PGA 582-16-60851-01, Amendment 3
Task 6.4, Deliverable 6.4.2

Secondary Analysis of Photochemical Modeling Data Report

Prepared by the Capital Area Council of Governments
June 15, 2018

PREPARED UNDER A GRANT FROM THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

The preparation of this report was financed through grants from the State of Texas through the Texas Commission on Environmental Quality. The content, findings, opinions, and conclusions are the work of the author(s) and do not necessarily represent findings, opinions, or conclusions of the TCEQ.

Executive Summary

This report provides insights into ground-level ozone (O_3) formation in the Austin-Round Rock Metropolitan Statistical Area (MSA) using existing photochemical modeling completed by the Capital Area Council of Governments (CAPCOG), the Alamo Area Council of Governments (AACOG), the Texas Commission on Environmental Quality (TCEQ), and the U.S. Environmental Protection Agency (EPA). Analyses developed for this report include the following:

- Projected Maximum Daily 8-Hour O_3 Average (MDA8 O_3) within the region and estimated probabilities of violating the 2015 O_3 National Ambient Air Quality Standard (NAAQS) of 70 parts per billion (ppb) from 2018 – 2023 (Section 2)
- Analysis of factors influencing the impact of O_3 precursor emissions on ground-level O_3 formation in the Austin-Round Rock MSA (Section 3)
- Estimated impacts of emission reduction strategies within the MSA (Section 5)
- Implications of other recent regional development on O_3 formation within the MSA (Section 6)

Table of Contents

1 Introduction

The purpose of this project is to gain additional insights into ground-level ozone formation within the region based on photochemical modeling that has already been conducted. In some cases, this will involve focusing what the implications are for the CAPCOG region of data developed by other agencies, while in other cases, CAPCOG will use photochemical modeling data that was developed for the CAPCOG region, but will perform additional analyses beyond what was originally conducted.

This report uses existing photochemical modeling data produced by the EPA, TCEQ, CAPCOG, and AACOG in order to support CAPCOG's ongoing regional air quality planning efforts. On May 9, 2018, the Central Texas Clean Air Coalition approved moving forward with a five-year voluntary regional air quality plan covering 2019-2023 with the primary goal of maximizing the probability of the Austin-Round Rock MSA's compliance with the NAAQS and a secondary goal of otherwise minimizing health and environmental impacts of regional air pollution. In order to support this planning effort, this report looks at:

- Projected O_3 levels within the region between 2019 and 2023
- The probability that the region's O_3 design value will exceed the 2015 O_3 NAAQS or a potentially tighter 65 ppb O_3 NAAQS if EPA tightened the NAAQS in 2020
- Adjusted estimates of source contributions to the region's 2017 O_3 levels value based on the MSA's final 2017 design value and estimated changes in contributions through 2023
- The estimated impact of various O_3 control strategies that could be implemented between 2019 and 2023

2 Projected Ozone Levels and Risks of Violating the NAAQS through 2023

One of the key pieces of information needed for CAPCOG's air quality planning process is understanding the potential risks of violating the O_3 NAAQS during the time period covered by the plan. This section includes an analysis of these risks based on recent modeling conducted by AACOG of O_3 levels in 2017, 2020, and 2023, O_3 monitoring data at C3 and C38 in Travis County in 2015-2017, and EPA's guidance for modeling future attainment of the NAAQS.

2.1 AACOG 2017, 2020, and 2023 Modeling

CAPCOG used photochemical modeling conducted by AACOG in 2017 and 2018 and the MSA's final 2015-2017 O_3 monitoring data in order to project the region's O_3 design values and the probabilities of violating the current 2015 O_3 NAAQS of 70 ppb and a potentially tighter 2020 O_3 NAAQS of 65 ppb.

In order to project O_3 levels, CAPCOG used a modified version of the "modeled attainment test" as described in EPA's 2014 Draft *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*.[1]

[1] EPA. *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*. December 2014. Available online at: https://www3.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf

EPA's 2014 Draft *Modeling Guidance for Conducting Modeled Attainment Tests* recommends that, "ozone RRFs be calculated on the 10 highest days in the base year modeling at the monitor location, as long as the base MDA8 values are greater than or equal to 60 ppb for that day. In cases for which the base model simulation does not have 10 days with MDA8 O_3 values greater than or equal to 60 ppb at a site, then EPA recommends using all days where MDA8 >=60 ppb, as long as there are at least 5 days that meet that criteria. If there are less than 5 days with MDA8 >=60 ppb, EPA recommends that air agencies do not calculate a DVF [future design value] for that site." For future values, a modeled MDA8 O_3 of less than 60 ppb can be used as long as the base modeling day has a modeled MDA8 O_3 of at least 60 ppb.

EPA's guidance goes on: "Once the MDA8 values are selected for each appropriate day for each monitoring site, they should be averaged together over the days while maintaining at least two places to the right of the decimal (round to the last decimal digit). The RRF is the ratio of the average future MDA8 values to the average base MDA8 values."

CAPCOG's modified version of the attainment test involves the following two modifications of the method described in EPA's guidance:

1. CAPCOG used the MDA8 O_3 values for the grid cell containing the monitor, rather than the grid cell with the highest MDA8 O_3 value in the base year in a 3 x 3 cell array around the cell containing the monitoring station
2. CAPCOG interpolated modeled MDA8 O_3 values for 2018, 2019, 2021, and 2022 based on the values modeled for 2017, 2020, and 2023
3. CAPCOG used the 4^{th}-highest MDA8 O_3 value modeled in each year as an alternative basis for the RRF calculations

For CAMS 3 and 38, the following tables show:

- the modeled MDA8 O_3 values for each day included in the analysis
- the count of days in each year with O_3 levels of at least 60 ppb
- the 4^{th}-highest MDA8 O_3 for each year
- the average of the MDA8 values for the top 10 days in the baseline when MDA8 O_3 >=60 ppb
- the RRF, calculated two different ways

Table 2-1. CAMS 3 Modeled MDA8 O_3 Levels for 2017, 2020, and 2023 for Selected Days

Date/Statistic	2017	2018	2019	2020	2021	2022	2023
5/17	59.42	58.78	58.13	57.49	57.13	56.77	56.40
5/21	70.74	69.92	69.10	68.28	67.74	67.19	66.65
6/8	60.05	59.18	58.32	57.45	56.92	56.38	55.85
6/9	65.89	65.25	64.62	63.99	63.57	63.16	62.74
6/25	61.52	60.93	60.33	59.73	59.32	58.91	58.50
6/26	71.32	70.30	69.28	68.25	67.55	66.84	66.14
6/27	66.89	66.04	65.19	64.34	63.79	63.24	62.68
8/22	57.54	57.07	56.60	56.13	55.77	55.42	55.06
8/23	61.80	61.09	60.38	59.67	59.14	58.62	58.09
8/30	59.80	59.24	58.68	58.12	57.65	57.18	56.70

Date/Statistic	2017	2018	2019	2020	2021	2022	2023
9/11	58.26	57.97	57.69	57.40	57.21	57.01	56.81
9/12	62.66	62.31	61.96	61.61	61.32	61.03	60.74
9/18	48.95	48.42	47.90	47.38	47.02	46.67	46.32
9/22	58.77	58.16	57.55	56.94	56.64	56.34	56.03
9/23	64.13	63.41	62.68	61.96	61.57	61.17	60.78
Count >=60 ppb	9	8	8	6	6	6	6
4th-High	65.89	65.25	64.62	63.99	63.57	63.16	62.68
Avg. 10 High ≥ 60 ppb in 2017	65.00	64.91	64.19	64.74	64.26	63.77	63.29
RRF Based on 4th-High	1.0000	0.9904	0.9808	0.9712	0.9649	0.9586	0.9514
RRF Based on 10 High ≥ 60 ppb in 2017	1.0000	0.9986	0.9876	0.9960	0.9885	0.9811	0.9737

Table 2-2. CAMS 38 Modeled MDA8 O_3 Levels for 2017, 2020, and 2023 for Selected Days

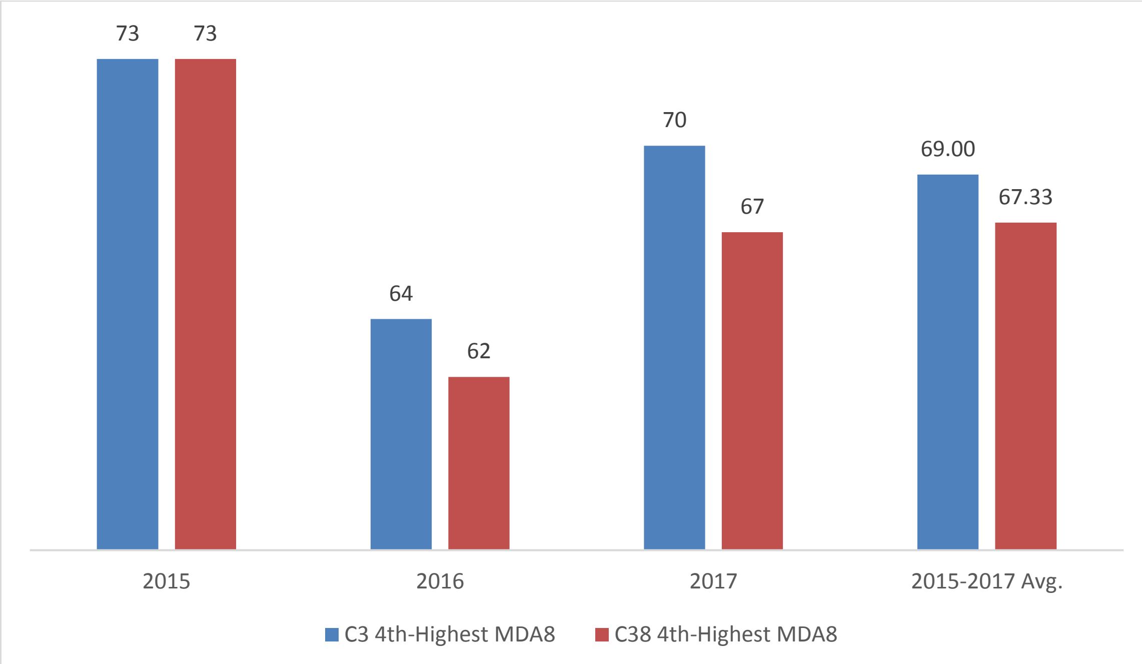
Date/Statistic	2017	2018	2019	2020	2021	2022	2023
5/17	60.21	59.47	58.73	57.99	57.57	57.16	56.75
5/21	70.73	69.90	69.06	68.22	67.67	67.11	66.56
6/8	54.45	53.75	53.06	52.37	51.93	51.50	51.07
6/9	66.83	66.10	65.38	64.66	64.18	63.70	63.22
6/25	60.37	59.80	59.22	58.65	58.28	57.90	57.53
6/26	69.83	68.80	67.76	66.73	66.02	65.31	64.59
6/27	70.53	69.51	68.49	67.47	66.81	66.15	65.49
8/22	57.98	57.51	57.04	56.57	56.23	55.88	55.54
8/23	62.53	61.78	61.03	60.29	59.74	59.20	58.65
8/30	61.51	60.95	60.39	59.83	59.37	58.91	58.44
9/11	59.33	58.97	58.60	58.24	57.99	57.73	57.48
9/12	64.53	64.05	63.56	63.08	62.72	62.35	61.99
9/18	47.15	46.76	46.36	45.97	45.68	45.38	45.09
9/22	57.56	56.90	56.25	55.60	55.26	54.92	54.58
9/23	62.26	61.55	60.84	60.13	59.72	59.32	58.92
Count >=60 ppb	10	8	8	7	5	5	5
4th-High	66.83	66.10	65.38	64.66	64.18	63.70	63.22
Avg. 10 High ≥ 60 ppb in 2017	64.93	65.33	64.56	64.37	65.48	64.92	64.37
RRF Based on 4th-High	1.0000	0.9892	0.9783	0.9675	0.9604	0.9532	0.9461
RRF Based on 10 High ≥ 60 ppb in 2017	1.0000	1.0061	0.9943	0.9913	1.0084	0.9999	0.9913

