TECHNICAL SUPPORT DOCUMENT FOR ON-ROAD MOBILE SOURCES: $PM_{2.5}$ EMISSIONS INVENTORY FOR 2017, 2026 and 2035 FOR THE PROVO, UT $PM_{2.5}$ NONATTAINMENT AREA AND SURROUNDING MODELING DOMAIN WITHIN UTAH

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Abstract

This report discusses the on-road mobile source section of the $PM_{2.5}$ SIP baseline and projection inventories for the Provo, UT $PM_{2.5}$ Nonattainment Area (NA) and the remaining 28 counties within the state of Utah.

On-road inventories were calculated using the EPA MOVES2014b (Motor Vehicle Emission Simulator). $PM_{2.5}$ and PM_{10} fugitive paved roads road dust were calculated using AP-42 Chapter 13.2.1, "Introduction to Fugitive Dust Sources, section 13.2.1, "Paved Roads" (published in Federal Register on Feb. 4, 2011).

Baseline and projection year on-road mobile source emissions inventories were developed by the following agencies:

Provo, UT $PM_{2.5}$ NA:
Mountainland Association of Governments (MAG): Utah County

Surrounding Modeling Domain:
Cache Metropolitan Planning Organization (CMPO): Cache County (Logan, UT/ID $PM_{2.5}$ NA)
Utah Division of Air Quality (UDAQ): Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Morgan, Piute, Rich, San Juan, Sanpete, Sevier, Summit, Uintah, Wasatch, Washington, and Wayne Counties
Wasatch Front Regional Council (WFRC): Box Elder, Davis, Salt Lake, Tooele and Weber Counties (Salt Lake City, UT $PM_{2.5}$ NA)

The on-road mobile source baseline and projection inventories were developed from meteorological conditions from three $PM_{2.5}$ episodes: 2011 January 1-12, 2013 December 7-19, and 2016 February 1-17. Hourly average temperature, relative humidity, and precipitation profiles were used to reflect the atmospheric conditions that represent the $PM_{2.5}$ season.

Local activity travel data inputs were developed and implemented to characterize winter travel conditions for a weekday Monday-Friday, Saturday, and Sunday expressed as Vehicle Miles of Travel (VMT).

Summary on-road emissions table inventories for a representative winter weekday are located at the end of the TSD for the following years: 2017, 2026, and 2035.

ON-ROAD MOBILE SOURCES $PM_{2.5}$ EMISSIONS INVENTORIES

i. Overview

The purpose of this document is to explain what emissions modeling assumptions were used to develop the on-road mobile emissions estimates for the Baseline and Projection Inventories for the $PM_{2.5}$ SIP for the Provo, UT $PM_{2.5}$ NA and the remaining 28 counties within the state of Utah.

Emission estimates are based on meteorological conditions that occurred during three $PM_{2.5}$ episodes: 2011 January 1-12, 2013 December 7-19, and 2016 February 1-17. The $PM_{2.5}$ Maintenance SIP covers 2017, 2026 and 2035. Inventory estimations were created at the county level for all twenty nine counties within the state of Utah representing an average January weekday, Saturday, and Sunday.

Emission estimates are confined to the EPA approved MOVES2014b (May 2017) emissions model. This model produces emissions estimates for on-road vehicles by providing emissions profiles for exhaust, evaporative, and wear conditions. Inputs include speeds, vehicle fuel profiles and specifications, vehicle miles traveled (VMT), Inspection and Maintenance program profiles, VMT mix, vehicle age distributions, and meteorological conditions. PM_{10} and $PM_{2.5}$ fugitive dust emissions from paved roads emissions are estimated by the EPA approved calculation identified in AP-42 Chapter 13.2 (2011). Inputs include VMT, precipitation, and average vehicle weight.

The following agencies developed on-road mobile source emissions inventories:

$PM_{2.5}$ SIP for the Provo, UT $PM_{2.5}$ NA:
MAG: Utah County

Surrounding Modeling Domain:
CMPO: Cache County (Logan, UT/ID $PM_{2.5}$ NA)
UDAQ: Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Morgan, Piute, Rich, San Juan, San Pete, Sevier, Summit, Uintah, Wasatch, Washington, and Wayne Counties.
WFRC: Box Elder, Davis, Salt Lake, Tooele, and Weber Counties (Salt Lake City, UT $PM_{2.5}$ NA)

ii. MOVES Modeling Procedure

The discussion below identifies the procedures followed to model the episodic inventories.

