



# **Possible Use of the Motor Vehicle Emission Simulator (MOVES) Model for the Dallas-Fort Worth (DFW) Area Attainment Demonstration State Implementation Plan (SIP)**

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Chris Kite  
Air Modeling and Data Analysis Section  
Air Quality Division

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# Presentation Overview

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- U.S. Environmental Protection Agency (EPA) on-road emission models since 1978
- Emission inventory development basics
- Macro-level versus "SIP-quality" on-road emissions inventory development
- Nine-county DFW area on-road emission estimates based on different model versions and levels of effort
- 2006/2012 DFW area on-road inventory estimates based on MOVES2010a by county, emission process, and day type
- Uncertainty in emission estimates
- EPA MOVES policy guidance excerpts
- Options for including MOVES in the DFW area attainment demonstration SIP
- MOVES run times for 2,891 non-Texas U.S. counties
- MOVES references in the attainment demonstration SIP proposal
- Differences in 2006/2012 summer weekday vehicle miles traveled (VMT) estimates by county
- Example Dallas County passenger car age distribution profiles from the summers of both 2009 and 2010
- Acknowledgements
- Questions



# EPA On-Road Emission Models Since 1978

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<b>EPA On-Road Model</b>	<b>Release Date/Year</b>
MOBILE1	1978
MOBILE2	1981
MOBILE3	1984
MOBILE4	1989
MOBILE5	1993
MOBILE6	2002
MOBILE6.2	September 2003
MOVES2010	March 2010
MOVES2010a	September 2010
MOVES2010b	Fall/Winter of 2011
MOVES2013	Sometime in 2013



# Emission Inventory Development Basics

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- An emissions inventory must be developed using the latest inputs available **AT THE TIME THE WORK IS DONE.**
  - Federal Clean Air Act, Section 172(c)(3)
  - 40 Code of Federal Regulations (CFR) Section 51.112(a)(1)
- For on-road emissions inventory development, the inputs that are most subject to change over time include:
  - The latest available version of the EPA emissions model (e.g., MOBILE6, MOBILE6.2, MOVES2010, MOVES2010a, etc.)
  - VMT estimates from either the local travel demand model or Highway Performance Monitoring System data collected by the Texas Department of Transportation
  - Projected age distribution by vehicle type of the fleet in a future year based on county-level queries of the vehicle registration database
- More time to perform the inventory development work leads to higher confidence and quality in the final emission estimates.
  - SIP-quality emissions inventory development can take several months.
  - Rough “need it now” estimates may only take a month or less, but rarely match or come close to the SIP-quality totals due to the simplifying assumptions that need to be made.



# Macro-Level versus SIP-Quality On-Road Emissions Inventory Development

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- Macro-level estimation per county, day type, and year:
  - VMT for 28 vehicle types in MOBILE6 and 23 in MOVES
  - 3 pollutants ( $\text{NO}_x$ , VOC, and CO) in MOBILE6 and 5 pollutants in MOVES (NO and  $\text{NO}_2$  estimated separately)
  - 84 total calculations for MOBILE6 and 115 for MOVES
- NCTCOG SIP-quality 2012 analysis for one day type:
  - 81,556 total links and zones from the travel demand model
  - VMT for each vehicle type
  - 24 hours per day
  - 11 emission pollutant/process combinations in MOBILE6:
    - exhaust running and start for  $\text{NO}_x$  and CO
    - both listed above plus crankcase, diurnal, hot soak, resting loss, and running loss for VOC
  - 33 emission pollutant/process combinations in MOVES:
    - running exhaust, crankcase running exhaust, start exhaust, crankcase start exhaust, extended idle exhaust, and crankcase extended idle exhaust for NO,  $\text{NO}_2$ ,  $\text{NO}_x$ , and CO
    - all listed above plus evaporative permeation, evaporative fuel vapor venting, and evaporative fuel leaks for VOC
  - 602,861,952 total calculations for MOBILE6
  - 1,125,641,280 total calculations for MOVES



# Nine-County DFW Area On-Road Emission Estimates Based on Different Models and Levels of Effort

Model Version and Level of Effort	2006 Summer Weekday Emissions (tpd)		
	NO <sub>x</sub>	VOC	CO
MOBILE6.2 SIP-Quality	225.31	105.04	1,234.98
MOVES2010 Sensitivity	317.44	114.69	1,135.27
MOVES2010a SIP-Quality	259.11	111.02	1,209.12

Model Version and Level of Effort	2012 Summer Weekday Emissions (tpd)		
	NO <sub>x</sub>	VOC	CO
MOBILE6.2 SIP-Quality	122.47	79.85	986.17
MOVES2010 Sensitivity	203.06	75.95	908.19
MOVES2010a SIP-Quality	181.40	80.48	955.75