2.2 Projected 4th-High MDA8 O_3 Levels and Design Values

CAPCOG projected 2018-2023 O_3 levels in terms of high, low, and average projected 4th-highest MDA8 O_3 concentration for each year by multiplying the RRFs for each year to the 2015, 2016, and 2017 4th-

highest MDA8 O_3 levels and the 2015-2017 averages of the 4th-highest MDA8 O_3 levels. The following figure shows the MDA8 O3 levels for each of the base years and the three-year average.

Figure 2-1. 4th-Highest MDA8 O_3 Monitored at C3 and C38, 2015-2017



CAPCOG then applied the relative response factors to each of these statistics in order to generate the projected design value and simulated 4th-highest MDA8 O_3 values for the three years that would be used in the design value calculation for each year.

Figure 2-2. Projected 4th-High MDA8 O_3 for CAMS 3, 2018-2023

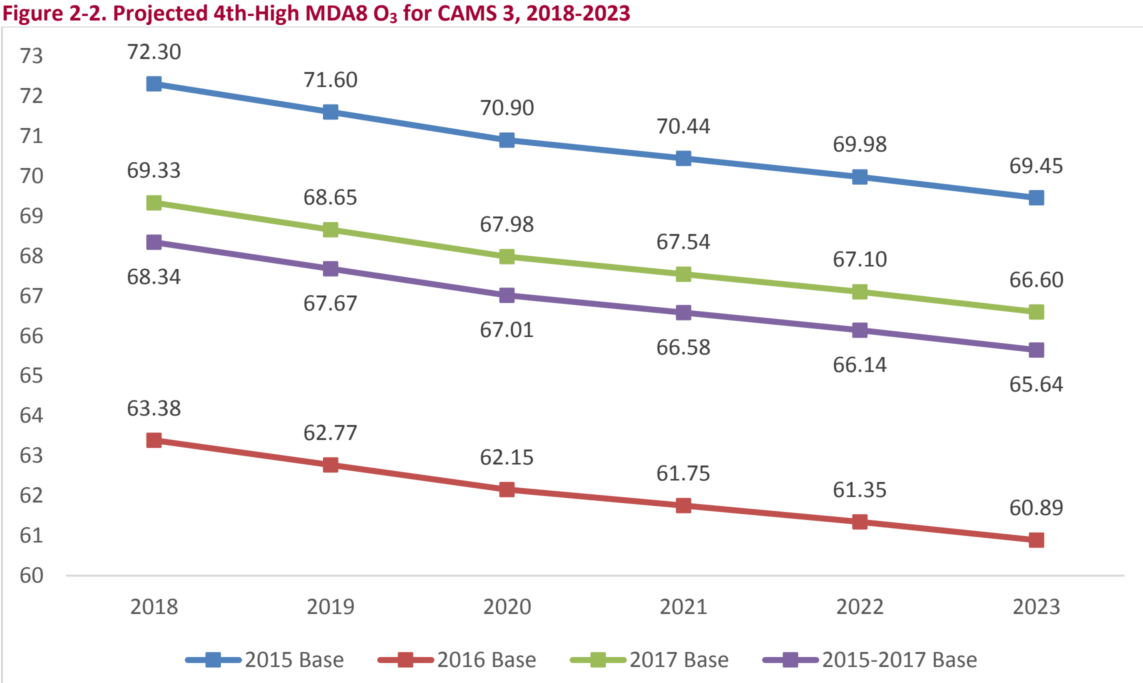
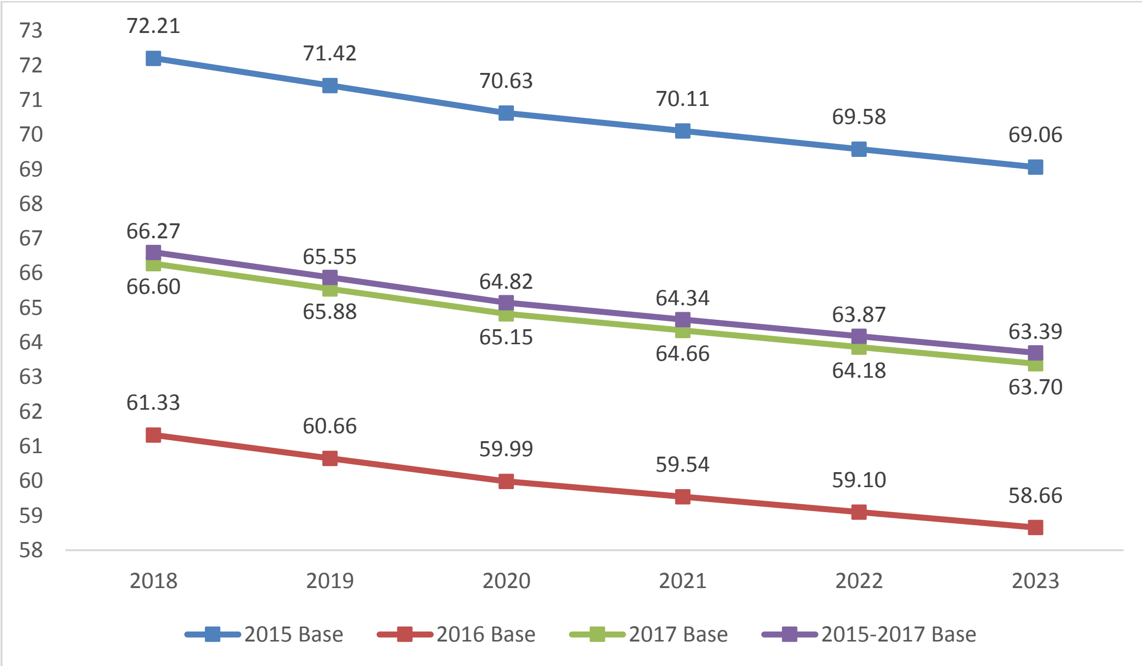


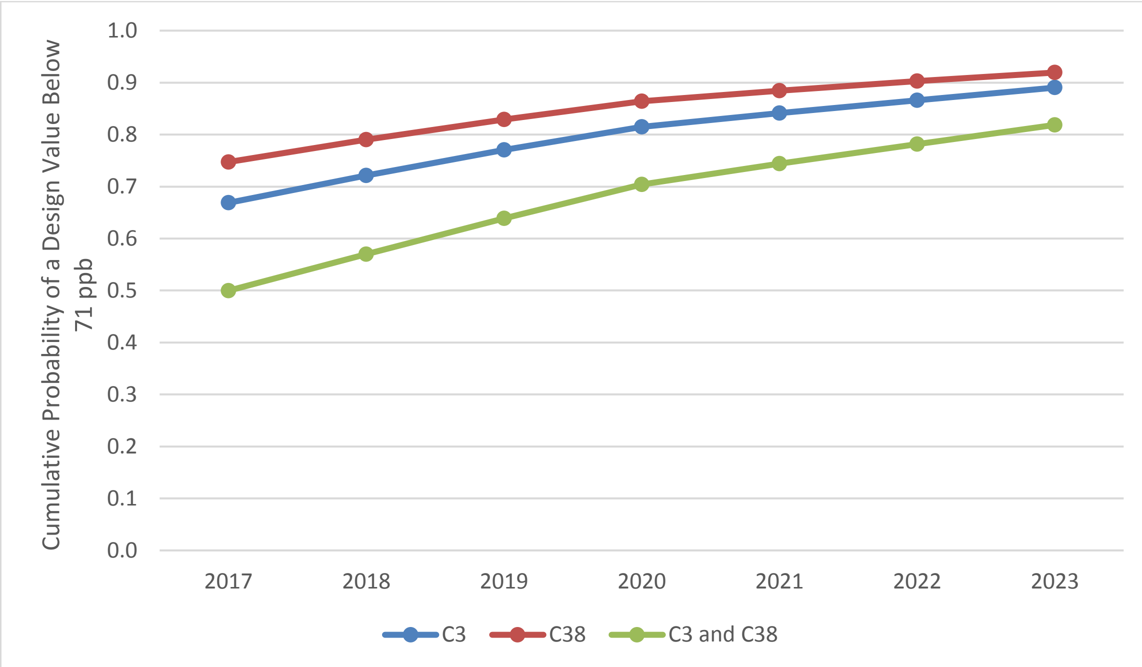
Figure 2-3. Projected 4th-High MDA8 O_3 for CAMS 38, 2018-2023



2.3 Probabilities of Design Values Exceeding the O_3 NAAQS by Year

Using the design value projection and the standard deviation among the projected values from the three bases, CAPCOG calculated the cumulative probabilities that each monitor's design value would be below 71 ppb for each analysis year, and also the joint probability that both monitors would have a design value below 71 ppb. This is shown in the figure below.

