Dallas-Fort Worth MOVES2014a-Based Reasonable Further Progress On-Road Inventories and Control Strategy Reductions for 2011, 2017, 2018, 2020, and 2021

Collin | Dallas | Denton | Ellis | Johnson
Kaufman | Parker | Rockwall | Tarrant | Wise

August 2018

North Central Texas
Council of Governments

What is NCTCOG?

The North Central Texas Council of Governments is a voluntary association of cities, counties, school districts, and special districts which was established in January 1966 to assist local governments in **planning** for common needs, **cooperating** for mutual benefit, and **coordinating** for sound regional development.

It serves a 16-county metropolitan region centered around the two urban centers of Dallas and Fort Worth. Currently the Council has **236 members**, including 16 counties, 168 cities, 24 independent school districts, and 28 special districts. The area of the region is approximately **12,800 square miles**, which is larger than nine states, and the population of the region is about **7 million** which is larger than 38 states.

NCTCOG's structure is relatively simple; each member government appoints a voting representative from the governing body. These voting representatives make up the **General Assembly** which annually elects a 17-member Executive Board. The **Executive Board** is supported by policy development, technical advisory, and study committees, as well as a professional staff of 350.

NCTCOG's offices are located in Arlington in the Centerpoint Two Building at 616 Six Flags Drive (approximately one-half mile south of the main entrance to Six Flags Over Texas).

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NCTCOG's Department of Transportation

Since 1974 NCTCOG has served as the Metropolitan Planning Organization (MPO) for transportation for the Dallas-Fort Worth area. NCTCOG's Department of Transportation is responsible for the regional planning process for all modes of transportation. The department provides technical support and staff assistance to the Regional Transportation Council and its technical committees, which compose the MPO policy-making structure. In addition, the department provides technical assistance to the local governments of North Central Texas in planning, coordinating, and implementing transportation decisions.

Prepared in cooperation with the Texas Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration, and Federal Transit Administration.

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ABSTRACT

TITLE:	Dallas-Fort Worth Motor Vehicle Emissions Simulator 2014a (MOVES2014a) – Based Reasonable Further Progress On-Road Inventories and Control Strategy Reductions for 2011, 2017, 2018, 2020, and 2021
DATE:	August 2018
AUTHORS:	Chris Klaus Senior Program Manager Jenny Narvaez Principal Air Quality Planner Jody Loza Senior Air Quality Planner Vivek Thimmavajjhala Transportation System Modeler II
SUBJECT:	Reasonable Further Progress
SOURCES OF COPIES:	Transportation Department North Central Texas Council of Governments PO Box 5888 Arlington, Texas 76005-5888 (817) 695-9240
NUMBER OF PAGES:	53
ABSTRACT:	The North Central Texas Council of Governments conducted a Reasonable Further Progress on-road mobile emissions inventories to support the Texas Commission on Environmental Quality to develop the Reasonable Further Progress State Implementation Plan for the Dallas-Fort Worth 10-county nonattainment area for the pollutant ozone. The 10 nonattainment counties are Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise. This report documents the on-road mobile methodologies applied and estimated emission results for analysis years 2011, 2017,

2018, 2020, and 2021. The estimated emissions are reported for oxides of nitrogen, volatile organic compounds, carbon monoxide, carbon dioxide, sulfur dioxide, ammonia, particulate matter with aerodynamic diameters equal to or less than 2.5 microns, and particulate matter with aerodynamic diameters equal to or less than 10 microns.

ACKNOWLEDGEMENTS

The North Central Texas Council of Governments would like to thank the following individuals for their invaluable assistance in preparing this report.

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Berrien Barks	Principal Transportation Planner
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Chris Kite	Texas Commission on Environmental Quality
Mary McGarry-Barber	Texas Commission on Environmental Quality
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GLOSSARY OF ABBREVIATIONS

ABY	Adjusted Base Year
ASM	Acceleration Simulation Mode
ASWT	Average School Season Weekday
ATR	Automatic Traffic Recorder
CAAA	Clean Air Act Amendments
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DFW	Dallas-Fort Worth
DFX	Dallas-Fort Worth Travel Model for the Expanded Area
EPA	Environmental Protection Agency
GISDK	Geographic Information System Developer Kit
HBW	Home-Based Work
HNW	Home-Based Non-Work
HOV	High Occupancy Vehicle
HPMS	Highway Performance Monitoring System
I/M	Inspection & Maintenance Program
LED	Low Emission Diesel
MPA	Metropolitan Planning Area
MPO	Metropolitan Planning Organization
MOVES2014a	Motor Vehicle Emissions Simulator 2014a
NAAQS	National Ambient Air Quality Standards
NCT	North Central Texas
NCTCOG	North Central Texas Council of Governments
NH_3	Ammonia
NHB	Non-Home Based
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen
NPMRDS	National Performance Management Research Data Set
NSWD	Non-Summer Week Day
O_3	Ozone
OBD	On-board Diagnostic Systems
Pb	Lead
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter 2.5 Microns
PM_{10}	Particulate Matter 10 Microns
ppb	parts per billion
RFG	Reformulated Gasoline
RFP	Reasonable Further Progress
RPM	Revolutions Per Minute
SHI	Source Hours Idling
SHP	Source Hours Parked
SHO	Source Hours Operating
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
SUT	Source Use Types
TCEQ	Texas Commission on Environmental Quality
TOD	Time-of-Day
TSZ	Traffic Survey Zone
TTI	Texas Transportation Institute
TxDMV	Texas Department of Motor Vehicles
TxDOT	Texas Department of Transportation
TxLED	Texas Low Emissions Diesel
VDF	Volume Delay Function
VHT	Vehicle Hours of Travel
VMT	Vehicle Miles of Travel
VOC	Volatile Organic Compounds

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TABLE OF EXHIBITS

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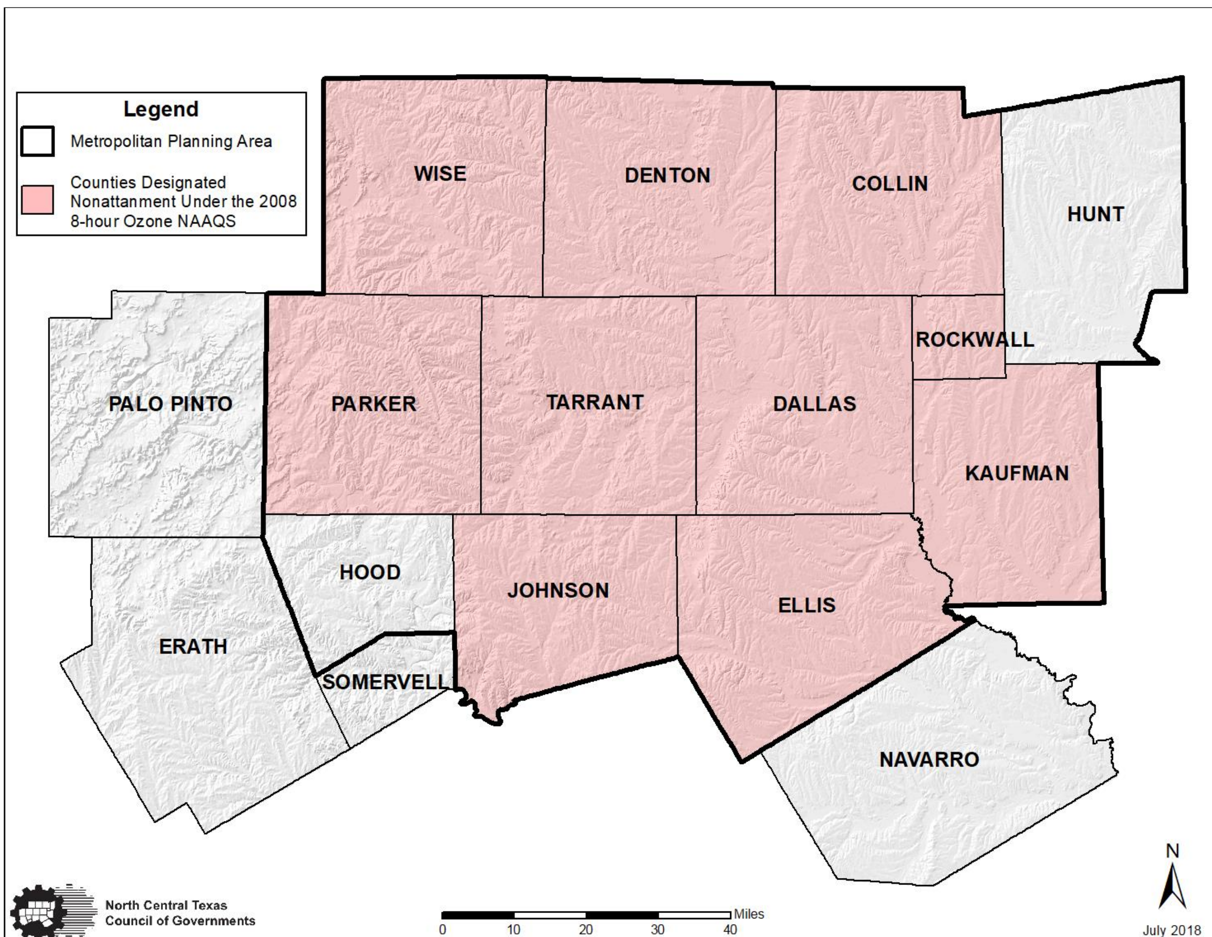
CHAPTER 1: INTRODUCTION

The North Central Texas Council of Governments (NCTCOG) ~~conducted~~ developed emissions inventories to support the Texas Commission on Environmental Quality's (TCEQ) efforts on developing the Reasonable Further Progress (RFP) analysis for the State Implementation Plan (SIP) revision for the 2008 8-Hour Ozone National Ambient Air Quality Standard (NAAQS). The inventory covers the Dallas-Fort Worth (DFW) 10-county area designated by the United States (U.S.) Environmental Protection Agency's (EPA) as nonattainment for the 2008 8-hour ozone standard: Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties, as shown in Exhibit 1.1. The RFP analysis years include an RFP base, milestone, milestone contingency, attainment, and an attainment contingency year (2011, 2017, 2018, 2020, and 2021, respectively). Pollutants being evaluated are volatile organic compounds (VOC), carbon monoxide, nitrogen oxides (NO_X), carbon dioxide, sulfur dioxide, ammonia, particulate matter with aerodynamic diameters equal to or less than 2.5 microns, and particulate matter with aerodynamic diameters equal to or less than 10 microns.

Exhibit 1.1: Dallas-Fort Worth 10-County Nonattainment Area Map



This report documents the methodology and results of the RFP emissions inventories. Chapter 1 outlines the background, purpose and scope, and modeling approach; and provides a summary of the 10-county estimated emissions totals, activity and control reduction summaries.

Chapter 2 documents the procedures used to develop regional vehicle activity estimates in terms of vehicle miles of travel (VMT) and average vehicle speed. These procedures include development of adjustment factors to more accurately reflect regional conditions. Seasonal and hourly adjustment factors were applied to produce 2011, 2017, 2018, 2020, and 2021 analysis year vehicle activity and report vehicle activity in hourly periods. Consistent with previous emissions inventory practices, a comparison was made between travel demand model VMT estimates and appropriate Highway Performance Monitoring System (HPMS) VMT to develop HPMS adjustment factors. Also, a nonrecurring congestion adjustment was applied to account for vehicle emissions due to traffic accidents not captured in the standard four-step travel modeling process.

Chapter 3 documents the parameters and inputs used to develop on-road mobile source emission factors by utilizing the U.S. EPA's Motor Vehicle Emission Simulator version 2014a (MOVES2014a) model. Regionally specific calculations, procedures, MOVES2014a emission factors, and adjustments are provided to better reflect regional vehicle emissions emitted. The calculations and procedures include source use type age distribution, fuel engine fractions, vehicle registration, hourly VMT, and trip length distribution. Also accounted for are low emission diesel NO_X adjustments and VMT mix.

Chapter 4 documents the 10-county nonattainment area vehicle emission calculation procedure and estimates.

Chapter 5 summarizes emissions of all pollutants by county and analysis years.

The Appendices contains supplemental information, including a table containing all pollutants calculated, and electronic data supporting the DFW RFP Emissions Inventory.