# 2006 Summer Weekday DFW Area On-Road Emission Estimates Based on MOVES2010a by County

DFW Area County	Summer Weekday VMT	2006 Summer Weekday Emissions (tpd)				
		NO	NO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
Collin	16,068,710	21.96	1.96	23.92	10.68	108.63
Dallas	64,281,838	95.73	8.33	104.06	46.18	510.42
Denton	13,408,318	20.57	1.80	22.37	9.29	93.23
Ellis	5,298,407	11.53	0.97	12.50	3.70	46.66
Johnson	4,345,589	8.38	0.72	9.10	3.65	44.84
Kaufman	4,533,347	9.47	0.82	10.29	2.83	36.59
Parker	3,796,119	8.86	0.74	9.60	2.94	34.37
Rockwall	1,926,972	3.72	0.32	4.04	1.42	15.73
Tarrant	40,494,762	58.17	5.06	63.23	30.33	318.63
Total	154,154,062	238.39	20.72	259.11	111.02	1,209.12



# 2012 Summer Weekday DFW Area On-Road Emission Estimates Based on MOVES2010a by County

DFW Area County	Summer Weekday VMT	2012 Summer Weekday Emissions (tpd)				
		NO	NO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
Collin	21,232,596	15.61	2.14	17.74	8.39	95.55
Dallas	72,976,845	61.05	8.22	69.27	31.83	390.53
Denton	17,746,832	14.22	1.96	16.18	7.14	80.03
Ellis	7,580,609	8.24	1.18	9.42	2.75	34.00
Johnson	5,829,182	5.68	0.73	6.41	2.56	30.15
Kaufman	6,170,056	7.18	1.14	8.32	2.20	27.06
Parker	5,027,970	6.70	1.05	7.76	2.23	24.16
Rockwall	2,422,684	2.59	0.41	3.00	1.10	11.21
Tarrant	47,401,269	38.32	4.98	43.30	22.28	263.06
Total	186,388,044	159.60	21.80	181.40	80.48	955.75





# 2006 Summer Weekday DFW Area On-Road Emission Estimates Based on MOVES2010a by Aggregate Process

Aggregate Emission Process	2006 Summer Weekday Emissions (tpd)				
	NO	NO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
Running Exhaust (includes crankcase)	199.21	18.98	218.19	30.32	864.40
Start Exhaust (includes crankcase)	32.36	1.27	33.63	36.07	341.51
Extended Idle Exhaust (includes crankcase)	6.81	0.47	7.29	2.15	3.21
Evaporative (includes permeation, fuel vapor venting, and fuel leaks)				42.49	
Total	238.39	20.72	259.11	111.02	1,209.12



# 2012 Summer Weekday DFW Area On-Road Emission Estimates Based on MOVES2010a by Aggregate Process

Aggregate Emission Process	2012 Summer Weekday Emissions (tpd)				
	NO	NO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
Running Exhaust (includes crankcase)	123.57	18.06	141.63	19.41	685.24
Start Exhaust (includes crankcase)	25.92	1.22	27.14	29.08	264.63
Extended Idle Exhaust (includes crankcase)	10.10	2.52	12.62	2.41	5.89
Evaporative (includes permeation, fuel vapor venting, and fuel leaks)				29.58	
Total	159.60	21.80	181.40	80.48	955.75



# 2006 and 2012 Nine-County DFW Area On-Road Emission Estimates With MOVES2010a by Day Type

Summer Day Type	Daily VMT	2006 On-Road Emissions (tpd)				
		NO	NO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
Weekday	151,358,205	238.39	20.72	259.11	111.02	1,209.12
Friday	167,642,908	242.67	21.65	264.31	114.61	1,308.99
Saturday	136,773,126	174.06	15.92	189.98	103.25	1,131.33
Sunday	112,618,220	155.21	13.74	168.95	96.60	988.74
Monday	148,101,765	232.29	20.14	252.43	109.12	1,186.90

Summer Day Type	Daily VMT	2012 On-Road Emissions (tpd)				
		NO	NO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
Weekday	186,388,044	159.60	21.80	181.40	80.48	955.75
Friday	200,764,362	160.25	21.99	182.24	81.87	1,013.94
Saturday	163,286,714	120.37	16.31	136.68	74.80	880.20
Sunday	139,048,881	110.09	14.74	124.84	71.37	784.28
Monday	180,038,229	154.31	21.02	175.33	78.97	930.45



