map of Texas

3.4.3 Summary of the May through September 2012 Ozone Episode

The May through September 2012, ozone episode was characterized by one- to four-day periods of ozone concentrations above the 2008 eight-hour ozone standard of 75 ppb, typical of recent years. The elevated ozone concentrations were usually confined to a few monitors per high ozone day. On some days the high ozone concentrations were widespread, affecting most monitors in the area as on June 26, 2012 with 31 monitors above 75 ppb. Only one monitor, Manvel Croix Park (C84), experienced 10 days above 75 ppb during the 153-day ozone episode as shown in Table 3-2: *Regulatory Monitor-Specific Ozone Conditions During May through September 2012 Episode*. Figure 3-8: *HGB Area Regulatory Ozone Monitoring Locations* shows the locations of the HGB area regulatory monitors active during the May through September 2012 episode. All regulatory monitors that operated the entire ozone season recorded more than 10 days above 60 ppb. The modeling guidance suggests using the top 10 modeled days above 60 ppb for the modeled attainment test.

Table 3-2: Regulatory Monitor-Specific Ozone Conditions During May through September 2012 Episode

HGB Regulatory Monitor and CAMS Code	Site Code	Episode Maximum Eight-Hour Ozone (ppb)	Number of Days Above 60 ppb	Number of Days Above 70 ppb	Number of Days Above 75 ppb	Number of Days Above 85 ppb	Baseline Design Value (ppb)
Baytown Garth - C1017*	BYTE	78	6	3	1	0	NA*
Channelview - C15	HCHV	79	14	5	3	0	73.00
Clinton - C403	CLTN	102	20	5	3	2	74.67
Conroe Relocated - C78	CNR2	85	12	4	3	0	78.00
Galveston 99th St. - C1034	GALV	84	15	4	2	0	75.33
Deer Park - C35	DRPK	91	17	7	5	2	78.33
Houston Aldine - C8	HALC	95	18	2	1	1	76.67
Houston Bayland Park - C53	BAYP	104	28	11	5	2	78.67
Houston Croquet - C409	HCQA	121	28	13	9	2	78.67
Houston East - C1	HOEA	100	22	8	4	2	78.00
Houston Monroe - C406	HSMA	104	23	10	6	4	76.67
Houston North Wayside - C405	HWAA	85	17	4	2	1	73.67
Houston Regional Office - C81*	HORC	93	6	3	1	1	NA*
Houston Texas Avenue - C411	HTCA	96	22	8	4	3	75.00
Houston Westhollow - C410	SHWH	91	25	8	6	1	77.67
Lake Jackson - C1016	LKJK	92	16	4	2	2	69.33
Lang - C408	HLAA	84	28	10	6	0	76.33
Lynchburg Ferry - C1015	LYNF	77	13	6	1	0	71.00
Manvel Croix Park - C84	MACP	136	36	13	10	5	85.00
Northwest Harris Co. - C26	HNWA	99	24	9	5	1	80.00
Park Place - C416	PRKP	114	23	10	5	2	77.33
Seabrook Friendship Park - C45	SBFP	89	19	7	5	2	76.33

*The Baytown Garth – C1017 monitor (started monitoring on June 5, 2012) and Houston Regional Office – C81 monitor (deactivated on June 25, 2012) did not have enough data for a baseline design value.

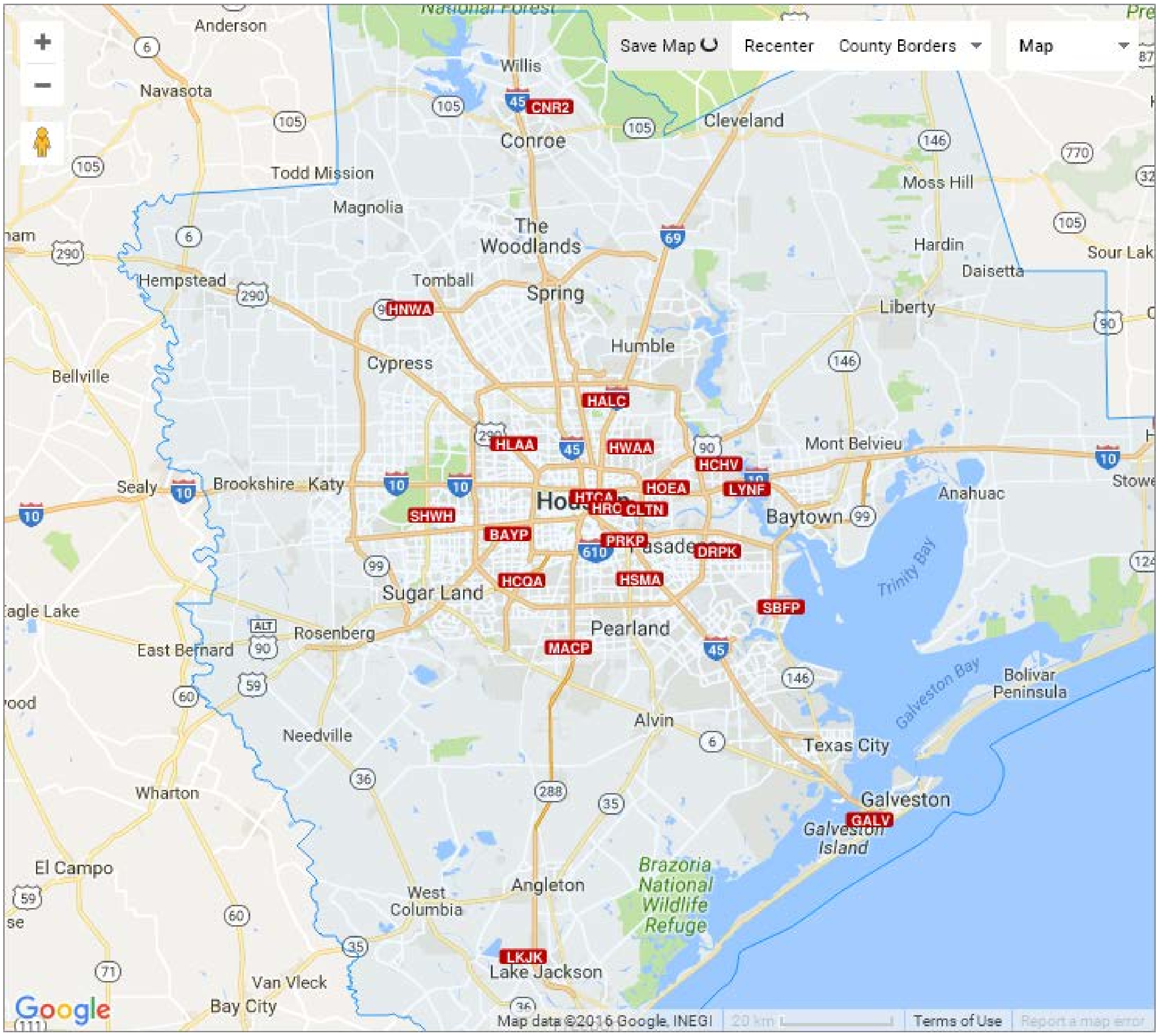


Figure 3-8: HGB Area Regulatory Ozone Monitoring Locations

Appendix D: *Conceptual Model for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard* describes the meteorological conditions that are generally present on days when the eight-hour ozone concentration exceeds the 2008 eight-hour ozone NAAQS. High ozone concentrations are typically formed in the HGB area on days with slower wind speeds that rotate clockwise throughout the day following land/sea breeze forcing. Other days approaching or following frontal passages can bring higher background ozone levels into the HGB area. High background ozone concentrations are then amplified as an air mass moves over the industrial area and urban core of the HGB area, both of which contain sources that emit significant amounts of NO_x and highly reactive volatile organic compounds (HRVOC).

3.4.3.1 May 2012

May is a month that historically observes high ozone concentrations (see Figure 3-2) and seven days in 2012 saw HGB-area monitors exceed 75 ppb as shown in Figure 3-9:

May 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors. The highest was May 21, 2012 where 14 monitors exceeded 75 ppb with the Texas City 34th St. (C620) monitor measuring the maximum eight-hour ozone concentration in the area of 93 ppb. The seven exceedance days came within a nine-day period, May 14 through May 22.

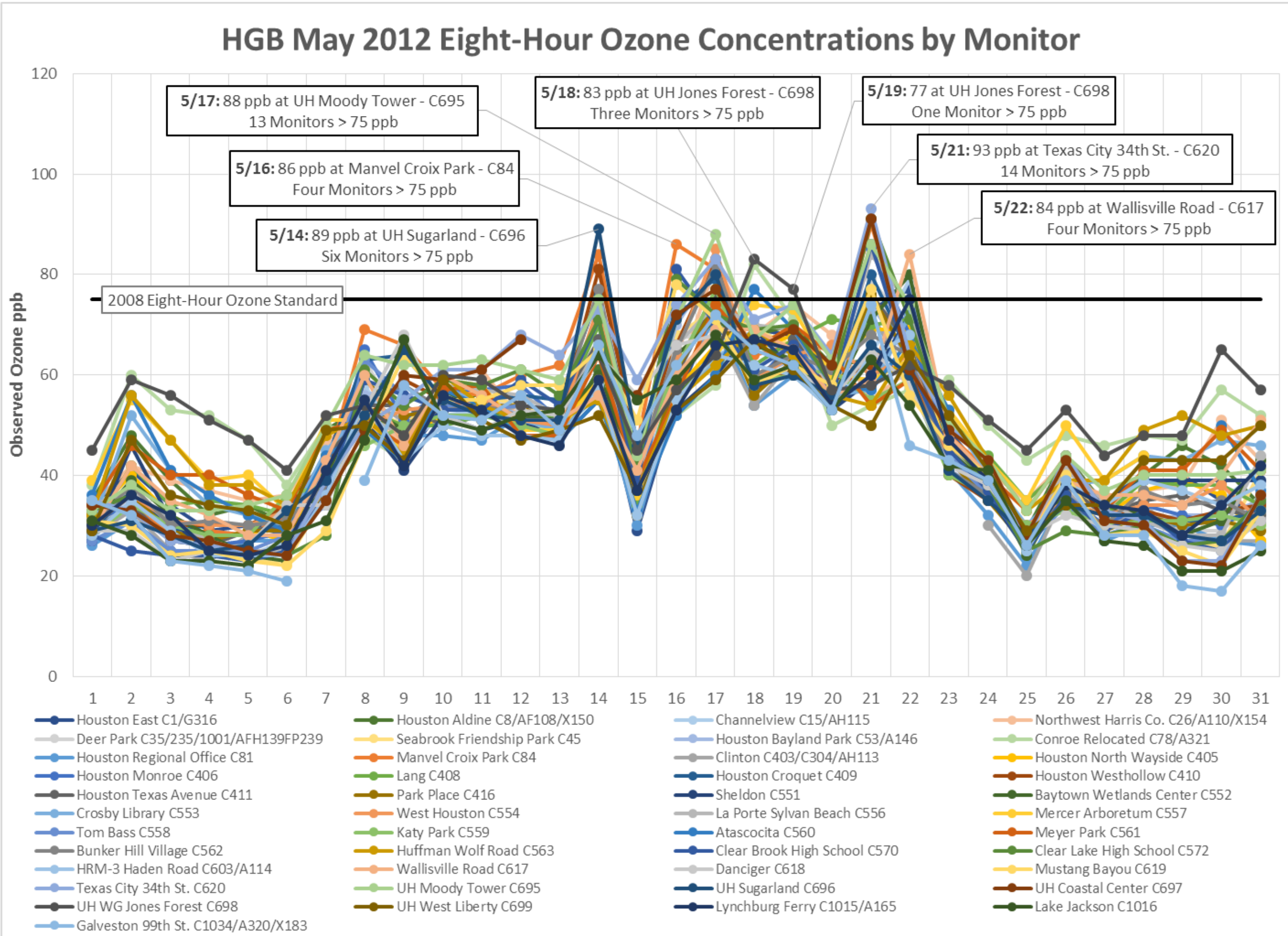


Figure 3-9: May 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors

3.4.3.2 June 2012

June is the first month of the bi-modal peak of high ozone concentrations in the HGB area (see Figure 3-2). The maximum eight-hour ozone measured at area monitors was 76 ppb or higher on seven days in June 2012 as shown in Figure 3-10: *June 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors*. The Manvel Croix Park (C84) monitor measured an eight-hour ozone maximum of 136 ppb on June 26, 2012, the highest ozone concentration observed since 2003. Thirty other regulatory and non-regulatory HGB-area monitors also measured exceedances on June 26, 2012.

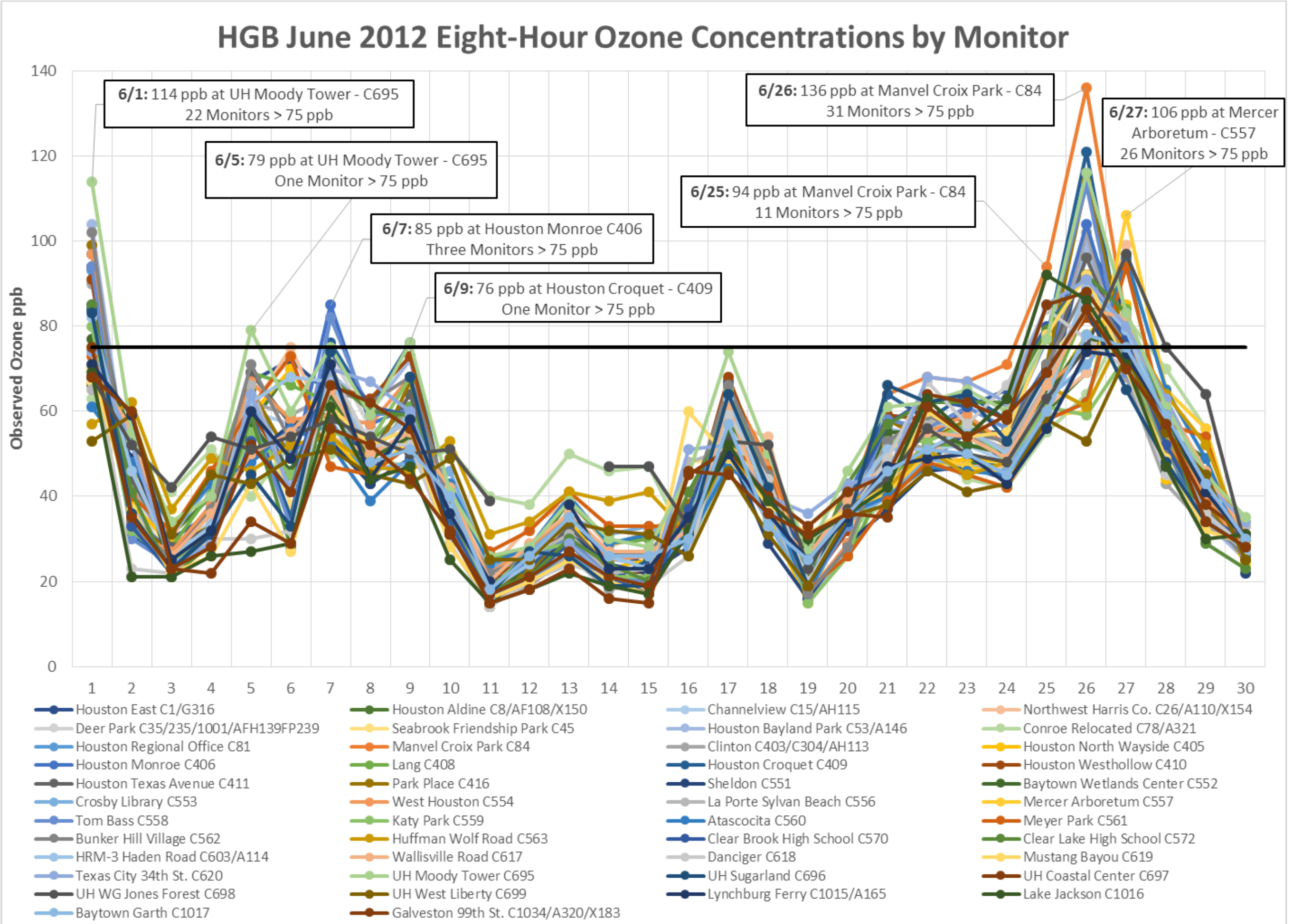


Figure 3-10: June 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors

3.4.3.3 July 2012

As shown in Figure 3-2, in July, the HGB area monitors do not typically observe many elevated eight-hour ozone concentrations. The location of the Bermuda High (the persistent high-pressure center in the Atlantic Ocean that strongly influences weather patterns throughout the southeast U.S. and the Gulf of Mexico) in July usually directs strong southerly flow from the Gulf of Mexico, bringing cleaner air into the region (Wang, 2015). Strong southerly flow dominated July 2012 and maximum eight-hour ozone concentrations did not exceed 60 ppb as shown in Figure 3-11: *July 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors*.

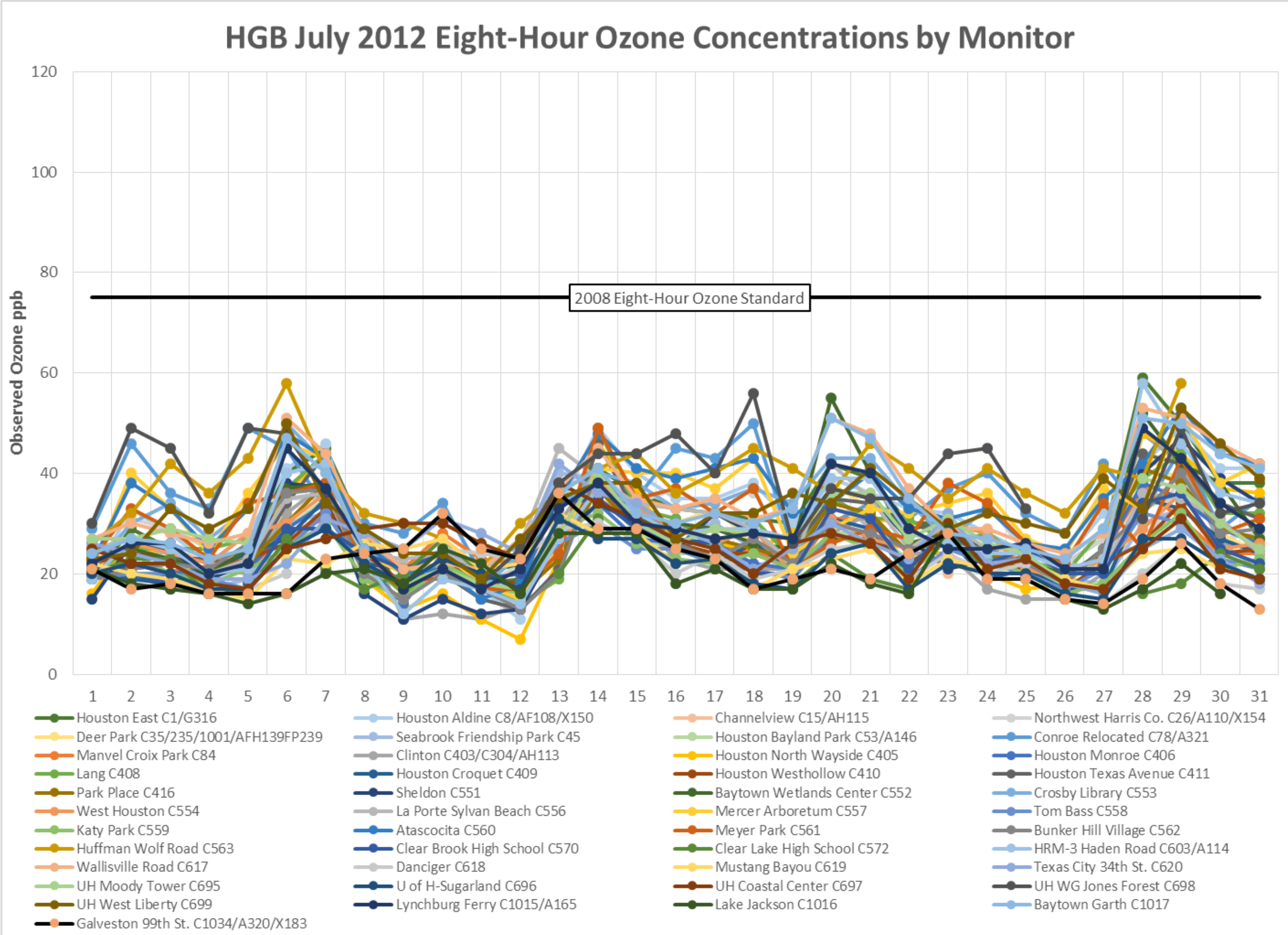


Figure 3-11: July 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors

3.4.3.4 August 2012

Historically, August is the beginning of the period with the most eight-hour ozone exceedances as shown in Figure 3-2. On August 20, 2012, 12 monitors recorded maximum eight-hour ozone concentrations in excess of 75 ppb, with the Clear Lake High School (C572) monitor measuring a peak eight-hour average of 97 ppb. Three other days had monitors with maximum eight-hour ozone above the 2008 eight-hour ozone NAAQS as shown in Figure 3-12: *August 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors*.

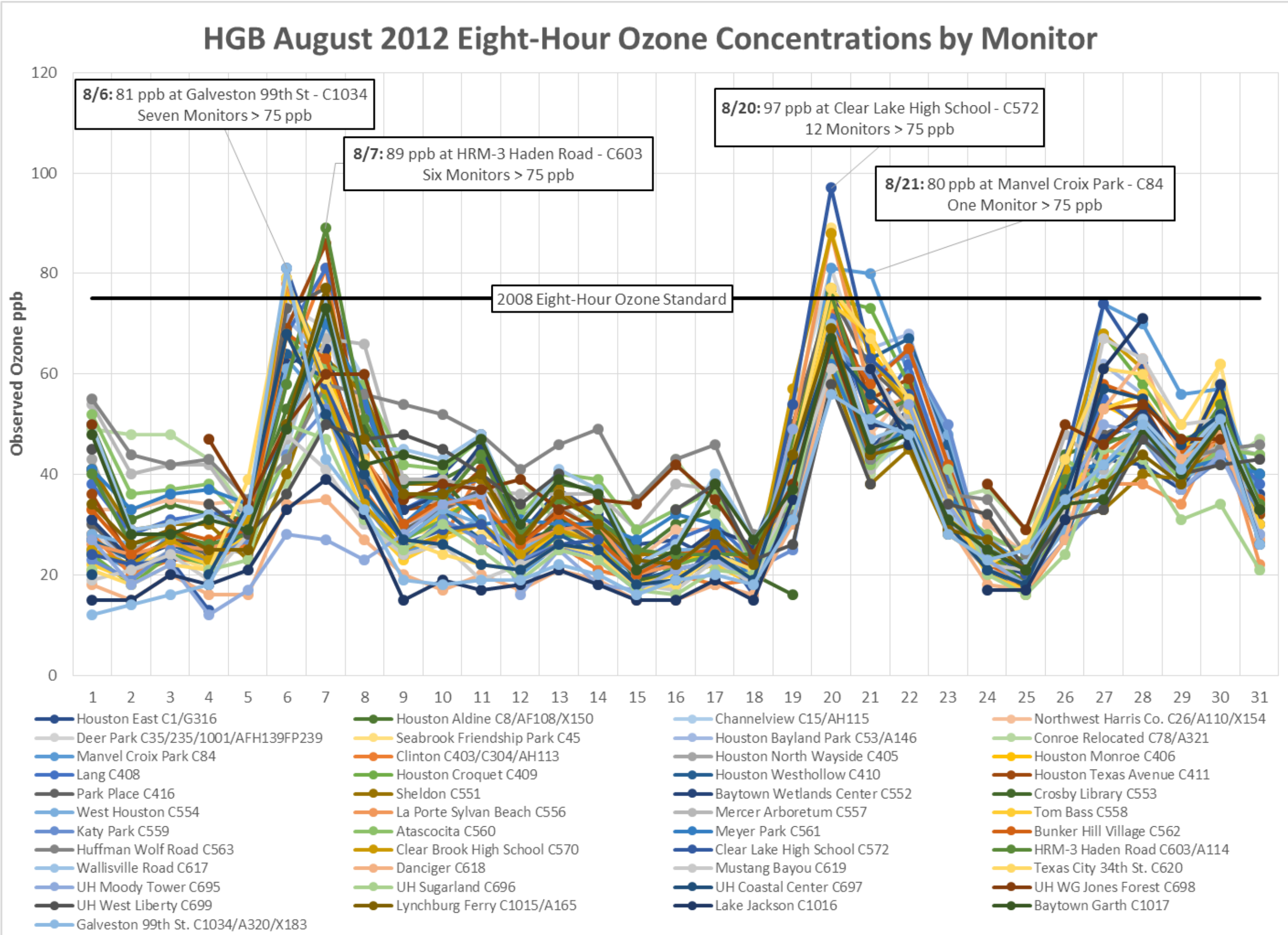


Figure 3-12: August 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors

3.4.3.5 September 2012

September ends the latter bi-modal peak of eight-hour ozone exceedances in the HGB area as shown in Figure 3-2. Seven HGB-area monitors measured exceedances in September 2012, with 87 ppb measured at the Manvel Croix Park (C84) monitor on September 20, 2012 being the highest eight-hour concentration of the month. The high ozone days in September 2012 had only one to three monitors with peak concentrations above 75 ppb as shown in Figure 3-13: *September 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors*. September 20 through September 24 saw five consecutive days with measurements exceeding 75 ppb.

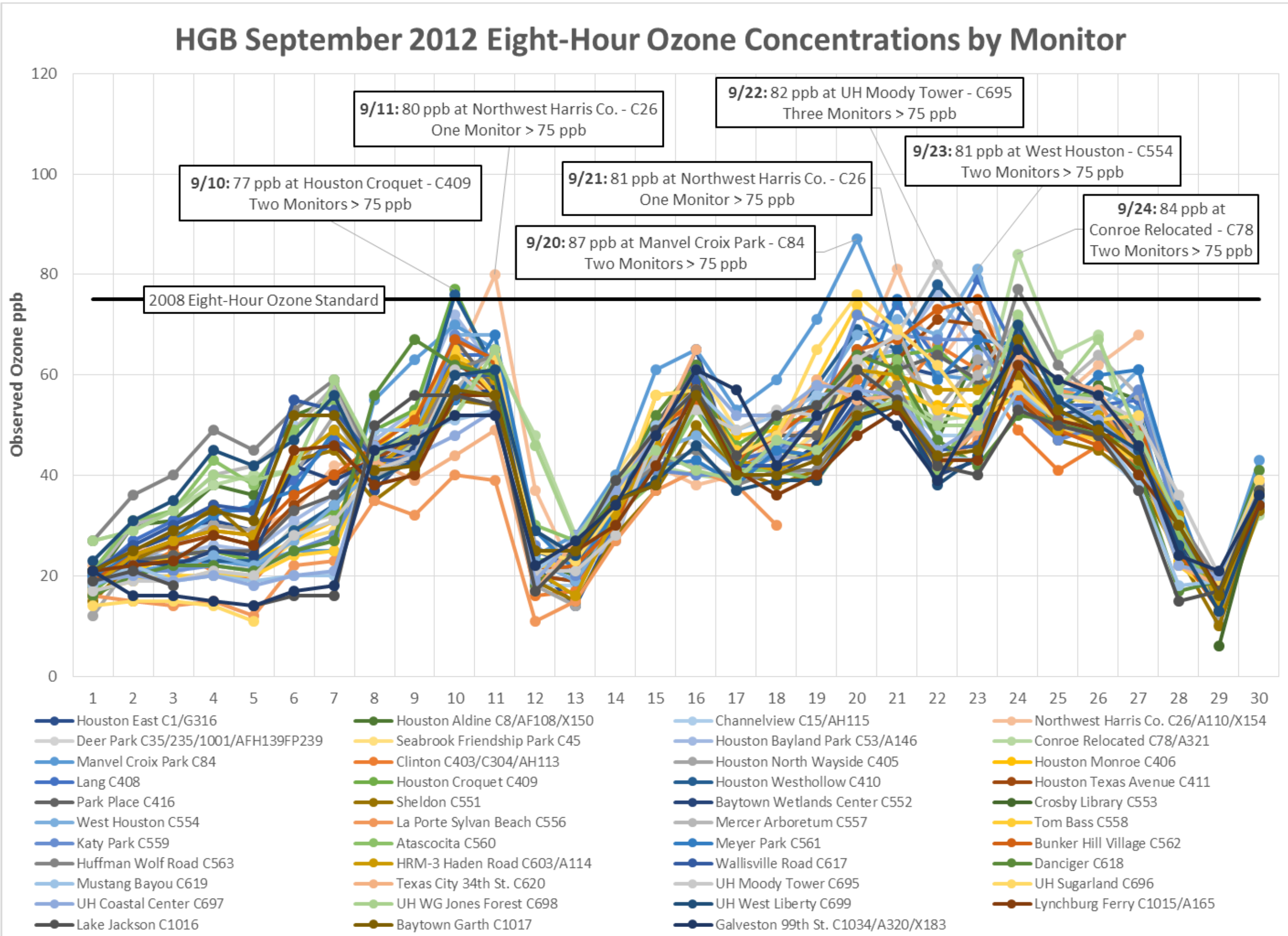


Figure 3-13: September 2012 Maximum Eight-Hour Ozone of Regulatory and Non-Regulatory HGB Monitors

3.5 METEOROLOGICAL MODEL

The TCEQ is using the Weather Research and Forecasting Model (WRF) to create the meteorological inputs for the photochemical model. The WRF model development is driven by a community effort to provide a modeling platform that supports the most recent research and allows testing in forecast environments. WRF was designed to be completely mass conservative and built to allow better flux calculations, both of which are of central importance to the air quality community. WRF is used by Texas universities, the Central Regional Air Planning Association, the EPA, and many other organizations for their respective meteorological modeling platforms.

3.5.1 Modeling Domains

As shown in Figure 3-14: *WRF Modeling Domains*, the meteorological modeling was configured with three nested grids at a resolution of 36 kilometers (km) for North America (na_36km), 12 km for Texas plus portions of surrounding states (sus_12km), and 4 km for the eastern portion of Texas (4 km). The extent of each of the WRF modeling domains was selected to accommodate the embedding of the commensurate air quality modeling domains. Table 3-3: *WRF Modeling Domain Definitions* provides the specific northing and easting parameters for these grid projections.

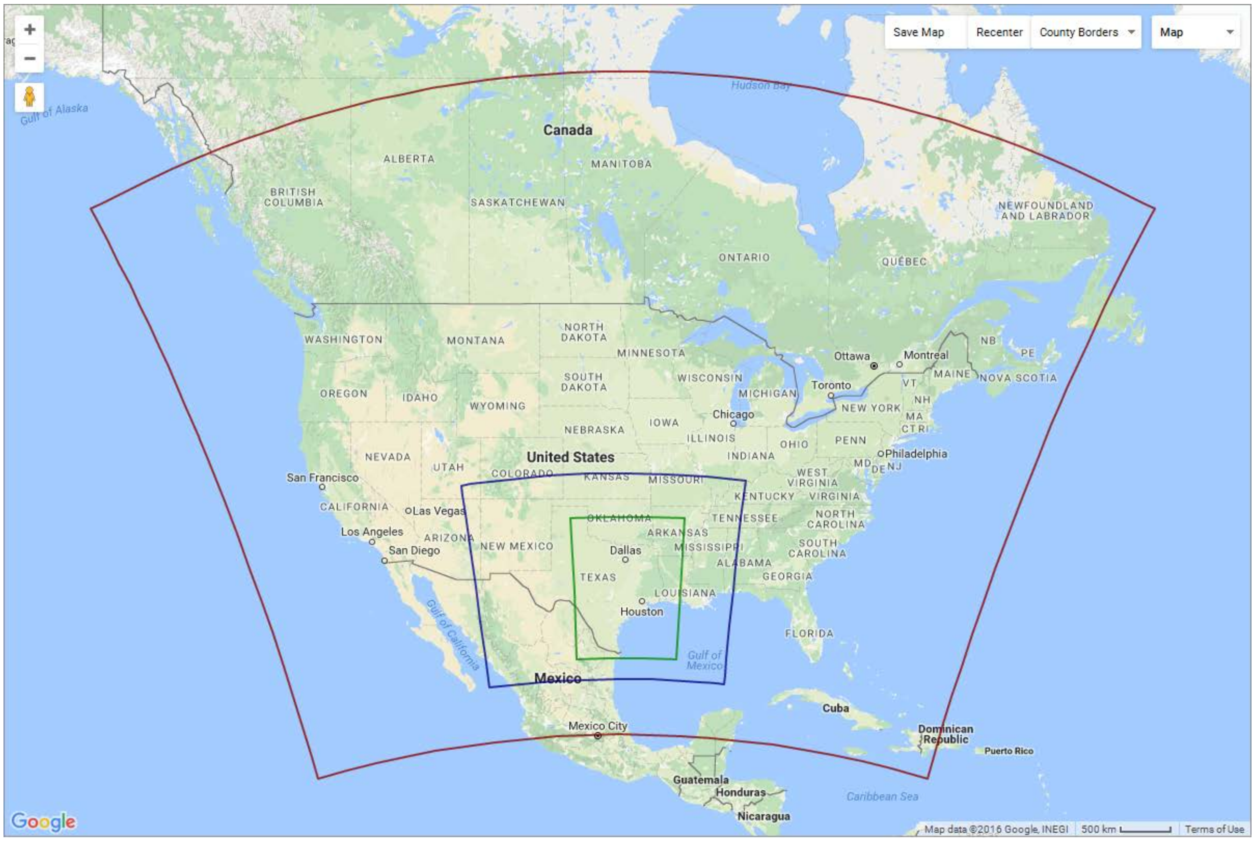


Figure 3-14: WRF Modeling Domains

Table 3-3: WRF Modeling Domain Definitions

Domain	Easting Range (km)	Northing Range (km)	East/West Grid Points	North/South Grid Points	Grid Cell Size (km)
na_36 km	(-2916,2916)	(-2304,2304)	163	129	36
sus_12km	(-1188,900)	(-1800,-144)	175	139	12
tx_4km	(-396,468)	(-1620,-468)	217	289	4

The vertical configuration of the WRF modeling domains consists of a varying 44-layer structure used with the three horizontal domains, as shown in Figure 3-15: *WRF Vertical Layer Structure* and Table 3-4: *WRF Vertical Layer and Sigma Layer Details*. Layers two through 21 are identical to the layers used with the Comprehensive Air Quality Model with Extensions (CAMx), while the other CAMx layers comprise multiple WRF layers.

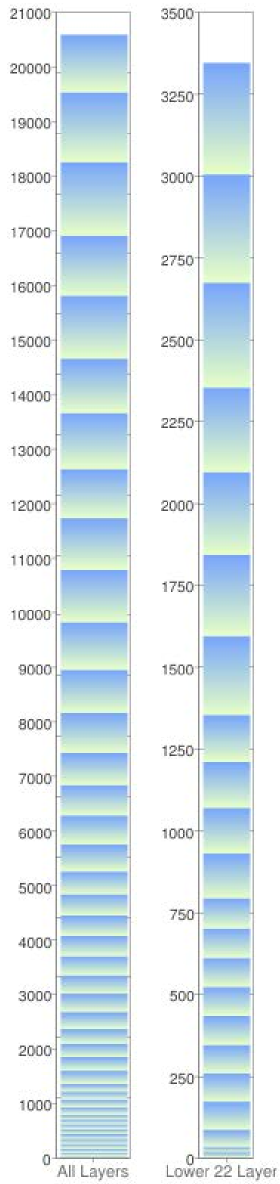


Figure 3-15: WRF Vertical Layer Structure

Table 3-4: WRF Vertical Layer and Sigma Layer Details

WRF Layer	Sigma Level	Top (m AGL)	Center (m AGL)	Thickness (m)
44	0.000	20581	20054	1054
43	0.010	19527	18888	1278
42	0.025	18249	17573	1353
41	0.045	16896	16344	1103
40	0.065	15793	15215	1156
39	0.090	14637	14144	987
38	0.115	13650	13136	1029
37	0.145	12621	12168	906
36	0.175	11716	11245	941
35	0.210	10774	10294	962
34	0.250	9813	9379	867
33	0.290	8946	8550	792
32	0.330	8154	7790	729
31	0.370	7425	7128	594
30	0.405	6830	6551	559
29	0.440	6271	6007	528
28	0.475	5743	5492	501
27	0.510	5242	5037	410
26	0.540	4832	4636	393
25	0.570	4439	4250	378
24	0.600	4061	3878	365
23	0.630	3696	3520	352
22	0.660	3344	3173	341
21	0.690	3003	2838	330
20	0.720	2673	2513	320
19	0.750	2353	2224	259
18	0.775	2094	1967	253
17	0.800	1841	1717	247
16	0.825	1593	1472	242
15	0.850	1352	1280	143
14	0.865	1209	1138	141
13	0.880	1068	999	139
12	0.895	929	860	137
11	0.910	792	746	91
10	0.920	701	656	90
9	0.930	611	566	89
8	0.940	522	477	89
7	0.950	433	389	88
6	0.960	345	301	87
5	0.970	258	214	87
4	0.980	171	128	86
3	0.990	85	60	51
2	0.996	34	26	17
1	0.998	17	8	17
0	1.000	0	0	0

3.5.2 Meteorological Model Configuration

The selection of the final meteorological modeling configuration for the May through September 2012 episode resulted from numerous sensitivity tests and model performance evaluation. The preparation of WRF input files involves the execution of different models within the Weather Research and Forecasting Model Preprocessing System (WPS). Analysis nudging files are generated as part of WPS preparation of WRF input and boundary condition files. Observational nudging files with radar profiler data were developed separately by the TCEQ.

For optimal photochemical model performance, low-level wind speed and direction are of greater importance than surface temperature. Wind speed and direction determine the placement of emissions while temperature has a minor contribution to ozone formation reactions. Additional meteorological features of critical importance for air quality modeling include cloud coverage and the strength and depth of the planetary boundary layer (PBL). Observational nudging using radar profiler data and one-hour surface analysis nudging improved wind performance. Using the Pleim-Xiu Land-Surface Model improved the representation of precipitation, temperature, vertical mixing, and PBL depths.

WRF output was post-processed using the WRFCAMx version 4.3 utility to convert the WRF meteorological fields to the appropriate CAMx grid and input format. The WRFCAMx now generates several alternative vertical diffusivity (Kv) files based upon multiple methodologies for estimating mixing given the same WRF meteorological fields. The Community Multi-Scale Air Quality modeling system Kv option was used to create the meteorological input for the 2012 CAMx runs. The vertical diffusivity coefficients were modified on a land-use basis to maintain vertical mixing within the first 100 meters of the model overnight using the KVPATCH program (Ramboll Environ, 2012). The diagnosis of sub-grid stratiform clouds was turned on for the 36 km and 12 km domains.

The TCEQ improved the performance of WRF through a series of sensitivities. The final WRF parameterization schemes and options selected are shown in Table 3-5: *WRF Model Configuration Parameters*. The selection of these schemes and options was based on extensive testing of model configurations that built upon experience from previous SIP revisions and other modeling exercises. Among all the meteorological variables that can be validated, minimizing wind speed bias was the highest priority for model performance consideration.

Table 3-5: WRF Model Configuration Parameters

Domain	Nudging Type	PBL	Cumulus	Radiation	Land-Surface	Microphysics
36 km and 12 km	3-D Analysis, and Observations	YSU	Multi-scale Kain-Fritsch	RRTM / Dudhia *	Pleim-Xiu	WSM5 †
4 km	3-D, Surface Analysis, Soil, and Observations	YSU	Multi-scale Kain-Fritsch	RRTM / Dudhia *	Pleim-Xiu	WSM6 †

* RRTM = Rapid Radiative Transfer Model
† WSM6 = WRF Single-Moment 5 or 6-Class Microphysics Scheme

3.5.3 WRF Performance Evaluation

The WRF modeling was evaluated by comparing the hourly modeled and measured wind speed, wind direction, and temperature for all monitors in the HGB area. Figure 3-16: *2012 HGB Area Average WRF Modeling Performance* exhibits the percent of hours for which the average absolute difference between the modeled and measured wind speed and direction was within the specified accuracy benchmarks for the average of HGB area monitors by 2012 episode month. These benchmarks are less than 30 degrees for wind direction, less than 2 meters per second (m/s) for wind speed, and less than 2 degrees Fahrenheit for temperature.

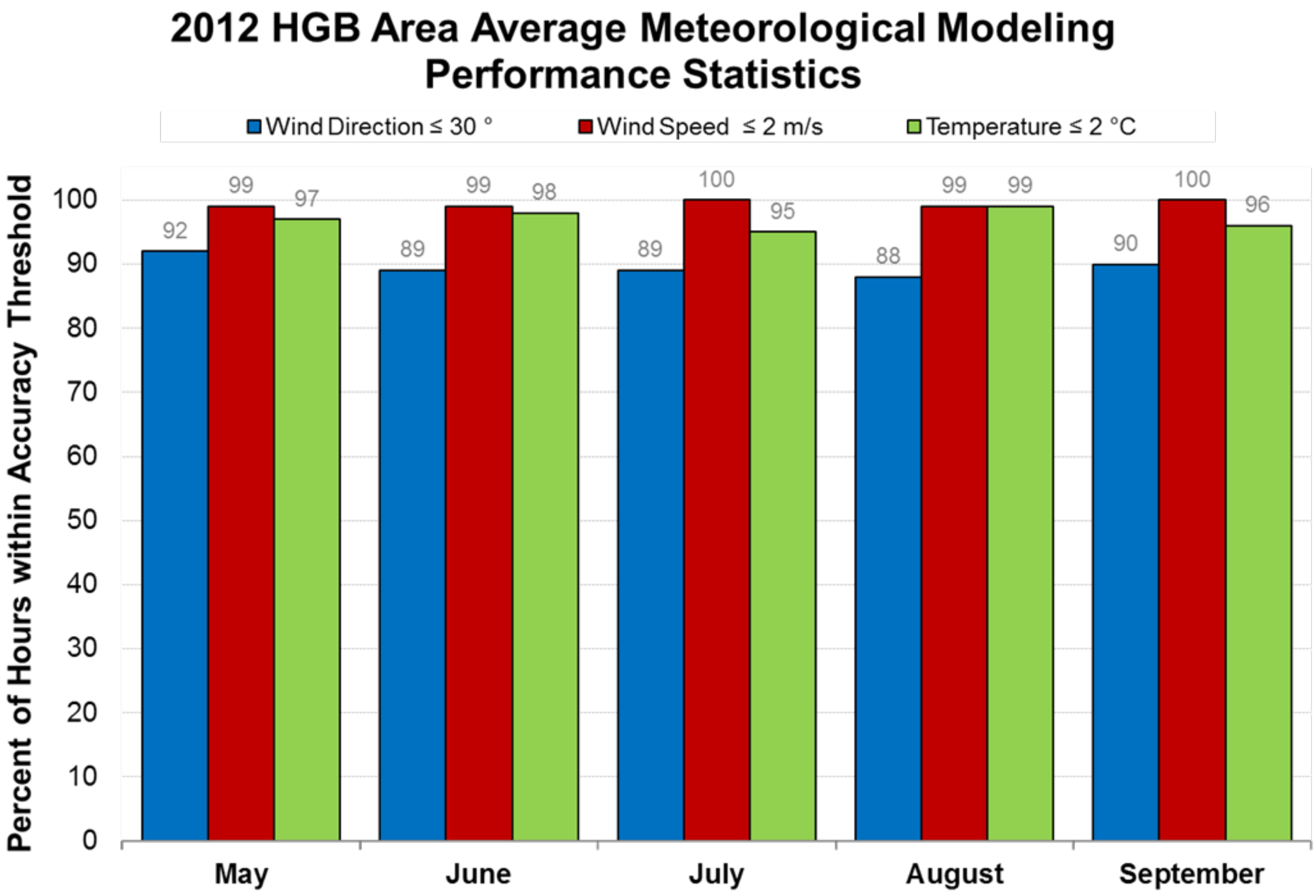


Figure 3-16: 2012 HGB Area Average WRF Modeling Performance

As Figure 3-16 shows, WRF performed well for wind speed, wind direction, and temperature for the HGB area. As noted above, the WRF configuration was selected for optimal performance on low-level wind speed since this meteorological variable strongly affects CAMx performance. Wind speed performance was excellent at the individual monitors, but observed wind direction is less accurate when wind speeds are low, a condition often observed during ozone exceedances. Table 3-6: *WRF Meteorological Modeling Percent Accuracy by 2012 Month for the HGB Area* provides an additional evaluation of WRF predictions to stricter benchmarks (Emery et al., 2001). The model's ability to replicate wind direction and speed within 20 degrees and 1 m/s on average enhances the confidence in this modeling setup.

Table 3-6: WRF Meteorological Modeling Percent Accuracy by 2012 Month for the HGB Area

2012 Month for HGB Area Average	Wind Direction (˚) Error ≤ 30 / 20 / 10	Wind Speed (m/s) Error ≤ 2 / 1 / 0.5	Temperature (˚C) Error ≤ 2 / 1 / 0.5
May	92 / 83 / 55	99 / 81 / 56	97 / 80 / 41
June	89 / 78 / 54	99 / 87 / 59	98 / 81 / 54
July	89 / 80 / 55	100 / 93 / 69	95 / 82 / 52
August	88 / 82 / 62	99 / 91 / 65	99 / 86 / 62
September	90 / 83 / 60	100 / 93 / 64	96 / 77 / 47

Appendix A: *Meteorological Modeling for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard* provides additional detail on the development and model performance evaluation of the meteorological modeling for the May through September 2012 period.

3.6 MODELING EMISSIONS

For the stationary emission source types, which consist of point and area sources, routine emission inventories provided the major inputs for the emissions modeling processing. Emissions from mobile and biogenic sources were derived from relevant emission models. Specifically, on-road mobile source emissions were derived from vehicle miles traveled (VMT) activity output coupled with emission rates from the EPA Motor Vehicle Emission Simulator (MOVES) model. Non-road mobile source emissions were derived from the Texas NONROAD (TexN) model and EPA's National Mobile Inventory Model (NMIM). The point, area, on-road, non-road, and off-road emission estimates were processed to air quality model-ready format using version three of the Emissions Processing System (EPS3; Ramboll Environ, 2015). Biogenic emissions were derived from version 3.61 of the Biogenic Emission Inventory System (BEIS; Bash et al, 2016).

An overview is provided below of the emission inputs used for the 2012 base case, 2012 baseline, and 2017 future case. Appendix B: *Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard* contains more detail on the development and processing of the emissions. Table 3 7: *Emissions Processing Modules* summarizes many of the steps taken to prepare chemically speciated, temporally allocated, and spatially distributed emission files needed for the air quality model.

Table 3-7: Emissions Processing Modules

EPS3 Module	Description
PREAM	Prepare area and non-link based area and mobile sources emissions for further processing
LBASE	Spatially allocate link-based mobile source emissions among grid cells
PREPNT	Group point source emissions into elevated and low-level categories for further processing
CNTLEM	Apply controls to model strategies, apply adjustments, make projections, etc.
TMPRL	Apply temporal profiles to allocate emissions by day type and hour
SPCEMS	Chemically speciate emissions into nitrogen oxide (NO), nitrogen dioxide (NO_2), and various Carbon Bond 6 (CB6) VOC species
GRDEM	Spatially distribute emissions by grid cell using source category surrogates
MRGUAM	Merge and adjust multiple gridded files for model-ready input
PIGEMS	Assign Plume-in-Grid (PiG) emissions and merges elevated point source files

Model-ready emissions were developed for the May through September 2012 period. Due to the compressed schedule required for this HGB AD SIP revision, the proposal included preliminary modeling emissions estimates for some source categories that have been updated for the adoption. For the 2012 base case, both the area and on-road source categories were updated from proposal to adoption. For the 2017 future case, modeling emissions estimates were updated for the area, marine, oil and gas production, on-road, and point source categories.

The following sections give a brief description of the development of each emissions source category.

3.6.1 Biogenic Emissions

The TCEQ used version 3.61 of the BEIS (Bash et al., 2016) within the Sparse Matrix Operation Kernel Emissions (SMOKE) System version 3.7 (available at https://www.cmascenter.org/smoke/). BEIS inputs from SMOKE defaults include the emissions factors input file (b360fac_beld4_csv_nlcd2006.txt) and the CB05 VOC speciation profiles (gspro.cmaq_cb05_soa.txt). The Biogenic Emission Landuse Database version 4.1 (BELD4.1) from EPA Modeling Platform 2011v6_v3 was re-gridded with the Spatial Allocator to create the grid-specific (rpo_36km, tx_12km, and tx_4km) land-use input files.

The WRF model provided the meteorological data needed to run the BEIS model for each 2012 episode day. Since biogenic emissions are dependent upon the meteorological conditions on a given day, the same episode-specific emissions were used in the 2012 baseline and 2017 future case modeling scenarios. The summaries of biogenic emissions for each day of the May through September 2012 episode are provided in Appendix B. Figure 3-17: *Sample Biogenic VOC Emissions for June 26, 2012 Episode Day* provides a graphical plot of biogenic VOC emissions distribution at a resolution of 4 km throughout eastern Texas.

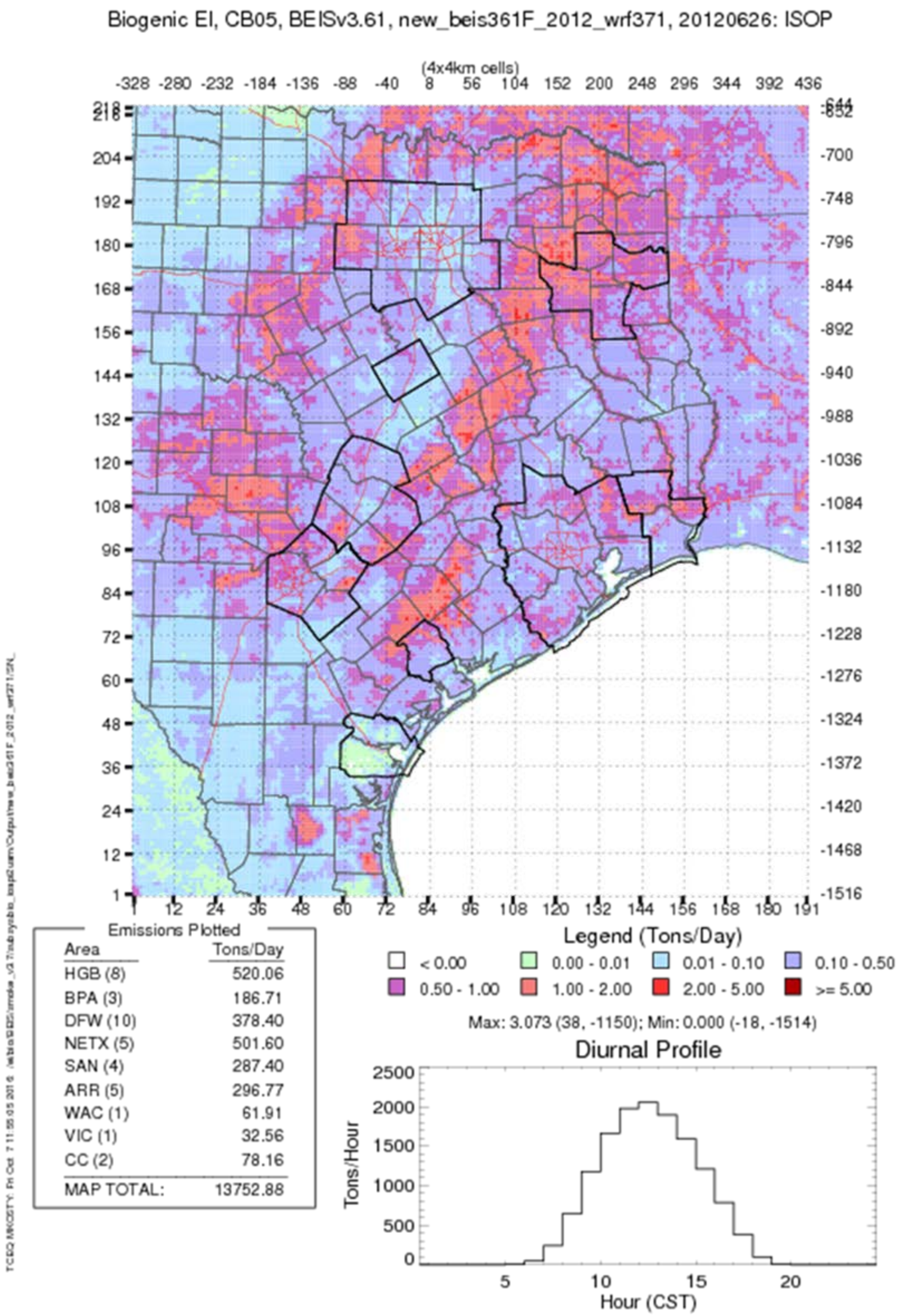


Figure 3-17: Sample Biogenic VOC Emissions for June 26, 2012 Episode Day

3.6.2 2012 Base Case Emissions

3.6.2.1 Point Sources

Point source modeling emissions were developed from regional inventories such as EPA's 2011 Modeling Platform, EPA's Air Markets Program Database (AMPD), state inventories including the State of Texas Air Reporting System (STARS), and local inventories. Data were processed with EPS3 to generate model-ready emissions.

Outside Texas

Point source emissions data for the regions of the modeling domains outside of Texas were obtained from a number of different sources. Emissions from point sources in the Gulf of Mexico (e.g., oil and gas production platforms) were obtained from the 2011 Gulf-Wide Emissions Inventory provided by the U.S. Bureau of Ocean Energy Management. Canadian emissions were obtained from the 2006 National Pollutant Release Inventory from Environment Canada, while Mexican emissions data were interpolated from EPA's 2011 Modeling Platform (EPA, 2015). For the non-Texas U.S. portion of the modeling domain, hourly NO_X emissions for major electric generating units (EGUs) were obtained from the AMPD for each hour of each base case episode day. Emissions for non-EGU sources in states beyond Texas were obtained from the EPA's 2011 Modeling Platform.

Within Texas

Hourly NO_X emissions from EGUs within Texas were obtained from the AMPD for each base case episode day. Emissions from non-EGU sources were obtained from the STARS database for the year 2012. In addition, agricultural and forest fire emissions for 2012 were created from the Fire Inventory from the National Center for Atmospheric Research, or FINN model. Fires are treated as point sources.

Table 3-8: *2012 Sample Base Case Point Source Emissions for Eight-County HGB* provides a summary of the HGB area point source emissions for the Tuesday, August 7, 2012 episode day. The EGU emissions vary each hour of each episode day based on real-time continuous emissions monitoring data that are reported to the EPA's AMPD. Emission estimates for the remaining non-EGU point sources do not vary by specific episode day, but are averaged by month for the May through September 2012 period.

Table 3-8: 2012 Sample Base Case Point Source Emissions for Eight-County HGB

HGB Point Source Category	NO_X tons per day (tpd)	VOC (tpd)	CO (tpd)
Point – EGUs on August 7, 2012	45.98	4.90	54.67
Point – non-EGUs	69.76	130.68	65.16
HGB Point Source Total	115.74	135.58	119.83

3.6.2.2 On-Road Mobile Sources

The 2012 on-road mobile source emission inputs were developed using the 2014 version of the MOVES model (MOVES2014). The VMT activity data sets that were used for these efforts are:

- travel demand model (TDM) output from the Houston-Galveston Area Council (H-GAC) for the eight-county HGB area;

- the Highway Performance Monitoring System (HPMS) data collected by the Texas Department of Transportation (TxDOT) for the 246 non-HGB Texas counties; and
- the EPA default information included with the MOVES2014 database for the non-Texas U.S. portions of the modeling domain.

The output from these emission modeling applications were processed through EPS3 to generate the on-road speciated and gridded inputs for photochemical modeling applications.

HGB Area

For the eight-county HGB area, the on-road emissions were developed by the Texas Transportation Institute (TTI) using 2012 TDM VMT estimates and MOVES2014 emission rates to generate average school and summer season on-road emissions for four day types of Monday-Thursday average weekday, Friday, Saturday, and Sunday.

Non-HGB Portions of Texas

For the 246 non-HGB Texas counties, on-road emissions were developed by TTI using MOVES2014 emission rates and 2012 HPMS VMT estimates. Average school and summer season emissions by vehicle type and roadway type were estimated for the four day types of Monday-Thursday average weekday, Friday, Saturday, and Sunday.

