

CHAPTER 7: EMISSION FACTORS/MOVES MODEL

7.1 Overview

This chapter discusses development of the regional motor vehicle emissions analysis for the North Central Texas nonattainment area, including all key assumptions used in the process. A regional emissions analysis must be conducted for multiple analysis years to satisfy the requirements of 40 Code of Federal Regulations Part 93.109 (40 CFR 93.109) of the conformity rule for ozone nonattainment areas. Specifically, the regional emissions analysis is used to conduct the emission budget test and to determine any contributions to emission reductions. The procedures for determining regional transportation-related emissions are described in 40 CFR Part 93.118 of the conformity rule. The following sections discuss the analysis years and a description of the modeling processes used to conduct the analysis.

7.2 Emissions Factor Estimation Model (MOVES3)

According to 40 CFR Part 93.111 of the conformity rule, the determination must be based on the latest emission estimation model. The Environmental Protection Agency (EPA) released the new Motor Vehicle Emission Simulator (MOVES) model, MOVES3, in late 2020, with an effective date of January 7, 2021. The EPA considers MOVES3 as an updated version of the MOVES2014 emissions model. Even though the grace period to use MOVES3 for conformity analysis ends on January 9, 2023, the MOVES3 model will be used for this conformity analysis.

As outlined in the Pre-Analysis Consensus Plan, included in Appendix 12.12, the Interagency Consultation Partners approved the use of MOVES3 to develop 2023, 2026, 2036, and 2045 vehicle emission factors. Emission factors are one component to determine volatile organic compounds and nitrogen oxides (NO_x) emissions from the region's on-road vehicles. MOVES3 input parameters are listed in Exhibits 7.2-1 through 7.2-7 with the appropriate data source and/or methodology applied. Information listed applies to all counties and analysis years unless otherwise specified. Referenced files identifying specific local data and MOVES3 technical reports are included in Appendix 12.13. MOVES3 input databases utilizing these parameters and data for each county are included in Appendix 12.14.

Exhibit 7.2-1: MOVES Model Details and Model Parameter Selections

Command	Function/Description	Input Parameter Values	Description
MOVES Model	Identifies the Model to be utilized for the analysis.	MOVES3	MOVES3, released in late 2020, with an effective date of January 2021
Calendar Year	Identifies calendar year for which emissions factors are to be calculated. (required to run model).	2023, 2026, 2036, 2045	Attainment Demonstration Years and Plan Forecast Years
Evaluation Month	Provides option of calculating emissions factors for each month of the calendar year.	7	Representing summer ozone season

Exhibit 7.2-2: MOVES Input Parameters and Source

Input Parameter Name	Description	Source
Source Type Population	Input the number of vehicles in the geographic area, which is to be modeled for each vehicle, and apply the appropriate growth factors for each analysis year. A methodology similar to Texas A&M Transportation Institute’s (TTI’s) MOVESpopulationBuild module is used to convert Texas Department of Motor Vehicles (TxDMV) registration data for each county into the MOVES source use type.	End-of-year 2018 TxDMV registration data
Source Type Age Distribution	Input that provides the distribution of vehicle counts by age for each calendar year and vehicle type. TxDMV registration data is used to estimate the age distribution of vehicle types up to 30 years. The distribution of Age fractions should sum up to 1.0 for all vehicle types for each analysis year.	End-of-year 2018 TxDMV registration data; MOVES default used for buses
Vehicle Type VMT	County-specific vehicle miles of travel (VMT) is distributed to 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. The 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 is distributed between the road type and must sum to 1.0 for each source 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.	Texas Commission on Environmental Quality (TCEQ), EPA fuel surveys, and default MOVES input where local data is unavailable
Fuel Formulation	Input county-specific fuel properties in the MOVES database.	TCEQ, EPA fuel surveys, and default MOVES input where local data is unavailable
Meteorology	County-specific data on temperature, relative humidity, and barometric pressure.	Regional data from TCEQ ²⁰
Inspection and Maintenance Coverage	Input Inspection and Maintenance coverage record for each combination of pollutants, process, county, fuel type, regulatory class, and model year are specified using this input.	TCEQ
Fuel Engine Fraction/Diesel Fraction	Input fuel engine fractions (i.e., Gasoline vs. Diesel Engine types in the vehicle population) for all vehicle types.	End-of-year 2018 TxDMV registration data; MOVES default used for light-duty vehicles and buses

