Texas A&M Transportation Institute

2020 On-Road Mobile Source Annual, Summer Weekday, and Winter Weekday Emissions Inventories

FINAL REPORT

Prepared for the Texas Commission on Environmental Quality (TCEQ)

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Texas A&M Transportation Institute

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Task 6.1: **Final Report – 2020 On-Road Mobile Source Annual, Summer Weekday, and Winter Weekday Emissions Inventories**

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EXECUTIVE SUMMARY

The State of Texas is required to submit periodic emissions inventories and U.S. Environmental Protection Agency (EPA) Motor Vehicle Emissions Simulator (MOVES) county database files (CDBs) under the Air Emissions Reporting Requirements (AERR) to support the EPA's comprehensive three-year cycle National Emissions Inventory (NEI). The Texas A&M Transportation Institute (TTI) produced the requisite on-road mobile source portion of the 2020 periodic emissions inventory and CDBs for all 254 Texas counties. TTI developed summer work weekday and winter work weekday (El Paso only) emissions inventory (EI) estimates of criteria air pollutants (CAPs) and CAP precursors, as well as annual EI estimates of CAPs, CAP precursors, and hazardous air pollutants (HAPs) as summarized in Table 1.

Table 1. 2020 AERR Emissions Inventories.

All 254 Texas Counties	Annual	CAPs, CAPs precursors, and HAPS
All 254 Texas Counties	Summer Weekday	CAPs and CAPs precursors
El Paso County	Winter Weekday	CAPs and CAPs precursors

[1] "Annual" represent the calendar year totals for all counties. "Summer" represents June, July, and August. "Winter" represents January, February, and December. "Weekday" represents the average Monday through Friday.

The work also included the preparation of inputs for the Texas Commission on Environmental Quality's (TCEQ) Road Dust Calculator necessary to develop a statewide 2020 calendar year EI. The inputs can be used in the Road Dust Calculator to produce both summer weekday and annual road dust EIs for each county in Texas.

The general methodology was consistent with the process TTI used to produce the 2017 AERR and county-level on-road inventories and inventory mode CDBs, with a change in the annual emissions calculation process. Seasonal weekday inventories were estimated using the detailed hourly link (roadway segment)-based method. CDBs for MOVES annual inventory mode runs were prepared using local input data (from the weekday EI activity data and various conversion factors) and some default input data. Annual EIs were produced from MOVES inventory mode runs using the local, annual inventory mode CDBs[1]. The seasonal weekday emission rates and annual inventory-mode runs were performed using the EPA's latest version of MOVES[2].

To estimate the seasonal weekday county-level inventories the hourly, MOVES rates-per-activity, detailed link-based inventory method was used with the latest available data, models, methods, and procedures. One of two vehicle miles of travel (VMT) activity bases were used, depending on data source availability. For counties in areas where regional travel demand model (TDM) data were available, TDM roadway network link data was the basis of VMT activity estimates. For counties not included in an area TDM, the virtual link-based method was used. The virtual link method uses Highway Performance Monitoring System (HPMS) data from the Texas Department of Transportation (TxDOT) as the basis of VMT activity.

The hourly and 24-hour EIs were estimated by MOVES source use type (SUT) and fuel type combination (SUT/fuel type or vehicle type), and by roadway class which includes an off-network category. A source-classification-code (SCC)-based 24-hour inventory summary was also produced. This EI analysis was performed for all Texas counties by the eight areas shown in Table 2. Table 2 provides the counties or number of counties included in each of the eight areas and their activity basis (TDM or HPMS).

[1] Computation of 2020 annual EIs using MOVES inventory mode is a change from previous TTI 2017 (and earlier) annual EI analyses in which TTI employed the summer weekday EI annualization process to produce the annual EIs.

[2] MOVES3 is the latest version of the U.S. EPA's on-road mobile emissions inventory software. MOVES3 was released in November 2020 (and updated in March 2021 and September 2021) and replaced the MOVES2014b version of the software. The March 2021 MOVES3.0.1 release was used for this work.

Table 2. Areas, Counties, and Activity Basis for 2020 AERR Inventories.

Area[1]	Counties	Activity Basis
1. Austin	Bastrop, Burnet, Caldwell, Hays, Travis, Williamson	TDM
2. Beaumont-Port Arthur	Jefferson, Hardin, and Orange	TDM
3. Dallas-Fort Worth	Collin, Denton, Dallas, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, Wise	TDM
4. El Paso[2]	El Paso	TDM
5. Houston-Galveston-Brazoria	Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller	TDM
6. San Antonio	Bexar, Comal, Guadalupe, Kendall, Wilson	TDM
7. Tyler-Longview-Marshall	Gregg, Smith Harrison, Rusk, Upshur	TDM HPMS
8. Remainder of Texas	214 Counties	HPMS
Totals by Activity Basis	37	TDM
	217	HPMS

[1] The 40 counties listed as (1) through (7) were modeled using county-level emission rates, whereas the remaining 214 counties (8) were modeled using the statewide inventory methodology, which produces emission rates estimates by county groups.
[2] El Paso is the only county for which a winter weekday inventory was produced.

The TDM and HPMS data were post-processed to estimate hourly, directional, link-level VMT and operational speeds for the emission calculations. The hourly off-network activity factors were estimated for the off-network emission calculations using estimates of vehicle operating hours (also known as vehicle hours traveled or VHT), vehicle type populations, combination long-haul truck hotelling, and other data. These off-network activity factors are off-network idling (ONI) hours, source hours parked (SHP), starts, and source hours extended idling (SHEI) and auxiliary power unit (APU) hours—where SHEI and APU are components of hotelling hours for combination long-haul trucks. Post-processing was performed using MOVES input, output, and default data to produce the off-network evaporative emission rates in terms of mass/SHP (currently not directly provided by MOVES). These post-processed emission rates were compiled with the other rates produced directly by MOVES emission rate mode runs yielding final emission rate look-up tables with all rates in terms of mass per vehicle activity unit (i.e., mass/mile, mass/SHP, mass/start, mass/ONI hour, mass/SHEI, mass/APU hour).

Since MOVES does not include the effects of the Texas Low Emissions Diesel (TxLED) program, adjustments were applied to incorporate TxLED effects in the 110 central and eastern counties in the program. The final rates were combined with their corresponding activity estimates in the seasonal weekday emissions calculations. Roadway-based rates were selected from the rate tables by hour, link speed, and road type for the roadway link-level hourly emissions calculations and off-network category rates were selected by hour for the off-network hourly emissions calculations.

A set of MOVES inventory mode CDBs was developed for producing annual emissions inventories consistent with the local data and with EPA's specifications for MOVES on-road input data submittals for the 2020 NEI. The resulting annual emissions output from MOVES was formatted similarly to the 24-hour summer weekday link-based emissions output (i.e., two tab-delimited summary files, one with standard MOVES category labeling, and one based on SCCs). The SCC-based 24-hour seasonal weekday and annual inventory summaries were converted to an Extensible Markup Language (XML) format suitable for uploading to the TCEQ's Texas Air Emissions Repository (TexAER) and/or EPA's Emissions Inventory System (EIS).

The inventories were produced using utilities developed by TTI to process on-road vehicle activity (TDM link-based or HPMS roadway-based), off-network vehicle activity, and SUT/fuel type emission rate data into spatially and temporally detailed emission estimates for use in air quality modeling, as well as various other needed reporting aggregations and formats. EPA's *Technical Guidance*[3] was the primary technical reference used for guidance on appropriate inputs and use of MOVES.

This analysis included both summer weekday and annual emission estimates for volatile organic compounds (VOC), carbon monoxide (CO), oxides of nitrogen (NO_X), sulfur dioxide (SO_2), ammonia (NH_3), carbon dioxide (CO_2), particulate matter with an aerodynamic diameter equal to or less than 2.5 microns ($PM_{2.5}$), and particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM_{10}); and annual estimates for HAPs, which include six priority mobile source air toxics (MSATs: benzene, methyl tertiary-butyl ether, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein) and the additional on-road mobile source air toxic pollutants included in the MOVES database (gaseous hydrocarbons, metals, dioxin/furans, and polycyclic aromatic hydrocarbons). Emission summaries by the on-road emissions processes available in MOVES were included (refueling emissions processes were excluded).

Table 3, Table 5, and Table 6 summarize the 2020 estimates of summer weekday 24-hour CAPs and CO_2 emissions, annual CAPs and CO_2 emissions, and annual HAPs emissions, for all of the counties in Texas. Summer weekday VMT, winter weekday VMT (El Paso only), speed, and annual VMT estimates are also included.

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[3] EPA. 2020. *MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity*, EPA-420-B-20-052, Office of Transportation and Air Quality. November 2020.

The detailed emissions inventory results in a tab-delimited file format (by pollutant and emissions process, for each vehicle type and roadway category) were provided in electronic form as described in Appendix A.

Table 3. Area 2020 Summer Weekday Emissions (Tons/Day).

Austin (AUS) Metropolitan Planning Area.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Bastrop	2,643,433	45.9	0.68	12.56	1.50	1,372.84	0.01	0.07	0.22	0.06
Burnet	2,033,722	42.5	0.46	9.77	1.24	1,078.60	0.01	0.05	0.20	0.05
Caldwell	1,360,308	49.0	0.34	7.27	0.83	738.28	0.00	0.04	0.11	0.03
Hays	5,931,596	47.7	1.18	24.00	2.71	2,894.27	0.01	0.16	0.43	0.11
Travis	25,920,364	43.3	4.65	97.99	9.88	12,688.88	0.07	0.66	2.14	0.50
Williamson	12,562,830	44.7	2.42	46.45	5.15	6,194.50	0.03	0.32	1.00	0.25
Area Total	**50,452,255**	**44.4**	**9.73**	**198.03**	**21.31**	**24,967.37**	**0.13**	**1.30**	**4.09**	**1.00**

Beaumont-Port Arthur (BPA) Metropolitan Planning Area.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Hardin	1,443,265	43.8	0.34	6.76	0.84	804.35	0.00	0.04	0.14	0.04
Jefferson	6,723,165	45.3	1.47	32.33	4.25	3,903.87	0.02	0.19	0.58	0.17
Orange	3,093,007	49.0	0.61	14.31	2.40	1,910.00	0.01	0.09	0.26	0.09
Area Total	**6,723,165**	**46.0**	**1.47**	**32.33**	**4.25**	**3,903.87**	**0.02**	**0.19**	**0.98**	**0.30**

Dallas-Fort Worth (DFW) Metropolitan Planning Area.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Collin	21,429,270	40.0	4.07	75.99	6.18	9,991.28	0.06	0.52	1.85	0.38
Dallas	67,487,160	40.3	8.33	268.86	22.09	30,930.47	0.18	1.67	5.85	1.22
Denton	17,336,833	41.1	3.68	62.48	6.17	8,338.33	0.05	0.43	1.47	0.33
Ellis	6,587,346	50.8	1.23	27.14	3.92	3,656.95	0.02	0.18	0.46	0.14
Hood	1,353,049	44.2	0.44	6.55	0.92	769.00	0.00	0.04	0.13	0.04
Hunt	3,490,945	51.1	0.91	18.51	3.32	2,353.57	0.01	0.11	0.30	0.11
Johnson	4,655,469	45.2	1.21	19.94	3.14	2,672.82	0.01	0.13	0.45	0.13
Kaufman	4,840,061	52.4	0.88	18.92	2.98	2,702.19	0.01	0.13	0.33	0.11
Parker	4,630,350	47.7	0.98	17.47	3.28	2,626.68	0.01	0.13	0.41	0.12
Rockwall	2,669,511	42.4	0.54	9.83	1.22	1,363.69	0.01	0.07	0.23	0.06
Tarrant	47,620,624	40.7	10.06	185.78	19.75	23,677.38	0.13	1.23	4.48	1.01
Wise	2,826,932	49.1	0.69	13.26	2.15	1,627.94	0.01	0.08	0.24	0.07
Area Total	**184,927,550**	**41.6**	**33.05**	**724.73**	**75.12**	**90,710.28**	**0.50**	**4.72**	**16.21**	**3.71**

El Paso Metropolitan Planning Area.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
El Paso	17,146,608	36.9	5.38	80.62	14.10	9,742.71	0.03	0.48	2.10	0.53

Houston-Galveston-Brazoria (HGB) Metropolitan Planning Area.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Brazoria	8,436,525	44.5	1.77	34.35	3.32	4,242.25	0.02	0.22	0.65	0.16
Chambers	3,075,877	59.4	0.43	13.26	2.69	2,084.27	0.01	0.09	0.20	0.08
Fort Bend	13,341,519	37.4	3.10	53.63	4.84	6,724.30	0.04	0.33	1.36	0.29
Galveston	6,906,452	40.1	1.56	29.28	2.35	3,392.30	0.02	0.18	0.62	0.13
Harris	114,027,492	36.6	21.74	477.96	41.69	57,396.71	0.35	2.99	11.83	2.48
Liberty	2,401,882	48.8	0.61	11.90	1.49	1,351.08	0.01	0.07	0.18	0.05
Montgomery	14,852,794	41.3	2.93	55.88	5.70	7,334.85	0.04	0.38	1.31	0.30
Waller	2,365,400	54.3	0.45	11.88	1.45	1,296.79	0.01	0.07	0.14	0.05
Area Total	**165,407,940**	**38.1**	**32.61**	**688.15**	**63.53**	**83,822.55**	**0.50**	**4.33**	**16.31**	**3.55**

San Antonio Metropolitan Planning Area.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Bexar	55,210,582	27.7	14.62	296.30	27.70	31,161.92	0.16	1.48	8.42	1.69
Comal	6,755,724	27.5	1.75	35.46	4.36	4,053.55	0.02	0.19	1.12	0.24
Guadalupe	6,251,783	29.7	1.80	34.97	4.78	3,994.24	0.02	0.17	1.03	0.24
Kendall	1,857,932	37.3	0.55	9.24	1.31	1,085.56	0.01	0.05	0.23	0.06
Wilson	2,132,974	26.0	0.69	13.29	1.63	1,389.15	0.01	0.06	0.40	0.09
Area Total	**72,208,995**	**28.0**	**19.42**	**389.25**	**39.79**	**41,684.42**	**0.21**	**1.96**	**11.20**	**2.32**

Tyler-Longview-Marshall (TLM) Metropolitan Planning Area.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Gregg	3,908,764	42.7	0.88	18.59	2.01	2,060.95	0.01	0.10	0.35	0.09
Harrison[3]	3,093,946	49.8	0.65	15.00	3.31	2,226.21	0.01	0.09	0.30	0.11
Rusk[3]	1,494,197	44.1	0.20	7.37	0.85	768.01	0.00	0.04	0.14	0.04
Smith	7,004,464	44.1	1.62	33.31	4.40	3,907.87	0.02	0.19	0.63	0.17
Upshur[3]	1,267,568	43.9	0.34	6.37	1.01	772.04	0.00	0.04	0.14	0.04
Area Total	**16,768,940**	**44.7**	**3.69**	**80.64**	**11.59**	**9,735.09**	**0.05**	**0.47**	**1.55**	**0.44**

All Other Texas Counties.[4]

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
214 counties[3]	260,184,064	44.1	59.62	1,284.99	231.78	165,624.09	0.75	7.37	28.19	8.44

Statewide Total.

County	VMT	Speed[1]	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
254 counties	778,355,789	40.0	165.91	3,499.83	464.70	432,904.73	2.21	20.93	80.63	20.29

[1] Miles-per-hour, aggregated by county.
[2] Particulate matter (PM) estimates are MOVES-based only (i.e., no re-suspended dust from roadways was included).
[3] An HPMS-based methodology was used for these counties. A TDM-based methodology was used for all other counties.
[4] Includes all Texas counties outside the areas comprising 39 counties of Austin, BPA, DFW, El Paso, HGB, San Antonio, and TLM metropolitan planning areas.

Table 4. Area 2020 Winter Weekday Emissions (Tons/Day).

El Paso Metropolitan Planning Area.

County	VMT	Speed	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
El Paso	18,968,664	36.2	4.79	72.86	16.68	10,379.29	0.06	0.54	2.41	0.62

[1] Miles-per-hour.

[2] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways was included).

Table 5. Area 2020 Annual Emissions (Tons/Year).

Austin Metropolitan Planning Area.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bastrop	915,577,255	222.62	3,944.85	577.33	474,181.37	2.55	26.51	45.54	17.04
Burnet	704,397,350	153.47	2,947.35	472.03	368,292.91	1.92	19.64	39.07	14.08
Caldwell	471,154,591	110.32	2,204.90	321.44	253,633.91	1.35	14.12	22.33	9.01
Hays	2,054,461,510	385.84	7,386.03	1,012.14	987,821.90	5.39	54.77	89.26	31.43
Travis	8,977,748,680	1,458.56	27,817.57	3,614.59	4,195,652.05	23.21	228.39	423.10	131.40
Williamson	4,351,251,723	773.87	13,675.16	1,908.97	2,078,581.06	11.42	110.96	205.60	67.08
Area Total	**17,474,591,110**	**3,104.69**	**57,975.85**	**7,906.50**	**8,358,163.20**	**45.83**	**454.39**	**824.91**	**270.04**

Beaumont-Port Arthur Metropolitan Planning Area.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Hardin	509,784,984	108.48	1,989.27	330.42	278,218.06	1.43	13.76	28.50	10.70
Jefferson	2,374,735,508	475.87	9,408.69	1,680.32	1,352,225.16	6.81	66.18	128.41	50.70
Orange	1,092,501,565	201.73	4,163.84	952.78	663,760.39	3.22	31.74	59.06	27.06
Area Total	**3,977,022,057**	**786.07**	**15,561.80**	**2,963.52**	**2,294,203.61**	**11.46**	**111.69**	**215.97**	**88.46**

Dallas-Fort Worth Metropolitan Planning Area.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Collin	7,296,552,628	1,253.66	21,206.64	2,320.59	3,236,765.98	19.63	176.79	352.56	95.93
Dallas	22,979,021,431	4,126.14	75,814.90	8,668.24	10,595,637.79	63.93	607.46	1,099.99	315.46
Denton	5,903,099,051	1,136.00	17,990.66	2,329.53	2,732,474.58	16.22	146.91	282.07	84.96
Ellis	2,242,955,318	395.49	7,696.74	1,536.35	1,219,592.25	6.27	63.10	97.89	42.47
Hood	454,607,141	137.66	1,951.60	345.05	254,958.67	1.32	12.34	26.80	10.34
Hunt	1,164,594,859	287.42	5,168.04	1,249.31	770,788.12	3.67	35.53	66.58	32.11
Johnson	1,564,179,914	385.53	5,953.71	1,195.22	884,122.42	4.53	43.99	89.21	35.72
Kaufman	1,648,015,635	282.02	5,449.53	1,187.94	906,833.07	4.61	46.48	70.68	32.21
Parker	1,555,738,855	320.10	5,292.23	1,254.63	875,853.54	4.45	43.74	82.94	35.32
Rockwall	908,953,907	170.80	2,816.85	479.88	450,726.39	2.42	23.34	44.88	15.77
Tarrant	15,999,923,819	3,119.09	52,695.00	7,197.48	7,637,348.26	45.16	415.09	847.73	257.51
Wise	949,814,446	227.54	3,986.24	847.43	547,126.26	2.78	28.42	51.57	22.82
Area Total	**62,667,457,005**	**11,841.45**	**206,022.14**	**28,611.65**	**30,112,227.30**	**174.99**	**1,643.19**	**3,112.91**	**980.63**

El Paso Metropolitan Planning Area.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso	6,816,681,023	1,795.33	27,551.73	5,804.70	3,762,522.57	17.30	194.93	474.81	166.25

Houston-Galveston-Brazoria Metropolitan Planning Area.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Brazoria	2,869,647,096	555.56	9,723.67	1,262.37	1,406,325.86	7.69	76.10	132.44	43.49
Chambers	1,086,451,246	142.11	3,606.52	1,051.39	713,408.76	3.32	31.41	49.44	27.17
Fort Bend	4,538,060,020	948.07	14,817.01	1,733.34	2,151,546.75	11.96	112.62	251.41	70.94
Galveston	2,349,204,936	487.72	8,237.29	884.78	1,119,903.47	6.29	61.28	121.72	34.77
Harris	38,785,926,709	6,755.61	130,766.91	15,248.50	18,520,384.63	103.74	1,021.22	2,139.41	598.19
Liberty	848,384,640	200.85	3,603.90	587.80	470,538.34	2.44	24.91	40.59	16.76
Montgomery	5,052,111,655	919.90	15,832.28	2,146.50	2,407,859.32	13.23	129.94	249.76	77.70
Waller	804,580,236	148.32	3,359.84	568.10	434,512.02	2.26	24.54	31.76	14.83
Area Total	**56,334,366,538**	**10,158.13**	**189,947.43**	**23,482.79**	**27,224,479.14**	**150.92**	**1,482.01**	**3,016.53**	**883.86**

San Antonio Metropolitan Planning Area.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bexar	15,148,815,928	3,546.05	64,251.41	7,703.01	7,772,692.56	43.21	400.58	1,070.12	297.25
Comal	1,886,722,378	433.31	7,855.27	1,234.41	1,026,655.66	5.52	51.06	138.08	42.88
Guadalupe	1,385,274,433	348.85	6,033.00	1,055.02	796,573.93	4.13	38.05	96.71	34.10
Kendall	451,855,755	120.34	1,858.35	339.19	250,079.11	1.27	12.09	28.11	10.34
Wilson	450,685,915	125.62	2,148.33	337.14	258,299.28	1.36	12.56	32.85	11.11
Area Total	**19,323,354,409**	**4,574.18**	**82,146.36**	**10,668.77**	**10,104,300.53**	**55.49**	**514.34**	**1,365.87**	**395.68**

Tyler-Longview-Marshall Metropolitan Planning Area.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Gregg	1,294,503,394	286.49	5,347.16	770.64	676,396.61	3.63	35.53	70.79	24.27
Harrison	1,008,069,300	208.42	4,172.70	1,226.32	716,608.45	3.28	30.77	64.57	31.92
Rusk	494,848,006	125.31	2,186.42	346.02	267,574.13	1.41	14.18	27.59	10.40
Smith	2,319,737,501	518.60	9,584.71	1,643.88	1,273,922.49	6.63	65.01	128.92	48.45
Upshur	412,999,477	109.09	1,853.31	380.06	250,154.75	1.25	12.11	27.09	11.12
Area Total	**5,530,157,677**	**1,247.91**	**23,144.29**	**4,366.92**	**3,184,656.43**	**16.20**	**157.60**	**318.96**	**126.16**

All Other Texas Counties.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
214 counties	88,398,573,516	19,629.20	376,626.24	86,620.46	55,414,770.02	269.83	2,561.53	5,769.20	2,416.10

Statewide Total.

County	VMT	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
254 counties	260,522,203,333	53,136.98	978,975.84	170,425.32	140,455,322.81	742.02	7,119.68	15,099.15	5,327.18

[1] PM estimates are MOVES-based only (i.e., no re-suspended dust from roadways was included).

Table 6. Area 2020 Annual Hazardous Air Pollutant Emissions (Tons/Year).

Austin Metropolitan Planning Area.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Bastrop	4.25	2.48	1.99	0.55	0.20	49.87	0.45	0.004	8.40E-08	38.97
Burnet	2.94	1.86	1.43	0.39	0.15	33.91	0.34	0.003	6.43E-08	32.70
Caldwell	2.10	1.32	1.03	0.27	0.10	24.47	0.24	0.002	4.29E-08	20.90
Hays	7.58	4.18	3.49	0.96	0.34	86.29	0.77	0.009	1.91E-07	66.98
Travis	27.48	15.02	12.54	3.41	1.24	326.27	2.77	0.039	8.43E-07	260.53
Williamson	14.83	8.27	7.02	1.92	0.70	171.88	1.52	0.019	4.07E-07	140.03
Area Total	**59.17**	**33.13**	**27.50**	**7.49**	**2.74**	**692.69**	**6.08**	**0.076**	**1.63E-06**	**560.11**

Beaumont-Port Arthur Metropolitan Planning Area.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Hardin	2.19	1.38	1.07	0.26	0.11	23.58	0.25	0.002	4.59E-08	25.35
Jefferson	9.37	6.84	5.03	1.09	0.55	101.78	1.16	0.010	2.11E-07	122.51
Orange	3.79	4.07	2.70	0.45	0.32	40.28	0.64	0.005	9.47E-08	75.65
Area Total	**15.35**	**12.30**	**8.81**	**1.79**	**0.99**	**165.64**	**2.05**	**0.017**	**3.52E-07**	**223.51**

Dallas-Fort Worth Metropolitan Planning Area.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Collin	21.43	11.33	10.98	3.57	0.95	282.17	2.22	0.032	6.95E-07	162.40
Dallas	67.81	39.85	35.23	10.81	3.16	933.51	7.51	0.100	2.18E-06	565.45
Denton	18.98	10.97	10.33	3.23	0.92	254.26	2.08	0.026	5.56E-07	164.11
Ellis	7.43	5.80	4.36	0.98	0.47	84.21	0.98	0.010	2.01E-07	103.52
Hood	2.61	1.42	1.25	0.36	0.12	30.83	0.26	0.002	4.06E-08	25.22
Hunt	5.29	4.47	3.30	0.71	0.36	60.82	0.74	0.005	9.78E-08	85.50
Johnson	7.20	4.73	3.82	0.98	0.39	84.52	0.83	0.007	1.39E-07	89.19
Kaufman	5.20	4.67	3.38	0.69	0.38	58.65	0.76	0.007	1.47E-07	84.16

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Parker	5.92	5.28	3.88	0.81	0.43	66.63	0.85	0.007	1.38E-07	98.22
Rockwall	3.28	2.25	1.80	0.44	0.19	36.77	0.38	0.004	8.41E-08	37.54
Tarrant	50.35	31.80	27.88	8.25	2.56	699.49	5.86	0.070	1.50E-06	539.57
Wise	4.28	3.80	2.74	0.58	0.30	47.55	0.61	0.004	8.42E-08	65.81
Area Total	**199.77**	**126.36**	**108.96**	**31.41**	**10.23**	**2,639.41**	**23.09**	**0.273**	**5.87E-06**	**2,020.70**

El Paso Metropolitan Planning Area.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
El Paso	32.17	22.70	17.28	4.42	1.82	392.74	3.95	0.030	6.23E-07	413.16

Houston-Galveston-Brazoria Metropolitan Planning Area.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Brazoria	8.46	5.67	4.82	1.38	0.45	124.58	1.03	0.013	2.68E-07	89.74
Chambers	2.13	3.72	2.40	0.33	0.29	25.95	0.55	0.005	9.07E-08	76.48
Fort Bend	14.34	8.57	7.88	2.39	0.71	214.55	1.60	0.020	4.30E-07	140.23
Galveston	7.47	4.32	3.89	1.21	0.35	110.89	0.82	0.010	2.23E-07	64.94
Harris	104.58	73.38	59.22	16.00	5.72	1,510.29	13.02	0.169	3.68E-06	1,200.11
Liberty	3.12	2.62	2.03	0.52	0.21	43.92	0.45	0.004	7.63E-08	42.05
Montgomery	14.30	10.10	8.45	2.33	0.81	204.66	1.80	0.022	4.75E-07	164.44
Waller	2.30	2.53	1.75	0.36	0.19	31.07	0.40	0.004	7.31E-08	40.25
Area Total	**156.70**	**110.90**	**90.45**	**24.51**	**8.73**	**2,265.90**	**19.67**	**0.246**	**5.32E-06**	**1,818.25**

San Antonio Metropolitan Planning Area.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Bexar	67.05	36.50	29.87	8.25	2.95	799.59	6.69	0.066	1.42E-06	615.94
Comal	7.99	5.65	4.24	0.99	0.45	94.73	0.96	0.008	1.74E-07	107.55
Guadalupe	6.33	4.58	3.45	0.81	0.37	76.14	0.78	0.006	1.24E-07	86.31

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Kendall	2.17	1.40	1.12	0.30	0.12	26.58	0.25	0.002	4.07E-08	25.69
Wilson	2.35	1.43	1.13	0.30	0.11	27.95	0.26	0.002	4.07E-08	27.15
Area Total	**85.88**	**49.56**	**39.82**	**10.65**	**4.00**	**1,024.99**	**8.93**	**0.084**	**1.80E-06**	**862.65**

Tyler-Longview-Marshall Metropolitan Planning Area.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
Gregg	5.57	3.36	2.72	0.71	0.27	63.50	0.60	0.006	1.19E-07	54.18
Harrison	3.74	4.35	2.94	0.50	0.35	41.29	0.68	0.004	8.17E-08	89.37
Rusk	2.45	1.46	1.18	0.32	0.12	27.82	0.26	0.002	4.48E-08	24.45
Smith	9.95	6.73	5.21	1.29	0.54	113.30	1.17	0.010	2.09E-07	114.86
Upshur	2.08	1.50	1.15	0.28	0.12	23.64	0.26	0.002	3.60E-08	28.83
Area Total	**23.79**	**17.39**	**13.19**	**3.11**	**1.39**	**269.54**	**2.97**	**0.024**	**4.91E-07**	**311.70**

All Other Texas Counties.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
214 counties	358.10	322.98	229.35	47.77	25.73	4,110.03	52.85	0.388	7.62E-06	6,461.25

Statewide Total.

County	Benz[1]	Form	Acet	1,3-But	Acrol	OGH	PAH	Metal	Dio/Fur	DPM +DEOG[2]
254 counties	930.93	695.34	535.36	131.15	55.61	11,560.94	119.59	1.138	2.37E-05	12,671.32

[1] Abbreviation from left: Benzene, Formaldehyde, Acetaldehyde, 1.3-Butadiene, Other Gaseous Hydrocarbon HAPs (Toluene, Xylene, 2,2,4-Trimethylpentane, Hexane, Ethyl Benzene, Styrene, Propionaldehyde), Polycyclic Aromatic Hydrocarbons (16 PAHs), Metal Compounds (Arsenic, Chromium, Manganese, Mercury, Nickel), Dioxins and Furans (17), and diesel particulate matter and diesel exhaust organic gases (represented as total of diesel fleet exhaust VOC and exhaust PM_{10}).

[2] Note that the DPM+DEOG emissions estimates are not exclusive of the other tabulated fleetwide HAPs emissions estimates.