1. MOVES Default Database Enhancement for Local Roads

The local road enhancement allows the EPA MOVES2014b model to produce emissions results according to the Highway Performance Monitoring System (HPMS) utilized by the Federal Highway Administration, Utah Department of Transportation, Mountainland Association of Governments (MAG), Cache Metropolitan Planning Organization (CMPO), Wasatch Front Regional Council (WFRC), and the Utah Division of Air Quality (UDAQ). Arterial and local roads have very different travel characteristics. This simplified approach allows each road type to have specific vmt, speed and vehicle distribution by road type (vehicle mix) inputs. Modeling specific road types creates an inventory approach that matches the HPMS road types that are reported within local transportation plans.

Modifications to Local Road Table

Table Names	Data Columns	Description of Change
avgspeeddistribution	roadTypeID	Road types rural local(32) and
drivescheduleassoc	avgSpeedBinID	urban local(52) added.
hourvmtfraction	driveScheduleID	
roadtype	hourVMTFraction	
roadtypedist	roadDesc	
zoneroadtype	roadTypeVMTFraction	

2. MOVES2014 Daily Pollutants

(a) Pollutants selected for analysis:

- Ammonia (NH3)
- Benzene
- Carbon Monoxide(CO)
- Chloride
- Methane
- Nitrogen Oxide(NO)
- Oxides of Nitrogen (NOx)
- $PM_{2.5}$ (Elemental Carbon, Organic Carbon, Sulfate Particulate)
- $PM_{2.5}$ & PM_{10} (Primary Exhaust, Brake, & Tire)
- Sulfur Dioxide (SO2)
- Toluene
- Non-methane Hydrocarbons
- Total Energy
- Total Gaseous Hydrocarbons
- Total Organic Gases
- Volatile Organic Compounds

- Xylene

3. MOVES2014 Local Model Inputs

(a) County Data Manager Development

MOVES organizes data inputs into databases called County Data Manager (CDM) tables. CDMs were developed for 29 counties for each year: 2017, 2026, and 2035 for an average weekday, Saturday, and Sunday.

(1) Average Speed Distribution

MAG method:

MAG utilized the 2015 Utah County Average Speed Distribution file the TDM produces in the format appropriate for use in the MOVES model.

CMPO method:

Cache MPO obtained average speed distributions from its Travel Demand Model. The TDM analyzes thousands of separate traffic segments called "links" that together comprise the network of roads in Cache County. Each link is assigned, for each of the four major time periods during the day (AM peak, midday, PM peak and nighttime), an average speed, an increment of VMT and an increment of VHT (vehicle hours traveled). A specific number of links are assigned to each of the UDOT HPMS functional classes (road types, e.g., rural local, urban local, rural minor arterial, urban minor arterial, and so on). In effect, average speeds, VMT and VHT for each of the functional classes are combined to obtain average speed, VMT and VHT for rural arterials, urban arterials, rural local roads and urban local roads. (There are no interstates in Cache County).

Year 2019 = 2019 TDM Speeds
Year 2026 = 2030 TDM Speeds
Year 2035 = 2040 TDM Speeds

UDAQ method:

The "Easy Mobile Inventory Tool" (EMIT) created by FHWA was used to create a MOBILE6 speed input file utilizing the Highway Capacity Manual method. UDOT Division of Systems Planning and Programing provided 2017 lane miles and VMT by county for the calculation.

WFRC method:

WFRC created a program titled TDM2MOVES to generate MOVES input files from the Cube 6.4 travel demand model output. The TDM2MOVES program creates speed profiles, road type distribution, ramp fractions, VMT by vehicle type, and vehicle population data files to be used in the MOVES model. WFRC has detailed MOVES input files extracted from travel demand model results for the years 2017, 2021, 2030, and 2040. The speed profile from the 2021 data set was used to model SIP year 2026; the speed profile for 2040 was used to model SIP year 2035.