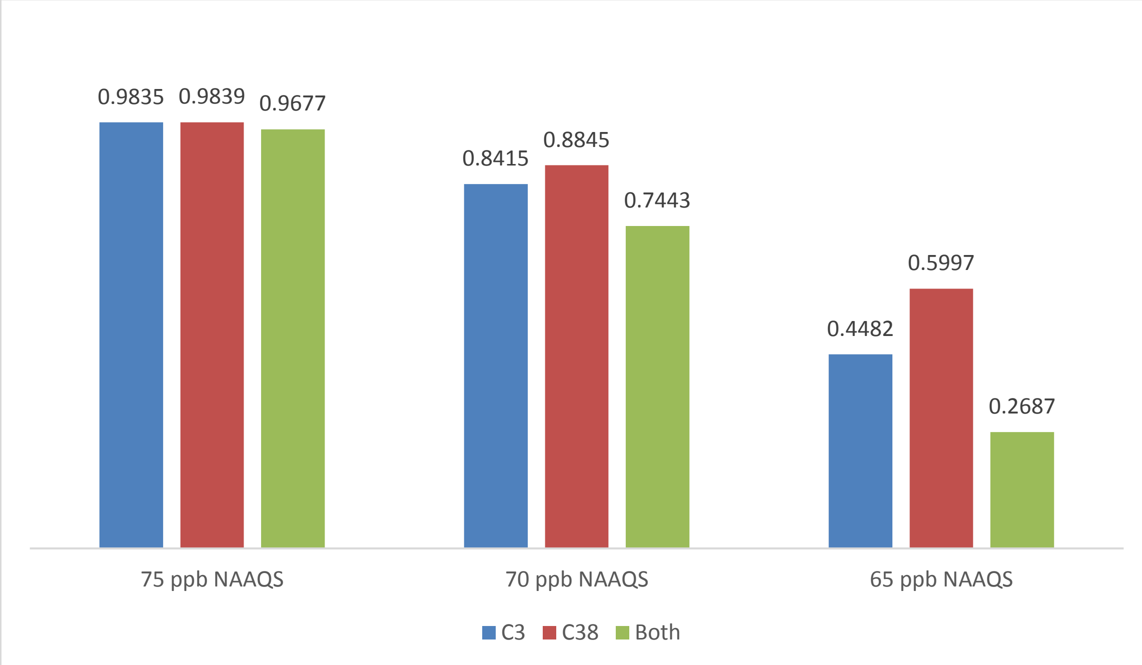
Figure 2-4. Probabilities that C3 and C38 Design Values Will Be Below 71 ppb



Interestingly, the probability that both monitors would have had a design value of less than 71 ppb in 2017 was just below 50%. If EPA completes its next review of the O_3 NAAQS by October 1, 2020, and revises the NAAQS, it would need to complete area designations by October 1, 2022.[2] The following figure shows the probability of the C3, C38, and both monitors attaining a standard set at a level anywhere between 65-75 ppb at the end of the 2021 O_3 season.

[2] Section 107(d)(1)(A) of the Clean Air Act states that, "By such date as the Administrator may reasonably require, but not later than 1 year after promulgation of a new or revised national ambient air quality standard for any pollutant under section 7409 of this title, the Governor of each state shall (and at any other time the Governor of a state deems the appropriate the Governor may) submit to the Administrator a list of all areas in the state, designating as…". Based on this language, if EPA retained an existing NAAQS at the end of a review, it may not necessarily mean that it would conduct a new round of designations.

Figure 2-5. Probabilities of C3 and C38 2021 Design Values Complying with O_3 NAAQS at 65 ppb, 70 ppb, and 75 ppb Levels



Lastly, CAPCOG calculated the change in probability of the area's design value complying with a 65 ppb, 70 ppb, and 75 ppb NAAQS as a result of a change in the design value of 0.5 ppb, 0.7 ppb, and 1.0 ppb.

Table 2-3. Change in Probabilities of Austin-Round Rock MSA Attaining a 65 ppb, 70 ppb, and 75 ppb NAAQS in 2021 from a 0.5 ppb, 0.7 ppb, and 1.0 ppb change in Design Value

Change in Design Value	75 ppb NAAQS	70 ppb NAAQS	65 ppb NAAQS
Minus 1.0 ppb	0.013	0.072	0.092
Minus 0.7 ppb	0.010	0.052	0.063
Minus 0.5 ppb	0.007	0.038	0.045
Plus 0.5 ppb	-0.009	-0.041	-0.041
Plus 0.7 ppb	-0.014	-0.059	-0.057
Plus 1.0 ppb	-0.021	-0.086	-0.079

This analysis shows that:

- A 0.5 ppb change in the area's 2021 design value would be expected to have a 0.007 – 0.045 impact on the probability of attaining an O_3 NAAQS set at these levels
- A 0.7 ppb change in the area's 2021 design value would be expected to have a 0.010 – 0.063 impact on the probability of attaining an O_3 NAAQS set at these levels
- A 1.0 ppb change in the area's 2021 design value would be expected to have a 0.013 – 0.092 impact on the probability of attaining an O_3 NAAQS set at these levels

3 Analysis of Factors Influencing Impact of Precursor Emissions within the MSA on O_3 Formation

This section provides analysis of three factors relevant to the impact of O_3 precursor emissions (NO_X and VOC) on MDA8 O_3 formation within the region. This includes:

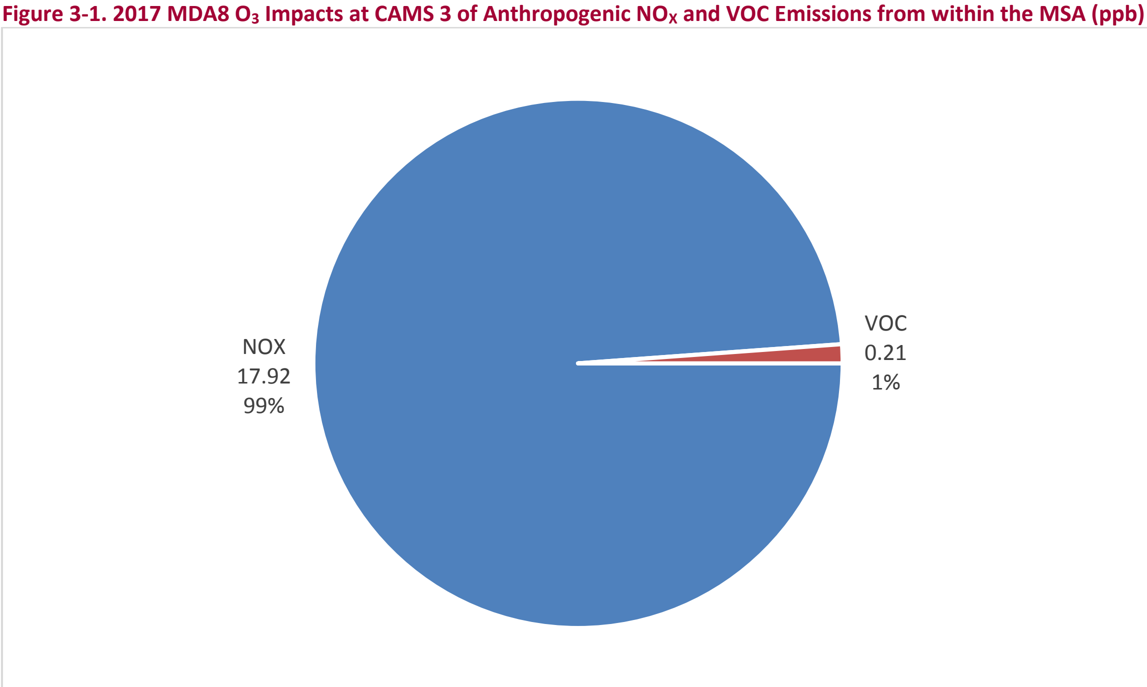
- Type of emissions (NO_X or VOC)
- Location of emissions (by county)
- Timing of emissions (by hour of day)

These analyses can be used to design or enhance the effectiveness of pollution control strategies.

3.1 Type of Emissions: NO_X or VOC

AACOG's 2017 source apportionment modeling for CAPCOG provided the impact of anthropogenic emissions from within the Austin-Round Rock MSA by precursor type. The following chart indicates the impact of anthropogenic NO_X emissions v. anthropogenic VOC emissions from within the MSA.[3]

Figure 3-1. 2017 MDA8 O_3 Impacts at CAMS 3 of Anthropogenic NO_X and VOC Emissions from within the MSA (ppb)



3.2 Location of Emissions: O_3 to NO_X Ratios for Austin-Round Rock MSA Counties

One of the questions posed in the QAPP for this project was: "What additional data can be developed from analyzing the source apportionment modeling data provided by AACOG under Task 6.1 of CAPCOG's Fiscal Year (FY) 2016-2017 work plan that may not have been within scope of the final report provided by CAPCOG to the TCEQ but are still useful for the CAPCOG region's air quality planning efforts?"

[3] http://www.capcog.org/documents/airquality/reports/2017/6.1.2-CAPCOG_Source_Apportionment_Modeling_Report.pdf

CAPCOG obtained from AACOG the NO_X emissions for Bastrop, Caldwell, Hays, Travis, and Williamson Counties used for the 2017 source apportionment modeling project in order to calculate the average contribution of each county's emissions to CAMS 3 and CAMS 38 MDA8 O_3 levels per ton of emissions. These ratios are shown in the figure below.

Figure 3-2. Avg. O_3/NO_X Ratios for Top 10 Modeled Days for 2017 ≥ 60 ppb at CAMS 3

