APPENDIX 10

DEVELOPMENT OF ON-ROAD EMISSION INVENTORIES FOR THE YEARS 2011, 2017, 2018, AND 2019

DALLAS-FORT WORTH 2008 EIGHT-HOUR OZONE NONATTAINMENT AREA REASONABLE FURTHER PROGRESS ON-ROAD MOBILE SOURCE EMISSIONS INVENTORIES

This appendix documents the development of the on-road mobile emissions inventory (EI) for the updates to the Dallas-Fort Worth Ozone Nonattainment Area (DFW) Rate of Further Progress (RFP) State Implementation Plan.

The development of the RFP EIs was done by the North Central Texas Council of Governments (NCTCOG) at the request and under the direction of the Texas Commission on Environmental Quality (TCEQ). The on-road mobile source EIs and control strategy reduction estimates reflect the most recent planning assumptions for the DFW transportation network. Complete documentation of the development and resulting EI is provided in the attached document, DFW RFP Inventories, Control Strategy Reductions, and Contingency Estimates for 2011, 2017, 2018, and 2019. The final emissions estimates are summarized in Chapter 5: *Summary of Vehicle Miles Travel, Speed, and Emissions*, in Exhibit 5-1. The supporting electronic documents for the EI development, including MOVES2014 input and output files and the post processing spreadsheets used to summarize the inventories are available upon request in electronic format. Please contact the TCEQ, Air Quality Division, Area and Mobile Source Inventory and Data Support Team if a copy of the electronic information is needed.

The report also documents the development of control strategy reduction estimates for each of the RFP milestone years between 2011 and 2018, and the contingency analysis year 2019. Control strategy emission reduction estimates include the effects of the Federal Motor Vehicle Control Program, the DFW vehicle inspection and maintenance program, federal reformulated gasoline Phase 1 and Phase 2, and the Texas Low Emission Diesel Program. The emissions summaries include estimates for all control scenarios. The control scenarios are the basis for quantifying the reductions for each control strategy.

North Central Texas
Council of Governments

Dallas-Fort Worth

Motor Vehicle Emissions Simulator 2014 (MOVES2014) - Based Reasonable Further Progress On-Road Inventories and Control Strategy Reductions

February 2015

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

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 **238 members**, including 16 counties, 169 cities, 22 independent school districts, and 31 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 over **6.5 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 15-member Executive Board. The **Executive Board** is supported by policy development, technical advisory, and study committees, as well as a professional staff of 310.

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).

North Central Texas Council of Governments
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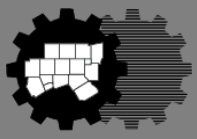
NCTCOG's Department of Transportation

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.



North Central Texas
Council of Governments

Dallas-Fort Worth

Motor Vehicle Emissions Simulator 2014 (MOVES2014) - Based Reasonable Further Progress On-Road Inventories and Control Strategy Reductions

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ABSTRACT

TITLE:	Dallas-Fort Worth Motor Vehicle Emissions Simulator (MOVES2014) - Based Reasonable Further Progress On-Road Inventories and Control Strategy Reductions
DATE:	February 2015
AUTHORS:	Jenny Narvaez Principal Air Quality Planner Jody Loza Air Quality Planner
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:	42
ABSTRACT:	The North Central Texas Council of Governments conducted a Reasonable Further Progress emission inventory to support the Texas Commission on Environmental Quality's effort to develop a Reasonable Further Progress State Implementation Plan for the Dallas-Fort Worth 10-county nonattainment area for the pollutant ozone. The ten 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, and 2019. The 10-county estimated on-road mobile source emissions are reported for volatile organic compounds, carbon monoxide, oxides of nitrogen, carbon dioxide, sulfur dioxide, ammonia, lead, particulate matter with aerodynamic diameters equal to or less than 2.5 microns,

particulate matter with aerodynamic diameters equal to or less than 10 microns, and all hazardous air pollutants for controlled and uncontrolled scenarios.

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GLOSSARY OF ABBREVIATIONS

ABY	-	Adjusted Base Year
ASM	-	Acceleration Simulation Model
ASWT	-	Average School Season Weekday
ATP	-	Anti-Tampering Program
ATR	-	Automatic Traffic Recorder
AVFT		Alternative Vehicle and Fuel Technologies
CAAA	-	Clean Air Act Amendments
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
DFW	-	Dallas-Fort Worth
DFX	-	Dallas-Fort Worth Expanded Travel Model
EPA	-	Environmental Protection Agency
GISDK	-	Geographic Information System Developer Kit
HAPs	-	Hazardous Air Pollutants
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
MOVES2014	-	Motor Vehicle Emissions Simulator
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
NSWD	-	Non-Summer Week Day
O_3	-	Ozone
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
SIP	-	State Implementation Plan
SO_2	-	Sulfur Dioxide
SUT	-	Source Use Type
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
VHT	-	Vehicle Hours of Travel
VMT	-	Vehicle Miles of Travel
VDF	-	Volume Delay Function
VOC	-	Volatile Organic Compounds

TABLE OF CONTENTS

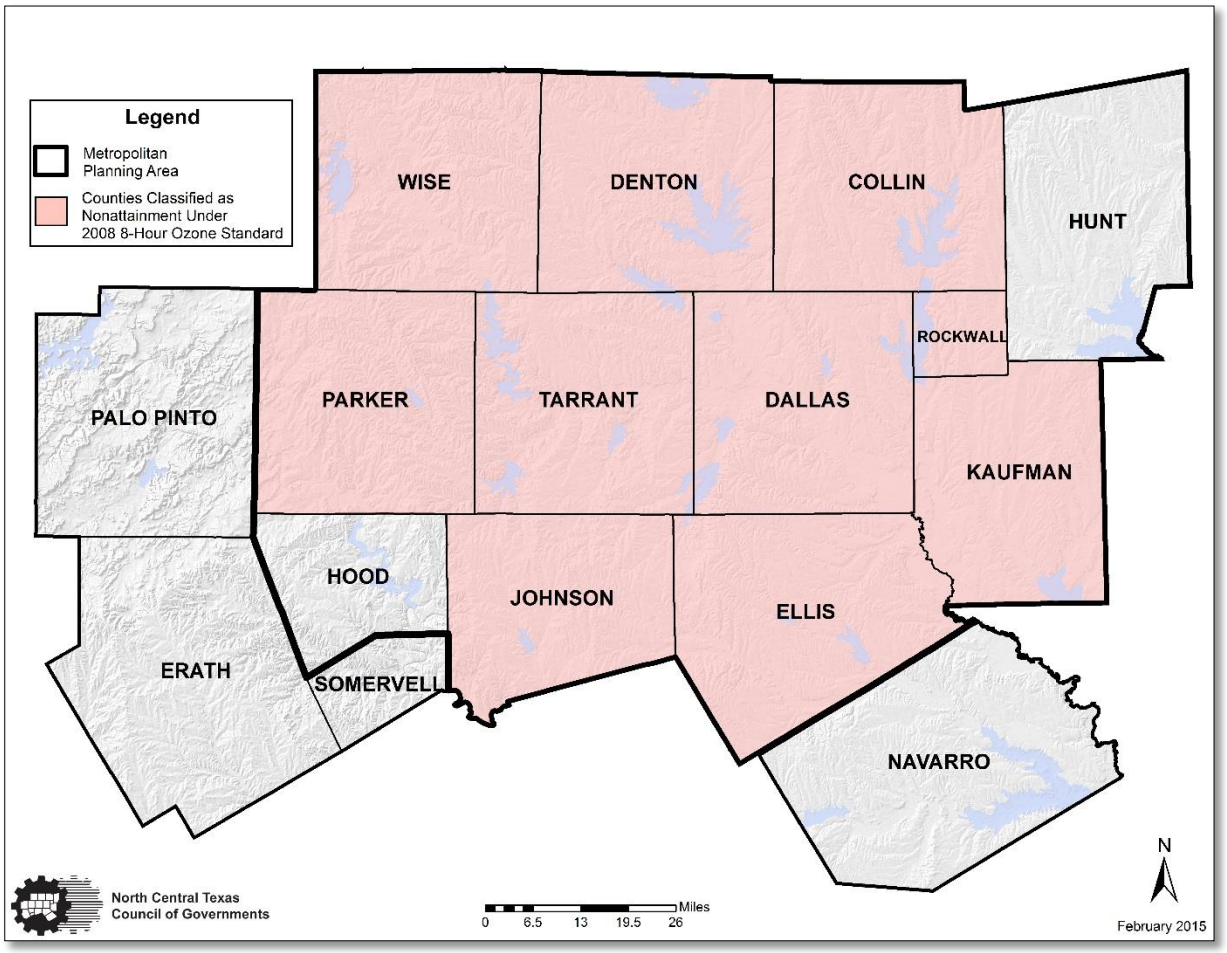
TABLE OF EXHIBITS

CHAPTER 1: INTRODUCTION

The North Central Texas Council of Governments (NCTCOG), in conjunction with the Texas Commission on Environmental Quality (TCEQ), has developed the Dallas-Fort Worth (DFW) Reasonable Further Progress (RFP) Emission Inventory.