Outside Texas

For the non-Texas U.S. portions of the modeling domain, the TCEQ used MOVES2014 in default mode to generate 2012 July weekday emission estimates for every non-Texas U.S. county. To create the non-Texas Friday, Saturday, and Sunday day types for the summer and school seasons, the 2012 Texas on-road temporal profiles were applied to the non-Texas 2012 summer weekday emissions. For the Canada portion of the modeling domain, a 2006 on-road inventory was projected to 2012 based on 2% annual VMT growth and the relative change in emission rates from 2006 to 2012 as estimated by the MOBILE6-Canada model. For the Mexico portion of the modeling domain, a 1999 on-road inventory was projected to 2012 based on 2% annual VMT growth and the relative change in emission rates from 1999 to 2012 as estimated by the MOBILE6-Mexico model.

Table 3-9: *Summary of On-Road Mobile Source Emissions Development* contains additional detail about the on-road mobile inventory development in different regions of the modeling domain.

Table 3-9: Summary of On-Road Mobile Source Emissions Development

On-Road Inventory Development Parameter	HGB	Non-HGB Texas	Non-Texas States/Counties
VMT Source and Resolution	TDM Roadway Links	HPMS Data Sets 19 Roadway Types	MOVES2014 12 Roadway Types
Season Types	School and Summer Seasons	School and Summer Seasons	Summer Season Adjusted to School
Day Types	Weekday, Friday, Saturday, and Sunday	Weekday, Friday, Saturday, and Sunday	Weekday Adjusted to Friday, Saturday, and Sunday
Roadway Speed Distribution	Varies by Hour and Roadway Type	Varies by Hour and Roadway Type	MOVES2014 Default
MOVES Fuel and Source Use Types	Gasoline and Diesel 13 Source Use Types	Gasoline and Diesel 13 Source Use Types	Gasoline and Diesel 13 Source Use Types

Table 3-10: *2012 Base Case On-Road Modeling Emissions for Eight-County HGB* summarizes the on-road mobile source emission estimates for the 2012 base case episode for the eight-county HGB area for all combinations of season and day type. The summer season on-road inventories presented in Table 3-10 were used for modeling episode days from June 1 through August 26, 2012, while the school season inventories were used for modeling episode days from May 1 through May 31, 2012 and August 27 through September 30, 2012.

Table 3-10: 2012 Base Case On-Road Modeling Emissions for Eight-County HGB

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Summer Weekday	157.09	73.60	835.49
Summer Friday	165.13	75.77	893.23
Summer Saturday	124.76	64.38	716.55
Summer Sunday	102.52	60.26	622.00
School Weekday	157.61	73.74	838.96
School Friday	166.41	76.10	901.30
School Saturday	123.47	64.17	711.73
School Sunday	101.51	60.10	618.31

3.6.2.3 Non-Road and Off-Road Mobile Sources

Non-road mobile sources include vehicles, engines, and equipment used for construction, agriculture, transportation, recreation, and many other purposes. Off-road mobile sources include aircraft, locomotives, and commercial marine vessels. Non-road and off-road mobile source modeling emissions were developed using TexN for non-road emissions within Texas, NMIM for non-road emissions outside of Texas, the EPA's NEI databases, and data sets from the TCEQ Texas Air Emissions Repository (TexAER). The output from these emission modeling applications and databases were processed through EPS3 to generate the air quality model-ready emission files for non-road and off-road sources.

Outside Texas

For the non-Texas U.S. portion of the modeling domains, the TCEQ used the EPA's NMIM to generate average summer weekday non-road mobile source emissions by county and ran it specifically for 2012. For the off-road categories of aircraft, locomotive, and commercial marine, the TCEQ used the EPA's 2011 NEI to create 2012 average summer weekday off-road emissions for the non-Texas U.S. portions of the modeling domain. Summer weekend day emissions for the non-road and off-road mobile source categories were developed as part of the EPS3 processing using temporal profiles specific to each source category.

Within Texas

The TCEQ used the TexN model to generate average summer weekday non-road mobile source category emissions by county for 2012. Airport ground support equipment (GSE) and oil and gas drilling rig emissions were estimated separately as detailed below. During EPS3 processing, temporal adjustments were made to create Saturday and Sunday non-road emission estimates. Table 3-11: *2012 Base Case Non-Road Modeling Emissions for Eight-County HGB* summarizes these non-road inputs by day type. The non-road emission estimates in Table 3-11 were developed with version 1.7.1 of TexN.

Table 3-11: 2012 Base Case Non-Road Modeling Emissions for Eight-County HGB

Ozone Season Day Type	NO_x (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	50.78	40.11	518.13
Saturday	37.69	77.62	678.12
Sunday	28.07	71.67	590.95

Airport emission inventories were developed with the Federal Aviation Administration (FAA) Emissions Dispersion Modeling System (EDMS) under contract to Eastern Research Group (ERG, 2016). The EDMS model was used instead of the Aviation Environmental Design Tool (AEDT) version 2b as work started prior to May 29, 2015, the effective date of AEDT 2b. EDMS outputs emission estimates for aircraft engines, auxiliary power units (APUs), and GSE. The HGB eight-county area airport emissions are summarized in Table 3-12: *2012 Base Case Airport Modeling Emissions for Eight-County HGB*.

Table 3-12: 2012 Base Case Airport Modeling Emissions for Eight-County HGB

HGB Area Airport	NO_x (tpd)	VOC (tpd)	CO (tpd)
George Bush Intercontinental	4.69	1.24	8.58
Houston Hobby	1.48	0.41	2.44
Other 268 Airports	0.27	0.47	8.92
HGB Airport Total	6.44	2.12	19.94

The 2012 locomotive emission estimates were developed under contract to ERG (ERG, 2015a). Emissions were estimated separately for Class I line-haul locomotives, Class II and III line-haul locomotives, and railyard switcher locomotives. Table 3-13: *2012 Base Case Locomotive Modeling Emissions for Eight-County HGB* summarizes the estimates for all locomotive activity in HGB.

Table 3-13: 2012 Base Case Locomotive Modeling Emissions for Eight-County HGB

Locomotive Source Classification	NO_x (tpd)	VOC (tpd)	CO (tpd)
Line-Haul Locomotives - Class I	11.97	0.74	2.65
Line-Haul Locomotives - Classes II and III	0.29	0.02	0.03
Rail Yard Switcher Locomotives	3.09	0.23	0.45
HGB Locomotive Total	15.35	0.99	3.13

The 2012 commercial marine emission estimates were developed under contract to Ramboll Environ (Ramboll Environ, 2010). The 2007 commercial marine emission estimates were projected to 2012 based on expected growth and changes in emission rates. The HGB eight-county area commercial marine emissions are summarized in Table 3-14: *2012 Base Case Commercial Marine Modeling Emissions for Eight-County HGB*.

Table 3-14: 2012 Base Case Commercial Marine Modeling Emissions for Eight-County HGB

Commercial Marine Source Classification	NO_x (tpd)	VOC (tpd)	CO (tpd)
Chemical Tanker	8.75	0.43	0.92
Tow Boat	5.05	0.22	1.60
Crude Tanker	2.95	0.15	0.31
General Cargo	2.16	0.10	0.22
Container Ship	2.07	0.14	0.26
Bulk	1.63	0.08	0.17
LNG/LPG Tanker	1.29	0.05	0.13
Ocean Towing	0.78	0.04	0.08
Dredging	0.70	0.03	0.25
Auto Carrier	0.68	0.03	0.07
Refrigerated Cargo	0.38	0.01	0.04
Other Tanker	0.37	0.02	0.04
Tug Barge	0.31	0.02	0.04
Cruise Ship	0.27	0.01	0.03
Harbor Vessel	0.20	0.01	0.04
Miscellaneous	0.13	0.01	0.01
Assist Tug	0.02	<0.01	0.01
HGB Commercial Marine Total	27.74	1.35	4.22

3.6.2.4 Area Sources

Area source modeling emissions were developed using the EPA's 2011 NEI and the TCEQ's TexAER database. The emissions information in these databases was processed through EPS3 to generate the air quality model-ready area source emission files.

Outside Texas

For the non-Texas U.S. portions of the modeling domain, the TCEQ projected the EPA's 2011 NEI to create 2012 daily area source emissions.

Within Texas

The TCEQ obtained emissions data from the 2011 TexAER database (TCEQ, 2011) and forecast these estimates to 2012 using Texas-specific economic growth factors for non-oil and gas sources. Temporal profiles were applied with EPS3 to obtain the figures presented in Table 3-15: *2012 Base Case Non-Oil and Gas Area Source Emissions for Eight-County HGB*.

Table 3-15: 2012 Base Case Non-Oil and Gas Area Source Emissions for Eight-County HGB

Ozone Season Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	19.28	277.97	96.73
Saturday	13.75	162.69	56.16
Sunday	8.24	113.70	16.41

The 2012 oil and gas drilling and production emissions were based on contract research projects by ERG (ERG, 2010; ERG, 2011; ERG, 2015) using activity data from the Railroad Commission of Texas (RRC) and emission factors compiled in the 2010 and 2015b ERG studies. Drilling rigs are non-road sources but are reported here with oil and gas production sources. Emission estimates by equipment type are summarized in Table 3-16: *2012 Base Case Oil and Gas Drilling and Production Emissions for Eight-County HGB*.

Table 3-16: 2012 Base Case Oil and Gas Drilling and Production Emissions for Eight-County HGB

Equipment Category	NO_X (tpd)	VOC (tpd)	CO (tpd)
Drilling Rigs	0.81	0.06	0.26
Production (Non-Point Source)	2.09	66.60	2.78
HGB Oil and Gas Total	2.90	66.66	3.04

3.6.2.5 Base Case Summary

Typical base case weekday emissions in the eight-county HGB area are summarized by source type in Table 3-17: *2012 Sample Base Case Anthropogenic Emissions for Eight-County HGB*. The EGU emissions presented in the table below are specific to the August 7, 2012 episode day, and are different for each of the remaining 152 episode days from May through September 2012.

Table 3-17: 2012 Sample Base Case Anthropogenic Emissions for Eight-County HGB

HGB Emission Source Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
On-Road (Summer Weekday)	157.09	73.60	835.49
Non-Road	50.78	40.11	518.13
Non-Road Oil and Gas Drilling	0.81	0.06	0.26
Off-Road - Airports	6.44	2.12	19.94
Off-Road - Locomotives	15.35	0.99	3.13
Off-Road - Commercial Marine	27.74	1.35	4.22
Area (Non-Oil and Gas)	19.28	277.97	96.73
Area - Oil and Gas Production	2.09	66.60	2.78
Point - EGUs (August 7, 2012 Episode Day)	45.98	4.90	54.67
Point - Non-EGUs (Ozone Season Average)	69.76	130.68	65.16
HGB Total	395.32	598.38	1,600.51

3.6.3 2012 Baseline Emissions

The baseline modeling emissions are based on typical ozone season emissions, except for biogenic emissions, whereas the base case modeling emissions are episode day-specific. The biogenic emissions, dependent on the day-specific meteorology, are an exception in that the same episode day-specific emissions are used in both the 2012 base case and baseline. The 2012 baseline emissions for on-road, non-road, off-road, oil and gas, and area sources are the same as used for the 2012 base case episode, since they are based on typical ozone season emissions. The EGU emissions were represented by monthly averages of the 2012 hourly AMPD emissions to reflect EGU emissions throughout the ozone season. Unlike the base case, fire emissions were not included in the 2012 baseline as they are not typical ozone season day emissions.

Table 3-18: *2012 August Baseline Anthropogenic Emissions for Eight-County HGB* provides the baseline emissions for an average August weekday. The only difference between Table 3-17 and Table 3-18 is that the former has episode day-specific EGU emissions.

Table 3-18: 2012 August Baseline Anthropogenic Emissions for Eight-County HGB

HGB Emission Source Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
On-Road	157.09	73.60	835.49
Non-Road	50.78	40.11	518.13
Non-Road - Oil and Gas Drilling	0.81	0.06	0.26
Off-Road - Airports	6.44	2.12	19.94
Off-Road - Locomotives	15.35	0.99	3.13
Off-Road - Commercial Marine	27.74	1.35	4.22
Area (Non-Oil and Gas)	19.28	277.97	96.73
Area - Oil and Gas Production	2.09	66.60	2.78
Point - EGUs (August Average)	36.49	3.91	40.27
Point - Non-EGUs (Ozone Season Average)	69.76	130.68	65.16
HGB Total	385.83	597.39	1,586.11

A summary of the 2012 point source baseline emissions by Standard Industrial Classification (SIC) within the eight-county HGB nonattainment area is provided in Table 3-19: *2012 HGB Point Source Baseline Emission Estimates by Industry Type*. The 515 HGB point source facilities operating in 2012 were represented by 89 different SIC types. Ten of these industry types emitted more than 1.0 NO_x tpd in 2012, with 79 other SICs reporting smaller emissions. The Industrial Organic Chemicals, Electric Services, and Petroleum Refining SICs reported the majority of NO_x and VOC emissions.

Table 3-19: 2012 HGB Point Source Baseline Emission Estimates by Industry Type

SIC Code	SIC Description	NO_x (tpd)	VOC (tpd)	CO (tpd)
2869	Industrial Organic Chemicals, Not Elsewhere Classified	33.88	39.46	26.10
4911	Electric Services	32.81	3.54	39.19
2911	Petroleum Refining	22.16	31.14	16.87
2813	Industrial Gases	2.50	0.69	3.98
4931	Electric and Other Services Combined	2.39	0.41	1.91
1321	Natural Gas Liquids	1.78	3.38	2.09
1311	Crude Petroleum and Natural Gas	1.30	9.00	2.18
2819	Industrial Inorganic Chemicals	1.08	0.86	0.68
2821	Plastic Materials and Resins	1.05	7.31	2.65
2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments	1.03	0.48	0.31
	Remaining 79 SICs less than 1.0 NO_x tpd	6.27	38.32	9.47
	HGB Point Source Total (89 SICs)	106.25	134.59	105.43

3.6.4 2017 Future Case Emissions

The biogenic emissions used for the 2017 future case modeling are the same episode day-specific emissions used in the base case. In addition, similar to the 2012 baseline, fire emissions were not included in the 2017 future case modeling.

3.6.4.1 Point Sources

Outside Texas

The 2017 non-EGU point source emissions data in Mexico and the non-Texas states were extracted from EPA's 2018 non-Integrated Planning Model (non-EGUs) files from EPA's 2011 Emissions Modeling Platform (EPA, 2014). EPA had not released its 2017 inventory at the time the TCEQ performed this future case modeling. On September 7, 2016, the EPA finalized the Cross-State Air Pollution Rule (CSAPR) Update Rule to address inter-state transport obligations related to the 2008 eight-hour ozone NAAQS. The CSAPR Update Rule finalized more stringent ozone season NO_x emissions state budgets for 22 states (including Texas) that are currently subject to the existing CSAPR ozone season NO_x program, removed three states (North Carolina, South Carolina, and Florida) from the CSAPR ozone season NO_x program, and added a new state (Kansas) to the CSAPR ozone season NO_x program.

For those non-Texas EGUs subject to the CSAPR ozone season NO_x program under the CSAPR Update Rule, the TCEQ applied the 2017 unit allocations finalized under the CSAPR Update Rule. In addition to the CSAPR finalized allocations, the TCEQ added to each unit the one-time conversion of banked 2015 and 2016 CSAPR allowances as allowed under the CSAPR Update Rule. The TCEQ added the converted 2015 and 2016 CSAPR allowances because the total 2015 NO_x ozone season emissions for all states in CSAPR were greater than the 2017 prescribed budgets in the CSAPR Update Rule. It is expected that some units might find it difficult to comply with the 2017 CSAPR budgets in such a short time. More details regarding the 2017 emissions for non-Texas EGU point sources can be found in Section 2.3.4.1 of Appendix B. For the EGU units that are no longer in the ozone season NO_x program but have to still comply with the CSAPR Annual NO_x Program, the 2017 emissions were based on the finalized 2017 annual unit level allocations. For the other non-Texas EGUs, the 2015 AMPD emissions were used for the 2017 future year. For the Gulf of Mexico and Canada portions of the modeling domain, the 2017 point source emissions were the same as the emissions used in the 2012 baseline.

Within Texas

The 2017 future case EGU emission estimates within Texas were based on the 2015 AMPD data and the modeled CSAPR cap of 56,074 NO_x tons for the five-month ozone season of May through September. The modeled cap includes the 2017 state budget of 52,301 NO_x tons prescribed in the CSAPR Update Rule plus 3,773 NO_x tons to account for the one-time conversion of banked 2015 and 2016 CSAPR allowances into 2017 allowances. Future year operational NO_x caps were based on the 2017 unit level allocations from the EPA, published as part of the CSAPR Update Rule, and the modeled cap. More details regarding Texas EGU point sources and CSAPR can be found in Section 2.3.1.1 of Appendix B. Since electricity generation varies based on energy demand (higher emissions during hotter days due to increased demand), operational profiles based on 2015 measurements were used to allocate hourly emissions for ozone season modeling purposes. Assignment of ozone season NO_x emissions to EGUs operational in 2015 resulted in a total less than the 2017 CSAPR unit level allocations. The remaining NO_x was combined with the 1,050 NO_x tons set aside for new units and units located in tribal counties per the CSAPR Update Rule. This NO_x combination was first assigned to the maximum allowable emission levels for newly permitted EGUs, and then spread proportionally among all existing EGUs.

For HGB point sources, the 2017 future year emissions were projected from the 2014 STARS data taking into consideration the effect of all applicable rules and regulations, including the Emissions Banking and Trading Programs (EBT). Specifically, the NO_x emissions of point sources within the eight-county HGB area that are subject to the Mass Emissions Cap and Trade (MECT) Program were limited to the 2017 annual MECT program cap of 39,984.8 tons per year (tpy). In addition, for point sources subject to the MECT program, an additional 1,242.1 tpy of emissions were added to account for the possible use of Discrete Emissions Reduction Credit (DERC) and Mobile Discrete Emission Reduction Credits (MDERC) use for MECT compliance. Similarly, the highly reactive volatile organic compounds (HRVOC) emissions of point sources within Harris County that are subject to the HRVOC Emissions Cap and Trade Program (HECT) were limited to the 2017 HECT program cap of 2,590.3 tpy. In addition to MECT and HECT program caps, certified credits (Emission Reduction Credits (ERC), DERCs, and

MDERCs) available in the TCEQ's public Emission Credit and Discrete Emission Credit Registries (EBT Credit Registry), as of September 16, 2016 were incorporated into the 2017 future year emissions of point sources in HGB. Details regarding these certified banked credits, the methodology for determining the appropriate modelable amount of credits that could be returned to the 2017 airshed, and the methodology used to distribute these emissions are provided in Section 2.3.3.1.2 of Appendix B.

Table 3-20: *2017 HGB Point Source Future Case Emission Projections by Industry* Type provides a summary of the 2017 point source emission projections by SIC. If a specific facility or group of facilities is subject to an emission program cap threshold, then that limit is modeled in the future year even if historical operational levels were lower. For example, the EGUs emitted an average of 36.49 NO_X tpd in August 2012, but the 2017 future year is modeled at the CSAPR caps of 41.95 NO_X tpd for August. This conservative approach of modeling the maximum allowable emission levels ensures that future emissions are not underestimated.

Table 3-20: 2017 HGB Point Source Future Case Emission Projections by Industry Type

SIC Code	SIC Description	NO_X (tpd)	VOC (tpd)	CO (tpd)
2869	Industrial Organic Chemicals, Not Elsewhere Classified	52.97	42.55	26.50
4911	Electric Services	40.05	2.22	43.49
2911	Petroleum Refining	31.01	30.09	20.72
2813	Industrial Gases	3.48	0.60	3.96
4931	Electric and Other Services Combined	2.82	0.15	1.80
4961	Steam and Air Conditioning Supply	2.07	0.07	1.27
1321	Natural Gas Liquids	2.03	4.25	1.65
2821	Plastic Materials and Resins	1.32	9.76	3.32
2819	Industrial Inorganic Chemicals	1.21	0.66	0.76
2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments	1.18	0.63	0.37
2812	Alkalies and Chlorine	1.08	0.22	0.60
1311	Crude Petroleum and Natural Gas	1.06	5.49	1.19
	Remaining 78 SICs Below 1.0 NO_X tpd	5.55	41.18	7.62
	HGB Point Source Total (90 SICs)	145.83	137.87	113.25

SIP Emissions Year and Emission Credit Generation

The EBT rules in 30 Texas Administrative Code §101.300 define SIP emissions as the state's emission inventory (EI) data from the year that was used to develop the projection-base year inventory for the modeling included in the most recent AD SIP revision. Currently for the HGB area, SIP emissions for credit generation projects use the state's 2007 EI data for EGUs with emissions recorded in the EPA's AMPD and the 2006 EI data for all other stationary point sources (non-EGUs). This HGB AD SIP revision would revise the SIP emissions years used for credit generation from 2007 to 2015 for EGUs and 2006 to 2014 for non-EGUs.

Potential Emission Credit Modeling Sensitivity

To determine the impacts of potential ERCs (reductions that may have already occurred but not yet certified) on the 2017 HGB DV_Fs, an additional 1,317.4 tpy of NO_X and 2,851.6 tpy of VOC reductions were modeled as future growth on non-EGU point sources that are not subject to the MECT or HECT programs. The potential ERCs were modeled in addition to the certified ERCs extracted from the EBT Credit Registry on September 16, 2016. Using the same procedure as certified ERCs, the potential ERCs were converted from tpy to tpd taking into consideration the 1.3:1 offset ratio in the HGB nonattainment area at the time of the extract. The addition of the potential ERCs to future emissions resulted in a 0.09 ppb increase to the maximum 2017 DV_F (79.41 ppb to 79.50 ppb at the Manvel Croix Park monitor). The DV_F increased across all monitors with the maximum increase of 0.15 ppb at the Clinton monitor. After rounding and truncation, the DV_F of the potential ERC sensitivity remains at 79 ppb. Additional details on the potential ERC sensitivity development is provided in Section 2.4 of Appendix B.

3.6.4.2 On-Road Mobile Sources

The 2017 on-road mobile source emission inputs were developed using MOVES2014 and MOVES2014a in combination with the following vehicle activity data sets:

- TDM output from H-GAC for the eight-county HGB area;
- HPMS data collected by TxDOT for the 246 non-HGB counties; and
- EPA default information included with the MOVES2014 database for the non-Texas U.S. portions of the modeling domain.

The output from these emission modeling applications was processed through EPS3 to generate the on-road speciated and gridded inputs for photochemical modeling applications.

HGB Area

For the eight-county HGB area, the on-road emissions were developed by TTI using 2017 TDM VMT estimates from H-GAC and MOVES2014a emission rates to generate average school and summer season on-road emissions for the four day types of Monday-Thursday average weekday, Friday, Saturday, and Sunday.

On-road mobile source emissions for the 2017 future case for the eight-county HGB area for each season and day type is summarized in Table 3-21: *2017 Future Case On-Road Modeling Emissions for Eight-County HGB.*

Table 3-21: 2017 Future Case On-Road Modeling Emissions for Eight-County HGB

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Summer Weekday	95.56	54.40	708.52
Summer Friday	99.18	55.51	756.03
Summer Saturday	74.71	48.43	606.58
Summer Sunday	61.85	46.15	529.42
School Weekday	97.15	54.71	719.81
School Friday	101.42	55.97	773.56
School Saturday	75.38	48.59	613.83
School Sunday	62.43	46.30	535.99

For the eight-county HGB area, the on-road mobile source NO_X emissions are reduced approximately 39% from the 2012 baseline (157.09 tpd) to the 2017 future case (95.56 tpd). VOC emissions are reduced approximately 26% from the 2012 baseline (73.60 tpd) to the 2017 future case (54.40 tpd). Due to the ongoing fleet turnover effect where older high-emitting vehicles are replaced with newer low-emitting ones, these substantial on-road reductions are projected to occur even with growth in VMT from 2012 through 2017.

Non-HGB Portions of Texas

On-road emissions for the 246 non-HGB Texas counties were developed by TTI using MOVES2014 emission rates and 2017 HPMS VMT projections for each county. Average school and summer season emissions by vehicle type and roadway type were estimated for the four day types of Monday-Thursday average weekday, Friday, Saturday, and Sunday.

Outside Texas

For the non-Texas U.S. portions of the modeling domain, the TCEQ used MOVES2014 in default mode to generate 2017 July weekday emission estimates for every non-Texas U.S. county. To create the non-Texas Friday, Saturday, and Sunday day types for the summer and school seasons, the 2017 Texas on-road temporal profiles were applied to the non-Texas 2017 summer weekday emissions. For the Canada portion of the modeling domain, a 2006 on-road inventory was projected to 2017 based on 2% annual VMT growth and the relative change in emission rates from 2006 to 2017 as estimated by the MOBILE6-Canada model. For the Mexico portion of the modeling domain, a 1999 on-road inventory was projected to 2017 based on 2% annual VMT growth and the relative change in emission rates from 1999 to 2017 as estimated by the MOBILE6-Mexico model.

<u>3.6.4.3 Non- and Off-Road Mobile Sources</u>

Outside Texas

For the non-Texas U.S. portion of the modeling domains, the TCEQ used the EPA's NMIM to generate average summer weekday non-road mobile source emissions by county for 2017. For the off-road categories of aircraft, locomotive, and commercial marine, the TCEQ used the EPA's 2011 NEI to create 2017 average summer weekday off-road emissions for the non-Texas U.S. portions of the modeling domain. Summer weekend day emissions for the non-road and off-road mobile source categories were developed as part of the EPS3 processing using temporal profiles specific to each source category.

Within Texas

The TCEQ used the TexN model to generate average summer weekday non-road mobile source category emissions by county for 2017. Airport GSE and oil and gas drilling rig emissions were estimated separately as detailed below. During EPS3 processing, temporal adjustments were made to create Saturday and Sunday non-road emission estimates. Table 3-22: *2017 Future Case Non-Road Modeling Emissions for Eight-County HGB* summarizes these non-road inputs by day type. The non-road emission estimates in Table 3-22 were developed with version 1.7.1 of TexN.

For the eight-county HGB area, non-road NO_X emissions are reduced by approximately 31% from the 2012 baseline (50.78 tpd) to the 2017 future case (34.97 tpd). VOC emissions are decreased approximately 26% from the 2012 baseline (40.11 tpd) to the 2017 future case (29.57 tpd). Due to the ongoing fleet turnover effect where older high-emitting equipment is replaced with newer low-emitting equipment, these substantial non-road reductions are projected to occur even with growth in overall non-road equipment population and activity from 2012 through 2017.

Table 3-22: 2017 Future Case Non-Road Modeling Emissions for Eight-County HGB

Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	34.97	29.57	475.47
Saturday	26.60	53.93	633.37
Sunday	20.40	50.01	561.19

Airport emission inventories were developed with the FAA EDMS tool, which outputs emission estimates for aircraft engines, APUs, and GSE. Table 3-23: *2017 Future Case Airport Modeling Emissions for Eight-County HGB* summarizes these estimates for the HGB eight-county nonattainment area airports. The airport-specific emission estimates are based on an ERG study done under contract to the TCEQ (ERG, 2016).

Table 3-23: 2017 Future Case Airport Modeling Emissions for Eight-County HGB

HGB Area Airports	NOX (tpd)	VOC (tpd)	CO (tpd)
George Bush Intercontinental	4.93	1.30	9.04
Houston Hobby	1.63	0.45	2.70
Other 268 Airports	0.28	0.49	9.58
HGB Area Airport Total	6.84	2.24	21.32

The 2017 locomotive emission estimates were developed using emission rate and activity adjustment factors from an ERG study (ERG, 2015a). Emissions were estimated separately for Class I line-haul locomotives, Class II and III line-haul locomotives, and rail-yard switcher locomotives. Table 3-24: *2017 Future Case Locomotive Emissions for*

Eight-County HGB summarizes these estimates for all locomotive activity in the HGB area.

For the eight-county HGB area, the locomotive NO_x emissions are estimated to be reduced by about 15% from the 2012 baseline (15.35 tpd) to the 2017 future case (13.08 tpd), and the VOC emissions are decreased about 25% from the 2012 baseline (0.99 tpd) to the 2017 future case (0.74 tpd). These substantial locomotive emissions reductions are projected to occur due to the ongoing fleet turnover effect where older high-emitting locomotive diesel engines are replaced with newer low-emitting ones.

Table 3-24: 2017 Future Case Locomotive Emissions for Eight-County HGB

Locomotive Source Classification	NOX (tpd)	VOC (tpd)	CO (tpd)
Line-Haul Locomotives - Class I	9.79	0.50	2.74
Line-Haul Locomotives - Classes II and III	0.30	0.02	0.04
Rail Yard Switcher Locomotives	2.99	0.22	0.48
HGB Area Locomotive Total	13.08	0.74	3.26

The 2017 commercial marine emission estimates were developed under contract to Ramboll Environ (Ramboll Environ, 2010). The 2007 commercial marine emission estimates were projected to 2017 based on expected growth and changes in emission rates. The HGB eight-county area commercial marine emissions are summarized in Table 3-25: *2017 Base Case Commercial Marine Modeling Emissions for Eight-County HGB*.

Table 3-25: 2017 Base Case Commercial Marine Modeling Emissions for Eight-County HGB

Commercial Marine Source Classification	NO_x (tpd)	VOC (tpd)	CO (tpd)
Chemical Tanker	7.21	0.44	0.93
Tow Boat	4.44	0.20	1.66
Crude Tanker	2.47	0.15	0.32
Container Ship	2.00	0.16	0.31
General Cargo	1.93	0.11	0.24
Bulk Cargo	1.42	0.08	0.18
LNG/LPG Tanker	1.07	0.06	0.13
Ocean Towing	0.69	0.04	0.09
Auto Carrier	0.63	0.03	0.07
Dredging	0.55	0.03	0.24
Refrigerated Cargo	0.34	0.02	0.04
Other Tanker	0.33	0.02	0.04
Tug Barge	0.27	0.01	0.04
Cruise Ship	0.21	0.01	0.02
Harbor Vessel	0.18	0.01	0.04
Miscellaneous	0.12	0.01	0.02
Assist Tug	0.02	<0.01	0.01
HGB Area Commercial Marine Total	23.88	1.38	4.37

3.6.4.4 Area Sources

Outside Texas

For the non-Texas U.S. within the modeling domains, the TCEQ used the EPA's 2011 NEI projected to 2017 for area source emissions.

Within Texas

The TCEQ used area source data from the 2014 TexAER database (TCEQ, 2011), and projected these estimates to 2017 using the Texas-specific economic growth factors for 2014 through 2017 for non-oil and gas sources. Temporal profiles were applied with EPS3 to obtain the figures presented in Table 3-26: *2017 Future Case Non-Oil and Gas Area Source Emissions for Eight-County HGB*.

Table 3-26: 2017 Future Case Non-Oil and Gas Area Source Emissions for Eight-County HGB

Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	19.21	264.62	87.10
Saturday	13.74	164.06	51.95
Sunday	8.29	115.03	17.50

For oil and gas sources, HGB production emissions estimated for 2014 based on RRC data were held constant for use in the 2017 future case. County-level drilling rig emission estimates were based on the latest available drilling activity data from the RRC in 2015 and 2017 emission rates from an ERG study (ERG, 2015). Drilling rigs are non-road sources but are reported with oil and gas production sources. The results are summarized in Table 3-27: *2017 Oil and Gas Drilling and Production Emissions for Eight-County HGB*.

Table 3-27: 2017 Oil and Gas Drilling and Production Emissions for Eight-County HGB

Equipment Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Drilling Rigs	0.57	0.07	0.25
Production (Non-Point Source)	1.96	47.92	2.85
HGB Oil and Gas Total	2.53	47.99	3.10

3.6.4.5 Future Case Summary

Typical 2017 future case weekday emissions in the eight-county HGB area are summarized by source type in Table 3-28: *2017 Future Case Anthropogenic Emissions for Eight-County HGB*.

Table 3-28: 2017 Future Case Anthropogenic Emissions for Eight-County HGB

HGB Emission Source Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
On-Road	95.56	54.40	708.52
Non-Road	34.97	29.57	475.47
Non-Road – Oil and Gas Drilling	0.57	0.07	0.25
Off-Road - Airports	6.84	2.24	21.32
Off-Road - Locomotives	13.08	0.74	3.26
Off-Road - Commercial Marine	23.88	1.38	4.37
Area (Non-Oil and Gas)	19.21	264.62	87.10
Area – Oil and Gas Production	1.96	47.92	2.85
Point - EGUs (August Average)	41.95	2.15	45.30
Point - Non-EGUs (Ozone Season Average)	103.88	135.72	67.95
HGB Total	341.90	538.81	1,416.39

3.6.5 2012 and 2017 Modeling Emissions Summary for HGB

Table 3-29: *2012 Baseline and 2017 Future Modeling Emissions for HGB Area* provides side-by-side comparisons of the NO_X and VOC emissions by source category from Table 3-18 and Table 3-28 for an average August summer weekday. The total eight-county HGB area anthropogenic NO_X emissions are projected to be reduced by approximately 11% from 2012 (385.83 tpd) to 2017 (341.90 tpd). The total eight-county HGB area anthropogenic VOC emissions are projected to be reduced by 10% from 2012 (597.39 tpd) to 2017 (538.81 tpd).

Table 3-29: 2012 Baseline and 2017 Future Modeling Emissions for HGB Area

HGB Emission Source Type	2012 NO_X (tpd)	2017 NO_X (tpd)	2012 VOC (tpd)	2017 VOC (tpd)
On-Road	157.09	95.56	73.60	54.40
Non-Road	50.78	34.97	40.11	29.57
Non-Road - Oil and Gas Drilling	0.81	0.57	0.06	0.07
Off-Road - Airports	6.44	6.84	2.12	2.24
Off-Road - Locomotives	15.35	13.08	0.99	0.74
Off-Road - Commercial Marine	27.74	23.88	1.35	1.38
Area (Non-Oil and Gas)	19.28	19.21	277.97	264.62
Area Oil and Gas Production	2.09	1.96	66.60	47.92
Point - EGUs (August Average)	36.49	41.95	3.91	2.15
Point - Non-EGUs (Ozone Season Average)	69.76	103.88	130.68	135.72
HGB Total	385.83	341.90	597.39	538.81

Figure 3-18: *2012 Baseline and 2017 Future Modeling Emissions for HGB Area* graphically compares the anthropogenic NO_X and VOC emission estimates presented in Table 3-29.

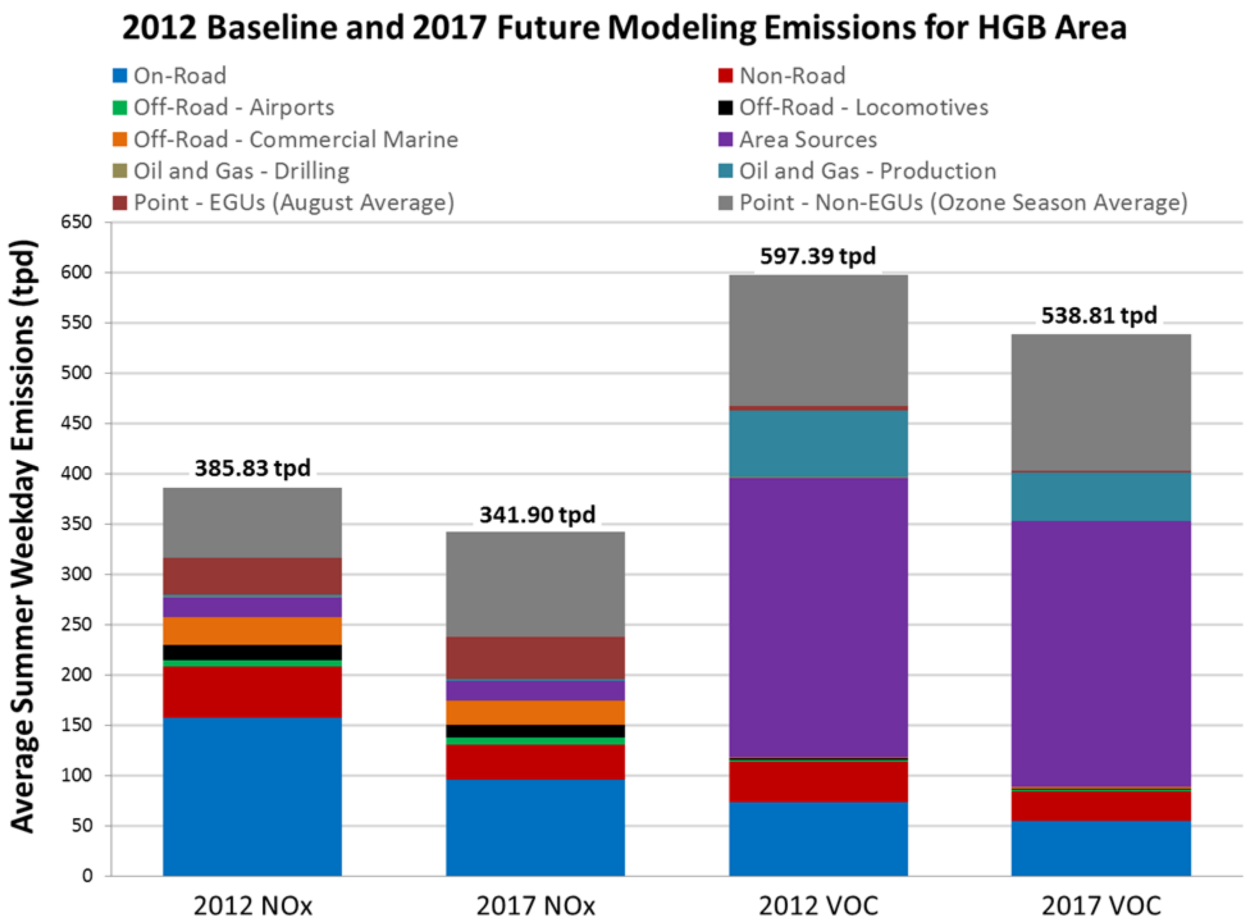


Figure 3-18: 2012 Baseline and 2017 Future Modeling Emissions for HGB Area

3.7 PHOTOCHEMICAL MODELING

To ensure that a modeling study can be successfully used as technical support for an AD SIP revision, the air quality model must be scientifically sound and appropriate for the intended application and freely accessible to all stakeholders. In a regulatory environment, it is crucial that oversight groups (e.g., the EPA), the regulated community, and the public have access to and have reasonable assurance of the suitability of the model. Consistent with the modeling guidance, the TCEQ used the following three prerequisites for selecting the air quality model to be used in the HGB attainment demonstration. The model must:

- have a reasonably current, peer-reviewed, scientific formulation;
- be available at no or low cost to stakeholders; and
- be consistent with air quality models being used for Texas SIP development.

The only model to meet all three of these criteria is CAMx. The model is based on well-established treatments of advection, diffusion, deposition, and chemistry. Another important feature is that NO_X emissions from large point sources can be treated with the Plume-in-Grid (PiG) sub-model, which helps avoid the artificial diffusion that occurs when large, hot, point source emissions are introduced into a grid volume. The model software and the CAMx user's guide are publicly available (Ramboll Environ, 2016). In addition, the TCEQ has many years of experience with CAMx. CAMx was used in previous HGB and DFW attainment demonstration SIP revisions, as well as for modeling being conducted in other areas of Texas by the TCEQ and other groups.

3.7.1 Modeling Domains and Horizontal Grid Cell Size

Figure 3-19: *CAMx Modeling Domains* and Table 3-30: *CAMx Modeling Domain Definitions* depict and define the fine resolution 4 km domain covering eastern Texas, a medium resolution 12 km domain covering all of Texas plus some or all of surrounding states, and a coarse resolution 36 km domain covering the continental U.S. plus southern Canada and northern Mexico. The 4 km is nested within the 12 km domain, which in turn is nested within the 36 km domain. All three domains were projected in a Lambert Conformal Conic (LCC) projection with the origin at 97 degrees west and 40 degrees north.

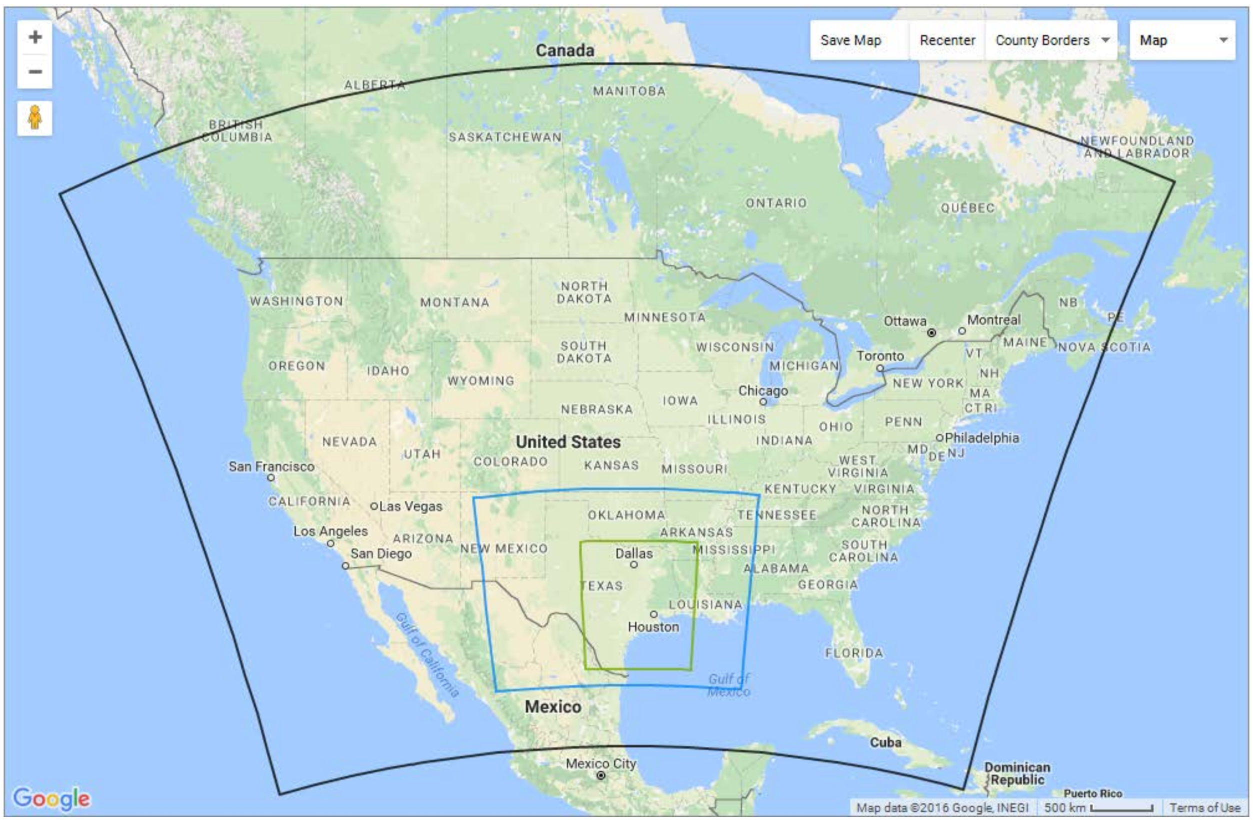


Figure 3-19: CAMx Modeling Domains

Table 3-30: CAMx Modeling Domain Definitions

Domain Code	Domain Cell Size	Dimensions (grid cells)	Lower left-hand corner	Upper right-hand corner
36 km	36 x 36 km	148 x 112	(-2736, -2088)	(2592,1944)
12 km	12 x 12 km	149 x 110	(-984,-1632)	(804,-312)
4 km	4 x 4 km	191 x 218	(-328,-1516)	(436,-644)

3.7.2 Vertical Layer Structure

The vertical configuration of the CAMx modeling domains consists of 29 layers of varying depths in units of meters (m) above ground level (AGL) as shown in Table 3-31: *CAMx Vertical Layer Structure*.

Table 3-31: CAMx Vertical Layer Structure

CAMx Layer	WRF Layer	Top (m AGL)	Center (m AGL)	Thickness (m)
29	42	18250	16445	3611
28	39	14639	13632	2015
27	37	12624	10786	3675
26	33	8949	7891	2115
25	30	6833	6289	1088
24	28	5746	5290	911
23	26	4835	4449	772
22	24	4063	3704	717
21	22	3346	3175	341
20	21	3005	2840	330
19	20	2675	2515	320
18	19	2355	2225	259
17	18	2096	1969	253
16	17	1842	1718	248
15	16	1595	1474	242
14	15	1353	1281	143
13	14	1210	1140	141
12	13	1069	1000	139
11	12	930	861	138
10	11	792	747	91
9	10	702	656	90
8	9	612	567	89
7	8	522	478	89
6	7	433	389	88
5	6	345	302	87
4	5	258	215	87
3	4	171	128	86
2	3	85	60	51
1	2	34	17	34

3.7.3 Model Configuration

The TCEQ used CAMx version 6.31, which includes a number of upgrades and features from previous versions (Ramboll Environ, 2016). The following CAMx 6.31 options were employed:

- revised gridded file formats for meteorology inputs, initial/boundary conditions, emission inputs, output concentration values, and deposition fields;
- photolysis rate updates based on inputs for surface albedo, height above ground, terrain height, solar zenith, clouds, temperature, and barometric pressure;

- new gas-phase chemistry mechanisms for Carbon Bond 6 (CB6) speciation and CB6 “revision 2” (CB6r2h), which added halogen chemistry; and
- Wesely dry deposition scheme.

In addition to the CAMx inputs developed from the meteorological and emissions modeling, inputs are needed for initial and boundary conditions, spatially resolved surface characteristic parameters, spatially resolved albedo/haze/ozone (i.e., opacity) and photolysis rates, and a chemistry parameters file. The TCEQ contracted with Ramboll Environ (Ramboll Environ, 2016a) to derive episode-specific boundary and initial conditions from the Goddard Earth Observing Station global atmospheric model with Chemistry model runs for 2012 and 2017. Boundary conditions were developed for each grid cell along all four edges of the outer 36 km modeling domain at each of the 29 vertical layers for each episode hour. Boundary conditions for the top of the modeling domain were also developed.

Surface characteristic parameters, including topographic elevation, leaf area index (LAI), vegetative distribution, and water/land boundaries are input to CAMx via a land-use file. The land-use file provides the fractional contribution (zero to one) of 26 land-use categories, as defined by Zhang et al (2003). For the 36 km domain, the TCEQ developed the land use file using version 3 of the Biogenic Emissions Land use Database for areas outside the U.S. and the 2006 National Land Cover Dataset (NLCD) for the U.S. For the 4 km and 12 km domains, the TCEQ used updated land-use files developed by Texas A&M University (Popescu et al., 2012), which were derived from more highly resolved data collected by the Texas Parks and Wildlife Department, Landscape Fire and Resource Management Planning Tools Project, LandSat, National Institute of Statistics and Geography, and the NLCD. Monthly averaged LAI was created from the eight-day 1 km resolution Moderate-Resolution Imaging Spectroradiometer (MODIS) MCD15A2 product.

Spatially resolved opacity and photolysis rates are input to CAMx via a photolysis rates file and an opacity file. These rates, which are specific to the chemistry parameters file for the CB6 mechanism, are also input to CAMx. The TCEQ used episode-specific satellite data from the Total Ozone Mapping Spectrometer to prepare the clear-sky photolysis rates and opacity files. Photolysis rates are internally adjusted by CAMx according to cloud and aerosol properties using the inline Tropospheric Ultraviolet Visible (TUV) model.

3.7.4 Model Performance Evaluation

The CAMx model configuration was applied to the 2012 base case using the episode-specific meteorological parameters, biogenic emission inputs, and anthropogenic emission inputs described above. The CAMx modeling results were compared to the measured ozone and ozone precursor concentrations at all regulatory monitoring sites, which resulted in a number of modeling iterations to implement improvements to the meteorological modeling, emissions modeling, and subsequent CAMx modeling. A detailed performance evaluation for the 2012 base case modeling episode is included in Appendix C: *Photochemical Modeling for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard*. Model performance evaluation products are available on the TCEQ modeling files FTP site (ftp://amdaftp.tceq.texas.gov/pub/TX/). Interactive model performance evaluation tools are available on the TCEQ Photochemical Modeling Web page (https://www.tceq.texas.gov/airquality/airmod/data/tx2012).

3.7.4.1 Performance Evaluations Overview

The performance evaluation of the base case modeling demonstrates the adequacy of the model to replicate the relationship between levels of ozone and the emissions of NO_x and VOC precursors. The model's ability to suitably replicate this relationship is necessary to have confidence in the model's prediction of the future year ozone and the response to various control measures. As recommended in the modeling guidance (EPA, 2014a), the TCEQ has incorporated the recommended eight-hour performance measures into its evaluations but also focuses on one-hour performance analyses, especially in the HGB area. The localized small-scale (i.e., high resolution) meteorological and emissions features characteristic of the HGB area require model evaluations to be performed at the highest resolution possible to determine whether the model is getting the right answer for the right reasons.

3.7.4.2 Operational Evaluations

Statistical measures of the Normalized Mean Bias (NMB) and the Normalized Mean Error (NME) were calculated by comparing monitored (measured) and four-cell bi-linearly interpolated modeled ozone concentrations for all episode days and monitors. For one-hour ozone comparisons, the EPA formerly recommended ranges of ±15% for bias and a 30% level for error, which is always positive because it is an absolute value. There are no recommended eight-hour ozone criteria for NMB and NME. Graphical measures including time series and scatter plots of hourly measured and bi-linearly interpolated modeled ozone were developed. Time series and scatterplots are ideal for examining model performance at specific monitoring locations. Time series plots offer the opportunity to follow ozone formation through the course of a day, while scatter plots provide a visual means to see how the model performs across the range of observed ozone and precursor concentrations. In addition, plots of modeled daily maximum eight-hour ozone concentrations were developed and overlaid with the measured daily maximum eight-hour ozone concentrations. Detailed operational evaluations for the 2012 base case modeling episode are included in Appendix C.

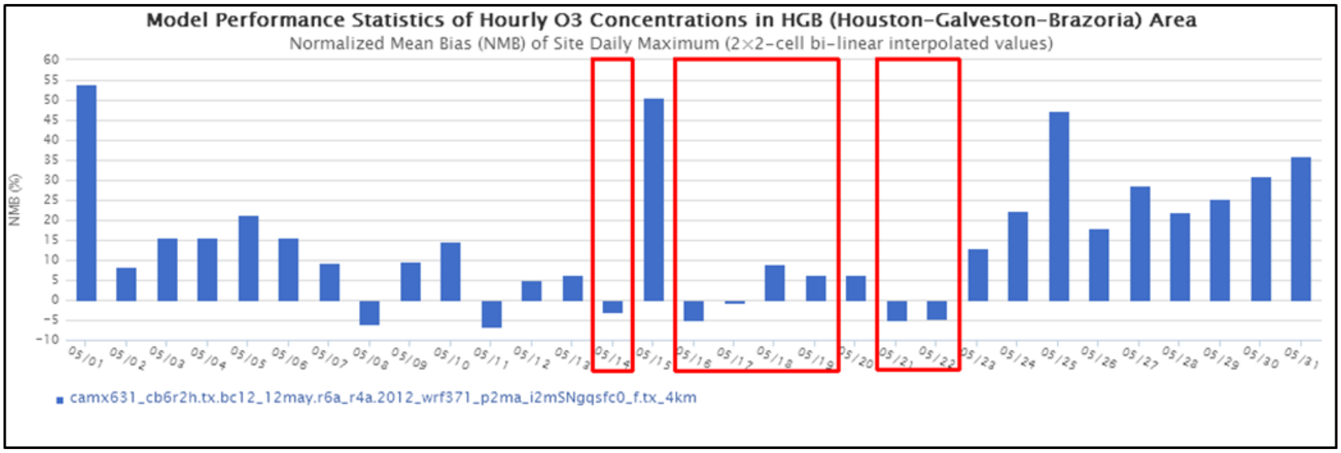
May through September Statistical and Graphical Evaluations

Modeling the May through September 2012 period has provided a wealth of data to evaluate. Because of the limited time for development of this HGB AD SIP revision, evaluations will be limited to HGB-area monthly summary statistics along with time series and scatter plots for the design-value setting Manvel Croix Park (C84) monitor. These performance evaluations provide many of the operational evaluation metrics suggested in the EPA's modeling guidance. Overall, the modeling replicated the periods of high ozone well, though under-predicted some of the highest peaks. Additional model performance evaluation is included in Appendix C and available on the TCEQ Texas Air Quality Modeling Files Web page (https://www.tceq.texas.gov/airquality/airmod/data/tx2012).

A. May 2012

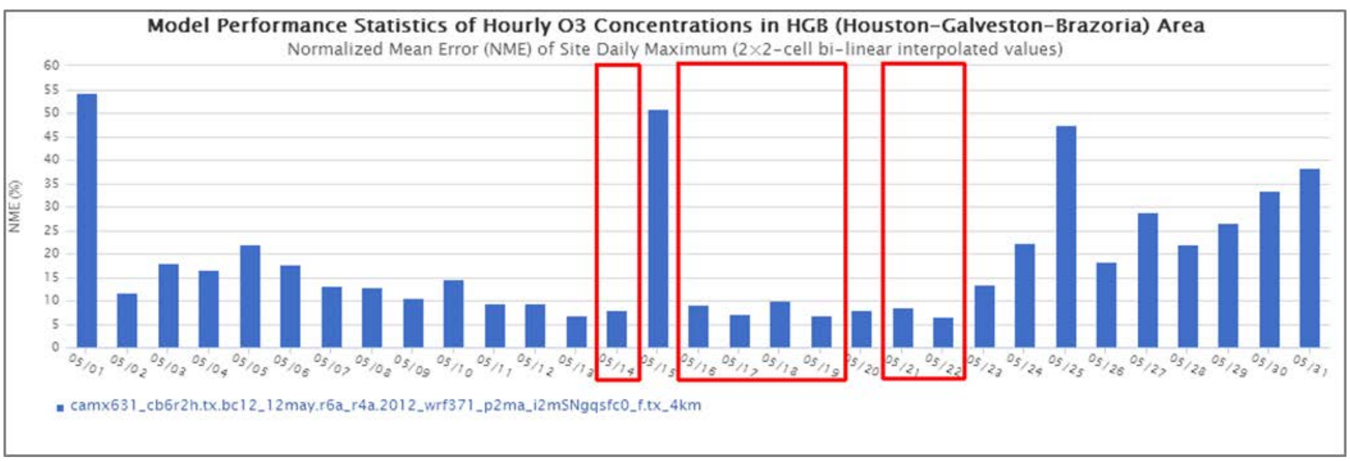
May 2012 had five days with site MDA8 concentrations above 75 ppb (see Figure 3-9). On those days the model under-predicted or over-predicted the site daily maximums slightly as shown in, Figure 3-20: *May 2012 HGB Normalized Mean Bias of Site Daily*

Maximum Hourly Ozone for the HGB Area Monitors. On the high ozone days the photochemical model performed well, replicating the average site daily maximum hourly ozone concentrations within approximately 13% as shown in Figure 3-21: *May 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors*. The model performed well on most other days during the period, with a few days, e.g., May 1, performing poorly. Those poor performing days had peak eight-hour concentrations less than 60 ppb (see Figure 3-9) and were not included in the attainment test calculation.



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-20: May 2012 HGB Normalized Mean Bias of Site Daily Maximum Hourly Ozone for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-21: May 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors

At the Manvel Croix Park (C84) monitor, the photochemical model mainly followed the diurnal pattern of eight-hour ozone but over-predicted the nighttime minimums frequently as shown in Figure 3-22: *May 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)*. The model prediction for May 1 through May 31 (x-axis) is shown as the blue continuous line with the three-by-three cell maximum and minimum range shown as the blue shaded region. The observations are shown as red dots corresponding to the y-axis. Eight-hour ozone peaks on the four days above 75 ppb were under-predicted by the model but concentrations above 75 ppb were predicted on three of the four days. Hourly NO_x concentrations were well represented, although the model over-predicted the overnight minimums on May 14, 16, and 17, perhaps due to improper vertical mixing as shown in Figure 3-23: *May 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)*. The scatter plot of hourly ozone at the Manvel Croix Park (C84) monitor exhibits the model's ability to replicate the concentrations (blue dots) throughout May, with only the highest concentrations not matched, as shown in Figure 3-24: *May 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)*. The purple dots exhibit the Quantile-Quantile plot (Q-Q plot), which compares how well the model predicts concentrations in the same range as the observed without respect to time.