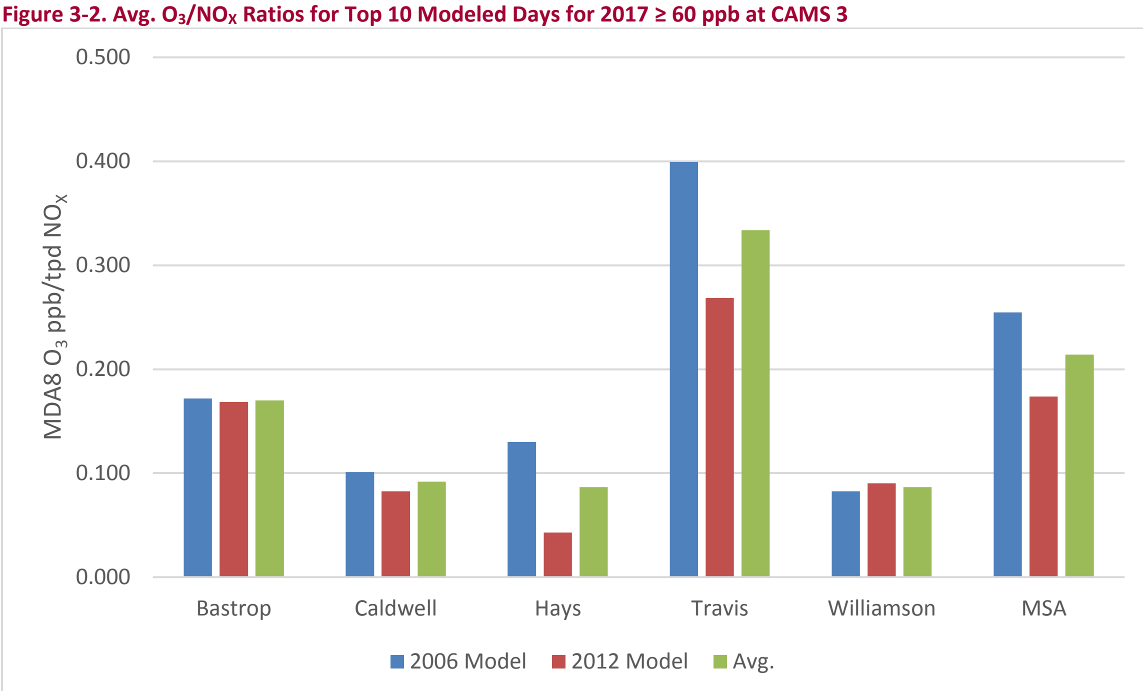
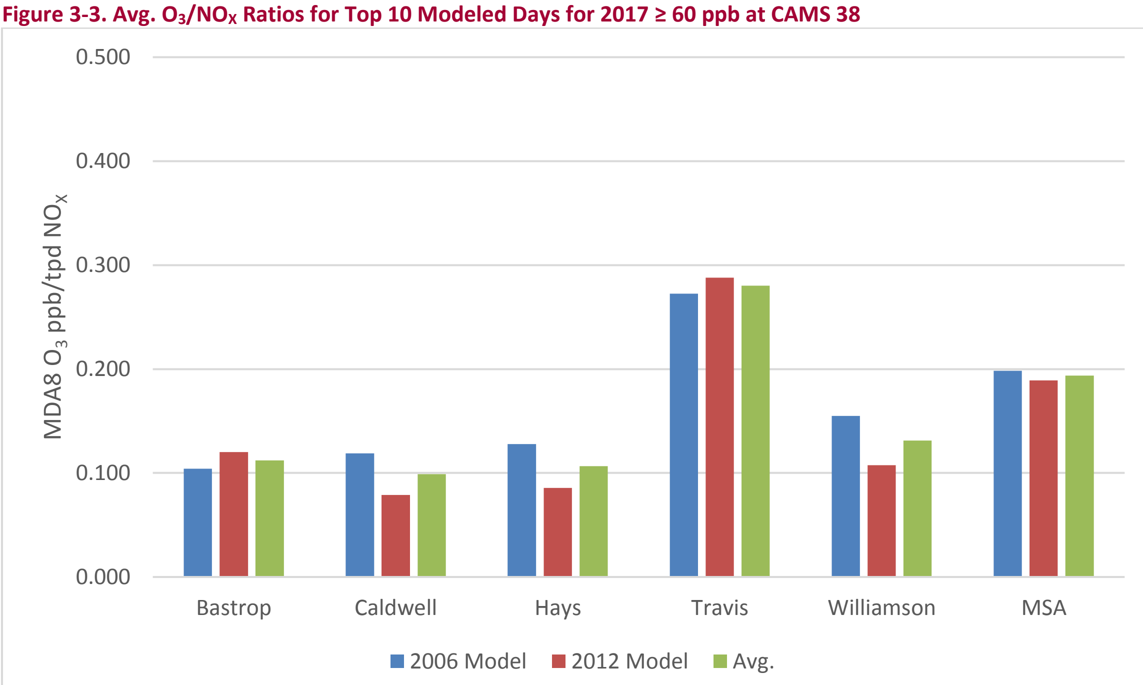


Figure 3-3. Avg. O_3/NO_X Ratios for Top 10 Modeled Days for 2017 ≥ 60 ppb at CAMS 38



These data suggest that the CAMS 3 O_3 design value is 3.1 – 3.3 times more sensitive to NO_X emissions from Travis County than NO_X emissions from the rest of the MSA, and that the CAMS 38 O_3 design value is 2.1 – 2.9 more sensitive to NO_X emissions from Travis County than the rest of the MSA. For both stations, NO_X emissions from Travis County have about 1.4 – 1.6 times the impact as NO_X emissions from the MSA as a whole.

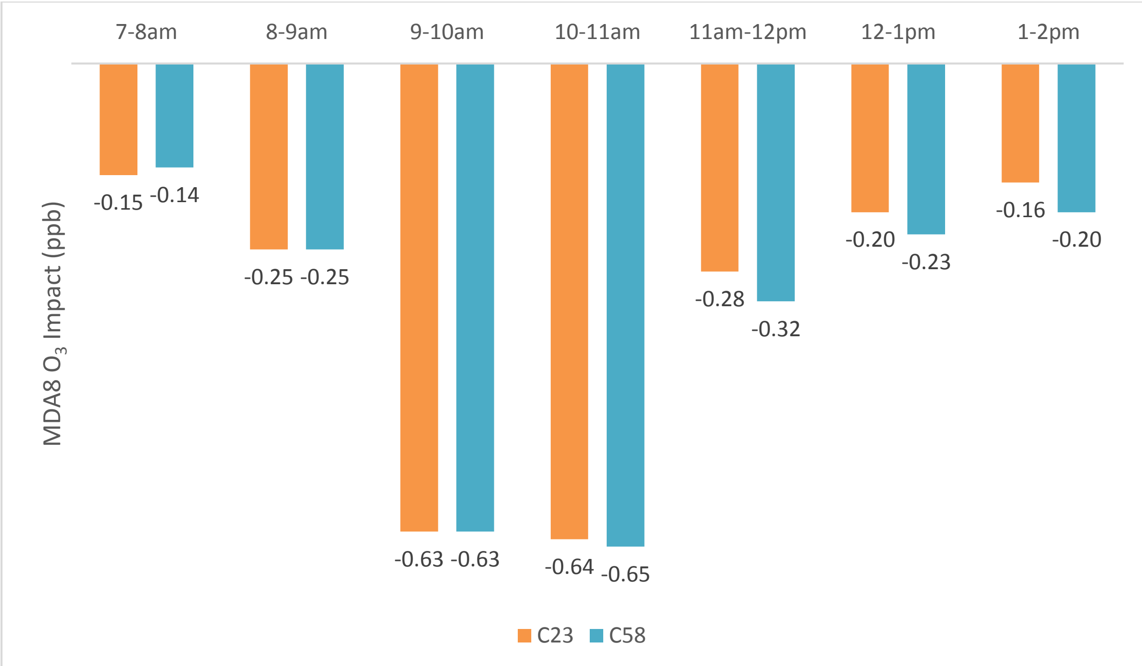
One of the implications of these data is that control strategy analyses that use the cost per ton of NO_X reduced as a point of comparison would benefit from accounting for additional O_3 reduction benefits of NO_X reductions in certain counties compared to others. A cost per ppb of O_3 reduction would be a better point of comparison for these types of projects. For example, one of the projects funded in the Austin area from the last round of Texas Emission Reduction Plan (TERP) Emission Reduction Incentive Grant (ERIG) projects provided $122,500.00 for the replacement of a truck in order to achieve 14.3547 tons of NO_X emissions over 7 years. This project would achieve a cost efficiency ratio of $8,532 per ton of NO_X reduced, and $21,800,341 per ton per day (tpd) of NO_X reductions over the seven-year period. If these emissions reductions were to occur across the MSA, the project would result in a cost efficiency ratio of $113 million per ppb of O_3 reduction at CAMS 38, for instance, but would result in a ratio of $77 million per ppb of O_3 reduction at CMS 38 if the emissions reductions were concentrated in Travis County.

3.3 Timing of Emissions: Hour of Day

One of the other key factors influencing the impact of emissions on MDA8 O_3 levels is the timing of emissions, and in particular, the hour of the day in which emissions are occurring. In 2015, AACOG completed photochemical modeling that involved reductions in one on of on-road NO_X emissions for each hour from 7 am – 2 pm across the San Antonio-New Braunfels MDA on MDA8 O_3 levels at its two "downwind" regulatory O_3 monitors. The following graph illustrates the impact.[4]

[4] http://aacog.com/DocumentCenter/View/34698/Ozone-Analysis-June-2006-Photochemical-Modeling-Episode-Dated-10-2015-PDF-Version---MPO

Figure 3-4. Impact of 1 ton of On-Road NO_X Emission Reductions from San Antonio-New Braunfels MSA on MDA O3 levels at C23 and C58



While the numbers for the Austin-Round Rock MSA would be expected to be somewhat different, the general pattern would be expected to be seen in the relationship between NO_X emissions and O_3 levels in the Austin-Round Rock MSA as well.

4 Estimated Impact of Emission Reduction Strategies Through 2023

One of the key pieces of information for CAPCOG's planning efforts is understanding the impact of various emission reduction strategies within the region. This section provides a synthesis of data produced from several different modeling studies carried out by CAPCOG from 2013 to 2017.

4.1 Across-the-Board Reductions in NO_X and VOC Emissions

In 2012, the University of Texas at Austin (UT) conducted sensitivity modeling for CAPCOG that involved across-the-board reductions in NO_X and VOC emissions from the Austin-Round Rock MSA and modeling the O_3 impact at CAMS 3, CAMS 38, and Travis County as a whole.[5] The following tables summarizes the calculated ratios of CAMS 3 and 38 MDA8 O_3 reductions to reductions in NO_X and VOC from this study for all days with baseline MDA8 O_3 ≥ 60 ppb.

Table 4-1. CAMS 3 Sensitivity to Across-the-Board NO_X and VOC Reductions from June 2006 Model

Scenario	NO_X Ratio (O_3 ppb/tpd NO_X)	VOC Ratio (O_3 ppb/tpd NO_X	NOX/VOC Ratio
25% Reduction from Baseline	0.0615	0.0018	34.2897
50% Reduction from Baseline	0.0700	0.0019	37.7893

[5] http://www.capcog.org/documents/airquality/reports/2013/Task_8.3-Precursor_Response_Runs_Final.pdf

Scenario	NO_X Ratio (O_3 ppb/tpd NO_X)	VOC Ratio (O_3 ppb/tpd NO_X	NOX/VOC Ratio
Reduction to 50% from 25%	0.0786	0.0019	41.0717

Table 4-2. CAMS 3 Sensitivity to Across-the-Board NO_X and VOC Reductions from June 2006 Model

Scenario	NO_X Ratio (O_3 ppb/tpd NO_X)	VOC Ratio (O_3 ppb/tpd NO_X	NOX/VOC Ratio
25% Reduction from Baseline	0.0631	0.0018	58.3332
50% Reduction from Baseline	0.0664	0.0019	58.4878
Reduction to 50% from 25%	0.0696	0.0019	58.6287

4.2 Inspection & Maintenance Program

In 2015, CAPCOG partnered with AACOG to model the impact of the Travis and Williamson County vehicle emissions inspection and maintenance program on 2012 O_3 levels using TCEQ's June 2006 base case photochemical modeling platform.[6] The following table shows the impact of the I/M program on the top 10 days in the 2012 baseline (which already included the I/M emission reductions at CAMS 3 and 38.

