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

AGENDA REQUESTED: September 11, 2019

DATE OF REQUEST: August 23, 2019

INDIVIDUAL TO CONTACT REGARDING CHANGES TO THIS REQUEST, IF NEEDED: Jamie Zech, (512) 239-3498

CAPTION: Docket No. 2019-0692-SIP. Consideration for publication of, and hearing on, the proposed Houston-Galveston-Brazoria Serious Classification Attainment Demonstration State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone National Ambient Air Quality Standard.

To meet Federal Clean Air Act requirements, the proposed SIP revision would include a photochemical modeling analysis, a weight of evidence analysis, a reasonably available control technology analysis, a reasonably available control measures analysis, motor vehicle emissions budgets for 2020, and a contingency plan. (Alison Stokes, John Minter) (Rule Project No. 2019-077-SIP-NR)

Tonya Baer

Deputy Director

Donna F. Huff

Division Director

Jamie Zech

Agenda Coordinator

Copy to CCC Secretary? NO X YES

Texas Commission on Environmental Quality
Interoffice Memorandum

To: Commissioners **Date:** August 23, 2019

Thru: Bridget C. Bohac, Chief Clerk
Toby Baker, Executive Director

From: Tonya Baer, Deputy Director
Office of Air

Docket No.: 2019-0692-SIP

Subject: Commission Approval for Proposed Houston-Galveston-Brazoria (HGB) Serious Classification Attainment Demonstration (AD) State Implementation Plan (SIP) Revision for the 2008 Eight-Hour Ozone National Ambient Air Quality Standard (NAAQS)
HGB 2008 Eight-Hour Ozone Serious Classification AD SIP Revision
Rule Project No. 2019-077-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 NAAQS for ozone nonattainment areas designated with a classification of moderate or higher. The HGB area, consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, was previously classified as moderate nonattainment for the 2008 eight-hour ozone NAAQS of 0.075 parts per million (ppm) with a July 20, 2018 attainment date. Attainment of the standard is achieved when an area's design value does not exceed 75 parts per billion (ppb). Based on 2017 monitoring data, the HGB area did not attain the 2008 eight-hour ozone NAAQS in 2017[1] and did not qualify for a one-year attainment date extension in accordance with FCAA, §181(a)(5)[2]. On November 14, 2018, the United States Environmental Protection Agency (EPA) proposed to reclassify the HGB area to serious nonattainment for the 2008 eight-hour ozone NAAQS (83 *Federal Register* (FR) 56781). On August 7, 2019, the EPA signed the final reclassification notice.

Since the HGB area has been reclassified by the EPA, the area is now subject to the serious nonattainment area requirements in FCAA, §182(c) and the Texas Commission on Environmental Quality (TCEQ) is required to submit serious area AD and reasonable further progress (RFP) SIP revisions to the EPA. As indicated in the EPA's *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements; Final Rule* (2008 eight-hour ozone standard SIP requirements rule), published on March 6, 2015, the attainment date for a serious classification is July 20, 2021 with a 2020 attainment year (80 FR 12264). The EPA set an August 3, 2020 deadline

[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 eight-hour ozone NAAQS by its attainment date would be eligible for the first 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 parts per billion (ppb)); the HGB area's fourth highest daily maximum eight-hour average for 2017 was 79 ppb as measured at the Conroe Relocated (C78/A321) monitor. The HGB area's design value for 2017 was 81 ppb.

for states to submit AD and RFP SIP revisions to address the 2008 eight-hour ozone standard serious nonattainment area requirements.

Scope of the SIP revision:
As a result of the reclassification, the commission is required to submit to the EPA an AD SIP revision consistent with FCAA requirements for areas classified as serious nonattainment for the 2008 eight-hour ozone NAAQS. The attainment date for the HGB serious ozone nonattainment area is July 20, 2021 with an attainment year of 2020. This memo applies to the attainment demonstration requirement under a serious ozone nonattainment classification. The details of the RFP SIP revision, also required for the area, are covered in a separate memo (Project No. 2019-079-SIP-NR).

A.) Summary of what the SIP revision will do:
This proposed HGB AD SIP Revision would contain all FCAA-required AD SIP elements for an area with a serious nonattainment classification. This HGB AD SIP revision would meet the requirements to demonstrate attainment of the 2008 eight-hour ozone NAAQS through photochemical modeling and corroborative weight of evidence (WoE) analysis. This HGB AD SIP revision would also include an analysis of reasonably available control measures (RACM), including reasonably available control technology (RACT), and contingency measures that would provide additional emissions reductions that could be implemented without further rulemaking if the area fails to attain the standard by the attainment date. To ensure that federal transportation funding conforms to the SIP, this HGB AD SIP revision would also contain motor vehicle emissions budgets (MVEBs) for 2020.

B.) Scope required by federal regulations or state statutes:
This proposed HGB AD SIP revision would be consistent with the requirements of FCAA, §182(c)(1) and the EPA's 2008 eight-hour ozone standard SIP requirements rule. The FCAA-required SIP elements include analyses for RACT and RACM, an MVEB, and a contingency plan. Consistent with the EPA's November 2018 modeling guidance,[3] this proposed 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; TCAA, §382.011, which authorizes the commission to control the quality of the state's air; and TCAA, §382.012, which authorizes the commission to

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[3] EPA. *Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze.* November 29, 2018. https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf.

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:
None.

B.) Public:
The general public in the HGB ozone nonattainment area may benefit from the HGB area ultimately meeting the ozone NAAQS and the area being redesignated as attainment the 2008 eight-hour ozone NAAQS.

C.) Agency programs:
None.

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. An SET PMTC meeting was held on July 15, 2019. Agenda topics included the status of HGB photochemical modeling development for the HGB 2008 Eight-Hour Ozone Serious Classification AD SIP Revision.

If the proposed HGB AD SIP revision is approved by the commission for public comment and public hearing, then a formal public comment period would be opened, and a public hearing would be held.

Potential controversial concerns and legislative interest:
Although the EPA finalized its 2015 eight-hour ozone standard SIP requirements rule (83 FR 25776), the final rule did not revoke the 2008 eight-hour ozone standard and the EPA stated that revocation of the 2008 eight-hour ozone standard would be addressed in a separate future action. However, because of the February 16, 2018 United States Court of Appeals for the District of Columbia Circuit opinion in the case *South Coast Air Quality Management District v. EPA, 882 F.3d 1138 (D.C. Cir. 2018)*, the requirement for the EPA

to reclassify the area and for the TCEQ to submit this AD SIP revision is expected to remain even if the 2008 eight-hour ozone standard is revoked.

Will 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. However, if an AD SIP revision is not submitted to the EPA, the EPA could issue a finding of failure to submit, requiring that the TCEQ submit the required SIP revision within a specified time period, and imposing sanctions on the state. The EPA would be required to promulgate a Federal Implementation Plan (FIP) any time within two years after finding the TCEQ failed to make the required submission. Sanctions could include transportation funding restrictions, grant withholdings, and 2-to-1 emissions offsets 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.

Key points in the proposal SIP revision schedule:
Anticipated proposal date: September 11, 2019
Anticipated public hearing dates: October 14, 2019 (Houston)
Anticipated public comment period: September 13, 2019 through October 28, 2019
Anticipated adoption date: March 4, 2020

Agency contacts:
Alison Stokes, SIP Project Manager, Air Quality Division, (512) 239-4902
John Minter, Staff Attorney, (512) 239-3935
Jamie Zech, Agenda Coordinator, (512) 239-5017

cc: Chief Clerk, 2 copies
Executive Director's Office
Jim Rizk
Martha Landwehr
Office of General Counsel
Alison Stokes
Jamie Zech

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 SERIOUS CLASSIFICATION ATTAINMENT DEMONSTRATION STATE IMPLEMENTATION PLAN REVISION FOR THE 2008 EIGHT-HOUR OZONE NATIONAL AMBIENT AIR QUALITY STANDARD

PROJECT NUMBER 2019-077-SIP-NR

Proposal
September 11, 2019

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EXECUTIVE SUMMARY

The Houston-Galveston-Brazoria (HGB) area, consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, was previously classified as moderate nonattainment for the 2008 eight-hour ozone National Ambient Air Quality Standard (NAAQS) of 0.075 parts per million (ppm) with a July 20, 2018 attainment date. Attainment of the standard is achieved when an area's design value does not exceed 75 parts per billion (ppb). Based on 2017 monitoring data, the HGB area did not attain the 2008 eight-hour ozone NAAQS in 2017[1] and did not qualify for a one-year attainment date extension in accordance with Federal Clean Air Act (FCAA), §181(a)(5).[2] On November 14, 2018, the United States Environmental Protection Agency (EPA) proposed to reclassify the HGB area to serious nonattainment for the 2008 eight-hour ozone NAAQS (83 *Federal Register* (FR) 56781). On August 7, 2019, the EPA signed the final reclassification notice.

Since the HGB area has been reclassified by the EPA, the area is now subject to the serious nonattainment area requirements in FCAA, §182(c) and the Texas Commission on Environmental Quality (TCEQ) is required to submit serious area attainment demonstration (AD) and reasonable further progress (RFP) state implementation plan (SIP) revisions to the EPA. As indicated in the EPA's *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements; Final Rule* (2008 eight-hour ozone standard SIP requirements rule) published on March 6, 2015, the attainment date for a serious classification is July 20, 2021 with a 2020 attainment year (80 FR 12264). The EPA set an August 3, 2020 deadline for states to submit AD and RFP SIP revisions to address the 2008 eight-hour ozone standard serious nonattainment area requirements.

This proposed HGB AD SIP revision includes the following FCAA-required SIP elements for an area with a serious nonattainment classification: a modeled attainment demonstration, a reasonably available control technology (RACT) analysis, a reasonably available control measures (RACM) analysis, a weight of evidence (WoE) analysis, a contingency plan, and motor vehicle emissions budgets (MVEBs). This HGB AD SIP revision is being proposed in conjunction with the Dallas-Fort Worth and HGB 2008 Eight-Hour Ozone Serious Classification RFP SIP Revision (Project No. 2019-079-SIP-NR).

This proposed HGB AD SIP revision meets the requirements to demonstrate attainment of the 2008 eight-hour ozone NAAQS by July 20, 2021 based on a photochemical modeling analysis of reductions in nitrogen oxides (NO_X) and volatile organic compounds (VOC) emissions from existing control strategies and a WoE analysis. The peak ozone design value for the HGB nonattainment area is projected to be 76 ppb in 2020, predicted through credited reductions but without considering additional

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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 eight-hour ozone NAAQS by its attainment date would be eligible for the first 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 2017 was 79 ppb as measured at the Conroe Relocated monitor (C78/A321). The HGB area's design value for 2017 was 81 ppb.

emissions reductions discussed in the WoE analyses. Examples of non-quantified emissions reductions include the TCEQ's Texas Emissions Reduction Plan, which accelerates the mobile source fleet turnover effect and the associated NO_X emissions reductions by providing financial incentives for purchases of lower-emitting vehicles and equipment. Since mobile sources are one of the largest sources of NO_X emissions in the HGB nonattainment area, ozone formation is expected to continue declining through the 2020 modeled attainment year as lower amounts of NO_X are emitted from these sources. The corroborative analyses presented in Chapter 5: *Weight of Evidence* supplements the photochemical modeling analysis detailed in Chapter 3: *Photochemical Modeling* to support the conclusion that the HGB ozone nonattainment area has met the requirements to demonstrate attainment of the 2008 eight-hour ozone standard by July 20, 2021.

This proposed HGB AD SIP revision includes base case modeling of an eight-hour ozone episode that occurred during May through September 2012. This modeling episode was chosen because the period is 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 2020 future year to project 2020 eight-hour ozone design values.

Table ES-1: *Summary of 2012 Baseline and 2020 Future Year Anthropogenic Modeling Emissions for the HGB Area* lists the August average anthropogenic modeling emissions in tons per day (tpd) by source category for the 2012 baseline and 2020 future year for NO_X and VOC ozone precursors. The differences in modeling emissions between the 2012 baseline and the 2020 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 2020 electric utility emission projections are based on the maximum ozone season caps required under the Cross-State Air Pollution Rule (CSAPR) Update Rule.[3] The emissions inputs in Table ES-1 were based on the latest available information at the time development work was done for this SIP proposal.

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[3] On July 28, 2015, the United States Court of Appeals for the District of Columbia Circuit found that the CSAPR 2014 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 finalized a new ozone season NO_X budget in its September 7, 2016 final CSAPR Update Rule to address interstate transport with respect to the 2008 eight-hour ozone NAAQS and determined that Texas will no longer be subject to the emissions budget calculated to address the 1997 eight-hour ozone NAAQS. On December 21, 2018, the EPA published a final close-out of CSAPR, determining that the CSAPR Update Rule fully addresses interstate pollution transport obligations for the 2008 eight-hour ozone NAAQS in 20 covered states, including Texas (83 FR 65878).

Table ES-1: Summary of 2012 Baseline and 2020 Future Year Anthropogenic Modeling Emissions for the HGB Area

HGB Emissions Source Type	2012 NO_X (tpd)	2020 NO_X (tpd)	2012 VOC (tpd)	2020 VOC (tpd)
On-Road	157.09	83.04	73.60	55.17
Non-Road	56.36	31.59	43.94	28.39
Off-Road - Airports	8.88	8.99	2.50	1.55
Off-Road - Locomotives	15.30	11.98	0.99	0.63
Off-Road - Commercial Marine	27.74	23.88	1.33	1.37
Area Sources	18.29	30.47	248.27	319.30
Oil and Gas - Drilling	0.79	0.21	0.06	0.01
Oil and Gas - Production	2.09	1.63	66.60	40.08
Point - EGUs (August Average)	36.49	38.54	3.99	1.75
Point - Non-EGUs (Ozone Season Average)	69.76	105.06	130.68	119.80
Eight-County HGB Total	392.79	335.39	571.96	568.05

Table ES-2: *Summary of Modeled 2012 Baseline and 2020 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 2020 future year design value (DV_F) for the regulatory ozone monitors in the HGB ozone nonattainment area. In accordance with the EPA's November 2018 *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*,[4] the 2020 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 modeling guidance. The 2020 future design values for all HGB regulatory monitors, except Manvel Croix Park (C84), are predicted to meet the 2008 eight-hour ozone NAAQS. Manvel Croix Park (C84) is predicted to have a 2020 future design value of 76 ppb, one ppb above the 2008 eight-hour ozone NAAQS. Since the modeling cannot provide an absolute prediction of future year ozone design values, additional information from corroborative analyses is used in assessing whether the area will attain the ozone standard by July 20, 2021.

Table ES-2: Summary of Modeled 2012 Baseline and 2020 Future Year Eight-Hour Ozone Design Values for HGB Monitors

Monitor Name	Site Code	2012 DV_B (ppb)	Relative Response Factor	2020 DV_F (ppb)
Manvel Croix Park - C84	MACP	85.00	0.901	76
Bayland Park - C53	BAYP	78.67	0.917	72
Houston East - C1	HOEA	78.00	0.925	72
Croquet - C409	HCQA	78.67	0.908	71
Deer Park - C35	DRPK	78.33	0.912	71
Houston Monroe - C406	HSMA	76.67	0.926	71
Houston Northwest - C26	HNWA	80.00	0.893	71

[4] https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf

Monitor Name	Site Code	2012 DV_B (ppb)	Relative Response Factor	2020 DV_F (ppb)
Park Place - C416	PRKP	77.33	0.922	71
Conroe Relocated - C78	CNR2	78.00	0.906	70
Houston Aldine - C8	HALC	76.67	0.916	70
Clinton Drive - C403	CLTN	74.67	0.933	69
Houston Texas Ave - C411	HTCA	75.00	0.929	69
Houston Westhollow - C410	SHWH	77.67	0.892	69
Lang - C408	HLAA	76.33	0.909	69
Galveston - C1034	GALV	75.33	0.907	68
Seabrook Friendship Park - C45	SBFP	76.33	0.901	68
Channelview - C15	HCHV	73.00	0.919	67
North Wayside - C405	HWAA	73.67	0.921	67
Lynchburg Ferry - C1015	LYNF	71.00	0.914	64
Lake Jackson - C1016	LKJK	69.33	0.880	61

The future year on-road mobile source emission inventories for this proposed HGB AD SIP revision were developed using the 2014a version of the Motor Vehicle Emission Simulator (MOVES2014a) model and vehicle miles traveled activity estimates from the HGB travel demand model managed by the Houston-Galveston Area Council. These 2020 attainment year inventories establish the NO_X and VOC MVEBs that, once found adequate or approved by the EPA, must be used in transportation conformity analyses. Areas must demonstrate that the estimated emissions from transportation plans, programs, and projects do not exceed the applicable MVEBs. The attainment MVEBs represent the updated future year on-road mobile source emissions that have been modeled for the attainment demonstration and include all of the on-road control measures. The MVEBs can be found in Table 4-2: *2020 Attainment Demonstration MVEBs for the Eight-County 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 proposed 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, 2015, and 2017. 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). 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. 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.

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 authorizes 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, 2017
TEXAS WATER CODE	September 1, 2017

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 May 31, 2018

Chapter 55: Requests for Reconsideration and Contested Case Hearings; Public Comment, all of the chapter except §55.125(a)(5) and (6) May 31, 2018

Chapter 101: General Air Quality Rules October 12, 2017

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

Chapter 111: Control of Air Pollution from Visible Emissions and Particulate Matter August 3, 2017

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 April 26, 2018

Chapter 115: Control of Air Pollution from Volatile Organic Compounds January 5, 2017

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 February 23, 2017

SECTION VI: CONTROL STRATEGY

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LIST OF ACRONYMS

ABY	adjusted base year
ACT	alternative control techniques
AD	attainment demonstration
AEDT	Aviation Environmental Design Tool
AGL	above ground level
AMPD	Air Markets Program Data
APU	auxiliary power unit
AQRP	Air Quality Research Program
AQS	Air Quality System
auto-GC	automated gas chromatographs
BACT	best available control technology
BEIS	Biogenic Emission Inventory System
CAIR	Clean Air Interstate Rule
CAMS	continuous ambient monitoring station
CAMx	Comprehensive Air Quality Model with Extensions
CASTNET	Clean Air Status and Trends Network
CB6	Carbon Bond 6
CEMS	continuous emissions monitoring systems
CFR	Code of Federal Regulations
CMV	commercial marine vessel
CO	carbon monoxide
CSAPR	Cross-State Air Pollution Rule
CTG	control techniques guidelines
D.C.	District of Columbia
DDM	decoupled direct method
DERA	Diesel Emissions Reduction Act
DERC	discrete emission reduction credit
DERI	Diesel Emissions Reduction Incentive
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
EE	energy efficiency
EGF	electric generating facility
EGU	electric generating unit
EI	emissions inventory
EIA	Energy Information Administration
EPA	United States Environmental Protection Agency
EPS3	Emissions Processing System
ERC	emission reduction credit
ERG	Eastern Research Group
ESL	Energy Systems Laboratory
FAA	Federal Aviation Administration
FCAA	Federal Clean Air Act
FINN	Fire Inventory from the National Center for Atmospheric Research
FR	*Federal Register*
FY	fiscal year
GEOS-Chem	Goddard Earth Observing System
GSE	ground support equipment
GW	gigawatts
HB	House Bill
HCHO	formaldehyde
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
IEEFA	Institute for Energy Economics and Financial Analysis
I/M	inspection and maintenance
IPT	inter-precursor trading
ITAC	Independent Technical Advisory Committee
km	kilometer
Kv	vertical diffusivity
LAI	leaf area index
LCC	Lambert Conformal Conic

LDAR	leak detection and repair
LIRAP	Low Income Vehicle Repair Assistance, Retrofit, and Accelerated Vehicle Retirement Program
m	meter
MACT	maximum achievable control technology
MATS	Modeled Attainment Test Software
MCR	mid-course review
MDA8	maximum daily average eight-hour
MDERC	mobile discrete emission reduction credit
MECT	Mass Emissions Cap and Trade
MODIS	Moderate-Resolution Imaging Spectroradiometer
MOVES	Motor Vehicle Emissions Simulator
MPE	model performance evaluation
MVEB	motor vehicle emissions budget
MW	megawatt
MWh	megawatt-hour
NAAQS	National Ambient Air Quality Standard
NADP	National Acid Deposition Program
NASA	National Aeronautics and Space Administration
NEI	National Emissions Inventory
NLCD	National Land Cover Dataset
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NO	nitric oxide
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
NSR	New Source Review
OMI	Ozone Monitoring Instrument
PHA	Port of Houston Authority
PBL	planetary boundary layer
pH_2O_2	hydrogen peroxide
$pHNO_3$	nitric acid
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
PUCT	Public Utility Commission of Texas
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	Railroad Commission of Texas
RRF	relative response factor
RS	redesignation substitute
SB	Senate Bill
SECO	State Energy Conservation Office
SET PMTC	Southeast Texas Photochemical Modeling Technical Committee
SIC	Standard Industrial Classification
SIP	state implementation plan
SMOKE	Sparse Matrix Operation Kernel Emissions
SO_2	sulfur dioxide
SPRY	Seaport and Rail Yard Areas Emissions Reduction
STARS	State of Texas Air Reporting System
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
TCM	transportation control measure
TDM	travel demand model
TERP	Texas Emissions Reduction Plan
TexAER	Texas Air Emissions Repository
TexN	Texas NONROAD

THSC	Texas Health and Safety Code
TNGVGP	Texas Natural Gas Vehicle Grant Program
TNMHC	total non-methane hydrocarbon
TNRCC	Texas Natural Resource Conservation Commission
tpd	tons per day
tpy	tons per year
TTI	Texas Transportation Institute
TUC	Texas Utilities Code
TxDOT	Texas Department of Transportation
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 Preprocessing System
WRF	Weather Research and Forecasting

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.

2000 HGB One-Hour Ozone AD and Post-1999 ROP SIP Revision (TCEQ Project No. 2000-011-SIP-AI, adopted December 6, 2000) Post-1999 Rate-of-Progress and Attainment Demonstration SIP for the Houston/Galveston Ozone Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2000-12-HGB/HGB_AD_ROP_dec2000.pdf)

2001 HGB Follow-Up One-Hour Ozone AD and ROP SIP Revision (TCEQ Project No. 2001-007-SIP-AI, adopted September 26, 2001) Post-1999 Rate-of-Progress and Attainment Demonstration Follow-Up SIP for the Houston/Galveston Ozone Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2001-09-HGB/HGB_AD_ROP_sep2001.pdf)

2002 HGB One-Hour Ozone AD Follow-Up SIP Revision (TCEQ Project No. 2002-046a-SIP-AI, adopted December 13, 2002) Post-1999 Rate-of-Progress and Attainment Demonstration Follow-Up SIP for the Houston/Galveston Ozone Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2002-12-HGB/HGB_AD_ROP_dec2002.pdf)

2004 HGB One-Hour Ozone Post-1999 ROP SIP Revision (TCEQ Project No. 2004-049b-SIP-NR, adopted October 27, 2014) Post 1999 Rate-of-Progress Demonstration Plan for the Houston-Galveston-Brazoria Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2004-05-HGBROP/HGB_ROP_oct2004.pdf)

2004 HGB One-Hour Ozone AD MCR SIP Revision (TCEQ Project No. 2004-042-SIP-NR, adopted December 1, 2014) Houston/Galveston/Brazoria Ozone Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2004-05-HGB/HGB_MCR_dec2004.pdf)

2007 HGB 1997 Eight-Hour Ozone SIP Revision (TCEQ Project No. 2006-027-SIP-NR, adopted May 23, 2007) Houston-Galveston-Brazoria Eight-Hour Ozone Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2007-HGB-SIPs/HGB_SIP_2007_Archive.pdf)

2007 HGB 1997 Eight-Hour Ozone RFP SIP Revision (TCEQ Project No. 2006-030-SIP-NR, adopted May 23, 2007) Houston-Galveston-Brazoria Eight-Hour Ozone Nonattainment Area Reasonable Further Progress SIP (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2007-HGB-SIPs/HGB_RFP_2007_archive.pdf)

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 (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2010-HGB-AD-RFP/HGB_AD_2010_archive.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 (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2010-HGB-AD-RFP/HGB_RFP_2010_archive.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 Revision for the 1997 Eight-Hour Ozone Standard (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2011-HGB-RACTupdate/HGB_RACTupdate_2011_archive.pdf)

2013 HGB 1997 Eight-Hour Ozone MVEB Update SIP Revision (TCEQ Project Number 2012-002-SIP-NR, adopted April 23, 2013) Houston-Galveston-Brazoria 1997 Eight-Hour Ozone Standard Nonattainment Area Motor Vehicle Emissions Budgets Update State Implementation Plan Revision (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2013-HGB-MVEB/HGB_MVEB_2013_archive.pdf)

2014 HGB/DFW 2008 Eight-Hour Ozone EI SIP Revision (TCEQ Project No. 2013-016-SIP-NR, adopted July 2, 2014) Emissions Inventory State Implementation Plan Revision for the 2008 Eight-Hour Ozone National Ambient Air Quality Standard for the Houston-Galveston-Brazoria and Dallas-Fort Worth Areas (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2014_Ozone_EI/EI_2014_archive.pdf)

2014 HGB One-Hour Ozone RS Report (Submitted to the EPA on July 22, 2014) Redesignation Substitute Report for the Houston-Galveston-Brazoria One-Hour Ozone Standard Nonattainment Area (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) Redesignation Substitute Report for the Houston-Galveston-Brazoria 1997 Eight-Hour Ozone Standard Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/hgb/1997ozone_RS_Report/HGB_RS_1997_8Hr_report.pdf)

2016 HGB 2008 Eight-Hour Ozone AD Moderate Classification SIP Revision (TCEQ Project No. 2016-016-SIP-NR, adopted December 15, 2016) Houston-Galveston-Brazoria Attainment Demonstration State Implementation Plan Revision for the 2008 Eight-Hour Ozone Standard Nonattainment Area

(https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2016-HGB-AD-RFP/HGBAD_2016_Archive.pdf)

2016 HGB 2008 Eight-Hour Ozone RFP Moderate Classification SIP Revision (TCEQ Project No. 2016-017-SIP-NR, adopted December 15, 2016) Houston-Galveston-Brazoria Reasonable Further Progress State Implementation Plan Revision for the 2008 Eight-Hour Ozone Standard Nonattainment Area (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2016-HGB-AD-RFP/HGBRFP_2016_Archive.pdf)

2018 HGB One-Hour and 1997 Eight-Hour Ozone Redesignation and Maintenance Plan SIP Revision (TCEQ Project No. 2018-026-SIP-NR, adopted December 12, 2018) Houston-Galveston-Brazoria Redesignation Request and Maintenance Plan State Implementation Plan Revision for the One-Hour and 1997 Eight-Hour Ozone National Ambient Air Quality Standards (https://www.tceq.texas.gov/assets/public/implementation/air/sip/sipdocs/2018-19_OzoneRedesignations/2018_HGB_1hr-1997Ozone_Redes_archive.pdf)

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CHAPTER 1: GENERAL

1.1 BACKGROUND

Information on the Texas State Implementation Plan (SIP) and a list of SIP revisions and other air quality plans adopted by the commission can be found on the Texas State Implementation Plan webpage (http://www.tceq.texas.gov/airquality/sip) on the Texas Commission on Environmental Quality's (TCEQ) website (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 is 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

On February 8, 1979, the United States Environmental Protection Agency (EPA) set the one-hour ozone NAAQS at 0.12 parts per million (ppm) (44 *Federal Register* (FR) 8202). A design value of 0.124 ppm, or 124 parts per billion (ppb), would round down and meet the NAAQS while a design value of 0.125 ppm, or 125 ppb, would round up and exceed the NAAQS. Because of these rounding conventions, the one-hour ozone NAAQS of 0.12 ppm is commonly referenced as 124 ppb. Violation of the one-hour ozone NAAQS is based on the maximum number of expected exceedances over all the monitors in an area with a threshold of 1.0 expected exceedances per year averaged over a three-year period.

In 1991, the EPA designated an eight-county HGB area, consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, as nonattainment for the one-hour ozone NAAQS with a severe-17 classification in accordance with the 1990 Federal Clean Air Act (FCAA) Amendments (56 FR 56694). The HGB area was given an attainment date of November 15, 2007. At that time, the FCAA also required submission of a SIP revision describing actions to be taken to reduce nitrogen oxides (NO_x) and volatile organic compounds (VOC) by November 1996. Before that deadline, however, modeling showed uncertainties in the actual impact that NO_x reductions would have on ground-level ozone formation. The HGB area was therefore granted a temporary exemption until December 1997 to fulfill its NO_x control requirements.

1.2.1.1 December 2000

The commission adopted the 2000 HGB One-Hour Ozone AD and Post-1999 ROP SIP Revision 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 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 rate-of-progress (ROP) plan portion of this SIP revision submittal provided emissions inventories, ROP analyses for milestone years 2002, 2005, and 2007, and motor vehicle emissions budgets (MVEBs) for NO_X and VOC. On November 14, 2001, the EPA published approval of this SIP revision and the 2001 HGB Follow-Up One-Hour Ozone AD and ROP SIP Revision (66 FR 57159).

1.2.1.2 September 2001

The commission adopted the 2001 HGB Follow-Up One-Hour Ozone AD and ROP SIP Revision on September 26, 2001. 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 emissions reductions necessary to address the remainder of the emissions reductions shortfall and demonstrate attainment of the one-hour ozone standard in the HGB area. On November 14, 2001, the EPA published approval of this SIP revision and the 2000 HGB One-Hour Ozone AD and Post-1999 ROP SIP Revision (66 FR 57159).

1.2.1.3 December 2002

The Business Coalition for Clean Air Appeal Group and several regulated companies challenged the 2000 HGB One-Hour Ozone AD 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 2002 HGB One-Hour Ozone AD 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. This 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 2002 HGB One-Hour Ozone AD 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 2004 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 MVEBs 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 2004 HGB One-Hour Ozone AD 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 attainment date. 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 Source Emissions Reduction Program (VMEP) 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 Emission Credit Banking and Trading Program, and the Discrete Emission 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 date, 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).[5] The anti-backsliding requirements that apply to the HGB severe one-hour ozone nonattainment area are: contingency measures,[6] nonattainment new source review (NSR) permitting requirements for severe nonattainment areas;[7] 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

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[5] *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.

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

[7] 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.

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.[8] Consequently, on May 22, 2013, the commission adopted the Severe Ozone Nonattainment Area Failure to Attain Fees rulemaking to implement the §185 penalty fee.

The EPA's *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirement: Final Rule* (2008 eight-hour ozone standard SIP requirements rule), published on March 6, 2015, included a mechanism for lifting anti-backsliding obligations for the revoked 1997 eight-hour or one-hour ozone NAAQS (80 FR 12264). States could provide a showing, termed a redesignation substitute (RS), based on FCAA, §107(d)(3)(E) redesignation criteria to demonstrate that an area qualified for lifting anti-backsliding obligations under a revoked standard consistent with the EPA's 2008 eight-hour ozone standard SIP requirements rule. The EPA's 2008 eight-hour ozone standard SIP requirements rule indicated that approval of an RS had 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 May 30, 2014, the EPA concurred that the data met all the quality requirements, and that the HGB area met the one-hour ozone NAAQS. On July 22, 2014, the TCEQ submitted the 2014 HGB One-Hour Ozone RS Report 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. On October 20, 2015, the EPA published its final rule approving the RS report, effective November 19, 2015 (80 FR 63429).

1.2.1.7 Redesignation Request and Maintenance Plan SIP Revision for the One-Hour Ozone NAAQS

On February 16, 2018, the United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit Court) issued an opinion in the case *South Coast Air Quality Management District v. EPA, 882 F.3d 1138 (D.C. Cir. 2018)*. The case was a challenge to the EPA's 2008 eight-hour ozone standard SIP requirements rule (80 FR 12264), which revoked the 1997 eight-hour ozone NAAQS as part of the implementation of the more stringent 2008 eight-hour ozone NAAQS. The court's decision vacated parts of the EPA's 2008 eight-hour ozone standard SIP requirements rule, including the RS, removal of anti-backsliding requirements for areas designated nonattainment under the 1997 eight-hour ozone NAAQS, waiving requirements for transportation conformity for maintenance areas under the revoked 1997 eight-hour ozone NAAQS, and elimination of the requirement to submit a second 10-year maintenance plan. The court's vacatur of removal of anti-backsliding requirements for areas designated nonattainment under

[8] On July 1, 2011, the D.C. Circuit Court 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 1997 eight-hour ozone NAAQS may also apply to areas that were designated nonattainment under the one-hour ozone NAAQS.

To address the D.C. Circuit Court's ruling, the commission adopted a formal redesignation request and maintenance plan SIP revision for the one-hour and the 1997 eight-hour ozone NAAQS on December 12, 2018. The 2018 HGB One-Hour and 1997 Eight-Hour Ozone Redesignation and Maintenance Plan SIP Revision includes a request that the HGB area be redesignated to attainment for the revoked one-hour NAAQS as well as the 1997 eight-hour ozone NAAQS and a maintenance plan that ensures the area remains in attainment of both standards through 2032. The maintenance plan uses a 2014 base year inventory and includes interim year inventories for 2020 and 2026, establishes MVEBs for 2032, and includes a contingency plan. The TCEQ submitted this SIP revision to the EPA on December 14, 2018. The EPA proposed approval on May 16, 2019 (84 FR 22093).

1.2.1.8 Severe Area Failure-to-Attain Fee Program (Section 185 Fees)

FCAA, §182(d)(3) and (e) and §185 (Section 185 requirements or Section 185) require severe and extreme ozone nonattainment area SIPs to include a program to assess and collect a Failure to Attain Fee (fee) from major stationary sources of VOC if that area fails to attain the ozone NAAQS by the applicable attainment date. FCAA, §182(f) requires all SIP provisions that apply to major stationary sources of VOC emissions to also apply to major stationary sources of NO_x emissions.

The EPA finalized its finding of failure to attain for the HGB one-hour ozone nonattainment area on June 19, 2012, effective July 19, 2012 (77 FR 36400). The anti-backsliding requirement to implement a penalty fee program under FCAA, §182(d)(3) and §185 was triggered with the EPA's failure-to-attain determination.

In response, the commission proposed revised rules requiring the assessment of Section 185 fees as published in the November 30, 2012 *Texas Register* (37 TexReg 9468). On May 22, 2013, the commission adopted these rules under 30 TAC Chapter 101, General Air Quality Rules, Subchapter B to implement the FCAA, §185 provisions.

The TCEQ has implemented the HGB one-hour ozone nonattainment area Section 185 fee obligation as required by the provisions of these rules. The Section 185 fee rules were submitted to the EPA on November 28, 2018 as a revision to the SIP. On May 16, 2019, the EPA proposed approval of the Severe Ozone Nonattainment Area Failure to Attain Fee SIP revision to address FCAA, §185 for the one-hour ozone NAAQS (84 FR 22093)

1.2.2 1997 Eight-Hour Ozone NAAQS History

On July 18, 1997, the EPA revised the NAAQS for ground-level ozone (62 FR 38856). The EPA phased out and replaced the previous one-hour ozone NAAQS with an eight-hour NAAQS set at 0.08 ppm 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. A design value of 0.084 ppm, or 84 ppb, would round down and meet the NAAQS while a design value of 0.085 ppm, or 85 ppb, would round up and exceed the NAAQS. Because of these rounding conventions, the 1997 eight-hour ozone NAAQS is commonly referenced as 84 ppb.

Effective June 15, 2004, the HGB area, consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, was 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 date 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

On May 23, 2007, the commission adopted two revisions to the Texas SIP for the HGB moderate 1997 eight-hour ozone nonattainment area. The 2007 HGB 1997 Eight-Hour Ozone SIP Revision was the first step in addressing the 1997 eight-hour ozone NAAQS in the HGB area. The revision included additional VMEP commitments, a reasonably available control technology (RACT) analysis, and the Texas 2002 Periodic Emissions Inventory for the HGB ozone nonattainment area. This SIP revision also incorporated amendments to 30 TAC Chapter 114, relating to the Texas Low Emission Diesel 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 approved portions of the RACT analysis for certain VOC categories and the VMEP commitments (applicable through 2009) in this SIP revision (78 FR 19599). The EPA approved the remaining source categories 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 RFP SIP Revision. This reasonable further progress (RFP) SIP revision demonstrated a 15% reduction in ozone precursor (VOC and NO_X) emissions for the period of 2001 through 2008. On April 22, 2009, the EPA approved this RFP 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. On October 1, 2008, the EPA approved Texas' request to reclassify the HGB 1997 eight-hour ozone nonattainment area from moderate to severe with a new attainment date of June 15, 2019 and set April 15, 2010 as the date for the state to submit a SIP revision addressing the severe-ozone nonattainment requirements (73 FR 56983).

1.2.2.3 March 2010

On March 10, 2010, the commission adopted two revisions to the Texas SIP for the HGB severe 1997 eight-hour ozone nonattainment area. The 2010 HGB 1997 Eight-Hour Ozone AD SIP Revision included a photochemical modeling analysis and a weight of evidence (WoE) analysis to demonstrate attainment of the 1997 eight-hour ozone NAAQS by the June 15, 2019 attainment date. This SIP revision also included MVEBs, VOC and NO_X RACT analyses, reasonably available control measures (RACM) analysis, contingency plan, and MCR commitment. In addition, this SIP revision incorporated revisions to 30 TAC Chapters 101 and 115, which addressed cap integrity in the MECT Program, a cap reduction and allowance reallocation for the HECT Program, and updated Control Technique Guidelines (CTG) documents for VOC used in offset lithographic printing.

On April 2, 2013, April 15, 2014, August 4, 2014, and March 27, 2015, the EPA approved 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 approved this AD SIP revision and revisions to the MECT and HECT Programs as well as the 2013 HGB 1997 Eight-Hour Ozone MVEB Update SIP Revision (79 FR 57).

The 2010 HGB 1997 Eight-Hour Ozone RFP SIP Revision demonstrated an 18% reduction in ozone precursor emissions for the period of 2002 through 2008 and an average annual emissions reduction of 3% between each of the milestone years 2008, 2011, 2014, 2017, and 2018. This SIP revision also included MVEBs, developed using the on-road mobile source emissions inventories based on the EPA's MOBILE 6.2 model, for each milestone year and a contingency plan. On January 2, 2014, the EPA approved 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. The EPA approved this RACT update SIP revision on March 27, 2015 (80 FR 16291).

1.2.2.5 April 2013

On April 23, 2013, the commission adopted the 2013 HGB 1997 Eight-Hour Ozone MVEB Update 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. This SIP revision also met the primary obligation of the MCR 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 approved this MVEB update 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

The HGB area demonstrated attainment of the 1997 eight-hour ozone NAAQS based on 2012 through 2014 monitoring data. The EPA published a final determination of attainment for the 1997 eight-hour ozone NAAQS for the HGB area on December 30, 2015 (80 FR 81466).

On August 18, 2015, the TCEQ submitted the 2015 HGB 1997 Eight-Hour Ozone RS Report, which fulfilled the EPA's RS requirements in its 2008 eight-hour ozone standard SIP requirements rule (80 FR 12264) to lift anti-backsliding obligations for the revoked 1997 eight-hour ozone NAAQS by ensuring that specific redesignation requirements are met for the HGB area under the revoked 1997 eight-hour ozone NAAQS. This RS took the place of a redesignation request and maintenance plan that the EPA would require for a standard that has not been revoked.

On November 8, 2016, the EPA approved this 2015 HGB 1997 Eight-Hour Ozone RS Report effective December 8, 2016 (81 FR 78691). This action included a determination that the area attained the 1997 eight-hour ozone NAAQS due to permanent and enforceable emissions reductions and that the area will maintain the standard for 10 years from the date of the EPA's approval of this demonstration.

1.2.2.7 Redesignation Request and Maintenance Plan SIP Revision for the 1997 Eight-Hour Ozone NAAQS

On February 16, 2018, the D.C. Circuit Court issued an opinion in the case *South Coast Air Quality Management District v. EPA, 882 F.3d 1138 (D.C. Cir. 2018)*. The case was a challenge to the EPA's 2008 eight-hour ozone standard SIP requirements rule (80 FR 12264), which revoked the 1997 eight-hour ozone NAAQS as part of the implementation of the more stringent 2008 eight-hour ozone NAAQS. The court's decision vacated parts of the EPA's final 2008 eight-hour ozone standard SIP requirements rule, including the redesignation substitute, removal of anti-backsliding requirements for areas designated nonattainment under the 1997 eight-hour ozone NAAQS, waiving requirements for transportation conformity for maintenance areas under the revoked 1997 eight-hour ozone NAAQS, and elimination of the requirement to submit a second 10-year maintenance plan.

As discussed in Section 1.2.1.7: *Redesignation and Maintenance Plan SIP Revision for the One-Hour Ozone NAAQS*, the commission adopted a formal redesignation request and maintenance plan SIP revision for the one-hour and the 1997 eight-hour ozone NAAQS on December 12, 2018 to address the D.C. Circuit Court's ruling. The 2018 HGB One-Hour and 1997 Eight-Hour Ozone Redesignation and Maintenance Plan SIP Revision includes a request that the HGB area be redesignated to attainment for the revoked 1997 eight-hour ozone NAAQS as well as the one-hour NAAQS and a maintenance plan that would ensure the area remains in attainment of both standards through 2032. The maintenance plan uses a 2014 base year inventory and includes interim year inventories for 2020 and 2026, establishes MVEBs for 2032, and includes a contingency plan. The TCEQ submitted this SIP revision to the EPA on December 14, 2018.

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 (73 FR 16436). Attainment of this standard is achieved when an area's design value does not exceed 75 ppb. On May 21, 2012, the HGB eight-county area, consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller Counties, was designated nonattainment and classified as marginal under the 2008 eight-hour ozone NAAQS, effective July 20, 2012. On May 21, 2012, the EPA published the implementation rule for the 2008 eight-hour ozone standard which set the attainment date for the HGB marginal nonattainment area as December 31, 2015 (77 FR 30160).

On December 23, 2014, the D.C. Circuit Court ruled on a lawsuit filed by the Natural Resources Defense Council, which resulted in vacatur of the EPA's December 31 attainment date for the 2008 eight-hour ozone NAAQS. As part of the EPA's final 2008 eight-hour 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, rather than the end of the 2012 calendar year. As a result, 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.

On July 2, 2014, the commission adopted the 2014 HGB/DFW 2008 Eight-Hour Ozone EI SIP Revision to satisfy FCAA, §172(c)(3) and §182(a)(1) emissions inventory reporting requirements for the HGB marginal nonattainment area under the 2008 eight-hour ozone NAAQS. The EPA published direct final approval of this EI SIP revision on February 20, 2015 (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). On May 4, 2016, the EPA published final approval of the one-year attainment date extension for the HGB 2008 eight-hour ozone marginal nonattainment area to July 20, 2016 with a 2015 attainment year (81 FR 26697).

Because the HGB area's 2015 design value of 80 ppb exceeded the 2008 eight-hour ozone NAAQS, the EPA published a final determination of nonattainment and reclassification of the HGB 2008 eight-hour ozone nonattainment area from marginal to moderate nonattainment on December 14, 2016 (81 FR 90207). The EPA set a January 1, 2017 deadline for the state to submit an attainment demonstration that addressed the 2008 eight-hour ozone NAAQS moderate nonattainment area requirements, including RFP. As indicated in the EPA's 2008 eight-hour ozone standard SIP requirements rule, the attainment date for moderate classification was July 20, 2018 with an attainment year of 2017.

1.2.3.2 December 2016

On December 15, 2016, the commission adopted two revisions to the Texas SIP for the HGB ozone nonattainment area. The 2016 HGB 2008 Eight-Hour Ozone AD Moderate Classification SIP Revision included a photochemical modeling analysis of reductions in NO_X and VOC emissions from existing control strategies and a WoE analysis, which met the requirements to demonstrate attainment of the 2008 eight-hour ozone NAAQS. Consistent with the requirements of FCAA, 182(b)(1) and the EPA's 2008 eight-hour ozone standard SIP requirements rule, the AD SIP revision also included a RACT analysis, a RACM analysis, MVEBs for the 2017 attainment year, and a contingency plan. The AD SIP revision also incorporated a rulemaking to 30 TAC Chapter 115 to implement RACT for VOC storage tanks in the HGB area (Rule Project No. 2016-039-115-AI).

The 2016 HGB 2008 Eight-Hour Ozone RFP Moderate Classification SIP Revision demonstrated a 15% emissions reduction in ozone precursors from the 2011 base year through the 2017 attainment year and a 3% reduction for contingency in 2018. The RFP SIP revision also set NO_X and VOC MVEBs for the 2017 attainment year.

1.2.3.3 Reclassification to Serious for the 2008 Eight-Hour Ozone NAAQS

Based on 2017 monitoring data, the HGB area did not attain the 2008 eight-hour ozone NAAQS in 2017[9] and did not qualify for a one-year attainment date extension in accordance with FCAA, §181(a)(5).[10] On November 14, 2018, the EPA proposed to reclassify the HGB area to serious nonattainment for the 2008 eight-hour ozone NAAQS (83 FR 56781). On August 7, 2019, the EPA signed the final reclassification notice. As indicated in the EPA's 2008 eight-hour ozone standard SIP requirements rule, the attainment date for a serious classification is July 20, 2021 with a 2020 attainment year. The EPA set an August 3, 2020 deadline for states to submit AD and RFP SIP revisions to address the 2008 eight-hour ozone standard serious nonattainment area requirements.

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

This proposed HGB 2008 Eight-Hour Ozone AD Serious Classification SIP Revision contains all FCAA-required AD SIP elements for an area with a serious nonattainment classification. This proposed HGB AD SIP revision meets the requirements to demonstrate attainment of the 2008 eight-hour ozone NAAQS through photochemical modeling and corroborative WoE analysis. This HGB AD SIP revision also includes an analysis of RACM, including RACT, and contingency measures that would provide additional emissions reductions that could be implemented without further rulemaking if the area fails to attain the standard by the attainment date. To ensure that federal transportation funding conforms to the SIP, this HGB AD SIP revision also contains 2020 attainment year MVEBs.

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 2018 are illustrated in Figure 1-1: *Ozone Design Values and Population in the HGB Area*. Both design values have decreased over the past 27 years. The 2018 one-hour ozone design value of 112 ppb

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

[10] An area that fails to attain the 2008 eight-hour ozone NAAQS by its attainment date would be eligible for the first 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 2017 was 79 ppb as measured at the Conroe Relocated monitor (C78/A321). The HGB area's design value for 2017 was 81 ppb.

decreased by 49%, almost half the 1991 design value of 220 ppb. The 2018 eight-hour ozone design value of 78 ppb is the lowest ever recorded in the HGB area. The 2018 eight-hour ozone design value represents a 37% decrease from the 1991 value of 124 ppb. These decreases in design values occurred despite a 81% increase in area population from 1991 through 2018, as shown in Figure 1-1. As of January 17, 2019, the 2018 design values are preliminary and subject to change.

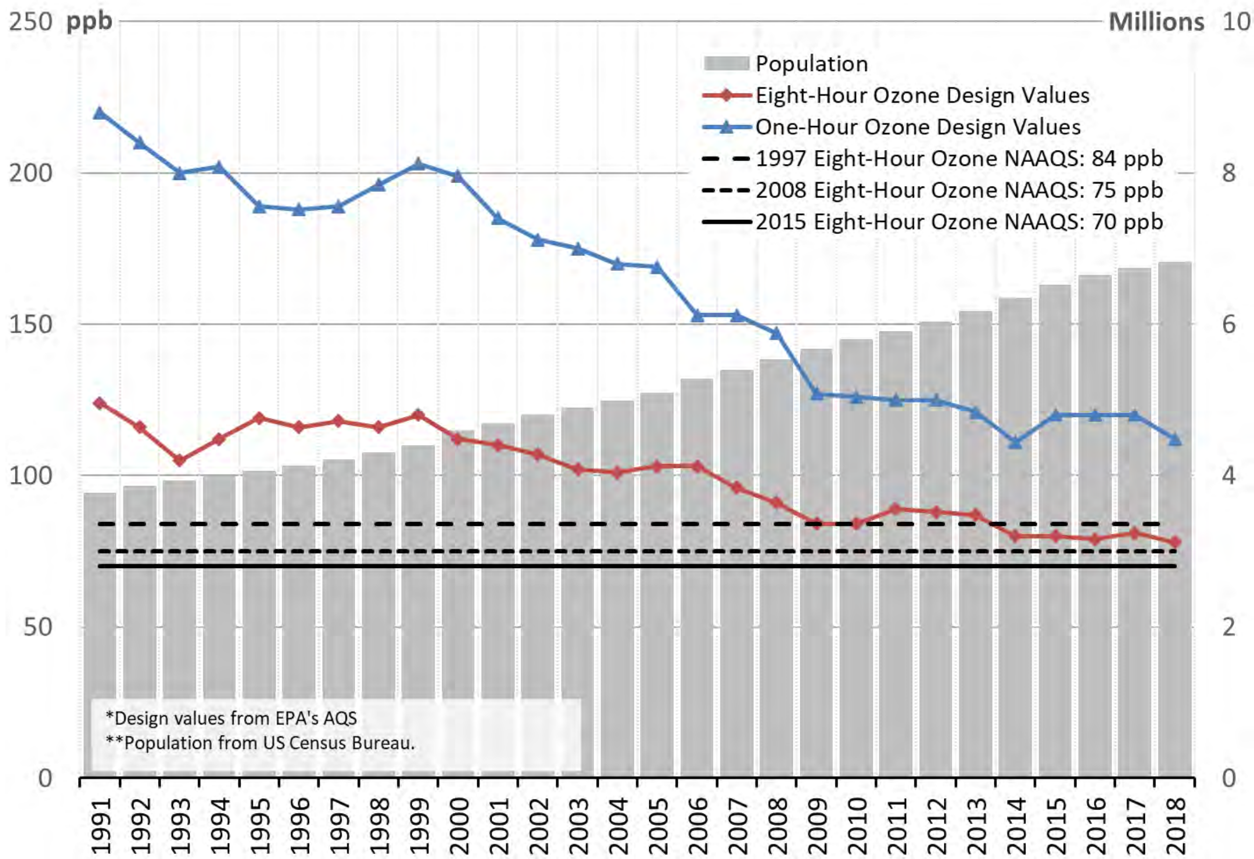


Figure 1-1: Ozone Design Values and Population in the HGB Area

1.3 HEALTH EFFECTS

In 2008, the EPA revised the primary eight-hour 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 0.08 ppm (84 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 webpage (http://www.h-gac.com/board-of-directors/advisory-committees/regional-air-quality-planning-advisory-committee/default.aspx).

1.4.2 Southeast Texas Photochemical Modeling Technical Committee 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. An SET PMTC meeting was held on July 15, 2019. Agenda topics included the status of HGB photochemical modeling development for the HGB 2008 Eight-Hour Ozone Serious Classification AD SIP Revision. More information about this committee is available on the SET PMTC webpage (https://www.tceq.texas.gov/airquality/airmod/committee/pmtc_set.html).

1.5 PUBLIC HEARING AND COMMENT INFORMATION

The commission will hold public hearings for this proposed SIP revision at the following times and locations:

Table 1-1: Public Hearing Information

City	Date	Time	Location
Houston	October 14, 2019	2:00 p.m.	Texas Department of Transportation District Office Auditorium 7600 Washington Avenue Houston, TX 77007

The public comment period will open on September 13, 2019 and close on October 28, 2019. Written comments will be accepted via mail, fax, or through the eComments (https://www6.tceq.texas.gov/rules/ecomments/) system. All comments should reference the “HGB 2008 Eight-Hour Ozone Serious Classification AD SIP Revision” and should reference Project Number 2019-077-SIP-NR. Comments may be submitted to Alison Stokes, MC 206, State Implementation Plan Team, Air Quality Division, Texas Commission on Environmental Quality, P.O. Box 13087, Austin, Texas 78711-3087 or faxed to (512) 239-6188. If you choose to submit electronic comments, they must be submitted through the eComments system. File size restrictions may apply to comments being submitted via the eComments system. Comments must be received by October 28, 2019.

An electronic version of this HGB AD SIP Revision for the 2008 Eight-Hour Ozone Standard Serious Nonattainment Area and appendices can be found at the TCEQ's HGB: Latest Ozone Planning Activities webpage (https://www.tceq.texas.gov/airquality/sip/hgb/hgb-latest-ozone).

1.6 SOCIAL AND ECONOMIC CONSIDERATIONS

Because rulemaking is not a part of this SIP revision, there are no changes that would impact society or the economy.

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 (FCAA) Amendments of 1990 require that attainment demonstration (AD) emissions inventories (EIs) be prepared for ozone nonattainment areas (57 *Federal Register* (FR) 13498). Ground-level (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 emissions 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 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 EI. To collect the data, the TCEQ provides detailed reporting instructions and tools for completing and submitting an EI. 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. Per FCAA, §182(a)(3)(B), 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 EI are reviewed for quality assurance purposes and then stored in the State of Texas Air Reporting System database. The TCEQ's Point Source Emissions Inventory webpage (https://www.tceq.texas.gov/airquality/point-source-ei/psei.html) contains guidance documents and historical point source emissions data. Additional information is available upon request from the TCEQ's Air Quality Division.

For this proposed HGB AD State Implementation Plan (SIP) revision, the TCEQ has designated the projection-base year for point sources as 2018 for electric generating units (EGUs) with emissions recorded in the United States Environmental Protection Agency's (EPA) Air Markets Program Database and 2016 for all other stationary point sources (non-EGUs). For more detail on the projection-base year for point sources, please see Chapter 3, Section 3.6.4.1: *Point Sources* and Appendix B: *Emissions Modeling for the DFW and HGB Attainment Demonstration SIP Revisions for the 2008 Eight-Hour Ozone Standard*.

