

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 all nonroad mobile sources except aircraft, airport ground support equipment and locomotives are derived from EPA's NONROAD2005 model (Core version 2005a, Feb. 2006). Aircraft and airport ground support equipment emission calculations were derived from individual surveys of county airports. Locomotive emission calculations were derived from surveys of the 3 railroad companies that have operations in the county (Burlington Northern Santa Fe, Union Pacific and Amtrak).

County specific temperature and fuel-related inputs are required for the operation of the NONROAD2005 model. Monthly temperature and fuel data were provided by the Arizona State Weights and Measures Department. The following table lists the local county inputs used:

Table 4.1-1. NONROAD2005 model county temperature and fuel-related inputs.

Month	Max (°F)	Min (°F)	Average (°F)	Fuel RVP (psi)	Diesel Sulfur (ppm)	Gasoline Sulfur (ppm)
January	81	41	57.8	9	354	39
February	72	46	59.2	9	318	43
March	88	46	63.9	9	303	29
April	96	53	72.3	8	301	39
May	109	60	82.7	7	299	43
June	114	71	90.4	7	286	84
July	116	79	97.3	6	260	45
August	113	72	92.2	7	287	40
September	108	70	89.6	7	314	37
October	101	58	78.3	8	339	30
November	90	40	66.3	9	364	34
December	78	35	56.8	9	389	30

Note: All other required temperature and fuel-related inputs not listed assumed NONROAD2005 default values

EPA recommends adjusting default NONROAD2005 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 NONROAD2005 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 is a considerable decrease in emissions from this category, compared with earlier results using EPA default data.

The NONROAD2005 model does not calculate emission values for NH₃. Ammonia emission calculations for NONROAD2005 model were derived by using a ratio of NO_x emissions developed by ENVIRON (2003).

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

Temporal allocations (used to calculate PM₁₀ average-day emissions) for nonroad equipment categories modeled in the NONROAD2005 model come from EPA recommendations on week-day 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 average-day 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 NONROAD2005 model, as discussed above. County-wide results are shown in Table 4.2–1.

Table 4.2-1. Annual emissions (in tons/yr) from agricultural equipment in Maricopa County.

PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
39.21	38.03	386.34	5.95	0.73

PM₁₀ nonattainment area annual emissions were calculated based on EIIP guidance (US EPA, 2002) which recommends using the ratio of agricultural land inside the nonattainment area (223,627 acres) to agricultural land inside the county (465,833 acres). See Section 1.5.2 for a discussion of land-use data used.

$$\begin{aligned}
 \text{PM}_{10} \text{ nonattainment area emissions from agricultural equipment} &= \text{County PM}_{10} \text{ emissions} \times \text{Agricultural land-use allocation factor} \\
 &= 39.21 \text{ tons} \times 48.01\% \\
 &= 18.83 \text{ tons PM}_{10} / \text{yr}
 \end{aligned}$$

Table 4.2-2. Annual emissions (in tons/yr) from agricultural equipment in the PM₁₀ NAA.

PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
18.83	18.26	185.46	2.86	0.35

County average-day emissions were calculated by multiplying annual emissions (generated by the NONROAD2005 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:

$$\begin{aligned}
 \text{Maricopa County PM}_{10} \text{ average-day emissions (lbs/day)} &= \text{Annual PM}_{10} \text{ emissions (tons/year)} \times 2000 \text{ (lb/ton)} \times \text{daily activity allocation factor for agricultural equipment expressed as (week/day)} \div 52 \text{ (weeks per year)} \\
 &= 39.21 \times 2000 \times 0.166667 \div 52 \\
 &= 251.4 \text{ lbs/day}
 \end{aligned}$$

Table 4.2-3. Typical daily emissions (lbs/day) from agricultural equipment in Maricopa County.

PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
251.4	243.8	2,476.5	38.2	4.7

PM₁₀ nonattainment area average-day emissions were calculated by multiplying County average-day emissions by the agricultural land-use allocation factor:

$$\begin{aligned}
 \text{PM}_{10} \text{ nonattainment area average-day emissions} &= \text{Maricopa County PM}_{10} \text{ average-day emissions} \times \text{Agricultural land-use allocation factor} \\
 &= 251.4 \text{ lbs/day} \times 48.01\% \\
 &= 120.7 \text{ lbs/day}
 \end{aligned}$$

Table 4.2-4. Typical daily emissions (lbs/day) from agricultural equipment in the PM₁₀ nonattainment area.

PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
120.7	117.0	1,188.9	18.3	2.2

4.3 Airport ground support equipment

Annual emissions from airport ground support equipment (GSE) were calculated based on the MAG Airport Emission Model. Activity data on aircraft operations was obtained through the Federal Aviation Administration website for 8 towered airports in Maricopa County. Since all 8 towered airports are in the PM₁₀ nonattainment area, the calculated emissions are equal to Maricopa County totals.

Table 4.3–1. Annual emissions (in tons/yr) from airport ground support equipment.

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
16.50	15.70	467.82	14.71		16.50	15.70	467.82	14.71	

Table 4.3–2. Typical daily emissions (in lbs/day) from airport ground support equipment.

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
90.4	86.0	2,563.4	80.6		90.4	86.0	2,563.4	80.6	

4.4 Commercial equipment

Annual emissions from commercial equipment in Maricopa County were calculated using EPA’s NONROAD2005 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-level 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 (in tons/yr) from commercial equipment.

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
119.34	114.47	1,449.72	17.32	23.18	118.48	113.65	1,439.36	17.20	23.01

County average-day emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2005 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 average-day emissions were calculated based on industrial employment ratios as described above.

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

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
765.0	733.8	9,293.1	111.0	148.6	759.5	728.5	9,226.7	110.2	147.5

4.5 Construction and mining equipment

Annual emissions from construction and mining equipment in Maricopa County were calculated using EPA’s NONROAD2005 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-level totals as a conservative estimate, as 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 population data used.

Table 4.5–1. Annual emissions (in tons/yr) from construction and mining equipment.

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
1,354.26	1,311.26	16,016.62	287.07	31.22	1,356.40	1,313.34	16,042.02	287.52	31.27

County average-day emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2005 model) by the most conservative weekday/weekend day activity allocation factor for construction/mining equipment (0.166667) 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 average-day emissions were calculated based on population ratios as described above.

Table 4.5–2. Typical daily emissions (in lbs/day) from construction and mining equipment.

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
8,681.1	8,405.5	102,670.7	1,840.2	200.1	8,694.9	8,418.8	102,833.5	1,843.1	200.4

4.6 Industrial equipment

Annual emissions from industrial equipment in Maricopa County were calculated using EPA’s NONROAD2005 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-level totals as a conservative estimate, as the number of employees in manufacturing 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 4.6–1. Annual emissions (in tons/yr) from industrial equipment.

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
110.02	107.01	3,316.67	26.63	79.21	109.23	106.25	3,292.98	26.44	78.64

County average-day emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2005 model) by the most conservative weekday/weekend day activity allocation factor for industrial equipment (0.166667) 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 average-day emissions were calculated based on industrial employment ratios as described above.

Table 4.6–2. Typical daily emissions (in lbs/day) from industrial equipment.

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
705.2	686.0	21,260.7	170.7	507.7	700.2	681.1	21,108.8	169.5	504.1

4.7 Lawn and garden equipment

Annual emissions from lawn and garden equipment in Maricopa County were calculated using EPA's NONROAD2005 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-level totals, since housing units was not available, as recommended by EIIP guidance (US EPA, 2002). See Section 1.5.1 for a discussion of the population data used.

Table 4.7-1. Annual emissions (in tons/yr) from lawn and garden equipment.

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
178.22	165.18	843.10	9.53	21.21	178.50	165.45	844.43	9.54	21.24

County average-day emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2005 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 the number of weeks (52) in the year (US EPA, 1999). PM₁₀ nonattainment area average-day emissions were calculated based on population as described above.

Table 4.7-2. Typical daily emissions (in lbs/day) from lawn and garden equipment.

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
1,226.0	1,135.5	5,882.8	64.2	155.6	1,228.0	1,137.3	5,892.2	64.3	155.8

4.8 Pleasure craft

Annual emissions from pleasure craft equipment in Maricopa County were calculated using EPA's NONROAD2005 model, as described in Section 4.1. Annual emissions for the PM₁₀ nonattainment area for this category were derived by applying the ratio of water surface area in the nonattainment area to Maricopa County-level 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 (in tons/yr) from pleasure craft equipment.

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
11.33	10.45	70.58	0.71	1.49	8.60	7.94	53.59	0.54	1.13

County average-day emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2005 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 average-day emissions were calculated based on water surface area as described above.

Table 4.8-2. Typical daily emissions (in lbs/day) from pleasure craft equipment.

