

4. Nonroad Mobile Sources

4.1 Introduction

Nonroad mobile sources are defined as those that move or are moved within a 12-month period and are not licensed or certified as highway vehicles. Nonroad mobile sources are vehicles and engines that fall under the following categories:

- Agricultural equipment, such as tractors, combines and balers;
- Airport ground support equipment, such as baggage tugs and terminal tractors;
- Commercial equipment, such as generators and pumps;
- Industrial equipment, such as forklifts and sweepers;
- Construction and mining equipment, such as graders, back hoes and trenchers;
- Lawn and garden equipment, such as leaf blowers and lawn mowers;
- Logging equipment (not present in Maricopa County);
- Pleasure craft, such as power boats and personal watercraft;
- Railway maintenance equipment, such as rail straighteners;
- Recreational equipment, such as all-terrain vehicles and off-road motorcycles;
- Underground mining and oil field equipment (not present in Maricopa County);
- Aircraft, such as jet and piston engines; and
- Locomotives, such as switching and line haul trains.

Emission calculations for most nonroad mobile source categories except aircraft, airport ground support equipment (GSE) and locomotives were derived using EPA's NONROAD2008a model (Core version 2008a, July 2009). Aircraft and airport GSE emission estimates were made using the Federal Aviation Administration's EDMS (Emissions Dispersion Modeling System) model, ver. 5.1.1. Locomotive emission calculations were derived from surveys of the three railroad companies that have operations in the county.

County specific temperature and fuel-related inputs are required for the operation of the NONROAD model. Monthly temperature and fuel data were provided by the Arizona Department of Weights and Measures. The following table lists the local county inputs used:

Table 4.1-1. NONROAD model county temperature and fuel-related inputs.

Month	Temperatures (°F)			Fuel	Diesel	Gasoline	Ethanol Blend		
	Max.	Min.	Average	RVP (psi)	Sulfur (ppm)	Sulfur (ppm)	ETOH (Vol%)	Market Share (%)	Total Oxygen (wt%)
January	64	45	54.9	9	9	15	9.92	100	3.66
February	69	48	58.5	9	9	16	10.29	100	3.85
March	79	54	66.8	8	9	11	9.52	100	3.58
April	87	61	74.2	8	9	14	7.90	100	2.98
May	91	66	78.7	7	9	13	9.41	100	3.48
June	107	80	93.4	7	10	18	9.38	100	3.45
July	106	84	95.2	7	9	21	9.70	100	3.62
August	104	82	93.2	7	6	18	9.58	100	3.70
September	101	79	90.1	7	6	18	9.73	100	3.60
October	91	65	78.1	8	9	15	9.49	100	3.56
November	81	56	68.7	8	6	14	10.17	100	3.80
December	65	46	56.0	8	16	12	9.02	100	3.41

Note: All other required temperature and fuel-related inputs not listed assumed NONROAD2008 default values.

EPA recommends adjusting default NONROAD2008a model values (such as equipment population, activity levels of equipment, growth factors, etc.) where local data is available, as the default values in the model are derived from national averages. The NONROAD2008a model defaults were adjusted in the following manner:

- Equipment population numbers and activity levels for commercial lawn and garden equipment were adjusted based on 2003 survey results of the commercial lawn and garden industry performed by ENVIRON as part of an inventory developed to study the impact of visibility impairing pollutants (ENVIRON et al., 2003). Survey results show that for most categories of lawn and garden equipment, the equipment populations for Maricopa County are significantly lower than EPA default values, while the average annual hours of operation for most equipment types are slightly higher than EPA's values. Using these new local data results in a considerable decrease in emissions from this category, compared with earlier results using EPA default data.

The NONROAD2008a model does not calculate emission values for NH₃. Ammonia emission calculations for the NONROAD2008a model were derived by using a multiplier of NO_x emissions developed by ENVIRON (2003).

Spatial allocation factors were developed (based on EPA guidance documents) to apportion non-road emissions to the PM₁₀ nonattainment area. The approaches used are described in each section of this chapter.

Temporal allocations (used to calculate PM₁₀ typical daily emissions) for nonroad equipment categories modeled in the NONROAD2008a model are based on EPA recommendations on weekday and weekend day activity levels for each nonroad equipment category (US EPA, 1999). Table 4.1–2 below lists the weighted activity level allocation fractions for each equipment class for weekdays and weekend days. For this report, the most conservative (highest) allocation fraction in each nonroad equipment class was used to calculate typical daily emissions.

Table 4.1–2. Default weekday and weekend day activity allocation fractions.

Equipment category	Weekday	Weekend day
Agricultural	0.1666667	0.0833334
Airport ground support	0.1428571	0.1428571
Commercial	0.1666667	0.0833334
Construction and mining	0.1666667	0.0833334
Industrial	0.1666667	0.0833334
Lawn and garden (residential)	0.1111111	0.2222222
Lawn and garden (commercial)	0.1600000	0.1000000
Logging	0.1666667	0.0833334
Pleasure craft	0.0600000	0.3500000
Railway maintenance	0.1800000	0.0500000
Recreational	0.1111111	0.2222222

4.2 Agricultural equipment

Annual emissions from agricultural equipment in Maricopa County were calculated using EPA's NONROAD2008a model as discussed above. County-wide results are shown in Table 4.2–1.