Background

The Clean Air Act Amendments (CAAA) of 1990 requires the EPA to set NAAQS for widespread pollutants considered harmful to public health and the environment. The EPA set NAAQS for six of the principal pollutants; ozone, particulate matter (PM), carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead.

With the signing of the CAAA into law, the four counties of Collin, Dallas, Denton, and Tarrant in the DFW area were designated as nonattainment under the 1-Hour Ozone NAAQS. The law also requires the EPA to periodically review the NAAQS to ensure they provide adequate health and environmental protection, and to update these standards as necessary. Upon completion of a scientific review of the 1-Hour Ozone NAAQS, EPA determined this standard was insufficient to protect human health. As a result, the EPA developed the 1997 8-Hour Ozone NAAQS, <85 parts per billions (ppb), to place greater emphasis on prolonged exposure to pollutants. In April 2004, EPA announced Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant counties comprise the new DFW nine-county nonattainment area for the pollutant ozone under the 1997 8-Hour Ozone NAAQS, with an effective designation date of June 15, 2004. The nine-county nonattainment area received a "Moderate" ozone classification with an attainment date of June 15, 2010. As a result of not reaching attainment by June 2010, the DFW area was classified as "serious" with the new attainment date of June 2013.

On July 20, 2012, the DFW area was reclassified as "moderate" nonattainment for the 2008 8-Hour Ozone NAAQS (≤75 ppb), Wise County was added as the tenth nonattainment county. On December 23, 2014, a District of Columbia Circuit ruled against the EPA, establishing July 20, 2018, as the attainment date for moderate nonattainment areas, which is exactly six years from the official date of designation. This change required the 2015-2017 design value to determine moderate nonattainment area's attainment status. In addition, these areas had to model a 2017 future year under the 75 ppb standard.

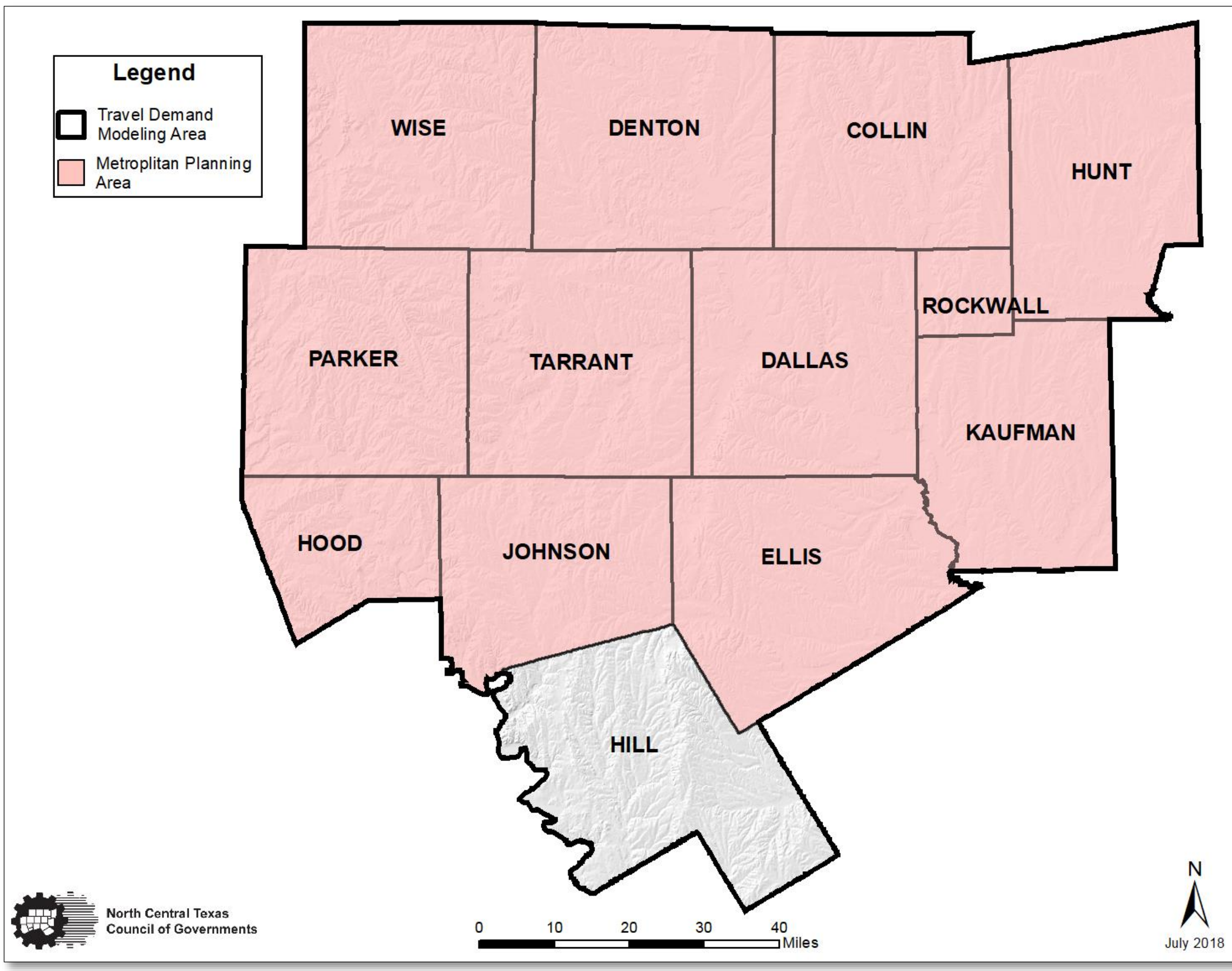
TCEQ, the State's environmental agency, is required under the CAAA to submit SIP revisions documenting the emission of ozone precursors are declining at rates to achieve the NAAQS. The SIP is an air quality plan containing a collection of regulations and measures to reduce emissions from stationary, area, mobile (on-road and non-road) sources, and demonstrate attainment of the air quality standards. The section of the SIP that outlines the plan to achieve these emissions reductions is subsequently defined as the "Reasonable Further Progress" (RFP) plan.

On-road mobile is a key component of the SIP, as a SIP places emission limits on on-road mobile sources. These on-road mobile emission limits are termed motor vehicle emission budgets and have a direct impact on transportation planning. NCTCOG serves as the Metropolitan Planning Organization for transportation in the DFW area and was contracted by the TCEQ to develop on-road mobile source emission inventories for the region consistent with the EPA's requirements for demonstrating RFP. NCTCOG applies a four-step travel demand model process using TransCAD software to forecast regional vehicle activity and utilizes EPA's MOVES2014a with a post-processing application to estimate regional mobile source emissions.

Modeling Approach

The DFW Travel Model for the Expanded Area (DFX) is utilized to estimate VMT and emissions for the 2011, 2017, 2018, 2020, and 2021 analysis years for summer weekday. DFX's modeling domain includes Collin, Dallas, Denton, Ellis, Hill, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties. Hill County is not part of the North Central Texas (NCT) Metropolitan Planning Area (MPA) boundary; however, to capture travel from outside areas, Hill County is included in the modeling domain. The NCT 12-county MPA and the 13-county DFX modeling domain is shown in Exhibit 1.2.

Exhibit 1.2: Dallas-Fort Worth Travel Demand Modeling Domain Map



Several components of the model were updated as part of this model expansion. These include improvements to the mode-choice model; vehicle ownership model; external stations; volume-delay-function; transit assignment; and traffic assignment convergence criteria, which are discussed in Chapter 2. Emissions are quantified by grouping control strategy scenarios as a model run. Exhibit 1.3 describes the control strategy scenarios modeled for all the analysis years.

Exhibit 1.3: Emissions Inventory Scenarios Modeled

Reasonable Further Progress Scenarios	Input Files
Adjusted Base Year[2]	ABY
Pre-1990 Federal Motor Vehicle Control Program (FMVCP)	PR90
FMVCP Tier 1 FMVCP Tier 2 FMVCP – Heavy-Duty 2007	FMVCP
Fuel Controls (FC)[3]	FC
Expanded Inspection & Maintenance (I/M)	IM
Texas Low-Emission Diesel[4]	TxLED

[1]In the table above, each scenario contains the control strategies of all previous scenarios.
[2]Base year (2011) VMT is used for all analysis years.
[3]Includes fuel controls (reformulated gasoline and ultra-low-sulfur diesel)
[4]I/M emission factors will be used to estimate TxLED emission benefits.

Final RFP on-road emission estimates by pollutant for summer weekday for each analysis year are shown in Exhibits 1.4 through 1.6. Exhibits 1.7 through 1.9 show the emissions reductions resulting from the application of each control scenario. These emission estimates and reductions are provided for the 10-county 2008 8-hour ozone nonattainment area. The CAAA 182(b)(1) requires moderate areas newly designated as nonattainment to show, within a six-year period, a 15 percent emissions reduction in VOC, not NO_X from the baseline year (January 1, 2012 – December 31, 2017). Appendix D contains the detailed emissions by county, pollutant, and by time-of-day for all NCT counties modeled.

VMT for summer weekday for each analysis year are shown in Exhibit 1.10. Appendix E contains the summarized VMT estimates by analysis year for all NCT counties modeled.

Exhibit 1.4: On-Road Emissions for the DFW 10-County Nonattainment Area

Summer Season, Midweek On-Road Emissions (tons/day)					
Nitrogen Oxides					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	768.26	768.19	768.17	768.11
PR90	767.76	903.58	921.03	957.91	974.43
FMVCP	343.42	215.51	193.79	161.24	147.72
FC	266.43	158.31	130.30	107.01	97.78
IM	245.30	146.42	121.47	100.14	91.75
TxLED	239.07	142.81	118.25	97.50	89.33
Volatile Organic Compounds					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	305.37	305.29	304.69	304.65
PR90	301.15	349.79	356.44	370.27	376.55
FMVCP	134.92	94.82	88.94	80.04	76.02
FC	115.88	79.42	72.23	64.87	61.59
IM	102.25	69.26	63.08	56.73	53.88
TxLED	102.25	69.26	63.08	56.73	53.88

[1]In the table above, each scenario contains the control strategies of all previous scenarios.

Exhibit 1.5: On-Road Emissions for Wise County

Summer Season, Midweek On-Road Emissions (tons/day)					
Nitrogen Oxides					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	18.26	18.26	18.25	18.25
PR90	18.39	20.78	21.31	22.29	22.78
FMVCP	8.66	5.55	5.10	4.43	4.14
FC	7.49	4.62	4.04	3.52	3.31
IM	7.49	4.62	4.04	3.52	3.31
TxLED	7.24	4.46	3.89	3.39	3.18
Volatile Organic Compounds					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	4.89	4.89	4.88	4.88
PR90	4.80	5.55	5.68	5.90	6.01
FMVCP	2.29	1.54	1.45	1.29	1.21
FC	2.05	1.36	1.25	1.12	1.05
IM	2.05	1.36	1.25	1.12	1.05
TxLED	2.05	1.36	1.25	1.12	1.05

[1]In the table above, each scenario contains the control strategies of all previous scenarios.

Exhibit 1.6: On-Road Emissions for the DFW Nine-County Nonattainment Area

Summer Season, Midweek On-Road Emissions (tons/day)					
Nitrogen Oxides					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	750.00	749.94	749.92	749.86
PR90	749.37	882.80	899.72	935.61	951.66
FMVCP	334.76	209.96	188.69	156.81	143.58
Fuel Controls	258.94	153.69	126.27	103.49	94.47
I/M	237.81	141.81	117.44	96.62	88.45
TxLED	231.83	138.35	114.36	94.10	86.14
Volatile Organic Compounds					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	300.48	300.40	299.81	299.77
PR90	296.35	344.24	350.76	364.37	370.54
FMVCP	132.63	93.27	87.49	78.75	74.81
Fuel Controls	113.82	78.06	70.98	63.75	60.54
I/M	100.19	67.90	61.83	55.61	52.83
TxLED	100.19	67.90	61.83	55.61	52.83

[1]In the table above, each scenario contains the control strategies of all previous scenarios.