# Uncertainty in Emission Estimates

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- All of the emission estimates and the models upon which they are based contain uncertainty.
- The greatest difficulty with the accuracy of on-road models is that they are developed to estimate emissions from vehicles/engines with technologies that are either very new or have not yet been introduced to the fleet.
- The bulk of the MOBILE6 model development was done in the late 1990s when:
  - 1994-and-newer model year Tier 1 vehicles had just started entering the fleet;
  - 2004-and-newer model year Tier 2 vehicles did not yet exist; and
  - 2007-and-newer heavy-duty engines did not exist.
- MOVES contains improved information on Tier 1, Tier 2, and some heavy-duty engines:
  - Updated information will be included as it becomes available for all vehicle categories.
  - Even more stringent Tier 3 light-duty standards are under consideration and MOVES2013 will have to estimate their benefits before vehicles meeting such standards are available.

- Page 3 of EPA's guidance for attainment modeling and other analyses:

<http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf>

**“Premise 1. There is uncertainty accompanying model predictions.** “Uncertainty” is the notion that model estimates will not perfectly predict observed air quality at any given location, neither at the present time nor in the future...”



# EPA MOVES Policy Guidance Excerpts

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- Available at <http://www.epa.gov/otaq/models/moves/420b09046.pdf>.
- MOVES utilizes more updated emissions information than MOBILE6 (page 4)  
“MOVES2010 improves upon MOBILE6.2 in many respects. For example, MOVES2010 is based on a review of the vast amount of in-use vehicle data collected and analyzed since the release of MOBILE6.2, including millions of emissions measurements from light-duty vehicles. Analysis of this in-use data has enhanced EPA’s understanding of how on-road mobile sources contribute to emissions inventories, and has also improved the agency’s understanding of the relative effectiveness of various control strategies.”
- SIP revisions should be based on MOVES if possible (page 6)  
“EPA believes that MOVES2010 should be used in ozone, CO, PM, and NO<sub>2</sub> SIP development as expeditiously as possible. The Clean Air Act requires that SIP inventories and control measures be based on the most current information and applicable models that are available when a SIP is developed...States should use MOVES2010 where SIP development is in its initial stages or has not progressed far enough along that switching to MOVES2010 would create a significantly adverse impact on state resources. MOVES2010 should be incorporated into these SIPs since the emissions estimates from MOVES2010 are based on the best information currently available.”



# Options for Including MOVES in DFW Area Attainment Demonstration SIP (Part 1 of 2)

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- 2006 base case and 2012 future case on-road emission inventories were developed using MOBILE6.2 prior to release of the MOVES model.
- There was insufficient time to develop SIP-quality on-road emission inventories with MOVES for 2006 and 2012 that could be included early in the attainment demonstration SIP process.
- Option #1 – Only use already developed MOBILE6.2 inventories:
  - significant SIP development work had already occurred with MOBILE6.2, and there would be no change in on-road estimates between proposal and adoption; but
  - the attainment demonstration analysis would not be based on the latest available information; and
  - it would be very difficult in the future to demonstrate conformity using the MOVES model to a motor vehicle emissions budget (MVEB) established with MOBILE6.2.
- Option #2 – Wait for SIP-quality MOVES inventories prior to proposing:
  - there would likely be no difference between on-road emission estimates between proposal and adoption; but
  - the final adoption and submission to EPA would have to occur after the required statutory deadline in January of 2012.



# Options for Including MOVES in DFW Area Attainment Demonstration SIP (Part 2 of 2)

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- Option #3 – TCEQ approach:
  - Keep SIP-quality MOBILE6.2-based inventories in the proposal.
  - Include a sensitivity analysis in the proposal where MOBILE6.2 inventory totals were adjusted to approximate NCTCOG estimates calculated with MOVES2010.
  - This NCTCOG analysis was presented at a September 2010 EPA conference [http://www.epa.gov/ttn/chief/conference/ei19/session6/venugopal\\_pres.pdf](http://www.epa.gov/ttn/chief/conference/ei19/session6/venugopal_pres.pdf)
  - Excel spreadsheets and output files showing how this was done are available at [ftp://amdaftp.tceq.texas.gov/pub/Mobile\\_EI/DFW/eps3/](ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/DFW/eps3/)
  - Solicit comment in the SIP proposal on possible use of MOVES for the adoption.
  - Develop SIP-quality on-road emission inventories with MOVES2010a that could be included in the adopted SIP, and make them available for public review as quickly as possible.
- MOVES2010a SIP-quality on-road inventory development completion dates:
  - DFW area 2006 and 2012 inventories from NCTCOG in May of 2011;
  - non-DFW 2006 and 2012 inventories for remaining Texas counties from the Texas Transportation Institute (TTI) in June of 2011; and
  - non-Texas default runs were completed by TCEQ staff in June of 2011.