²⁰ Data provided by the Texas Commission on Environmental Quality based on combined data from Leading Environmental Analysis and Display System, NWS, and US Air Force

Exhibit 7.2-3: 2012 Hourly Temperature Data²¹

	Collin	Dallas	Denton	Ellis	Johnson	Kaufman	Parker	Rockwall	Tarrant	Wise
12:00 AM	80.61	81.36	80.23	78.98	79.2	78.9	80.53	79.99	81.15	79.22
1:00 AM	79.47	80.19	78.93	77.86	78.07	77.84	79.14	78.77	80.07	77.97
2:00 AM	78.54	79.19	77.92	76.92	77.11	76.91	77.93	77.72	78.94	77.12
3:00 AM	77.66	78.25	77.05	76.05	76.19	75.95	76.84	76.88	78.02	76.17
4:00 AM	76.86	77.42	76.21	75.19	75.28	75.18	75.83	76.03	77.17	75.07
5:00 AM	76.19	76.63	75.34	74.47	74.43	74.44	75.05	75.42	76.18	74.37
6:00 AM	75.65	76.02	74.71	73.78	73.67	73.98	74.43	74.91	75.61	73.52
7:00 AM	77.00	76.88	75.85	74.48	74.35	75.93	75.03	75.34	76.55	73.68
8:00 AM	79.93	79.45	78.90	77.67	77.46	79.68	77.34	77.28	79.69	76.36
9:00 AM	83.21	82.45	82.20	81.31	81.07	83.16	80.44	79.88	82.88	79.72
10:00 AM	86.03	85.51	85.09	84.61	84.46	86.38	83.39	82.62	85.66	83.04
11:00 AM	88.54	88.15	87.76	87.61	87.43	89.06	86.23	85.36	88.56	85.95
12:00 PM	90.83	90.44	90.11	89.85	89.77	91.29	88.5	87.61	90.77	88.47
1:00 PM	92.48	92.24	91.82	91.57	91.6	92.89	90.13	89.58	92.32	90.44
2:00 PM	93.47	93.57	92.95	92.73	92.64	93.7	91.04	90.78	93.58	91.58
3:00 PM	94.36	94.45	93.50	93.58	93.32	94.38	92.01	91.5	94.22	92.15
4:00 PM	93.99	94.37	93.58	93.92	93.55	94.3	92.52	91.93	94.34	92.64
5:00 PM	93.33	93.82	93.28	93.44	93.41	93.46	92.24	91.68	93.9	92.36
6:00 PM	92.27	92.77	92.42	92.44	92.29	91.82	91.03	91.14	92.8	91.27
7:00 PM	89.96	90.80	90.16	90.22	90.39	89.13	89.25	89.51	90.84	89.38
8:00 PM	86.85	88.04	87.08	86.55	87.17	85.37	86.51	86.81	87.52	86.44
9:00 PM	84.77	85.60	84.80	83.38	84.04	82.98	84.27	84.32	85.44	83.46
10:00 PM	83.21	84.04	83.17	81.53	82.05	81.44	82.85	82.67	83.94	81.64
11:00 PM	81.81	82.70	81.52	80.22	80.63	79.93	81.74	81.03	82.42	80.4

²¹ Data provided by TCEQ based on combined data from LEADS, NWS, and US Air Force. County-specific data located in Appendix 12.14