Table 4.2–1. Annual emissions from agricultural equipment in Maricopa County.

Geographic area	Annual emissions (tons/yr)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Maricopa County	29.45	28.56	330.49	0.19	0.62

Annual emissions for the PM₁₀ nonattainment area were calculated based on EIIP guidance (US EPA, 2002) which recommends using the ratio of agricultural land inside the nonattainment area to agricultural land inside the county. See Section 1.5.2 for a discussion of land use data used.

$$\begin{aligned}
 \text{PM}_{10} \text{ NAA emissions from agricultural equipment} &= \text{Total County PM}_{10} \text{ emissions from agricultural equipment} \times \text{Agricultural land use allocation factor} \\
 &= 29.45 \text{ tons} \times 42.96\% \\
 &= 12.65 \text{ tons PM}_{10} / \text{yr}
 \end{aligned}$$

Table 4.2–2. Annual emissions from agricultural equipment in the PM₁₀ NAA.

Geographic area	Annual emissions (tons/yr)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
PM ₁₀ NAA	12.65	12.27	141.97	0.08	0.26

County typical daily emissions were calculated by multiplying annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for agricultural equipment listed in Table 4.1–2, and dividing the product by the number of weeks (52) in the year (US EPA, 1999), as follows:

$$\begin{aligned}
 \text{Average County PM}_{10} \text{ daily emissions (lbs/day)} &= \text{Annual PM}_{10} \text{ emissions (tons/yr)} \times \text{daily activity allocation factor for agricultural equipment (week/day)} \times 2000 \text{ (lbs/ton)} \div 52 \text{ (wks/yr)} \\
 &= 29.45 \times 0.166667 \times 2000 \div 52 \\
 &= 188.8 \text{ lbs/day}
 \end{aligned}$$

Table 4.2–3. Typical daily emissions from agricultural equipment in Maricopa County.

Geographic area	Typical daily emissions (lbs/day)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Maricopa County	188.8	183.1	2,118.5	1.2	4.0

PM₁₀ nonattainment area typical daily emissions were calculated by multiplying County typical daily emissions by the agricultural land use allocation factor:

$$\begin{aligned}
 \text{PM}_{10} \text{ NAA average-day emissions} &= \text{Maricopa County PM}_{10} \text{ typical daily emissions} \times \text{Agricultural land use allocation factor} \\
 &= 188.8 \text{ lbs/day} \times 42.96\% \\
 &= 81.1 \text{ lbs/day}
 \end{aligned}$$

Table 4.2–4. Typical daily emissions from agricultural equipment in the PM₁₀ NAA.

Geographic area	Typical daily emissions (lbs/day)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
PM ₁₀ NAA	81.1	78.6	910.0	0.5	1.7

4.3 Airport ground support equipment

Annual emissions from airport ground support equipment (GSE) and auxiliary power units (APUs) were calculated using the Emissions Dispersion Modeling System (EDMS, v. 5.1.3) from the U.S. Federal Aviation Administration (FAA). Activity data on 2011 aircraft operations and GSE use for eight major airports were obtained from FAA's Air Traffic Activity Data System. In addition, activity data for 2011 for six small general aviation airports were assumed to be the same as those in 2008, which was included in MAG's 2009 survey data. (Further details concerning the modeling input data and results are described in Section 4.11, Aircraft). Emissions from GSE and APUs at Luke Air Force Base (AFB) for the year 2011 are assumed to be the same as those used in the 2008 PM₁₀ Periodic Emissions Inventory Report for the Maricopa County, Arizona, Nonattainment Area (MCAQD, 2011) based on input from Luke AFB.

Table 4.3–1. Annual emissions (tons/yr) from airport ground support equipment (GSE) and auxiliary power units (APUs).

	Maricopa County					PM ₁₀ NAA				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃ *	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃ *
GSE	9.08	8.63	317.86	7.01		8.90	8.46	312.28	6.90	
APUs	12.99	12.99	88.18	12.15		12.98	12.98	88.10	12.13	
Total:	22.07	21.62	406.04	19.16		21.88	21.44	400.37	19.03	

* The EDMS model does not include calculation of ammonia emissions.

Table 4.3–2. Typical daily emissions (lbs/day) from airport GSE and APUs.

	Maricopa County					PM ₁₀ NAA				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃ *	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃ *
GSE	49.8	47.3	1,741.7	38.4		48.8	46.4	1,711.1	37.8	
APUs	71.2	71.2	483.2	66.6		71.1	71.1	482.7	66.5	
Total:	120.9	118.5	2,224.9	105.0		119.9	117.5	2,193.8	104.3	

* The EDMS model does not include calculation of ammonia emissions.

4.4 Commercial equipment

Annual emissions from commercial equipment in Maricopa County were calculated using EPA's NONROAD2008a model, as described in Section 4.1. Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of industrial employment in the nonattainment area to Maricopa County totals, as data on the number of wholesale establishments recommended by EIIP guidance (US EPA, 2002) was not available. See Section 1.5.1 for a discussion of the industrial employment data used.

Table 4.4–1. Annual emissions from commercial equipment.

