ATTACHMENT F

DEVELOPMENT OF DFW ON-ROAD EMISSION INVENTORIES FOR THE YEARS 2012, 2014, 2017, 2020, 2023, 2026, AND 2028

DALLAS-FORT WORTH ON-ROAD EMISSION INVENTORIES TO SUPPORT THE ONE-HOUR OZONE AND 1997 EIGHT-HOUR OZONE NATIONAL AMBIENT AIR QUALITY STANDARD REDESIGNATION SUBSTITUTE STATE IMPLEMENTATION PLAN

This attachment documents the development of the on-road mobile emissions inventory (EI) for the updates to the Dallas-Fort Worth Ozone Nonattainment Area (DFW) Redesignation Substitution (RS) 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, *Dallas-Fort Worth On-Road Emission Inventories to Support One-Hour Ozone and 1997 Eight-Hour Ozone Redesignation Substitute*. The final emissions estimates are summarized in Chapter 1: *Introduction*, in Exhibit 1.3: *On-road Emissions for the DFW Four-County Modeling Domain* and Exhibit 1.4: *On-road Emissions for the DFW Nine-County Modeling Domain*. 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 year-to-year control strategy reduction estimates for each of the RS milestone years between 2012 and 2028. 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 control scenarios are the basis for quantifying the year-to-year reductions.

North Central Texas
Council of Governments

Dallas-Fort Worth On-road Emission Inventories to Support One-Hour Ozone and 1997 Eight-Hour Ozone Redesignation Substitute

March 2015

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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
P. O. Box 5888
Arlington, Texas 76005-5888
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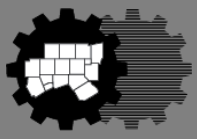
NCTCOG's Department of Transportation

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
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Dallas-Fort Worth On-road Emission Inventories to Support One-Hour Ozone and 1997 Eight-Hour Ozone Redesignation Substitute

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ABSTRACT

TITLE:	Dallas-Fort Worth On-road Emission Inventories to Support One-Hour Ozone and 1997 Eight-Hour Ozone Redesignation Substitute
DATE:	March 2015
AUTHORS:	Jenny Narvaez Principal Air Quality Planner Jody Loza Air Quality Planner
SUBJECT:	Redesignation for the One-Hour Ozone and 1997 Eight-Hour Ozone Standards
SOURCES OF COPIES:	Transportation Department North Central Texas Council of Governments PO Box 5888 Arlington, Texas 76005-5888 (817) 695-9240
NUMBER OF PAGES:	40
ABSTRACT:	The North Central Texas Council of Governments conducted on-road emission inventories to assist the Texas Commission on Environmental Quality to develop the one-hour ozone and 1997-eight-hour ozone redesignation substitute State Implementation Plan for the Dallas-Fort Worth region. Four counties were previously designated as nonattainment for the one-hour ozone standard: Collin, Dallas, Denton and Tarrant Counties; and nine counties previously designated as nonattainment for the 1997 eight-hour ozone standard: Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker Rockwall, and Tarrant. This report documents the on-road mobile methodologies applied and estimated emission results for analysis years 2012, 2014, 2017, 2020, 2023, 2026, and 2028. The estimated emissions are reported for oxides of nitrogen, volatile organic compounds,

carbon monoxide, carbon dioxide, 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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GLOSSARY OF ABBREVIATIONS

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
DV	-	Design Value
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
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
NHB	-	Non-Home Based
NO	-	Nitrogen Oxide
NO_2	-	Nitrogen Dioxide
NO_X	-	Oxides of Nitrogen
Pb	-	Lead
PM	-	Particulate Matter
$PM_{2.5}$	-	Particulate Matter 2.5 Microns
PM_{10}	-	Particulate Matter 10 Microns
ppb	-	parts per billion
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
VHT	-	Vehicle Hours of Travel
VMT	-	Vehicle Miles of Travel
VDF	-	Volume Delay Function
VOC	-	Volatile Organic Compounds

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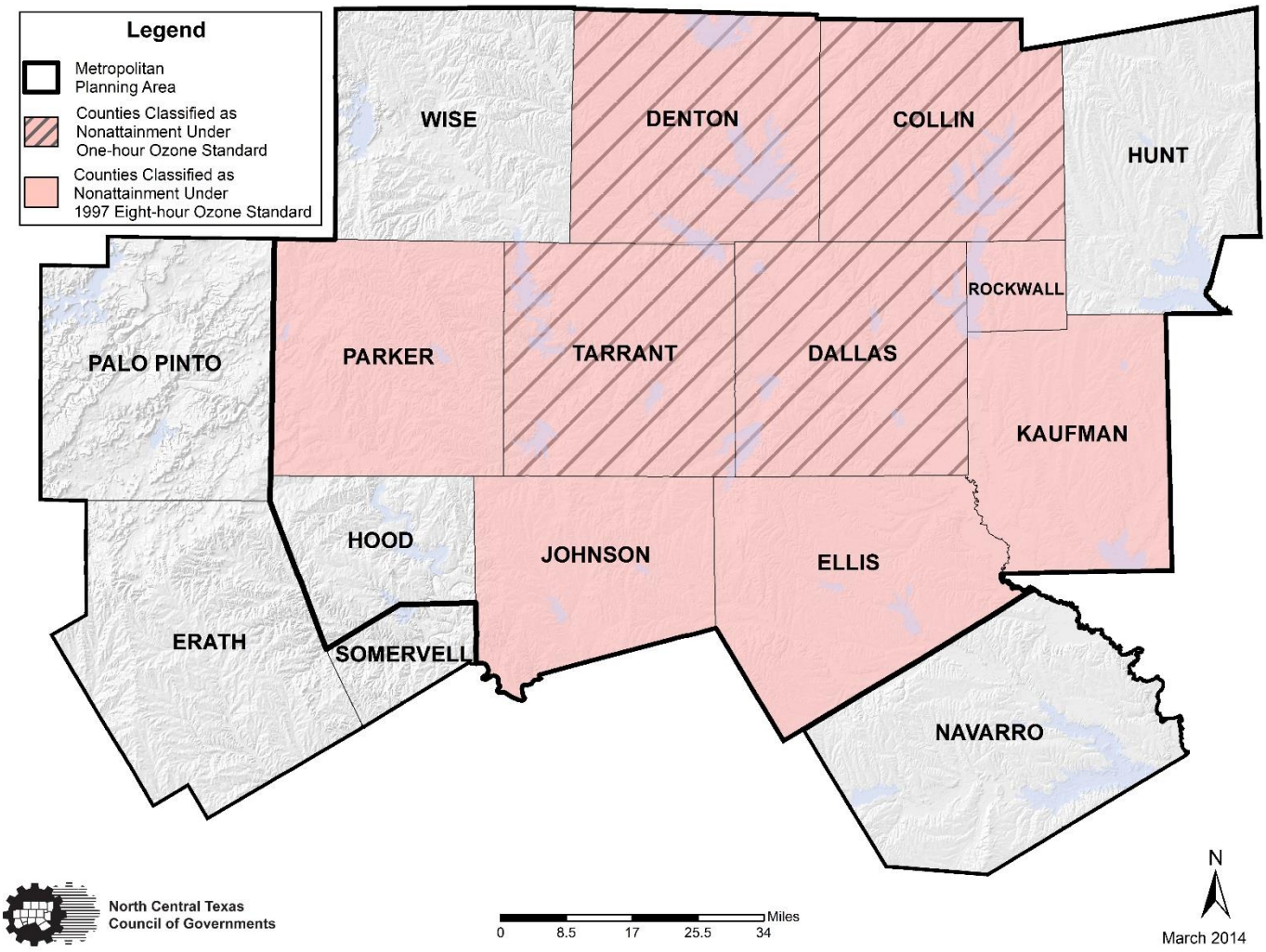
TABLE OF EXHIBITS