Table 4-3. Modeled Impact of I/M Program on Top 10 2012 MDA8 O_3 Levels at CAMS 3 and 38 (reference: baseline)

MDA8 O_3 Day Rank	CAMS 3 Date	CAMS 3 MDA8 O_3 Impact	CAMS 38 Date	CAMS 38 MDA8 O_3 Impact
1	6/13	0.2455	6/29	0.2294
2	6/3	0.3189	6/30	0.1453
3	6/8	0.1848	6/9	0.1552
4	6/29	0.0944	6/8	0.1449
5	6/30	0.0438	6/4	0.0983
6	6/9	0.0622	6/12	0.1292
7	6/4	0.1169	6/28	0.2093
8	6/7	0.2538	6/13	0.0421
9	6/28	0.1432	6/10	0.1024
10	6/12	0.0523	6/3	0.0910
Top 10 MDA8 O_3 ≥ 60 ppb	**n/a**	**0.1626**	**n/a**	**0.1517**

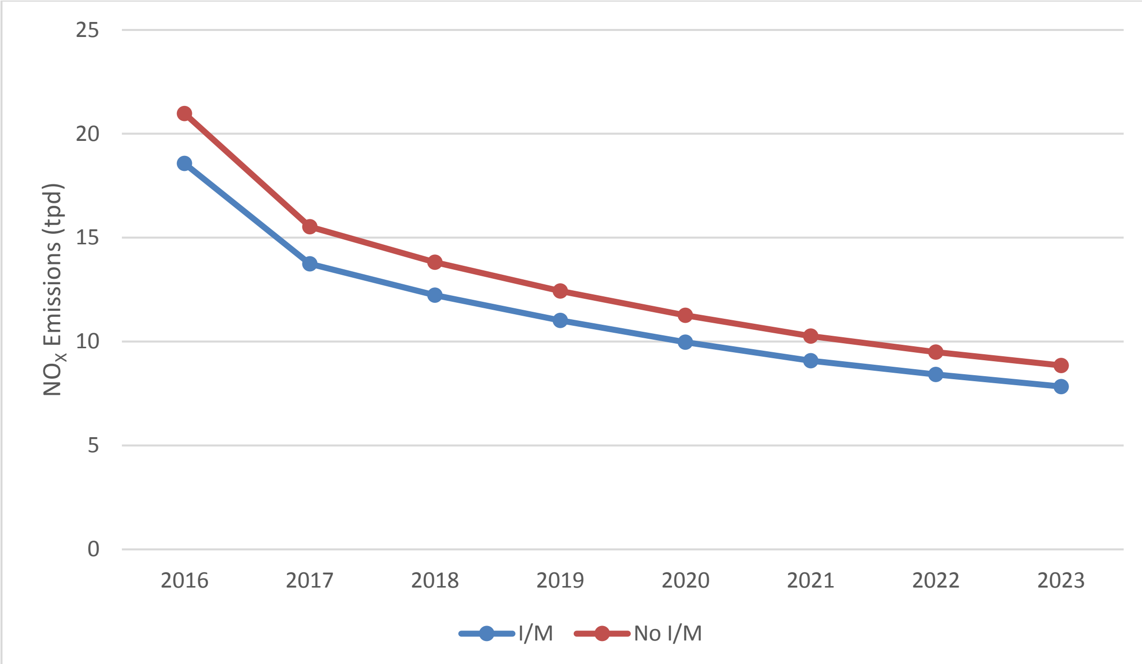
Note: for CAMS 3, the 6/12 and 6/28 dates that are in the top 10 did not have MDA8 ≥ 60 ppb and are therefore not included in the average at the bottom of the table. Similarly, 6/3, 6/10, 6/13, and 6/28 were among the top 10 days in the CAMS 38 base case scenario but had MDA8 O_3 below 60 ppb, and were therefore excluded from the average at the bottom of the table.

In 2015, ERG conducted a study of the emission reduction benefits of the I/M program in Travis and Williamson Counties, which included estimates of the NO_X reduction benefits estimated for 2018. This study modeled a 11.47% reduction in NO_X in 2018 for light-duty gasoline vehicles. CAPCOG used this

[6] http://www.capcog.org/documents/airquality/reports/2015/Photochemical_Modeling_Analysis_Report_2015-09-04_Final_Combined.pdf

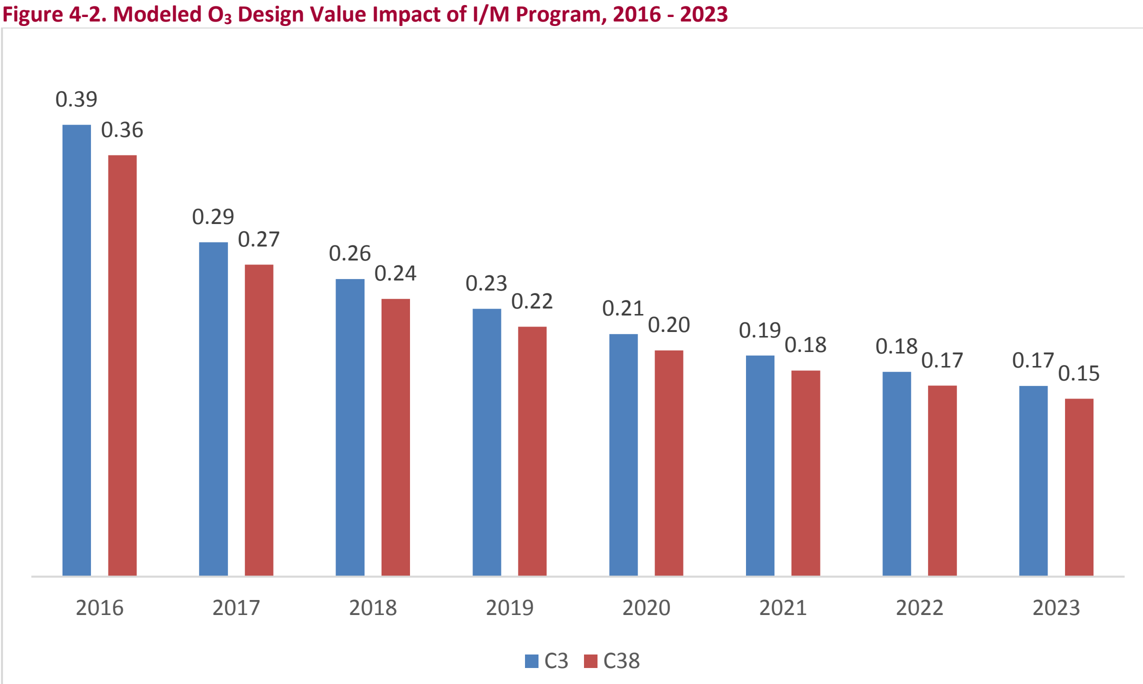
assumption and calculated the NO_X emissions from light-duty vehicles in Travis and Williamson Counties with and without the I/M program from 2016-2023, shown in the figure below.

Figure 4-1. Projected Light-Duty Gasoline Vehicles NO_X Emissions in Travis County with and Without the I/M Program



The overall NO_X reduction benefit shrinks over this period from 2.41 tpd in 2016 to 1.02 tpd in 2023 due to the reduction in emissions attributable to fleet turnover. CAPCOG then calculated the impact of the I/M program on CAMS 3 and 38 for 2016-2023, as shown in the figure below.

Figure 4-2. Modeled O_3 Design Value Impact of I/M Program, 2016 - 2023



CAPCOG cautions that the smaller benefits calculated further out are based on a number of assumptions about the impact of an I/M program (i.e., modeling the benefit of an I/M program based on “reference rates” from data collected on Tier 1 and older vehicles, which may not be an accurate representation of the extent of the relative benefit of an I/M program once standards are much tighter, as they are under the Tier 2 and 3 regimes. For example, if a Tier 1 vehicle certified at 0.4 grams of NO_X per mile had problems with its exhaust system causing it to have a 1.0 gram per mile exhaust rate consistent with the standard for a Tier 0 light-duty vehicle, that increase of 0.6 grams per mile would represent a 15% increase in NO_X emissions for a pool of 10 vehicles all certified to the Tier 1 level. However, if a Tier 2 vehicle certified at a rate of 0.07 grams per mile and was having problems with its exhaust system causing it to have a 1.0 gram per mile exhaust rate, that would represent a 0.93 gram per mile increase, that would mean that a group of 10 Tier 2 vehicles that included that one vehicle would now have an average emissions rate of 0.163 grams per mile, 113% higher than the Tier 2 level. The failure of a pollution control system in a Tier 2-certified or Tier-3 certified vehicle could have a much larger relative impact on the area’s NO_X emissions than the above analysis would represent.

4.3 TERP Grants

In 2017, CAPCOG and AACOG partnered to model the impact of NO_X emission reductions from TERP grants awarded to the Austin-Round Rock MSA on 2012 MDA8 O_3 levels using TCEQ’s June 2012 base case modeling platform.[7] CAPCOG and AACOG modeled the on-road and non –road TERP grant emission reductions separately. Since the 2012 emissions inventory inputs for on-road sources already accounted for the emission reductions from the TERP grants due to the impact on the age distribution input for the MOtor Vehicle Emissions Simulator (MOVES) model, CAPCOG and AACOG modeled what the O_3 levels across the 4 k m x 4 km grid would be if on-road emissions within the Austin-Round Rock MSA in 2012 had not already been reduced through these grants.

The following table shows the MDA8 O_3/NO_X emissions impact ratios for the top 10 days modeled for the baseline at CAMS 3 and 38 (each monitor had more than 10 days with MDA8 $O_3 \geq 60$ ppb during this period).

Table 4-4. MDA8 O_3 Impact - NO_X Emissions Change Impact Ratios for On-Road TERP Grants, 2012

Baseline MDA8 O_3 Rank	CAMS 3 Impact Ratio (ppb O_3/tpd NO_X)	CAMS 38 Impact Ratio (ppb O_3/tpd NO_X)
1	0.1452	0.1266
2	0.0718	0.1302
3	0.0421	0.1021
4	0.0707	0.1969
5	0.0596	0.0911
6	0.1384	0.0702
7	0.0523	0.0413
8	0.0346	0.0827

[7] http://www.capcog.org/documents/airquality/reports/2017/6.3.2a-AACOG_Sensitivity_and_Control_Strategy_Modeling_Report.pdf

Baseline MDA8 O_3 Rank	CAMS 3 Impact Ratio (ppb O_3/tpd NO_X)	CAMS 38 Impact Ratio (ppb O_3/tpd NO_X)
9	0.0452	0.0655
10	0.0378	0.0483
Avg. Top 4 Days	0.0858	0.1339
Avg. Top 10 Days	0.0676	0.0899

For non-road sources, since the age distribution is an intermediate model output in the Texas NONROAD (TexN) model, the TERP emission reductions are not already accounted for in the existing modeling inventories. Therefore, CAPCOG modeled a reduction in NO_X emissions from non-road sources consistent with the emission reductions actually achieved through 2012 from non-road sources in the Austin area. The following table shows the NO_X impact ratios for non-road TERP emission reductions.