Annual emissions (tons/yr)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
114.81	109.77	1,361.42	1.89	20.84	114.77	109.73	1,360.88	1.89	20.83

County typical daily emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for commercial equipment (0.1666667) listed in Table 4.1–2, and dividing the product by the number of weeks (52) in the year (US EPA, 1999). PM₁₀ nonattainment area typical daily emissions were calculated based on industrial employment ratios as described above.

Table 4.4–2. Typical daily emissions (lbs/day) from commercial equipment.

Typical daily emissions (lbs/day)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
736.0	703.7	8,727.0	12.1	133.6	735.7	703.4	8,723.6	12.1	133.5

4.5 Construction and mining equipment

Annual emissions from construction and mining equipment in Maricopa County were calculated using EPA’s NONROAD2008a model as described in Section 4.1. Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of construction employment in the nonattainment area to Maricopa County totals as a conservative estimate, since the EIIP-recommended allocation factor of total dollar value of construction was unavailable (US EPA, 2002). See Section 1.5.1 for a discussion of the employment data used.

Table 4.5–1. Annual emissions from construction and mining equipment.

Annual emissions (tons/yr)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
1,179.08	1,141.28	12,937.30	9.31	24.44	1,133.79	1,097.44	12,440.29	8.95	23.50

County typical daily emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for construction/mining equipment (0.1666667) listed in Table 4.1–2, and dividing the product by the number of weeks (52) in the year (US EPA, 1999). PM₁₀ nonattainment area typical daily emissions were calculated based on construction employment ratios as described above.

Table 4.5–2. Typical daily emissions from construction and mining equipment.

Typical daily emissions (lbs/day)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
7,558.2	7,315.9	82,931.4	59.7	156.6	7,267.9	7,034.9	79,745.5	57.4	150.6

4.6 Industrial equipment

Annual emissions from industrial equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of industrial employment in the nonattainment area to Maricopa County totals as a conservative estimate, since the number of employees in manufacturing, as recommended by EIIP guidance (US EPA, 2002), was unavailable. See Section 1.5.1 for a discussion of the industrial employment data used.

Table 4.6–1. Annual emissions from industrial equipment.

Annual emissions (tons/yr)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
97.08	94.54	1,839.35	3.47	32.72	97.04	94.50	1,838.63	3.47	32.71

County typical daily emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for industrial equipment (0.1666667) listed in Table 4.1–2, and dividing the product by the number of weeks (52) in the year (US EPA, 1999). PM₁₀ nonattainment area typical daily emissions were calculated based on industrial employment ratios as described above.

Table 4.6–2. Typical daily emissions from industrial equipment.

Typical daily emissions (lbs/day)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
622.3	606.0	11,790.7	22.2	209.8	622.1	605.8	11,786.1	22.2	209.7

4.7 Lawn and garden equipment

Annual emissions from lawn and garden equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. These results reflect new equipment population and usage estimates from survey work done in early 2003 for the Arizona Department of Environmental Quality (discussed further in Section 4.1). Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of population in the nonattainment area to Maricopa County totals, since the number of housing units, as recommended by EIIIP guidance (US EPA, 2002), was not available. See Section 1.5.1 for a discussion of the population data used. The annual emissions for Maricopa County and the PM₁₀ nonattainment area are shown in Table 4.7–1.

Table 4.7–1. Annual emissions from lawn and garden equipment.

Annual emissions (tons/yr)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
209.49	193.80	866.64	2.10	21.81	210.83	195.04	872.19	2.11	21.95

County typical daily emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for lawn and garden equipment (0.1600000 for the commercial segment, 0.2222222 for residential) listed in Table 4.1–2, and dividing the product by 52 (the number of weeks in a year; US EPA, 1999). PM₁₀ nonattainment area typical daily emissions were calculated based on population as described above. The typical daily emissions for Maricopa County and the PM₁₀ nonattainment area are shown in Table 4.7–2.

Table 4.7–2. Typical daily emissions from lawn and garden equipment.

Typical daily emissions (lbs/day)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
1,424.6	1,317.2	6,062.0	15.1	160.5	1,433.7	1,325.6	6,100.9	15.2	161.5

4.8 Pleasure craft

Annual emissions from pleasure craft equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of lake surface area in the

nonattainment area to Maricopa County totals, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.2 for a discussion of the land use data used.

Table 4.8-1. Annual emissions from pleasure craft equipment.

Annual emissions (tons/yr)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
7.06	6.52	96.56	0.11	2.40	5.36	4.95	73.32	0.08	1.83

County typical daily emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for pleasure craft (0.3500000) listed in Table 4.1-2, and dividing the product by the number of weeks (52) in the year (US EPA, 1999). PM₁₀ nonattainment area typical daily emissions were calculated based on lake surface area as described above.

Table 4.8-2. Typical daily emissions from pleasure craft equipment.

Typical daily emissions (lbs/day)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
95.0	87.8	1,299.9	1.5	32.4	72.1	66.7	987.0	1.1	24.6

4.9 Railway maintenance equipment

Annual emissions from railway maintenance equipment in Maricopa County were calculated using EPA's NONROAD2008a model, as described in Section 4.1. Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of population in the nonattainment area to Maricopa County totals, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.1 for a discussion of the population data used.