Exhibit 7.2-4: 2012 Hourly Relative Humidity Data²²

	Collin	Dallas	Denton	Ellis	Johnson	Kaufman	Parker	Rockwall	Tarrant	Wise
12:00 AM	69.54	60.69	63.74	68.35	69.26	68.74	59.71	72.06	61.06	58.01
1:00 AM	71.95	63.47	66.61	71.14	72.59	71.22	62.70	73.33	63.28	60.89
2:00 AM	73.90	65.88	69.07	73.61	75.47	73.47	65.26	75.89	66.62	63.15
3:00 AM	75.91	68.43	71.21	75.98	77.62	75.94	67.84	76.06	69.01	65.89
4:00 AM	76.87	70.70	73.33	78.32	80.95	77.98	70.47	78.94	71.03	68.55
5:00 AM	78.33	73.05	75.80	80.53	83.07	80.09	72.76	79.29	73.78	70.55
6:00 AM	79.91	75.32	77.58	81.96	85.63	81.61	74.83	82.11	75.58	72.98
7:00 AM	76.05	73.87	74.96	81.16	87.13	77.65	74.46	84.11	73.72	72.82
8:00 AM	68.86	68.53	67.64	73.49	82.53	69.49	68.33	83.33	66.39	67.33
9:00 AM	60.83	61.69	60.04	64.50	74.28	61.58	60.86	77.78	59.18	59.99
10:00 AM	54.34	55.04	54.04	55.86	65.85	54.19	53.86	72.00	53.54	53.20
11:00 AM	49.62	49.33	48.75	48.96	57.82	48.52	47.73	65.11	47.36	47.48
12:00 PM	45.36	44.69	44.30	44.72	51.94	44.35	42.99	60.11	43.11	42.15
1:00 PM	42.25	41.33	41.16	40.88	46.45	41.29	39.41	54.26	40.28	38.31
2:00 PM	39.90	38.77	38.63	38.27	42.85	39.36	37.23	50.42	37.83	36.36
3:00 PM	39.08	36.78	37.28	36.61	40.64	38.17	36.31	50.21	36.67	35.52
4:00 PM	40.18	36.67	37.28	35.98	40.19	38.42	35.40	47.42	36.57	34.44
5:00 PM	40.77	37.55	37.94	36.65	39.11	39.64	35.66	47.89	36.83	34.53
6:00 PM	42.98	38.76	38.68	38.31	41.78	42.05	37.25	46.63	38.39	36.45
7:00 PM	47.67	41.66	42.59	42.65	44.07	46.54	40.05	47.11	41.35	39.22
8:00 PM	54.89	47.06	48.33	49.93	49.10	53.77	45.02	53.89	47.37	43.93
9:00 PM	59.93	51.79	52.40	56.98	55.48	58.46	50.16	59.50	51.31	48.91
10:00 PM	63.42	54.67	56.11	61.61	61.49	62.13	54.02	63.94	54.48	52.36
11:00 PM	66.75	57.52	60.57	64.86	64.66	66.05	56.94	71.39	58.01	55.10

²² Data provided by TCEQ based on combined data from LEADS, NWS, and US Air Force. County-specific data located in Appendix 12.14

Exhibit 7.2-5: 2012 Barometric Pressure Data²³

County	Barometric Pressure
Collin	29.92
Dallas	29.90
Denton	29.90
Ellis	29.90
Johnson	29.90
Kaufman	29.92
Parker	29.88
Rockwall	29.92
Tarrant	29.90
Wise	29.88

Exhibit 7.2-6: MOVES3 Inspection and Maintenance Descriptive Inputs for Subject Counties