This emission inventory covers the DFW 10-county nonattainment area of Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties as shown in Exhibit 1.1.

Exhibit 1.1: DFW Nonattainment Area Map



This report documents the methodology and results of the RFP emission inventory. The RFP emission inventory analysis years include: 2011, 2017, 2018, and 2019. Chapter 1 outlines the background for the RFP emission inventory, the purpose and scope of the study, the modeling approach, and provides a summary of the ten-county estimated emission 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, and 2019 analysis year vehicle activity and report vehicle activity in hourly periods. Consistent with previous emission inventory practices, a comparison was made between the Dallas-Fort worth Expanded Travel Demand Mode (DFX) 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 United States Environmental Protection Agency's (EPA) mobile source model, Motor Vehicle Emission Simulator version 2014 (MOVES2014). This chapter documents regionally specific calculations, procedures, MOVES2014 emission factors, and adjustments to more accurately reflect regional vehicle emissions emitted. The calculations and procedures include vehicle registration, diesel fractions, 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.

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 National Ambient Air Quality Standards (NAAQS) for widespread pollutants considered harmful to public health and the environment. The EPA set NAAQS for six of the principal pollutants; ozone (O_3), particulate matter (PM), carbon monoxide (CO), sulfur dioxide (SO_2), oxides of nitrogen (NO_X), and lead (Pb).

With the signing of the CAAA into law, the four counties of Collin, Dallas, Denton, and Tarrant County in the DFW region were designated as nonattainment under the 1-hour NAAQS for the pollutant ozone. 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 NAAQS, EPA determined the 1-hour NAAQS was insufficient to protect human health. As a result, the EPA developed the 1997 8-hour 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 NAAQS, with an effective designation date of June 15, 2004. The nine-county nonattainment region 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 region was classified as "Serious" with the new attainment date of June 2013. On May 21, 2012, the DFW region was reclassified as "moderate" nonattainment for the 2008 8-hour ozone standard (≤75 ppb), Wise County was added as the tenth nonattainment county. Under this revised standard, the ten counties, shown in Exhibit 1.2, must reach attainment in 2018.

The TCEQ, state's environmental agency, is required under the CAAA to submit State Implementation Plan (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 emission reductions is subsequently defined as the "Reasonable Further Progress" 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 is responsible for developing and maintaining on-road mobile source emission inventories for the region. NCTCOG applies a four-step travel demand model process using TransCAD software to forecast regional vehicle activity and utilizes EPA's MOVES2014 with a post-processing application to estimate regional mobile source emissions.

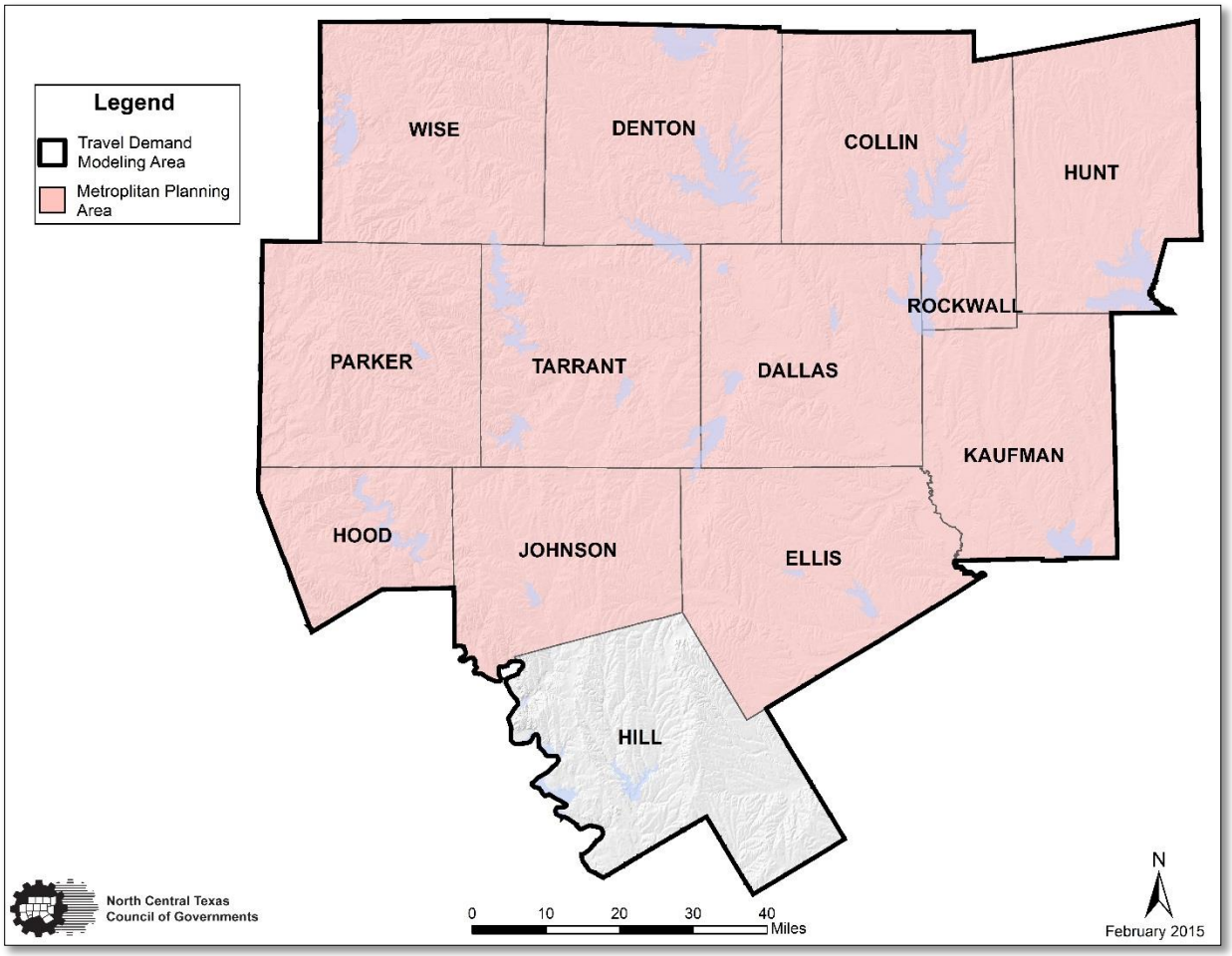
Purpose and Scope of Study

NCTCOG conducted 2011, 2017, 2018, and 2019 analysis year on-road emission inventories to support TCEQ's efforts to develop a RFP SIP for the DFW ten-county nonattainment area. The on-road mobile pollutants evaluated for these analysis years are volatile organic compounds (VOC), (CO), oxides of nitrogen (NO_X), carbon dioxide (CO_2), sulfur dioxide (SO_2), ammonia (NH_3), lead (Pb), particulate matter with aerodynamic diameters equal to or less than 2.5 microns ($PM_{2.5}$), particulate matter with aerodynamic diameters equal to or less than 10 microns (PM_{10}), and all hazardous air pollutants (HAPs).

Modeling Approach

The DFX is employed to estimate VMT and emissions for the 2011, 2017, 2018, and 2019 analysis years. 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 NCT Metropolitan Planning Area (MPA) boundary; however, to capture travel from outside areas, Hill County is included in the modeling domain. The 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. Adjusted Base Year is modeled for 2017, 2018, and 2019 utilizing 2011 base year VMT.

Exhibit 1.3: Emissions Inventory Scenarios Modeled[1]

Reasonable Further Progress Scenarios	Input Files
Adjusted Base Year	ABY
Pre-1990 Federal Motor Vehicle Control Program	PR90
Federal Reformulated Gasoline Model Only Phase 2	RFG
FMVCP Tier 1 FMVCP Tier 2 FMVCP – Heavy-Duty 2007	FMVCP
Expanded Inspection & Maintenance (I/M) and Anti-Tampering Program (ATP)	Control Strategy
Tier-3 Gasoline Sulfur Rule	T3
Texas Low-Emission Diesel[2]	TxLED

[1]In the table above, each scenario contains the control strategies of all previous scenarios.
[2]Control Strategy 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 Exhibit 1.4. Appendix G contains the detailed emissions by county by pollutant and by time-of-day for all NCT counties modeled.