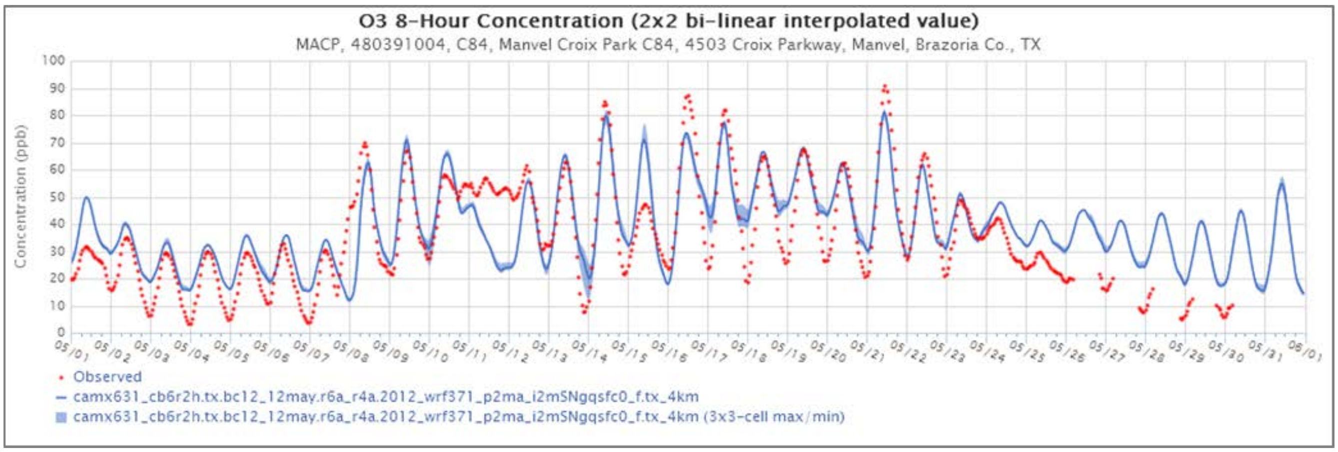


Figure 3-22: May 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

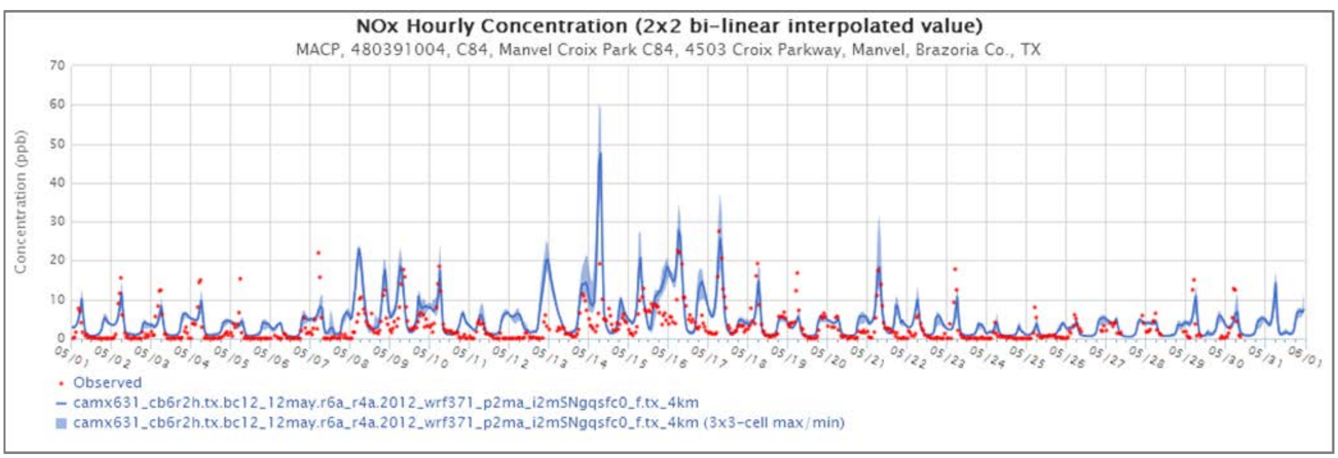


Figure 3-23: May 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

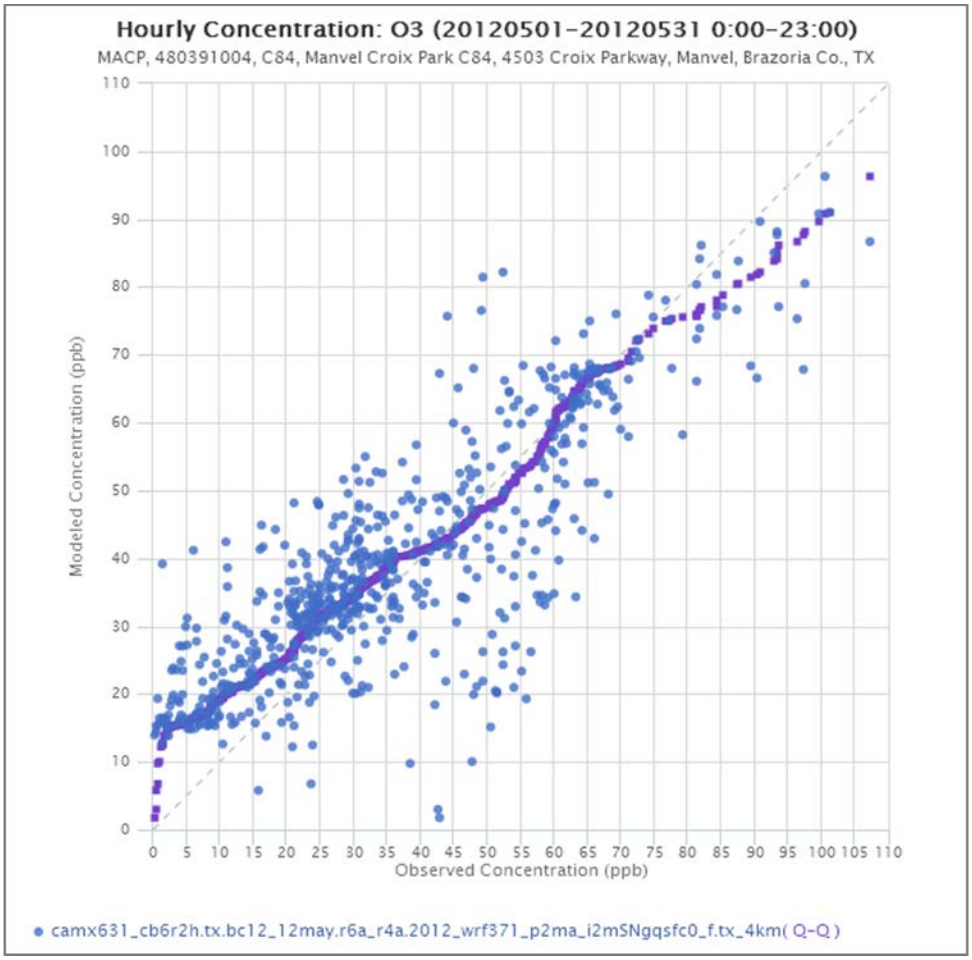
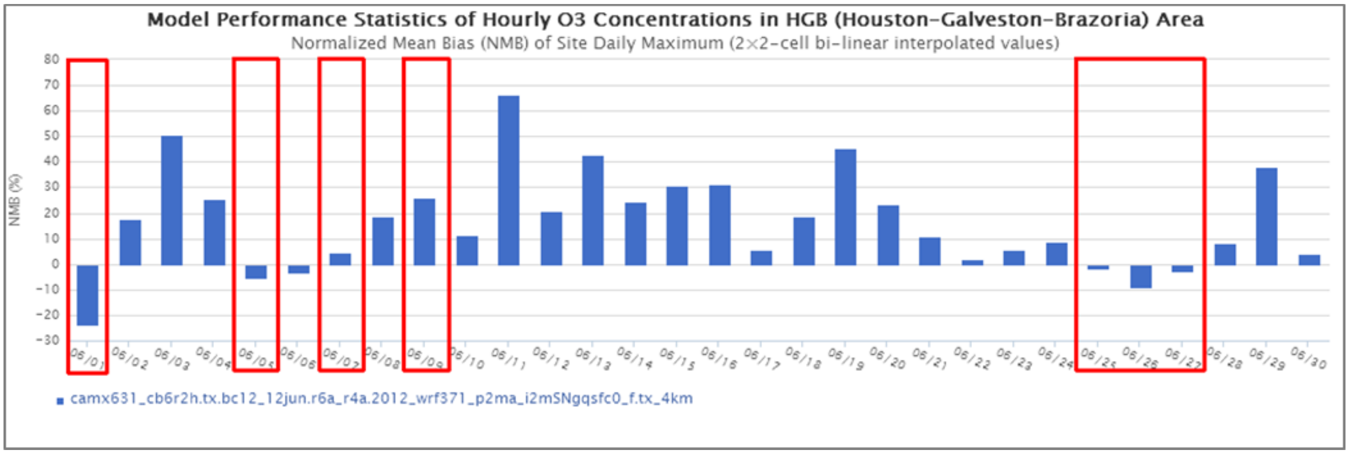


Figure 3-24: May 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

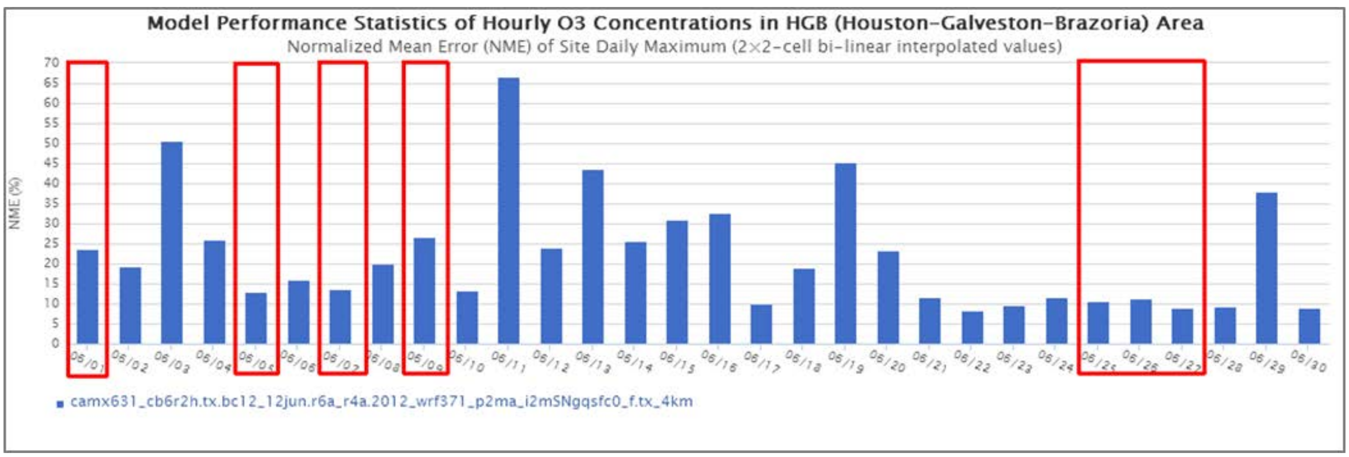
B. <u>June 2012</u>

June 2012 had seven days where HGB monitors observed eight-hour ozone concentrations greater than 75 ppb (see Figure 3-10). On the highest monitored day of 2012, June 26, the model under-predicted the HGB site daily maximum eight-hour ozone concentrations but bias was within 15% of the measured ozone values as depicted in Figure 3-25: *June 2012 HGB Normalized Mean Bias of Site Daily Maximum Hourly Ozone for the HGB Area Monitors*. As in May 2012, the model's bias was both positive and negative on the high ozone days, indicating the model does not have a tendency for consistent over- or under-prediction. In general, the photochemical model produced site daily maximum concentrations within 25% of observations on those days, highlighted in red in Figure 3-26: *June 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors*.



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-25: June 2012 HGB Normalized Mean Bias of Site Daily Maximum Hourly Ozone for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-26: June 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors

In June 2012, the photochemical model predicted the observed eight-hour ozone concentrations at the Manvel Croix Park (C84) monitor very well (the monitor did not operate the first 14 days of June). The Manvel Croix Park (C84) monitor measured the highest eight-hour concentration of 2012 on June 26 at 136 ppb. The model was unable to match this peak, only predicting 96 ppb as shown in Figure 3-27: *June 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)*. Observed NO_x at the Manvel Croix Park (C84) monitor on June 26, 2012 peaked near 22 ppb, which the model matched well, as depicted in Figure 3-28: *June 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)*. However, the model had a significant high bias in the early morning hours on June 26, which may have limited ozone formation. Most of the month was simulated well for NO_x at the Manvel Croix Park (C84) monitor. The scatter plot of hourly ozone at the Manvel Croix Park (C84) monitor, Figure 3-29: *June 2012 Observed versus Modeled Hourly Ozone Scatter Plot at*

Manvel Croix Park (C84), shows the model correctly predicts the low and moderate concentrations of hourly ozone but misses the highest concentrations in June 2012.

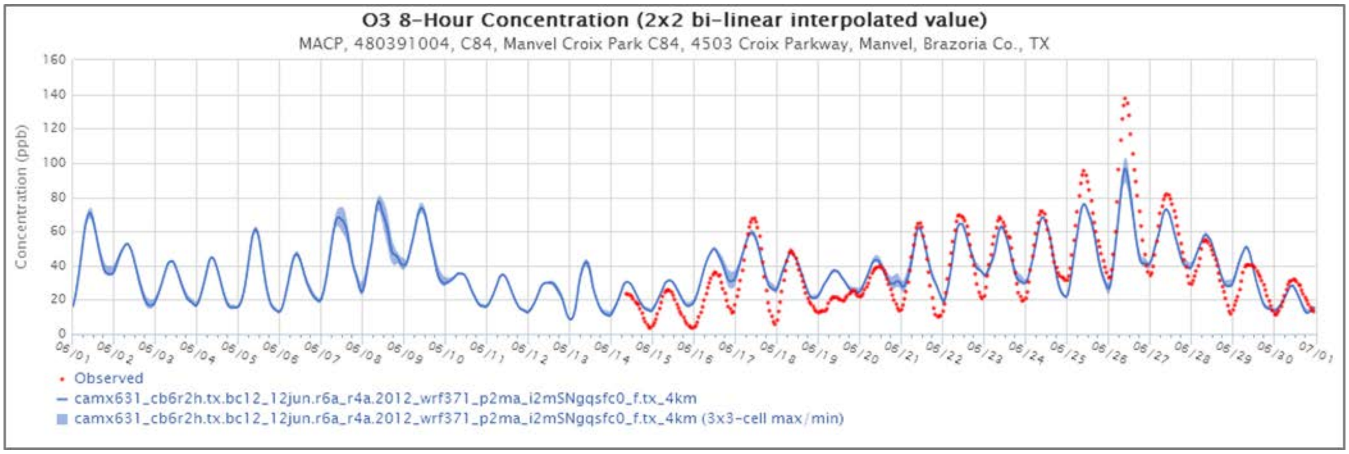


Figure 3-27: June 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

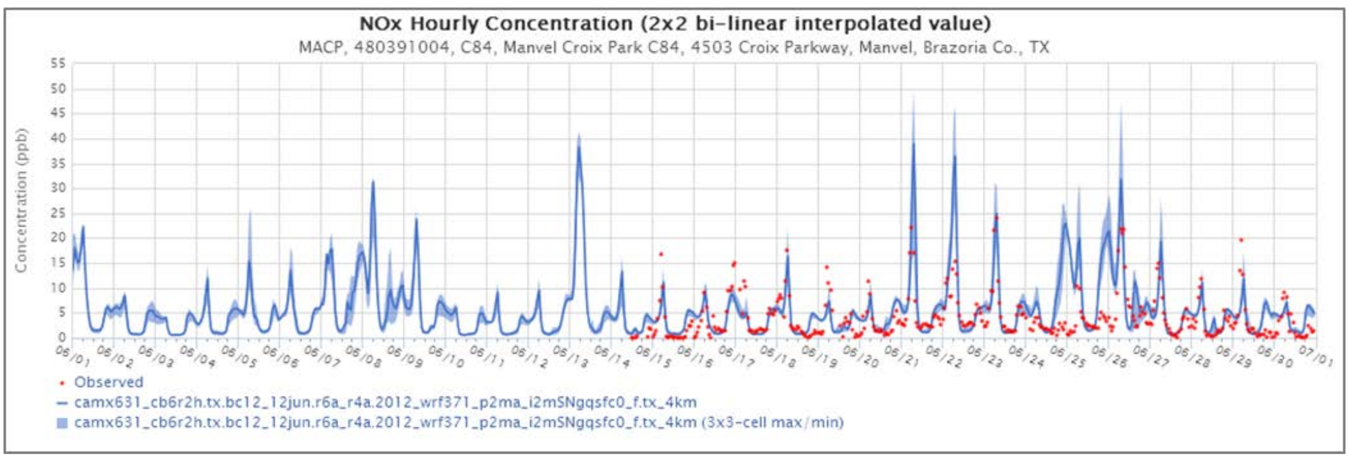


Figure 3-28: June 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

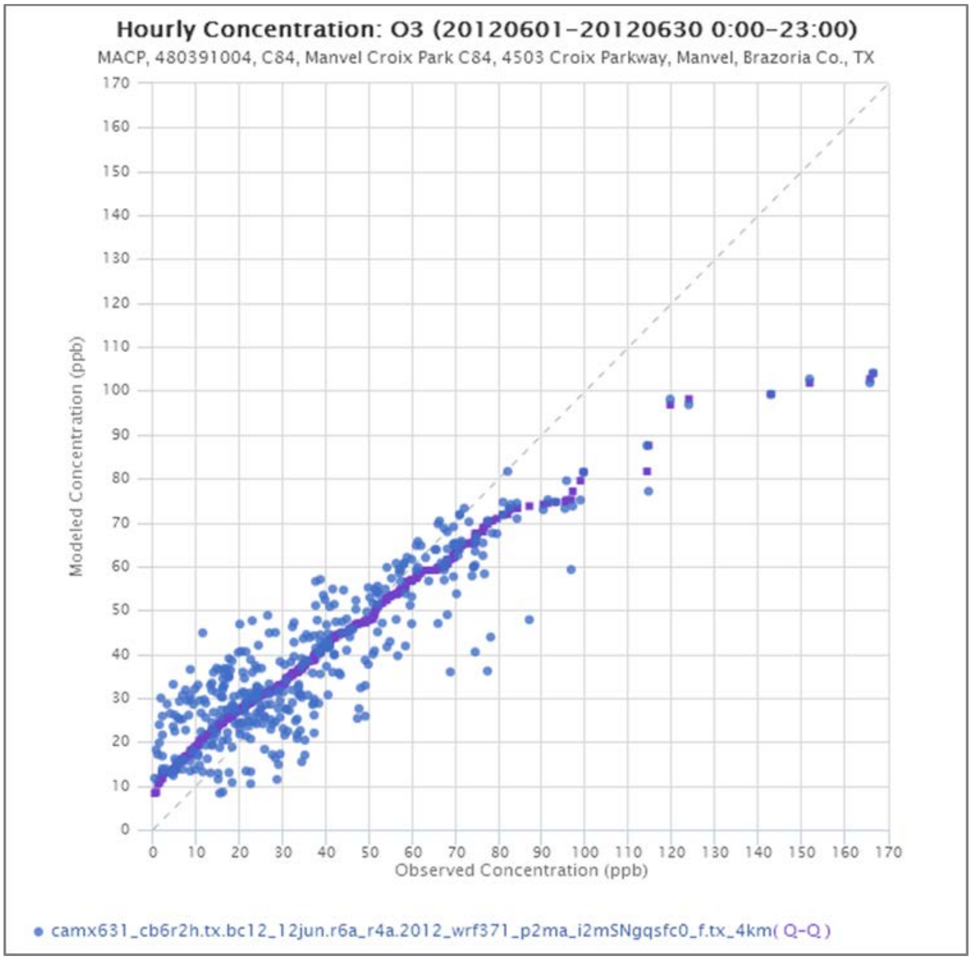
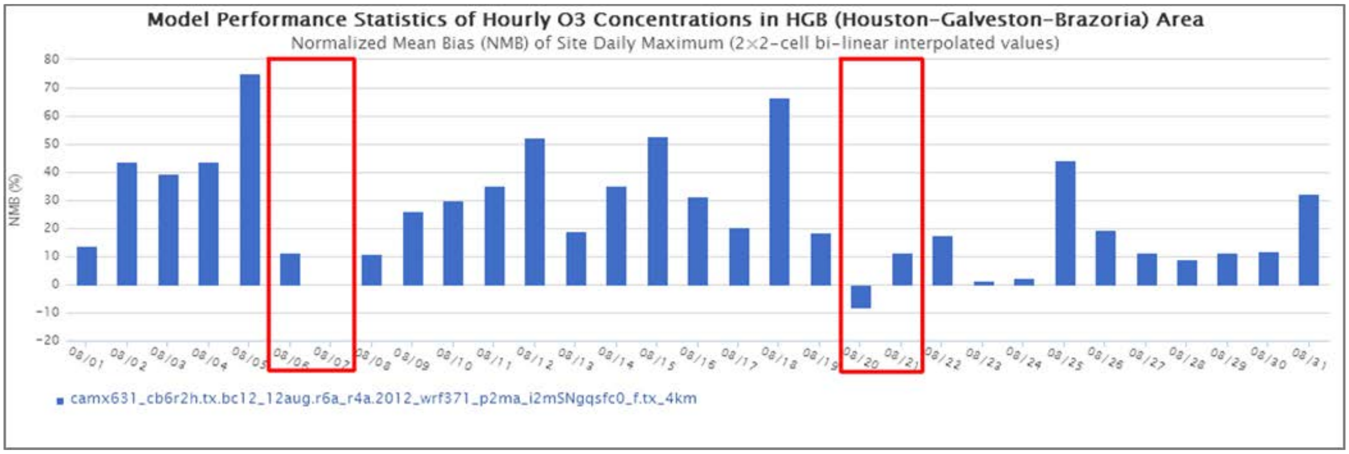


Figure 3-29: June 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

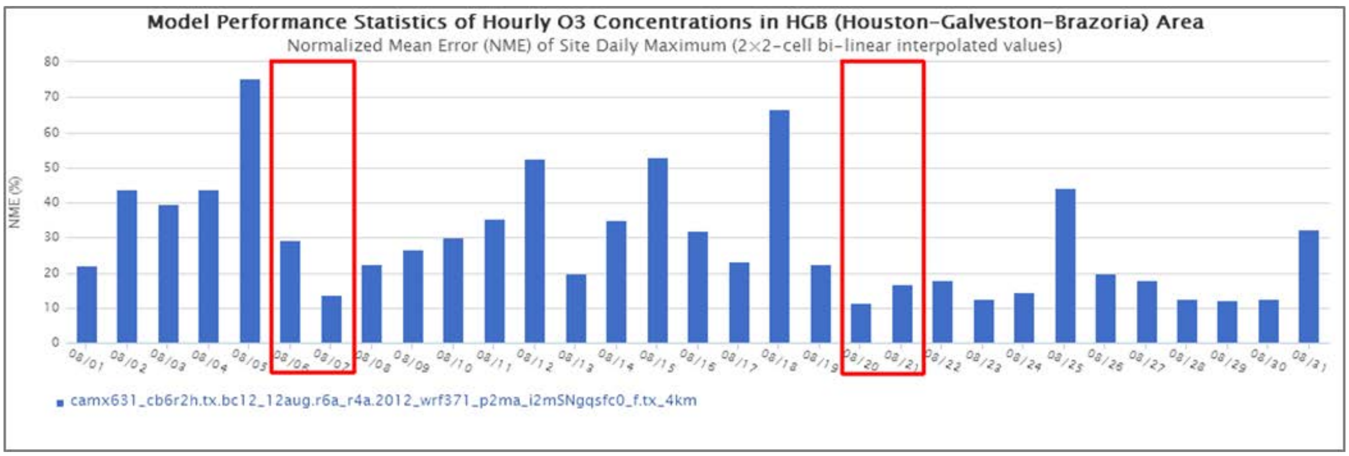
C. <u>July 2012</u>
Because of the limited time for development of this HGB AD SIP revision and that eight-hour ozone concentrations in the HGB area throughout July were less than 60 ppb, model performance evaluations are not included here. Limited model performance evaluation for July 2012 is included in Appendix C.

D. <u>August 2012</u>
Four August 2012 days observed eight-hour ozone concentrations above 75 ppb (see Figure 3-12). The normalized mean bias of the site daily maximum hourly ozone on the highest ozone days was very small, indicating the model performed well on the most important days (see Figure 3-30: *August 2012 HGB Normalized Mean Bias of Site Daily Maximum Hourly Ozone for the HGB Area Monitors*). The normalized mean error of the site daily maximums was below 20% for the high ozone days except August 6, 2012, as shown in Figure 3-31: *August 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors*. The NME was highest in August on days with observed site daily hourly ozone maximums below 60 ppb. When ozone concentrations were high in August, the model simulation matched well.



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-30: August 2012 HGB Normalized Mean Bias of Site Daily Maximum Hourly Ozone for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-31: August 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors

The model's pattern of replicating the high ozone periods well and over-predicting the lower concentrations is shown for the Manvel Croix Park (C84) monitor in Figure 3-32: *August 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)*). The period of August 8 through August 18 exhibits the over-prediction of the lower ozone periods. The scatter plot of hourly ozone at Manvel Croix Park (C84) also shows this pattern (Figure 3-33: *August 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)*). For NO_x, the model simulates the observed concentrations very well at the Manvel Croix Park (C84) monitor. Only August 28 through August 30 have large over-predictions with the rest of the month matching the diurnal pattern well, as depicted in Figure 3-34: *August 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84).*

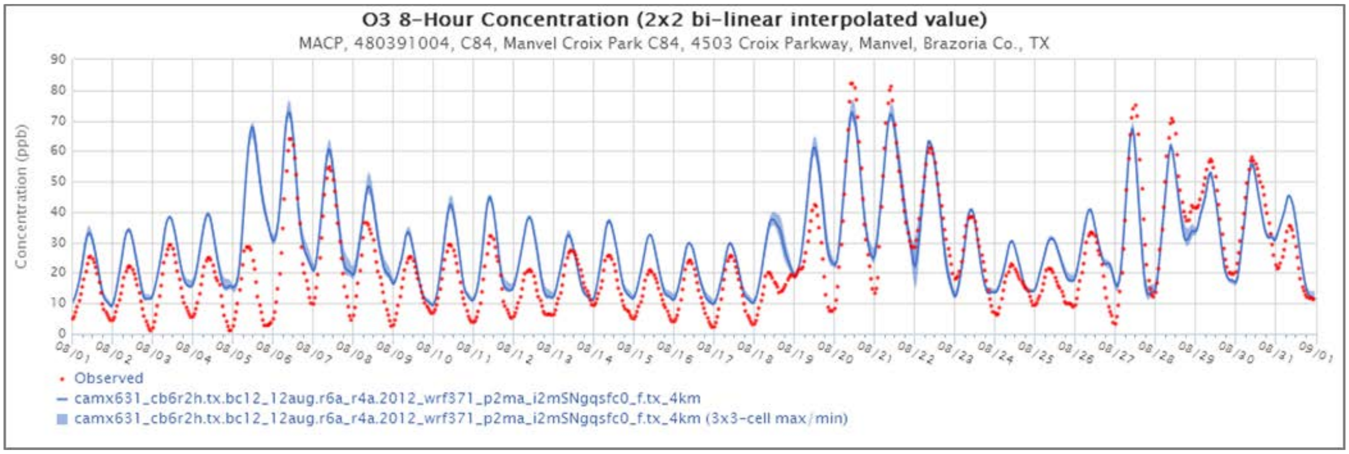


Figure 3-32: August 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

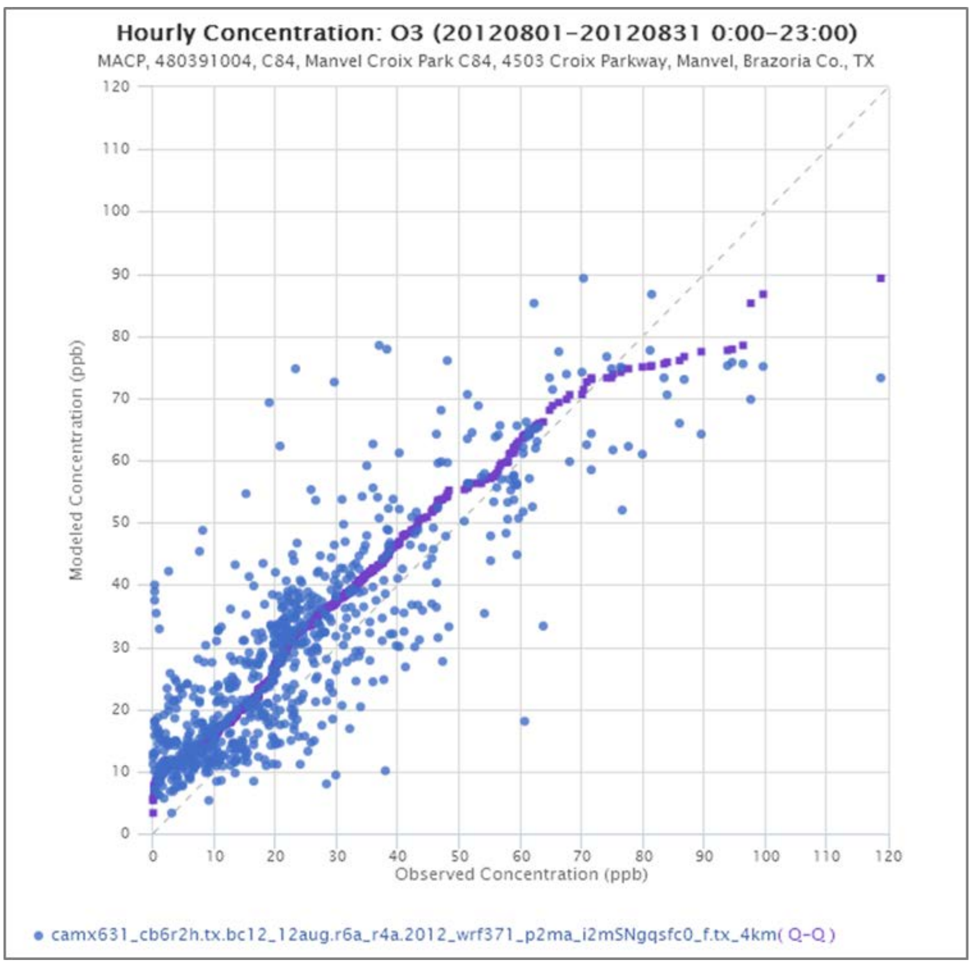


Figure 3-33: August 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

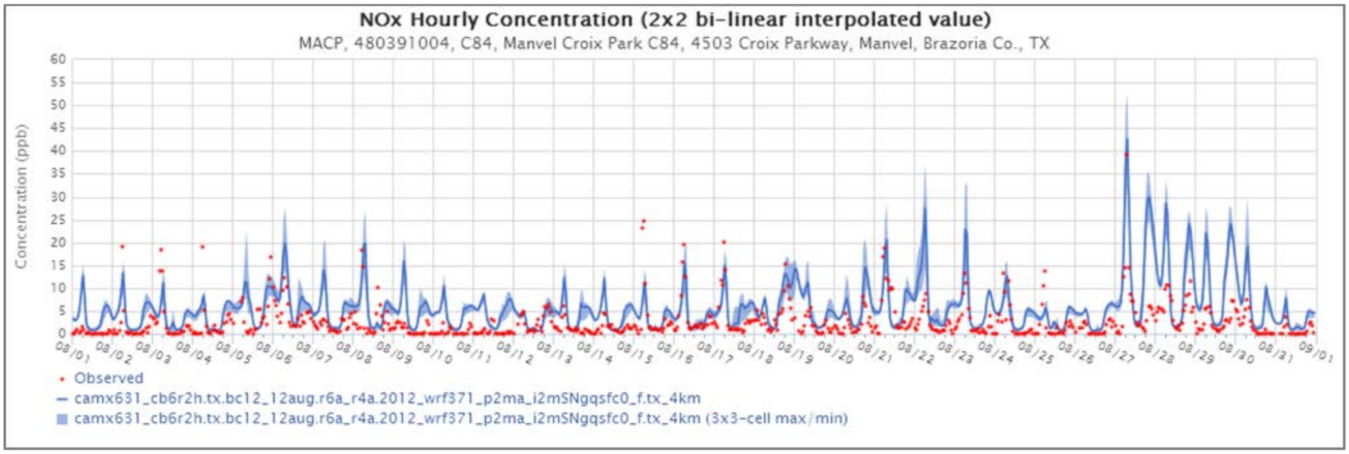
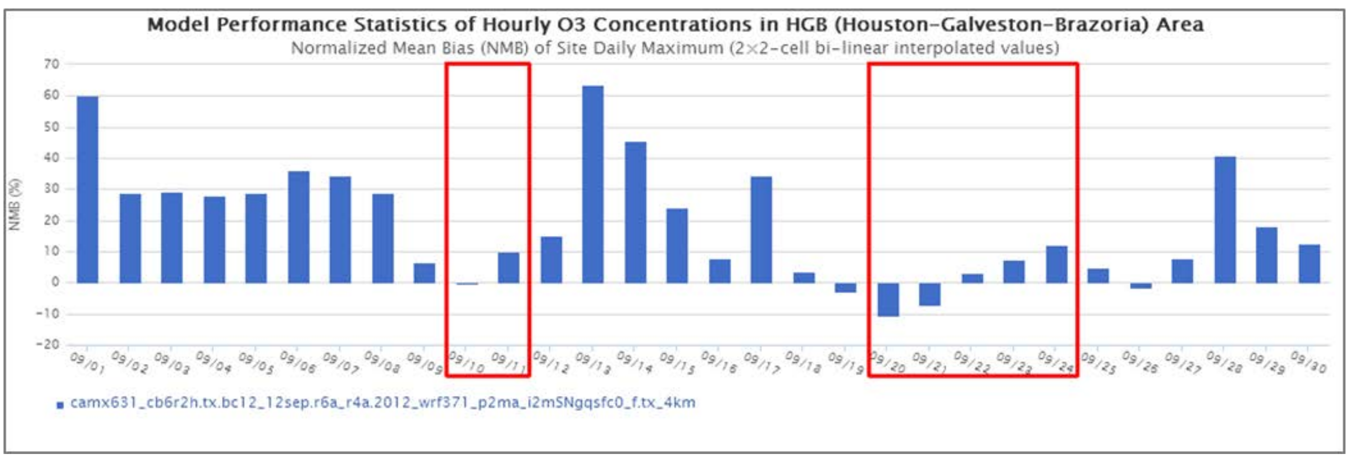


Figure 3-34: August 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

E. <u>September 2012</u>

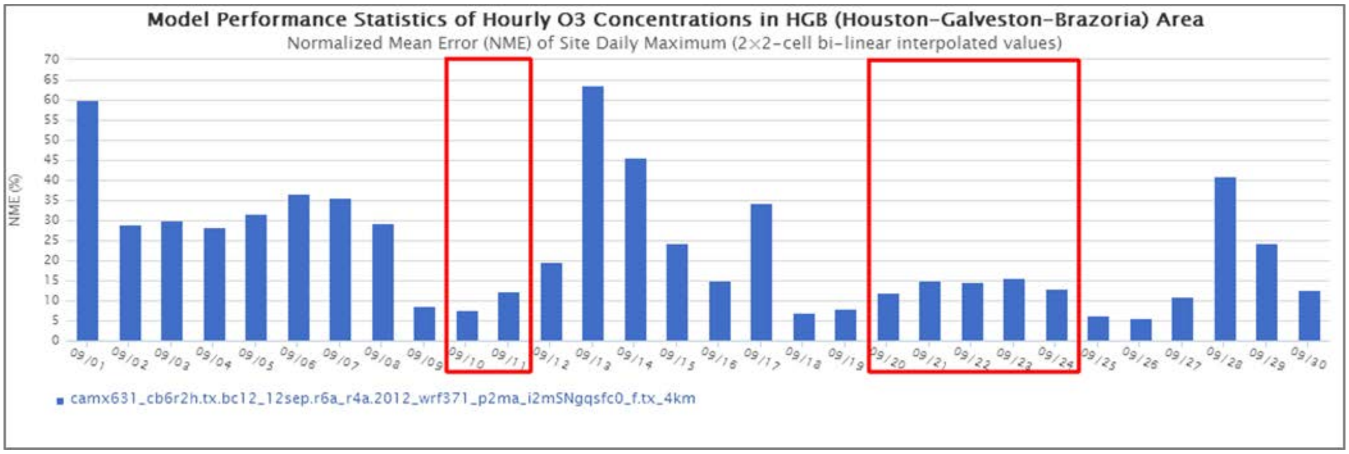
Seven days in September 2012 exceeded the 2008 eight-hour ozone NAAQS. The model slightly under-predicted and over-predicted on the high ozone days as with the other 2012 months (see Figure 3-35: *September 2012 Normalized Mean Bias of Site Daily Maximum Hourly Ozone for the HGB Area Monitors*).

As with the other 2012 months, the model performed well in September by matching the site daily maximums as shown in Figure 3-36: *September 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors*. The model did not replicate well the days with the lowest daily maximums, but those days were not included in the attainment test.



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-35: September 2012 HGB Normalized Mean Bias of Site Daily Maximum Hourly Ozone for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb marked in red.

Figure 3-36: September 2012 HGB Normalized Mean Error of Site Daily Maximum Hourly Ozone for the HGB Area Monitors

At the Manvel Croix Park (C84) monitor, the model under-predicted the daily peaks when observed ozone was 60 ppb or greater as shown in Figure 3-37: *September 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)*. Also in Figure 3-37, the model had difficulty replicating the diurnal range, over-predicting the nighttime minimum concentrations. NO_x concentrations were generally well simulated but some overnight maximums were missed that may have influenced the modeled nighttime ozone minimums (see Figure 3-38: *September 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)*). The hourly ozone scatter plot for the Manvel Croix Park (C84) monitor exhibits the high bias in the lower concentrations and the under-prediction of the highest peaks in September 2012, as displayed in Figure 3-39: *September 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)*.

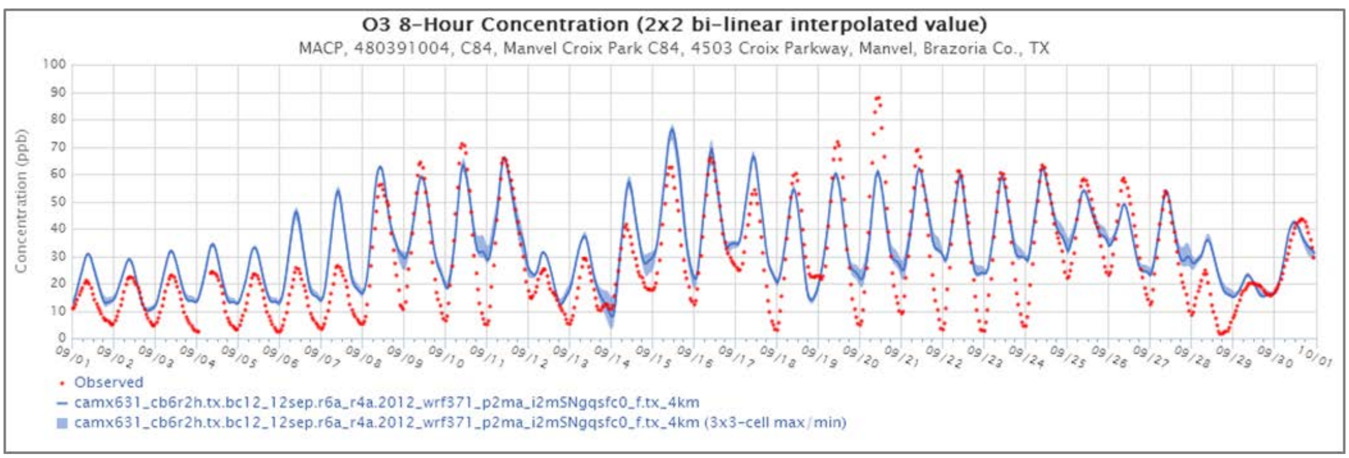


Figure 3-37: September 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

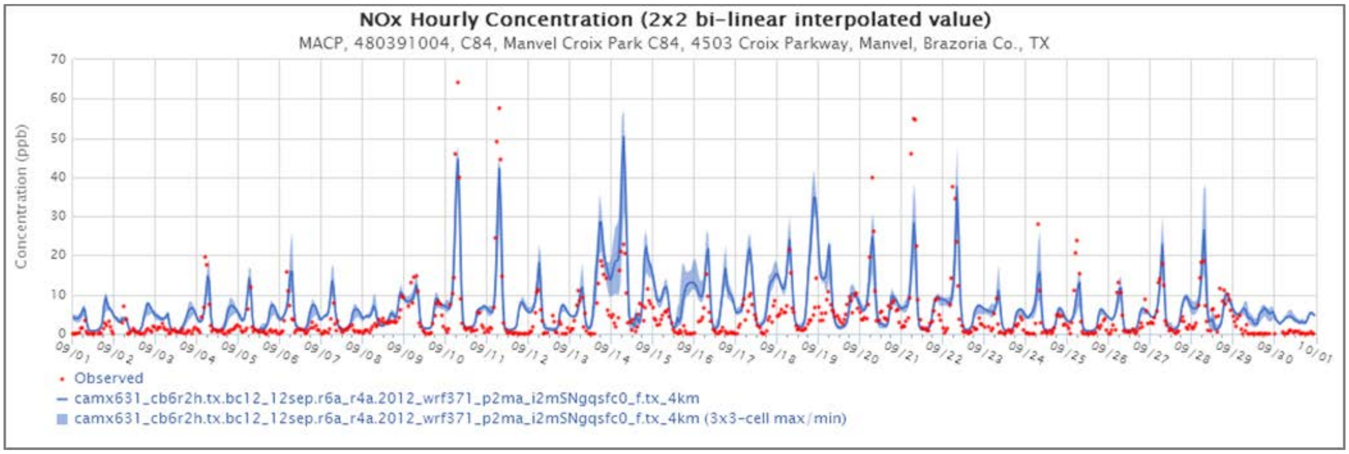


Figure 3-38: September 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

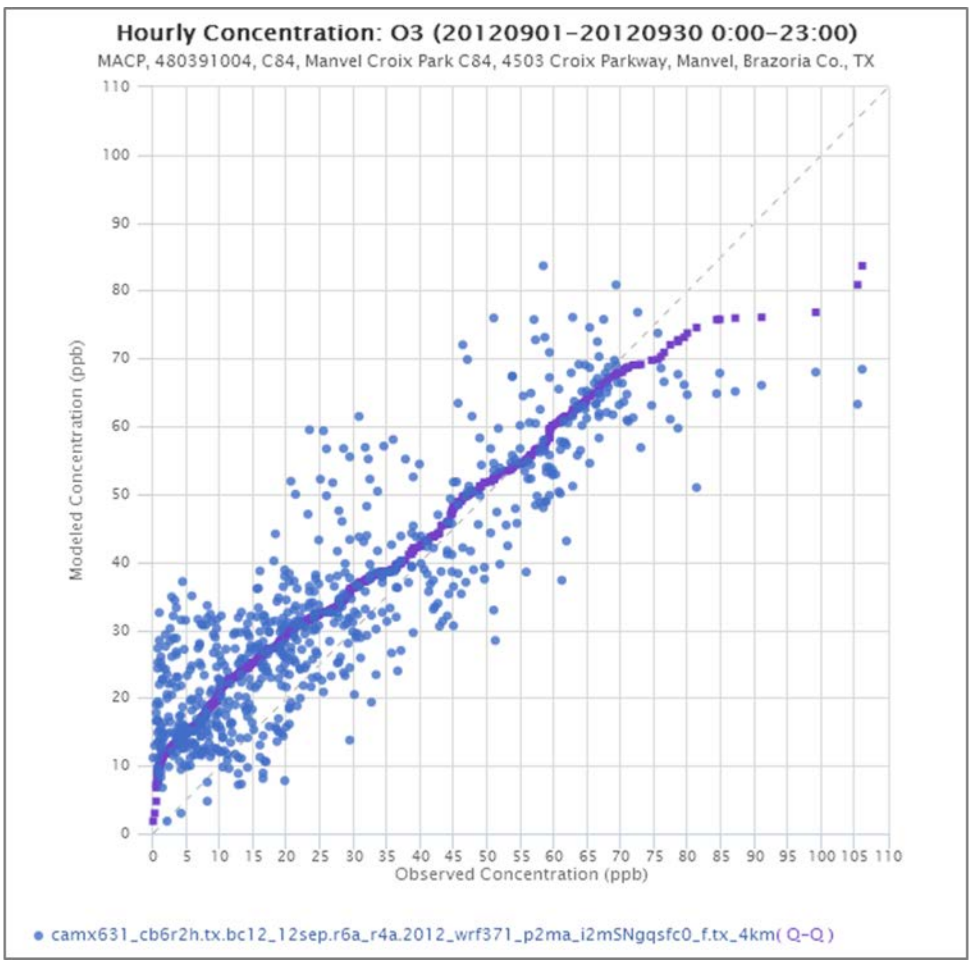


Figure 3-39: September 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

3.7.4.3 Diagnostic Evaluations

While most model performance evaluation (MPE) focuses on how well the model reproduces observations in the base case, a second and perhaps more important aspect of model performance is how well the model predicts changes as a result of modifications to its inputs (Smith, 2010). The former type of MPE is static in the sense that it is based on a fixed set of observations that never change, while evaluating the model's response to perturbations in its inputs is dynamic in the sense that the change in the model's output is evaluated. Dynamic MPE is performed much less often than static MPE, simply because there is often little observational data available that can be directly related to quantifiable changes in model inputs. Since the attainment demonstration is based on modeling the future by changing the model's inputs due to growth and controls, it is important to pursue dynamic MPE. The modeling guidance recommends assessing the model's response to emission changes. Two such dynamic MPEs are prospective modeling analysis and weekday/weekend analysis.

Because of the limited time for development of this HGB AD SIP revision, the diagnostic evaluations were not completed.

3.8 ATTAINMENT TEST

3.8.1 Relative Response Factor and Future Design Values

The TCEQ selected 2012 as the baseline year for conducting the attainment modeling and used the 2012 baseline emissions discussed in Section 3.6.3: *2012 Baseline Emissions* as model inputs. In accordance with modeling guidance (EPA, 2014a), the top 10 baseline episode days with modeled eight-hour maximum concentrations above 60 ppb, per monitor, were used for the modeled attainment test. All regulatory HGB monitors that operated the entire season had 10 modeled baseline days above 60 ppb. Similar to the 2012 baseline modeling, 2017 future case modeling was conducted for each of the 2012 episode days using the emission inputs discussed in Section 3.6.4: *2017 Future Case Emissions*.

From the baseline modeling, the maximum concentration of the three-by-three grid cell array surrounding each monitor (see Figure 3-40: *Location of HGB Ozone Monitors with 4 km Grid Cell Array*) for each top 10 modeled day was averaged and used for the denominator of the RRF. From the future year modeling, the concentrations from the corresponding baseline top 10 modeled days and maximum grid cells were averaged for the numerator of the RRF, as shown in Table 3-32: *HGB Monitor-Specific Relative Response Factors for Attainment Test*.

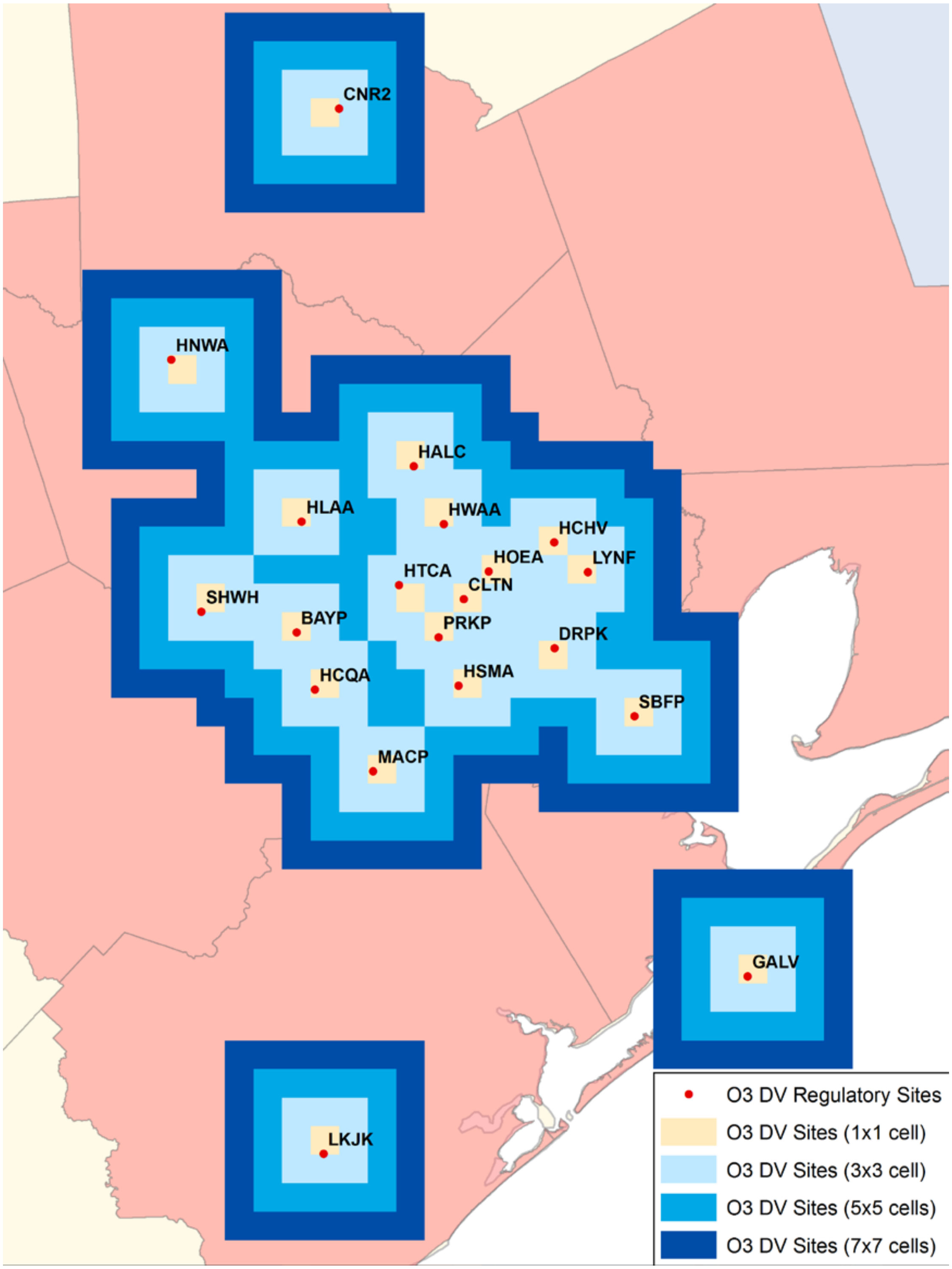


Figure 3-40: Location of HGB Ozone Monitors with 4 km Grid Cell Array

Table 3-32: HGB Monitor-Specific Relative Response Factors for Attainment Test

HGB Monitor	Site Code	2012 Baseline Top 10-Day Mean (ppb)	2017 Future Top 10-Day Mean (ppb)	Relative Response Factor (RRF)
Manvel Croix Park - C84	MACP	80.58	75.29	0.934
Deer Park - C35	DRPK	76.67	73.32	0.956
Houston East - C1	HOEA	79.84	76.83	0.962
Park Place - C416	PRKP	82.40	78.73	0.956
Houston Northwest - C26	HNWA	83.69	77.42	0.925
Bayland Park - C53	BAYP	86.33	81.43	0.943
Croquet - C409	HCQA	86.64	80.93	0.934
Houston Monroe - C406	HSMA	79.83	76.43	0.957
Seabrook Friendship Park - C45	SBFP	80.54	76.34	0.948
Houston Texas Ave - C411	HTCA	81.98	78.83	0.961
Houston Aldine - C8	HALC	79.39	75.17	0.947
Conroe Relocated - C78	CNR2	74.97	70.20	0.936
Clinton Drive - C403	CLTN	80.27	77.67	0.968
Houston Westhollow - C410	SHWH	88.19	81.13	0.920
Lang - C408	HLAA	85.62	79.99	0.934
Galveston - C1034	GALV	83.11	78.49	0.944
Channelview - C15	HCHV	77.08	73.90	0.959
North Wayside - C405	HWAA	79.33	75.62	0.953
Lynchburg Ferry - C1015	LYNF	76.82	73.44	0.956
Lake Jackson - C1016	LKJK	71.50	66.98	0.937

The RRF is multiplied by the 2012 baseline design value (DV_B) to obtain the 2017 future design value (DV_F) for each ozone monitor. In accordance with modeling guidance (EPA, 2014a), the final regulatory future design value is obtained by rounding to the tenths digit and truncating to zero decimal places. The DV_Fs are presented in Table 3 33: *Summary of RRF and 2017 Future Ozone Design Values* and Figure 3 41: *2017 Future Design Values by HGB Monitoring Location.* Application of the attainment test results in only the Manvel Croix Park (C84) monitor above the 2008 eight-hour ozone standard of 75 ppb in 2017.