(2) AVFT (Diesel and Gasoline Fractions)

MAG method:
The MOVES default file for AVFT (alternative vehicle and fuel technology) was updated with 2015 State DMV data on fuel type for registered light duty vehicles (passenger cars and light duty trucks). The DMV fractions were applied to all model years. MOVES2014b default AVFT values were used for all remaining source type vehicles. This local data shows a higher percentage of diesel fueled vehicles among the light duty trucks (vehicle types 31 and 32, or SUV's and pickup trucks) than the default AVFT data.

CMPO & UDAQ method:
The MOVES default file for AVFT was updated with 2017 State DMV registration data on fuel type for registered light duty vehicles (passenger cars and light duty trucks). The DMV fractions were applied to all model years. MOVES2014b default AVFT values were used for all remaining source type vehicles.

WFRC method:
The MOVES default file for AVFT was updated with 2017 State DMV registration data on fuel type for registered light duty vehicles (passenger cars and light duty trucks). The DMV fractions were applied to all model years. MOVES2014b default AVFT values were used for all remaining source type vehicles.

(3) Fuel

MAG, CMPO, UDAQ and WFRC method:
An adjustment was made for 2017 to account for gasoline sulfur level in Utah since small volume refiners are not required to comply with federal Tier 3 gasoline (10 ppm sulfur) requirements until January 1, 2020. EPA Office of Transportation and Air Quality (OTAQ) provided 2017 local gasoline sulfur values of 20.9 ppm. Default fuel parameter values for Tier 3 gasoline of 10ppm sulfur were used for 2026 and 2035. MOVES 2014a default fuel parameters were used for diesel and CNG.

(4) HourVMTFraction

MAG, CMPO, UDAQ, and WFRC method:
MOVES2014b default Hour VMT Fraction values were used.

(5) HPMSvTypeYear (VMT)

MAG method:
MAG utilized UDOT HPMS 2016 counts.

CMPO method:
CMPO utilized UDOT HPMS 2016 counts.

UDAQ method:
The Utah Department of Transportation (UDOT) provided HPMS VMT data reported as average annual day traffic (AADT) for calendar years 1996-2017. VMT was projected to the year 2050 via linear regression for positive growth and curvilinear fit for negative growth. UDOT provided average vmt daily adjustment factors (2016) to provide winter month and daily activity detail.

WFRC method:
Improvement to the WFRC travel demand model practice and procedure is an ongoing process. Version 8.3 of the travel demand model updates the former 2011 base year with socio-economic data and transportation networks for the new 2015 base year. The new model also incorporates the results of the 2012 Household Travel Survey conducted by WFRC. Version 8.3 of the model adds more traffic analysis zones, and the transit mode choice portion of the model has been enhanced.

The WFRC travel model is used to estimate and forecast highway Vehicle Miles Traveled (VMT) and vehicle speeds for Weber, Davis, and Salt Lake Counties. The Utah State Travel Model (USTM) is used to estimate VMT and speed in Box Elder County and Tooele County. The WFRC travel demand model is based on the latest available planning assumptions and a computerized representation of the transportation network of highways and transit service. The base data for the travel demand model is reviewed regularly for accuracy and updates.

Seasonal factors for highway VMT variations have been revised and refined by research commissioned by the Utah Department of Transportation. Seasonal factors are determined for each link of the highway system based on the functional class (freeway or arterial) and the area type (rural, transitional, suburban, and urban). Other considerations include traffic volume and recreational activity.

After validating the travel demand model volumes to reflect observed volumes at the highway segment level, the overall VMT by functional class and county is adjusted to match the corresponding VMT reported in the HPMS system for the 2015 base year. The various county and functional class adjustment factors for the 2015 base year are then applied to all future travel demand model VMT estimates. In most cases the HPMS adjustment factor is within +/- 10%.

Vehicle type VMT percentages, commonly referred to as VMT mix in the MOVES modeling domain, were estimated from UDOT vehicle type classification counts by county based on vehicle length. Weigh-in-motion data was used to distinguish longer vehicle types (particularly vehicle pulling trailers).