VMT for summer weekday for each analysis year are shown in Exhibit 1.5. Appendix E contains the summarized VMT estimates by the analysis year for all NCT counties modeled.

Exhibit 1.4: On-Road Emissions for the DFW 10-County Modeling Domain

Summer Season, Midweek On-Road Emissions (tons/day)				
Oxides of Nitrogen (NO_x)				
	2011	**2017**	**2018**	**2019**
ABY	N/A	743.22	742.64	742.34
PR90	746.30	870.71	892.46	911.16
FMVCP	343.92	219.32	198.97	181.29
RFG	268.21	165.92	149.56	135.84
CS	247.71	153.66	138.69	126.15
Tier 3	N/A	138.75	124.42	112.84
TxLED	241.13	134.87	120.94	109.68
Volatile Organic Compounds (VOC)				
	2011	**2017**	**2018**	**2019**
ABY	N/A	338.78	338.55	338.36
PR90	334.25	392.00	401.79	410.60
FMVCP	147.07	104.96	99.17	94.41
RFG	117.71	83.50	78.88	75.08
CS	104.12	72.93	68.82	65.61
Tier 3	N/A	70.16	66.09	62.91
TxLED	104.12	70.16	66.09	62.91

Exhibit 1.5: Vehicle Miles of Travel for the DFW 10-County Modeling Domain

Summer Season, Midweek Vehicle Miles of Travel (miles/day)				
	2011	**2017**	**2018**	**2019**
ABY	N/A	187,951,748	187,951,748	187,951,748
PR90	187,951,748	216,097,722	221,520,532	225,856,541
FMVCP	187,951,748	216,097,722	221,520,532	225,856,541
RFG	187,951,748	216,097,722	221,520,532	225,856,541
CS	187,951,748	216,097,722	221,520,532	225,856,541
Tier 3	N/A	216,097,722	221,520,532	225,856,541
TxLED	187,951,748	216,097,722	221,520,532	225,856,541

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 (DFW) Expanded Travel Demand model (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. The DFX supports federally required regional transportation planning efforts for the DFW region. 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 Inventory 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, and 2019. Each facility link in the network has the following attributes:

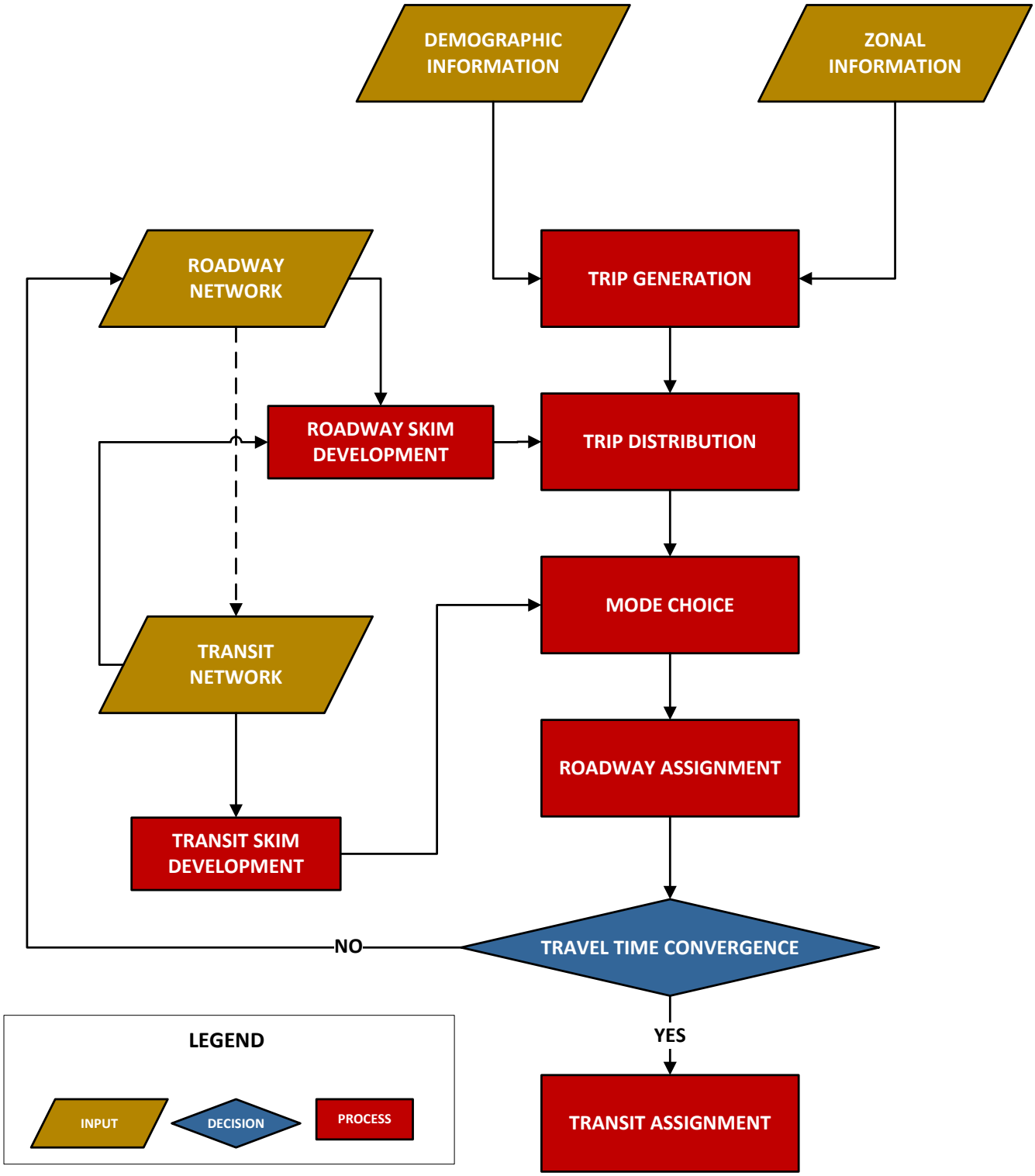
- Network node numbers (defining the beginning and end of each link)
- Number of Operational Lanes in the AM PM Peak and Off-Peak Periods
- Functional Classification
- Divided/Undivided Roadway Code
- Type of Traffic Control At Each End of the Link
- Traffic Direction (One- or Two-Way)
- Length of Link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

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 socioeconomic variables for each zone. The data is organized by traffic survey zone (TSZ), the smallest zone size available in the DFX. The data for each TSZ includes zone centroid; median household income; number of households; population; basic, retail, and service employment; and land area. There are 5,386 TSZs in the model (5,303 internal zones plus 83 externals), which is the level of detail 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. Exhibit 2.1 depicts the flowchart of the DFX process, 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.

Exhibit 2.1: DFW Expanded Travel Model Process Forecast Flowchart



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, and 2019 population and employment forecasts were generated with the Disaggregate Residential Allocation Model/Employment Allocation Model model using travel times from the Roadway and Transit Assignment Steps consistent with current planning practice. The data can be seen in Exhibit 2.2. 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 US 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 2.2: Socio-Economic Demographic Summary

DFW Nonattainment Area				
Analysis Year	**2011**	**2017**	**2018**	**2019**
Population	6,323,168	7,044,148	7,167,649	7,291,202
Number of Households	2,303,683	2,542,166	2,584,079	2,623,179
Employment Types				
Basic	989,806	1,060,756	1,070,407	1,080,003
Retail[1]	614,623	451,633	458,281	464,886
Service	2,315,389	2,940,297	3,001,796	3,063,217
Total Employment	3,919,818	4,452,686	4,530,484	4,608,106

[1]The decrease in Retail Employment between 2011 and 2017 is a result of a change in employment categorization by the National American Industry Classification System.

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 am to 9:00 am Morning Peak, 3:00 pm to 6:30 pm 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+ 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 curves were calibrated based on the available 2004 daily link traffic counts at more than 10,000 locations (collected by the Texas Department of Transportation [TxDOT]), and the travel time runs along freeway and arterial corridors (performed by several consultants as part of other projects). The time-of-day link counts were not available for the calibration of the model in each time period.