Table 3-33: Summary of RRF and 2017 Future Ozone Design Values

HGB Monitor	Site Code	2012 DV_B (ppb)	RRF	2017 DV_F (ppb)	Regulatory 2017 DV_F (ppb)
Manvel Croix Park - C84	MACP	85.00	0.934	79.41	79
Deer Park - C35	DRPK	78.33	0.956	74.91	74
Houston East - C1	HOEA	78.00	0.962	75.06	75
Park Place - C416	PRKP	77.33	0.956	73.89	73
Houston Northwest - C26	HNWA	80.00	0.925	74.01	74
Bayland Park - C53	BAYP	78.67	0.943	74.21	74
Croquet - C409	HCQA	78.67	0.934	73.49	73
Houston Monroe - C406	HSMA	76.67	0.957	73.40	73
Seabrook Friendship Park - C45	SBFP	76.33	0.948	72.34	72
Houston Texas Ave - C411	HTCA	75.00	0.961	72.11	72
Houston Aldine - C8	HALC	76.67	0.947	72.59	72
Conroe Relocated - C78	CNR2	78.00	0.936	73.04	73
Clinton Drive - C403	CLTN	74.67	0.968	72.25	72
Houston Westhollow - C410	SHWH	77.67	0.920	71.45	71
Lang - C408	HLAA	76.33	0.934	71.31	71
Galveston - C1034	GALV	75.33	0.944	71.15	71
Channelview - C15	HCHV	73.00	0.959	69.99	70
North Wayside - C405	HWAA	73.67	0.953	70.23	70
Lynchburg Ferry - C1015	LYNF	71.00	0.956	67.88	67
Lake Jackson - C1016	LKJK	69.33	0.937	64.94	64

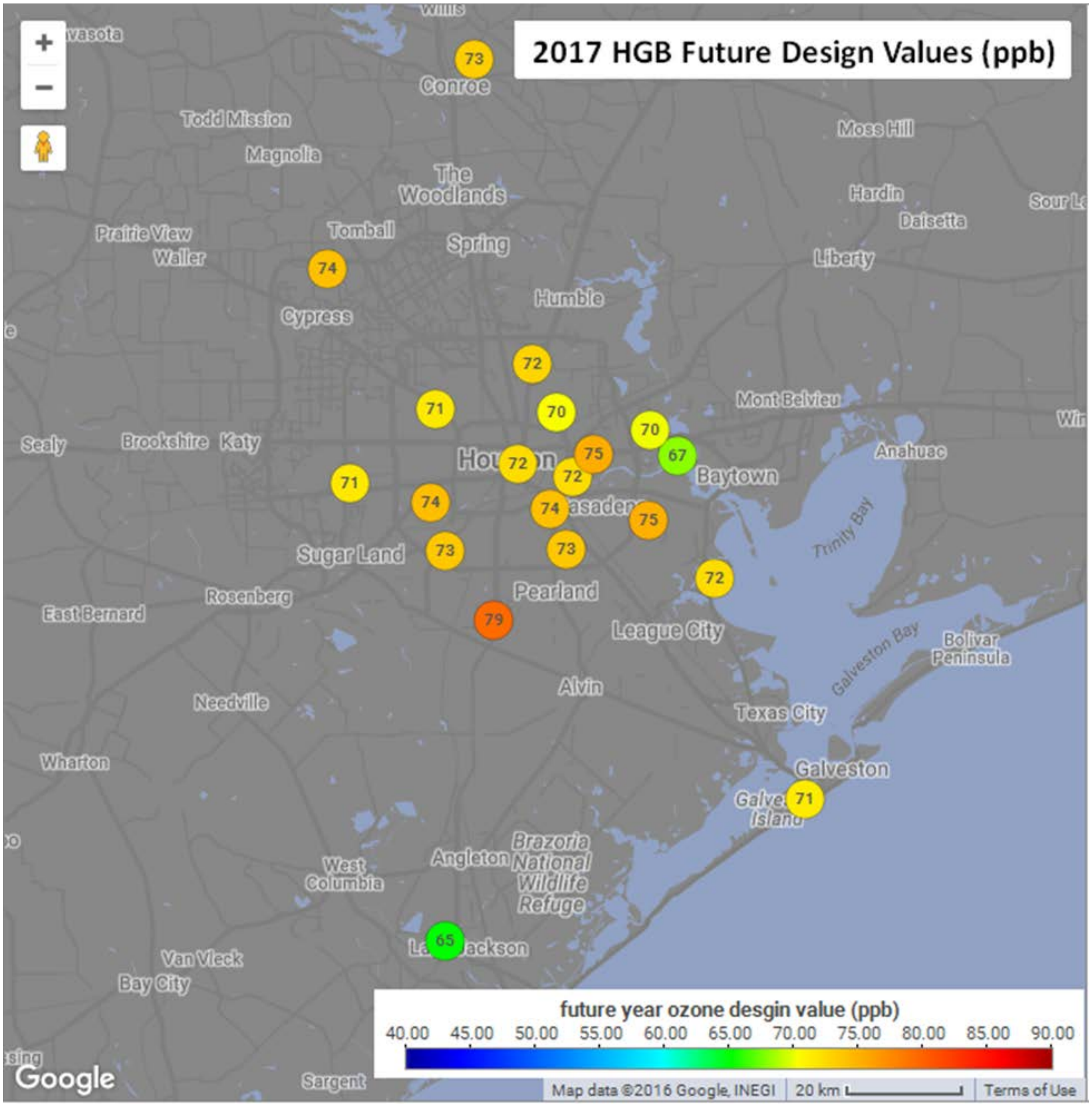


Figure 3-41: 2017 Future Design Values by HGB Monitoring Location

3.8.2 Unmonitored Area Analysis

The modeling guidance (EPA, 2014a) recommends that areas not near monitoring locations (unmonitored areas) be subjected to an unmonitored area (UMA) analysis to demonstrate that these areas are expected to reach attainment by the required future year. The standard attainment test is applied only at monitor locations, and the UMA analysis is intended to identify any areas not near a monitoring location that are at risk of not meeting the attainment date. Recently, the EPA provided Modeled Attainment Test Software (MATS), which can be used to conduct UMA analyses, but has not specifically recommended using its software in the modeling guidance, instead stating, "Air agencies can use the EPA-provided software or are free to develop alternative techniques that may be appropriate for their areas or situations."

The TCEQ used its own procedure to conduct the UMA analysis for several reasons. Both procedures incorporate modeled predictions into a spatial interpolation procedure, using the Voronoi Neighbor Averaging technique. However, the TCEQ Attainment Test for Unmonitored areas (TATU) is already integrated into the TCEQ's model post-processing stream while MATS requires that modeled concentrations be exported to a personal computer-based platform. Additionally, MATS requires input in latitude/longitude, while TATU works directly off the LCC projection data used in TCEQ modeling applications. More information about TATU is provided in Appendix C: *Photochemical Modeling for the HGB Attainment Demonstration SIP Revision for the 1997 Eight-Hour Ozone Standard* of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision.

Color contour maps of ozone concentrations for the 2012 baseline and the 2017 future case design values are presented in Figure 3-42: *Spatially Interpolated 2012 Baseline Design Values for the HGB Area* and Figure 3-43: *Spatially Interpolated 2017 Future Design Values for the HGB Area*. The figures show the extent and magnitude of the expected improvements in ozone design values, with few grid cells at or above 76 ppb in the future case plot. The area wide maximum is located near the Manvel Croix Park (C84) monitor in Brazoria County. A small, unmonitored area on the Harris and Montgomery County border is also predicted to be above the 2008 eight-hour ozone standard in 2017. Areas in the Gulf of Mexico are also predicted to be above 75 ppb but because of the lack of monitors along and in the Gulf of Mexico, the spatial interpolation and predicted future design along and near Galveston Island are not considered reliable.

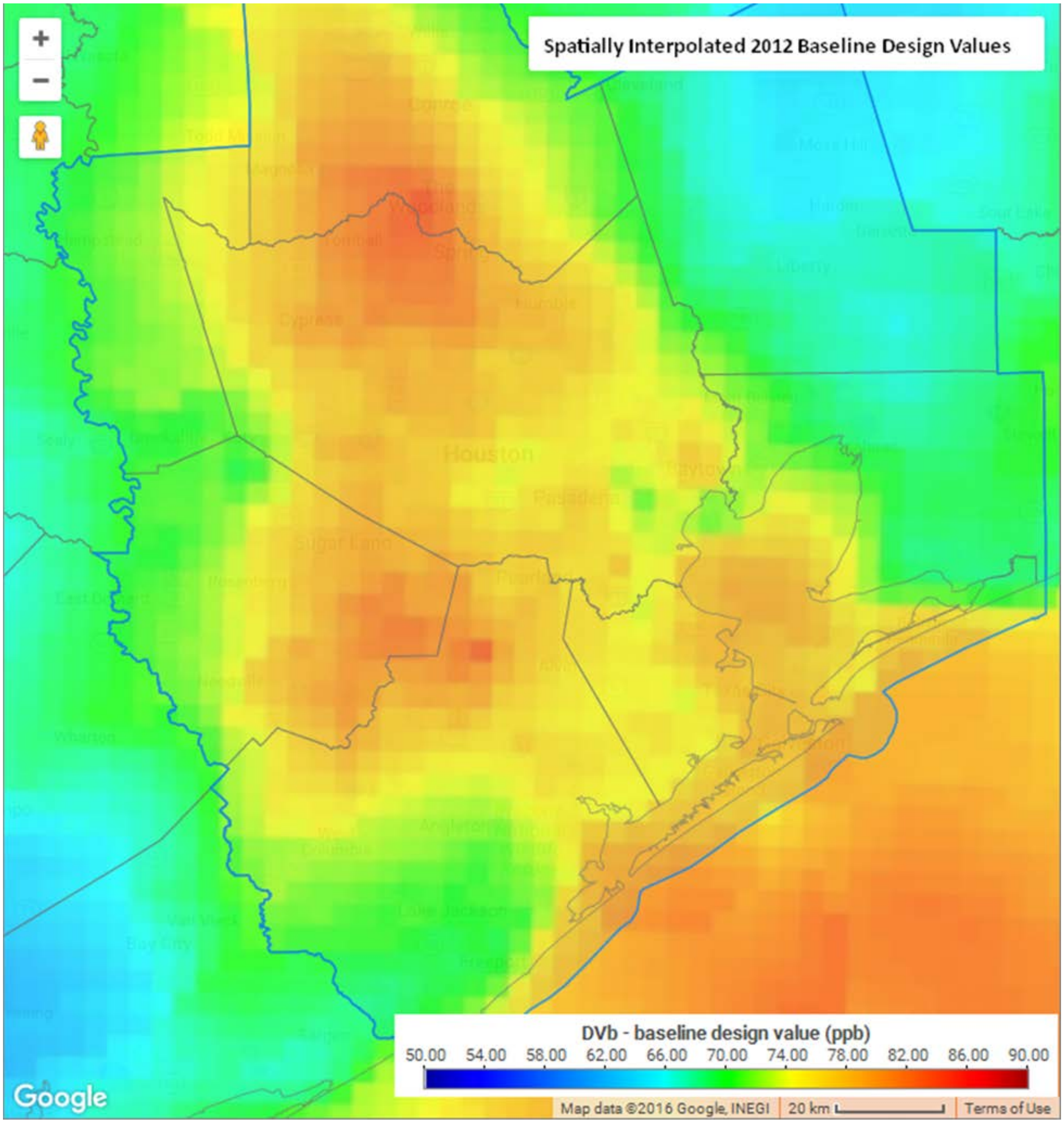


Figure 3-42: Spatially Interpolated 2012 Baseline Design Values for the HGB Area

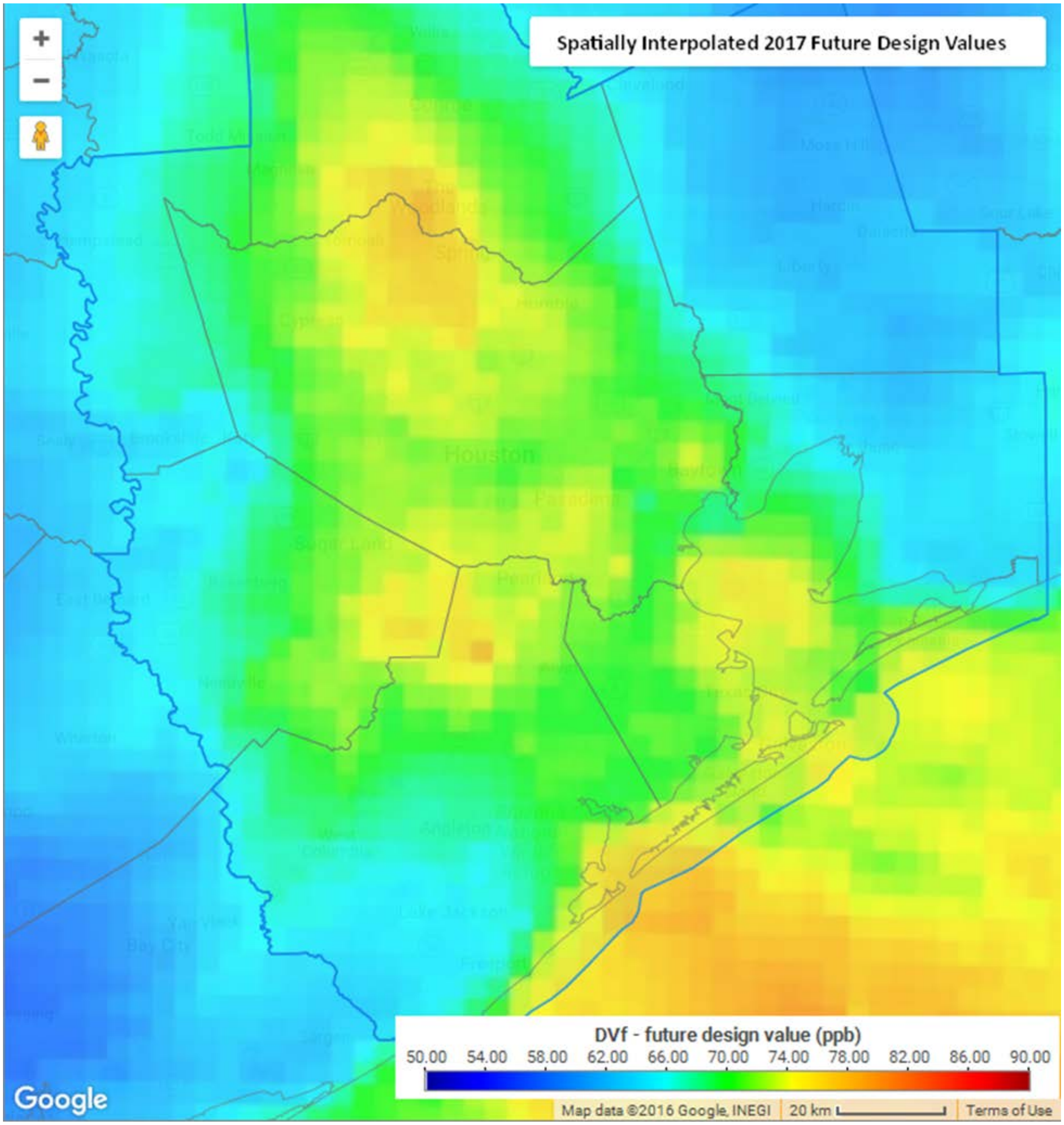


Figure 3-43: Spatially Interpolated 2017 Future Design Values for the HGB Area

3.9 MODELING ARCHIVE AND REFERENCES

3.9.1 Modeling Archive

The TCEQ has archived all modeling documentation and modeling input/output files generated as part of this HGB AD SIP revision modeling analysis. Interested parties can contact the TCEQ for information regarding data access or project documentation. Most modeling files and performance evaluation products may be found on the TCEQ modeling FTP site (ftp://amdaftp.tceq.texas.gov/pub/TX/camx/). The 2012 base case and baseline EI component files for each source category are available on the TCEQ modeling FTP site (ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/hgb_sip/). The

2017 future case EI component files are available on the TCEQ modeling FTP site (ftp://amdaftp.tceq.texas.gov/pub/EI/2012_episodes/hgb_sip/).

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CHAPTER 4: CONTROL STRATEGIES AND REQUIRED ELEMENTS

4.1 INTRODUCTION

The Houston-Galveston-Brazoria (HGB) nonattainment area for the 2008 eight-hour ozone National Ambient Air Quality Standard (NAAQS), which consists of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, includes a wide variety of major and minor industrial, commercial, and institutional entities. The Texas Commission on Environmental Quality (TCEQ) has implemented stringent and innovative regulations that address emissions of nitrogen oxides (NO_X) and volatile organic compounds (VOC) from these sources. This chapter describes existing ozone control measures for the HGB nonattainment area, as well as how Texas meets the following moderate ozone nonattainment area state implementation plan (SIP) requirements for the 2008 eight-hour ozone NAAQS: reasonably available control technology (RACT), reasonably available control measures (RACM), motor vehicle emissions budget (MVEB), and contingency measures.

4.2 EXISTING CONTROL MEASURES

Since the early 1990s, a broad range of control measures have been implemented for each emission source category for ozone planning in the HGB nonattainment area. Table 4-1: *Existing Ozone Control and Voluntary Measures Applicable to the HGB Eight-County Nonattainment Area* lists the existing ozone control strategies that were implemented for the one-hour and 1997 and 2008 eight-hour ozone standards in the HGB area.

Table 4-1: Existing Ozone Control and Voluntary Measures Applicable to the HGB Eight-County Nonattainment Area

Measure	Description	Start Date(s)
Highly Reactive Volatile Organic Compounds (HRVOC) Emissions Cap and Trade (HECT) Program and HRVOC Rules 30 Texas Administrative Code (TAC) Chapter 101, Subchapter H, Division 6 and 30 TAC Chapter 115, Subchapter H, Divisions 1 and 2	Affects cooling towers, process vents, and flares, and establishes an annual emissions limit with a cap and trade for each affected site in Harris County Seven perimeter counties subject to permit allowable limits and monitoring requirements	Monitoring requirements began January 31, 2006 HECT program implemented January 1, 2007 HECT cap incrementally stepped-down from 2014 through 2017 for a total 25% cap reduction
HRVOC Fugitive Rules 30 TAC Chapter 115, Subchapter D, Division 3	More stringent leak detection and repair (LDAR) requirements for components in HRVOC service Additional components included in LDAR program: more stringent repair times, lower leak detection, and third-party audit requirements	March 31, 2004

Measure	Description	Start Date(s)
Volatile Organic Compounds (VOC) Control Measures – Storage Tanks 30 TAC Chapter 115, Subchapter B, Division 1	Requires controls for slotted guide poles and more stringent controls for other fittings on floating roof tanks, and control requirements or operational limitations on landing floating roof tanks Eliminates exemption for storage tanks for crude oil or natural gas condensate, and regulates flash emissions from these tanks	January 1, 2009 Compliance with revised monitoring and testing requirements required by March 1, 2013
VOC Control Measures – Degassing Operations 30 TAC Chapter 115, Subchapter F, Division 3	Requires vapors from degassing to be vented to a control device for a longer time period, and removes exemption from degassing to control for tanks with capacity of 75,000 to 1,000,000 gallons Clarification of rule and monitoring and testing requirements, additional control options, and notification requirements	January 1, 2009 February 17, 2011
VOC Control Measures 30 TAC Chapter 115	Additional control technology requirements for batch processes and bakeries by December 31, 2002 Additional VOC measures adopted earlier for reasonably available control technology (RACT) and other SIP planning purposes: general vent gas control, industrial wastewater, loading and unloading operations, general VOC LDAR, solvent using process, etc.	December 31, 2002 and earlier
VOC Control Measures – Offset Lithographic Printers 30 TAC Chapter 115, Subchapter E, Division 4	Revised to limit VOC content of solvents used by offset lithographic printing facilities and to include smaller sources in rule applicability (see Appendix D: *Reasonably Available Control Technology Analysis* of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision for more details)	March 1, 2011 for major sources March 1, 2012 for minor sources
VOC Control Measures – Solvent-Using Processes 30 TAC Chapter 115, Subchapter E	Revised to implement RACT requirements per control technique guidelines published by the United States Environmental Protection Agency (EPA) Seven emission source categories in the Houston-Galveston-Brazoria (HGB) area: industrial cleaning solvents; flexible package printing; paper, film, and foil coatings; large appliance coatings; metal furniture coatings; miscellaneous metal and plastic parts coatings; and miscellaneous industrial adhesives (see the 2011 HGB 1997 Eight-Hour Ozone RACT Update SIP Revision for more details)	March 1, 2013

Measure	Description	Start Date(s)
Refueling – Stage I 30 TAC Chapter 115, Subchapter C, Division 2	Captures gasoline vapors that are released when gasoline is delivered to a storage tank Vapors returned to the tank truck as the storage tank is being filled with fuel, rather than released into the ambient air	1990 A SIP revision related to Stage I regulations was approved by the EPA, effective June 29, 2015
Refueling – Stage II 30 TAC Chapter 115, Subchapter C, Division 4	Captures gasoline vapors when a vehicle is being fueled at the pump Vapors returned through the pump hose to the petroleum storage tank, rather than released into the air	1992 A SIP revision authorizing the decommissioning of Stage II vapor control equipment was approved by the EPA on March 17, 2014. Facilities may continue operating Stage II until August 31, 2018
Nitrogen Oxides (NO_x) Mass Emissions Cap and Trade (MECT) Program and Chapter 117 NOx Emission Standards for Attainment Demonstration Requirements 30 TAC Chapter 101, Subchapter H, Division 3 and 30 TAC Chapter 117, Subchapter B, Division 3 Subchapter C, Division 3, Subchapter D, Division 1	Overall 80% NO_x reduction from existing industrial sources and utility power plants, implemented through a cap and trade program Affects utility boilers, gas turbines, heaters and furnaces, stationary internal combustion engines, industrial boilers, and many other industrial sources	April 1, 2003 and phased in through April 1, 2007
NO_x System Cap Requirements for Electric Generating Facilities (EGFs) 30 TAC Chapter 117, Subchapter B, Division 3 and Subchapter C, Division 3	Mandatory daily and 30-day system cap emission limits (independent of the MECT Program) for all EGFs at utility power plants and certain industrial/commercial EGFs that also provide power to the electric grid	March 31, 2007 (industrial/commercial EGFs) March 31, 2004 (utility power plants)
Utility Electric Generation in East and Central Texas 30 TAC Chapter 117, Subchapter E, Division 1	NO_x control requirements (approximately 55%) on utility boilers and stationary gas turbines at utility electric generation sites in East and Central Texas	May 1, 2003 through May 1, 2005

Measure	Description	Start Date(s)
NO_X Emission Standards for Nitric Acid and Adipic Acid Manufacturing 30 TAC Chapter 117, Subchapter F	NO_X emission standards for nitric acid and adipic acid manufacturing facilities in the HGB area	November 15, 1999
Stationary Diesel Engines 30 TAC Chapter 117, Subchapter B, Division 3 and Subchapter D, Division 1	Prohibition on operating stationary diesel and dual-fuel engines for testing and maintenance purposes between 6:00 a.m. and noon	April 1, 2002
Natural Gas-Fired Small Boilers, Process Heaters, and Water Heaters 30 TAC Chapter 117, Subchapter E, Division 3	NO_X emission limits on small-scale residential and industrial boilers, process heaters, and water heaters equal to or less than 2.0 million British thermal units per hour	2002
Minor Source NO_X Controls for Non-MECT Sites 30 TAC Chapter 117, Subchapter D, Division 1	NO_X emission limits on boilers, process heaters, stationary engines, and turbines at minor sites not included in the MECT Program (uncontrolled design capacity to emit less than 10 tons per year)	March 31, 2005
Texas Low Emission Diesel (TxLED) 30 TAC Chapter 114, Subchapter H, Division 2	Requires all diesels for both on-road and non-road use to have a lower aromatic content and a higher cetane number	October 31, 2005 and phased in through January 31, 2006
TxLED for Marine Fuels 30 TAC Chapter 114, Subchapter H, Division 2	Adds marine distillate fuels X and A, commonly known as DMX and DMA, or Marine Gas Oil, into the definition of diesel fuels, requiring them to be TxLED compliant	October 1, 2007 and phased in through January 1, 2008
Vehicle Inspection/ Maintenance 30 TAC Chapter 114, Subchapter C	Yearly computer checks for 1996 and newer vehicles and dynamometer testing for pre-1996 vehicles	May 1, 2002 in Harris County May 1, 2003 in Brazoria, Fort Bend, Galveston, and Montgomery Counties
Texas Low Reid Vapor Pressure (RVP) Gasoline 30 TAC Chapter 114, Subchapter H, Division 1	Requires all gasoline for both on-road and non-road use to have an RVP of 7.8 pounds per square inch or less from May 1 through October 1 each year	April 2000
Texas Emissions Reduction Plan (TERP) 30 TAC Chapter 114, Subchapter K	Provides grant funds for on-road and non-road heavy-duty diesel engine replacement/retrofit	January 2002

Measure	Description	Start Date(s)
Voluntary Mobile Emission Reduction Program	Various local on-road and non-road measures committed to as part of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision and administered by the Houston-Galveston Area Council (H-GAC) (see Appendix F: *Evaluation of Mobile Source Control Strategies for the Houston-Galveston-Brazoria State Implementation Plan With Detailed Strategies* of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision)	Phase in through 2018
Federal Area/Non-Road Measures	Series of emissions limits, implemented by the EPA, for area and non-road sources Examples: diesel and gasoline engine standards for locomotives and leaf-blowers	Phase in through 2018
Federal Marine Measures	International Marine Diesel Engine and Marine Fuel Standards for Oceangoing Vessels and Emissions Control Areas (MARPOL) requires marine diesel fuels used by oceangoing vessels (OGV) in the North American Emission Control Area to be limited to a maximum sulfur content of 1,000 parts per million, and all new engines on OGV operating in these areas must use emission controls that achieve an 80% reduction in NO_X emissions	January 1, 2015 for fuel standards and January 1, 2016 for engine standards
Federal On-Road Measures	Series of emissions limits implemented by the EPA for on-road vehicles: Tier 1, Tier 2, and Tier 3 light-duty and medium-duty passenger vehicle standards; heavy-duty vehicle standards; low sulfur gasoline and diesel standards; National Low Emission Vehicle standards; and reformulated gasoline	Phase in through 2025
Speed Limit Reduction 43 TAC Chapter 25, Subchapter B	Five miles per hour (mph) below the speed limit posted before May 1, 2002 on roadways with speeds that were 65 mph or higher	September 2003
California Standards for Certain Gasoline Engines	California standards for non-road gasoline engines 25 horsepower and larger	May 1, 2004

Measure	Description	Start Date(s)
Transportation Control Measures	Various transportation-related, local measures implemented under the previous one-hour and 1997 eight-hour ozone standards (see Appendix F of the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision) H-GAC has implemented all TCM commitments and provides an accounting of TCMs as part of the transportation conformity process. TCMs are not required to be considered for a moderate nonattainment area.	Phase in through 2013
Voluntary Energy Efficiency/Renewable Energy	Energy efficiency and renewable energy projects enacted by the Texas Legislature outlined in Section 5.4.1.3: *Energy Efficiency and Renewable Energy Measures*	See Section 5.4.1.3

4.3 UPDATES TO EXISTING CONTROL MEASURES

4.3.1 Updates to NO_x Control Measures

In 2015, the commission adopted a 30 TAC Chapter 117 major source rule revision (Rule Project Number 2013-049-117-AI) to provide statewide compliance flexibility to testing requirements for temporary boilers and process heaters. The rulemaking also revises the definition of electric power generating system to distinguish rule requirements for independent power producers located in Texas ozone nonattainment areas.

4.3.1.1 NO_x Mass Emissions Cap and Trade (MECT) Program

On June 3, 2015, the commission adopted revisions to the MECT Program rules in 30 TAC Chapter 101, Division 3 (Rule Project No. 2014-007-101-AI).

The rulemaking revised the MECT rules to provide clarity and additional flexibility for the use of allowances for nonattainment New Source Review (NSR) offsets. The previous MECT rules limited the use of allowances for offsets to a new or modified facility that either did not have an administratively complete application for a permit under 30 TAC Chapter 116 before January 2, 2001, or did not qualify for a permit by rule under 30 TAC Chapter 106 and commence construction before January 2, 2001. The rules were expanded to allow for the use of MECT allowances to satisfy NO_x offset requirements for any facility in the HGB area that is required to participate in the MECT Program. The previous MECT rules only addressed the use of allowances for the one-to-one portion of the offset requirement. The rules were expanded to provide for the use of allowances to satisfy any portion of the nonattainment NSR offset requirement. The revisions provided additional flexibility and did not adversely affect air quality because the amount of allowances in the MECT cap will not increase. The expansion of the rules to provide for the use of allowances to satisfy the environmental contribution portion of the nonattainment NSR offset requirement could ultimately cause a permanent reduction in the overall MECT cap because the allowances used to satisfy the environmental contribution portion of the offset requirement will be permanently retired, will not be used to simultaneously comply with the MECT Program, and will not be returned when the facility shuts down.

The rules were revised to require 1 ton per year (tpy) of MECT allowances to be permanently surrendered for each 1 tpy of emission reduction credits (ERCs) generated from reducing NO_X emissions from a MECT source. Because excessive use of this provision could substantially reduce the total MECT allowances available for compliance, the executive director is given discretion on whether to approve the retirement of allowances.

The rulemaking added a new requirement for the executive director to deduct allowances equal to the NO_X emissions quantified under this subsection plus an additional 10% if emissions are quantified using alternate data due to non-compliance with the Chapter 117 monitoring and testing requirements. This additional amount of allowances ensures that the emissions reported using alternate data are at least the amount that would have been deducted if required monitoring data had been used to calculate emissions.

A new provision was added to specify that if the site's compliance account does not hold sufficient allowances to accommodate this reduction, the executive director will issue a Notice of Deficiency and require the owner or operator to obtain sufficient allowances within 30 days of the notice. This new requirement was necessary to ensure an owner or operator resolves any deficiencies in a timely manner. The rule also clarifies that these actions do not preclude additional enforcement action by the executive director.

A new provision was added to allow the owner or operator to request a waiver from the reporting requirements if a site subject to the MECT Program no longer has authorization to operate any affected facilities. If TCEQ approves the request, the annual compliance report will not be required until a new affected facility is authorized at the site.

4.3.2 Updates to VOC Control Measures

4.3.2.1 Updates to VOC Storage Tank Rule

The concurrent rulemaking (Rule Project Number 2016-039-115-AI) with this HGB AD SIP revision updates the existing requirements for VOC storage tanks in 30 TAC Chapter 115, Subchapter B, Division 1 in the HGB nonattainment area to update RACT. Additional detail concerning this update can be found in the RACT discussion in Section 4.4.3: *VOC RACT Determination* of this chapter.

4.3.2.2 Highly Reactive Volatile Organic Compounds Emissions Cap and Trade (HECT) Program

On June 3, 2015, the commission adopted revisions to the HECT Program rules in 30 TAC Chapter 101, Division 5 (Rule Project No. 2014-007-101-AI).

The rulemaking continued to provide for the use of HECT allowances to satisfy VOC offset requirements for any facility in Harris County that is required to participate in the HECT Program. The previous HECT rules only addressed the use of allowances for the one-to-one portion of the offset requirement. The rulemaking expanded the rules to provide for the use of allowances to satisfy any portion of the nonattainment NSR offset requirement. The revisions provided additional flexibility and did not adversely affect air quality because the amount of allowances in the HECT cap will not increase. The expansion of the rules to provide for the use of allowances to satisfy the environmental contribution portion of the nonattainment NSR offset requirement could ultimately cause a permanent reduction in the overall HECT cap because the allowances used to satisfy the environmental contribution portion of the offset requirement will be permanently retired, will not be used to simultaneously comply with the HECT Program, and will not be returned when the facility shuts down.

A new provision was added to allow the owner or operator of a facility subject to the HECT Program to generate VOC ERCs from the reduction of HRVOC emissions if 1 tpy of HECT allowances is permanently surrendered for each 1 tpy of ERCs generated from HRVOC emissions. The HECT allowances are only required to be surrendered for ERCs generated from HRVOC emissions, regardless of whether ERCs were simultaneously generated from other VOCs. An owner or operator will not be required to retire an allocation of HECT allowances when generating VOC ERCs, except to generate ERCs from HRVOC reductions by affected facilities. Because excessive use of this provision could substantially reduce the total HECT allowances available for compliance, the executive director is given discretion on whether to approve the retirement of allowances.

The rulemaking added a new requirement for the executive director to deduct allowances equal to the HRVOC emissions quantified under this subsection plus an additional 10% if emissions are quantified using alternate data due to non-compliance with the Chapter 115 monitoring and testing requirements. This additional amount of allowances ensures that the emissions reported using alternate data are at least the amount that would have been deducted if required monitoring data had been used to calculate emissions.

The rulemaking removed the provision that allowed VOC ERCs to be converted to HECT allowances. The provision was deleted because it has only been used once and, because of the cost of VOC ERCs compared to HECT allowances and the great reduction in allowances from the ERCs that are converted, is unlikely to be used in the future.

A new provision was added to allow the owner or operator to request a waiver from the reporting requirements if a site subject to the HECT Program no longer has authorization to operate any affected facilities. If TCEQ approves the request, the annual compliance report will not be required until a new affected facility is authorized at the site.

Section 101.396(b) requires HRVOC emissions to be calculated for each hour of the year and summed to determine the annual emissions for compliance. During rulemaking in 2010, the TCEQ inadvertently deleted the portion of §101.396(b) that specified for emissions from emissions events subject to the requirements of §101.201, the hourly emissions included in the calculation must not exceed the short-term limits in §115.722(c) and §115.761(c). The 2010 revision to §101.396(b) was initially proposed for deletion as part of an attempt to create an emissions event set-aside pool for affected facilities. In response to public comments, the rule revisions adopted by the commission did not include the emissions event set-aside. The preamble to the adopted 2010 rulemaking indicates that the commission's intent was to continue to treat emissions events in the same manner for purposes of the HECT Program and only deduct allowances for emissions during emissions events up to the short-term limits in §115.722(c) and §115.761(c) (35 TexReg 2537). The 2015 revision replaced the previous language in §101.396(b) with the version of the rule that existed before the 2010 revision.

4.3.3 Decommissioning of Stage II Vapor Recovery

The Stage II vapor recovery program involves use of technology that prevents gasoline vapors from escaping during refueling of on-road motor vehicles. The EPA mandated that Stage II refueling requirements apply to all public and private refueling facilities dispensing 10,000 gallons or more of gasoline per month. The federal throughput constitutes a minimum threshold, but a state may be more stringent in adopting a throughput standard. The TCEQ applied a more stringent throughput standard in the applicable ozone nonattainment counties by requiring all facilities constructed after November 15, 1992 to install Stage II vapor recovery regardless of throughput.

The EPA currently allows the state to revise its SIP to allow the removal of Stage II gasoline vapor recovery equipment if the state can demonstrate that widespread use of an onboard refueling vapor recovery has occurred at the gasoline dispensing facilities (GDFs) dedicated to corporate or commercial fleets. Onboard Refueling Vapor Recovery (ORVR) systems are passive systems that force gasoline vapors displaced from a vehicle’s fuel tank during refueling to be directed to a carbon-canister holding system and ultimately to the engine where they are consumed.

In the May 16, 2012 *Federal Register* (FR) (77 FR 28772), the EPA finalized a rulemaking for 40 Code of Federal Regulations (CFR) Part 51 determining that vehicle ORVR technology is in widespread use for the purposes of controlling motor vehicle refueling emissions throughout the motor vehicle fleet. This action allows the EPA to waive the requirement for states to implement Stage II gasoline vapor recovery systems at GDFs in nonattainment areas classified as moderate and above for the ozone NAAQS. States that have implemented a Stage II program may revise their Stage II SIP showing that the air quality will be maintained after removing the Stage II equipment.

According to the EPA’s guidance document for decommissioning Stage II, it is necessary for the executive director to demonstrate under the FCAA, §110(l) that air quality is not affected by the decommissioning of, or failure to install, Stage II equipment. An assessment was performed of the amount of benefit loss from removing Stage II and any effect on air quality programs in the four Texas ozone air quality planning areas using the method documented in the EPA’s guidance document. It was found that removal of Stage II requirements does not interfere with attainment or maintenance of the NAAQS in the Texas air quality plans.

On October 9, 2013, the commission adopted a revision (Rule Project Number 2013-001-115-AI) to 30 TAC Chapter 115, Subchapter C, Division 4 establishing that owners and operators of GDFs are no longer required to install Stage II equipment and requiring the decommissioning of Stage II equipment at all GDFs no later than August 31, 2018. This adopted rule change requires that GDFs electing to retain Stage II equipment until the mandatory removal date of August 31, 2018 continue to comply with current Stage II rules. A SIP revision authorizing the decommissioning of Stage II vapor control equipment was approved by the EPA on March 17, 2014.

4.3.4 Updates to Stage I Vapor Recovery

The Stage I vapor recovery rules regulate the filling of gasoline storage tanks at gasoline stations by tank trucks. To comply with Stage I requirements, a vapor balance system is typically used to capture the vapors from the gasoline storage tanks that would otherwise be displaced to the atmosphere as these tanks are filled with gasoline. The captured vapors are routed back to the tanker truck and processed by a vapor control system when the tanker truck is subsequently refilled at a gasoline terminal or gasoline bulk plant. The effectiveness of Stage I vapor recovery rules depends on the captured vapors being: effectively contained within the gasoline tanker truck during transit; and controlled when the transport vessel is refilled at a gasoline terminal or gasoline bulk plant.

On September 10, 2014, the commission adopted a revision (Rule Project Number 2013-022-115-AI) to the requirements for Stage I vapor recovery testing in 30 TAC Chapter 115, Subchapter C, Division 2. This rulemaking preserves existing Stage I testing requirements in ozone nonattainment counties and specify Stage I testing requirements for GDFs located in the 12 ozone nonattainment and four ozone maintenance counties that will be affected by the decommissioning of the Stage II vapor recovery equipment rule revision and in the 95 counties that are subject to the state Stage I rule but not Stage II requirements. The Stage I rule revision establishes testing requirements that are more consistent with federal Stage I testing in 40 CFR Part 63, Subpart CCCCCC.

4.3.5 Surface Coating Application System Requirements

On October 23, 2013, the commission adopted a revision (Rule Project Number 2013-012-115-AI) to revise the coating application system requirements to reflect the recommendations provided in the EPA's *Control Techniques Guidelines for Miscellaneous Metal and Plastic Parts Coatings* (EPA 453/R-08-003) document. The control requirements include air-assisted and airless spray systems as approved coating application systems.

4.3.6 Clarification of Various VOC Rules

On June 3, 2015, the commission adopted revisions (Rule Project Number 2013-048-115-AI) to clarify a portion of the coating application system requirement, add a definition of "Automotive/transportation plastic parts," and update equation variables in 30 TAC Chapter 115, Subchapter E, Division 5. The rulemaking clarifies the motor vehicle coating applicability and incorporates types of coatings or coating processes into existing exemptions. The rulemaking clarifies which adhesives being used for miscellaneous metal or plastic parts coating are exempt from this division.

The commission also adopted revisions to clarify that true vapor pressure must be corrected to storage temperature using the measured actual storage temperature or the maximum local monthly average ambient temperature as reported by the National Weather Service, and add a new American Standard Testing and Materials International test method in 30 TAC Chapter 115, Subchapter C, Division 1.

The commission adopted revisions to clarify carbon adsorption monitoring requirements and add an American Society for Testing and Materials, Method D6377 for crude oil in 30 TAC Chapter 115, Subchapter B, Division 1. The rulemaking adds a definition of 'Solvent' to 30 TAC Chapter 115, Subchapter E, Division 6 to more clearly indicate the applicability of this division.

4.3.7 Revisions to Vehicle Inspection and Maintenance (I/M) Program

House Bill (HB) 2305, 83rd Texas Legislature, 2013, Regular Session, replaced the previous Texas dual inspection and registration sticker system with a single vehicle registration insignia sticker system (single sticker system). HB 2305, which became effective on September 1, 2013, required:

- eliminating the use of the safety and emissions inspection windshield certificate, also known as the safety and emissions inspection windshield sticker;
- verifying compliance with inspection requirements using the vehicle inspection report or vehicle registration sticker instead of the current safety and emissions inspection windshield sticker; and
- passing of the vehicle safety and emissions inspection no more than 90 days prior to the expiration of the vehicle's registration instead of on the expiration of the vehicle's safety and emissions inspection windshield sticker.

HB 2305 required the commission to adopt rules by March 1, 2014 and implement the changes by March 1, 2015. The commission adopted rules and revisions to the I/M SIP on February 12, 2014, modifying the design of the vehicle emissions I/M program. On March 1, 2015, the single sticker system and additional I/M program design changes were implemented by the commission and in conjunction with the Texas Department of Public Safety (DPS) and the Texas Department of Motor Vehicles (TxDMV).

Prior to HB 2305, the vehicle emissions I/M program required vehicles subject to emissions inspections to demonstrate compliance by displaying a valid, current safety and emissions inspection sticker and a valid, current registration sticker on vehicle windshields. Since the expiration dates for vehicle registration and vehicle inspection did not match for most Texas vehicle owners, the TxDMV, the DPS, and the commission decided to implement the requirements of HB 2305 in two phases.

Phase one, which began on March 1, 2015, allowed vehicle owners one year to synchronize their inspection and registration dates. During phase one, vehicle owners were permitted to delay annual vehicle inspection until the month that vehicle registration expired. Phase one provided a method for transitioning to the single sticker system without penalizing vehicle owners whose vehicle inspection and vehicle registration expiration dates did not match, which may have required their vehicles to be inspected twice within a 12-month window.

Full implementation of the single sticker program, or phase two, started on March 1, 2016. Beginning March 1, 2016, the TxDMV only allows vehicle registration issuance or renewal after receiving proof that a vehicle has passed vehicle safety and emissions inspection within the 90-day window immediately prior to the vehicle's registration expiration date.

4.4 RACT ANALYSIS

4.4.1 General Discussion

Nonattainment areas classified as moderate and above are required to meet the mandates of the Federal Clean Air Act (FCAA) under §172(c)(1) and §182(b)(2) and (f). According to EPA's final *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements* (2008 ozone standard SIP requirements rule) published in the March 6, 2015 *Federal Register* (80 FR 12264), states containing areas classified as moderate nonattainment or higher must submit a SIP revision demonstrating that their current rules fulfill the RACT requirements for all control techniques guidelines (CTG) emission source categories and all non-CTG major sources of NO_X and VOC.

The TCEQ submitted a redesignation substitute report to the EPA demonstrating the HGB area attained and would continue to attain the one-hour ozone NAAQS on July 22, 2014, which was approved by the EPA on October 20, 2015 (80 FR 63429). On August 18, 2015, the TCEQ submitted a redesignation substitute report to the EPA demonstrating the HGB area attained and will continue to attain the 1997 eight-hour ozone NAAQS. On November 8, 2016, the EPA published its final approval of the HGB area redesignation substitute and a finding of attainment for the 1997 eight-hour ozone NAAQS (81 FR 78691) effective December 8, 2016. The EPA's final approval of the 1997 eight-hour ozone NAAQS redesignation substitute changes the HGB area's major source threshold from the potential to emit (PTE) 25 tons per year (tpy) to the PTE 100 tpy of NO_X or VOC in accordance with the area's marginal classification for the 2008 eight-hour ozone NAAQS. Upon the effective date of the EPA's expected reclassification for the area, the major source threshold is based on the area's anticipated moderate classification for the 2008 eight-hour ozone NAAQS of a PTE 100 tpy of NO_X or VOC. The PTE of 25 tpy is retained as the major source threshold for this HGB AD SIP revision RACT analysis because the timing of the EPA's final redesignation substitute approval did not allow the necessary adjustments to be made for this RACT analysis.

RACT is defined as the lowest emissions limitation that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility (44 FR 53762, September 17, 1979). RACT requirements for moderate and higher classification nonattainment areas are included in the FCAA to assure that significant source categories at major sources of ozone precursor emissions are controlled to a reasonable extent, but not necessarily to best available control technology (BACT) levels expected of new sources or to maximum achievable control technology (MACT) levels required for major sources of hazardous air pollutants.

While RACT and RACM have similar consideration factors like technological and economic feasibility, there is a significant distinction between RACT and RACM. A control measure must advance attainment of the area towards the meeting the NAAQS for that measure to be considered RACM. Advancing attainment of the area is not a factor of consideration when evaluating RACT because the benefit of implementing RACT is presumed under the FCAA.

State rules that are consistent with or more stringent than controls implemented in other nonattainment areas were also determined to fulfill RACT requirements. Federally approved state rules and rule approval dates can be found in 40 CFR §52.2270(c), *EPA Approved Regulations in the Texas SIP*. Emission sources subject to the more stringent BACT or MACT requirements were determined to also fulfill RACT requirements.

The TCEQ reviewed the emission sources in the HGB area and the applicable state rules to verify that all CTG or alternative control techniques (ACT) emission source categories and non-CTG or non-ACT major emission sources in the HGB area were subject to requirements that meet or exceed the applicable RACT requirements, or that further emission controls on the sources were either not economically feasible or not technologically feasible. Additional detail can be found in Appendix F: *Reasonably Available Control Technology Analysis* of this HGB AD SIP revision

4.4.2 NO_X RACT Determination

The Chapter 117 rules represent one of the most comprehensive NO_X control strategies in the nation. The NO_X controls and reductions implemented through Chapter 117 for the HGB nonattainment area for the 1997 eight-hour ozone standard encompass both RACT and beyond-RACT levels of control. In 2013, the EPA determined that NO_X control measures in 30 TAC Chapter 117 and the most recent RACT analysis submitted on April 6, 2010 met RACT requirements for major sources of NO_X in the HGB area under the 1997 eight-hour ozone NAAQS (78 FR 19599, April 2, 2013). The current EPA-approved Chapter 117 rules continue to fulfill RACT requirements for ACT NO_X source categories that exist in the HGB area. Table F-3: *State Rules Addressing NO_X RACT Requirements in ACT Reference Documents* of Appendix F provides additional details on the ACT source categories. For major NO_X emission sources for which NO_X controls are technologically and economically feasible, RACT is fulfilled by existing source-specific rules in Chapter 117 and other federally enforceable measures. Additional NO_X controls on certain major sources were determined to be either not economically feasible or not technologically feasible. Table F-4: *State Rules Addressing NO_X RACT Requirements for Major Emission Sources in the HGB Area* of Appendix F provides additional detail on NO_X major emission sources.

4.4.3 VOC RACT Determination

All VOC emission source categories addressed by CTG and ACT documents in the HGB area are controlled by existing rules in 30 TAC Chapter 115 or other EPA-approved regulations that fulfill RACT requirements. The EPA approved the existing Chapter 115 VOC rule revisions as RACT for all CTG documents issued after 2006 for the HGB area under the 1997 eight-hour ozone NAAQS (78 FR 19599, April 2, 2013; 79 FR 21144, April 15, 2014; 79 FR 45105, August 4, 2014; and 80 FR 16291, March 27, 2015). The EPA determined that VOC RACT is in place for all CTG and non-CTG major sources in the HGB area for the one-hour and 1997 eight-hour ozone NAAQS. The current EPA-approved Chapter 115 rules continue to fulfill RACT requirements for the 2008 eight-hour ozone NAAQS. As discussed in Section 4.4.3.1: *VOC Storage Tanks*, the concurrent rulemaking (Rule Project No. 2016-039-115-AI) satisfies CTG and non-CTG major source RACT for VOC storage tanks in the HGB area. Specified information regarding the TCEQ's VOC RACT analysis is provided in Appendix F: *Reasonably Available Control Technology Analysis*. Tables F-1: *State Rules Addressing VOC RACT*

Requirements in CTG Reference Documents and F-2*: State Rules Addressing VOC RACT Requirements in ACT Reference Documents* of Appendix F provide additional details on the CTG and ACT source categories.

For all major VOC emission sources for which VOC controls are technologically and economically feasible, RACT is fulfilled by existing Chapter 115 rules, other federally enforceable measures, and by concurrent revisions to Chapter 115. Additional VOC controls on certain major sources were determined to be either not economically feasible or not technologically feasible. Table F-5: *State Rules Addressing VOC RACT Requirements for Major Emission Sources in the HGB Area* of Appendix F provides additional detail on VOC major emission sources.

4.4.3.1 VOC Storage Tanks

The concurrent rulemaking (Rule Project No. 2016-039-115-AI) satisfies CTG and non-CTG major source RACT for VOC storage tanks in the HGB area. The updated RACT revisions increase the control efficiency of control devices, other than vapor recovery units or flares, from 90% to 95%. In addition to increasing the required control efficiency for all storage tanks, the rulemaking enhances inspection, repair, and recordkeeping requirements for fixed roof crude oil and condensate storage tanks with the uncontrolled VOC emissions of more than 25 tpy in the HGB area. The amendments also expand the rule applicability to include the aggregate of fixed roof crude oil and condensate storage tanks at pipeline breakout stations in the HGB area. Emissions from all of the fixed roof crude oil and condensate tanks at each pipeline breakout station will now be considered when determining applicability to the Chapter 115 VOC storage tank rule. These revisions are consistent with previously adopted RACT revisions in the Dallas-Fort Worth (DFW) 1997 eight-hour ozone nonattainment area. The increased control efficiency requirement of 95% scheduled to be adopted concurrently with this HGB AD SIP revision for the HGB area was approved as RACT by the EPA in 2014 (79 FR 45105, August 4, 2014) for the DFW area. The increased control efficiency requirements; inspection, repair, and recordkeeping requirements; and expanded applicability for fixed roof crude oil and condensate storage tanks in this concurrent rulemaking are already in place for VOC storage tanks in the DFW area. The rule revisions address RACT for both CTG and non-CTG major source VOC storage tanks in the HGB area.

4.5 RACM ANALYSIS

4.5.1 General Discussion

FCAA, §172(c)(1) requires states to provide for implementation of all RACM as expeditiously as practicable and to include RACM analyses in the SIP. In the general preamble for implementation of the FCAA Amendments published in the April 16, 1992 *Federal Register* (57 FR 13498), the EPA explains that it interprets FCAA, §172(c)(1) as a requirement that states incorporate into their SIP all RACM that would advance a region's attainment date; however, states are obligated to adopt only those measures that are reasonably available for implementation in light of local circumstances.

The TCEQ used a two-step process to develop the list of potential stationary source control strategies evaluated during the RACM analysis for the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision submitted to the EPA on April 6, 2010. The same list was used for this HGB AD SIP revision. First, the TCEQ compiled a list of potential control strategy concepts based on an initial evaluation of the existing control strategies in the HGB area and existing sources of VOC and NO_x in the HGB area. The EPA allows states the option to consider control measures outside the ozone nonattainment area that can be shown to advance attainment; however, consideration of these sources is not a requirement of the FCAA. A draft list of potential control strategy concepts was developed from this initial evaluation. The TCEQ also invited stakeholders to suggest any additional strategies that might help advance attainment of the HGB area. The final list of potential control strategy concepts for the RACM analysis includes the strategies on the initial draft list and the strategies suggested by stakeholders during the informal stakeholder comment process.

Each control measure identified through the control strategy development process was evaluated to determine if the measure would meet established criteria to be considered reasonably available. The TCEQ used the general criteria specified by the EPA in the proposed approval of the New Jersey RACM analysis published in the January 16, 2009 *Federal Register* (74 FR 2945).

RACM is defined by the EPA as any potential control measure for application to point, area, on-road and non-road emission source categories that meets the following criteria:

- the control measure is technologically feasible;
- the control measure is economically feasible;
- the control measure does not cause ‘‘substantial widespread and long-term adverse impacts’’;
- the control measure is not ‘‘absurd, unenforceable, or impracticable’’; and
- the control measure can advance the attainment date by at least one year.

The EPA did not provide guidance on how to interpret the criteria "advance the attainment date by at least one year." Considering the July 20, 2018 attainment date for this attainment demonstration, the TCEQ evaluated this aspect of RACM based on advancing the attainment deadline by one year, to July 20, 2017.

In order for a control measure to “advance attainment,” it would need to be implemented prior to the beginning of ozone season in the attainment year, so suggested control measures that could not be implemented by January 1, 2017 could not be considered RACM because the measures would not advance attainment. To “advance the attainment date by at least one year” to July 20, 2017, suggested control measures would have to have been fully implemented by January 1, 2016 which has already passed. In order to provide a reasonable amount of time to fully implement a control measure, the following must be considered: availability and acquisition of materials; the permitting process; installation time; and the availability of and time needed for testing.

The TCEQ also considered whether the control measure was similar or identical to control measures already in place in the HGB area. If the suggested control measure would not provide substantive and quantifiable benefit over the existing control measure, then the suggested control measure was not considered RACM because reasonable controls were already in place. Tables G-1: *HGB Area Stationary Source*

RACM Analysis and G-2: *HGB Area On-Road and Non-Road Mobile Source RACM Analysis* of Appendix G: *Reasonably Available Control Measures Analysis* presents the final list of potential control measures as well as the RACM determination for each measure.

4.5.2 Results of RACM Analysis

The TCEQ determined that no potential control measures met the criteria to be considered RACM. All potential control measures evaluated for stationary sources were determined to not be RACM due to the inability to implement control measures early enough to advance attainment of the 2008 eight-hour ozone NAAQS. Based on a July 20, 2018 attainment deadline, a control measure would have to be in place prior to the beginning of ozone season in the attainment year to be considered RACM, or January 1, 2017.

4.6 MOTOR VEHICLE EMISSIONS BUDGET

The MVEB refers to the maximum allowable emissions from on-road mobile sources for each applicable criteria pollutant or precursor as defined in the SIP. The budget must be used in transportation conformity analyses. Areas must demonstrate that the estimated emissions from transportation plans, programs, and projects do not exceed the MVEB. The attainment budget represents the summer weekday on-road mobile source emissions that have been modeled for the attainment demonstration, and includes all of the on-road control measures reflected in Chapter 4: *Control Strategies and Required Elements* of the demonstration. Due to the compressed schedule required for this HGB AD SIP revision, the proposal included a preliminary on-road emissions inventory (EI) developed using the 2014 version of the EPA's Motor Vehicle Emission Simulator model (MOVES2014).The updated on-road EI establishing this MVEB was developed with the 2014a version of the MOVES model (MOVES2014a), and is shown in Table 4-2: *2017 Attainment Demonstration MVEB for the Eight-County HGB Area*.

Table 4-2: 2017 Attainment Demonstration MVEB for the Eight-County HGB Area

Eight-County HGB Area On-Road Emissions Inventory Description	NO_X tons per day (tpd)	VOC (tpd)
2017 On-Road MVEB based on MOVES2014a	95.56	54.40

The on-road mobile emissions estimates have been updated in this HGB AD SIP revision using the most current on-road mobile inventories based on MOVES2014a and vehicle miles traveled (VMT) estimates from the HGB travel demand model managed by the Houston-Galveston Area Council. For additional detail, refer to Section 3 of Appendix B: *Emissions Modeling for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard*.

4.7 MONITORING NETWORK

The TCEQ operates a variety of monitors supporting ambient air quality assessment throughout the state of Texas. These monitors meet the requirements for several federally required networks including the State or Local Air Monitoring Stations network, Photochemical Assessment Monitoring Stations network, and National Core Multipollutant Monitoring Stations network.

The Texas annual monitoring network plan provides information on ambient air monitors established to meet federal ambient monitoring requirements including comparison to the NAAQS. Under 40 CFR Part 58.10, all states are required to submit an annual monitoring network plan to the EPA by July 1. The annual monitoring network plan is made available for public inspection for 30 days prior to submission to the EPA. The plan and any comments received are forwarded to the EPA for final review and approval. The TCEQ's 2016 plan presented the current Texas network, as well as proposed changes to the network from July 1, 2016, through December 31, 2017. The plan was posted for public comment from May 16, 2016, through June 16, 2016, and was submitted to the EPA on June 30, 2016.

The current HGB area monitoring network consists of 20 regulatory ambient air ozone monitors located in Brazoria, Galveston, Harris, and Montgomery Counties. The City of Houston operates seven of the monitors at the Clinton, Houston North Wayside, Houston Monroe, Lang, Houston Croquet, Houston Westhollow, and Park Place air monitoring stations. The TCEQ operates the remaining 13 ozone monitors at the Houston East, Houston Aldine, Channelview, Northwest Harris County, Houston Deer Park #2, Seabrook Friendship Park, Houston Bayland Park, Conroe Relocated, Manvel Croix Park, Lynchburg Ferry, Lake Jackson, Baytown Garth, and Galveston 99th Street air monitoring stations.

The monitors are managed in accordance with 40 CFR Part 58 to verify the attainment status of the area. The TCEQ ensures compliance with monitoring siting criteria and data quality requirements for these and all other federally required monitors in accordance with 40 CFR Part 58.

4.8 CONTINGENCY PLAN

Attainment demonstration SIP revisions for nonattainment areas are required by FCAA, §172(c)(9) to provide for specific measures to be implemented should a nonattainment area fail to meet reasonable further progress (RFP) requirements or attain the applicable NAAQS by the EPA's prescribed attainment date. If these conditions are not met, these contingency measures are to be implemented without further action by the state or the EPA. In the General Preamble for implementation of the FCAA Amendments of 1990 published in the April 16, 1992 *Federal Register* (57 FR 13498), the EPA interprets the contingency requirement to mean additional emissions reductions that are sufficient to equal up to 3% of the emissions in the adjusted RFP base year inventory. These emissions reductions should be realized in the year following the year in which the failure is identified.

The EPA's final 2008 ozone standard SIP requirements rule removed the requirement for states to account for non-creditable reductions when determining compliance with RFP emission reduction requirements. Although previously attainment demonstration contingency calculations were based on the RFP adjusted base year (ABY) EI, one result of removing the non-creditable reductions from the RFP calculations is the RFP ABY inventory becomes equal to the RFP base year inventory. Previously, attainment demonstration contingency calculations were based upon the RFP ABY EI.

This HGB AD SIP revision uses the 2011 base year inventory from the concurrent HGB RFP SIP Revision for the 2008 Eight-Hour Ozone Standard as the inventory from which to calculate the required 3% reductions for contingency. The 3% contingency analysis for 2018 is based on a 2% reduction in NO_x and a 1% reduction in VOC, to be achieved between 2017 and 2018. Analyses were performed on the fleet turnover effects for the federal emissions certification programs for on-road vehicles. The emissions reductions from 2017 through 2018 were estimated for those programs. A summary of the 2018 contingency analysis is provided in Table 4-3*: 2018 HGB Attainment Contingency Demonstration (tons per day).* The analysis demonstrates that the 2018 contingency reductions exceed the 3% reduction requirement; therefore, the attainment demonstration contingency requirement is fulfilled for the HGB area. Additional documentation for the attainment contingency demonstration calculations is available in the HGB RFP SIP Revision for the 2008 Eight-Hour Ozone Standard, which is scheduled to be adopted concurrently with this HGB AD SIP revision.