1.0 INTRODUCTION

The Texas Commission on Environmental Quality (TCEQ) works with local planning districts, the Texas Department of Transportation (TxDOT), and the Texas A&M Transportation Institute (TTI) to provide on-road mobile source emissions inventories of air pollutants. TxDOT typically funds transportation conformity determinations required under 40 Code of Federal Regulations (CFR) Part 93. The TCEQ funds mobile source inventory work in support of federal Clean Air Act (CAA) requirements, such as attainment of the National Ambient Air Quality Standards (NAAQS), as well as the control of hazardous air pollutants (HAPs).

Under the U.S. Environmental Protection Agency's (EPA) Air Emissions Reporting Requirements (AERR), the state of Texas is required to prepare and submit a comprehensive statewide periodic emissions inventory (EI) and provide EPA Motor Vehicle Emissions Simulator (MOVES) county database files (CDBs) to support the EPA's National Emissions Inventory (NEI) every three years. The three-year cycle inventory year for this work was 2020 and is due to the EPA by January 15, 2022.

This report describes work conducted by TTI on behalf of the TCEQ and details how TTI produced the Texas 2020 on-road mobile source triennial (periodic) EIs and CDBs according to AERR requirements. The work involved the development of 2020 mobile source model inputs for MOVES and emission estimates for criteria air pollutants (CAPs), CAP precursors, and HAPs. The on-road mobile CDBs and inventories prepared under this work incorporated recently collected data for the calendar year 2020 and used the latest version of the MOVES model. The work also included preparation of requisite vehicle miles of travel (VMT) inputs for the TCEQ's Texas Road Dust Calculator necessary to develop a statewide 2020 calendar year emissions inventory. The work was conducted in accordance with the associated TCEQ-approved pre-analysis plan.

1.1 Objective

The purpose of this document is to describe the methods and data used to develop the 2020 year EIs and CDBs for all 254 Texas counties. TTI developed for summer work weekday and winter work weekday (El Paso only) (together referred to as daily EIs) inventory estimates of CAPs and CAP precursors, and annual EI estimates of CAPs, CAP precursors, and HAPs. The objective also included providing the requisite VMT inputs for the TCEQ's Texas Road Dust Calculator for the statewide 2020 EI.

For this statewide AERR, TTI used travel demand model (TDM) network link-based VMT for the counties in the seven areas with current TDMs listed in Table 7 and used Highway Performance Monitoring System (HPMS)-based VMT for counties not included in a TDM.

Table 7. Areas, Counties, and Activity Basis for AERR Inventory.

Area[1]	Counties	Activity Basis
1. Austin (AUS)	Bastrop, Burnet, Caldwell, Hays, Travis, Williamson	TDM
2. Beaumont-Port Arthur (BPA)	Jefferson, Hardin, and Orange	TDM
3. Dallas-Fort Worth (DFW)	Collin, Denton, Dallas, Ellis, Hood, Hunt, Johnson, Kaufman, Parker, Rockwall, Tarrant, Wise	TDM
4. El Paso[2]	El Paso	TDM
5. Houston-Galveston-Brazoria (HGB)	Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller	TDM
6. San Antonio	Bexar, Comal, Guadalupe, Kendall, Wilson	TDM
7. Tyler-Longview-Marshall (TLM)	Gregg, Smith	TDM
	Harrison, Rusk, Upshur	HPMS
8. Remainder of Texas	214 Counties	HPMS
Totals by Activity Basis	37 Counties	TDM
	217 Counties	HPMS

[1] The 40 counties listed as (1) through (7) were modeled using county-level emission rates, whereas the remaining 214 counties (8) were modeled using the statewide inventory methodology, which produces emission rates estimates by county groups.
[2] El Paso was the only county for which a winter weekday inventory was produced.

The methods used to calculate the daily and annual EIs are an extension of historically-consistent traffic activity and emission rate methods developed by TTI. The emissions inventory calculations described in this document were based on an hourly, link-level analysis that uses the outputs of the regional TDM or HPMS, as well as other local data sources (e.g., seasonal, day type, and hourly travel factors, vehicle population data, and environmental inputs) consistent with the region, and MOVES default inputs. This report details the data sources, methods, and the annual and seasonal weekday combinations used to define each EI developed for this project.

At the request of TCEQ, the EIs were developed using the latest version of the EPA's on-road emissions inventory software—MOVES3. MOVES3 was released (and replaced the MOVES2014b version of the software) in November 2020 (initially as MOVES3.0.0) and was updated in March 2021 (MOVES3.0.1), then in September 2021 (MOVES3.0.2), and again in January 2022 (MOVES3.0.3). The EI methods described in this document have been developed to incorporate the latest information on on-road mobile source emissions and methods outlined in the associated EPA guidance for conducting

MOVES3-based EIs. Using the TDM VMT data and HPMS VMT data developed during this project, TTI also produced updated Texas-specific activity input where needed for the year 2020. The data was specifically formatted for use with the Texas Road Dust Calculator for 254 Texas counties.

This project involved the development of electronic deliverables that were post-processed from each county EI into formats described below.

- Tabular summaries of activity and emissions by county based on MOVES source use types.
- Tabular summaries of activity and emissions by county based on the EPA's Source Classification Codes (SCCs).
- MOVES CDBs, MOVES run specification files, and utilities used to process the data files for the MOVES runs.
- Emissions inventory files and CDBs formatted and ready for upload to the EPA's Emissions Inventory System (EIS).
- Input files for use in the Texas Road Dust Calculator for all 254 Texas counties.

1.2 Summary of Modeling Methodology

The EIs were calculated using a detailed MOVES rates-per-activity estimation method based on the areas described in Table 7. This approach calculates on-network emissions for each link defined by the regional TDM or HPMS outputs and formats results as needed for subsequent uses. The TTI rates-per-activity estimation method was performed using four basic steps as described below.

- **Step 1 – Estimate Emission Rates:** MOVES3 was used to estimate regional emission rates (or factors) relevant to the analysis area. The rates were calculated based on local inputs to MOVES such as temperature and humidity, fuel formulation, etc.
- **Step 2 – Estimate Traffic Activity:** The local HPMS and TDM data were processed to derive 24 hourly VMT and speed estimates for all virtual HPMS links and TDM links (as well as for added TDM intrazonal links). Further processing was used to convert VMT-based HPMS factors and seasonal and daily adjustment factors. Local automatic traffic recorder (ATR) traffic count data was used to process the HPMS and TDM data. After on-network activity was estimated, off-network activity was calculated using outputs from the

processed HPMS and TDM data, vehicle population data, and MOVES default inputs. The traffic activity was processed to replicate the operating conditions for each EI.

- **Step 3 – Develop Seasonal Emissions:** The seasonal weekday emission rates calculated in Step 1 were multiplied by the on- and off-network activity calculated in Step 2. This yielded emission estimates in units of mass calculated at a spatial scale of each link (on-network) or county (off-network) for each hour of the day.

Step 4 – Develop Annual Emissions: The summer weekday on- and off-network activities were used in the development of annual activities which in turn was used to develop the county-level CDBs used in the annual inventory runs using MOVES.

- **Step 5 – Post-Process EI Outputs:** Outputs for each pollutant were post-processed into a variety of formats and electronic deliverables for reporting purposes and for downstream air quality planning.

Subsequent sections of this report describe these basic steps in more detail.

1.3 Emissions Inventory Scope

TTI developed and produced the Texas 2020 on-road mobile source triennial EIs and CDBs for all 254 counties according to the AERR requirements and the pre-analysis plan, as approved by the TCEQ. The following six subsections (Emissions Inventory Parameters; Source Use Types, Activity, and Pollutant Processes; Pollutants Modeled; Emission Rate (MOVES) Input Data; Traffic Activity Input Data; and Emissions Inventory Outputs) provide detailed lists of the scope of criteria used for the preparation of the emissions inventory products.

Emissions Inventory Parameters:

Emissions inventories were developed to model the following emissions parameters:

- Analysis year—2020.
- Summer work weekday (Monday through Friday) emissions statewide for all 254 counties. Adjust the average annual weekday to the average for summer months.
- Winter work weekday (Monday through Friday) emissions for El Paso County. Adjust the average annual weekday to the average for winter months.

- Annual emissions (calendar year totals for all counties) statewide for all 254 counties.

These emissions inventories were estimated by combining traffic activity estimates for each county and each daily (summer work weekday and winter work weekday) or annual EI as described above. The final EIs were calculated by multiplying the activity rate scenarios by the corresponding emission rates.

Source Use Types, Activity, and Pollutant Processes:

- *Source use types (SUT) and fuel types* modeled—the various combinations of these are referred to as *vehicle types* as described in Table 8.
- *Traffic activity modeled*: VMT, vehicle starts, hotelling hours (classified by auxiliary power unit [APU], engine on, engine off), source hours parked, off-network idling.
- *Vehicle-based emission processes modeled*: running exhaust; crankcase running exhaust; start exhaust; crankcase start exhaust; extended idle exhaust; crankcase extended idle exhaust; auxiliary power exhaust; evaporative permeation; evaporative fuel vapor venting; evaporative liquid leaks; brakewear; and tirewear.

Table 8. MOVES SUT/Fuel Types (Vehicle Types).

SUT ID	SUT Description	SUT Abbreviation[1]	Fuel Types
11	Motorcycle	MC	Gasoline
21	Passenger Car	PC	Gasoline, Diesel
31	Passenger Truck	PT	Gasoline, Diesel
32	Light Commercial Truck	LCT	Gasoline, Diesel
41	Other Buses	OBus	Gasoline, Diesel
42	Transit Bus	TBus	Gasoline, Diesel
43	School Bus	SBus	Gasoline, Diesel
51	Refuse Truck	RT	Gasoline, Diesel
52	Single Unit Short-Haul Truck	SUShT	Gasoline, Diesel
53	Single Unit Long-Haul Truck	SULhT	Gasoline, Diesel
54	Motor Home	MH	Gasoline, Diesel
61	Combination Short-Haul Truck	CShT	Gasoline, Diesel
62	Combination Long-Haul Truck	CLhT	Diesel

[1] The SUT/fuel type, or vehicle type labels are the combined SUT abbreviation and fuel type names separated by an underscore (e.g., MC_Gas, RT_Diesel, and SBus_Gas are gasoline-powered motorcycles, diesel-powered refuse trucks, and gasoline-powered school buses).

Pollutants Modeled:

- *CAPs and CAP precursors* for the daily and the annual emissions inventories—the CAP precursors include volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxide (SO_2), ammonia (NH_3), carbon dioxide (CO_2), particulate matter with an aerodynamic diameter equal to or less than 2.5 microns ($PM_{2.5}$), and particulate matter with an aerodynamic diameter of equal to or less than 10 microns (PM_{10}).
- *HAPs* for annual emissions inventories—HAPs include six priority mobile source air toxics (MSATs: benzene, methyl tertiary-butyl ether, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein) and the additional on-road mobile source air toxic pollutants included in the MOVES database (gaseous hydrocarbons, metals, dioxin/furans, and polycyclic aromatic hydrocarbons) which includes all 21 MSATs listed in the EPA's 2001 MSAT rule.

Emission Rate (MOVES) Input Data:

- *Emission rates:* EPA's latest mobile source emission rate model—MOVES3.0.1 (herein abbreviated to MOVES). The latest version of the model upon commencement of this work was released in March 2021. MOVES installation suites were downloaded from the following link: https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves [4]

- *Local meteorologic data*: 2019 climate inputs (temperature, humidity, barometric pressure) provided by the TCEQ.
- *Local fuel formulation input data:*
  - Consistent with TCEQ 2020 Summer Fuel Field Study conducted by Eastern Research Group (ERG) under contract to TCEQ, available at https://www.tceq.texas.gov/airquality/airmod/project/pj_report_mob.html.
  - MOVES individual fuel parameter inputs were used to model the Low Reid Vapor Pressure (RVP) gasoline control strategy for applicable counties, consistent with Sections 114.301-114.309 of TCEQ rules.[5]
  - Modeled reformulated gasoline for the HGB area and the four DFW counties—Collin, Dallas, Denton, and Tarrant.
  - Modeled the effects of the oxygenated fuel program for El Paso.
  - Modeled Texas Low Emission Diesel (TxLED) program effects by post-processing diesel NO_X emission factors consistent with 30 Texas Administrative Code (TAC) Sections 114.312 – 114.319.
- *Inspection and maintenance (I/M) program information*: Modeled I/M programs currently administered in the Austin-Round Rock, DFW, HGB, and El Paso areas.
- *Federal motor vehicle control programs (FMVCP)*: Modeled the effects of all FMVCP in Texas, as incorporated by default in MOVES.

Traffic Activity Input Data:

- Validated TDM link-based VMT for the analysis year 2020 for the seven areas with current TDMs listed in Table 7 and HPMS-based VMT for counties not included in a TDM.
- Texas Department of Transportation (TxDOT) traffic count data (latest available 2019) to derive seasonal, day type, and hour of day traffic patterns.

[4] Note that the daily inventories were produced earlier in the project than the annual inventories. MOVES3.0.1 released in March 2021 was used to develop the emission rates for the daily inventories while the annual emissions inventories produced toward the end of the project period used MOVES3.0.3 released in January 2022.

[5] Code of Federal Regulations, Title 40 – Protection of the Environment, Part 80 – Regulation of Fuels and Fuel Additives, Section 27 – Controls and Prohibitions on Gasoline Volatility.

    - HPMS data for deriving HPMS adjustment factors and historical year county VMT control totals.
    - Base hotelling hours data sourced from TTI's 2017 hotelling study.[6]
    - MOVES default hotelling mode distributions.
- MOVES defaults for the number of vehicle starts per local vehicle type population estimates.
    - Vehicle population data: End of year 2018 vehicle registrations and age class data classified by source use and fuel type provided by the Texas Department of Motor Vehicles (TxDMV) with VMT-based scaling factors for estimating 2020.
    - For local fleet mix:
        - TxDOT traffic classification data.
        - TxDMV vehicle registrations data.
        - MOVES default data as needed.

Emissions Inventory Outputs:

- County-level activity and control program tables sufficient for the CDBs to be used in MOVES inventory mode.
- A document listing all the files being submitted and detailing file naming conventions.
- MOVES CDBs, MOVES run spec files, and MySQL files used to process data files for MOVES runs.
- All pertinent data relating to task activities.
- Two standard sets of activity and inventory summary files: one based upon MOVES SUTs and one based upon the EPA's SCCs.
- TexAER-ready formatted inventory files.
- Inventory files formatted ready for uploading to the EPA's EIS.
- CDBs formatted and ready for uploading to the EPA's EIS.

The EPA requires 2020 emissions inventory data to be reported through the Central Data Exchange (CDX) system. TTI provided inventory summary data in a loadable format

[6] Heavy-Duty Vehicle Idle Activity Study Final Report, prepared by TTI for TCEQ, July 2019.

compatible with the EPA's EIS and the TCEQ's Texas Air Emissions Repository (TexAER). The format was based upon the most recent version of the EPA's NEI format with the Consolidated Emissions Reporting Schema (CERS) written in Extensible Markup Language (XML). The loadable inventory files were based upon the SCCs that are compatible with the 2020 NEI code list.

1.4 Report Structure

The remainder of this report provides a detailed description of the methods used to estimate the daily and annual EI products outlined in the summarized scope. The subsequent chapters broadly follow the simplified analysis steps reported in Section 1.2.

- Section 2—Estimating Traffic Activity—details the data and calculations used to calculate regional on-network and off-network traffic activity.
- Section 3—Estimating Weekday Emission Rates—details the calculation of emission rates via MOVES and subsequent rates modifications.
- Section 4—Developing Emissions Inventories—details the methods used to calculate regional emissions for the summer weekday and annual emissions.
- Section 5—Texas Road Dust Calculator Input Development—details the process, inputs, and considerations used to prepare the Texas Road Dust Calculator input tables.
- Section 6—Quality Assurance—details the internal review and quality assurance/quality control (QA/QC) procedures, including independent verification and reasonableness checks.

2.0 ESTIMATING TRAFFIC ACTIVITY

On-network and off-network activity are required to estimate mobile source emissions. TTI uses a method that calculates on-network daily emissions using VMT by hour and direction for each link in a TDM or each virtual link in a county HPMS data set. Off-network daily emissions are calculated using county-level, hourly estimates of activity, including off-network idling (ONI) hours, source hours parked (SHP), starts, source hours extended idling (SHEI), and APU hours. Annual roadway-based activity is estimated at a more aggregate level (i.e., not a the link-level). Both on- and off-network activity (and emissions) are produced for each of the on-road fleet vehicle types. This section describes the methods used to develop on- and off-network activity for the summer weekday and annual estimations.

2.1 Vehicle Type VMT Mix

VMT mix represents the fraction of on-road fleet VMT attributable to each SUT by fuel type and was needed for the daily and annual activity estimations. VMT mixes were used to subdivide the total VMT estimates on each link into VMT by vehicle type. Hourly VMT estimates by vehicle type were combined with the appropriate emission factors in the link-emissions calculations.

VMT mixes were calculated and applied at the scale of:

- Each TxDOT district.
- Each year (EI years and other applicable years).
- Each MOVES roadway type.
- Day type (Weekday).
- Four time periods per day (AM peak, midday, PM peak, and overnight).

VMT mixes were calculated using local vehicle classification count and ATR data, MOVES defaults, and local registration data. Figure 1 shows a simplified view of the method used to estimate VMT mix[7], which includes the following steps (numbered in Figure 1):

1. MOVES – Data files of MOVES default values extracted from MOVES databases or pro forma runs.
2. TxDOT Classification Counts – Data files of standard TxDOT classification data assembled and used for determining the in-use road fleet mix.

[7] *Developing MOVES Source Use Types and VMT Mix for Conformity Analysis* (TxDOT Air Quality / Conformity IAC-A - TTI Task 409252-0643: Maintain, Update and Enhance Traffic Activity Estimation and Forecasting Methods), Texas Department of Transportation, Austin, TX, August 2016.

3. TxDMV Registration Data – Data files of standard TxDMV vehicle registration summary data assembled and used for determining the in-use road fleet mix.
4. TxDOT ATR Data – Data files of TxDOT ATR data assembled and used to allocate VMT by season and day of week.
5. Single Unit Local vs. Total SUT_HDVyy – Procedure based on registration data to generate factors to separate Single Unit versus Combined Unit trucks by region. (SUT_HDVyy has multiple outputs based on vehicle category and fuel.)
6. Combination Local vs. Total SUT_HDXyy – Procedure based on MOVES default data to generate short-haul and long-haul combination truck proportions by region.
7. Day of Week (DOW) Factors by Urban Area/TxDOT District – Seasonal day-of-week factors from TxDOT ATR data used to allocate VMT by season and day-of-week by urban area/TxDOT district.
8. Single Unit Short-Haul vs. Long-Haul SUT_SSHZ – Procedure to separate single unit short-haul versus single unit long-haul using factors generated at SUT_HDVyy and classification count data. Short-haul and long-haul are functionally defined as local and pass through.
9. Combination Short-Haul vs. Long-Haul SUT_CSHZ – Procedure to separate combination short-haul versus combination long-haul with factors generated using MOVES defaults and classification count data. Short-haul and long-haul are functionally defined as local and pass-through.
10. PV and LDT Fuel MF_Fuelyy – Procedure to generate passenger vehicle and light truck fuel allocation by year based on MOVES national default values and local registration data.
11. Single Unit and Combination Truck Fuel SUT_HDVyy – Procedure to generate single unit and combined truck fuel allocation factors from registration data. (SUT_HDVyy has multiple outputs based on vehicle category and fuel.)
12. SUT_yyddtt – Procedure to generate SUT proportions by year, day type, and time period, based on the previous steps.
13. MOVES SUTs – Output file of MOVES SUTs by region, analysis year, day type, and time period. For MOVES3, P_ICB41D was renamed P_OB41D (per the redefined MOVES3 category equivalent to the previous MOVES2014 category), and P_OB41G was added and set to zero (since we have no data to support the proportion of the "Other Buses" category that is gasoline fueled).[8]

[8] Specifically, the intercity bus category (ICB41) is redefined and renamed "Other Buses" (OB41). Intercity bus was previously considered diesel only. While there is currently no data available to determine the

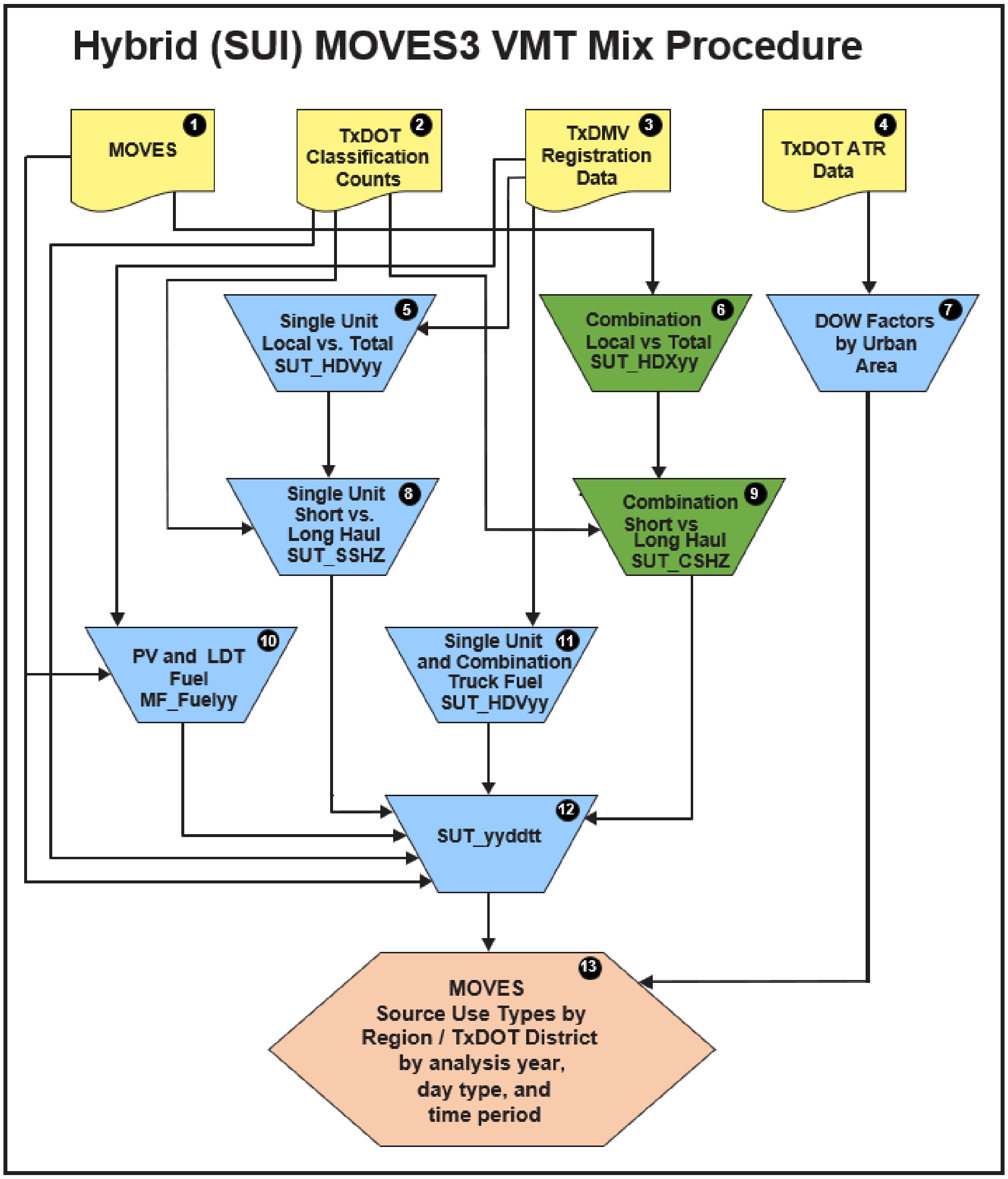

Figure 1. Simplified Overview of the VMT Mix Process.

Using the same data sets and a similar procedure, aggregate (i.e., all road-type categories), TxDOT district-level weekday vehicle type VMT mixes (used in the vehicle population estimation process) were also produced. To ensure general applicability and

proportion, or even existence of gas fueled "Other Buses" vehicles, the category is necessary to be consistent with MOVES3. Pending additional data, "Other Buses" (OB41) is treated as equivalent to "Intercity Bus" (ICB41) and a placeholder null gasoline fueled "Other Buses" (OB41G) is added. The rest of the procedure is identical to the current VMT mix procedure. Thus, these measures and procedures, as modified, provide a functional, hybrid region-specific, disaggregate link-level application of MOVES3 to the extent possible with the data currently available. This hybrid is consistent with previous applications in terms of activity inputs and fleet data.

consistency across all study areas, all VMT mixes were developed in five-year increments beginning with the year 2005 and applied to the analysis years based on Table 9.

Table 9. VMT Mix Year/Analysis Year Correlations.

VMT Mix Year	Analysis Years
2005	2003 through 2007
2010	2008 through 2012
2015	2013 through 2017
2020	2018 through 2022
2025	2023 through 2027
2030	2028 through 2032
2035	2033 through 2037
2040	2038 through 2042
2045	2043 through 2047
2050	2048 through 2050

2.2 Seasonal Weekday Activity

This section describes the methods used to estimate the daily (summer work weekday and winter work weekday [El Paso only]) activity used in the EI.

2.2.1 Vehicle Miles of Travel

The hourly, link-based emissions process requires VMT estimates by hour and direction for each link in the TDM or virtual link in HPMS. VMT was adjusted to be consistent with HPMS and to reflect estimated traffic activity patterns characteristic of the typical seasonal day type scenarios (i.e., 2020 summer work weekday for all counties and winter work weekday for El Paso) needed. Operational (congested) link speeds estimates corresponding to these traffic conditions were also required. All calculations were conducted using a suite of EI utilities developed by TTI (see Appendix A).

2.2.1.1 *Data Sources*

There were three major traffic data sources used for developing the VMT estimates and VMT adjustment and allocation factors for the AERR. These were ATR counts, HPMS

VMT estimates, and TDM estimates. The first two are collected and developed regularly by TxDOT as part of the larger HPMS data collection program. In addition to these traffic data, U.S. Census and Texas State Data Center (TSDC) county population statistics and projections were also used in developing VMT forecasts, if applicable. TDM VMT estimates were derived from the TDMs prepared by each of the associated metropolitan areas.

HPMS VMT estimates were developed based on ATR data collected according to a statistical sampling procedure specified by the Federal Highway Administration (FHWA) designed to estimate VMT. TxDOT compiles and reports Texas HPMS data in its annual Roadway Inventory Functional Classification Record (RIFCREC) reports. A wide range of traffic data is collected under the HPMS program; however, the focus for this application was specifically the VMT, centerline miles, and lane miles estimates. The HPMS roadway data were categorized by seven roadway functional classifications and four area types.

TDM directional link VMT and speeds were calculated using the latest available TDM link data, trips data, and zonal radii data sets extracted from the TDMs. Since intrazonal VMT are not accounted for in the TDMs, the intrazonal VMT was estimated using the TDM trip matrix and zonal radii data.

Several other data sources were used to adjust the VMT for HPMS consistency and to estimate the season and day type-specific VMT. HPMS VMT estimates[9] were used to adjust the total TDM based VMT for consistency with HPMS.

Seasonal and day type factors derived from local ATR data were used to translate the traffic activity represented by the TDM to those defined for each emissions scenario. These seasonal and day type factors were estimated using ATR data collected during 2010 through 2019. TxDOT collects ATR vehicle counts at selected locations on a continuous basis throughout Texas. These counts are available by season, month, and day type, as well as on an annual average daily traffic (AADT) basis. Since they are continuous, they are well suited for making seasonal, day-of-week, and time-of-day comparisons (i.e., adjustment factors), even though there may be relatively few ATR data collection locations in any area.

[9] HPMS VMT estimates are based on traffic count data collected according to a statistical sampling procedure specified by the FHWA. The EPA and FHWA have endorsed HPMS as the appropriate source of VMT and require that VMT used to construct on-road mobile source emissions estimates be consistent with that reported through HPMS.

2.2.1.2VMT Adjustments

The following sections describe the steps TTI used to transform TDM-based and HPMS-based VMT estimates to the hourly VMT estimates required for the 2020 summer weekday and winter weekday emissions analysis. The total VMT was adjusted for HPMS consistency (applicable to TDM-based estimates) and to represent the activity for each seasonal weekday scenario. For this 2020 AERR, which by definition is a historical year (i.e., HPMS VMT data exists for the year), county-level VMT control totals were used to develop VMT adjustment factors.

VMT Control Totals and VMT Adjustments

To estimate the HPMS-consistent link VMT, county-level VMT control totals were used to develop county-level VMT adjustment factors. The VMT control totals are comprised of two key components: the analysis year county-level HPMS AADT VMT acquired from TxDOT and the AADT-to-seasonal weekday adjustment factors.

The AADT-to-seasonal weekday adjustment factors were developed for each county using aggregated TxDOT district ATR data for the years 2010 through 2019. These factors were calculated by dividing the seasonal weekday average traffic count by the AADT count. Appendix C (electronic only) provides the TxDOT district AADT-to-seasonal weekday adjustment factors used in developing the VMT control totals.

The VMT control totals were calculated by multiplying the AADT VMT estimates for each county by the seasonal weekday adjustment factors. To develop the county-level VMT adjustment factors, the county's control totals were then divided by the county total VMT from the TDM (TDM assignment VMT plus intrazonal VMT estimate) or HPMS-based travel model. For each link, the volume was multiplied by the corresponding county-level VMT adjustment factor. The adjusted link volumes were then multiplied by the associated link lengths to produce the analysis year link-level, HPMS consistent, seasonal weekday VMT estimates. For TDM counties this same adjustment was applied to the intrazonal VMT.

Seasonal Weekday Adjustment Factors

Seasonal weekday adjustment factors were used to adjust the virtual link VMT, and the TDM and estimated intrazonal VMT estimates. The seasonal adjustment factors were developed using aggregated ATR data for the years 2010 through 2019. These factors were calculated using local ATR data by dividing the average seasonal weekday traffic counts by the average non-summer weekday (ANSWT) traffic counts as represented by the TDM VMT, or divided by the AADT counts as represented by the HPMS (virtual link) VMT. Appendix C provides the seasonal adjustment factors for each county.