(6) I/M Coverage: Davis, Salt Lake, Utah, and Weber Counties

UDAQ constructed I/M Program coverages in consultation with the local county health departments in Cache, Davis, Salt Lake, Utah, and Weber Counties. Vehicles older than 1995 undergo a Two Speed Idle (TSI) test and vehicles newer than 1996 undergo On Board Diagnostic Testing (OBD). Years that were covered include 2017, 2026, and 2035. Davis, Salt Lake, Utah and Weber Counties I/M programs exempt the first two model years, biennially test the third through sixth model years, and perform an annual test on the remaining vehicles. The Cache County I/M program exempts the first six model years and perform a biennial test on vehicles beginning in the seventh model year. Please note that Cache County I/M program will remove the Two Speed Idle test procedure in 2021. DAQ provided a Section 110(l) demonstration to EPA region 8 in May 2019 indicating that removing the testing procedure will not interfere with the ability of the Logan, UT-ID NA to continue to attain the EPA 24 hour $PM_{2.5}$ NAAQS. Below is a summary covering I/M programs in the year 2017.

Summary of the I/M Programs for Davis, Salt Lake, Utah, and Weber Counties covering 2017.

Year	Vehicle Type	Beg Model Year	End Model Year	Frequency	I/M Test
2017	Cars & Trucks	1968	1995	Annual	TSI
2017	Cars & Trucks	1996	2011	Annual	OBD
2017	Cars & Trucks	2012	2015	Biennial	OBD

Summary of the I/M Program for Cache County covering 2017

Year	Vehicle Type	Beg Model Year	End Model Year	Frequency	I/M Test
2017	Cars & Trucks	1968	1995	Biennial	TSI
2017	Cars & Trucks	1996	2011	Biennial	OBD

Summary of additional I/M Program coverage test procedures

County	Beg Model Year	End Model Year	I/M Test
Davis	1990	2001	Gas Cap Pressure Test
Salt Lake	1968	2001	Gas Cap Pressure Test
Weber	1968	2001	Gas Cap Pressure Test

(7) Road Type Distribution

MAG method:
MAG utilized the 2015 Utah County RoadtypeDistribution file the TDM produces in the format appropriate for use in the MOVES model. The file is reported as percentage of vehicle activity on each road type with the sum for each vehicle type equal to 100%.

CMPO & UDAQ method:
UDOT Division of Systems Planning and Programming provided 2017 VMT travel fractions for FHWA vehicle classes grouped by Gross Vehicle Weight Rating (GVWR) ranges. The travel fractions were obtained by county from automated pneumatic counters that detect axle spacing and "weigh-in motion" (WIM) counters placed on arterial, interstate, and local roads. VMT and Vehicle Mix data were used to construct road type distribution and VMT by sourcetype.

WFRC method:
The TDM2MOVES program discussed in the Speed Profile section also generates road distribution files to be used in the MOVES model. Road distribution files from the 2021 data set were used to model SIP year 2026; the road distribution for 2040 was used to model SIP years 2035.

(8) Source Type Age Distribution

MAG method:
MAG utilized DMV and local IM data and UDOT HPMS data in combination with MOVES age default for truck data for the appropriate year.

CMPO & UDAQ method:
The vehicle age distribution data for vehicle types 11, 21, 31, and 32 (motorcycles, passenger cars, passenger trucks, and light duty commercial trucks) was based on DMV registration data for 2017. DMV provided a single age distribution for passenger cars (21) and light trucks (31,32). The age distribution was prepared for each county and held constant for all years modeled in the SIP. For other vehicle types the age distribution used MOVES default values because the state DMV data is an incomplete source for these vehicle types. The age distribution was held constant for all years modeled in the SIP.
WFRC method:
The vehicle age distribution data for vehicle types 11, 21, 31, 32, and 54 (motorcycles, passenger cars, passenger trucks, light duty commercial trucks, and motor homes) was based on DMV registration data for 2017. For other vehicle types the age distribution used MOVES default values because the state DMV data is an incomplete source for these vehicle types. The Age Distribution

Projection Tool for MOVES 2014 was used to project vehicle age profiles from 2017 data to all future years.