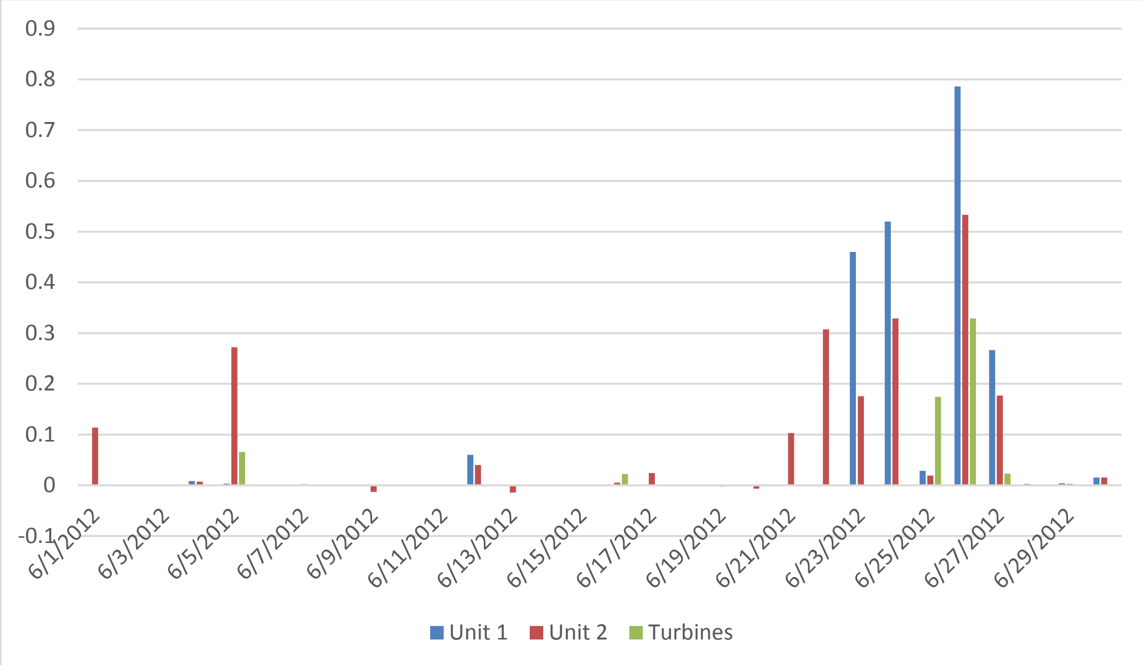
Table 4-5. MDA8 O_3 Impact - NO_X Emissions Change Impact Ratios for Non-Road TERP Grants, 2012

Baseline MDA8 O_3 Rank	CAMS 3 Impact Ratio (ppb O_3/tpd NO_X)	CAMS 38 Impact Ratio (ppb O_3/tpd NO_X)
1	0.0920	0.0784
2	0.0335	0.1310
3	0.0278	0.1049
4	0.0746	0.3892
5	0.0615	0.1440
6	0.2039	0.0369
7	0.0602	0.0451
8	0.0125	0.0467
9	0.0367	0.0353
10	0.0339	0.0582
Avg. Top 4 Days	0.0601	0.1449
Avg. Top 10 Days	0.0562	0.0867

4.4 Reducing NO_X Emissions at Decker Creek Power Plant

In 2017 AACOG conducted photochemical modeling of the impact of zeroing out NO_X emissions at each of the two boiler units and all of the turbines at the Decker Creek Power Plant in June 2012 in order to develop data that could be used for estimated the impact reducing NO_X emissions at this facility, including the possible closure of the two boiler units in 2020 and 2021 as described in Austin Energy's most recent update to their generation plan. The figure below shows the modeled impact of each scenario on MDA8 O_3 values in June 2012.

Figure 4-3. MDA8 O_3 Impacts of Decker Boilers and Turbines on MDA8 O_3 at CAMS 3, June 2012



CAPCOG compared the O_3 impact to each unit's NO_X emissions on the same day, calculating O_3 impact/NO_X emissions ratios for each day, and then also for the days with the top 4 and top 10 MDA8 O_3 values at CAMS 3.

Table 4-6. MDA8 O_3 Impact - NO_X Emissions Change Impact Ratios from Decker Unit 1 NO_X, June 2012

Baseline MDA8 O_3 Rank	CAMS 3 Impact Ratio (ppb O_3/tpd NO_X)	CAMS 38 Impact Ratio (ppb O_3/tpd NO_X)
1	0.2670	0.1324
2	0.0960	0.1008
3	n/a	n/a
4	0.0141	0.1836
5	n/a	0.2072
6	0.3036	-0.0029
7	0.2845	0.0092
8	0.0020	n/a
9	n/a	n/a
10	0.0116	0.0006
Avg. Top 4 Days	0.1650	0.1061
Avg. Top 10 Days	0.1393	0.1317

Table 4-7. MDA8 O_3 Impact - NO_X Emissions Change Impact Ratios from Decker Unit 2 NO_X, June 2012

Baseline MDA8 O_3 Rank	CAMS 3 Impact Ratio (ppb O_3/tpd NO_X)	CAMS 38 Impact Ratio (ppb O_3/tpd NO_X)
1	0.1973	0.1034
2	0.0740	0.0870
3	-0.0209	0.0192
4	0.0117	0.1619
5	0.0013	0.1810
6	0.2353	-0.0013
7	0.1895	0.0092
8	0.0022	0.1501
9	0.0032	0.0112
10	0.1510	0.0052
Avg. Top 4 Days	0.1113	0.0746
Avg. Top 10 Days	0.0972	0.1012

Table 4-8. MDA8 O_3 Impact - NO_X Emissions Change Impact Ratios from Decker Turbine NO_X, June 2012

Baseline MDA8 O_3 Rank	CAMS 3 Impact Ratio (ppb O_3/tpd NO_X)	CAMS 38 Impact Ratio (ppb O_3/tpd NO_X)
1	0.0709	0.0136
2	0.0054	0.0357
3	n/a	n/a
4	0.0399	n/a
5	n/a	n/a
6	n/a	n/a
7	n/a	-0.0002
8	n/a	n/a
9	n/a	n/a
10	n/a	n/a
Avg. Top 4 Days	0.0398	0.0169
Avg. Top 10 Days	0.0397	0.0252

The most recent NO_X emissions data for Decker from 2017 showed the following:

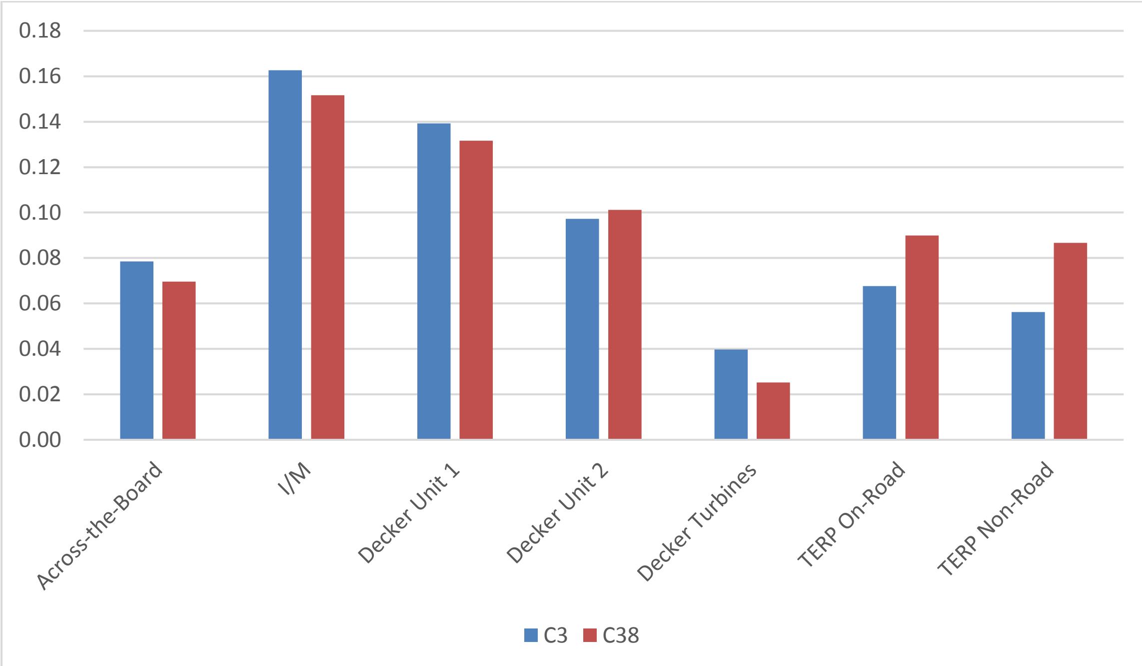
Table 4-9. Decker Creek Power Plant 2017 Ozone Season Day (OSD) NO_X Emissions (tpd)

Days	Unit 1	Unit 2	Turbines	Total
Avg. May 1 – September 30	1.2896	0.5707	0.1548	2.0152
Avg. for Top 4 Days at CAMS 3	1.8030	0.4334	0.1232	2.3597
Avg. for Top 4 Days at CAMS 38	0.5435	0.0000	0.0717	0.6222

4.5 Comparison of Impact Ratios

The following graph summarizes the impact ratios for each of the sensitivity or control strategy analyses detailed above.