2.2.1.3 Hourly Travel Factors

Hourly travel factors were used to distribute link VMT estimates to each hour of the day. These hourly travel factors were developed using multi-year (2010 through 2019) aggregated ATR station data for each region. For the weekday analyses, the total VMT and volumes (by the 24-hour period for virtual link-based and by the four time-of-day periods for TDM link-based) were reallocated to replicate weekday traffic profiles. To maintain VMT proportions within each of the four TDM assignment time periods, the hourly fractions were normalized within each time period to produce the time period hourly travel factors. Each factor (i.e., 24 or one for each hour of the day) was then multiplied by the link volume (in addition to the other VMT adjustment factors). These adjusted link volumes were then multiplied by their respective link lengths to estimate the link-level VMT for seasonal weekday. Hourly travel factors are provided in Appendix E.

2.2.1.4 Link Speeds

On-network emission factors are based on the congested (or operational) speed for each link. Three different speed models were used to estimate speed for each TDM link or virtual link in the analysis: The TTI speed model, the Houston speed model, and the virtual link speed model. The TTI speed model was used for all metropolitan areas that provided a TDM, except for the Houston/Galveston TDM area, which uses the Houston speed model designed specifically for the Houston/Galveston TDM. All HPMS-based virtual link areas use the virtual link speed model. Each of the three methods are described in the following sections.

TTI Speed Model

For each TDM network link (other than from the Houston/Galveston area TDM) congested speeds were estimated using the TTI speed model. The TTI speed model calculates directional delay (as a function of volume and capacity) relative to the free flow speed of the link. Intrazonal link congested speeds (i.e., links not explicitly represented in the TDM) were estimated using the average operational speed of the TDM centroid connectors (for the corresponding traffic analysis zone [TAZ]). The congested speed formula is:

$$Congested\ Speed = \frac{60}{\frac{60}{Freeflow\ Speed} + Delay}$$

Free-flow speeds were derived from the TDM link data. The directional delay (in minutes per mile) due to congestion was calculated using the following volume/delay equation:

$$Delay = Min\left[A\, e^{B(V/C)}, M\right]$$

Where:

Delay = congestion delay (in minutes/mile).
A & *B* = volume/delay equation coefficients.
M = maximum minutes of delay per mile.
V/C = time-of-day directional v/c ratio.

The delay model parameters (*A*, *B*, and *M*) were developed for the Dallas/Fort Worth area and verified for other Texas urban areas. Table 10 provides these parameters and Appendix F (electronic only) provides the facility types (link or road classifications) used in the various area TDMs and their capacity category.

Table 10. Volume/Delay Equation Parameters.

Facility Category	A	B	M
High-Capacity Facilities	0.015	3.5	5
Low-Capacity Facilities	0.050	3.0	10

The time-of-day directional v/c ratios were estimated using the directional volume (from the VMT estimation) and the time-of-day directional capacity.

Capacity data were not used for the centroid connector and intrazonal links. The traffic assignment speeds from the TDM were used to represent centroid connector operational speeds. Operational speeds for intrazonal trips were estimated for each TAZ as the average of the zone's centroid connector speeds.

The hourly and 24-hour speed (VMT/vehicle hours traveled [VHT]) summaries by county and road type were provided electronically to TCEQ (see Appendix B for electronic data descriptions).

Houston Speed Model

The operational speeds for each link of the Houston/Galveston TDM, excluding centroid connectors and the special intrazonal links, were calculated using the Houston speed model. The Houston speed model calculates these speeds using the travel model speed, speed factors (consisting of a free-flow speed factor and level of service [LOS] E speed factor), and a volume-to-capacity (V/C) ratio-based speed reduction factor (SRF) associated with each link.

The speed factors were used to convert the link-level travel model (input) speed to a free-flow speed and an LOS E speed (i.e., application of these factors results in two speeds). The free-flow speed factors (grouped by functional class and area type) were calculated by dividing the distance-weighted free-flow speed by the distance-weighted input speed for each functional class/area type combination. The distance-weighted free-flow speeds were calculated using output from the detailed speed model used by Houston-Galveston Area Council (H-GAC) in the travel model development process (as provided by H-GAC) with link volumes set to 0 (i.e., V/C = 0). The LOS E speed factors were calculated in a similar manner (distance-weighted LOS E speed divided by distance-weighted input speed) using the detailed speed model output with link volumes set equal to capacity (i.e., V/C = 1). Appendix G shows the speed factors and the network functional class and functional group relationship.

The link-specific V/C ratio was calculated as the time period (hourly) volume divided by the time period capacity. The V/C ratio is expressed as:

$$v/c\ ratio = Vh\ /\ Ch$$

Where:

Vh = the hourly link volume (travel model × HPMS factor × seasonal adjustment factor × hourly time period factor; Weekend profile factor for Saturday and Sunday [not applicable]); and

Ch = the hourly link capacity (travel model capacity × hourly capacity factor). Appendix G shows the hourly capacity factors.

After the V/C ratio was calculated, the link-specific SRF was determined using the V/C ratio, the link-specific SRF area type, the link-specific SRF functional class, and the SRFs. The SRFs are for V/C ratios of 0 to 1 in 0.05 increments (i.e., 0, 0.05, 0.10, … , 0.95, 1.0). Appendix G shows these SRFs. The link-specific SRF was calculated using linear interpolation. For V/C ratios greater than 1.0, an SRF is not required.

The speed model (for V/C ratios from 0.00 to 1.00) is expressed as:

$$S_{V/C} = S_{0.0} - SRF_{V/C} \times (S_{0.0} - S_{1.0})$$

Where:

$S_{V/C}$ = estimated directional speed for the forecast V/C ratio on the link in the given direction;

$S_{0.0}$ = estimated free-flow speed for the V/C ratio equal to 0.0;

$S_{1.0}$ = estimated LOS E speed for the V/C ratio equal to 1.0; and

$SRF_{V/C}$ = SRF for the V/C ratio on the link. The V/C ratio can be 0.0 to 1.0.

For V/C ratios greater than 1.0 and less than 1.5, the following speed model extension was used:

$$S_{V/C} = S_{1.0} \times (1.15/(1.0 + (0.15 \times (v/c)^4)))$$

Where:

$S_{v/c}$ = estimated directional speed for the forecast V/C ratio on the link in the given direction;

$S_{1.0}$ = estimated LOS E speed for the V/C ratio equal to 1.0; and

v/c = the forecast V/C ratio on the link. The V/C ratio can be 1.0 to 1.5.

For V/C ratios greater than 1.5, the speed was calculated using the previous speed model extension, except the V/C ratio was set to 1.5.

These speed models were applied to all functional classes, excluding the centroid connector and intrazonal functional classes. For these functional classes, capacity data were not used. The centroid connector travel model input speeds were used as the centroid connector operational speeds estimates. Operational speeds for the intrazonal functional class were estimated by zone as the average of the zone's centroid connector speeds.

The hourly and 24-hour speed (VMT/VHT) summaries by county and road type were provided electronically to TCEQ (see Appendix B for electronic data descriptions).

Virtual Link Speed Model

The virtual link speed model was applied to the 214 Texas counties that are not included in a TDM. There are three critical parameters for estimating operational speeds on virtual links: hourly lane capacity, free-flow speed, and hourly volume by direction. The hourly lane capacity is the maximum flow past a given point on a roadway, which varies by road type (or functional classification). The free-flow speed is the maximum speed that traffic will move along a given roadway if there are no impediments (e.g., congestion, bad weather). The hourly volume by direction is the hourly link VMT by direction (discussed in the previous section) divided by the link's centerline miles.

The virtual link speed model was applied to estimate a link's directional, time-of-day congested speed. This speed model involves both the estimated free-flow speed and estimated directional delay as a function of volume and capacity for the link and time period (i.e., hour). The speed model was applied to each link for each hour and direction. Development of the hourly lane capacities and free-flow speeds input to the speed model is discussed first, followed by the estimation of congested speeds (including the model delay and congested speed equations).

Capacities and Free-Flow Speeds

The capacities and free-flow speeds used in the virtual link speed model procedure are based on the Highway Capacity Manual (HCM). For HPMS functional classifications 1 and 2 (Interstate and Freeway), both capacities and free-flow speeds are consistent with HCM guidance (HCM Chapters 13 and 30). The capacity (2,400 passenger cars per hour per lane [pcphpl]) and free-flow speed (70 mph) for four-lane freeways are used for all interstates and rural freeways. Similarly, a free-flow speed of 65 mph and capacity of 2,300 pcphpl was used for small urban and urban freeways (HCM Exhibits 13-3 and 30-2).

The only adjustment applied to these two highest-level roadways is for the impact of heavy trucks on capacity (which is measured in passenger car equivalents). Table 11 shows the capacities for Interstates and Freeways based on the VMT mix (discussed in Section 2.1 of this report) for these roads in the three area types (procedure discussed next), and HCM-designated passenger car equivalents (1.5 per HCM Exhibit 23-8).

Table 11. Adjusted Interstate and Freeway Flow Rate (pcphpl) by Area Type.

Area Type	Ideal Flow	HDV[1]	Factor	Adjusted Flow
Rural	2,400	0.2832	0.8760	2,102
Small Urban	2,400	0.1140	0.9461	2,271
Urban	2,400	0.0616	0.9701	2,328
Rural	2,300	NA	NA	NA
Small Urban	2,300	0.1140	0.9461	2,176
Urban	2,300	0.0616	0.9701	2,231

[1] Heavy-duty vehicle.

HPMS functional classifications 3, 4, 5, 6, and 7 (Principal Arterial, Minor Arterial, Major Collector, Minor Collector, and Local) are interrupted flow facilities (i.e., they have traffic control devices). The capacities of these interrupted flow facilities are estimated as a function of adjusted flow and available green time (per HPMS Appendix N, Equation 20):

$$Cap = Sat \times (gr/c).$$

Where:

Cap = capacity of lane group, vehicles per hour (vph);
Sat = saturation flow rate of lane group, vehicles per hour of effective green time (vphg); and
gr/c = effective green ratio for the lane group.

The saturation flow rate (*Sat*) is the flow in vph that could be accommodated by the lane group assuming that the green phase is always available to the lane group (i.e., green ratio = 1.0). Calculation of the adjusted saturation flow rate begins with the ideal saturation flow rate (HCM Exhibit 10-12) of 1,900 pcphpl, which is adjusted to reflect deviation from ideal conditions. The saturation flow rate is adjusted using the following logic (from HCM equation 16-4, with parameter estimates consistent with HCM Exhibit 16-7 and Chapter 10):

$$S = fw \times fhv \times fg \times fp \times fbb \times fa \times flu \times frt \times flt \times flpb \times frpb$$

Where:

S = saturation flow rate adjustment factor;
fw = lane width factor (NA, 12-foot lane for all area types assumed);
fhv = heavy vehicle adjustment factor (based on area type VMT mix);
fg = approach grade factor (NA, level terrain assumed);
fp = parking lane adjustment (NA, unusual for rural or small urban areas, inappropriate for urban areas given HPMS aggregation);
fbb = bus blocking factor (NA, negligible per area type VMT mix);
fa = area type adjustment (NA, since the default of 0.9 is for urban area central business districts [CBDs] and urban is more broadly defined in HPMS);
flu = lane utilization adjustment (NA, data unavailable in HPMS);
frt = right turn adjustment factor (exclusive lanes for urban areas, 90 percent shared lane for right turns for rural areas, midpoint for small urban areas);
flt = left turn adjustment factor (exclusive lanes for urban areas, 90 percent shared left-turn lanes for rural areas, midpoint for small urban areas).
flpb = left turn pedestrian-bike adjustment (NA, no significant pedestrian-bike activity on average); and
frpb = right turn pedestrian-bike adjustment (NA, no significant pedestrian-bike activity).

Table 12 shows the saturation flow rate adjustment factors used for the three different area types. Unitary factors (i.e., factors whose value is 1 for all area types, or which are otherwise not applicable) for parameters fw, fg, fp, fbb fa, flu, flpb, and frpb are not shown.

Table 12. Saturation Flow Rate Adjustment Factors by Area Type.

Area Type	fhv	Frt	flt	Factor
Rural	0.8918	0.9850	0.9950	0.8740
Small Urban	0.9380	0.9175	0.9725	0.8369
Urban	0.9661	0.8500	0.9500	0.7801

Table 13 shows the adjusted saturation flow rate (expressed in pcphpl) for all interrupted flow facilities (i.e., signalized streets, not Interstate or Freeway) for the three area types.

Table 13. Adjusted Saturation Flow Rate (pcphpl) by Area Type.

Area Type	Ideal Flow	Adjustment Factor	Adjusted Saturation Flow
Rural	1,900	0.8740	1,661
Small Urban	1,900	0.8369	1,590
Urban	1,900	0.7801	1,482

Table 14 shows the effective green ratios used for different functional classes and area types. Since the virtual link procedure is highly aggregated, individual green ratio calculations are not meaningful. Instead, assuming a hierarchical interface of classifications, ratios of adjacent roadway functional category group AADT were used to estimate effective green ratios. The ratio of AADT between the two highest categories of Arterials, scaled to a hypothetical 0.5 balance, is used for Arterials. The ratio of the highest category of Collector AADT to the lowest category of Arterial AADT is used for Collectors, again scaled to a hypothetical 0.5 balance. Locals are the default values recommended in the HPMS procedures (HPMS Appendix N). The overall approach is based on, and consistent with, HPMS guidance.

Note that Interstates and Freeways are uninterrupted flow facilities, i.e., they have no traffic control devices, and therefore do not require green ratios. For this calculation, area type definitions are made at the county level and are based on U.S. Census criteria.

Table 14. Estimated Effective Green Ratios (gr/c) by Area Type.

Area Type	Arterials	Collectors	Locals
Rural	0.613	0.448	0.400
Small Urban	0.600	0.487	0.400
Urban	0.508	0.478	0.400

Table 15 incorporates Table 12, Table 13, Table 14, and Table 15 to produce hourly lane capacities by functional class and area type.

Table 15. Hourly Lane Capacities (vehicles per hour per lane [vphpl]) by Roadway Functional Classification.

Area Type	Interstate	Freeway	Arterials	Collectors	Local
Rural	2,102	2,102	1,018	744	664
Small Urban	2,271	2,176	954	774	636
Urban	2,328	2,231	753	708	593

The free-flow speed for rural and urban Interstates, Freeways, and Arterials are consistent with HCM guidance (HCM Chapter 10, especially Exhibit 10-5), with appropriate modifications for the aggregation inherent in the virtual link procedure. Minor Collectors and Locals are grouped. In recognition of the aggregation inherent in the process, a lower limit of 30 mph is set on free-flow speed. Free-flow speeds are provided for each of the three area types and seven roadway functional classifications (i.e., 21 HPMS virtual links). Table 16 shows the free-flow speeds.

Table 16. Free-Flow Speeds (mph) by HPMS Roadway Functional Classification.

HPMS Area Type	Interstate	Freeway	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector and Local
Rural	70	70	60	50	40	30
Small Urban	70	60	50	40	35	30
Urban	70	60	40	35	30	30

Estimation of Congested Speeds

The estimation of congested speeds is a two-step process. The first step is the v/c ratio calculation. The second step is the application of the congested speed model to estimate the congested speed.

V/C ratios are generated for each combination of time period (hour), roadway functional classification, area type, and direction using the hourly lane capacities and VMT. The calculations for this procedure are:

- Volume: hourly VMT by direction (discussed in the previous section) is divided by centerline miles, yielding volume for each hour. This procedure was performed for each virtual link (i.e., roadway functional classification and area type combination);

- Capacity: lane miles are divided by centerline miles to produce lanes. Lanes are multiplied by the hourly lane capacities (i.e., adjusted saturation flows) generated by the process described previously, producing hourly capacities. This procedure was performed for each virtual link. (Capacity is the same for each hour and each direction.); and
- V/C ratios: the speed model uses the hourly volumes and capacities to produce hourly, directional v/c ratios for each roadway functional classification and area type combination. These v/c ratios are used to calculate hourly, directional congestion-related delay, and congested speeds (as described in the next section) by functional classification and area type combination.

The congested speed model calculates delay on the link and then applies this delay to the link free-flow speed to calculate the link operational congested speed estimate. The volume/delay equation is:

$$Delay = Min\left[A\, e^{B(V/c)}, M\right]$$

Where:

Delay = congestion delay (in minutes/mile);
A & B = volume/delay equation coefficients;
M = maximum minutes of delay per mile; and
V/C = time-of-day directional v/c ratio.

There are two sets of delay model parameters A, B, and M, as shown in Table 17—one set for high-capacity facilities and one set for low-capacity facilities. The HPMS high-capacity facilities are the Interstate and Freeway classifications.

Table 17. Volume/Delay Equation Parameters.

Facility Category	A	B	M
High-Capacity Facilities (> 3,400 vph one way, e.g., Interstates and Freeways)	0.015	3.5	1.0
Low-Capacity Facilities ($\leq$ 3,400 vph, e.g., Arterials, Collectors and Locals)	0.050	3.0	2.0

Given the estimated directional delay (in minutes/mile) and the estimated free-flow speed, the directional congested speed is calculated as follows:

$$Congested\ Speed = \frac{60}{\frac{60}{Freeflow\ Speed} + Delay}$$

For each daily inventory, this model was applied to each link, based on functional class and area type, for each hour and each direction. The hourly and 24-hour speed summaries (time period VMT/time period VHT) by county and road type were included with the detailed inventory data provided (see inventory data file descriptions in Appendix B).

2.2.2 Off-Network

Off-network activity includes ONI hours, SHP, starts, and long-haul combination truck hotelling hours (split into various fractions of activity, such as SHEI and diesel APU hours). These quantities are estimated for each hour of the day at a spatial scale of a county and for each MOVES SUT and fuel type combination.

2.2.2.1 *Vehicle Populations*

Vehicle population data were used to estimate SHP and vehicle starts off-network activity. The vehicle population estimates were derived from end of year 2018, county-specific vehicle registration data provided by the TxDMV, TxDOT district-level VMT mix data, and HPMS reported county-level VMT totals.

A single set of vehicle population data inputs were used for the EI 2020 calendar year (i.e., the model assumes that vehicle populations remain constant across seasons and day types).

The end of year 2018 TxDMV vehicle registration data was provided in the form of total vehicles registered by county, aggregated by the vehicle categories shown in the first column of Table 18. These TxDMV vehicle categories were disaggregated to MOVES SUT and fuel type aggregations shown in the corresponding rows of the second column of Table 18. As previously mentioned, in MOVES emissions analyses, TTI uses the term *vehicle type* as synonymous with MOVES SUT and fuel type combination.

Table 18. TxDMV Vehicle Registration Aggregations and Associated Vehicle Types for Estimating Vehicle Populations.

Vehicle Registration[1] Aggregation	MOVES SUT and Fuel Type (Vehicle Type)[2]
Motorcycles	MC_Gas
Passenger Cars	PC_Gas; PC_Diesel
Trucks <= 8.5 K gross vehicle weight rating (GVWR: pounds)	PT_Gas; PT_Diesel; LCT_Gas; LCT_Diesel
Trucks > 8.5 and <= 19.5 K GVWR	RT_Gas; RT_Diesel SUShT_Gas; SUShT_Diesel MH_Gas; MH_Diesel Obus_Gas; Obus_Diesel TBus_Gas; TBus_Diesel SBus_Gas; SBus_Diesel
Trucks > 19.5 K GVWR	CShT_Gas; CShT_Diesel
NA[1]	SULhT_Gas; SULhT_Diesel CLhT_Gas; CLhT_Diesel

[1] The four long-haul SUT/fuel type populations are estimated using a long-haul-to-short-haul weekday SUT VMT mix ratio applied to the short-haul SUT population estimate.

The following steps were used to disaggregate the TxDMV vehicle registration data to vehicle population data by vehicle type.

- **Step 1** – VMT mix data was used to calculate the proportional representation of each MOVES vehicle type within each TxDMV aggregation class (first column of Table 18).
- **Step 2** – The proportional fractions calculated in Step 1 were multiplied by the total number of vehicles reported in each TxDMV vehicle registration category to obtain the estimated number of vehicles (populations) for each modeled MOVES vehicle type.
- **Step 3** – The long-haul truck vehicle type populations (see last row of Table 18) were estimated as an extension of their estimated short-haul vehicle type population counterparts by multiplying a long-haul-to-short-haul ratio derived from the weekday vehicle type VMT mix, by the associated short-haul truck vehicle type populations, from Step 2.

The VMT mix data used in these calculations was the TxDOT district-level, 24-hour weekday VMT mix described in more detail in the "Development of Vehicle Type VMT Mix" section and included in Appendix D. The methods above yielded end of year 2018 vehicle population data for each of the vehicle types modeled in the EIs.

Analysis year vehicle type populations were then calculated by applying a vehicle types population growth factor (VPGF). The VPGF was calculated using county-level HPMS reported total VMT for the registration data year (2018) and the 2020 analysis year.

$$VPGF = Analysis\ Year\ VMT\ /\ Registration\ Year\ VMT$$

2.2.2.2 ONI Hours

Off-network idling or ONI is idling activity that occurs while a vehicle is idling in a parking lot, drive-through, driveway, while waiting to pick up passengers or loading/unloading cargo. ONI applies to all MOVES source types.

TTI estimates ONI activity for each hour of the day using the following formula:

$$ONI\ Hours = (SHO_{network} * TIF - SHI_{network})\ /\ (1 - TIF).$$

Where:

$SHO_{network}$ = the source hours operating (SHO) on each link. This is calculated by dividing the VMT associated with each link by the link's congested speed.

$SHI_{network}$ = the total source hours idling (SHI) that occurs on the network (idling that occurs as a component of drive cycles) and is calculated by multiplying $SHO_{network}$ by a road idle fraction (RIF). RIF is the proportion of idling (in units of time) that occurs within a drive-cycle at a specified operational speed. Default values for RIF were used as defined in the MOVES data table *roadidlefraction*.

TIF = the total idle fraction, i.e., the ratio of total source hours idling and total source hours operating. Default values for TIF were used as defined in the MOVES database table *totalidlefraction* (three-month seasonal averages).

2.2.2.3 SHP

County-level vehicle type SHP was calculated for each hour of the day and each SUT as the difference between the local vehicle population (total available vehicle hours) minus SHO. This calculation is performed for each SUT.

Adjusted SHP was then calculated by subtracting ONI hours from the previously calculated SHP. Appendix H details county-level SHP and adjusted SHP by hour and vehicle type for each analysis year and activity scenario. Hourly summaries were provided electronically to TCEQ; see Appendix B for electronic data descriptions.

2.2.2.4Vehicle Starts

Vehicle starts were estimated using county-level vehicle type populations and data from MOVES representing the average number of vehicle starts per vehicle type per hour.

The starts per vehicle were calculated using MOVES with data on the age distribution and fuel fractions of the local fleet[10]. TTI used local age distributions and fuelfractions inputs to MOVES combined with MOVES default parameters (startsageadjustment, startsmonthadjust [three-month seasonal average], and startspervehicle) to produce hourly starts per vehicle output representative of each seasonal period. The MOVES output provided the scenario-specific starts per vehicle defined by the study scope.

For each hour of the day, the MOVES starts per vehicle data were multiplied by the local vehicle type population estimates to produce the total number of starts by vehicle type per hour.

The starts per vehicle data were used with constant vehicle type populations (i.e., vehicle type populations were assumed to be constant throughout the calendar year).

2.2.2.5Hotelling: SHEI and APU Hours

Hotelling hours were calculated for heavy-duty, long-haul trucks only (i.e., SUT 62[11]) in several steps. First total hotelling hours were calculated using information from a TCEQ extended idling study[12]. Scaling factors were then used to convert these base hotelling hours to those relevant to the analysis scenario (defined by analysis year, season, and day type), which were then allocated to each hour of the day. Estimations were then made of the proportions of hotelling hours that occur in each of the four hotelling categories: idling using the main engine (SHEI), idling using a diesel APU, idling using an electric APU, or idling with no engine or auxiliary power[13].

[10] Previously with MOVES2014, TTI used MOVES default start per vehicle (which varied only by MOVES day type) in combination with local vehicle populations to estimate vehicle starts activity. In MOVES3, vehicle starts per hour also vary by county (because age distributions also vary by county).

[11] SUT 62 represents long-haul combination trucks, for which only diesel fuel types are modeled.

[12] *Heavy-Duty Vehicle Idle Activity Study, Final Report*. Texas A&M Transportation Institute, Environment and Air Quality Division. July 2019. https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/582177430806-20190722-TTI-HeavyDutyIdleActivityStudyFinal.pdf

[13] Note that only SHEI and APU diesel hotelling generate emissions. The other fractions are calculated for completeness.

24-Hour Hotelling

County-level hotelling scaling factors were developed to transform base, 2017 winter weekday, total daily hotelling hours to daily hotelling hours for the 2020 EIs. Scaling factors were calculated using the ratio of heavy-duty long haul VMT for a 2017 winter weekday relative to heavy-duty long haul VMT for each EI scenario (e.g., analysis seasonal weekday SUT 62 VMT divided by base 2017 winter weekday SUT 62 VMT).

Total daily hotelling for each county in the EI scenario was calculated by multiplying the appropriate scaling factor by the total daily hotelling hours contained in the 2017 winter weekday total daily hotelling hours study.

Hotelling by Hour

Hotelling by hour was estimated by allocating daily hotelling hours to each hour of the day as a function of the inverse of the EI hourly VHT fractions for SUT 62. The hourly VHT fractions were calculated using the hourly VHT from the SHP estimation process (VHT = SHO). The inverses of these hourly VHT fractions were calculated and then normalized across all hours to produce the county-level, hotelling hours hourly distribution.

If the hourly hotelling hours (as calculated above) were greater than SHP (for SUT 62), the final hotelling hours estimate was set equal to the SHP.

SHEI and APU Hours

The hourly, county-level, hotelling estimates were then factored to calculate SHEI and diesel APU hours activity components using extended idle and APU fractions. The SHEI and APU fractions were obtained using MOVES defaults based on SUT 62 model year data. The updated MOVES SHEI and APU hotelling distributions[14] are shown in Table 19. Note that only SHEI and diesel APU are used to calculate emissions.

[14] Current MOVES3 defaults (previously adopted for use in the TCEQ 2017 truck extended idling study while MOVES3 was in draft stage).

Table 19. Hotelling Activity Distributions by Model Year.

First Model Year	Last Model Year	200 ExtendIdling	201 Diesel Aux	203 Battery AC	204 APU Off
1960	2009	0.80	0	0	0.20
2010	2020	0.73	0.07	0	0.20
2021	2023	0.48	0.24	0.08	0.20
2024	2026	0.40	0.32	0.08	0.20
2027	2050	0.36	0.32	0.12	0.20

2.3 Annual Activity

To estimate the annual emissions and build the annual MOVES inventory mode databases in a consistent manner, the summer weekday activity was converted to annual activity based on the MOVES calculation procedures to a format suitable for use with the MOVES inventory mode. Annual off-network activity estimate procedures for VMT, ONI hours, SHP, starts, and hotelling hours are described in the following sections.

2.3.1 Vehicle Miles of Travel

The MOVES calculation procedure for VMT allocates annual VMT by the MOVES-defined HPMS vehicle types to summer weekday VMT by HPMS vehicle type using month VMT fractions, day VMT fractions, number of days in the month, and the number of days in the period for the day VMT fraction. The formula for the MOVES VMT allocation procedure is:

$$SWkdVMT_{HPMSVtype} = AVMT_{HPMSVtype} * monthFract_{Month} * dayFract_{Month,DayType} / (noOfDays / 7) / noOfRealDays$$

Where:

$SWkdVMT_{HPMSVtype}$ = summer weekday VMT by HPMS vehicle type;
$AVMT_{HPMSVtype}$ = annual VMT by HPMS vehicle type;
$monthFract_{Month}$ = month VMT fraction for the desired month;
$dayFract_{Month,DayType}$ = day VMT fraction for the desired day type (weekday or weekend day by month);
$noOfDays$ = number of days in the desired month; and
$noOfRealDays$ = number of days in the desired day type (5 for weekday, 2 for weekend day).

Since the objective was to estimate annual VMT from the summer weekday VMT, the formula from the MOVES VMT allocation procedure can be transformed to calculate the annual VMT from the summer weekday VMT by reversing the calculations. The formula for calculating the annual VMT by HPMS vehicle type from the summer weekday VMT is:

$$AVMT_{HPMSVtype} = SWkdVMT_{HPMSVtype} * noOfRealDays * (noOfDays / 7) / dayFract_{Month,DayType} / monthFract_{Month}$$

The number of days in the day type (*noOfRealDays*) and number of days in the month (*noOfDays*) were determined by the seasonal activity scenario being analyzed. Since the inventories were for summer (July) weekday, the number of days in the day type was set to 5 and the number of days in the month was set to 31. Day VMT fractions and month VMT fractions were developed by TxDOT district using aggregated ATR data (years 2010-2019). See Appendix C for the day VMT fractions and the month VMT fractions. By county, this calculation procedure was applied to the summer weekday VMT for each HPMS vehicle type and saved for use in building the annual MOVES inventory mode databases.

2.3.2 Off-Network

Annual off-network activity estimate procedures for ONI hours, SHP, starts, and hotelling hours are described in the following sections.

2.3.2.1 *Vehicle Population*

Vehicle population data were used to estimate SHP and vehicle starts off-network activity. The vehicle populations were estimated as described in Section 2.1.2.1.

2.3.2.2 *Off-Network Idling*

TTI estimated off-network idling using the MOVES inventory mode process. MOVES default data was used for the county-level TotalIdleFraction input table to indicate the total time spent idling as a fraction of source hours operating by source type, model year range, month, and day type. TotalIdleFraction was processed to reflect annual weekday and weekend activity. MOVES internally calculated the off-network idling hours for inventory mode. Idle time while hotelling for long-haul combination trucks (SUT 62) are not included in this estimate and is discussed in the next section. All off-network idling calculations were performed at the county level.

2.3.2.3 *Hotelling Hours*

The annual hotelling hours were calculated using similar logic and input parameters as the annual VMT procedure. The annual hotelling hours were redistributed to each month and day type to calculate the monthly weekday hotelling hours and the monthly weekend hotelling hours. The monthly weekday hotelling hours and the monthly weekend hotelling hours were each summed to produce the annual weekday hotelling hours and annual weekend hotelling hours. Next, the annual weekday hotelling hours were divided by the number of annual weekdays to calculate annual weekday hotelling hours per day. Similarly, the annual weekend hotelling hours were divided by the number of annual weekend days to calculate annual weekend hotelling hours per day. The annual weekday hotelling hours per day and annual weekend hotelling hours per day were converted to the proper format for use with the MOVES inventory mode databases (hotelling hours per day by day type).