Exhibit 1.7: Control Strategy Emission Reductions for the DFW 10-County Nonattainment Area

Summer Season, Midweek On-Road Emission Reductions (tons/day)						
Nitrogen Oxides						
		2011	**2017**	**2018**	**2020**	**2021**
Inventory	**PR90**	767.76	903.58	921.03	957.91	974.43
	Control Strategies	239.07	142.81	118.25	97.50	89.33
Reductions	**FMVCP**	424.34	688.07	727.24	796.67	826.71
	FC	76.99	57.20	63.49	54.23	49.95
	IM	21.13	11.89	8.83	6.87	6.03
	TxLED	6.23	3.62	3.22	2.64	2.43
	Total	**528.69**	**760.77**	**802.78**	**860.41**	**885.10**
Volatile Organic Compounds						
		2011	**2017**	**2018**	**2020**	**2021**
Inventory	**PR90**	301.15	349.79	356.44	370.27	376.55
	Control Strategies	102.25	69.26	63.08	56.73	53.88
Reductions	**FMVCP**	166.24	254.97	267.50	290.22	300.53
	FC	19.04	15.40	16.70	15.17	14.43
	IM	13.63	10.16	9.15	8.14	7.71
	TxLED	0.00	0.00	0.00	0.00	0.00
	Total	**198.90**	**280.53**	**293.36**	**313.54**	**322.67**

Exhibit 1.8: Control Strategy Emission Reductions for Wise County

Summer Season, Midweek On-Road Emission Reductions (tons/day)						
Nitrogen Oxides						
		2011	**2017**	**2018**	**2020**	**2021**
Inventory	**PR90**	18.39	20.78	21.31	22.29	22.78
	Control Strategies	7.24	4.46	3.89	3.39	3.18
Reductions	**FMVCP**	9.73	15.24	16.21	17.87	18.63
	FC	1.17	0.93	1.07	0.91	0.83
	IM	N/A	N/A	N/A	N/A	N/A
	TxLED	0.25	0.16	0.15	0.13	0.12
	Total	**11.15**	**16.32**	**17.42**	**18.90**	**19.60**
Volatile Organic Compounds						
		2011	**2017**	**2018**	**2020**	**2021**
Inventory	**PR90**	4.80	5.55	5.68	5.90	6.01
	Control Strategies	2.05	1.36	1.25	1.12	1.05
Reductions	**FMVCP**	2.51	4.01	4.23	4.61	4.79
	FC	0.23	0.18	0.20	0.17	0.16
	IM	N/A	N/A	N/A	N/A	N/A
	TxLED	0.00	0.00	0.00	0.00	0.00
	Total	**2.75**	**4.19**	**4.43**	**4.78**	**4.96**

Exhibit 1.9: Control Strategy Emission Reductions for the Nine-County Nonattainment Area

Summer Season, Midweek On-Road Emission Reductions (tons/day)						
Nitrogen Oxides						
		2011	**2017**	**2018**	**2020**	**2021**
Inventory	**PR90**	749.37	882.80	899.72	935.61	951.66
	Control Strategies	231.83	138.35	114.36	94.10	86.14
Reductions	**FMVCP**	414.61	672.83	711.03	778.80	808.08
	FC	75.82	56.27	62.43	53.33	49.11
	IM	21.13	11.89	8.83	6.87	6.03
	TxLED	5.98	3.46	3.08	2.52	2.30
	Total	**517.54**	**744.45**	**785.36**	**841.51**	**865.52**
Volatile Organic Compounds						
		2011	**2017**	**2018**	**2020**	**2021**
Inventory	**PR90**	296.35	344.24	350.76	364.37	370.54
	Control Strategies	100.19	67.90	61.83	55.61	52.83
Reductions	**FMVCP**	163.72	250.96	263.27	285.61	295.74
	FC	18.81	15.22	16.50	15.00	14.26
	IM	13.63	10.16	9.15	8.14	7.71
	TxLED	0.00	0.00	0.00	0.00	0.00
	Total	**196.16**	**276.34**	**288.93**	**308.76**	**317.71**

Exhibit 1.10: Vehicle Miles of Travel for the DFW 10-County Nonattainment Area

Summer Season, Midweek Vehicle Miles of Travel (miles/day)					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	191,251,636	191,251,636	191,251,636	191,251,636
PR90	191,251,636	219,457,725	223,163,467	231,949,231	235,603,162
FMVCP	191,251,636	219,457,725	223,163,467	231,949,231	235,603,162
FC	191,251,636	219,457,725	223,163,467	231,949,231	235,603,162
IM	191,251,636	219,457,725	223,163,467	231,949,231	235,603,162
TxLED	191,251,636	219,457,725	223,163,467	231,949,231	235,603,162

Exhibit 1.11: Vehicle Miles of Travel for Wise County

Summer Season, Midweek Vehicle Miles of Travel (miles/day)					
	2011	**2017**	**2018**	**2020**	**2021**
ABY	N/A	3,538,731	3,538,731	3,538,731	3,538,731
PR90	3,538,731	4,056,522	4,151,131	4,312,239	4,395,107
FMVCP	3,538,731	4,056,522	4,151,131	4,312,239	4,395,107
FC	3,538,731	4,056,522	4,151,131	4,312,239	4,395,107
IM	3,538,731	4,056,522	4,151,131	4,312,239	4,395,107
TxLED	3,538,731	4,056,522	4,151,131	4,312,239	4,395,107

Exhibit 1.12: Vehicle Miles of Travel for the Nine-County Nonattainment Area

Summer Season, Midweek Vehicle Miles of Travel (miles/day)					
	2011	**2017**	**2018**	**2020**	**2021**
ABY		187,712,905	187,712,905	187,712,905	187,712,905
PR90	187,712,905	215,401,203	219,012,336	227,636,992	231,208,055
FMVCP	187,712,905	215,401,203	219,012,336	227,636,992	231,208,055
FC	187,712,905	215,401,203	219,012,336	227,636,992	231,208,055
IM	187,712,905	215,401,203	219,012,336	227,636,992	231,208,055
TxLED	187,712,905	215,401,203	219,012,336	227,636,992	231,208,055

CHAPTER 2: VEHICLE ACTIVITY ESTIMATION PROCEDURES

This chapter discusses the methodology used in estimating the vehicle activity measures influencing air quality in the North Central Texas area. These measures include: vehicle miles of travel (VMT) and average speed. The current Dallas-Fort Worth Travel Model for the Expanded Area (DFX) covers the 12-county Metropolitan Planning Area (MPA) of Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties, plus Hill County. The VMT and speeds were estimated with the DFX using a link-based methodology for each time period.

Dallas-Fort Worth Expanded Travel Model

The source of VMT estimates for the Reasonable Further Progress (RFP) Emission Inventories for the nonattainment counties is the network-based DFX executed by the North Central Texas Council of Governments (NCTCOG) Transportation Department in the TransCAD environment. TransCAD is a Geographic Information System-based commercial travel demand software package for transportation planning. DFX supports federally required regional transportation planning efforts for the Dallas-Fort Worth (DFW) area. Since 1974, NCTCOG has served as the Metropolitan Planning Organization (MPO) for the DFW area. The Transportation Department provides technical support and staff assistance to the Regional Transportation Council and its technical committees that comprise the MPO policy-making structure.

Multimodal Transportation Analysis Process

The forecasting technique of the DFX is based on a four-step sequential process designed to model travel behavior and predict travel demand at regional, sub-area, or corridor levels. These four steps are: Trip Generation, Trip Distribution, Mode Choice, and Roadway Assignment.

The roadway network developed for the RFP Emissions Inventories contains over 30,000 unique segments constructed to replicate the transportation system of the coverage area. For this RFP inventory, the transportation network was developed for the years 2011, 2017, 2018, 2020, and 2021. Each facility link in the network has the following attributes:

- Network Node Numbers (defining the beginning and end of each link)
- Number of Operational Lanes in the AM PM Peak and Off-Peak Periods
- Functional Classification
- Divided/Undivided Roadway Code
- Type of Traffic Control at Each End of the Link
- Traffic Direction (One- or Two-Way)
- Length of Link
- Estimated Loaded Speeds in Each Period
- Speed Limit
- Traffic Survey Zone
- Tolls
- Area Type
- Free-Flow Speeds
- Hourly Capacities
- Truck Exclusion Code
- Length of Link

Every roadway segment in the network falls in one of the functional classes of centroid connectors, freeways, principal arterials, minor arterials, collectors, ramps, frontage roads, and high occupancy vehicle (HOV) lanes.

Trip purposes in the DFX are defined in one of four ways: home-based work (HBW), which includes trips from home to work or work to home; home-based non-work (HNW), which includes non-work trips beginning or ending at home; non-home based (NHB), which includes trips where home is neither the origin nor the destination; and other trips that include all truck trips as well as all external-internal, internal-external, and external-external vehicle trips.

The model process begins with an estimate of the socio-economic variables for each zone. The data is organized by traffic survey zone (TSZ), the smallest zone size available in the DFX. There are 5,386 TSZs in the model (5,303 internal zones plus 83 externals). The data for each TSZ includes: zone centroid; median household income; number of households; population; basic, retail, and service employment; and land area. This level of detail is retained in all four modeling steps.

The Trip Generation Model generates the number of weekday person trips sent to and received from each zone. The Trip Distribution Model determines the trip interaction between each zone and the rest of the zones in the MPA. The Mode Choice Model divides the person trips into two categories of transit and automobile trips. The Assignment Model loads the auto demand onto the roadway network, and the transit passenger trips onto the transit network, commonly referred to as the four-step transportation modeling process. The DFX model application is written by NCTCOG staff in the TransCAD script language known as the Geographic Information System Developer Kit (GISDK), and integrated with a user interface developed in visual basic programming language.

Trip Generation Model

The Trip Generation Model is a computer program written in GISDK script language by NCTCOG staff. The Trip Generation Model converts the population and employment data into person trip ends and outputs the total number of trips produced by and attracted to each zone by trip purpose. The 2011, 2017, 2018, 2020, and 2021 population and employment forecasts were generated with the Disaggregate Residential Allocation Model/Employment Allocation Model using travel times from the Roadway and Transit Assignment Steps consistent with current planning practice. The data can be seen in Exhibit 2.1. The cross-classified trip production model is stratified by income quartile and household size. The allocation of TSZ households into the four income quartiles and six household size categories is based on distribution curves developed from the United States Census Population data. The cross-classified trip attraction model is stratified by area type, employment type (basic, retail, and service), and, for the case of the HBW trip purpose, income quartile. Area type designations are a function of the population and employment density of a zone.

Exhibit 2.1: Socio-Economic Demographic Summary

DFW Nonattainment Area					
Analysis Year	**2011**	**2017**	**2018**	**2020**	**2021**
Population	6,341,202	7,137,178	7,277,987	7,524,572	7,647,835
Number of Households	2,299,092	2,541,704	2,591,691	2,678,167	2,721,382
Employment Types					
Basic	931,999	1,112,279	1,134,264	1,138,900	1,141,186
Retail	382,816	439,942	448,857	465,249	473,497
Service	2,663,566	3,076,418	3,137,179	3,238,685	3,289,499
Total Employment	3,978,381	4,628,639	4,720,300	4,842,834	4,904,182

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The Trip Generation Model allows the user to input trip rates and trip generation units associated with special generators such as regional shopping malls, hospitals, and colleges/universities. At the end of the generation process, HBW trips are balanced to the estimated trip attractions. All other purposes are balanced to the estimated trip productions in that zone. Because of the uniqueness of the NHB trips, zonal productions for NHB trips are later set equal to the attractions in a given zone.

The regional trip productions and attractions are balanced for each trip purpose. The total trip attractions are balanced to the estimated trip productions in that zone for all other trip purposes.

Trip Distribution Model

The Trip Distribution Model creates the production-attraction person trip tables for each of the 5,386 model zones. The Trip Distribution Model uses the person trips produced by and attracted to each zone, generated in the Trip Generation Model, plus zone-to-zone minimum travel time information from the roadway network to estimate the number of person trips between each pair of zones for each trip purpose. All estimates of roadway travel times include a representation of the time needed for locating a parking space, paying for parking, and walking from the car to the final destination. Estimates of these terminal times were derived from NCTCOG's 1994 Workplace Survey and 1996 Household Travel Survey. NCTCOG is in the process of updating the trip distribution model component based on 2009 household survey data. The model uses a gamma-based gravity formulation technique to estimate the zone-to-zone interchange of trips. Iterations of the gravity model are required to ensure that the estimated number of zonal trips received equals the projected number of trip attractions generated by the Trip Generation Model.