The TCEQ requested regulated entities submit revisions to the 2016 or 2018 (as appropriate) point source EI by January 4, 2019. The point source emissions in this HGB AD SIP revision incorporate these updates. The TCEQ did not receive 2018 EGU EI revisions. Revised 2016 non-EGU point source emissions in this HGB AD SIP revision totaled less than one ton per day each of VOC and NO_X emissions.

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 that emit NO_X include: oil and gas production sources, stationary source fossil fuel combustion at residences and businesses, outdoor refuse burning, and structure fires.

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 emissions data for the different area source categories are developed, reviewed for quality assurance, stored in the Texas Air Emissions Repository database system, and compiled to develop the statewide area source EI.

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 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 proposed 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 following sections describe the emissions estimates methodologies used for the non-road mobile source subcategories.

2.4.1 NONROAD Model Categories Emissions Estimation Methodology

The Motor Vehicle Emission Simulator 2014b (MOVES2014b) model is the EPA's latest mobile source emissions model for estimating non-road source category emissions. The most recent Texas-specific utility used in conjunction with the non-road mobile component of MOVES2014b model, called Texas NONROAD (TexN2), was used to calculate emissions from all non-road mobile source equipment and recreational vehicles, except for 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 MOVES2014b model or the TexN2 utility, the emissions for these categories are estimated using other EPA-approved methods and guidance.

2.4.2 Drilling Rig Diesel Engines Emissions Estimation Methodology

Although emissions for drilling rig diesel engines are included in the MOVES2014b model, alternate emissions estimates were developed for that source category to develop more accurate county-level inventories. The equipment populations for drilling rigs were set to zero in the TexN2 utility to avoid double counting emissions from these sources.

Due to significant growth in the oil and gas exploration and production industry, a 2015 TCEQ-commissioned 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 county-level 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 method and procedures used to develop the eight-county HGB ozone nonattainment area locomotive EI for this AD SIP revision can be found in the Eastern Research Group, Inc. (ERG) report *2014 Texas Statewide Locomotive Emissions Inventory and 2008 through 2040 Trend Inventories*, available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155153802FY15-20150826-erg-locomotive_2014aerr_inventory_trends_2008to2040.pdf.

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. The method and procedures used to develop the eight-county HGB ozone nonattainment area CMV EI for this AD SIP revision can be found in the ERG report *2014 Texas Statewide Commercial Marine Vessel Emissions Inventory and 2008 through 2040 Trend Inventories*, available at:

https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155149301FY15-20150826-erg-commercial_marine_vessel_2014aerr_inventory_trends_2008to2040.pdf.

2.4.4 The Airport Emissions Estimation Methodology

The airport EI was developed from a TCEQ-commissioned study using the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT). AEDT is the most recent FAA model for estimating airport emissions and has replaced the FAA's Emissions and Dispersion Modeling System. 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.

The method and procedures used to develop the eight-county HGB ozone nonattainment area airport EIs for this AD SIP revision can be found in the Eastern Research Group, Inc. reports:

- *Development of the Statewide Aircraft Inventory for 2011* (available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582188250819-20190515-erg-2011_statewide_airport_emissions_inventory.pdf) and
- *Development of the Statewide Aircraft Inventory for 2020* (available at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582188250819-20190515-erg-2020_statewide_airport_emissions_inventory.pdf).

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.

Updated on-road EIs and emission factors for this proposed HGB AD SIP revision were developed using the EPA's mobile emissions factor model, MOVES2014a.[11] 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 MOVES2014b 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

[11] For on-road EI development, MOVES2014a is technically the most recent on-road model release. The more recent MOVES2014b update only impacts non-road model components and does not change the on-road portion of the model.

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 EI. 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 webpage (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 proposed Houston-Galveston-Brazoria (HGB) Serious Classification 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 November 2018 *Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*[12] (EPA, 2018; 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 proposed HGB AD SIP revision uses photochemical modeling and other analyses to meet the requirements of the EPA's *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements: Final Rule* (2008 eight-hour ozone standard SIP requirements rule) published on March 6, 2015 (80 *Federal Register* (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. Most 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

[12] https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf

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, as detailed in Appendix E*: Modeling Protocol for the DFW and HGB Attainment Demonstration SIP Revisions 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 February 25, 2019 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 into 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: *2012 Baseline Design Value Calculation*.

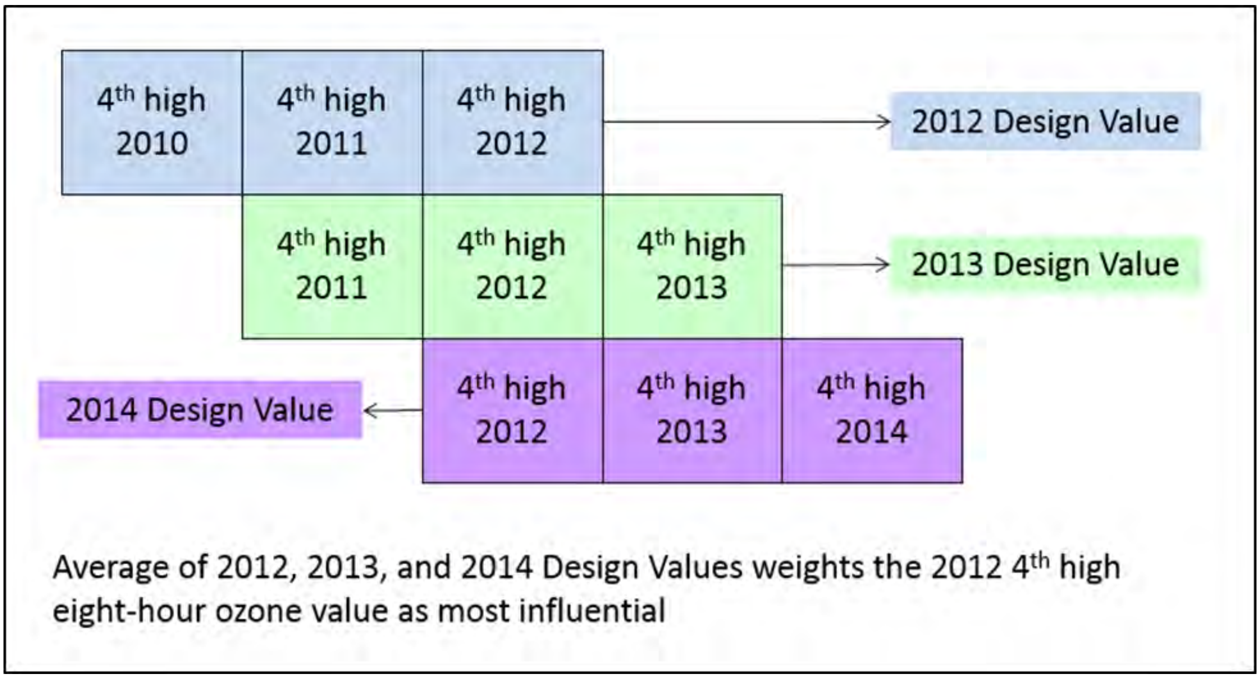


Figure 3-1: 2012 Baseline Design Value Calculation

3.4 EPISODE SELECTION

The 2012 ozone season modeling episode used in the 2016 HGB AD SIP Revision was chosen for this proposed attainment demonstration. Because the timeframe for SIP development was limited, the episode selection process was not updated.

3.4.1 Modeling Guidance for Episode Selection

The November 2018 EPA modeling guidance (EPA, 2018) notes that "…computer speed and storage issues are no longer an impediment to modeling long time periods. In fact, most recent regulatory assessment modeling platforms have been inclusive of entire summers and/or full years (as appropriate) for ozone, $PM_{2.5}$, and regional haze," and consistent with that guidance, the TCEQ modeled an entire ozone season for this attainment demonstration. The EPA guidance also recommends the following criteria that should be considered in the episode selection process:

- Model time periods that are close to the most recently compiled and quality assured National Emissions Inventory (NEI). However, other factors should be considered when selecting a base modeling year, such as the availability and magnitude of observed ambient data, meteorology, and availability of special study data. After consideration of all factors, the most appropriate base year may or may not be an NEI year.
- Model time periods in which observed concentrations are close to the appropriate base year design value or level of visibility impairment and ensure there are a sufficient number of days so that the modeled test applied at each monitor is based on multiple days.
- Model time periods both before and following elevated pollution concentration (poor air quality) episodes to ensure the modeling system appropriately characterizes low pollution periods, development of elevated periods, and transition back to low pollution periods through synoptic cycles.
- Simulate a variety of meteorological conditions conducive to elevated/poor air quality. For eight-hour ozone, choose time periods which reflect a variety of meteorological conditions that frequently correspond with observed eight-hour daily maxima concentrations greater than the level of the NAAQS at monitoring sites in the nonattainment area.

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, which reflects the continuing improvement in measured ozone concentrations in the HGB area. Modeling an entire ozone season also allows the attainment demonstration to reflect the historical bimodal (two peak) pattern of elevated eight-hour ozone concentrations that occurs during the season as shown in Figure 3-2: *HGB Eight-Hour Ozone Exceedance Days by Month from 1990 through 2017*.

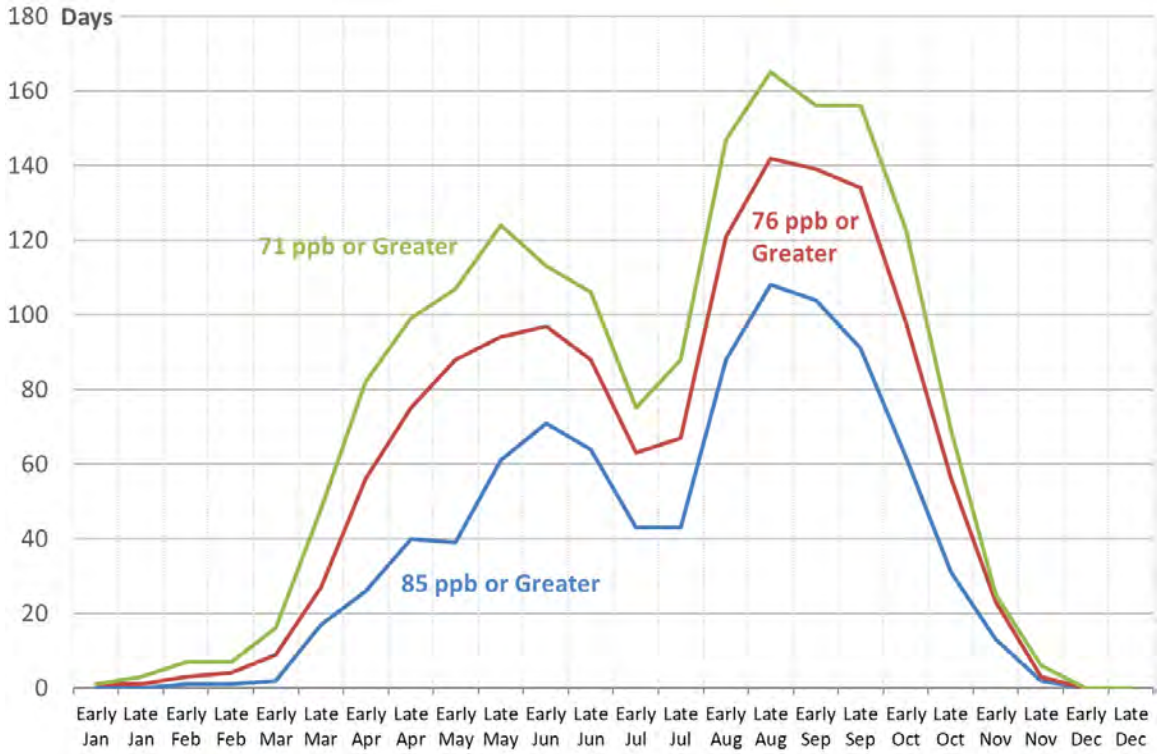


Figure 3-2: HGB Eight-Hour Ozone Exceedance Days by Month from 1990 through 2017

Since ozone and precursor concentrations have declined, it was important to evaluate entire ozone seasons to have sufficient high ozone days for the attainment test. Years 2011 through 2013 were reviewed because DV_Bs could be calculated using official monitoring data. The number of days the HGB area measured a maximum daily average eight-hour (MDA8) ozone concentration above 75 parts per billion (ppb) is shown in Figure 3-3: *HGB Number of Days MDA8 Ozone Concentrations Greater than 75 ppb by Year from 2000 through 2018*. The year 2013 stands out from 2011 and 2012 as having fewer days above the eight-hour ozone NAAQS.

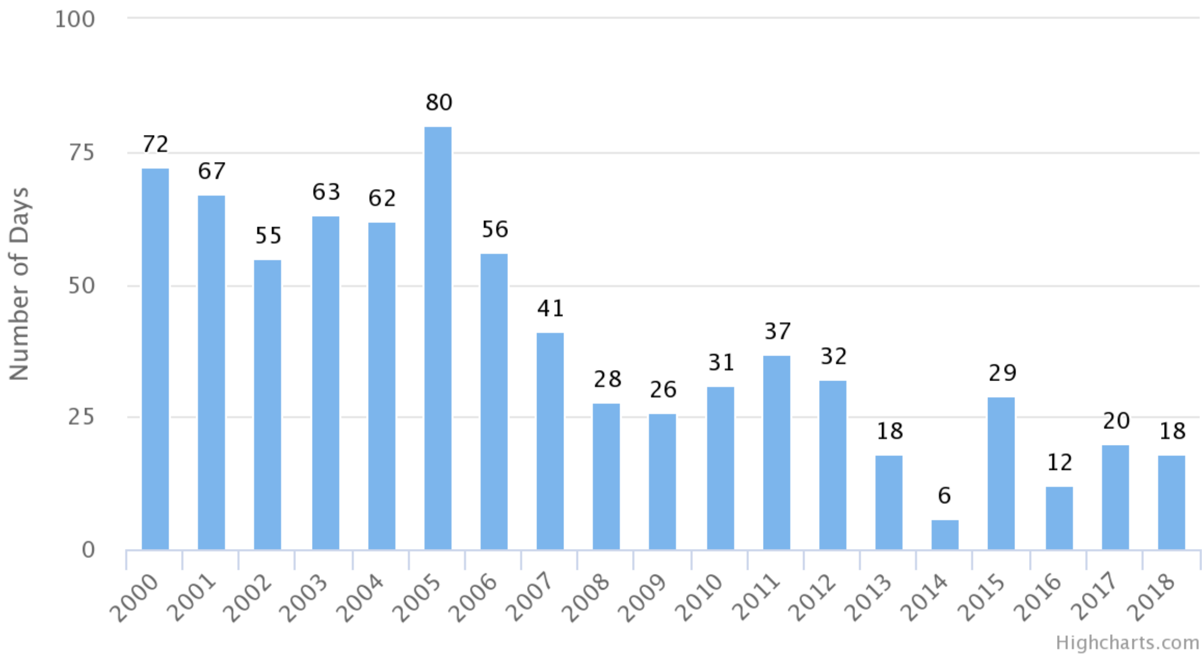


Figure 3-3: HGB Number of Days MDA8 Ozone Concentrations Greater than 75 ppb by Year from 2000 through 2018

June, typically a month with multiple exceedances (see Figure 3-2), only had two days in 2013 with regulatory monitored MDA8 ozone concentrations greater than 75 ppb as shown in Table 3-1: *HGB Days with MDA8 Ozone Concentrations Exceeding 75 ppb by Month from 2011 through 2013*. July 2013 had four exceedances, which is unusual compared to typical July trends.

Table 3-1: HGB Days with MDA8 Ozone Concentrations Exceeding 75 ppb 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 ozone concentrations greater than 75 ppb on seven days as shown in Figure 3-4: *2013 HGB Number of Days with MDA8 Ozone Concentrations Exceeding 75 ppb by Monitor.* Four of those exceedance days at the Manvel Croix Park (C84) monitor and three at the Bayland Park (C53) monitor were observed in July, atypical of HGB ozone seasons. Because high ozone concentrations did not follow the historical bi-modal pattern and did not occur at the typical monitors, 2013 was not considered for ozone season modeling.

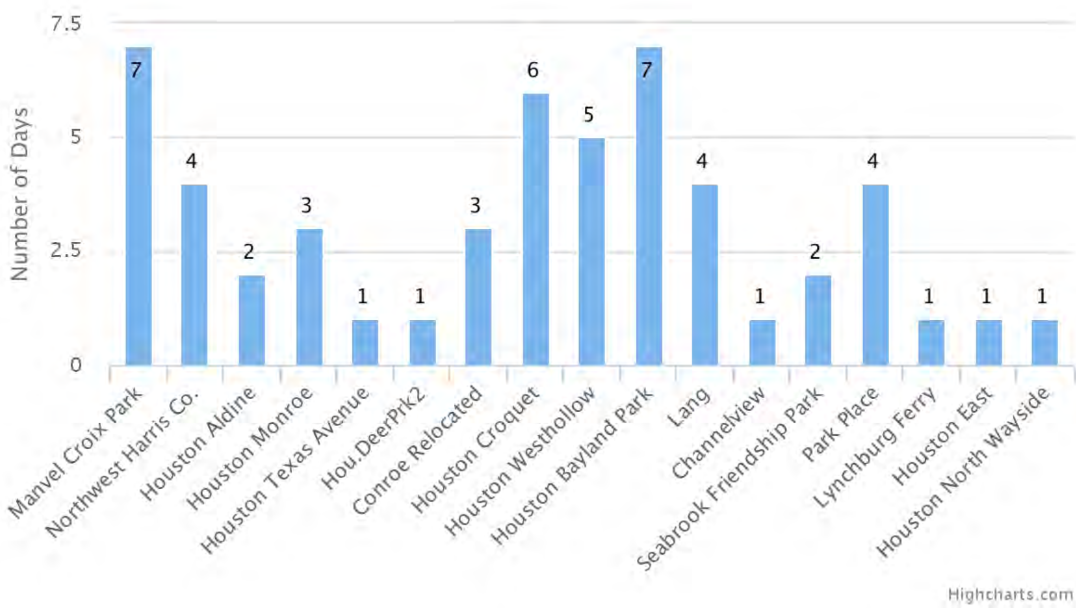


Figure 3-4: 2013 HGB Number of Days with MDA8 Ozone Concentrations Exceeding 75 ppb by Monitor

For 2011, an NEI year, the HGB ozone 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 recordkeeping began in 1895. Figure 3-5: *August 9, 2011 United States (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 (large-scale) 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.

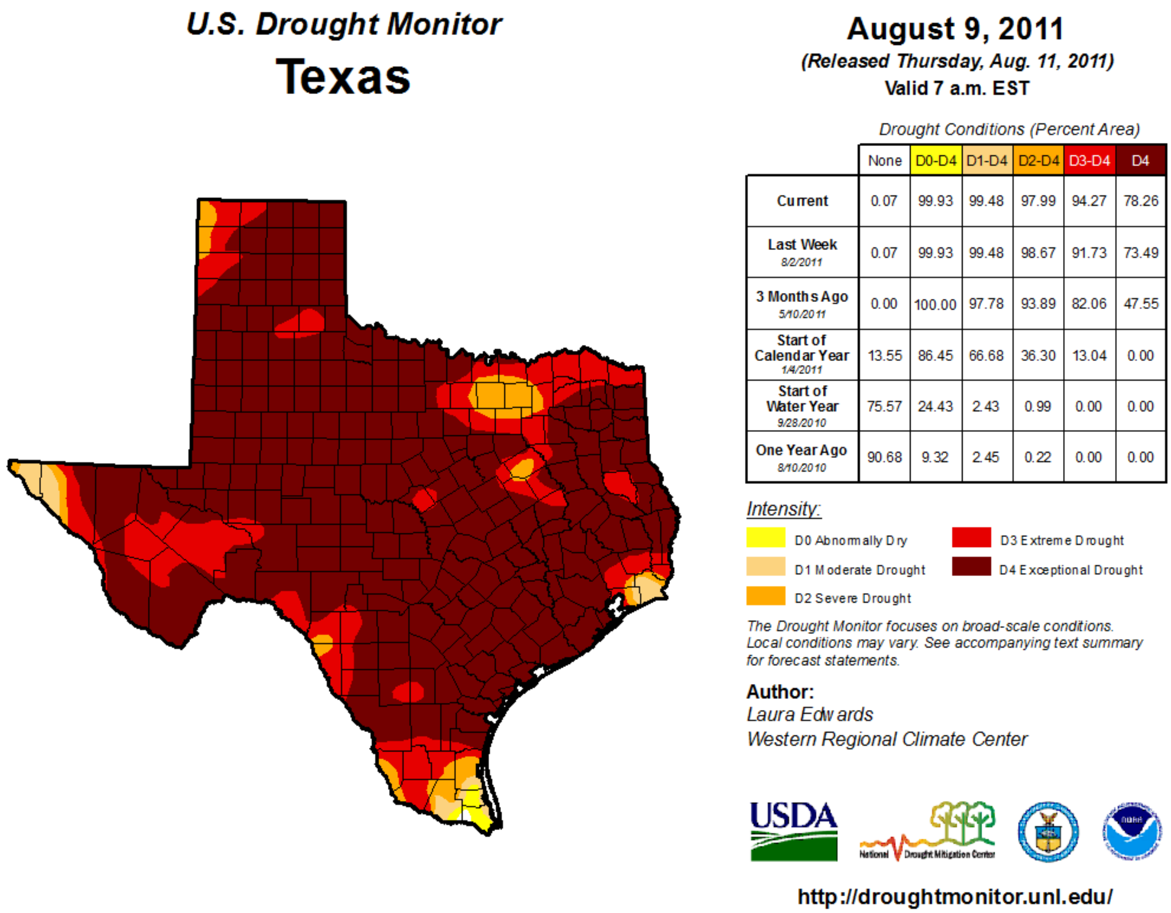


Figure 3-5: August 9, 2011 United States (U.S.) Drought Monitor Map of Texas

In 2012, the HGB ozone 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 as shown in Figure 3-6: *2012 HGB Number of Days with MDA8 Ozone Concentrations Exceeding 75 ppb by Monitor*. Typical of historical ozone exceedance episodes, the Manvel Croix Park (C84) and Bayland Park (C53) monitors were two of the monitors that observed the highest ozone concentrations during 2012.

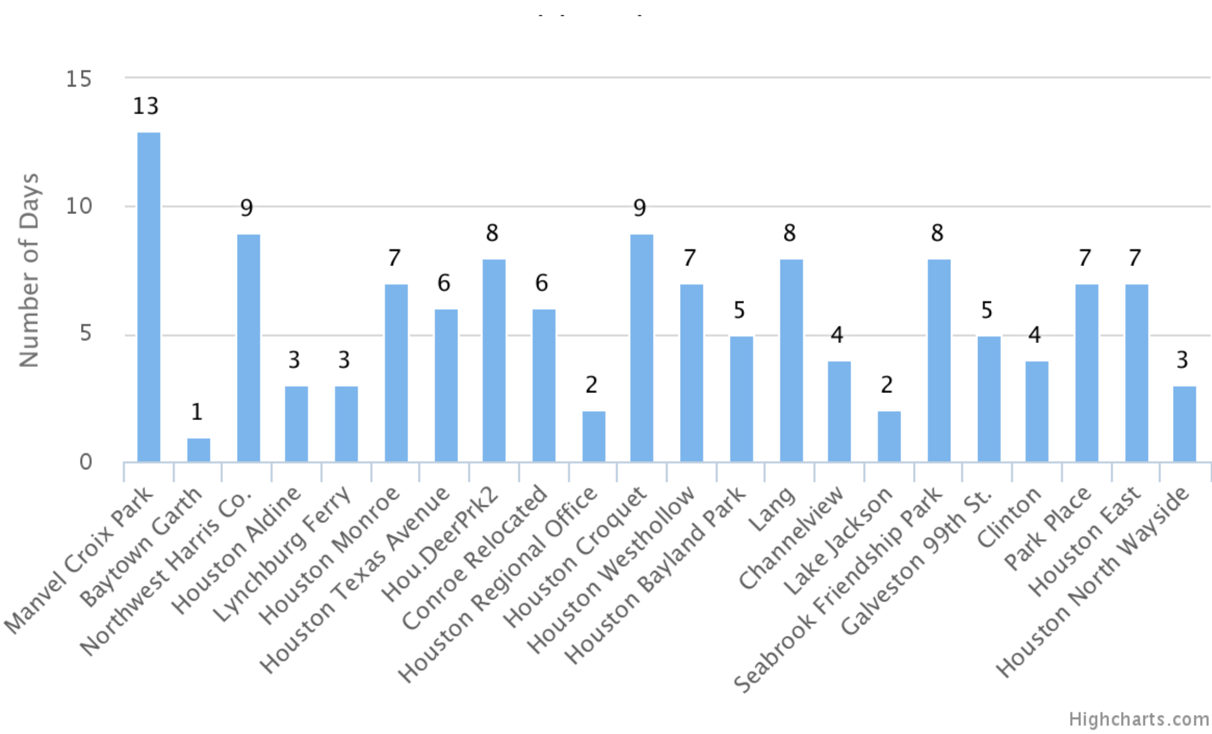


Figure 3-6: 2012 HGB Number of Days with MDA8 Ozone Concentrations Exceeding 75 ppb by Monitor

Texas drought conditions in 2012 were typical of previous years, except for 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 concentrations, and suitable for ozone season modeling.

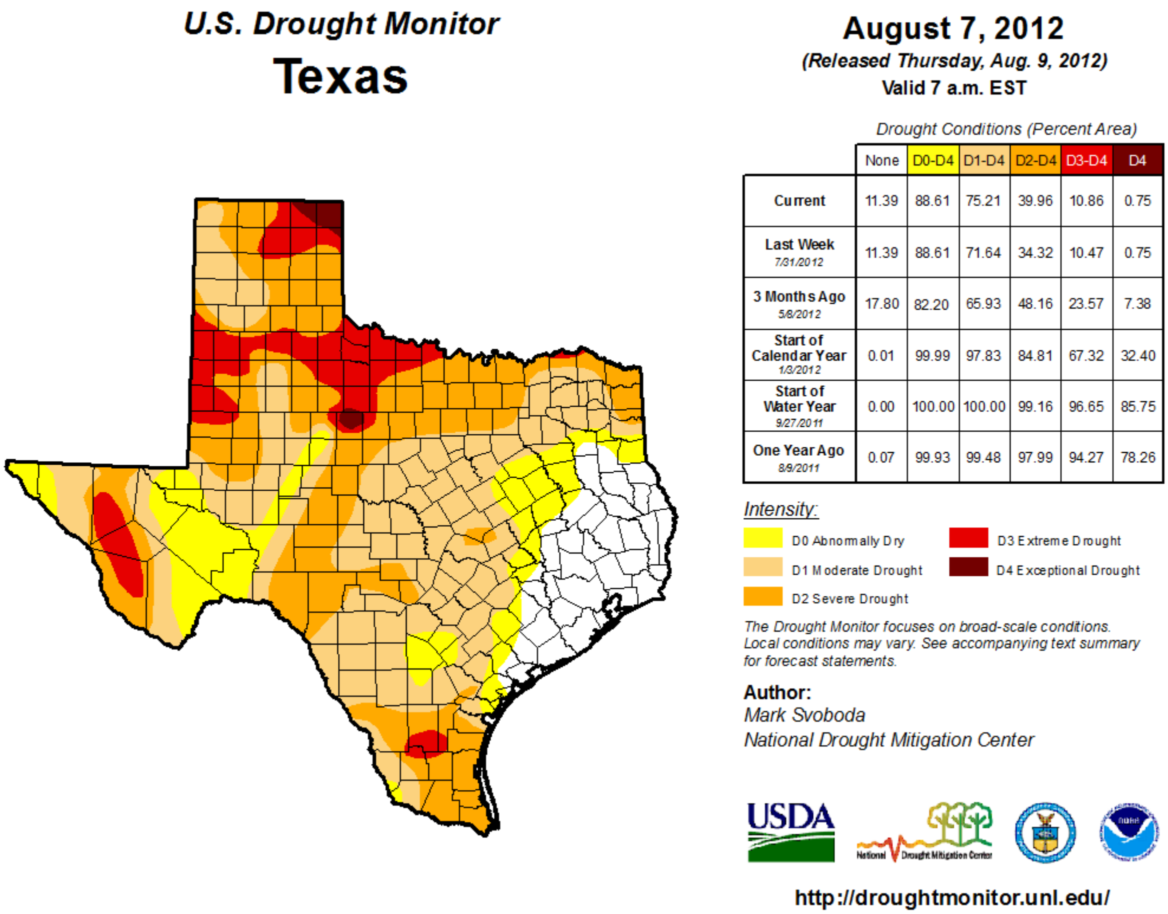


Figure 3-7: August 7, 2012 U.S. Drought Monitor Map of Texas

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, but on some days the high ozone concentrations were widespread, affecting most monitors in the area. For example, on June 26, 2012, 31 monitors observed ozone concentrations 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.

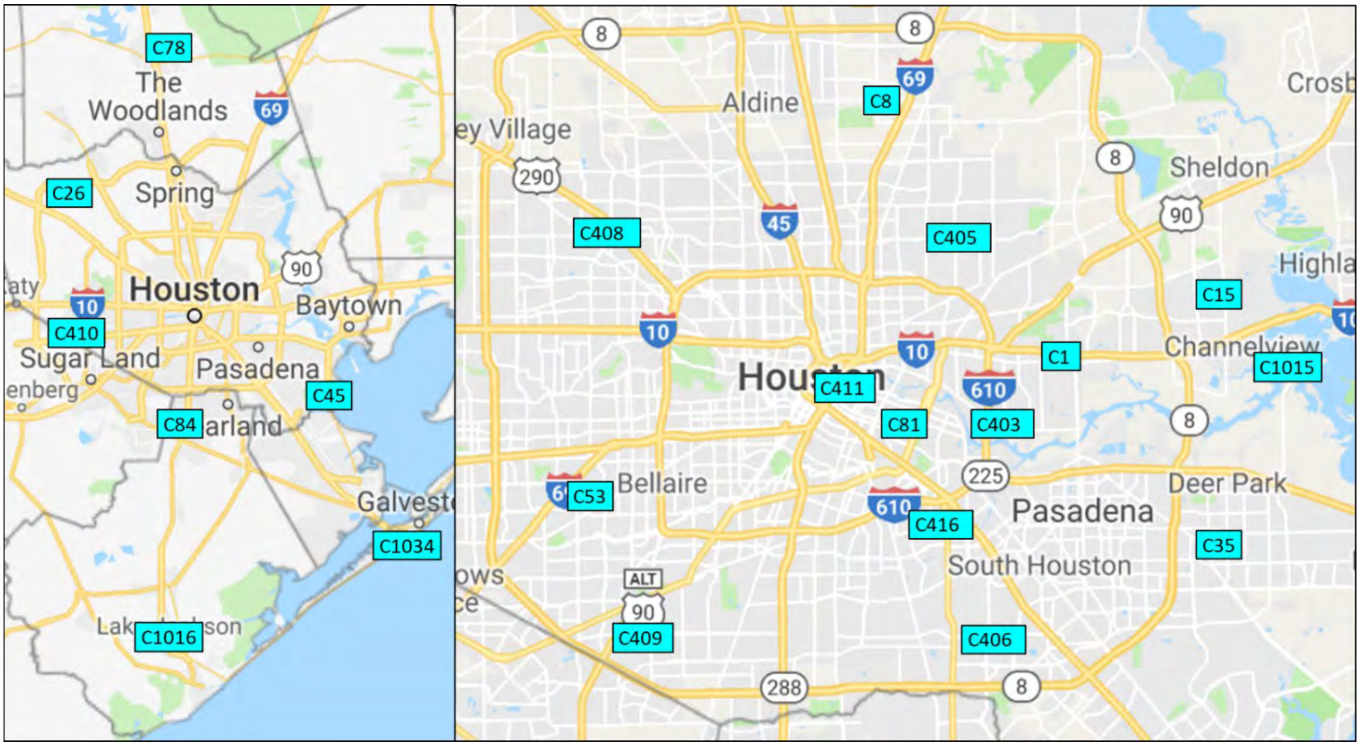


Figure 3-8: HGB Area Regulatory Ozone Monitoring Locations

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 sunny days with slow 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 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors*. The highest observed ozone concentrations in May occurred on May 21, 2012 where 14 monitors exceeded 75 ppb. The Texas City 34th St. (C620) monitor measured the maximum eight-hour ozone concentration of 93 ppb in the area. The seven exceedance days came within a nine-day period, May 14, 2012 through May 22, 2012.

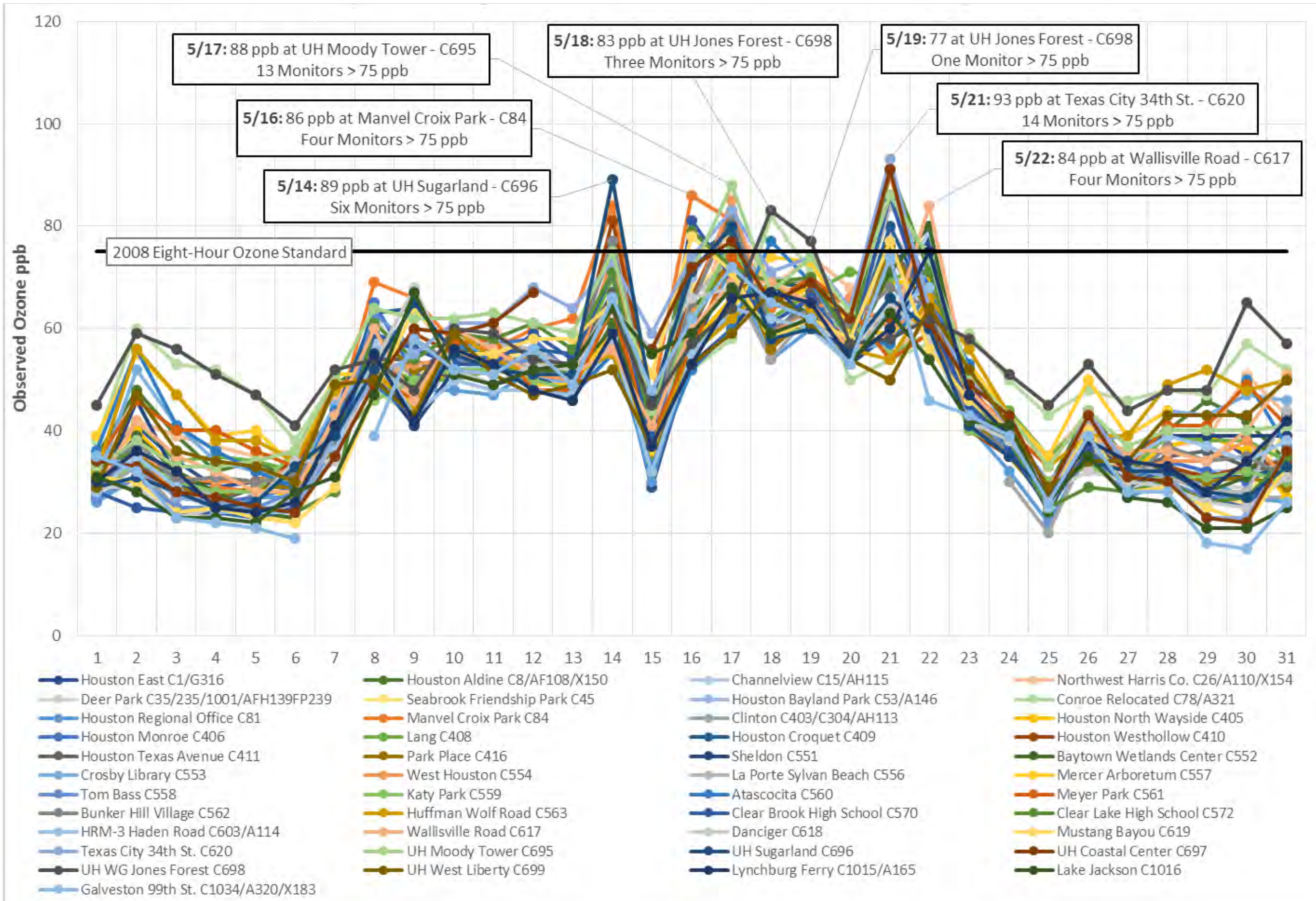


Figure 3-9: May 2012 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors

<u>3.4.3.2 June 2012</u>

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 MDA8 Ozone Concentrations at 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 eight-hour ozone concentration observed since 2003 in the HGB area. Thirty other regulatory and non-regulatory HGB area monitors also measured exceedances on June 26, 2012.

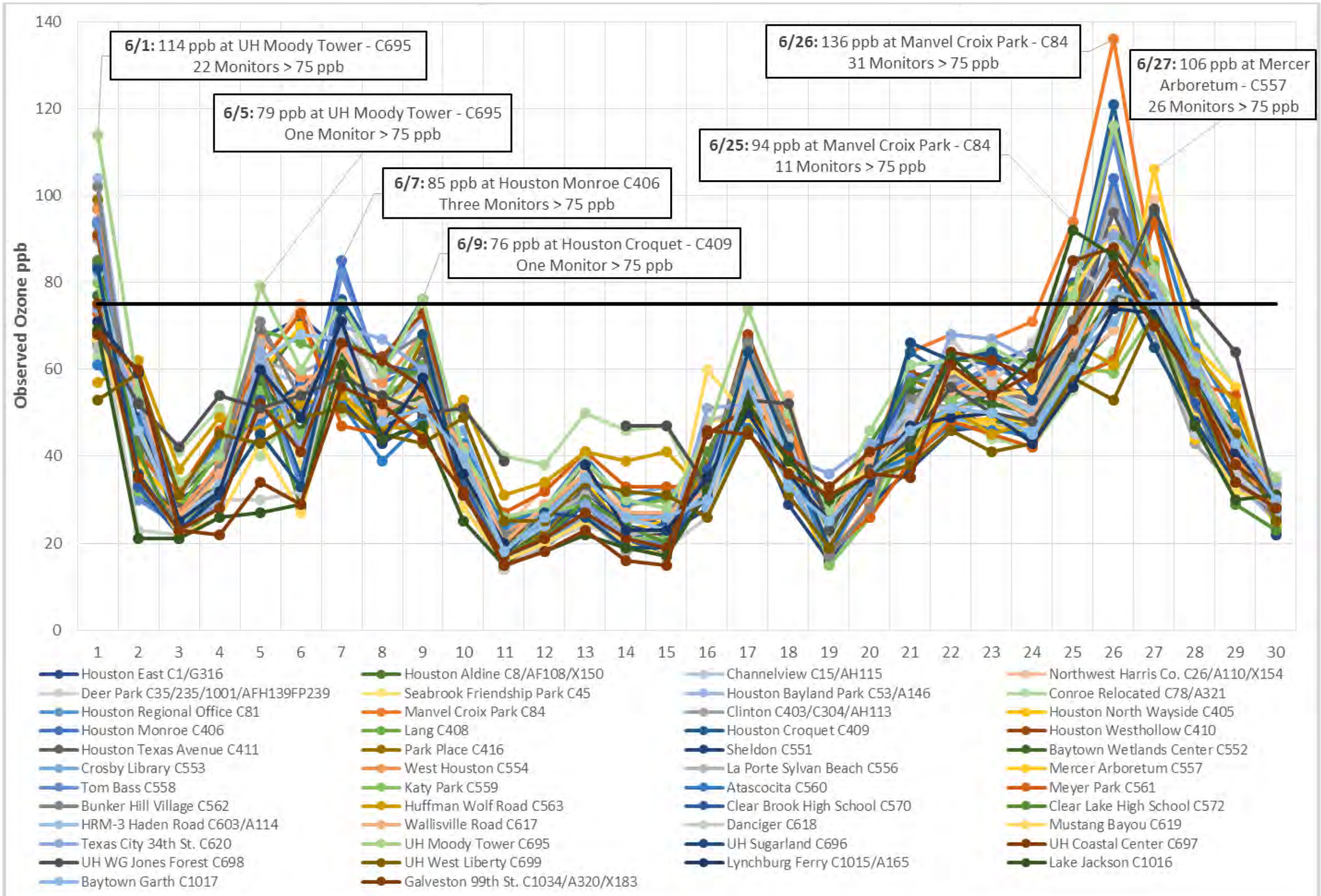


Figure 3-10: June 2012 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors

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 United States (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 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors*.

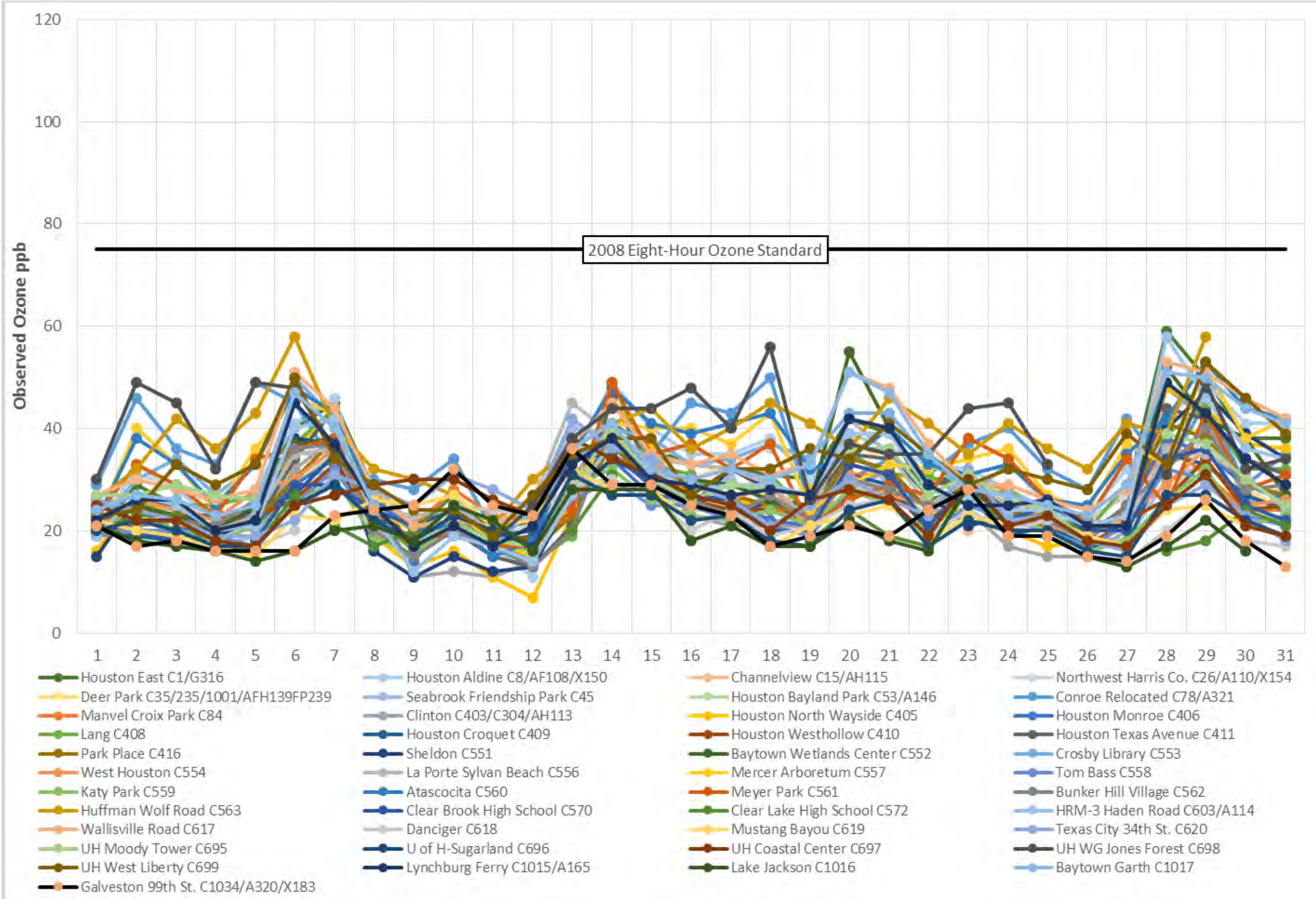


Figure 3-11: July 2012 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors

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 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors.*

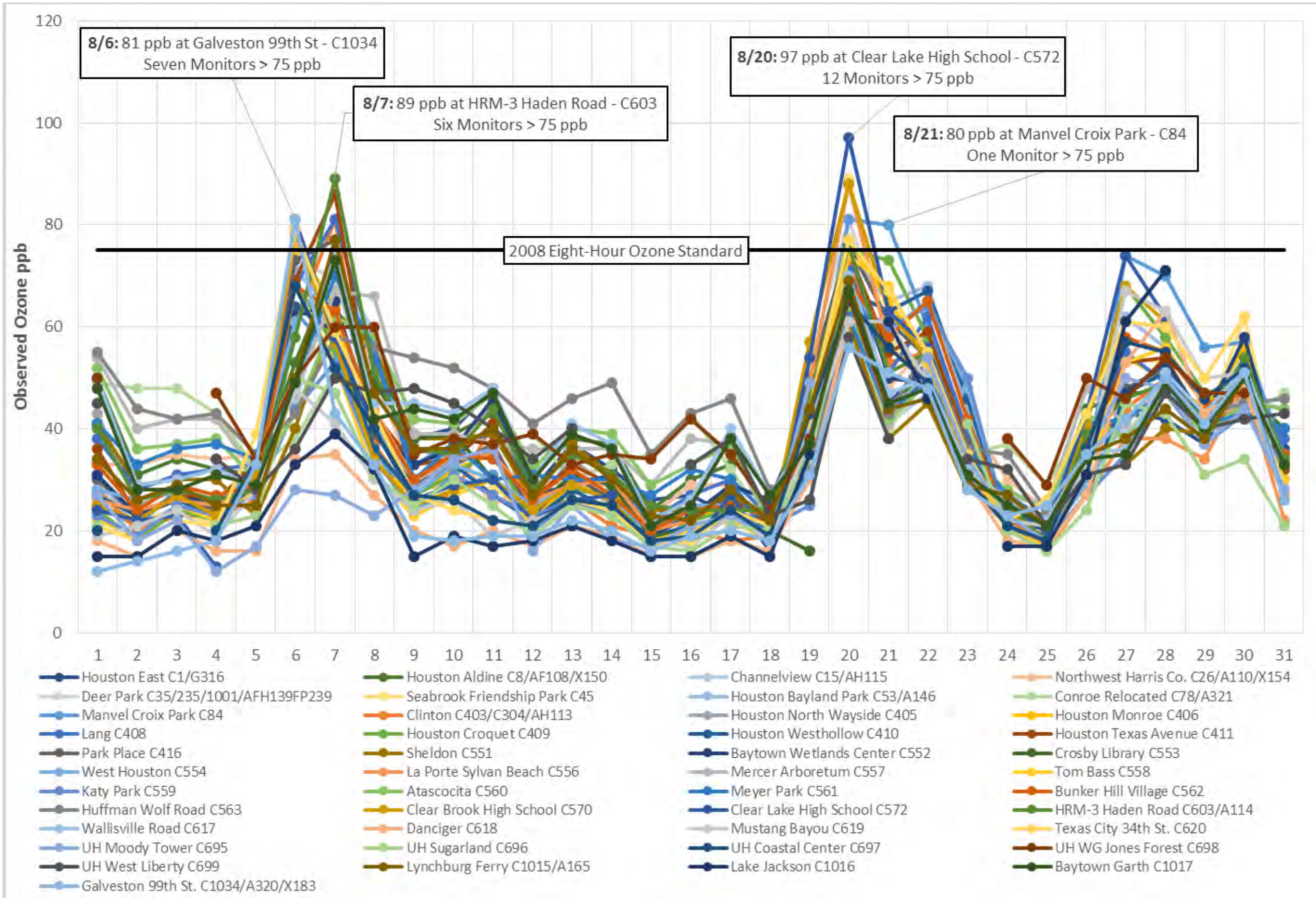


Figure 3-12: August 2012 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors

3.4.3.5 September 2012

The latter bi-modal peak of eight-hour ozone exceedances in the HGB area typically ends during September, as shown in Figure 3-2. Seven HGB area monitors measured exceedances in September 2012. The highest eight-hour ozone concentration of the month was 87 ppb measured at the Manvel Croix Park (C84) monitor on September 20, 2012. 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 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors*. September 20, 2012 through September 24, 2012 saw five consecutive days with measurements exceeding 75 ppb.

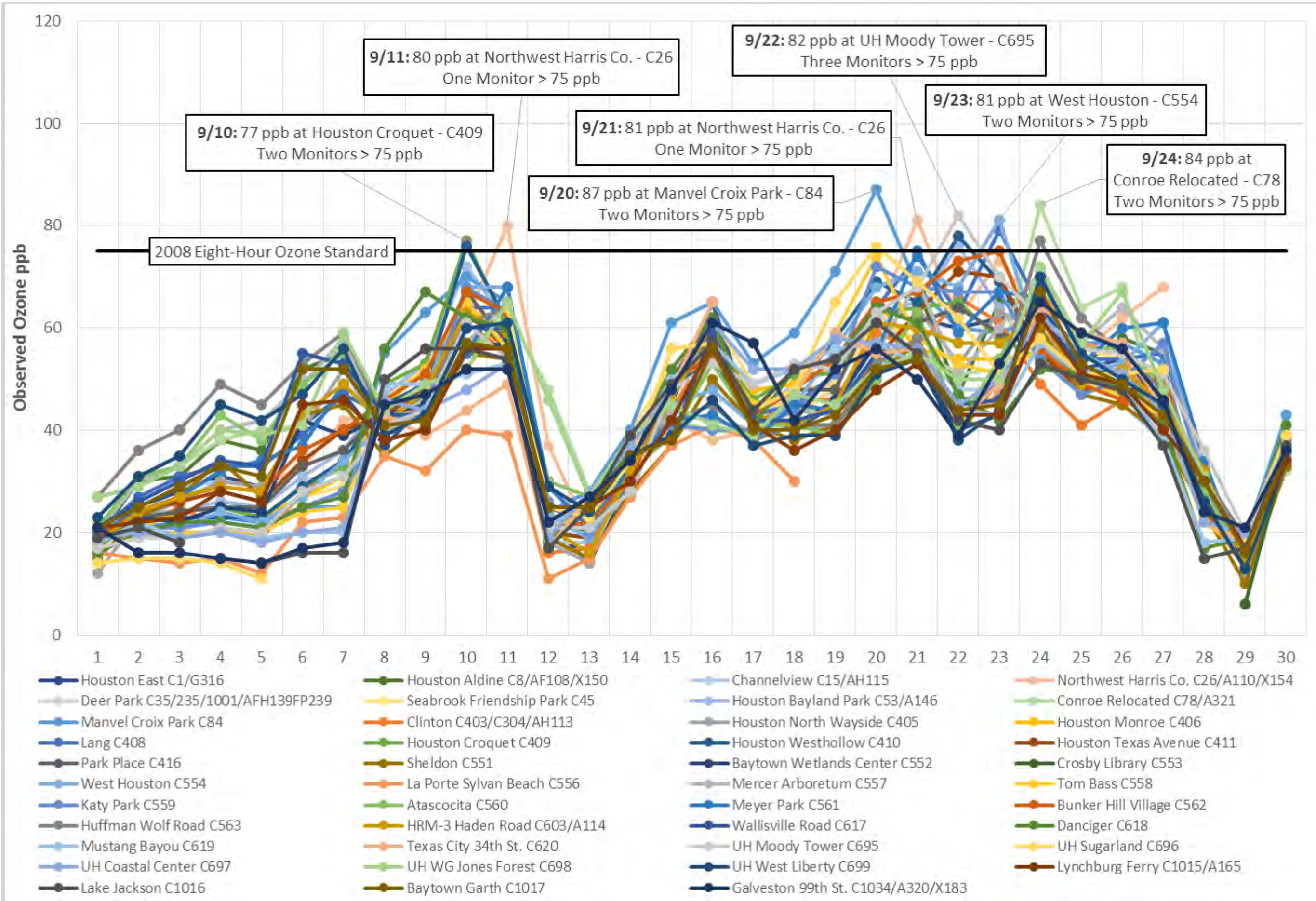


Figure 3-13: September 2012 MDA8 Ozone Concentrations at Regulatory and Non-Regulatory HGB Monitors

3.5 METEOROLOGICAL MODEL

The TCEQ is using the Weather Research and Forecasting (WRF) model 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. The WRF model was designed to be completely mass conservative and built to allow better flux calculations, both of which help to improve air quality modeling. The WRF model 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.