The following annual activity formulas were used to calculate the annual hotelling hours, annualization factors, weekday hotelling hours per day, and weekend hotelling hours per day.

- **Step 1** – Summer weekday hotelling hours per day to annual hotelling hours:

$$\begin{aligned} &\mathit{Annual\ Hotelling\ Hours} \\ &\quad = \mathit{swkd\ Hotelling\ Hours\ per\ day} \times \mathit{Annualization\ Factors}_{\mathit{swkd\ to\ Annual}} \\ &\quad = \frac{\mathit{swkd\ Hotelling\ Hours} \times 31 \times 5/7}{\mathit{dayVMTfraction}_{\mathit{monthID}=7,\mathit{dayID}=5} \times \mathit{monthVMTfraction}_{\mathit{monthID}=7}} \end{aligned}$$

$$\begin{aligned} &\mathit{Annualization\ Factors}_{\mathit{swkd\ to\ Annual}} \\ &\quad = \frac{\mathit{Annual\ Hotelling\ Hours}}{\mathit{swkd\ Hotelling\ Hours}} \\ &\quad = \frac{31 \times 5/7}{\mathit{dayVMTfraction}_{\mathit{monthID}=7,\mathit{dayID}=5} \times \mathit{monthVMTfraction}_{\mathit{monthID}=7}} \end{aligned}$$

- **Step 2** – Annual hotelling hours to annual weekday hotelling hours and annual weekend hotelling hours (based on same algorithm used in Step 1):

$$\begin{aligned} &\mathit{Annual\ Weekday\ Hotelling\ Hours} \\ &\quad = \sum_{i\ \mathit{from}\ 1\ \mathit{to}\ 12} \mathit{Annual\ Hotelling\ Hours} \times \mathit{dayVMTfraction}_{\mathit{monthID}=i,\mathit{dayID}=5} \\ &\qquad \times \mathit{monthVMTfraction}_{\mathit{monthID}=i} \end{aligned}$$

$$\begin{aligned}&Annual\ Weekend\ Hotelling\ Hours\\&\quad= \sum_{i\ from\ 1\ to\ 12} Annual\ Hotelling\ Hours \times dayVMTfraction_{monthID=i,dayID=2}\\&\qquad\times monthVMTfraction_{monthID=i}\end{aligned}$$

- **Step 3** – Hotelling hours per day for weekday and hotelling hours per day for weekend:

$$\begin{aligned}&Annual\ Weekday\ Hotelling\ Hours\ per\ day\\&\quad= Annual\ Weekday\ Hotelling\ Hours/\ (365 \times 5/7)\end{aligned}$$

$$\begin{aligned}&Annual\ Weekend\ Hotelling\ Hours\ per\ day\\&\quad= Annual\ Weekend\ Hotelling\ Hours/\ (365 \times 2/7)\end{aligned}$$

Where:

swkd = summer weekday.
i = monthID (1 through 12).

The hotelling annualization factor was then calculated by dividing the county total hotelling hours by the county total summer weekday hotelling hours. This hotelling annualization factor was used for annualizing the SHEI and APU hours activity in the emissions annualization process. Appendix K shows the annual hotelling hours, summer weekday hotelling hours, and annualization factors for each county.

3.0 ESTIMATING WEEKDAY EMISSION RATES

This section describes the development of the emission rates for each CAP and CO_2 for the seasonal weekday EIs. The emission rates were calculated using EPA's MOVES3 emission factor model parameterized using local and default data. The resulting MOVES3 emission rates were then post-processed using the TTI EI utilities to yield the emission rates used to calculate total, seasonal weekday emissions for each county (summer for all counties plus winter for El Paso County). The emission rates were developed based on the *TTI Emissions Inventory Utilities User's Guide* methods and procedures, but updated as needed to accommodate MOVES3 and EPA's *Technical Guidance*[15] applicable to MOVES3 inventory development.

The following sections describe the (seasonal) weekday emission rates development process. In a few places (e.g., on fuels and meteorological inputs) additional information is provided on inputs used later in the process for developing MOVES inventory mode county inputs database (CDB) inputs needed for production of the annual EIs.

3.1 PROCESS OVERVIEW

MOVES emission rates mode runs were developed to produce MOVES output databases containing emissions and activity data (some of which were used during the activity estimation methods described previously). Data contained in each MOVES output database were then post-processed into the final on-road emission rates used in each weekday EI.

As previously described in Table 1, the weekday EIs were based generally on two EI methods, one primarily for TDM region counties that uses county-level emission rates for 40 metropolitan area counties and the other, statewide virtual link method that uses county group level emission rates (by 34 groups) for 214 generally less populated counties. County groups are discussed in greater detail at the end of this section.

Emission rates were developed for the 2020 summer weekday and 2020 winter weekday (winter weekday for El Paso only). These emission rates were then used with the corresponding traffic activity rate estimates (corresponding to county and season) to calculate the full EI.

[15] EPA. 2020. *MOVES3 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity*, EPA-420-B-20-052, Office of Transportation and Air Quality. November 2020.

Post-processing was performed using TTI's on-road rates look-up table post-processor utility to convert the rates output by MOVES into the units defined by the on- and off-network activity defined in the previous sections (e.g., emissions per mile for VMT, emissions per start for vehicle starts, etc.) and to incorporate TxLED effects on diesel vehicle NO_X emissions for counties to which TxLED applies.

Table 20 defines the rates produced for the external inventory calculations relative to traffic activity measures. Each county group is represented by one county in the group as shown in Appendix I.

Table 20. Emission Rates by MOVES Emissions Process and Activity Factor.

Emissions Process	Activity[1]	Emission Rates[2]
Running Exhaust	VMT	mass/mile (mass/mi)
Crankcase Running Exhaust	VMT	mass/mi
Brake Wear	VMT	mass/mi
Tire Wear	VMT	mass/mi
Start Exhaust	Starts	mass/start
Crankcase Start Exhaust	Starts	mass/start
Extended Idle Exhaust	SHEI	mass/hour
Crankcase Extended Idle Exhaust	SHEI	mass/hour
Auxiliary Power Exhaust	APU Hours	mass/hour
Running exhaust (1) – Road Type 1 off-network	ONI Hours	mass/hour
Evaporative Permeation Evaporative Fuel Vapor Venting Evaporative Fuel Leaks	VMT, SHP	mass/mi, mass/hour

[1] VMT, ONI hours, SHP, vehicle starts, and the SHEI and APU hours components of hotelling are the basic activity factors. SHEI and APU hours are for combination long-haul trucks only.
[2] All mass per activity rates shown are available in MOVES rate mode table output except for mass/hour associated with SHP, which is produced using the TTI rates post-processing utility.

As previously mentioned, the 214 Texas counties were processed using the statewide virtual link method were grouped into 34 MOVES input data aggregation categories (see tabulation of the 214 counties by county group IDs in Appendix I).

The county grouping scheme was based on prior statewide on-road mobile source inventory modeling projects. The county groups were delineated by the intersecting boundaries of geographic data aggregations (or area coverages) for input parameters based on local data, regulations, or conditions. Fleet input (age distributions based on TxDMV vehicle registration data) and meteorological input parameters are at the TxDOT district level (25 districts); fuel formulations and fuel supply inputs are at the MOVES Texas fuel regions (or Texas fuel policy jurisdictions) level. Time zone (Central and Mountain) subdivides the TxDOT El Paso District counties into separate groups for estimating meteorological inputs. The county Federal Information Processing System (FIPS) code of the first county (alphanumerically) in each county group in ascending alphabetical order by county name was used as the MOVES countyID input value for the MOVES runs and represents all of the counties in the group.

3.2 MOVES Run Specification Input Files

The MOVES Run Specification (MRS) is a file (in XML format) that defines the place, time, road categories, vehicle and fuel types, pollutants and emissions processes, and the overall scale and level of output detail for the modeling scenario. TTI created an MRS for one county and scenario using the MOVES graphical user interface (GUI), then converted the MRS to a template and used it as a base from which to build all the required MRS files. Table 21 describes the MRS selections used, followed by sections describing the input data used per selection.

Table 21. MRS Selections by MOVES GUI Navigation Panel.

Navigation Panel	Detail Panel	Selection
Scale[1]	Model; Domain/Scale; Calculation Type	On-Road; County; Emission Rates
Time Spans[1]	Years – Months – Days – Hours	***<YEAR>*** - ***<MONTH>*** - ***<DAY TYPE>*** - All
Geographic Bounds[1]	States; Counties; Selections	Texas - ***<COUNTY>***;[1] ***<TX COUNTY SELECTION>***
On-Road Vehicles[2]	SUT/Fuel Combinations: 1 – Gasoline, 2 – Diesel, 3 – Compressed natural gas (CNG), 5 – E85 (85% ethanol-15% gasoline blend), 9 – Electric	SUT — Fuel Types Motorcycle: 1 - - - - Passenger Car: 1 2 - 5 9 Passenger Truck: 1 2 - 5 9 Light Commercial Truck: 1 2 - 5 9 Other Buses: 1 2 3 - - Transit Bus: 1 2 3 - - School Bus: 1 2 3 - - Refuse Truck: 1 2 3 - - Single Unit Short-Haul Truck: 1 2 3 - - Single Unit Long-Haul Truck: 1 2 3 - - Motor Home: 1 2 3 - - Combination Short-Haul Truck: 1 2 3 - - Combination Long-Haul Truck: - 2 - - -
Road Type	Selected Road Types	Off-Network – Rural Restricted Access – Rural Unrestricted Access – Urban Restricted Access – Urban Unrestricted Access
Pollutants[3] and Processes	VOC; CO; NO_X; SO_2; NH_3; Atmospheric CO_2; $PM_{2.5}$: Total Exhaust, Brakewear, and Tirewear; PM_{10}: Total Exhaust, Brakewear, Tirewear and the MOVES HAPs	Dependent on pollutant: Running Exhaust, Start Exhaust, Extended Idle Exhaust, Auxiliary Power Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Crankcase Extended Idle Exhaust, Evap Permeation, Fuel Vapor Venting, Fuel Leaks; Brakewear, Tirewear
General Output	Output Database; Units; Activity	***<MOVES OUTPUT DATABASE NAME>***;[1] Grams, KiloJoules, Miles; Distance Travelled, Hotelling Hours, Population, Starts
Create Input Database	Domain Input Database	***< CDB NAME>***[1]
Output Emissions Detail	Output Aggregation; For All Vehicles/Equipment; On Road	Time: Hour, Geographic: Link; Fuel Type, Emissions Process; Road Type, Source Use Type
Advanced Features	Aggregation and Data Handling	Only the "clear BaseRateOutput after rate calculations" box is checked

[1] Limited to one county per County Scale run. County Federal Information Processing Standards (FIPS) code, year, and season/day type labels were included in the MRS file and output database names. For county group runs, the first county alphabetically in each group was used as the group representative for each MOVES run.

[2] Although MOVES requires all fuel types be included in MRSs, only gasoline and diesel were modeled.

[3] Pre-requisite pollutants that were needed to model the reported pollutants are not shown.

3.2.1 Scale

The MOVES Domain/Scale "County" is required for state implementation plan (SIP) inventory estimates. The MOVES Calculation Type "Emission Rates" was selected for MOVES to produce the emission rates with speed bin indexing required for the link-based inventory estimation process.

3.2.2 Time Span

The Time Spans parameters were specified to provide hourly rates, for all hours of the day, for the selected year, month, and day type. One analysis year (2020), "Months" (July for all counties and January for El Paso County), and "Days" (Weekdays) selection were made per run.

3.2.3 Geographic Bounds

Per the MOVES County Scale, only one county was selected per run. For county group runs, the first county alphabetically in each group was used as the group representative for each MOVES run.

3.2.4 On-Road Vehicle and Road Type

The local VMT mixes developed for the study include the SUT/fuel type combinations modeled with MOVES, namely, gasoline and diesel vehicle types. The VMT mixes specify the vehicle fleet as the gasoline and diesel SUTs designated as "on-road vehicles" selections in Table 21. These SUT/fuel type combinations were selected in all the MRSs. All other SUT/fuel type combinations available in MOVES were also selected as required by MOVES, but only gasoline and diesel were modeled. Fuel types output was controlled through adjustments to the MOVES default fuel engine fractions via the MOVES Alternate Vehicle and Fuel Technology (AVFT) table (discussed later). All five MOVES road type categories were selected.

3.2.5 Pollutants and Processes

In addition to the pollutants defined by the scope of the inventory, MOVES requires that additional pollutants be selected for "chained" pollutants (i.e., pollutants that are calculated as a function of another MOVES pollutant). Chained pollutants were only reported if required. All of the associated on-road processes available by the selected pollutants were included.

3.2.6 General Output

The output units were grams, kilojoules, and miles. The activity categories were pre-set by MOVES rates mode (and not adjustable) for inclusion in the output database. The selected output detail level was by hour, link (in MOVES rates mode "link" is the combination of county, road type, and speed bin), pollutant, process, road type, SUT, and fuel type.

The MOVES model produces results at different aggregation levels that are specified in the MRS. Detailed, hourly, link-based weekday inventories were required, thus MOVES weekday day type-specific rates were specified in the MRS at the following output detail level:

- Source use types.
- Fuel types.
- Road types (four actual MOVES road categories and off-network).
- Hours of day.
- Speed bin (16 – in miles-based rate tables).
- Pollutants.
- On-road emissions processes.

The vehicle fleet fuel types were modeled using only the predominant on-road fuels of gasoline and diesel (alternate fuels were considered de minimis). The five road type categories in MOVES are Off-Network[16], Rural Restricted Access, Rural Unrestricted Access, Urban Restricted Access, and Urban Unrestricted Access. The rates for each of the actual four MOVES road types are indexed by the 16 MOVES speed bin average speeds: 2.5, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 mph.

3.3 MOVES County Input Databases

MOVES CDBs were created for each county in the seven metropolitan areas and for the 34 county group representative counties for the rest of Texas for the weekday emission rate runs. The CDBs were populated with local input data (such as local fleet age distributions, fuel formulations, meteorological conditions) as well as MOVES defaults.

[16] The off-network road type is not a 'real' road type and is instead used as a placeholder to define off-network emissions.

TTI developed procedures to build and check CDBs for each emissions scenario. The basic procedure was to write a MySQL script to produce one CDB and convert it to a template from which all of the CDB scripts were built. The scripts were then run in batch mode to produce all CDBs for the analysis.

Data for populating the CDBs were first prepared in the form of text files and/or MySQL databases (e.g., for local fuels, weather data), and some values provided directly in the CDB builder MySQL script. Any default data used were selected from the MOVES default database, MOVESDB20210209. After running the scripts to produce the CDBs, the CDBs were checked to verify that all CDB tables were built and populated as intended.

Table 22 provides an outline and brief description of the CDBs, followed by a discussion of the development of the local data and the defaults contained therein. Unless otherwise stated, the CDB table data applies to all counties (including the counties representing county groups) used in the analysis.

Table 22. CDB Input Tables.

Table	Data Source	Notes
auditlog	empty table used	Table required for MOVES to recognize CDB
year	MOVES default	Designates analysis year as base year (i.e., activity inputs supplied, not forecast by MOVES)
state	MOVES default	Identifies the state and idle region
hourvmtfraction	MOVES default	Hourly VMT fractions for each source type, road type, day type
dayvmtfraction	MOVES default	Weekend and weekday period VMT fractions by month for each source type and road type
monthvmtfraction	MOVES default (3-month average)	Month VMT fractions by source type
hpmsvtypeyear	MOVES default	Annual VMT by HPMS vehicle type
roadtypedistribution	MOVES default	Source type VMT fractions by MOVES road type
avgspeeddistribution	MOVES default	Driving time fractions by speed bin for each source type, road type, day type, hour
sourcetypeyear	MOVES default	Source type populations
startsperdaypervehicle	MOVES default	Average starts per day by source type and day type
startshourfraction	MOVES default	Average hourly allocation of starts by source type and day type
startsmonthadjust	MOVES default (3-month average)	Average monthly multiplicative adjustment to startspervehicleperday

Table	Data Source	Notes
startsageadjustment	MOVES default	Starts by vehicle age within each source type, relative to the number of starts at age 0 (lower frequency of starts with age)
startsopmodedistribution	MOVES default	Distribution of engine start soak times by source type, age, day type, hour
totalidlefraction	MOVES default (3-month average)	Ratio of total SHI and total SHO for each source type by month, day type, idle region, county type (Metropolitan Statistical Area [MSA] or non-MSA)
hotellingactivitydistribution	MOVES default	Allocation of hotelling to four operating modes by zone (e.g., county) and model year group
hotellingagefraction	empty table used	Hourly hotelling distribution by age for each zone and day type – included to preempt commandline execution errors
hotellinghourfraction	empty table used	Zone and day type hotelling hourly allocations – included to preempt commandline execution errors
hotellinghoursperday	empty table used	Year, zone, day type hotelling hours – included to preempt commandline execution errors
hotellingmonthadjust	empty table used	Hotelling monthly adjustment for each zone and month – included to preempt commandline execution errors
zone	MOVES default (set factors = 1)	SHO geographic allocation factors, set to 1.0 for county scale runs
zoneroadtype	MOVES default (set factors = 1)	Road type VMT allocation factors to county road type VMT, set to 1.0 for county scale runs
fuelusagefraction	MOVES default (except usage for fueltype 5 = 0)	Flex fuel vehicle fuel type usage, set for Texas modeling assumptions, i.e., flex-fuel vehicles operate totally on gasoline
fuelsupply	Local /defaults	Market shares of fuel formulations set to reflect Texas modeling assumptions of gasoline and diesel only, although all MOVES default fuels were included as required to run MOVES3 (i.e., CNG, E85, and electric are included but are not used as specified in the AVFT and fuel usage configurations)
fuelformulation	Local /defaults	Gasoline and diesel formulations by fuel region based on Texas regional survey data and defaults as needed, with MOVES default CNG, E85, and electric as required to run MOVES3
avft	Local /defaults	Set for Texas modeling assumptions, i.e., gasoline and diesel only, but also including default flex fuel vehicle fractions which were set to 100% gasoline use via the fuelusagefraction table
sourcetypeagedistribution	local/default (actual analysis year default)	Distribution by 31 age categories for each source type, based on latest available county vehicle registrations (TxDOT district level for county group CDBs), and MOVES defaults where needed (i.e., for buses, refuse trucks, motor homes)

Table	Data Source	Notes
imcoverage	local	Empty for non-I/M counties, or includes I/M program modeling parameters characterizing the local program applicable to the county, to include updated compliance factors based on TCEQ area-specific I/M program statistics
county	local	Identifies the county, barometric pressure (TxDOT district level for county group CDBs), high or low altitude, and whether the county is an MSA or non-MSA county
zonemonthhour	local	Provides zone (i.e., county or TxDOT district level for county group CDBs) hourly temperatures and relative humidity by month using month ID 7 (July) to represent the summer season (populated with local, 2019 June through August averages)
countyyear	local	Stage II refueling control program adjustments are typically set to zero to reflect the program is no longer in effect however refueling emissions were not modeled and this table was left empty

3.3.1 Year, State, and County Inputs

The year, state, and county tables were populated with data defining the analysis year, state, and county of the run.

The yearID field of the "year" table was populated with the analysis year value, and the year was set as a base year (to specify that certain user-input fleet and activity data were to be used, rather than forecast by MOVES during the model runs). As part of designating the appropriate fuel supply for the modeling run, the fuelyearID in the year table was also set to the analysis year. With MOVES3, an idleregionID was added to modify the state table.

StateID "48" (Texas) was inserted in the state table. In addition to identifying the county of analysis, the county table contains barometric pressure and altitude information (discussed further with other meteorological inputs). The county data were selected from a prepared local "meteorology" database containing tables of weather data records for the analysis. For county group modeling runs, the meteorological inputs were district-level estimates, as opposed to the county-level estimates used in the metropolitan area individual county runs.

3.3.2 Activity and Vehicle Population Inputs

The TTI EI methodology uses an emission rate by activity method that calculates emissions by multiplying local activity estimates and MOVES-based emission rates external to MOVES. However, MOVES rates mode CDBs require activity inputs in order to calculate the emission rates per activity estimates used in the TTI EI method.

For this reason, default activity input parameters were used to populate the following MOVES tables: hourvmtfraction, dayvmtfraction, monthvmtfraction, hpmsvtypeyear, roadtypedistribution, avgspeeddistribution, sourcetypeyear, startsperdaypervehicle, startshourfraction, totalidelfraction, and hotellingactivitydistribution. Data for all these tables were selected and inserted from the MOVES default database. In the case of the totalidlefraction, which varies by month, the MOVES default data was averaged for the three-month seasonal period.

The zone and zoneroadtype tables contain zonal sub-allocation activity factors. For county scale analyses, county is equal to zone; therefore, these allocation factors were set to 1.0.

3.3.3 Age Distributions and Fuel Engine Fractions Inputs

Local age distributions, or age fractions for each SUT, and local fuel fractions by model year (or technology), were used, in conjunction with MOVES defaults as needed. These data were sourced from TxDMV 2018 year end registration data for each county. The age distributions and fuel engine fractions inputs were calculated and written to text files in preparation for loading the data into the appropriate CDB input tables: the sourcetypeagedistribution table for age distributions and the avft table for fuel engine fractions. MySQL scripts were used to populate the CDB input tables.

The local TxDMV registration data provides fuel type fractions (proportion of gasoline or diesel-powered vehicles) for heavy-duty vehicles but not for light-duty vehicles. MOVES default fuel fractions were therefore applied to estimate light-duty fuel fractions. Only gasoline and diesel vehicles were explicitly included in the CDBs[17].

Table 23 summarizes the data sources and aggregation levels used to estimate the local sourcetypeagedistribution and AVFT inputs to MOVES (inputs summarized in Appendix J).

[17] This was decided after consultation with the TCEQ sponsor.

Table 23. Sources and Aggregations for Age Distributions and Fuel Fractions.

SUT Name	SUT ID	TxDMV Category[1] Aggregations for Age Distributions and Fuel/Engine Fractions	Geographic Aggregation for Age Distributions[2]	Geographic Aggregation for Fuel/Engine Fractions[3]
Motorcycle	11	Motorcycles	County or TxDOT district	NA – 100% gasoline, no Fuel/Engine Fractions
Passenger Car	21	Passenger Cars	County or TxDOT district	MOVES default[2]
Passenger Truck	31	Total Trucks<=8500	County or TxDOT district	MOVES default[2]
Light Commercial Truck	32	Total Trucks<=8500	County or TxDOT district	MOVES default[2]
Single-Unit Short-Haul Truck	52	>8500+ >10000+ >14000+>16000	Region or TxDOT district	Texas Statewide
Single-Unit Long-Haul Truck	53	>8500+ >10000+ >14000+>16000	Texas Statewide	Texas Statewide
Refuse Truck	51	MOVES default[4]	MOVES default[4]	MOVES default[4]
Motor Home	54	MOVES default[4]	MOVES default[4]	MOVES default[4]
Other Buses	41	MOVES default[4]	MOVES default[4]	MOVES default[4]
Transit Bus[2]	42	MOVES default[4]	MOVES default[4]	MOVES default[4]
School Bus	43	MOVES default[4]	MOVES default[4]	MOVES default[4]
Combination Short-Haul Truck	61	>19500+ >26000+ >33000+ >60000	Region or TxDOT district	Texas Statewide
Combination Long-Haul Truck	62	>19500+ >26000+ >33000+ >60000	Texas Statewide	NA – 100 % diesel, no Fuel/Engine Fractions

[1] TxDMV year-end 2018 (latest available, used for all years) county vehicle registrations data were used for developing local inputs (weights are gross vehicle weight rating in units of pounds). The MOVES model default age distributions were from the MOVESDB20210209 database.

[2] County and region aggregations were used for individual counties in the metropolitan regions. TxDOT district aggregations were used for the county group modeling.

[3] MOVES fuel engine fraction defaults (for gasoline, diesel, E85 capability) were used for light-duty SUTs (with E85 use set to zero in the fuelusagefraction table). MOVES default fuel engine fractions were taken from the MOVESDB20210209 sample vehicle population table.

[4] MOVES default values consistent with the analysis year.

3.3.4 Meteorological Inputs

Texas statewide AERR inventory analyses use local meteorological input data prepared by 25 TxDOT districts, whereas the individual county EI analyses use county level meteorological inputs. District and county-level meteorological inputs were prepared for the four seasonal periods of spring (March through May), summer (June, July, August), fall (September, October, November), and winter (December, January, February) for all districts and individual counties. The “county” table contains barometric pressure and “zonemonthhour” table houses temperature and relative humidity data.

TCEQ produced the hourly temperature, hourly relative humidity, and 24-hour barometric pressure averages by season and year, using latest available 2019 calendar year hourly data from numerous weather stations within each district and county. Since the El Paso District spans two time zones (Mountain and Central), TCEQ divided it into two separate data sets by time zone. TTI used the seasonal averages for temperature, relative humidity, and barometric pressure for the seasonal weekday analyses. The inputs for all four seasons were used as input by month ID in the annual EI analysis, detailed in a later section.

The MOVES zonemonthhour table includes the monthID column. MOVES uses the standard month numbers as monthIDs (i.e., 1 through 12 is January through December). Summer was represented by the monthID “7” in the zonemonthhour table and winter represented by “1”. Altitude, another MOVES county table input, was set to “low” for all areas.

For the annual EI analysis annual average barometric pressure was the county table input for all 12 months and the seasonal zonemonthhour table inputs were applied as follows:

- Spring – month IDs 3, 4, 5;
- Summer – month IDs 6, 7, 8;
- Fall – month IDs 9, 10, 11;
- Winter – month IDs 12, 1, 2.

Two sets of meteorological data were used, one based on county-level data and one based on the district level data. TTI assigned the district level meteorological inputs to their corresponding individual counties, for all 254 counties, for use in building the county group CDBs. See Appendix K for temperatures, relative humidity, and barometric pressure input value summaries.

3.3.5 Fuels Inputs

This section provides details on the development of the fuel formulation and fuel supply inputs used for the seasonal weekday emission rates analyses. Details are also provided on the additional fuel formulation inputs needed for the annual EI mode CDBs used in the annual emissions analysis detailed in a later section.

3.3.5.1Overview and Assumptions

TTI used various data sources to produce the best available Texas summer and winter fuel formulation inputs to MOVES. There are four MOVES fuels input tables that must be consistent between the fuel types in the scope of the inventory analysis. These are:

- AVFT (source type population fuel type distributions by model year).
- fuelformulation (fuel properties for each fuel sub type supplied in the study area).
- fuelsupply (market shares of each fuel sub-type formulation).
- fuelusagefraction (flex fuel vehicle fuel type usage).

The fuel types in the scope of the inventory analysis were gasoline and diesel, with alternative fuels assumed to have an insignificant impact. Thus the AVFT model year fuel fractions were normalized for only gasoline, diesel, and flex fuel vehicles (i.e., vehicles with the capability to be powered by gasoline or E85 [a blend of 85 percent ethanol and 15 percent gasoline, by volume]). Since the analysis scope was gasoline and diesel, flex fuel vehicle fuel usage was set to 100 percent gasoline (via the fuelusagefraction table). With solely gasoline and diesel set by the AVFT and fuelusagefraction tables, the fuelformulation and fuelsupply table's gasoline and diesel fuel properties and market shares were then specified.[18]

3.3.5.2Texas Fuel Type Details

The Texas MOVES3 fuels inputs consist of:

- gasohol (gasoline blended with roughly 10 percent ethanol - for conventional gasoline [CG] and reformulated gasoline [RFG] - fuelsubtypeID 12) and

[18] New with MOVES3 is the requirement that fuel formulations and fuel supplies for all on-road vehicle fuel types available in MOVES, regardless of the local inventory scope, must be included in each run. Inclusion of all on-road fuels in the MOVES MRS files is needed to prevent MOVES “missing fuels inputs” run errors.

- biodiesel (BD) (ultra-low sulfur diesel [ULSD] - in Texas blended with roughly 5 percent BD - fuelsubtypeid 21).

The alternative fuels available in MOVES3 were treated as negligible and excluded from the analysis (via the use of the MOVES AVFT, fuelusagefraction tables, and fuelfraction inputs). Since MOVES3 requires all (5) available fuel types in the model to be included in the fuelformulation and fuelsupply inputs, the MOVES3 default fuelformulations for the following—each with 1.0 market shares in the fuel supply—were included in the CDBs.[19]

- CNG (fuelsubtypeid 30),
- E85 (ethanol - blended with roughly 15 percent gasoline - fuelsubtypeid 51), and
- electricity (fuelsubtypeid 90).

3.3.5.3*Data Sources*

The local data include historical and current, latest available retail outlet seasonal fuel surveys of gasoline and diesel fuel, and annual, estimated state-level fuels sales statistics. The local data also include summaries from which to estimate biodiesel volumes relative to petroleum diesel sales volumes and gasoline sales estimates by the three grades (regular, mid-grade, premium).

The applicable retail outlet survey data included the TCEQ 2020 summer season statewide gasoline and diesel surveys and the EPA RFG compliance 2020 summer and winter survey data with separate data for Houston and Dallas areas. TTI used RFG compliance survey data for the RFG areas and the TCEQ E10 conventional gasoline (blend of 10% ethanol and 90% conventional gasoline) data processed by MOVES fuel regions for non-RFG regions. TTI produced the statewide average of diesel sulfur content from the survey data, and used the statewide average for all counties (there is minimal variation in sulfur content sampled across Texas). Diesel formulations were supplemented with biodiesel volume content estimates based on the Department of Energy’s (DOE) Energy Information Administration's (EIA) diesel sales statistics. Biodiesel percentages were based on EIA State Energy Data System (SEDS) state-level 2018 (latest available) transportation sector BD consumption estimates for Texas.

Additionally, MOVES defaults were used as needed. This was the case for winter conventional gasoline formulations and for winter RFG RVP for which local data were unavailable. Additionally, MOVES3 includes default fuel formulations for shoulder

[19] TTI inserted these alternative fuel formulations and supplies, and the updated AVFT fuel fractions [i.e., gasoline, diesel, and flex fuel types only], and set flex fuel vehicles to 100 percent gasoline use in the fuelusagefraction table, via CDB builder scripts.

months (April and October), the transitional months between summer and winter gasoline, which were used in the annual EI analysis.

3.3.5.4General Procedure

The best available local fuel survey data by season for the study year were used, supplemented as needed by MOVES defaults and other data (e.g., DOE annual fuel sales statistics).