Figure 4-4. Comparison of the MDA8 O_3 Impact of NO_X Reductions at CAMS 3 and 38 (ppb O_3/tpd NO_X)



5 Implications of Other Recent Regional Developments on Ozone

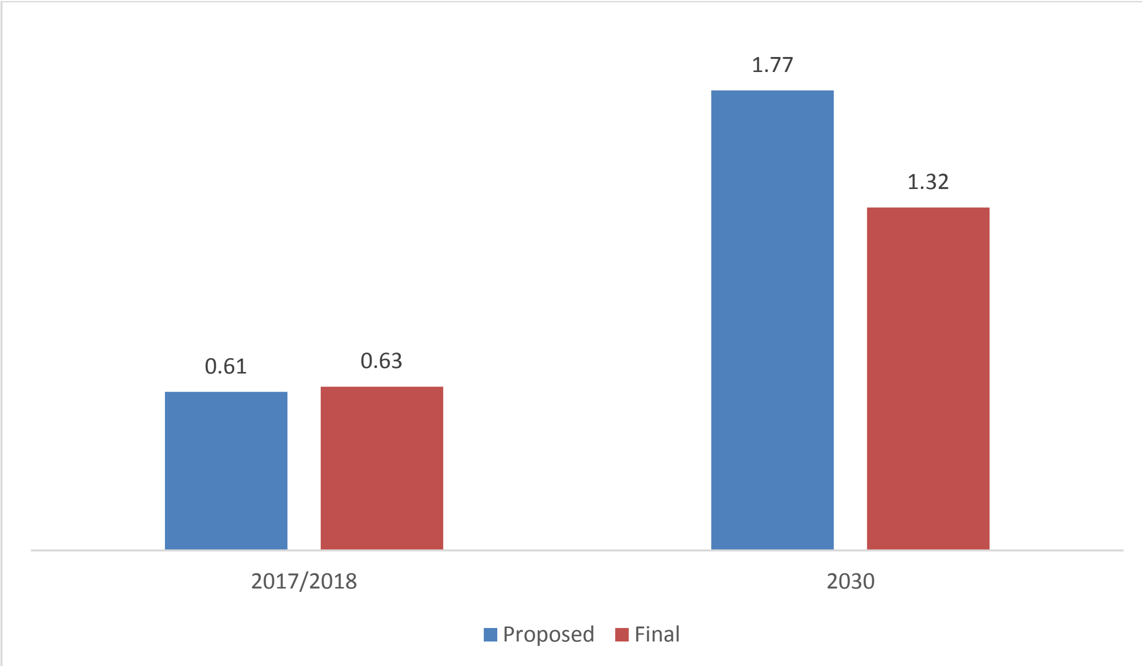
5.1 Gasoline Sulfur Reductions

One of the key factors in reductions in NO_X emissions modeled for the Austin-Round Rock MSA starting in 2017 is the reduction in gasoline sulfur content as a result of EPA's Tier 3 standards for gasoline and light-duty vehicles. This regulation reduced the maximum allowable gasoline fuel sulfur content at the refinery gate from 30 ppm to 10 ppm, which enables a higher degree of NO_X reductions from pollution control equipment on light-duty vehicles, while allowing for downstream sulfur content of up to 95 ppm.

As documented in the modeling for the final rule[8] and proposed rule (each of which used different base cases), the Tier 3 standards are modeled to have had an impact of 0.61 – 0.63 ppb for 2017/2018, and raising to 1.32 – 1.77 ppb for 2030.

[8] http://nepis.epa.gov/Exe/ZyPDF.cgi/P100HX23.PDF?Dockey=P100HX23.PDF

Figure 5-1. O_3 Reduction Benefit of Tier 3 Fuel and Vehicle Standards, 2017/2018 and 2030



EPA's emissions modeling technical support document indicated the on-road MOVES emissions inputs that varied by scenario.[9] The table below summarizes these inputs.

Table 5-1. Emissions Inputs for Final Tier 3 Vehicle Standards

Input	Reference Scenarios	Control Scenarios
Fuel Sulfur Level (ppm)	30 ppm	10 ppm
% of Tier 2 and Older Vehicles, 2018	96%	86%
% of Tier 2 and Older Vehicles, 2030	76%	21%

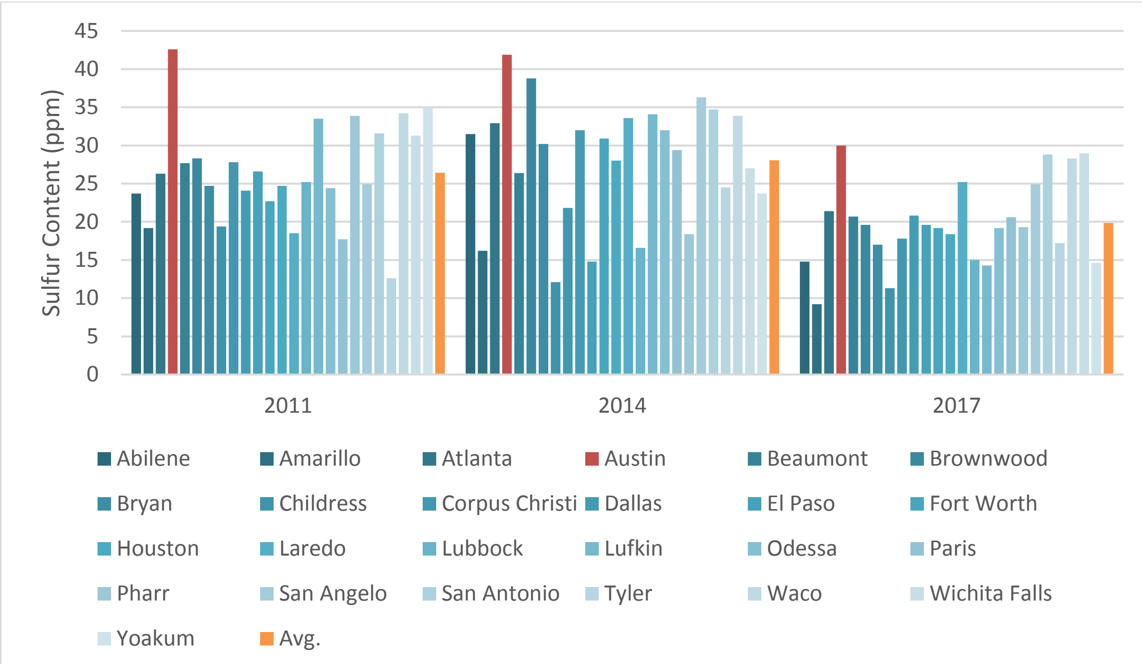
These rules were finalized and published in the Federal Register on April 28, 2014. TCEQ's "Trends" Emissions Inventories for 1999-2050, developed in August 2015, used the MOVES2014 model and it assumed a 10 ppm gasoline sulfur level for 2017 and thereafter, consistent with the maximum allowable concentration at the refinery gate.[10]

CAPCOG's review of TCEQ's 2017 fuel sampling data for the region showed that the average gasoline sulfur levels for the region are actually 30 ppm, rather than the 10 ppm modeled by EPA, making it again the highest in the state, while the state-wide average was also almost double the 10 ppm level modeled by EPA and Texas Transportation Institute (TTI).[11] The statewide average was also 19.85 ppm,

[9] http://nepis.epa.gov/Exe/ZyPDF.cgi/P100HX5N.PDF?Dockey=P100HX5N.PDF
[10] ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/mvs14_trends/reports/mvs14_trends_final_report_aug_2015.pdf
[11] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582177149010-20170831-ergi-2017SummerFuelFieldStuday.pdf

considerably higher than the 10 ppm level modeled by EPA and TTI. The Austin area's sulfur levels were also the highest in the state in the 2011[12] and 2014[13] fuel sampling studies.

Figure 5-2. TxDOT Region Gasoline Sulfur Properties in 2011, 2014, and 2017 Fuel Sampling Studies



The Austin district's average gasoline sulfur levels have been the highest in the state and 50-61% higher than the state average in all of these studies.

The main implication of the 2017 fuel sampling data is that the state and the Austin area in particular did not receive the full emission reduction benefit of the Tier 3 standards adopted by EPA that had been modeled for the first year of the implementation of these standards. While the downstream levels are in compliance with the downstream caps, the higher-than-expected sulfur content in the area's and state's gasoline means that the expected NO_X reductions that will occur between 2017 and 2023 may not be as large as has previously believed.

Notably – all fuel sampled within the Austin District was as low as 10 ppm. The following table shows a summary of the samples collected within the region.

Table 5-2. 2017 Gasoline Sulfur Content Sampled in the Austin District (ppm)

Station	City	County	Regular	Medium	Premium
1625 E. Parmer Ln.	Austin	Travis	36	26	17
7200 N IH 35	Austin	Travis	35	29	19
528 W Main St.	Fredericksburg	Gillespie	25	21	13
5511 Cameron Rd.	Austin	Travis	35	26	20

[12] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/5821199776FY1103-20110831-ergi-summer_2011_fuels.pdf

[13] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/5821199776FY1420-20140815-ergi-summer_2014_fuels.pdf

Station	City	County	Regular	Medium	Premium
2501 S. Water St.	Burnet	Burnet	26	22	15
Avg.	**Avg.**	**n/a**	**31.4**	**24.8**	**16.8**

Using just the samples collected in the City of Austin and the same 2015 fuel market share data used by Eastern Research Group (ERG) for the 2017 study, there's an even higher gasoline sulfur average of 33.7 ppm. Using the 2017 gasoline fuel market share now available from the Energy Information Administration (86.10% regular, 6.42% medium, 7.48% premium),[14] the City of Austin average would be 33.6 ppm (compared to 29.89 ppm for the weighted average for all five stations in the district). Without additional modeling, it's not clear exactly what the impact of this elevated sulfur level is having on emissions or regional O_3 levels. A TTI sensitivity analysis for the MOVES2010 model did include an analysis of the difference in NO_X emissions for Tier 2 and earlier gasoline vehicle NO_X emissions for 2008 – 2030, including at the 30 ppm and 10 ppm levels.[15] CAPCOG conducted an analysis of the potential impact of the elevated gasoline sulfur levels sampled in the 2014 study as part of a report to TCEQ in 2015. A modified version of the table presented in that report is reproduced below for 2017-2023.