The on-road mobile source category EIs and the corresponding control strategy reductions for this contingency analysis were developed from the RFP EIs, which used the MOVES2014a model. The on-road mobile EI estimates in the proposed version of this contingency analysis were preliminary as the schedule for the inventory development did not allow time to incorporate the most current quality-assured RFP on-road mobile EIs. However, the quality assurance activities that were ongoing at the time of proposal did not change the preliminary on-road mobile EI estimates. As a result, no changes to the contingency analysis were necessary between proposal and adoption.

Table 4-3: 2018 HGB Attainment Contingency Demonstration (tons per day)

Contingency Element Description	NO_x	VOC
2011 HGB RFP base year1 (BY) emissions inventory (EI)	459.94	531.40
Percent for contingency calculation (total of 3%)	2.00	1.00
2017 to 2018 AD required contingency reductions (RFP BY1 EI x [contingency percent])	9.20	5.31
Control reductions to meet contingency requirements		
Excess reductions from 2017 attainment demonstration	0.00	0.00
Subtract reductions reserved for 2017 attainment demonstration MVEB safety margin	0.00	0.00
Post-1990 Federal Motor Vehicle Control Program (FMVCP), HGB I/M program, on-road reformulated gasoline (RFG), 2017 Low Sulfur Gasoline Standard, and on-road TxLED	24.35	8.78
Total attainment demonstration contingency reductions	**24.35**	**8.78**
Contingency Excess (+) or Shortfall (-)	**+15.15**	**+3.47**

Note 1: The EPA published the final implementation rule for the 2008 ozone NAAQS (SIP requirements rule) in the *Federal Register* (FR) on March 6, 2015 (80 FR 12263). The final rule removed the requirement for states to account for non-creditable reductions when determining compliance with Reasonable Further Progress (RFP) emission reduction requirements. One result of removing the non-creditable reductions from the RFP calculations is the RFP adjusted base year inventory (ABY) becomes equal to the RFP base year inventory. The HGB attainment contingency demonstration calculations use the 2011 RFP base year EI to calculate required contingency reductions.

4.9 ADDITIONAL FCAA REQUIREMENTS

FCAA, §182 sets out a graduated control program for ozone nonattainment areas. This section describes how Texas meets certain requirements applicable to the HGB 2008 eight-hour ozone nonattainment area not discussed elsewhere in this HGB AD SIP revision.

4.9.1 Vehicle Inspection/Maintenance

On November 10, 1993, and in several later amendments, the commission adopted a vehicle emissions I/M program that met the requirements of the FCAA Amendments of 1990 and the Federal I/M rule promulgated on November 5, 1992 (57 FR 52950). The EPA published final approval of the state's I/M program, which met requirements for a serious ozone nonattainment classification in the HGB one-hour ozone nonattainment area, in the *Federal Register* on August 22, 1994 (59 FR 43046).

On September 18, 1995 (60 FR 48029), the EPA finalized the I/M Flexibility Amendments, which revised the Federal I/M rule to give states greater flexibility in implementing their I/M programs. The commission repealed the state's existing I/M program and adopted a low-enhanced vehicle I/M program called the Texas Motorist's Choice (TMC) Program on May 29, 1996. Based on that submittal and several later amendments, the EPA published final approval of the TMC on November 14, 2001 (66 FR 57261). The TMC vehicle I/M program in the HGB ozone nonattainment area meets the federal requirements for areas classified as serious or above.

4.9.2 New Source Review

An NSR permitting program for ozone nonattainment areas is required by FCAA §182(a)(2)(C). Nonattainment NSR permits for ozone authorize construction of new major sources or major modifications of existing sources of NO_X or VOC in an area that is designated nonattainment for the ozone NAAQS. The EPA initially approved Texas' nonattainment NSR program for ozone on November 27, 1995 (60 FR 49781).

Emissions thresholds and pollutant offset requirements under the nonattainment NSR program are based on the nonattainment area's classification. At the time of this writing, emissions thresholds and offset requirements for the HGB area are based on its severe classification under the one-hour and 1997 eight-hour ozone standards; however, the EPA's final approval of the HGB area's redesignation substitute for the 1997 eight-hour ozone NAAQS (81 FR 78691) would remove the requirement to comply with nonattainment NSR requirements for those standards. After final approval of the redesignation substitute for the 1997 ozone NAAQS becomes effective (December 8, 2016), the nonattainment NSR threshold and offset requirements for the 2008 ozone NAAQS classification apply to major sources in the HGB area.

4.9.3 Emission Statement Program

On August 26, 1994, the EPA approved a revision to the Texas SIP that included revisions to 30 TAC §101.10: *Emissions Inventory Requirements* and implemented an emission statement program for stationary sources within ozone nonattainment areas (59 FR 44036). Approval of this HGB AD SIP revision satisfies FCAA, §182 requirements and EPA's *Guidance on the Implementation of an Emission Statement Program* (July 1992).

4.10 EMISSION CREDIT GENERATION

The Emissions Banking and Trading rules in 30 Texas Administrative Code §101.300 define SIP emissions as the state's EI data from the year that was used to develop the projection-base year inventory for the modeling included in the most recent AD SIP revision. Currently, for the HGB area, SIP emissions for credit generation projects use the state's 2007 EI data for electric generating units (EGUs) with emissions recorded in the EPA's Air Markets Program Database (AMPD) and the 2006 EI data for all other stationary point sources (non-EGUs). This HGB AD SIP revision would revise the SIP emissions years used for credit generation from 2007 to 2015 for EGUs and 2006 to 2014 for non-EGUs. The 2014 and 2015 projection-base year inventories were selected because these were the most recent state EI and AMPD data sets available.

CHAPTER 5: WEIGHT OF EVIDENCE

5.1 INTRODUCTION

The corroborative analyses presented in this chapter demonstrate the progress that the Houston-Galveston-Brazoria (HGB) nonattainment area is making towards attainment of the 2008 eight-hour ozone National Ambient Air Quality Standard (NAAQS) of 0.075 parts per million or 75 parts per billion (ppb). This corroborative information supplements the photochemical modeling analysis presented in Chapter 3: *Photochemical Modeling*. The United States Environmental Protection Agency's (EPA) *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone,* $PM_{2.5}$*, and Regional Haze* (EPA, 2014) states that all modeled attainment demonstrations should include supplemental evidence that the conclusions derived from the basic attainment modeling are supported by other independent sources of information. This chapter details the supplemental evidence, i.e., the corroborative analyses, for this HGB attainment demonstration (AD) State Implementation Plan (SIP) revision.

This chapter describes analyses that corroborate the conclusions of Chapter 3. First, information regarding trends in ambient concentrations of ozone and ozone precursors in the HGB nonattainment area is presented. Analyses of ambient data corroborate the modeling analyses and independently support the attainment demonstration. Supplemental analysis used in the photochemical modeling steps of the attainment demonstration are based in part on an extensive body of scientific research work that has been carried out in the HGB area during the past two decades. As the modeling guidance states, EPA expects that the attainment demonstrations will mitigate the uncertainty as much as possible given the current state of the science. An overview is provided of background ozone levels transported into the HGB nonattainment area. Second, this chapter also discusses the results of additional air quality studies and their relevance to this HGB AD SIP revision. Third, this chapter describes air quality control strategies that are expected to yield tangible air quality benefits, even though they were not included in the attainment demonstration modeling discussed in Chapter 3.

5.2 ANALYSIS OF AMBIENT TRENDS

The modeling guidance states that a way to qualitatively assess progress toward attainment is to examine recently observed air quality and emissions trends. Downward trends in observed air quality and in emissions (past and projected) are consistent with progress toward attainment. The strength of evidence produced by emissions and air quality trends is increased if an extensive monitoring network exists, which is the case in an area like HGB that currently has 21 regulatory monitors for ozone, 23 monitors for nitrogen oxides (NO_X), and 12 automated gas chromatographs (auto-GC) for volatile organic compounds (VOC). More detail on these specific locations and pollutants measured per monitor can be found on the Texas Commission on Environmental Quality's (TCEQ) Air Monitoring Sites Web page (https://www.tceq.texas.gov/airquality/monops/sites/mon_sites.html). This section examines ambient trends from the extensive ozone and ozone-precursor monitoring network in the HGB area. Despite a continuous increase in the population of the eight-county HGB nonattainment area, a strong economic development pattern, and other factors that includes, but not limited to, growth in vehicle miles traveled (VMT), the observed trends for ozone and its precursors of NO_X and VOC reveal a downward pattern.

5.2.1 Ozone Design Value Trends

An ozone design value is the statistic used to determine compliance with the 2008 eight-hour ozone NAAQS. Eight-hour ozone design values are calculated by averaging fourth-highest eight-hour ozone value at each monitor site over three years. The ozone design value in a metropolitan area is the highest design value of all of the area's monitors' individual design values. Although Figure 5-1: *Eight-Hour and One-Hour Ozone Design Values in the HGB Area from 2005 through 2016* displays results through 2016, complete data was only available through 2015 at the time of the culmination of this study (November 10, 2016). As such, all results for 2016 presented in this study are preliminary and subject to change.

As presented in Figure 5-1, both eight-hour and one-hour ozone design values have decreased over the past 12 years in the HGB area. The 2015 HGB one-hour ozone design value of 120 ppb demonstrates continued attainment of the revoked one-hour ozone NAAQS. The 2015 eight-hour ozone design value for the HGB nonattainment area of 80 ppb derives from measurements at the Manvel Croix Park (C84) monitor, which is in attainment of the former 84 ppb standard and demonstrates progress toward the current 75 ppb standard. This monitor is located to the south of the Houston urban core and west of the Houston Ship Channel. The preliminary 2016 HGB one-hour ozone design value remains at 120 ppb, and the preliminary 2016 eight-hour ozone design value is 79 ppb. The 2016 eight-hour ozone design value results from measurements at the Houston Aldine (C8) monitor, which also is in attainment of the former 84 ppb 1997 eight-hour ozone NAAQS and demonstrates progress toward the current 75 ppb 2008 eight-hour ozone NAAQS. This monitor is located to the north of the Houston urban core and northwest of the Houston Ship Channel.

The linear trend line for the one-hour ozone design value shows a decrease of about 4 ppb per year, and the linear trend line for the eight-hour ozone design value shows a decrease of about 2 ppb per year. The one-hour ozone design values decreased about 29% from 2005 through 2016 and the eight-hour ozone design values decreased about 23% over that same time. The largest decreases in both design values appear to occur from 2006 through 2009, when the one-hour ozone design value dropped by 26 ppb and the eight-hour ozone design value decreased by 19 ppb. These decreases suggest that emission controls programs including the Highly Reactive Volatile Organic Compound Emissions Cap and Trade (HECT) program (30 Texas Administrative Code (TAC) §101.394 (2004)), which was effective in 2004, and the Mass Emissions Cap and Trade (MECT) Program (30 TAC §101.351 (2001)), which controls NO_X have been effective. The slower change in the eight-hour ozone design values compared to the one-hour ozone design values could relate to background ozone, which appears to affect the eight-hour ozone much more than the one-hour ozone. A detailed discussion of background ozone and transported ozone can be found in Section 5.3: *Studies of Ozone Formation, Accumulation, Background, and Transport Related to the HGB Area*.

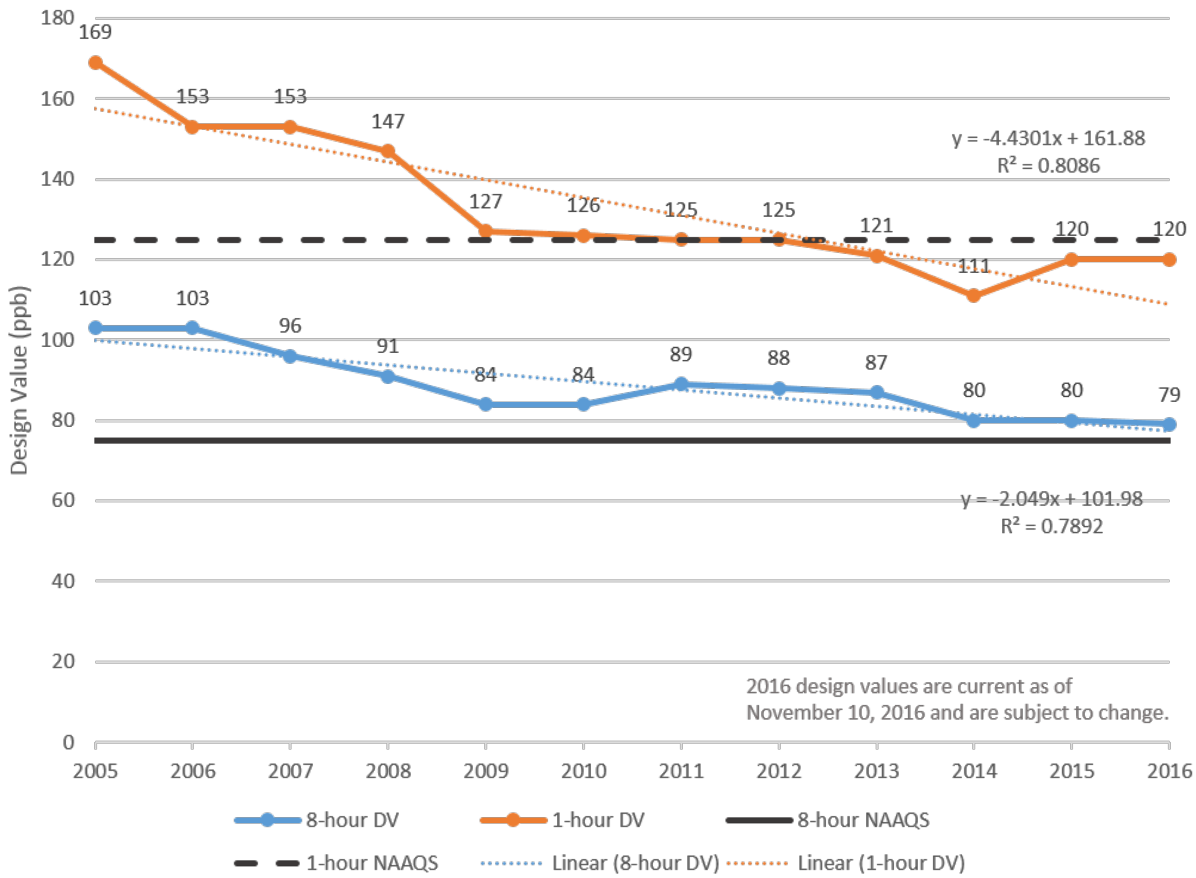


Figure 5-1: Eight-Hour and One-Hour Ozone Design Values in the HGB Area from 2005 through 2016

Because ozone varies spatially, it is also prudent to investigate trends at all monitors in an area. Figure 5-2: *Eight-Hour Ozone Design Value Statistics in the HGB Area* displays three summary statistics for eight-hour design values: the maximum, median, and minimum values computed across all monitors in the HGB area. This figure facilitates assessment of the range of design values observed within a year, as well as how these distributions change over time. Figure 5-2 covers the years 2005 through 2016; however, data from 2016 is current as of November 10, 2016, and is subject to change. The figure shows that eight-hour ozone design values at both the maximum, median, and minimum levels exhibited a noticeable downward trend from 2005 through 2009. Following 2009, the trend in eight-hour ozone design values is relatively flat; however, the most recent three years examined (2014 through 2016) have the lowest maximum, median, and minimum, eight-hour ozone design values of all the years examined. Also, before 2008, no monitors in the HGB area met the more-stringent 2008 eight-hour ozone NAAQS of 75 ppb; as of 2008, one or more monitors in the area have met this standard every year. By 2008, over half the monitors in the area attained the 1997 eight-hour ozone standard, as indicated by the median value falling below 84 ppb that year (the median statistic as used here indicates that half the observed design values are above the median, and half below it). By 2014, all the monitors in the HGB area attained the 1997 eight-hour ozone standard and over half of the monitors attained the 2008 eight-hour ozone standard.

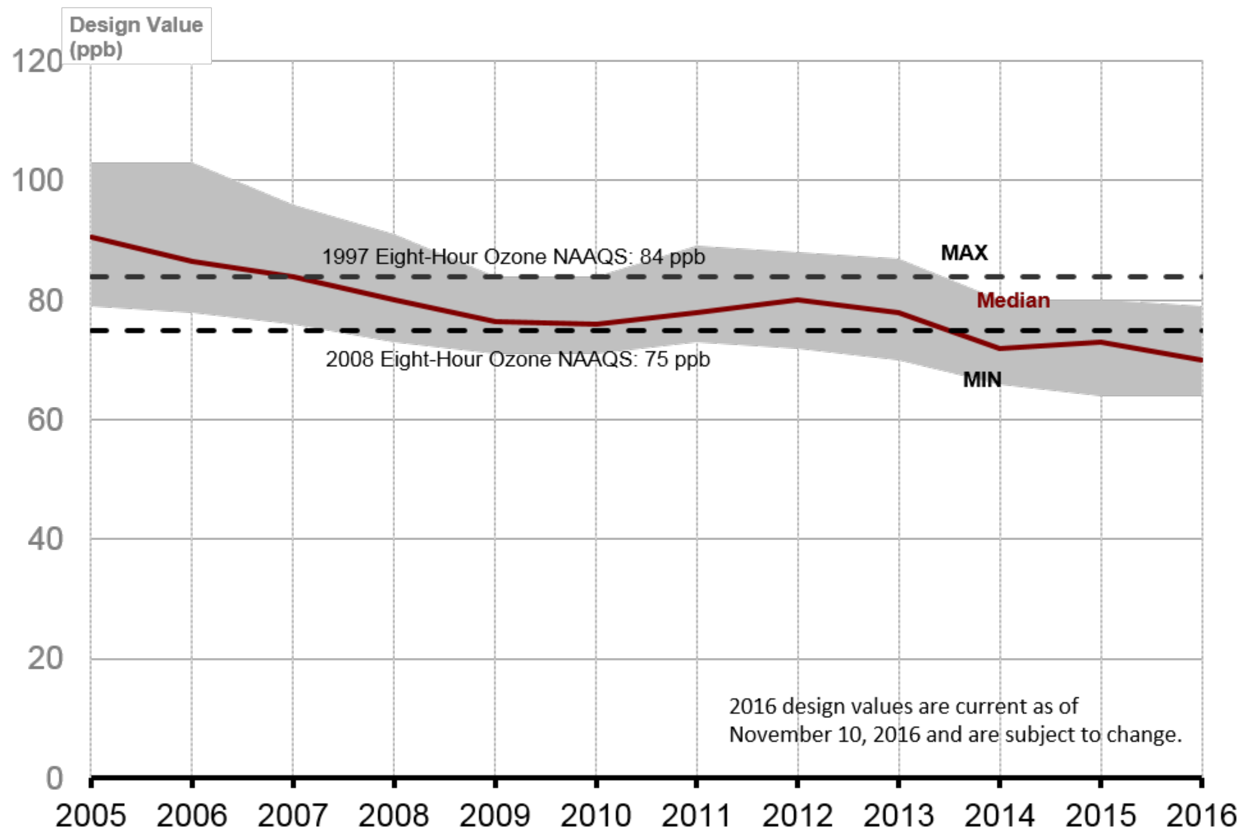


Figure 5-2: Eight-Hour Ozone Design Value Statistics in the HGB Area

Based on data that are current as of November 10, 2016, in 2016 only three monitors in the HGB area had design values above the 2008 eight-hour ozone NAAQS. This was an improvement from 2015 when five monitors exceeded the standard. The monitors listed in Table 5-1: *Annual Fourth-Highest Eight-Hour Ozone Values and Design Values for Regulatory HGB Monitors with Preliminary 2016 Design Values at or above the 2008 NAAQS* include the three monitors that exceeded the 2008 eight-hour ozone NAAQS in 2016 and two additional monitors on the verge of exceeding this standard. The Houston Aldine (C8) monitor sets the preliminary 2016 eight-hour ozone design value for the HGB area. Its 2016 design value, 79 ppb, is calculated (like all monitors) by averaging the 2014 through 2016 fourth highest concentrations, and truncating any decimal. At the Houston Aldine (C8) monitor, these values were 68, 95, and 74 ppb, respectively. Because 2014 will be excluded from the 2017 calculation, the Houston Aldine (C8) monitor would need to record a fourth-high ozone concentration of 59 ppb or higher in 2017 to violate the 2008 NAAQS that year. Of the four other HGB area monitors with preliminary 2016 design values at or above 75 ppb displayed in Table 5-1, the 2017 fourth high values needed to violate the NAAQS in 2017 range from 70 to 73 ppb. Among the five monitors, the highest 2016 fourth-high value was 79 ppb recorded at the Houston Westhollow (C410) monitor, and the lowest was 74 ppb recorded at both the Houston Aldine (C8) and Galveston 99th Street (C1034) monitors.

Table 5-1: Annual Fourth-Highest Eight-Hour Ozone Values and Design Values for Regulatory HGB Monitors with Preliminary 2016 Design Values at or above the 2008 NAAQS

Monitor	2014 4th High (ppb)	2015 4th High (ppb)	2016 4th High (ppb)	2016 Design Value (ppb)	2017 4th High needed to Violate the 2008 NAAQS (ppb)
Houston Aldine (C8)	68	95	74	79	59
Houston Westhollow (C410)	70	79	79	76	70
Galveston 99th St. (C1034)	71	84	74	76	70
Houston Bayland Park (C53)	67	80	78	75	70
Manvel Croix Park (C84)	71	86	69	75	73

Note: 2016 data current as of November 10, 2016, and is subject to change.

Ozone trends can also be investigated by looking at the number of days that the maximum eight-hour ozone levels were above a certain threshold, termed a high ozone day. A high eight-hour ozone day is considered any day that any monitor in the area measures an eight-hour average ozone concentration greater than 75 ppb. The number of high eight-hour ozone days for the HGB area are displayed in Figure 5-3: *Number of High Eight-Hour Ozone Days by Monitor*. The figure covers the years 2005 through 2016; however, data from 2016 is current as of November 10, 2016, and is subject to change. When comparing 2005 to 2015, the number of high eight-hour ozone days occurring in the HGB area has fallen 69%, and when comparing 2005 to preliminary data from 2016, the number of days has fallen by 85%. The number of high eight-hour ozone days for each year from 2008 through 2016 remains relatively consistent with the exception of the low years of 2013, 2014, and 2016, which had 18, 6, and 11 high ozone days, respectively. The range of years from 2008 through 2016 had an average of 24 high eight-hour ozone days per year, and the entire range of years examined in the study (2005 through 2016) had an average of 33 days per year. These results emphasize the overall reduction of high ozone days since 2005. Results for individual monitors in Figure 5-3 indicate that select monitors contribute a disproportionate amount to the total number of high eight-hour ozone days for the year in question. Overall, the trends in high eight-hour ozone days match those observed in the eight-hour ozone design values, with the largest decreases occurring from 2005 through 2009.

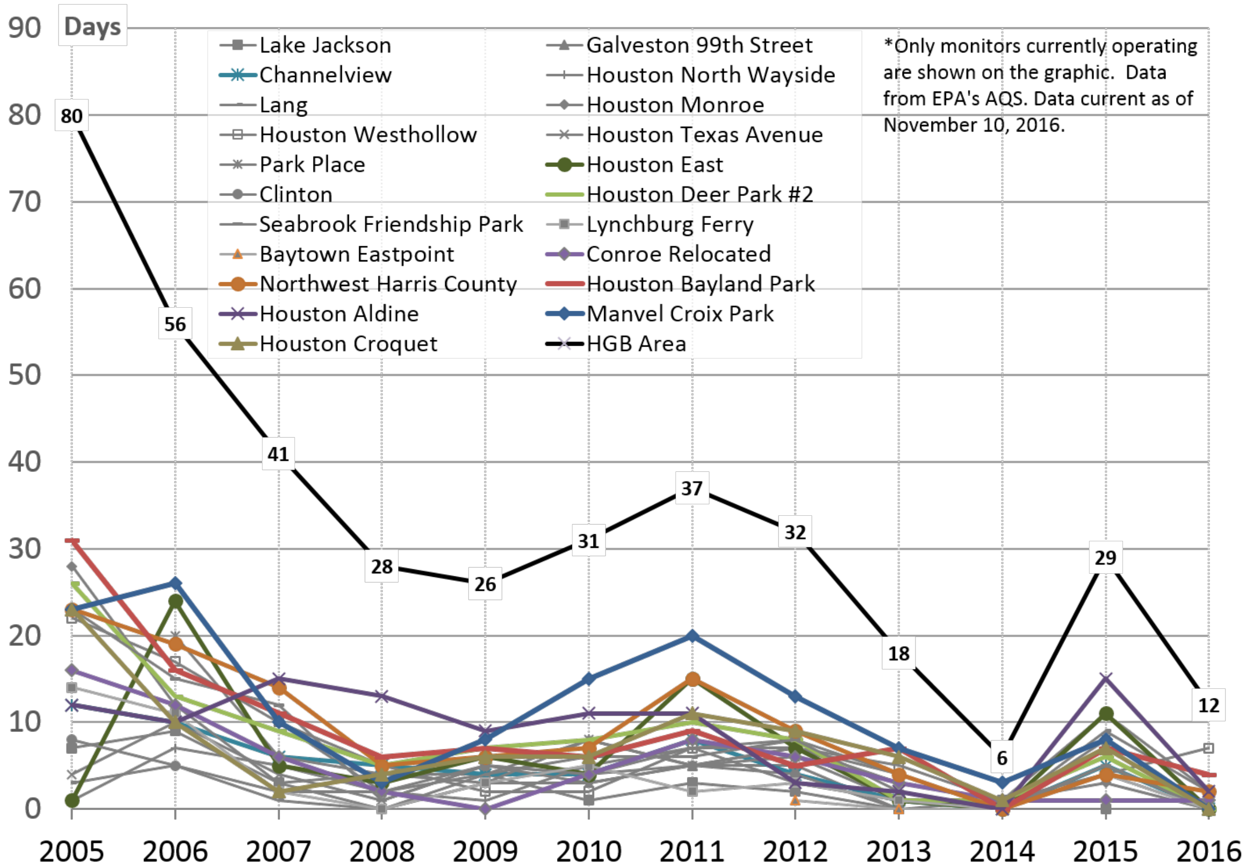


Figure 5-3: Number of High Eight-Hour Ozone Days by Monitor

5.2.2 NO_X Trends

NO_X, a precursor to ozone formation, is a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). NO_X is primarily emitted by fossil fuel combustion, lightning, biomass burning, and soil. Examples of common NO_X emission sources in urban areas are automobiles, diesel engines, other small engines, residential water heaters, industrial heaters, flares, and industrial and commercial boilers. Mobile, residential, and commercial NO_X sources are usually numerous smaller sources distributed over a large geographic area, while industrial sources are usually large point sources, or numerous small sources, clustered in a small geographic area. Because of the large number of NO_X sources, elevated ambient NO_X concentrations can occur throughout the HGB nonattainment area. This section discusses trends in ambient NO_X concentrations.

Trends for ambient NO_X concentrations are presented in Figure 5-4: *Daily Peak Nitrogen Oxide Trends in the HGB Area*. Trends represent the 90th percentile, the 50th percentile, and the 10th percentile of daily peak NO_X concentrations from all NO_X monitors in the HGB nonattainment area. Only NO_X monitors that report data to the EPA were used for these trends. The 90th percentile NO_X concentrations and the median NO_X concentrations in the HGB area appear to be decreasing and stabilizing over time, while the 10th percentile concentrations have remained relatively flat. Like the ozone trends, the area-wide NO_X trends show that most of the decreases occur prior to 2009. A dotted line is provided to highlight the trends in ambient NO_X concentrations.

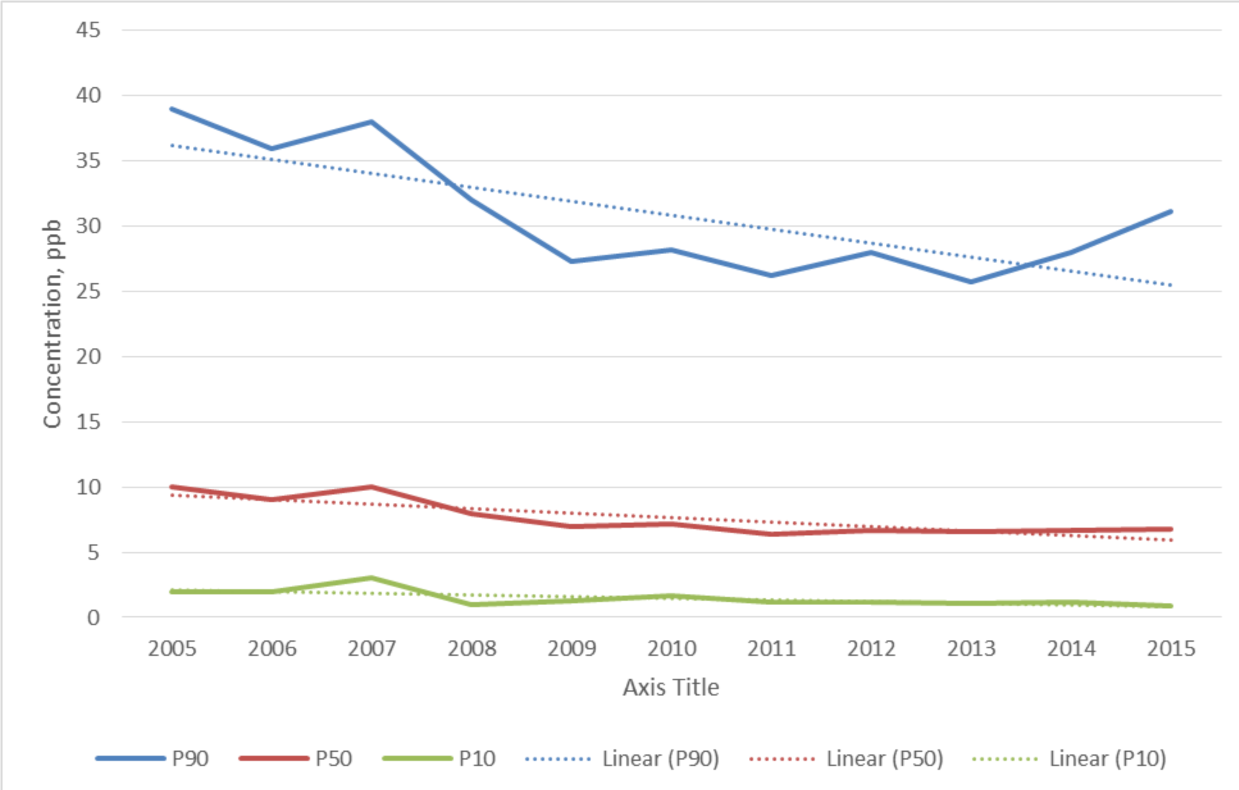


Figure 5-4: Daily Peak Nitrogen Oxide Trends in the HGB Area

Similar to ozone, NO_x concentrations can vary based on location. NO_x values tend to be higher at monitors located in urban areas or near large NO_x sources. Due to these variations, NO_x trends by monitor in the HGB area were also examined and are presented in Figure 5-5: *90th Percentile Daily Peak Nitrogen Oxide Concentrations in the HGB Area by Monitor*. Like the area wide NO_x trends, the monitor trends only use data from monitors that report to the EPA. The trends show that NO_x concentrations have decreased for all monitors reporting to the EPA in service since 2005. The higher values at two monitors in 2014 and 2015 are due to their location at major Houston roadways (Southwest Freeway and North Loop); since these monitors only began operation in 2014 and 2015 respectively, there currently is not enough data at these two monitors to determine a trend.

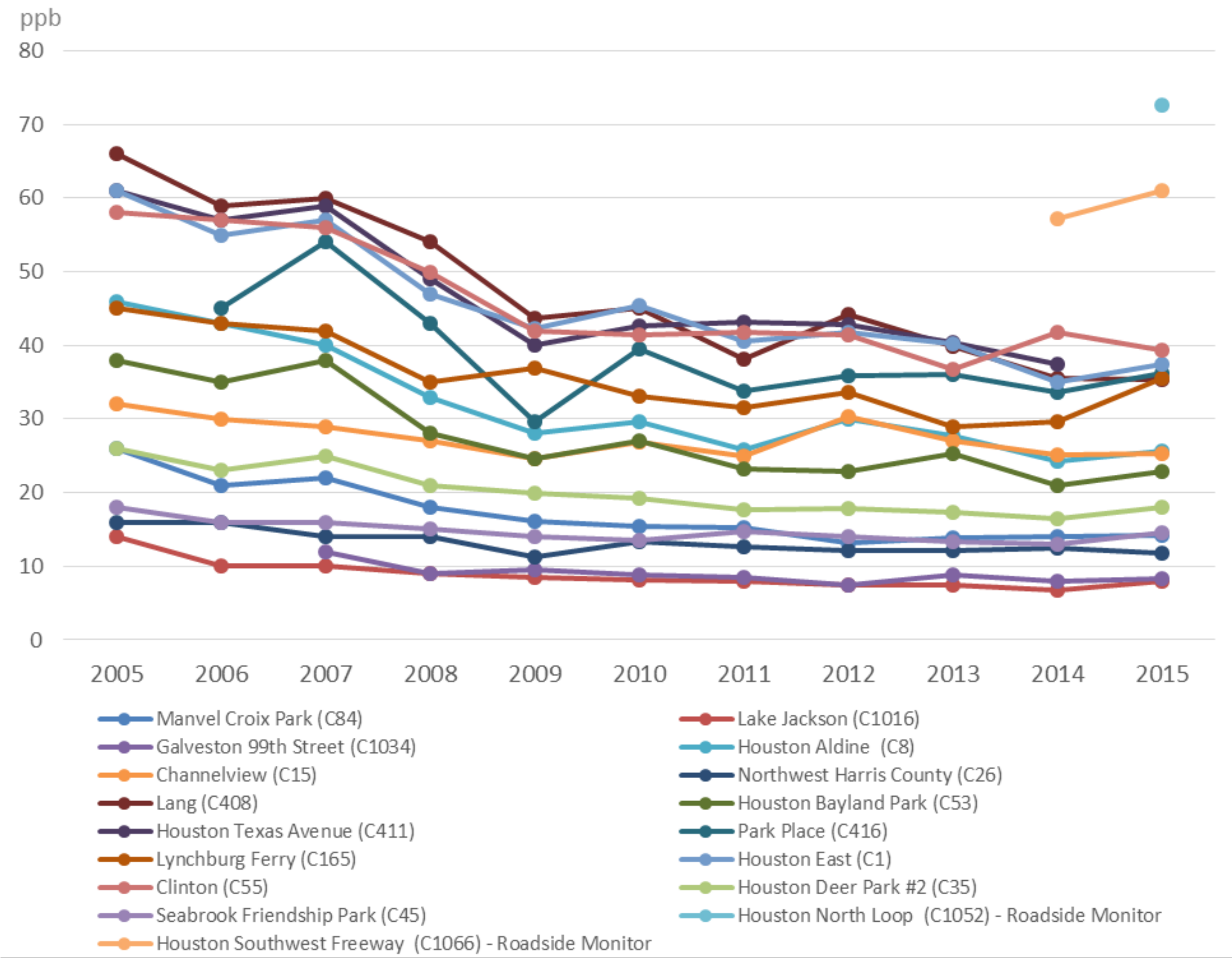


Figure 5-5: 90th Percentile Daily Peak Nitrogen Oxide Concentrations in the HGB Area by Monitor

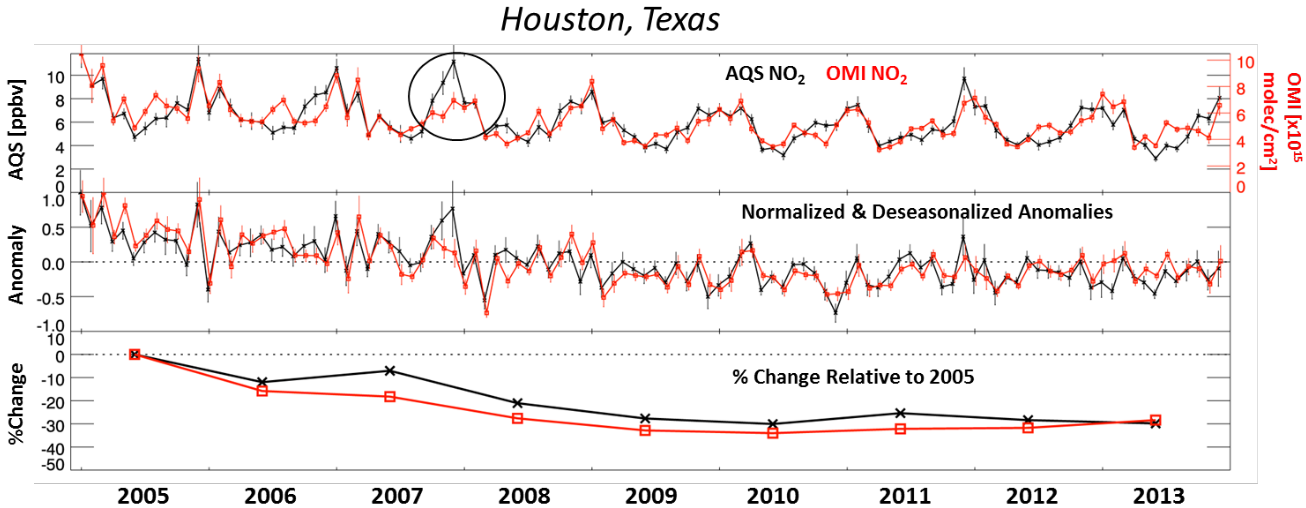
Figure 5-4 and Figure 5-5 show substantial drops in NO_X concentrations in the HGB area. These decreases are corroborated by two additional independent data sets. The first is the satellite-based NO_2 monitoring conducted using satellite observations from satellites operated by the National Aeronautics and Space Administration (NASA). Satellites measure trace gases differently than surface or aircraft instrumentation. Rather than bringing a sample of air directly into the device, a satellite measurement examines the wavelengths of light that the gas of interest (NO_2, in this case) absorbs. Variations in the intensity of those wavelengths can quantify the amount of the gas present in a column of the atmosphere, not just at the surface. The satellite can theoretically measure how many molecules of the gas are present in a vertical column extending from the surface up to the top of the atmosphere. In the case of NO_2, most of the gas is located close to the surface. The uncertainties in this type of measurement make it difficult to precisely estimate the emissions from an area, but changes in NO_2 column densities over time can accurately detect trends in NO_X emissions.

The trend of Ozone Monitoring Instrument (OMI) NO_2 column measurements made for the HGB area are shown in Figure 5-6: *Trends in Houston Nitrogen Dioxide*

Concentrations, as Measured by Satellite (OMI) and Surface monitoring (AQS), from 2005 through 2013 (Duncan, AQAST presentation). Also shown on the graph is the trend in NO_2 measured by the surface monitoring network. The top graph shows the actual time series observed by the two methods. The middle graph shows the normalized time series with the mean and the seasonal variations filtered out. The bottom graph shows how the values have changed since 2005. Like the NO_x trends in Figure 5-4 and Figure 5-5, the middle and bottom figures show a substantial decrease in NO_2 from 2005 to 2009, and little change since 2009.

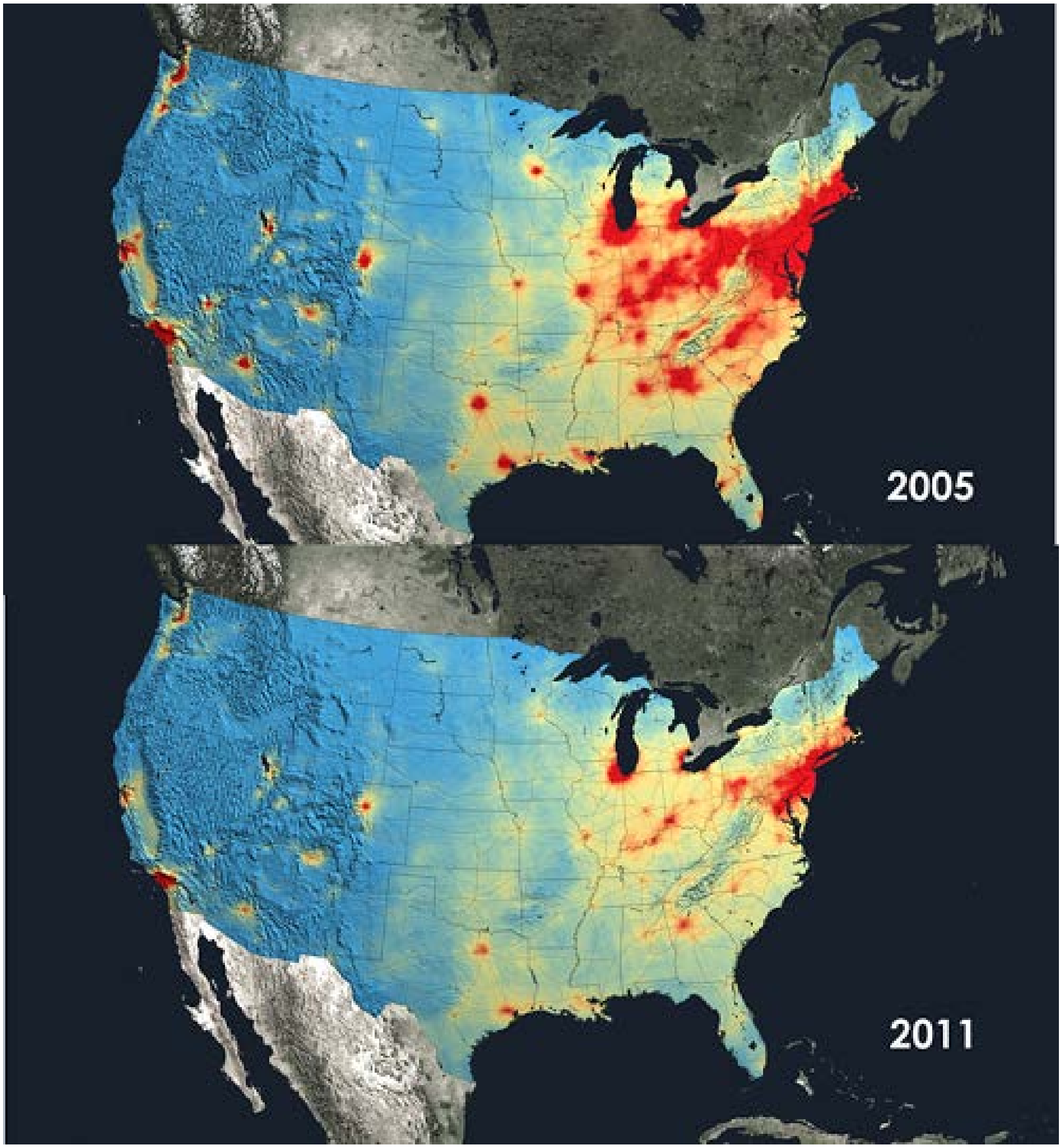
The NO_2 measured by the OMI satellite in 2005 and 2011 is mapped in Figure 5-7: *Maps of Nitrogen Dioxide Column Density in the Continental U.S. in 2005 and 2011 (from Bryan Duncan of NASA-Goddard).* With the highest NO_2 column densities shown in red, a large decrease in NO_2 from 2005 through 2011 in most urban areas in the US is apparent from comparing the two maps. There are two interesting implications from these maps. First, NO_x decreases throughout the eastern United States (U.S.) are a likely cause of the decreasing trends in background ozone throughout the eastern U.S. (Cooper et al. 2012) and the HGB area (Berlin et al. 2013). Second, urban areas throughout the U.S., including areas such as Dallas-Fort Worth (DFW), where NO_x emissions are dominated by mobile sources, have decreasing NO_x. Therefore, it is likely that part of the NO_x decrease in the HGB area can be attributed to decreases in on-road mobile NO_x.

These data from NASA-Goddard represents only one of several different research teams that have examined the NO_2 trends in the HGB metropolitan area. The trend analyses made by these researchers, using data from different satellites, different retrievals, and different time periods are compared in Table 5-2: Satellite *Observations of Nitrogen Dioxide Columns in the HGB Metropolitan Area between 2002 and 2013.* All show substantial decreases in NO_x since the early-to-mid-2000s; however, Figure 5-6, and the results of two studies listed in Table 5-2 (i.e., Russell et al., Lamsal et al.) show that NO_2 concentrations show little change in recent years in Houston.



(Top) A comparison of U.S. EPA AQS surface NO_2 data (ppbV) to OMI column densities (x1015 molecules/cm^2) that are averaged over the Houston metropolitan area. (Middle) The normalized, de-seasonalized anomalies for both datasets. (Bottom) The percent change in NO_2 relative to 2005 for both datasets.

Figure 5-6: Trends in Houston Nitrogen Dioxide Concentrations, as Measured by Satellite (OMI) and Surface Monitoring (AQS), from 2005 through 2013



In these maps, the intensity of NO_2 column density is indicated by color, with red indicating the highest densities, and blue indicating the lowest. See the NASA website for more information (https://www.nasa.gov/content/goddard/new-nasa-images-highlight-us-air-quality-improvement/#.V6tC1nrHo7I).

Figure 5-7: Maps of Nitrogen Dioxide Column Density in the Continental U.S. in 2005 and 2011 (from Bryan Duncan of NASA-Goddard)

Table 5-2: Satellite Observations of Nitrogen Dioxide Columns in the HGB Metropolitan Area between 2002 and 2013

Document Source	Period	Annual rate (%)	Cumulative decrease (%)	Piecewise changes in NOx (%)
Russell et al. (2012)	2005-2011	-4.67	-27.99	2005-2007: -7.65 2007-2009: -7.74 2009-2011: +0.30
Schneider et al. (2015)	2002-2012	-5.4 ± 1.6	--	--
Tong et al. (2015): OMI AQS	2005-2012	-3.4 -3.6	-24 -25	--
Lamsal et al. (2015)	2005-2013	-5.63	-39.4 ± 4.9	2005-2008: -7.9 ± 1.4 2010-2013: +0.5 ± 0.3
Lu et al. (2015): OMI AQS	2006-2013	-5.1 ± 2.1 -4.8	-49 -38.4	--

A second independent data set for observing NO_x trends is from solar occultation flux (SOF) measurements made by researchers from Chalmers University, who have been measuring NO_2 fluxes in Houston-area field campaigns since 2006 (Johanssen et al. 2014). The measurements by the Chalmers group are unique in that they can be used to estimate fluxes rather than only measuring concentrations; if none of a compound is destroyed between the place where it is emitted and the place where it is measured, then the measurement when combined with meteorological measurements can be used to estimate emissions. There are no other reliable methods of independently estimating emissions from ambient observations, so this measurement technique gives insight that traditional measurements cannot.

The Chalmers group estimated emission fluxes three times in different subregions of the HGB area: 2006, 2009, and 2011. For NO_x, they estimated emission changes for all of Harris County from 2006 through 2011 of -48.7%. From 2006 through 2009, the decrease in Harris County was 42.1%, relative to 2006 emissions, but from 2009 through 2011, the decrease in Harris County was only 6.6% relative to 2006 emissions (Johanssen et al. 2014). Therefore, the flux measurements, the satellite measurements, and the surface NO_x measurements agree: NO_x concentrations have decreased by almost 50% in the HGB area, but most of that decrease took place between 2006 and 2010, and that decreasing trend has been much less since 2010. This downward trend in NO_x may be the result of the state controls placed on point sources and state programs implemented to reduce mobile NO_x emissions, along with the federal standards implemented for on-road vehicles and non-road equipment.

5.2.3 VOC Trends

Total non-methane hydrocarbon (TNMHC), which is used to represent VOC concentrations, can enhance ozone production in combination with NO_x and sunlight. TNMHC is an important precursor to ozone formation, particularly in the HGB area where the Houston Ship Channel, a large source of VOC emissions, is located. Two types of monitors record TNMHC data in the HGB nonattainment area: auto-GCs, which record hourly data, and canisters, which record 24-hour data. Due to the reactive nature of VOC, the hourly auto-GC measurements are preferred when assessing trends.

The mean monthly TNMHC concentrations from the eight auto-GC sites in Harris County are presented in Figure 5-8: *Mean Monthly TNMHC Concentrations in Harris County*. All eight auto-GC monitors show a decrease in TNMHC from 2005 through 2015. The decreases range from a 10% decrease at the Wallisville Road (C617) monitor up to a 52% decrease at the Lynchburg Ferry (C165) monitor. While all eight monitors show an overall decrease from 2005 through 2015, most of that decrease occurred prior to 2011; this is consistent with trends observed in NO_x and ozone. After 2011, some monitors observed a slight increase in TNMHC. Of the eight auto-GC monitors, five observed slight increases in TNMHC from 2011 through 2015; those monitors include Cesar Chavez (C175), Clinton (C55), HRM#3 Haden Road (C114), Milby Park (C169), and Wallisville Road (C617).

Highly reactive volatile organic compounds (HRVOC) are especially important to ozone formation in the HGB area. This subset of VOC, which includes ethylene, propylene, butenes, and 1-3 butadiene, have higher reactivity, meaning they are more efficient at producing ozone. Trends in the mean monthly HRVOC concentrations from the eight auto-GC sites in Harris County are shown in Figure 5-9: *Mean Monthly Total HRVOC Concentrations in Harris County*. All eight sites observed decreases in total HRVOC concentrations from 2005 through 2015. The total HRVOC has decreased at a faster rate than the total TNMHC, with decreases in HRVOC ranging from a 31% decrease at the Lynchburg Ferry (C165) monitor to a 75% decrease at the HRM 3 Hayden Road monitor. These large decreases in HRVOC could be due to the implementation of the Highly Reactive Volatile Organic Compounds Emissions Cap and Trade (HECT) program, which had its first compliance period in 2007 (29 TexReg 11594 (2004)). Similar to the TNMHC, ozone, and NO_x trends, the majority of these decreases occurred prior to 2011. Although several monitors in Harris County have continued to observe decreases in total HRVOC after 2011, four auto-GC monitors have had mostly flat trends since that time; those monitors include Cesar Chavez (C175), Clinton (C55), Lynchburg Ferry (C165), and Milby Park (C169).

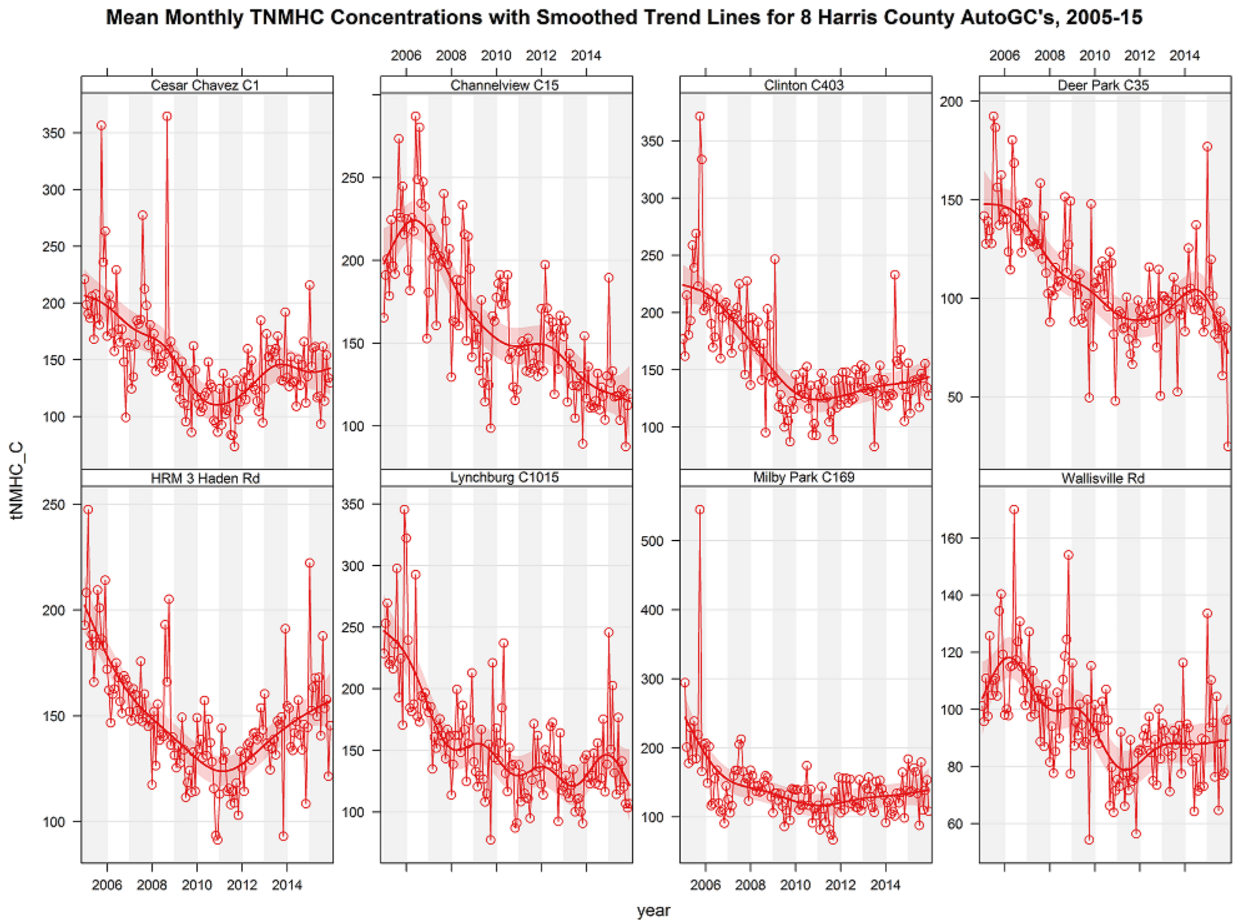


Figure 5-8: Mean Monthly TNMHC Concentrations in Harris County

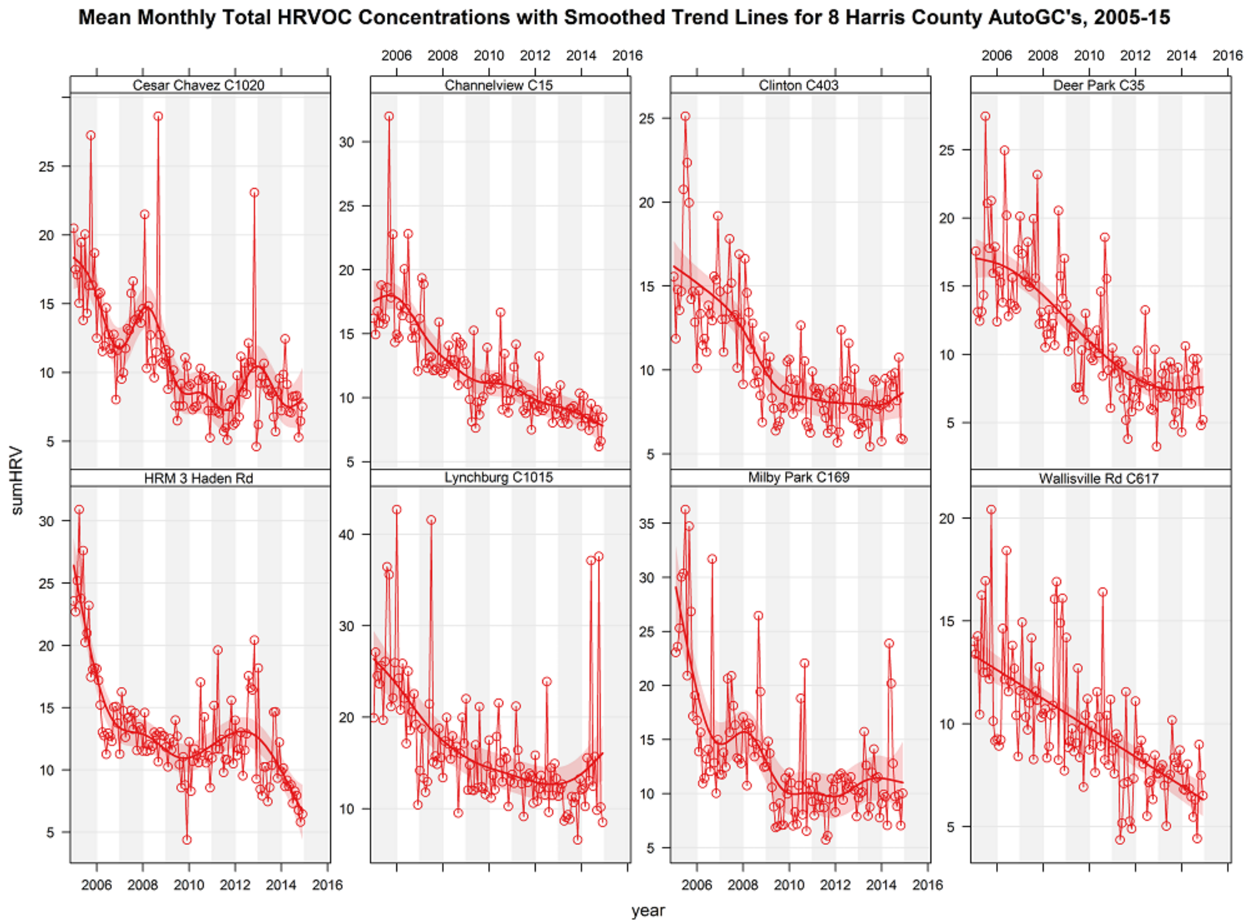


Figure 5-9: Mean Monthly Total HRVOC Concentrations in Harris County

5.2.4 VOC and NO_x Limitations

The VOC and NO_x limitation of an air mass can help determine how immediate reductions in VOC and NO_x concentrations might affect ozone concentrations. A NO_x-limited (or NO_x-sensitive) region occurs where NO_x is scarce and the radicals from VOC oxidation are abundant, and therefore the ozone formation is more sensitive to the amount of NO_x present in the atmosphere. In these regions, controlling NO_x would be more effective in reducing the ozone concentrations. In VOC-limited (or VOC-sensitive) regions, NO_x is abundant and therefore the ozone formation is more sensitive to the amount of radicals from VOC oxidation present in the atmosphere. In VOC-limited regions, controlling VOC emissions would be more effective in reducing the ozone concentrations. Areas where ozone formation is not strongly limited by either VOC or NO_x are considered transitional, and controlling either VOC or NO_x emissions would reduce ozone concentrations in these regions.