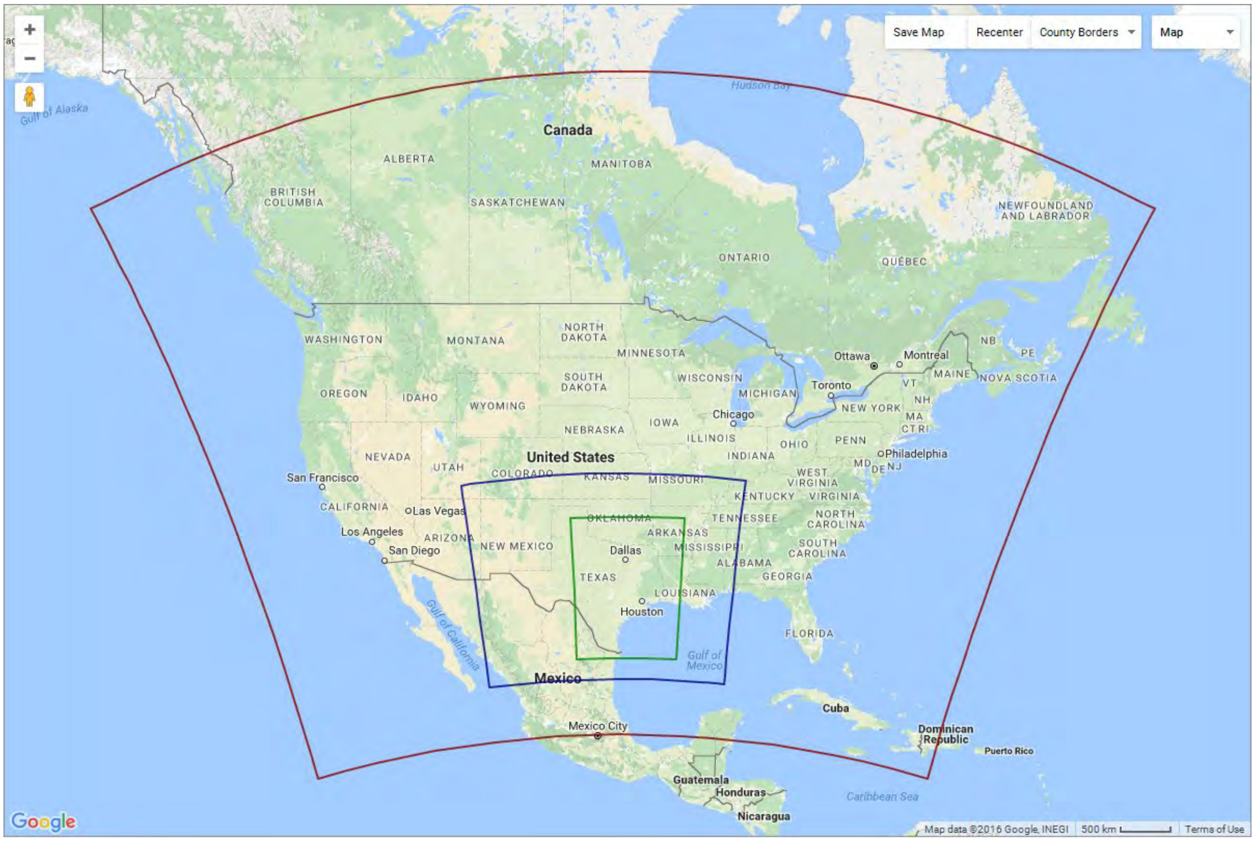


Figure 3-14: WRF Modeling Domains

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*. Table 3-4: *WRF Vertical Layer and Sigma Layer Details* provides details about the sigma coordinate system, which is used to represent scaled pressure levels. 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 model layers.

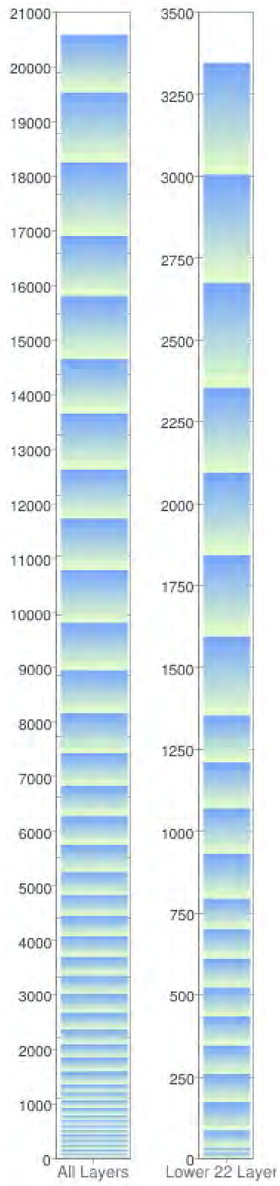


Figure 3-15: WRF Vertical Layer Structure

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 (MPE). The preparation of WRF input files involves the execution of different models within the Weather Research and Forecasting Model Preprocessing System (WPS). Analysis nudging[13] 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 model 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 (m) 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 the WRF model through a series of sensitivities. The final WRF model 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.

[13] Nudging is a form of data assimilation that adjusts dynamic model variables to provide a more realistic representation of atmospheric processes at a specific time. Nudging is a continuous, four-dimensional technique, since the assimilation is applied to a three-dimensional model at every time step over a specified period.

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 Model 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 Meteorological Modeling Performance Statistics* 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.

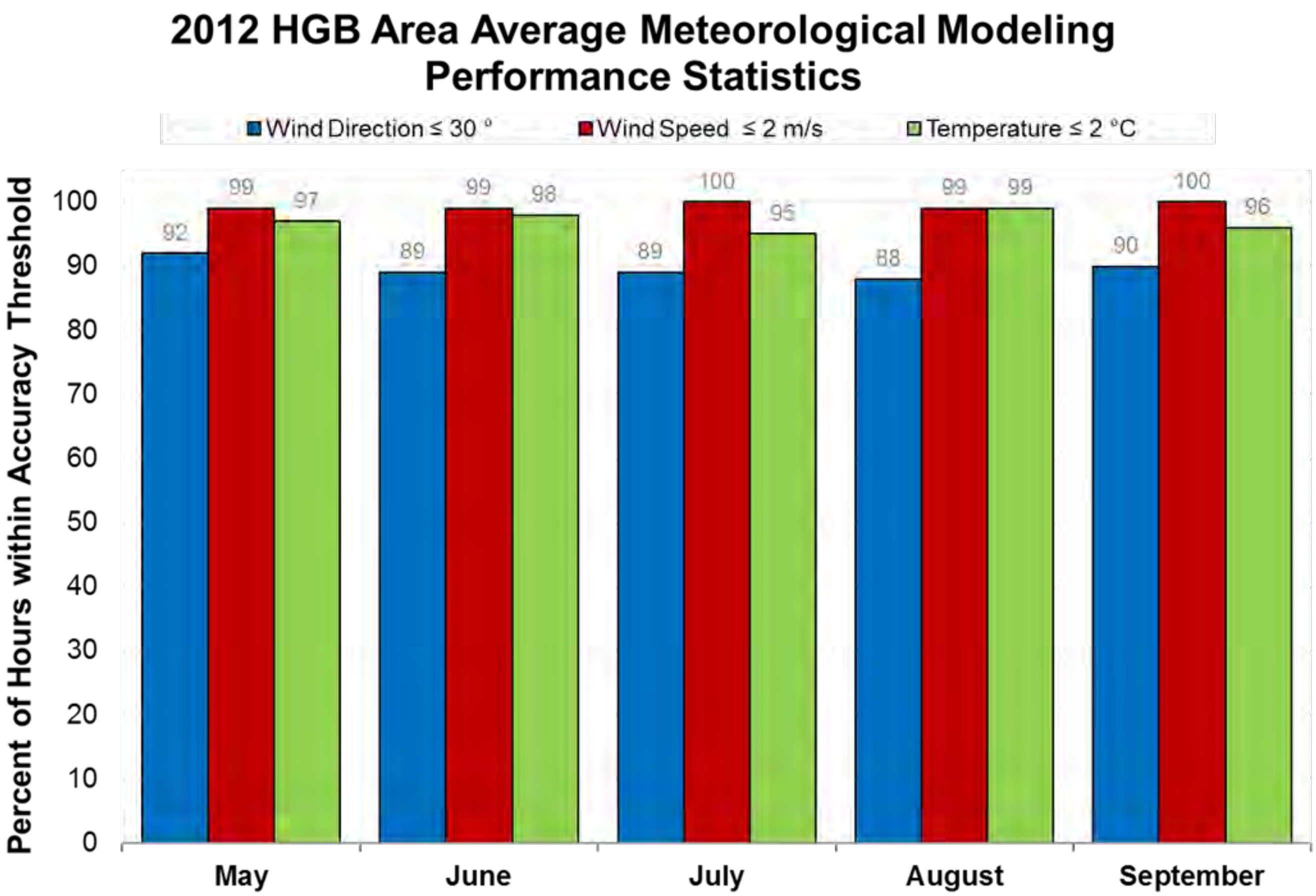


Figure 3-16: 2012 HGB Area Average Meteorological Modeling Performance Statistics

As Figure 3-16 shows, the WRF model performed well for wind speed, wind direction, and temperature for the HGB area. As noted in Section 3.5.2: *Meteorological Model Configuration*, the WRF model 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 DFW and HGB Attainment Demonstration SIP Revisions for the 2008 Eight-Hour Ozone Standard* provides additional detail on the development and MPE 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 emissions inventories (EIs) 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's Motor Vehicle Emissions Simulator (MOVES) model. Non-road mobile source emissions were derived from the Texas NONROAD (TexN) model and MOVES. 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 in this section of the emission inputs used for the 2012 base case, 2012 baseline, and 2020 future case. Appendix B: *Emissions Modeling for the DFW and HGB Attainment Demonstration SIP Revisions 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. 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 2020 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.

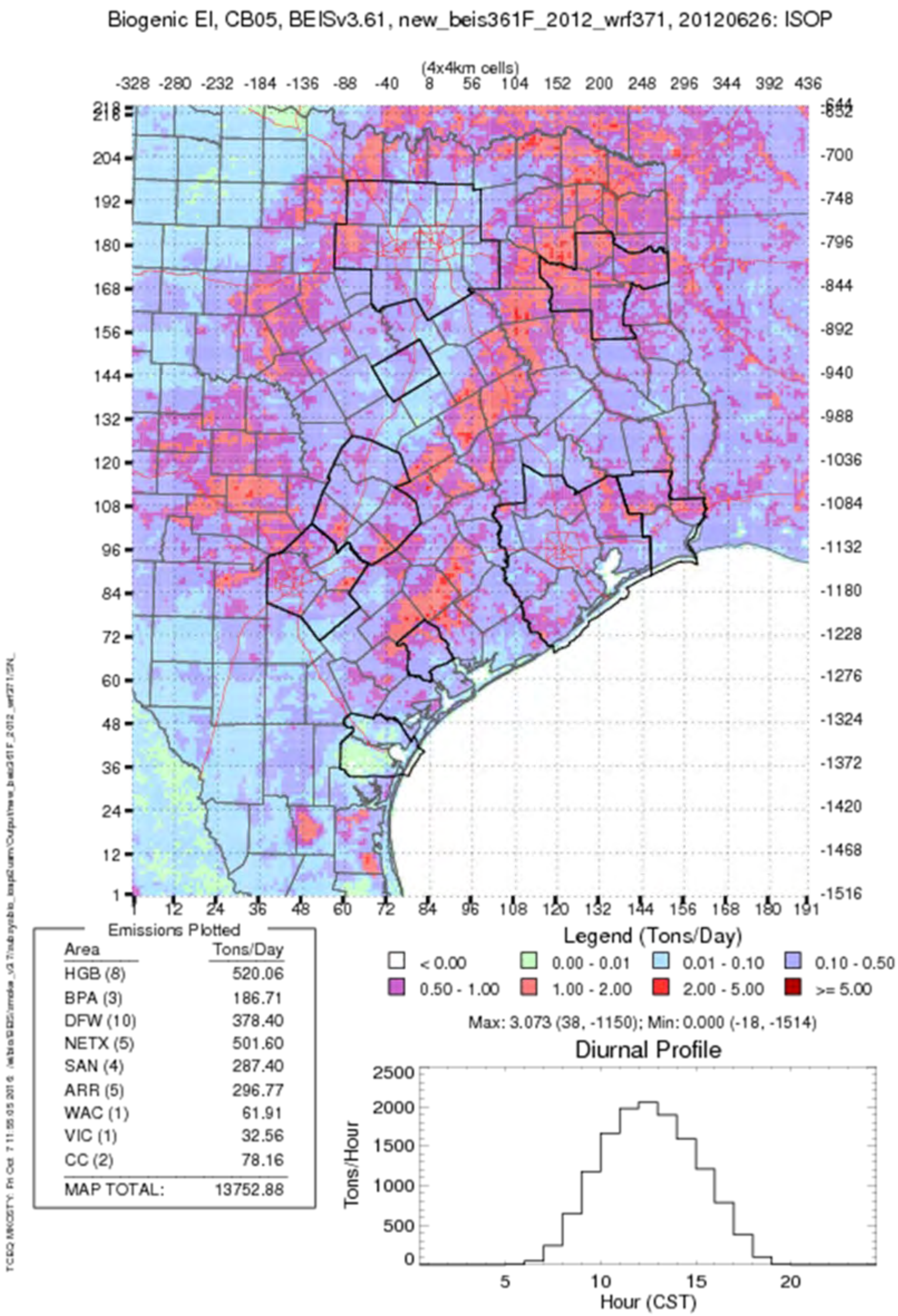


Figure 3-17: Sample Biogenic VOC Emissions for June 26, 2012 Episode Day

3.6.2 2012 Base Case Emissions

3.6.2.1 Point Sources

Point source modeling emissions were developed from regional inventories such as the EPA's 2011 Modeling Platform, the EPA's Air Markets Program Data (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 several 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 2010 National Pollutant Release Inventory from Environment Canada, while Mexican emissions data were interpolated from the 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 the Eight-County HGB Area* 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 the Eight-County HGB Area

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 (Ozone Season Monthly Average)	69.76	130.68	65.16
Eight-County 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: average weekday (Monday - Thursday), 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: average weekday (Monday - Thursday), 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 2012 on-road inventory was interpolated between 2010 and 2017 on-road inventories available from the EPA's 2011 Modeling Platform (EPA, 2015). For the Mexico portion of the modeling domain, a 2012 on-road inventory was interpolated between 2011 and 2023 on-road inventories developed with MOVES-Mexico that were obtained from the EPA's 2011 Modeling Platform (EPA, 2015).

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 the Eight-County HGB Area* 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: *2012 Base Case On-Road Modeling Emissions for the Eight-County HGB Area* 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 the Eight-County HGB Area

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Summer Weekday	157.09	73.60	835.50
Summer Friday	165.16	75.77	893.36
Summer Saturday	124.78	64.38	716.66
Summer Sunday	102.54	60.26	622.08
School Weekday	157.60	73.73	838.94
School Friday	166.44	76.10	901.44
School Saturday	123.49	64.17	711.83
School Sunday	101.53	60.10	618.39

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, MOVES 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 MOVES to generate average summer weekday non-road mobile source emissions by county, specifically for 2012. For the off-road categories of aircraft, locomotive, and commercial marine, the TCEQ used the EPA's 2014 and 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 version 2.0 of the TexN model (Eastern Research Group (ERG), 2018) to generate average summer weekday non-road mobile source category emissions by county for 2012 except for airports and oil and gas drilling rigs emissions, which were estimated separately. Aggregate weekday 2012 non-road emission estimates for the HGB area are detailed in Table 3-11: *2012 Base Case Non-Road Model Source Emissions for the Eight-County HGB Area*. During EPS3 processing, temporal adjustments were made to create Saturday and Sunday non-road emission estimates. Table 3-12: *2012 Base Case Non-Road Modeling Emissions by Day Type for the Eight-County HGB* Area summarizes these non-road inputs by day type.

Table 3-11: 2012 Base Case Non-Road Model Source Emissions for the Eight-County HGB Area

Non-Road Source Classification	NO_X (tpd)	VOC (tpd)	CO (tpd)
Construction and Mining Equipment	26.22	4.64	44.55
Industrial Equipment	13.54	2.69	64.84
Agricultural Equipment	6.57	0.83	6.40
Commercial Equipment	6.15	7.63	171.46
Lawn and Garden Equipment	2.08	11.77	138.91
Pleasure Craft	1.33	10.06	28.09
Recreational Equipment	0.25	6.19	24.62
Logging Equipment	0.16	0.12	1.22
Railroad Equipment	0.06	0.01	0.06
Eight-County HGB Non-Road Total	56.36	43.94	480.15

Table 3-12: 2012 Base Case Non-Road Modeling Emissions by Day Type for the Eight-County HGB Area

Ozone Season Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	56.36	43.94	480.15
Saturday	45.51	94.39	677.27
Sunday	35.52	88.15	589.09

Airport EIs were developed with the Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT) version 2d for 2011 under contract to ERG (ERG, 2019a). 2011 emission estimates were held constant to 2012. AEDT estimates emissions for aircraft engines, auxiliary power units (APUs), and ground support equipment (GSE). The 2012 eight-county HGB area airport emissions are summarized in Table 3-13: *2012 Base Case Airport Modeling Emissions for the Eight-County HGB Area*.

Table 3-13: 2012 Base Case Airport Modeling Emissions for the Eight-County HGB Area

HGB Area Airport	NO_X (tpd)	VOC (tpd)	CO (tpd)
George Bush Intercontinental	6.17	0.90	9.74
William P. Hobby	1.86	0.56	5.17
Ellington Field	0.54	0.70	6.33
Other Regional Airports	0.31	0.34	8.34
Eight-County HGB Airport Total	8.88	2.50	29.58

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 3-14: *2012 Base Case Locomotive Modeling Emissions for the Eight-County HGB Area* summarizes the estimates for all locomotive activity in HGB.

Table 3-14: 2012 Base Case Locomotive Modeling Emissions for the Eight-County HGB Area

Locomotive Source Classification	NO_X (tpd)	VOC (tpd)	CO (tpd)
Line-Haul Locomotives - Class I	11.93	0.74	2.65
Line-Haul Locomotives - Classes II and III	0.28	0.02	0.04
Rail Yard Switcher Locomotives	3.09	0.23	0.45
Eight-County HGB Locomotive Total	15.30	0.99	3.14

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 eight-county HGB area commercial marine emissions are summarized in Table 3-15: *2012 Base Case Commercial Marine Modeling Emissions for the Eight-County HGB Area*.

Table 3-15: 2012 Base Case Commercial Marine Modeling Emissions for the Eight-County HGB Area

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 Cargo Vessels	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
Harbor Vessels	0.34	0.01	0.05
Tug Barge	0.31	0.02	0.04
Cruise Ship	0.27	0.00	0.02
Assist Tug	0.01	0.00	0.01
Eight-County HGB Marine Total	27.74	1.33	4.21

3.6.2.4 Area Sources

Area source modeling emissions were developed using the EPA's 2014 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 2014 NEI to create 2012 daily area source emissions.

Within Texas

The TCEQ obtained emissions data from the 2014 TexAER database (TCEQ, 2014) and backcast 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 3-16: *2012 Base Case Non-Oil and Gas Area Source Emissions for the Eight-County HGB Area*.

Table 3-16: 2012 Base Case Non-Oil and Gas Area Source Emissions for the Eight-County HGB Area

Ozone Season Day Type	NO_x (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	18.29	248.27	86.91
Saturday	13.31	156.73	55.15
Sunday	8.34	110.79	24.01

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 with the oil and gas production sources category since most drilling rigs are used for oil and gas production. Emission estimates by equipment type are summarized in Table 3-17: *2012 Base Case Oil and Gas Drilling and Production Emissions for the Eight-County HGB Area*.

Table 3-17: 2012 Base Case Oil and Gas Drilling and Production Emissions for the Eight-County HGB Area

Equipment Category	NO_X (tpd)	VOC (tpd)	CO (tpd)
Drilling Rigs	0.79	0.06	0.26
Production (Non-Point Source)	2.09	66.60	2.78
Eight-County 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 3-18: *2012 Sample Base Case Anthropogenic Emissions for the Eight-County HGB Area*. The EGU emissions presented in Table 3-18 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 3-18: 2012 Sample Base Case Anthropogenic Emissions for the Eight-County HGB Area

HGB Emission Source Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
On-Road	157.09	73.60	835.50
Non-Road	56.36	43.94	480.15
Off-Road - Airports	8.88	2.50	29.58
Off-Road - Locomotives	15.30	0.99	3.14
Off-Road - Commercial Marine	27.74	1.33	4.21
Area Sources	18.29	248.27	86.91
Oil and Gas - Drilling	0.79	0.06	0.26
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
Eight-County HGB Total	402.28	572.87	1,562.36

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 3-19: *2012 August Baseline Anthropogenic Emissions for the Eight-County HGB Area* provides the baseline emissions for an average August weekday. The only difference between Table 3-18 and Table 3-19 is that Table 3-18 has episode day-specific EGU emissions.

Table 3-19: 2012 August Baseline Anthropogenic Emissions for the Eight-County HGB Area

HGB Emission Source Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
On-Road	157.09	73.60	835.50
Non-Road	56.36	43.94	480.15
Off-Road - Airports	8.88	2.50	29.58
Off-Road - Locomotives	15.30	0.99	3.14
Off-Road - Commercial Marine	27.74	1.33	4.21
Area Sources	18.29	248.27	86.91
Oil and Gas - Drilling	0.79	0.06	0.26
Oil and Gas - Production	2.09	66.60	2.78
Point - EGUs (August Average)	36.49	3.99	41.90
Point - Non-EGUs (Ozone Season Average)	69.76	130.68	65.16
Eight-County HGB Total	392.79	571.96	1,549.59

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 3-20: *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 3-20: 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	3.62	40.82
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

SIC Code	SIC Description	NO_X (tpd)	VOC (tpd)	CO (tpd)
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	9.48
	Eight-County HGB Point Source Total (89 SICs)	106.25	134.67	107.07

3.6.4 2020 Future Case Emissions

The biogenic emissions used for the 2020 future case modeling are the same episode day-specific emissions used in the base case. Similar to the 2012 baseline, fire emissions were not included in the 2020 future case modeling.

3.6.4.1 Point Sources

Outside Texas

The 2020 non-EGU point source emissions data in Mexico and the non-Texas states were derived by interpolating between the EPA's 2017 and 2023 non-EGU files from the EPA's 2011 Emissions Modeling Platform (EPA, 2014). Non-Texas EGU point source emissions for 2020 were determined based on 2018 AMPD emissions and whether the state had an emissions budget under the 2016 Cross-State Air Pollution Rule (CSAPR) Update Rule.

For non-Texas EGUs in states with prescribed budgets under the CSAPR Update Rule ozone season NO_X program, the 2018 AMPD emissions were scaled to meet the applicable state budgets. For non-Texas EGUs not subject to the CSAPR Update Rule, the 2018 AMPD emissions were used for the 2020 future year. For the Gulf of Mexico point sources, the 2020 emissions were set equal to the 2012 baseline. Canadian point sources were 2023 projections sourced from the EPA's 2011 Modeling Platform (EPA, 2014).

Within Texas

The 2020 future case EGU emission estimates within Texas were based on the 2018 AMPD data and the prescribed CSAPR Update Rule ozone season NO_X program budget of 52,301 NO_X tons for the five-month ozone season of May through September. Since electricity generation varies based on energy demand (higher emissions during hotter days due to increased demand), operational profiles based on 2018 AMPD data were used to allocate hourly emissions for ozone season modeling purposes. Future case EGU estimates accounted for retirements as well as newly permitted EGUs. More details regarding Texas EGU point sources and CSAPR can be found in Appendix B, Section 2.3: *2020 Future Year Point Source Modeling Emissions Development*.

For HGB point sources, the 2020 future year emissions were projected from the 2016 STARS data considering the effect of all applicable rules and regulations, including the Emissions Banking and Trading (EBT) programs and expected growth (ERG, 2016). 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 2020 annual MECT program cap of 40,248.7 tons per year (tpy). In addition, for point sources subject to the MECT Program, an additional 1,232.0 tpy of emissions were added to account for the possible use of discrete emission reduction credits (DERCs) and mobile discrete emission reduction credits (MDERCs) for MECT compliance as allowed under 30 Texas Administrative Code (TAC) §101.356(h). Similarly, the HRVOC emissions of point sources within Harris County that are subject to the Highly Reactive Volatile Organic Compounds Emissions Cap and Trade (HECT) Program were limited to the 2020 HECT program cap of 2,590.3 tpy.

For non-EGU HGB point sources not subject to MECT or HECT programs, the available certified emission reduction credits (ERCs), DERCs, and MDERCs as of February 2, 2019 needed to offset future emissions growth per Nonattainment New Source Review permitting rules were considered when determining 2020 future year emissions. Details regarding the certified credits, the methodology used for determining the appropriate amount of credits that might be used to offset emissions growth in 2020, and the methodology used to distribute the associated emissions are provided in Appendix B, Section 2.3.2.4: *Non-EGU Sources in Nonattainment Areas*.

Table 3-21: *2020 HGB Point Source Future Case Emission Projections by Industry Type* provides a summary of the 2020 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 2020 future year is modeled at the CSAPR caps of 38.54 NO_X tpd for August. This conservative approach of modeling the maximum allowable emission levels ensures that future emissions are not underestimated.

Table 3-21: 2020 HGB Point Source Future Case Emission Projections by Industry Type

SIC Code	SIC Description	NO_X (tpd)	VOC (tpd)	CO (tpd)
4911	Electric Services	52.69	1.76	37.58
2869	Industrial Organic Chemicals, Not Elsewhere Classified	47.67	36.97	27.78
2911	Petroleum Refining	23.05	25.62	14.76
4931	Electric and Other Services Combined	4.07	0.18	2.89
2813	Industrial Gases	2.62	0.43	4.37
4961	Steam and Air Conditioning Supply	2.16	0.07	1.08
2819	Industrial Inorganic Chemicals	1.59	0.57	0.71
1321	Natural Gas Liquids	1.39	1.84	1.42
2821	Plastic Materials and Resins	1.20	9.06	3.43
2865	Cyclic Organic Crudes and Intermediates, and Organic Dyes and Pigments	1.09	0.50	0.46
	Remaining 79 SICs Less than 1.0 NO_X tpd	6.07	44.55	9.80
	Eight-County HGB Point Source Total (89 SICs)	143.60	121.55	104.28

SIP Emissions Year and Emission Credit Generation

The EBT rules in 30 TAC §101.300 and §101.370 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. This proposed HGB AD SIP revision revises the SIP emissions years used for point source credit generation to

2018 for EGUs with emissions recorded in the EPA's AMPD and 2016 for all other point sources.

Potential Emission Credit Modeling Sensitivity

As stated earlier, future year emissions estimation in HGB accounts for the projected growth and the availability of ERCs to offset the projected growth. A sensitivity modeling run was performed to determine the impact of certified and potential (submitted applications that have not yet been certified) ERCs on the 2020 future design value in HGB. The sensitivity was performed to ensure that the emissions associated with ERCs remain surplus, as required by 30 TAC Chapter 101, Subchapter H, Division 1.

To determine the impact of modeling all certified and potential ERCs as future year emissions without being limited by expected growth, a total of 652.3 tpy of NO_X and 1,407.5 tpy of VOC ERCs were modeled on non-EGU point sources that are not subject to the MECT or HECT programs. The modeling of all ERCs without being limited by expected growth resulted in a 0.002 ppb increase to the maximum 2020 DV_F (76.584 ppb to 76.586 ppb at the Manvel Croix Park (C84) monitor). The DV_F increased across all monitors except at the non-regulatory Houston Regional Monitoring (HRM)-sponsored HRM-3 (C603) monitor, where a decrease of 0.028 ppb occurred. The maximum increase of 0.024 ppb occurred at the Galveston 99th Street (C1034) monitor. After rounding and truncation, the DV_F of the potential ERC sensitivity remains at 76 ppb. Additional details of the ERC sensitivity development are provided in Appendix B, Section 2.3.2.4.

3.6.4.2 On-Road Mobile Sources

The 2020 on-road mobile source emission inputs were developed using 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 MOVES2014a 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 2020 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 2020 future case for the eight-county HGB area for each season and day type is summarized in Table 3-22: *2020 Future Case On-Road Modeling Emissions for the Eight-County HGB Area*.

Table 3-22: 2020 Future Case On-Road Modeling Emissions for the Eight-County HGB Area

Season and Day Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Summer Weekday	83.04	55.17	759.99
Summer Friday	85.57	56.13	808.27
Summer Saturday	65.15	49.37	647.67
Summer Sunday	54.38	47.27	566.48
School Weekday	81.67	54.88	747.38
School Friday	84.87	55.98	802.40
School Saturday	64.43	49.24	642.77
School Sunday	53.37	47.09	558.53

For the eight-county HGB area, the on-road mobile source NO_X emissions are reduced approximately 47% from the 2012 baseline (157.09 tpd) to the 2020 future case (83.04 tpd). VOC emissions are reduced approximately 25% from the 2012 baseline (73.60 tpd) to the 2020 future case (55.17 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 2020.

Non-HGB Portions of Texas

On-road emissions for the 246 non-HGB Texas counties were developed by TTI using MOVES2014a emission rates and 2020 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 MOVES2014a in default mode to generate 2020 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 2020 Texas on-road temporal profiles were applied to the non-Texas 2020 summer weekday emissions. For the Canada portion of the modeling domain, a 2020 on-road inventory was interpolated between 2017 and 2023 on-road inventories available from the EPA’s 2011 Modeling Platform (EPA, 2015). For the Mexico portion of the modeling domain, a 2020 on-road inventory was interpolated between 2011 and 2023 on-road inventories developed with MOVES-Mexico that were obtained from the EPA’s 2011 Modeling Platform (EPA, 2015).

3.6.4.3 Non-Road and Off-Road Mobile Sources

Outside Texas

For the non-Texas U.S. portion of the modeling domains, the TCEQ used the EPA’s MOVES2014b to generate average summer weekday non-road mobile source emissions by county for 2020. For the off-road categories of aircraft, locomotive, and commercial marine, the TCEQ used the EPA’s 2014 NEI to create 2020 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 version 2.0 of the TexN model (ERG, 2018) to generate 2020 average summer weekday emissions by county for all non-road mobile sources except for airports and oil and gas drilling rigs, which were estimated separately. Aggregate weekday 2020 non-road emission estimates for the HGB area are detailed in Table 3-23: *2020 Future Case Non-Road Model Source Emissions for the Eight-County HGB Area*. During EPS3 processing, temporal adjustments were made to create summer weekend day (Saturday and Sunday) non-road emission estimates. Table 3-24: *2020 Future Case Non-Road Modeling Emissions for the Eight-County HGB Area* summarizes these non-road inputs by day type.

For the eight-county HGB area, non-road NO_x emissions are reduced by approximately 43% from the 2012 baseline (56.36 tpd) to the 2020 future case (31.59 tpd). VOC emissions are decreased approximately 35% from the 2012 baseline (43.94 tpd) to the 2020 future case (28.39 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 2020.

Table 3-23: 2020 Future Case Non-Road Model Source Emissions for the Eight-County HGB Area

Non-Road Source Classification	NO_x (tpd)	VOC (tpd)	CO (tpd)
Construction and Mining Equipment	14.63	2.77	33.60
Industrial Equipment	5.84	0.72	22.21
Agricultural Equipment	4.95	6.23	186.56
Commercial Equipment	2.95	0.28	3.15
Lawn and Garden Equipment	1.56	9.73	138.24
Pleasure Craft	1.35	4.78	22.66
Recreational Equipment	0.24	3.76	24.85
Logging Equipment	0.04	0.01	0.02
Railroad Equipment	0.03	0.11	1.05
Eight-County HGB Non-Road Total	31.59	28.39	432.34

Table 3-24: 2020 Future Case Non-Road Modeling Emissions for the Eight-County HGB Area

Day Type	NO_x (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	31.59	28.39	31.59
Saturday	28.63	54.08	28.63
Sunday	23.53	50.16	23.53

Airport EIs were developed by ERG under contract to TCEQ (ERG, 2019b) with the FAA AEDT tool, which estimates emissions for aircraft engines, APUs, and GSE. The 2020 emission estimates for the eight-county HGB nonattainment area airports are summarized in Table 3-25: *2020 Future Case Airport Modeling Emissions for the Eight-County HGB Area*.

Table 3-25: 2020 Future Case Airport Modeling Emissions for the Eight-County HGB Area

HGB Area Airports	NO_X (tpd)	VOC (tpd)	CO (tpd)
George Bush Intercontinental	6.72	0.82	6.46
William P. Hobby	1.62	0.26	2.69
Ellington Field	0.41	0.21	0.97
Other Regional Airports	0.24	0.26	6.77
Eight-County HGB Area Airport Total	8.99	1.55	16.89

The 2020 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 3-26: *2020 Future Case Locomotive Emissions for the Eight-County HGB Area* summarizes these estimates for all locomotive activity.

For the eight-county HGB area, the locomotive NO_X emissions are estimated to be reduced by about 22% from the 2012 baseline (15.30 tpd) to the 2020 future case (11.98 tpd), and the VOC emissions are decreased about 36% from the 2012 baseline (0.99 tpd) to the 2020 future case (0.63 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 3-26: 2020 Future Case Locomotive Emissions for the Eight-County HGB Area

Locomotive Source Classification	NO_X (tpd)	VOC (tpd)	CO (tpd)
Line-Haul Locomotives - Class I	8.84	0.41	2.86
Line-Haul Locomotives - Classes II and III	0.31	0.02	0.04
Rail Yard Switcher Locomotives	2.83	0.20	0.50
Eight-County HGB Area Locomotive Total	11.98	0.63	3.40

The 2020 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. Due to time constraints the commercial marine emissions were held constant from 2017 to 2020. The eight-county HGB area commercial marine emissions are summarized in Table 3-27: *2020 Base Case Commercial Marine Modeling Emissions for the Eight-County HGB Area*.

Table 3-27: 2020 Base Case Commercial Marine Modeling Emissions for the Eight-County HGB Area

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 Vessels	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
Harbor Vessel	0.30	0.01	0.06
Tug Barge	0.27	0.01	0.04
Cruise Ship	0.21	0.01	0.02
Assist Tug	0.02	0.00	0.02
Eight-County HGB Marine Total	23.88	1.37	4.39

3.6.4.4 Area Sources

Outside Texas

For the non-Texas U.S. within the modeling domains, the TCEQ used the EPA's 2014 NEI projected to 2020 for area source emissions.

Within Texas

The TCEQ used area source data from the 2017 TexAER database (TCEQ, 2017), and projected these estimates to 2020 using the Texas-specific growth factors for 2017 through 2020 for non-oil and gas sources (ERG, 2016). Temporal profiles were applied with EPS3 to obtain the figures presented in Table 3-28: *2020 Future Case Non-Oil and Gas Area Source Emissions for the Eight-County HGB Area.*

Table 3-28: 2020 Future Case Non-Oil and Gas Area Source Emissions for the Eight-County HGB Area

Day Type	NO_x (tpd)	VOC (tpd)	CO (tpd)
Monday – Friday Average Weekday	30.47	319.30	96.77
Saturday	20.95	182.31	57.36
Sunday	11.45	141.33	18.67

For the eight-county HGB area oil and gas sources, production emissions estimated for 2017 based on RRC data were held constant for use in the 2020 future case. County-level drilling rig emission estimates were based on the latest available drilling activity data from the RRC in 2018 and 2017 emission rates from an ERG study (ERG, 2015). Drilling rigs are non-road sources but are reported with the oil and gas production sources category since most drilling rigs are used for oil and gas production. The results are summarized in Table 3-29: *2020 Oil and Gas Drilling and Production Emissions for the Eight-County HGB Area*.

Table 3-29: 2020 Oil and Gas Drilling and Production Emissions for the Eight-County HGB Area

Equipment Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
Drilling Rigs	0.21	0.01	0.02
Production (Non-Point Source)	1.63	40.08	2.59
Eight-County HGB Oil and Gas Total	1.84	40.09	2.61

3.6.4.5 Future Case Summary

Typical 2020 future case weekday emissions in the eight-county HGB area are summarized by source type in Table 3-30: *2020 Future Case Anthropogenic Emissions for the Eight-County HGB Area*.

Table 3-30: 2020 Future Case Anthropogenic Emissions for the Eight-County HGB Area

HGB Emission Source Type	NO_X (tpd)	VOC (tpd)	CO (tpd)
On-Road	83.04	55.17	759.99
Non-Road	31.59	28.39	432.34
Off-Road - Airports	8.99	1.55	16.89
Off-Road - Locomotives	11.98	0.63	3.40
Off-Road - Commercial Marine	23.88	1.37	4.39
Area Sources	30.47	319.30	96.77
Oil and Gas - Drilling	0.21	0.01	0.02
Oil and Gas - Production	1.63	40.08	2.59
Point - EGUs (August Average)	38.54	1.75	40.79
Point - Non-EGUs (Ozone Season Average)	105.06	119.80	63.49
Eight-County HGB Total	335.39	568.05	1,420.67

3.6.5 2012 and 2020 Modeling Emissions Summary for HGB

Table 3-31: *2012 Baseline and 2020 Future Modeling Emissions for the Eight-County HGB Area* provides side-by-side comparisons of the NO_X and VOC emissions by source category for 2012 and 2020 for an average August summer weekday. The total eight-county HGB area anthropogenic NO_X emissions are projected to be reduced by approximately 15% from 2012 (392.79 tpd) to 2020 (335.39 tpd). The total eight-county HGB area anthropogenic VOC emissions are projected to be reduced by 1% from 2012 (571.96 tpd) to 2020 (568.05 tpd).

Table 3-31: 2012 Baseline and 2020 Future Modeling Emissions for the Eight-County HGB Area

HGB Emission Source Type	2012 NO_x (tpd)	2020 NO_x (tpd)	2012 VOC (tpd)	2020 VOC (tpd)
On-Road	157.09	83.04	73.60	55.17
Non-Road	56.36	31.59	43.94	28.39
Off-Road - Airports	8.88	8.99	2.50	1.55
Off-Road - Locomotives	15.30	11.98	0.99	0.63
Off-Road - Commercial Marine	27.74	23.88	1.33	1.37
Area Sources	18.29	30.47	248.27	319.30
Oil and Gas - Drilling	0.79	0.21	0.06	0.01
Oil and Gas - Production	2.09	1.63	66.60	40.08
Point - EGUs (August Average)	36.49	38.54	3.99	1.75
Point - Non-EGUs (Ozone Season Average)	69.76	105.06	130.68	119.80
Eight-County HGB Total	392.79	335.39	571.96	568.05

Figure 3-18: *2012 Baseline and 2020 Future Modeling Emissions for the Eight-County HGB Area* graphically compares the anthropogenic NO_x and VOC emission estimates presented in Table 3-31.

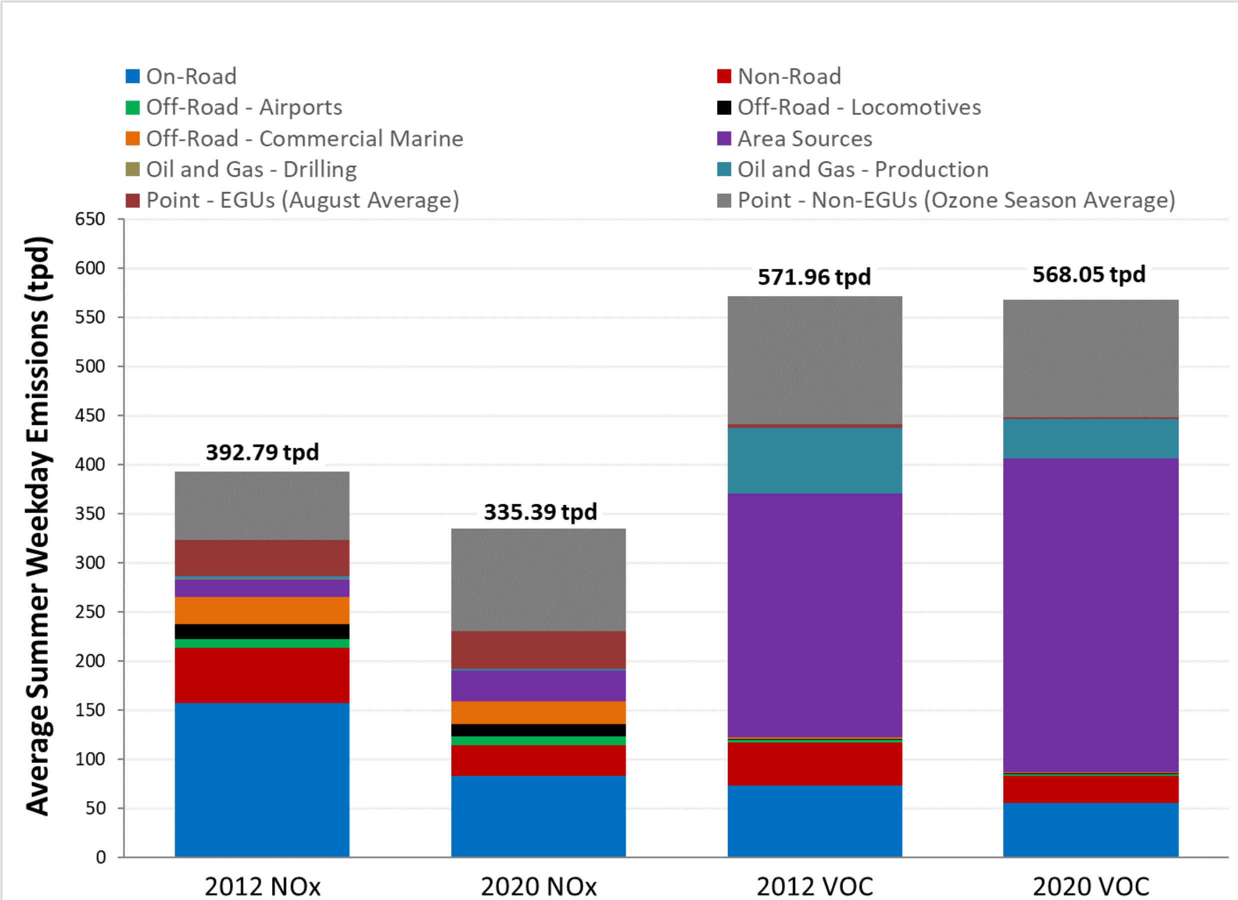


Figure 3-18: 2012 Baseline and 2020 Future Modeling Emissions for the Eight-County HGB Area

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 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, 2018). In addition, the TCEQ has many years of experience with CAMx. CAMx was used in previous HGB and DFW AD 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 3-32: *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.

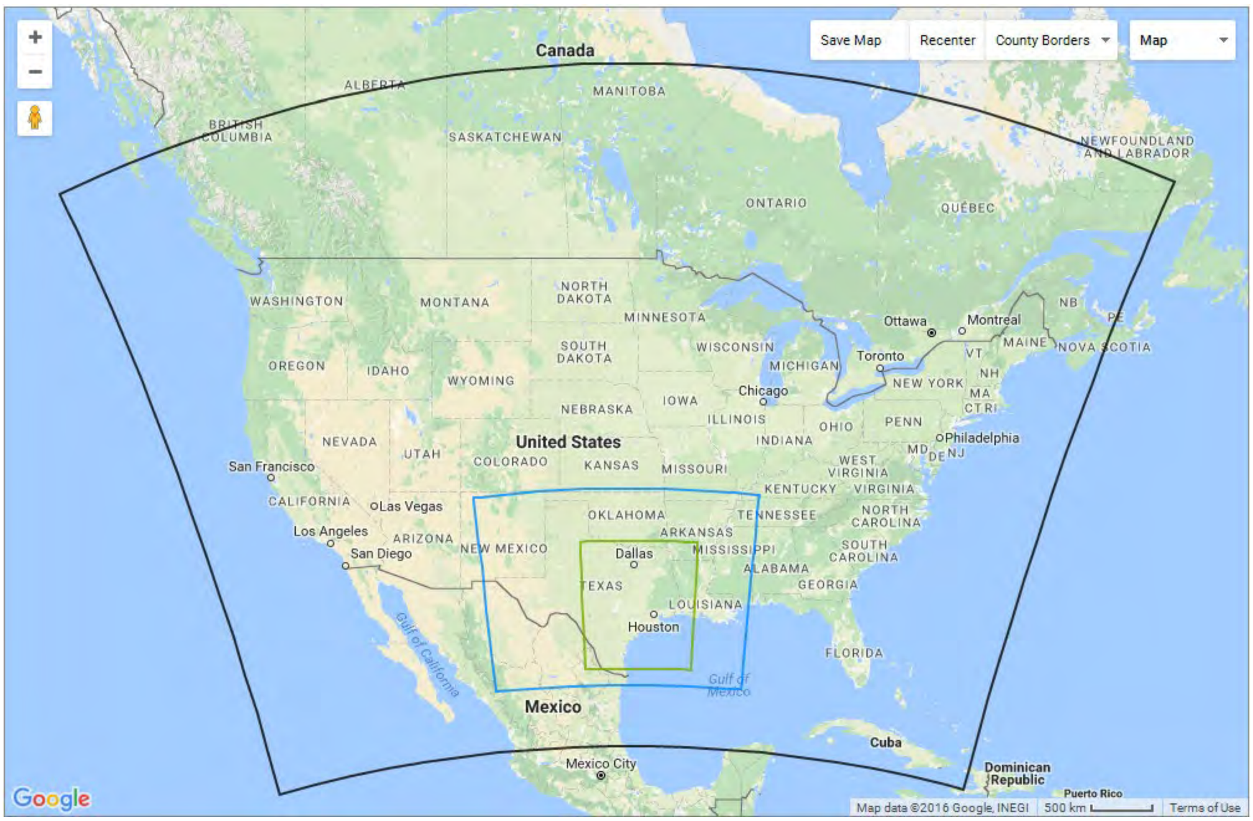


Figure 3-19: CAMx Modeling Domains

Table 3-32: 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 3-33: *CAMx Vertical Layer Structure*.

Table 3-33: 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 6.50, which includes several upgrades and features from previous versions (Ramboll Environ, 2016). The following CAMx 6.50 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 4" (CB6r4h), which added condensed halogen chemistry and inline sea salt emissions; 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 ran the global atmospheric chemistry model driven by assimilated meteorological observations from the Goddard Earth Observing System (GEOS-Chem) for 2012 and 2020 to derive episode-specific boundary and initial conditions. 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 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. The CAMx modeling results were compared to the measured ozone and ozone precursor concentrations at all regulatory monitoring sites, which resulted in many 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: *Regional and Global Photochemical Modeling for the DFW and HGB Attainment Demonstration SIP Revisions 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 MPE tools are available on the

TCEQ Photochemical Modeling webpage (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

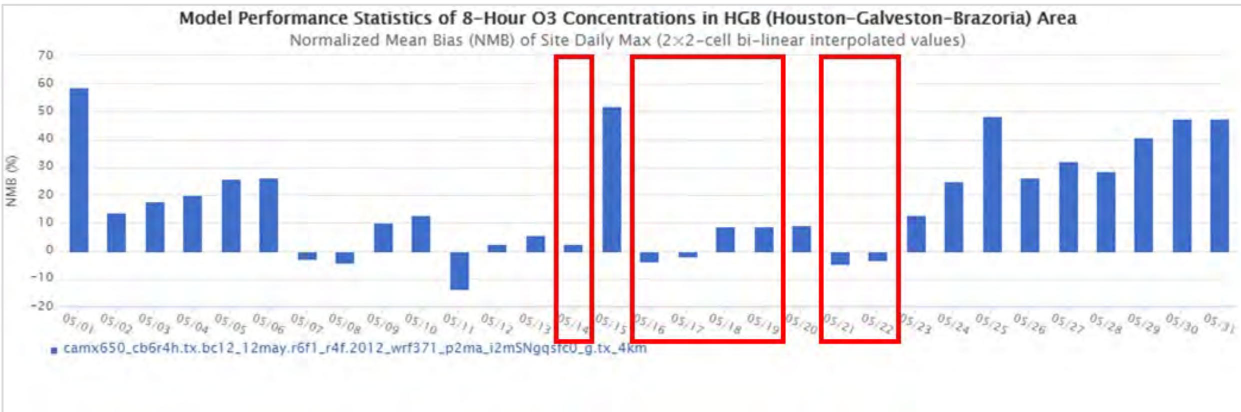
Statistical measures of the Normalized Mean Bias (NMB) and the Normalized Mean Error (NME) were calculated by comparing monitored (measured) and four-cell bi-linearly interpolated modeled ozone concentrations for all episode days and monitors. For one-hour ozone comparisons, the EPA formerly recommended 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 were 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 MPE is included in Appendix C and available on the TCEQ Texas Air Quality Modeling Files webpage (https://www.tceq.texas.gov/airquality/airmod/data/tx2012).

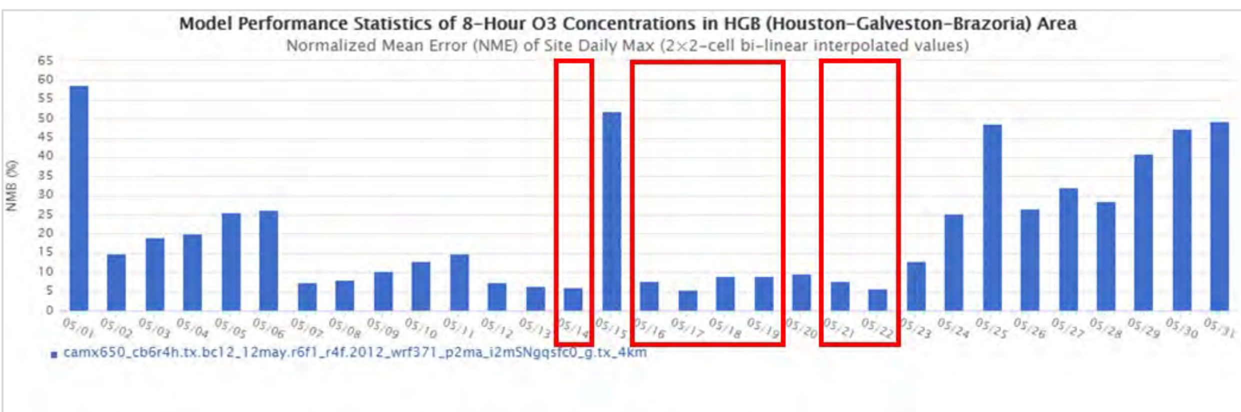
May 2012

May 2012 had seven days with site MDA8 ozone 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 Normalized Mean Bias of Site MDA8 Ozone Concentrations for the HGB Area Monitors*. On the high ozone days the photochemical model performed well, replicating the average site daily maximum eight-hour ozone concentrations within approximately 10% as shown in Figure 3-21: *May 2012 Normalized Mean Error of Site MDA8 Ozone Concentrations 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 ozone 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 outlined in boxes.

Figure 3-20: May 2012 Normalized Mean Bias of Site MDA8 Ozone Concentrations for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb outlined in boxes.

Figure 3-21: May 2012 Normalized Mean Error of Site MDA8 Ozone Concentrations for the HGB Area Monitors

At the Manvel Croix Park (C84) monitor, the photochemical model primarily 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 continuous line with the three-by-three cell maximum and minimum range shown as the shaded region. The observations are shown as 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 as 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 squares exhibit the Quantile-Quantile plot (Q-Q plot), which compares how well the model predicts ozone concentrations in the same range as the observed without respect to time.