2023			
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data			
Inspection and Maintenance (I/M) Program ID	20	24	MOVES3
Pollutant Process ID	101, 102, 201, 202, 301, 302	112	MOVES3
Source Use Type	21, 31, 32	21, 31, 32	MOVES3
Begin Model Year	1999	1999	Annual testing; program specifications
End Model Year	2021	2021	Annual testing; program specifications
Inspection Frequency	1	1	Annual testing; program specifications
Test Standards Description	Exhaust On-Board Diagnostic (OBD) Systems Check	Evaporative Gas Cap OBD Systems Check	Annual testing; program specifications
Test Standards ID	51	45	MOVES3
I/M Compliance	94.00% for source type 21, 90.35% for source type 31, and 70.74% for source type 32		Expected compliance (%) - MOVES3 Default

²³ Data provided by TCEQ based on combined data from LEADS, NWS, and US Air Force. County-specific data located in Appendix 12.14

**Exhibit 7.2-6: MOVES3 Inspection and Maintenance Descriptive Inputs for Subject Counties
(continued)**

2026			
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data			
I/M Program ID	20	24	MOVES3
Pollutant Process ID	101, 102, 201, 202, 301, 302	112	MOVES3
Source Use Type	21, 31, 32	21, 31, 32	MOVES3
Begin Model Year	2002	2002	Annual testing; program specifications
End Model Year	2024	2024	Annual testing; program specifications
Inspection Frequency	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	Evaporative Gas Cap and OBD Check	Annual testing; program specifications
Test Standards ID	51	45	MOVES3
I/M Compliance	94.00% for source type 21, 90.35% for source type 31, and 70.74% for source type 32		Expected compliance (%) - MOVES3 Default

2036			
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data			
I/M Program ID	20	24	Differentiates I/M programs
Pollutant Process ID	101, 102, 201, 202, 301,302	112	Identifies the pollutant and vehicle process
Source Use Type	21, 31, 32	21, 31, 32	Identifies the vehicle type
Begin Model Year	2012	2012	Model year I/M Program begins
End Model Year	2034	2034	Model year I/M Program ends
Inspection Frequency	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	Evaporative Gas Cap and OBD Check	Identifies test type
Test Standards ID	51	45	Identifies test with MOVES3 database test standards IDs
I/M Compliance	94.00% for source type 21, 90.35% for source type 31, and 70.74% for source type 32		Expected compliance (%) - MOVES3 Default

**Exhibit 7.2-6: MOVES3 Inspection and Maintenance Descriptive Inputs for Subject Counties
(continued)**

2045			
Collin, Dallas, Denton, Ellis, Johnson, Kaufman, Parker, Rockwall, and Tarrant I/M Data			
I/M Program ID	20	24	Differentiates I/M programs
Pollutant Process ID	101, 102, 201, 202, 301, 302	112	Identifies the pollutant and vehicle process
Source Use Type	21, 31, 32	21, 31, 32	Identifies the vehicle type
Begin Model Year	2021	2021	Model year I/M Program begins
End Model Year	2043	2043	Model year I/M Program ends
Inspection Frequency	1	1	Annual testing; program specifications
Test Standards Description	Exhaust OBD Check	Evaporative Gas Cap and OBD Check	Identifies test type
Test Standards ID	51	45	Identifies test with MOVES3 database test standards IDs
I/M Compliance	94.00% for source type 21, 90.35% for source type 31, and 70.74% for source type 32		Expected compliance (%) - MOVES3 default

Exhibit 7.2-7: MOVES3 Fuel Supply

Fuel Formulation ID	Market Share	Market Share CV ²⁴
14714/14702	1	0
30600	1	0

²⁴ Coefficient of Variation

Exhibit 7.2-8 MOVES3 Fuel Properties²⁵

Fuel Type County Group	Gasoline		Diesel
	Core	Perimeter	All Counties
Fuel Formulation ID	14714	14702	30600
Fuel Subtype ID	12	12	21
RVP	7.09	7.80	-
Sulfur Level	10.00	10.00	6
ETOH Volume	9.56	9.56	-
MTBE Volume	0	0	-
ETBE Volume	0	0	-
TAME Volume	0	0	-
Aromatic Content	16.96	22.22	-
Olefin Content	10.13	8.69	-
Benzene Content	0.37	0.99	-
e200	47.00	49.64	-
e300	84.95	84.60	-
Vol to Wt Percent Oxy	0.3653	0.3653	-
BioDiesel Ester Volume	-	-	4.86
Cetane Index	-	-	-
PAH Content	-	-	-
T50	210.35	202.53	-
T90	325.30	319.75	-