A traditional method of evaluating the VOC- and NO_x-sensitivity of ozone formation in an area is to examine the VOC to NO_x ratio. VOC to NO_x ratios are calculated by dividing hourly VOC concentrations in parts per billion by carbon (ppbC) by hourly NO_x concentrations in parts per billion by volume (ppbV). Ratios less than 5 ppbC/ppbV are considered VOC-limited, ratios above 15 ppbC/ppbV are considered NO_x-limited, and ratios between 5 ppbC/ppbV and 15 ppbC/ppbV are considered transitional. This type of VOC/NO_x limitation analysis is limited due to uncertainties in the cutoff points. In addition, analyses such as this do not investigate the reactivity of the VOC mix, which can alter the sensitivity of an air mass. Nevertheless, this analysis provides a general idea as to the sensitivity of the air in the HGB area.

There are 10 auto-GC monitors in the HGB area that are collocated with NO_x monitors. Median VOC to NO_x ratios were calculated for each year at each of these 10 monitors and the results are shown in Figure 5-10: *Median VOC/NO_x Ratios in the HGB Area*. Monitors in or near the Houston Ship Channel exhibit transitional VOC to NO_x ratios. Although the ratios at these monitors vary from year-to-year, they do not appear to show increasing or decreasing trends. The monitors located in Brazoria County, which is further from the traffic of the urban core of Houston, have trended from transitional conditions to NO_x-limited conditions. Overall, the transitional conditions observed at most monitors in the HGB area show that decreases in both VOC emissions and NO_x emissions could help to lower ozone concentrations.

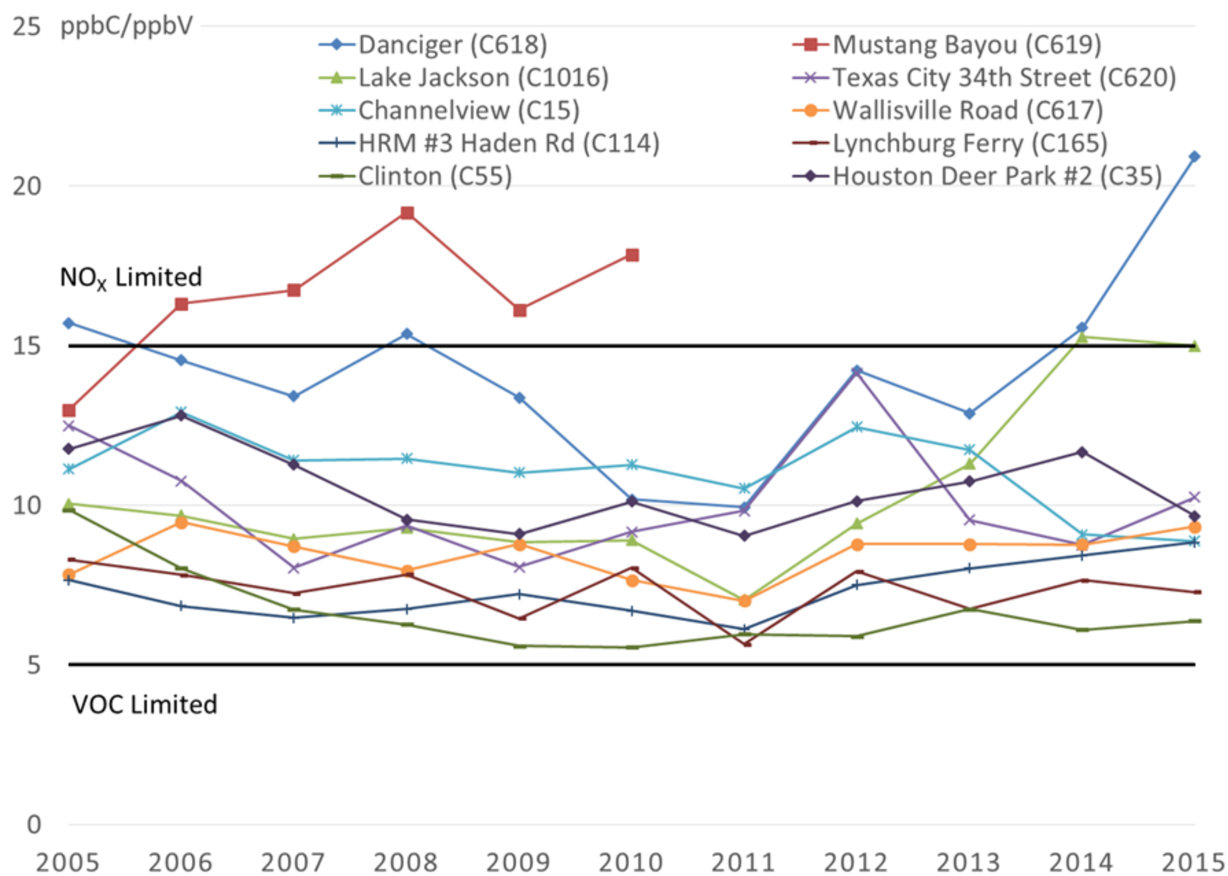
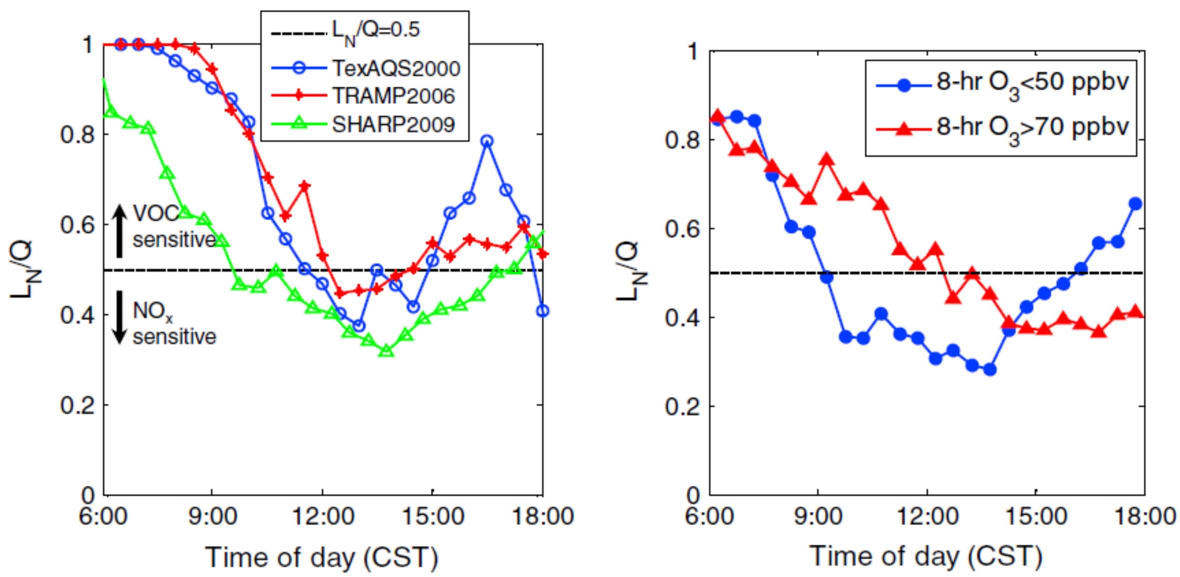


Figure 5-10: Median VOC/NO_x Ratios in the HGB Area

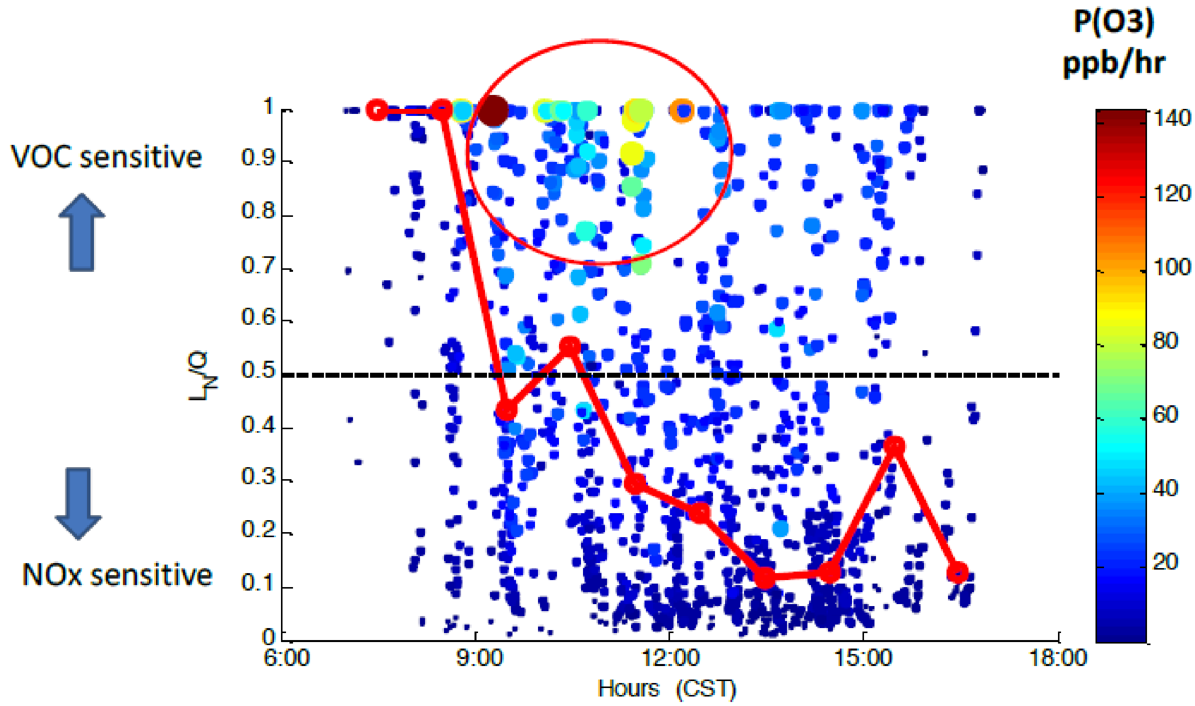
Another data set available for examining the VOC- and NO_x-sensitivity of ozone formation in the HGB area is data from the field campaigns in Houston during 2000, 2006, 2009, and 2013. Because of the wider suite of compounds measured during these field studies, it is possible to investigate the chemical state of the atmosphere in greater detail than is possible with routine measurements. Several studies have examined a quantity, LN/Q, which is a measure of ozone sensitivity. LN/Q measures whether the chemical radicals driving ozone chemistry are dropping out of the ozone formation process by reacting with nitrogen compounds (LN), or reacting with each other (Q). If the radicals are reacting with nitrogen compounds, there is an abundance of NO_x, and the ozone formation is NO_x-rich, or VOC-sensitive. If they are reacting with each other, there is an abundance of radicals, and a shortage of NO_x; therefore, ozone formation is NO_x-sensitive.

Figure 5-11: *VOC and NO_X sensitivity during field studies in the HGB area in 2000, 2006, and 2009*, from Ren et al. (2013), show how LN/Q varies by time of day during three different field studies. The left graph shows that ozone was more NO_x-sensitive in 2009 than in 2000 and 2006. The median LN/Q values show that ozone formation began in a VOC-sensitive regime in the morning, but in 2009 ozone formation drops out of the VOC-sensitive regime several hours earlier than in 2000 and 2006. The right graph shows how high ozone days are more VOC-sensitive than low ozone days. A similar graph derived from the DISCOVER-AQ field study in 2013 is displayed in Figure 5-12: *VOC and NO_X sensitivity during DISCOVER-AQ in Houston in 2013*.



The graphs are from Ren et al. (2013), which examined VOC- and NO_X-sensitivity at the La Porte airport site during Texas Air Quality Study (TexAQS) 2000, and the TexAQS 2006 and the Study of Houston Atmospheric Radical Precursors (SHARP) 2009 studies, which used the Moody Tower site at the University of Houston. They show the median LN/Q values for each hourly bin.

Figure 5-11: VOC and NO_x sensitivity during field studies in the HGB area in 2000, 2006, and 2009



The y-axis shows LN/Q, a measure of VOC- and NO_x-sensitivity; the color-coding and size of the markers are linked to ozone production rate P(O3). The red line with red dots shows the median value of LN/Q in each hourly bin. The figure is from Mazzuca et al. (2015).

Figure 5-12: VOC and NO_x sensitivity during DISCOVER-AQ in Houston in 2013

Figure 5-12 shows that the highest ozone production is linked to VOC-sensitive conditions, and that VOC-sensitive conditions tend to occur before 9:00 am Central Standard Time. Figure 5-11 shows that in 2000 and 2006, the VOC-sensitive ozone formation regime persisted until later in the day; this was one of the causes of much higher ozone production in 2000 and 2006 compared to 2009 and 2013 because VOC-sensitive regimes have higher ozone production than NO_x-sensitive regimes (Mazzuca 2015; Ren 2013; Mao et al. 2009). When the NO_x concentrations decrease, as shown in Section 5.2.2: *NO_x Trends*, ozone formation cannot remain in the VOC-sensitive regime for very long, and so less ozone is formed.

An easily measured quantity that is related to the rate of ozone production is the strength of ozone gradients observed in the Houston area, as measured by daily peak one-hour increase in ozone concentrations measured at surface sites. Rapid ozone formation is a critical factor for creating high ozone concentrations in the HGB area. The HGB area does not have geographic barriers, such as those in Los Angeles, to trap air in the metropolitan area day after day; proximity to the coast results in brisk sea breeze flow that can ventilate the HGB area efficiently each day. Usually, if ozone is to accumulate to high levels in the HGB area, it must form rapidly. One of the key findings of the TexAQS 2000 study was that HGB area's mixture of HRVOC emissions could explain the rapid ozone increases observed at surface monitors. Rapid ozone formation leads to high ozone concentrations measured at the monitoring sites. Since ozone is formed rapidly within plumes containing industrial emissions, air with high ozone concentrations could be found next to air with relatively low concentrations; low-ozone and high-ozone air in close proximity show up as rapid spikes of ozone in the monitoring data. If ozone formed more slowly, the precursors would mix with the surrounding air, and no strong discontinuity would be observed in ozone concentrations.

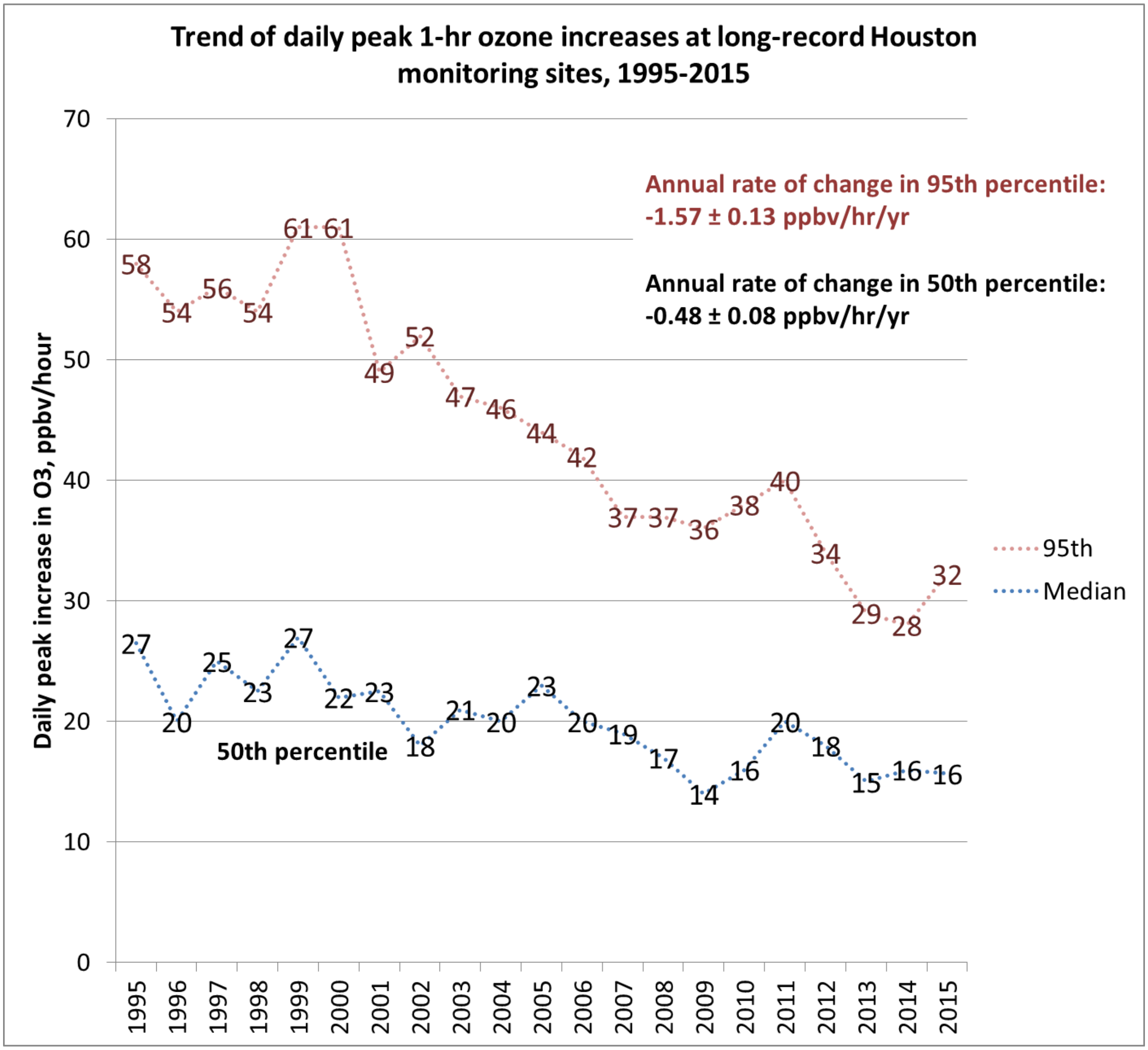


Figure 5-13: Trend in strength of ozone gradients in the HGB area, as measured by one-hour changes in ozone

The trend in ozone gradient strength can be estimated by examining the trend in daily peak one-hour ozone increase in the HGB area at individual monitors (TCEQ, 2010; Couzo et al.). The trend in ozone gradient observations in the HGB area from 1995 to 2015 is shown in Figure 5-13: *Trend in strength of ozone gradients in the HGB area, as measured by one-hour changes in ozone*. The monitors included in this analysis are those that have operated for the entire period of interest: Houston East (C1), Houston Aldine (C8), Channelview (C15), Houston Deer Park #2 (C35), Clinton (C55), Houston North Wayside (C405), Houston Monroe (C406), Lang (C408), and Houston Croquet

(C409). In 2000, one-hour ozone increases greater than 40 ppb occurred 115 times. In the period from 2011 to 2015, they have occurred an average of six times per year, which is a decrease of 92% since 2000. The large reduction in the strength of observed ozone gradients, and in the frequency of high ozone gradients, can be interpreted as a result of the reduction of VOC reactivity in the HGB area and consequent slowing of the ozone formation rates. The decrease in ozone spikes is a signal of less local ozone formation.

Overall, VOC- and NO_X-sensitivity studies have shown that the HGB area is trending toward more NO_X-limited conditions. Data show that ozone is formed more efficiently in VOC-limited conditions, so this trend towards NO_X-limited conditions may be a reason why the HGB area has seen less ozone formation in recent years. Decreasing NO_X concentrations mean that the HGB area cannot remain in VOC-limited conditions for as long, which in turn leads to less ozone formation. The reduction in the strength of ozone gradients may be evidence of the decrease in VOC reactivity and slowing of ozone formation rates in the HGB area.

5.2.5 Meteorological Influences on Ozone

Meteorological conditions play an important role in ozone formation. Year-to-year variability in meteorological conditions in turn causes variability in the ozone trends. Although design values consider this variability by averaging the fourth-highest eight-hour averaged ozone concentrations over three-years, this is often not enough to account for years with extreme meteorological conditions such as low winds speeds, drought, or extremely high temperatures. Removing meteorological influences from ozone trends allows one to examine how ozone trends are behaving based on changes in emissions rather than changes in the meteorology.

The EPA has a generalized linear model (Camalier et.al. 2007) that uses the local weather data to adjust the ozone trends according to the meteorology for that year. The trends compare the average ozone from May through September to the meteorologically-adjusted average ozone from May through September. The meteorologically-adjusted average ozone trends from 2000 through 2015 are displayed in Figure 5-14: *Meteorologically Adjusted Ozone Trends for Houston, TX (EPA, 2016).* The trends show that, even when adjusted for meteorological conditions, ozone concentrations have been decreasing in the HGB area.

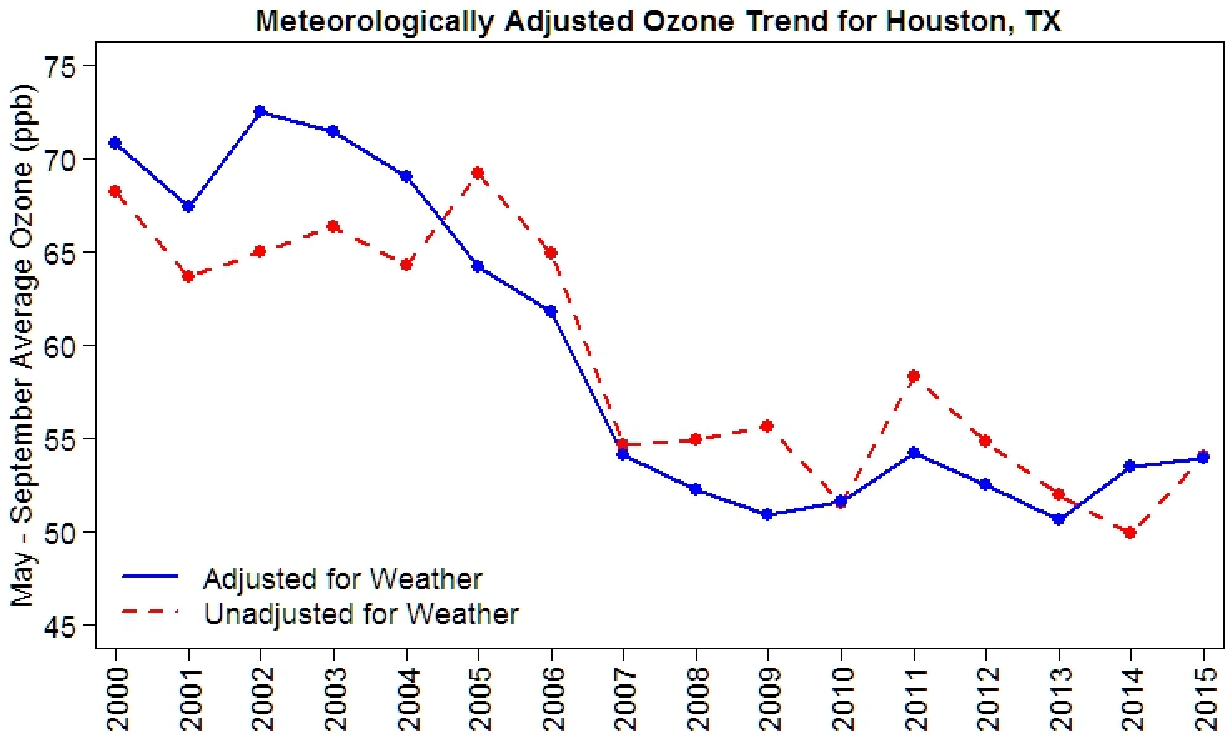
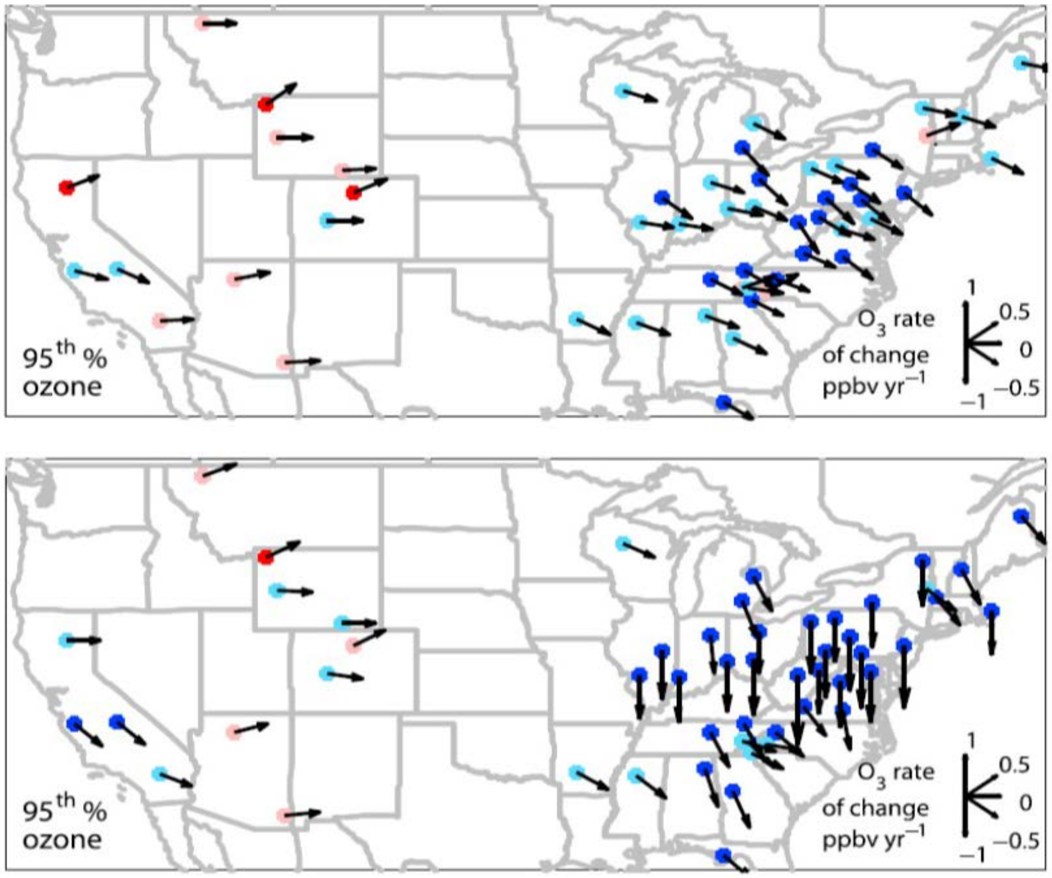


Figure 5-14: Meteorologically Adjusted Ozone Trends for Houston, TX (EPA, 2016)

5.3 STUDIES OF OZONE FORMATION, ACCUMULATION, BACKGROUND, AND TRANSPORT RELATED TO THE HGB AREA

Recent studies on the western coast of the U.S. have shown that ozone is being carried by winds from the Pacific Ocean onshore to the cities in California and Oregon, where it can adversely affect air quality (Jaffe and Ray, 2007; Cooper et al. 2010). These studies have shown that the background ozone is increasing along the west coast and inland to the intermountain west region (Cooper et al. 2012) and these upward trends are occurring in part because of increasing anthropogenic emissions from east and south Asia (Cooper et al. 2010, Lin et al. 2012). In the eastern U.S., however, ozone trends are heading downward (Cooper et al. 2012). The differing 20-year trends of high ozone values as measured at rural sites in the eastern and western U.S. are shown in Figure 5-15: *Rate of change in 95th percentile ozone concentrations (from Cooper et al. 2012).* The data shown in these maps represent daytime (1100-1600 local standard time (LST)) hourly average ozone data, collected from 1990 to 2010. Since these data are from rural monitoring sites, they represent background ozone concentrations better than urban monitoring sites.



The top figure shows rate of change in daytime hourly average ozone concentrations during March, April, and May, from 1990 to 2010; the bottom figure shows rate of change during June, July, and August. The trend is quantified by the angle of the arrow, as shown on the key in the lower right corner of each map. Darker colors for the dots indicate the trend is statistically significant; lighter colors indicate the trends are not significant.

Figure 5-15: Rate of change in 95th percentile ozone concentrations (from Cooper et al. 2012)

Given the disparate trends observed throughout the continental U.S., the TCEQ and other researchers have undertaken studies to examine background ozone in Texas, and especially in southeast Texas, in order to see which trends prevail in Texas. Nielsen-Gammon (2005) used an upwind/downwind method of estimating background ozone concentrations in the HGB area, and found that estimated background ozone varies by month, peaking in spring, late summer and early fall, and reaching a minimum in late June and early July. Langford et al. (2009) examined background ozone using both the upwind/downwind method of Nielsen-Gammon, and an empirical orthogonal factor technique. The latter technique quantified the major sources of ozone variation in the HGB area by examining its temporal variations at monitoring sites in the HGB area during the TexAQS 2000 and TexAQS 2006 field campaigns. They found that the factor contributing the largest source of variation (83%) affected all of the monitors simultaneously, and could be attributed to background ozone. Berlin et al. (2013) repeated the Langford and Nielsen-Gammon techniques for a longer period (2000 through 2014), and found that background ozone concentrations were decreasing in the HGB area, especially for the top 5% of background ozone days. The decreasing trends observed by both background-ozone estimation techniques match the trends observed at rural monitoring sites throughout the eastern half of the U.S. (Cooper et al. 2012). The trends observed in background ozone (as estimated by the upwind/downwind method) from 2005 through 2015 in the HGB area are shown in Figure 5-16a: *Ozone trends in the HGB Area, 2005 through 2015*. Figure 5-16b shows trends in the maximum daily eight-hour average (MDA8) ozone. Figure 5-16c shows how the daily difference between Houston MDA8 and background eight-hour ozone has changed from 2005 to 2015.

The trends in the 95th percentile for background ozone, peak ozone, and local increment ozone are all statistically significant downward trends. Because the peak and background ozone concentrations in the HGB area are well-correlated (Berlin et al. 2013), one can conclude that the decrease in high background ozone is likely one of the causes of decreasing peak ozone. It is not the only cause, however, because the local increment ozone 95th percentile is also decreasing (Figure 5-16c). The local increment ozone decrease implies that locally formed ozone production is decreasing as well as ozone transported into the HGB area.

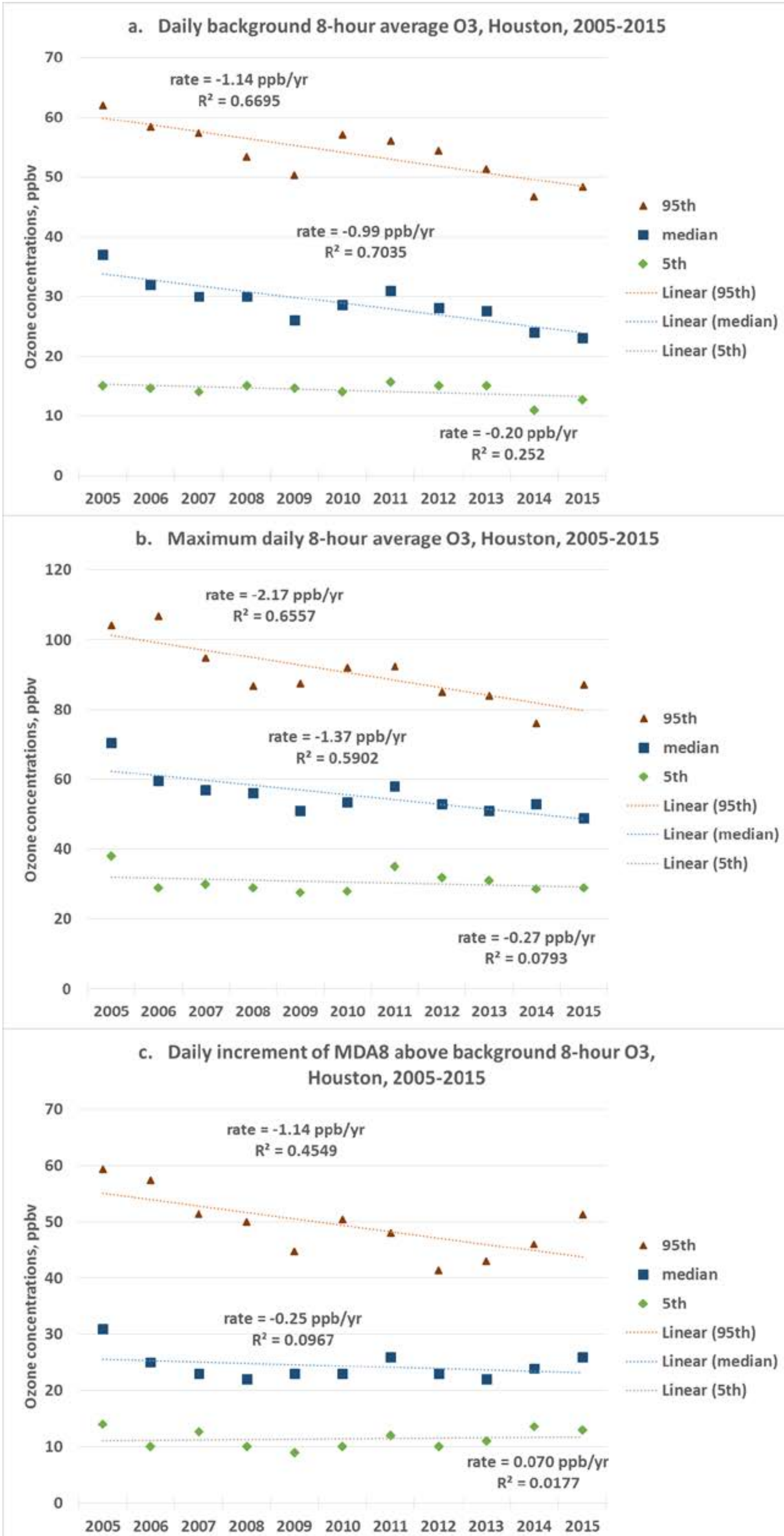


Figure 5-16: Ozone trends in the HGB Area, 2005 through 2015

Several research groups have investigated causes of high background ozone and locally formed ozone in southeast Texas. The following discussions examine the results of studies that have analyzed long-range transport patterns and synoptic-scale meteorological patterns, and their relationship to ozone in the HGB area. These studies employed different data sources, using different multivariate statistical analysis techniques over different time periods that range from the 1980s to the 2010s, and their findings are remarkably similar. They create a coherent picture of the transport patterns responsible for the highest ozone concentrations in the HGB area, and the synoptic-scale meteorological causes for these transport patterns.

A number of investigations have determined common characteristics of HGB area high ozone days. Below is a list of well-established findings from ozone studies between 2000 and 2015.

- High ozone often occurs in the HGB area on days when local mesoscale flows dominate, implying that large-scale synoptic forcing is weak. In addition to the well-known ozone-conducive conditions—light winds, strong sunlight, few clouds, hot temperatures—the location of Houston at 30° North latitude contributes to the strength of the sea breeze, and how the synoptic scale winds can accentuate or depress the mesoscale circulations induced by the Coriolis effect and the land-sea temperature gradients. (Banta et al. 2005)
- Southerly nocturnal winds lead to low ozone on the next day. (Tucker et al. 2010)
- Stability in the atmosphere leads to high ozone on days with a northerly wind component, but seems to have little effect on ozone for days with southerly winds. (Langford et al. 2010)
- High ozone seems to be linked to post-frontal conditions in spring and late summer/early fall, i.e., sunny, dry conditions. (Rappenglück et al. 2008, Lefer et al. 2010)
- Background ozone in the HGB area drops during mid-summer, and peaks in spring and late summer/early fall. (Nielsen-Gammon et al. 2005; Estes et al. 2013, 2014)
- Wind speed is a critical factor in ozone concentrations in the HGB area; weak winds are much more likely to foster high ozone than strong winds. Temperature and afternoon boundary layer depth are not as important as wind speed in determining ozone concentrations in the lower atmosphere. (Banta et al., 2011)
- Slow growth of the morning boundary layer appears to be associated with high ozone in the HGB area. (Senff et al. 2010; Haman et al. 2012, 2014)

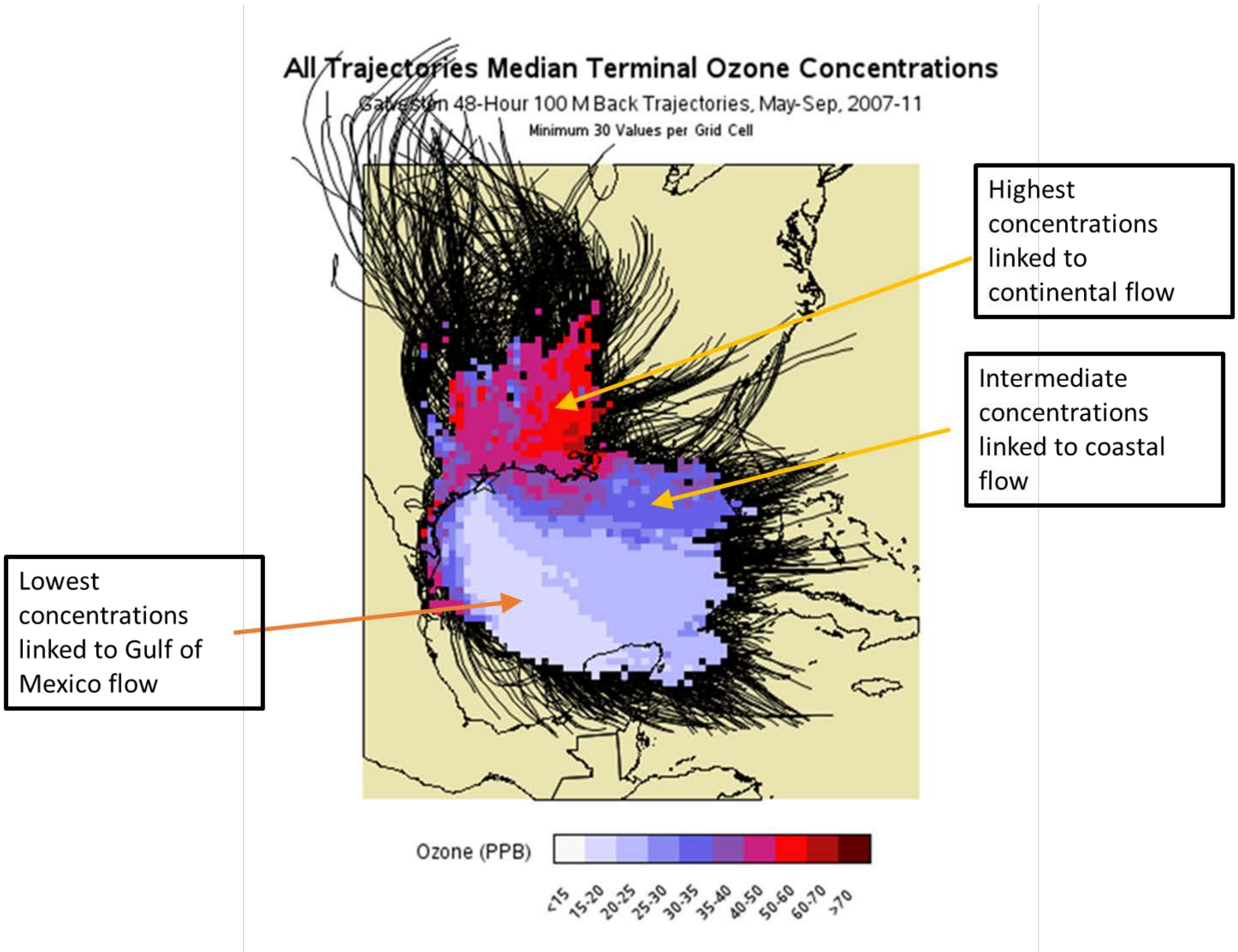
The findings of these disparate studies do fit together, but putting together the puzzle requires larger-scale studies that examine long-range transport and synoptic meteorology. The studies discussed below are able to assemble the pieces into a coherent picture of the weather patterns conducive to high ozone in the HGB area.

Though there are many ways to investigate how the winds can carry ozone from distant regions to the HGB area, most of the studies begin with two basic pieces of information: the concentration of ozone in the HGB area, and wind data that covers much of continental North America over an extended time. Wind data is collected at ground sites in the HGB area but the winds measured near the ground cannot describe the transport of ozone from distant areas and can only describe conditions near the surface, not at higher levels of the atmosphere where the transport winds are often located. Therefore, investigators rely upon computer-simulated winds or a mixture of observations and simulated winds called a reanalysis product. For either of these data products, there is information about the wind speed and direction at multiple layers of the atmosphere, at uniformly spaced points throughout continental North America, at regularly spaced intervals of time for each day. The investigators then may use trajectory models to examine how a parcel of air arriving in the HGB area must have traveled through the atmosphere in order to reach the area at a specific time and place. They use the wind data, and the physics of atmospheric transport contained within the model, to project back in time the location of the air parcel for the previous 24, 48, or 72 hours. There is uncertainty in the location of this estimated pathway, or backward trajectory, so scientists usually will not analyze only a single or a few trajectories, but many hundreds or thousands, so that they can marshal the power of statistical analysis to obtain a more reliable answer.

After the trajectories have been calculated, investigators will usually perform a multivariate statistical analysis called cluster analysis upon the trajectory data. The purpose of this analysis is to compare the trajectories to each other in order to group them together in clusters with members that have much in common. Trajectories that traverse the same geographic areas at about the same speed will be classified together, and those that move over different areas or at different speeds will be grouped with other trajectories more similar to themselves. The result will be a set of categorized trajectories that have been grouped together in an objective manner by mathematical similarity. The cluster analysis technique is not completely objective because an investigator must choose among dozens of different measures of mathematical similarity, and because scientists tend to prefer to create a manageable number of clusters rather than tens or hundreds; the cluster analyses described here all ended up with six or seven different clusters.

After the clusters have been created, the ozone concentrations for the time represented by the termination point of each trajectory can be statistically summarized and the ozone concentrations can be compared to see which cluster is most closely associated with high ozone. Another relevant statistic is the frequency of each cluster—how often does each trajectory pattern occur? If there is a sufficiently long data record, it may also be possible to discover if the frequency of different transport patterns is changing, which could strongly affect the ozone trends.

Trajectory studies discussed in this document include Sullivan (2009), Chan and Vet (2010), Smith et al. (2014), and Souri et al. (2015). An example of a trajectory study is shown in Figure 5-17: *Example of trajectory study (Smith et al. 2014), showing the relationship between transport and ozone concentrations*. Figure 5-17 depicts all of the calculated trajectories and the color-coding indicating ozone concentrations linked to the respective transport pathways.



Trajectories have been color-coded according to the median one-hour ozone concentration at the terminal site (Galveston) for all grid cells containing at least 30 trajectories. The resulting pattern shows how trajectories from different directions are linked to ozone concentrations in Galveston.

Figure 5-17: Example of trajectory study (Smith et al. 2014), showing the relationship between transport and ozone concentrations

A second type of analysis described below focuses more upon the large-scale meteorological patterns rather than the backward trajectories. The large-scale, or synoptic meteorological patterns, can be considered the cause of the wind fields that drive the transport of ozone. Objective analysis of these patterns can be done by a multivariate statistical technique called principal components analysis, or empirical orthogonal function (EOF) analysis. A detailed explanation of this technique is beyond the scope of this document, but more information can be found in Ngan and Byun (2011). Roughly, EOF analysis examines the weather pattern data, determines which data are varying together, and then mathematically transforms the data to create groups of variables with lower inherent variability. In the process, each weather pattern is dropped into a category full of similar patterns. Ozone concentrations can then be compared among the different categories to see which weather pattern is most closely linked to high ozone. Although the synoptic weather pattern analysis and the trajectory analysis may yield similar results, there are likely to be important differences among these types of classifications; these differences may prove interesting in themselves.

A third type of objective weather-classification study involves cluster analysis of meteorological variables at one or more surface sites. Davis et al. (1998) carried out a study of HGB-area weather and ozone for 1981 through 1992, and these results are still relevant today.

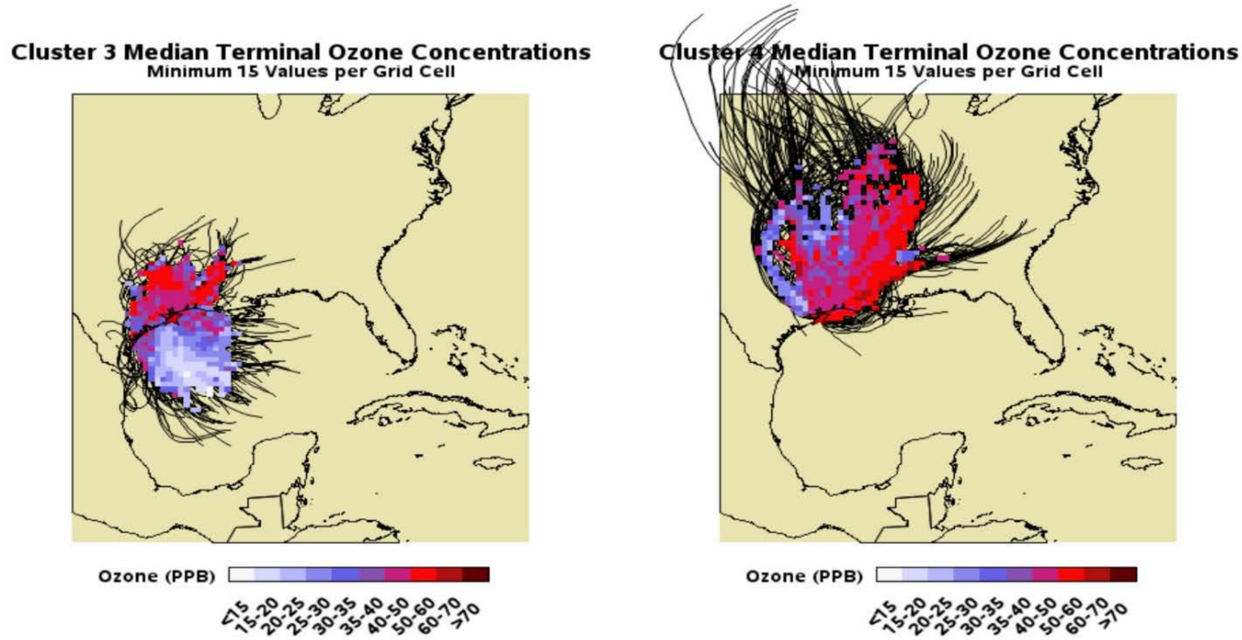
Table 5-3: Studies describing trajectories and weather patterns associated with high and low ozone in the HGB area

	High Ozone: easterly	High Ozone: stagnant	Low Ozone: strong SE	Low Ozone: moderate SW	Ozone data	Meteorological data
Souri: May - September, 2000-2014, 2252 days	Souri-4	Souri-5	Souri-1	Souri-2	13 SE Texas sites that collected data from 2000-2014	NCEP-NARR data, at 32km resolution, 900 hPa winds, at0600,0900, 1200 LST; analyzed with two-stage cluster analysis
Days in each class	188	331	351	918		
% of total days	8.3%	14.7%	15.6%	40.8%		
Ozone, ppbv	35	31	22	22		
Smith: May - September, 2007-2011, 642 days	Smith-4	Smith-3	Smith-5	Smith-1	Galveston only, 1-hour Ozone, at termination time	EDAS data, at 40km resolution, every 2 hrs to drive HYSPLIT, with trajectories terminating at 100 m above ground level; analyzed with SAS FASCLUS analysis
Days in each class	57	85	94	141		
% of total days	8.9%	13.2%	14.7%	21.9%		
Ozone, ppbv	45	36	25	20		
Sullivan: May - October, 2000-2007, 1441 days	Sullivan-5	Sullivan-4	Sullivan-1	Sullivan-2	12 HGB sites, MDA8	EDAS data, at 40km resolution, 1800 LST (one trajectory per day), terminating at 300m above ground level; analyzed with default cluster analysis from HYSPLIT
Days in each class	166	312	217	506		

	High Ozone: easterly	High Ozone: stagnant	Low Ozone: strong SE	Low Ozone: moderate SW	Ozone data	Meteorological data
% of total days	11.5%	21.7%	15.1%	35.1%		
Ozone, ppbv	73.3	71.6	40.6	48.5		
Ngan: May - September, 2005-2006, 301 days	Ngan-2	Ngan-3	Ngan-1	Ngan-5	65 sites, mean hourly Ozone	NCEP-NAM data, at 40km resolution, wind data at 850 hPa, 0600 LST; analyzed with principal components analysis and two-stage cluster analysis
Days in each class	56	69	93	40		
% of total days	18.6%	22.9%	30.9%	13.3%		
Ozone, ppbv	65	61	35	40		
Davis: April - October, 1981-1992, 2568 days	Davis-K3	Davis-K7	Davis-K2	Davis-K1	11 sites, median daily 1-hour maximum	Houston International Airport observational data, every 3 hours; analyzed with two-stage cluster analysis
Days in each class	339	151	337	968		
% of total days	13.2%	5.9%	13.1%	37.7%		
Ozone, ppbv	88.69	71.74	39.59	67.52		

NCEP: National Center for Environmental Prediction
NARR: North American Regional Reanalysis
EDAS: Eta Data Assimilation System
HYSPLIT: Hybrid Single Particle Lagrangian Integrated Trajectory Model
NAM: North American Model

The classes of transport that are most closely associated with high ozone in the HGB area as identified by five different studies are shown in Figure 5-18: *Transport patterns linked to high ozone, from Smith et al. 2013*. In spite of the many differences in how the classifications were made (see Table 5-3: *Studies describing trajectories and weather patterns associated with high and low ozone in the HGB area*), the high-ozone transport patterns are very similar among all of the studies. The transport category with highest ozone concentrations in the HGB area brings weak winds from the north and east. As Table 5-3 indicates, this category occurs 8 to 13% of the time. The second highest category is characterized by relatively stagnant conditions, as shown by short back trajectories. Four of the five studies indicate that stagnant conditions occur more often than weak north and east winds, with frequency ranging from 13 to 23%; the Davis study has fewer days in this category. When transport falls into one of these patterns, a high pressure system is usually located north or northeast of the HGB area. Davis et al. (1998) referred to these systems as "migratory anticyclones" to distinguish them from the persistent, stationary Bermuda High anticyclone that establishes itself in the Atlantic Ocean off the east coast of the U.S. during mid-summer. Migratory anticyclones follow behind cold fronts, and so they tend to occur more often in spring and late summer/early fall instead of mid-summer.



Trajectories have been color-coded according to the median one-hour ozone concentration at the terminal site (Galveston) for all grid cells containing at least 30 trajectories. The resulting pattern shows how trajectories from different directions are linked to ozone concentrations in Galveston.

Figure 5-18: Transport patterns linked to high ozone, from Smith et al. 2013

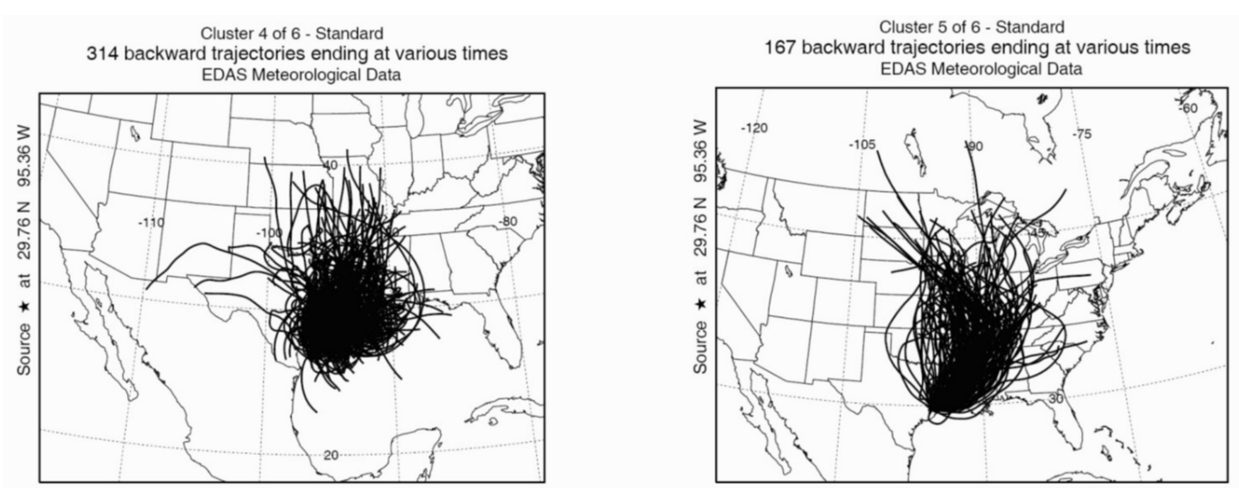
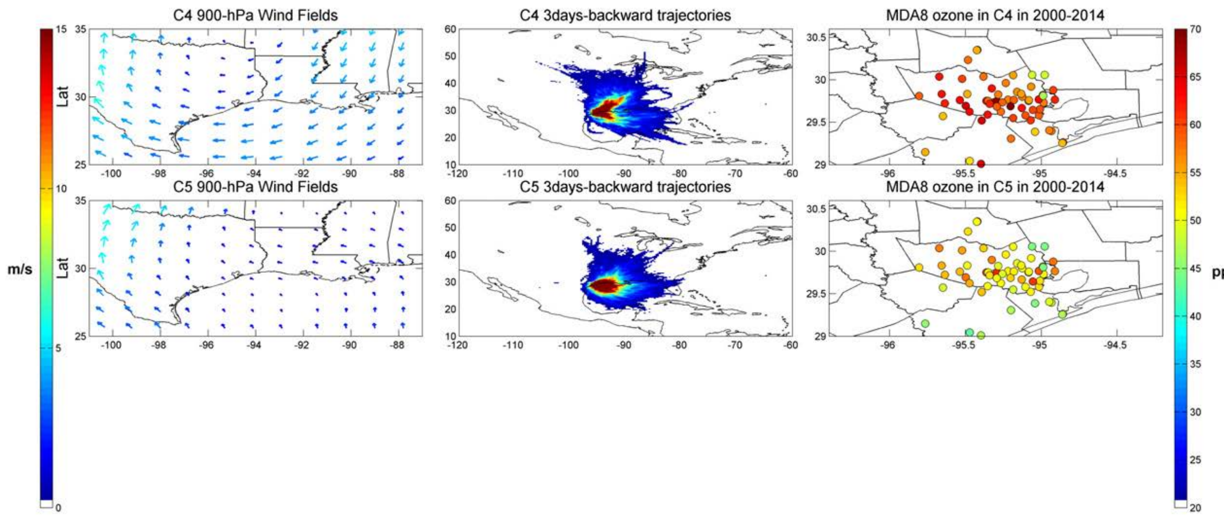
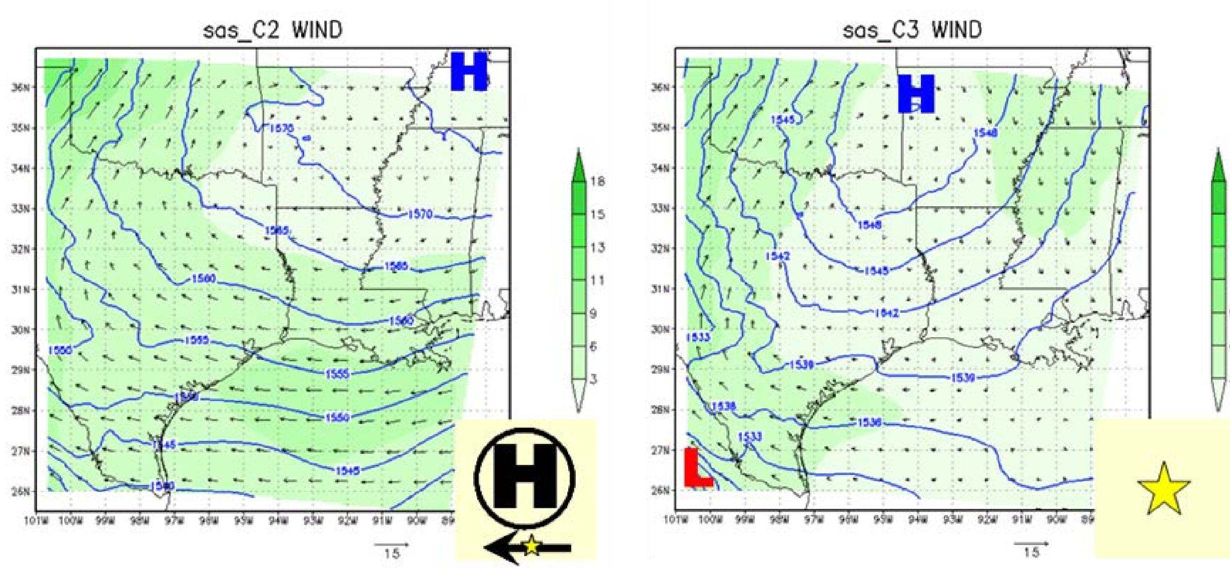


Figure 5-19: Transport patterns linked to high ozone, from Sullivan, 2009



Left figures show WRF-modeled 900 hPa wind fields associated with the trajectory cluster. Center figures show the trajectories, with the number of trajectories passing through each grid cell illustrated by color-coding, with hotter colors indicating higher numbers. Right figures show maps of the HGB area with the average MDA8 ozone observed at each monitoring site on the days represented by the trajectory cluster. Ozone concentrations are coded according to the color bar on the far right.