Table 4.9-1. Annual emissions from railway maintenance equipment.

Annual emissions (tons/yr)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
1.03	1.00	8.55	0.00	0.02	1.04	1.01	8.60	0.00	0.02

County typical daily emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for railway maintenance equipment (0.1800000) listed in Table 4.1-2, and dividing the product by the number of weeks (52) in the year (US EPA, 1999). PM₁₀ nonattainment area typical daily emissions were calculated based on the population ratio as described above.

Table 4.9-2. Typical daily emissions from railway maintenance equipment.

Typical daily emissions (lbs/day)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
7.1	6.9	59.2	0.0	0.1	7.2	7.0	59.5	0.0	0.1

4.10 Recreational equipment

Annual emissions from recreational equipment in Maricopa County were calculated using EPA’s NONROAD2008a model, as described in Section 4.1. Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of passive open space and vacant land use in the nonattainment area to Maricopa County totals as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.2 for a discussion of the land use data used.

Table 4.10–1. Annual emissions from recreational equipment.

Annual emissions (tons/yr)									
Maricopa County					PM ₁₀ nonattainment area				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
43.65	40.20	66.10	0.28	2.19	7.79	7.17	11.79	0.05	0.39

County typical daily emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2008a model) by the most conservative weekday/weekend day activity allocation factor for recreational equipment (0.2222222) listed in Table 4.1–2, and dividing the product by the number of weeks (52) in the year (US EPA, 1999). PM₁₀ nonattainment area typical daily emissions were calculated based on land use as described above.

Table 4.10–2. Typical daily emissions from recreational equipment.

Typical daily emissions (lbs/day)									
Maricopa County					PM ₁₀ NAA				
PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
373.1	343.6	565.0	2.4	18.7	66.6	61.3	100.8	0.4	3.3

4.11 Aircraft

Emissions from aircraft at the largest airports in Maricopa County were estimated using the Federal Aviation Administration’s Emissions and Dispersion Model (EDMS, v. 5.1.3). The FAA EDMS model combines specified aircraft and activity levels with default emissions factors in order to estimate annual emissions inventories for a specific airport. The model calculates emissions of sulfur oxides (SO_x), nitrogen oxides (NO_x), particulate matter (only for certain categories of airframes and engines), carbon monoxide (CO), and hydrocarbons (HC). The model can also estimate emissions from ground support equipment (GSE) and auxiliary power units (APUs), using either default profiles or user-specified activity of these components. The EDMS runs were executed by the Maricopa Association of Governments. The contact person for the EDMS emission estimates is Adam Xia (602-254-6300).

Aircraft emissions are estimated for four aircraft categories:

- Air carriers (abbreviated “AC”): Larger commercial aircraft with at least 60 seats or 18,000 lbs payload capacity, used for scheduled service to transport passengers and/or freight;
- Air taxis (“AT”): Smaller commercial turbine- or piston-powered aircraft with less than 60 seats or 18,000 lbs payload capacity;
- General aviation (“GA”): Aircraft used on an unscheduled basis for recreational flying, personal transportation, and other activities, including business travel; and
- Military (“ML”): Aircraft used to support military operations.

First, three databases from FAA's website provide the year 2011 aircraft activity, fleet mix for the types of aircraft used, and hourly/weekly/monthly operational profiles for eight major airports (Chandler Municipal, Falcon Field, Glendale Municipal, Phoenix Deer Valley, Phoenix Goodyear, Phoenix-Mesa Gateway, Phoenix Sky Harbor, and Scottsdale airport). The three databases are (1) FAA's Air Traffic Activity Data System (ATADS) (FAA, 2012a); (2) Enhanced Traffic Management System Counts (ETMSC) database; and (3) FAA Aviation Performance Metrics (APM) database (FAA, 2012b).

To supplement the FAA's database for the eight major airports, MAG conducted a survey of six additional small general aviation airports (Buckeye Municipal, Gila Bend Municipal, Pleasant Valley, Sky Ranch at Carefree, Stellar Airpark, and Wickenburg Municipal airport) in Maricopa County to gather the year 2008 data on aircraft activity (landing and take-off or LTOs) and estimated average taxi/idle times in 2009. The year 2008 data for these small general aviation airports are assumed to be the same as those in year 2011, since no updated aircraft activity data were available for the year 2011. Table 4.11-1 summarizes the activity level for each aircraft category for each airport included in the modeling, and indicates the data sources for each airport's activity (reported number of operations) and fleet mix.

One required meteorological input for EDMS is an atmospheric mixing height, which is defined as the height (or depth) above ground where relatively vigorous vertical mixing occurs due to convection. To calculate the time-varying mixing height, the latest version of the EPA AERMOD Meteorological Preprocessor (AERMET version 11059) was employed.

Both the 2011 hourly surface meteorological data and the 2011 one-minute Automated Surface Observing System (ASOS) wind data from the National Weather Service (NWS) station at the Phoenix Sky Harbor were used (NCDC, 2012). Full year upper air data in 2011 at the Tucson station (station number 23160) were obtained from the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Radiosonde Database (ESRL, 2012). Ultimately, a single mixing height dataset in 2011 is used for all airports, except Luke Air Force Base.