# MOVES Run Times for 2,891 Non-Texas U.S. Counties

<http://www.epa.gov/otaq/models/moves/conference2011/inventory-regional-moves-2011.pdf>

Calendar Year	Month and Day Type	Run Time for 2,891 Non-Texas U.S. Counties		
		Days	Hours	Average Minutes per County
2006	July Weekday	68	1,634	34
	July Weekend	80	1,927	40
2008	July Weekday	81	1,938	40
	July Weekend	89	2,138	44
2012	July Weekday	86	2,060	43
	July Weekend	88	2,113	44
2018	July Weekday	98	2,343	49
	July Weekend	104	2,489	52





# MOVES References in Attainment Demonstration SIP Proposal

- Page ES-3, 1-7, and 2-3: “The commission solicits comment on using on-road mobile emissions inventories based on the EPA’s MOBILE model as well as the Motor Vehicle Emission Simulator (MOVES) model in the adopted version of this SIP revision.”
- Section 3.7.6 on page 3-62, Possible Use of MOVES Model for SIP Revision Adoption:
  - Discussion of MOVES2010 sensitivity emission estimates on pages 3-62 to 3-66.
  - Discussion of photochemical modeling sensitivity with MOVES on pages 3-66 to 3-71.
- Page 3-71: “In the event that MOVES-based emission inventories are used for the photochemical modeling inputs included with the adopted SIP revision, it is expected that the final emission figures and attainment demonstration results are expected to be different than those reported in this SIP revision proposal.”
- TCEQ FTP site directories with more MOVES inventory development detail:
  - [ftp://amdaftp.tceq.texas.gov/pub/Mobile\\_EI/DFW/mvs/](ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/DFW/mvs/) for DFW area
  - [ftp://amdaftp.tceq.texas.gov/pub/Mobile\\_EI/Statewide/mvs/](ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/) for non-DFW counties within Texas
  - [ftp://amdaftp.tceq.texas.gov/pub/Mobile\\_EI/USA/mvs/](ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/USA/mvs/) for non-Texas portions of modeling domain
- TCEQ FTP site directories with on-road photochemical modeling input files:
  - [ftp://amdaftp.tceq.texas.gov/pub/Mobile\\_EI/DFW/eps3/](ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/DFW/eps3/) for DFW area
  - [ftp://amdaftp.tceq.texas.gov/pub/Mobile\\_EI/Statewide/eps3/](ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/eps3/) for non-DFW counties within Texas
  - [ftp://amdaftp.tceq.texas.gov/pub/Mobile\\_EI/USA/eps3/](ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/USA/eps3/) for non-Texas portions of modeling domain



## Difference in 2006 Summer Weekday Vehicle Miles Traveled Estimates by County

DFW Area County	2006 Summer Weekday VMT Estimates			
	MOBILE6.2	MOVES2010a	Difference	Change
Collin	16,068,710	15,622,536	-446,174	-2.8%
Dallas	64,281,838	62,826,353	-1,455,485	-2.3%
Denton	13,408,318	13,205,166	-203,152	-1.5%
Ellis	5,298,407	5,503,696	205,290	3.9%
Johnson	4,345,589	4,448,585	102,997	2.4%
Kaufman	4,533,347	4,460,300	-73,048	-1.6%
Parker	3,796,119	3,723,312	-72,807	-1.9%
Rockwall	1,926,972	1,891,799	-35,173	-1.8%
Tarrant	40,494,762	39,676,458	-818,304	-2.0%
Total	154,154,062	151,358,205	-2,795,857	-1.8%