Mode Choice Model

The Mode Choice Model determines the mode of travel and auto occupancy. Using the information regarding trip maker characteristics (e.g., income and auto ownership), roadway and transit system characteristics (e.g., in-vehicle time and out-of-vehicle time), and travel costs (e.g., auto operating costs, parking costs, and transit fare), the model splits the trips among all applicable modes of travel. The model uses a nested logic formulation for all the trip purposes. The "other" trips are assumed to be vehicle trips with one occupant and are not processed by the Mode Choice Model. The trip purposes of HBW, HNW, and NHB have nine choice sets: drive alone, two occupant shared ride, three + occupancy shared ride, walk access to bus service, auto access to bus service, walk access to rail service, auto access to rail service, walk access to bus and rail service with transfer, and auto access to bus and rail service with transfer.

Roadway Assignment

The Roadway Assignment Model consists of simultaneous user equilibrium origin-destination assignments of drive alone, shared-ride, and truck vehicle classes for three separate time-of-day periods (6:30 a.m. – 8:59 a.m. Morning Peak, 3:00 p.m. – 6:29 p.m. Evening Peak, and the 18-Hour Off-peak). The drive alone vehicle class is kept separate from the shared-ride vehicle class so that HOV assignments can be performed as an integral part of an equilibrium assignment. Trucks are kept separate from the other vehicle classes so that the modeled truck volumes on all links can be tracked, and a separate value-of-time can be defined for them. A generalized cost path building technique is embedded within the model, in which the iterative calculation of zone-to-zone impedances are based on weighting factors applied to the capacity-restrained travel time, the distance (representing fuel cost), and tolls. As is standard with all User Equilibrium procedures, the TransCAD program uses an iterative process to achieve a convergent solution in which no travelers can improve their path by shifting routes. Since the results of the three time-of-day assignments can be combined to obtain total weekday modeled volumes, validation checks can be performed with either time-of-day or weekday observed traffic counts.

Speed Estimation Procedure

The link speed in the DFX is estimated by dividing the length of the link by its loaded travel time. The loaded travel time is the sum of the free-flow travel time, traffic congestion delay, and the delay caused by the traffic control devices (e.g., stop signs, yield signs, and signals). These three elements of the loaded travel time are all functions of the link volume to capacity ratio. These functions are programmed in the volume delay function (VDF) that is an essential input to the traffic assignment step. The result of the traffic assignment step is the final time-period-specific average loaded speeds for each of the 30,000 plus links in the roadway network. The VMT and vehicle hours of travel (VHT) for different time periods is included in the output as well to obtain an overall average speed (VMT/VHT) for any desired length of time.

The free-flow (uncongested) speed is defined as the speed limit. Free-flow speeds are an important link attribute since they are the base for calculating the congested (loaded) speeds in the Traffic Assignment step.

The VDF in the DFX uses a conical congestion delay form defined for each link functional classification, a non-linear delay curve based on the Webster's uniform delay formulation at signalized intersections, and a linear delay curve for the stop and yield controlled approaches.

The volume-delay functions were originally calibrated based on more than 8,000 traffic counts collected in 2004. These functions were later adjusted based on National Performance Management Research Data Set (NPMRDS) and 2014 time-of-day traffic counts collected at about 20,000 locations. NPMRDS contained travel time data by 5-minute interval.

Finally, all of the delay elements are added to the uncongested travel time (based on the free-flow speeds) to produce the total loaded travel time on each roadway segment. Appendix E contains speeds by county for each hour of the day. The resulting congested DFX county speeds, weighted by VMT, are listed in Exhibit 2.2.

Exhibit 2.2: Average Congested Speeds

County	2011	2017	2018	2020	2021
Collin	35.83	35.80	35.48	35.13	34.90
Dallas	35.55	35.94	35.71	35.64	35.54
Denton	36.56	37.57	37.22	36.70	36.48
Ellis	45.62	46.92	46.74	46.26	46.01
Johnson	42.12	41.94	41.83	41.51	41.35
Kaufman	46.29	46.35	46.01	45.29	44.89
Parker	44.24	44.06	43.89	43.73	43.62
Rockwall	40.15	40.81	40.56	40.08	39.87
Tarrant	36.48	37.49	37.28	37.16	37.04
Wise	45.82	44.71	44.54	44.39	44.27
Weighted 10-County Average	**37.01**	**37.59**	**37.36**	**37.17**	**37.03**

Local Street VMT

The roadway network of the DFX does not contain the details of local (residential) streets. However, a VMT estimate is possible based on data provided by the travel model. Local street VMT is calculated for each county by multiplying the number of intrazonal trips by the intrazonal trip length and then adding the VMT from the zone centroid connectors. The temporal distribution is assumed to be the same as for non-local streets.

<u>**Adjustments**</u>

Seasonal, Daily, and Hourly Adjustments

The vehicle activity data used for this analysis is representative of the summer season. This section outlines the process used to convert the DFX non-summer weekday (NSWD) activity to summer (June, July, and August) weekday activity. Automatic Traffic Recorder (ATR) data, collected by TxDOT, is used to calculate the necessary conversions. For 2011 analysis year, 2011 ATR was used to convert NSWD activity to summer. For 2017, 2018, 2020, and 2021 analysis years, ATR data averaged over five years (2012-2016) was used to convert NSWD activity to summer.

Seasonal and Daily Adjustments

ATR data is organized into five day types: Sunday, Monday, Midweek (Tuesday, Wednesday, and Thursday), Friday, and Saturday. To adjust the representative average school season weekday (ASWT) data from the DFX to summer weekday, an ASWT to summer ATR conversion ratio is calculated. The summer portion of the ratio includes traffic volumes recorded between June and August. Seasonal midweek (Tuesday-Thursday) adjustments by area type for DFX counties are listed in Exhibit 2.3.

Exhibit 2.3: Seasonal/Daily Adjustment Factors

	County Type	Midweek
2011 DFX Counties (ASWT to Summer)	Core (Dallas/Tarrant)	1.040
	Rural (Collin/Denton)	1.050
	Perimeter (Other Counties)	1.081
2017, 2018, 2020 & 2021 DFX Counties (ASWT to Summer)	Core (Dallas/Tarrant)	1.010
	Rural (Collin/Denton)	0.998
	Perimeter (Other Counties)	1.054

Hourly Adjustments

Daily volumes recorded for midweek, described above, are aggregated by hour to determine the percent of daily traffic occurring during each hour, representing hourly vehicle activity estimates. The DFX county midweek is further detailed by utilizing a time period volume for aggregation, as opposed to the daily volumes provided for the other day types. These time periods correspond to the time periods utilized in the DFX where AM Peak is 6:30 a.m. to 8:59 a.m., PM Peak is 3:00 p.m. to 6:29 p.m., and Off-Peak represents all other hours of the day (12:00 a.m. to 6:29 a.m., 9:00 a.m. to 2:59 p.m., and 6:30 p.m. to 11:59 p.m.). Periods split by mid-hour times utilize an equal division of traffic recorded during the hour. The hourly adjustments for DFX counties are shown in Exhibit 2.4.

Exhibit 2.4: Average 2012-2016 Hourly Distribution Factors[1]

Hours	County Groups		
	Core/Urban	Rural	Perimeter
12:00 a.m. – 12:59 a.m.	0.94%	0.68%	1.08%
1:00 a.m. – 1:59 a.m.	0.61%	0.44%	0.83%
2:00 a.m. – 2:59 a.m.	0.56%	0.36%	0.76%
3:00 a.m. – 3:59 a.m.	0.62%	0.35%	0.90%
4:00 a.m. – 4:59 a.m.	1.11%	0.61%	1.40%
5:00 a.m. – 5:59 a.m.	2.96%	1.73%	2.81%
6:00 a.m. – 6:29 a.m.	2.90%	2.21%	2.32%
6:30 a.m. – 6:59 a.m.	2.90%	2.21%	2.32%
7:00 a.m. – 7:59 a.m.	7.14%	6.38%	6.08%
8:00 a.m. – 8:59 a.m.	6.31%	6.42%	5.49%
9:00 a.m. – 9:59 a.m.	5.16%	5.32%	5.30%
10:00 a.m. – 10:59 a.m.	4.77%	4.89%	5.47%
11:00 a.m. – 11:59 a.m.	4.95%	5.24%	5.61%
12:00 p.m. – 12:59 p.m.	5.20%	5.65%	5.74%
1:00 p.m. – 1:59 p.m.	5.36%	5.76%	5.94%
2:00 p.m. –2:59 p.m.	5.79%	5.91%	6.27%
3:00 p.m. – 3:59 p.m.	6.55%	6.45%	6.74%
4:00 p.m. – 4:59 p.m.	7.33%	7.38%	7.33%
5:00 p.m. – 5:59 p.m.	7.52%	8.34%	7.53%
6:00 p.m. – 6:29 p.m.	3.15%	3.80%	2.92%
6:30 p.m. – 6:59 p.m.	3.15%	3.80%	2.92%
7:00 p.m. – 7:59 p.m.	4.60%	5.52%	4.35%
8:00 p.m. – 8:59 p.m.	3.55%	4.08%	3.46%
9:00 p.m. – 9:59 p.m.	3.02%	3.16%	2.78%
10:00 p.m. – 10:59 p.m.	2.31%	2.08%	2.10%
11:00 p.m. – 11:59 p.m.	1.55%	1.21%	1.55%

Source: TxDOT

[1] The 24-hour totals may be less than or greater than 100% due to rounding.

Model VMT Adjustments (HPMS vs. DFX)
Consistent with previous emission inventory practices, the DFW MPO used TxDOT's Highway Performance Monitoring System (HPMS) data to adjust modeled VMT to reflect the HPMS data for consistent reporting across the State. This adjustment is based on EPA's guidance for emission inventory development.

NCTCOG performed a validation on the DFX model in 2014 in order to meet the transportation conformity requirements per the *Code of Federal Regulation*s, which states, "Network-based travel models must be validated against observed counts (peak and off-peak, if possible) for a base year that is not more than 10 years prior to the date of the conformity determination" (40CFR §93.122(b)(1)(i). NCTCOG incorporated the updated DFX model validation which is based on 2010 demographics. Exhibit 2.5 shows the calculation performed to develop the new HPMS adjustment factor, 0.9703, based on a comparison of 2010 VMT for HPMS and DFX.

Exhibit 2.5: 2010 DFW and HPMS VMT Analysis

Model VMT Adjustment Factor	
	2010 VMT
HPMS (ASWT)[1]	165,292,084
DFX (ASWT)	170,346,118
HPMS/DFX Ratio	0.9703

[1]Annual Average Daily Traffic to ASWT conversion factor applied.

Nonrecurring Congestion
According to a paper published in the January 1987 Institute of Transportation Engineers Journal by Jeffrey A. Lindley entitled Urban Freeway Congestion: Quantification of the Problem and Effectiveness of Potential Solutions, congestion due to traffic incidents accounts for twice as much as congestion from bottleneck situations. Congestion due to incidents, or nonrecurring congestion, causes emissions not represented in the VMT-based calculations of the base emissions. In order to include these effects, the delay caused by nonrecurring congestion is added to the freeway travel times and congestion delay due to bottlenecks to obtain an increased freeway travel time, which translates into reduced speed on freeway facilities. Reducing the freeway speeds increases volatile organic compounds (VOC) and oxides of nitrogen (NO_X) emissions by 4.9 percent, resulting in a factor of 1.049 for freeway VOC and NO_X emissions in urban and rural counties. This is thought to be a conservative estimate of increased emissions due to nonrecurring congestion. Arterial street emissions are not significantly affected by incidents because alternate routes on the arterial system are generally available; therefore, this factor is not applied to non-freeway type facilities.

VMT Estimates
The RFP VMT estimates are located in Exhibit 2.6 for all counties in the nonattainment area. VMT is summarized by 2011, 2017, 2018, 2020 and 2021 model years for each county. Appendix E contains the VMT by county for each hour for all counties.