Table 4.11–1. Annual airport operations (by aircraft category) and related data sources.

Airport	Airport Code	Operations Data Source¹	Fleet Mix Data Source²	Aircraft Type³	2011 Operations
Buckeye Municipal	BXK	airnav.com	Generic GA profile	GA	53,070
Chandler Municipal	CHD	FAA/ATADS	FAA/ETMSC	AC	6
				AT	2,168
				GA	158,960
				ML	456
Falcon Field	FFZ	FAA/ATADS	FAA/ETMSC	AC	4
				AT	2,718
				GA	214,486
				ML	2,872
Gila Bend Municipal	E63	airnav.com	Generic GA profile	GA	3,536
Glendale Municipal	GEU	FAA/ATADS	FAA/ETMSC	AT	1,070
				GA	85,998
				ML	56
Luke Air Force Base	LUF	[2008 F-16 aircraft emissions are scaled based on the number of F-16s in 2008 vs. 2011]			
Phoenix Deer Valley	DVT	FAA/ATADS, Survey response	Survey response, FAA/ETMSC	AC	2
				AT	3,832
				GA	313,362 *
				ML	248
Phoenix Goodyear	GYR	FAA/ATADS, Survey response	Survey response, FAA/ETMSC	AC	146
				AT	312
				GA	132,566 *
				ML	5,582
Phoenix-Mesa Gateway (formerly Williams Gateway)	IWA	FAA/ATADS	FAA/ETMSC	AC	7,782
				AT	9,176
				GA	147,596
				ML	6,646
Phoenix Sky Harbor	PHX	FAA/ATADS	FAA/ETMSC	AC	375,104
				AT	63,796
				GA	20,582
				ML	2,506
Pleasant Valley	P48	airnav.com	Generic GA profile	GA	6,010
Scottsdale	SDL	FAA/ATADS	FAA/ETMSC	AC	6
				AT	12,970
				GA	127,924
				ML	740
Sky Ranch at Carefree	18AZ	Survey response	Generic GA profile	GA	3,030
Stellar Airpark	P19	airnav.com	Generic GA profile	GA	39,056
Wickenburg Municipal	E25	Survey responses	Generic GA profile	GA	12,000

1. FAA/ATADS: Federal Aviation Administration’s Air Traffic Activity Data System (database); <http://aspm.faa.gov>.

2. FAA/ETMSC: Federal Aviation Administration’s Enhanced Traffic Management System Counts (database); <http://aspm.faa.gov>.

3. AC: Air Commercial; AT: Air Taxi; GA: General Aviation; ML: Military

* includes touch-and-go operations reported by airport.

F-16 aircraft emissions calculations at Luke AFB for the year 2011 were scaled using a ratio of the number of F-16s in 2011 to the number of F-16s in 2008. The emissions from “transient” aircraft and on-wing engine testing in 2011 were assumed to be the same as those in 2008 based on input from Luke AFB. Emissions from the military aircraft, “transient” aircraft, and on-wing engine testing were summed into a single “ML” category for Luke AFB. This summation method is consistent with that used in the 2008 PM₁₀ Periodic Emissions Inventory for the Maricopa County, Arizona, Nonattainment Area (MCAQD, 2011).

As with all other airports included in this inventory, emissions from ground support equipment (GSE) at Luke AFB are addressed in Section 4.3, Airport ground support equipment.

The following section describes how activity and emissions were estimated for a representative airport, Falcon Field (FFZ). The FAA's Air Traffic Activity System (ATADS, www.aspm.faa.gov) provided 2011 activity by aircraft type; these results are contained in Table 4.11-1. While ATADS reported a total of 214,486 general aviation operations at this airport in 2011, further information on the aircraft types comprising this activity was needed. The FAA's Enhanced Traffic Management System Counts (ETMSC) database was used to "grow" available aircraft-specific operational data as described below.

The ETMSC database on general aviation activity at Falcon Field airport (FFZ) in 2011 comprises 145 different aircraft types, totaling 3,731 operations (See Table 4.11-2). To simplify modeling input requirements, this aircraft-specific activity data were ranked in order of decreasing frequency. Activity data for the most frequently reported aircraft was then grown to represent all general aviation activity. How this approach was applied for general aviation activity at Falcon Field airport is shown in Table 4.11-2.

This approach of ranking reported activity, and then growing this subset of data, typically resulted in 10 to 30 aircraft types being modeled for each airport/aircraft class combination, representing 75 to 100% of all reported activity.

Since the EDMS model includes estimates of PM₁₀ emissions only for certain aircraft/engine types, all model output files were reviewed for missing data. Where the EDMS model contained no PM₁₀ emission estimates, the default EPA emission factors listed in Table 4.11-3 were assigned (US EPA, 2003).

Per EPA guidance, PM_{2.5} emissions were estimated as 92% of PM₁₀ emissions (US EPA, 2003). All activity was assumed to occur evenly throughout the year, typical daily emissions were calculated by dividing annual totals by 365 [= days per year in 2011]. Tables 4.11-4 and 4.11-5 list the total annual emissions and typical daily emissions by aircraft type, for airports located inside and outside the PM₁₀ NAA, respectively.