(9) Source Type Year (Vehicle Population)

MAG method:
MAG utilized historical DMV and local I/M data & growth factors combined with UDOT HPMS counts for the appropriate year and MOVES default for truck distribution.

CMPO & UDAQ method:
UDAQ utilized Utah DMV 2017 registration data for Model Years 2017-1969 for MOVES vehicle types 11, 21,31, and 32 (motorcycles, passenger cars, and light duty trucks) up to 10,000 GVWR. The MOVES default vehicle fraction for these vehicles was used to determine the difference between cars and trucks since the DMV data cannot discern between a passenger car (21) and light duty trucks (31,32). The projected VMT growth rate was used to estimate future population growth for motorcycles, passenger cars, and light duty trucks up to 10,000 GVWR.

WFRC method:
WFRC estimates vehicle population as a function of estimated vehicle miles traveled (VMT). The WFRC estimates VMT using a sophisticated travel demand model which is based on projections for employment, population, land use, mode choice, and other factors. By associating vehicle population with travel demand model VMT estimates, the resulting vehicle population estimates will reflect to some degree the variations in future socio-economic factors, as well as shifts in mode choice resulting from transportation plans that emphasize alternative modes of travel. For example, a transportation plan that invests in an increase in transit mode choice should also result in some reduction in the number of vehicles. The WFRC compiled an inventory of 2017 vehicle population using State DMV data, State School bus reports, Utah Transit Authority annual reports, and MOVES defaults.

For MOVES vehicle types 21, 31, and 32 (passenger cars, and light duty trucks), the DMV total was multiplied by the MOVES default percentage for these vehicle types. This eliminates vehicle classification discrepancies between the MOVES default and the state classification. The vehicle population values were then divided by the 2017 VMT from HPMS to create a vehicle population factor for each vehicle type.

(10) ZoneMonthHour (Meteorological Data)

WFRC, CMPO, MAG, UDAQ method:

The UDAQ Technical Analysis Section provided metrological conditions from Meso West University of Utah from three $PM_{2.5}$ episodes: 2011 January 1-12, 2013 December 7-19, and 2016 February 1-17. The UDAQ modeling section provided hourly temperature and relative humidity profiles from representative weather stations in Box Elder, Cache, Davis, Salt Lake, Tooele, Utah, and Weber counties. The meteorology data represents the hour by hour average for all of the days in the 2011 January 1-12, 2013 December 7-19, and 2016 February 1-17 $PM_{2.5}$ episodes. The average of all the hourly temperatures and relative humidity readings over the three episodes for each representative weather station was used to reflect the atmospheric conditions that represent the $PM_{2.5}$ season.

4. Fugitive Dust: Local Data Inputs & Procedures

1. Fugitive Dust Emissions

(1) Method

PM_{10} and $PM_{2.5}$ fugitive dust emissions from paved roads ("re-entrained road dust") calculated according to Chapter 13 of AP-42 dated January 2011.

The hourly basis equation was used to estimate dust emissions:

= [k(sL)^0.91(W)^1.02][1 - (1.2P/N)]

Inventories of fugitive dust from paved roads are in units of tons per year as requested by UDAQ Technical Analysis Section.

1. Precipitation

   UDAQ Technical Analysis Section provided precipitation data from MesoWest University of Utah. Number of hours per day with precipitation greater than 0.01 inch were collected for the following counties: Box Elder, Davis, Cache, Salt Lake, Tooele, Utah, and Weber. County specific precipitation data was collected and combined for each of the three $PM_{2.5}$ episodes: 2011 January1-12, 2013 December 7-19, and 2016 February 1-17. The Salt Lake precipitation profiles were utilized for the remaining 22 rural counties within the state of Utah to provide relative background emissions for on-road fugitive dust emissions. County specific fugitive dust emissions estimates were configured for an average weekday, Saturday, and Sunday using precipitation data from all the episodes.

2. Average Vehicle Weight

   In general, average vehicle weight is highest on interstates and lowest on local roads. In rural counties, average vehicle weight is often a factor of three or four times higher than in large urban counties due to the relatively higher percentage of large trucks in rural areas compared to urban areas with large volumes of commuter traffic.