Exhibit 2.6: Vehicle Miles of Travel

DFW Nonattainment Area					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	21,878,235	26,267,831	26,906,397	28,460,810	29,173,045
Dallas	74,439,892	83,276,006	84,318,522	86,540,958	87,352,141
Denton	18,575,666	21,121,344	21,551,320	22,440,507	22,822,768
Ellis	6,774,544	8,051,780	8,264,272	8,767,257	9,025,573
Johnson	4,952,616	5,904,299	6,033,090	6,366,463	6,527,777
Kaufman	5,734,878	7,025,002	7,238,266	7,687,597	7,907,878
Parker	4,921,961	6,156,798	6,320,018	6,630,680	6,776,194
Rockwall	2,436,477	2,798,689	2,857,891	3,001,820	3,066,582
Tarrant	47,998,636	54,799,454	55,522,560	57,740,902	58,556,096
Wise	3,538,731	4,056,522	4,151,131	4,312,239	4,395,107
Total	**191,251,636**	**219,457,725**	**223,163,467**	**231,949,231**	**235,603,162**

CHAPTER 3 ESTIMATION OF OFF-NETWORK ACTIVITY

To estimate the off-network (or parked vehicle) emissions using the mass per activity emissions rates, county-level analysis years 2011, 2017, 2018, 2020, and 2021 weekday estimates of the source hours parked (SHP), starts, source hours idling (SHI), and auxiliary power units (APU) hours are required by hour and vehicle (SHI and APU hours are for diesel combination long-haul trucks only). One of the main components of the SHP and starts off-network activity estimation is the analysis year county-level vehicle population. Appendix A contains the vehicle population and hourly SHP, starts, SHI, and APU hours.

Texas A&M Transportation Institute's (TTI) MOVESpopulationBuild module is used to convert Motor Vehicle Emissions Simulator version 2014a (MOVES2014a) based Texas Department of Motor Vehicles registration data for each county into 13 MOVES2014a source use type (SUT) population (or vehicle population). The county-level SHP, starts, SHI, and APU hours of off-network activity were developed using the "OffNetActCalc" utility and methodology provided by TTI.

Estimation of SHP

The first activity measure needed to estimate the off-network emissions using the mass per activity emissions rates are county-level analysis year weekday estimates of SHP by hour and vehicle type. For each hour, the county-level vehicle type SHP was calculated by taking the difference between the vehicle type total available hours minus the vehicle type vehicle hours travelled (VHT). Since this calculation was performed at the hourly level, the vehicle type total available hours was set equal to the vehicle type population. The Source Hours Operating (SHO) was calculated using the link vehicle miles of travel (VMT) and speeds and the VMT mixes by MOVES road-type category. Appendix A includes the 24-hour summaries of the county-level weekday estimates of SHP by hour and vehicle type for all analysis years.

Vehicle Type Total Available Hours

The vehicle type total available hours is typically calculated as the vehicle type population times the number of hours in the time period. Since this calculation was performed at the hourly level, the vehicle type total available hours was set equal to the vehicle type vehicle.

Vehicle Type VHT

To calculate the VHT for a given link, the VMT was allocated to each vehicle type using the Texas Department of Transportation district-level vehicle type VMT mixes by MOVES road-type category, which was then divided by the link speed to calculate the link vehicle type VHT. These VMT mixes are the same VMT mixes used to estimate emissions in the emissions estimation process. This SHO calculation was performed for each link in a given hour, aggregating the VHT to one value per vehicle type per hour.

Estimation of Starts

The second activity measure needed to estimate the off-network emissions using the mass per activity emissions rates are county-level analysis year weekday estimates of starts by hour and vehicle type. The vehicle type hourly default starts per vehicle were multiplied by the analysis year county-level vehicle type vehicle population to estimate the county-level vehicle type starts by hour. Appendix A includes the 24-hour summaries of the county-level vehicle type starts by hour for each analysis year.

For the hourly default starts per vehicle, the MOVES defaults were used. The MOVES activity output was used to estimate the hourly starts per vehicle for a MOVES weekday run by dividing the MOVES start output by the MOVES vehicle population output. These MOVES national default starts per vehicle do not vary by year, only by MOVES day type. For this weekday analysis, the MOVES national default "weekday" starts per vehicle were used.

Estimation of SHI and APU Hours

The remaining activity measures needed to estimate the off-network emissions using the mass per activity emissions rates are the hourly, county-level analysis year weekday heavy-duty diesel truck (SUT 62, fuel type 2 [CLhT_Diesel]) SHI and APU hours (hotelling activity). During hotelling, the truck's main engine is assumed to be in idling mode or its APU is in use. To calculate the SHI and APU hours activity, the hotelling hours activity were calculated, which was then allocated to the SHI and APU hours components.

The hotelling activity was based on information from a Texas Commission on Environmental Quality extended idling study, which produced 2017 winter weekday extended idling estimates for each Texas County. Hotelling scaling factors (by analysis year) were applied to the base 2017 winter weekday hotelling values from the study to estimate the 24-hour hotelling by analysis year. Hotelling hourly factors were then applied to allocate the 24-hour hotelling by analysis year to each hour of the day. To ensure that valid hourly hotelling values are used, the hourly hotelling activity was compared to the CLhT_Diesel hourly SHP (i.e., hourly hotelling values cannot exceed the hourly SHP values). SHI and APU hours factors were then applied to the hotelling hours to produce the hourly SHI and APU hours of activity. Appendix A incudes the 24-hour summaries of the county-level estimates of hotelling hours, SHI, and APU hours for each analysis year.

Hotelling Activity Scaling Factors

To estimate the analysis year county-level 24-hour hotelling activity, county-level hotelling activity scaling factors were developed using the county-level 2017 winter weekday link-level VMT and speeds, the VMT mix (by MOVES road type), the county-level analysis year weekday link-level VMT and speeds, and the VMT mix (by MOVES road type). The 2017 winter weekday link-level VMT and speeds were developed using a process similar to the 2011, 2017, 2018, 2020, and 2021 weekday link-level VMT speed estimation. The vehicle type VMT mixes were the same VMT mixes used to estimate emissions in the emissions estimation process. For the base weekday vehicle type VMT mix, the 2017 weekday vehicle type VMT mix was used.

For each link in the 2017 winter weekday link-level VMT and speeds, the link VMT was allocated to CLhT_Diesel using the base weekday vehicle type VMT mix. This VMT allocation was performed for each link and hour in the 2017 winter weekday link-level VMT and speeds, with the individual link VMT aggregated by hour to produce the CLhT_Diesel hourly and 24- hour 2017 weekday VMT. Using a similar allocation process, the analysis year weekday CLhT_Diesel hourly and 24-hour VMT was calculated using the analysis year weekday link-level VMT and speeds and the analysis year vehicle type VMT mix. The county- level 24-hour hotelling activity scaling factors by analysis year were calculated by dividing the analysis year and day type CLhT_Diesel 24-hour VMT by the CLhT_Diesel 24-hour 2017 winter weekday VMT.

Hotelling Activity Hourly Factors

To allocate the analysis year weekday county-level 24-hour hotelling activity to each hour of the day, hotelling activity hourly factors were used. These hotelling activity hourly factors were calculated as the inverse of the analysis year weekday CLhT_Diesel hourly VHT fractions. The analysis year weekday CLhT_Diesel hourly VHT fractions were calculated using the hourly analysis year weekday CLhT_Diesel VHT. The hourly analysis year weekday CLhT_Diesel VHT was converted to hourly fractions, therefore creating analysis year weekday CLhT_Diesel hourly VHT fractions. The inverse of these hourly VHT fractions were calculated and the inverse for each hour was divided by the sum of the inverse hourly VHT fractions across all hours to calculate the county-level analysis year weekday hotelling activity hourly factors for each analysis year.

County-Level CLhT_Diesel Hotelling Activity by Hour Estimation

The four analysis years' weekday CLhT_Diesel hotelling activity by hour was calculated by multiplying the 24-hour 2004 weekday hotelling hours by the analysis year hotelling activity scaling factor and by the analysis year hotelling activity hourly factors. For each hour, the analysis year weekday hotelling activity was then compared to the analysis year weekday CLhT_Diesel SHP to estimate the final analysis year weekday hotelling activity by hour. If the analysis year weekday hotelling activity value was greater than the analysis year weekday SHP value, then the final analysis year weekday hotelling activity for that hour was set to the analysis year weekday CLhT_Diesel SHP value. Otherwise, the final analysis year weekday hotelling activity for that hour was set to the base analysis year weekday hotelling activity value. All calculations (scaling factors, hotelling activity hourly factors, and hotelling activity by hour calculations) were performed by county and analysis year (i.e., 10 hotelling activity scaling factors were calculated per analysis year).

County-Level CLhT_Diesel SHI and APU Hours Estimation

Weekday hourly county-level hotelling activity for all analysis years was then allocated to SHI and APU hours activity components using the aggregate extended idle mode and APU mode fractions. For each hour, the analysis year weekday hotelling activity was multiplied by the SHI fraction to calculate the analysis year weekday hourly SHI activity and by the APU fraction to calculate the analysis year weekday hourly APU activity.

The aggregate SHI and the APU fractions were estimated using model year travel fractions (based on source type age distribution and relative mileage accumulation rates used in the MOVES runs) and the MOVES default hotelling activity distribution (i.e., a bi-modal distribution of 1.0 SHI prior to the 2010 model year and a 0.7/0.3 SHI/APU activity allocation for 2010 and later model years). The associated travel fractions were applied to the appropriate extended idle and APU operating mode fractions (of the hotelling operating mode distribution) by model year and summed within each mode to estimate the aggregate (across model years) individual SHI and APU fractions (which sum to 1.0).

CHAPTER 4: EMISSION FACTOR ESTIMATION PROCEDURE

<u>MOVES201a and Input Parameters</u>

The Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator version 2014a (MOVES2014a) is used to develop vehicle emission factors to conduct the Reasonable Further Progress (RFP) emission inventory for the Dallas-Fort Worth (DFW) 10-county ozone nonattainment area for analysis years 2011, 2017, 2018, 2020, and 2021. The emission factors are one component in the equation to determine vehicle emissions emitted from the region's on-road vehicles. MOVES2014a parameters used to develop emissions inventory are listed in Exhibits 4.1 through 4.5 with the appropriate data source and/or methodology applied. Information listed applies to all counties unless otherwise specified. Referenced files identifying specific local data are included in Appendix A. MOVES2014a input files utilizing these parameters and data for each county are included in Appendix B.

Exhibit 4.1: MOVES2014 Modeled Pollutants

Command	Input Parameter Values and Molecular Formulas	Description
Pollutant	VOC, CO, NO_X, CO_2, SO_2, NH_3, $PM_{2.5}$, and PM_{10},	Volatile Organic Compounds (VOC), Carbon Monoxide (CO), Nitrogen Oxides (NO_X), Carbon Dioxide (CO_2), Sulfur Dioxide (SO_2), ammonia (NH_3), Particulate Matter with aerodynamic diameters equal to or less than 2.5 microns ($PM_{2.5}$), and Particulate Matter with aerodynamic diameters equal to or less than 10 microns (PM_{10}).