Figure 5-20: Transport patterns linked to high ozone, from Souri et al. 2015



For each map, the icon at the lower right corner shows the location of Houston as a star, relative to the dominant high (H) or low (L) pressure centers. The large arrow through the star indicates the approximate direction of the prevailing winds in Houston. The arrow heads arranged in a regular grid on each map indicate the direction of winds at the height of the 850 millibar (mb) pressure level. The wind speed in meters per second is color-coded according to the key on the right of each map. The blue lines, called isoheights, show the height above sea level of the 850 mb pressure. Widely spaced isoheights indicate a weak pressure gradient and light winds; narrowly spaced isoheights indicate strong pressure gradients and strong winds.

Figure 5-21: Meteorological patterns linked to high ozone in the HGB area, from Ngan and Byun, 2011

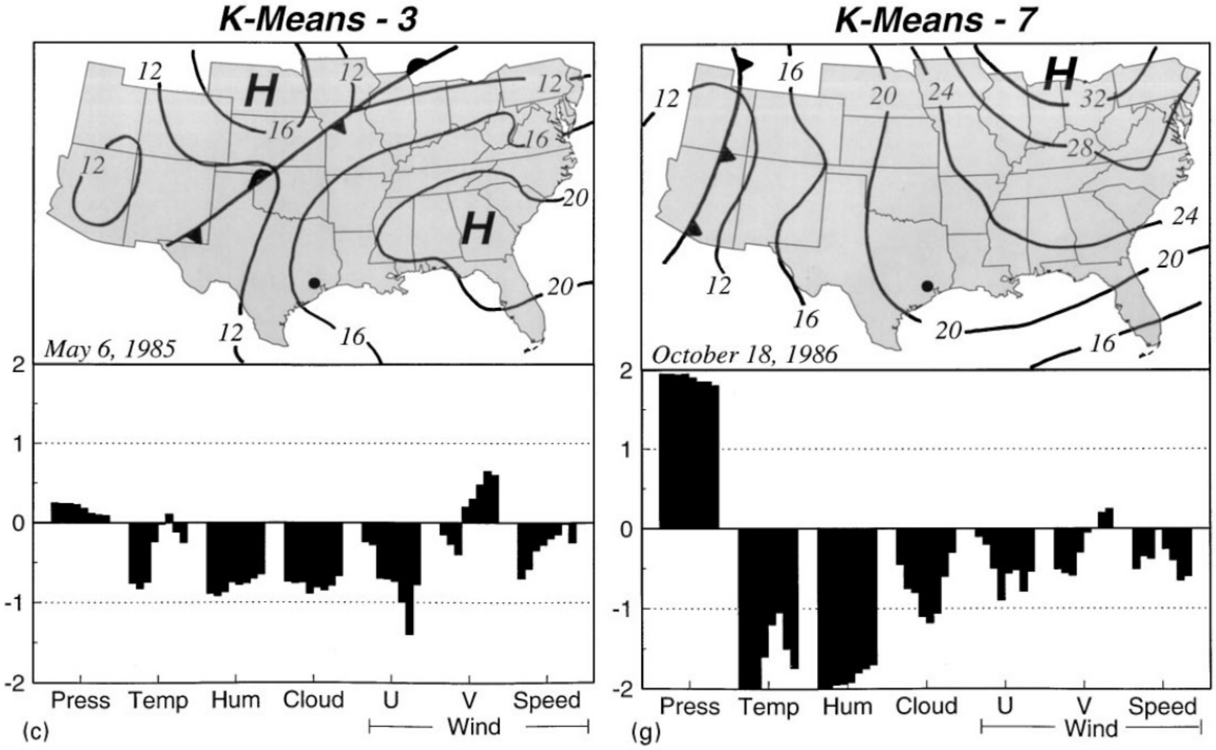
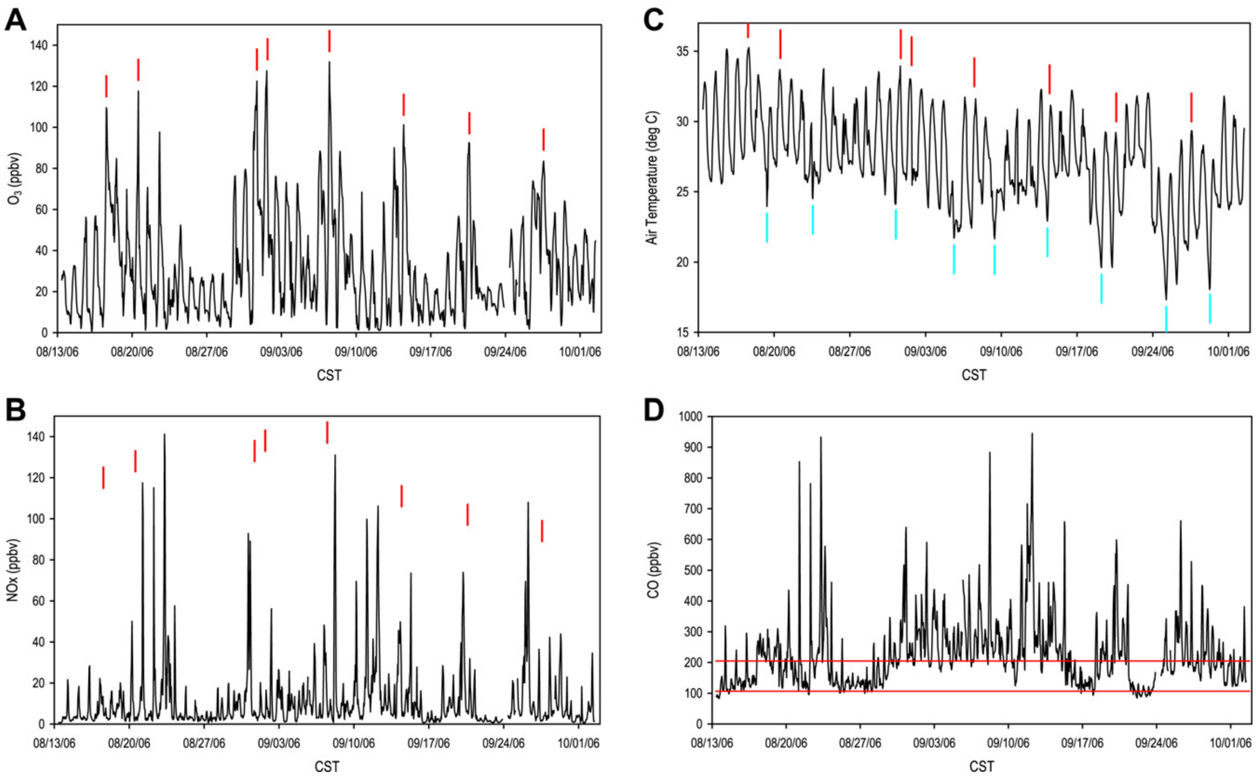


Figure 5-22: Meteorological patterns linked to high ozone in Houston, from Davis et al. 1998

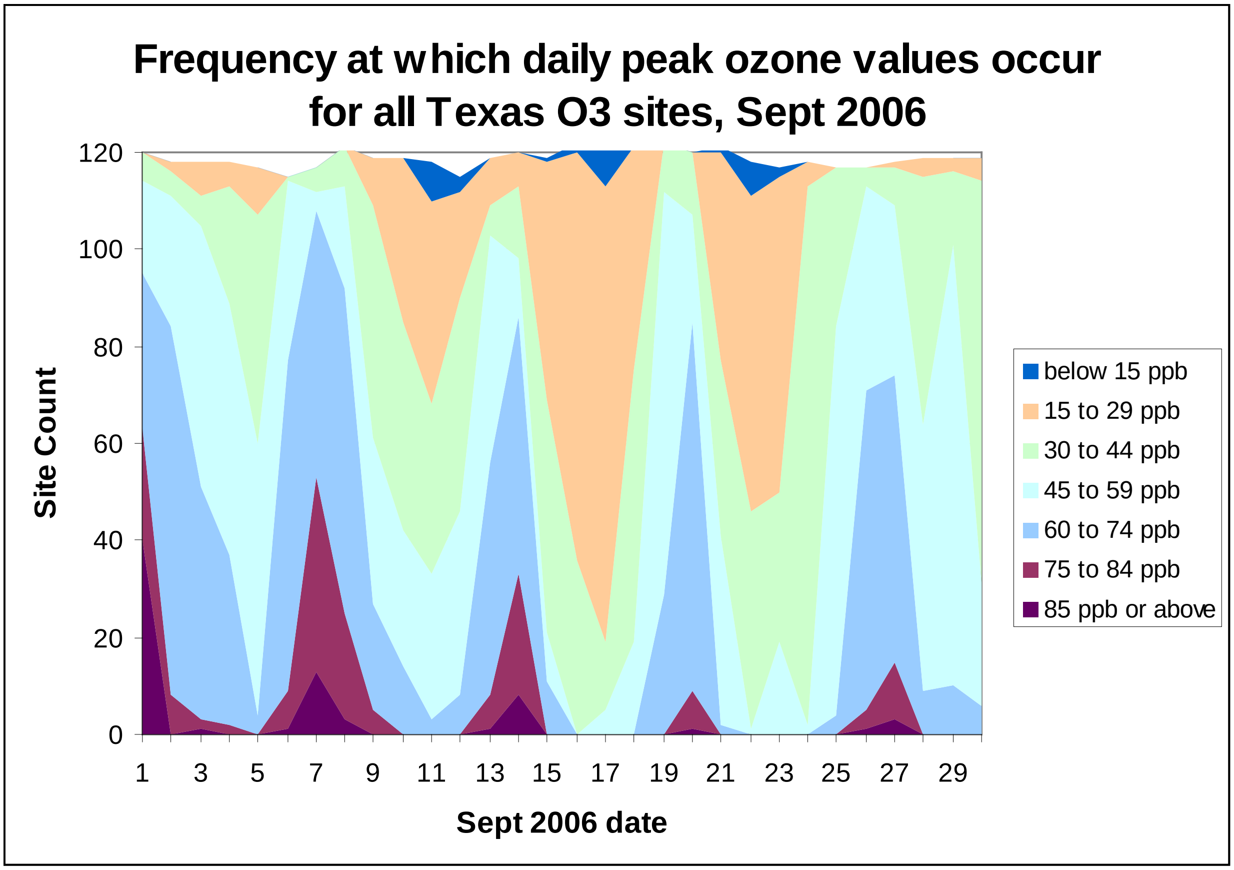
Weak northerly and easterly winds are linked to high ozone days in the HGB area as shown in the results in Table 5-3 and Figure 5-18, Figure 5-19: *Transport patterns linked to high ozone, from Sullivan, 2009*, and Figure 5-20: *Transport patterns linked to high ozone, from Souri et al. 2015*. These winds occur in a post-frontal synoptic environment as shown by the meteorological analysis in Figure 5-21: *Meteorological patterns linked to high ozone in the HGB area, from Ngan and Byun, 2011* and Figure 5-22: *Meteorological patterns linked to high ozone in Houston, from Davis et al. 1998*. Rappenglück et al. (2008) and Lefer et al. (2010) also showed that during the TexAQS 2006 study, the weather conditions one or two days after a frontal passage were often well-suited to high local ozone production. Figure 5-23: *Time series of pollutants and temperature during August-September 2006, from Lefer et al. 2010* shows that ozone, NO_X, CO, and temperature measured in the HGB area all have marked decreases in the days before a high ozone day, reflecting frontal passage. Figure 5-24: *Time series of frequency distribution of MDA8 ozone at all Texas sites, September 2006* shows the distribution of ozone concentrations during September 2006 from all TCEQ ozone monitors in the state of Texas; the frontal passages described by Lefer et al. are indicated by low ozone concentrations. Figure 5-24 shows that in the aftermath of a frontal passage, ozone concentrations increase dramatically across the state. Davis et al. results (Figure 5-22) show that high ozone is linked to weather patterns with lower than average humidity, higher than average temperatures, and lighter than average winds, which are all consistent with post-frontal high pressure regimes.

These analyses indicate which transport patterns are linked to high ozone days, but generally cannot explain whether HGB's peak ozone is affected more by background ozone transported into the area or by ozone forming from local emissions in stagnant, sunny, and dry conditions. However, these analyses do explain that these conditions occur at the same time: background ozone is higher when transport is from the continent rather than the Gulf of Mexico, when northerly winds interact with sea breeze and Coriolis oscillations to create stagnant conditions, and when high pressure brings dry, sunny conditions and a stable atmosphere, promoting local ozone formation. The results from these studies also indicate that ozone-conducive patterns occur more often in spring, late summer, and early autumn, and do not usually occur in mid-summer (Souri et al. 2015; Smith et al. 2013; Davis et al. 1998; Ngan and Byun 2011).



The vertical red bars show the ozone exceedance days; the blue bars indicate low temperatures associated with frontal passage.

Figure 5-23: Time series of pollutants and temperature during August-September 2006, from Lefer et al. 2010



Frontal passages bring low ozone statewide on Sept 5, 11, 16-18, and 22-24; high ozone follows within few days on Sept 7, 14, 20, and 27.

Figure 5-24: Time series of frequency distribution of MDA8 ozone at all Texas sites, September 2006

The transport and meteorological patterns linked to low ozone concentrations in the HGB area are displayed in Figure 5-25: *Transport patterns linked to low ozone, from Smith et al. 2013*, Figure 5-26: *Transport patterns linked to low ozone, from Sullivan, 2009*, Figure 5-27: *Transport patterns associated with low ozone, from Souri et al. 2015*, Figure 5-28: *Meteorological patterns linked to low ozone, from Ngan and Byun, 2011*, and Figure 5-29: *Meteorological patterns linked to low ozone, from Davis et al. 1998*. These various studies again gave consistent results, showing that brisk flow from the Gulf of Mexico is strongly associated with low ozone. All of the studies indicate that these patterns are quite common during the ozone season, comprising approximately 45% to 55% of the days. These patterns indicate the influence of the Bermuda High, the persistent high-pressure center in the Atlantic Ocean that strongly influences weather patterns throughout the southeast U.S. and the Gulf of Mexico during mid-summer (Shen et al. 2015; Wang et al. 2015). Clockwise flow around the western edges of the Bermuda High bring clean Gulf air into southeast Texas. This pattern occurs frequently in mid-June to mid-August, with early July as the peak season for strong southerly flow.

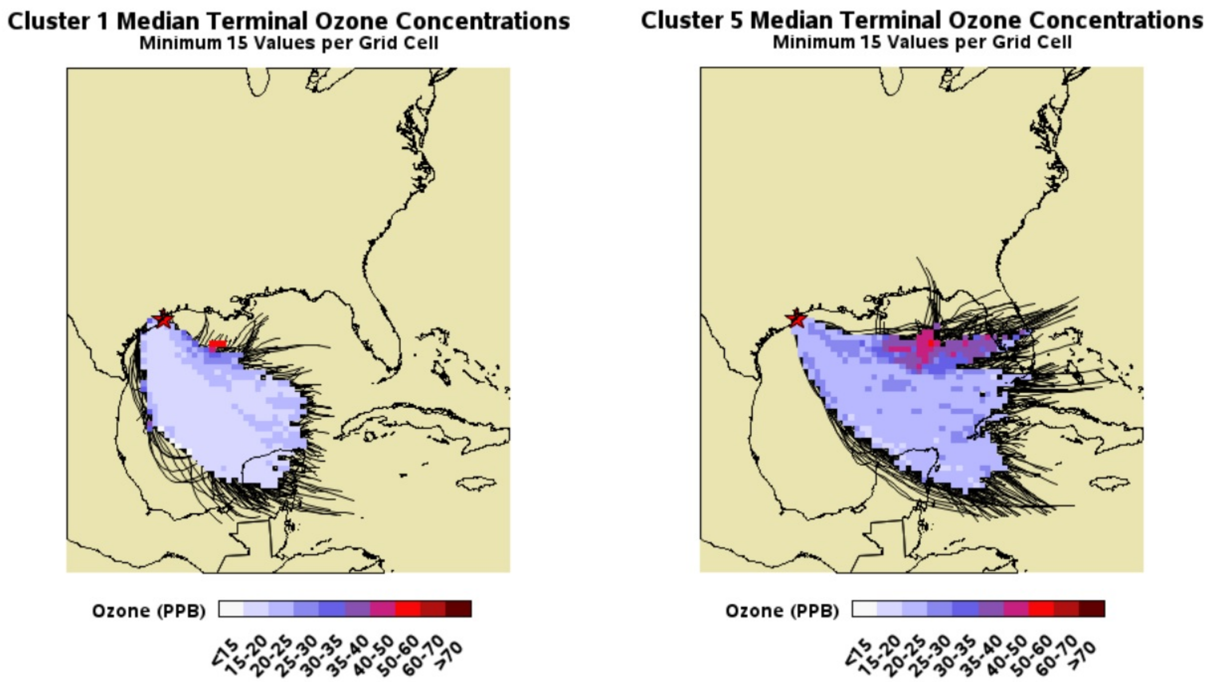


Figure 5-25: Transport patterns linked to low ozone, from Smith et al. 2013

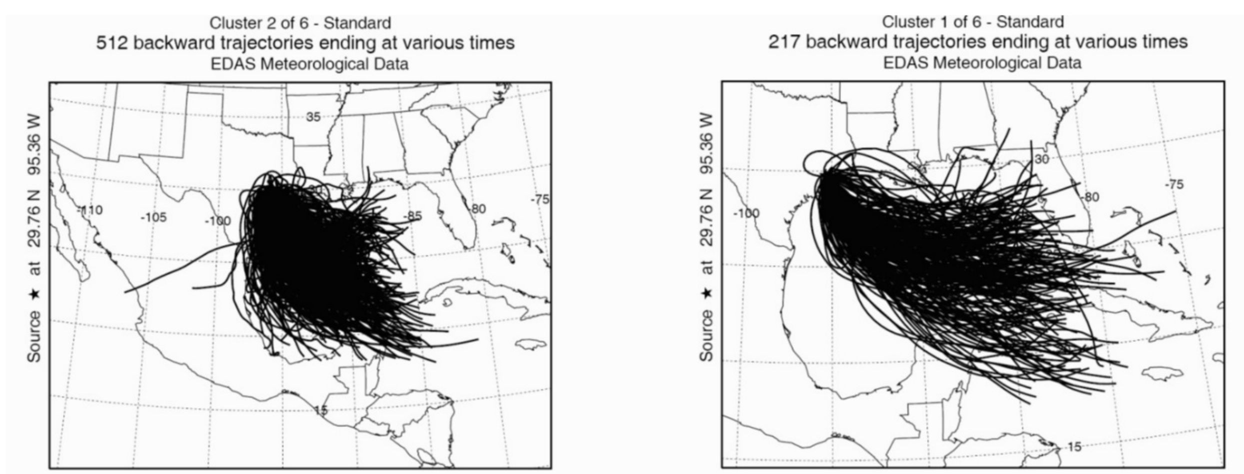


Figure 5-26: Transport patterns linked to low ozone, from Sullivan, 2009

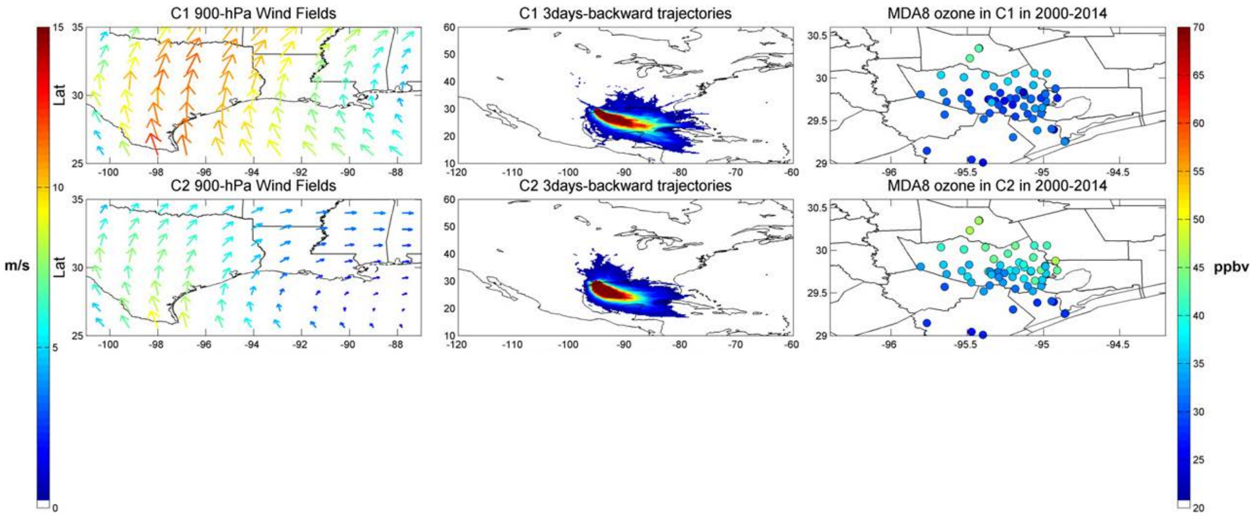
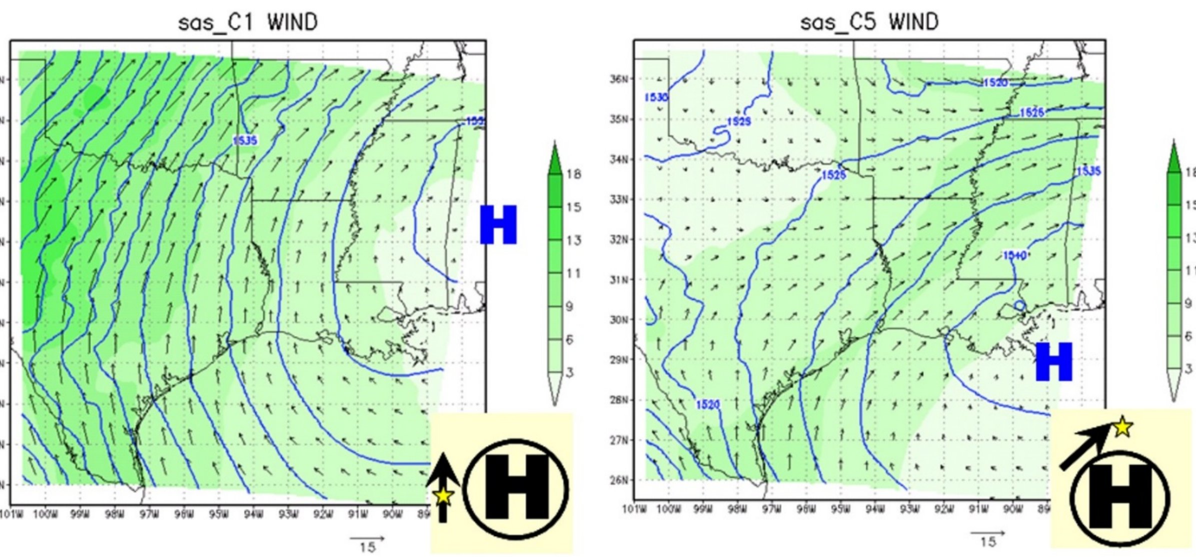


Figure 5-27: Transport patterns associated with low ozone, from Souri et al. 2015



The features shown on these maps follow the same convention as those shown on Figure 5-21.

Figure 5-28: Meteorological patterns linked to low ozone, from Ngan and Byun, 2011

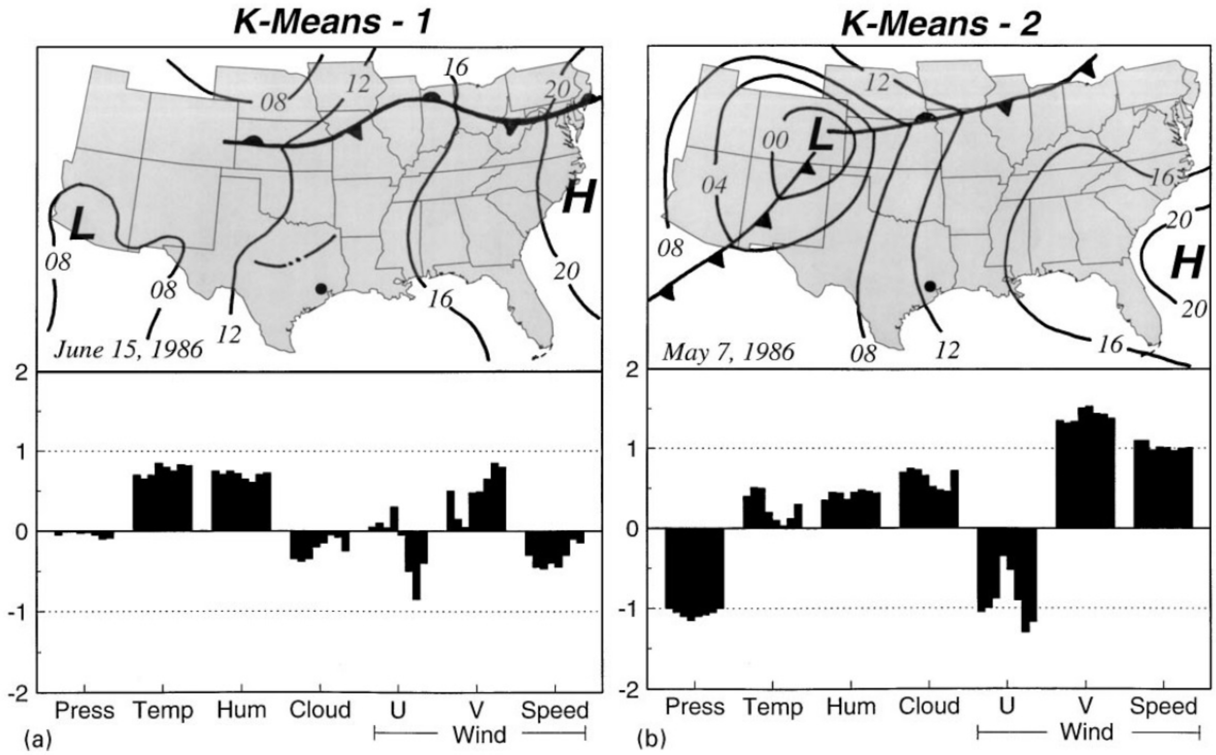


Figure 5-29: Meteorological patterns linked to low ozone, from Davis et al. 1998

Again, there are probably multiple causes for the low ozone under these flow patterns. Gulf of Mexico air tends to have much lower ozone concentrations than continental air, as shown by the Galveston data in Figure 5-25, and other measurements in and near the Gulf (e.g., Berlin et al. 2013; Gilman et al. 2009; Helmig et al. 2009). When the synoptic-scale forcing accentuates sea breeze formation and persistence, southerly winds can be continuous and strong, effectively diluting both ozone precursors emitted in the HGB area and the ozone that forms in the HGB area.

Based upon the transport studies presented above, a summary of transport patterns, meteorological patterns, and their relationships to ozone observed in the HGB area is presented below in Figure 5-30: *Summary of meteorology and transport patterns linked to high ozone* and 5-31: *Summary of meteorology and transport patterns linked to low ozone*.

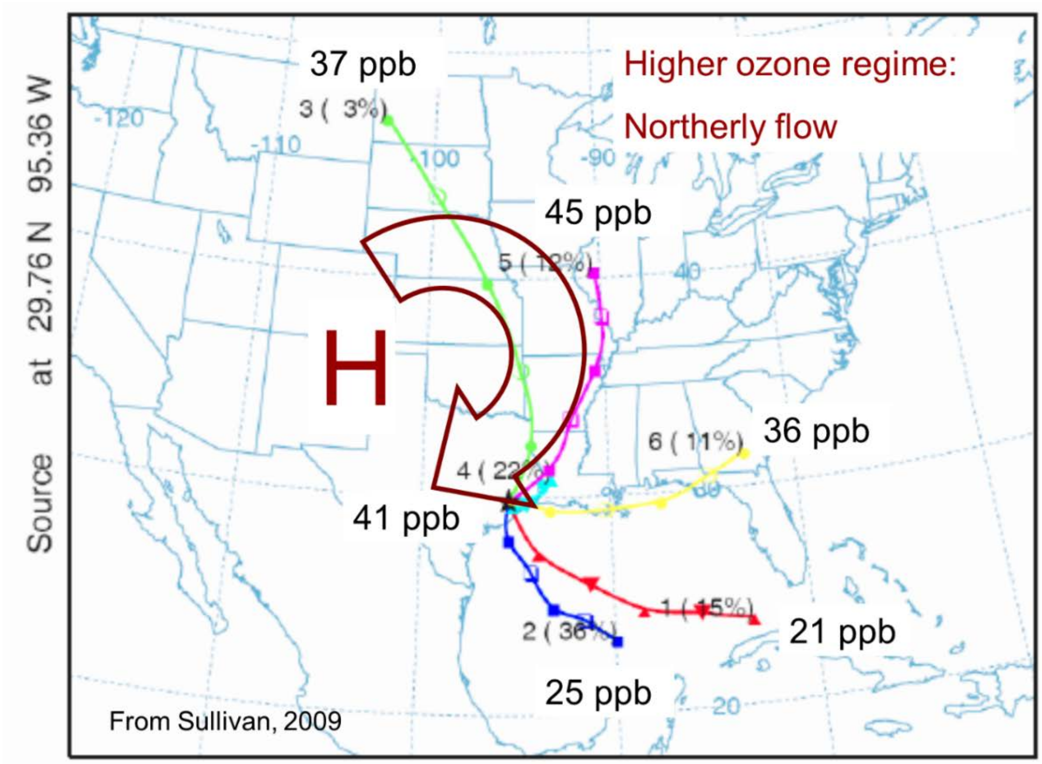


Figure 5-30: Summary of meteorology and transport patterns linked to high ozone

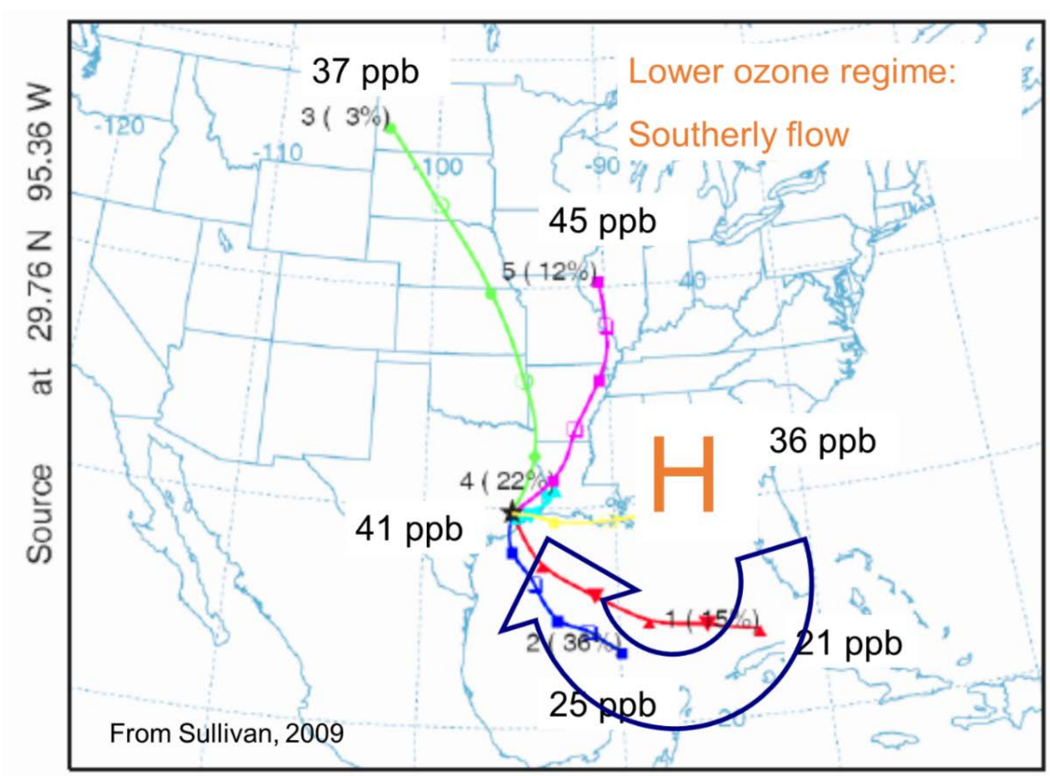
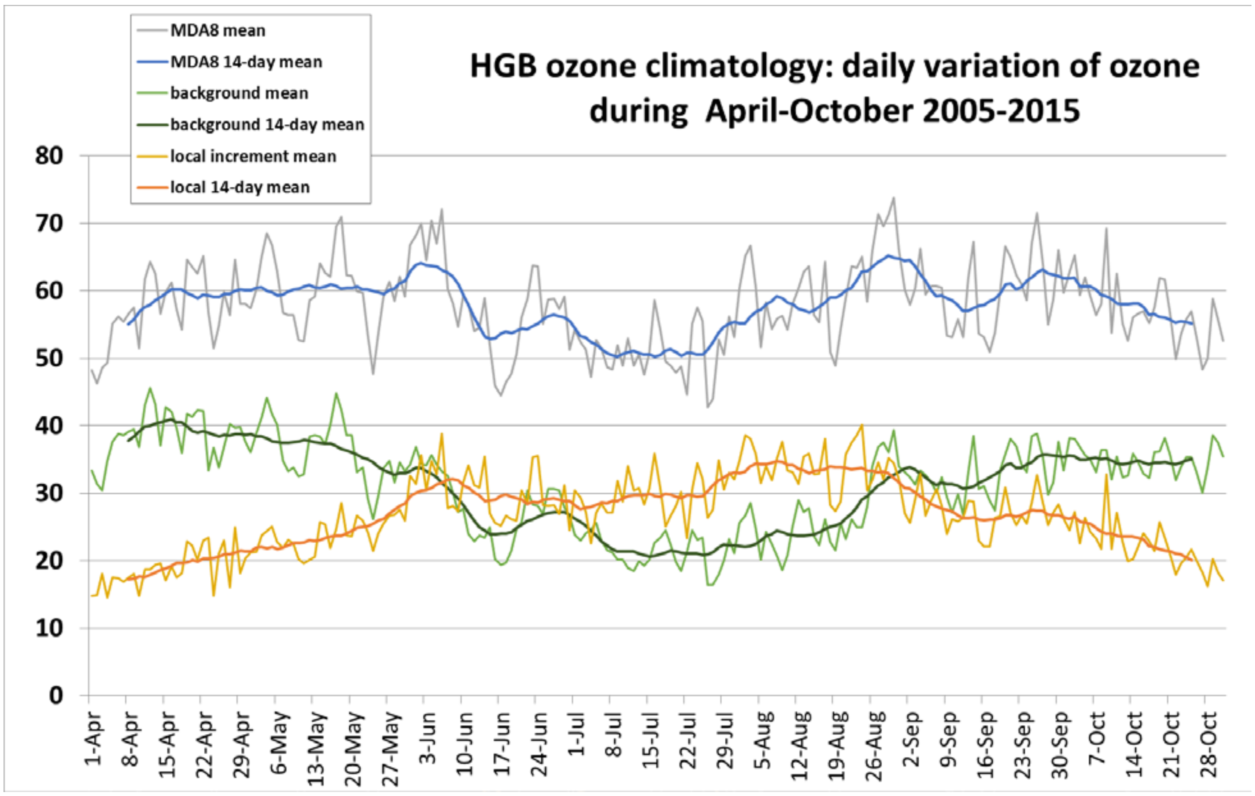


Figure 5-31: Summary of meteorology and transport patterns linked to low ozone

The results of the transport studies suggest that the background ozone is a crucial component of the peak ozone observed in the HGB area each day. As discussed above, and shown in Figure 5-16, background ozone can be estimated for the HGB area using the extensive ozone monitoring network. The technique for estimating background ozone concentrations is described in Berlin et al. (2013); it is similar to methods used by Nielsen-Gammon et al. (2005). To estimate background ozone concentrations, monitoring sites capable of measuring background ozone were selected based upon their distance from local emission sources in the urban core and industrial areas of the HGB area. Each of these selected sites is expected to receive air with regional background ozone when it is upwind (or at least, not downwind) of the urban and industrial areas. The selected sites changed from year to year as sites were added to, or removed from the monitoring network. Background ozone was estimated as the lowest maximum daily average eight-hour ozone (MDA8) ozone value observed at the selected background sites for each ozone season day (April through October) from 2005 through 2015. Inherent in this method is the assumption that the lowest MDA8 from the selected sites represents background ozone. If there is a gradient in background ozone across the metropolitan area, the method will select the lowest end of the gradient as background; therefore, the method is conservative in that it represents the lowest measured background value.

Inaccurate background ozone estimates may result if HGB area emissions from a previous day have recirculated and re-entered the area, or if the sea breeze was weak and penetrated only partially inland, affecting only one or two coastal sites rather than the entire urban area. For the first case, any method of estimating background ozone would fail to identify an air mass unaffected by HGB's emissions on days with multiday recirculation or stagnation; all background ozone estimates on such days are likely to be uncertain. For the second case, additional analysis was performed to determine whether the sea breeze had only partially entered the HGB area. If sea-breeze influenced sites are erroneously identified as representative of background ozone in the HGB area, then there are particularly large differences between the area-wide peak ozone and the background ozone. To identify such cases, the daily local increment data (the difference between MDA8 ozone and background ozone) were examined for anomalously high values. For those days, the five-minute ozone data for all sites in the HGB area were reviewed to determine whether coastal site ozone concentrations were notably different from those of all of the other sites from 0900 to 1800 LST. If they were, an appropriate noncoastal site was then chosen to represent background ozone. On average, only 2% to 3% of days were identified as "partial sea breeze" days.

Background ozone data (Nielsen-Gammon et al. 2005; Estes et al. 2013, 2014) show that the lowest background ozone in the HGB area is observed during July as demonstrated in Figure 5-32: *Daily average variation of HGB area peak, background, and local increment ozone during 2005 through 2015*. Consequently, the lowest background ozone occurs when the flow is predominantly from the Gulf of Mexico, due to the influence of the persistent, stationary Bermuda High anticyclone that establishes itself in the Atlantic Ocean off the east coast of the U.S. during mid-summer. Clockwise flow around the western edges of the Bermuda High bring clean Gulf air into southeast Texas. This pattern occurs frequently in mid-June to mid-August, with early July as the peak season for strong southerly flow. Davis et al. (1998), Shen et al. (2015) and Wang et al. (2015) all show that the Bermuda High is dominant during the period when persistent southerly flow tends to occur, and when background (and peak) ozone is lowest. Wang et al. (2015) showed that the western extent of the Bermuda High accounts for much of the ozone variation (about 70%) in the HGB area during the months of June and July, but not during the months of August and September. Figure 5-32 shows that low background ozone in July coincides with the peak local ozone production period in the HGB area. As the Bermuda High influence wanes in August, the combination of higher background ozone and high local ozone production results in the peak ozone season, which usually occurs around late August to mid-September in the HGB area.



Mean MDA8 is calculated for each day by averaging the HGB MDA8 for each date from 2005 through 2015, so that the mean MDA8 represents the average of 11 MDA8 values. For example, all 11 April 1st MDA8 values are averaged to obtain the mean MDA8 for April 1st. Likewise, the mean background ozone represents the average of background ozone for the respective date for each of the 11 years. Local increment is obtained from the daily difference between MDA8 and background, averaged over 11 occurrences of each date. The 14-day average is a rolling average of the week before and after the date of interest, so it is a method for smoothing.

Figure 5-32: Daily average variation of HGB area peak, background, and local increment ozone during 2005 through 2015

The data shown in Figure 5-32 are useful in interpreting interannual trends and seasonal variations of the different components of ozone, but they represent long-term averages rather than individual days or years. Therefore, their usefulness lies in their ability to help interpret interannual trends in ozone, seasonal variations, and links to transport and meteorology, not in their ability to predict attainment status. However, deviations from the long-term patterns may be useful in identifying exceptional events.

As a final verification of the trajectory patterns linked to high and low ozone in the HGB area, one can consider another study for an area in a neighboring state. Chan and Vet (2010) undertook a study to investigate ozone observations at urban and rural ozone monitoring sites and the transport patterns associated with those observations. None of the monitoring sites were in Texas, but one site, Caddo Valley in SW Arkansas, is close enough to examine for similarities to Texas transport patterns. The study used a different set of meteorological data, and a different procedure for analysis of trajectory and ozone data, but the patterns for high and low ozone days are strikingly similar to those observed in the HGB area. The patterns, which are nearly identical to patterns discussed above for the HGB area, are displayed in Figure 5-33: *Transport patterns linked to high and low ozone at Caddo Valley, Arkansas, from Chan and Vet (2010)*. This match indicates that the transport patterns driving high and low ozone are indeed large-scale patterns, because they not only exist for Houston (Souri et al.) and Galveston (Smith et al.), but also for Caddo Valley (Chan and Vet), and Aransas Pass (Smith et al., not shown). The dependence upon the Bermuda High not only holds for Houston (Wang et al.), but also for Pensacola and Mobile (Wang et al. submitted).

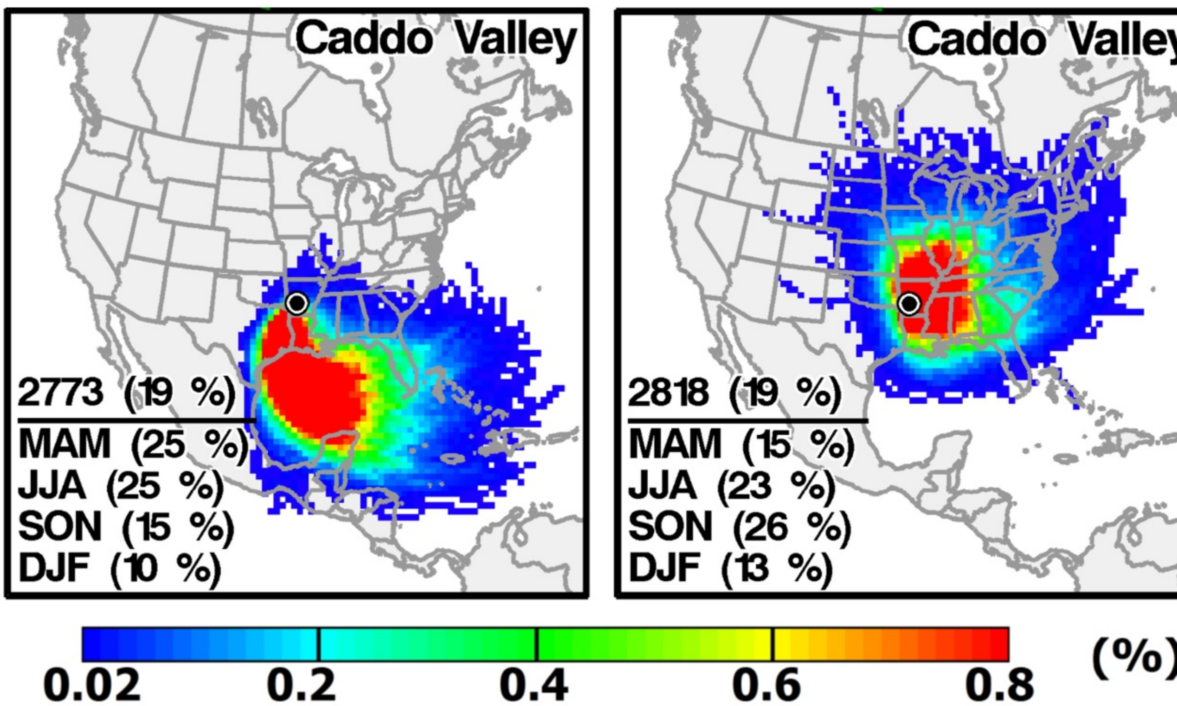
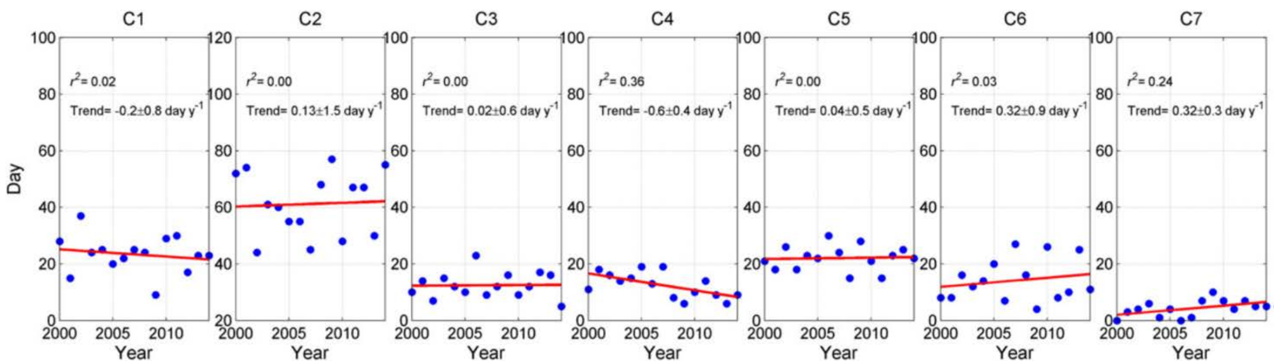


Figure 5-33: Transport patterns linked to high and low ozone at Caddo Valley, Arkansas, from Chan and Vet (2010)

A brief discussion of meteorological impacts on ozone trends can be found in Section 5.2.5 *Meteorological Influences on Ozone*. Another way to reduce or remove ozone variations due to meteorology is to isolate transport patterns into clusters. By doing so, ozone variations due to meteorology are reduced or removed from each cluster. It is therefore possible to look at trends in ozone within each cluster to see how ozone is changing when the effects of meteorology are isolated.

The transport patterns identified by Souri et al. (2015), and displayed in Figures 5-20 and 5-27, were analyzed for trends. Most transport patterns show no discernable trend, as shown in Figure 5-34 *Trends in the frequency of seven different transport patterns identified by Souri et al. (2015);* Souri et al. note that only transport pattern C4 has a statistically significant trend. Since C4 is closely linked to high ozone days, the downward trend in this pattern implies that at least some of the ozone reductions observed in the HGB area may be due to an ozone-conducive transport pattern becoming less common from 2000 to 2014.



Only patterns C4 (high ozone pattern) and C7 (low ozone pattern) have evident trends. Pattern C4 has become less common (six fewer days per decade), and C7 has become more common (three more days per decade). Only the C4 trend is statistically significant. C7 is so rare that its increase (if real) probably has no impact.

Figure 5-34: Trends in the frequency of seven different transport patterns identified by Souri et al. (2015)

Souri et al. also examined the ozone trends for the different clusters. With the influence of transport removed, the trends should show whether other factors besides transport are causing decreases in ozone. The trend graphs for the transport patterns are shown in Figure 5-35: *Ozone trends for trajectory clusters identified by Souri et al. (2015)*. The researchers used MDA8 ozone data averaged for all stations.

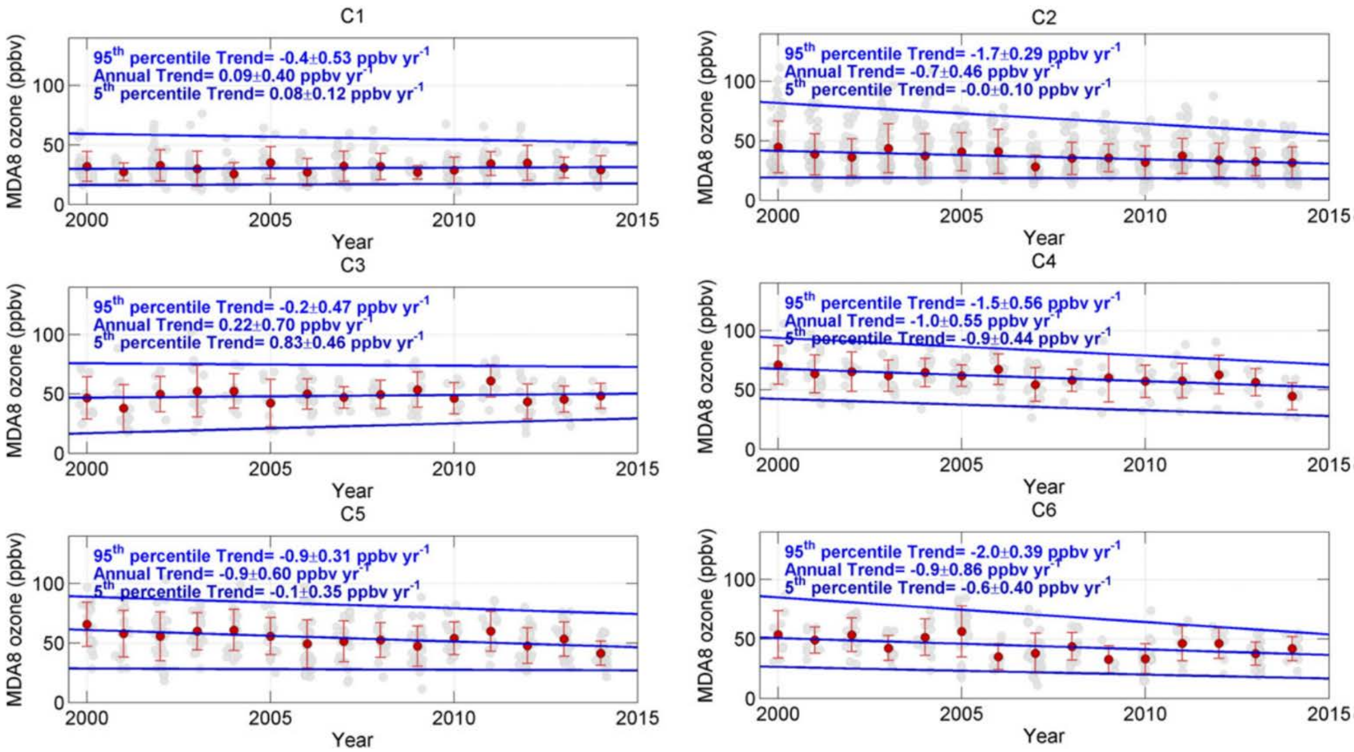


Figure 5-35: Ozone trends for trajectory clusters identified by Souri et al. (2015)

Souri et al. (2015) found that the two patterns with the highest ozone, C4 and C5, both showed downward trends in ozone concentrations, with especially large trends in the 95th percentile ozone concentrations. Of the two patterns, C4 was considered to be more influenced by background ozone, and C5 was considered to be more local, due to the lower winds during C5. Since transport pattern variability had been removed from the trend analyses, the resultant downward trends were likely due to decreases in background (C4) and locally produced (C5) ozone.

5.4 QUALITATIVE CORROBORATIVE ANALYSIS

This section outlines additional measures, not included in the photochemical modeling, that are expected to further reduce ozone levels in the HGB ozone nonattainment area. Various federal, state, and local control measures exist that are anticipated to provide real emissions reductions; however, these measures are not included in the photochemical model because they may not meet all of the EPA's criteria for modeled reductions.

5.4.1 Additional Measures

5.4.1.1 SmartWay Transport Partnership and the Blue Skyway Collaborative

Among its various efforts to improve air quality in Texas, the TCEQ continues to promote two voluntary programs in cooperation with the EPA: SmartWay Transport Partnership and Blue Skyways Collaborative.

The SmartWay Transport Partnership is a market-driven partnership aimed at helping businesses move goods in the cleanest most efficient way possible. This is a voluntary

EPA program primarily for the freight transport industry that promotes strategies and technologies to help improve fleet efficiency while also reducing air emissions.

There are over 3,000 SmartWay partners in the U.S., including most of the nation's largest truck carriers, all the Class 1 rail companies, and many of the top Fortune 500 companies. Since its founding, SmartWay has reduced oil consumption by 170.3 million barrels and prevented the release of 1,458,000 tons of NO_X and 59,000 tons of PM into the atmosphere.[12] Ports in the U.S. rely on SmartWay's Port Drayage Truck program to help reduce pollution in and around major national ports. The Port of Houston Authority's (PHA) partnership with the Environmental Defense Fund and the Houston-Galveston Area Council (H-GAC) in the Port Drayage Truck Bridge Loan Program received $9 million from the EPA's Diesel Emissions Reduction Act (DERA) SmartWay Program in 2009. On average, four trucks a month, or about 50 trucks a year, were approved for replacement funding.

In April 2015, the EPA awarded the PHA with a DERA grant of nearly $900,000. This newest grant, which will have matching funds of $1,680,142, will have a total commitment of more than $2.5 million. A total of 25 drayage trucks will replace trucks operating in the Port of Houston. The latest funding will provide for new trucks powered by certified engines that are model year 2011 or newer, which are estimated to be 90% cleaner. These drayage trucks operate in the Port of Houston and along the Houston Ship Channel. The new trucks will also have Global Positioning System units to collect data on idling and port operations, which will allow fleet owners and operators to gauge opportunities for additional fuel savings and emissions reduction.[13]

Approximately 170 Texas companies are SmartWay partners. The SmartWay Transport Partnership will continue to benefit the HGB area by reducing emissions as more companies and affiliates join, and additional idle reduction, trailer aerodynamic kits, low-rolling resistance tire, and retrofit technologies are incorporated into SmartWay-verified technologies.

The Blue Skyways Collaborative was created to encourage voluntary air emission reductions by planning or implementing projects that use innovations in diesel engines, alternative fuels, and renewable energy technologies applicable to on-road and non-road sources. The Blue Skyways Collaborative partnerships include international, federal, state, and local governments, non-profit organizations, environmental groups, and private industries.