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
152.5	140.7	950.0	9.5	20.1	115.8	106.9	721.4	7.2	15.2

4.9 Railway maintenance equipment

Annual emissions from railway maintenance equipment in Maricopa County were calculated using EPA's NONROAD2005 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-level 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 (in tons/yr) from railway maintenance equipment.

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
1.20	1.16	9.27	0.14	0.02	1.20	1.17	9.29	0.14	0.02

County average-day emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2005 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 average-day emissions were calculated based on the population ratio as described above.

Table 4.9-2. Typical daily emissions (in lbs/day) from railway maintenance equipment.

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
8.3	8.1	64.2	1.0	0.1	8.3	8.1	64.3	1.0	0.1

4.10 Recreational equipment

Annual emissions from recreational equipment in Maricopa County were calculated using EPA's NONROAD2005 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, golf courses and vacant land use in the nonattainment area to Maricopa County-level 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 (in tons/yr) from recreational equipment.

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
42.29	38.95	59.99	0.68	1.97	8.89	8.19	12.61	0.14	0.41

County average-day emissions were calculated by multiplying Maricopa County annual emissions (generated by the NONROAD2005 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 average-day emissions were calculated based on land use as described above.

Table 4.10-2. Typical daily emissions (in lbs/day) from recreational equipment.

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
361.4	332.9	512.7	5.8	16.8	76.0	70.0	107.8	1.2	3.5

4.11 Aircraft

A survey of 17 airports in Maricopa County was conducted to collect data on the total number of landing and take-off operations (LTO's) as well as fleet mix to determine the types of aircraft used and idle times to calculate annual emissions. Of these airports, four locations (Buckeye Municipal Airport, Gila Bend Municipal Airport, Gila Bend Air Force Auxiliary Field and Wickenburg Municipal Airport) are outside of the nonattainment area.

Emissions were derived from both computer modeling results and National Emissions Inventory (NEI) default emission factors. For airports that provided complete survey data, the FAA's latest airport Emissions and Dispersion Modeling Software (EDMS 4.5) was used to calculate emissions. Parameters required to apply this model include annual LTO figures, fleet mix of types of aircraft in each activity category, and average taxi-in and taxi-out times.

For those airports that provided only partial data, the EDMS model could not be used to calculate emissions for that specific airport. Instead, emission factors from similar airports that provided complete information was used. Examples of missing data were detailed fleet mix data or unknown idle times. For airports that did not respond to the survey, LTO figures, taxi-in/taxi-out times and aircraft types were derived from online databases that provide detailed aeronautical information on airports at <http://www.transtats.bts.gov>, <http://www.apo.data.faa.gov> and <http://www.airnav.com>.

The EDMS model was used to estimate emissions for all pollutants for the air carrier category and only for NO_x and SO_x for air taxi, general aviation and military. This is due to the fact that the EDMS model version 4.5 does not estimate emissions for PM₁₀ or PM_{2.5} for air taxi, general aviation and military. For these aircraft categories, 2002 NEI default emission factors for PM₁₀ and PM_{2.5} were used (ERG, 2001). The PM₁₀ and PM_{2.5} emission factors are shown in Table 4.11-1.

Table 4.11-1. NEI default emission factors for PM₁₀ and PM_{2.5}, by aircraft category.

Aircraft category	Abbreviation	SCC	PM ₁₀ Emission Factor (lbs/LTO)	PM _{2.5} Emission Factor (lbs/LTO)
Air Taxi	AT	2275060000	0.60333	0.42
General Aviation	GA	2275050000	0.2367	0.163
Military	ML	2275001000	0.60333	0.42

The following provides an example of how aircraft emissions were calculated using the FAA's EDMS modeling software for Sky ranch at Carefree, a small, general-aviation only airport that has an ordinance mandate that the airport can only accept aircraft that weigh 12,500 lbs or less.

Since the EDMS model requires an exact LTO value for each airframe considered in the model, and since the survey did not require respondents to supply exact LTO counts for each individual airframe, an averaging method was used. EDMS was run to produce a composite emission factor for an airport based on the most common type of aircraft using that facility. The composite emission factor was then applied to the actual reported activity for the airport. For Sky ranch, a composite profile was created by selecting within the EDMS model, 12 aircraft likely to utilize the airport, based on data provided by the airport survey and follow-up correspondence. These 12 aircraft types are: Cessna 150, Comanche, Robin R 2160, Socata Tampico, Cessna 172 Skyhawk, Piper PA-28, Robin R 3000, Socata Tobago, Cherokee six, Robin DR 400, Rockwell Commander, and Spencer S-12 Air Car.