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 2.3.

Exhibit 2.3: Average Congested Speeds

County	2011	2017	2018	2019
Collin	36.31	36.39	36.10	35.52
Dallas	36.34	36.31	36.24	36.03
Denton	36.93	36.78	37.23	36.79
Ellis	45.80	46.87	46.79	46.56
Johnson	41.62	42.14	41.90	41.74
Kaufman	46.20	45.85	45.47	45.06
Parker	44.78	45.42	45.29	45.14
Rockwall	41.41	40.80	40.41	39.99
Tarrant	37.01	37.51	37.33	37.11
Wise	46.83	46.57	46.42	46.26
Weighted Average	**37.80**	**38.02**	**37.92**	**37.65**

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.

Adjustments

Seasonal, Daily, and Hourly Adjustments

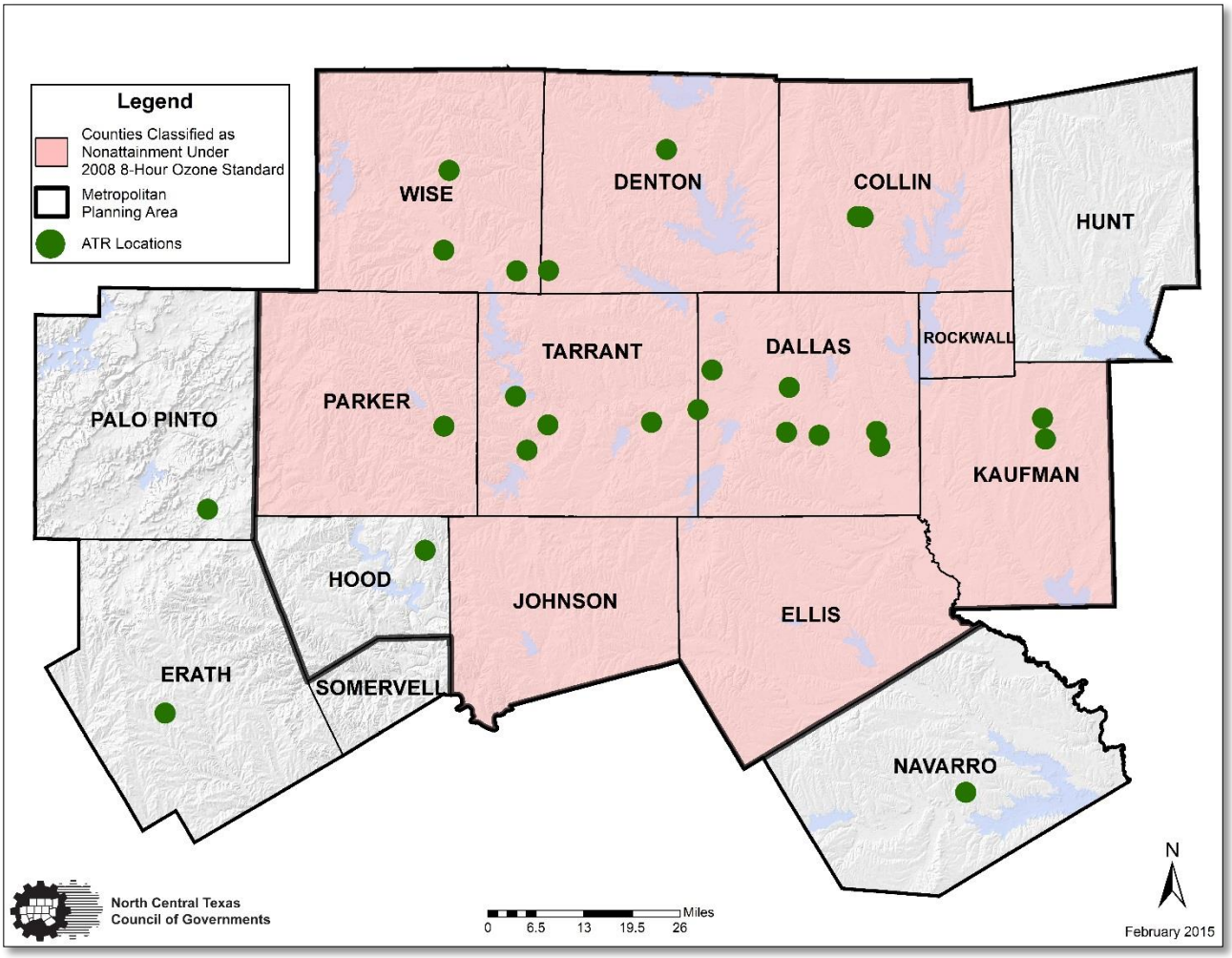
The vehicle activity data used for this analysis is representative of the summer season. This section outlines the process used to convert the DFX non-summer weekday (NSWD) activity to summer (June, July, and August) weekday activity. Automatic Traffic Recorder (ATR) data, collected by TxDOT, is used to calculate the necessary conversions.

For 2011 analysis year, 2011 ATR was used to convert NSWD activity to summer. For 2017, 2018, and 2019 analysis years, 2012 data was used to convert NSWD activity to summer. Exhibit 2.4 lists the stations used in this analysis and Exhibit 2.5 is a map showing the ATR locations.

Exhibit 2.4: ATR Stations

Station	Name	Road	County
1	A301 ARLINGTON	US0080	Tarrant
2	S016 JACKSBORO	US0281	Jack
3	S017 DALLAS	US0175	Dallas
4	S026 MCKINNEY	SH0005 S	Collin
5	S027 DENTON	FM0428 S	Denton
6	S040 CORSICANA	IH0045	Navarro
7	S055 DALLAS	SH0183	Dallas
8	S121 MCKINNEY	US0075	Collin
9	S126 DALLAS	IH035E	Dallas
10	S130 FT. WORTH	IH0030	Tarrant
11	S133 TERRELL	US0080	Kaufman
12	S145 TERRELL	IH0020	Kaufman
13	S148 DALLAS	IH035E	Dallas
15	S171 DALLAS	IH0635	Dallas
17	S192 ARLINGTON	IH0030	Tarrant
18	S193 FT. WORTH	IH0820	Tarrant
19	S208 WEATHERFORD	IH0020	Parker
20	S220 DALLAS	IH0045	Dallas
24	S264 WISE	SH0114	Wise
26	S292 ERATH	US0067	Erath
28	S297 TARRANT	IH0020	Tarrant
29	S337 WISE	SH 114	Wise
30	S338 WISE	USE 380	Wise
31	S339 WISE	US0081	Wise
32	S340 HOOD	US0377	Hood
33	S341 PALO PINTO	IH0020	Palo Pinto

Exhibit 2.5: ATR Station Map



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 2.6. 2011 adjustment factors were used for all analysis years.

Exhibit 2.6: 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 & 2019 DFX Counties (ASWT to Summer)	Core (Dallas/Tarrant)	0.991
	Rural (Collin/Denton)	0.971
	Perimeter (Other Counties)	1.030

Hourly Adjustments

Daily volumes recorded for each of the five day types 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 am to 8:59 am, PM Peak is 3:00 pm to 6:29 pm, and Off-Peak represents all other hours of the day (12:00 am to 6:29 am, 9:00 am to 2:59 pm, and 6:30 pm to 11:59 pm). Periods split by mid-hour times utilize an equal division of traffic recorded during the hour. Exhibit 2.7 shows the hourly adjustments for DFX counties for school and summer season.