3. Silt Loading Factors

   Default silt loading factors were used.

Table 1. PM2.5 SIP On-road Mobile Sources Inventory 2017-2035 Winter Weekday Emissions (Tons per Winter Weekday)

Year		Modeling Area	NH3	NOx	PM10***	PM2.5****	SO2	VOC	VOC Refueling	PM10 Dust*****	PM2.5 Dust*****	VMT
2017*	Baseline Year	PM2.5 Nonattainment Area Counties +	0.49	17.57	1.72	0.88	0.11	9.74	0.47	1,379	345	14,021,718
2017*	Baseline Year	Modeling Domain Counties ++	2.52	124.62	10.10	5.26	0.61	52.07	2.96	9,187	2,297	
2026**	Intermediate Year	PM2.5 Nonattainment Area Counties +	0.41	6.56	1.18	0.40	0.06	4.87	0.26	1,565	391	16,279,116
2026**	Intermediate Year	Modeling Domain Counties ++	2.20	57.17	7.90	2.57	0.35	27.55	1.72	10,205	2,551	
2035**	Final Year	PM2.5 Nonattainment Area Counties +	0.50	4.50	1.28	0.32	0.06	4.20	0.25	1,996	499	20,278,299
2035**	Final Year	Modeling Domain Counties ++	2.40	42.18	7.82	1.88	0.34	22.54	1.52	11,690	2,923	

* Gasoline 20.9 ppm Sulfur

** Gasoline 10 ppm Sulfur

*** PM 10 = PM10 Exhaust + Brake and Tire Wear

**** PM 2.5 = PM2.5 Exhaust (Elemental Carbon, Organic Carbon, Sulfate Particulate) + Brake and Tire Wear

***** PM10 & PM2.5 Dust Emission are in Tons Per Year

\+ Provo, UT PM2.5 Nonattainment Area

++ Box Elder, Beaver, Cache, Carbon, Davis, Daggett, Duchesne, Emery, Garfield, Grand, Irion, Juab, Kane, Millard, Morgan, Piute, Rich, San Juan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Wasatch, Washington, Wayne, Weber Counties

iii. Appendix: Episodic Year Inventories For $PM_{2.5}$ SIP

Input files will be furnished upon request:

iv. References

The following documents were used as references in creating the on-road mobile source $PM_{2.5}$ SIP emissions inventories:

1. Federal Register, Friday, February 4, 2011, "Official Release of the January 2011 AP–42 Method for Estimating Re-Entrained Road Dust From Paved Roads", Announcement of Availability, https://www.federalregister.gov/documents/2011/02/04/2011-2422/official-release-of-the-january-2011-ap-42-method-for-estimating-re-entrained-road-dust-from-paved

2. U.S. Environmental Protection Agency, Office of Transportation and Air Quality (OTAQ), Assessment and Standards Division, "MOVES2014b User Guide", EPA-420-B-095, November 2015, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NNCY.txt

3. U.S. Environmental Protection Agency, OTAQ, Transportation and Regional Programs Division, "MOVES2014 and 2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity", EPA-420-B-15-093), https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NN9L.txt , November 2015.

4. I/M Programs

a. Davis County Health Department, Environmental Health Services Division, Davis County Testing Center, 20 North 600 West, Kaysville, UT 84037, 801-546-8860.

b. Salt Lake County Health Department, Environmental Health, Air Pollution Control, I/M Tech Center, 788 East Woodoak Lane (5380 South), Murray, UT 84107-6369, 385-468-4837.

c. UT County Health Department, UT County Environment Health, Bureau of Air Quality, I/M Tech Center, 3255 North Main Street, Spanish Fork, UT, 84660, 801-851-7600.

d. Weber-Morgan Health Department, Environmental Health, 477 23rd Street, 2nd floor, Ogden, UT 84401, 801-399-7160.

e.Bear River Health Department, 655 East 1300 North. Logan, UT 84341, 801-792-6500

5. MESOWEST UT, (met data archive), University of UT, Department of Atmospheric Sciences, http://mesowest.UT.edu/.