The fuel formulation development procedures were performed by six MOVES fuel regions for Texas. In general, the sample data were aggregated and averaged by fuel grade within each MOVES fuel region (e.g., consistent with Texas fuel regulation jurisdictions and distribution networks), then weighted into gasoline composite averages using relative sales volumes by grade (results of this procedure were available directly from the TCEQ 2020 survey summary for the summer season). For the MOVES RFG region, TTI developed separate RFG formulation estimates for the DFW and HGB RFG counties for summer and winter seasons.

The application of summer and winter fuel formulations in the seasonal weekday emission rates was via month ID where MOVES month IDs 1 and 7 (January and July) were used to represent winter and summer seasons. For the annual emissions analysis the fuel formulations were input by month (or month ID, where 1, 2, 3… is January, February, March…) as follows:

- Summer fuel formulations: month IDs 5, 6, 7, 8, 9;
- Winter fuel formulations: month IDs 11, 12, 1, 2, 3;
- Shoulder fuel formulations: month IDs 4, 11.

The fuels inputs to MOVES were supplied in the CDB fuelsupply and fuelformulation tables. The local fuel supply for each county, year, and month (or season) consisted of one gasoline and one diesel formulation (with the exception of the other MOVES default alternative fuels required to run MOVES). Each gasoline and diesel formulation market share in the fuel supply was therefore 1.0.

3.3.5.5 Fuel Formulations

Table 24, Table 25, and Table 27 provide the summer, winter, and shoulder months (April and October) fuel formulations used for the 2020 analysis year. Table 26 summarizes the MOVES default shoulder month fuel formulations by fuel region. Table 27 provides the diesel formulations used. Although CetaneIndex and PAHContent (not listed in Table 27) are also diesel property fields of the fuelformulation table, they are not currently enabled for use in MOVES.

Table 24. Summer 2020 Gasoline Fuel Formulation Input Estimates by Region.

MOVES Fuel Formulation Field[1, 2]	Units	R1	R2	R3	R4	R4	R5	R6
fuelFormulationID	-	13701	13702	13703	13714	13724	13705	13706
fuelSubtypeID[2]	-	12	12	12	12	12	12	12
RVP	psi	9.34	7.77	6.84	7.09	7.15	7.50	9.20
sulfurLevel	ppm	8.04	8.63	4.89	9.57	10.01	8.17	8.31
ETOHVolume	vol.%	8.96	9.56	9.50	9.56	9.56	9.60	9.54
MTBEVolume	vol.%	0	0	0	0	0	0	0
ETBEVolume	vol.%	0	0	0	0	0	0	0
TAMEVolume	vol.%	0	0	0	0	0	0	0
aromaticContent	vol.%	22.60	22.22	24.24	16.96	16.89	27.19	14.72
olefinContent	vol.%	9.77	8.69	5.94	10.13	10.29	5.47	11.55
benzeneContent	vol.%	0.68	0.58	0.48	0.37	0.42	0.65	0.66
e200	vap.%	53.34	49.64	44.61	47.00	48.26	46.49	59.79
e300	vap.%	85.68	84.60	84.63	84.95	84.89	84.18	90.43
BioDieselEster Volume	vol.%	\N	\N	\N	\N	\N	\N	\N
T50	deg. F	183.10	202.53	220.24	210.35	206.18	218.42	163.64
T90	deg. F	316.17	319.75	317.73	325.30	326.87	316.48	295.74

[1] The fuel region labels and associated MOVES fuel region IDs are defined as:

Label	fuelregionid	Counties	Description
R1	300000000	132	Federal 9.0 RVP limit (RVP waiver available for E10)
R2	178010000	95	State 7.8 RVP limit (no available RVP waiver) and TxLED
R3	370010000	1	El Paso 7.0 RVP (no RVP waiver)
R4	1370011000	12	RFG (ID 19714 is DFW; ID 19724 is HGB) and TxLED
R5	178000000	3	Federal 7.8 RVP limit (RVP waiver available for E10) and TxLED
R6	100000000	11	Same as R1, except a different distribution network (per EPA Office of Transportation and Air Quality [OTAQ]).

[2] Fuel subtype IDs 12 is E10 gasoline (either CG or RFG with a nominal 10 percent by volume ethanol content).

Table 25. Winter 2020 Gasoline Fuel Formulation Input Estimates by Region.

MOVES Fuel Formulation Field[1, 2]	Units	R1	R2	R3	R4	R4	R5	R6
fuelFormulationID	-	13101	13102	13101	13114	13124	13102	13102
fuelSubtypeID[2]	-	12	12	12	12	12	12	12
RVP	psi	11.50	12.50	11.50	12.30	12.30	12.50	12.50
sulfurLevel	ppm	10.00	10.00	10.00	10.78	8.26	10.00	10.00
ETOHVolume	vol.%	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MTBEVolume	vol.%	0	0	0	0	0	0	0
ETBEVolume	vol.%	0	0	0	0	0	0	0
TAMEVolume	vol.%	0	0	0	0	0	0	0
aromaticContent	vol.%	22.90	20.54	22.90	16.39	14.06	20.54	20.54
olefinContent	vol.%	11.14	9.68	11.14	9.19	8.45	9.68	9.68
benzeneContent	vol.%	0.67	0.91	0.67	0.47	0.43	0.91	0.91
e200	vap.%	49.86	52.82	49.86	59.85	59.91	52.82	52.82
e300	vap.%	85.17	85.64	85.17	86.59	87.94	85.64	85.64
BioDieselEster Volume	vol.%	\N	\N	\N	\N	\N	\N	\N
T50	deg. F	199.39	182.40	199.39	155.21	153.91	182.40	182.40
T90	deg. F	320.54	318.57	320.54	318.00	312.02	318.57	318.57

[1] The fuel region labels and associated MOVES fuel region IDs are defined as:

Label	fuelregionid	Counties	Description
R1	300000000	132	Federal 9.0 RVP limit (RVP waiver available for E10)
R2	178010000	95	State 7.8 RVP limit (no available RVP waiver) and TxLED
R3	370010000	1	El Paso 7.0 RVP (no RVP waiver)
R4	1370011000	12	RFG (ID 19714 is DFW; ID 19724 is HGB) and TxLED
R5	178000000	3	Federal 7.8 RVP limit (RVP waiver available for E10) and TxLED
R6	100000000	11	Same as R1, except a different distribution network (per EPA Office of Transportation and Air Quality [OTAQ]).

[2] Fuel subtype IDs 12 is E10 gasoline (either CG or RFG with a nominal 10 percent by volume ethanol content).

Table 26. Shoulder Month[1] 2020 Fuel Formulation Inputs by Region.

MOVES Fuel Formulation Field[2, 3]	Units	R1	R2	R3	R4	R5	R6
fuelFormulationID	-	9071	9110	9101	9059	9032	9050
fuelSubtypeID[2]	-	12	12	12	12	12	12
RVP	psi	10.50	10.50	10.50	10.50	10.50	10.50
sulfurLevel	ppm	10.00	10.00	10.00	10.00	10.00	10.00
ETOHVolume	vol.%	10.00	10.00	10.00	10.00	10.00	10.00
MTBEVolume	vol.%	0	0	0	0	0	0
ETBEVolume	vol.%	0	0	0	0	0	0
TAMEVolume	vol.%	0	0	0	0	0	0
aromaticContent	vol.%	24.35	23.28	24.35	15.53	23.28	23.28
olefinContent	vol.%	11.35	10.23	11.35	11.83	10.23	10.23
benzeneContent	vol.%	0.69	0.95	0.69	0.50	0.95	0.95
e200	vap.%	49.90	51.97	49.90	55.67	51.97	51.97
e300	vap.%	85.17	85.64	85.17	87.15	85.64	85.64
BioDieselEster Volume	vol.%	\N	\N	\N	\N	\N	\N
T50	deg. F	199.13	187.28	199.13	166.07	187.28	187.28
T90	deg. F	320.52	318.54	320.52	312.21	318.54	318.54

[1] Shoulder months represent RVP/distillation between summer and winter (April and October).

[2] The fuel region labels and associated MOVES fuel region IDs are defined as:

Label	fuelregionid	Counties	Description
R1	300000000	132	Federal 9.0 RVP limit (RVP waiver available for E10)
R2	178010000	95	State 7.8 RVP limit (no available RVP waiver) and TxLED
R3	370010000	1	El Paso 7.0 RVP (no RVP waiver)
R4	1370011000	12	RFG (DFW and HGB) and TxLED
R5	178000000	3	Federal 7.8 RVP limit (RVP waiver available for E10) and TxLED
R6	100000000	11	Same as R1, except a different distribution network (per EPA Office of Transportation and Air Quality [OTAQ]).

[3] Fuel subtype IDs 12 is E10 gasoline (either CG or RFG with a nominal 10 percent by volume ethanol content).

Table 27. 2020 Statewide Diesel Fuel Formulation Input Estimates.

MOVES Fuel Formulation Field[1]	Units	2020
fuelFormulationID	-	30585
fuelSubtypeID[2]	-	21
RVP	psi	0
sulfurLevel	ppm	5.85
ETOHVolume	vol.%	0
MTBEVolume	vol.%	0
ETBEVolume	vol.%	0
TAMEVolume	vol.%	0
aromaticContent	vol.%	0

olefinContent	vol.%	0
benzeneContent	vol.%	0
e200	vap.%	0
e300	vap.%	0
BioDieselEster Volume	vol.%	4.86
T50	deg. F	0
T90	deg. F	0

[1] The fuel region labels, associated MOVES fuel region IDs, and TxLED requirements are:

Label	fuelregionid	Counties	Description
R1	300000000	132	No TxLED requirement
R2	178010000	95	TxLED required
R3	370010000	1	No TxLED requirement
R4	1370011000	12	TxLED required
R5	178000000	3	TxLED required
R6	100000000	11	No TxLED requirement

[2] Fuel subtype ID 21 is conventional diesel.

3.3.6 I/M Inputs

To model a local I/M program design, it must be defined by source type using MOVES I/M coverage parameters, entered in the MOVES imcoverage table. The appropriate internal MOVES I/M factors for modeling a local I/M program are designated in a model run by the local program input data in the imcoverage table.[20]

MOVES adjusts emissions (Hydrocarbons [HC], CO, and NO_X) at the source-type level to incorporate the benefits of the local I/M program design defined using the MOVES imcoverage table parameters. TTI previously produced a comprehensive set of MOVES imcoverage records for Texas I/M counties to use in place of MOVES defaults. An I/M program is required in 17 Texas counties of the Austin, DFW, El Paso, and Houston areas (see Table 28 notes for a list of the counties).

TTI produced the local I/M coverage input parameters to represent Texas I/M program designs as specified in the Texas I/M SIP and Texas rules. The I/M program requires annual emissions testing of gasoline vehicles within a 2-through-24 year vehicle age coverage window (excluding motorcycles, military tactical vehicles, diesel-powered vehicles, and antique vehicles). The vehicle model years input to MOVES corresponding

[20] In general, MOVES produces a local I/M program effect as an adjustment to the model's internal reference I/M program effect (i.e., represented as the "standard I/M difference" in the pair of MOVES emission rates [I/M – No I/M], which are specific to vehicle regulatory class categories of which the source types are composed). MOVES contains a large set of "I/M factors" by source type (in the imfactor table) computed specifically for adjusting the MOVES standard I/M difference to reflect the effects of various local I/M program design alternatives.

to this age coverage window were calculated by subtracting "2" and "24" from the analysis year (2020), resulting in 1996 through 2018 model years subject to testing. The PC, PT, and LCT SUTs were modeled for exhaust and evaporative I/M tests including a gas cap integrity test and On-Board Diagnostics (OBD) exhaust and evaporative tests.

Table 28 and associated notes describe MOVES imcoverage records developed by TTI in consultation with TCEQ for all 17 Texas I/M counties, for the 2020 analysis year. For additional I/M program details, see the current I/M SIP and/or pertinent Texas Administrative Code.[21]

Table 28. MOVES I/M Coverage Inputs for Annual Inspections of Gasoline Vehicles, 2020 Analysis Year, All 17 Texas I/M Counties.

yearID	begModelYearID	endModelYearID	testStandardsID[1]	Sourcetypeid[2]
2020	1996	2018	51 (Exh OBD)	21 (PC), 31 (PT), and 32 (LCT)
2020	1996	2018	45 (Evp Cap, OBD)	21 (PC), 31 (PT), and 32 (LCT)

[1] The model processes/pollutants affected are start and running exhaust HC, CO, NO_X, and tank vapor venting HC.

[2] Source type compliance factor field input values were updated and provided by TCEQ for this analysis (March 2021), per Section 4.9.6, *MOVES Technical Guidance*, EPA, November 2020. The compliance factors were based on local I/M program statistics by analysis year, and the latest available data (2019). The I/M county MOVES compliance factors by I/M area for 2019 and later, in percent, are:

DFW:	PC – 94.00;	PT – 90.35;	LCT – 70.74.
HGB:	PC – 95.00;	PT – 91.31;	LCT – 71.49.
Austin:	PC – 94.49;	PT – 90.83;	LCT – 71.12.
El Paso:	PC – 94.50;	PT – 90.83;	LCT – 71.12.

Note: I/M counties by area are Austin: Travis and Williamson; DFW: Dallas, Tarrant, Collin, Denton, Ellis, Johnson, Kaufman, Parker, and Rockwall; El Paso: El Paso; HGB: Harris, Brazoria, Fort Bend, Galveston, and Montgomery.

3.3.7 Control Programs Modeling

Table 32 shows the modeling approaches used for the emissions control strategies.

[21] Revision to the State Implementation Plan Mobile Source Strategies, Inspection and Maintenance State Implementation Plan Revision, TCEQ, adopted February 12, 2014.

Table 29. Emissions Control Strategies and Modeling Approaches.

Control Strategy	Approach
Federal Motor Vehicle Control Program Standards	MOVES defaults.
Federal Heavy-Duty Diesel Engines Rebuild and 2004 Pull-Ahead Programs (to Mitigate NO_X Off-Cycle Effects)	MOVES defaults.
CG Properties	Local input to MOVES consistent with regulatory standards – summer based on TCEQ's 2020 survey data; for winter, MOVES defaults in the absence of local data.
RFG Properties	Local input to MOVES consistent with regulatory standards – based on EPA summer and winter 2020 RFG compliance survey data for Dallas and Houston areas; and MOVES default winter RVP.
Diesel Sulfur	Local input to MOVES – statewide average based on TCEQ's 2020 diesel fuel survey (summer 2020).
TxLED	MOVES output post-processing – TTI adjusted diesel NO_X rates for TxLED counties using 2020 NO_X reduction factors produced by TCEQ (using reductions of 4.8% for 2002 and later, and 6.2% for 2001 and earlier model years).
I/M Program	Local input to MOVES – For I/M counties, available MOVES I/M coverage parameters for I/M vehicles, consistent with current program descriptions and latest I/M modeling protocols, to include latest I/M area-specific MOVES compliance factor inputs provided by TCEQ based on the latest (2019) I/M program statistics.
Federal On-board Refueling Vapor Recovery Program	MOVES defaults.
Federal Stage II Gasoline Vapor Recovery Program	Not applicable – refueling emissions not modeled.

3.4 Checks and Runs

After completing the input data preparation, the CDBs were checked to verify that all tables were in the appropriate CDBs and the tables were populated with data as intended. The MOVES RunSpecs were executed in batches using the MOVES commandline tool. After completion, TTI verified that the MOVES runs were error-free (i.e., checked all run log text files for errors and warnings and compared record counts in each rate table between output databases).

3.5 Post-Processing

Each MOVES output database was post-processed for on-road mobile emission rates to produce the on-road rate tables input to the inventory calculations. The following post-processing procedures were performed on the MOVES output database.

On-Road Mobile Emission Rates

1. This step calculated the mass/SHP off-network evaporative process rates using data from the CDB, the MOVES default database, and the MOVES rateperprofile and ratepervehicle emission rate output. The utility also copied the mass/mile, mass/start, and mass/hour rates along with the units into emission rate tables. The utility created the look-up tables ttirateperdistance (which also includes the rateperhour rates for off-network idling), ttirateperstart, ttirateperhour (for SHEI and APU hours), and ttiratepershp.

2. This step applied TxLED adjustments (see factors provided by TCEQ in Table 30) to the diesel vehicle NO_X emission rates in all counties where TxLED applies. TCEQ produced these average diesel SUT NO_X adjustments using 4.8 percent and 6.2 percent reductions for 2002 and later, and 2001 and earlier model years, respectively.[22, 23] For on-road, these final rates inputs to the emissions calculator were merged into one on-road mobile rates input table, "ttiemissionrate."

[22] Reductions as detailed in the EPA Office of Transportation and Air Quality Memorandum, RE: Texas Low Emission Diesel [LED] Fuel Benefits, September 27, 2001.

[23] The TxLED counties list may be found at: http://www.tceq.texas.gov/airquality/mobilesource/txled/txled-affected-counties. For full details on the TCEQ TxLED factor development procedure, see TxLED estimation spreadsheets at: ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/txled/.

Table 30. TxLED Adjustment Factors Summary.

Diesel Fuel Source Use Type	2020 Reduction	2020 Adjustment
Passenger Car	4.92%	0.9508
Passenger Truck	5.23%	0.9477
Light Commercial Truck	5.27%	0.9473
Other Buses	5.32%	0.9468
Transit Bus	4.98%	0.9502
School Bus	5.19%	0.9481
Refuse Truck	5.21%	0.9479
Single Unit Short-Haul Truck	4.86%	0.9514
Single Unit Long-Haul Truck	4.87%	0.9513
Motor Home	5.44%	0.9456
Combination Short-Haul Truck	4.94%	0.9506
Combination Long-Haul Truck	5.08%	0.9492

Source: TCEQ, March 2021. The TCEQ procedure used MOVES3 and the latest available data (i.e., statewide age distributions and local AVFT inputs based on year-end 2018 TxDMV vehicle registrations data).

See Appendix A for more information on the TTI MOVES on-road emission rate calculation and adjustment utilities.

The resulting hourly on-road emission rates were input to emissions utilities to calculate and summarize the separate on-road mobile source inventories for each county.

4.0 DEVELOPING EMISSIONS INVENTORIES

This section describes the methods used to calculate the seasonal weekday link-based EIs using the TTI EI utilities (with MOVES emission rates) and the annual EIs using MOVES in inventory mode. The methods for developing the annual CDBs for the EPA's NEI application are discussed in this section as well.

4.1 SEASONAL WEEKDAY EMISSIONS INVENTORIES

TTI calculated the hourly, seasonal weekday, on-road mobile EIs by county (TDM link-based and HPMS virtual link-based) using the TTI EI utilities.

The VMT-based emissions calculations used link-based VMT and congested speeds to estimate link-level emissions. The off-network emissions calculations used county-based off-network activity (ONI hours, SHP, starts, SHEI, and APU hours) to estimate county-level emissions.

The hourly roadway-link-based and off-network emissions for the seasonal weekday EIs were calculated using the TTI EI utility inputs:

- County of inventory – from study area counties list, including county FIPS, link data county code, TxDOT district ID, county group FIPS, TxLED flag, county type flag (MSA or non-MSA);
- Vehicle type VMT mix – time period TxDOT district-level VMT mix by MOVES roadway type;
- Time period designation – the time-of-day (AM peak, mid-day, PM peak, overnight) VMT mix to hour-of-day associations;
- HPMS (virtual-link) roadway-based activity – link-specific, hourly, directional, operational VMT and speed estimates as developed by the TTI EI utility to include: HPMS area-type code, HPMS functional class code, county number, HPMS area-type and functional-class combination code, HPMS centerline miles, congested speed, and VMT;
- TDM roadway-based activity – link (and intrazonal link)-specific, hourly, directional, operational VMT and speed estimates as developed by the EI utility to include A node, B node, county number, TDM road type (functional class) code, link length, congested (operational) speed, VMT, and TDM area type code;
- HPMS road type designations – HPMS road type and area type codes to MOVES road type codes (and to VMT mix road type, and rates road type codes);
- TDM road type designations – TDM road type and area type codes to MOVES road type codes (and to VMT mix road type, and to rates road type codes);

- Off-network activity – county ONI hours, SHP, starts, SHEI, and APU hours by vehicle type and hour;
- Pollutant/process/units list for emissions;
- Roadway-based emission factors – MOVES-based, county-level by pollutant, process, hour, average speed, MOVES road type, SUT, and fuel type; and
- Off-network (parked vehicle) emission factors – MOVES-based, county-level by pollutant, process, hour, SUT, and fuel type.

The TTI EI utilities produced emissions outputs aggregated by county, hour, road functional class, road area type, vehicle type, pollutant, pollutant process, and link for on-network emissions; and county, hour, road functional class, vehicle type, pollutant, and pollutant process for off-network emissions. These outputs were then post-processed to produce electronic files in formats suitable for submission to the TCEQ sponsor.

A summary of EIs for the seasonal weekday CAPs and CAP precursors by metropolitan area and county are provided in Appendix L.

4.1.1 Roadway-based Emissions Calculations

County information were identified (e.g., county group ID, county ID, TxDOT district) and inputs were selected for the inventory calculations based on these IDs.

The VMT-based emissions were calculated for each hour using the time-period, TxDOT district-level vehicle type VMT mix, the link VMT and speeds estimates, the MOVES-based on-network emission factors, and the link road type/area type-to-MOVES road type designations. For each link, the link was assigned a MOVES road type based on the link's road type and area type. The link VMT was distributed to each vehicle type using the VMT mix from the appropriate time period based on the link's designated MOVES road type. The AM peak, mid-day, PM peak, and overnight VMT mixes were applied by hour according to the local area time periods designation file which assigns each hour of the day to one of the four periods.

The emission factors by hour for each vehicle type were selected based on the designated hour of the link file, the link's designated MOVES road type and the link speed. For link speeds falling between MOVES speed bin average speeds, emission factors were interpolated from the bounding speeds. For link speeds falling outside of the MOVES speed range (less than 2.5 mph and greater than 75 mph), the emission factors for the associated bounding speeds were used. The mass per mile rates were multiplied by the link vehicle type VMT producing the link-level emissions estimates. This was performed for each hour of the day.

4.1.2 Off-Network Emissions Calculations

The hourly off-network emissions were calculated at the county-level by multiplying the hourly MOVES-based vehicle type off-network emission factors by the appropriate county-level hourly vehicle type off-network activity, which was determined by the pollutant process and associated emission rate table. For selecting the ONI emission rate from the rate per distance table, the road type column was used (i.e., to look up rates with road-type ID "1" for off-network). The off-network emissions calculations used off-network activity (ONI hours, SHP, starts, SHEI, and APU hours) to estimate hourly county-level emissions.

4.1.3 Output

The following output files were developed from the raw EI output.

- A tab-delimited MOVES SUT-based summary output file consisting of one header section followed by hourly and 24-hour totals data blocks of on-road activity and emissions (in units of pounds). Hourly and 24-hour total summaries are by road type and vehicle type of VMT, VHT, speed (VMT/VHT), pollutant totals, and pollutant process totals (with the "off-network" category listed as the last road type preceding the TOTALS row in each data block), and with starts, ONI hours, SHP, SHEI, and APU activity rows last in the activity data block for each time period; and
- A tab-delimited SCC-based summary output file that contains the 24-hour totals of VMT and emissions (in units of pounds) using inventory data aggregations, SCCs, and pollutant codes consistent with the EPA's 2020 NEI.

The seasonal weekday SUT-based EIs consisted of the standard MOVES CAPs and CAP precursors by MOVES pollutant IDs listed in listed in Table 31 (prior to coding and particular MOVES pollutant aggregations needed for the NEI).

Table 31. CAPs and CAP Precursors Included in the Seasonal Weekday and Annual Inventories.

Pollutant ID	Pollutant Name
2	CO
3	NO_X
30	NH_3
31	SO_2
87	VOC
90	Atmospheric CO_2
100	Primary Exhaust PM_{10} – Total
106	Primary PM_{10} – Brakewear Particulate
107	Primary PM_{10} – Tirewear Particulate
110	Primary Exhaust $PM_{2.5}$ – Total
116	Primary $PM_{2.5}$ – Brakewear Particulate
117	Primary $PM_{2.5}$ – Tirewear Particulate

See Appendix A for further details on the utilities and Appendix B for descriptions of the emissions inventory electronic data files provided.

4.2 Annual Emissions Inventories

The MOVES CDBs used to produce summer weekday emission rates for the link-based inventory analyses were designed only for use in MOVES rates mode runs. For the annual emissions, the MOVES CDBs TTI developed for the EPA's 2020 NEI project TTI also used in MOVES (MOVES3.0.3) runs performed in inventory mode to produce the 2020 AERR annual emissions estimates for each Texas county.

The summaries of 2020 annual CAPs, CAP precursors, and HAPs by metropolitan area and county are provided in Appendix M.

4.2.1 MOVES Inventory Mode Inputs and CDBs

The sources for the MOVES inventory mode input data sets used to produce the CDBs for each Texas county for the 2020 AERR annual EIs (and EPA's NEI) consisted of data from the link-based inventory analysis supplemented with other needed data. Data for the annual analysis were from the daily EI MOVES rates inputs, link-based activity outputs and off-network activity outputs, and particular MOVES defaults or modified MOVES defaults consistent with the local inventories, supplemented with other data as needed for the annual analysis and described in previous sections. TTI used the EI utilities to process the data into the MOVES3 inventory mode inputs for the annual runs.

The utility accesses the data sources, performs needed processing of data into MOVES input form, and organizes the resulting MOVES input files in folders by county, year, period, and day type, for populating the CDBs. Table 32 lists the 32 input tables produced and the sources of the data.

Table 32. MOVES Annual Inventory Mode CDBs and Data Sources.

Table[1]	Data Source
auditlog	Rates CDB + I/M records conditions from MOVES default database
avft	Rates CDB
avgspeeddistribution	MOVESactivityInputBuild utility output for dayID 5 and MOVES default avgspeeddistribution for dayID 2
county	Rates CDB[2], barometric pressure values updated using local data
countyyear	Rates CDB[2]
dayofanyweek	MOVES default database
dayvmtfraction	Local Data (see Appendix J)
fuelsupply	Rates CDB with monthID 1 data for months 1-3, 11-12; monthID 7 data for months 5-9; shoulder fuel for months 4, 10.
fuelformulation	Rates CDB
fuelusagefraction	Rates CDB
hotellingactivitydistribution	Rates CDB
hotellingagefraction	Rates CDB
hotellinghourfraction	MOVESactivityInputBuild utility output
hotellinghoursperday	Post-processing output including weekday and weekend day
hotellingmonthadjust	Local data with 12-month adjustment
hourvmtfraction	Local Data (see Appendix J)
hpmsvtypeyear	Annual activity[3]
imcoverage	Rates CDB[2]
monthofanyyear	MOVES default database
monthvmtfraction	Local Data (see Appendix J)
roadtypedistribution	MOVESactivityInputBuild utility output
sourcetypeagedistribution	Rates CDB
sourcetypeyear	MOVESactivityInputBuild utility output
startshourfraction	MOVESactivityinputbuild utility output
startsmonthadjust	monthvmtfraction * 12
startsperdaypervehicle	MOVES default database
state	Rates CDB
totalidlefraction	MOVES default database for 12 months

year	Rates CDB
zone	Rates CDB[2]
zonemonthhour	Rates CDB[2] with local data for 12 months. (winter = 12, 1, 2; spring = 3, 4, 5; summer = 6, 7, 8; fall = 9, 10, 11)
zoneroadtype	Rates CDB[2]

[1] Per EPA NEI instructions, these 12 empty tables not shown were also included: emissionratebyage, hpmsvtypeday, idledayadjust, idlemodelyeargrouping, idlemonthadjust, onroadretrofit, sourcetypedayvmt, sourcetypeyearvmt, startsageadjustment, startsopmodedistribution, starts and startsperday.

[2] For virtual link counties, the "Rates CDBs" are for county groups represented by one countyID. County information taken from these Rates CDBs (such as countyid or zoneid in county, countyyear, zone, zonemonthhour, zoneroadtype, imcoverage) were updated for the county of the MOVES inventory mode CDB created.

[3] From the activity annualization procedures.

Additional details on most of these MOVES inputs tables may be found in the MOVES3 inventory development guidance and MOVES technical information at EPA's MOVES model website. Appendix A describes the TTI EI utilities and Appendix B describes the files provided.

4.2.2 Emissions Calculations

The annual emissions were calculated using MOVES with the annual MRSs by county and the associated annual inventory mode CDBs. See Appendix B for description of files provided.

4.2.3 Output

Similarly to the daily EI analysis, the following output files were produced by post-processing the MOVES annual EI output.

- A tab-delimited MOVES SUT-based summary output file consisting of one header section followed by calendar year totals data blocks of on-road activity and emissions (in units of pounds). Year total summaries are by road type and vehicle type of VMT, VHT, speed (VMT/VHT), pollutant totals, and pollutant process totals (with the "off-network" category listed as the last road type preceding the TOTALS row in each data block), and with starts, ONI hours, SHP, SHEI, and APU activity rows last in the activity data block; and
- A tab-delimited SCC-based summary output file that contains the calendar year totals of VMT and emissions (in units of pounds) using inventory data aggregations, SCCs, and pollutant codes consistent with the EPA's 2020 NEI.

These files were further processed by the TTI EI utility to produce the various inventory extracts and summaries including those coded, aggregated, and formatted (i.e., in XML) for uploading to EPA's EIS and to the TCEQ's TxAER.

The CAPs and CAPs precursors included in the annual EIs are listed in Table 31 and the HAPs included are listed in Table 33 (prior to particular MOVES pollutant aggregations and coding needed for the NEI).

See the electronic data submittal description (Appendix B) for further details on conversions, coding, and files provided for uploading to TxAER and EIS.

Table 33. HAPs Included in Annual Inventories.