CHAPTER 1: INTRODUCTION

The North Central Texas Council of Governments (NCTCOG) conducted an on-road emissions inventory to support the Texas Commission on Environmental Quality's (TCEQ) efforts to develop modeling work for the One-hour Ozone and 1997 Eight-hour Ozone Redesignation State Implementation Plan (SIP). This emission inventory covers the Dallas-Fort Worth (DFW) four-county nonattainment area for the one-hour standard: Collin, Dallas, Denton, and Tarrant counties as well as the nine-county nonattainment area for the 1997 eight-hour ozone standard: Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant counties as shown in Exhibit 1.1.

Exhibit 1.1: DFW Nonattainment Area Map



This report documents the methodology and results of the Redesignation Substitute emission inventory. The Redesignation Substitute emission inventory analysis years include: 2012, 2014, 2017, 2020, 2023, 2026, and 2028. Chapter 1 outlines the background for the Redesignation Substitute emission inventory, the purpose and scope of the study, the modeling approach, and provides a summary of the four-county and nine-county estimated emission totals and activity 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 2012, 2014, 2017, 2020, 2023, 2026, and 2028 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 oxides of nitrogen (NO_X) adjustments and VMT mix.

Chapter 4 documents the four-county and nine-county nonattainment area vehicle emission calculation procedure.

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

The Appendices contains supplemental information, including a table containing all pollutants calculated, and electronic data supporting the DFW Redesignation Substitute 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, particulate matter (PM), carbon monoxide (CO), sulfur dioxide, NO_X, and lead.

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 one-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 one-hour NAAQS, EPA determined the one-hour NAAQS was insufficient to protect human health. As a result, the EPA developed the 1997 eight-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 February 10, 2015, the EPA proposed to reclassify the DFW area as "Severe" nonattainment for the 1997 eight-hour ozone standard, since DFW failed to meet the June 15, 2013, deadline to reach attainment; however, the EPA subsequently published a final rule revoking the 1997 eight-hour ozone standard with an effective date of April 6, 2015. Since EPA cannot reclassify or redesignate areas based on a revoked standard, the DFW region is no longer subject to being reclassified as "Severe". The DFW area's 2014 design value (DV), the three-year average of the annual fourth highest daily maximum eight-hour ozone concentration measured at each monitoring site, is 81 ppb[1], bringing the region's DV below the 1997 eight-hour ozone standard. Although the DFW region can no longer redesignated to attainment under the revoked standard, the DFW region is eligible to submit a redesignation substitute to remove the "Serious" anti-backsliding requirements for the one-hour and 1997 eight-hour standard.

The TCEQ, state's environmental agency, is required under the CAAA to submit a SIP revisions requesting designation to attainment. A maintenance plan must also be submitted with the redesignation, including a selection of regulations and measures to reduce emissions from stationary, area, mobile (on-road and non-road) sources, which demonstrates how the region will stay in attainment.

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 (MPO) 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.