Exhibit 2.7: Hourly Adjustment Factors for the DFW 10-County Modeling Domain

	Sunday	Monday	Midweek	Friday	Saturday
12:00 am – 12:59 am	2.15%	0.92%	0.95%	1.78%	2.15%
1:00 am – 1:59 am	1.52%	0.63%	0.66%	1.19%	1.52%
2:00 am – 2:59 am	1.34%	0.59%	0.63%	1.05%	1.34%
3:00 am – 3:59 am	0.91%	0.64%	0.63%	0.81%	0.91%
4:00 am – 4:59 am	0.78%	1.10%	1.00%	0.90%	0.78%
5:00 am – 5:59 am	1.08%	2.72%	2.35%	1.52%	1.08%
6:00 am – 6:29 am	0.81%	2.70%	2.33%	1.27%	0.81%
6:30 am – 6:59 am	0.81%	2.70%	2.33%	1.27%	0.81%
7:00 am – 7:59 am	2.15%	7.02%	6.11%	3.43%	2.15%
8:00 am – 8:59 am	3.02%	6.18%	5.49%	4.37%	3.02%
9:00 am – 9:59 am	4.28%	5.19%	4.84%	5.18%	4.28%
10:00 am – 10:59 am	5.56%	4.96%	4.90%	5.89%	5.56%
11:00 am – 11:59 am	6.20%	5.20%	5.29%	6.41%	6.20%
12:00 pm – 12:59 pm	7.29%	5.42%	5.59%	6.70%	7.29%
1:00 pm – 1:59 pm	7.70%	5.57%	5.82%	6.77%	7.70%
2:00 pm – 2:59 pm	7.63%	5.95%	6.23%	6.77%	7.63%
3:00 pm – 3:59 pm	7.54%	6.68%	6.85%	6.77%	7.54%
4:00 pm – 4:59 pm	7.48%	7.49%	7.29%	6.67%	7.48%
5:00 pm – 5:59 pm	7.24%	7.81%	7.35%	6.50%	7.24%
6:00 pm – 6:29 pm	3.25%	3.09%	3.16%	2.99%	3.25%
6:30 pm – 6:59 pm	3.25%	3.09%	3.16%	2.99%	3.25%
7:00 pm – 7:59 pm	5.39%	4.38%	4.96%	5.00%	5.39%
8:00 pm – 8:59 pm	4.38%	3.41%	3.84%	4.14%	4.38%
9:00 pm – 9:59 pm	3.65%	2.88%	3.32%	3.78%	3.65%
10:00 pm – 10:59 pm	2.76%	2.20%	2.83%	3.32%	2.76%
11:00 pm – 11:59 pm	1.85%	1.48%	2.09%	2.53%	1.85%

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.

Prior to beginning the development of this RFP SIP, NCTCOG performed a validation on the DFX model in order to meet the transportation conformity requirements per the *Code of Federal Regulations*, 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). The previous DFX

validation was performed in 2004, triggering an update to the validation. In order to be consistent with the planning assumptions incorporated in the *2014 Transportation Conformity*, NCTCOG incorporated the updated DFX model validation which is based on 2010 demographics. Exhibit 2.8 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 2.8: 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 VOC and 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 2.9 for all counties in the nonattainment area. VMT is summarized by 2011, 2017, 2018, and 2019 model years for each county. Appendix E contains the VMT by county for each hour for all counties.

Exhibit 2.9: Vehicle Miles of Travel

DFW Nonattainment Area				
County	**2011**	**2017**	**2018**	**2019**
Collin	21,595,365	26,286,747	27,052,719	27,885,016
Dallas	73,356,914	80,630,330	82,293,890	83,430,739
Denton	17,773,320	20,960,059	21,999,802	22,575,867
Ellis	6,787,844	8,267,444	8,530,620	8,803,682
Johnson	5,127,996	6,180,756	6,274,070	6,427,466
Kaufman	5,757,584	7,027,324	7,245,585	7,467,696
Parker	4,624,887	5,651,650	5,801,400	5,956,813
Rockwall	2,355,510	2,730,556	2,795,026	2,863,300
Tarrant	47,267,822	54,781,427	55,850,317	56,677,222
Wise	3,304,507	3,581,429	3,677,105	3,768,741
Total	**187,951,748**	**216,097,722**	**221,520,532**	**225,856,541**

CHAPTER 3: EMISSION FACTOR ESTIMATION PROCEDURE

Mobile Model and Input Parameters

The Environmental Protection Agency's (EPA) mobile source model, Motor Vehicle Emission Simulator version 2014 (MOVES2014), is used to develop vehicle emission factors to conduct the Reasonable Further Progress (RFP) emission inventory for the DFW 10-county ozone nonattainment area for analysis years 2011, 2017, 2018, and 2019. The emission factors are one component in the equation to determine vehicle emissions emitted from the region's on-road vehicles. MOVES2014 parameters used to develop emissions inventory are listed in Exhibits 3.1 through 3.5 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. MOVES2014 input files utilizing these parameters and data for each county are included in Appendix B.

Exhibit 3.1: MOVES2014 Modeled Pollutants

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

Exhibit 3.2: MOVES2014 External Conditions

Command	Input Parameter Values	Description
Calendar Year	2011, 2017, 2018, and 2019	RFP analysis years
Evaluation Month	7	Summer
Minimum/Maximum Temperature	N/A	See Hourly Temperatures
Hourly Temperatures	Average Summer	County specific, provided by TCEQ
Relative Humidity	Average Summer	County specific, provided by TCEQ
Barometric Pressure	Average Summer	County specific, provided by TCEQ

Exhibit 3.3: MOVES2014 Input Parameters

Input Parameter	Description	Source
Source Type Population	Input number of vehicles in geographic area to be modeled for each vehicle. Texas Transportation Institute's (TTI) MOVESpopulationBuild module is used to convert MOVES2014 based Texas Department of Motor Vehicles (TxDMV) registration data for each county into 13 MOVES2014 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 MOVES2014 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
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

Exhibit 3.3: MOVES2014 Input Parameters (continued)

Input Parameter	Description	Source
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 MOVES2014 input where local data unavailable
Meteorology	Regional average summer data on temperature and humidity.	Local data from TCEQ
Fuel Formulation	Input county specific fuel properties in the MOVES2014 database.	TCEQ, EPA Fuel Surveys, and default MOVES2014 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.	Local data from 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 MOVES2014 default used for light duty vehicles and buses

Exhibit 3.4: MOVES2014 I/M Descriptive Inputs for Subject Counties

2011, 2017, 2018, and 2019						
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data*						
I/M Program ID	20	21	22	23	24	Identifies program number with MOVES2014 database
Pollutant Process ID	101, 102, 201, 202, 301, 302,	101, 102, 201, 202, 301, 302,	101, 102, 201, 202, 301, 302,	112	112	
Source Use Type	21, 31, 32	21, 31, 32	52, 54	21, 31, 32	21, 31, 32	
Begin Model Year	1996	X	X	X	1996	
End Model Year	Y	1995	Y	1995	Y	
Inspect 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	
I/M Compliance	93.12% for source type 21, 91.26% for source type 31 and 86.6% for source type 32^					Expected compliance (%)

Source: TCEQ
ASM – Acceleration Simulation Mode
RPM – Revolutions Per Minute
Note: Begin Model Year and End Model Year define the range of vehicle model years covered by I/M program. Begin Model Year, represented by "X" is calculated as YearID – 2 and End Model Year, represented by "Y" is calculated as YearID – 24.
*Wise County does not have an I/M program
^http://www.epa.gov/otaq/models/moves/documents/420b15007.pdf

Exhibit 3.5: MOVES2014 Fuel Properties

	PR90			2011			2017, 2018, 2019		
Counties	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**
Fuel Type	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**
Fuel Formulation ID	9500		20670	9500		20670	9500		20670
Fuel Subtype ID	12	10	20	12	12	20	12	12	20
RVP	7.80	8.70	0.00	7.00	7.80	0.00	7.00	7.80	0.00
Sulfur Level	402.00	429.96	1,000.00	24.93	24.93	11.00	10.00	10.00	11.00
Ethanol Volume	0.00	0.00	0.00	9.69	9.69	0.00	9.69	9.69	0.00
Methyl Tertiary Butyl Ether (MTBE) Volume	0.00	0.00	0.00	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	0.00	0.00	0.00
Tertiary Amyl Methyl Ether (TAME) Volume	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aromatic Content	26.40	26.40	0.00	14.53	14.53	0.00	13.76	13.76	0.00
Olefin Content	11.90	11.90	0.00	12.03	12.03	0.00	12.03	12.03	0.00
Benzene Content	1.64	1.64	0.00	0.48	0.48	0.00	0.44	0.44	0.00
e200	50.00	46.04	0.00	47.23	47.23	0.00	48.32	48.32	0.00
e300	83.00	81.43	0.00	85.09	85.09	0.00	84.70	84.70	0.00
Vol To Wt Percent Oxy	0.37	0.00	0.00	3.38	3.38	0.00	3.38	3.38	0.00
BioDiesel Ester Volume	0.00	0.00	0.00	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	0.00	0.00	0.00
PAH Content	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T50	199.82	207.90	0.00	209.37	209.37	0.00	205.41	205.41	0.00
T90	329.41	336.54	0.00	325.92	325.92	0.00	329.31	329.31	0.00

Area Specific Calculations and Procedures

SourceUse Type Distribution

Sourceuse type age distributions are calculated from TxDOT's vehicle registration data. July data sets of corresponding analysis years are utilized for light- and heavy-duty vehicle classes. MOVES2014 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 American Community Survey for the five-year period between 2006 and 2010. Exhibit 3.6 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 B.