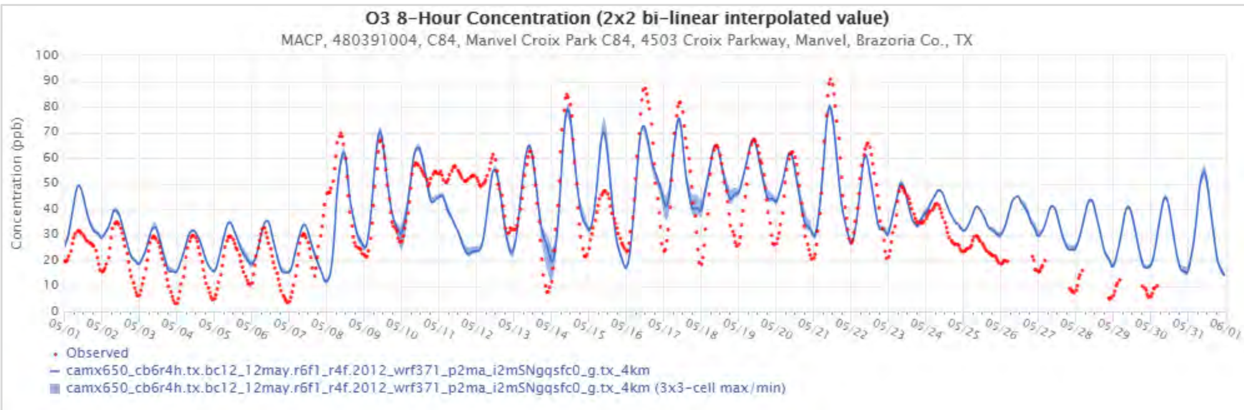


Figure 3-22: May 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

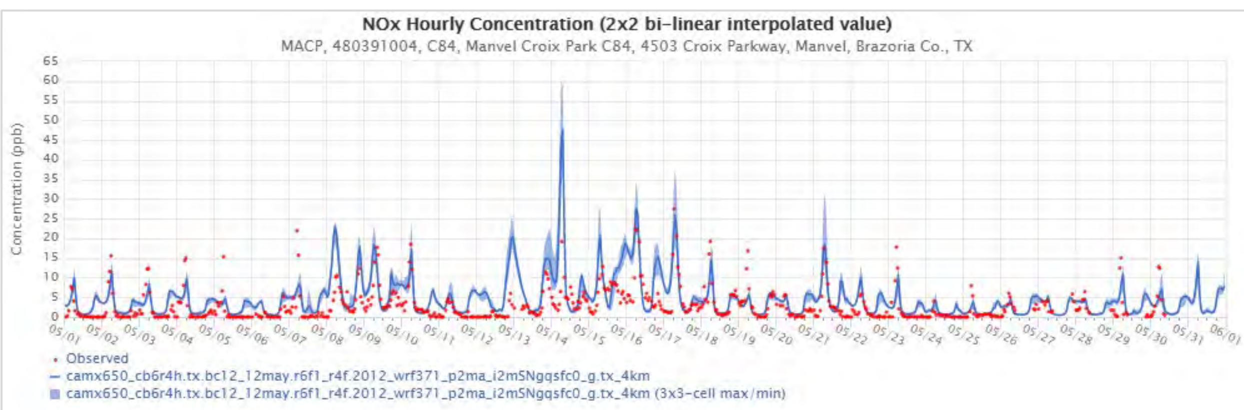


Figure 3-23: May 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

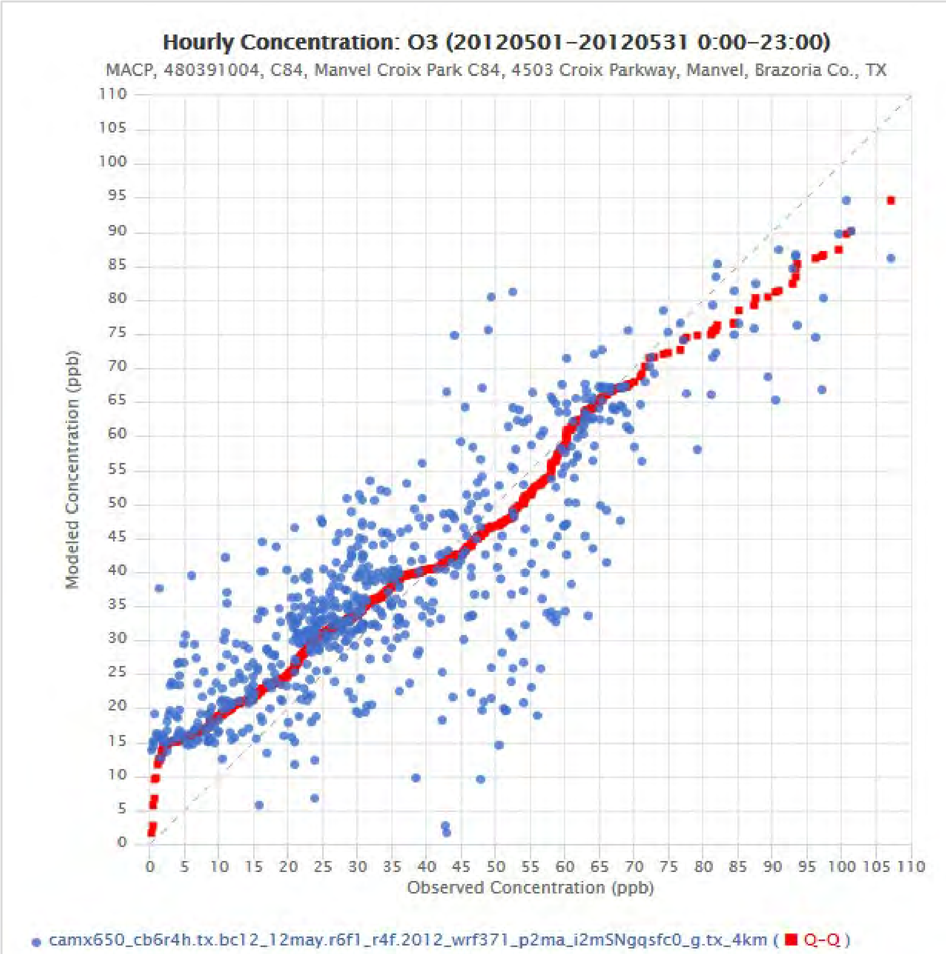
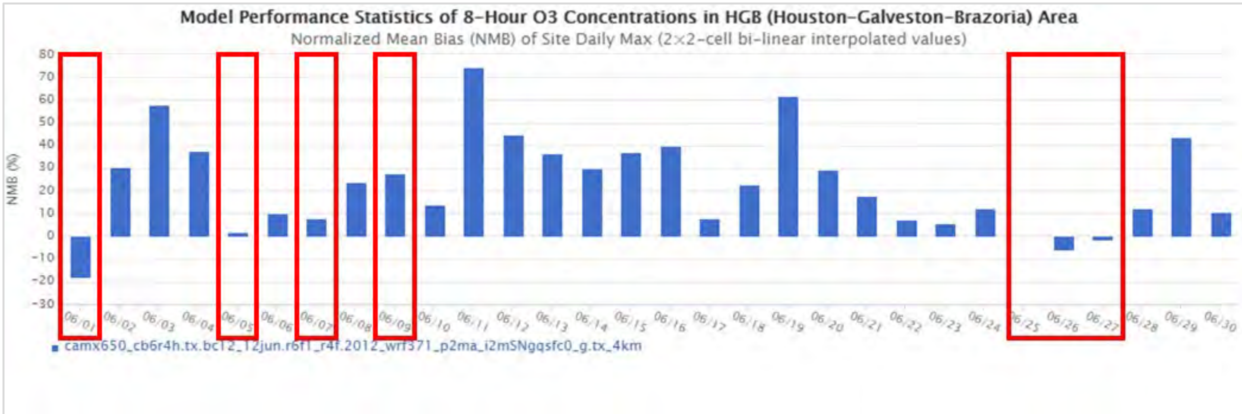


Figure 3-24: May 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

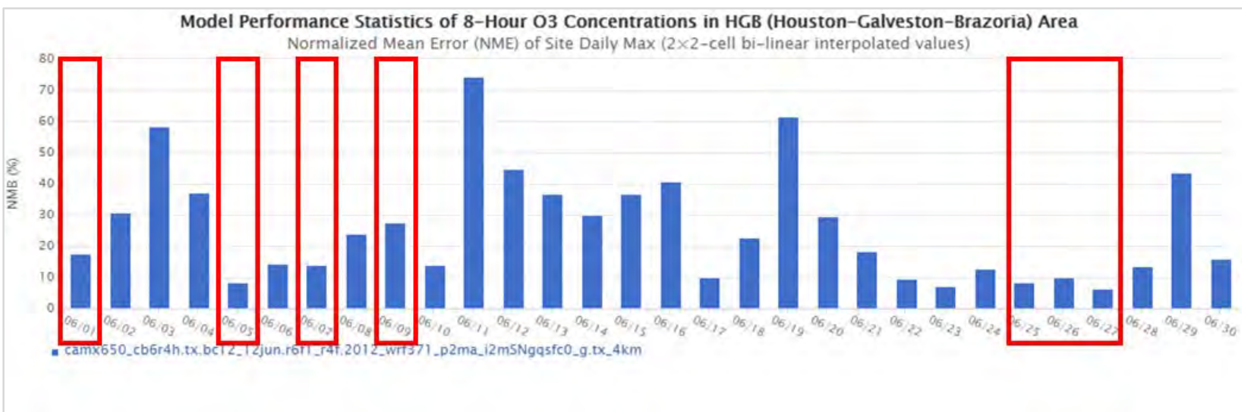
<u>June 2012</u>

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 MDA8 ozone concentrations but bias was within 10% of the measured ozone concentrations as depicted in Figure 3-25: *June 2012 Normalized Mean Bias of Site MDA8 Ozone Concentrations 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 MDA8 ozone concentrations within 25% of observations on those days, outlined in boxes in Figure 3-26: *June 2012 Normalized Mean Error of Site MDA8 Ozone Concentrations for the HGB Area Monitors*.



Days with eight-hour daily maximum concentrations above 75 ppb outlined in boxes.

Figure 3-25: June 2012 Normalized Mean Bias of Site MDA8 Ozone Concentrations for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb outlined in boxes.

Figure 3-26: June 2012 HGB Normalized Mean Error of Site MDA8 Ozone Concentrations 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 ozone concentration of 2012 on June 26 at 136 ppb. The model was unable to match this peak, only predicting 95 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 ozone concentrations of hourly ozone but misses the highest concentrations in June 2012.

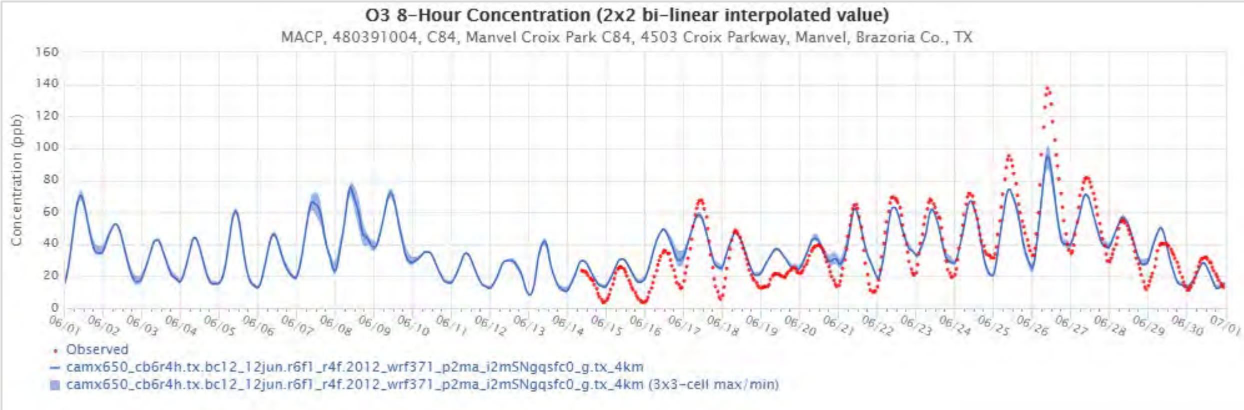


Figure 3-27: June 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

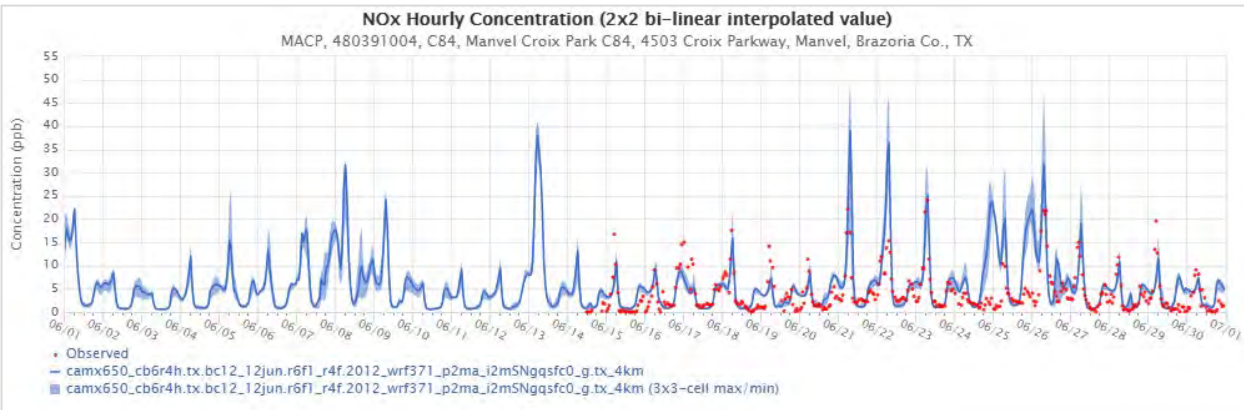


Figure 3-28: June 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

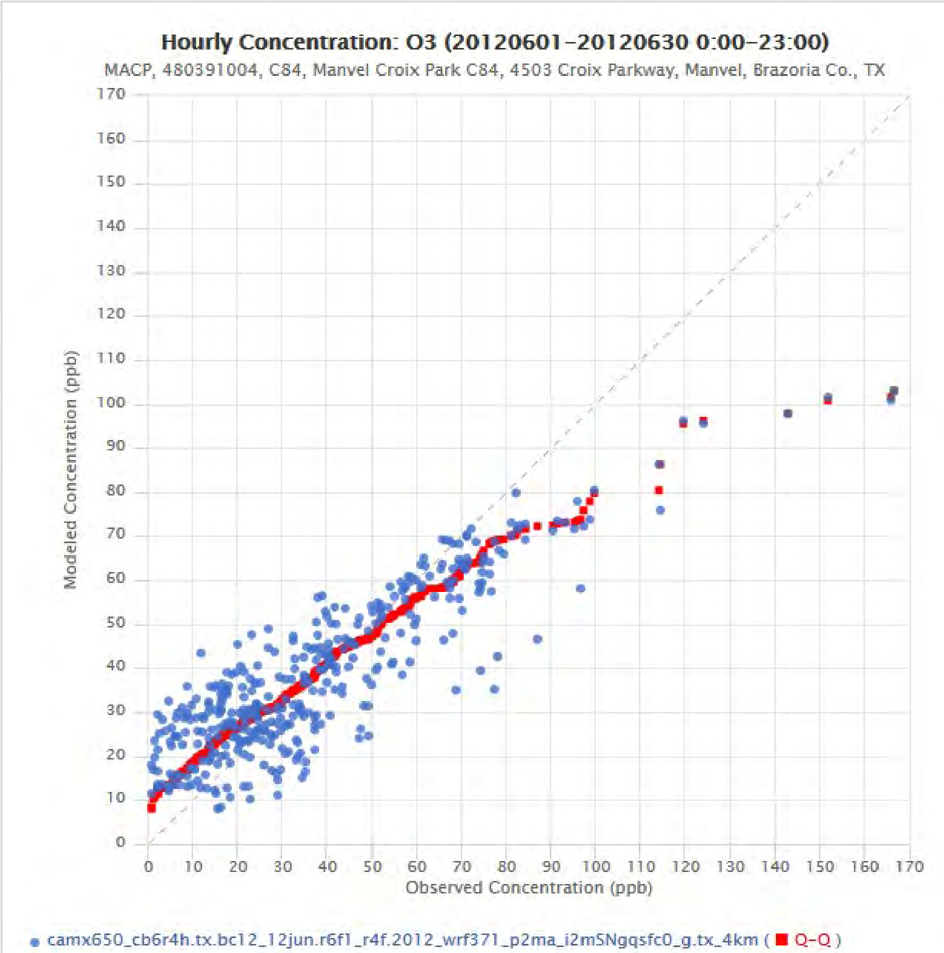


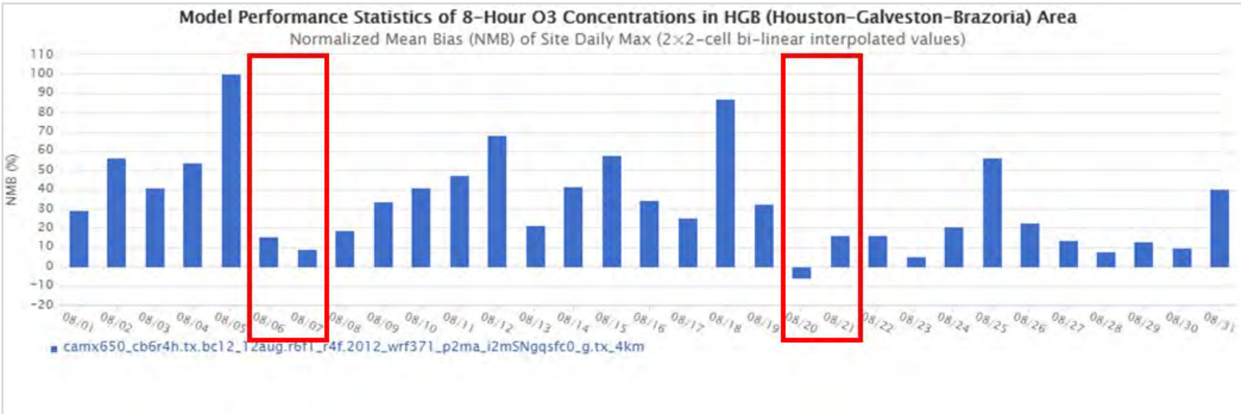
Figure 3-29: June 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

July 2012

Because of the limited time for development of this proposed HGB AD SIP revision and since eight-hour ozone concentrations in the HGB area throughout July were less than 60 ppb, MPEs are not included here. Limited MPE for July 2012 is included in Appendix C.

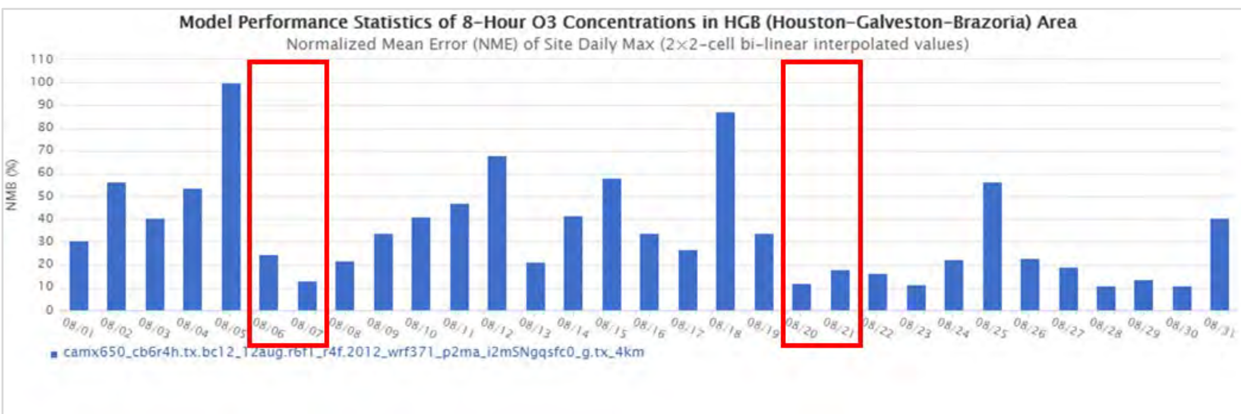
August 2012

Four August 2012 days observed eight-hour ozone concentrations above 75 ppb (see Figure 3-12). The NMB of the site MDA8 ozone concentrations on the highest ozone days was very small, indicating the model performed well on the most important days as shown in Figure 3-30: *August 2012 Normalized Mean Bias of Site MDA8 Ozone Concentrations for the HGB Area Monitors*. The NME 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 Normalized Mean Error of Site MDA8 Ozone Concentrations 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 outlined in boxes.

Figure 3-30: August 2012 Normalized Mean Bias of Site MDA8 Ozone Concentrations for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb outlined in boxes.

Figure 3-31: August 2012 Normalized Mean Error of Site MDA8 Ozone Concentrations 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 in 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)*.

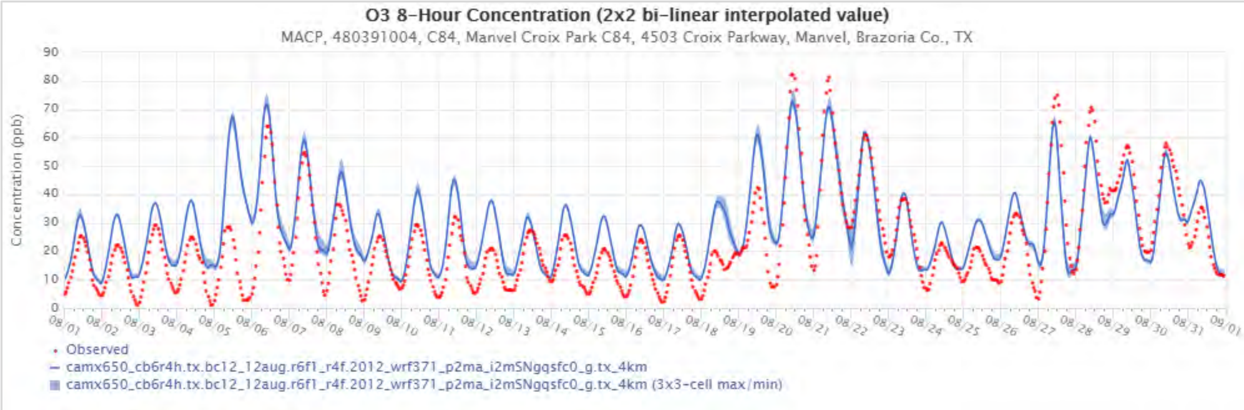


Figure 3-32: August 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

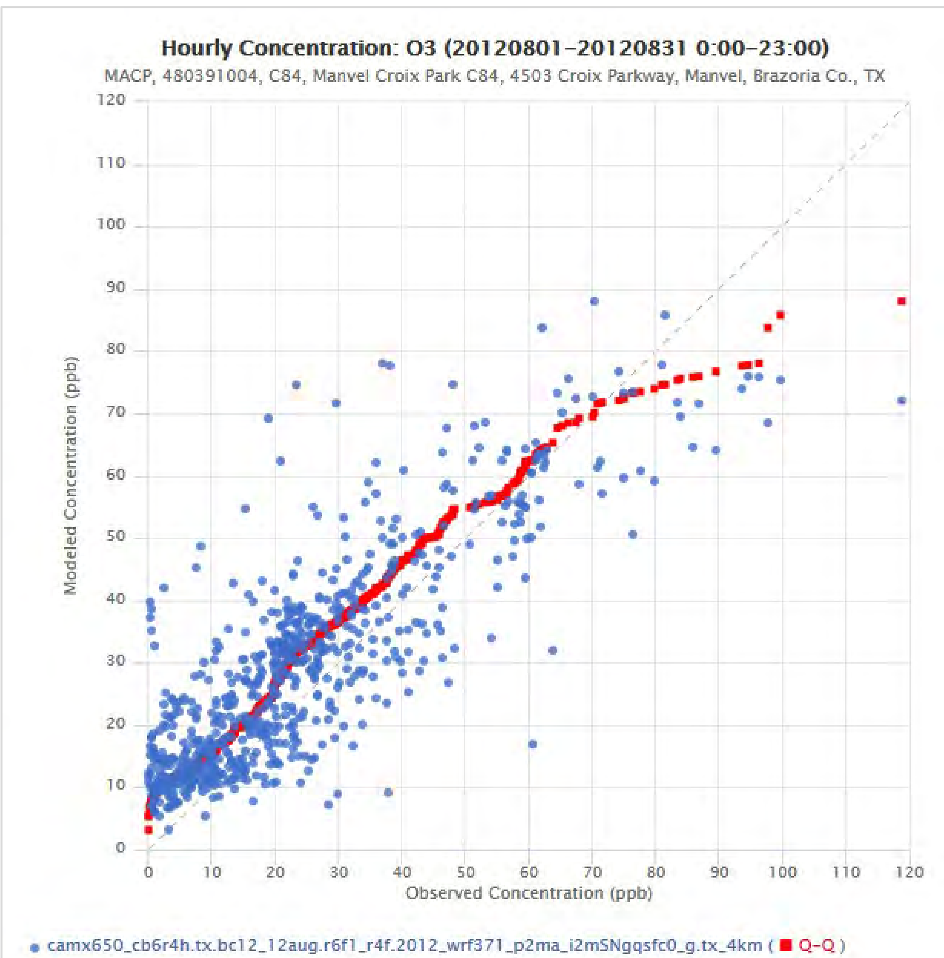


Figure 3-33: August 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

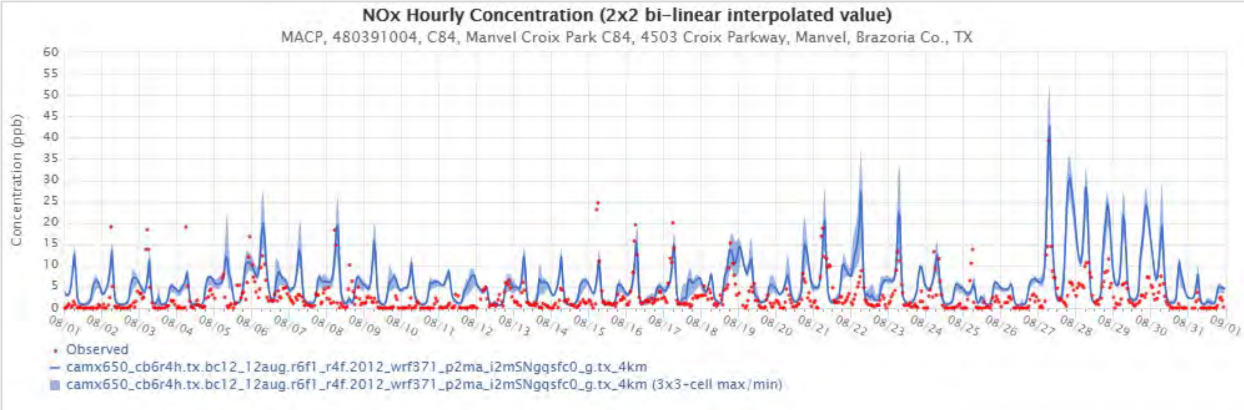
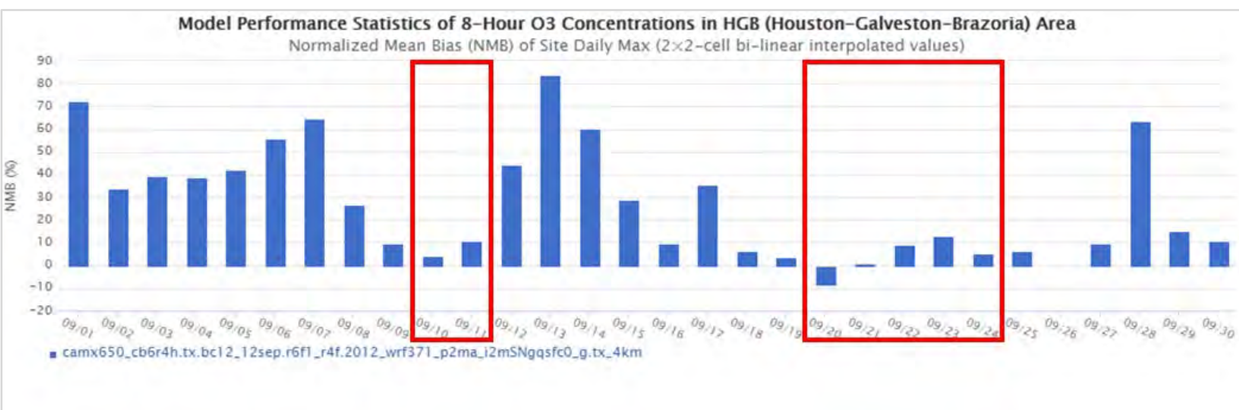


Figure 3-34: August 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

<u>September 2012</u>

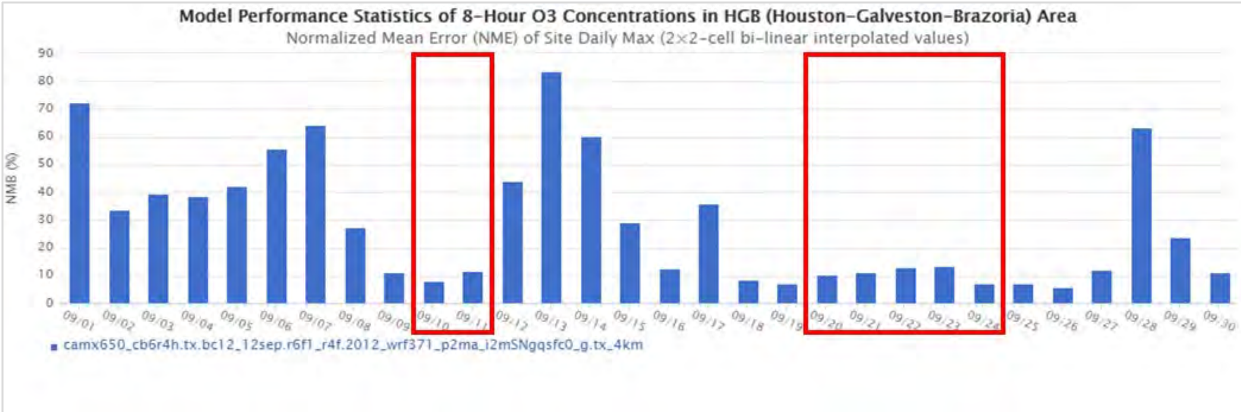
Seven days in September 2012 exceeded the 2008 eight-hour ozone NAAQS. The model slightly under-predicted and over-predicted on the high ozone days as with the other 2012 months as shown in Figure 3-35: *September 2012 Normalized Mean Bias of Site MDA8 Ozone Concentrations for the HGB Area Monitors*).

As with the other 2012 months, the model performed well in September by matching the site MDA8 ozone concentrations as shown in Figure 3-36: *September 2012 Normalized Mean Error of Site MDA8 Ozone Concentrations 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 outlined in boxes.

Figure 3-35: September 2012 Normalized Mean Bias of Site MDA8 Ozone Concentrations for the HGB Area Monitors



Days with eight-hour daily maximum concentrations above 75 ppb outlined in boxes.

Figure 3-36: September 2012 Normalized Mean Error of Site MDA8 Ozone Concentrations for the HGB Area Monitors

At the Manvel Croix Park (C84) monitor, the model replicated the daily eight-hour peaks well 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)*. In Figure 3-37, the model also had difficulty replicating the diurnal range, over-predicting the nighttime minimum ozone 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)*.

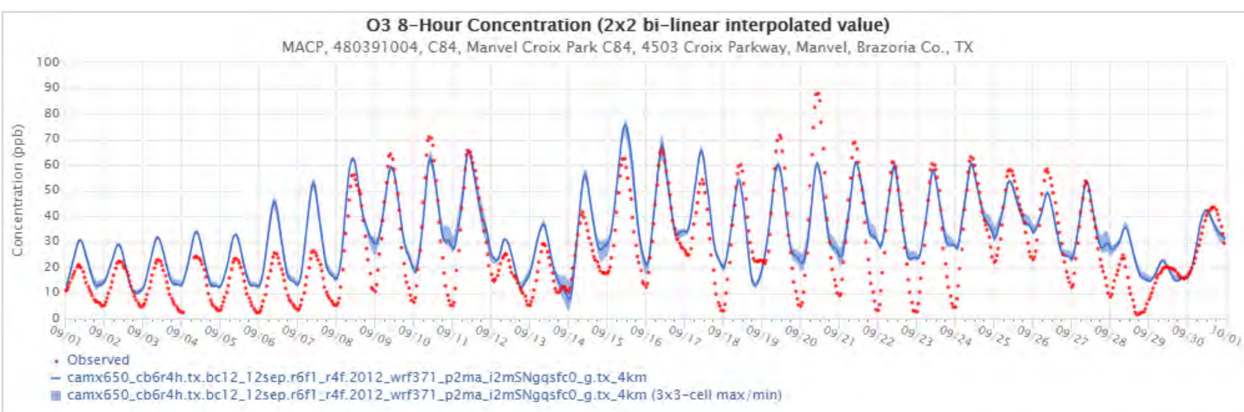


Figure 3-37: September 2012 Observed versus Modeled Eight-Hour Ozone at Manvel Croix Park (C84)

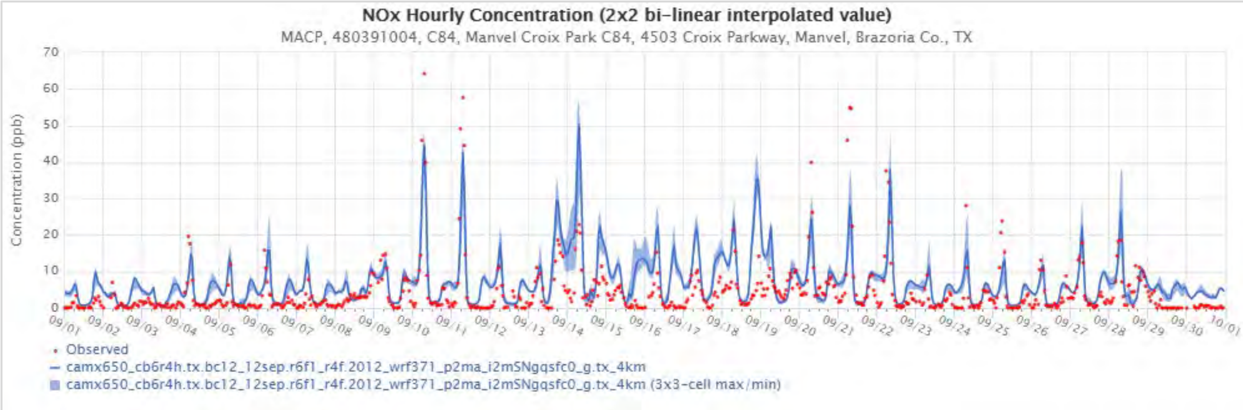


Figure 3-38: September 2012 Observed versus Modeled Hourly Nitrogen Oxides at Manvel Croix Park (C84)

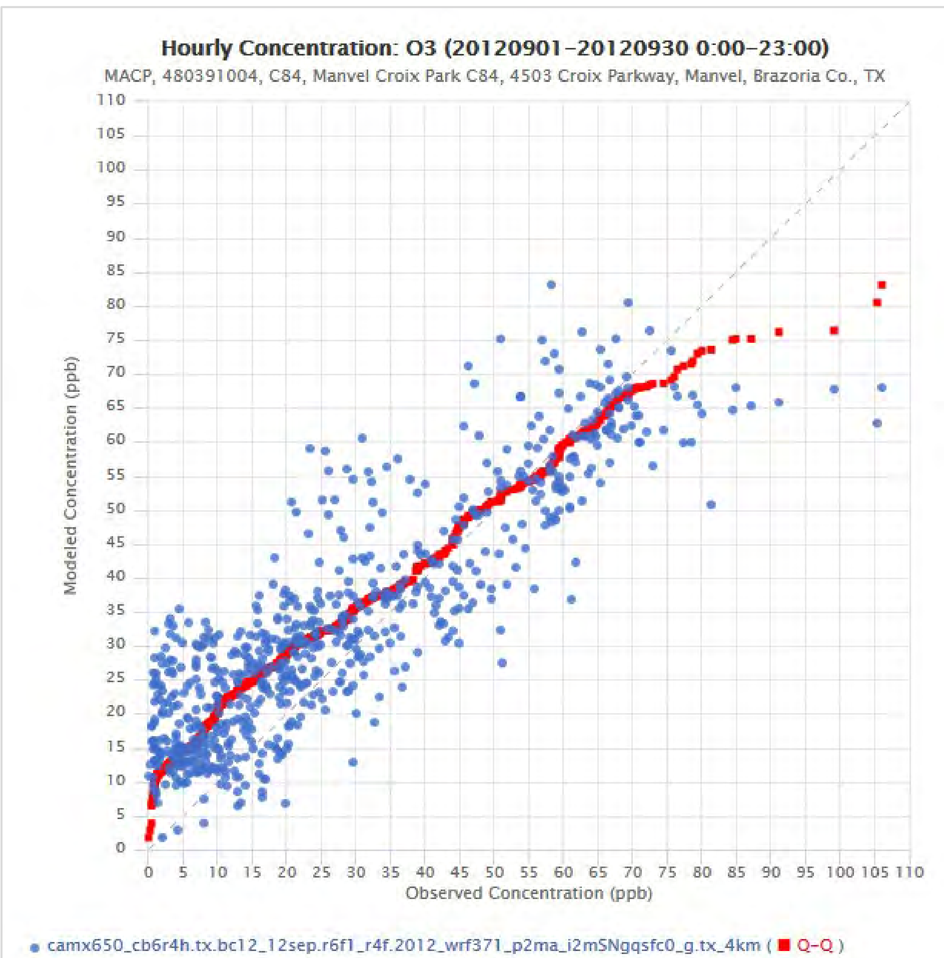


Figure 3-39: September 2012 Observed versus Modeled Hourly Ozone Scatter Plot at Manvel Croix Park (C84)

3.7.4.3 Diagnostic Evaluations

While most 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 proposed 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, 2018), 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, 2020 future case modeling was conducted for each of the 2012 episode days using the emission inputs discussed in Section 3.6.4: *2020 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 3-34: *HGB Monitor-Specific Relative Response Factors for Attainment Test*.

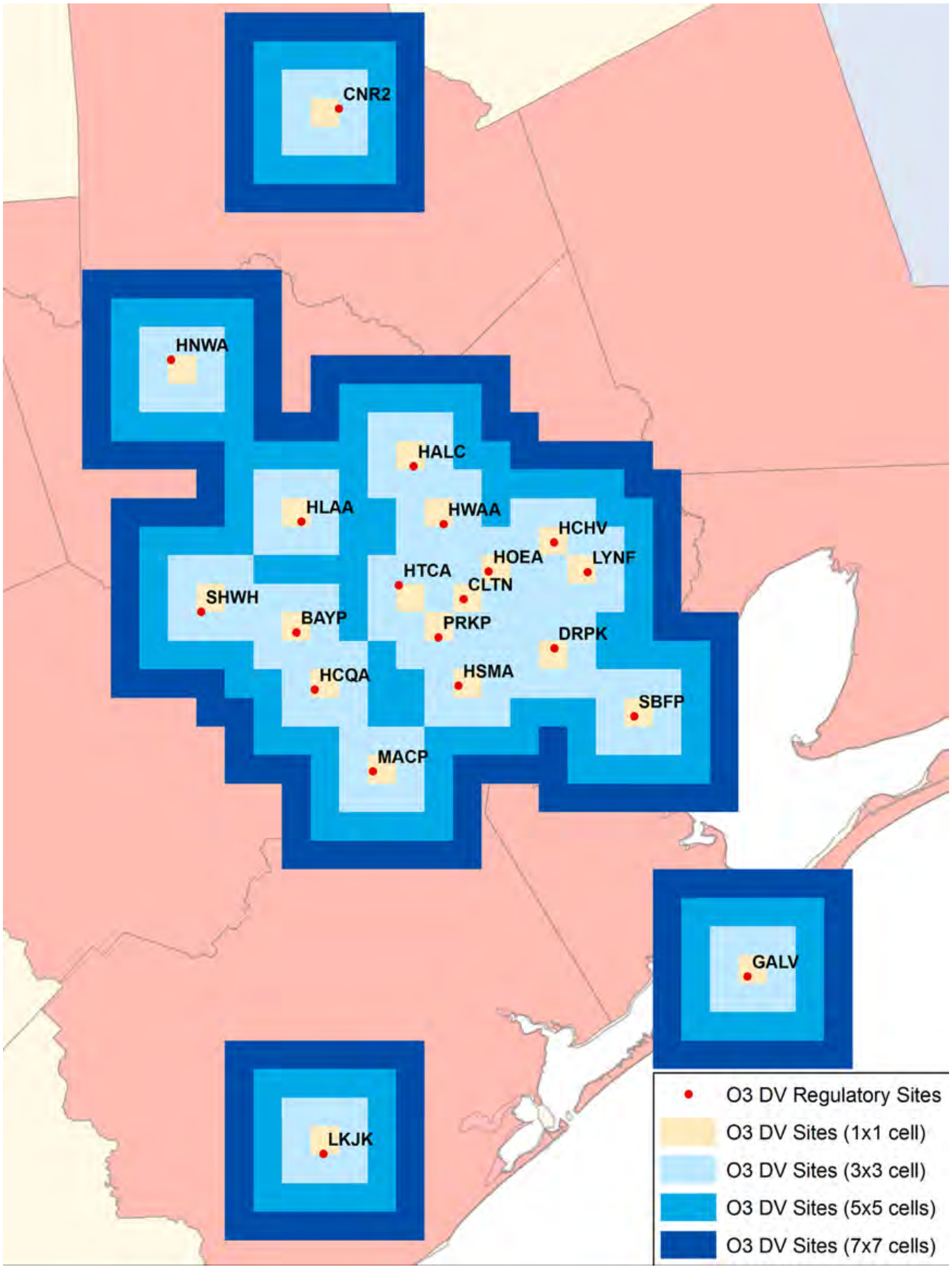


Figure 3-40: Location of HGB Ozone Monitors with 4 km Grid Cell Array

Table 3-34: HGB Monitor-Specific Relative Response Factors for Attainment Test

HGB Monitor	Site Code	2012 Baseline Top 10-Day Mean (ppb)	2020 Future Top 10-Day Mean (ppb)	Relative Response Factor (RRF)
Manvel Croix Park - C84	MACP	79.45	71.59	0.901
Bayland Park - C53	BAYP	84.71	77.68	0.917
Houston East - C1	HOEA	78.25	72.41	0.925
Croquet - C409	HCQA	85.05	77.23	0.908
Deer Park - C35	DRPK	75.17	68.57	0.912
Houston Monroe - C406	HSMA	78.09	72.27	0.926
Houston Northwest - C26	HNWA	82.46	73.67	0.893
Park Place - C416	PRKP	80.87	74.56	0.922
Conroe Relocated - C78	CNR2	74.09	67.15	0.906
Houston Aldine - C8	HALC	78.18	71.60	0.916
Clinton Drive - C403	CLTN	78.79	73.51	0.933
Houston Texas Ave - C411	HTCA	80.49	74.74	0.929
Houston Westhollow - C410	SHWH	86.42	77.05	0.892
Lang - C408	HLAA	84.18	76.55	0.909
Galveston - C1034	GALV	82.01	74.38	0.907
Seabrook Friendship Park - C45	SBFP	79.17	71.37	0.901
Channelview - C15	HCHV	75.58	69.44	0.919
North Wayside - C405	HWAA	77.96	71.76	0.921
Lynchburg Ferry - C1015	LYNF	75.31	68.83	0.914
Lake Jackson - C1016	LKJK	70.38	61.96	0.880

The RRF is multiplied by the 2012 DV_B to obtain the 2020 DV_F for each ozone monitor. In accordance with modeling guidance (EPA, 2018), 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 3-35: *Summary of RRF and 2020 Future Ozone Design Values* and Figure 3-41: *2020 Future Design Values by HGB Monitoring Location*. Application of the attainment test results in one monitor above the 2008 eight-hour ozone standard of 75 ppb in 2020, Manvel Croix Park (C84) with a DV_F of 76 ppb.

Table 3-35: Summary of RRF and 2020 Future Ozone Design Values

HGB Monitor	Site Code	2012 DV_B (ppb)	RRF	2020 DV_F (ppb)	Regulatory 2020 DV_F (ppb)
Manvel Croix Park - C84	MACP	85.00	0.901	76.58	76
Bayland Park - C53	BAYP	78.67	0.917	72.14	72
Houston East - C1	HOEA	78.00	0.925	72.18	72
Croquet - C409	HCQA	78.67	0.908	71.44	71
Deer Park - C35	DRPK	78.33	0.912	71.45	71
Houston Monroe - C406	HSMA	76.67	0.926	70.96	71
Houston Northwest - C26	HNWA	80.00	0.893	71.46	71
Park Place - C416	PRKP	77.33	0.922	71.29	71
Conroe Relocated - C78	CNR2	78.00	0.906	70.69	70
Houston Aldine - C8	HALC	76.67	0.916	70.21	70
Clinton Drive - C403	CLTN	74.67	0.933	69.66	69
Houston Texas Ave - C411	HTCA	75.00	0.929	69.64	69
Houston Westhollow - C410	SHWH	77.67	0.892	69.25	69
Lang - C408	HLAA	76.33	0.909	69.42	69
Galveston - C1034	GALV	75.33	0.907	68.32	68
Seabrook Friendship Park - C45	SBFP	76.33	0.901	68.81	68
Channelview - C15	HCHV	73.00	0.919	67.07	67
North Wayside - C405	HWAA	73.67	0.921	67.82	67
Lynchburg Ferry - C1015	LYNF	71.00	0.914	64.89	64
Lake Jackson - C1016	LKJK	69.33	0.880	61.04	61

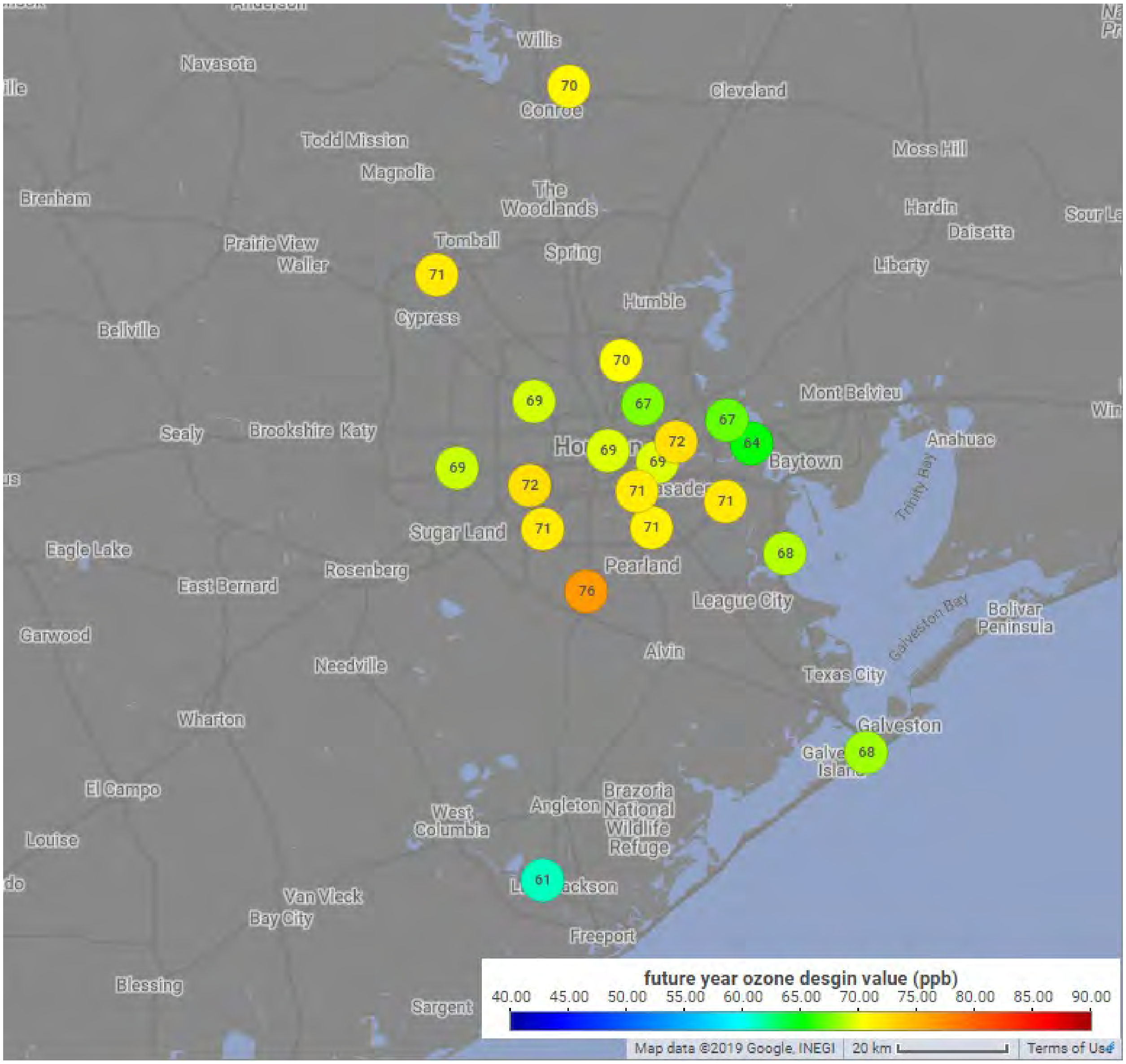


Figure 3-41: 2020 Future Design Values by HGB Monitoring Location

3.8.2 Unmonitored Area Analysis

The modeling guidance (EPA, 2018) 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 2020 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 2020 Future Design Values for the HGB Area*. The figures show the extent and magnitude of the expected improvements in ozone design values, with zero 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, UMA on the Harris and Montgomery County border is also predicted to have similar future design values but below the 2008 eight-hour ozone standard in 2020. Areas in the Gulf of Mexico are 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 are not considered reliable.

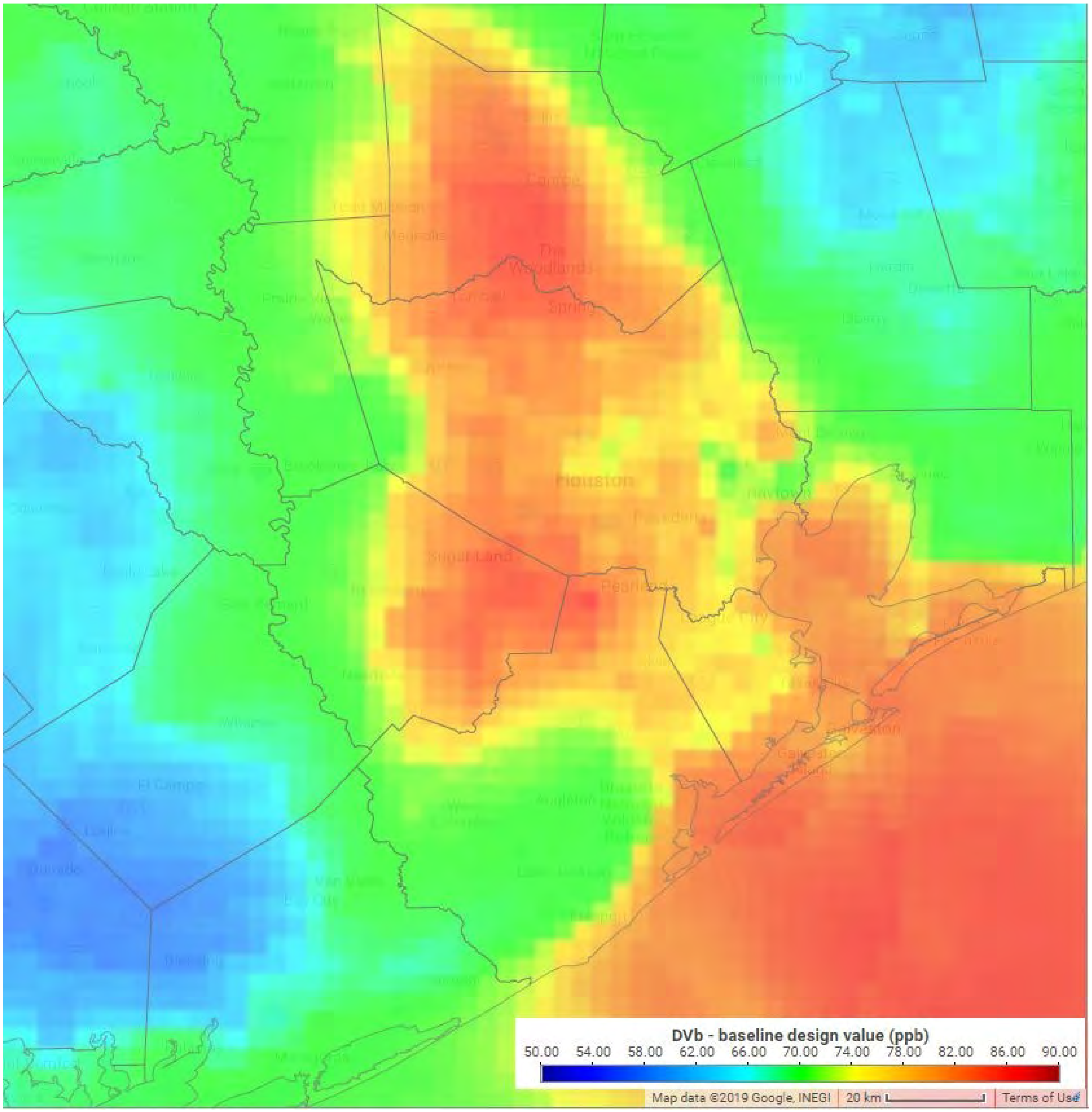


Figure 3-42: Spatially Interpolated 2012 Baseline Design Values for the HGB Area

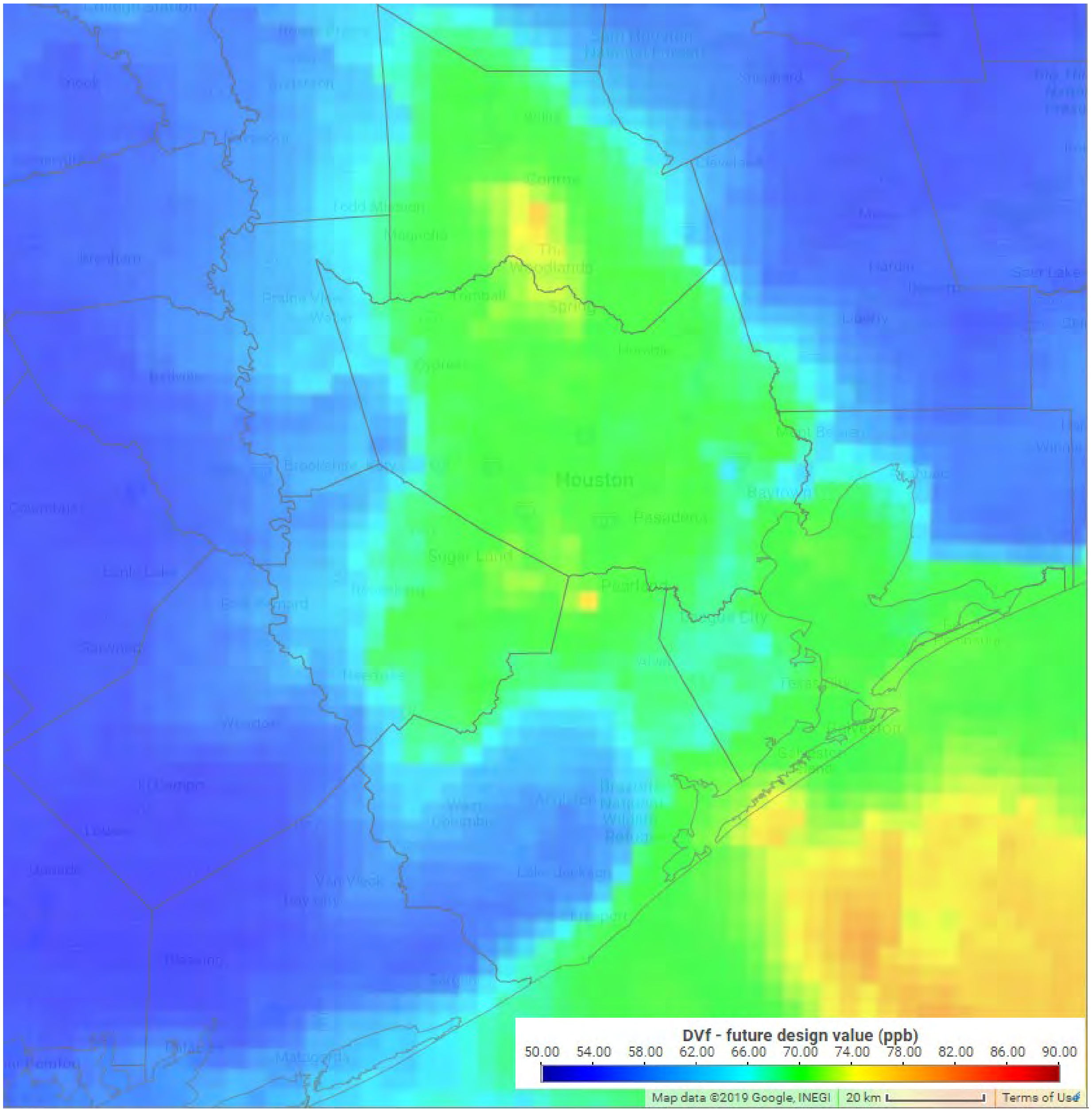


Figure 3-43: Spatially Interpolated 2020 Future Design Values for the HGB Area

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/EI/2012_episodes/dfw_hgb_fy20_sip/base_2012/). The

2020 future case EI component files are available on the TCEQ modeling FTP site (ftp://amdaftp.tceq.texas.gov/EI/2012_episodes/dfw_hgb_fy20_sip/future_2020/).