[1] http://www.tceq.state.tx.us/cgi-bin/compliance/monops/8hr_attainment.pl

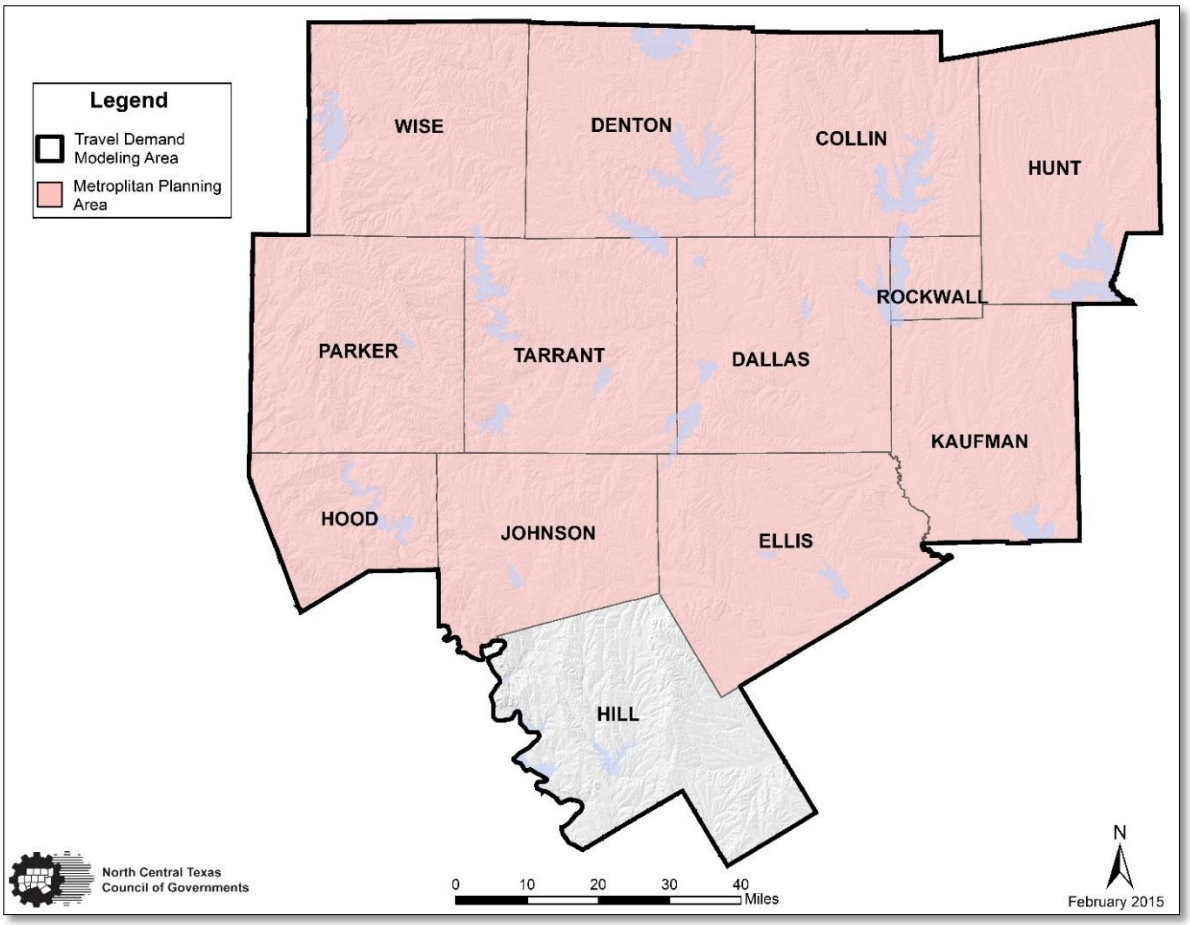
Purpose and Scope of Study

NCTCOG conducted 2012, 2014, 2017, 2020, 2023, 2026, and 2028 analysis year on-road emission inventories to support TCEQ's efforts to develop a Redesignation Substitute SIP for the DFW four-county and nine-county nonattainment areas. The pollutants to be included are: NO_X, volatile organic compounds (VOC), CO, carbon dioxide (CO_2), $PM_{2.5}$, and PM_{10}.

Modeling Approach

The DFX is employed to estimate VMT and emissions for the 2012, 2014, 2017, 2020, 2023, 2026, and 2028 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 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 12-county MPA and the 13-county DFX modeling domain is shown in Exhibit 1.2.

Exhibit 1.2: DFW 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.The final 2012, 2014, 2017, 2020, 2023, 2026, and 2028 on-road emissions by pollutant and VMT for average summer weekday types are shown in Exhibit 1.3 and 1.4. Appendix G contains the detailed emissions by county by pollutant and time-of-day for all NCT counties modeled.

Exhibit 1.3: On-road Emissions for the DFW Four-County Modeling Domain

Four-county Total Emissions (tons per day)							
	2012	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
VMT	158,968,136	166,904,345	182,658,562	193,804,121	203,852,679	214,346,979	225,718,496
NO_X	171.20	147.42	96.74	69.67	54.44	43.33	38.83
VOC	78.56	71.20	55.59	46.81	41.53	35.85	32.94
CO	1,012.11	970.62	877.61	813.08	744.34	645.90	597.70
CO_2	86,955.07	89,632.14	93,630.82	93,609.47	91,308.15	88,741.64	88,658.97
HONO	1.37	1.18	0.77	0.56	0.44	0.35	0.31
NO	152.85	130.42	83.88	58.98	44.66	33.91	29.96
NO_2	16.98	15.82	12.09	10.13	9.34	9.07	8.56
$PM_{2.5}$	5.10	4.29	3.00	2.30	1.75	1.47	1.34
PM_{10}	5.60	4.71	3.30	2.55	1.95	1.64	1.49

Exhibit 1.4: On-road Emissions for the DFW Nine-County Modeling Domain

Nine-county Total Emissions (tons per day)							
	2012	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
VMT	183,855,804	193,671,709	212,516,292	226,113,715	238,584,779	251,758,922	265,309,733
NO_X	216.74	188.65	129.19	95.95	77.87	64.62	59.75
VOC	92.17	83.75	65.62	55.36	49.21	42.70	39.49
CO	1,161.55	1,117.46	1,010.18	936.65	859.88	748.53	694.05
CO_2	102,142	105,707	111,055	111,582	109,491	107,128	107,375
HONO	1.73	1.51	1.03	0.77	0.62	0.52	0.48
NO	193.33	166.38	110.85	79.73	62.07	48.75	44.16
NO_2	21.68	20.76	17.30	15.46	15.17	15.35	15.11
$PM_{2.5}$	6.48	5.48	3.83	2.94	2.22	1.85	1.68
PM_{10}	7.10	6.01	4.21	3.24	2.46	2.06	1.87

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 Redesignation Substitute Emission Inventories for the four and nine 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 (GIS)-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 Redesignation Substitute Emissions Inventories contains over 30,000 unique segments constructed to replicate the transportation system of the coverage area. For these inventories, the transportation network was developed for the years 2012, 2014, 2017, 2020, 2023, 2026, and 2028. Each facility link in the network has the following attributes:

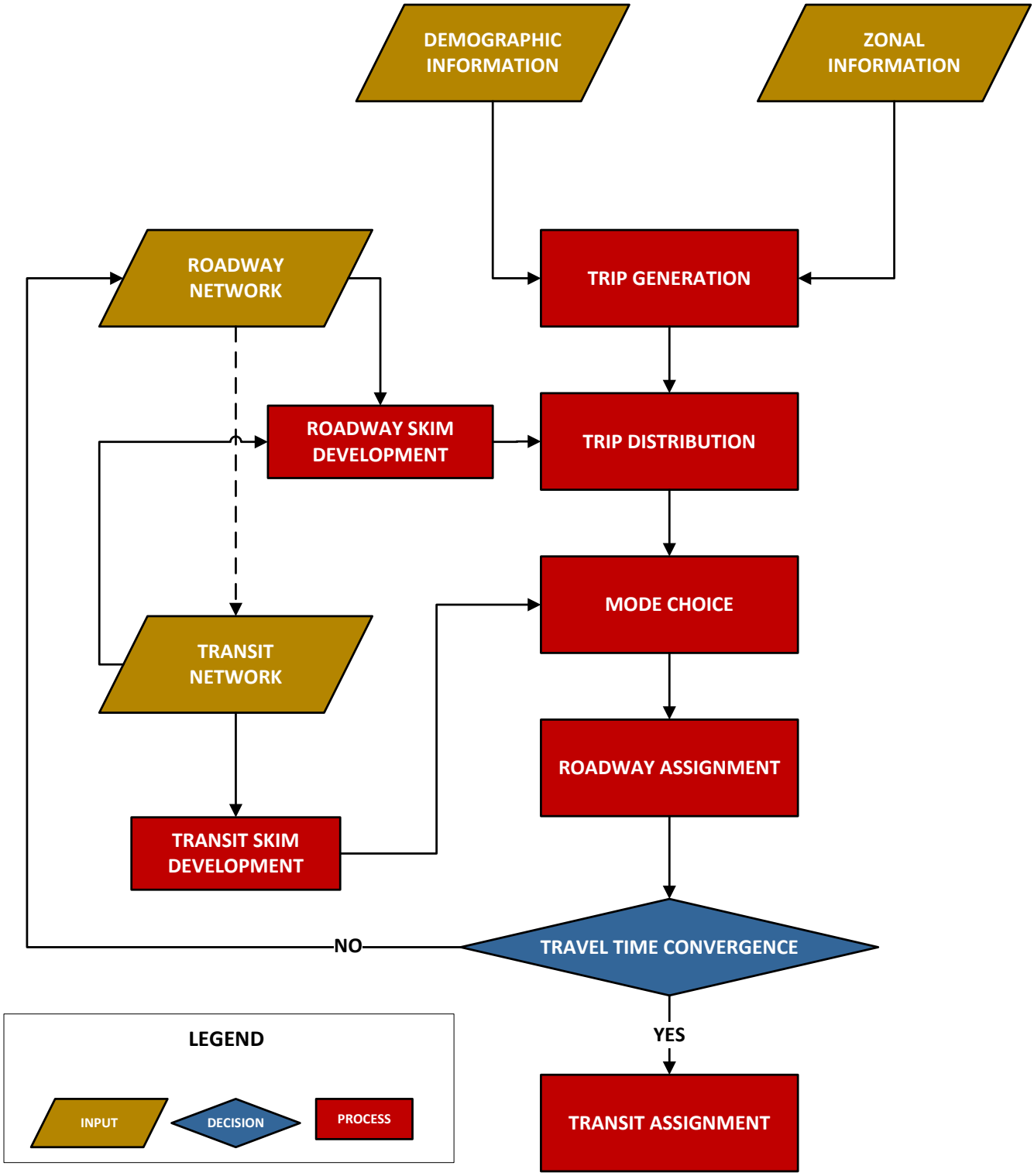
- Network Node Numbers (defining the beginning and end of each link)
- Number of Operational Lanes in the AM PM Peak and Off-Peak Periods
- Functional Classification
- Divided/Undivided Roadway Code
- Type of Traffic Control At Link End
- Traffic Direction (One- or Two-Way)
- Length of Link
- Estimated 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 2012, 2014, 2017, 2020, 2023, 2026, and 2028 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 2.2. 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

Socio-economic Demographic Summary By County							
	2012	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Population	6,381,750	6,616,981	6,979,143	7,345,926	7,735,614	8,138,777	8,425,438
Number of Households	2,321,348	2,399,456	2,518,598	2,638,704	2,765,501	2,896,288	2,988,707
Employment Types							
Basic	992,680	1,016,468	1,047,494	1,076,044	1,105,453	1,136,319	1,158,627
Retail	566,421	478,639	447,911	467,615	488,520	510,351	525,789
Service	2,427,176	2,679,536	2,928,246	3,111,986	3,313,504	3,519,420	3,662,658
Total Employment	3,986,277	4,174,643	4,423,651	4,655,645	4,907,477	5,166,090	5,347,074

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 are listed in Exhibit 2.3.

Exhibit 2.3: Average Congested Speeds

County	2012	2014	2017	2020	2023	2026	2028
Collin	36.18	35.75	36.39	35.14	34.61	32.99	32.68
Dallas	36.36	36.13	36.31	35.89	35.42	34.91	34.90
Denton	36.67	36.09	36.78	36.41	35.87	34.96	34.86
Ellis	45.71	45.35	46.87	46.33	45.91	44.91	44.54
Johnson	41.62	41.69	42.14	41.61	41.38	40.80	40.37
Kaufman	46.04	45.57	45.85	44.63	43.65	42.27	40.73
Parker	44.85	44.58	45.42	44.99	44.65	44.07	43.86
Rockwall	41.28	40.57	40.80	39.53	38.98	37.55	36.16
Tarrant	37.06	36.96	37.51	36.90	36.21	35.48	35.63