Table 4.11–2. Growing aircraft-specific activity for EDMS modeling input.

Rank	Aircraft Type	ETMSC- Reported Operations	% of Total Reported Operations	Cumulative Percent	“Grown” Operations for EDMS Modeling
1	DA40 - Diamond Star DA40	536	14.37%	14.37%	40,796
2	BE9L - Beech King Air 90	350	9.38%	23.75%	26,640
3	P28R - Cherokee Arrow/Turbo	250	6.70%	30.45%	19,028
4	DA42 - Diamond Twin Star	163	4.37%	34.82%	12,406
5	BE20 - Beech 200 Super King	130	3.48%	38.30%	9,894
6	C25B - Cessna Citation CJ3	118	3.16%	41.46%	8,982
7	PC12 - Pilatus PC-12	110	2.95%	44.41%	8,372
8	C680 - Cessna Citation Sovereign	103	2.76%	47.17%	7,840
9	C441 - Cessna Conquest	99	2.65%	49.83%	7,536
10	B350 - Beech Super King Air 350	86	2.31%	52.13%	6,546
11	BE36 - Beech Bonanza 36	84	2.25%	54.38%	6,394
12	C172 - Cessna Skyhawk 172/Cutlass	83	2.22%	56.61%	6,318
13	CL60 - Bombardier Challenger 600/601/604	70	1.88%	58.48%	5,328
14	P46T - Piper Malibu Meridian	68	1.82%	60.31%	5,176
15	SR22 - Cirrus SR 22	67	1.80%	62.10%	5,100
16	P28A - Piper Cherokee	62	1.66%	63.76%	4,718
17	COL4 - Lancair LC-41 Columbia 400	52	1.39%	65.16%	3,958
18	TBM7 - Socata TBM-7	50	1.34%	66.50%	3,806
19	C182 - Cessna Skylane 182	48	1.29%	67.78%	3,654
20	C560 - Cessna Citation V/Ultra/Encore	47	1.26%	69.04%	3,578
21	M20P - Mooney M-20C Ranger	46	1.23%	70.28%	3,502
22	C210 - Cessna 210 Centurion	44	1.18%	71.46%	3,348
23	PAY2 - Piper Cheyenne 2	40	1.07%	72.53%	3,044
24	C525 - Cessna CitationJet/CJ1	38	1.02%	73.55%	2,892
25	BE35 - Beech Bonanza 35	37	0.99%	74.54%	2,816
26	C414 - Cessna Chancellor 414	37	0.99%	75.53%	2,814
∴	∴	∴	∴	∴	
145	T34P - Beech T-34B Mentor	1	< 0.1%	100.00%	(n/a)
Total:		3,731			214,486

Table 4.11–3. Default PM₁₀ emission factors for aircraft.

Activity type	PM ₁₀ Emission Factor (lb/LTO)
Air Carrier, Air Taxi, Military	0.6033
General Aviation	0.2367

Table 4.11–4. Annual and typical daily emissions, by aircraft type, from airports in the PM₁₀ NAA.

Facility	Cate- gory	Annual emissions (tons/yr)				Typical daily emissions (lbs/day)			
		PM ₁₀	PM _{2.5}	NO _x	SO _x	PM ₁₀	PM _{2.5}	NO _x	SO _x
Chandler Municipal	AC	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
	AT	0.33	0.30	1.23	0.27	1.8	1.7	6.7	1.5
	GA	9.41	8.66	14.18	5.55	51.6	47.4	77.7	30.4
	ML	0.07	0.06	0.04	0.02	0.4	0.4	0.2	0.1
	Total	9.81	9.02	15.45	5.84	53.8	49.5	84.7	32.0
Falcon Field	AC	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
	AT	0.41	0.38	2.27	0.39	2.2	2.1	12.4	2.1
	GA	12.69	11.67	31.13	8.61	69.5	64.0	170.6	47.2
	ML	0.43	0.40	2.67	0.33	2.4	2.2	14.6	1.8
	Total	13.53	12.45	36.07	9.33	74.1	68.2	197.6	51.1
Glendale Municipal	AT	0.16	0.15	0.88	0.16	0.9	0.8	4.8	0.9
	GA	5.09	4.68	17.14	5.35	27.9	25.7	93.9	29.3
	ML	0.01	0.01	0.01	0.00	0.1	0.1	0.1	0.0
	Total	5.26	4.84	18.02	5.51	28.8	26.5	98.8	30.2
Luke Air Force Base	ML	57.00	56.99	347.83	28.85	312.3	312.3	1,905.9	158.1
Phoenix Deer Valley	AC	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
	AT	0.58	0.53	3.00	0.51	3.2	2.9	16.4	2.8
	GA	19.61	18.04	52.99	12.73	107.5	98.9	290.4	69.7
	ML	0.04	0.04	0.11	0.02	0.2	0.2	0.6	0.1
	Total	20.23	18.61	56.10	13.26	110.8	102.0	307.4	72.7
Phoenix Goodyear	AC	0.02	0.02	0.40	0.05	0.1	0.1	2.2	0.3
	AT	0.05	0.05	1.01	0.11	0.3	0.3	5.5	0.6
	GA	7.84	7.21	13.80	3.45	43.0	39.5	75.6	18.9
	ML	0.84	0.77	1.31	0.36	4.6	4.2	7.2	2.0
	Total	8.75	8.05	16.52	3.96	47.9	44.1	90.6	21.7
Phoenix Sky Harbor Intl	AC	56.58	52.05	1823.15	190.30	310.0	285.2	9,989.9	1,042.8
	AT	9.62	8.85	101.94	15.54	52.7	48.5	558.6	85.1
	GA	1.22	1.12	7.41	1.78	6.7	6.2	40.6	9.8
	ML	0.38	0.35	14.01	2.44	2.1	1.9	76.7	13.3
	Total	67.80	62.38	1946.50	210.06	371.5	341.8	10,665.8	1,151.0
Phoenix-Mesa Gateway Airport	AC	1.17	1.08	27.46	3.69	6.4	5.9	150.5	20.2
	AT	1.38	1.27	3.53	0.95	7.6	7.0	19.3	5.2
	GA	8.73	8.03	9.81	3.61	47.8	44.0	53.8	19.8
	ML	1.00	0.92	25.62	3.78	5.5	5.0	140.4	20.7
	Total	12.28	11.31	66.42	12.02	67.3	61.9	364.0	65.9
Pleasant Valley	GA	0.36	0.33	1.61	0.33	2.0	1.7	8.9	1.8
Scottsdale	AC	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
	AT	1.96	1.80	8.19	1.62	10.7	9.9	44.9	8.9
	GA	7.57	6.96	67.08	15.31	41.5	38.2	367.6	83.9
	ML	0.11	0.10	0.35	0.09	0.6	0.6	1.9	0.5
	Total	9.64	8.87	75.63	17.03	52.8	48.6	414.4	93.3
Skyranch at Carefree	GA	0.18	0.17	0.58	0.14	1.0	0.9	3.2	0.8
Stellar Airpark	GA	2.31	2.13	2.38	0.88	12.7	11.6	13.0	4.8
PM₁₀ NAA total:		207.15	195.15	2,583.11	307.21	1,135.0	1,069.1	14,154.3	1,683.4