Exhibit 4.2: MOVES2014a External Conditions

Command	Input Parameter Values	Description
Calendar Year	2011, 2017, 2018, 2020 and 2021	RFP analysis years
Altitude	1	Low altitude; EPA default
Evaluation Month	7	Representing Summer
Minimum/Maximum Temperature	N/A	See Hourly Temperatures
Hourly Temperatures	Average Summer (June, July and August)	2011 County specific, provided by the Texas Commission on Environmental Quality (TCEQ)
Relative Humidity	Average Summer (June, July and August)	2011 County specific, provided by TCEQ
Barometric Pressure	Average Summer (June, July and August)	2011 County specific, provided by TCEQ

Exhibit 4.3: MOVES2014a Input Parameters

Input Parameter	Description	Source
Source Type Population	Input number of vehicles in geographic area to be modeled for each vehicle, and apply the appropriate growth factors for each analysis year. Texas A&M Transportation Institute's (TTI) MOVESpopulationBuild module is used to convert MOVES2014a based Texas Department of Motor Vehicles (TxDMV) registration data for each county into 13 MOVES2014a SUT population.	2011 and 2014 TxDMV registration data
Source Type Age Distribution	Input provides distribution of vehicle counts by age for each calendar year and vehicle type. TxDMV registration data used to estimate age distribution of vehicle types up to 30 years. Distribution of Age fractions should sum up to 1.0 for all vehicle types for each analysis year.	2011 and 2014 TxDMV registration data MOVES2014a default used for buses
Vehicle Type Vehicle Miles of Travel	County specific vehicle miles of travel (VMT) distributed to six highway performance monitoring system (HPMS) Vehicle types.	Travel Model Output
Average Speed Distribution	Input average speed data specific to vehicle type, road type, and time of day/type of day into 16 speed bins. Sum of speed distribution to all speed bins for each road type, vehicle type, and time/day type is 1.0.	Travel Model Output

Exhibit 4.3: MOVES2014a Input Parameters (continued)

Input Parameter	Description	Source
Road Type Distribution (VMT Fractions)	Input county specific VMT by road type. VMT fraction distributed between the road type and must sum to 1.0 for each source type.	Travel Model Output
Ramp Fraction	Input county specific fraction of ramp driving time on rural and urban restricted roadway type.	Travel Model Output
Fuel Supply	Input to assign existing fuels to counties, months, and years, and to assign the associated market share for each fuel.	TCEQ, EPA Fuel Surveys and default MOVES2014a input where local data unavailable
Meteorology	Regional average summer data on temperature and humidity.	2011 data provided by TCEQ
Fuel Formulation	Input county specific fuel properties in the MOVES2014a database.	TCEQ, EPA Fuel Surveys, and default MOVES2014a input where local data unavailable
Inspection and Maintenance Coverage	Input inspection and maintenance (I/M) coverage record for each combination of pollutants, process, county, fuel type, regulatory class and model year are specified using this input.	State I/M program data provided by TCEQ
Fuel Engine Fraction / Diesel Fraction (AVFT)	Input fuel engine fractions (i.e. Gasoline vs. Diesel Engines types in the vehicle population) for all vehicle types.	2011 and 2014 TxDMV registration data MOVES2014a default used for light duty vehicles and buses

Exhibit 4.4 MOVES2014a I/M Descriptive Inputs for Subject Counties

2011						
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data[2]						
I/M Program ID	20	21	22	23	24	MOVES2014a
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	112	MOVES2014a
Source Use Type	21, 31, 32	21, 31, 32	52, 54	21, 31, 32	21, 31, 32	MOVES2014a
Begin Model Year	1996	1987	1987	1987	1996	Annual testing; program specifications[3]
End Model Year	2009	1995	2009	1995	2009	Annual testing; program specifications
Inspection Frequency	1	1	1	1	1	Annual testing; program specifications[4]
Test Standards Description	Exhaust OBD[5] Check	ASM[6] 2525/ 5015 Phase-in Cut points	Two-mode, 2500 RPM[7]/Idle Test	Evaporative Gas Cap Check	Evaporative Gas Cap and OBD Check	Annual testing; program specifications[8]
Test Standards ID	51	23	12	41	45	MOVES2014a
I/M Compliance	93.12% for source use type 21, 91.26% for source use type 31 and 85.67% for source use type 32[9]					MOVES2014a

[2] Wise County does not have an I/M Program
[3] Inputs provided by the TCEQ
[4] Inputs provided by the TCEQ
[5] On-board Diagnostic
[6] Acceleration Simulation Mode
[7] Revolutions Per Minute
[8] Inputs provided by the TCEQ
[9] http://www.epa.gov/otaq/models/moves/documents/420b15007.pdf

Exhibit 4.4. MOVES2014a I/M Descriptive Inputs for Subject Counties (continued)

2017						
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data						
I/M Program ID	20	21	22	23	24	MOVES2014a
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	112	MOVES2014a
Source Use Type	21, 31, 32	21, 31, 32	52, 54	21, 31, 32	21, 31, 32	MOVES2014a
Begin Model Year	1996	1993	1993	1993	1996	Annual testing; program specifications
End Model Year	2015	1995	2015	1995	2015	Annual testing; program specifications
Inspection Frequency	1	1	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	ASM 2525/ 5015 Phase-in Cut points	Two-mode, 2500 RPM/ Idle Test	Evaporative Gas Cap Check	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
Test Standards ID	51	23	12	41	45	MOVES2014a
I/M Compliance	93.12% for source use type 21, 91.26% for source use type 31 and 85.67% for source use type 32					Expected compliance (%) - MOVES2014a Default

Exhibit 4.4. MOVES2014a I/M Descriptive Inputs for Subject Counties (continued)

2018						
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data						
I/M Program ID	20	21	22	23	24	MOVES2014a
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	112	MOVES2014a
Source Use Type	21, 31, 32	21, 31, 32	52, 54	21, 31, 32	21, 31, 32	MOVES2014a
Begin Model Year	1996	1994	1994	1994	1996	Annual testing; program specifications
End Model Year	2016	1995	2016	1995	2016	Annual testing; program specifications
Inspection Frequency	1	1	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	ASM 2525/5015 Phase-in Cut points	Two-mode, 2500 RPM/Idle Test	Evaporative Gas Cap Check	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
Test Standards ID	51	23	12	41	45	MOVES2014a
I/M Compliance	93.12% for source use type 21, 91.26% for source use type 31 and 85.67% for source use type 32					Expected compliance (%) - MOVES2014a Default

Exhibit 4.4. MOVES2014a I/M Descriptive Inputs for Subject Counties (continued)

2020				
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data				
I/M Program ID	20	22	24	MOVES2014a
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	MOVES2014a
Source Use Type	21, 31, 32	52, 54	21, 31, 32	MOVES2014a
Begin Model Year	1996	1996	1996	Annual testing; program specifications
End Model Year	2018	2018	2018	Annual testing; program specifications
Inspect Frequency	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	Two-mode, 2500 RPM/Idle Test	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
Test Standards ID	51	12	45	MOVES2014a
I/M Compliance	93.12% for source use type 21, 91.26% for source use type 31 and 85.67% for source use type 32			Expected compliance (%) - MOVES2014a Default

Exhibit 4.4. MOVES2014a I/M Descriptive Inputs for Subject Counties (continued)

2021				
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data				
I/M Program ID	20	22	24	MOVES2014a
Pollutant Process ID	101, 102, 201, 202, 301, 302	101, 102, 201, 202, 301, 302	112	MOVES2014a
Source Use Type	21, 31, 32	52, 54	21, 31, 32	MOVES2014a
Begin Model Year	1997	1997	1997	Annual testing; program specifications
End Model Year	2019	2019	2019	Annual testing; program specifications
Inspect Frequency	1	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	Two-mode, 2500 RPM/Idle Test	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
Test Standards ID	51	12	45	MOVES2014a
I/M Compliance	93.12% for source use type 21, 91.26% for source use type 31 and 85.67% for source use type 32			Expected compliance (%) - MOVES2014a Default

Exhibit 4.5. Fuel Formulations

	Pre-1990 Controls			2011		
Counties	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**
Fuel Type	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**
Fuel Formulation ID	10001	10002	32500	10707	10727	30572
Fuel Subtype ID	10	10	20	12	12	20
RVP	7.80	8.70	0.00	6.99	7.39	0.00
Sulfur Level	429.96	432.12	2,500.00	24.80	29.27	5.72
Ethanol Volume	0.00	0.00	0.00	9.70	9.78	0.00
Methyl Tertiary Butyl Ether (MTBE) Volume	0.00	0.00	0.00	0.00	0.00	0.00
Ethyl Tertiary Butyl Ether (ETBE) Volume	0.00	0.00	0.00	0.00	0.00	0.00
Tertiary Amyl Methyl Ether (TAME) Volume	0.00	0.00	0.00	0.00	0.00	0.00
Aromatic Content	26.40	26.40	0.00	14.48	25.23	0.00
Olefin Content	11.90	11.90	0.00	11.79	11.16	0.00
Benzene Content	1.64	1.64	0.00	0.48	0.96	0.00
e200	46.04	50.00	0.00	47.19	49.08	0.00
e300	81.43	83.00	0.00	85.22	81.36	0.00
Vol To Wt Percent Oxy	0.00	0.00	0.00	0.3653	0.3653	0.00
BioDiesel Ester Volume	0.00	0.00	0.00	0.00	0.00	0.00
Cetane Index	0.00	0.00	0.00	0.00	0.00	0.00
PAH Content	0.00	0.00	0.00	0.00	0.00	0.00
T50	207.90	199.82	0.00	209.44	204.74	0.00
T90	336.54	329.41	0.00	325.41	334.89	0.00

Exhibit 4.5. Fuel Formulations (continued)

	2017			2018, 2020, 2021		
Counties	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**
Fuel Type	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**
Fuel Formulation ID	17724	17734	30572	18724	18734	30011
Fuel Subtype ID	12	12	20	12	12	20
RVP	7.00	7.54	0	7.00	7.80	0
Sulfur Level	22.11	21.28	6.37	10.00	10.00	11.00
Ethanol Volume	9.67	9.66	0	9.67	9.66	0
MTBE Volume	0	0	0	0	0	0
ETBE Volume	0	0	0	0	0	0
TAME Volume	0	0	0	0	0	0
Aromatic Content	14.74	25.35	0	14.74	25.35	0
Olefin Content	10.74	8.33	0	10.74	8.33	0
Benzene Content	0.46	0.76	0	0.46	0.61	0
e200	49.21	49.45	0	49.21	49.45	0
e300	85.13	82.68	0	85.13	82.68	0
Vol To Wt Percent Oxy	0.3653	0.3653	0	0.3653	0.3653	0
BioDiesel Ester Volume	0	0	0	0	0	0
Cetane Index	0	0	0	0	0	0
PAH Content	0	0	0	0	0	0
T50	202.52	203.73	0	202.52	203.73	0
T90	325.77	327.68	0	325.77	327.68	0

Notes: (TTI, January 2018): **Pre-1990 controls** gasoline: used select MOVES 1990 default formulations (see defaults: fuelformulationID [FFID] 1007 and 1034) with RVP adjustment (for FFID 1034), and replaced the default FFIDs with unique, arbitrary values. Pre-1990 diesel sulfur: based on NIPER U.S. refiner survey summary information which placed average sulfur for the typical No. 2 diesel, within the post-1979/pre-1993 regulation period, in the 2500-3000 ppm range. **2011/2017** gasoline: used Texas summer gasoline data from EPA DFW RFG compliance surveys and TCEQ/ERG statewide surveys from each year. TTI calculated gasoline grade averages then the overall weighted composites using 2011 and 2016 [latest] gasoline sales fractions (based on Texas annual reformulated and conventional gasoline volumes from EIA "Prime Supplier Sales Volumes for Petroleum Products" data). TTI updated TCEQ/ERG survey summary results using the MOVES fuel region aggregations (instead of the original TxDOT District aggregation). Diesel sulfur: TTI aggregated data to the state level to calculate average diesel sulfur content. **2018 and later** (future) gasoline: formulations are the same as 2017 (based on latest local survey data), except for RFG, average sulfur level was set to the expected future year value (i.e., MOVES default [Tier 3 annual average standard]); and for conventional gasoline the regulated properties RVP, sulfur level, and benzene content were replaced with expected future year values (i.e., the appropriate MOVES defaults). Diesel sulfur: set to the expected Texas future year value (conservative level based on local data and also within the ULSD annual average standard).

Area Specific Calculations and Procedures

SourceUse Type Distribution

Sourceuse type age distributions are calculated from TxDMV vehicle registration data. July data sets of 2014 utilized for light- and heavy-duty vehicle classes. MOVES2014a default values are used for bus categories. Light-duty registration data for Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties are weighted for commute patterns with the County-to-County Worker Flow data from the 2013 five-year American Community Survey. Exhibit 4.6 identifies the percentages applied for this weighted adjustment. The TTI methodology is applied to the heavy-duty vehicle data for developing registration for all heavy-duty vehicles. These files are included in Appendix A.