The model run with the 12 aircraft types resulted in total NO_x emissions of 0.277 tons (assuming each of the 12 aircraft types had 1000 LTOs each during the period).

$$\begin{aligned} \text{Composite NO}_x \text{ emission factor (lb/LTO)} &= \Sigma \text{ modeled NO}_x \text{ emissions (tons/yr)} \times 1 \text{ yr} / 12,000 \text{ LTOs} \times 2000 \text{ lb/ton} \\ &= 0.046 \text{ lb NO}_x \text{ /LTO} \end{aligned}$$

This composite emission factor was then multiplied by the actual number of LTOs at the airport to derive an annual NO_x emissions total:

$$\begin{aligned} \text{NO}_x \text{ emissions (lb/ yr)} &= 2,248 \text{ LTO/yr} \times 0.046 \text{ lb NO}_x \text{ /LTO} \\ &= 103.6 \text{ lb NO}_x \text{ /yr} \end{aligned}$$

The above approach was used to calculate annual NO_x and SO_x directly from the EDMS model. Annual PM₁₀ and PM_{2.5} emissions were calculated by multiplying the default emission factor shown in Table 4.11–1 by the activity level (LTO/year) for the airport and its appropriate aircraft category.

Table 4.11–2 summarizes the activity level for each aircraft category for each airport surveyed as well as the emission factor for each pollutant.

Table 4.11–2. 2005 airport activity data and emission factors.

Airport name	Activity category	2005 LTOs	Lbs/LTO			
			PM ₁₀	PM _{2.5}	NO _x	SO _x
Arizona Army National Guard ²	ML	1,080	0.603	0.420	2.251	0.136
Buckeye Municipal Airport ^{1,2}	GA	21,457	0.237	0.163	1.412	0.112
Chandler Municipal Airport ⁴	AT	1,370	0.603	0.420	2.036	0.333
	GA	116,158	0.237	0.163	1.412	0.112
	ML	28	0.603	0.420	4.243	0.371
Falcon Field ²	AC	24	0.175	0.175	26.34	1.425
	AT	4,098	0.603	0.420	2.036	0.333
	GA	128,835	0.237	0.163	1.214	0.076
	ML	2,136	0.603	0.420	4.243	0.371
Gila Bend Air Force Auxiliary Field ^{1,2}	ML	31,003	0.603	0.420	4.174	0.345
Gila Bend Municipal Airport ^{1,3}	GA	6,935	0.237	0.163	1.214	0.076
Glendale Municipal Airport ⁴	AT	935	0.603	0.420	2.036	0.333
	GA	65,438	0.237	0.163	1.214	0.076
	ML	62	0.603	0.420	4.243	0.371
Luke Air Force Base ²	ML	59,500	0.603	0.420	14.327	0.809
Phoenix Deer Valley Airport ⁴	AT	2,293	0.603	0.420	2.036	0.333
	GA	186,231	0.237	0.163	1.214	0.076
	ML	30	0.603	0.420	4.243	0.371
Phoenix Goodyear Airport ⁴	AC	172	0.175	0.180	26.34	1.425
	AT	1,893	0.603	0.420	2.036	0.333
	GA	46,440	0.237	0.163	1.214	0.076
	ML	2,005	0.603	0.420	4.243	0.371
Phoenix Sky Harbor International ⁴	AC	204,856	0.168	0.168	16.889	1.373
	AT	48,118	0.603	0.420	5.494	0.636
	GA	20,670	0.237	0.163	1.412	0.112
	ML	1,447	0.603	0.420	35.936	1.814
Pleasant Valley Airport ²	GA	14,096	0.237	0.163	0.354	0.064
Scottsdale Airport ²	AT	5,903	0.603	0.420	2.036	0.333
	GA	100,164	0.237	0.163	1.412	0.112
	ML	155	0.603	0.420	4.243	0.371
Skyranch at Carefree ²	GA	2,248	0.237	0.163	0.046	0.002
Stellar Airpark ²	GA	19,528	4.421	0.163	1.214	0.076
Wickenburg Municipal Airport ¹	AT	485	0.603	0.420	2.036	0.333
	GA	23,059	0.237	0.163	1.214	0.076
	ML	728	0.603	0.420	4.243	0.371
Williams Gateway Airport ⁴	AC	450	0.175	0.180	26.34	1.425
	AT	3,874	0.603	0.420	2.036	0.333
	GA	128,310	0.237	0.163	1.214	0.076
	ML	5,689	0.603	0.420	19.82	1.429

1. Airport is outside the nonattainment area.
2. Activity data reported from source.
3. No data reported from source. Data derived from <http://www.airnav.com>
4. No data reported from source. Data derived from <http://www.apo.data.faa.gov/main/atads.asp>

For all airports, activity is presumed to occur evenly over a 7-day week and average daily emissions were calculated by dividing annual totals by 365 days per year. Table 4.11–3 lists the total annual emissions and average daily emissions, for each airport and aircraft type.