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

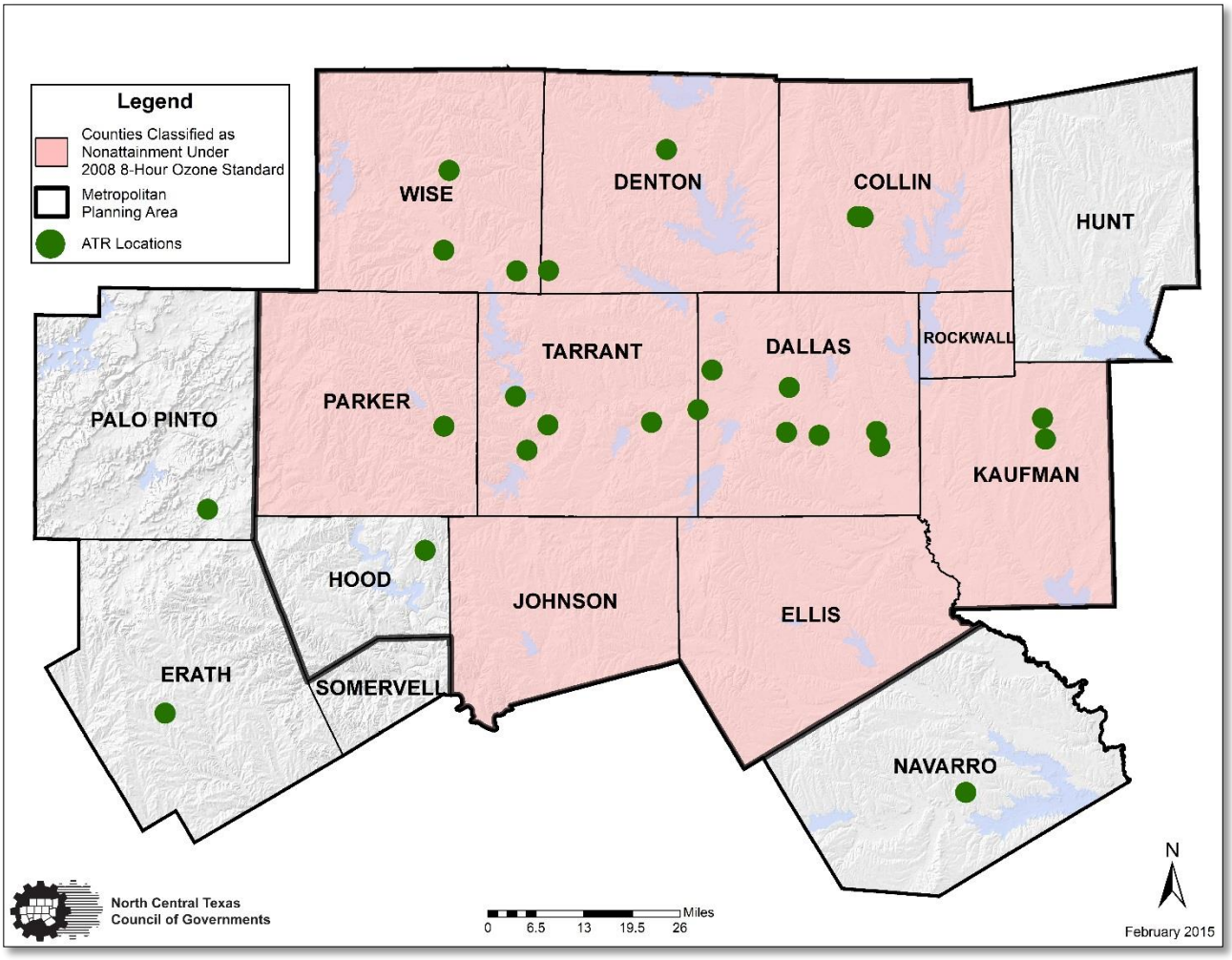
Seasonal, Daily, and Hourly Adjustments

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 activity to summer (June, July, and August) weekday activity. Automatic Traffic Recorder (ATR) data, collected by the Texas Department of Transportation (TxDOT), is used to calculate the necessary conversions. 2012 ATR data was used for all analysis years. 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. 2012 Midweek adjustment factors were used for all analysis years.

Exhibit 2.6: Seasonal/Daily Adjustment Factors

	County Type	Midweek
2012, 2014, 2017, 2020, 2023, 2026, and 2028 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 the summer season.

Exhibit 2.7: Hourly Adjustment Factors for the DFW Four-County and Nine-County Modeling Domains

	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 these emission inventories for the Redesignation Substitute State Implementation Plan, 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 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 VMT estimates are located in Exhibit 2.9 for all counties in the nonattainment area. VMT is summarized by 2012, 2014, 2017, 2020, 2023, 2026, and 2028 analysis years for each county. Appendix E contains the VMT by county for each hour for all counties.

Exhibit 2.9: Vehicle Miles of Travel (Miles/Day)

COUNTY	2012	2014	2017	2020	2023	2026	2028
Collin	21,747,390	23,326,944	26,286,747	28,681,086	30,690,351	33,028,116	34,814,978
Dallas	72,537,006	75,096,046	80,630,330	84,495,542	87,760,530	91,354,976	95,690,598
Denton	17,698,236	18,800,191	20,960,059	23,077,361	24,809,322	26,220,152	28,168,734
Ellis	6,892,381	7,367,499	8,267,444	9,017,262	9,787,285	10,593,073	11,158,402
Johnson	5,150,957	5,617,011	6,180,756	6,562,122	6,977,379	7,478,108	7,863,226
Kaufman	5,816,886	6,254,501	7,027,324	7,688,720	8,303,318	9,031,372	9,682,475
Parker	4,681,023	5,045,329	5,651,650	6,108,185	6,577,402	6,983,513	7,309,865
Rockwall	2,346,421	2,483,024	2,730,556	2,933,304	3,086,717	3,325,878	3,577,270
Tarrant	46,985,504	49,681,164	54,781,427	57,550,132	60,592,476	63,743,735	67,044,186
Total	**183,855,804**	**193,671,709**	**212,516,292**	**226,113,715**	**238,584,779**	**251,758,922**	**265,309,733**

CHAPTER 3: EMISSION FACTOR ESTIMATION PROCEDURE

Mobile Model and Input Parameters

The Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator version 2014 (MOVES2014), is used to develop 2012, 2014, 2017, 2020, 2023, 2026, and 2028 vehicle emission factors for this analysis. 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 these emissions inventories 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	NO_X, VOC, CO, CO_2, PM_{10} and $PM_{2.5}$	Oxides of Nitrogen (NO_X), Volatile Organic Compounds (VOC), Carbon Monoxide (CO), Carbon Dioxide (CO_2), and Particulate Matter with aerodynamic diameters equal to or less than 10 (PM_{10}) and 2.5 microns ($PM_{2.5}$).

Exhibit 3.2: MOVES2014 External Conditions

Command	Input Parameter Values	Description
Calendar Year	2012, 2014, 2017, 2020, 2023, 2026, and 2028	One-hour and 1997 Eight-hour Redesignation analysis years
Evaluation Month	7	Summer
Minimum/Maximum Temperature	N/A	See Hourly Temperatures
Hourly Temperatures	Average Summer	County specific, provided by the Texas Commission on Environmental Quality (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.	2012 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.	2012 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 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
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

Exhibit 3.3: MOVES2014 Input Parameters (continued)

Input Parameter	Description	Source
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.	2012 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

2012, 2014, 2017, 2020, 2023, 2026, and 2028						
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.
*http://www.epa.gov/otaq/models/moves/documents/420b15007.pdf