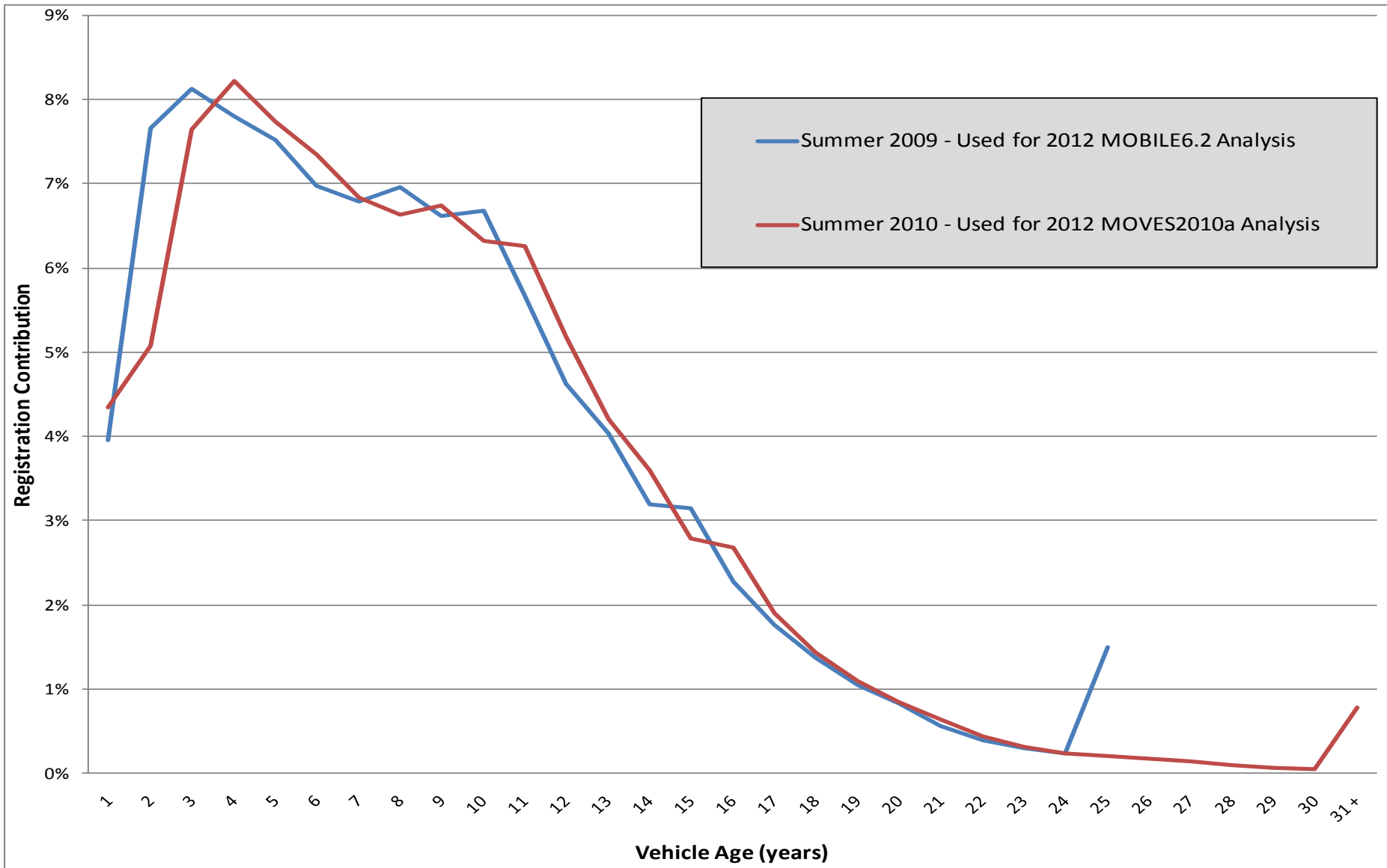


## Difference in 2012 Summer Weekday Vehicle Miles Traveled Estimates by County

DFW Area County	2012 Summer Weekday VMT Estimates			
	MOBILE6.2	MOVES2010a	Difference	Change
Collin	20,189,452	21,232,596	1,043,144	5.2%
Dallas	75,484,002	72,976,845	-2,507,157	-3.3%
Denton	18,516,332	17,746,832	-769,500	-4.2%
Ellis	7,237,704	7,580,609	342,906	4.7%
Johnson	5,343,688	5,829,182	485,494	9.1%
Kaufman	5,632,724	6,170,056	537,332	9.5%
Parker	4,663,328	5,027,970	364,642	7.8%
Rockwall	2,321,347	2,422,684	101,336	4.4%
Tarrant	48,745,787	47,401,269	-1,344,518	-2.8%
Total	188,134,364	186,388,044	-1,746,320	-0.9%



# Dallas County Passenger Car Age Distribution Profiles Used for Developing 2012 Future Case Inventories





# Acknowledgements

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- NCTCOG, and a special thanks to Madhusudhan Venugopal in particular, for developing these DFW area on-road emission inventories:
  - SIP-quality 2006 and 2012 with MOBILE6.2;
  - approximate 2006 and 2012 with MOVES2010 for the sensitivity analysis; and
  - SIP-quality 2006 and 2012 with MOVES2010a.
- TTI staff for developing:
  - methodologies and electronic utilities for SIP-quality inventory production with MOVES; and
  - both MOBILE6.2 and MOVES2010a inventories for all Texas counties for multiple calendar years.
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# Questions?

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Chris Kite

Chris.Kite@tceq.texas.gov

512-239-1959