Category[1]	MOVES Pollutant ID[2]		Pollutant Name[2]	NEI Pollutant Code
Gaseous HC	20		Benzene	71432
	24		1,3-Butadiene	106990
	25		Formaldehyde	50000
	26		Acetaldehyde	75070
	27		Acrolein	107028
	40		2,2,4-Trimethylpentane	540841
	41		Ethyl Benzene	100414
	42		Hexane	110543
	43		Propionaldehyde	123386
	44		Styrene	100425
	45		Toluene	108883
	46		Xylene	1330207
Polycyclic Aromatic HC (PAH)	**Gas**	**PM**		
	170	70	Acenaphthene	83329
	171	71	Acenaphthylene	208968
	172	72	Anthracene	120127
	173	73	Benz(a)anthracene	56553
	174	74	Benzo(a)pyrene	50328
	175	75	Benzo(b)fluoranthene	205992
	176	76	Benzo(g,h,i)perylene	191242
	177	77	Benzo(k)fluoranthene	207089
	178	78	Chrysene	218019
	168	68	Dibenzo(a,h)anthracene	53703
	169	69	Fluoranthene	206440
	181	81	Fluorene	86737
	182	82	Indeno(1,2,3,c,d)pyrene	193395
	185	23	Naphthalene	91203
	183	83	Phenanthrene	85018
	184	84	Pyrene	129000
Metal	60		Mercury Elemental Gaseous	200

	61	Mercury Divalent Gaseous	201
	62	Mercury Particulate	202
	63	Arsenic Compounds	93
	65	Chromium 6+	18540299
	66	Manganese Compounds	7439965
	67	Nickel Compounds	7440020
Dioxin/Furan	130	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	19408743
	131	Octachlorodibenzo-p-dioxin	3268879
	132	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	35822469
	133	Octachlorodibenzofuran	39001020
	134	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	39227286
	135	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	40321764
	136	2,3,7,8-Tetrachlorodibenzofuran	51207319
	137	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673897
	138	2,3,4,7,8-Pentachlorodibenzofuran	57117314
	139	1,2,3,7,8-Pentachlorodibenzofuran	57117416
	140	1,2,3,6,7,8-Hexachlorodibenzofuran	57117449
	141	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	57653857
	142	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	1746016
	143	2,3,4,6,7,8-Hexachlorodibenzofuran	60851345
	144	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562394
	145	1,2,3,4,7,8-Hexachlorodibenzofuran	70648269
	146	1,2,3,7,8,9-Hexachlorodibenzofuran	72918219

[1] MOVES models two groups of metal emissions, those used for air quality modeling, and metals due to their known toxicity (i.e., the seven metal species in this table) (See Section 2.3 in *Air Toxic Emissions from On-Road Vehicles in MOVES2014*, EPA, November 2016). The other metals (e.g., iron, aluminum) were not estimated separately as HAPs, but were, by default, included in the aggregate exhaust $PM_{2.5}$ estimates.

4.3 Reporting for TexAER and EIS

TTI converted the county-level seasonal weekday (CAPs and CAP precursors) annual emissions (CAPs, CAP precursors and HAPs) and activity results to a format compatible for uploading to the TCEQ's TexAER and EPA's EIS based on the EPA's EIS NEI CERS XML format, which uses EPA's EIS inventory data codes. Particular MOVES pollutants required aggregation and re-coding for EIS compatibility (i.e., combining gas and particle PAHs; combining the three mercury compounds; and combining PM from exhaust, brakewear, and tirewear). Each run produced the XML file and one output summary of SCC-labeled inventory data in a tab-delimited text file form for each county included in the resulting XML file. All these files were included in the electronic data submittal with additional descriptive information (see Appendix A for more details).

5.0 TEXAS ROAD DUST CALCULATOR INPUT DEVELOPMENT

Estimates of road dust PM from vehicles driving on paved and unpaved roads are relatively large compared to the direct exhaust, brakewear, and tirewear estimates from vehicles driving on these roads. The EPA has developed a paved and unpaved roads calculator tool for the NEI that uses on-road mobile VMT activity data. TTI developed the Microsoft Excel "Texas Road Dust Calculator" to develop EIs of road dust PM, using VMT activity inputs consistent with the on-road mobile source EIs. The road dust calculator estimates the road dust emissions at county-level.

TTI developed inputs for use in the TCEQ Texas Road Dust Calculator for the statewide 254 counties for the 2020 analysis year using the current TDM-link and HPMS-virtual link activity data described for the statewide, on-road mobile source direct vehicle emissions inventories. Inputs were developed as described in TTI's August 2020 Revised Final Technical Report *Area Source Texas Calculator for Paved and Unpaved Roads* prepared for the TCEQ.

5.1 DATA USED TO DEVELOP INPUT FILES

The Texas road dust calculator includes Texas-specific activity input and was designed to accommodate input parameter changes, as may be needed. The TCEQ also requested that TTI also provide average vehicle weight data formatted for use with the Texas Road Dust Emission Calculator; however—based on TTI's communications with the EPA—none of the average vehicle weights used in the Texas Road Dust Emission Calculator had changed from the data that is currently in the calculator; therefore, no revised average vehicle weights are provided for the calculator.

The following steps were performed to produce the VMT, centerline miles, traffic volumes, and speed inputs to the calculator (referred to as HPMS and TDM Staging Inputs):

HPMS Staging Inputs

The 2020 analysis year HPMS total AADT VMT and unpaved AADT VMT for the 217 HPMS counties was formatted, and processed into road dust calculator input form, by the 14 FHWA roadway types, consistent with the TxDOT county HPMS Staging Inputs format.

- Paved AADT VMT and centerline miles were calculated.

- Paved and unpaved summer weekday (SWKD) VMT were calculated using the latest TxDOT district level summer weekday factors.
- AADT and SWKD traffic volumes were calculated (for paved road emission factors).
- For roadway types with unpaved segments, 24-hour average speed estimates were added (from the HPMS-based county 2020 AERR SWKD on-road mobile source inventories activity data).

TDM Staging Inputs

TCEQ 2020 AERR activity data for the 37 TDM counties in the 2020 AERR on-road inventories were updated, formatted, and processed into road dust calculator input form, by the 14 FHWA roadway types, consistent with the HPMS Staging Inputs format.

- 24-hour SWKD activity summaries of VMT and VHT, and centerline miles by TDM roadway and area type were mapped to the FHWA roadway types.
- For each county, the TDM activity data was updated (scaled) to the actual TxDOT 2020 HPMS AADT VMT totals, using the ratio county HPMS AADT VMT/Old SWKD TDM VMT.
- Since TDM data do not include unpaved roadway information, the TxDOT HPMS unpaved AADT VMT (from the HPMS Staging Inputs analysis) were subtracted from the TDM total AADT VMT to produce the paved, unpaved, and total AADT VMT estimates by TDM county. The same was performed for centerline miles.
- The latest summer weekday factors were applied to the AADT VMT estimates to produce the updated SWKD VMT estimates for the analysis.
- AADT and SWKD traffic volumes were calculated (for the paved analysis), and speeds were calculated (for the unpaved analysis) based on the original SWKD VMT and VHT aggregated by the pertinent FHWA roadway types.

For information on the process used in the development of the road dust calculator tool inputs, refer to TTI's August 2020 Revised Final Technical Report *Area Source Texas Calculator for Paved and Unpaved Roads* prepared for the TCEQ.

5.2 Estimating Road Dust Emissions

Once the development of the road dust inputs were complete, the data was organized into a format specified for input into the Texas road dust calculator for the road dust inventory calculations. For simplicity, TTI placed the updated input tables directly into a 2020 version of the Texas road dust inventory calculator as an electronic deliverable. Installing the updated tables directly into the calculator allowed TTI to confirm that the files worked properly.

The TCEQ road dust inventory calculator input files and the updated Texas road dust calculator were provided as electronic data.

6.0 QUALITY ASSURANCE

Analyses and results were subjected to appropriate internal review and QA/QC procedures, including independent verification and reasonableness checks. All work was completed consistent with applicable elements of American Society for Quality, American National Standard Institute (ASQ/ANSI): E4:2014: *Quality Management Systems for Environmental Information and Technology Programs – Requirements with Guidance for Use,* February 2014, and the TCEQ Quality Management Plan.

The Quality Assurance Project Plans (QAPP) category and project type most closely matching the intended use of this analysis are QAPP Category II (for important, highly visible Agency projects involving areas such as supporting the development of environmental regulations or standards) and Modeling for NAAQS Compliance. Internal review and quality control measures consistent with the QA category and project type-specific requirements provided in Guidance for Quality Assurance Project Plans for Modeling, EPA QA/G-5M,[24] along with appropriate audits or assessments of data and reporting of findings, were employed. These include but are not limited to the elements outlined, per EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5),[25] in the following description.

6.1 PROJECT MANAGEMENT

The definition and background of the problem addressed by this project, the project/task description, and project documents and records are as described in the Purpose and Background sections of the Grant Activity Description (GAD). No special training or certification was required. The TTI project manager ensured project personnel used the most current, approved version of the QAPP.

The objective was to produce emissions inventories of the quality level required for air quality modeling, according to the guidance and methods documents as referenced, and in consultation with the TCEQ project manager.

Basic criteria were used to assure the acceptable quality of the product, to include:

- The product met the purpose of the emissions analysis;
- The full extent of the modeling domain was included;

[24] PDF available at: https://www.epa.gov/sites/production/files/2015-06/documents/g5m-final.pdf.
[25] PDF available at: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf.

- Agreed methods, models, tools, and data were used;
- The output data sets were produced in required formats;
- Any deficiencies found (as discussed in Section 6.5) were corrected; and
- Aggregate results were comparable with available, similarly produced emissions estimates.

6.2 Measurement and Data Acquisition

Note that no sampling of data was involved in the emissions inventory development; thus, only existing data (non-direct measurements) were used for this project.

The data needed for project implementation was for the development of emission rate and emissions inventory model inputs and adjustment factors and the development of the activity inputs for both internal (relatively aggregate) and external (detailed, link-level) emissions calculations. Existing data acquired from various organizations (e.g., TxDOT, MPOs, TCEQ, EPA) was reviewed by TTI for suitability, and in most cases was previously QA'd by the providing agency. These data sets may include: HPMS data (from TxDOT's RIFCREC report); regional travel demand model data; speed model data; vehicle registration data; ATR data; vehicle classification count data; meteorological data; fuels data; MOVES emissions model data; extended idling activity data; and vehicle I/M program design data.

Any significant problems found during review, verification, and/or validation (see QA criteria and methods discussed in Section 6.5) were corrected, and the QA procedure was repeated until satisfied. No significant problems were found.

6.3 Data Management

Project staff used the same electronic project folder structure on each individual workstation. As various scripts, inputs, and outputs were developed in the process, data were shared within the team for crosschecking. To perform the MOVES model runs, a computer cluster (multiple computers) configuration or individual workstation configuration was used. After input data were QA'd, data sets were backed up and stored in compressed files.

After the final product was completed, all the project data archives were compiled on USB 3.0-compatible external hard drive storage media and/or a shared folder using a secure file sharing website as agreed upon by the TCEQ project manager. A complete archive of the project data is kept by TTI (including the computer models and emissions inventory development utilities used in the process). The electronic data submittal package (containing the project deliverables as listed in Appendix B) was produced along with data description (and copied to a shared folder or external hard drive) and delivered to TCEQ.

6.4 Assessment and Oversight

The following assessments were performed.

- Verified that the overall scope was met (i.e., consistent with the intended purpose, for specified temporal resolution and geographic coverage, for specified sources, pollutants, and emissions processes).
- Checked that input data was prepared according to the plan; and
- Checked that correct output data was produced. Records were kept of the checks performed.

In the case of any inconsistency or deficiency found, the issue was directly communicated to responsible staff for correction (or outside agency staff involved, if any). After any correction, QA checks were repeated to assure the additional work resulted in the intended result, and were noted in the QA record.

Any major problems were reported to the project manager and communicated to the project team as needed, as well as when various data elements passed QA checks and were ready for next steps. The project manager ensured all of the QA checks performed were compiled and maintained in the project archives.

In addition, technical systems audits were performed. Audits of data quality at the requisite 25 percent level were performed for any data produced as part of this study. QA findings were reported in both the draft and the final reports.

6.5 Data Validation

Erroneous or improper inputs at any point during the emissions inventory development process may produce inaccurate emissions estimates. The TTI project team performed QA checks at each step of the analysis to ensure data quality.

The criteria for passing quality checks are summarized in the following. These QA guidelines were used to ensure the development of emissions inventories that were as accurate as possible and met the requirements of TCEQ's intended use.

As previously stated, TTI verified the overall scope of the emissions analysis to include:

- Purpose (i.e., needed for AERR reporting purposes).
- Modeling domain (e.g., analysis years, geographic coverage, seasonal periods, days, sources, pollutants).
- Methods, models, and data (e.g., default versus local input data sources).
- Procedures, tools, and required emissions output data sets.

TTI performed checks on input data, model execution, and output, as follows:

- Input data preparation:
  - The basis of input data sets as planned (e.g., actual, historical, latest available, validated model); aggregation levels.
  - Depending on the procedure and input data set, verification of calculations.
  - Use of correct data dimensions, fields, coding, labeling, formats; distributions sum to 1.0 where appropriate.
  - Reasonability checks: (discussed in the next section).
  - External data sources quality assurance verification.
- Model or utility execution:
  - Correct number of utility or model run input files per application.
  - Utility control or model run specifications verification (e.g., per applicable user guide, correct inputs, output options).
- Output:
  - Correct output files by type and quantity.
  - Expected output file sizes.
  - Warnings and errors (e.g., checks of any written to output run logs).
  - Required data, proper coding/labeling, formats.
  - Assessment of any unusual results.

TTI performed further checks for consistency, completeness, and reasonability of data output from model or utility applications.

- Any activity, emission rate, or emissions adjustments were performed as intended.
- Noted whether directional differences were as expected (e.g., between scenarios with temporal or geographic variation).
- Checked for consistency (e.g., input data control totals versus output summaries, utility raw results versus post-processed results).
- 24-hour, aggregate emission rates (e.g., from county totals) compared between counties to identify potential outliers and assess relative and directional differences. Comparisons of results to results from previous similar analyses, where available.

Any additional data products required for the emissions analysis were subjected to the appropriate QA checks previously listed. Any issues found needing resolution were corrected, and appropriate QA checks were performed until satisfied, ensuring the project results met the TCEQ requirements, i.e., as outlined in the GAD and QAPP.

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APPENDIX A: EMISSIONS UTILITIES FOR MOVES-BASED EMISSIONS INVENTORIES (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX B: ELECTRONIC DATA SUBMITTAL DESCRIPTION (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX C: COUNTY VMT CONTROL TOTALS AND SEASONAL WEEKDAY ADJUSTMENT FACTORS (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX D: TXDOT DISTRICT AGGREGATE WEEKDAY VMT MIX (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX E: TXDOT DISTRICT HOURLY TRAVEL FACTORS (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX F: TTI SPEED MODEL VOLUME DELAY EQUATION PARAMETERS AND FACILITY TYPE CATEGORIES (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX G: HOUSTON SPEED MODEL CAPACITY FACTORS, SPEED FACTORS, AND SPEED REDUCTION FACTORS

Capacity Factors

Time of Day Assignment	Capacity Factor[1]
AM Peak	0.3333333
Mid-Day	0.1666667
PM Peak	0.2500000
Overnight	0.0909091

[1] To obtain hourly capacities, a single capacity factor for each time-of-day assignment is used for all area types and functional classes.

Free-Flow (V/C=0) Speed Factors for the Houston/Galveston Speed Model.

Functional Class Code	Functional Class Description	Area Type Code	Area Type Description	Distance Weighted Input Speeds[1]	Distance Weighted Free-Flow Speeds[2]	Free-Flow Speed Factor[3]
1	Urban Interstate	1	CBD	50.85	56.40	1.10906
1	Urban Interstate	2	Urban	52.55	61.40	1.16842
2	Urban Other Freeway	1	CBD	NA	58.00	1.21154
2	Urban Other Freeway	2	Urban	52.00	63.00	1.21154
3	Toll Road	1	CBD	NA	34.50	0.62652
3	Toll Road	2	Urban	57.58	36.08	0.62652
3	Toll Road	3	Urban Fringe	61.69	36.14	0.58577
3	Toll Road	4	Suburban	64.34	37.99	0.59040
3	Toll Road	5	Rural	59.13	38.43	0.64991
4	Ramp	1	CBD	28.62	35.13	1.22734
4	Ramp	2	Urban	40.06	36.26	0.90509
4	Ramp	3	Urban Fringe	43.22	38.52	0.89119
4	Ramp	4	Suburban	44.82	45.71	1.01987
4	Ramp	5	Rural	55.16	52.11	0.94478
5	Urban Principal Arterial	1	CBD	24.72	26.52	1.07262
5	Urban Principal Arterial	2	Urban	35.78	29.69	0.82974
6	Urban Other Arterial	1	CBD	22.00	24.64	1.11996
6	Urban Other Arterial	2	Urban	34.57	27.31	0.79001
7	Urban Collector	1	CBD	20.94	24.17	1.15413
7	Urban Collector	2	Urban	35.36	25.78	0.72901
10	Rural Interstate	3	Urban Fringe	57.84	61.40	1.06152
10	Rural Interstate	4	Suburban	59.15	67.20	1.13613
10	Rural Interstate	5	Rural	62.00	68.57	1.10599
11	Rural Other Freeway	3	Urban Fringe	62.00	63.00	1.01613
11	Rural Other Freeway	4	Suburban	62.00	69.00	1.11290
11	Rural Other Freeway	5	Rural	64.00	71.00	1.10938
12	Rural Principal Arterial	3	Urban Fringe	40.23	33.75	0.83890
12	Rural Principal Arterial	4	Suburban	46.12	42.48	0.92125
12	Rural Principal Arterial	5	Rural	60.00	55.53	0.92536
13	Rural Other Arterial	3	Urban Fringe	39.05	30.51	0.78131
13	Rural Other Arterial	4	Suburban	43.03	39.85	0.92612
13	Rural Other Arterial	5	Rural	53.97	54.07	1.00194
14	Rural Major Collector	3	Urban Fringe	38.00	27.76	0.73061
14	Rural Major Collector	4	Suburban	41.00	49.22	1.20059
14	Rural Major Collector	5	Rural	53.00	54.06	1.02009
15	Rural Collector	3	Urban Fringe	36.00	24.07	0.66864
15	Rural Collector	4	Suburban	40.00	35.58	0.88938
15	Rural Collector	5	Rural	49.00	49.86	1.01762

[1] Based on 2012 TDM data

[2] Calculated from detailed speed model runs by H-GAC with link volumes set to 0 (v/c = 0).

[3] When inputs speeds are not available, speed factors are taken from the nearest area type.

LOS E (V/C=1) Speed Factors for the Houston/Galveston Speed Model.

Functional Class Code	Functional Class Description	Area Type Code	Area Type Description	Distance Weighted Input Speeds[1]	Distance Weighted LOS E Speeds [2]	LOS Speed Factor[3]
1	Urban Interstate	1	CBD	50.85	34.35	0.67549
1	Urban Interstate	2	Urban	52.55	34.35	0.65370
2	Urban Other Freeway	1	CBD	N/A	35.00	0.67308
2	Urban Other Freeway	2	Urban	52.00	35.00	0.67308
3	Toll Road	1	CBD	N/A	24.77	0.43011
3	Toll Road	2	Urban	57.58	24.77	0.43011
3	Toll Road	3	Urban Fringe	61.69	26.52	0.42983
3	Toll Road	4	Suburban	64.34	29.54	0.45920
3	Toll Road	5	Rural	59.13	29.70	0.50229
4	Ramp	1	CBD	28.62	31.68	1.10692
4	Ramp	2	Urban	40.06	30.03	0.74952
4	Ramp	3	Urban Fringe	43.22	33.24	0.76908
4	Ramp	4	Suburban	44.82	41.22	0.91979
4	Ramp	5	Rural	55.16	49.01	0.88861
5	Urban Principal Arterial	1	CBD	24.72	22.13	0.89529
5	Urban Principal Arterial	2	Urban	35.78	24.44	0.68294
6	Urban Other Arterial	1	CBD	22.00	20.80	0.94565
6	Urban Other Arterial	2	Urban	34.57	22.76	0.65833
7	Urban Collector	1	CBD	20.94	20.06	0.95782
7	Urban Collector	2	Urban	35.36	21.23	0.60033
10	Rural Interstate	3	Urban Fringe	57.84	39.25	0.67860
10	Rural Interstate	4	Suburban	59.15	49.08	0.82973
10	Rural Interstate	5	Rural	62.00	49.08	0.79157
11	Rural Other Freeway	3	Urban Fringe	62.00	40.00	0.64516
11	Rural Other Freeway	4	Suburban	62.00	50.00	0.80645
11	Rural Other Freeway	5	Rural	64.00	50.00	0.78125
12	Rural Principal Arterial	3	Urban Fringe	40.23	27.30	0.67871
12	Rural Principal Arterial	4	Suburban	46.12	32.64	0.70784
12	Rural Principal Arterial	5	Rural	60.00	38.32	0.63858
13	Rural Other Arterial	3	Urban Fringe	39.05	24.81	0.63540
13	Rural Other Arterial	4	Suburban	43.03	30.15	0.70070
13	Rural Other Arterial	5	Rural	53.97	38.46	0.71270
14	Rural Major Collector	3	Urban Fringe	38.00	22.22	0.58465
14	Rural Major Collector	4	Suburban	41.00	34.09	0.83151
14	Rural Major Collector	5	Rural	53.00	36.83	0.69499
15	Rural Collector	3	Urban Fringe	36.00	19.74	0.54845
15	Rural Collector	4	Suburban	40.00	26.40	0.65994
15	Rural Collector	5	Rural	49.00	34.33	0.70057

[1] Based on 2012 TDM data.
[2] Calculated from detailed speed model runs by H-GAC with link volumes set to capacity 0 (v/c = 0).
[3] When inputs speeds are not available, speed factors are taken from the nearest area type.

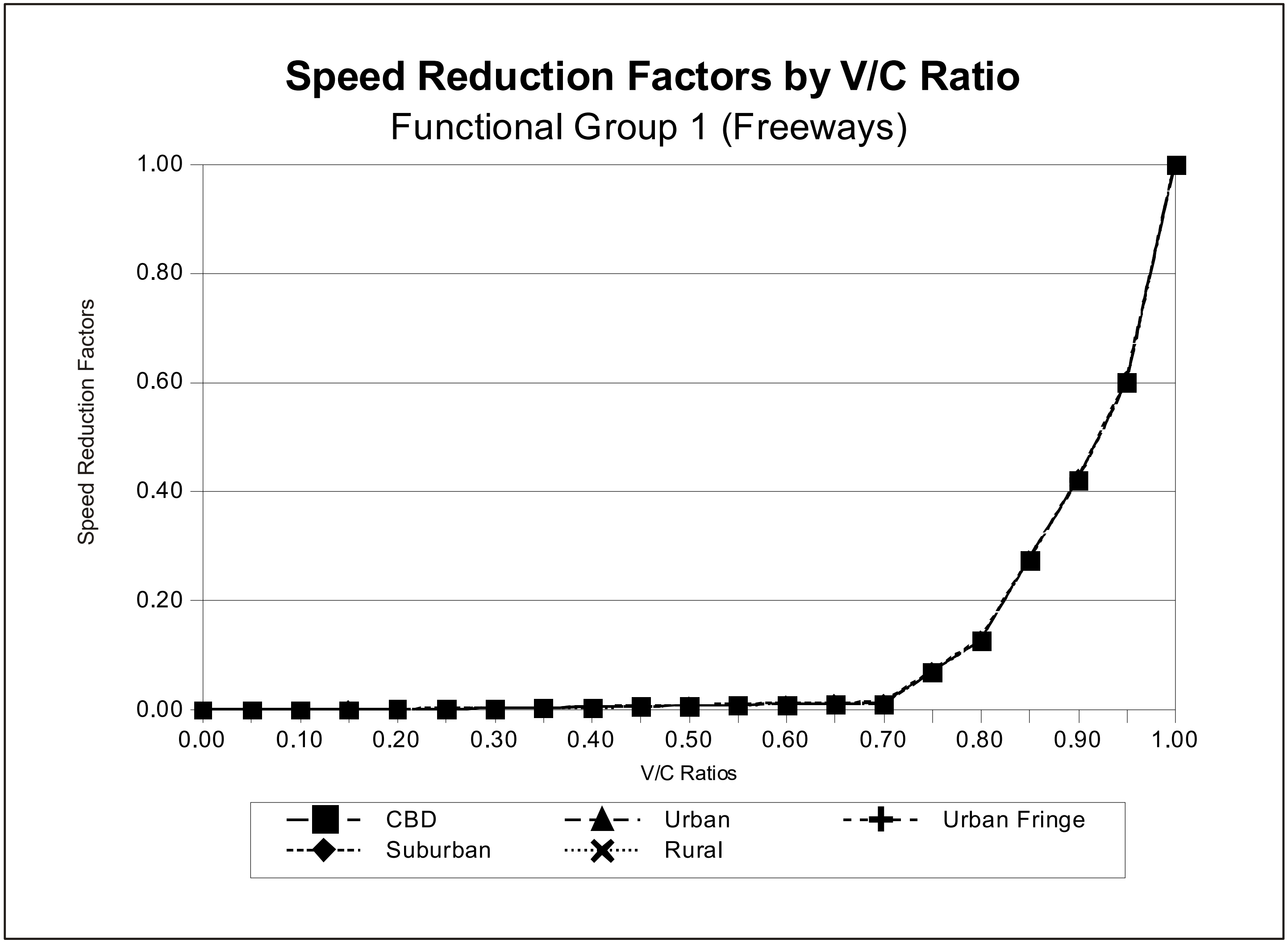

Figure 1. Freeway Speed Reduction Factors by V/C Ratio.

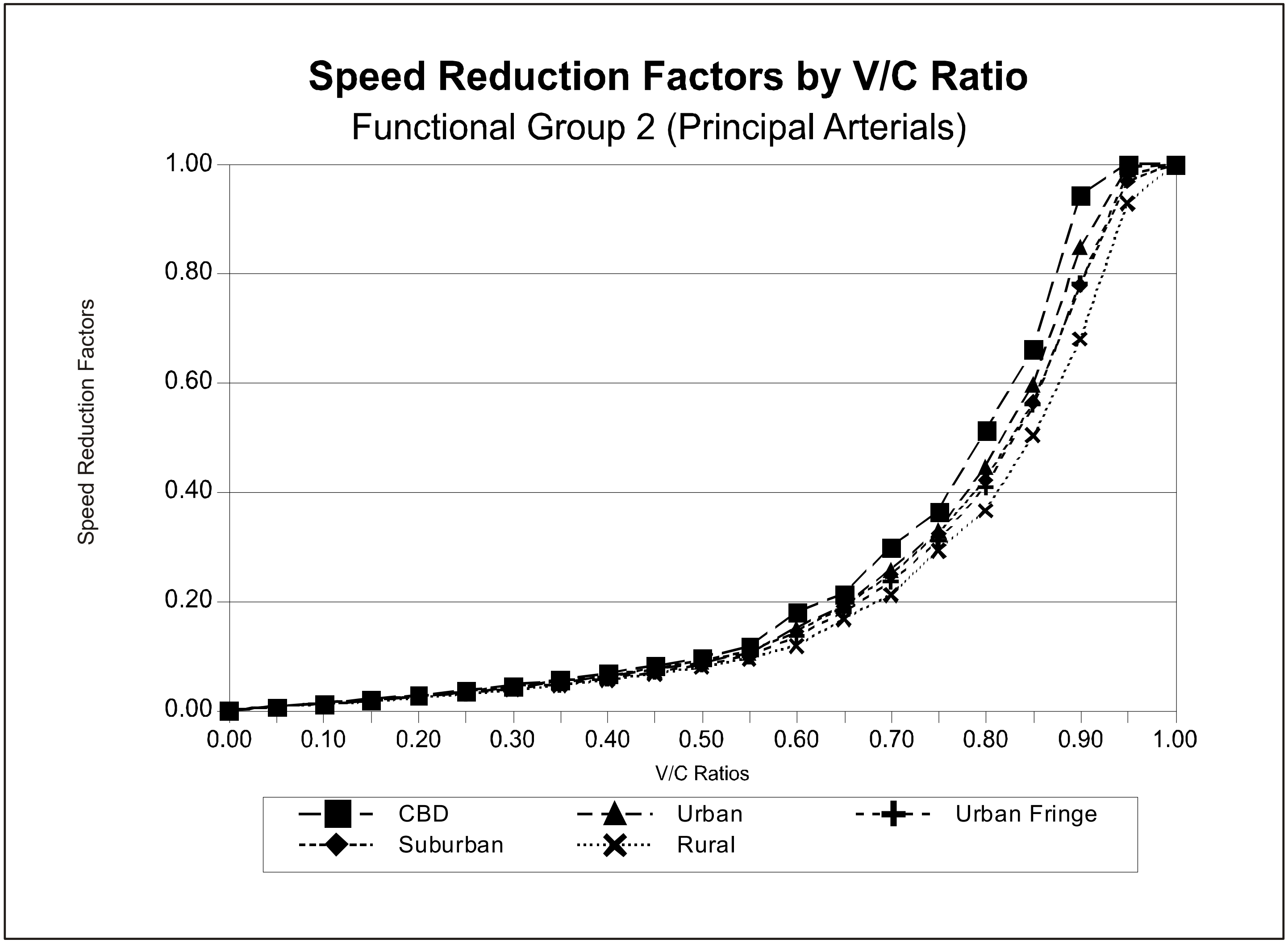

Figure 2. Principal Arterial Speed Reduction Factors by V/C Ratio.