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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 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 serious 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 budgets (MVEBs), and contingency measures.

4.2 EXISTING CONTROL MEASURES

Since the early 1990s, a broad range of control measures has 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 the 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 H, Division 3	Leak detection and repair (LDAR) requirements for components in HRVOC service Requirements include more stringent repair times and lower leak detection than general VOC LDAR, and third-party audits	March 31, 2004

Measure	Description	Start Date(s)
Volatile Organic Compounds (VOC) Control Measures – Storage Tanks 30 TAC Chapter 115, Subchapter B, Division 1	Controls on fixed and floating roof tanks storing VOC liquids, including oil and condensate, based on the size of the tank and vapor pressure of the liquid being stored Control efficiency of 95% required on control devices, other than flares and vapor recovery units, for all storage tanks; enhanced inspection, repair, and recordkeeping requirements for fixed roof crude oil or condensate storage tanks with uncontrolled VOC emissions of more than 25 tons per year (tpy) Rule applicability includes fixed roof crude oil or condensate tanks at pipeline breakout stations	July 20, 2018 and earlier
VOC Control Measures – Degassing Operations 30 TAC Chapter 115, Subchapter F, Division 3	Requires vapors from degassing of storage tanks, transport vessels, and marine vessels to be vented to a control device Extended time period required for degassing and lower threshold of storage tanks required to comply with the rule	March 1, 2012 and earlier
VOC Control Measures 30 TAC Chapter 115	VOC measures adopted for reasonably available control technology (RACT) and other state implementation plan (SIP) planning purposes: bakeries, batch processes, general vent gas control, general VOC LDAR, industrial wastewater, loading and unloading operations, solvent-using processes, etc.	December 31, 2002 and earlier
VOC Control Measures – Offset Lithographic Printers 30 TAC Chapter 115, Subchapter E, Division 4	Limits VOC content of inks and cleaning solvents used in offset lithographic printing facilities Revised to lower VOC content limit of solvents and to include smaller sources in the rule	March 1, 2011 for major sources March 1, 2012 for minor sources

Measure	Description	Start Date(s)
VOC Control Measures – Solvent-Using Processes 30 TAC Chapter 115, Subchapter E	Limits VOC content of coatings and requires work practices for coating processes and cleaning operations Revised to implement RACT requirements per control techniques 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	March 1, 2013 and earlier
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	1979 A SIP revision related to Stage I regulations was approved by the EPA, effective June 29, 2015
Nitrogen Oxides (NO_x) Mass Emissions Cap and Trade (MECT) Program and 30 TAC Chapter 117 NO_x Emission Standards for Attainment Demonstration Requirements 30 TAC Chapter 101, Subchapter H, Division 3 30 TAC Chapter 117, Subchapter B, Division 3, Subchapter C, Division 3, and 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 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)

Measure	Description	Start Date(s)
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
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	November 15, 1999
Stationary Diesel and Dual-Fuel 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 tpy)	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 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 See Section 5.4.1.5: *Texas Emissions Reduction Plan (TERP)*

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)	Phased 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 requires marine diesel fuels used by oceangoing vessels 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 oceangoing vessels 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 §25.23(f)	Five miles per hour below the speed limit posted before May 1, 2002 on roadways with speeds that were 65 miles per hour or higher	September 2003
California Standards for Certain Gasoline Engines	California standards for non-road gasoline engines 25 horsepower and larger	May 1, 2004
Transportation Control Measures (TCMs)	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.	Phased in through 2013

Measure	Description	Start Date(s)
Voluntary Energy Efficiency/Renewable Energy	Energy efficiency and renewable energy projects enacted by the Texas Legislature outlined in Section 5.4.1.2: *Energy Efficiency and Renewable Energy Measures*	See Section 5.4.1.2

4.3 UPDATES TO EXISTING CONTROL MEASURES

4.3.1 Updates to VOC Control Measures

On December 15, 2016, the commission adopted revisions to the VOC storage tank rules in 30 Texas Administrative Code (TAC) Chapter 115, Subchapter B, Division 1 (Rule Project Number 2016-039-115-AI). The rulemaking increased 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 revisions included enhanced inspection, repair, and recordkeeping requirements for fixed roof crude oil or condensate storage tanks with uncontrolled VOC emissions of more than 25 tons per year (tpy) in the HGB area. The amendments also expanded the rule applicability to include the aggregate of fixed roof crude oil or condensate storage tanks at pipeline breakout stations in the HGB area. Emissions from all of the fixed roof crude oil or condensate tanks at each pipeline breakout station are now considered when determining rule applicability.

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 the United States Environmental Protection Agency's (EPA) *Implementation of the 2008 National Ambient Air Quality Standards for Ozone: State Implementation Plan Requirements: Final Rule* (2008 eight-hour ozone standard SIP requirements rule) published on March 6, 2015, 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 (80 *Federal Register* (FR) 12264).

The HGB area was classified as moderate nonattainment for the 2008 eight-hour ozone NAAQS with a July 20, 2018 attainment date. Based on 2017 monitoring data, the HGB moderate ozone nonattainment area did not attain the 2008 eight-hour ozone NAAQS in the 2017[14] attainment year and did not qualify for a one-year attainment date extension in accordance with FCAA, §181(a)(5).[15] On November 14, 2018, the EPA

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

[15] An area that fails to attain the 2008 eight-hour ozone NAAQS by its attainment date would be eligible for the first 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 parts per billion (ppb)); the HGB area's fourth highest daily maximum eight-hour average for 2017 was 79 ppb as measured at the Conroe Relocated monitor (C78/A321). The HGB area's design value for 2017 was 81 ppb.

proposed to reclassify the HGB area to serious nonattainment for the 2008 eight-hour ozone NAAQS (83 FR 56781). On August 7, 2019, the EPA signed the final reclassification notice. The major source threshold is based on the area's serious classification for the 2008 eight-hour ozone NAAQS of a potential to emit 50 tpy of NO_x or VOC.

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 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 Code of Federal Regulations (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*.

4.4.2 NO_x RACT Determination

The 30 TAC Chapter 117 rules represent one of the most comprehensive NO_x control strategies in the nation. The NO_x controls and reductions implemented through 30 TAC Chapter 117 for the HGB nonattainment area for the 1997 eight-hour ozone NAAQS encompass both RACT and beyond-RACT levels of control, and the NO_x controls implemented for the 2008 eight-hour ozone NAAQS encompass RACT level control. In 2013, the EPA determined that NO_x control measures in 30 TAC Chapter 117 and the 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). On April 30, 2019, the EPA approved the NO_x RACT analysis submitted on December 29, 2016 for the HGB moderate nonattainment area under the 2008 eight-hour ozone NAAQS (84 FR 18145). The current EPA-approved 30 TAC Chapter 117 rules continue to fulfill RACT requirements for the HGB serious ozone nonattainment area under the 2008 eight-hour ozone NAAQS. 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 30 TAC 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. On October 20, 2016, the EPA issued a CTG for the Oil and Natural Gas Industry (81 FR 74798). On March 9, 2018, the EPA proposed withdrawal of the CTG (83 FR 10478). Due to the pending withdrawal, this CTG is not being addressed in this RACT analysis.

The EPA approved the existing 30 TAC 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. On April 30, 2019, the EPA approved the VOC RACT rules for the HGB moderate nonattainment area under the 2008 eight-hour ozone NAAQS (84 FR 18145). The current EPA-approved 30 TAC Chapter 115 rules continue to fulfill VOC RACT requirements for the HGB serious ozone nonattainment area under the 2008 eight-hour ozone NAAQS. Specific information regarding the TCEQ's VOC RACT analysis is provided in Appendix F. 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 30 TAC Chapter 115 rules and other federally enforceable measures. 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.

4.5 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 SIPs 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 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. 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 in 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, 2021 attainment date for this attainment demonstration, the TCEQ evaluated this aspect of RACM based on advancing the attainment date by one year, to July 20, 2020.

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, 2020 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, 2020, suggested control measures would have had to be fully implemented by January 1, 2019, which has already passed. 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 Sources RACM Analysis* of Appendix G: *Reasonably Available Control Measures Analysis* present 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, 2021 attainment date, a control measure would have to be in place no later than the beginning of ozone season in the attainment year to be considered RACM, or January 1, 2020.

4.6 MOTOR VEHICLE EMISSIONS BUDGETS

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. Adequate or approved budgets must be used in transportation conformity analyses. Areas must demonstrate that the estimated emissions from transportation plans, programs, and projects do not exceed applicable MVEBs. The attainment NO_x and VOC budgets represent the summer weekday on-road mobile source emissions that have been modeled for the attainment demonstration and include all of the on-road control measures reflected in Chapter 4: *Control Strategies and Required Elements* of the demonstration. The on-road NO_x and VOC emissions inventories (EIs) establishing these MVEBs were developed with the 2014a version of the MOVES model (MOVES2014a) and are shown in Table 4-2: *2020 Attainment Demonstration MVEBs for the Eight-County HGB Area*.

Table 4-2: 2020 Attainment Demonstration MVEBs for the Eight-County HGB Area

Eight-County HGB Area On-Road Emissions Inventory Description	NO_x tons per day (tpd)	VOC (tpd)
2020 On-Road MVEBs based on MOVES2014a	83.04	55.17

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 DFW and HGB Attainment Demonstration SIP Revisions for the 2008 Eight-Hour Ozone Standard*.

4.7 MONITORING NETWORK

The ambient air quality monitoring network provides data to verify the attainment status of the 2008 eight-hour ozone NAAQS.

The HGB nonattainment area monitoring network in 2019 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: Clinton (C403); Houston Croquet (C409); Houston Monroe (C406); Houston North Wayside (C405); Houston Westhollow (C410); Lang (C408); and Park Place (C416). The TCEQ operates the remaining 13 ozone monitors: Baytown Garth (C1017); Channelview (C15); Conroe Relocated (C78); Galveston 99th Street (C1034); Houston Aldine (C8); Houston Bayland Park (C53); Houston Deer Park #2 (C35); Houston East (C1); Lake Jackson (C1016); Lynchburg Ferry (C1015); Manvel Croix Park (C84); Northwest Harris County (C26); and Seabrook Friendship Park (C45).

The monitors are managed in accordance with 40 CFR Part 58 to verify the area's attainment status. The TCEQ commits to maintaining an air monitoring network that meets regulatory requirements in the HGB area. The TCEQ continues to work with the EPA through the air monitoring network review process, as required by 40 CFR Part 58, to determine: the adequacy of the ozone monitoring network; additional monitoring needs; and recommended monitor decommissions. Air monitoring data from these monitors will continue to be quality assured, reported, and certified according to 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 one of these conditions is 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 RFP adjusted base year (ABY) inventory. These emissions reductions should be realized in the year following the year in which the failure is identified.

The EPA's final 2008 eight-hour 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 attainment demonstration contingency calculations were previously based on the RFP 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 EI. Accordingly, attainment demonstration contingency reductions for the 2008 eight-hour ozone standard are calculated based on the RFP base year EI.

This proposed HGB AD SIP revision uses the 2011 RFP base year inventory from the concurrent proposed Dallas-Fort Worth (DFW) and HGB Serious Classification RFP SIP Revision for the 2008 Eight-Hour Ozone NAAQS (Project Number 2019-079-SIP-NR) as the inventory from which to calculate the required 3% contingency reductions. The 3% contingency analysis for 2021 is based on a 3% reduction in NO_x and a 0% reduction in VOC, to be achieved between 2020 and 2021. Analyses were performed to assess emissions reductions between 2020 and 2021 from the federal emissions certification programs and for fuel control programs for both on-road and non-road vehicles.

A summary of the 2021 contingency analysis is provided in Table 4-3: *2021 HGB Attainment Contingency Demonstration (tons per day)*. The analysis demonstrates that the 2021 contingency reductions exceed the 3% reduction requirement; therefore, the attainment demonstration contingency requirement is met. Additional documentation for the attainment contingency demonstration calculations is available in the DFW and HGB Serious Classification RFP SIP revision being proposed concurrently with this HGB AD SIP revision.

Table 4-3: 2021 HGB Attainment Contingency Demonstration (tons per day)

Contingency Element Description	NO_X	VOC
2011 HGB RFP base year[1] (BY) EI	442.92	535.06
Percent for contingency calculation (total of 3%)	3.00	0.00
2020 to 2021 attainment demonstration required contingency reductions (RFP BY EI x [contingency percent])	**13.29**	**0.00**
Control reductions to meet contingency requirements		
2020 to 2021 emission reductions due to Post-1990 Federal Motor Vehicle Control Program, HGB Inspection/Maintenance Program, ultra low sulfur diesel, on-road reformulated gasoline (RFG), 2017 Low Sulfur Gasoline Standard, and on-road Texas Low Emissions Diesel (TxLED)	24.19	13.05
2020 to 2021 emission reductions due to federal non-road mobile new vehicle certification standards, non-road RFG, and non-road TxLED	4.59	2.29
Total attainment demonstration contingency reductions	**28.78**	**15.34**
Contingency Excess (+) or Shortfall (-)	**+15.49**	**+15.34**

Note 1: The EPA's final 2008 eight-hour ozone standard SIP requirements rule (80 FR 12263, March 6, 2015) removed the requirement for states to account for non-creditable reductions when determining compliance with RFP emissions reduction requirements. One result of removing the non-creditable reductions from the RFP calculations is the RFP ABY inventory becomes equal to the RFP BY inventory. The HGB attainment demonstration contingency calculations use the 2011 RFP base year EI to calculate required contingency reductions.

Note 2: This SIP revision does not provide a transportation conformity safety margin for the 2020 attainment demonstration MVEBs. Therefore, emissions reductions reserved for an MVEB safety margin are not included in the post attainment year contingency calculation (refer to Appendix 2: *HGB Reasonable Further Progress Demonstration Spreadsheet* of the RFP SIP revision).

4.9 ADDITIONAL FCAA REQUIREMENTS

FCAA, §182 sets out a graduated control program for ozone nonattainment areas. Section 4.9 of the 2016 HGB 2008 Eight-Hour Ozone AD Moderate Area SIP Revision adopted by the commission on December 15, 2016 included a description of how FCAA requirements for vehicle inspection and maintenance, nonattainment new source review, and emission statements from stationary point sources are met in the HGB area for the 2008 eight-hour ozone NAAQS. On May 15, 2017, the EPA approved Section 4.9 of the attainment demonstration SIP revision, effective July 14, 2017 (82 FR 22291). The TCEQ will monitor current aggregate vehicle mileage, aggregate vehicle emissions, and congestion levels as required by FCAA, §182(c)(5). The commission will determine if submittal of a demonstration to the EPA regarding transportation control would be necessary in the future if current levels exceed those included in this AD SIP revision.

4.10 EMISSION CREDIT GENERATION

The Emissions Banking and Trading (EBT) rules in 30 TAC Chapter 101, Subchapter H, Divisions 1 and 4 require sources in nonattainment areas to have SIP emissions to be eligible to generate emission credits. SIP emissions are the actual emissions from a facility or mobile source during the SIP emissions year, not to exceed any applicable local, state, or federal requirement. For point sources, the SIP emissions cannot exceed the amount reported to the state's EI; if no emissions were reported for a point source facility in the SIP emissions year, then the facility is not eligible for credits.

This proposed HGB AD SIP revision would revise the SIP emissions year used for emission credit generation. If adopted, the new SIP emissions year will be 2018 for point source electric generating units with emissions recorded in the EPA's Air Markets Program Data for 2018, 2016 for all other point sources, and 2017 for all area and mobile sources. In anticipation of this change, the TCEQ posted notice on the EBT webpages and sent notice through the EBT email notification system informing the public that emission credit applications submitted after January 18, 2019 must use the new SIP emissions year in the baseline assessment for sources in nonattainment areas.

CHAPTER 5: WEIGHT OF EVIDENCE

5.1 INTRODUCTION

The corroborative analyses presented in this chapter demonstrates the progress towards attainment of the 2008 eight-hour ozone National Ambient Air Quality Standard (NAAQS) that the Houston-Galveston-Brazoria (HGB) ozone nonattainment area continues to make. This corroborative information supplements the photochemical modeling analysis presented in Chapter 3: *Photochemical Modeling* to support a conclusion that the HGB nonattainment area will reach attainment of the 2008 eight-hour ozone standard by July 20, 2021. The United States Environmental Protection Agency's (EPA) *Modeling Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze* (EPA, 2018; hereafter referred to as modeling guidance) states that all modeled attainment demonstrations (AD) 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 proposed HGB 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 AD. An overview is provided of background ozone levels transported into the HGB nonattainment area. More detail on these ozone and emissions trends in the HGB area is provided in Appendix D: *Conceptual Model for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard*.

Second, this chapter also discusses the results of additional air quality studies and their relevance to the HGB AD. Third, this chapter describes air quality control measures that are not quantified but are nonetheless expected to yield tangible air quality benefits, even though they were not included in the AD modeling discussed in Chapter 3.

5.2 ANALYSIS OF AMBIENT TRENDS AND EMISSIONS TRENDS

The EPA's modeling guidance states that examining recently observed air quality and emissions trends is an acceptable method to qualitatively assess progress toward attainment. Declining trends in observed concentrations of ozone and its precursors 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. The eight-county HGB ozone nonattainment area has an extensive monitoring network that currently has 20 regulatory and 19 non-regulatory ozone monitors, 22 nitrogen oxides (NO_x) monitors, and 13 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 (TCEQ) Air Monitoring Sites webpage (https://www.tceq.texas.gov/airquality/monops/sites/air-mon-sites).

This section examines emissions trends as well as ambient trends from the extensive ozone and ozone-precursor monitoring network in the HGB area. Overall, despite a continuous increase in the population of the eight-county HGB ozone nonattainment area, a strong economic development pattern, and growth in vehicle miles traveled (VMT), the observed trends are declining for ozone concentrations and NO_X and VOC precursor emissions.

Appendix D provides multiple graphics that detail ozone trends in the region primarily from 2007 through 2016. The graphics and analyses also illustrate the wealth of monitoring data examined including regulatory ozone monitors and a network of auto-GCs. The one-hour and the eight-hour ozone design values both have overall sustained decreasing trends over the past 10 years, and the HGB area has monitored attainment of the revoked one-hour ozone standard since 2013.

The categories of on-road, non-road, and electric generating units (EGUs) have historically been primary sources of anthropogenic NO_X, VOC, and carbon monoxide (CO) emissions in the eight-county HGB nonattainment area. From the late 1990s to the present, federal, state, and local measures have resulted in significant NO_X reductions from these source categories within HGB. The TCEQ funded a study by the Texas Transportation Institute (TTI) to estimate on-road emissions trends throughout Texas from 1999 through 2050 using the 2014a version of the Motor Vehicle Emission Simulator (MOVES2014a) model (TTI, 2015). As shown in Figure 5-1: *On-Road Emissions Trends in the Eight-County HGB Area from 1999 through 2050*, HGB on-road emissions were estimated to be 386 NO_X tons per day (tpd) in 1999 and have decreased roughly 78% by 2018, even as daily VMT is estimated to have increased by 40% during this period. Figure 5-1 also shows that this reduction in on-road NO_X is projected to continue as older, higher-emitting vehicles are removed from the fleet and are replaced with newer, lower-emitting ones.

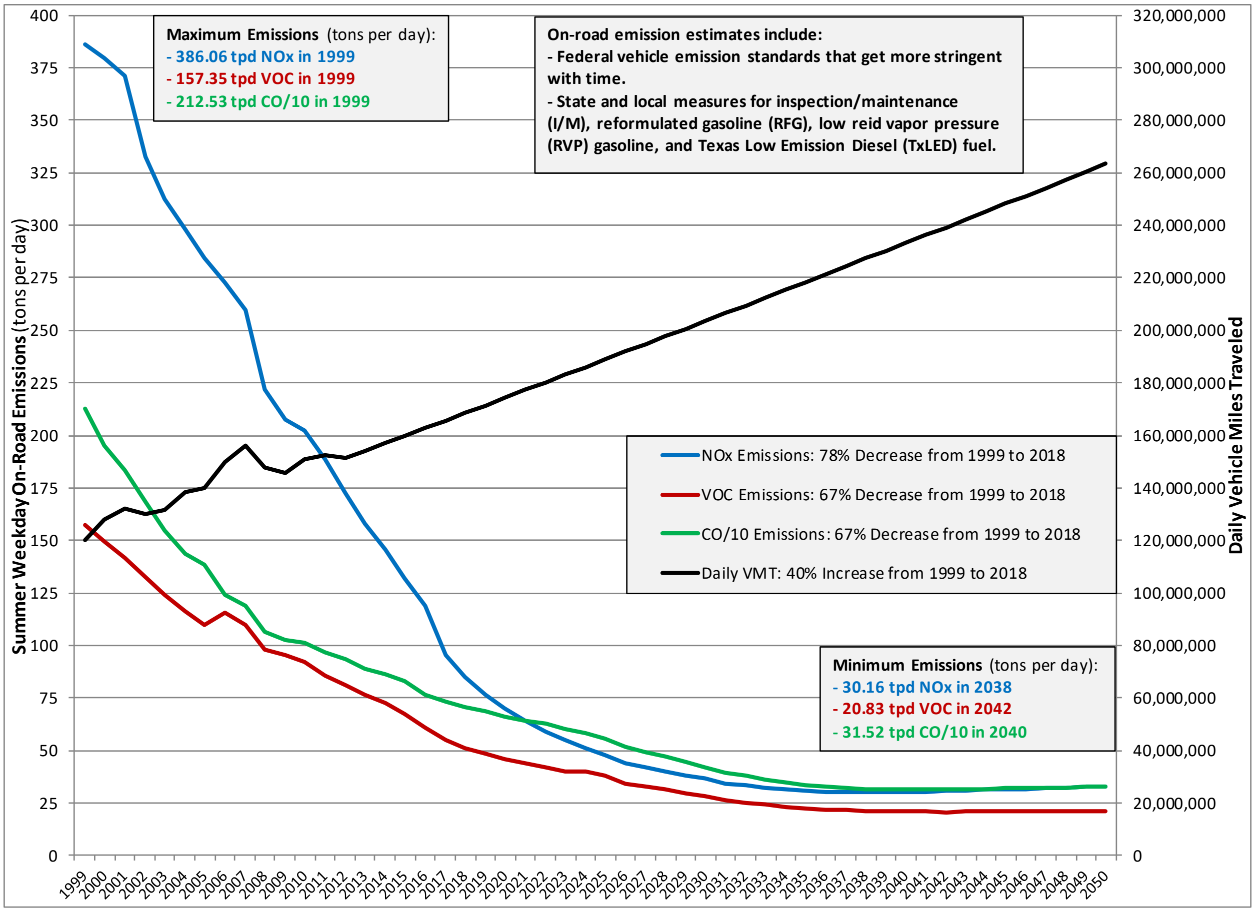


Figure 5-1: On-Road Emissions Trends in the Eight-County HGB Area from 1999 through 2050

A similar pattern is reflected in a TCEQ non-road emissions trends analysis using the Texas NONROAD (TexN) model. As shown in Figure 5-2: *Non-Road Emissions Trends in the Eight-County HGB Area from 1999 through 2050*, non-road emissions were estimated to be 97 NO_x tpd in 1999 and have decreased roughly 62% by 2018, even as the number of non-road engines (equipment population) has increased by 46% during this period. As with the on-road fleet turnover effect presented in Figure 5-1, Figure 5-2 shows that reductions in non-road NO_x emissions are projected to continue as older higher-emitting equipment is removed from the fleet and replaced with newer lower-emitting equipment.

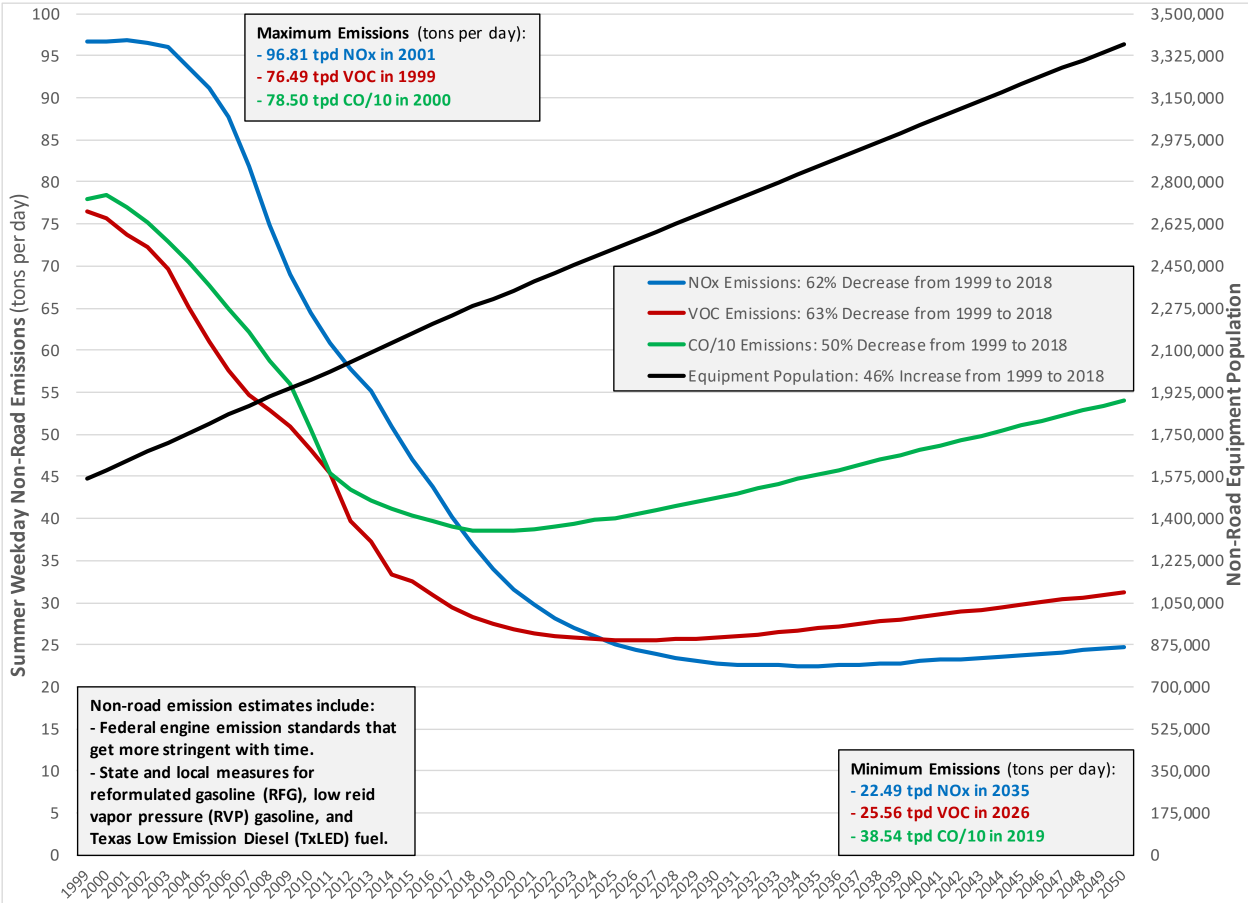


Figure 5-2: Non-Road Emissions Trends in the Eight-County HGB Area from 1999 through 2050

Operational data for HGB area EGUs from 1997 through 2018 were extracted from the EPA's Air Markets Program Data (AMPD) tool and are presented in Figure 5-3: *EGU Emissions Trends in the Eight-County HGB Area from 1997 through 2018*. As shown, HGB area EGUs emitted an average of 229 NO_x tpd during the summer of 1997 and have reduced these emissions by 84% through 2018, even though the amount of electricity generated during this time has increased by 46%. Due to the emission controls installed on existing units and the retirement of older plants, the summer daily average EGU NO_x has not exceeded 40 tpd from 2007 through 2018, except for the unusually hot summer of 2011.

These trends in on-road, non-road, and EGU sources demonstrate the substantial progress in reducing HGB area NO_x emissions that has already occurred and is expected to be sustained in the future.

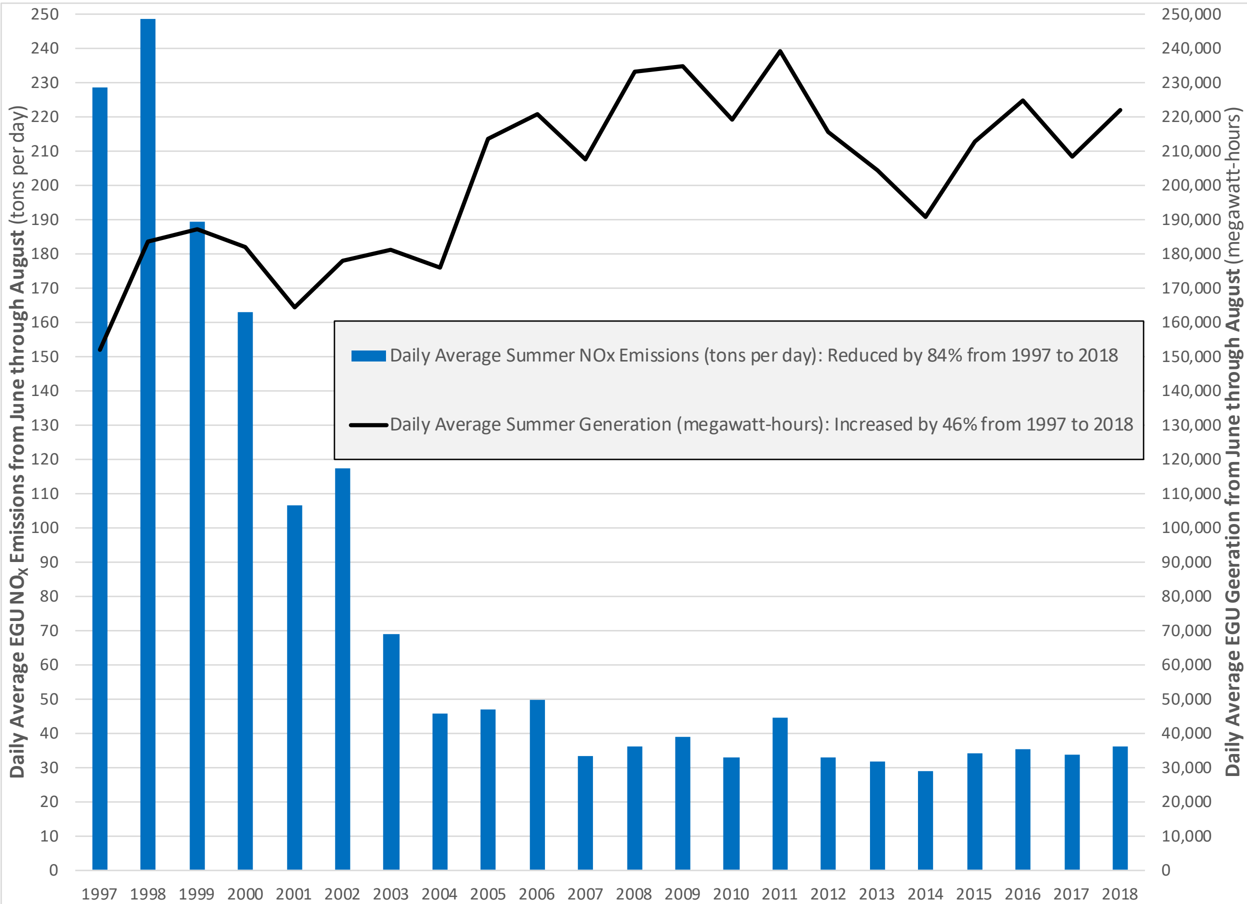


Figure 5-3: EGU Emissions Trends in the Eight-County HGB Area from 1997 through 2018

5.2.1 Ozone Trends

Because ozone varies both temporally and spatially, there are several ways that trends in ozone concentrations are analyzed. This section will discuss ozone design value trends, trends in the fourth-highest eight-hour ozone concentrations, trends in ozone exceedance days, and background ozone trends. These trends provide evidence to support the conclusion that the eight-county HGB area is making progress towards attainment of the 2008 eight-hour ozone NAAQS. Ozone data used in this section is only from regulatory monitors that report to the EPA's Air Quality System (AQS) unless otherwise noted.

5.2.1.1 Ozone Design Value Trends

A design value is the statistic used to determine compliance the NAAQS. For the 2008 eight-hour ozone NAAQS, design values are calculated by averaging fourth-highest daily-maximum eight-hour averaged ozone value at each monitor site over three years. The eight-hour ozone design value for a metropolitan area is the maximum design value from all the area's monitors' individual design values. Design values of 76 parts per billion (ppb) and greater exceed the 2008 eight-hour ozone NAAQS of 75 ppb. Although this HGB AD SIP revision focuses on eight-hour ozone, the one-hour ozone design values can also be useful to determine ozone trends. The one-hour ozone design values are calculated differently than the eight-hour ozone design values. The one-hour ozone design value is calculated by determining the fourth-highest daily-maximum one-hour ozone value over three years at each monitor. Like the eight-hour ozone design values, the one-hour ozone design value for a metropolitan area is the maximum design value from all the monitors within that area.

Both eight-hour and one-hour ozone design values have decreased in the eight-county HGB area over the past 14 years, as shown in Figure 5-4: *Eight-Hour and One-Hour Ozone Design Values in the HGB Area*. The 2018 HGB one-hour ozone design value is 112 ppb, which demonstrates continued attainment of the revoked one-hour ozone NAAQS and a 34% decrease from the 2005 design value of 169 ppb. The 2018 eight-hour ozone design value of 78 ppb represents a 24% decrease from the 2005 design value of 103 ppb.

The largest decreases in both design values appear to occur from 2005 through 2009, when the one-hour ozone design value dropped by 42 ppb and the eight-hour ozone design value decreased by 19 ppb. These decreases may be evidence of the success of emission controls as they coincide with the adoption (in 2004) and first compliance period (in 2007) of the Highly Reactive Volatile Organic Compound Emissions Cap and Trade (HECT) Program (30 Texas Administrative Code (TAC) §101.394 (2004) and 29 TexReg 11594 (2004)) and the Mass Emissions Cap and Trade (MECT) Program for NO_X (30 TAC §101.352). One-hour ozone trends have decreased at a faster rate compared to eight-hour ozone trends, which could be attributed to several factors. One is the nature of the design value calculation itself; one-hour ozone is a fourth-highest value over three years whereas eight-hour ozone is an average of the fourth-highest values. Taking the average tends to smooth trends so that decreases are smaller from year-to-year. Another reason for the difference could relate to background ozone, which appears to affect the eight-hour averaged ozone concentrations much more than the one-hour ozone concentrations.

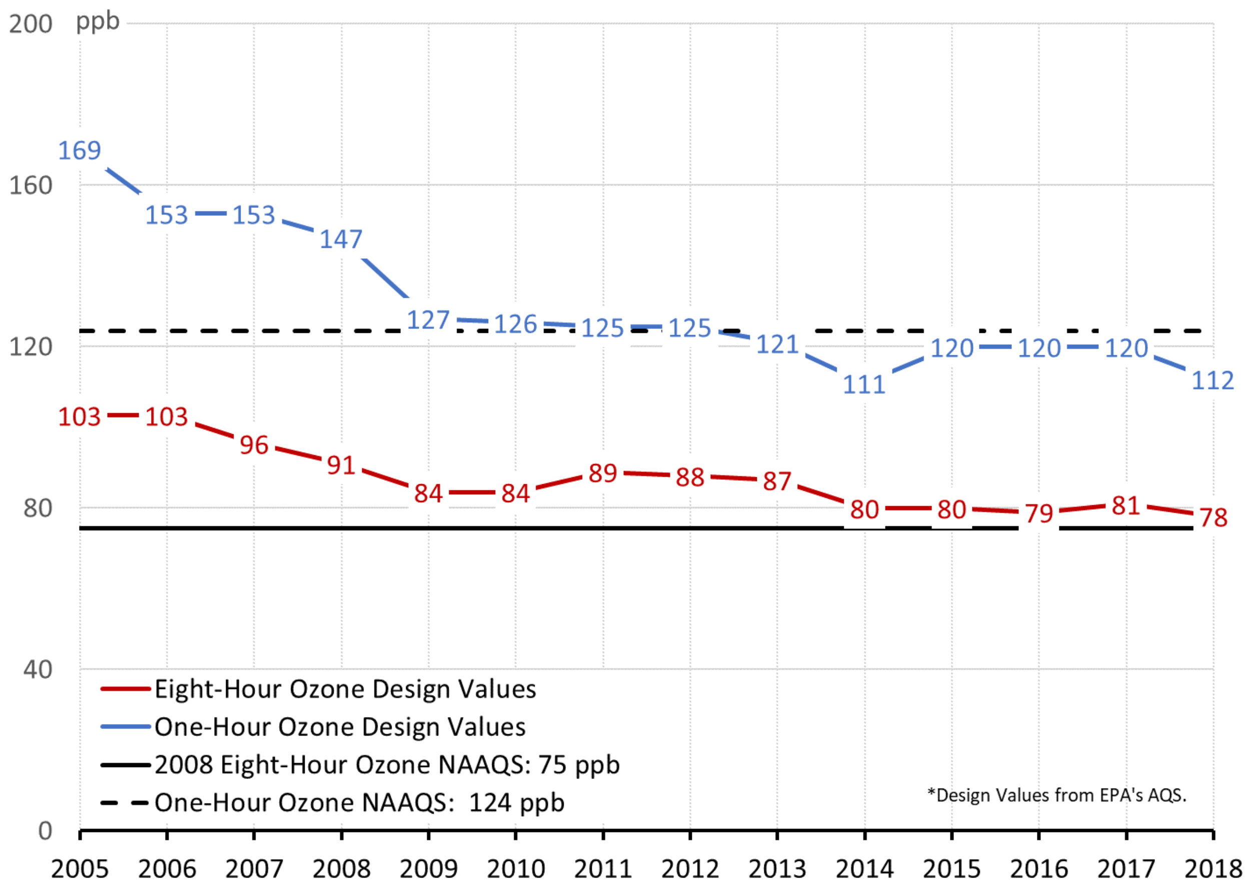


Figure 5-4: Eight-Hour and One-Hour Ozone Design Values in the HGB Area

Because ozone varies spatially, it is also prudent to investigate trends at all monitors in an area. Figure 5-5: *Eight-Hour Ozone Design Values by Monitor in the HGB Area* displays the eight-hour design values from 2005 through 2018 at each monitor in the HGB area. The individual monitors' trends in this graphic are less important than the overall range in design values across the HGB area. Figure 5-5 demonstrates that design values have been decreasing across the HGB area. Prior to 2007, no monitors in the HGB area measured below the 2008 eight-hour ozone NAAQS of 75 ppb. From 2007 forward, the HGB area observed successively more monitors measuring design values below the 2008 eight-hour ozone NAAQS. By 2018 only two out of 20 monitors measured design values above the 2008 eight-hour ozone NAAQS. Note that the difference between the maximum eight-hour ozone design value and the minimum eight-hour ozone design value has decreased from 24 ppb in 2005 to 17 ppb in 2018. This may indicate that there is less local contribution to the ozone concentration occurring in more recent years.

Figure 5-5 also shows how the monitor with the highest eight-hour ozone design value in the HGB area has changed over time. From 2005 through 2009, the Houston Bayland Park (C53) monitor observed eight-hour ozone design values several ppb higher than other monitors. In 2010, the Houston Bayland Park (C53) monitor no longer observed the highest eight-hour ozone design values. Instead, the highest design values were observed at the Manvel Croix Park (C84) monitor. The Manvel Croix Park (C84) monitor continued to have the highest design values in the HGB area until 2016, when the Houston Aldine (C8) monitor observed the highest eight-hour ozone design value. The Houston Aldine (C8) monitor has continued to have the highest design values in the HGB area.

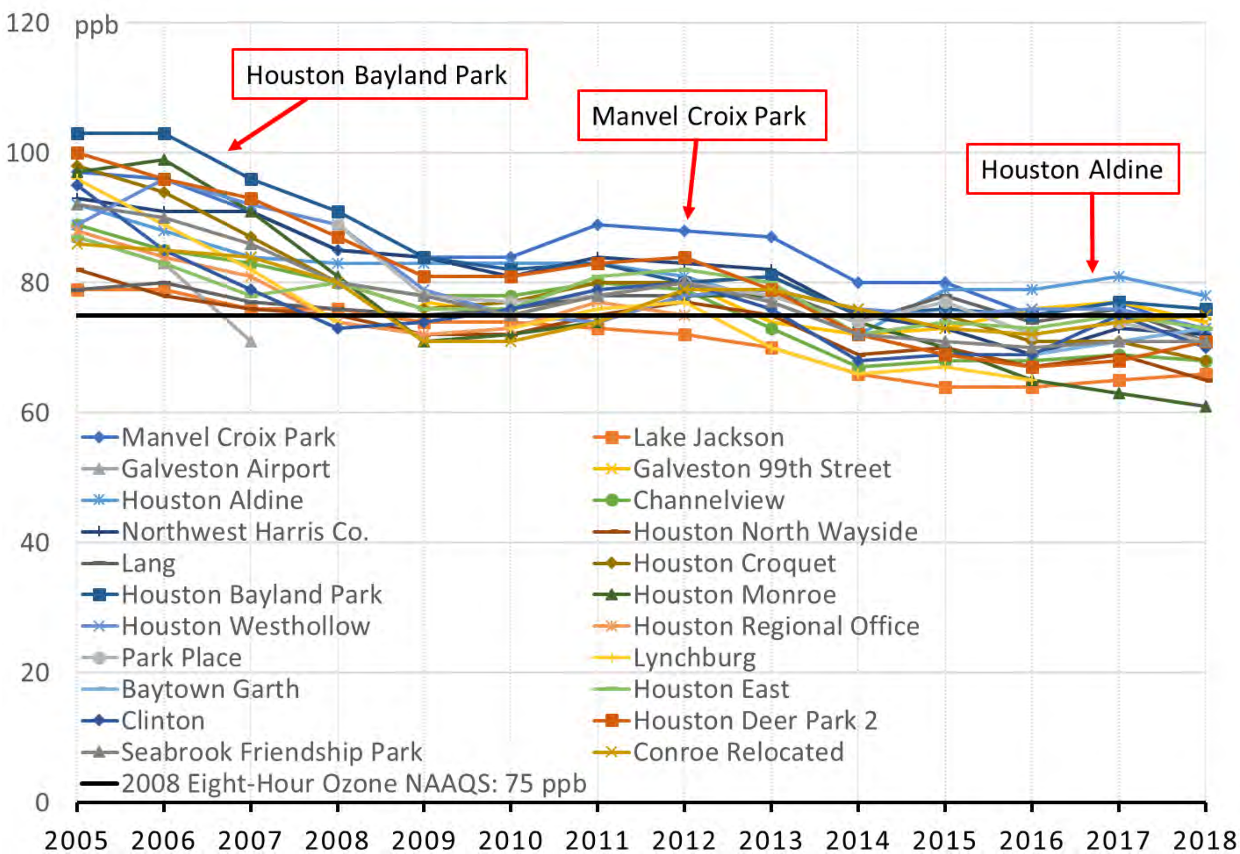


Figure 5-5: Eight-Hour Ozone Design Values by Monitor in the HGB Area

Design value trends by monitor can be more useful when displayed on a map. Kriging interpolation[16] was used to determine the spatial variation of eight-hour ozone design values across the HGB area. The maps of those values for three different years are displayed in Figure 5-6: *Eight-Hour Ozone Design Value Map for the HGB Area*. Only the monitors with the maximum eight-hour ozone design value in the HGB area for each year are labeled on the maps. The three maps show the design values from 2006, 2012 and 2018. The map demonstrates how much eight-hour ozone design values have decreased across the entire HGB area. The minimum design value observed (78 ppb) in 2006 is now the maximum design value observed in 2018.

In addition to the level of the design values, the map also illustrates the changing location of the minimum and maximum eight-hour ozone design values in the HGB area. The monitor with the maximum design value in 2006, Houston Bayland Park (53),

[16] Kriging interpolation is a method of spatial interpolation that uses a limited set of sampled data points to estimate the value of a variable over a continuous spatial field.

is located to the west of the Houston Ship Channel, an area with a large amount of industrial activity. In 2012, the maximum design value was located at the Manvel Croix Park (C84) monitor, located to the southeast of the Houston Bayland Park (C53) monitor, and to the southwest of the Houston Ship Channel. In 2018, the maximum eight-hour ozone design value was located at the Houston Aldine (C8) monitor, which is north of the Houston Ship Channel. The location of the minimum eight-hour ozone design value has also changed; however, lower design values for all three of the years shown are observed to the south and in the center of the HGB area. In 2006 and 2012, higher ozone design values were observed in areas closer to the Houston Ship Channel, at monitors such as Houston Monroe (C406) in 2006 and Houston Deer Park #2 (C35) in 2012. Design values near the ship channel were much lower in 2018, with the Houston Monroe (C406) monitor observing the lowest design value in the HGB area.

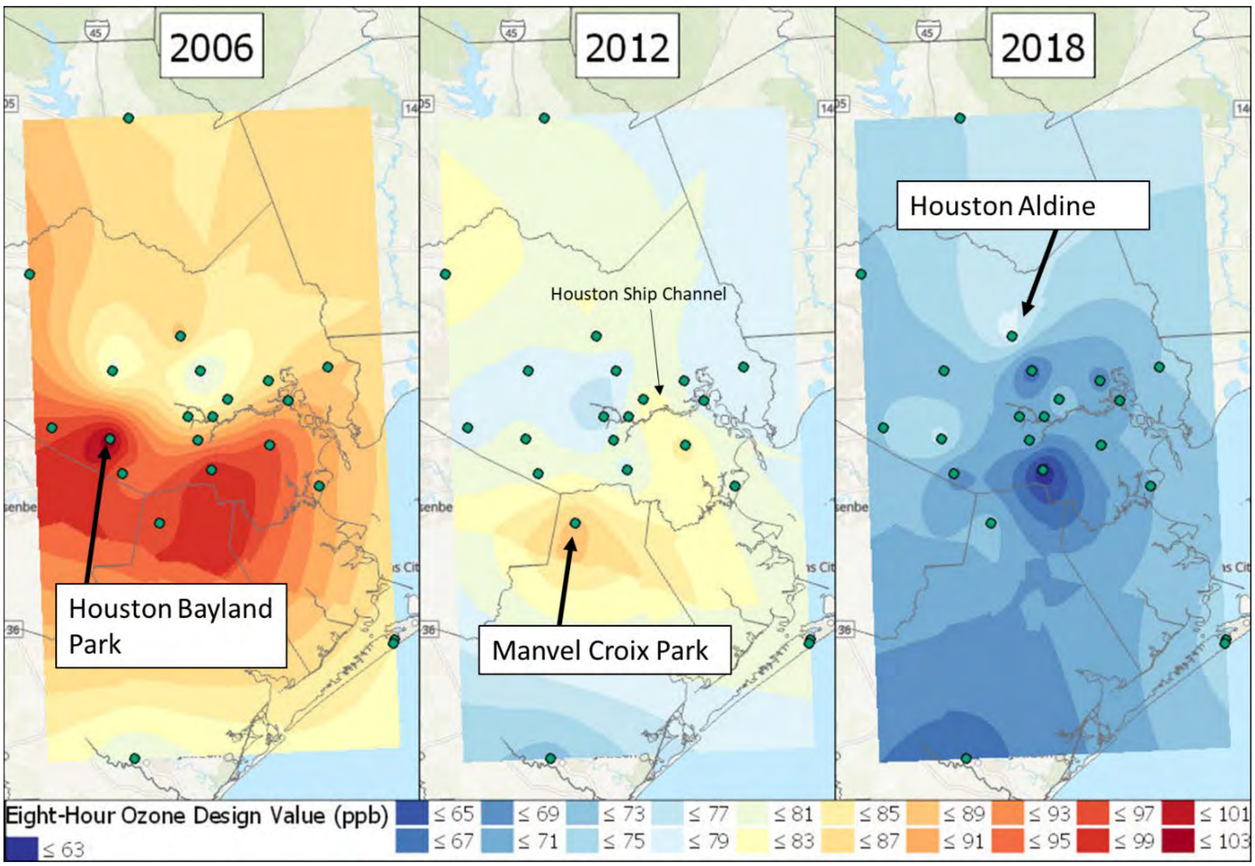


Figure 5-6: Eight-Hour Ozone Design Value Map for the HGB Area

5.2.1.2 Fourth-Highest Eight-Hour Ozone Trends

Because eight-hour ozone design values are three-year averages, the trends tend to be smoother, and year-to-year variations in ozone concentrations due to factors such as meteorology are less apparent. Investigating the trends in the yearly fourth-highest maximum daily average eight-hour (MDA8) ozone concentrations can provide more insight into each individual year. Fourth-highest MDA8 ozone trends can also help determine what levels of ozone are required in order for the area to monitor attainment. Area-wide fourth-highest MDA8 ozone trends are not very instructive because design values are calculated on a per monitor basis. Instead fourth-highest MDA8 ozone trends are investigated at each monitor in the HGB area in Figure 5-7:

Fourth-Highest MDA8 Ozone Concentration by Monitor in the HGB Area. The fourth-highest MDA8 ozone trends span from 2003 though 2018 in order to examine all years used in the design value calculations.

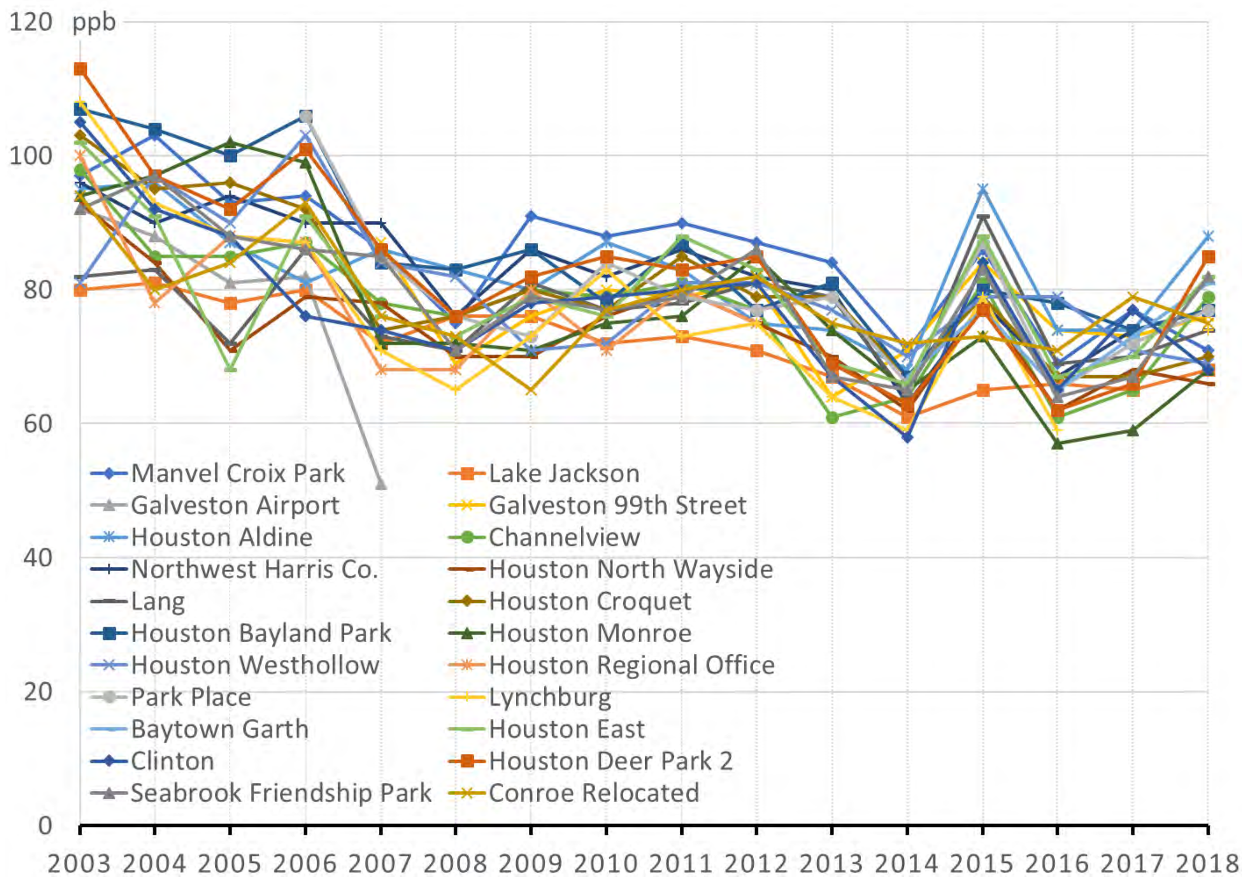


Figure 5-7: Fourth-Highest MDA8 Ozone Concentration by Monitor in the HGB Area

Figure 5-7 shows that, in general, trends in the fourth-highest MDA8 ozone values are decreasing from 2003 through 2018, although there have been some increases at some monitors in recent years. There is much more variability present in the fourth-highest MDA8 ozone values when compared to design values. Although the HGB area has recorded some of the lowest eight-hour ozone design values in 2018, the fourth-highest MDA8 ozone values indicate that 2018 experienced higher ozone than the previous two years. Like the design values, the difference between the minimum fourth-highest MDA8 ozone concentration and the maximum fourth-highest MDA8 ozone concentration has decreased from 33 ppb in 2005 to 22 ppb in 2018, indicating that there may be less local contribution to the ozone values occurring in more recent years.