5.4.1.2 American Waterways Operators Tank Barge Emissions Best Management Practices

Using infrared gas imaging technology in field studies conducted in the summer of 2005, the TCEQ detected inadvertent VOC emissions from tank barges operating in the HGB area. The Louisiana Department of Environmental Quality (LDEQ) also detected inadvertent emissions from tank barges in similar field studies conducted in the same time period. In response to these field studies, the American Waterways Operators

[12] https://www.epa.gov/smartway/learn-about-smartway

[13] http://www.portofhouston.com/inside-the-port-authority/communications/business-news/epa-administrator-visits-port-of-houston-authority-to-make-formal-announcement/

(AWO) voluntarily developed industry best management practices (BMP) to reduce VOC emissions from tank barges. The BMP include procedures to reduce VOC emissions from equipment and operations on tank barges. The recommendations are a combination of inspection, corrective action, preventative maintenance, and operational, procedural, and training practices.

The BMP were reviewed by the Chemical Transportation Advisory Committee, United States Coast Guard, LDEQ, and TCEQ. The BMP document was distributed to AWO members in 2006 for implementation on a voluntary basis. While the BMP are voluntary measures and do not impose an enforceable commitment on AWO members, the implementation of the BMP, where applicable, may contribute to reducing inadvertent VOC emissions from barges during dock operations and during transit, which will help improve air quality in the HGB area. A copy of the 2006 BMP document is provided in the 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision as Appendix J: *Recommendations for Best Management Practices to Control and Reduce Inadvertent Cargo Vapor Emissions in the Tank Barge Community*. Based on discussions with AWO staff, the BMP is currently under review for possible revisions. The AWO may issue an updated BMP in the future.

5.4.1.3 Energy Efficiency and Renewable Energy (EE/RE) Measures

Energy efficiency (EE) measures are typically programs that reduce the amount of electricity and natural gas consumed by residential, commercial, industrial, and municipal energy consumers. Examples of EE measures include: increasing insulation in homes; installing compact fluorescent light bulbs; and replacing motors and pumps with high efficiency units. Renewable energy (RE) measures include programs that generate energy from resources that are replenished or are otherwise not consumed as with traditional fuel-based energy production. Examples of renewable energy include wind energy and solar energy projects.

Texas leads the nation in RE generation from wind. As of July 1, 2016, Texas has 17,911 megawatts (MW) of installed wind generation capacity,[14] more than the next three states (Iowa, California, and Oklahoma) combined (17,480 MW). Texas' total net electrical generation from renewable wind generators for the first eight months in 2016 is estimated to be approximately 38.3 million megawatt-hours (MWh),[15] approximately 26% of the total wind net electrical generation for the U.S.

While EE/RE measures are beneficial and do result in lower overall emissions from fossil fuel-fired power plants in Texas, emission reductions resulting from these programs are not explicitly included in photochemical modeling for SIP purposes because local efficiency efforts may not result in local emissions reductions or may be offset by increased demand in electricity. The complex nature of the electrical grid makes accurately quantifying emission reductions from EE/RE measures difficult. At any given time, it is impossible to determine exactly where a specific user's electricity was produced. The electricity for users in a nonattainment area may not necessarily be

[14] U.S. Department of Energy, National Renewable Energy Laboratory, http://apps2.eere.energy.gov/wind/windexchange/wind_installed_capacity.asp

[15] U.S. Department of Energy, Energy Information Administration, Form EIA-923 data, http://www.eia.gov/electricity/data/eia923/

generated solely within that nonattainment area. For example, some of the electricity used within an ozone nonattainment area in East Texas could be generated by a power plant in a nearby attainment county or even in West Texas. If electrical demand is reduced in a nonattainment area due to local efficiency measures, the resulting emission reductions from power generation facilities may occur in any number of locations around the state. Similarly, increased RE generation may not necessarily replace electrical generation from local fossil fuel-fired power plants within a particular nonattainment area.

While specific emission reductions from EE/RE measures are not provided in the SIP, persons interested in estimates of energy savings and emission reductions from EE/RE measures can access additional information and reports from the Texas A&M Engineering Experiment Station's Energy Systems Laboratory website (http://esl.tamu.edu/). The reports submitted to the TCEQ regarding EE/RE measures are available under TERP Letters and Reports.

Finally, the Texas Legislature has enacted a number of EE/RE measures and programs. The following is a summary of Texas EE/RE legislation since 1999.

76th Texas Legislature, 1999

- Senate Bill (SB) 7
- House Bill (HB) 2492
- HB 2960

77th Texas Legislature, 2001

- SB 5
- HB 2277
- HB 2278
- HB 2845

78th Texas Legislature, 2003

- HB 1365 (Regular Session)

79th Texas Legislature, 2005

- SB 20 (First Called Session)
- HB 2129 (Regular Session)
- HB 2481 (Regular Session)

80th Texas Legislature, 2007

- SB 12
- HB 66
- HB 3070
- HB 3693

81st Texas Legislature, 2009

- None

82nd Texas Legislature, 2011

- SB 898 (Regular Session)
- SB 924 (Regular Session)
- SB 981 (Regular Session)
- SB 1125 (Regular Session)
- SB 1150 (Regular Session)
- HB 51 (Regular Session)
- HB 362 (Regular Session)

83rd Texas Legislature, 2013

- None

84th Texas Legislature, 2015

- SB 1626
- HB 1736

Renewable Energy

SB 5, 77th Texas Legislature, 2001, set goals for political subdivisions in affected counties to implement measures to reduce energy consumption from existing facilities by 5% each year for five years from January 1, 2002 through January 1, 2006. In 2007, the 80th Texas Legislature passed SB 12, which extended the timeline set in SB 5 through 2007 and made the annual 5% reduction a goal instead of a requirement. The State Energy Conservation Office (SECO) is charged with tracking the implementation of SB 5 and SB 12. Also during the 77th Texas Legislature, the Energy Systems Laboratory (ESL), part of the Texas Engineering Experiment Station, Texas A&M University System, was mandated to provide an annual report on EE/RE efforts in the state as part of the TERP under Texas Health and Safety Code (THSC), §388.003(e).

The 79th Texas Legislature, 2005, Regular and First Called Sessions, amended SB 5 through SB 20, HB 2129, and HB 2481 to add, among other initiatives, renewable energy initiatives that require: 5,880 MW of generating capacity from renewable energy by 2015; the TCEQ to develop a methodology for calculating emission reductions from renewable energy initiatives and associated credits; the ESL to assist the TCEQ in quantifying emissions reductions from EE/RE programs; and the Public Utility Commission of Texas (PUCT) to establish a target of 10,000 MW of installed renewable technologies by 2025. Wind power producers in Texas exceeded the renewable energy generation target by installing over 10,000 MW of wind electric generating capacity by 2010.

HB 2129, 79th Texas Legislature, 2005, Regular Session, directed the ESL to collaborate with the TCEQ to develop a methodology for computing emission reductions attributable to use of RE and for the ESL to annually quantify such emission reductions. HB 2129 directed the Texas Environmental Research Consortium to use the

Texas Engineering Experiment Station to develop this methodology. With the TCEQ's guidance, the ESL produces an annual report, *Statewide Air Emissions Calculations from Energy Efficiency, Wind and Renewables*, detailing these efforts.

In addition to the programs discussed and analyzed in the ESL report, local governments may have enacted measures beyond what has been reported to SECO and the PUCT. The TCEQ encourages local political subdivisions to promote EE/RE measures in their respective communities and to ensure these measures are fully reported to SECO and the PUCT.

SB 981, 82nd Texas Legislature, 2011, Regular Session, allows a retail electric customer to contract with a third party to finance, install, or maintain a distributed renewable generation system on the customer's side of the electric meter, regardless of whether the customer owns the installed system. SB 981 also prohibits the PUCT from requiring registration of the system as an electric utility if the system is not projected to send power to the grid.

HB 362, 82nd Texas Legislature, 2011, Regular Session, helps property owners install solar energy devices such as electric generating solar panels by establishing requirements for property owners associations' approval of installation of solar energy devices. HB 362 specifies the conditions that property owners associations may and may not deny approval of installing solar energy devices.

SB 1626, 84th Texas Legislature, 2015, modifies the provisions established by HB 362 from the 82nd Texas Legislature, 2011, Regular Session, regarding property owners associations' authority to approve and deny installations of solar energy devices such as electric generating solar panels. HB 362 included an exception that allowed developers to prohibit installation of solar energy devices during the development period. SB 1626 limits the exception during the development period to developments with 50 or fewer units.

Residential and Commercial Building Codes and Programs

THSC, Chapter 388, Texas Building Energy Performance Standards, as adopted in SB 5 of the 77th Texas Legislature, 2001, Regular Session, states in §388.003(a) that single-family residential construction must meet the energy efficiency performance standards established in the energy efficiency chapter of the International Residential Code. The Furnace Pilot Light Program includes energy savings accomplished by retrofitting existing furnaces. Also included is a January 2006 federal mandate raising the minimum Seasonal Energy Efficiency Ratio SEER for air conditioners in single-family and multi-family buildings from 10 to 13.

THSC, Chapter 388, as adopted in SB 5 of the 77th Texas Legislature, 2001, states in §388.003(b) that non-single-family residential, commercial, and industrial construction must meet the energy efficiency performance standards established in the energy efficiency chapter of the International Energy Conservation Code.

HB 51, 82nd Legislature, 2011, Regular Session, requires municipalities to report implementation of residential and commercial building codes to SECO.

HB 1736, 84th Texas Legislature, 2015, updates THSC §388.003 to adopt, effective September 1, 2016, the energy efficiency chapter of the International Residential Code as it existed on May 1, 2015. HB 1736 also establishes a schedule by which SECO could adopt updated editions of the International Residential Code in the future, not more often than once every six years.

Federal Facility EE/RE Projects

Federal facilities are required to reduce energy use by Presidential Executive Order 13123 and the Energy Policy Act of 2005 (Public Law 109-58 EPACT20065). The Energy Systems Laboratory compiled energy reductions data for the federal EE/RE projects in Texas.

Political Subdivisions Projects

SECO funds loans for energy efficiency projects for state agencies, institutions of higher education, school districts, county hospitals, and local governments. Political subdivisions in nonattainment and affected counties are required by SB 5, 77th Texas Legislature, 2001, to report EE/RE projects to SECO. These projects are typically building systems retrofits, non-building lighting projects, and other mechanical and electrical systems retrofits such as municipal water and waste water treatment systems.

Electric Utility Sponsored Programs

Utilities are required by SB 7, 76th Texas Legislature, 1999, and SB 5, 77th Texas Legislature, 2001, to report demand-reducing energy efficiency projects to the PUCT (see THSC, §386.205 and Texas Utilities Code (TUC), §39.905). These projects are typically air conditioner replacements, ventilation duct tightening, and commercial and industrial equipment replacement.

SB 1125, 82nd Texas Legislature, 2011, Regular Session, amended the TUC, §39.905 to require energy efficiency goals to be at least 30% of annual growth beginning in 2013. The metric for the energy efficiency goal remains at 0.4% of peak summer demand when a utility program accrues that amount of energy efficiency. SB 1150, 82nd Texas Legislature, 2011, Regular Session, extended the energy efficiency goal requirements to utilities outside the Electric Reliability Council of Texas area.

State Energy Efficiency Programs

HB 3693, 80th Texas Legislature, 2007, amended the Texas Education Code, Texas Government Code, THSC, and TUC. The bill:

- requires state agencies, universities and local governments to adopt energy efficiency programs;
- provides additional incentives for electric utilities to expand energy conservation and efficiency programs;
- includes municipal-owned utilities and cooperatives in efficiency programs;
- increases incentives and provides consumer education to improve efficiency programs; and
- supports other programs such as revision of building codes and research into alternative technology and renewable energy.

HB 51, 82nd Texas Legislature, 2011, Regular Session, requires new state buildings and major renovations to be constructed to achieve certification under an approved high-performance design evaluation system.

HB 51 also requires, if practical, that certain new and renovated state-funded university buildings comply with approved high-performance building standards.

SB 898, 82nd Texas Legislature, 2011, Regular Session, extended the existing requirement for state agencies, state-funded universities, local governments, and school districts to adopt energy efficiency programs with a goal of reducing energy consumption by at least 5% per state fiscal year (FY) for 10 state FYs from September 1, 2011 through August 31, 2021.

SB 924, 82nd Texas Legislature, 2011, Regular Session, requires all municipally owned utilities and electric cooperatives that had retail sales of more than 500,000 MWh in 2005 to report each year to SECO information regarding the combined effects of the energy efficiency activities of the utility from the previous calendar year, including the utility's annual goals, programs enacted to achieve those goals, and any achieved energy demand or savings goals.

5.4.1.4 Consent Decrees with Refineries

The EPA's National Petroleum Refinery Initiative[16] has resulted in multi-issue settlement agreements with the nation's major petroleum refineries. As of October 2016, 112 refineries representing more than 95% of total domestic refining capacity are under settlement. The EPA consent decrees limit emissions from fluidized catalytic cracking units, sulfur recovery units, heaters and boilers, and flares. The EPA estimates that full implementation of the current settlements will result in more than 95,000 tpy of NO_X emission reductions. The EPA also anticipates VOC emission reductions will result from consent decree requirements that reduce hydrocarbon flaring including:

- installing continuous emissions monitoring systems (CEMS) or predictive emissions monitoring systems;
- operating a flare gas recovery system to control continuous or routine flaring;
- limiting flaring to only process upset gases, fuel gas released as a result of relief valve leakage, or gas released due to a malfunction; and
- eliminating the routes of generated fuel gases and monitoring the flare with CEMS or a flow meter.

Since approximately 14% of the nation’s petrochemical refining capacity is located in the HGB area, the commission expects the HGB area will benefit from the NO_X and VOC emission reductions required by these settlements.

5.4.1.5 Clean Air Interstate Rule (CAIR) and Cross-State Air Pollution Rule (CSAPR)

In March 2005, the EPA issued CAIR to address electric generating unit (EGU) emissions that transport from one state to another. The rule incorporated the use of three cap and trade programs to reduce sulfur dioxide (SO_2) and NO_X: the ozone-season NO_X

[16] https://www.epa.gov/enforcement/petroleum-refinery-national-case-results

trading program, the annual NO_X trading program, and the annual SO_2 trading program.

Texas was not included in the ozone season NO_X program but was included for the annual NO_X and SO_2 programs. As such, Texas was required to make necessary reductions in annual SO_2 and NO_X emissions from new and existing EGUs to demonstrate that emissions from Texas do not contribute to nonattainment or interfere with maintenance of the 1997 particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers ($PM_{2.5}$) NAAQS in another state. CAIR consisted of two phases for implementing necessary NO_X and SO_2 reductions. Phase I addressed required reductions from 2009 through 2014. Phase II was intended to address reductions in 2015 and thereafter.

In July 2006, the commission adopted a SIP revision to address how the state would meet emissions allowance allocation budgets for NO_X and SO_2 established by the EPA to meet the federal obligations under CAIR. The commission adopted a second CAIR-related SIP revision in February 2010. This revision incorporated various federal rule revisions that the EPA had promulgated since the TCEQ's initial submittal. It also incorporated revisions to 30 TAC Chapter 101 resulting from legislation during the 80th Texas Legislature, 2007.

A December 2008 court decision found flaws in CAIR but kept CAIR requirements in place temporarily while directing the EPA to issue a replacement rule. In July 2011, the EPA finalized CSAPR to meet Federal Clean Air Act (FCAA) requirements and respond to the court's order to issue a replacement program. Texas was included in CSAPR for ozone season NO_X, annual NO_X, and annual SO_2 due to the EPA's determination that Texas significantly contributes to nonattainment or interferes with maintenance of the 1997 eight-hour ozone NAAQS and the 1997 $PM_{2.5}$ NAAQS in other states. As a result of numerous EGU emission reduction strategies already in place in Texas, the annual and ozone season NO_X reduction requirements from CSAPR were relatively small but still significant. CSAPR required an approximate 7% reduction in annual NO_X emissions and less than 5% reduction in ozone season NO_X emissions.

On August 21, 2012, the U.S. Court of Appeals for the District of Columbia (D.C.) Circuit vacated CSAPR. Under the D.C. Circuit Court's ruling, CAIR remained in place until the EPA developed a valid replacement.

The EPA and various environmental groups petitioned the Supreme Court of the United States to review the D.C. Circuit Court's decision on CSAPR. On April 29, 2014, a decision by the Supreme Court reversed the D.C. Circuit and remanded the case. On October 23, 2014, the D.C. Circuit lifted the CSAPR stay and on November 21, 2014, the EPA issued rulemaking, which shifted the effective dates of the CSAPR requirements to account for the time that had passed after the rule was stayed in 2011. Phase 1 of CSAPR took effect January 1, 2015 and Phase 2 is scheduled to begin January 1, 2017. On July 28, 2015, the D.C. Circuit Court ruled that the 2014 annual SO_2 budgets and the 2014 ozone season NO_X budgets for Texas were invalid because they required over control of Texas emissions, and remanded these budgets back to the EPA without vacatur.

On January 22, 2015, the EPA issued a memorandum to provide information on how it intends to implement FCAA interstate transport requirements for the 2008 ozone NAAQS. The EPA provided preliminary modeling results for 2018, which show contribution to nonattainment of the 2008 ozone NAAQS in the HGB area from sources outside of Texas. On July 23, 2015, the EPA issued a notice of data availability regarding updated ozone transport modeling results for a 2017 attainment year.

On June 27, 2016, the EPA issued a memorandum outlining the agency's approach for responding to the D.C. Circuit's July 2015 remand of the Phase 2 SO_2 emissions budgets, providing a choice of two paths for states with remanded budgets. Under the first path, states can voluntarily continue to participate in CSAPR at the state's current Phase 2 SO_2 and annual NO_X budget levels through a SIP revision. Under the second path, if a state does not choose to participate in CSAPR, the EPA will initiate rulemaking by fall of 2016 to remove the state's sources from CSAPR's SO_2 and annual NO_X programs and address any remaining interstate transport or regional haze obligations on a state-by-state basis. On November 10, 2016, the EPA published a proposal to remove Texas sources from the CSAPR SO_2 and annual NO_X trading programs.

On September 7, 2016, the EPA signed the final CSAPR Update Rule for the 2008 eight-hour ozone standard. The EPA's modeling shows that emissions from within Texas no longer significantly contribute to downwind nonattainment or interference with maintenance for the 1997 eight-hour ozone NAAQS even without implementation of the original CSAPR ozone season NO_X emissions budget. Accordingly, sources in Texas will no longer be subject to the emissions budget calculated to address the 1997 eight-hour ozone NAAQS. However, this rule finalizes a new ozone season NO_X emissions budget for Texas to address interstate transport with respect to the 2008 eight-hour ozone NAAQS. This new budget will be effective for the 2017 ozone season, the same period in which the Phase 2 budget that was invalidated by the court was scheduled to become effective.

CSAPR budgets for Texas may be subject to change in the future based on any additional rulemaking to address remanded budgets or changes resulting from further appeals.

As discussed in Section 3.5.4: *2017 Future Case Emissions*, the TCEQ used the CSAPR Update Rule as the basis for allocating EGU emission caps in the 2017 future year.

5.4.1.6 Low Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program (LIRAP)

The LIRAP provisions of HB 2134, 77th Texas Legislature, 2001, established a financial assistance program to assist low-income individuals with repairs, retrofits, or retirement of vehicles that fail emissions inspections. Under the program, monetary assistance is provided for emission-related repairs directly related to bringing the vehicle into compliance or for replacement assistance for a vehicle that has failed the required emissions test. In 2005, HB 1611, 79th Texas Legislature, Regular Session, modified the program to apply only to counties that implement a vehicle inspection and maintenance program and have elected to implement LIRAP fee provisions. The counties currently participating in the LIRAP are Brazoria, Fort Bend, Galveston, Harris, Montgomery, Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, Travis, and Williamson Counties.

SB 12, 80th Texas Legislature, 2007, expanded the LIRAP participation criteria by increasing the income eligibility to 300% of the federal poverty rate, increasing the amount of assistance toward the replacement of a retired vehicle, and making assistance available for retirement of vehicles that are 10 years old or older. HB 3272, 82nd Texas Legislature, 2011, Regular Session, expanded the class of vehicles eligible for a $3,500 voucher to include hybrid, electric, natural gas, and federal Tier 2, Bin 3 or cleaner Bin certification vehicles. The program provides $3,500 for a replacement hybrid, electric, natural gas, and federal Tier 2, Bin 3 or cleaner Bin certification vehicle of the current model year or the previous three model years; $3,000 for cars of the current or three model years; and $3,000 for trucks of the current or previous two model years. The retired vehicle must be 10 years old or older or must have failed an emissions test. From December 12, 2007 through August 31, 2016, the program has retired and replaced 57,474 vehicles at a cost of $172,653,812.80. During the same period, an additional 40,895 vehicles have had emissions-related repairs at a cost of $21,704,431.69. The total retirement/replacement and repair expenditure from December 12, 2007 through August 31, 2016 is $194,358,244.49.

In the HGB nonattainment area, the LIRAP is currently available to vehicle owners in five counties: Brazoria, Fort Bend, Galveston, Harris, and Montgomery. Between December 12, 2007 and August 31, 2016, the program has repaired 19,690 vehicles and retired and replaced 23,800 vehicles at a cost of $82,457,502.25.[17] HB 1, General Appropriations Bill, 84th Texas Legislature, 2015, appropriated $43.5 million per year for FY 2016 and FY 2017 to continue this clean air strategy in the five participating counties. Participating HGB area counties were allocated approximately $20.1 million per year for the LIRAP for FYs 2016 and 2017. This is an increase of approximately $17.5 million per year over the previous biennium.

5.4.1.7 Local Initiative Projects (LIP)

SB 12, 80th Texas Legislature, 2007, created the LIP program to provide funds to counties participating in the LIRAP for implementation of air quality improvement strategies through local projects and initiatives. In the HGB area, LIP program funding is available to the five counties currently participating in the LIRAP: Brazoria, Fort Bend, Galveston, Harris, and Montgomery. HB 1, General Appropriations Bill, 84th Texas Legislature, 2015, appropriated $4.8 million per year for FY 2016 and FY 2017 to continue this clean air strategy. The five HGB area counties were allocated approximately $2.2 million per year for FYs 2016 and 2017. This is an increase of approximately $1.9 million per year over the previous biennium.

Harris County used LIP funds in 2010 to establish the Harris County Clean Air Emissions Task Force and initiate an emissions enforcement program. The task force's initial objective in its first five years was to reduce the number of fraudulent, fictitious, or improperly issued safety and emissions inspection windshield certificates. During

[17] The LIRAP program statistics included in the proposal were inadvertently substituted with data from the DFW program area and were incorrect. These statistics were corrected for adoption and updated based on the most recent data available.

this time, the On-Road Enforcement Program portion of the task force targeted high-emitting vehicles, smoking vehicles, and suspicious vehicles to verify that the state safety and emissions inspection windshield certificates on those vehicles were legitimate and in compliance with air quality standards. Beginning in March 2015, in accordance with the provisions of HB 2305, 83rd Texas Legislature, 2013, Regular Session, the program adjusted its objectives to concentrate on the identification of vehicles with counterfeit registration insignia and the reduction of fraudulent vehicle inspection reports. This program partners with local and state agencies to enforce state laws, codes, rules, and regulations regarding air quality and mobile emissions in Harris County. The citizens of the entire southeast Texas region benefit from this program as a result of the reduction in NO_X emissions from each vehicle brought into emissions compliance.

Brazoria, Fort Bend, Galveston, and Harris Counties used LIP funding to enhance the regional transportation system by expanding their bus transit networks. Fort Bend County used LIP funds to purchase buses and initiate a new park-and-ride transit service in 2010. LIP program funding continues to support the park-and-ride program as of 2016. Fort Bend County's service links county residents with the Texas Medical Center area to create immediate and long-term benefits for reducing emissions and congestion by supporting approximately 9,500 commuter trips per month. Brazoria and Galveston Counties used LIP funds to expand their existing bus transit networks by establishing Saturday transit service in 2013. This transportation option provides residents along fixed-routes in Brazoria and Galveston Counties with access to jobs, services, and amenities on Saturdays. Air quality benefits are provided by removing older cars from the roads, reducing the number of single-occupancy vehicles, reducing overall vehicle miles traveled, and reducing short trips by car. LIP program funding continues to support both counties' programs as of 2016. Harris County used LIP funds in 2016 to support establishment and operation of a new evening and weekend service route of the Greenlink Circulator, a transit service operating within downtown Houston since 2012. The project provides a fare-free transportation alternative in the most congested part of the region. The service benefits the entire region through its positive impact on mobility, air quality, and congestion.

Montgomery County used LIP funds for signal light synchronization projects in 2010, 2012, and 2014. Synchronizing traffic signalization reduces idling by decreasing the number of times a vehicle must stop at a traffic light. The "exhaust phase" of an engine emits the most emissions during starting, idling, and breaking stationary inertia. Synchronizing traffic signalization reduces both idling and the number of times a vehicle must resume travel, i.e., break stationary inertia. In 2015 and 2016, the county used LIP funds to further upgrade its traffic signal network by installing advanced radar-based vehicle detection equipment to create an open architecture adaptive traffic network that reduces vehicle emissions by decreasing traffic congestion. The project increases the emissions reduction benefits by continuously optimizing real-time traffic flow to better manage peak-hour congestion, while minimizing cross-traffic congestion, and reducing emissions.

5.4.1.8 Texas Emissions Reduction Plan (TERP)

The TERP program was created in 2001 by the 77th Texas Legislature to provide grants to offset the incremental costs associated with reducing NO_X emissions from high-emitting heavy-duty internal combustion engines on heavy-duty vehicles, non-road equipment, marine vessels, locomotives, and some stationary equipment.

The primary emissions reduction incentives are awarded under the Diesel Emissions Reduction Incentive Program (DERI). DERI incentives are awarded to projects to replace, repower, or retrofit eligible vehicles and equipment to achieve NO_X emission reductions in Texas ozone nonattainment areas and other counties identified as affected counties under the TERP program where ground-level ozone is a concern.

From 2001 through August 2016, $1,013,259,223 in DERI grants were awarded for projects projected to help reduce 171,945 tons of NO_X. Over $423.6 million in DERI grants were awarded to projects in the HGB area, with a projected 75,739 tons of NO_X reduced. These projects are estimated to reduce up to 14.1 tons per day (tpd) of NO_X in the HGB area in 2017. This estimate will change yearly as older projects reach the end of the project life and new projects begin achieving emissions reductions. Also, of the $423.6 million awarded in the HGB area, $4.14 million were awarded by H-GAC through third-party grants to administer sub-grants in the HGB area. H-GAC has used this funding to target the replacement of drayage trucks operating in and from the Port of Houston with newer models with lower emission ratings. An additional $51 million is available to be awarded from the DERI program through August 2017.

Three other incentive programs under the TERP program will result in the reduction in NO_X emissions in the HGB area.

The Drayage Truck Incentive Program (DTIP) was established in 2013 to provide grants for the replacement of drayage trucks operating in and from seaports and rail yards located in nonattainment areas. Through August 2016, the program awarded grants to 9 projects with a combined 47 replacement activities totaling $3.95 million, with a projected 233 tons of NO_X reduced. Eight of the projects, 37 replacement activities, were in the HGB area and totaled $3.45 million. These projects are projected to reduce up to 208 tons of NO_X, representing approximately 0.17 tpd of NO_X reduced in 2017. An additional $4.7 million is available to be awarded from the DTIP through August 2017.

The Texas Clean Fleet Program (TCFP) was established in 2009 to provide grants for the replacement of light-duty and heavy-duty diesel vehicles with vehicles powered by alternative fuels, including: natural gas, liquefied petroleum gas, hydrogen, methanol (85% by volume), or electricity. This program is for larger fleets, therefore applicants must commit to replacing at least 20 eligible diesel-powered vehicles with qualifying alternative fuel or hybrid vehicles. From 2009 through August 2016, over $38.8 million in TCFP grants were awarded for projects to help reduce a projected 498 tons of NO_X. Over $14 million in TCFP grants were awarded to projects in the HGB area, with a projected 146 tons of NO_X reduced. These projects are estimated to reduce up to 0.32 tpd of NO_X in the HGB area in FY 2017. An additional $8.2 million is available to be awarded from the TCFP through August 2017.

The Texas Natural Gas Vehicle Grant Program (TNGVGP) was established in 2011 to provide grants for the replacement of medium-duty and heavy-duty diesel vehicles with vehicles powered by natural gas. This program may include grants for individual vehicles or multiple vehicles. The majority of the vehicle's operation must occur in the Texas nonattainment areas, other counties designated as affected counties under the

TERP, and the counties in and between the triangular area between Houston, San Antonio, and DFW. From 2011 through August 2016, over $44 million in TNGVGP grants were awarded for projects to help reduce a projected 1,573 tons of NO_x. Over $12.1 million in TNGVGP grants were awarded to projects in the HGB area, with a projected 339 tons of NO_x reduced. These projects are estimated to reduce up to 0.32 tpd of NO_x in the HGB area in 2017. An additional $35.9 million is available to be awarded from the TNGVGP through August 2017.

5.4.1.9 Clean School Bus Program

HB 3469, 79th Texas Legislature, 2005, Regular Session, established the Clean School Bus Program, which provides monetary incentives for school districts in the state for reducing emissions of diesel exhaust from school buses. As of August 2016, the TCEQ Clean School Bus Program had reimbursed approximately $31.6 million in grants for over 7,400 school buses across the state, with $9.3 million being used for 2,688 school buses in the HGB area. An additional $5.9 million is available to be awarded from the Clean School Bus Program through August 2017.

5.4.1.10 Local Initiatives

Local strategies in the HGB nonattainment area are being implemented by H-GAC in the eight-county HGB area. Due to the continued progress of these measures, additional air quality benefits are expected to be gained that will further reduce precursors to ground level ozone formation. Because of the limited time to develop this HGB AD SIP revision, a description of these local measures was not included in this SIP revision, but may be included in future SIP revisions. Information on local measures is available on the Houston-Galveston Area Council website (http://www.h-gac.com/home/residents.aspx).

5.5 CONCLUSIONS

The TCEQ has used several techniques and various types of data to evaluate the past and present causes of high ozone in the HGB nonattainment area. Historical trends in ozone and ozone precursor concentrations and their causes have been investigated extensively. Photochemical grid modeling performance has been evaluated, and the 2012 ozone episode has been used to match the times of year when the highest ozone levels have historically been measured in the HGB nonattainment area. The following conclusions can be reached from these evaluations.

The one-hour and the eight-hour ozone design values have overall decreasing trends over the past 12 years. The HGB area has monitored attainment of the revoked one-hour ozone standard since 2013. The eight-hour design value was 79 ppb for the 2016 ozone season, which is in attainment of the 1997 eight-hour ozone standard of 84 ppb. In 2016, only three of the 21 HGB area regulatory ozone monitors in the HGB area had eight-hour ozone design values greater than the 2008 ozone NAAQS of 75 ppb. Of the 18 monitors in the HGB area that recorded eight-hour ozone design values in 2005 and 2016, 16 monitors observed a 15% or greater decrease in eight-hour ozone design values during this time span, with 10 monitors observing over a 20 ppb decrease in design values during this time. The majority of these decreases occur prior to 2009. After 2009, the ozone design value trend was less noticeable; however, 2014 through 2016 shows a downward pattern. Ozone adjusted for meteorological conditions also showed similar trends: a large drop in ozone concentration occurred between 2006 and 2007.

Ambient NO_X and VOC monitoring data match the trends observed in ozone, with decreases in both ambient NO_X and VOC concentrations observed in the HGB nonattainment area over the past 10 years. Similar to the ozone trends, the majority of the NO_X and VOC trends appear to occur prior to 2009. Many monitors observed a flat trend in both NO_X and VOC after 2009. This provides evidence that continued and additional reductions in NO_X and VOC can lead to substantial reductions in ozone concentrations.

Studies of VOC- and NO_X-sensitivity have shown that the HGB area is trending toward more NO_X-limited conditions. Data show that ozone is formed more efficiently in VOC-limited conditions, so this trend towards NO_X-limited conditions may be a reason why the HGB area has seen less ozone formation in recent years. Decreasing NO_X concentrations mean that the HGB area cannot remain in VOC-limited conditions for as long, which in turn leads to less ozone formation. The reduction in the strength of ozone gradients may be evidence of the decrease in VOC reactivity and slowing of ozone formation rates in the HGB area.

On average, the ozone produced outside of the HGB nonattainment area, in addition to the natural background ozone, accounts for a large portion of the maximum ozone concentrations within the HGB nonattainment area. Analyses discussed in Section 5.3 *Studies of Ozone Formation, Accumulation, Background, and Transport Related to the HGB Area* suggest that background ozone is trending downward across the U.S., which may be another reason, in addition to local reductions in NO_X and VOC, that ozone has been decreasing in the HGB area. Other studies showed that weather conditions one or two days after a frontal passage were often well suited to high local ozone production in the HGB area. High ozone days in the HGB area are also associated with weak northerly and easterly winds while low ozone days are associated with brisk flow from the Gulf of Mexico. These transport patterns linked with high ozone days cannot determine whether the high ozone is due to higher incoming background or higher local ozone productions because these conditions frequently occur at the same time. Typically, both background ozone and local ozone production is higher when transport is from the continent rather than the Gulf of Mexico, when northerly winds interact with sea breeze and Coriolis oscillations to create stagnant conditions, and when high pressure brings dry, sunny conditions and a stable atmosphere. Ozone-conducive patterns appear to occur more often in spring, late summer, and early autumn, and do not usually occur in mid-summer.

As documented in Chapter 3 and Appendix C: *Photochemical Modeling for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard*, the photochemical grid modeling performed well, with one weakness being an overproduction of ozone primarily during nighttime hours and days when lower ozone concentrations were measured. Problems observed with the base case ozone modeling are known to exist in most photochemical modeling exercises, particularly when an ozone season is modeled rather than short time periods of just one or two weeks. The model can be used with confidence to predict future ozone design values because the EPA's draft modeling guidance document recommends applying the relative response in modeled ozone to monitored design values. Application of the EPA recommended top 10 days attainment test predicts a 79 ppb future design value at the Manvel Croix Park (C84) monitor. This HGB AD SIP revision documents a fully-evaluated, high-quality modeling analysis with future year design values for one monitor above and 19 monitors below the 75 ppb 2008 eight-hour ozone standard for the HGB ozone nonattainment area. This HGB AD SIP revision meets the requirements to demonstrate attainment of the 2008 ozone NAAQS through photochemical modeling and corroborative analysis.

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CHAPTER 6: ONGOING AND FUTURE INITIATIVES

6.1 INTRODUCTION

The Texas Commission on Environmental Quality (TCEQ) is committed to maintaining healthy air quality in the Houston-Galveston-Brazoria (HGB) area and continues to work toward this goal. Texas is investing resources into technological research and development for advancing pollution control technology, refining quantification of emissions, and improving the science for ozone modeling and analysis. Refining emissions quantification helps improve understanding of ozone formation, which benefits the state implementation plan (SIP). Additionally, the TCEQ is working with the United States Environmental Protection Agency (EPA), local area leaders, and the scientific community to evaluate new measures for addressing ozone precursors. This chapter describes ongoing technical work that will be beneficial to improving air quality in Texas and the HGB ozone nonattainment area.

6.2 ONGOING AND RECENT WORK

6.2.1 EPA Oil and Gas Emission Estimation Tool

Under EPA Contract EP-D-11-006, Work Assignment (WA) 2-05, Eastern Research Group, Inc. (ERG) has developed a Microsoft Access-based tool that may be used by the EPA, states, and local agencies to develop state- or region-specific non-point (area source) emission inventories for the upstream oil and gas sector based on EPA-supplied default data or user-supplied activity and emissions inputs. The tool has been published and is currently being reviewed for potential updates by the Oil and Gas National Committee, a collection of representatives from national, state, and local environmental agencies. As part of the Oil and Gas National Committee, the TCEQ has provided feedback on the calculation methodologies used by the tool as well as provided Texas-specific emission factors, activity data, and research for several source categories. The TCEQ also identified some source categories where additional research should be done to try to improve the equipment profiles and activity data. For specific examples of these improvements, see Sections 6.2.2: *Oil and Gas Well Drilling Activities* and 6.2.3: *New Source Performance Standards Subpart OOOO* below.

6.2.2 Oil and Gas Well Drilling Activities

There has been a large fluctuation in drilling activity in certain regions of Texas over the past 10 years. As a result, the TCEQ has made significant investments to improve emissions inventory (EI) estimates related to drilling activities. For example, emissions from mud degassing and hydraulic pump engines are a relatively new category of emissions that the TCEQ has begun to report to the National Emissions Inventory. The TCEQ used the EPA Oil and Gas Emission Estimation Tool to develop the 2011 emissions. Also, ERG completed a study in August 2014 through a contract with the TCEQ to improve the emission factors and activity data for these two categories with Texas basin-specific data. The updated factors and activity data are incorporated in this HGB attainment demonstration (AD) SIP revision and the associated HGB reasonable further progress (RFP) SIP revision.

6.2.3 New Source Performance Standards Subpart OOOO

The New Source Performance Standards (NSPS) in 40 Code of Federal Regulations, Part 60, Subpart OOOO require companies to reduce VOC emissions from newly constructed or modified oil and gas sources that were not previously regulated at the national level. The rule includes requirements to control emissions from unconventional natural gas well completions, oil and condensate storage tanks, and pneumatic devices, along with other sources. Many of the control requirements had a compliance date in 2012, although some sources had a compliance date in 2015. ERG completed a study in August 2014 through a contract with the TCEQ to evaluate how the NSPS Subpart OOOO rules will affect area source oil and gas emissions estimates. The updated factors and activity data are incorporated in this HGB AD SIP revision and the associated RFP SIP revision.

6.2.4 Other Emissions Inventory Improvement Projects

The TCEQ EI reflects years of emissions data improvement, including extensive point and area source inventory reconciliation with ambient emissions monitoring data. Other reports detailing recent TCEQ EI improvement projects can be found at the TCEQ's Air Quality Research and Contract Projects Web page (https://www.tceq.texas.gov/airquality/airmod/project/pj.html).

6.2.5 Air Quality Research Program

The specific goal of the State of Texas Air Quality Research Program (AQRP) is to support scientific research related to Texas air quality in the areas of emissions inventory development, atmospheric chemistry, meteorology, and air quality modeling. Research topics are identified and prioritized by an Independent Technical Advisory Committee (ITAC). Projects to be funded by the AQRP are selected from the list of ITAC recommended projects by the TCEQ and an Advisory Council.

The Texas AQRP is administered by the University of Texas at Austin, and is funded by the TCEQ through the Texas Emission Reduction Plan (TERP) Program. TERP funds emissions reduction projects in communities throughout Texas. To help ensure that air quality strategies in Texas are as effective as possible in understanding and improving air quality, a portion of the TERP funding is used to improve our scientific understanding of how emissions impact air quality in Texas.

More information on the strategic research plan of the AQRP, lists of the current members of the ITAC and Council, and reports from completed projects can be found at the AQRP Web page (http://aqrp.ceer.utexas.edu/).

Appendices Available Upon Request

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RESPONSE TO COMMENTS RECEIVED CONCERNING THE HOUSTON-GALVESTON-BRAZORIA (HGB) ATTAINMENT DEMONSTRATION (AD) STATE IMPLEMENTATION PLAN (SIP) REVISION FOR THE 2008 EIGHT-HOUR OZONE STANDARD

The Texas Commission on Environmental Quality (commission or TCEQ) conducted a public hearing in Houston on October 24, 2016, at 2:00 p.m. During the comment period, which closed on October 24, 2016, the commission received comments from Air Alliance Houston (Air Alliance).

Comments more directly related to the concurrent rulemaking in 30 Texas Administrative Code (TAC) Chapter 115 Volatile Organic Compounds (VOC) Reasonably Available Control Technology (RACT) Rule Revisions (Rule Project No. 2016-039-115-AI), which are incorporated by reference into this HGB AD SIP revision, are responded to in the Response to Comments section of the rulemaking preamble.

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GENERAL COMMENTS

General Support

Air Alliance thanked TCEQ staff for their work on the SIP revision, and expressed appreciation for the opportunity for public input.

The TCEQ appreciates the support and encourages public participation in the SIP development process.

Air Quality Concerns

Air Alliance commented that the HGB area is not meeting a number of ozone standards including the current ozone standard. Air Alliance further commented that while good strides have been made in Houston over the decades, there is still a long way to go.

The TCEQ agrees that progress has been made in the HGB area as shown by decreases in both eight-hour and one-hour ozone design values over the past 27

years. The HGB area is meeting both the one-hour ozone National Ambient Air Quality Standard (NAAQS) and the 1997 eight-hour ozone NAAQS, and the United States Environmental Protection Agency (EPA) has approved redesignation substitutes for the HGB area for both standards.

The HGB area eight-hour ozone design value has decreased 34% from 1991 through 2016 and 23% from 2005 through 2016. In 2016, only three of the 21 regulatory ozone monitors in the HGB area had eight-hour ozone design values greater than the 2008 ozone NAAQS of 75 parts per billion (ppb). Of the 18 monitors in the HGB area that recorded eight-hour ozone design values in both 2005 and 2016, 16 monitors observed a 15% or greater decrease in eight-hour ozone design values during this time span, with 10 monitors observing over a 20 ppb decrease in design values during this time. The ozone design value in 2017 for the HGB nonattainment area is projected to be 75 ppb at all sites except the Manvel Croix Park monitor site (79 ppb) using draft modeling guidance released by the EPA in December 2014. Note that 2016 values are as of October 19, 2016 and are subject to change.

The TCEQ is committed to developing and applying the best science and technology towards addressing and reducing ozone formation as required in the HGB and other ozone nonattainment areas in Texas. The TCEQ continues to use new technology and investigate possible emission reduction strategies and other practical methods to address the ozone NAAQS. No changes were made in response to this comment.

<u>Health Effects</u>

Air Alliance commented that the ambient ozone pollution in Houston is related to a variety of public health impacts including elevated asthma rates, cardiac arrest, respiratory illness exacerbation, chronic obstructive pulmonary disease (COPD), and premature death.

The TCEQ takes the health and concerns of Texans seriously and, through regulatory and voluntary efforts with area industry, communities, and individuals, concentrations of ozone and ozone precursors have steadily decreased in Texas and in the Greater Houston area over the last 12 years. Specifically, between 2005 and 2016, the eight-hour ozone design value in the HGB area has decreased 23% and the HGB area is measuring attainment of both the one-hour ozone NAAQS and the 1997 eight-hour ozone NAAQS.

The TCEQ does not agree that ambient ozone concentrations, particularly at the levels monitored in the HGB area, cause increased asthma rates, cardiac arrest, respiratory illness exacerbation, COPD, or premature death because the data do not consistently support these claims. Clinical studies have shown only a range of mild, reversible respiratory effects in people that were exposed to between 60 ppb and 120 ppb ozone (representative of ambient concentrations) for up to eight hours

while exercising vigorously (Adams 2006[1], Schelegle et al. 2009[2]). Basic toxicological principles indicate that concentrations of ozone (or any other chemical) that only cause a mild, reversible effect cannot also increase the incidence of more severe effects, like COPD or all causes of death. More specific discussion of the TCEQ's evaluation of health effect data is available in official comments[3] to the EPA on the Proposed Rule for Ozone, Policy Assessment for Ozone and Related Photochemical Oxidants, Health Risk and Exposure Assessment (HREA) for Ozone and Related Photochemical Oxidants, and the three external reviews for the Draft Integrated Science Assessment for Ozone and Related Photochemical Oxidants. No changes were made in response to these comments.

TCEQ Opposition to Ozone Standards

Air Alliance commented that the TCEQ and the State of Texas have been fairly critical of ozone science and the work of the federal government and the EPA in particular. Air Alliance further commented that there have been a lot of resources put into fighting the federal government over ozone standards, suing over ozone standards, and commissioning studies to support scientific conclusions contrary to EPA and other scientists around the country. Air Alliance expressed concern over the TCEQ's use of resources in evaluating and disagreeing with the ozone standards and science.

The current SIP revision relates to the attainment demonstration for the 2008 eight-hour ozone NAAQS for the HGB area. Comments regarding the commission's scientific research and review efforts and litigation activities relating to EPA review of the ozone NAAQS are outside the scope of this SIP revision.

However, the TCEQ agrees with the EPA that the NAAQS should protect public health. As noted in the previous response, the TCEQ has invested staff resources and state-allocated funds in the analysis of ozone health effect data in an effort to provide a scientific peer review of this important ambient air chemical that has many far-reaching regulatory implications. The TCEQ's efforts in analysis of the ozone literature is consistent with its mission to protect our state's public health and natural resources consistent with sustainable economic development and with professional obligations as scientists in a common field. The results of the TCEQ's work, including scientific publications and official comments to the EPA, have filled in some gaps in the EPA's analysis that are important to understanding the health effects of ozone. The TCEQ looks forward to additional collegial work with the EPA, ozone scientists, and public health experts to ensure regulatory standards are necessary and provide meaningful protection to Texans. It is the responsibility and legal duty of every state (and indeed, every interested person) to carefully review and fully participate in the review and development of any NAAQS, including participation in legal review of such standards. The TCEQ has done so on behalf of

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[1] Adams, WC. 2006. "Comparison of chamber 6.6-h exposures to 0.04-0.08 ppm ozone via square-wave and triangular profiles on pulmonary responses." *Inhal Toxicol* 18(2):127-136.

[2] Schelegle, ES; Morales, CA; Walby, WF; Marion, S; Allen, RP. 2009. "6.6-Hour inhalation of ozone concentrations from 60 to 87 parts per billion in healthy humans." *Am J Respir Crit Care Med* 180(3):265-272.

[3] http://www.tceq.com/assets/public/implementation/tox/hrea.pdf

the State of Texas by providing extensive comments to the EPA during the NAAQS review process. No changes were made in response to this comment.

REASONABLY AVAILABLE CONTROL TECHNOLOGY (RACT)

Control Techniques Guidelines (CTG)

Air Alliance encouraged the TCEQ to evaluate the recent CTG issued by the EPA for tanks, when appropriate, and indicated that there are always newer reviews of technologies and guidelines being put out by the federal government.

The TCEQ acknowledges that the EPA recently issued a new CTG for the Oil and Natural Gas Industry (EPA-453/B-16-001, October 2016). However, addressing the 2016 CTG document for oil and natural gas sources is not required as part of this HGB AD SIP revision and therefore the commission is not including a corresponding RACT analysis for this particular CTG document. As with previous CTG documents issued by the EPA, the commission will review the EPA's 2016 CTG for the Oil and Natural Gas Industry and determine RACT for the emission source categories addressed by the document in accordance with Federal Clean Air Act requirements and EPA guidance regarding RACT. No changes were made in response to this comment.

Continuous Monitoring

Air Alliance commented that compliance with the efficiency requirements for the measures in this SIP revision and in the SIP generally is best determined with continuous direct monitoring. Air Alliance further commented that continuous emission monitors should be used at particular types of operations, including flares, because these are the best means of determining compliance with emission rates.

The TCEQ agrees that continuous monitoring of emissions and of certain operating parameters serves to sufficiently demonstrate compliance with established emission specifications, where continuous monitoring requirements have been established in the 30 TAC Chapter 115 VOC regulations and Chapter 117 nitrogen oxides (NO_x) regulations. For example, the Highly-Reactive Volatile Organic Compounds (HRVOC) rules in 30 TAC Chapter 115 include rule provisions specific to flares requiring continuous monitoring of certain, specified parameters of the gas stream flow to the flare. For other 30 TAC Chapter 115 VOC and Chapter 117 NO_x regulations, existing provisions also require continuous monitoring of certain parameters to ensure proper functioning of control devices to adequately demonstrate compliance with applicable emission specifications.

While the TCEQ agrees that a continuous emission monitoring system (CEMS) can be effective for demonstrating compliance with emission rates, the TCEQ is not adopting the use of a CEMS for determining compliance with the emission rates of a flare, as suggested by the commenter. The use of traditional CEMS on a combustion source would be a post-combustion monitoring method. However, there are significant technical challenges and costs associated with such continuous direct measurement of pollutant concentration on flares. As noted regarding the HRVOC rules in 30 TAC Chapter 115, the TCEQ has required continuous monitoring on

certain gas streams sent to flares as a part of the HRVOC reasonably available control measure strategy for the HGB area. However, the TCEQ does not consider use of such monitoring on flares necessary for satisfying RACT requirements for the concurrent rulemaking (Rule Project No. 2016-039-115-AI).

The controls being adopted as part of this HGB AD SIP revision address RACT for VOC storage tanks in the HGB area for consistency with the previously-adopted RACT-requirements for VOC storage tanks in the Dallas Fort-Worth area (Rule Project No. 2013-039-115-AI). Furthermore, the existing VOC storage tank monitoring requirements section associated with the concurrent rulemaking currently contain continuous monitoring provisions which are adequate for ensuring compliance with the control requirements. No changes were made in response to this comment.

<u>Leak Detection and Repair (LDAR)</u>

Air Alliance commented that continuous monitoring LDAR programs also are good programs for determining compliance for tank farms and other fugitive emission points.

The TCEQ agrees that many of the TCEQ 30 TAC Chapter 115 VOC rules contain continuous monitoring and LDAR programs that are sufficient to demonstrate continuous compliance with the applicable control requirements. The TCEQ has LDAR regulations in place for certain fugitive emission sources at natural gas processing plants, refineries, and certain petrochemical plants in 30 TAC Chapter 115, Subchapter D, Division 3. Although there is not an existing LDAR program applicable to tank farms, the concurrent 30 TAC Chapter 115 VOC storage rulemaking (Rule Project No. 2016-039-115-AI) extends LDAR-type requirements to upstream oil and condensate tank batteries, including visual, audio, and olfactory inspection of closure devices, gaskets, and vapor sealing surfaces not connected to a vapor control device. No changes were made in response to this comment.

EMISSIONS FACTORS

Air Alliance encouraged the TCEQ to pay attention to recent EPA updates to VOC emissions factors, particularly in the refinery, chemical, and oil and gas sectors.

The TCEQ reviews EPA updates to emissions factors and emissions factor-related guidance as notice is received. As appropriate, the TCEQ may either provide official comments on the emissions factors if the EPA solicits comment (e.g., flare emissions factors) and/or issue guidance on the proper use of updated emissions factors.

The TCEQ also has performed state-of-the-science studies to identify and quantify emissions sources. These studies result in refined emissions factors, activity data, or emissions determination methods that are incorporated directly into the development of the appropriate inventory source category.

The above efforts ensure the best possible inventory data is used for control strategy and SIP development. No changes were made in response to this comment.

ENFORCEMENT

Air Alliance commented that more investigation and enforcement activities in the Houston region aimed at emissions of ozone precursors would lead to pollution reductions. Air Alliance further commented that fines create economic disincentives to pollute and favored its use in the investigation and enforcement process.

The TCEQ utilizes emissions events and maintenance activity records, reconnaissance, scheduled and unscheduled compliance investigations, and an established enforcement process to address unauthorized emissions of pollutants, including ozone precursors. The compliance investigation and enforcement process has been developed and implemented in accordance with applicable state and federal rules. The TCEQ enforces federal regulations under its EPA-delegated authority.

The following table shows the total assessed penalties for effective administrative orders with air violations for the last five fiscal years in the HGB eight-county area. No changes were made in response to this comment.

Fiscal Year	Number of Air Quality Effective Orders	Assessed Amount
2012	108	$3,425,212
2013	77	$2,165,912
2014	67	$1,550,778
2015	102	$2,943,953
2016	89	$3,512,450
Total	443	$13,598,305

TEXAS EMISSIONS REDUCTION PLAN (TERP)

Air Alliance commented on issues regarding the TERP including the desire to see full funding of the TERP. Air Alliance also expressed opposition to using the TERP for transportation projects, such as road building. Air Alliance stated the desire to hear about any recommendations that the TCEQ has for how the TERP can be better utilized, and expressed the hope that those recommendations would be passed on to the Texas Legislature.

The TCEQ appreciates the continued support for the TERP. Any changes to the TERP statutes and TERP funding are outside the scope of this SIP revision. Decisions on TERP funding levels and the TERP statutory provisions are made by the Texas Legislature. When requested, the commission provides input to the Texas Legislature regarding TERP funding and possible program changes. No changes were made in response to this comment.

ORDER ADOPTING AMENDED RULES AND REVISIONS TO THE STATE IMPLEMENTATION PLAN

Docket Nos. 2016-1243-SIP and 2016-0956-RUL
Project Nos. 2016-016-SIP-NR and 2016-039-115-AI

On December 15, 2016, the Texas Commission on Environmental Quality (Commission), during a public meeting, considered adoption of the Houston-Galveston-Brazoria (HGB) Area 2008 Eight-Hour Ozone National Ambient Air Quality Standard (NAAQS) Attainment Demonstration state implementation plan (SIP) revision; and amended §§115.112, 115.114, 115.118, and 115.119 in 30 Texas Administrative Code Chapter 115, Control of Air Pollution from Volatile Organic Compounds, Subchapter B, General Volatile Organic Compounds. The Commission adopts the HGB 2008 Eight-Hour Ozone NAAQS Attainment Demonstration SIP revision; the amended rules in 30 Texas Administrative Code Chapter 115; and corresponding revisions to the SIP. This SIP revision demonstrates attainment of the 2008 eight-hour ozone NAAQS based on a photochemical modeling analysis, a weight of evidence analysis, a reasonably availably control technology (RACT) analysis, a reasonably available control measures analysis, a motor vehicle emissions budget for 2017, and contingency plan. The Federal Clean Air Act (FCAA), §172(c)(1) requires that the SIP incorporate all reasonably available control measures, including RACT, for sources of relevant pollutants. For ozone nonattainment areas classified as moderate and above, FCAA, §182(b)(2) requires the state to submit a SIP revision that implements RACT for sources of volatile organic compounds (VOC) addressed in a control techniques guidelines (CTG) document and for all non-CTG major sources. The adopted Chapter 115, Subchapter B, Division 1 rule revisions would address RACT for both CTG and non-CTG major source VOC storage tanks in the HGB area. Under Tex. Health & Safety Code Ann. §§ 382.011, 382.012, and 382.023 (Vernon 2010), the Commission has the authority to control the quality of the state's air and to issue orders consistent with the policies and purposes of the Texas Clean Air Act, Chapter 382 of the Tex. Health & Safety Code. The proposed rules and notice of the proposed SIP revision were published for comment in the October 7, 2016, issue of the *Texas Register* (41 TexReg 7934 and 8125).

Pursuant to Tex. Health & Safety Code Ann. § 382.017 (Vernon 2010), Tex. Gov't Code Ann. Chapter 2001 (Vernon 2016), and 40 Code of Federal Regulations § 51.102, and after proper notice, the Commission conducted a public hearing to consider the amended rules and revisions to the SIP. Proper notice included prominent advertisement in the area affected at least 30 days prior to the date of the hearing. A public hearing was held in Houston on October 24, 2016.

The Commission circulated hearing notices of its intended action to the public, including interested persons, the Regional Administrator of the EPA, and all applicable local air pollution control agencies. The public was invited to submit data, views, and recommendations on the proposed amended rules and SIP revision, either orally or in writing, at the hearing or during the comment period. Prior to the scheduled hearing, copies of the proposed amended rules and SIP revision were available for public inspection at the Commission's central office and on the Commission's website.

Data, views, and recommendations of interested persons regarding the proposed amended rules and SIP revision were submitted to the Commission during the comment period, and were considered by the Commission as reflected in the analysis of testimony incorporated by reference to this Order. The Commission finds that the analysis of testimony includes the names of all interested groups or associations offering comment on the proposed amended rules and SIP revision and their position concerning the same.

IT IS THEREFORE ORDERED BY THE COMMISSION that the amended rules and revisions to the SIP incorporated by reference to this Order are hereby adopted. The Commission further authorizes staff to make any non-substantive revisions to the rules necessary to comply with *Texas Register* requirements. The adopted rules and the preamble to the adopted rules and the revisions to the SIP are incorporated by reference in this Order as if set forth at length verbatim in this Order.

IT IS FURTHER ORDERED BY THE COMMISSION that on behalf of the Commission, the Chairman should transmit a copy of this Order, together with the adopted rules and revisions to the SIP, to the Regional Administrator of EPA as a proposed revision to the Texas SIP pursuant to the FCAA, codified at 42 U.S. Code Ann. §§ 7401 - 7671q, as amended.

This Order constitutes the Order of the Commission required by Tex. Gov't Code Ann., Chapter 2001 (Vernon 2016).

If any portion of this Order is for any reason held to be invalid by a court of competent jurisdiction, the invalidity of any portion shall not affect the validity of the remaining portions.

TEXAS COMMISSION ON
ENVIRONMENTAL QUALITY

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Bryan W. Shaw, Ph.D., P.E., Chairman

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Date Signed