Exhibit 3.6: County-to-County Worker Flow

Resident County	County of Employment											
	Collin	Dallas	Denton	Ellis	Hood	Hunt	Johnson	Kaufman	Parker	Rockwall	Tarrant	Wise
Collin	65.4%	10.2%	5.1%	0.3%	0.1%	4.2%	0.2%	1.0%	0.0%	7.6%	0.9%	0.0%
Dallas	19.1%	66.0%	10.2%	10.7%	0.9%	3.9%	1.3%	15.8%	1.0%	23.6%	7.7%	0.7%
Denton	11.5%	7.9%	75.6%	0.4%	0.3%	0.0%	0.2%	0.7%	0.9%	0.6%	3.3%	3.1%
Ellis	0.2%	1.8%	0.2%	79.4%	0.2%	0.1%	1.4%	0.7%	0.1%	0.0%	0.6%	0.2%
Hood	0.0%	0.1%	0.0%	0.1%	84.0%	0.0%	2.3%	0.0%	2.4%	0.0%	0.5%	0.4%
Hunt	0.8%	0.4%	0.1%	0.1%	0.0%	84.3%	0.0%	4.4%	0.0%	9.4%	0.0%	0.0%
Johnson	0.0%	0.3%	0.3%	3.5%	3.2%	0.0%	76.2%	0.0%	1.4%	0.2%	3.2%	0.7%
Kaufman	0.3%	1.6%	0.1%	0.7%	0.1%	1.2%	0.0%	72.6%	0.0%	3.6%	0.1%	0.0%
Parker	0.0%	0.1%	0.1%	0.1%	4.3%	0.0%	0.5%	0.0%	77.4%	0.0%	2.6%	5.9%
Rockwall	0.7%	1.2%	0.1%	0.1%	0.5%	5.6%	0.1%	3.7%	0.0%	53.9%	0.1%	0.1%
Tarrant	2.0%	10.3%	7.4%	4.6%	6.2%	0.4%	17.5%	1.1%	14.1%	1.0%	80.3%	10.7%
Wise	0.1%	0.1%	0.8%	0.0%	0.2%	0.2%	0.3%	0.0%	2.5%	0.0%	0.8%	78.2%

Source: American Community Survey for the five-year period between 2006 and 2010.

Fuel Engine Fractions

Diesel fractions for heavy-duty vehicle categories utilized 12-county summed yearly July registration data for modeling 2011, 2017, 2018, and 2019 analysis years. July 2011 registration data is used for modeling 2011 and July 2014 is used for modeling 2017, 2018, and 2019 analysis years. Light-duty and bus categories utilize MOVES2014 default values. All diesel fraction files, included in Appendix B, list specific data used for this analysis.

MOVES2014 Emission Factors

MOVES2014 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

NCTCOG developed TxLED factors for the DFW region for the analysis years 2011, 2017, 2018, and 2019 using the Texas Commission on Environmental Quality (TCEQ) Excel template (ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/txled/). The factors produced employed the TCEQ average diesel SUT NO_X adjustments using 4.8 percent reductions for 2002 and later, and 6.2 percent reductions for 2001 and earlier model years NO_X reductions are from the EPA Memorandum, *Texas Low Emission Diesel (LED) Fuel Benefits*, September 2001). The TxLED analyses employed 2011 and 2014 regional age distribution factors for MOVES2014 runs. NOx, NO, and NO_2 emissions for Dallas County (DFW Area representative county) for all vehicle models years were produced for all analysis years of the RFP. MOVES2014 emissions were extracted from the MOVES2014 output table. The extracted emissions were used in the template to estimate TxLED factors for all diesel vehicles for the pollutants NO_X, NO, and NO_2. Exhibit 3.7 shows the TxLED factors used.

Exhibit 3.7: TxLED NO_x Adjustments

Source Use Type	Adjustment Factors			
	2011	2017	2018	2019
Passenger Car	0.94140	0.94844	0.95019	0.95055
Passenger Truck	0.94669	0.94955	0.94987	0.95009
Light Commercial Truck	0.94309	0.94667	0.94705	0.94786
Intercity Bus	0.94167	0.94258	0.94295	0.94336
Transit Bus	0.94190	0.94282	0.94317	0.94357
School Bus	0.94203	0.94280	0.94315	0.94353
Refuse Truck	0.94379	0.94580	0.94628	0.94682
Single Unit Short-Haul Truck	0.94915	0.95108	0.95120	0.95139
Single Unit Long-Haul Truck	0.94948	0.95122	0.95132	0.95147
Motor Home	0.94389	0.94534	0.94581	0.94629
Combination Short-Haul Truck	0.94601	0.94887	0.94913	0.94948
Combination Long-Haul Truck	0.94380	0.94684	0.94719	0.94766

Source: NCTCOG

Sourceusetype Population

TxDOT 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, and 2019 analysis years SUT population. For years 2017, 2018, and 2019 VMT growth rate was used to forecast SUT population. Exhibit 3.8 summarizes the SUT by county for all analysis years. All SUT population files are included in Appendix B.

Exhibit 3.8: Sourceusetype Population

Counties	2011	2017	2018	2019
Collin	566,215	686,428	703,483	717,242
Dallas	1,668,348	1,956,518	2,005,125	2,044,340
Denton	455,550	556,692	570,523	581,682
Ellis	122,968	139,404	142,866	145,662
Johnson	118,985	137,712	141,132	143,891
Kaufman	75,999	90,440	92,682	94,497
Parker	93,541	111,481	114,248	116,484
Rockwall	61,948	73,301	75,121	76,590
Tarrant	1,289,961	1,525,046	1,562,927	1,593,500
Wise	52,631	60,443	61,941	63,154
Total	**4,506,146**	**5,337,465**	**5,470,048**	**5,577,042**

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: AM-Peak, PM-Peak and Off-Peak.

Vehicle counts reported in the latest available 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 MOVES2014 Source Use Types by applying appropriate TxDOT registration data and/or MOVES2014 defaults. Exhibit 3.9 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 am to 8:59 am, PM peak is 3:00 pm to 6:29 pm, 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 3.9: Vehicle Classification Process

Axle-Based Vehicle Classifications		Intermediate Groups/HPMSVtypeID		Detailed Groups	
C	Passenger Vehicles	PV	Passenger Vehicles (20)	Passenger Car	Passenger Gasoline Vehicle
					Passenger Diesel Vehicle
					Motorcycle (MC)^
P	2 Axle, 4 Tire Single Unit		Light Duty Trucks (30)	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, Single 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*

Exhibit 3.9: Vehicle Classification Process (continued)