²⁵ Fuel subtype ID 12 is E10 gasoline, either conventional (CG) or RFG, with a nominal 10 percent by volume ethanol content. Fuel subtype ID 21 is biodiesel (BD), currently in Texas, ULSD estimated with a near 5% biodiesel ester volume content.

Gasoline: Texas latest available (2020) summer survey data were the basis of both the CG and RFG input estimates, updated with MOVES defaults as needed, for particular expected future year properties. For RFG, TTI estimated the average fuel properties by fuel grade combined into overall averages using EIA latest available (2019) Texas RFG relative sales volumes by grade. EPA summer 2020 RFG survey data were used (with hundreds of RFG samples) for Dallas and Houston RFG areas, separately. For CG, TTI used the TCEQ summer 2020 CG survey-based regional estimates produced by ERG for TCEQ's fuel study. TTI updated CG and RFG summer 2020 fuel formulations for use in future years by replacing particular fuel property values with the expected future year values (MOVES3 defaults). These include sulfur level for RFG, and RVP, sulfur level, and benzene content for CG.

Diesel: Diesel sulfur for future years is set to the MOVES3 default expected value, which is close to the actual, relatively stable, statewide averages observed in the last four TCEQ fuel surveys (2011, 2014, 2017, 2020). TTI based the estimated biodiesel ester volume content on EIA 2018 (latest available), Texas, transportation sector biodiesel and diesel consumption data.

7.2.1 Vehicle Registration Distribution

Vehicle age distributions are calculated from TxDMV vehicle registration data. End-of-year 2018 data sets are utilized for light- and heavy-duty vehicle classes. MOVES 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 County-to-County Worker Flow data. Exhibit 7.2.1-1 identifies percentages applied for this weighted adjustment. The 12-county summed heavy-duty vehicle data is used for developing the heavy-duty registration portion for heavy-duty vehicles.

Exhibit 7.2.1-1: County-to-County Worker Flow

Resident County	County of Employment									
	Collin	Dallas	Denton	Ellis	Johnson	Kaufman	Parker	Rockwall	Tarrant	Wise
Collin	55.22%	6.48%	13.29%	0.95%	0.67%	7.41%	0.23%	3.70%	0.21%	9.23%
Dallas	37.87%	82.64%	32.35%	36.93%	3.17%	17.36%	5.50%	47.96%	3.45%	49.85%
Denton	3.90%	2.18%	44.30%	0.62%	0.32%	0.62%	0.40%	0.84%	1.10%	0.39%
Ellis	0.05%	0.49%	0.04%	51.18%	0.02%	0.03%	2.50%	1.14%	0.06%	0.11%
Hood	0.00%	0.01%	0.01%	0.07%	65.80%	0.00%	0.93%	0.00%	1.98%	0.19%
Hunt	0.39%	0.10%	0.02%	0.10%	0.53%	61.57%	0.17%	1.02%	0.00%	5.35%
Johnson	0.03%	0.05%	0.06%	0.67%	3.62%	0.19%	45.79%	0.06%	0.98%	0.05%
Kaufman	0.03%	0.36%	0.02%	0.32%	0.00%	2.79%	0.00%	40.42%	0.01%	2.13%
Parker	0.02%	0.02%	0.06%	0.05%	4.89%	0.11%	0.58%	0.01%	45.90%	0.00%
Rockwall	0.47%	0.76%	0.04%	0.13%	0.00%	9.18%	0.00%	3.12%	0.00%	31.39%
Tarrant	2.02%	6.88%	9.55%	8.85%	20.89%	0.73%	43.79%	1.73%	44.87%	1.31%
Wise	0.01%	0.01%	0.25%	0.13%	0.08%	0.00%	0.11%	0.00%	1.45%	0.00%

Source: Census Transportation Planning Products Program (CTPP) 2012 - 2016.