Table 4.11-3. Annual and typical daily emissions, by airport and aircraft type.

Facility	Cate- gory ¹	Tons/yr				Lbs/day			
		PM ₁₀	PM _{2.5}	NO _x	SO _x	PM ₁₀	PM _{2.5}	NO _x	SO _x
Arizona Army National Guard	ML	0.33	0.22	1.22	0.07	1.8	1.2	6.7	0.4
Chandler Municipal Airport	AT	0.41	0.29	1.39	0.23	2.3	1.6	7.6	1.2
	GA	13.75	9.49	82.01	6.50	75.3	52.0	449.4	35.6
	ML	0.01	0.01	0.06	0.01	0.0	0.0	0.3	0.0
Falcon Field	AC	0.00	0.00	0.32	0.02	0.0	0.0	1.7	0.1
	AT	1.24	0.85	4.17	0.68	6.8	4.7	22.9	3.7
	GA	15.25	10.52	78.20	4.90	83.5	57.6	428.5	26.8
	ML	0.64	0.44	4.53	0.40	3.5	2.4	24.8	2.2
Glendale Municipal Airport	AT	0.28	0.19	0.95	0.16	1.5	1.1	5.2	0.9
	GA	7.74	5.34	39.72	2.49	42.4	29.3	217.6	13.6
	ML	0.02	0.01	0.13	0.01	0.1	0.1	0.7	0.1
Luke Air Force Base	ML	17.94	12.38	426.23	24.07	98.3	67.8	2,335.5	131.9
Phoenix Deer Valley Airport.	AT	0.69	0.48	2.33	0.38	3.8	2.6	12.8	2.1
	GA	22.04	15.21	113.04	7.08	120.8	83.3	619.4	38.8
	ML	0.01	0.01	0.06	0.01	0.0	0.0	0.3	0.0
Phoenix Goodyear Airport	AC	0.02	0.02	2.27	0.12	0.1	0.1	12.4	0.7
	AT	0.57	0.39	1.93	0.32	3.1	2.2	10.6	1.7
	GA	5.50	3.79	28.19	1.76	30.1	20.8	154.5	9.7
	ML	0.60	0.42	4.25	0.37	3.3	2.3	23.3	2.0
Phoenix Sky Harbor International	AC	17.21	17.21	1,729.91	140.63	94.3	94.3	9,478.9	770.6
	AT	14.52	10.02	132.18	15.30	79.5	54.9	724.3	83.8
	GA	2.45	1.69	14.59	1.16	13.4	9.2	80.0	6.3
	ML	0.44	0.30	26.00	1.31	2.4	1.6	142.5	7.2
Pleasant Valley Airport	GA	1.67	1.15	2.49	0.45	9.1	6.3	13.7	2.5
Scottsdale Airport	AT	1.78	1.23	6.01	0.98	9.8	6.7	32.9	5.4
	GA	11.85	8.18	70.72	5.61	65.0	44.8	387.5	30.7
	ML	0.05	0.03	0.33	0.03	0.3	0.2	1.8	0.2
Skyranch at Carefree	GA	0.27	0.18	0.05	0.00	1.5	1.0	0.3	0.0
Stellar Airpark	GA	2.31	1.59	11.85	0.74	12.7	8.7	65.0	4.1
Williams Gateway Airport	AC	0.04	0.04	5.93	0.32	0.2	0.2	32.5	1.8
	AT	1.17	0.81	3.94	0.65	6.4	4.4	21.6	3.5
	GA	15.19	10.48	77.88	4.88	83.2	57.4	426.8	26.7
	ML	1.72	1.18	56.38	4.06	9.4	6.5	308.9	22.3
PM₁₀ nonattainment area totals:		157.68	114.15	2,929.27	225.69	864.0	625.5	16,050.8	1,236.7
Airports outside the nonattainment area:									
Buckeye Mun. Airport	GA	2.54	1.75	15.15	1.20	13.9	9.6	83.0	6.6
Gila Bend AF Aux Field	ML	9.35	6.45	64.70	5.35	51.2	35.3	354.5	29.3
Gila Bend Mun. Airport	GA	0.82	0.57	4.21	0.26	4.5	3.1	23.1	1.4
Wickenburg Municipal Airport	AT	0.15	0.10	0.49	0.08	0.8	0.6	2.7	0.4
	GA	2.73	1.88	14.00	0.88	15.0	10.3	76.7	4.8
	ML	0.22	0.15	1.54	0.14	1.2	0.8	8.5	0.7
Maricopa County totals:		173.48	125.05	3,029.37	233.60	950.6	685.2	16,599.3	1,280.0