AC: Air Commercial; AT: Air Taxi; GA: General Aviation; ML: Military

Table 4.11–5. Annual and typical daily emissions, by aircraft type, from airports outside the PM₁₀ NAA.

Facility	Cate- gory	Annual emissions (tons/yr)				Typical daily emissions (lbs/day)			
		PM ₁₀	PM _{2.5}	NO _x	SO _x	PM ₁₀	PM _{2.5}	NO _x	SO _x
Buckeye Municipal	GA	3.14	2.89	2.69	0.86	17.2	15.8	14.7	4.7
Gila Bend Municipal	GA	0.21	0.19	0.18	0.06	1.1	1.0	1.0	0.3
Wickenburg Municipal	GA	0.71	0.65	2.84	0.66	3.9	3.6	15.6	3.6
Maricopa County total:		211.21	198.88	2,588.82	308.79	1,157.2	1,089.5	14,185.6	1,692.0

4.12 Locomotives

Annual emissions from locomotives were calculated based on diesel fuel usage data provided by Burlington Northern/Santa Fe Railway (BNSF), Union Pacific Railway (UP) and Amtrak. Railway operations from these companies fall into three categories: Class I haul lines, yard/switching operations, and passenger trains. Annual emissions from these categories were calculated by multiplying diesel fuel usage by the emission factors shown in Table 4.12–1 (US EPA, 2009; Environ, 2007).

Table 4.12–1. Emission factors for locomotives.

Activity type	Emission factors (lbs/gal diesel)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Class I haul line	0.010	0.010	0.328	0.037	0.0003
Yard/switch operations	0.012	0.012	0.517	0.037	0.0003
Passenger trains	0.010	0.010	0.367	0.037	0.0003

Fuel use reported by railroads and emission totals are summarized in Table 4.12–2.

Table 4.12–2. Total diesel use and annual emissions from locomotives in Maricopa County.

Locomotive type	Diesel use (gals/yr)	Annual emissions (tons/yr)				
		PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Class I haul line	7,706,715	37.30	36.18	1,263.13	141.57	0.98
Yard/switch operations	520,076	3.03	2.94	134.44	9.55	0.07
Passenger trains	46,301	0.23	0.22	8.51	0.85	0.01
Total:	8,273,092	40.56	39.34	1,406.08	151.98	1.06

PM₁₀ nonattainment area emissions were calculated by multiplying Maricopa County emissions by the percentage of track miles within the PM₁₀ nonattainment area, determined by GIS mapping. Results are shown in Table 4.12–3.

Table 4.12–3. Annual emissions from locomotives in the PM₁₀ NAA.

Locomotive type	Track in PM ₁₀ NAA(%)	Annual emissions (tons/yr)				
		PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Class I haul line	44.27	16.51	16.02	559.19	62.67	0.44
Yard/switch operations	100.00	3.03	2.94	134.44	9.55	0.07
Passenger trains	0.00	0.00	0.00	0.00	0.00	0.00
Total:		19.54	18.96	693.63	72.23	0.50

PM₁₀ typical daily emissions for both the county (shown in Table 4.12–4) and the PM₁₀ nonattainment area (Table 4.12–5) were calculated by dividing annual totals by 365 days, as locomotive activity is assumed to be uniform throughout the year.