Exhibit 4.6: County-to-County Worker Flow[10]

	County of Employment									
Resident County	**Collin**	**Dallas**	**Denton**	**Ellis**	**Johnson**	**Kaufman**	**Parker**	**Rockwall**	**Tarrant**	**Wise**
Collin	65.38%	10.25%	5.08%	0.28%	0.20%	0.97%	0.05%	7.63%	0.87%	0.00%
Dallas	19.09%	65.97%	10.19%	10.73%	1.32%	15.83%	0.98%	23.65%	7.69%	0.69%
Denton	11.45%	7.85%	75.56%	0.37%	0.17%	0.66%	0.94%	0.58%	3.30%	3.12%
Ellis	0.16%	1.79%	0.17%	79.39%	1.43%	0.74%	0.10%	0.00%	0.55%	0.21%
Hood	0.03%	0.06%	0.05%	0.10%	2.27%	0.00%	2.39%	0.00%	0.53%	0.37%
Hunt	0.76%	0.42%	0.13%	0.12%	0.00%	4.37%	0.03%	9.42%	0.03%	0.00%
Johnson	0.05%	0.32%	0.32%	3.46%	76.23%	0.00%	1.45%	0.16%	3.21%	0.69%
Kaufman	0.29%	1.57%	0.14%	0.74%	0.02%	72.64%	0.00%	3.59%	0.11%	0.02%
Parker	0.02%	0.14%	0.09%	0.06%	0.52%	0.02%	77.41%	0.00%	2.57%	5.86%
Rockwall	0.68%	1.23%	0.14%	0.12%	0.06%	3.70%	0.00%	53.95%	0.06%	0.13%
Tarrant	2.02%	10.29%	7.36%	4.63%	17.47%	1.06%	14.11%	1.02%	80.26%	10.75%
Wise	0.07%	0.11%	0.76%	0.01%	0.31%	0.02%	2.55%	0.00%	0.82%	78.15%

Source: 2013 5-year American Community Survey.

[10] The sum of each county maybe less than or more than 100% due to rounding.

Fuel Engine Fractions
Diesel fractions for heavy-duty vehicle categories utilized 12-county summed yearly July registration data for modeling 2011, 2017, 2018, 2020 and 2021 analysis years. July 2011 registration data is used for modeling 2011 and July 2014 is used for modeling 2017, 2018, 2020, and 2021 analysis years. Light-duty and bus categories utilize MOVES2014 default values. All diesel fraction files, included in Appendix A, list specific data used for this analysis.

MOVES2014 Emission Factors
MOVES2014a emission factors for all the control scenarios are reported in Appendix C.

Adjustments
Adjustments are applied to the emission factors in a post-process step. Texas Low Emission Diesel (TxLED) NO_X Adjustment is applied to the emission factors. VMT Mix adjustment is applied simultaneously with the emission calculation procedure discussed in Chapter 4.

TxLED NOx Adjustment
NO_X emission factors for diesel vehicle classes are adjusted to apply the federal low emission diesel program. Exhibit 4.7 lists the appropriate adjustment for each vehicle class.

Exhibit 4.7: TxLED NO_x Adjustments

Source Use Type	Adjustment Factors				
	2011	2017	2018	2020	2021
Passenger Car	0.9413	0.9483	0.9501	0.9508	0.9509
Passenger Truck	0.9465	0.9495	0.9498	0.9501	0.9505
Light Commercial Truck	0.9429	0.9465	0.9469	0.9481	0.9481
Intercity Bus	0.9417	0.9426	0.9430	0.9439	0.9443
Transit Bus	0.9419	0.9428	0.9432	0.9441	0.9445
School Bus	0.9420	0.9428	0.9431	0.9439	0.9444
Refuse Truck	0.9438	0.9458	0.9463	0.9474	0.9479
Single Unit Short-Haul Truck	0.9491	0.9511	0.9512	0.9515	0.9516
Single Unit Long-Haul Truck	0.9495	0.9512	0.9513	0.9516	0.9516
Motor Home	0.9439	0.9453	0.9458	0.9467	0.9471
Combination Short-Haul Truck	0.9460	0.9489	0.9491	0.9499	0.9502
Combination Long-Haul Truck	0.9438	0.9469	0.9474	0.9482	0.9490

Source: NCTCOG

Sourceusetype Population
TxDMV registration data was used for developing sourceusetype (SUT) population for DFW area. July 2011 registration data is used for developing 2011 SUT population and July 2014 registration date is used for developing 2017, 2018, 2020, and 2021 analysis years SUT population. For years 2017, 2018, 2020, and 2021 VMT growth rate was used to forecast SUT

population. Exhibit 4.8 summarizes the SUT by county for all analysis years. All SUT population files are included in Appendix A.

Exhibit 4.8: Sourceusetype Population

Counties	2011	2017	2018	2020	2021
Collin	566,217	671,965	683,311	710,212	721,399
Dallas	1,668,348	1,915,291	1,947,630	2,024,308	2,056,198
Denton	455,549	544,958	554,161	575,981	585,048
Ellis	122,968	136,468	138,776	144,236	146,505
Johnson	118,988	134,802	137,079	142,478	144,717
Kaufman	76,000	88,533	90,029	93,573	95,045
Parker	93,542	109,135	110,979	115,347	117,163
Rockwall	61,947	71,756	72,967	75,839	77,033
Tarrant	1,289,964	1,492,912	1,518,118	1,577,885	1,602,745
Wise	52,630	59,144	60,145	62,512	63,497
Total	**4,506,153**	**5,224,964**	**5,313,195**	**5,522,371**	**5,609,350**

Vehicle Miles of Travel Mix (or Fractions)

VMT Mix is applied to the emission factors in a post-process methodology. The VMT mix enables assignment of emission factors by vehicle type to a total volume to calculate emissions on a link or functional class. VMT mix is estimated for rural and urban freeways, arterials, collectors and high occupancy vehicle lanes for three time periods.

Vehicle counts reported in the latest available Texas Department of Transportation (TxDOT) Vehicle Classification Report provide a base for the distribution of vehicles by type and functional class for the freeway, arterial, and collector VMT Mixes. The number of vehicles in each of the 12 axle-based categories are combined into intermediate groups, and then disaggregated into MOVES2014a Source Use Types by applying appropriate TxDMV registration data and/or MOVES2014a defaults. Exhibit 4.9 outlines this process. For each functional class, the values are aggregated across the total vehicles to determine the fraction of vehicles from each class. Motorcycles are allocated as 0.1 percent for each functional class, subtracted from the Light-duty Gasoline Vehicles category.

This “temporary” VMT mix calculation is then redistributed using local truck and non-truck splits identified by the DFX model. This process is performed for each of the three functional classes and three time periods, where AM peak is 6:30 a.m. to 8:59 a.m., PM peak is 3:00 p.m. to 6:29 p.m., and Off-Peak represents all other hours of the day. Motorcycles, light-duty vehicles, and two-axle light-duty trucks are classified as non-trucks. Trucks and heavy-duty vehicles with three axles or more, to include buses, are defined as trucks.

Exhibit 4.9: Vehicle Classification Process

Axle-Based Vehicle Classifications		Intermediate Groups/HPMSVtypeID[11]		Detailed Groups	
C	**Passenger Vehicles**	PV	Light-Duty Vehicles (25)	Passenger Car	Passenger Gasoline Vehicle
					Passenger Diesel Vehicle
					Motorcycle (MC)[12]
P	**2 Axle, 4 Tire Single Unit**			Passenger Truck	Passenger Gasoline Truck
					Passenger Gasoline Truck
				Light Commercial Truck	Light Commercial Gasoline Truck
					Light Commercial Gasoline Truck
B	**Buses**	Bus	Buses (40)	School Bus	Gasoline School Bus*
					Diesel School Bus*
				Transit Bus	Gasoline Transit Bus*
					Diesel Transit Bus*
				Diesel Intercity Bus*	
SU2	**2 Axle, 6 Tire Single Unit**	Heavy-Duty Trucks	Single Unit Heavy-Duty Vehicles (50)	Single Unit Short-haul Truck	Single Unit Short-haul Gasoline Truck*
SU3	**3 Axle, Singe Unit**				Single Unit Short-haul Diesel Truck*
SU4	**4+ Axle, Single Unit**			Single Unit Long-haul Truck	Single Unit Long-haul Gasoline Truck*
SE4	**3 or 4 Axle, Single Trailer**				Single Unit Long-haul Diesel Truck*

[11] HPMS – Highway Performance Monitoring System
[12] Motorcycles are allocated as 0.1 percent for each functional class, subtracted from the light-duty vehicles.

Exhibit 4.9. Vehicle Classification Process (continued)

<table>
<tr><th colspan="2">Axle-Based Vehicle Classifications</th><th colspan="2">Intermediate Groups/HPMSVtypeID[2]</th><th colspan="2">Detailed Groups</th></tr>
<tr><td>SE5</td><td>5 Axle, Single Trailer</td><td rowspan="5">Heavy-Duty Trucks</td><td rowspan="5">Combination Heavy-Duty Vehicles (60)</td><td rowspan="3">Combination Short-haul Truck</td><td rowspan="2">Combination Short-haul Gasoline Truck*</td></tr>
<tr><td>SE4</td><td>3 or 4 Axle, Single Trailer</td></tr>
<tr><td>SD5</td><td>5 Axle, Multi Trailer</td><td>Combination Short-haul Diesel Truck*</td></tr>
<tr><td>SD6</td><td>6 Axle, Multi Trailer</td><td colspan="2" rowspan="2">Combination Long-haul Diesel Truck*</td></tr>
<tr><td>SD7</td><td>7+ Axle, Multi Trailer</td></tr>
</table>

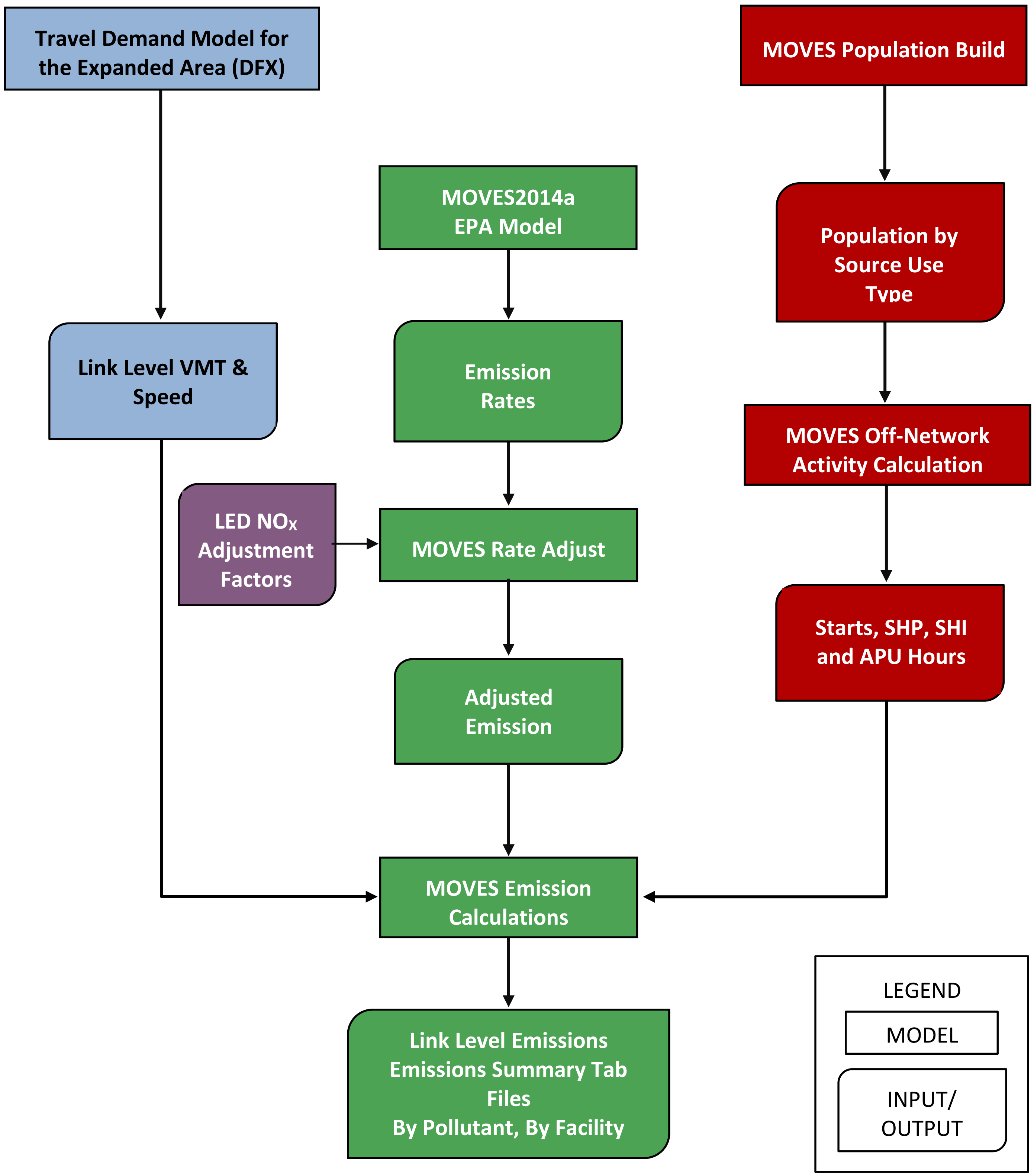
*Categories calculated using MOVES2014a defaults

CHAPTER 5: EMISSION CALCULATION PROCEDURE

Emissions estimates are calculated using *"TTI emissions inventory estimation utilities using moves: movesutl"* developed by the Texas A&M Transportation Institute (TTI). This software combines vehicle activity and emission factors to create emission estimates.