Exhibit 3.5: MOVES2014 Fuel Properties

	2012 and 2014			2017, 2020, 2023, 2026, and 2028		
Counties	**Core**	**Perimeter**	**All**	**Core**	**Perimeter**	**All**
Fuel Type	**Gasoline**		**Diesel**	**Gasoline**		**Diesel**
Fuel Formulation ID	9500		20670	9500		20670
Fuel Subtype ID	12	12	20	12	12	20
RVP	7.00	7.80	0.00	7.00	7.80	0.00
Sulfur Level	24.93	24.93	11.00	10.00	10.00	11.00
Ethanol Volume	9.69	9.69	9.69	9.69	9.69	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	13.76	13.76	13.76	13.76	13.76	0.00
Olefin Content	12.03	12.03	12.03	12.03	12.03	0.00
Benzene Content	0.44	0.44	0.44	0.44	0.44	0.00
e200	48.32	48.32	48.32	48.32	48.32	0.00
e300	84.70	84.70	84.70	84.70	84.70	0.00
Vol To Wt Percent Oxy	3.38	3.38	3.38	3.38	3.38	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	205.41	205.41	205.41	205.41	205.41	0.00
T90	329.31	329.31	329.31	329.31	329.31	0.00

Area Specific Calculations and Procedures

SourceUse Type Distribution

Sourceuse type age distributions are calculated from the Texas Department of Transportation's (TxDOT) 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 2006-2010 Census. 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 state and regional summed data from July registration data for modeling 2012, 2014, 2017, 2020, 2023, 2026, and 2028 analysis years. July 2012 registration data is used for modeling 2012 and July 2014 is used for modeling 2017, 2020, 2023, 2026, and 2028 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 analysis years 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

The North Central Texas Council of Governments (NCTCOG) developed TxLED factors for the Dallas-Fort Worth (DFW) region for the analysis years 2012, 2014, 2017, 2020, 2023, 2026, and 2028 using the TCEQ Excel template (ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/txled/). The factors produced employed the TCEQ average diesel source use types (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. NO_X, nitrogen oxide (NO), and nitrogen dioxide (NO_2) emissions for Dallas County (DFW Area representative county) for all vehicle models years were produced for all analysis years. 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						
	2012	2014	2017	2020	2023	2026	2028
Passenger Car	0.94161	0.94409	0.94843	0.95087	0.95153	0.95169	0.95162
Passenger Truck	0.94672	0.94749	0.94955	0.95020	0.95060	0.95062	0.95132
Light Commercial Truck	0.94337	0.94400	0.94667	0.94817	0.94942	0.95000	0.95024
Intercity Bus	0.94173	0.94199	0.94258	0.94387	0.94505	0.94666	0.94819
Transit Bus	0.94196	0.94223	0.94282	0.94407	0.94547	0.94721	0.94892
School Bus	0.94207	0.94231	0.94280	0.94395	0.94527	0.94690	0.94863
Refuse Truck	0.94405	0.94465	0.94580	0.94739	0.94915	0.95083	0.95154
Single Unit Short-Haul Truck	0.94937	0.94970	0.95108	0.95154	0.95179	0.95194	0.95198
Single Unit Long-Haul Truck	0.94969	0.95006	0.95122	0.95157	0.95178	0.95191	0.95196
Motor Home	0.94402	0.94440	0.94534	0.94678	0.94790	0.94925	0.95042
Combination Short-Haul Truck	0.94644	0.94727	0.94887	0.94986	0.95086	0.95151	0.95177
Combination Long-Haul Truck	0.94415	0.94495	0.94684	0.94809	0.94978	0.95081	0.95130

Source: NCTCOG

Sourceusetype Population

TxDOT registration data was used for developing sourceusetype population for the DFW area. July 2012 registration data is used for developing 2012 sourceusetype population and July 2014 registration date is used for developing 2014, 2017, 2020, 2023, 2026, and 2028 analysis years sourceusetype population. For years 2017, 2020, 2023, 2026, and 2028, VMT growth rate was used to forecast sourceusetype population. All analysis sourceusetype population files are included in Appendix B.

Exhibit 3.8: Population for the DFW Four-County and Nine-County Modeling Domains

	2012	2014	2017	2020	2023	2026	2028
Collin	585,036	620,227	686,428	724,097	764,527	807,551	850,693
Dallas	1,691,351	1,767,818	1,956,518	2,063,880	2,179,121	2,301,755	2,424,710
Denton	471,003	503,003	556,692	587,238	620,032	654,927	689,907
Ellis	126,882	125,962	139,404	147,055	155,266	164,004	172,763
Johnson	120,315	124,429	137,712	145,265	153,379	162,012	170,665
Kaufman	77,503	81,717	90,440	95,401	100,728	106,397	112,080
Parker	95,330	100,729	111,481	117,596	124,163	131,151	138,157
Rockwall	63,637	66,227	73,301	77,323	81,639	86,234	90,839
Tarrant	1,319,720	1,377,959	1,525,046	1,608,726	1,698,552	1,794,145	1,889,986
Four-County Total	4,067,110	4,269,007	4,724,684	4,983,941	5,262,232	5,558,378	5,855,296
Nine-County Total	4,550,777	4,768,071	5,277,022	5,566,581	5,877,407	6,208,176	6,539,800

Vehicle Miles of Travel Mix (or Fractions) (VMT Mix)

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 SUT 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)