7.3 Adjustments to Emission Factors

Adjustments are applied to emission factors as a post-process step. The Low Emission Diesel NO_x Adjustment is applied to the emission factors. VMT mix is applied simultaneously with the emission calculation.

7.3.1 Low Emission Diesel NO_x Adjustment

NO_x emission factors for diesel vehicle classes are adjusted by adjustment factors developed by the North Central Texas Council of Governments, using the spreadsheet the Texas Commission on Environmental Quality provided, to apply the Texas Low Emission Diesel Program. Exhibit 7.3.1-1 lists the appropriate adjustment for each vehicle class.

Exhibit 7.3.1-1: Texas Low Emissions Diesel NO_x Adjustments

Vehicle Classification	2023	2026	2036	2045
Passenger Car	0.9514	0.9517	0.9520	0.9520
Passenger Truck	0.9489	0.9498	0.9520	0.9520
Light Commercial Truck	0.9485	0.9494	0.9520	0.9520
Intercity Bus	0.9481	0.9494	0.9520	0.9520
Transit Bus	0.9508	0.9512	0.9520	0.9520
School Bus	0.9494	0.9503	0.9520	0.9520
Refuse Truck	0.9495	0.9508	0.9520	0.9520
Single Unit Short-Haul Truck	0.9518	0.9519	0.9520	0.9520
Single Unit Long-Haul Truck	0.9516	0.9518	0.9520	0.9520
Motor Home	0.9467	0.9483	0.9520	0.9520
Combination Short-Haul Truck	0.9513	0.9517	0.9520	0.9520
Combination Long-Haul Truck	0.9507	0.9514	0.9520	0.9520

Source: Texas Commission on Environmental Quality and NCTCOG

7.3.2 Vehicle Miles of Travel Mix (or Fractions)

The VMT mix designates the vehicle types included in the analysis. It specifies the fraction of on-road fleet VMT attributable to each vehicle type by day type (i.e., average weekday) and MOVES road type.

TTI provided the VMT mixes. TTI estimated the VMT mix based on TTI's 24-hour average VMT mix method, expanded to produce the four-period, time-of-day estimates.²⁶ The procedure sets Texas vehicle registration category aggregations for MOVES source use type categories to be used in the VMT mix estimates and for developing other fleet parameter inputs needed in the process (e.g., vehicle age distributions). The VMT mix procedure produced a set of four-period, time-of-day average vehicle type VMT allocations by MOVES road type and by day type, estimated for each Texas Department of Transportation (TxDOT) district for use with each county for each year analyzed. The data sources used were recent 2009 to 2018 TxDOT vehicle classification counts, year-end 2018 TxDOT/TxDMV registration data and MOVES default data. Appendix 12.16 includes MOVES3 emission factors for all counties in the nonattainment area.