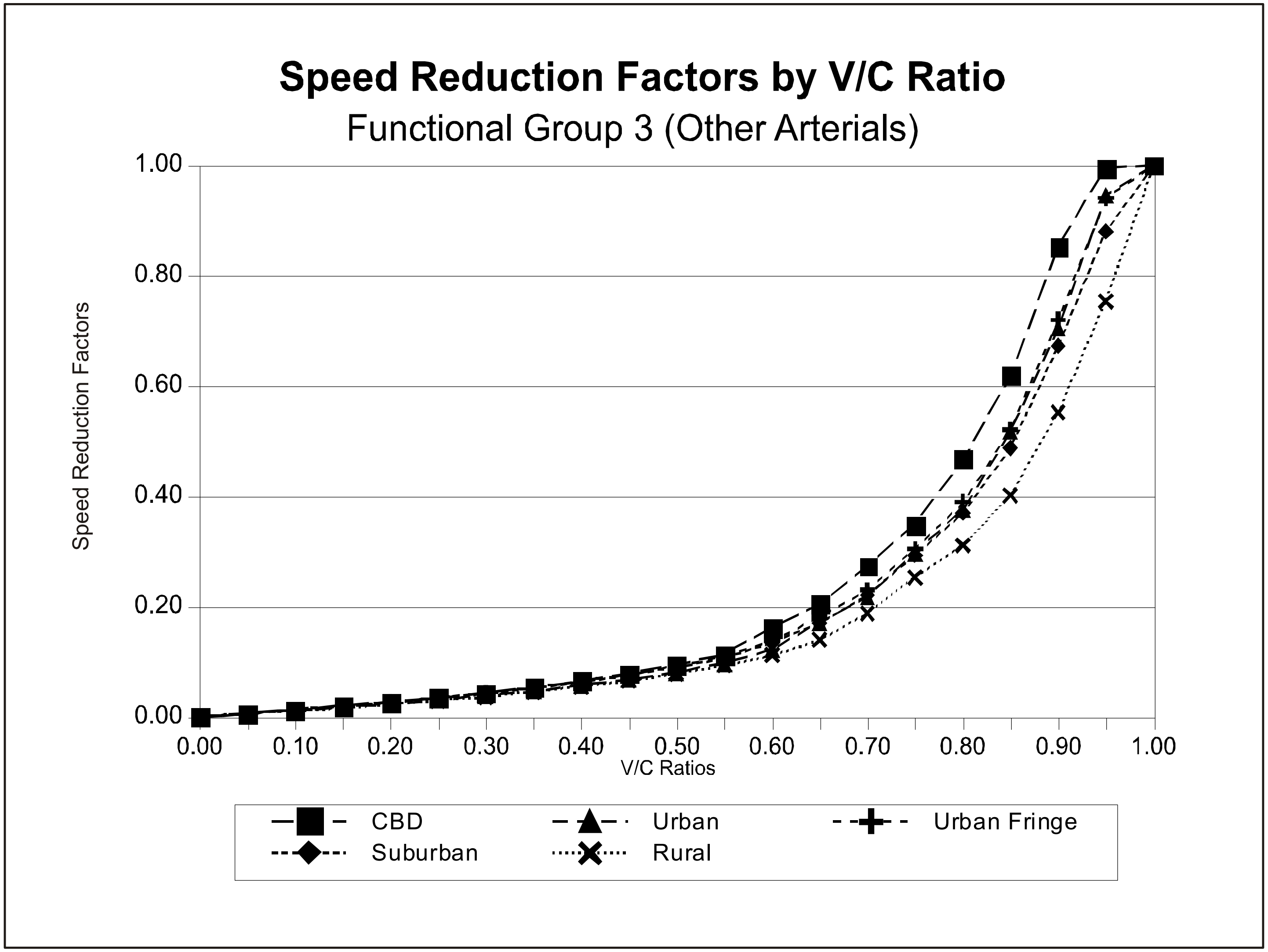

Figure 3. Other Arterial Speed Reduction Factors by V/C Ratio.

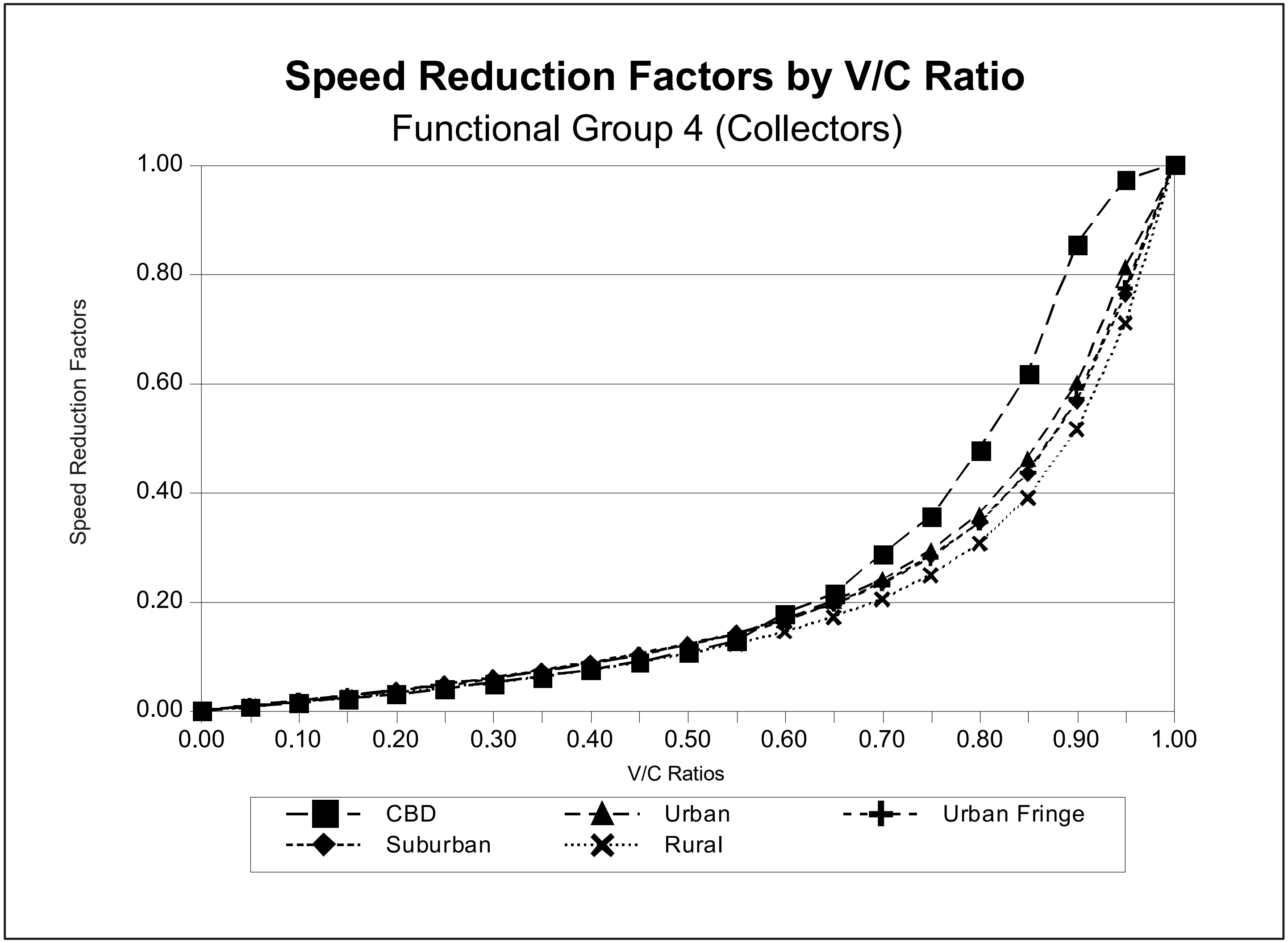

Figure 4. Collector Speed Reduction Factors by V/C Ratio.

Functional Classification to Functional Group Relationship for the Application of Speed Reduction Factors.

Functional Group	Corresponding Network Functional Classifications
1. Freeways, Interstates	1. Urban Interstate Freeways 2. Urban Other Freeways 3. Toll Roads 10. Rural Interstate Freeways 11. Rural Other Freeways
2. Principal Arterials	5. Urban Principal Arterials 12. Rural Principal Arterials
3. Other Arterials, Major Collectors	6. Urban Other Arterials 13. Rural Other Arterials 14. Rural Major Collectors
4. Collectors	4. Ramps 7. Urban Collectors 15. Rural Collectors

APPENDIX H: VEHICLE POPULATION ESTIMATES AND 24-HOUR ONI HOURS, SHP, STARTS, SHEI, AND APU HOURS SUMMARIES (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX I:
INDIVIDUAL COUNTIES AND TEXAS COUNTY GROUPS FOR THE EMISSION FACTOR ANALYSIS (ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX J:
SOURCE TYPE AGE AND FUEL ENGINE FRACTIONS INPUTS TO MOVES
(ELECTRONIC ONLY)

This appendix is available separately in an electronic format (e.g., .docx, .xlsx, .pdf, .txt, .zip, or other format.) and can be provided upon request.

APPENDIX K: METEOROLOGICAL INPUTS TO MOVES (ELECTRONIC ONLY)

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APPENDIX L: SEASONAL WEEKDAY ON-ROAD MOBILE SOURCE EMISSIONS

Texas Statewide
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
All Texas Counties	165.91	3,499.83	464.70	432,904.73	2.21	20.93	80.63	20.29

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

El Paso Metropolitan Planning Area
2020 Winter Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso	4.79	72.86	16.68	10,379.29	0.06	0.54	2.41	0.62

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

AUS Metropolitan Planning Area
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bastrop	0.68	12.56	1.50	1,372.84	0.01	0.07	0.22	0.06
Burnet	0.46	9.77	1.24	1,078.60	0.01	0.05	0.20	0.05
Caldwell	0.34	7.27	0.83	738.28	0.00	0.04	0.11	0.03
Hays	1.18	24.00	2.71	2,894.27	0.01	0.16	0.43	0.11
Travis	4.65	97.99	9.88	12,688.88	0.07	0.66	2.14	0.50
Williamson	2.42	46.45	5.15	6,194.50	0.03	0.32	1.00	0.25
Area Total	**9.73**	**198.03**	**21.31**	**24,967.37**	**0.13**	**1.30**	**4.09**	**1.00**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

BPA Metropolitan Planning Area
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Hardin	0.34	6.76	0.84	804.35	0.00	0.04	0.14	0.04
Jefferson	1.47	32.33	4.25	3,903.87	0.02	0.19	0.58	0.17
Orange	0.61	14.31	2.40	1,910.00	0.01	0.09	0.26	0.09
Area Total	**1.47**	**32.33**	**4.25**	**3,903.87**	**0.02**	**0.19**	**0.98**	**0.30**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

DFW Metropolitan Planning Area
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Collin	4.07	75.99	6.18	9,991.28	0.06	0.52	1.85	0.38
Dallas	8.33	268.86	22.09	30,930.47	0.18	1.67	5.85	1.22
Denton	3.68	62.48	6.17	8,338.33	0.05	0.43	1.47	0.33
Ellis	1.23	27.14	3.92	3,656.95	0.02	0.18	0.46	0.14
Hood	0.44	6.55	0.92	769.00	0.00	0.04	0.13	0.04
Hunt	0.91	18.51	3.32	2,353.57	0.01	0.11	0.30	0.11
Johnson	1.21	19.94	3.14	2,672.82	0.01	0.13	0.45	0.13
Kaufman	0.88	18.92	2.98	2,702.19	0.01	0.13	0.33	0.11
Parker	0.98	17.47	3.28	2,626.68	0.01	0.13	0.41	0.12
Rockwall	0.54	9.83	1.22	1,363.69	0.01	0.07	0.23	0.06
Tarrant	10.06	185.78	19.75	23,677.38	0.13	1.23	4.48	1.01
Wise	0.69	13.26	2.15	1,627.94	0.01	0.08	0.24	0.07
Area Total	**33.05**	**724.73**	**75.12**	**90,710.28**	**0.50**	**4.72**	**16.21**	**3.71**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

El Paso Metropolitan Planning Area
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso	5.38	80.62	14.10	9,742.71	0.03	0.48	2.10	0.53

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

HGB Metropolitan Planning Area
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Brazoria	1.77	34.35	3.32	4,242.25	0.02	0.22	0.65	0.16
Chambers	0.43	13.26	2.69	2,084.27	0.01	0.09	0.20	0.08
Fort Bend	3.10	53.63	4.84	6,724.30	0.04	0.33	1.36	0.29
Galveston	1.56	29.28	2.35	3,392.30	0.02	0.18	0.62	0.13
Harris	21.74	477.96	41.69	57,396.71	0.35	2.99	11.83	2.48
Liberty	0.61	11.90	1.49	1,351.08	0.01	0.07	0.18	0.05
Montgomery	2.93	55.88	5.70	7,334.85	0.04	0.38	1.31	0.30
Waller	0.45	11.88	1.45	1,296.79	0.01	0.07	0.14	0.05
Area Total	**32.61**	**688.15**	**63.53**	**83,822.55**	**0.50**	**4.33**	**16.31**	**3.55**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

San Antonio Metropolitan Planning Area
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bexar	14.62	296.30	27.70	31,161.92	0.16	1.48	8.42	1.69
Comal	1.75	35.46	4.36	4,053.55	0.02	0.19	1.12	0.24
Guadalupe	1.80	34.97	4.78	3,994.24	0.02	0.17	1.03	0.24
Kendall	0.55	9.24	1.31	1,085.56	0.01	0.05	0.23	0.06
Wilson	0.69	13.29	1.63	1,389.15	0.01	0.06	0.40	0.09
Area Total	**19.42**	**389.25**	**39.79**	**41,684.42**	**0.21**	**1.96**	**11.20**	**2.32**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

TLM Metropolitan Planning Area
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Gregg	0.88	18.59	2.01	2,060.95	0.01	0.10	0.35	0.09
Harrison[2]	0.65	15.00	3.31	2,226.21	0.01	0.09	0.30	0.11
Rusk[2]	0.20	7.37	0.85	768.01	0.00	0.04	0.14	0.04
Smith	1.62	33.31	4.40	3,907.87	0.02	0.19	0.63	0.17
Upshur[2]	0.34	6.37	1.01	772.04	0.00	0.04	0.14	0.04
Area Total	**3.69**	**80.64**	**11.59**	**9,735.09**	**0.05**	**0.47**	**1.55**	**0.44**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

[2] An HPMS-based methodology was used for these counties. A TDM-based methodology was used for Gregg and Smith Counties.

All Other Counties in Texas (VLink)[1]
2020 Summer Season Weekday On-Road Mobile Source Emissions - MOVES3 (Tons/Day).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Anderson	0.37	7.07	0.83	747.26	0.00	0.04	0.13	0.03
Andrews	0.17	4.60	1.17	787.72	0.00	0.03	0.15	0.04
Angelina	0.71	12.72	2.39	1,662.67	0.01	0.07	0.33	0.10
Aransas	0.17	3.57	0.39	396.41	0.00	0.02	0.08	0.02
Archer	0.06	2.16	0.55	336.09	0.00	0.01	0.06	0.02
Armstrong	0.06	1.82	0.58	335.68	0.00	0.01	0.04	0.02
Atascosa	0.38	9.49	1.70	1,324.05	0.01	0.06	0.18	0.06
Austin	0.35	7.70	1.84	1,190.38	0.01	0.05	0.18	0.06
Bailey	0.06	1.17	0.23	157.91	0.00	0.01	0.03	0.01
Bandera	0.17	2.74	0.39	315.83	0.00	0.01	0.05	0.02
Baylor	0.05	1.31	0.35	217.67	0.00	0.01	0.03	0.01
Bee	0.17	3.71	0.52	468.96	0.00	0.02	0.08	0.02
Bell	2.46	49.29	6.93	5,742.37	0.03	0.27	1.00	0.28
Blanco	0.15	3.65	0.57	465.45	0.00	0.02	0.07	0.02
Borden	0.01	0.33	0.08	52.52	0.00	0.00	0.01	0.00
Bosque	0.18	3.37	0.43	368.76	0.00	0.02	0.07	0.02
Bowie	0.85	19.15	3.75	2,630.73	0.01	0.11	0.39	0.13
Brazos	0.61	23.31	2.71	2,410.96	0.01	0.11	0.50	0.12
Brewster	0.09	1.48	0.31	185.48	0.00	0.01	0.04	0.01
Briscoe	0.02	0.43	0.12	60.76	0.00	0.00	0.01	0.00
Brooks	0.07	2.49	0.36	312.32	0.00	0.02	0.04	0.01
Brown	0.31	5.15	0.82	559.49	0.00	0.03	0.10	0.03
Burleson	0.19	4.22	0.76	575.03	0.00	0.03	0.10	0.03
Calhoun	0.20	3.44	0.74	482.65	0.00	0.02	0.10	0.03
Callahan	0.17	4.48	1.57	860.72	0.00	0.03	0.10	0.04
Cameron	2.33	44.89	3.64	4,061.54	0.02	0.21	0.79	0.17
Camp	0.10	1.72	0.29	202.74	0.00	0.01	0.04	0.01
Carson	0.09	3.72	1.10	633.40	0.00	0.03	0.08	0.03
Cass	0.27	5.17	0.88	635.18	0.00	0.03	0.11	0.03
Castro	0.07	1.46	0.33	205.18	0.00	0.01	0.04	0.01
Cherokee	0.36	7.07	0.87	764.18	0.00	0.04	0.13	0.04
Childress	0.11	2.37	0.77	369.34	0.00	0.02	0.05	0.02
Clay	0.15	4.24	1.17	708.27	0.00	0.03	0.11	0.04
Cochran	0.03	0.58	0.13	80.62	0.00	0.00	0.02	0.01
Coke	0.04	0.87	0.18	117.98	0.00	0.01	0.02	0.01
Coleman	0.09	2.04	0.34	245.18	0.00	0.01	0.04	0.01
Collingsworth	0.04	0.65	0.19	90.67	0.00	0.00	0.02	0.01
Colorado	0.33	9.20	2.41	1,511.52	0.01	0.06	0.19	0.08

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Comanche	0.13	2.44	0.41	280.13	0.00	0.01	0.05	0.01
Concho	0.04	1.38	0.26	190.31	0.00	0.01	0.03	0.01
Cooke	0.45	10.38	2.18	1,452.00	0.01	0.06	0.21	0.07
Coryell	0.44	7.80	0.92	819.10	0.00	0.04	0.16	0.04
Cottle	0.02	0.38	0.11	56.94	0.00	0.00	0.01	0.00
Crane	0.05	1.39	0.39	262.42	0.00	0.01	0.04	0.01
Crockett	0.10	3.09	1.24	627.62	0.00	0.02	0.07	0.03
Crosby	0.04	0.87	0.20	123.63	0.00	0.01	0.02	0.01
Culberson	0.08	3.45	1.02	589.08	0.00	0.03	0.06	0.03
Dallam	0.10	2.38	0.76	405.71	0.00	0.02	0.07	0.02
Dawson	0.11	2.66	0.52	374.66	0.00	0.02	0.06	0.02
Deaf Smith	0.19	2.92	0.89	441.51	0.00	0.02	0.09	0.03
Delta	0.05	1.01	0.14	109.95	0.00	0.01	0.02	0.01
DeWitt	0.21	4.12	0.87	576.43	0.00	0.02	0.12	0.04
Dickens	0.03	0.56	0.16	83.41	0.00	0.00	0.02	0.01
Dimmit	0.11	3.09	0.48	368.49	0.00	0.02	0.06	0.02
Donley	0.09	2.74	0.80	424.57	0.00	0.02	0.06	0.02
Duval	0.10	2.05	0.36	259.96	0.00	0.01	0.04	0.01
Eastland	0.28	6.50	2.38	1,196.15	0.00	0.05	0.13	0.06
Ector	1.09	22.32	3.49	2,838.03	0.01	0.13	0.55	0.14
Edwards	0.03	0.57	0.10	70.60	0.00	0.00	0.02	0.00
Erath	0.29	6.39	0.94	781.70	0.00	0.04	0.13	0.04
Falls	0.14	3.71	0.54	466.14	0.00	0.02	0.07	0.02
Fannin	0.34	5.84	0.81	612.97	0.00	0.03	0.12	0.03
Fayette	0.34	8.80	2.11	1,374.31	0.01	0.05	0.21	0.08
Fisher	0.03	0.83	0.20	126.38	0.00	0.01	0.03	0.01
Floyd	0.05	0.80	0.18	110.21	0.00	0.00	0.02	0.01
Foard	0.02	0.29	0.09	41.44	0.00	0.00	0.01	0.00
Franklin	0.16	3.55	1.05	593.78	0.00	0.02	0.07	0.03
Freestone	0.27	7.32	1.83	1,182.51	0.01	0.05	0.14	0.06
Frio	0.11	5.89	1.07	832.49	0.00	0.04	0.10	0.03
Gaines	0.17	3.94	0.83	548.45	0.00	0.03	0.10	0.03
Garza	0.06	2.00	0.42	303.99	0.00	0.01	0.04	0.01
Gillespie	0.23	4.70	0.59	555.59	0.00	0.03	0.09	0.02
Glasscock	0.04	1.40	0.26	191.15	0.00	0.01	0.04	0.01
Goliad	0.07	1.70	0.34	262.36	0.00	0.01	0.05	0.01
Gonzales	0.26	7.15	1.71	1,137.80	0.00	0.04	0.17	0.06
Gray	0.20	3.86	1.21	606.20	0.00	0.02	0.10	0.04
Grayson	1.30	24.65	3.95	2,901.05	0.01	0.13	0.51	0.15
Grimes	0.26	5.49	0.94	722.68	0.00	0.03	0.12	0.04
Hale	0.27	5.44	1.39	817.81	0.00	0.03	0.12	0.04
Hall	0.05	1.34	0.40	209.02	0.00	0.01	0.03	0.01
Hamilton	0.08	1.81	0.25	206.11	0.00	0.01	0.03	0.01
Hansford	0.05	0.89	0.29	140.87	0.00	0.01	0.03	0.01
Hardeman	0.08	2.13	0.69	337.47	0.00	0.01	0.05	0.02

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Hartley	0.08	2.28	0.73	402.02	0.00	0.02	0.07	0.02
Haskell	0.05	1.13	0.27	171.78	0.00	0.01	0.03	0.01
Hemphill	0.04	0.74	0.24	125.55	0.00	0.00	0.02	0.01
Henderson	0.64	11.37	1.27	1,167.16	0.01	0.06	0.21	0.05
Hidalgo	4.68	90.24	7.34	8,023.27	0.04	0.42	1.70	0.36
Hill	0.46	12.18	2.87	1,834.71	0.01	0.08	0.22	0.09
Hockley	0.18	3.50	0.69	459.56	0.00	0.02	0.09	0.03
Hopkins	0.47	10.79	2.57	1,593.17	0.01	0.07	0.20	0.08
Houston	0.18	3.39	0.69	459.10	0.00	0.02	0.09	0.03
Howard	0.28	6.57	1.93	1,112.58	0.00	0.04	0.14	0.05
Hudspeth	0.15	6.46	1.98	1,103.30	0.00	0.05	0.10	0.04
Hutchinson	0.18	2.45	0.70	353.94	0.00	0.01	0.08	0.02
Irion	0.03	0.94	0.18	131.71	0.00	0.01	0.02	0.01
Jack	0.07	1.47	0.24	191.78	0.00	0.01	0.03	0.01
Jackson	0.20	4.95	1.14	735.99	0.00	0.03	0.14	0.05
Jasper	0.24	5.49	0.69	648.12	0.00	0.03	0.11	0.03
Jeff Davis	0.03	0.80	0.22	125.13	0.00	0.01	0.02	0.01
Jim Hogg	0.03	0.63	0.08	71.15	0.00	0.00	0.01	0.00
Jim Wells	0.26	6.19	1.07	876.96	0.00	0.04	0.14	0.04
Jones	0.12	2.37	0.53	348.09	0.00	0.01	0.06	0.02
Karnes	0.18	4.88	0.93	714.81	0.00	0.03	0.15	0.04
Kenedy	0.03	1.53	0.19	201.57	0.00	0.01	0.02	0.01
Kent	0.01	0.23	0.06	35.50	0.00	0.00	0.01	0.00
Kerr	0.41	7.73	1.04	892.75	0.00	0.04	0.13	0.04
Kimble	0.10	3.04	1.22	626.27	0.00	0.02	0.07	0.03
King	0.01	0.44	0.13	71.74	0.00	0.00	0.01	0.00
Kinney	0.03	0.96	0.15	119.78	0.00	0.01	0.02	0.01
Kleberg	0.10	4.31	0.58	548.40	0.00	0.02	0.10	0.03
Knox	0.05	0.94	0.26	134.91	0.00	0.01	0.02	0.01
La Salle	0.20	6.41	2.20	1,163.55	0.00	0.04	0.13	0.06
Lamar	0.48	8.65	1.26	931.06	0.00	0.05	0.17	0.05
Lamb	0.11	2.23	0.45	304.00	0.00	0.01	0.05	0.02
Lampasas	0.21	3.96	0.62	443.67	0.00	0.02	0.08	0.02
Lavaca	0.21	3.75	0.76	498.04	0.00	0.02	0.11	0.03
Lee	0.15	3.39	0.43	417.95	0.00	0.02	0.07	0.02
Leon	0.24	7.17	1.71	1,152.92	0.00	0.05	0.14	0.05
Limestone	0.20	3.94	0.50	427.58	0.00	0.02	0.09	0.02
Lipscomb	0.03	0.58	0.20	95.65	0.00	0.00	0.02	0.01
Live Oak	0.21	7.63	1.97	1,330.31	0.01	0.05	0.15	0.06
Llano	0.19	3.43	0.45	399.76	0.00	0.02	0.08	0.02
Loving	0.05	1.98	0.61	364.55	0.00	0.01	0.11	0.03
Lubbock	1.93	35.26	5.35	4,046.07	0.02	0.20	0.84	0.21
Lynn	0.06	1.84	0.42	285.75	0.00	0.01	0.04	0.01
Madison	0.12	4.59	1.08	758.36	0.00	0.03	0.09	0.04
Marion	0.23	2.22	0.33	214.80	0.00	0.01	0.04	0.01

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Martin	0.32	4.98	1.43	871.84	0.00	0.03	0.13	0.04
Mason	0.06	1.08	0.15	130.12	0.00	0.01	0.02	0.01
Matagorda	1.34	9.07	1.54	837.41	0.00	0.03	0.19	0.06
Maverick	0.11	5.59	0.70	620.41	0.00	0.03	0.11	0.03
McCulloch	0.10	1.73	0.30	195.97	0.00	0.01	0.03	0.01
McLennan	0.75	36.80	5.60	4,924.73	0.02	0.23	0.82	0.23
McMullen	0.05	1.18	0.22	164.72	0.00	0.01	0.03	0.01
Medina	0.18	7.58	1.05	881.13	0.00	0.04	0.14	0.04
Menard	0.03	0.76	0.15	102.95	0.00	0.00	0.02	0.01
Midland	1.22	26.51	4.56	3,548.98	0.02	0.16	0.66	0.17
Milam	0.23	4.51	0.76	569.58	0.00	0.03	0.10	0.03
Mills	0.06	1.24	0.21	147.37	0.00	0.01	0.02	0.01
Mitchell	0.10	3.20	1.14	636.99	0.00	0.02	0.06	0.03
Montague	0.22	4.52	1.13	668.48	0.00	0.03	0.12	0.04
Moore	0.21	3.48	1.09	545.85	0.00	0.02	0.10	0.03
Morris	0.13	2.86	0.68	449.31	0.00	0.02	0.06	0.02
Motley	0.02	0.30	0.09	44.83	0.00	0.00	0.01	0.00
Nacogdoches	0.51	9.70	1.89	1,295.93	0.01	0.06	0.25	0.08
Navarro	0.41	10.97	1.55	1,396.30	0.01	0.07	0.16	0.05
Newton	0.10	2.10	0.29	256.16	0.00	0.01	0.05	0.01
Nolan	0.19	5.21	1.86	986.60	0.00	0.04	0.11	0.05
Nueces	2.01	48.85	4.30	5,166.21	0.03	0.26	0.87	0.21
Ochiltree	0.09	1.71	0.56	271.00	0.00	0.01	0.06	0.02
Oldham	0.09	3.87	1.20	682.16	0.00	0.03	0.07	0.03
Palo Pinto	0.23	5.43	0.92	691.76	0.00	0.03	0.10	0.03
Panola	0.25	5.44	0.97	684.03	0.00	0.03	0.12	0.04
Parmer	0.10	2.11	0.47	302.69	0.00	0.01	0.05	0.02
Pecos	0.21	6.04	2.22	1,182.43	0.00	0.05	0.15	0.06
Polk	0.48	9.33	1.86	1,272.64	0.01	0.06	0.21	0.07
Potter	1.08	19.57	5.90	2,878.31	0.01	0.12	0.62	0.20
Presidio	0.06	0.99	0.21	128.06	0.00	0.01	0.02	0.01
Rains	0.11	2.02	0.28	216.75	0.00	0.01	0.04	0.01
Randall	1.15	16.22	4.38	2,215.78	0.01	0.08	0.53	0.16
Reagan	0.04	1.23	0.25	164.91	0.00	0.01	0.04	0.01
Real	0.03	0.59	0.11	72.73	0.00	0.00	0.02	0.00
Red River	0.13	2.51	0.34	275.32	0.00	0.01	0.05	0.01
Reeves	0.24	8.16	2.63	1,567.80	0.01	0.06	0.22	0.08
Refugio	0.10	3.49	0.72	565.43	0.00	0.02	0.09	0.03
Roberts	0.02	0.42	0.14	74.58	0.00	0.00	0.01	0.00
Robertson	0.17	4.17	0.77	584.83	0.00	0.03	0.09	0.03
Runnels	0.11	2.21	0.40	280.17	0.00	0.01	0.05	0.01
Sabine	0.10	1.69	0.31	217.10	0.00	0.01	0.04	0.01
San Augustine	0.09	1.72	0.33	232.54	0.00	0.01	0.04	0.01
San Jacinto	0.24	4.54	0.86	612.20	0.00	0.03	0.11	0.03
San Patricio	0.51	12.84	1.97	1,712.16	0.01	0.08	0.26	0.08

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
San Saba	0.07	1.25	0.21	139.22	0.00	0.01	0.03	0.01
Schleicher	0.03	0.71	0.13	91.31	0.00	0.00	0.01	0.00
Scurry	0.07	2.86	0.54	380.61	0.00	0.02	0.07	0.02
Shackelford	0.03	0.69	0.17	104.59	0.00	0.00	0.02	0.01
Shelby	0.23	4.23	0.81	564.60	0.00	0.02	0.10	0.03
Sherman	0.05	1.46	0.48	260.09	0.00	0.01	0.04	0.01
Somervell	0.08	1.46	0.23	185.10	0.00	0.01	0.04	0.01
Starr	0.36	6.08	0.52	552.92	0.00	0.03	0.10	0.02
Stephens	0.08	1.38	0.23	152.96	0.00	0.01	0.03	0.01
Sterling	0.03	0.94	0.18	131.65	0.00	0.01	0.02	0.01
Stonewall	0.01	0.32	0.08	50.06	0.00	0.00	0.01	0.00
Sutton	0.09	2.97	1.20	632.35	0.00	0.02	0.06	0.03
Swisher	0.09	2.24	0.77	401.22	0.00	0.02	0.06	0.02
Taylor	1.00	17.93	3.92	2,470.39	0.01	0.10	0.42	0.13
Terrell	0.01	0.28	0.08	52.01	0.00	0.00	0.01	0.00
Terry	0.10	2.56	0.53	362.23	0.00	0.02	0.06	0.02
Throckmorton	0.02	0.39	0.11	63.89	0.00	0.00	0.01	0.00
Titus	0.32	7.58	1.50	1,082.50	0.00	0.05	0.14	0.05
Tom Green	0.83	14.13	1.95	1,509.11	0.01	0.07	0.32	0.08
Trinity	0.12	2.08	0.40	278.86	0.00	0.01	0.05	0.02
Tyler	0.12	2.59	0.34	311.53	0.00	0.01	0.05	0.01
Upton	0.05	1.51	0.44	284.39	0.00	0.01	0.06	0.02
Uvalde	0.20	4.15	0.52	471.56	0.00	0.02	0.08	0.02
Val Verde	0.35	5.00	0.55	453.29	0.00	0.02	0.08	0.02
Van Zandt	0.57	13.22	2.95	1,979.65	0.01	0.08	0.26	0.10
Victoria	0.86	15.96	4.19	2,448.45	0.01	0.09	0.60	0.18
Walker	0.50	12.32	2.49	1,739.81	0.01	0.08	0.24	0.08
Ward	0.19	5.98	1.95	1,141.74	0.00	0.04	0.15	0.06
Washington	0.33	7.07	1.07	869.77	0.00	0.04	0.14	0.04
Webb	1.74	34.40	4.73	3,487.67	0.02	0.16	0.67	0.18
Wharton	0.45	9.30	2.12	1,359.85	0.01	0.05	0.28	0.09
Wheeler	0.10	3.18	0.77	420.61	0.00	0.02	0.06	0.02
Wichita	0.91	16.84	2.42	1,826.05	0.01	0.09	0.30	0.09
Wilbarger	0.13	3.41	0.82	526.51	0.00	0.02	0.08	0.03
Willacy	0.12	2.57	0.32	281.00	0.00	0.01	0.05	0.01
Winkler	0.10	3.25	0.86	579.33	0.00	0.02	0.12	0.03
Wood	0.38	6.41	0.79	669.72	0.00	0.03	0.13	0.03
Yoakum	0.07	1.52	0.34	213.40	0.00	0.01	0.05	0.01
Young	0.16	2.57	0.56	348.87	0.00	0.01	0.07	0.02
Zapata	0.08	1.65	0.16	157.83	0.00	0.01	0.02	0.01
Zavala	0.09	2.20	0.34	258.46	0.00	0.01	0.04	0.01
All Counties[1]	**59.62**	**1,284.99**	**231.78**	**165,624.09**	**0.75**	**7.37**	**28.19**	**8.44**

[1] This table includes all Texas counties outside the areas comprised of the 39 counties of the Austin, BPA, DFW, El Paso, HGB, San Antonio, and TLM metropolitan planning areas. An HPMS-based methodology was used for these counties.