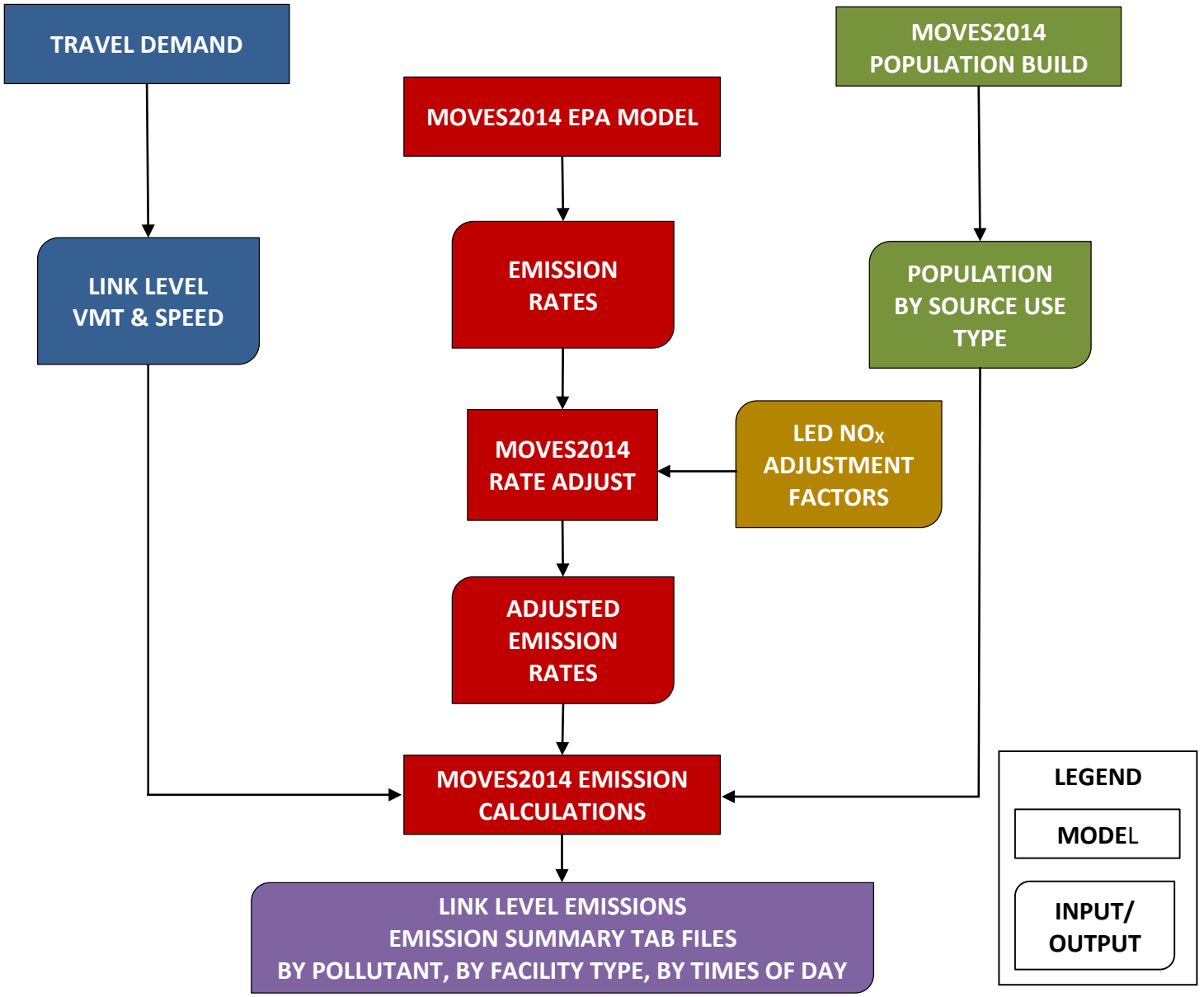
<table>
<tr><th colspan="2">Axle-Based Vehicle Classifications</th><th colspan="2">Intermediate Groups/HPMSVtypeID</th><th colspan="2">Detailed Groups</th></tr>
<tr><td rowspan="2">SE5</td><td rowspan="2">5 Axle, Single Trailer</td><td rowspan="5">Heavy Duty Trucks</td><td rowspan="5">Combination Heavy-Duty Vehicles (60)</td><td rowspan="3">Combination Short-Haul Truck</td><td rowspan="2">Combination Short-Haul Gasoline Truck*</td></tr>
<tr><td rowspan="2">SE6</td><td rowspan="2">6+ Axle, Single Trailer</td></tr>
<tr><td rowspan="2">SD5</td><td rowspan="2">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>

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 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, Johnson, Kaufman, Parker, Rockwall, and Tarrant counties as discussed in Chapter 1. Emission estimation using Motor Vehicle Emission Simulator version 2014 is broken down into three phases.

Rate Per Distance

These include emissions for the processes occurring 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 high occupancy vehicle 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. Rate per profile and rate per vehicle-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

The vehicle miles of travel (VMT) by county is summarized in Exhibit 5.1. 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 are summarized in Exhibit 5.2. 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, TOD, functional class, and vehicle type.

Exhibit 5.1: VMT by County

COUNTY	2012	2014	2017	2020	2023	2026	2028
Collin	21,747,390	23,326,944	26,286,747	28,681,086	30,690,351	33,028,116	34,814,978
Dallas	72,537,006	75,096,046	80,630,330	84,495,542	87,760,530	91,354,976	95,690,598
Denton	17,698,236	18,800,191	20,960,059	23,077,361	24,809,322	26,220,152	28,168,734
Ellis	6,892,381	7,367,499	8,267,444	9,017,262	9,787,285	10,593,073	11,158,402
Johnson	5,150,957	5,617,011	6,180,756	6,562,122	6,977,379	7,478,108	7,863,226
Kaufman	5,816,886	6,254,501	7,027,324	7,688,720	8,303,318	9,031,372	9,682,475
Parker	4,681,023	5,045,329	5,651,650	6,108,185	6,577,402	6,983,513	7,309,865
Rockwall	2,346,421	2,483,024	2,730,556	2,933,304	3,086,717	3,325,878	3,577,270
Tarrant	46,985,504	49,681,164	54,781,427	57,550,132	60,592,476	63,743,735	67,044,186
Four-County Total	**158,968,136**	**166,904,345**	**182,658,563**	**193,804,121**	**203,852,679**	**214,346,979**	**225,718,496**
Nine-County Total	**183,855,804**	**193,671,709**	**212,516,292**	**226,113,715**	**238,584,779**	**251,758,922**	**265,309,733**

Exhibit 5.2: Final Emission Estimates by County

Oxides of Nitrogen (NO_X) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	22.06	19.37	13.06	9.77	7.90	6.48	5.58
Dallas	78.90	66.87	43.32	30.32	23.24	18.14	16.40
Denton	20.83	18.30	12.02	9.18	7.44	6.16	5.84
Ellis	13.83	12.50	9.92	8.05	7.35	6.71	6.62
Johnson	7.83	7.16	5.29	4.13	3.57	3.13	3.03
Kaufman	10.65	9.66	7.48	6.17	5.47	5.01	4.97
Parker	9.74	8.85	7.56	6.37	5.75	5.32	5.26
Rockwall	3.49	3.07	2.20	1.56	1.29	1.11	1.05
Tarrant	49.41	42.88	28.35	20.40	15.86	12.54	11.00
Total	**216.74**	**188.65**	**129.19**	**95.95**	**77.87**	**64.62**	**59.75**

Exhibit 5.2: Final Emission Estimates by County (continued)