Table 5-3. NOX Emissions for Tier 2 and Older Gasoline Vehicles from TTI MOVES 2010 Sensitivity Analysis, 2016-2023

Year	30 ppm	10 ppm	Difference	% Difference
2016	193,177	191,363	-1,814	-0.94%
2017	184,229	182,437	-1,792	-0.97%
2018	175,281	173,512	-1,769	-1.01%
2019	166,333	164,586	-1,747	-1.05%
2020	157,385	155,660	-1,725	-1.10%
2021	148,437	146,735	-1,702	-1.15%
2022	139,489	137,809	-1,680	-1.20%
2023	130,541	128,884	-1,657	-1.27%
Change 2017-2023	-62,636	-62,479	157	-0.25%
% Change 2017-2023	-34.00%	-34.25%	0.25%	0.73%

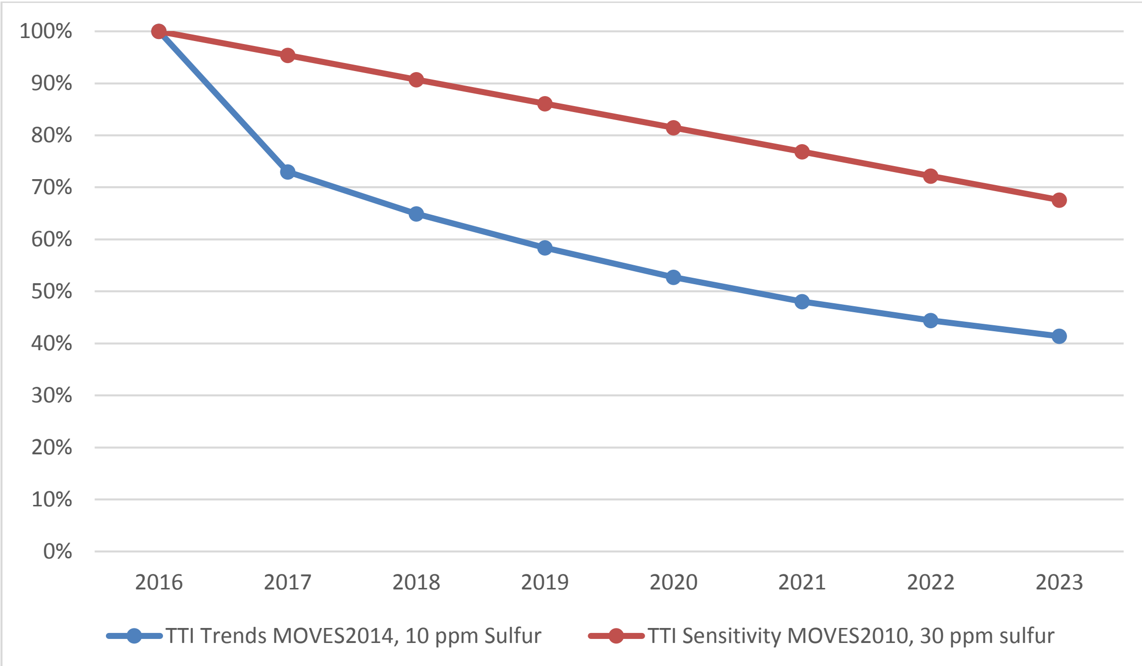
Based on the dependency of the Tier 3 vehicle standards on 10 ppm gasoline sulfur level, we can assume that the 34.00% reduction in NO_X emissions between 2016 and 2023 for the 30 ppm scenario above represents the most that can be achieved from gasoline vehicles due to fleet turnover during this time frame if the 30 ppm average in the Austin area persisted through 2023. This effectively would mean that whatever extra emission reductions that could be achieved from pollution control equipment on Tier 3 vehicles not achievable from Tier 2 vehicles would be negated, leaving their emission rates as comparable to new Tier 2 vehicles. This reduction in emissions can then be compared to the difference in emissions from the most recently modeled "Trends" emissions reductions produced by TTI using the MOVES2014 model and incorporating the Tier 3 standards. Using Travis County as a reference point, the TTI MOVES2014 "Trends" inventory estimates a 58% in NO_X emissions from gasoline-powered vehicles

[14] https://www.eia.gov/dnav/pet/pet_cons_refmg_d_STX_VTR_mgalpd_a.htm

[15] This report is no longer posted on TCEQ's FTP server – a PDF copy will be needed to fully cite.

between 2016 and 2023. The following figure compares the projected reductions from a 2016 base year based on the 30 ppm scenario described above and a 10 ppm sulfur level for Travis County.

Figure 5-3. Comparison of NO_X Emissions for Gasoline Vehicles Relative to 2016 based on 10 ppm and 30 ppm Gasoline Sulfur Scenarios



This analysis suggests that the on-road NO_X emissions in the Austin area in 2017 may have been as much as 31% higher than TTI's MOVES 2014 trends inventory suggests, and that the relative difference grows such that by 2023, actual on-road NO_X emissions in the area may be more than 63% higher than what TTI's Trends Inventory suggests. This also suggests that the projected O_3 levels modeled by AACOG using some of these projections by TTI may overshoot the magnitude of O_3 reduction that that would be expected within the Austin area between 2017 and 2023, leaving a higher risk of potential violation of the NAAQS within that timeframe without any additional emission reductions.

The uncertainty regarding the magnitude of NO_X reductions expected from fleet turnover between 2017 and 2023 also reinforces the need for the I/M program in order to minimize emissions from gasoline-powered vehicles. To the extent that elevated sulfur content remains high through 2023, the absolute emission reductions from the I/M program will be higher than what would be expected based on TTI's "Trends" inventory and application of the NOX reduction ratio for 2018 based on ERG's 2015 study.

5.2 Shut-Down of Three Coal-Fired Power Plants in 2018

In late 2017, Luminant announced the closure of three large coal-fired power plants (Big Brown, Monticello, and Sandow), including one (Sandow) that is located quite close to the Austin-Round MSA. These three base-load plants collectively accounted for 27,578,352 MW-hours of electricity generated in 2017 and 16,486.31 tons of NO_X emissions in 2017. The closure of these plants will shift the electricity load to other plants across the state, with the average increase across all plants of 9.1% for the year and an 8.7% increase from May - September. This makes an analysis of the impact of these closures more complicated than simply estimating the O_3 reduction attributable to the reduction in emissions from these three plants. The average NO_X rate of these three plants – 1.19 lbs NO_X/MW-hr, is substantially higher than the average for the remaining fossil-fueled plants in the state – 0.62 lbs NO_X/MW-hr, which suggests that there would be a net reduction in NO_X emissions overall. However, this type of an analysis ignores the extent to which the shift in load may be uneven across the state. If baseload plants don't have much of an ability to increase output, more of the load will shift to peaker plants, which tend to have even higher NO_X emissions rates than some of these older coal plants (all of the Decker and Sim Gideon units had higher NO_X emissions rates in 2017 than all of the units that are being shut down).

Assuming that the load was spread evenly across all fossil fuel plants in Texas, the following table summarizes the emissions impact and net MDA8 O_3 impact of the changes at Sandow and the power plants within the area based on UT's prior point source modeling and – for Decker- the most recent AACOG modeling.

Table 5-4. Simulated Impact of Luminant Plant Closures on Regional Power Plant O3 Season NO_X Emissions Assuming Uniform Reallocation of Load and 2017 O_3 Season Emissions Data

Plant & Unit	OSD NO_X Change (tpd)	MDA8 O_3 Sensitivity (ppd O_3/tpd NO_X)	Estimated MDA8 O_3 Change (ppb)
Sandow 4, 5A and 5B	-9.3627	0.0441	-0.4129
Bastrop Clean Energy Center	+0.0557	0.1348	0.0075
Lost Pines	+0.0456	0.0328	0.0015
Sim Gideon	+0.1623	0.0419	0.0068
Hays Energy Facility	+0.0476	0.0405	0.0019
Decker Unit 1	+0.1128	0.1650	0.0186
Decker Unit 2	+0.0499	0.1113	0.0056
Decker Turbines	+0.0135	0.0397	0.0005
Sand Hill	+0.0179	0.1673	0.0030
Fayette Power Project	+1.7456	0.0030	0.0052
Net	**-7.1118**	**0.0509**	**-0.3622**

6 Conclusions

This report included a number of secondary analyses of existing photochemical modeling data in order to improve the understanding of ground-level O3 formation within the region. Broadly, what these analyses indicated were:

1. While the Austin-Round Rock MSA is currently attaining the 2015 O_3 NAAQS through the end of the 2017 O_3 season and is highly likely to remain in attainment of the NAAQS through the end of the 2018 O_3 season, there are still significant risks of the region violating the NAAQS at some point within the 2019 – 2023 time frame, with the probability dropping from 36% for the 2017-2019 O_3 DV to 18% for the 2021-2023 DV.

2. There is a 26% chance that the region's 2019-2021 DV, which will likely be used for the next round of O_3 NAAQS designations, would exceed the current 70 ppb NAAQS, and a 73% chance that it would exceed a more stringent 65 ppb NAAQS.
3. Approximately 99% of the impact of anthropogenic emissions from within the Austin-Round Rock MSA on MDA8 O_3 levels in the region is attributable to emissions of nitrogen oxides (NO_X), and only approximately 1% is attributable to emissions of volatile organic compounds (VOC)
4. A tpd of NO_X emissions from Travis County has approximately 2-4 times the impact of NO_X emissions from the other four counties in the MSA
5. A ton of NO_X emissions that occurs between 9 am and 11 am has 2.5 – 4.6 times the impact of a ton of NO_X emissions between 7 am – 9 am or 11 am – 2 pm.
6. The I/M program and NO_X reductions from Decker units 1 and 2 have a higher MDA8 O3 impact per ton of NO_X reduced than an across-the-board reduction in NOX emissions from within the Austin-Round Rock MSA, whereas NO_X emissions from Decker's turbines has a much lower impact per ton of NO_X reduced.
7. NO_X emissions reductions from the TERP program have a somewhat higher-than-average impact on MDA8 O_3 formation at CAMS 3 and a somewhat lower-than-average impact on MDA8 O_3 formation at CAMS 3.
8. Closure of Decker Unit 1 no later than the beginning of the 2021 O_3 season, as envisioned in Austin Energy's most recent generation plan will be important to the region's ability to minimize the chances of violating the NAAQS.
9. The higher than expected gasoline sulfur levels raise questions about the pace of projected O3 reductions in the Austin-Round Rock MSA and highlight the need for maintaining the I/M program in order to control on-road NO_X emissions.
10. The recent closure of several coal-fired power plants across the state is expected to have a positive impact on O_3 levels within the Austin-Round Rock MSA, even with the shift of that load towards plants within the MSA.

Appendix

Table A-1. 2017 NO_X Emissions by County and Day Type Used in Source Apportionment Modeling Project (tpd)

County	Mon. – Thu.	Fri.	Sat.	Sun.	Avg.
Bastrop	7.819	7.915	6.420	6.099	7.387
Caldwell	4.554	4.608	3.773	3.605	4.315
Hays	14.871	15.044	13.210	12.520	14.323
Travis	36.244	37.160	28.443	25.629	33.744
Williamson	12.045	12.400	7.430	6.384	10.628
TOTAL	**75.533**	**77.128**	**59.276**	**54.237**	**70.396**

Table A-2. Modeled Impact of Anthropogenic NO_X on Top 10 MDA8 O_3 ≥ 60 ppb at CAMS 3 (ppb)

County	2006 Model	2012 Model	Avg.
Bastrop	1.2688	1.2443	1.2566
Caldwell	0.4359	0.3569	0.3964
Hays	1.8628	0.6155	1.2392
Travis	13.4734	9.0556	11.2645
Williamson	0.8767	0.9611	0.9189
TOTAL	**17.9176**	**12.2335**	**15.0755**

Table A-3. Modeled Impact of Anthropogenic NO_X on Top 10 MDA8 O_3 ≥ 60 ppb at CAMS 3 (ppb)

County	2006 Model	2012 Model	Avg.
Bastrop	0.7704	0.8870	0.8287
Caldwell	0.5133	0.3406	0.4270
Hays	1.8304	1.2259	1.5282
Travis	9.1978	9.7190	9.4584
Williamson	1.6476	1.1428	1.3952
TOTAL	**13.9596**	**13.3153**	**13.6375**