Except for Manvel Croix Park (C84) from 2009 through 2013, the monitor with the maximum fourth-highest MDA8 ozone concentration in the HGB area is not consistent from 2003 through 2018. For many years, the individual monitors did not exhibit similar trends, and different monitors may have had increasing or decreasing fourth-highest MDA8 ozone values from year to year. This indicates that there may be more local influences affecting ozone concentrations. However, there are several more recent years, such as 2014 and 2015, where almost all the monitors appear to exhibit similar trends. This indicates that ozone concentrations in those years may be strongly influenced by non-local factors such as meteorology.

5.2.1.3 Ozone Exceedance Day Trends

Ozone trends can also be investigated by looking at the number of days that the maximum eight-hour ozone levels were above a NAAQS threshold, termed an ozone exceedance day. For the 2008 eight-hour ozone NAAQS, an eight-hour ozone exceedance day is considered any day that any monitor in the area measures an eight-hour average ozone concentration greater than 75 ppb. Because the number of monitors can influence the number of exceedance days, it is important to look at the number of ozone exceedance days at each individual monitor. When exceedances are calculated for the area, days with multiple monitors with ozone exceedances are only counted as one day.

The number of eight-hour ozone exceedance days for the HGB area are displayed in Figure 5-8: *Number of Eight-Hour Ozone Exceedance Days in the HGB Area*. When comparing 2005 through 2018, the number of eight-hour ozone exceedance days occurring in the HGB area has fallen 78%; however, most of that decrease (65%) occurred from 2005 through 2008. Like with the fourth-highest MDA8 ozone values, there is not a monitor that consistently has the most ozone exceedances, except for the Manvel Croix Park (C84) monitor, from 2010 through 2012. The number of ozone exceedance days at each individual monitor has also decreased from 2005 through 2018. The ozone exceedance day trends vary from year to year with each monitor but in 2014 and 2015 all the monitors exhibited similar trends, similar to what was observed with the fourth-highest MDA8 ozone values. This is further evidence that there was a non-local factor, such as meteorology, that affected the ozone concentrations in those years.

Many monitors also show an increase in exceedance days from 2017 through 2018; however, area-wide ozone exceedances decreased from 2017 through 2018. This discrepancy is because many of the ozone exceedance days in 2017 had only one monitor exceed, whereas many of the ozone exceedance days in 2018 had multiple monitors exceed. This indicates that high ozone in 2017 was more likely caused by localized issues, and that ozone in 2018 was more likely caused by area-wide issues. Note that the difference in the monitor with the maximum number of exceedance days and the monitor with the minimum number of exceedance days has also decreased from a 30-day difference in 2005 to a seven-day difference in 2018.

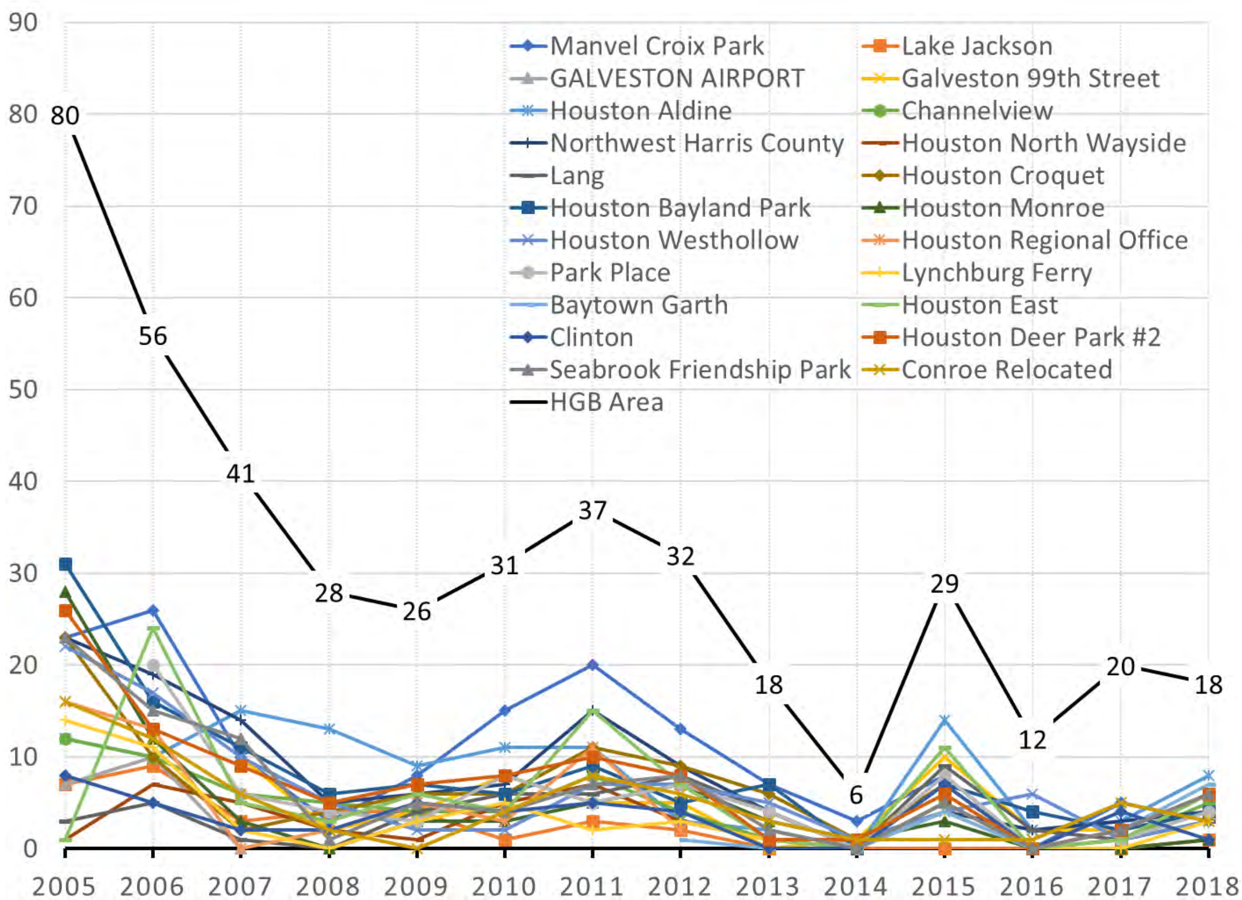


Figure 5-8: Number of Eight-Hour Ozone Exceedance Days in the HGB Area

5.2.1.4 Background Ozone Trends

Background ozone reflects the ozone produced from all sources outside of the eight-county HGB nonattainment area. Determining the background ozone concentrations in the HGB area will indicate how much ozone the area produces from local emissions. Since background ozone concentrations are not easily controlled, the local component of ozone formation is then the amount of ozone that the area could potentially control to meet the 2008 eight-hour ozone NAAQS.

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. For this analysis the sites selected included: Baytown Garth (C1017), Channelview (C15), Conroe Relocated (C78), Galveston Airport (C34), Galveston 99th Street (C1034), Houston Aldine (C8), Houston Bayland Park (C53), Houston Croquet (C409), Houston Deer Park #2 (C35), Houston Monroe (C406), Houston North Wayside (C405), Houston

Westhollow (C410), Lake Jackson (C1016), Lynchburg Ferry (C1015), Manvel Croix Park (C84), Northwest Harris County (C26), and Seabrook Friendship Park (C45).

Background ozone was estimated as the lowest MDA8 ozone value observed at the selected background sites for each day from 2005 through 2018. Although the HGB area has a year-round ozone season, very few high ozone days occur outside of the months of April through October. To focus on the months that observed the highest eight-hour ozone levels, this analysis uses ozone data from only the months of April through October, which is referred to as the "ozone season." Inherent in this method is the assumption that the lowest MDA8 ozone 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.

Daily background ozone values and MDA8 ozone values were averaged for each year and are displayed in Figure 5-9: *Average MDA8 Ozone and Average Background Eight-Hour Ozone Trends for the Ozone Season (April through October) in the HGB Area*. Trends in background ozone have been decreasing during the ozone season from 2005 through 2018. Like with ozone design values, the largest decrease in background ozone was from 2005 through 2009, when the background value dropped from 36 ppb to 28 ppb. From 2008 through 2018 background ozone levels have been more consistent and range from 33 ppb to 27 ppb. MDA8 ozone concentrations have also decreased, but at a slightly faster rate compared to background values. This indicates that there has also been a decrease in locally produced ozone in addition to background ozone.

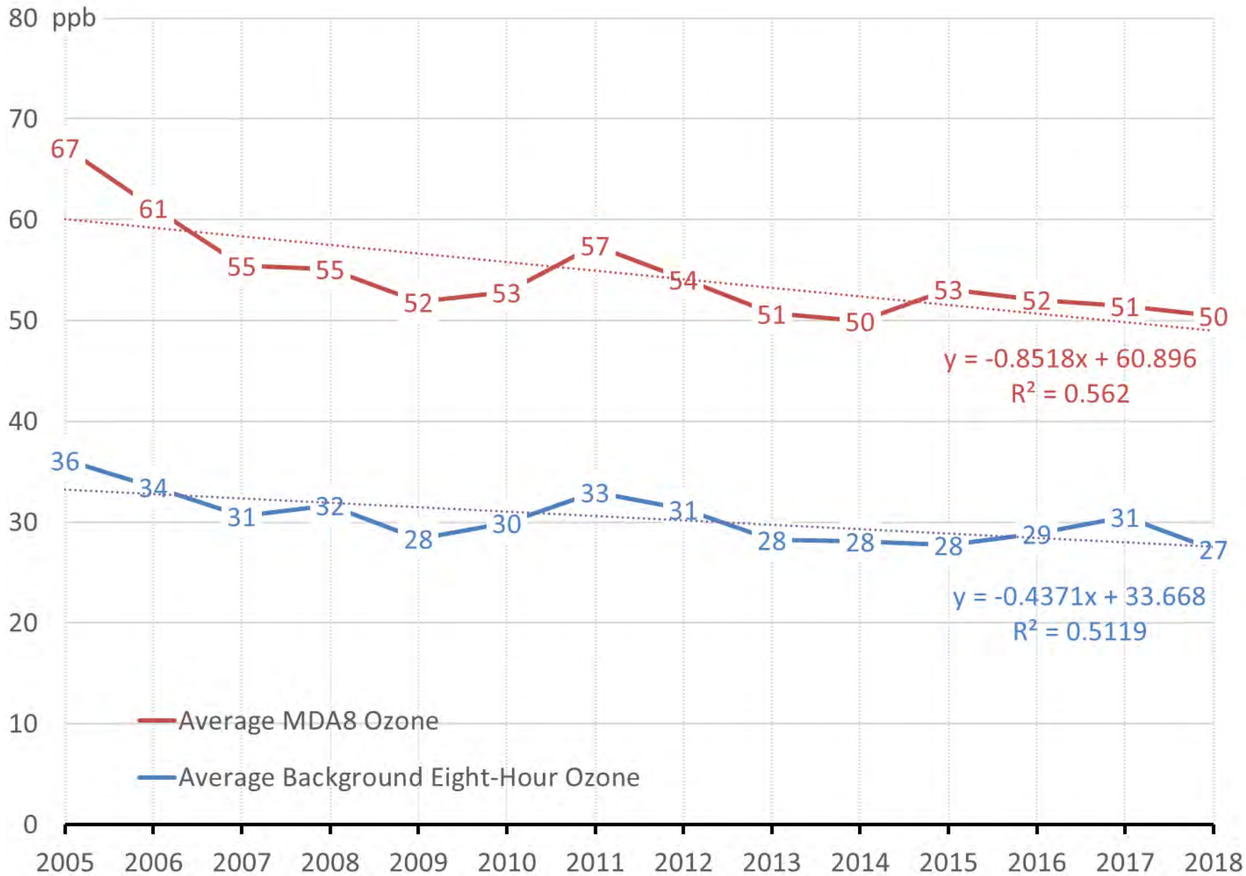


Figure 5-9: Average MDA8 Ozone and Average Background Eight-Hour Ozone Trends for the Ozone Season (April through October) in the HGB Area

5.2.2 Nitrogen Oxide Trends

NO_X, a precursor to ozone formation, is a mixture of nitrogen 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 will discuss trends in ambient NO_X concentrations. Although the HGB area currently has 22 NO_X monitors, only 17 report data to the EPA. Only monitors that report data to the EPA are used in this section. Out of those 17 NO_X monitors, two are near-road monitors and only started operation in 2014 and 2015. These near-road monitors will measure higher NO_X values since they are located closer to the road. Using these monitors in an overall HGB area analysis might artificially inflate the trends in later years. For this reason, only 13 of the 17 NO_X monitors were used to calculate area-wide trends. The 13 monitors are monitors that were in operation every year from 2005 through 2018.

Because NO_x reacts in the presence of sunlight, NO_x concentrations tend to be lower in the summer and higher in the winter. To focus on the NO_x values that lead to ozone formation, this analysis uses only NO_x concentrations that occur during April through October, or the "ozone season." NO_x trends were calculated by first determining the daily-peak NO_x from the 13 long-term NO_x monitors in the HGB area. The daily maximums from April through October were then used to calculate the average NO_x, the 90th percentile NO_x, and the 10th percentile NO_x.

Ozone season trends for ambient NO_x concentrations are presented in Figure 5-10: *Daily-Peak* NO_x *Trends for the Ozone Season in the HGB Area*. Overall, NO_x trends in the HGB area are decreasing for all three statistics with mostly similar rates. From 2005 through 2018, average NO_x decreased by 48%, 90th percentile NO_x decreased by 42%, and 10th percentile NO_x decreased by 48%. Like with ozone trends, most NO_x decreases appear to have occurred from 2005 through 2009. After 2009, NO_x decreases have continued, but at a slower rate.

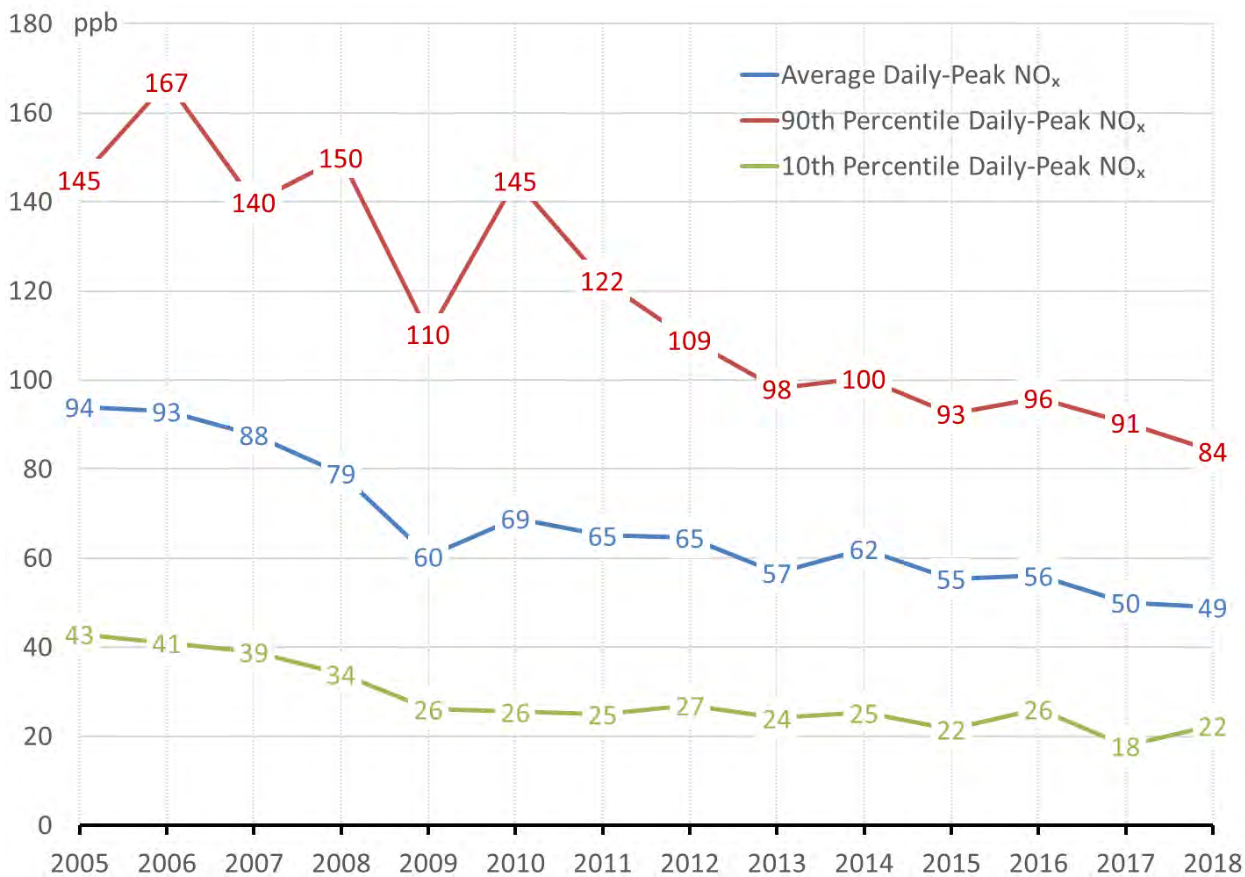


Figure 5-10: Daily-Peak NO_x Trends for the Ozone Season in the HGB Area

Like 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 for the 17 HGB area monitors that report NO_x data to the EPA were examined. Like with the area-wide NO_x trends, only NO_x data from April through October, or the "ozone season," was examined at each monitor. In addition, the NO_x data was checked for completeness because incomplete data may show inaccurate trends. Only years with at least 75% complete data were used in this analysis.

Ozone season NO_x trends by monitor in the HGB area are presented in Figure 5-11: *Average Daily-Peak* NO_x *Concentrations by Monitor for the Ozone Season in the HGB Area*. The trends show that NO_x concentrations have decreased across all monitors. Decreases for monitors operating from 2005 through 2018 range from 30% to 58%. Again, most of the decreasing trends at the various monitor sites appears to occur prior to 2009. The higher values at two monitors from 2014 through 2018 are due to their location at major Houston roadways (Southwest Freeway (C166) and North Loop (C1052)); although these monitors only have three to five years of data, there is still a slight downward trend observed from 2014 through 2018. The other monitors in the HGB area with higher NO_x values are located in more urban areas, near roadways, or near industrial sources. Decreases at these monitors indicate that the HGB area may be experiencing decreases in NO_x concentrations due to decreases in mobile source and industrial NO_x emissions.

Overall, since 2005, ambient NO_x concentrations in the HGB area are trending downward. These downward trends match the trends observed in ozone, with most of the decreases occurring from 2005 through 2009, and then continuing at a slower rate through 2018. These trends are likely the result of state controls placed on point sources, along with the federal standards implemented for on-road vehicles and non-road equipment.

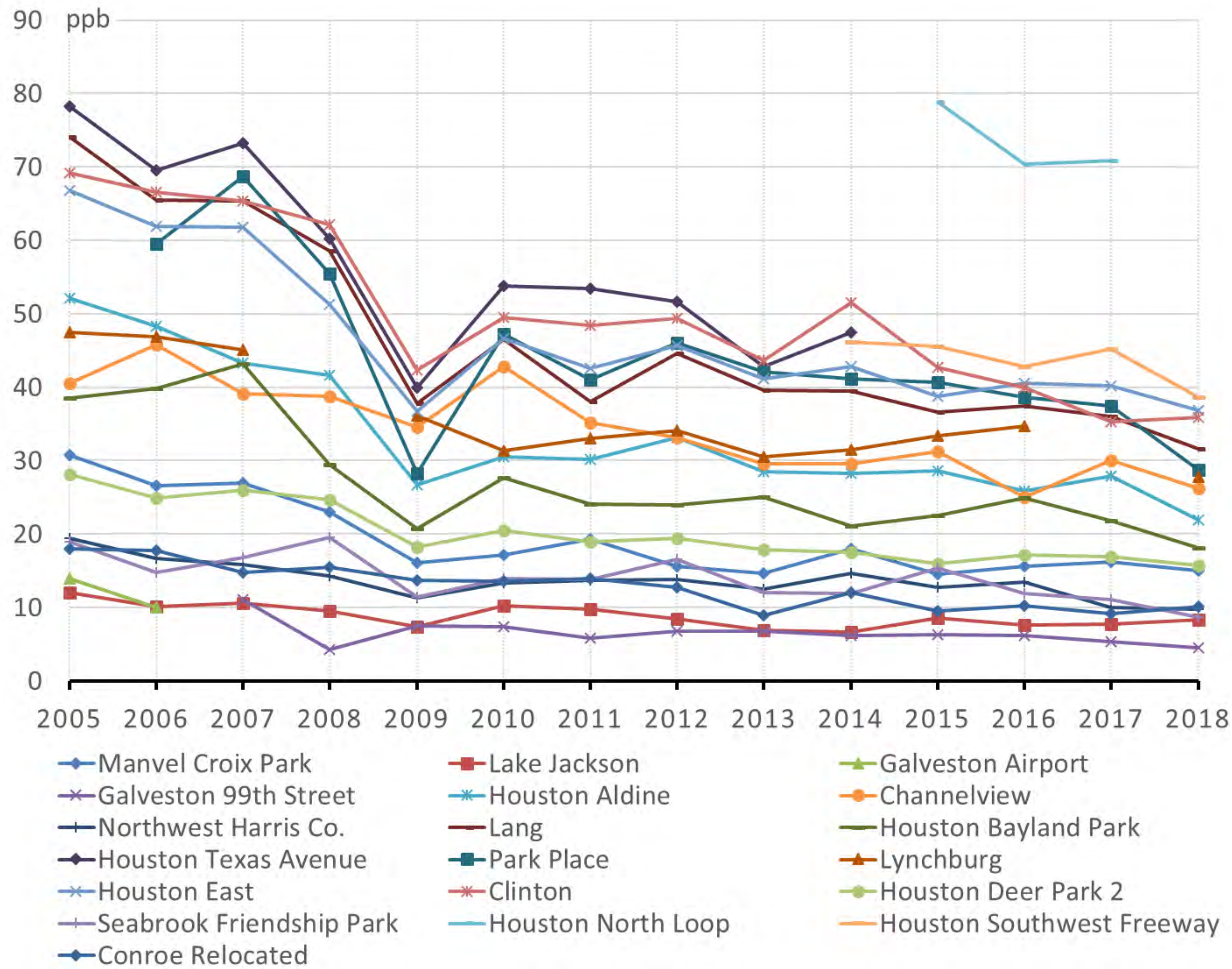


Figure 5-11: Average Daily-Peak NO_x Concentrations by Monitor for the Ozone Season in the HGB Area

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 area: auto-GCs, which record hourly data; and canisters, which record 24-hour data. Due to the reactive nature of VOCs, the hourly auto-GC measurements are preferred when assessing trends.

This section will discuss trends in ambient TNMHC concentrations from the auto-GC monitors. Only the 11 auto-GC monitors in operation from 2005 through 2018 were used to calculate area-wide trends. Not all of these 11 auto-GC monitors report data to the EPA, but they are used here due to the lack of auto-GC data. Note that 2018 data has not been quality assured and is subject to change. Like both ozone and NO_x, VOCs react in the presence of sunlight. To focus on the VOC concentrations that affect ozone formation, this analysis uses only data from April through October, or the "ozone season." TNMHC trends were calculated by first determining the daily-peak TNMHC concentration from the 11 long-term auto-GC monitors in the HGB area. The daily maximums from April through October were then used to calculate the average TNMHC, the 90th percentile TNMHC, and the 10th percentile TNMHC.

Ozone season trends for ambient TNMHC concentrations are presented in Figure 5-12: *Daily-Peak TNMHC Trends for the Ozone Season in the HGB Area*. Overall, daily-peak TNMHC trends in the HGB area are decreasing for all three statistics. From 2005 through 2018, average daily-peak TNMHC decreased by 71%, 90th percentile daily-peak TNMHC decreased by 62%, and 10th percentile daily-peak TNMHC decreased by 61%. Like with ozone and NO_x trends, the largest TNMHC decreases appear to have occurred from 2005 to 2009. After 2009, TNMHC decreases have continued, but at a slower rate.

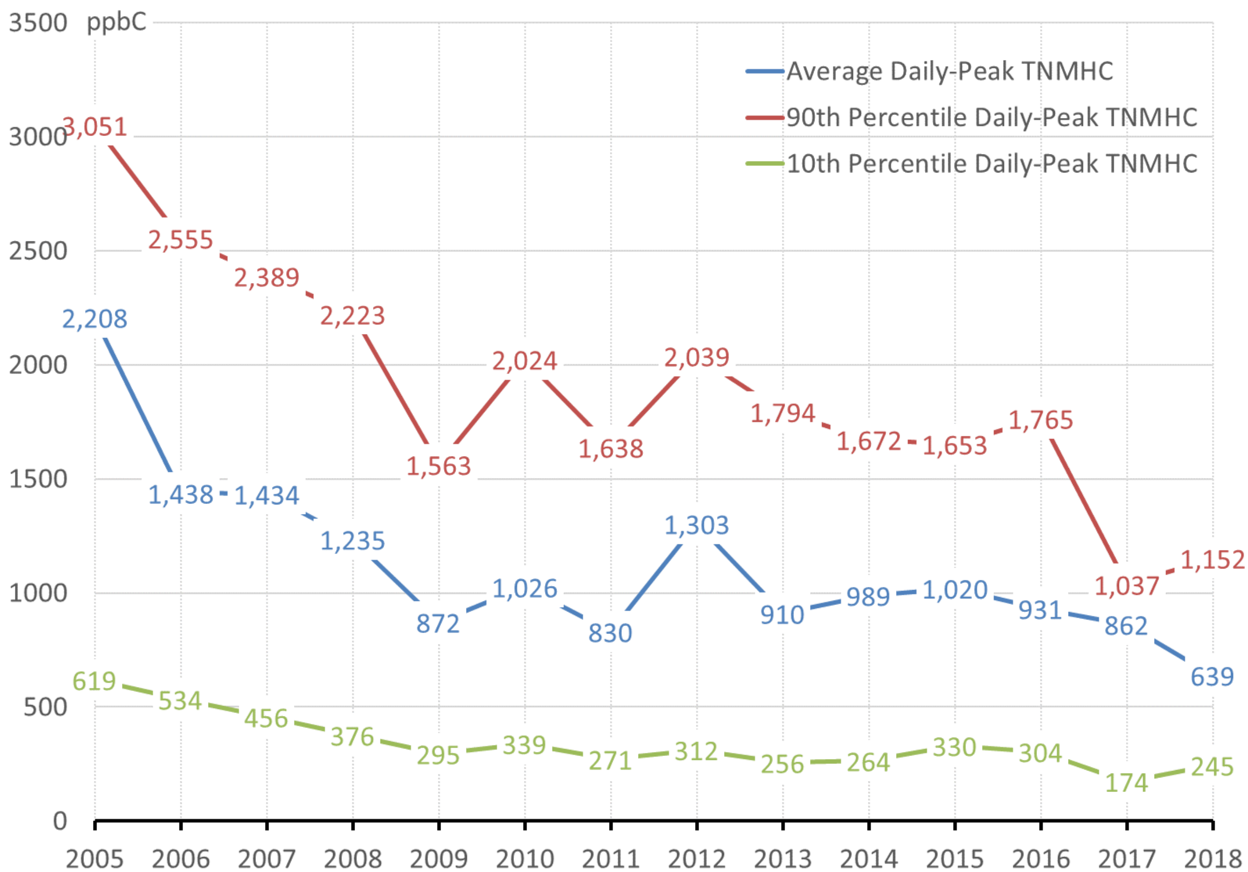


Figure 5-12: Daily-Peak TNMHC Trends for the Ozone Season in the HGB Area

Like ozone and NO_x, TNMHC concentrations can vary widely based on location. TNMHC values tend to be higher when located nearer to VOC emission sources. Due to these variations, TNMHC trends for the 14 HGB area auto-GC monitors that reported TNMHC data at any point from 2005 through 2018 were examined. Like with the area-wide trends, only data from April through October, or the "ozone season," was examined at each monitor. In addition, the TNMHC data was checked for completeness because incomplete data may show inaccurate trends. Only years with at least 75% complete data were used in this analysis.

Ozone season TNMHC trends by monitor in the HGB area are presented in Figure 5-13: *Average Daily-Peak TNMHC Concentrations by Monitor for the Ozone Season in the HGB*

Area. The trends show that, overall, TNMHC concentrations have decreased across all monitors. Decreases for monitors operating from 2005 through 2018 range from 15% to 83%. Again, most of the decreasing trends at the various monitor sites appear to occur prior to 2009. From 2009 through 2018 trends slowed and even increased slightly at some monitors (Danciger (C618) and Wallisville Road (C17)), though no monitor recorded levels above those observed prior to 2009. The graph shows that monitors located in Galveston and Brazoria Counties (Danciger (C618), Lake Jackson (C1016), and Texas City 34th Street (C620)) typically have lower TNMHC concentrations while the monitors located in Harris County, near the Houston Ship Channel, typically have higher TNMHC concentrations. One monitor, Galena Park (C167), had very high values in 2016 and 2017, but because there are only two complete years of data at this monitor, no trend can be discerned. Since the primary source of VOC emissions in the HGB area is from industrial sources, the large decreases at these monitors indicate that decreases of TNMHC in the area are due to decreases in industrial VOC emissions.

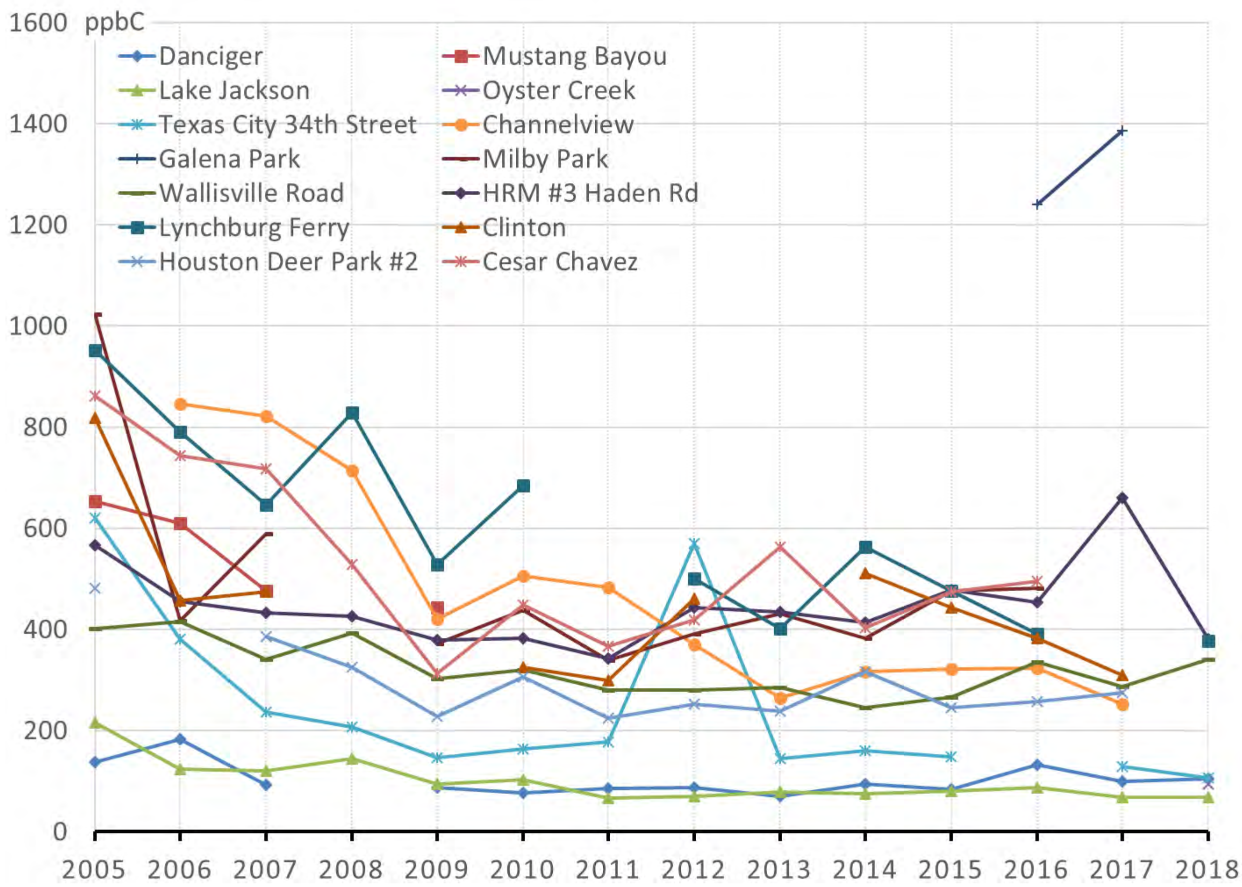


Figure 5-13: Average Daily-Peak TNMHC Concentrations by Monitor for the Ozone Season in the HGB Area

Highly reactive volatile organic compounds (HRVOC) are especially important to ozone formation in the HGB area. This subset of VOC, which includes ethylene, propylene, 1,3-butadiene, and all isomers of butene, have higher reactivities, meaning the compounds are more efficient at producing ozone. The same process used to investigate TNMHC trends was also used to investigate HRVOC trends. Only HRVOC data from April through October, or the “ozone season,” from the 11 auto-GC monitors that recorded data from 2005 through 2018 were used.

Ozone season trends for ambient HRVOC concentrations are presented in Figure 5-14: *Daily-Peak HRVOC Trends for the Ozone Season in the HGB Area*. Overall, daily-peak HRVOC trends in the HGB area are decreasing for all three statistics. From 2005 through 2018, average daily-peak HRVOC decreased by 44%, 90th percentile daily-peak HRVOC decreased by 40%, and 10th percentile daily-peak HRVOC decreased by 61%. Like with all prior trends investigated in this section, the largest HRVOC decreases appear to have occurred from 2005 to 2009. After 2009, HRVOC trends become more variable, increasing and decreasing from year to year. Average and 90th percentile HRVOC concentrations in 2018 are higher than those observed in 2009. Note that the largest average daily-peak HRVOC occurred in 2014, a year with very low ozone values. The second largest 90th percentile HRVOC concentrations occurred in 2015, which was a year with very high ozone values.

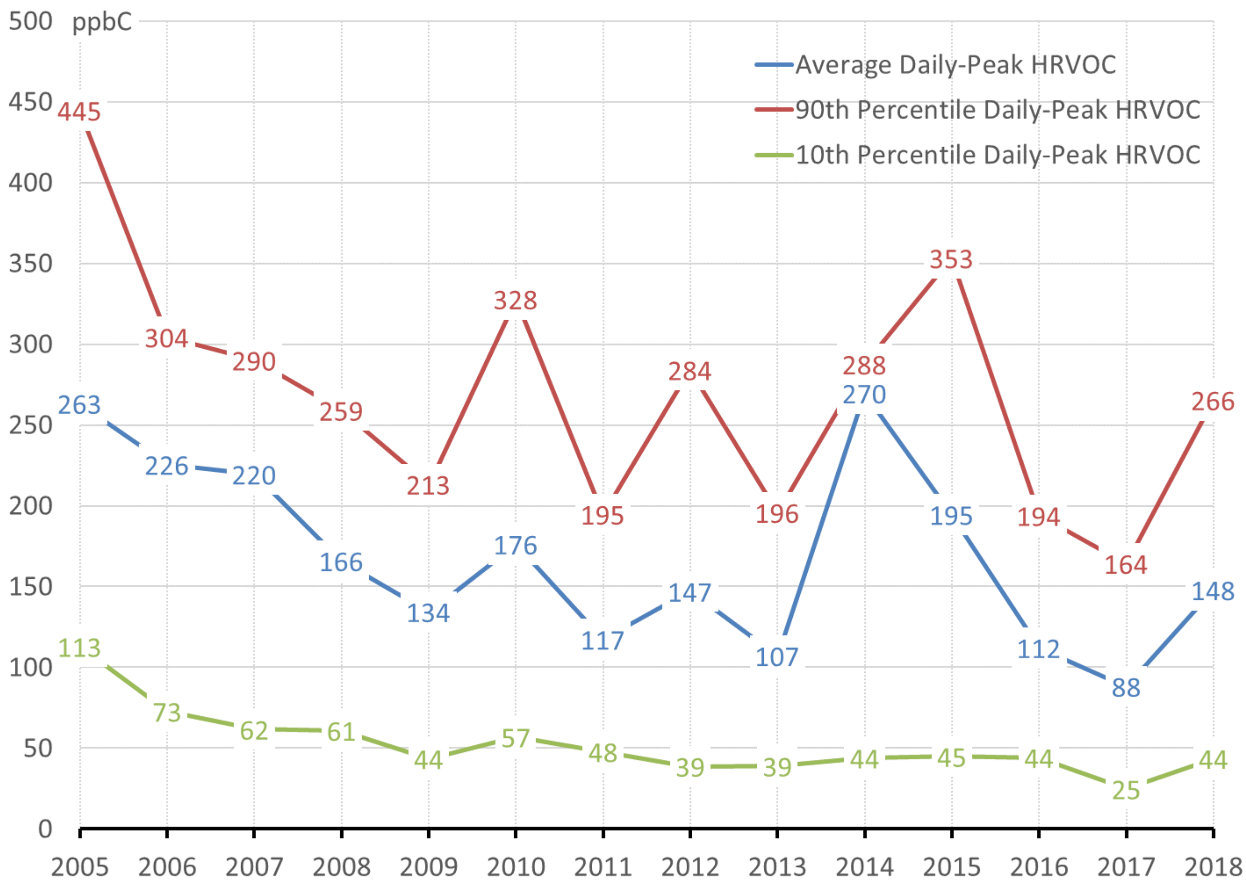


Figure 5-14: Daily-Peak HRVOC Trends for the Ozone Season in the HGB Area

HRVOC trends at each of the 14 HGB area auto-GC monitors that reported HRVOC data at any point from 2005 through 2018 were also examined. Like with the area-wide trends, only data from April through October, or the “ozone season,” was examined at each monitor. In addition, the HRVOC data was checked for completeness and only years with at least 75% complete data were used in this analysis. The HRVOC trends by monitor are shown in Figure 5-15: *Average Daily-Peak HRVOC Concentrations by*

Monitor for the Ozone Season in the HGB Area. The trends show that overall HRVOC concentrations have decreased across all monitors. Decreases for monitors operating from 2005 through 2018 range from 28% to 74%. Again, most of the decreasing trends at the various monitors appear to occur prior to 2009. From 2009 through 2018 trends slowed and even increased slightly at some monitors (Lake Jackson (C1016), Milby Park (C169), Wallisville Road (C616), Lynchburg Ferry C1015), and Clinton (C403)), though no monitor recorded levels above those observed prior to 2009.

The Galena Park (C167) monitor, which had very high TNMHC values in 2016 and 2017, has HRVOC values in 2016 and 2017 that are like other monitors in the area. This indicates that the high TNMHC values at the Galena Park (C167) monitor were due to VOCs with lower reactivities. The Lynchburg Ferry (C1015) and Milby Park (C169) monitors had much higher mean daily-peak HRVOC in 2014 and 2015 compared to other HGB area monitors. 2014 was a year that observed very low ozone concentrations while 2015 was a year that observed very high ozone concentrations.

The HRVOC trends indicate that controls appear to have influenced concentrations prior to 2009. Trends in HRVOC after 2009 have not shown as much of a decline and have shown an increase for some monitors. Since HRVOC have more of an effect on ozone concentrations compared to other VOC, a more detailed look at increasing HRVOC trends will need to be conducted to determine why trends have not continued to decline.

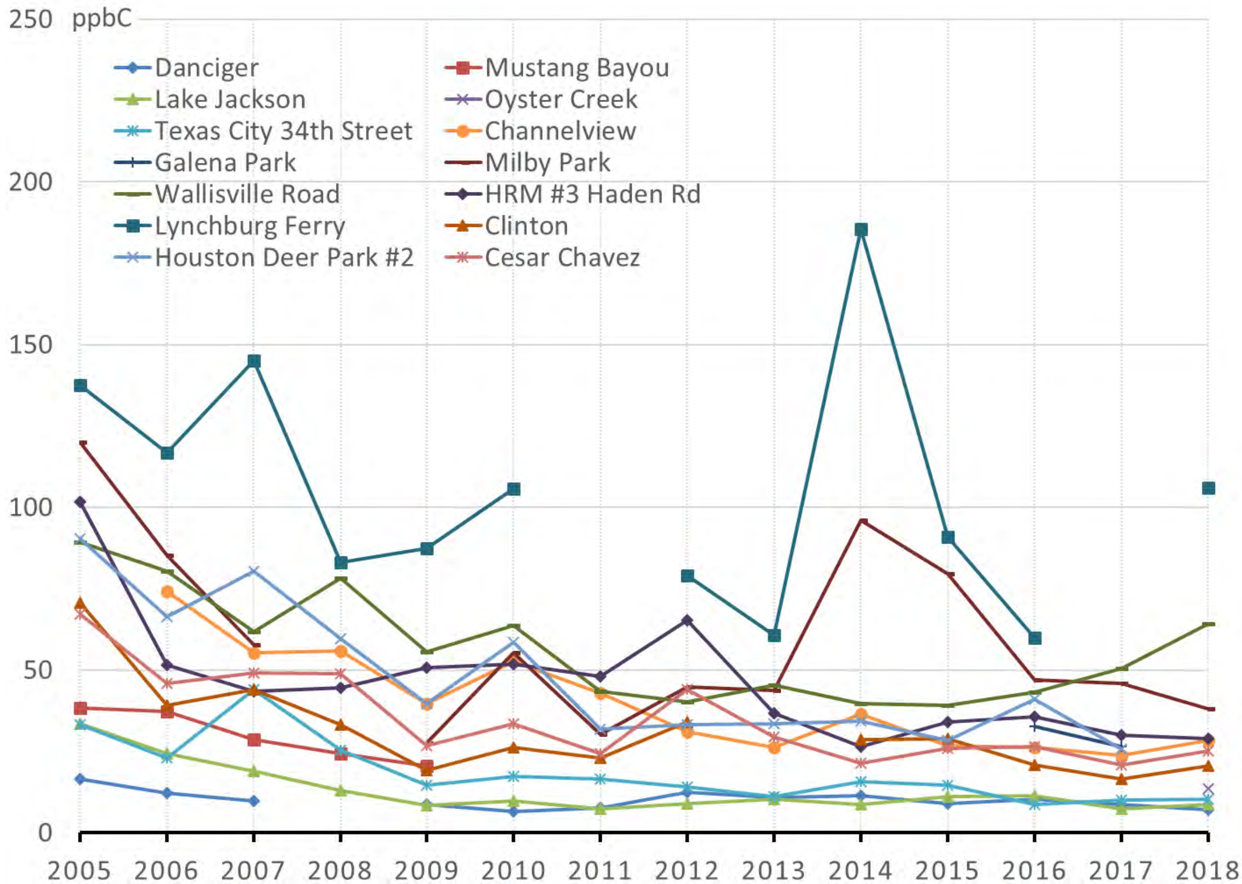


Figure 5-15: Average Daily-Peak HRVOC Concentrations by Monitor for the Ozone Season in the HGB Area

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 region occurs where 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 regions, NO_x is abundant, and therefore the ozone formation is more sensitive to the number 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.

VOC-to-NO_x ratios are calculated by dividing hourly TNMHC 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. Calculation of VOC-to-NO_x ratios are limited by the number of collocated auto-GC and NO_x monitors available in the area. In addition, auto-GC monitors are often source-oriented, and therefore they will only provide information on the air mass located near the source and not throughout the whole area.

There are currently 10 auto-GC monitors in the HGB area that are collocated with NO_X monitors, and not all of those 10 monitors report data to the EPA. One monitor, Oyster Creek (C1607) in Brazoria County, started operation in December 2016. Since there is limited data at that monitor, it is not included in this trend analysis. Only data for April through October (referred to as the "ozone season") was used in this analysis. Data was further split into high ozone days and low ozone days. High ozone days in this analysis are defined as a day when any monitor in the HGB area measured a daily-peak eight-hour average ozone value greater than 75 ppb and low ozone days are days where the daily-peak eight-hour average ozone from all monitors within the HGB area was less than or equal to 75 ppb.

Median VOC-to-NO_X ratios were calculated using all hours during the ozone season for each year at each of the nine monitors. These results are shown in Figure 5-16: *Median VOC-to-NO_X Ratios for High versus Low Ozone Days During the Ozone Season in the HGB Area*.

Only two monitors have a noticeable difference in VOC-to-NO_X ratios on high versus low ozone days, Lake Jackson (C1016) and Wallisville Road (C617). The Lake Jackson (C1016) monitor is in Brazoria County and the Wallisville Road (C617) monitor is in Harris County near the Houston Ship Channel. For both monitors, VOC-to-NO_X ratios are more NO_X-limited on high ozone days versus low ozone days. For most monitors the trends for high ozone days are similar to those for the low ozone days except for Lake Jackson (C1016). Since 2013, the VOC-to-NO_X ratio trends at the Lake Jackson (C1016) diverged for high and low ozone days, with the ratio on low ozone days showing transitional conditions with a slight trend towards VOC-limited conditions, while the ratio on high ozone days has been trending higher towards NO_X-limited conditions.

Most HGB area monitors, especially those in the more urbanized areas, show transitional ratios. VOC-to-NO_X ratio trends are not consistent across monitors in the HGB area, with some monitors trending to more NO_X-limited conditions, some trending toward more VOC-limited conditions, and some showing no change. One monitor, Danciger (C618), observed NO_X-limited conditions and is trending towards even more NO_X-limited conditions. This monitor is in Brazoria County and typically observes lower NO_X levels than observed at the more urban monitors. The monitors located in the Houston Ship Channel observe more transitional conditions. Most of the ship channel monitors have trended from more NO_X-limited ratios towards more VOC-limited ratios. The Clinton (C403) monitor is the most VOC-limited monitor in the HGB area, with recent VOC-to-NO_X ratios very close to 5 ppbC/ppbV. Overall, monitors in the more rural areas of the HGB area observe NO_X-limited conditions while the monitors in the more urban areas observed more transitional conditions.

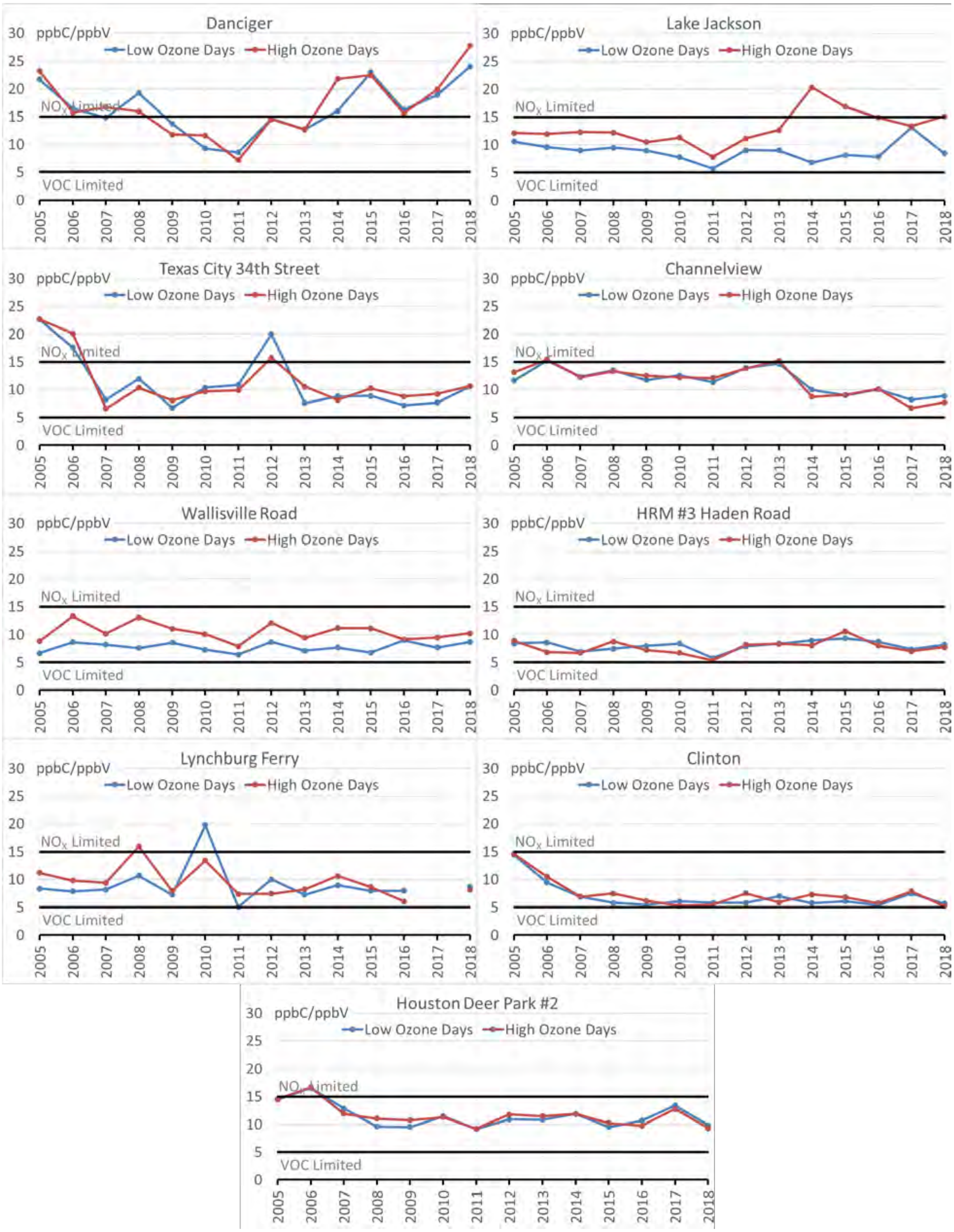


Figure 5-16: Median VOC-to-NO_X Ratios for High versus Low Ozone Days During the Ozone Season in the HGB Area

5.2.5 Meteorological Influences on Ozone Trends

Meteorological conditions play an important role in ozone formation. Year-to-year variability in meteorological conditions in turn cause variability in ozone concentration 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. Investigating meteorological influences on ozone trends allows analysis of how ozone concentrations respond to changes in emissions rather than changes in the meteorology.

The EPA has a statistical model (Camalier, Cox, Dolwick, 2007) that uses 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 latest meteorologically adjusted average ozone trends from the EPA are displayed in Figure 5-17: *Meteorologically Adjusted Ozone Trends for Houston, Texas (EPA, 2018b)*. The trends show that, even when adjusted for meteorological conditions, ozone concentrations have been decreasing in the HGB area. As shown in ozone and precursor trends in the previous sections, the largest decrease in ozone occurs prior to 2009, even when adjusted for weather. After 2009, the trends in ozone adjusted for the weather appear relatively flat and may even be slightly increasing from 2009 levels. It appears that meteorological conditions have only played a very small part in observed ozone concentrations in 2015 through 2017.