[2] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

APPENDIX M: ANNUAL ON-ROAD MOBILE SOURCE EMISSIONS

Texas
2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
All Texas Counties	53,152.58	979,311.65	170,440.80	140,462,261.87	742.06	7,120.47	15,099.72	5,327.57

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

AUS Metropolitan Planning Area
2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bastrop	222.62	3,944.85	577.33	474,181.37	2.55	26.51	45.54	17.04
Burnet	153.47	2,947.35	472.03	368,292.91	1.92	19.64	39.07	14.08
Caldwell	110.32	2,204.90	321.44	253,633.91	1.35	14.12	22.33	9.01
Hays	385.84	7,386.03	1,012.14	987,821.90	5.39	54.77	89.26	31.43
Travis	1,458.56	27,817.57	3,614.59	4,195,652.05	23.21	228.39	423.10	131.40
Williamson	773.87	13,675.16	1,908.97	2,078,581.06	11.42	110.96	205.60	67.08
Area Total	**3,104.69**	**57,975.85**	**7,906.50**	**8,358,163.20**	**45.83**	**454.39**	**824.91**	**270.04**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

BPA Metropolitan Planning Area
2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Hardin	108.48	1,989.27	330.42	278,218.06	1.43	13.76	28.50	10.70
Jefferson	475.87	9,408.69	1,680.32	1,352,225.16	6.81	66.18	128.41	50.70
Orange	201.73	4,163.84	952.78	663,760.39	3.22	31.74	59.06	27.06
Area Total	**786.07**	**15,561.80**	**2,963.52**	**2,294,203.61**	**11.46**	**111.69**	**215.97**	**88.46**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

DFW Metropolitan Planning Area
2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Collin	1,253.66	21,206.64	2,320.59	3,236,765.98	19.63	176.79	352.56	95.93
Dallas	4,126.14	75,814.90	8,668.24	10,595,637.79	63.93	607.46	1,099.99	315.46
Denton	1,136.00	17,990.66	2,329.53	2,732,474.58	16.22	146.91	282.07	84.96
Ellis	395.49	7,696.74	1,536.35	1,219,592.25	6.27	63.10	97.89	42.47
Hood	137.66	1,951.60	345.05	254,958.67	1.32	12.34	26.80	10.34
Hunt	287.42	5,168.04	1,249.31	770,788.12	3.67	35.53	66.58	32.11
Johnson	385.53	5,953.71	1,195.22	884,122.42	4.53	43.99	89.21	35.72
Kaufman	282.02	5,449.53	1,187.94	906,833.07	4.61	46.48	70.68	32.21
Parker	320.10	5,292.23	1,254.63	875,853.54	4.45	43.74	82.94	35.32
Rockwall	170.80	2,816.85	479.88	450,726.39	2.42	23.34	44.88	15.77
Tarrant	3,119.09	52,695.00	7,197.48	7,637,348.26	45.16	415.09	847.73	257.51
Wise	227.54	3,986.24	847.43	547,126.26	2.78	28.42	51.57	22.82
Area Total	**11,841.45**	**206,022.14**	**28,611.65**	**30,112,227.30**	**174.99**	**1,643.19**	**3,112.91**	**980.63**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

El Paso Metropolitan Planning Area
2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
El Paso	1,795.33	27,551.73	5,804.70	3,762,522.57	17.30	194.93	474.81	166.25

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

HGB Metropolitan Planning Area
2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Brazoria	555.56	9,723.67	1,262.37	1,406,325.86	7.69	76.10	132.44	43.49
Chambers	142.11	3,606.52	1,051.39	713,408.76	3.32	31.41	49.44	27.17
Fort Bend	948.07	14,817.01	1,733.34	2,151,546.75	11.96	112.62	251.41	70.94
Galveston	487.72	8,237.29	884.78	1,119,903.47	6.29	61.28	121.72	34.77
Harris	6,755.61	130,766.91	15,248.50	18,520,384.63	103.74	1,021.22	2,139.41	598.19
Liberty	200.85	3,603.90	587.80	470,538.34	2.44	24.91	40.59	16.76
Montgomery	919.90	15,832.28	2,146.50	2,407,859.32	13.23	129.94	249.76	77.70
Waller	148.32	3,359.84	568.10	434,512.02	2.26	24.54	31.76	14.83
Area Total	**10,158.13**	**189,947.43**	**23,482.79**	**27,224,479.14**	**150.92**	**1,482.01**	**3,016.53**	**883.86**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

San Antonio Metropolitan Planning Area 2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Bexar	3,546.05	64,251.41	7,703.01	7,772,692.56	43.21	400.58	1,070.12	297.25
Comal	433.31	7,855.27	1,234.41	1,026,655.66	5.52	51.06	138.08	42.88
Guadalupe	348.85	6,033.00	1,055.02	796,573.93	4.13	38.05	96.71	34.10
Kendall	120.34	1,858.35	339.19	250,079.11	1.27	12.09	28.11	10.34
Wilson	125.62	2,148.33	337.14	258,299.28	1.36	12.56	32.85	11.11
Area Total	**4,574.18**	**82,146.36**	**10,668.77**	**10,104,300.53**	**55.49**	**514.34**	**1,365.87**	**395.68**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.

TLM Metropolitan Planning Area 2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[1]	$PM_{2.5}$[1]
Gregg	286.49	5,347.16	770.64	676,396.61	3.63	35.53	70.79	24.27
Harrison[2]	208.42	4,172.70	1,226.32	716,608.45	3.28	30.77	64.57	31.92
Rusk[2]	125.31	2,186.42	346.02	267,574.13	1.41	14.18	27.59	10.40
Smith	518.60	9,584.71	1,643.88	1,273,922.49	6.63	65.01	128.92	48.45
Upshur[2]	109.09	1,853.31	380.06	250,154.75	1.25	12.11	27.09	11.12
Area Total	**1,247.91**	**23,144.29**	**4,366.92**	**3,184,656.43**	**16.20**	**157.60**	**318.96**	**126.16**

[1] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.
[2] An HPMS-based methodology was used for these counties. A TDM-based methodology was used for Gregg and Smith Counties.

All Other Counties in Texas (VLink)[1] 2020 Annual On-Road Mobile Source Emissions - MOVES3 (Tons/Year).

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Anderson	119.23	2,075.11	317.10	246,049.35	1.31	13.20	26.05	9.64
Andrews	54.72	1,238.76	396.09	247,175.17	1.16	10.42	27.49	11.00
Angelina	229.50	3,758.52	938.79	574,623.59	2.75	24.77	71.34	29.21
Aransas	52.88	966.65	137.64	123,793.44	0.65	5.85	15.02	4.95
Archer	31.98	602.53	217.14	113,460.97	0.50	4.37	13.16	5.98
Armstrong	19.55	508.70	210.31	109,590.81	0.48	4.61	9.95	5.10
Atascosa	122.40	2,804.02	652.67	445,198.97	2.17	20.60	37.90	17.58
Austin	115.06	2,312.30	709.40	414,110.18	1.87	16.87	39.20	19.79
Bailey	19.54	359.55	85.76	53,868.61	0.26	2.57	5.70	2.33
Bandera	53.01	787.73	144.33	104,387.54	0.52	5.06	10.42	4.19
Baylor	16.74	357.10	133.64	70,769.50	0.31	2.83	6.88	3.42
Bee	51.60	1,004.85	184.36	147,264.85	0.74	6.71	15.39	5.94
Bell	758.13	13,648.69	2,511.03	1,862,618.77	9.45	90.17	196.57	75.29
Blanco	51.09	1,102.94	220.55	160,053.21	0.82	8.41	14.18	5.98
Borden	3.63	96.77	29.79	17,613.00	0.08	0.77	2.00	0.83
Bosque	56.15	989.33	160.83	122,000.64	0.64	6.33	12.05	4.77
Bowie	268.82	5,238.27	1,378.91	840,097.36	3.95	37.77	80.46	37.09
Brazos	355.13	6,838.02	1,088.68	886,512.75	4.62	43.41	102.97	35.53

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Brewster	29.61	488.00	118.78	66,269.64	0.32	3.12	7.87	3.17
Briscoe	7.39	122.39	42.65	19,880.56	0.09	0.79	2.61	1.18
Brooks	28.16	853.93	149.35	113,223.64	0.59	6.26	9.68	4.10
Brown	102.59	1,630.59	320.01	197,233.97	0.99	9.92	22.23	8.87
Burleson	63.49	1,330.65	310.80	205,759.12	1.00	9.39	21.41	9.21
Calhoun	62.56	1,046.82	284.79	168,779.14	0.79	6.76	21.15	9.02
Callahan	59.69	1,409.26	601.33	296,923.45	1.26	11.47	23.36	13.56
Cameron	758.00	13,932.80	1,365.93	1,402,854.94	7.84	78.08	158.10	46.33
Camp	31.83	493.25	105.60	65,324.31	0.32	3.06	7.04	2.99
Carson	39.97	1,082.31	417.29	215,888.90	0.95	9.05	17.63	9.64
Cass	85.61	1,496.30	328.66	205,761.89	1.02	10.19	21.73	9.36
Castro	23.97	441.78	116.98	69,064.21	0.33	3.14	7.70	3.20
Cherokee	115.90	2,047.86	328.72	250,048.17	1.32	13.32	25.28	9.76
Childress	34.92	675.02	281.67	123,701.01	0.55	5.59	12.35	6.73
Clay	50.96	1,150.18	438.85	228,401.02	1.00	9.25	22.51	11.23
Cochran	9.18	173.50	46.97	26,804.84	0.13	1.17	3.49	1.36
Coke	12.42	261.99	64.20	39,725.71	0.20	1.98	3.80	1.70
Coleman	31.14	639.37	133.94	85,922.31	0.42	4.37	8.18	3.55
Collingsworth	12.24	187.31	66.97	29,722.19	0.13	1.21	3.88	1.81
Colorado	113.93	2,779.99	942.58	527,727.16	2.34	21.64	45.42	25.05
Comanche	42.46	764.19	157.25	97,735.16	0.48	4.87	10.10	4.25
Concho	15.66	418.24	99.25	65,009.73	0.32	3.25	6.10	2.64
Cooke	142.04	2,822.48	806.84	465,145.01	2.16	20.57	43.56	21.03
Coryell	135.69	2,209.14	330.25	267,014.32	1.42	13.60	30.54	10.67
Cottle	5.61	107.71	38.76	18,763.88	0.08	0.77	2.22	1.04
Crane	14.23	368.00	131.98	82,163.62	0.37	3.33	7.79	3.45
Crockett	35.48	941.01	467.12	215,001.10	0.89	7.94	17.17	10.48
Crosby	15.13	267.12	72.90	42,091.39	0.20	2.01	4.12	1.87
Culberson	34.01	1,207.17	404.33	213,927.14	0.96	9.54	15.59	8.72
Dallam	32.78	681.75	272.83	132,755.29	0.59	5.35	15.20	7.05
Dawson	36.77	804.24	193.80	127,508.49	0.63	6.18	12.85	5.24
Deaf Smith	60.06	868.00	316.67	144,298.46	0.64	5.74	17.90	8.26
Delta	16.50	290.18	51.73	36,334.66	0.19	1.90	3.43	1.47
DeWitt	67.59	1,251.20	333.73	201,383.33	0.94	8.23	24.63	10.52
Dickens	8.56	162.35	56.17	27,879.41	0.12	1.17	3.09	1.48
Dimmit	35.59	906.75	183.65	123,029.90	0.61	5.98	12.76	5.18
Donley	30.03	775.97	290.60	142,286.59	0.64	6.50	13.05	6.97
Duval	30.28	606.97	133.26	85,683.36	0.42	4.07	8.56	3.63
Eastland	98.10	2,097.98	942.33	422,937.26	1.77	16.52	33.37	20.82
Ector	344.59	6,144.15	1,193.28	893,002.77	4.55	41.81	102.80	34.74
Edwards	8.65	171.03	37.95	23,788.89	0.12	1.11	2.83	1.10
Erath	97.53	1,899.04	368.38	263,415.10	1.32	12.88	26.24	10.39
Falls	47.08	1,081.63	204.51	154,641.28	0.79	7.80	14.48	5.95
Fannin	106.63	1,669.99	300.22	200,037.57	1.03	10.00	22.85	9.08
Fayette	115.44	2,689.41	828.72	482,430.10	2.19	19.80	46.72	23.30
Fisher	11.52	248.23	72.56	42,630.63	0.20	1.85	4.84	2.02
Floyd	14.92	245.43	63.15	37,008.39	0.18	1.68	4.13	1.73
Foard	4.90	81.56	29.25	13,483.53	0.06	0.54	1.76	0.80

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Franklin	50.76	964.33	398.24	195,550.57	0.84	7.66	16.62	9.80
Freestone	94.23	2,332.45	757.09	425,487.82	1.92	18.05	34.68	19.18
Frio	56.79	1,771.36	439.86	293,861.56	1.38	13.57	21.66	10.87
Gaines	60.07	1,213.00	309.29	187,551.79	0.92	8.86	20.34	8.35
Garza	21.88	604.51	159.77	104,314.27	0.51	5.17	8.97	4.02
Gillespie	75.81	1,431.95	229.11	191,496.92	0.99	9.83	18.57	6.88
Glasscock	13.92	430.17	99.92	65,483.84	0.32	3.16	7.11	2.82
Goliad	20.93	466.52	120.50	82,687.74	0.39	3.42	8.71	3.77
Gonzales	88.16	2,176.06	672.03	399,538.41	1.80	16.12	37.59	18.86
Gray	65.53	1,138.37	434.52	198,476.98	0.87	8.25	20.25	10.41
Grayson	403.25	6,793.15	1,450.95	939,209.17	4.65	44.74	101.28	42.40
Grimes	86.90	1,734.14	380.87	258,869.36	1.27	11.98	26.57	11.30
Hale	90.67	1,667.40	518.18	279,142.88	1.28	12.06	26.24	12.58
Hall	17.67	381.82	144.70	69,957.16	0.31	3.05	7.14	3.62
Hamilton	26.04	538.12	96.65	69,090.00	0.35	3.68	6.38	2.66
Hansford	16.43	257.40	96.77	45,211.23	0.20	1.71	5.82	2.62
Hardeman	28.02	604.25	249.77	113,009.65	0.50	5.08	11.24	6.01
Hartley	28.46	653.67	262.57	131,619.96	0.58	5.29	14.31	6.74
Haskell	15.98	342.29	100.87	58,814.52	0.28	2.64	6.03	2.67
Hemphill	11.76	216.41	86.65	40,937.09	0.18	1.64	4.60	2.21
Henderson	203.32	3,310.05	478.76	381,936.24	2.04	20.29	40.71	14.78
Hidalgo	1,540.59	28,340.27	2,805.99	2,789,244.38	15.65	153.35	340.37	97.11
Hill	156.72	3,613.16	1,102.61	614,802.47	2.86	28.41	50.41	27.46
Hockley	61.34	1,073.60	251.94	156,198.08	0.77	7.31	17.95	7.06
Hopkins	151.12	2,951.45	973.55	524,502.71	2.35	22.12	45.58	24.67
Houston	58.34	1,028.24	274.43	159,646.22	0.76	7.01	18.63	8.19
Howard	93.73	2,014.18	734.33	381,905.99	1.69	15.67	33.36	17.30
Hudspeth	61.89	2,263.13	786.11	402,685.72	1.80	18.07	25.94	15.88
Hutchinson	56.90	739.57	245.39	115,548.95	0.52	4.40	15.70	6.82
Irion	11.12	295.95	69.90	45,344.28	0.22	2.19	4.85	1.97
Jack	21.94	436.66	95.94	64,667.22	0.32	3.08	6.37	2.66
Jackson	67.71	1,480.72	444.39	256,783.52	1.19	10.85	30.49	13.61
Jasper	81.09	1,638.49	272.88	224,826.68	1.18	11.47	22.43	8.60
Jeff Davis	10.70	272.25	85.24	45,027.05	0.21	2.00	3.93	1.97
Jim Hogg	9.83	211.08	32.11	25,379.79	0.13	1.33	2.53	0.95
Jim Wells	82.70	1,735.74	379.82	276,456.16	1.35	12.48	28.01	11.28
Jones	39.66	720.06	197.31	118,589.43	0.56	5.29	12.13	5.29
Karnes	55.89	1,351.75	327.92	226,544.37	1.09	9.43	26.05	10.57
Kenedy	11.78	545.71	86.54	74,555.08	0.39	4.20	5.47	2.34
Kent	3.11	72.15	20.89	12,208.63	0.06	0.53	1.40	0.58
Kerr	129.82	2,263.23	396.84	299,015.53	1.51	14.77	27.62	11.04
Kimble	35.65	930.27	458.33	214,987.76	0.89	7.90	16.24	10.19
King	4.31	122.08	46.00	23,913.07	0.11	1.03	2.37	1.18
Kinney	10.89	280.58	57.81	40,117.29	0.20	1.97	3.45	1.54
Kleberg	56.76	1,200.97	218.75	180,268.16	0.91	8.46	18.48	6.85
Knox	15.72	272.68	95.11	45,225.94	0.20	1.91	5.05	2.45
La Salle	71.35	1,991.27	843.88	392,207.26	1.64	15.35	31.56	19.30
Lamar	149.94	2,448.51	469.74	305,188.19	1.56	15.56	34.50	13.93
Lamb	37.14	682.17	165.66	103,433.94	0.51	4.94	10.81	4.48

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Lampasas	69.90	1,211.95	236.93	153,663.41	0.77	7.69	17.16	6.71
Lavaca	68.82	1,153.41	290.07	173,466.59	0.82	7.08	21.94	9.23
Lee	49.49	1,058.18	171.20	145,597.31	0.78	7.50	14.31	5.28
Leon	87.25	2,290.65	709.49	415,925.99	1.89	17.77	33.01	18.04
Limestone	62.13	1,150.44	185.60	141,113.18	0.75	7.19	16.06	5.87
Lipscomb	9.06	163.96	66.37	30,614.93	0.13	1.16	4.11	1.80
Live Oak	69.43	2,138.56	710.35	423,268.76	1.89	17.48	32.71	18.64
Llano	60.58	1,021.51	168.17	135,212.11	0.70	6.65	15.11	5.36
Loving	14.36	503.20	195.88	111,006.11	0.51	4.01	17.38	6.09
Lubbock	642.49	10,667.48	1,938.50	1,359,006.47	7.03	69.19	167.05	57.44
Lynn	22.60	553.94	158.08	97,472.71	0.46	4.59	8.74	3.99
Madison	45.03	1,468.50	453.60	274,242.75	1.25	11.76	21.68	11.65
Marion	68.61	672.18	118.28	69,437.76	0.35	3.17	7.34	3.31
Martin	97.02	1,381.33	486.42	273,551.42	1.22	10.43	25.31	12.22
Mason	19.47	336.79	57.85	44,895.16	0.23	2.26	4.29	1.69
Matagorda	401.47	2,907.42	568.01	291,492.68	1.38	10.53	39.15	17.30
Maverick	45.77	1,753.27	294.83	215,528.38	1.12	11.30	23.73	8.61
McCulloch	33.03	541.74	114.00	68,337.54	0.34	3.47	7.05	3.03
McLennan	256.97	10,217.35	2,102.98	1,617,541.41	8.12	79.10	160.68	62.32
McMullen	16.53	361.66	83.72	55,334.03	0.28	2.72	5.78	2.36
Medina	118.52	2,216.96	419.79	310,491.22	1.55	15.22	28.20	11.68
Menard	9.91	229.17	52.89	34,725.20	0.17	1.70	3.45	1.46
Midland	385.38	7,218.02	1,542.24	1,110,576.18	5.58	52.10	121.86	43.44
Milam	77.91	1,431.19	312.40	204,946.51	1.01	9.67	21.22	9.10
Mills	19.31	392.21	82.09	51,830.94	0.26	2.62	5.13	2.19
Mitchell	35.51	1,003.34	438.97	220,110.99	0.93	8.35	15.91	9.65
Montague	71.39	1,249.22	420.30	215,415.65	0.96	8.78	23.72	11.10
Moore	68.81	1,021.94	386.10	178,079.72	0.79	7.18	20.79	9.90
Morris	41.35	788.52	252.84	144,269.25	0.65	5.98	12.21	6.48
Motley	5.04	89.25	30.74	14,869.26	0.07	0.61	1.76	0.83
Nacogdoches	167.45	2,857.57	745.95	447,320.54	2.13	19.53	53.84	22.74
Navarro	133.99	3,176.07	632.69	475,288.88	2.41	24.14	35.99	16.57
Newton	31.60	618.21	111.48	87,611.25	0.45	4.26	9.50	3.63
Nolan	67.09	1,598.42	711.73	338,489.23	1.44	13.52	27.23	15.91
Nueces	608.46	12,834.51	1,471.07	1,584,791.76	8.67	83.98	158.00	50.79
Ochiltree	30.29	495.71	194.89	87,446.77	0.39	3.40	11.87	5.25
Oldham	34.07	1,149.35	444.24	226,134.43	0.99	9.68	16.01	9.63
Palo Pinto	77.61	1,615.96	358.56	232,394.54	1.14	11.60	20.39	9.23
Panola	82.00	1,591.49	369.41	223,956.61	1.11	11.22	23.84	10.37
Parmer	32.90	639.99	173.64	102,929.23	0.50	4.90	10.05	4.48
Pecos	69.42	1,661.05	775.88	376,816.98	1.64	15.04	32.22	17.60
Polk	158.39	2,785.52	741.27	441,247.66	2.10	19.85	47.39	21.47
Potter	347.54	5,598.90	2,070.33	927,215.71	4.16	38.92	123.64	54.29
Presidio	21.02	332.60	83.97	46,257.27	0.22	2.20	4.53	2.08
Rains	35.82	584.06	106.87	71,442.03	0.37	3.68	7.32	3.09
Randall	360.90	4,760.68	1,525.22	715,186.47	3.22	27.60	103.00	42.83
Reagan	14.52	374.24	92.80	55,910.81	0.28	2.64	6.77	2.66
Real	10.23	173.42	37.76	24,121.84	0.12	1.14	2.68	1.08

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Red River	39.92	724.42	130.95	90,859.92	0.47	4.72	8.97	3.77
Reeves	78.25	2,228.10	909.16	498,705.84	2.22	19.98	44.99	21.90
Refugio	33.48	951.67	257.02	178,684.56	0.84	7.63	17.02	7.74
Roberts	5.20	115.86	48.67	23,963.21	0.10	0.96	2.66	1.26
Robertson	57.13	1,308.37	317.33	209,707.26	1.02	9.85	20.01	9.05
Runnels	34.57	654.85	144.95	94,102.75	0.47	4.60	9.34	3.94
Sabine	32.18	516.68	125.14	75,463.39	0.36	3.28	8.54	3.73
San Augustine	28.28	519.73	132.42	80,780.35	0.38	3.58	8.64	3.88
San Jacinto	78.54	1,378.58	343.41	212,877.67	1.01	9.37	22.78	10.16
San Patricio	154.76	3,419.66	687.04	532,013.72	2.62	24.27	49.02	20.65
San Saba	23.31	394.68	80.73	48,544.26	0.24	2.37	5.40	2.22
Schleicher	10.59	217.68	47.29	31,263.72	0.16	1.55	2.91	1.26
Scurry	43.69	883.49	215.67	137,313.13	0.67	6.34	14.54	5.90
Shackelford	11.13	211.64	60.58	35,450.37	0.17	1.57	3.70	1.63
Shelby	75.57	1,296.17	327.83	197,251.27	0.94	8.66	22.11	9.73
Sherman	17.81	416.30	174.77	85,194.33	0.37	3.50	8.85	4.35
Somervell	24.81	426.51	88.08	61,281.82	0.31	2.85	6.68	2.65
Starr	121.91	2,057.70	219.42	202,403.27	1.13	11.15	22.07	6.94
Stephens	26.85	437.18	86.36	53,545.48	0.27	2.66	5.99	2.41
Sterling	9.93	284.88	69.91	45,152.24	0.22	2.33	3.84	1.77
Stonewall	4.49	98.74	28.85	17,091.46	0.08	0.76	1.78	0.78
Sutton	32.64	912.43	455.79	217,764.90	0.89	7.74	15.69	10.06
Swisher	29.81	679.00	287.75	137,106.43	0.59	5.44	12.16	6.59
Taylor	323.95	5,325.20	1,454.55	834,464.60	3.90	36.09	88.99	37.81
Terrell	3.11	74.62	27.60	16,393.28	0.08	0.71	1.44	0.68
Terry	35.71	773.71	195.46	123,199.63	0.60	6.03	12.47	5.19
Throckmorton	5.80	107.30	40.50	20,375.42	0.09	0.77	2.39	1.11
Titus	102.36	2,111.72	561.46	349,030.25	1.63	15.54	30.38	14.75
Tom Green	265.46	4,118.58	692.95	499,818.86	2.58	24.92	60.94	21.10
Trinity	39.31	639.75	161.28	96,964.50	0.46	4.13	11.52	4.97
Tyler	39.61	765.68	134.17	107,314.03	0.56	5.33	10.59	4.20
Upton	14.65	398.98	144.66	88,459.18	0.41	3.49	10.28	4.11
Uvalde	64.23	1,210.01	200.15	158,052.47	0.81	8.00	16.51	6.04
Val Verde	107.47	1,470.31	208.53	151,378.02	0.79	7.68	16.87	6.10
Van Zandt	186.19	3,712.86	1,116.24	645,405.79	2.95	27.69	55.97	28.76
Victoria	276.52	4,715.94	1,598.17	848,670.34	3.82	31.20	127.39	52.13
Walker	165.86	3,694.51	992.91	612,934.23	2.90	27.84	55.40	26.75
Ward	60.47	1,647.05	677.01	363,622.93	1.60	14.36	31.23	15.88
Washington	109.80	2,174.03	428.37	309,021.16	1.56	14.93	31.51	12.77
Webb	542.49	9,671.19	1,736.52	1,138,955.49	5.72	55.28	132.91	49.30
Wharton	147.55	2,800.62	821.69	475,199.09	2.20	19.36	58.97	25.64
Wheeler	34.97	936.50	279.68	140,584.89	0.65	6.96	11.79	6.46
Wichita	281.56	4,557.25	882.65	576,645.85	2.86	29.05	57.61	23.61
Wilbarger	42.91	914.87	307.18	169,073.07	0.76	7.19	16.22	7.88
Willacy	39.92	842.24	127.72	99,663.39	0.52	5.09	9.34	3.62
Winkler	32.88	870.08	289.19	181,680.04	0.85	7.27	22.43	8.48
Wood	121.06	1,851.86	293.79	217,100.04	1.14	11.00	24.79	9.19

County	VOC	CO	NO_X	CO_2	SO_2	NH_3	PM_{10}[2]	$PM_{2.5}$[2]
Yoakum	23.97	456.61	122.23	71,505.93	0.34	3.20	8.49	3.43
Young	48.66	721.13	205.30	111,771.26	0.51	4.54	12.99	5.70
Zapata	28.48	550.60	69.91	58,232.15	0.31	3.20	5.39	2.02
Zavala	28.04	620.20	123.99	85,034.94	0.42	4.18	8.24	3.44
All Counties[1]	**19,629.20**	**376,626.24**	**86,620.46**	**55,414,770.02**	**269.83**	**2,561.53**	**5,769.20**	**2,416.10**

[1] This table includes all Texas counties outside the areas comprised of the 39 counties of the Austin, BPA, DFW, El Paso, HGB, San Antonio, and TLM metropolitan planning areas. An HPMS-based methodology was used for these counties.

[2] PM emissions are total, direct vehicle emissions (exhaust, brakewear, tirewear). No re-suspended dust from roadways was included.