Table 4.12–4. Typical daily emissions from locomotives in Maricopa County.

Locomotive type	Typical daily emissions (lbs/day)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Class I haul line	204.4	198.3	6,921.3	775.7	5.4
Yard/switch operations	16.6	16.1	736.7	52.3	0.4
Passenger trains	1.3	1.2	46.6	4.7	0.0
Total:	222.3	215.6	7,704.5	832.7	5.8

Table 4.12–5. Typical daily emissions from locomotives in the PM₁₀ NAA

Locomotive type	Typical daily emissions (lbs/day)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Class I haul line	90.5	87.8	3,064.0	343.4	2.4
Yard/switch operations	16.6	16.1	736.7	52.3	0.4
Passenger trains	0.0	0.0	0.0	0.0	0.0
Total:	107.1	103.9	3,800.7	395.8	2.7

4.13 Summary of all nonroad mobile source emissions

Table 4.13–1 summarizes annual and typical daily emissions of PM₁₀, PM_{2.5}, NO_x, SO_x and NH₃ from nonroad mobile sources in Maricopa County. Table 4.13–2 shows annual and typical daily emissions for these pollutants in the PM₁₀ nonattainment area.

Table 4.13–1. Annual and typical daily emissions from nonroad mobile sources in Maricopa County.

Category	Annual emissions (tons/yr)					Typical daily emissions (lbs/day)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Agricultural	29.45	28.56	330.49	0.19	0.62	188.8	183.1	2,118.5	1.2	4.0
Airport GSE+APUs	22.07	21.62	406.04	19.16		120.9	118.5	2,224.9	105.0	
Commercial	114.81	109.77	1,361.42	1.89	20.84	736.0	703.7	8,727.0	12.1	133.6
Construction & mining	1,179.08	1,141.28	12,937.30	9.31	24.44	7,558.2	7,315.9	82,931.4	59.7	156.6
Industrial	97.08	94.54	1,839.35	3.47	32.72	622.3	606.0	11,790.7	22.2	209.8
Lawn & garden	209.49	193.80	866.64	2.10	21.81	1,424.6	1,317.2	6,062.0	15.1	160.5
Pleasure craft	7.06	6.52	96.56	0.11	2.40	95.0	87.8	1,299.9	1.5	32.4
Railway maintenance	1.03	1.00	8.55	0.00	0.02	7.1	6.9	59.2	0.0	0.1
Recreational	43.65	40.20	66.10	0.28	2.19	373.1	343.6	565.0	2.4	18.7
Aircraft	211.21	198.88	2,588.82	308.79		1,157.2	1,089.5	14,185.6	1,692.0	
Locomotives	40.56	39.34	1,406.08	151.98	1.06	222.3	215.6	7,704.5	832.7	5.8
Total:	1,955.49	1,875.51	21,907.35	497.28	106.10	12,505.5	11,987.8	137,668.7	2,743.9	721.5

Table 4.13–2. Annual and typical daily emissions from nonroad mobile sources in the PM₁₀ NAA.

Category	Annual emissions (tons/yr)					Typical daily emissions (lbs/day)				
	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
Agricultural	12.65	12.27	141.97	0.08	0.26	81.1	78.6	910.0	0.5	1.7
Airport GSE+APUs	21.88	21.44	400.37	19.03		119.9	117.5	2,193.8	104.3	
Commercial	114.77	109.73	1,360.88	1.89	20.83	735.7	703.4	8,723.6	12.1	133.5
Construction & mining	1,133.79	1,097.44	12,440.29	8.95	23.50	7,267.9	7,034.9	79,745.5	57.4	150.6
Industrial	97.04	94.50	1,838.63	3.47	32.71	622.1	605.8	11,786.1	22.2	209.7
Lawn & garden	210.83	195.04	872.19	2.11	21.95	1,433.7	1,325.6	6,100.9	15.2	161.5
Pleasure craft	5.36	4.95	73.32	0.08	1.83	72.1	66.7	987.0	1.1	24.6
Railway maintenance	1.04	1.01	8.60	0.00	0.02	7.2	7.0	59.5	0.0	0.1
Recreational	7.79	7.17	11.79	0.05	0.39	66.6	61.3	100.8	0.4	3.3
Aircraft	207.15	195.15	2,583.11	307.21		1,135.0	1,069.1	14,154.3	1,683.4	
Locomotives	19.54	18.96	693.63	72.23	0.50	107.1	103.9	3,800.7	395.8	2.7
Total:	1,831.84	1,757.66	20,424.78	415.10	101.99	11,648.4	11,173.8	128,562.2	2,292.4	687.7

4.14 Quality assurance procedures

Established procedures were used to check, and correct when necessary, the nonroad mobile sources emissions estimates. All NONROAD2008a model input and output files, and Excel spreadsheets used to calculate the emissions, were checked by personnel not involved in developing the modeling inputs/outputs and spreadsheets being reviewed. In addition, the emissions estimates were reviewed for reasonableness by external agency staff.

4.15 References

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