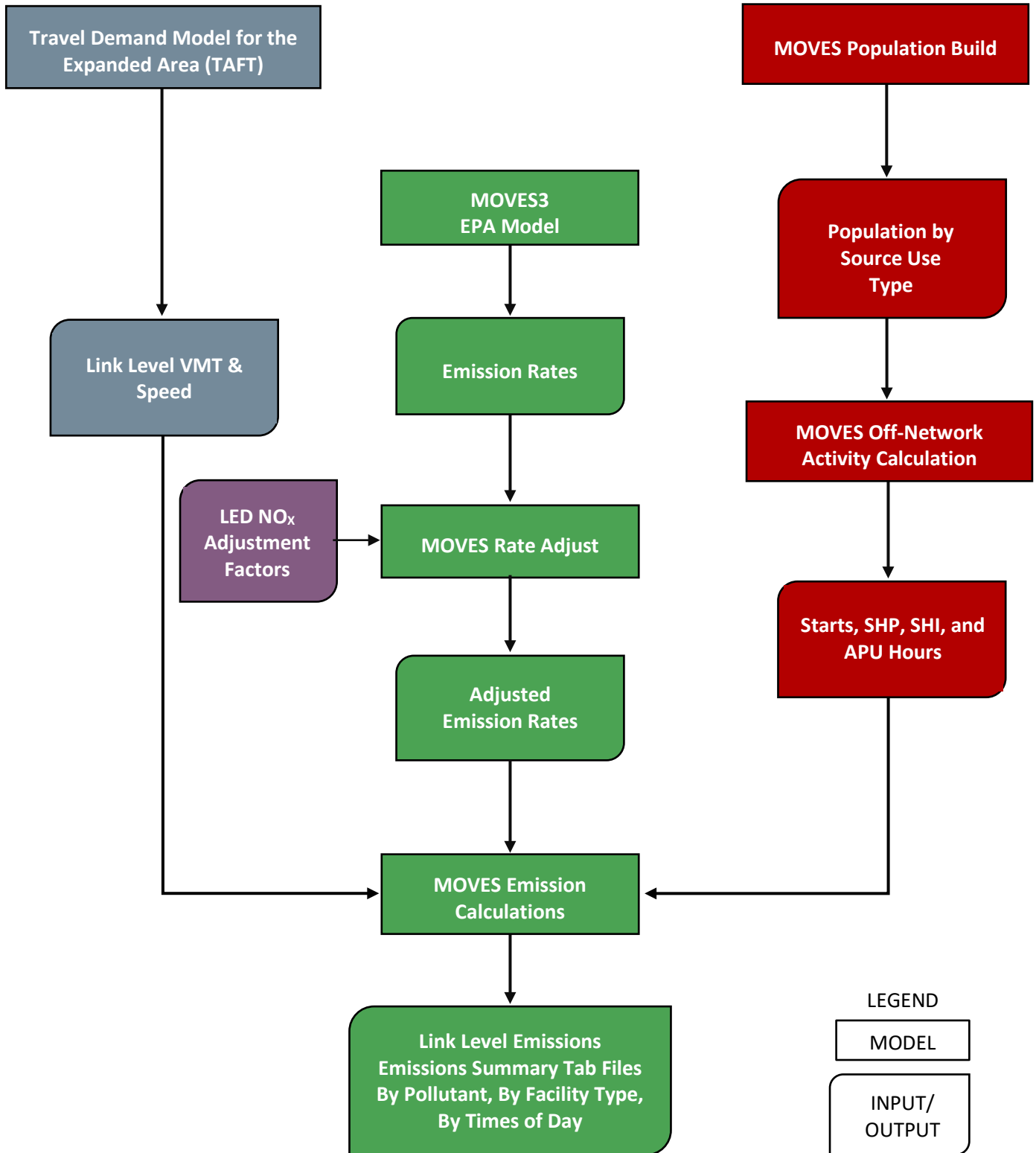
7.4 Modeled Emission Estimation

Emissions estimates are calculated using "TTI emissions inventory estimation utilities using MOVES3 UTL," developed by the Texas A&M Transportation Institute. This software combines vehicle activity and emission factors to create emission estimates.

Exhibit 7.4-1 outlines the emission calculation modeling process that is used to calculate the emissions estimates for the Dallas-Fort Worth ozone nonattainment area. Different procedures were applied for Dallas-Fort Worth Travel Demand Model counties outlined in the following sections.

²⁶ MOVES Source Use Type and VMT Mix for Conformity Analysis, TTI, August 2017

Exhibit 7.4-1: MOVES3 Emission Modeling Process



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