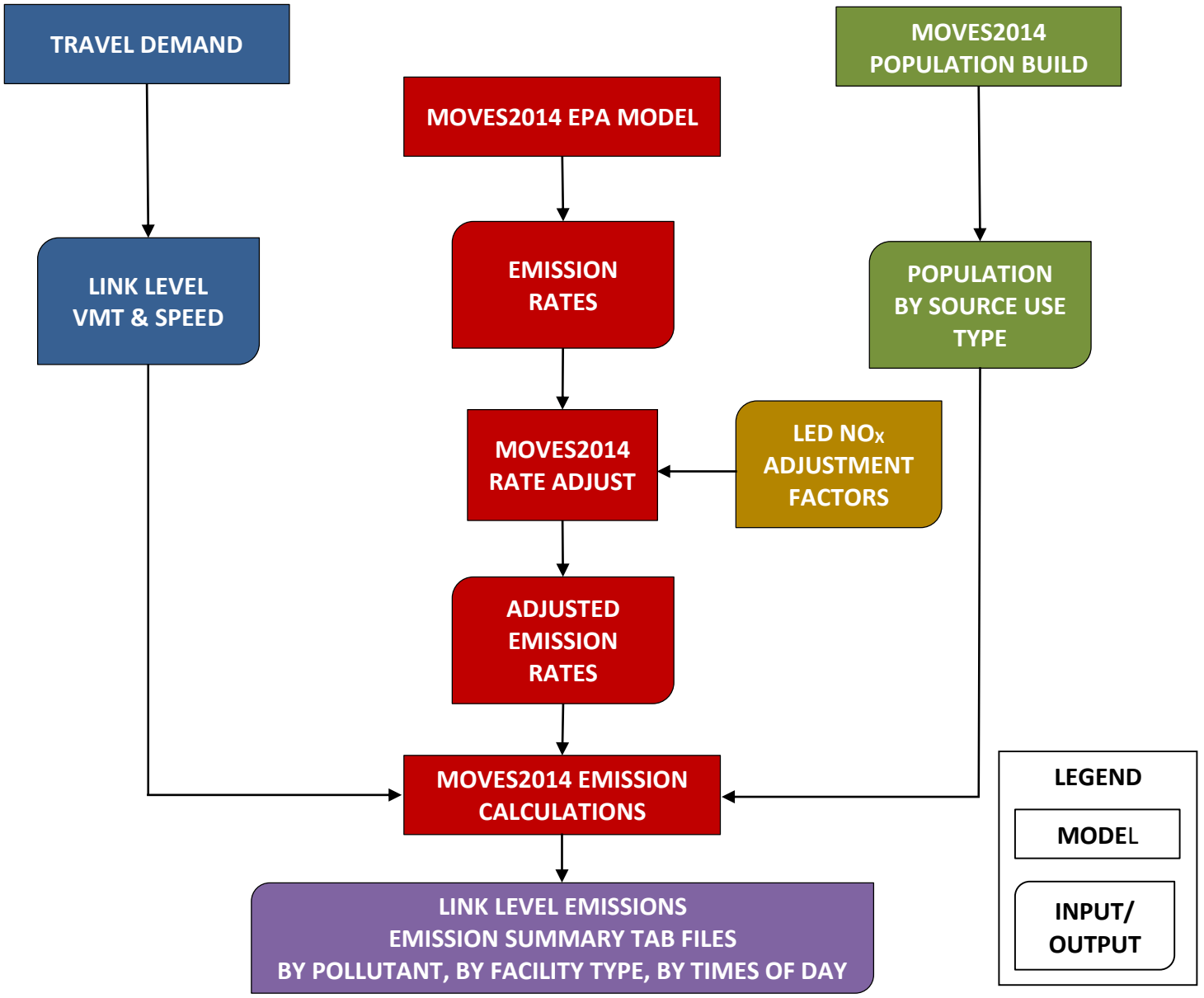
Axle-Based Vehicle Classifications		Intermediate Groups/HPMSVtypeID		Detailed Groups	
SE5	5 Axle, Single Trailer	Heavy Duty Trucks	Combination Heavy-Duty Vehicles (60)	Combination Short-Haul Truck	Combination Short-Haul Gasoline Truck*
SE6	6+ Axle, Single Trailer				
SD5	5 Axle, Multi Trailer				Combination Short-Haul Diesel Truck*
SD6	6 Axle, Multi Trailer			Combination Long-haul Diesel Truck*	
SD7	7+ Axle, Multi Trailer				

Source: Dallas-Fort Worth Ozone Nonattainment Area SIP Support, 2013, Texas Transportation Institute.
^Motorcycles are allocated as 0.1 percent for each functional class, subtracted from the light-duty vehicles.
*Categories calculated using MOVES2014 defaults.

CHAPTER 4: EMISSION CALCULATION PROCEDURE

Emissions estimates are calculated using *"TTI emissions inventory estimation utilities using moves: movesutl"* developed by the Texas Transportation Institute (TTI). This software combines vehicle activity and emission factors to create emission estimates. Exhibit 4.1 outlines the emission calculation modeling process that is used to calculate the emissions estimates for the Dallas-Fort Worth (DFW) ozone nonattainment area. Rate per Distance, Rate per Vehicle, and Rate per Profile are applied for DFW Expanded Travel Demand Model (DFX) counties outlined in the following sections.

Exhibit 4.1: MOVES2014 Emission Calculation Modeling Process



Emission Estimation

The DFX captures the vehicle activity information for each roadway segment in the transportation network in Collin, Dallas, Denton, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise counties as discussed in Chapter 1. Emission estimation using MOVES2014 is broken down into three phases.

Rate Per Distance

These include emissions for the processes occuring while vehicles are operating (i.e., running exhaust tire wear, brake wear, evaporative permeation, evaporative fuel vapor venting, evaporative fuel leaks, crankcase running exhaust, refueling displacement, and refueling spillage). The quantity of emissions estimated is directly related to the activity.

Application of emission factors to each of these roadway network links requires assignment of vehicle miles of travel (VMT) mix, also known as VMT mix, and coordination of functional classes. First, an appropriate VMT mix is identified for each link. For principal and minor arterials, frontage roads, collectors, zone connectors, and intrazonal functional, rural or urban unrestricted access emission rates are applied depending on the area type the link represents. For Interstate, freeways, and HOV lanes, rural or urban restricted access emission rates are applied depending on the area type the link represents. Exhibit 4.2 shows the area type used to apply emission rates. Links that fall under area type 1-4 are applied with an urban restricted/unrestricted emission rate and links that fall under area type 5 are applied with a rural restricted/unrestricted emission rate. Emission factors are specific to the speed identified on the roadway segments.

Exhibit 4.2: DFX Area Type

Area Type	Description	Activity Density Range (Per Acre)
1	Central Business District	> 125
2	Outer Business District	30-125
3	Urban Residential	7.5-30
4	Suburban Residential	1.8-7.5
5	Rural	<1.8

Rate Per Vehicle

These include emissions for most processes that occur while vehicles are stationary (i.e., start exhaust, start crankcase, permeation, liquid leaks, and extended idle [long haul combination trucks only]).

Rate Per Profile

These include emissions from the vapor venting process when vehicles are stationary. Vapor venting emissions vary depending on activity and previous temperatures. Rateperprofile and ratepervehicle-based emissions are directly related to the source type population.

CHAPTER 5: SUMMARY OF VEHICLE MILES OF TRAVEL, SPEED, AND EMISSIONS

Summary emissions results are available in this chapter.

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 5.1. Additional modeled pollutants not shown in this section are available in Appendices D and G. Appendix G contains the detailed emissions by pollutant, day, and TOD for all counties. Appendix D contains the detailed tab summary of VMT, speeds, and emissions for all counties by analysis year, control scenarios, TOD, functional class, and vehicle type. Appendix G contains a summary of all emissions.

Exhibit 5.1: Final Emission Estimates for the 10-County Modeling Domain

Oxides of Nitrogen Emissions (tons/day) Summer Season, Midweek				
Adjusted Base Year				
County	**2011**	**2017**	**2018**	**2019**
Collin	N/A	79.07	79.01	78.97
Dallas	N/A	275.84	275.70	275.55
Denton	N/A	69.63	69.63	69.61
Ellis	N/A	38.38	38.23	38.19
Johnson	N/A	24.43	24.40	24.39
Kaufman	N/A	29.16	29.09	29.09
Parker	N/A	23.22	23.19	23.17
Rockwall	N/A	10.87	10.84	10.83
Tarrant	N/A	176.43	176.36	176.37
Wise	N/A	16.19	16.19	16.17
Total	**N/A**	**743.22**	**742.64**	**742.34**
Pre-90 Controls				
County	**2011**	**2017**	**2018**	**2019**
Collin	79.14	97.27	100.09	103.19
Dallas	277.30	310.31	316.89	321.68
Denton	70.59	82.20	85.75	88.02
Ellis	38.30	47.33	48.81	50.30
Johnson	24.30	29.88	30.43	31.21
Kaufman	29.76	36.26	37.32	38.44
Parker	23.57	29.10	29.94	30.77
Rockwall	10.89	12.44	12.72	13.03
Tarrant	176.05	207.55	211.68	215.21
Wise	16.40	18.37	18.83	19.31
Total	**746.30**	**870.71**	**892.46**	**911.16**

Exhibit 5.1: Final Emission Estimates for the 10-County Modeling Domain (continued)

Oxides of Nitrogen Emissions (tons/day) Summer Season, Midweek				
FMVCP				
County	**2011**	**2017**	**2018**	**2019**
Collin	35.16	23.18	21.09	19.31
Dallas	128.14	77.23	69.36	62.49
Denton	32.04	20.12	18.60	17.02
Ellis	18.78	13.41	12.32	11.50
Johnson	11.38	7.87	7.13	6.57
Kaufman	14.71	10.34	9.56	8.93
Parker	11.23	8.28	7.73	7.28
Rockwall	5.28	3.34	3.04	2.79
Tarrant	79.86	51.19	46.22	41.84
Wise	7.34	4.36	3.92	3.56
Total	**343.92**	**219.32**	**198.97**	**181.29**
RFG				
County	**2011**	**2017**	**2018**	**2019**
Collin	26.50	16.82	15.19	13.84
Dallas	97.21	55.97	49.71	44.49
Denton	25.04	15.10	13.86	12.64
Ellis	16.15	11.57	10.62	9.93
Johnson	9.25	6.40	5.80	5.35
Kaufman	12.51	8.84	8.19	7.67
Parker	11.23	8.28	7.73	7.28
Rockwall	4.27	2.67	2.43	2.24
Tarrant	59.95	36.68	32.81	29.49
Wise	6.10	3.59	3.22	2.91
Total	**268.21**	**165.92**	**149.56**	**135.84**