Exhibit 5.1 outlines the emission calculation modeling process that is used to calculate the emissions estimates for the Dallas-Fort Worth (DFW) ozone nonattainment area. Different procedures were applied for DFW Expanded Travel Demand Model (DFX) counties outlined in the following sections.

Exhibit 5.1: MOVES2014a Emission Modeling Process



CHAPTER 6: SUMMARY OF VEHICLE MILES OF TRAVEL, SPEED, AND EMISSIONS

Vehicle Miles of Travel Estimates

Appendix E contains the summarized VMT estimates by the analysis year and time-of-day (TOD) for the counties.

Speed Estimates

Appendix E contains the summarized speeds by the analysis year and TOD for the counties.

Emission Estimates

The final county emission estimates for each analysis year and control scenarios are summarized in Exhibit 6.1. Additional modeled pollutants not shown in this section are available in Appendices D and E.

Appendix D contains the detailed emissions for all counties by analysis year, control scenarios TOD.

Appendix E contains the summarized emissions for all counties by analysis year, control scenarios TOD.

Exhibit 6.1: Final Emission Estimates for the 10-County Nonattainment Area

Oxides of Nitrogen Emissions (tons/day) Summer Season, Midweek					
Adjusted Base Year					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	N/A	82.26	82.23	82.18	82.14
Dallas	N/A	285.35	285.31	285.53	285.57
Denton	N/A	74.40	74.40	74.35	74.33
Ellis	N/A	35.56	35.56	35.56	35.55
Johnson	N/A	23.26	23.25	23.25	23.25
Kaufman	N/A	27.48	27.48	27.49	27.49
Parker	N/A	23.10	23.10	23.10	23.10
Rockwall	N/A	10.93	10.93	10.89	10.89
Tarrant	N/A	187.65	187.67	187.58	187.55
Wise	N/A	18.26	18.26	18.25	18.25
Total	**N/A**	**768.25**	**768.19**	**768.18**	**768.12**
Pre-90 Controls					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	82.33	99.71	102.24	107.97	110.58
Dallas	284.72	329.01	333.85	344.09	348.14
Denton	74.40	84.69	86.57	89.30	90.91
Ellis	35.88	44.78	46.11	48.89	50.31
Johnson	23.38	28.55	29.27	30.93	31.73
Kaufman	27.91	34.18	35.21	37.38	38.43
Parker	23.58	29.63	30.52	32.23	33.01
Rockwall	10.99	12.66	12.94	13.41	13.69
Tarrant	186.18	219.59	223.01	231.42	234.85
Wise	18.39	20.78	21.31	22.29	22.78
Total	**767.76**	**903.58**	**921.03**	**957.91**	**974.43**

Exhibit 6.1: Final Emission Estimates for the 10-County Nonattainment Area (continued)

Nitrogen Oxides Emissions (tons/day) Summer Season, Midweek					
FMVCP					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	35.44	22.44	20.23	16.99	15.63
Dallas	129.28	79.49	71.12	58.58	53.33
Denton	32.25	19.46	17.53	14.43	13.24
Ellis	16.39	10.85	9.83	8.31	7.70
Johnson	10.53	6.75	6.06	5.05	4.64
Kaufman	12.87	8.37	7.59	6.43	5.94
Parker	10.39	7.17	6.58	5.70	5.34
Rockwall	5.22	3.30	3.00	2.53	2.34
Tarrant	82.38	52.14	46.75	38.80	35.43
Wise	8.66	5.55	5.10	4.43	4.14
Total	**343.41**	**215.52**	**193.79**	**161.25**	**147.73**
Fuel Controls					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	26.62	15.84	12.89	10.65	9.75
Dallas	97.32	56.44	45.66	37.00	33.54
Denton	24.95	14.18	11.66	9.44	8.64
Ellis	14.11	8.89	7.58	6.36	5.89
Johnson	8.69	5.23	4.36	3.59	3.29
Kaufman	10.96	6.74	5.71	4.80	4.43
Parker	10.39	7.17	6.58	5.70	5.34
Rockwall	4.31	2.59	2.21	1.86	1.72
Tarrant	61.59	36.62	29.62	24.09	21.88
Wise	7.49	4.62	4.04	3.52	3.31
Total	**266.43**	**158.32**	**130.31**	**107.01**	**97.79**

Exhibit 6.1: Final Emission Estimates for the 10-County Nonattainment Area (continued)

Nitrogen Oxides Emissions (tons/day) Summer Season, Midweek					
Inspection/Maintenance					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	24.34	14.55	11.93	9.89	9.08
Dallas	88.66	51.70	42.19	34.33	31.22
Denton	23.06	13.14	10.89	8.85	8.11
Ellis	13.34	8.43	7.24	6.09	5.65
Johnson	8.08	4.88	4.10	3.38	3.10
Kaufman	10.29	6.35	5.42	4.58	4.24
Parker	9.89	6.83	6.28	5.46	5.12
Rockwall	4.02	2.43	2.09	1.76	1.64
Tarrant	56.15	33.49	27.30	22.27	20.29
Wise	7.49	4.62	4.04	3.52	3.31
Total	**245.32**	**146.42**	**121.48**	**100.13**	**91.76**
TxLED					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	23.77	14.22	11.64	9.65	8.86
Dallas	86.65	50.55	41.17	33.51	30.47
Denton	22.43	12.81	10.59	8.61	7.89
Ellis	12.87	8.14	6.98	5.88	5.45
Johnson	7.85	4.75	3.98	3.29	3.02
Kaufman	9.94	6.15	5.24	4.42	4.09
Parker	9.52	6.59	6.06	5.27	4.94
Rockwall	3.90	2.35	2.02	1.71	1.59
Tarrant	54.91	32.79	26.68	21.78	19.84
Wise	7.24	4.46	3.89	3.39	3.18
Total	**239.08**	**142.81**	**118.25**	**97.51**	**89.33**

Exhibit 6.1: Final Emission Estimates for the 10-County Nonattainment Area (continued)

Volatile Organic Compounds (tons/day) Summer Season, Midweek					
Adjusted Base Year					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	N/A	35.37	35.36	35.28	35.26
Dallas	N/A	119.49	119.45	119.26	119.26
Denton	N/A	29.55	29.54	29.47	29.47
Ellis	N/A	9.53	9.53	9.51	9.51
Johnson	N/A	7.88	7.88	7.87	7.87
Kaufman	N/A	7.31	7.31	7.29	7.29
Parker	N/A	6.41	6.41	6.40	6.40
Rockwall	N/A	4.04	4.04	4.03	4.03
Tarrant	N/A	80.89	80.88	80.70	80.68
Wise	N/A	4.89	4.89	4.88	4.88
Total	**N/A**	**305.36**	**305.29**	**304.69**	**304.65**
Pre-90 Controls					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	34.96	42.17	43.21	45.49	46.57
Dallas	118.35	134.69	136.87	141.03	142.83
Denton	29.07	33.68	34.43	35.78	36.45
Ellis	9.33	11.01	11.28	11.91	12.23
Johnson	7.73	9.22	9.41	9.89	10.12
Kaufman	7.23	8.82	9.08	9.64	9.91
Parker	6.32	7.80	8.00	8.37	8.53
Rockwall	4.00	4.61	4.71	4.92	5.02
Tarrant	79.36	92.23	93.75	97.35	98.88
Wise	4.80	5.55	5.68	5.90	6.01
Total	**301.15**	**349.78**	**356.42**	**370.28**	**376.55**

Exhibit 6.1: Final Emission Estimates for the 10-County Nonattainment Area (continued)

Volatile Organic Compounds (tons/day) Summer Season, Midweek					
FMVCP					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	14.80	10.84	10.23	9.31	8.90
Dallas	53.53	36.36	33.97	30.37	28.78
Denton	12.42	8.91	8.41	7.60	7.25
Ellis	4.44	3.09	2.89	2.59	2.45
Johnson	3.66	2.60	2.43	2.18	2.06
Kaufman	3.36	2.31	2.15	1.91	1.80
Parker	2.82	2.06	1.94	1.75	1.65
Rockwall	1.92	1.33	1.25	1.13	1.07
Tarrant	35.68	25.77	24.21	21.91	20.84
Wise	2.29	1.54	1.45	1.29	1.21
Total	**134.92**	**94.81**	**88.93**	**80.04**	**76.01**
Fuel Controls					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	12.58	8.97	8.19	7.44	7.12
Dallas	45.03	29.85	26.98	24.08	22.82
Denton	10.58	7.44	6.81	6.15	5.86
Ellis	4.02	2.70	2.46	2.19	2.07
Johnson	3.36	2.31	2.11	1.88	1.78
Kaufman	2.94	1.97	1.79	1.59	1.49
Parker	2.82	2.06	1.94	1.75	1.65
Rockwall	1.76	1.19	1.09	0.98	0.93
Tarrant	30.73	21.56	19.63	17.69	16.82
Wise	2.05	1.36	1.25	1.12	1.05
Total	**115.87**	**79.41**	**72.25**	**64.87**	**61.59**

Exhibit 6.1: Final Emission Estimates for the 10-County Nonattainment Area (continued)

Volatile Organic Compounds (tons/day) Summer Season, Midweek					
Inspection/Maintenance					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	11.05	7.80	7.14	6.48	6.20
Dallas	39.57	25.91	23.45	20.96	19.87
Denton	9.34	6.50	5.95	5.37	5.12
Ellis	3.57	2.37	2.17	1.94	1.83
Johnson	2.96	2.01	1.84	1.65	1.56
Kaufman	2.62	1.74	1.58	1.41	1.33
Parker	2.51	1.81	1.71	1.55	1.46
Rockwall	1.56	1.04	0.96	0.86	0.82
Tarrant	27.01	18.71	17.05	15.39	14.64
Wise	2.05	1.36	1.25	1.12	1.05
Total	**102.24**	**69.25**	**63.10**	**56.73**	**53.88**
TxLED					
County	**2011**	**2017**	**2018**	**2020**	**2021**
Collin	11.05	7.80	7.14	6.48	6.20
Dallas	39.57	25.91	23.45	20.96	19.87
Denton	9.34	6.50	5.95	5.37	5.12
Ellis	3.57	2.37	2.17	1.94	1.83
Johnson	2.96	2.01	1.84	1.65	1.56
Kaufman	2.62	1.74	1.58	1.41	1.33
Parker	2.51	1.81	1.71	1.55	1.46
Rockwall	1.56	1.04	0.96	0.86	0.82
Tarrant	27.01	18.71	17.05	15.39	14.64
Wise	2.05	1.36	1.25	1.12	1.05
Total	**102.24**	**69.25**	**63.10**	**56.73**	**53.88**

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CHAPTER 7: LIST OF APPENDICES

Appendix A: MOVES2014a External Files

Appendix B: MOVES2014a Input and Output Database Files

Appendix C: MOVES2014a Emission Factor Files

Appendix D: County Emission Estimates (Tab-delimited Format)

Appendix E: Inventory Summary Files (Tab-delimited Format)

Appendix F: SCC and XML Files

Appendix G: Project Quality Control Report and Travel Model Validation Report

Appendix H: Supplement Files (MOVES RunSpecs and MYSQL Script)

Appendix I: Electronic Data Submittal Description