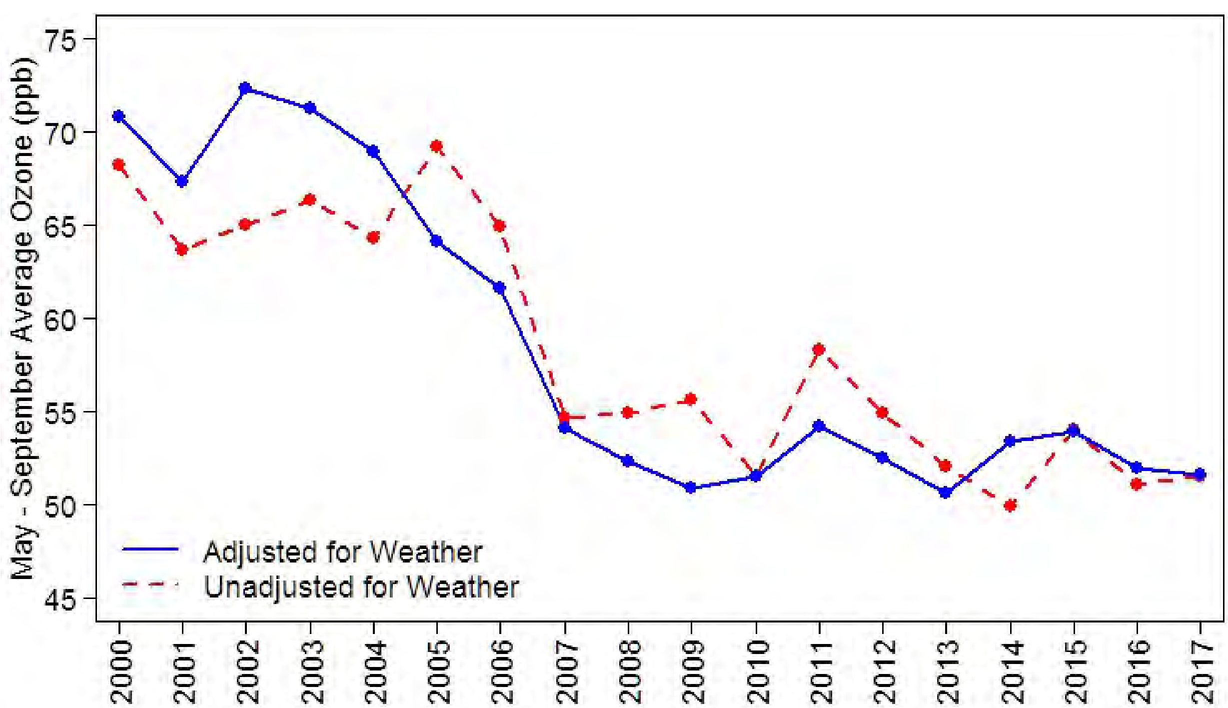


Figure 5-17: Meteorologically Adjusted Ozone Trends for Houston, Texas (EPA, 2018b)

5.3 LITERATURE SURVEY

In this section, details are presented regarding the literature and modeling studies that the TCEQ reviewed as part of its efforts to understand and evaluate ozone formation and the attainment status of the HGB nonattainment area.

5.3.1 Meteorological Patterns Associated with High and Low Ozone in the HGB Area

Several studies have identified wind patterns linked to high or low ozone days. Each of these studies have classified weather regimes using a multivariate statistical technique such as cluster analysis or principal components analysis. In each case, these studies have found that when winds flow briskly from the Gulf of Mexico into southeast Texas, ozone concentrations are usually very low. By contrast, when winds are slow and northeasterly, high ozone concentrations often occur.

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 in the HGB area 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, and 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 to reach the HGB area at a specific time and place. Wind data and the physics of atmospheric transport contained within the model are used 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 usually scientists will not analyze only a single or a few trajectories, but many hundreds or thousands, so that statistical analysis can be employed to obtain a more reliable answer.

After the trajectories have been calculated, investigators usually will 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 to group them together in clusters with members that have many similarities. 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 more similar trajectories. The final 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, or how often each trajectory pattern occurs. 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 by Sullivan (2009), Smith et al. (2014), and Souri et al. (2015) found very similar patterns associated with high ozone days and low ozone days. Figure 5-18: *HYSPLIT Trajectory Patterns to the Galveston 99th Street (C1034) Monitor* from Smith et al. illustrates all of the patterns observed. All trajectories calculated for May through September of 2007 through 2011 are illustrated; these HYSPLIT trajectories extend backward in time to show the approximate path that the air arriving at the Galveston 99th Street (C1034) monitor traversed during the previous 48 hours. The color-coded grid overlaid on the trajectories is linked to the average ozone concentration at the monitoring site when the trajectory arrived. Each grid cell must include at least 30 trajectory points before an average will be calculated for it.

The map indicates that the lowest ozone concentrations are linked to transport from the Gulf of Mexico, and the highest concentrations are linked to transport from northeast, i.e., the southeastern states. All of the trajectory studies show very similar links between transport pattern and ozone concentration.

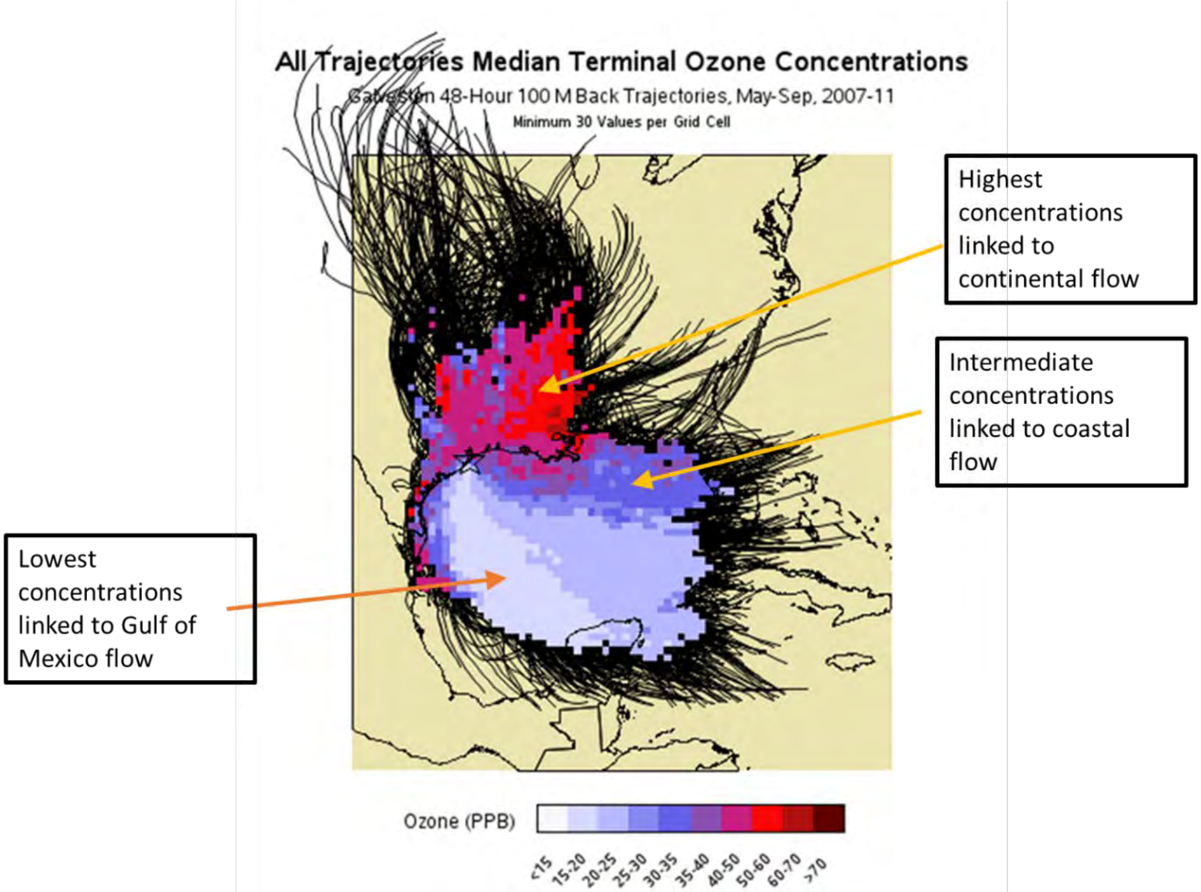


Figure 5-18: HYSPLIT Trajectory Patterns to the Galveston 99th Street (C1034) Monitor

Other studies that evaluated transport patterns differently also saw similar correlations. Daytime hours with weak northerly or easterly flow were followed by weak southerly low-level jet during the evening hours, and high ozone the next day (Tucker et al., 2010; Darby, 2005; Pakalapati et al., 2009; Langford et al., 2010, Rappenglück et al., 2008; Ngan and Byun, 2011). Predominant southerly flow, however, usually resulted in low ozone on the next day (Tucker et al., 2010; Ngan and Byun 2011).

The synoptic (large-scale) meteorological features driving these wind patterns have largely been identified. Studies examining how the movements of the Bermuda High affect air quality in the eastern and central United States (U.S.) (Zhu and Liang, 2013; Shen et al., 2015; Wang et al., 2016) found that the typical mid-summer position of the high, with its western edge at approximately 92 degrees west latitude, causes brisk southerly winds in eastern and central Texas, bringing in clean air from deep in the Gulf of Mexico. Thus, mid-summer is often a period of low ozone in the HGB area and other eastern Texas cities, at a time when the southeast U.S. is suffering under hot, hazy, stagnant, polluted weather. If, however, the pattern breaks, and the western edge of the Bermuda High retreats eastward, other weather systems can enter southeast Texas that are conducive to high ozone. Wang et al. (2016) found a strong relationship between the location of the western extent of the Bermuda High and ozone concentrations in the HGB area. Tucker et al. (2010) found that if a southerly low-level jet was present at night over the HGB area, the following day usually had low ozone concentrations, whereas if winds above the nocturnal boundary layer had a northerly or easterly component, ozone was more likely to be high.

Another synoptic pattern linked to the HGB area's air quality is frontal passages. Davis et al. (1998) recognized that the "migratory" high pressure centers that dominate weather after frontal passage in the warm season are often accompanied by higher ozone concentrations. Rappenglück et al. (2008) and Ngan and Byun (2011) recognized that high ozone days often occur a day or two after the passage of a cold front through the HGB area. Lei et al. (2018) investigated the impacts of cold fronts on area-wide peak ozone and regional background ozone mixing ratios on a daily scale over the HGB area during April through October of 2003 through 2016. They found that the change in wind direction from southerly to northerly was the most important factor that increased ozone levels. Wind direction shifts caused variation of other meteorological factors (i.e., wind speed, precipitation, temperature, cloud cover, and relative humidity) and tended to overshadow the effects of these less important variables on ozone concentrations in the HGB area. On a long-term and large-scale view, cold fronts over the HGB area could be regarded as interruptions in the cleansing effects of predominantly marine southerly flow from the Gulf of Mexico.

Though frontal passage in the warm season in southeast Texas often does not bring cold air into the area, it does change the dominant air mass, and often brings in drier and more polluted air than the clean, humid air that originates deep in the Gulf of Mexico. The transport patterns observed by Ngan and Byun (2011), Sullivan (2009), Smith et al. (2013), and Souri et al. (2016) identified wind and pressure patterns characteristic of continental high-pressure centers that pull polluted air from the U.S. Midwest and southeast into eastern Texas. The dominance of these systems brings light northeasterly or easterly winds into eastern Texas, often a few days after frontal passage. The intensity of the ozone episode depends upon many factors, including the structure and stability of the mid- to low-troposphere (Langford et al. 2010, Haman et al. 2014), the degree of stagnation, and the air quality behind the front.

Nielsen-Gammon et al. (2005) identified local- to regional-scale wind features that arise in eastern and central Texas in the absence of strong synoptic flow. They found that as the large-scale forcing of winds diminishes, local, weaker factors can dominate the meteorological situation, resulting in flow reversals or gradual clockwise shifts in wind direction. These weak but distinct wind patterns can result in ozone patterns that are difficult to interpret. Darby (2005) and Pakalapati et al. (2009) observed these wind shifts in the HGB area and tracked how they moved ozone around the city. There are several underlying causes of these patterns: inertial oscillation, Coriolis forcing, and land/sea/bay breezes. Research is continuing to understand the forces that move air around the HGB area in the absence of strong synoptic forcing.

Ozone concentrations in the residual layer, above the nocturnal boundary layer, are often much higher than the surface concentrations on high ozone days. Days that are conducive to high ozone often begin with very stable, shallow nocturnal boundary layers, within which the surface ozone is often titrated down to zero ppb. After sunrise, the nocturnal boundary layer begins mixing with the residual layer, bringing ozone to the surface, and rapidly increasing observed ozone concentrations at surface stations. These events were observed during the 2006 Texas Air Quality Study (TexAQS 2006), and on other days between 2004 and 2009 by Morris et al. (2010).

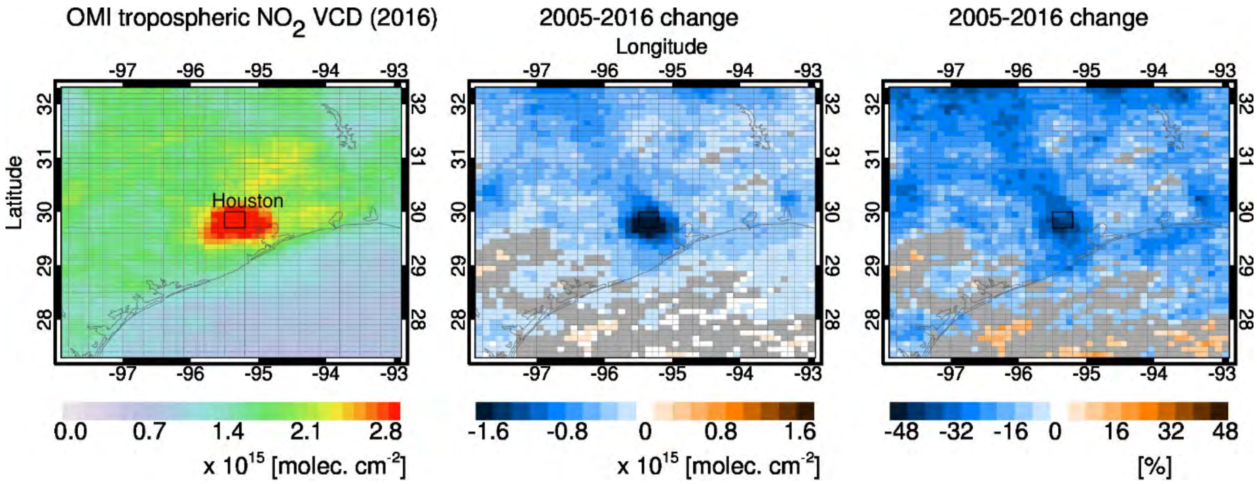
In summary, the number and intensity of high ozone episodes depend strongly upon meteorological conditions. If the HGB area is under the influence of the Bermuda High, the winds are brisk and southerly, stagnation is unlikely, atmospheric moisture is abundant, and the air arriving from the Gulf of Mexico carries little ozone into the HGB area. If, however, a frontal passage occurs, the drier, subsiding air behind the front suppresses clouds and brings abundant sun. The high pressure behind the front can cause stagnant conditions, cultivating local ozone formation, and can draw polluted air from the continental U.S. into southeast Texas, raising the background ozone concentrations. The post-frontal environment diminishes the large-scale pressure gradient, and hence, allows subtler local forces to move air around the area with weak winds. These weak forces allow for flow reversals and slowly veering winds that can accentuate ozone formation. Since most of these factors are predictable, high ozone days are often predicted by TCEQ forecasters. The knowledge of how meteorology affects ozone formation makes interpretation of monitoring and modeling data much easier.

5.3.2 Satellite and Other Remote Sensing Estimates of Emissions: Independent, Top-Down Estimates of Emissions Changes Regionally, Nationally, and Internationally

One method of evaluating pollutant trends is with satellite observations. Recently, researchers have examined NO_2 and formaldehyde (HCHO) trends in the HGB area using the Ozone Monitoring Instrument (OMI) satellite. Satellites do not measure concentrations at the surface, as a continuous ambient monitoring station (CAMS) does, but measure the pollutants present in a vertical column of air from the surface to the top of the atmosphere. To estimate the amount of a pollutant within the column, the researchers make assumptions about the vertical distribution of the pollutant within this column of air and consider the characteristics of the remote sensing instrument itself.

In the 2016 HGB 2008 Eight-Hour Ozone AD Moderate Classification SIP Revision, Chapter 5: *Weight of Evidence* included a discussion of NO_2 trends observed by satellites (TCEQ, 2016, Table 5-2: *Satellite Observations of Nitrogen Dioxide Columns in the HGB Metropolitan Area between 2002 and 2013*). Since that time, the National Aeronautics and Space Administration (NASA) has created a webpage that incorporates updated analyses that follow the methods of Lamsal et al. (2015) to show NO_2 trends for all large U.S. cities, and some international cities.

Several studies that examined satellite NO_2 trends beginning in 2005 found that after 2009, the NO_2 trends either became level or increased (Russell et al. 2012; Tong et al. 2015; deFoy et al. 2016; Lamsal et al. 2015). Some of the leveling can be attributed to the recovery from the recession, but the latest NASA data (Figure 5-19: *NO_2 Imagery from the OMI Satellite* and Figure 5-20: *Absolute and De-seasonalized NO_2 Trends, Derived from OMI Satellite Observations*) show that even after the recovery, the NO_2 trend has become level: NO_2 column densities have changed little since about 2011. Georgoulias et al. (2018) examined global satellite data for different cities and countries to determine whether NO_2 trends have changed since 1996, but found no change for Houston, observing a consistent relative drop in NO_2 column density of the city of -1.73±0.3% per year from 1996 through 2017.



Left: NO_2 column density over Houston; Middle: Absolute NO_2 column density change from 2005 to 2016 over Houston; Right: Percent NO_2 column density change from 2005 to 2016

Figure 5-19: NO_2 Imagery from the OMI Satellite

Since the EPA's National Emissions Inventory (NEI) data indicate that NO_X emissions have continued to decrease since 2011, researchers have investigated whether these NEI inventories are accurate. For example, Jiang et al. 2018 has noted a "significant slowdown in decreasing U.S. emissions of nitrogen oxides (NO_X) and carbon monoxide (CO) for 2011 through 2015 using satellite and surface measurements. This observed slowdown in emission reductions is significantly different from the trend expected using U.S. Environmental Protection Agency (EPA) bottom-up inventories…" In response, a recent study by Silvern et al. (2019) addresses these discrepancies by examining several long-term, well-respected measurement data sets. The trends found in these data sets, which are independent of the satellite data, the inventory data, or the CAMS monitoring data, should help assess which trend is correct. Silvern et al. examined satellite NO_2 columns, AQS and Clean Air Status and Trends Network (CASTNET) rural monitoring data, NEI data, and National Acid Deposition Program (NADP) wet deposition data, as well as simulations of these data sets with the global atmospheric chemistry model driven by assimilated meteorological observations from the Goddard Earth Observing System (GEOS-Chem). OMI and NADP trends drop until about 2009, then flatten and appear to remain approximately constant through 2017. Trends observed with AQS and CASTNET match NEI trends, but NADP and OMI NO_2 do not. GEOS-Chem results replicate the trends, showing that NADP and OMI NO_2 trends are more dependent upon background NO_2 than the other data sets. Thus, Silvern et al. (2019) conclude that the NEI trend is relatively accurate. Further research is necessary to confirm this conclusion.

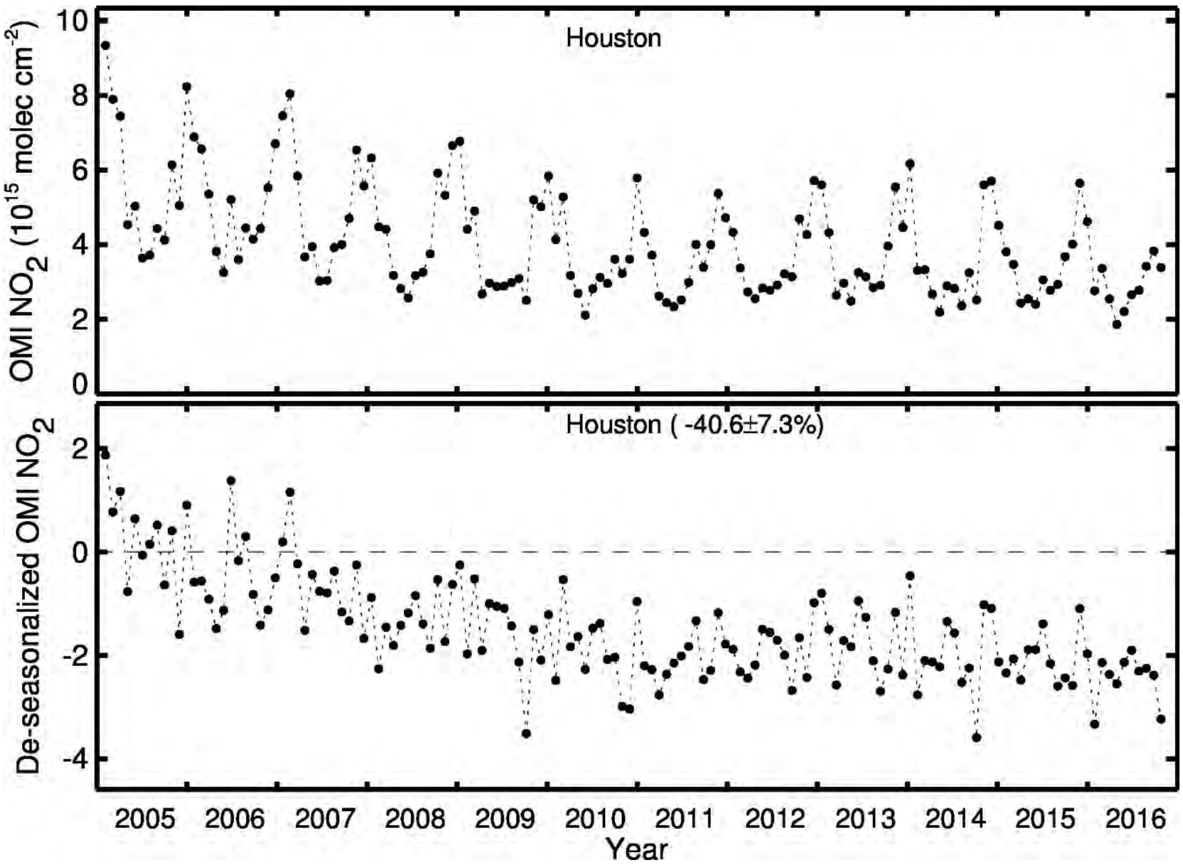
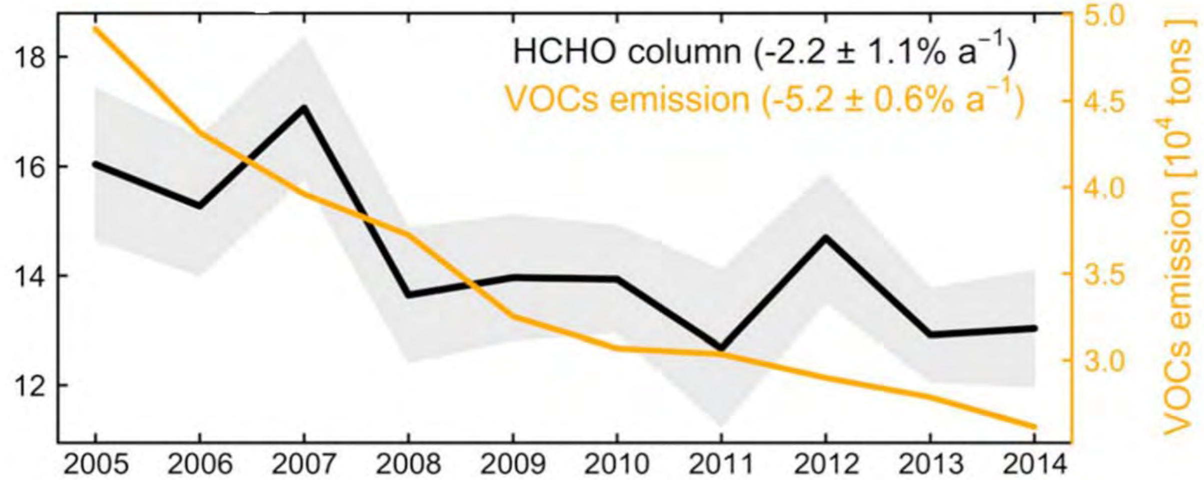


Figure 5-20: Absolute and De-seasonalized NO_2 Trends, Derived from OMI Satellite Observations

VOC trends can also be observed by satellite, using OMI observations of HCHO as a surrogate. Since VOC oxidation leads to HCHO formation, HCHO is often used to track VOC emissions. Zhu et al. (2017) developed a technique for separating the biogenic portion of the HCHO signal from the anthropogenic portion. Figure 5-21: *Formaldehyde Trends in HGB, from Satellite Observations and TCEQ Anthropogenic Point Source VOC Emissions Inventory Data for May through September 2005 through 2014* shows the results for the HGB area. The biogenic signal is highly correlated with temperature, thus Zhu et al.'s technique involved adjusting the HCHO column observations according to temperature to remove the contributions from biogenic VOC emissions. Overall, Figure 5-21 demonstrates that VOC emissions are declining.



From Zhu et al., 2017

Figure 5-21: Formaldehyde Trends in HGB, from Satellite Observations and TCEQ Anthropogenic Point Source VOC Emissions Inventory Data for May through September 2005 through 2014

The trends in NO_2 and HCHO observed by satellites are consistent with the trend analyses described earlier in this chapter using surface monitoring data in HGB.

5.3.3 Background Ozone and International Contributions

5.3.3.1 Studies of the HGB Area's background ozone

Nielsen-Gammon et al. (2005) found that background ozone could be estimated with a technique in use at the TCEQ, whereby the minimum MDA8 ozone concentration at monitoring sites capable of measuring background ozone was used as an estimate of background ozone. This study found a seasonal cycle in background ozone in the HGB area, with a peak in the late spring/early summer period and a second peak in late summer/early fall. The mid-summer period had low ozone in the HGB area except during brief, infrequent episodes.

Senff et al. (2010) analyzed ozone data collected by a downward-looking laser measurement installed on an aircraft and flown during 2000 and 2006. This data showed ozone distribution throughout the HGB area, and their aircraft sampled upwind and downwind of the city, thus showing how the HGB area's urban/industrial plume affected the background ozone. On many days, the HGB area's urban/industrial plume was easily distinguished from the background by a relatively sharp ozone gradient.

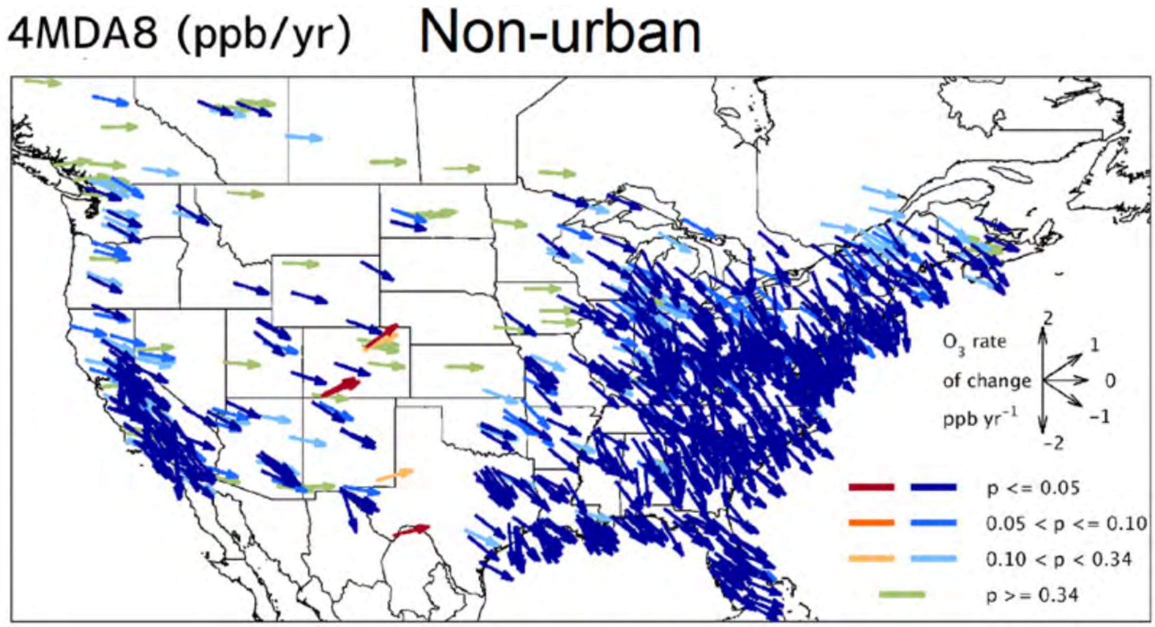
Langford et al. (2009) examined background ozone by analyzed surface monitoring data during the TexAQS 2000 and 2006 field campaigns with principal component analysis. His analysis found that the most important statistical factor affecting ozone in the HGB area caused the concentrations to rise and fall at all monitoring sites throughout the entire city simultaneously. This behavior reflects the influence of background ozone. Langford et al.'s study was the first study to systematically show that background ozone in the HGB area rivaled the importance of locally formed ozone on many days.

Berlin et al. (2013) performed a long-term background ozone study, using the techniques of Nielsen-Gammon and Langford, and compared the results. Both techniques determined that there was a strong downward trend in 95th percentile MDA8 ozone concentration in the HGB area, that the background ozone comprised a considerable portion of the peak ozone, and that background ozone was also decreasing, at a rate slower than the peak ozone. They also showed a positive correlation between the HGB area MDA8 ozone concentration and background ozone, implying that meteorological conditions well-suited to local ozone production are also well-suited to regional ozone production.

Suciu et al. (2017) used techniques similar to Langford et al., but refined them by also examining NO_x and meteorological variables in an effort to define regional background ozone in the HGB area more precisely. Their technique used hourly ozone data instead of eight-hour averages, and thus tend to be higher. They also found a downward trend in regional background ozone over the 17-year period of analysis.

Souri et al. (2015), along with Sullivan (2009) and Smith et al. (2013), showed that the transport pattern is strongly related to MDA8 ozone concentration in the HGB area. However, it is difficult to determine from this study how much of the MDA8 ozone concentration can be linked to background ozone. Wind patterns from the Gulf of Mexico strongly tend to be cleaner than winds from other directions, whereas slow, easterly and northeasterly winds are associated with the highest ozone days. But these studies cannot attribute the local and background portions of the ozone on the highest ozone days. Trend data from individual wind patterns linked to high ozone did show downward trends, indicating that when the meteorology does not vary, the ozone concentrations trend downward. The downward trend can be attributed to local emissions decreases or to background ozone, though the local ozone precursor emissions have dropped sharply, strongly suggesting the local contribution accounts for most of the decrease.

These background ozone studies indicate that background ozone in the HGB area is behaving like the background ozone in the eastern half of the U.S., not the western half. The western U.S. is experiencing background ozone increases, and the days with the highest MDA8 ozone concentrations are much more strongly affected by background ozone than the eastern half of the U.S. (e.g., Fleming et al., 2018). Figure 5-22: *Non-Urban Fourth-High MDA8 Ozone Concentration Trends Measured from 2000 through 2014 at Surface Monitoring Sites* shows ozone trends at rural monitoring sites throughout the U.S. from 2000 through 2014; the only sites with increases are in the western U.S., and the southeastern Texas trend is sharply and significantly downward, like most of the eastern U.S. sites.



Darker Arrows Indicate Statistically Significant Trends ($p < 0.05$) (from Fleming et al., 2018)

Figure 5-22: Non-Urban Fourth-High MDA8 Ozone Concentration Trends Measured from 2000 through 2014 at Surface Monitoring Sites

Another finding from these studies is that there are seasonal patterns to background ozone in HGB; from mid-June to mid-August, there is a consistent drop in background ozone concentrations, and this pattern is linked to transport.

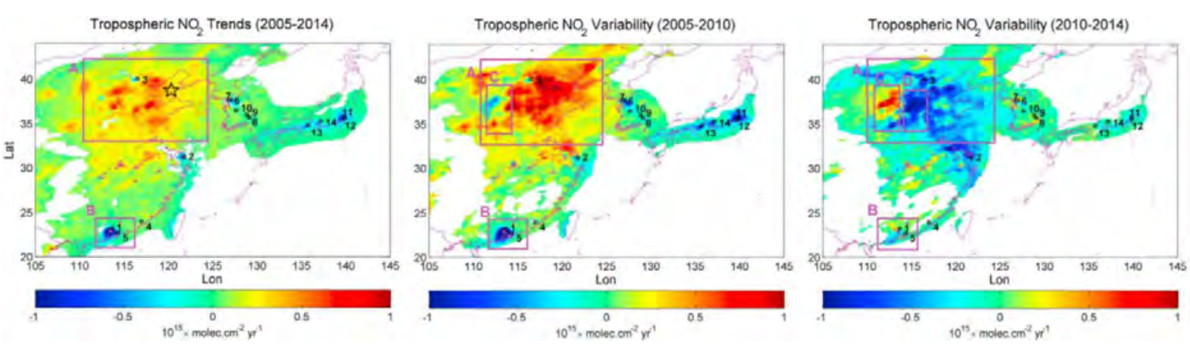
5.3.3.2 Studies of U.S. Background Ozone and International Contributions

The lowering of the ozone NAAQS and the increasing development of Asian economies has raised questions about the level of background ozone entering the U.S. and the origins of that ozone. It should be noted that U.S. background ozone is not a measurable quantity; it can only be estimated from modeling analyses. Ozone measured on the Pacific Coastline of the U.S. is called "baseline" ozone, because it is not clear whether it includes any contributions from U.S. or North American emissions. Since U.S. background ozone can only be ascertained through modeling, there is an inherent uncertainty in its estimation. Many different modeling exercises have been performed to estimate U.S. background ozone concentrations. Many of these relevant modeling and observational studies have been reviewed by the TCEQ. The following is a summary of some of the findings about background ozone.

- Background ozone concentrations on the west coast of the U.S. and the intermountain west have been increasing, especially in the spring. The spring increase is linked to two factors: transport of pollutants across the Pacific Ocean, which occurs more efficiently in the spring than in the summer; and enhanced stratosphere-troposphere exchange (Cooper et al., 2011, 2012, 2014; Jaffe et al., 2003; Lefohn et al., 2012, 2014; Oltmans et al., 2008).
- Regional background ozone has been decreasing in the eastern U.S., as measured by CASTNET and other networks (Figure 5-22, Fleming et al., 2018). Modeling studies indicate that North American background and United States background have been increasing even in the eastern U.S., but North American background is not

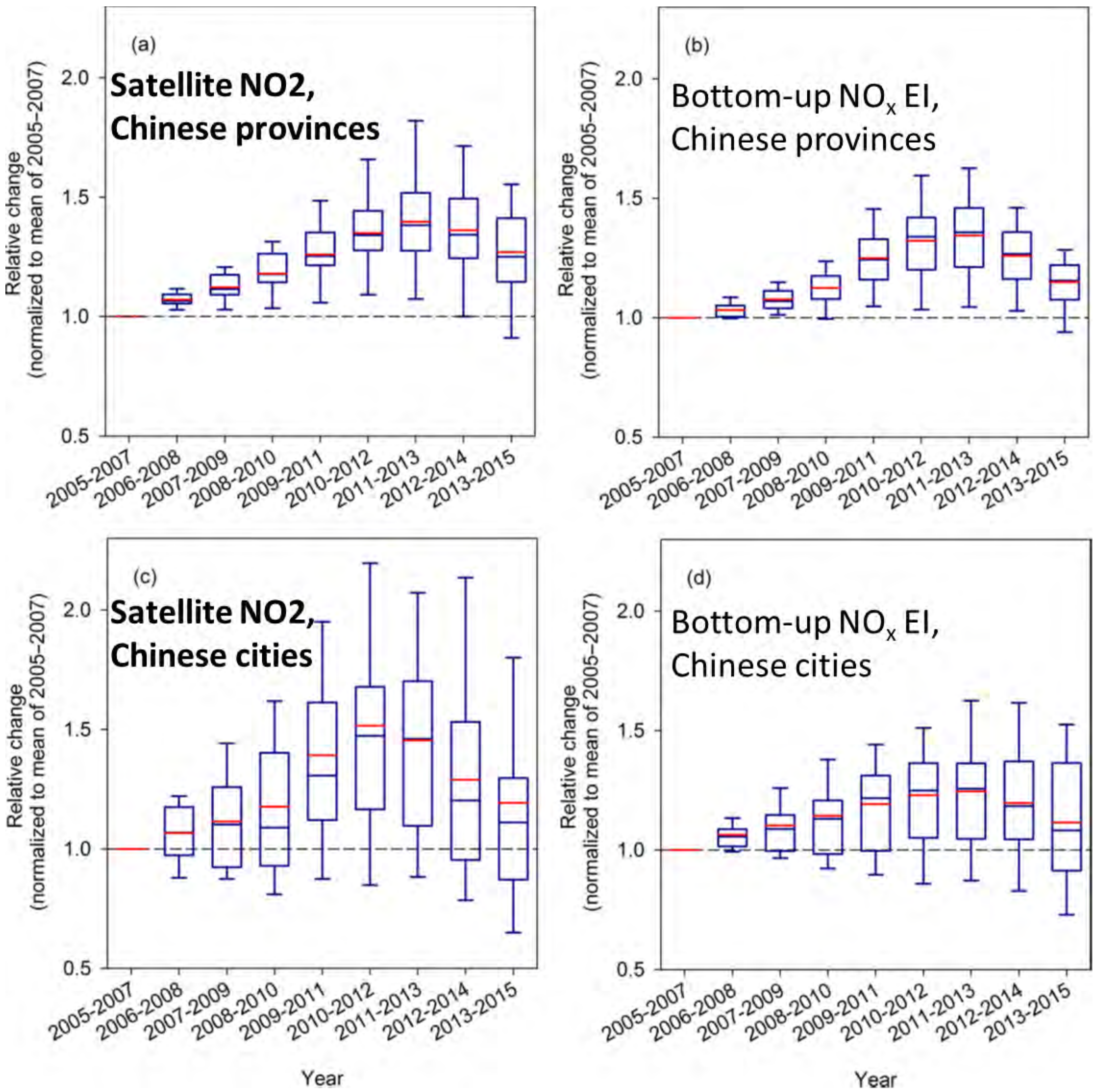
correlated with high ozone days in the east, unlike in the west (Cooper et al., 2012; Fiore et al., 2014; Zhang et al., 2011).

- Chinese NO_X emissions increased dramatically from 1995 through 2010, but have been decreasing since 2010, at a slower pace (see Figure 5-23: *Map of Satellite-Derived NO_2 Trends in China* and Figure 5-24: *Trends in Three-Year Average NO_2 Column Densities, Normalized to Mean of 2005 through 2007*. These trends have been observed by satellite, i.e., they are not bottom-up emissions inventory (EI) estimates, but top-down observations of NO_2 columns (Souri et al., 2016; Liu et al., 2017). Modeling studies of NO_X emission sources within China have found that manufacture and transport of goods for China-to-U.S. trade account for 21% of the emissions (Lin, J. et al., 2014).
- Asian pollutants are transported across the Pacific by two routes, northern and southern. The southern route is the most important in bringing ozone to the continental U.S. Pollutants are transported in the form of peroxyacetylnitrates (PAN), and when they descend from the free troposphere and thermally decompose, they create ozone. This finding is not only based upon modeling exercises, but also upon aircraft observations during field studies designed to investigate this phenomenon (Pfister et al., 2010; Heald et al., 2003; Hudman et al., 2009; Huang et al., 2013).
- Modeling studies show that the greatest impact from Asian emissions on ozone concentrations has been occurring in the intermountain west, including west Texas, but the impacts from Asian emissions in the eastern half of the U.S. are low. The impacts of Asian emissions throughout the U.S. occur primarily in the spring and are not strongly linked to the highest ozone days in the eastern U.S., though they are linked in the intermountain west (Lin et al. 2012).
- The U.S. baseline ozone concentrations had been increasing since the 1980s, but reached a peak in the mid-2000s, and have begun to decrease since then (see Figure 5-25: *Changing Baseline Ozone Trends Measured on the Pacific Coast of the U.S.* Parish et al., 2017).
- Background ozone concentrations created by natural emissions emanating from the U.S. have been increasing due to higher biogenic emissions. Biogenic emissions have been increasing because temperatures have been increasing (Koo et al., 2010; Lin et al., 2008; Lin et al., 2017; Fiore et al., 2014).
- Measured background ozone trends are decreasing, but modeled background ozone (i.e., natural origin) is increasing (Lin et al., 2017).



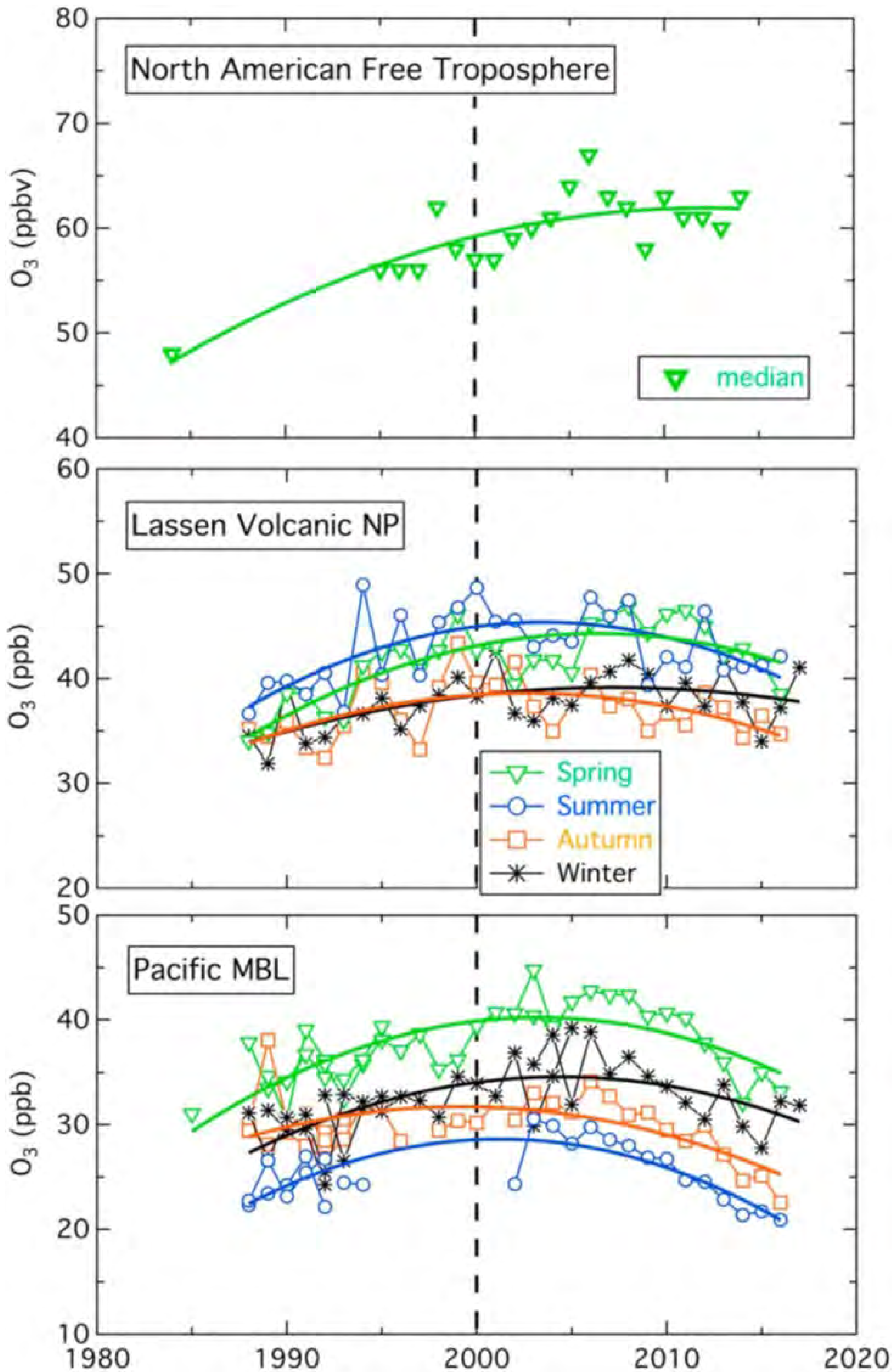
Left: Overall NO_2 trend from 2005 through 2014; Center: NO_2 trend from 2005 through 2010; Right: NO_2 trend from 2010 through 2014 (from Souri et al., 2016)

Figure 5-23: Map of Satellite-Derived NO_2 Trends in China



From Liu et al., 2017

Figure 5-24: Trends in Three-Year Average NO_2 Column Densities, Normalized to Mean of 2005 through 2007



From Parrish et al., 2017

Figure 5-25: Changing Baseline Ozone Trends Measured on the Pacific Coast of the U.S.

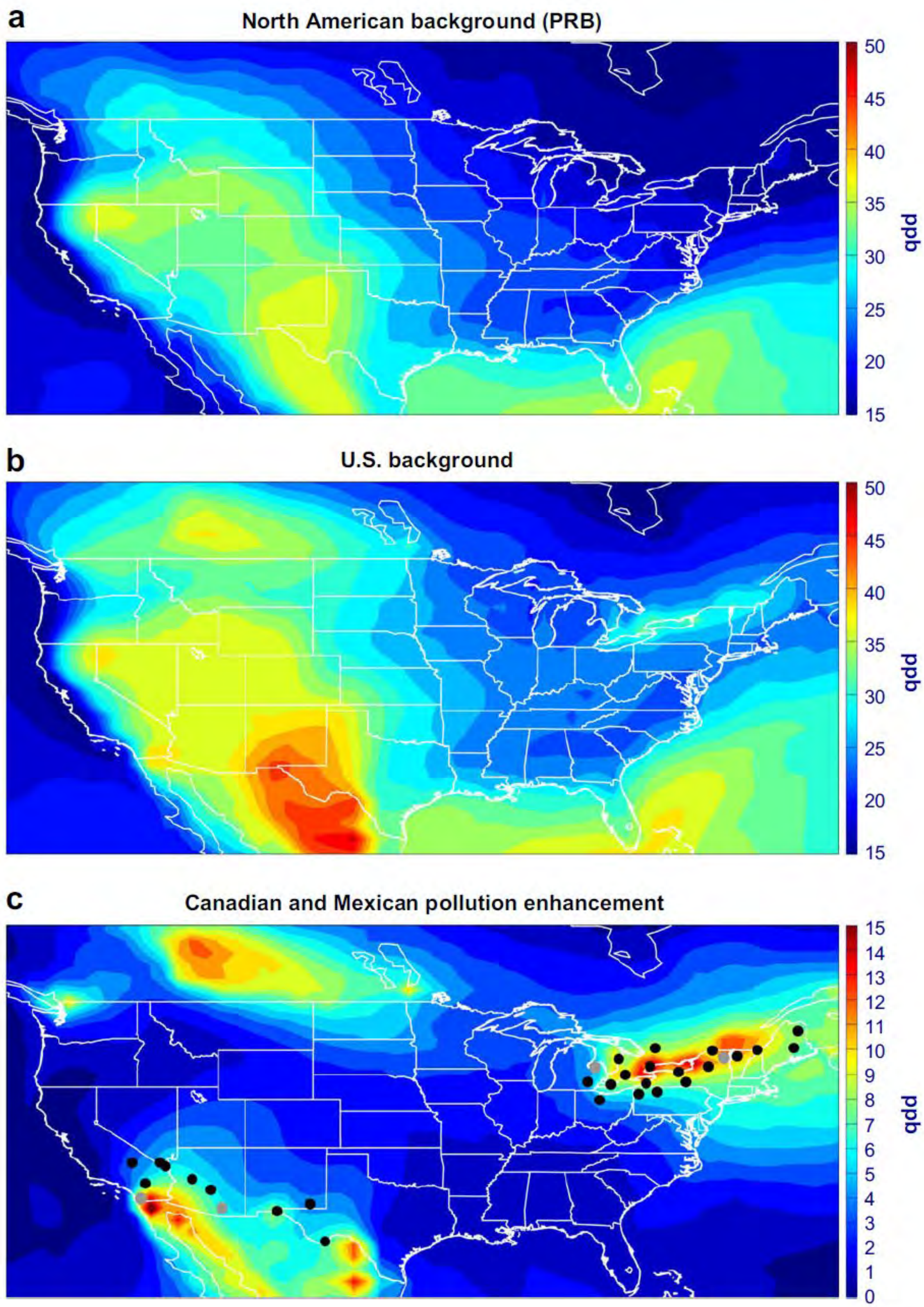
Jaffe et al. (2018) conducted the most recent critical review of the background ozone literature and synthesized the results of many studies into several consensus findings. One of their most critical findings is that seasonal mean U.S. background estimates (which must be determined by modeling) have an uncertainty of ±10 ppb. Since the modeled estimates of seasonal U.S. background ozone (see Table 5-2: *Estimated U.S. Background Ozone in the HGB Area*) in the HGB area is about 25 - 28 ppb (e.g., Nopmongcol et al., 2016; Dunker et al., 2017), this is a substantial degree of uncertainty. Maps of estimated U.S. background ozone (Figure 5-26: *Zero-Out Modeling Analysis Showing June through August Mean MDA8 Ozone Concentrations*) and the anthropogenic contributions to different background components (Figure 5:27: *Relative Contributions to the Anthropogenic Component of the 10 Highest Eight-Hour Ozone Days*) show that contributions from Mexico, Canada, and other countries are all less than 10 ppb.

Further, Jaffe et al. conclude that for an average of fewer days than an entire season (approximately 90 days), the uncertainty of U.S. background ozone estimates is even higher. An accurate and scientifically defensible estimate of U.S. background ozone in the HGB area is currently not readily available. Likewise, the contribution from international emissions cannot currently be accurately and precisely calculated with the available tools. Jaffe et al. (2018) offer several recommendations for improving quantification of U.S. background; these recommendations include an enhanced continuous monitoring network and a possible large-scale field campaign. Additional monitoring may also help quantify contributions from domestic and international wildfires. The issue of the influence of Mexican fires will be discussed later in this document.

Table 5-1: Estimated U.S. Background Ozone in the HGB Area

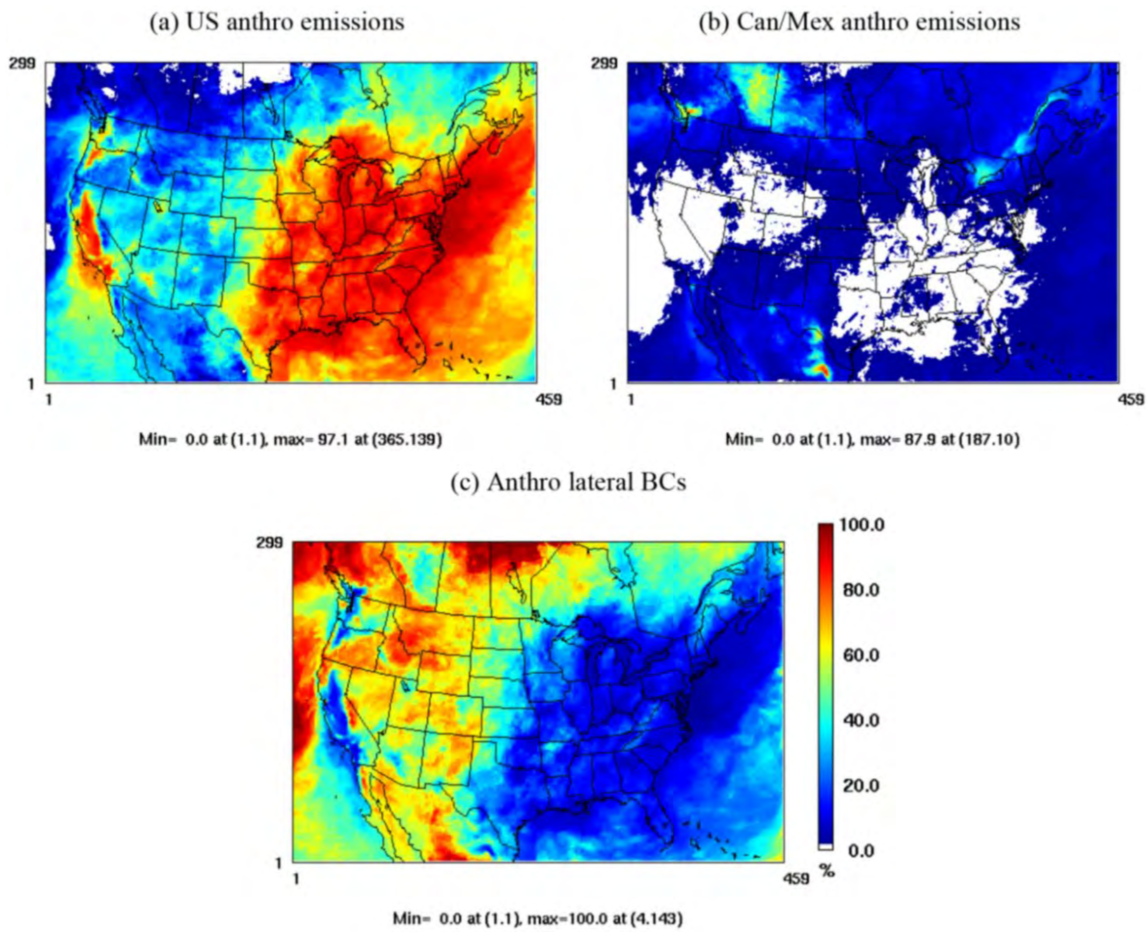
Metric	1970	1980	1990	2000	2005	2020
Summer MDA8	25.5	26.1	26.7	27.1	27.4	28.5
Top 30 MDA8	31.2	32.1	33.0	33.7	34.2	35.9
H4 MDA8	36.9	37.9	39.1	39.9	40.6	40.8

Summer MDA8 is June, July, and August annual average MDA8; Top 30 MDA8 is the average from the top 30 MDA8 ozone concentration days per year; H4 MDA8 is the annual average of the fourth-highest MDA8 (from Nopmongcol et al., 2016)



(a) North American background (Policy Relevant Background (PRB); (b) U.S. background; (c) Contributions from Canada and Mexico (from Wang, H. et al., 2009)

Figure 5-26: Zero-Out Modeling Analysis Showing June through August Mean MDA8 Ozone



Percent ozone contribution from anthropogenic sources: (a) United States; (b) Canada and Mexico; and (c) lateral boundary conditions (BCs) (From Dunker et al. 2017)

Figure 5-27: Relative Contributions in Percent to the Anthropogenic Component of the 10 Highest Ozone Days

5.3.4 VOC- and NO_X-Sensitivity of Ozone Formation in the HGB Area

The TCEQ modeling described in Chapter 3 has been analyzed to extract VOC- and NO_X-sensitivity information. Chemical process analysis (Ramboll, 2018) is a model probing technique used to calculate the chemical production of intermediate reaction products; it can be used to show the chemistry of ozone formation in detail. From the information about individual chemical reactions, it is possible to directly calculate whether ozone formation in each grid cell during each hour is VOC-limited or NO_X-limited. It is also possible to calculate the metrics calculated from field campaign data by Mazzuca et al. (2016), Ren et al. (2013), and Zhou et al. (2014), so that we can verify whether the modeled chemical processes resemble the observed processes.