Exhibit 5.1: Final Emission Estimates for the 10-County Modeling Domain (continued)

Oxides of Nitrogen Emissions (tons/day) Summer Season, Midweek				
Control Strategy				
County	**2011**	**2017**	**2018**	**2019**
Collin	24.26	15.43	13.96	12.73
Dallas	88.70	51.14	45.45	40.71
Denton	23.22	14.00	12.86	11.74
Ellis	15.42	11.09	10.19	9.55
Johnson	8.67	6.03	5.47	5.06
Kaufman	11.87	8.43	7.83	7.35
Parker	10.76	7.98	7.46	7.04
Rockwall	4.00	2.51	2.29	2.11
Tarrant	54.71	33.46	29.96	26.95
Wise	6.10	3.59	3.22	2.91
Total	**247.71**	**153.66**	**138.69**	**126.15**
Tier-3				
County	**2011**	**2017**	**2018**	**2019**
Collin	N/A	13.67	12.28	11.15
Dallas	N/A	45.34	39.91	35.57
Denton	N/A	12.61	11.50	10.47
Ellis	N/A	10.47	9.59	8.98
Johnson	N/A	5.57	5.03	4.65
Kaufman	N/A	7.90	7.32	6.87
Parker	N/A	7.98	7.46	7.04
Rockwall	N/A	2.31	2.11	1.94
Tarrant	N/A	29.62	26.30	23.54
Wise	N/A	3.28	2.92	2.63
Total	**N/A**	**138.75**	**124.42**	**112.84**

Exhibit 5.1: Final Emission Estimates for the 10-County Modeling Domain (continued)

Oxides of Nitrogen Emissions (tons/day) Summer Season, Midweek				
TxLED				
County	**2011**	**2017**	**2018**	**2019**
Collin	23.68	13.33	11.97	10.87
Dallas	86.66	44.25	38.97	34.74
Denton	22.56	12.25	11.17	10.17
Ellis	14.82	10.05	9.20	8.61
Johnson	8.39	5.38	4.86	4.49
Kaufman	11.43	7.59	7.03	6.60
Parker	10.33	7.66	7.17	6.76
Rockwall	3.87	2.24	2.04	1.87
Tarrant	53.49	28.95	25.71	23.02
Wise	5.90	3.17	2.82	2.55
Total	**241.13**	**134.87**	**120.94**	**109.68**

Volatile Organic Compounds (tons/day) Summer Season, Midweek				
Adjusted Base Year				
County	**2011**	**2017**	**2018**	**2019**
Collin	N/A	39.95	39.93	39.89
Dallas	N/A	132.59	132.53	132.46
Denton	N/A	32.73	32.72	32.70
Ellis	N/A	10.76	10.70	10.69
Johnson	N/A	8.67	8.65	8.65
Kaufman	N/A	8.12	8.10	8.09
Parker	N/A	6.70	6.69	6.68
Rockwall	N/A	4.13	4.12	4.12
Tarrant	N/A	90.64	90.62	90.59
Wise	N/A	4.49	4.49	4.49
Total	**N/A**	**338.78**	**338.55**	**338.36**

Exhibit 5.1: Final Emission Estimates for the 10-County Modeling Domain (continued)

Volatile Organic Compounds (tons/day) Summer Season, Midweek				
Pre-90 Controls				
County	**2011**	**2017**	**2018**	**2019**
Collin	39.40	48.31	49.76	51.33
Dallas	131.44	149.20	152.54	155.25
Denton	32.41	39.04	40.32	41.43
Ellis	10.43	12.45	12.76	13.13
Johnson	8.44	10.19	10.39	10.64
Kaufman	8.11	9.89	10.19	10.50
Parker	6.60	7.99	8.19	8.39
Rockwall	4.07	4.76	4.88	5.01
Tarrant	88.94	105.18	107.64	109.67
Wise	4.41	4.99	5.12	5.25
Total	**334.25**	**392.00**	**401.79**	**410.60**
FMVCP				
County	**2011**	**2017**	**2018**	**2019**
Collin	16.23	12.18	11.57	11.09
Dallas	57.84	39.40	37.05	35.12
Denton	13.64	10.10	9.63	9.21
Ellis	5.24	3.80	3.57	3.41
Johnson	4.06	2.98	2.80	2.67
Kaufman	3.98	2.84	2.68	2.55
Parker	3.16	2.37	2.26	2.17
Rockwall	1.99	1.41	1.33	1.27
Tarrant	38.89	28.52	27.00	25.71
Wise	2.04	1.36	1.28	1.21
Total	**147.07**	**104.96**	**99.17**	**94.41**

Exhibit 5.1: Final Emission Estimates for the 10-County Modeling Domain (continued)

Volatile Organic Compounds (tons/day) Summer Season, Midweek				
RFG				
County	**2011**	**2017**	**2018**	**2019**
Collin	12.76	9.48	9.01	8.63
Dallas	45.17	30.63	28.79	27.28
Denton	10.85	7.94	7.57	7.24
Ellis	4.59	3.32	3.13	2.99
Johnson	3.54	2.60	2.44	2.33
Kaufman	3.39	2.44	2.32	2.21
Parker	3.16	2.37	2.26	2.17
Rockwall	1.75	1.23	1.16	1.11
Tarrant	30.77	22.32	21.11	20.09
Wise	1.73	1.17	1.09	1.03
Total	**117.71**	**83.50**	**78.88**	**75.08**
Control Strategy				
County	**2011**	**2017**	**2018**	**2019**
Collin	11.23	8.25	7.83	7.51
Dallas	39.70	26.53	24.90	23.63
Denton	9.61	6.94	6.61	6.33
Ellis	4.16	2.99	2.81	2.70
Johnson	3.15	2.29	2.16	2.06
Kaufman	3.08	2.20	2.09	2.00
Parker	2.85	2.13	2.03	1.95
Rockwall	1.56	1.08	1.02	0.98
Tarrant	27.05	19.35	18.28	17.42
Wise	1.73	1.17	1.09	1.03
Total	**104.12**	**72.93**	**68.82**	**65.61**

Exhibit 5.1: Final Emission Estimates for the 10-County Modeling Domain (continued)

Volatile Organic Compounds (tons/day) Summer Season, Midweek				
Tier-3				
County	**2011**	**2017**	**2018**	**2019**
Collin	N/A	7.92	7.51	7.18
Dallas	N/A	25.44	23.82	22.57
Denton	N/A	6.68	6.35	6.07
Ellis	N/A	2.89	2.72	2.60
Johnson	N/A	2.21	2.08	1.99
Kaufman	N/A	2.12	2.01	1.92
Parker	N/A	2.13	2.03	1.95
Rockwall	N/A	1.05	0.99	0.94
Tarrant	N/A	18.60	17.54	16.70
Wise	N/A	1.12	1.04	0.99
Total	**N/A**	**70.16**	**66.09**	**62.91**
TxLED				
County	**2011**	**2017**	**2018**	**2019**
Collin	11.23	7.92	7.51	7.18
Dallas	39.70	25.44	23.82	22.57
Denton	9.61	6.68	6.35	6.07
Ellis	4.16	2.89	2.72	2.60
Johnson	3.15	2.21	2.08	1.99
Kaufman	3.08	2.12	2.01	1.92
Parker	2.85	2.13	2.03	1.95
Rockwall	1.56	1.05	0.99	0.94
Tarrant	27.05	18.60	17.54	16.70
Wise	1.73	1.12	1.04	0.99
Total	**104.12**	**70.16**	**66.09**	**62.91**

CHAPTER 6: LIST OF APPENDICES

Appendix A: MOVES2014 External Files

Appendix B: MOVES2014 Inputs and Outputs

Appendix C: MOVES2014 Emission Factors

Appendix D: Tab Summary Files

Appendix E: Emission, VMT, and Speed Estimates

Appendix F: XML

Appendix G: RFP Emission Inventory Summary Tables

Appendix H: Project Quality Control Report