Nitrogen Oxide (NO) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	19.68	17.12	11.29	8.22	6.42	5.01	4.28
Dallas	70.43	59.16	37.58	25.76	19.17	14.29	12.71
Denton	18.56	16.11	10.31	7.62	5.92	4.65	4.31
Ellis	12.30	10.89	8.22	6.32	5.41	4.64	4.45
Johnson	6.98	6.29	4.47	3.34	2.73	2.25	2.12
Kaufman	9.44	8.40	6.18	4.83	4.03	3.46	3.34
Parker	8.65	7.69	6.24	4.98	4.23	3.68	3.54
Rockwall	3.11	2.69	1.86	1.28	1.00	0.81	0.75
Tarrant	44.19	38.03	24.70	17.39	13.15	9.95	8.66
Total	**193.33**	**166.38**	**110.85**	**79.73**	**62.07**	**48.75**	**44.16**

Nitrogen Dioxide (NO_2) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	2.21	2.10	1.67	1.48	1.42	1.42	1.26
Dallas	7.84	7.17	5.39	4.32	3.89	3.70	3.56
Denton	2.10	2.04	1.61	1.49	1.45	1.46	1.49
Ellis	1.43	1.51	1.62	1.66	1.88	2.03	2.12
Johnson	0.78	0.81	0.78	0.76	0.81	0.86	0.89
Kaufman	1.12	1.19	1.24	1.29	1.40	1.51	1.58
Parker	1.02	1.09	1.26	1.34	1.47	1.59	1.67
Rockwall	0.35	0.35	0.32	0.27	0.28	0.29	0.29
Tarrant	4.83	4.51	3.42	2.85	2.58	2.49	2.25
Total	**21.68**	**20.76**	**17.30**	**15.46**	**15.17**	**15.35**	**15.11**

Exhibit 5.2: Final Emission Estimates by County (continued)

Volatile Organic Compounds (VOC) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	10.22	9.41	7.50	6.44	5.77	5.02	4.57
Dallas	35.18	31.37	24.15	20.04	17.68	15.22	14.03
Denton	8.74	8.13	6.34	5.44	4.85	4.21	3.91
Ellis	3.84	3.50	2.79	2.38	2.16	1.94	1.86
Johnson	2.87	2.67	2.11	1.79	1.59	1.39	1.31
Kaufman	2.83	2.62	2.05	1.76	1.57	1.41	1.37
Parker	2.68	2.50	2.08	1.82	1.63	1.47	1.42
Rockwall	1.39	1.26	1.00	0.82	0.73	0.64	0.60
Tarrant	24.41	22.29	17.60	14.89	13.22	11.41	10.43
Total	**92.17**	**83.75**	**65.62**	**55.36**	**49.21**	**42.70**	**39.49**

Carbon Monoxide (CO) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	126.76	123.97	115.29	109.04	101.58	89.02	81.25
Dallas	473.43	446.79	397.80	365.15	331.65	285.93	263.13
Denton	102.10	99.84	90.16	86.11	79.35	68.48	63.63
Ellis	39.65	38.80	35.43	33.57	31.75	28.41	26.61
Johnson	31.75	31.62	27.99	25.66	23.66	20.86	19.35
Kaufman	32.00	31.58	28.82	27.25	25.74	23.20	22.16
Parker	31.87	31.22	28.17	25.96	24.18	21.14	19.67
Rockwall	14.16	13.62	12.16	11.14	10.21	9.02	8.56
Tarrant	309.81	300.03	274.36	252.78	231.75	202.48	189.69
Total	**1,161.55**	**1,117.46**	**1,010.18**	**936.65**	**859.88**	**748.53**	**694.05**

Exhibit 5.2: Final Emission Estimates by County (continued)

Carbon Dioxide (CO_2) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	11,768	12,399	13,272	13,654	13,549	13,531	13,523
Dallas	39,784	40,474	41,700	41,232	39,806	38,270	38,069
Denton	9,898	10,341	10,854	11,205	11,087	10,841	11,045
Ellis	4,356	4,598	5,044	5,263	5,386	5,480	5,565
Johnson	3,005	3,217	3,426	3,461	3,452	3,455	3,483
Kaufman	3,487	3,695	4,026	4,194	4,257	4,339	4,474
Parker	3,011	3,180	3,467	3,579	3,636	3,659	3,700
Rockwall	1,328	1,385	1,461	1,475	1,452	1,454	1,495
Tarrant	25,505	26,418	27,805	27,518	26,867	26,101	26,022
Total	**102,142**	**105,707**	**111,055**	**111,582**	**109,491**	**107,128**	**107,375**

Particulate Matter less than 2.5 ($PM_{2.5}$) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	0.63	0.55	0.39	0.31	0.24	0.21	0.19
Dallas	2.39	1.98	1.37	1.04	0.78	0.65	0.59
Denton	0.62	0.53	0.35	0.28	0.21	0.17	0.16
Ellis	0.43	0.37	0.26	0.20	0.14	0.12	0.11
Johnson	0.23	0.20	0.14	0.11	0.08	0.07	0.06
Kaufman	0.32	0.27	0.19	0.15	0.11	0.09	0.08
Parker	0.30	0.26	0.18	0.14	0.10	0.08	0.08
Rockwall	0.10	0.08	0.06	0.04	0.03	0.03	0.02
Tarrant	1.46	1.24	0.88	0.68	0.52	0.44	0.40
Total	**6.48**	**5.48**	**3.83**	**2.94**	**2.22**	**1.85**	**1.68**

Exhibit 5.2: Final Emission Estimates by County (continued)

Particulate Matter less than 10 (PM_{10}) (tons/day)							
County	**2012**	**2014**	**2017**	**2020**	**2023**	**2026**	**2028**
Collin	0.69	0.60	0.43	0.34	0.27	0.23	0.21
Dallas	2.62	2.17	1.51	1.15	0.87	0.72	0.65
Denton	0.68	0.58	0.39	0.31	0.23	0.19	0.18
Ellis	0.47	0.40	0.28	0.22	0.16	0.13	0.12
Johnson	0.25	0.22	0.15	0.12	0.09	0.07	0.07
Kaufman	0.34	0.30	0.21	0.16	0.12	0.10	0.09
Parker	0.33	0.28	0.20	0.15	0.11	0.09	0.08
Rockwall	0.11	0.09	0.06	0.05	0.03	0.03	0.03
Tarrant	1.61	1.36	0.97	0.75	0.58	0.49	0.45
Total	**7.10**	**6.01**	**4.21**	**3.24**	**2.46**	**2.06**	**1.87**

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: Redesignation Substitute Emission Inventory Summary Tables

Appendix H: Project Quality Control Report