Chemical process analysis modeling calculates VOC- and NO_X-sensitivity of ozone production by examining the ratio of production of hydrogen peroxide (pH_2O_2) to production of nitric acid ($pHNO_3$). This ratio illustrates which reactants are present in abundance by comparing the production rates of termination products. If there is an abundance of NO_X, the rate of $pHNO_3$ production will be high, as the chemical free radicals driving ozone formation react with NO_2 instead of contributing to ozone formation. If there is a shortage of NO_X, the radicals react with each other, creating pH_2O_2 instead of contributing to ozone formation. The dividing line between VOC-sensitive ozone production and NO_X-sensitive ozone production is a $pH_2O_2/pHNO_3$ value of 0.35, with higher values indicating VOC-sensitive ozone production, and lower values indicating NO_X-sensitive production. The ratio is calculated each hour for each grid cell and each layer, and whatever ozone production is occurring in the grid cell and layer at that hour is assigned accordingly.

This ratio provides a sharp threshold between VOC- and NO_X-sensitivity; its significance requires careful interpretation. The ratio varies from hour to hour and from grid cell to grid cell, so the overall effectiveness of proposed controls cannot be derived from values for single hours or single cells. The metric can show, however, how the atmospheric chemistry over the city varies by hour and by site, which offers clues about the most important factors affecting ozone formation during each day. Figure 5-28: *Chemical Process Analysis Ozone Production Rates (ppb/day) for June 21 through 27, 2012* shows that total ozone production within the mixed layer varies by as much as a factor of eight from day to day, depending on whether a day is suitable for high ozone formation. As expected, ozone formation at monitoring sites in the urban/industrial core (e.g., the Lang (C408, HLAA) monitor and the Houston Monroe (C406, HSMA) monitor) is VOC-limited, because NO_X is abundant. At suburban or ex-urban sites (e.g., the Conroe Relocated (C78) monitor) ozone formation is NO_X-limited because NO_X is less abundant and biogenic VOCs are plentiful. Another reason for NO_X-limited ozone formation at the Conroe Relocated (C78) monitor is that air transported from central Houston to the suburbs has had the NO_X depleted by chemical reactions on the way to the site.

The highest ozone production is observed at sites just on the edge of the most urbanized parts of the eight-county HGB nonattainment area (e.g., the Aldine (C8, HALC) and Manvel Croix Park (C84, MACP) monitors). These two sites routinely observe the highest ozone concentrations in the eight-county HGB area, and both have been the design value site for multiple historical years. Both sites observe a crucial change on the highest ozone day, June 26, 2012: most of the ozone is formed in a VOC-sensitive regime, instead of a NO_X-sensitive regime as observed on the other days. This change may have major regulatory implications. It suggests that different control strategies will be effective on the highest ozone days compared to the lower ozone days. These lower ozone days may still be above the standard; in this case, June 24, 25, and 27 are all exceedance days which show that NO_X-sensitive ozone formation is more important, but June 26, the highest day, shows that VOC-sensitive ozone formation is more important.

VOC-sensitive (i.e., NO_X-rich) ozone production is indicated by the bottom (blue) bars; NO_X-sensitive ozone production is indicated by the top (orange) bars; all single bars are orange except for the Lynchburg Ferry (C1015) monitor plot, where the bars are blue. HALC = the Houston Aldine (C8) monitors; MACP = the Manvel Croix Park (C84) monitor; HSMA = the Houston Monroe (C406) monitor; HLAA = the Lang (C408) monitor; CNR2 = the Conroe Relocated (C78) monitor; LYNF = the Lynchburg Ferry (C1015) monitor

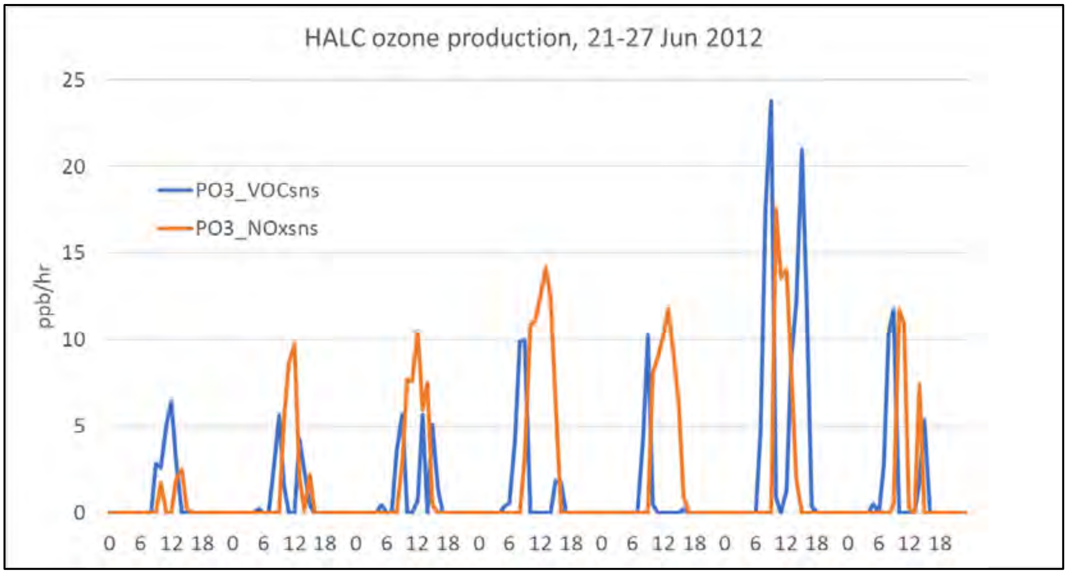
Figure 5-28: Chemical Process Analysis Ozone Production Rates (ppb/day) for June 21 through 27, 2012

This finding from the TCEQ modeling agrees with the findings of Schroeder et al. 2018, derived from observational aircraft data obtained during the DISCOVER-AQ NASA field campaign in September 2013. In that study, the researchers examined chemical observations from aircraft spirals over monitoring sites in the HGB area, which could give a vertical profile of chemical observations from the ground up to approximately 10,000 feet. They were trying to determine whether the ratio of satellite observations of HCHO and NO_2 could be used as a surrogate for VOC/NO_X ratios, and thus a measure of the VOC- or NO_X-sensitivity of ozone formation.

The findings call into doubt the effectiveness of satellite-derived VOC- and NO_X-sensitivity observations, for two reasons: (1) the sensitivity of ozone formation varies by time of day, but the current generation of satellites only pass over once per day, therefore missing most of the diurnal variation of ozone sensitivity; and (2) long-term averages usually used in satellite studies cannot accurately capture the sensitivity of ozone formation because these averages mix together many low and high ozone days. Schroeder et al. found that ozone formation sensitivity shifted from NO_X-sensitive to VOC-sensitive on the highest ozone days. The sensitivity of ozone production in the TCEQ modeling matches these observations by Schroeder et al.

The final chart in Figure 5-28 shows ozone production at the Lynchburg Ferry (C1015, LYNF) monitor. This site routinely observes the highest concentrations of HRVOCs in the HGB area; it sits on the Houston Ship Channel, near the highly industrialized parts of the HGB area, where there are large sources of ethylene and propylene. Ozone formation at this site is lower than at every other site. The implication is that each day, the ozone formation process has just begun at this site; the reactions leading to ozone usually have not progressed far enough to result in ozone formation. It also implies that the emissions most responsible for ozone formation originate near the Lynchburg Ferry (C1015, LYNF) monitor. If the Lynchburg Ferry (C1015, LYNF) monitor were further displaced from these critical emissions, more ozone would be forming. The assessment of VOC- and NO_X-sensitivity of ozone formation based upon the TCEQ modeling done for this HGB AD SIP revision is consistent with observations made during the DISCOVER-AQ NASA field campaign in September 2013.

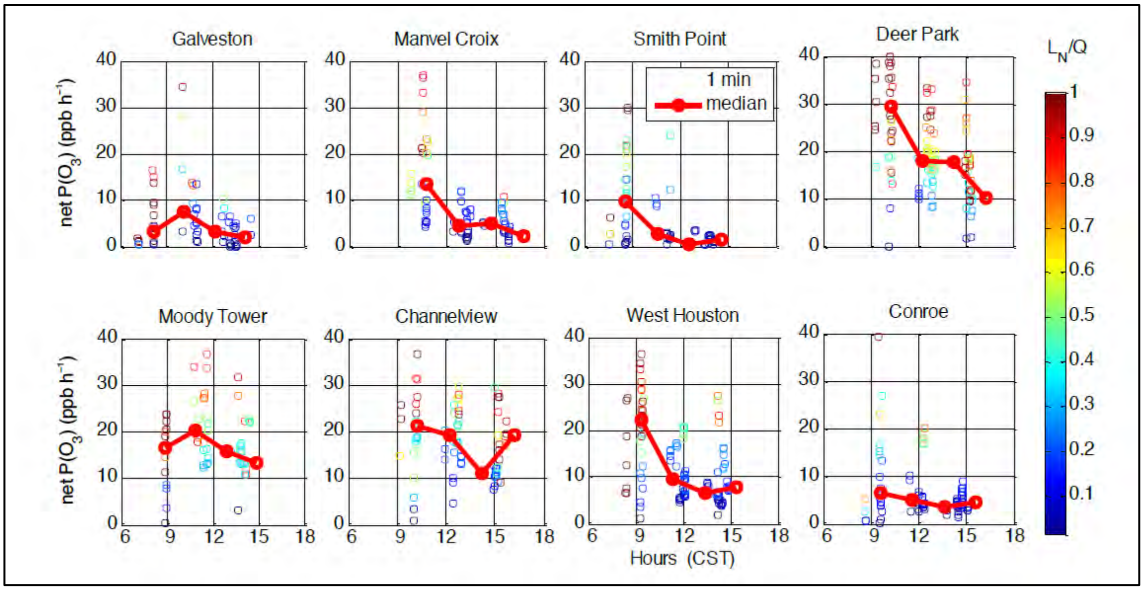
Schroeder et al. (2018) studied the $HCHO/NO_2$ ratios present above the HGB area during the DISCOVER-AQ field campaign in September 2013. Their original purpose was to determine whether satellite-measured vertical column densities of HCHO and NO_2 could be used to indicate the VOC- or NO_X-sensitivity of ozone formation. By contrasting the vertical column density ratios of $HCHO/NO_2$ measured by aircraft spirals and by satellite, they found that the satellite values diverged substantially from the in-situ aircraft measurements. They also found, however, that VOC- and NO_X-sensitivity of ozone formation varies between low and high ozone days, indicating that long-term averages of sensitivity indices ($HCHO/NO_2$, VOC/NO_X) do not show how the ozone is forming on the highest days. They found on the highest ozone day, September 25, 2013, that ozone formation was VOC-sensitive, but on other days ozone formation had a greater degree of NO_X-sensitivity. This finding is consistent with the process analysis results discussed in Figure 5-28 and Figure 5-29: *Chemical Process Analysis Modeled Ozone Production at the Aldine (C8, HALC) Monitor for the High Ozone Period of June 21 through 27, 2012.*



VOC-sensitive (i.e., NO_X-rich) ozone production is indicated by the blue lines; NO_X-sensitive ozone production is indicated by the orange lines

Figure 5-29: Chemical Process Analysis Modeled Ozone Production at Aldine (HALC, C8) Monitor for the High Ozone Period of June 21 through 27, 2012

Another DISCOVER-AQ study by Mazzuca et al. (2013) examined an indicator ratio called LN/Q. This ratio measures whether the chemical radicals driving ozone chemistry are removed from the ozone formation process by reacting with nitrogen compounds (LN) or reacting with each other (Q) (Ren et al., 2009). If LN/Q is greater than 0.5, the reactions with nitrogen compounds are dominating, and the ozone is forming in a NO_X-rich, or VOC-sensitive regime. If LN/Q is less than 0.5, the radicals are reacting with each other, indicating a shortage of NO_X, or NO_X-sensitive regime. Figure 5-30: *Net Ozone Production Rate (P(O_3)) by Time of Day at Each Monitoring Site Visited by the Aircraft During DISCOVER-AQ in September 2013* shows that the highest rates of ozone production are invariably associated with high values of LN/Q, strongly suggesting that the highest ozone is forming in a VOC-sensitive environment. This finding is consistent with the findings of Schroeder et al. (2018) and the TCEQ modeling illustrated in Figure 5-28 and Figure 5-29.



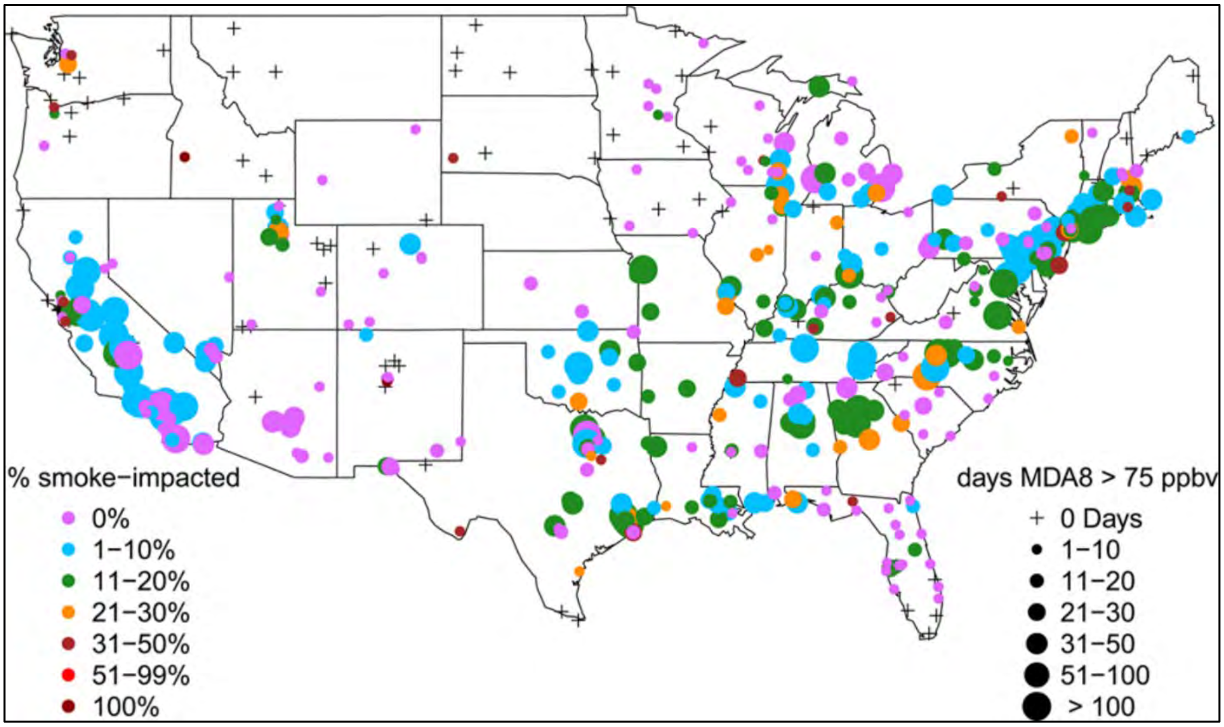
The markers are color-coded by LN/Q, an indicator of VOC-sensitive (>0.5) or NO_X-sensitive (<0.5) ozone formation.

Figure 5-30: Net Ozone Production Rate ($P(O_3)$) by Time of Day, at Each Monitoring Site Visited by the Aircraft During DISCOVER-AQ in September 2013

5.3.5 Wildfire Influence and Background Ozone

Scientific studies published in the literature indicate that wildfires can affect ozone in the HGB area. This section describes the scientific inquiries into the effects of wildfires and agricultural burning upon ozone in the HGB area.

Junquera et al. examined the influence of a marsh fire near Beaumont, Texas on ozone in the HGB area during the TexAQS 2000 study in September 2000. This modeling demonstrated that the wildfire plume did not enhance ozone formation or concentrations in rural areas, but when the plume passed over urban and industrial areas, vigorous ozone formation occurred in the plume. Brey and Fischer (2016) studied cities throughout the U.S., concluding that the wildfire impacts were greatest on cities with the highest NO_X emissions, implying that a combination of wildfire plumes and local emissions were needed to result in high ozone (Figure 5-31: *Frequency of Smoke Impact Upon Monitors and Number of Days Per Year with MDA8 Ozone Concentrations Greater than 75 ppb*).



Marker color indicates frequency of smoke impacts; Marker size indicates number of days per year MDA8 ozone was greater than 75 ppb (from Brey and Fischer, 2015)

Figure 5-31: Frequency of Smoke Impact Upon Monitors and Number of Days Per Year with MDA8 Ozone Concentrations Greater than 75 ppb

Other researchers also studied the HGB area ozone and its possible impact from wildfires during September 2000. Buzcu et al., (2006) observed compounds often used as biomass burning tracers (e.g., levoglucosan) in particulate matter samples collected on the days believed to be affected by fires. Nopmongcol et al. (2006, 2007) performed modeling analyses to study particulate matter formation during the same event. Myers-Pigg et al. (2016) examined another marsh fire event and also observed levoglucosan and other chemical traces of biomass burning in particles collected in the HGB area. The results of these studies indicate that plumes from marsh fires along the upper Texas Gulf Coast do enter the HGB area, and can foster vigorous ozone formation when their plumes enter urban and industrial emissions in the area. These marsh fires are relatively near the HGB area, so that their plumes are not dramatically aged.

Several studies over the years have examined whether distant fires play a role in the HGB area's ozone. Fires from Mexico and Central America, and fires from the western U.S. and Canada have both been studied to determine if they affect ozone in the HGB area.

It is well known that fires have a seasonal cycle. In spring, cropland is burned in Central America and Mexico to prepare fields for planting. These fires occur annually, though some years the fires are more widespread and intense, and some years the fire plumes are not carried by the winds into Texas. May 1998 and May 2003 were particularly notable years, in that the fires were widespread, large, and the plumes were transported effectively into Texas. Cheng and Lin (2001) used the highly-visible transport of fire plumes to test a method for discovering where distant emissions originate, i.e., the potential source contribution function method. They were able to show, independent of satellite analysis, that the May 1998 plumes originated in the Yucatan peninsula of Mexico. Rogers and Bowman (2001) also studied the May 1998 fires, and their climatological analysis showed that the fires made a serious impact upon the central U.S., including Texas. May 2003 was studied by Wang, J. et al. (2006a, 2006b) to track smoke emissions with mesoscale modeling. They found that the presence of a layer of smoke can increase the stability of lower layers of the atmosphere, such that pollutants emitted at the surface can accumulate more effectively. Most recently, Wang, S.-C. et al. (2018) studied cities along the Gulf Coast to determine how frequently and intensely the Mexican and Central American fire plumes have affected air quality. The researchers found that when fires were present, and their plumes were carried to the HGB area, MDA8 ozone concentrations increased by 9.7±1.7 ppbV above the concentrations observed during clean maritime flow from the Gulf. But only 15 ozone exceedance days occurred under the influence of Mexican fires during April through May 2002 through 2015 and only one of those 15 days affected the design value (May 18, 2003). Although these studies show that the Mexican and Central American agricultural fires can affect Texas air quality, these fires have very rarely affected the ozone design value between 2002 and 2015 (i.e., one day out of 854 days, or 0.12% (Wang et al., 2018)).

Other investigators have examined the influence of distant fires occurring in other parts of North America. Morris et al. (2006) examined satellite, ozonesonde, and trajectory data that suggested the HGB area was affected by wildfire plumes from Alaska and Canada on July 19 and 20, 2004. McMillan et al. (2010) found evidence that the HGB area was affected by wildfire plumes from the Pacific Northwest during August 23 through 30, 2006. Duncan et al. (2014) showed an example of Mississippi Valley agricultural burning smoke entering the HGB area during the DISCOVER-AQ 2013 study in the HGB area. Both McMillan et al. and Duncan et al. noted that the smoke passed through the HGB area as the result of a frontal passage. Duncan also noted that the smoke observed by satellite did not actually reach the ground; particulate matter measurements with surface monitors did not detect smoke at the surface.

Based upon the studies examined, it can be concluded that several conditions must be met before the HGB area ozone attainment is affected by a biomass burning plume: (1) there must be fire present in the source region; (2) the plume from the fire must be carried to the HGB area; (3) the plume must mix down to the surface; and (4) the plume must contain a large enough quantity of ozone and/or ozone precursors to affect the local air quality substantially enough to increase the ozone above the standard on a design-value-relevant day. Most of the studies have fulfilled the first three conditions, but none have met the fourth condition. Given that the transport pattern which brings fire plumes from Mexico and Central America usually occurs under meteorological regimes that are not conducive to ozone formation, it seems unlikely that Mexican fire emissions are readily able to affect the HGB area's ozone attainment status. Fire plumes that enter the HGB area during meteorological conditions favorable to high ozone, e.g., behind cold fronts, are more likely to result in an impact on the HGB area's ozone attainment.

5.3.6 Potential Effects of Economically Driven Coal-Burning Power Plant Closures

Within the past decade, the economic viability of coal-burning power plants has been transitioning. The advent of hydraulic fracturing, the resulting shale oil and gas production, federal rules that impact coal-fired power plants, and the carbon cost of emissions in certain states are some of the factors that have impacted the cost-effectiveness of coal-fired power generation.

The Energy Information Administration (EIA) reported that 12.9 gigawatts (GW) of coal-fired generating capacity was retired in 2018 in the United States[17]. Texas experienced the largest retirement of coal-fired generating capacity at 4.3 GW[12]. Specifically, the EIA included the retirements of Luminant Energy's Big Brown, Monticello, and Sandow (Units 4 and 5) plants, which permanently ceased operations in November 2017 through February 2018. Additional shutdowns include City Public Services' J.T. Deely plant, which ceased operations on December 31, 2018 and is currently mothballed, and Texas Municipal Power Agency's Gibbons Creek Steam Electric Station, which had been operating seasonally since 2017 but was mothballed indefinitely as of June 1, 2019.

The closure of these large NO_X sources is likely to have air quality impacts, especially since many EGUs are located in rural areas, where biogenic VOC is available for reaction with the NO_X emitted by the coal plants. Some of the closures are accounted for in this HGB AD SIP revision's modeling EI, but there may be additional closures that are not accounted for. In addition, if a facility is mothballed but not closed, its emissions remain in the inventory, since its permit is still active, and the facility could resume operation in the future. Therefore, the SIP modeling demonstration may not include all the NO_X emission reductions that will take place before the attainment date because the emissions from facilities whose closure have not yet been announced or from mothballed facilities are still part of the EI.

Though the emissions from the coal-burning power plants may cease, the electrical generating capacity must be replaced in some manner, and renewable, zero-emission power generation such as wind, solar, or nuclear may not be available to supply the missing capacity. It cannot be assumed, then, that the emissions will simply disappear; part of the generating capacity is likely to be met by another plant that has non-zero NO_X emissions. Given the complexity of power supply networks, it may not be possible to predict exactly how EGU NO_X emissions will redistribute, but despite the uncertainties, the overall trend is moving towards shutdown of coal-burning power plants. That opens the possibility that the modeling EI does not account for all the emissions reductions affecting background ozone concentrations. Therefore, this section of the literature review will examine the effects of coal-burning power plants and the potential benefits to background ozone levels that may arise from their shutdown.

Ryerson et al. (2001) found that the rate and efficiency of ozone formation from power plant plumes depended in part upon the availability of reactive VOCs; in rural areas, biogenic isoprene filled that role very effectively. They also learned that power plants with extremely high emission rates (13.9 tons NO_X per hour) made ozone much less effectively than smaller plants (e.g., 1 to 2 tons NO_X per hour), because the very high

[17] https://www.eia.gov/todayinenergy/detail.php?id=38632

NO_x concentrations fostered conversion of the NO_x to nitrates instead of supporting ozone formation. All the Texas coal-burning power plants fit into the second category of more efficient ozone production rather than the first.

Springston et al. (2005) examined data from 12 aircraft transects flown downwind and perpendicular to the Sandow Alcoa plume in September 2000. They found that the lignite-burning power plant plume enhanced ozone by 15 ppb above the background ozone. The ozone enhancement persisted even 63 kilometers (km) downwind of the facility.

Neuman et al. (2004) examined aircraft transect data for eight Texas power plants during TexAQS 2000 (W.A. Parish, Tradinghouse, Limestone, Big Brown, Sandow, Martin Lake, Monticello, and Welsh). Neuman et al. (2002) showed ozone enhancement of 8 to 12 ppb above background ozone levels at 77 km downwind of Tradinghouse power plant. Frost et al. (2006) examined the ozone production efficiency of the different Texas plants, along with other power plants throughout the eastern U.S., and found that for Welsh, Monticello, Limestone, Big Brown, Tradinghouse, and Martin Lake, the ozone production efficiency was about six molecules of ozone per molecule of NO_x oxidized. The Zhou et al. study found similar ozone production efficiency six years later during TexAQS 2006. All studies of W.A. Parish have shown different ozone production efficiency than other plants with similar rates of NO_x emission, probably due to Parish's proximity to the HGB area; the urban and industrial environment into which Parish releases its plume lead to lower ozone production efficiency than the rural environments of northeast and central Texas.

Zhou et al. (2012) showed that flights made downwind of Martin Lake, Monticello, and Welsh power plants in northeast Texas during TexAQS 2006 generated 4.5 to 9.7 ppb of ozone above the regional background ozone at approximately 70 km downwind. Ozone production efficiency within these plumes was high compared to some studies, with all three plumes generating six to 10 ozone molecules per molecule of NO_x oxidized, much higher than the ozone production efficiency of 2.2 observed by Ryerson for W.A. Parish plant in 2000 (Ryerson et al. 2003), but about the same order of magnitude as the Johnsonville power plant observed in 1999 (Ryerson et al. 2001). The Johnsonville plant was in a similar rural, biogenic-isoprene-rich environment as the three northeast Texas plants, which may account for their similarity.

Strasert et al. (2019) is the most relevant analysis for this HGB SIP revision. The researchers used part of the same modeling episode that TCEQ has used for this SIP revision, June 15 through 30, 2012 and August 1 through 15, 2012, and used a version of the same Texas EI that TCEQ employs. Strasert and his colleagues studied the potential air quality impacts of the hypothetical shutdown of individual coal-fired power plants in Texas. Specifically, this study focused on 13 out of the 21 coal-burning power plants located in eastern and central Texas: Big Brown, Coleto Creek, Fayette Power Project, J.K. Spruce, J.T. Deely, Limestone, Martin Lake, Monticello, Oak Grove, San Miguel, Sandow, W.A. Parish, and Welsh.

The NO_x emissions (EPA 2017 estimates) from these plants range from 5.6 tpd for San Miguel to 27.3 tpd for Martin Lake. This study quantified the potential individual impact of each plant upon MDA8 ozone concentrations in two ways: averaged over the entire domain for the entire 30-day modeling period; and for single monitors averaged over the 30-day modeling period. Unfortunately, these assessments do not quantify the contribution to background ozone on high ozone days in nonattainment areas, nor do the assessments quantify the contribution on MDA8 ozone concentrations on individual days at monitors that exceed the 2008 eight-hour ozone standard. The authors do discuss maximum impacts at a few monitors; for example, the W.A. Parish plant near the HGB area increased the MDA8 ozone concentration at the Northwest Harris (C26) monitor by 3.3 ppb, despite the stringent selective catalytic reduction controls installed at the facility.

Figure 5-32: *Modeling Impacts upon MDA8 Ozone Concentrations at Key Monitors from Hypothetical Closure of Individual Coal-Burning Power Plants in Texas* estimates the impact of hypothetically closing individual plants upon the peak ozone at selected monitoring sites in Dallas-Fort Worth, HGB, and San Antonio. The analysis does not consider the accumulated impact of all closures at once, which might be more relevant to the current situation. Nine coal-burning power plant units have been shut down or mothballed since April 1, 2016; eight of these shutdowns/mothballs occurred in 2018. The TCEQ modeling for 2018 and 2020 accounts for the shutdown of two units at Big Brown, three units at Sandow, one unit at Welsh, and three units at Monticello. In addition, two units at JT Deely are mothballed as of January 2019, but are still included in the EI, since they have not been completely decommissioned. The shutdown units accounted for 54 tpd NO_X emission during the 2012 ozone season; mothballed units accounted for 9.5 tpd ozone season NO_X emissions in 2012. Shutdown of multiple units are likely to decrease background ozone more than the shutdown of single units.

			MDA8 Ozone Impact (ppb)				
Monitor	Column	Row	Big Brown	J T Deely	Monticell o	Sandow	Welsh
25-Jun							
San Antonio Northwest	42	88	0.020	0.179	0.003	0.071	0.003
Manvel Croix Park	121	88	0.010	0.000	0.001	0.000	0.001
Camp Bullis	43	91	0.056	0.137	0.001	0.085	0.002
Park Place	123	93	0.003	0.000	0.001	0.000	0.001
Houston Aldine	122	99	-0.002	0.000	0.004	0.000	0.011
Arlington Municipal Airport	79	175	0.103	0.000	0.107	0.041	0.021
Denton Airport South	77	191	0.077	0.007	0.031	0.066	-0.002
26-Jun							
San Antonio Northwest	42	88	0.169	0.273	0.217	0.087	0.118
Manvel Croix Park	121	88	-0.005	0.000	0.258	-0.001	0.061
Camp Bullis	43	91	0.179	0.234	0.245	0.032	0.135
Park Place	123	93	-0.006	0.000	0.202	-0.001	0.052
Houston Aldine	122	99	-0.012	-0.001	0.058	-0.002	0.022
Arlington Municipal Airport	79	175	0.040	0.002	0.039	0.024	0.016
Denton Airport South	77	191	0.037	0.005	0.025	0.026	0.006
27-Jun							
San Antonio Northwest	42	88	0.002	1.238	0.067	-0.001	0.022
Manvel Croix Park	121	88	-0.012	0.000	-0.005	-0.001	0.001
Camp Bullis	43	91	0.010	0.798	0.087	0.000	0.029
Park Place	123	93	-0.012	0.000	-0.005	-0.001	0.001
Houston Aldine	122	99	-0.015	-0.001	-0.010	-0.002	-0.001
Arlington Municipal Airport	79	175	0.156	0.000	0.059	-0.001	0.126
Denton Airport South	77	191	-0.004	0.000	0.138	0.000	0.190

From Strasert, personal communication, 2019

Figure 5-32: Modeling Impacts upon MDA8 Ozone Concentrations at Key Monitors from Hypothetical Closure of Individual Coal-Burning Power Plants in Texas

These estimated impacts are rather small for individual plants on the high ozone days of June 25 through 27, 2012. By contrast, the plume studies by Ryerson et al. (2001), Springston et al. (2005), Neuman et al. (2004), and Zhou et al. (2012) show that these plants can raise ozone concentrations by 10 ppb or more above the local background ozone. It is possible that the short time scale of the aircraft transects studied by these other researchers gives the impression of a larger impact than the modeled impact to the eight-hour ozone concentration as performed by Strasert et al. (2019). It is also possible that the high spatial resolution of the aircraft transects does not smear out the impact from the plumes as a photochemical grid model may do. The issue warrants further research and analysis, but one can conclude that the impact from closure of several coal-burning power plants in Texas lies between the low values observed from individual plant closures in Strasert et al. and the larger impacts observed from aircraft transects. Further study is needed to determine the exact impact, but there is ample evidence to suggest that the accelerating closure of coal-burning power facilities is likely to affect regional background ozone concentrations in the HGB area. This evidence indicates that higher reductions in MDA8 ozone concentrations than those modeled in this proposed HGB AD SIP revision are plausible.

5.3.7 Wildfire/Smoke Impact

The TCEQ has begun reviewing ambient air monitoring data from monitors in the HGB area during 2018 and has determined that there were ozone episodes during the periods of July 26 and 27 and August 23 and 24, 2018, that appear to have been influenced by smoke from wildfires. The TCEQ will be flagging the relevant data in the AQS as being influenced by emissions from wildfires and further investigating the circumstances that affected the development of these ozone episodes.

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 the EPA's standard tests of SIP creditability (permanent, enforceable, surplus, and quantifiable) but are crucial to the success of the air quality plan in the HGB area.

5.4.1 Additional Measures

5.4.1.1 SmartWay Transport Partnership and the Blue Skyways 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 3,500 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 in 2004, SmartWay has reduced oil consumption by 248.8 million barrels.[18] Between 2009 and 2016, the SmartWay Truck Carrier Partners

[18] https://www.epa.gov/smartway/smartway-program-successes

prevented the release of 1,700,000 tons of NO_X and 70,000 tons of particulate matter into the atmosphere.[19] 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.

The EPA has awarded the PHA with three additional DERA grants. In 2015, the PHA received two grants of nearly $900,000 each, to replace 41 older drayage trucks operating in the Port of Houston with newer, cleaner trucks. In 2017, the EPA awarded the PHA with a DERA grant of $143,500 to replace diesel buses with clean diesel-powered vehicles.

Approximately 200 Texas companies are SmartWay partners, 36 of which are in the HGB area.[20] 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 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 light-emitting diode or 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 the first quarter 2019, Texas has 24,895 megawatts (MW) of installed wind generation capacity,[21] 25.6% of all installed wind capacity in the U.S. In 2018, Texas' total net electrical generation from renewable wind generators was 75.7 million megawatt-hours (MWh),[22] approximately

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[19] https://www.epa.gov/smartway/smartway-trends-indicators-and-partner-statistics-tips
[20] https://www.epa.gov/smartway/smartway-partner-list
[21] U.S. Department of Energy, National Renewable Energy Laboratory, https://windexchange.energy.gov/maps-data/321
[22] U.S. Department of Energy, Energy Information Administration, https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=008&geo=0000000002&sec=g&li

27.6% of the total wind net electrical generation for the U.S at that time. In 2018, Texas' total net electrical generation from renewable wind generators in Texas increased approximately 13% more than in 2017.

Texas non-residential solar electricity generation in 2018 totaled 3.3 million MWh, [23] a 53% increase from 2017. The 2018 total installed solar electricity generation capacity in Texas was 2,924 MW, [24] a 52% increase from 2017.

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 or renewable energy efforts may not result in local emissions reductions or may be offset by increased demand in electricity. The difficulty in determining the accuracy of historical dispatch patterns and predicting future dispatch patterns makes accurately quantifying emission reductions from EE/RE measures difficult.

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 (ESL) website (http://esl.tamu.edu/). The Texas Emissions Reduction Plan (TERP) reports submitted to the TCEQ regarding EE/RE measures are available on the ESL website on the TERP Reports webpage (http://esl.tamu.edu/terp/documents/terp-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

nechart=ELEC.GEN.WND-TX-99.A&columnchart=ELEC.GEN.WND-TX-99.A&map=ELEC.GEN.WND-TX-99.A&freq=A&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=

[23] U.S. Department of Energy, Energy Information Administration, https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=0000k&geo=0000000002&sec=g&freq=A&start=2001&end=2018&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0

[24] Solar Energy Industries Association, https://www.seia.org/state-solar-policy/texas-solar

- 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

85th Texas Legislature, 2017

- HB 1571 (Regular Session)

86th Texas Legislature, 2019

- HB 2546

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 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 owner's associations' approval of installation of solar energy devices. HB 362 specifies the conditions that property owner's 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 owner's 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 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).

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.

HB 1571, 85th Texas Legislature, 2017, Regular Session, expanded Education Code and Government Code provisions for local governmental entities, schools, and state agencies entering into energy saving performance contracts by authorizing the entities to use any available money to pay the provider for energy or water conservation measures. Previously, only money other than money borrowed from the state could be used to pay for such conservation measures.

HB 2546, 86th Texas Legislature, 2019, Regular Session, allows manufacturers or builders of industrialized housing to meet energy efficiency performance standards in the energy code (Texas Health and Safety Code, §388.003(a)) or in a local amendment to the energy code. The bill extends the benefits of energy code modifications to industrialized housing by allowing it to be eligible for the energy code modifications available to site-built homes.

5.4.1.3 8 Consent Decrees with Refineries

The EPA's National Petroleum Refinery Initiative[25] has resulted in multi-issue settlement agreements with the nation's major petroleum refineries. As of March 2019, 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.

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

In March 2005, the EPA issued CAIR to address 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 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

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

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 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 United States Court of Appeals for the District of Columbia Circuit (D.C. Circuit Court) 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 eight-hour ozone NAAQS. The EPA provided preliminary modeling results for 2018, which show contribution to nonattainment of the 2008 eight-hour 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 Court'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. On July 10, 2018, the EPA published a proposed close-out of CSAPR, proposing to determine that the CSAPR Update Rule fully addresses interstate pollution transport obligations for the 2008 eight-hour ozone NAAQS in 20 covered states, including Texas. The EPA's modeling analysis projects that by 2023 there will be no remaining nonattainment or maintenance areas for the 2008 eight-hour ozone NAAQS in the CSAPR Update region and therefore the EPA would have no obligation to establish additional control requirements for sources in these states. As a result, these states would not need to submit SIP revisions establishing additional control requirements beyond the CSAPR Update. The final rule was published on December 21, 2018 with an effective date of February 19, 2019 (83 FR 65878).

As discussed in Section 3.6.4: *2020 Future Case Emissions*, the TCEQ used the CSAPR Update Rule as the basis for allocating EGU emission caps in the 2020 future year.

5.4.1.5 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 (DERI) program. DERI grants 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 2018, $1,102,232,075 in DERI grants were awarded for projects projected to help reduce an estimated 179,879 tons of NO_X in the period over which emissions reductions are reported for each project under the program. This includes $455,054,219 going to activities in the HGB area with an estimated 78,704 tons of NO_X reduced in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $52.2 million in grants under the DERI program in FY 2019 for an estimated 5,044 tons of NO_X reduced.

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 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. The name of this program was recently changed to the Seaport and Rail Yard Areas Emissions Reduction (SPRY) program, and replacement or repower of cargo handling equipment was added to the eligible project list. Through August 2018, the program awarded $6.2 million, with an estimated 362 tons of NO_x reduced in the period over which emissions reductions are reported for each project under the program. In the HGB area the funding totaled approximately $5.6 million, with projects estimated to reduce up to 331 tons of NO_x, in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $9.3 million in grants under the SPRY Program in FY 2019 for an estimated 298 tons of NO_x reduced.

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 vehicle fleets, therefore applicants must commit to replacing at least 10 eligible diesel-powered vehicles with qualifying alternative fuel or hybrid vehicles. From 2009 through August 2018, over $55.9 million in TCFP grants were awarded for projects to help reduce an estimated 633 tons of NO_x in the period over which emissions reductions are reported for each project under the program. Over $20.7 million in TCFP grants were awarded to projects in the HGB area, with an estimated 189 tons of NO_x reduced in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $7.7 million in grants under the TCFP in FY 2019 for an estimated 44 tons of NO_x reduced.

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. From 2011 through August 2018, over $42.3 million in TNGVGP grants were awarded for projects to help reduce an estimated 1,495 tons of NO_x in the period over which emissions reductions are reported for each project under the program. Over $10.3 million in TNGVGP grants were awarded to projects in the HGB area, with an estimated 298 tons of NO_x reduced in the period over which emissions reductions are reported for each project under the program. The TCEQ expects to award an additional $14.4 million in grants under the TNGVGP in FY 2019 for an estimated 74 tons of NO_x reduced.

Through FY 2017, both the TCFP and TNGVGP required that the majority of the grant-funded vehicle's operation 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 Dallas-Fort Worth. Legislative changes in 2017 expanded the eligible areas into a new Clean Transportation Zone, to include the counties in and between an area bounded by Dallas-Fort Worth, Houston, Corpus Christi, Laredo, and San Antonio.

5.4.1.6 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 through retrofit of older school buses with diesel oxidation catalysts, diesel particulate filters, and closed crankcase filters. As a result of legislative changes in 2017, this program also includes replacement of older school buses with newer, lower-emitting models. Through August 2018, the TCEQ Clean School Bus Program had reimbursed approximately $37.5 million in grants for over 7,500 retrofit and replacement activities across the state. This amount included $4.7 million in federal funds. Of the total amount, approximately $10.4 million was used for 2,751 school bus retrofit projects and five school bus replacement projects in the HGB area. The TCEQ awarded an additional $3.1 million in projects under the Clean School Bus Program in FY 2019 for an estimated 36 tons of NO_X reduced.

5.4.1.7 86th Texas Legislature, 2019

Summaries of the bills passed during the 86th Texas Legislature, 2019, Regular Session, that have the potential to impact the HGB area are discussed in this section. For legislative updates regarding EE/RE measures and programs, see Section 5.4.1.2: *Energy Efficiency and Renewable Energy Measures*.

HB 1346

HB 1346 gives the TCEQ authority to set the minimum usage of TERP grant funded equipment in nonattainment and affected areas under the DERI program lower than the current 75%, but not lower than 55%. This could increase the number of projects funded, though the NO_X emissions reductions for projects that include equipment used less than 75% in the eligible areas could be lower than projects to date.

HB 3745

HB 3745 creates a TERP Trust Fund, effective September 1, 2021, and extends the TERP fees until attainment, effective August 30, 2019. This fund would exist outside of the state treasury and would allow the TCEQ to expend all the revenue from the TERP fees that accrue over the state biennium. HB 3545 could potentially result in the TCEQ funding more TERP projects and achieving greater NO_X emissions reductions.

5.4.1.8 Local Initiatives

The H-GAC has a number of locally implemented strategies in the HGB nonattainment area including projects, programs, partnerships, and policies. These programs are expected to be implemented in the eight-county nonattainment area by 2020. Due to the continued progress of these measures, additional air quality benefits will be gained and will further reduce precursors to ground-level ozone formation. A summary of each strategy is included in Appendix H: *Local Initiatives Submitted by the Houston-Galveston Area Council*.

5.5 CONCLUSIONS

The TCEQ has used several sophisticated technical tools to evaluate the past and present causes of high ozone in the HGB nonattainment area to predict the area's future air quality. Historical trends in ozone and ozone precursor concentrations and their causes have been investigated extensively. The following conclusions can be reached from these evaluations.

The one-hour and the eight-hour ozone design values both have overall sustained decreasing trends over the past 13 years. The HGB area has monitored attainment of the revoked one-hour ozone standard since 2013. At the end of the 2018 ozone season, the eight-hour design value was 78 ppb, which is in attainment of the 1997 eight-hour ozone standard of 84 ppb and is the lowest design value ever measured in the HGB area. In 2018, only two out of 20 ozone monitors had eight-hour ozone design values greater than the 2008 eight-hour ozone NAAQS of 75 ppb: the Houston Aldine (C8) monitor with a design value of 78 ppb and the Houston Bayland Park (C53) monitor with a design value of 76 ppb.

The largest decreases in eight-hour ozone were observed prior to 2009. After 2009 these decreases occur at a slower rate. These trends are not only seen in ozone design values, but also in the fourth-highest eight-hour ozone values, ozone exceedance days, background ozone, ambient NO_X, ambient VOC, ambient HRVOC, and meteorologically adjusted ozone trends. Most trends indicate a slower decrease after 2009 except for HRVOC trends. Trends in HRVOC at many monitors have shown overall decreases from 2005 levels, but many monitors observed increases from levels observed in 2009. This is strong evidence that controls put in place prior to 2009 were effective in not only reducing precursor concentrations, but also in reducing ozone concentrations. The slowing of trends and increasing of some HRVOC trends indicate that these are potential areas for further research should the HGB area not attain the more stringent 2015 eight-hour ozone standard.

Trends in VOC-to-NO_X ratios shows that areas in Brazoria County are more NO_X- limited while areas near the Houston Ship Channel are more transitional. Many monitors show no trend in VOC-to-NO_X ratios; however, some Brazoria County monitors have trended towards more NO_X-limited conditions while some Houston Ship Channel monitors have trended towards more VOC-limited conditions. With many monitors showing transitional conditions, controls on either NO_X or VOC emissions may be effective in reducing ozone in the HGB area.

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: *Literature Survey* 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: *Regional and Global Photochemical Modeling for the DFW and HGB Attainment Demonstration SIP Revisions for the 2008 Eight-Hour Ozone Standard*, the photochemical grid modeling performs 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 entire 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 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 peak future design value of 76 ppb at the Manvel Croix Park (C84) monitor.

This HGB AD SIP revision and its appendices document a fully evaluated high-quality modeling analysis with future year design values that are close to or below the 75 ppb eight-hour ozone standard for all HGB area ozone monitors. Trend analyses show that eight-hour ozone design values have decreased by 24% since 2005. NO_X and VOC precursor emissions trends also show significant decreases, which has led to reduced ozone formation. These reductions in precursors in the HGB ozone nonattainment area are due to a combination of federal, state, and local emissions controls.

As shown in this chapter, Chapter 3, and Appendix B: *Emissions Modeling for the DFW and HGB Attainment Demonstration SIP Revisions for the 2008 Eight-Hour Ozone Standard*, the on-road and non-road mobile source categories are one of the largest sources of NO_X emissions in the HGB ozone nonattainment area, and are expected to continue their downward decline due to fleet turnover where older, high-emitting sources are replaced with newer, low-emitting ones. The TERP, managed by the TCEQ, continues to accelerate the mobile source fleet turnover effect by providing financial incentives for purchases of lower-emitting vehicles and equipment. Ozone formation is expected to decline through the 2020 modeled attainment year as lower amounts of NO_X are emitted from these sources.

This HGB AD SIP revision documents a fully evaluated, high-quality photochemical modeling analysis with a thorough weight of evidence assessment that meets the requirements to demonstrate attainment of the 2008 eight-hour ozone NAAQS by July 20, 2021.

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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 continues to invest resources in air quality scientific research and the advancement of pollution control technology, refining quantification of emissions, and improving the science for ozone modeling and state implementation plan (SIP) analysis. 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 Emissions Inventory Improvement Projects

The TCEQ emissions inventory (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 webpage (https://www.tceq.texas.gov/airquality/airmod/project/pj.html).

6.2.2 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 EI 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 Emissions 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 Advisory Council, and reports from completed projects can be found at the AQRP webpage (http://aqrp.ceer.utexas.edu/).

6.2.3 2016 Collaborative Modeling Platform Development

The TCEQ has joined a collaborative group of the EPA, states, tribes, and multi-jurisdictional organizations in creating a 2016 national emissions modeling platform that can be used as the basis for future regulatory modeling activities. Workgroups for key emission sectors were formed to create 2016 EIs for photochemical modeling input including on-road, non-road, electric generating units (EGU) points, non-EGU points, area, and biogenic sources. The beta version of the 2016 platform was released on March 13, 2019. Version 1.0 is planned for release in summer 2019. Details on the

2016 collaborative inventory are on the Inventory Collaborative 2016beta Emissions Modeling Platform webpage (http://views.cira.colostate.edu/wiki/wiki/10197).

6.2.4 International Emissions and Background Contribution

The EPA has acknowledged that domestic air quality could be impacted by emissions from Canada, Mexico, and other continents (80 *Federal Register* (FR) 12293). The EPA also acknowledged that sites along the United States (U.S.) - Mexico border could have overwhelming influence of background ozone (EPA, 2015). Background ozone is defined by the EPA as "ozone formed from sources or process other than U.S. manmade emissions of nitrogen oxides (NO_X), volatile organic compounds (VOC), methane (CH_4), and carbon monoxide (CO)" (EPA, 2015) and includes ozone due to natural events such as stratospheric intrusions, wildfires, and ozone from non-U.S. anthropogenic sources (80 FR 65436). The TCEQ plans to use a combination of modeling and data analysis to better understand international transport into the HGB nonattainment area and to quantify the contribution of international emissions and background to 2020 future year design values (DV_F) at the HGB monitors. The TCEQ will use a combination of a global photochemical model, the global atmospheric chemistry model driven by assimilated meteorological observations from the Goddard Earth Observing System (GEOS-Chem), and a regional photochemical model, the Comprehensive Air Quality Model with Extensions (CAMx), to estimate the contribution of international emissions and background to the 2020 DV_F at HGB monitors.

6.2.5 Inter-Precursor Trading Ratio for Nonattainment New Source Review Permit Offset Requirements

To satisfy nonattainment new source review permit offset requirements, 30 TAC §101.306(d) and §101.376(g) allow the use of emission credits and discrete emission credits of one ozone precursor to offset emissions of another ozone precursor (i.e., NO_X credits for VOC offsets and vice-versa). The TCEQ has developed guidance[26] on the use of regional photochemical modeling with models such as CAMx to demonstrate on a case-by-case basis that inter-precursor trading (IPT) of credits will not adversely affect the air quality in the HGB nonattainment area.

On November 17, 2016, as part of the proposed implementation requirements for the 2015 eight-hour ozone NAAQS, the EPA proposed provisions that would allow each state to establish a default IPT ratio for each nonattainment area. Once a nonattainment area's specific default IPT ratio has been established, photochemical modeling demonstrations will not be required for each IPT use. In May 2018, the EPA published a technical support document, *Technical Guidance for Demonstration of Inter-Precursor Trading (IPT) for Ozone in the Nonattainment New Source Review Program*, describing technical analysis that can be used by states to establish area-specific default IPT ratios. On December 6, 2018, the EPA finalized the implementation rule for the 2015 eight-hour ozone NAAQS providing states with the option to establish a default IPT ratio for each nonattainment area and requiring that the default

[26] *Guidance on the Inter-Pollutant Use of Credits for Nonattainment New Source Review Permit Offset Requirements*, TCEQ, January 2017, available at: https://www.tceq.texas.gov/assets/public/implementation/air/banking/guidance/inter-pollutant.pdf

IPT ratio results in equivalent or improved ozone air quality in the nonattainment area (83 FR 63016).

The TCEQ has executed a contract with Ramboll to conduct the technical analysis required to establish a default IPT ratio for the HGB nonattainment area. The technical analysis will use the decoupled direct method (DDM) feature in CAMx to examine the sensitivity of ozone to changes in emissions of NO_X, VOC, and/or highly reactive volatile organic compounds (HRVOC) from hypothetical "model facilities" located within the HGB area. The number of "model facilities," their operating and physical parameters, and their emission rates and speciation profiles will be selected to represent the industrial activities typical of HGB. The DDM-CAMx runs will be conducted on a grid with four-kilometer resolution that will encompass only the eight counties in the HGB nonattainment area and the run(s) will cover time periods (episodes) that capture at least eight of the top 10 days used to calculate 2020 DV_F in this HGB AD SIP revision. The outputs from the DDM-CAMx runs will provide sensitivities of maximum daily average eight-hour (MDA8) ozone concentrations to changes in NO_X, VOC, and HRVOC emissions for each model plant in HGB. The sensitivities will then be used to determine the default IPT ratio for HGB.

6.2.6 Supplemental Flare Operations Training

The TCEQ and the University of Texas developed Supplemental Flare Operations Training based on findings from the 2010 TCEQ Flare Study. The training was developed for industry personnel and focuses on the proper operation of dual-service flares in routine or non-emergency service—specifically, elevated air- and steam-assisted flares. Please note that ground, pressure-assisted (sonic), enclosed, and non-assisted flares are outside the scope of the training.

This training provides practical information about key variables affecting flare performance, allowing operators to maximize flare efficiency using existing on-site resources. The training is free and available online 24 hours a day, seven days a week; users are required to register to track progress through the individual training modules and to receive a training completion certificate. To date, more than 1,300 users have registered to take the training. The training can be accessed on the Supplemental Flare Operations Training webpage: https://sfot.ceer.utexas.edu/.

6.2.7 Optical Gas Imaging Technology

Optical gas imaging technology has proved to be highly effective in detecting VOC emissions. Optical gas imaging systems assist the agency in actions such as facility investigations, reconnaissance investigations, mobile monitoring, and special projects. The TCEQ manages 20 optical gas imaging cameras statewide, which provides staff the ability to quickly respond to on-demand and emergency response events whenever they occur. The TCEQ also continues to invest in periodic contracted aerial surveys allowing the agency to survey large geographic areas.

This technology is also useful for identifying sources of VOC emissions that are underestimated, underreported, unreported, or previously unregulated. Examples of how the TCEQ uses this technology include: offsite surveillance to identify potential sources of contaminants in response to ambient or other monitoring results; identification of sites, or areas within a specific site, where a focused investigation may be conducted; identification of potential source control strategies or to assist in assessments of existing strategies; and identification of sources for emissions inventory issues.

The current state of optical gas imaging technology has some technical limitations, e.g., commercially available instruments are not capable of speciating contaminants. Emerging advancements in this technology have led to the development of at least one commercially available system for quantifying leak emissions rates. However, the composition of the imaged leak must be known for the camera to quantify emissions. Additionally, effective use of optical gas imaging technology is highly dependent on the training and experience of the instrument operator.

Overall, optical gas imaging technology provides opportunities for more rapid detection and repair of VOC emission leaks. Many industrial facilities now use this technology as part of their VOC emissions minimization program and to enhance identification and repair of hydrocarbon leaks.

6.2.8 References

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Appendices Available Upon Request

Alison Stokes
Alison.Stokes@tceq.texas.gov
512.239.4902