1. AC = air carrier, GA = general aviation, AT = air taxi, ML = military.

4.12 Locomotives

Annual emissions from locomotives were calculated based on diesel fuel usage provided by Burlington Northern/Santa Fe Railway (BNSF), Union Pacific Railway (UP) and Amtrak. Railway operations from these companies fall into two categories: Class I haul lines and yard/switching operations. Annual emissions from Class I haul operations and yard/switching operations were calculated by multiplying diesel fuel usage by the emission factors listed in Table 4.12–1.

Table 4.12–1. Emission factors for locomotives.

Activity type	Emission factors (lbs/gal diesel)				
	PM ₁₀ ⁽¹⁾	PM _{2.5} ⁽¹⁾	NO _x ⁽¹⁾	SO _x ⁽²⁾	NH ₃ ⁽³⁾
Class I haul line	0.015	0.013	0.595	0.036	0.00095
Yard/switch operations	0.020	0.019	0.798	0.036	0.00095

Sources: (1) EPA, 1997. (2) EPA, 1992. (3) EPA, 1998.

The example below illustrates how emissions were calculated for each locomotive activity type. Fuel use reported by railroads, and emission totals are summarized in Table 4.12–2.

$$\begin{aligned}
 \text{PM}_{10} \text{ emissions from UP Class I haul lines} &= \text{Diesel fuel used (gals)} \times \text{EPA emission factor (lbs/gal) for PM}_{10} \div 2000 \text{ lbs/ton} \\
 &= 7,598,448 \text{ gallons} \times 0.015 \text{ lbs/gal} \div 2000 \text{ lbs/ton} \\
 &= 56.99 \text{ tons PM}_{10}/\text{yr}
 \end{aligned}$$

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

Locomotive type	Diesel fuel used (gals)	Annual emissions (tons/yr)				
		PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
BNSF Class I haul line	1,089,969	8.17	7.08	324.27	19.62	0.52
UP Class I haul line	7,598,448	56.99	49.39	2,260.54	136.77	3.61
BNSF yard/switch operations	500,000	5.00	4.75	199.50	9.00	0.24
UP yard/switch operations	415,740	4.16	3.95	165.88	7.48	0.20
Amtrak	17,000	0.13	0.11	5.06	0.31	0.01
Totals:	9,621,157	74.45	65.28	2,955.24	173.18	4.57

PM₁₀ nonattainment area emissions were calculated by multiplying Maricopa County emissions by the percentage of track miles inside the PM₁₀ nonattainment area, determined by GIS mapping:

$$\begin{aligned}
 \text{PM}_{10} \text{ nonattainment area emissions from UP Class I haul lines} &= \text{County PM}_{10} \text{ emissions} \times \text{Percentage of track in the nonattainment area} \\
 &= 56.99 \text{ tons PM}_{10}/\text{yr} \times 44.27\% \\
 &= 30.56 \text{ tons PM}_{10}/\text{yr}
 \end{aligned}$$

Table 4.12–3. Annual emissions (in tons/yr) from locomotives in the PM₁₀ NAA.

Locomotive type	Track in nonattainment area (%)	Annual emissions (tons/yr)				
		PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
BNSF Class I haul line	44.27	3.62	3.14	143.55	8.69	0.23
UP Class I haul line	44.27	25.23	21.86	1,000.74	60.55	1.60
BNSF yard/switch operations	100.00	5.00	4.75	199.50	9.00	0.24
UP yard/switch operations	100.00	4.16	3.95	165.88	7.48	0.20
Amtrak	0.00	0.00	0.00	0.00	0.00	0.00
Totals:		38.01	33.70	1,509.67	85.72	2.26

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 per year, as locomotive activity is assumed to be uniform throughout the year.

$$\begin{aligned}
 \text{PM}_{10} \text{ typical daily emissions from haul lines} &= \text{Annual PM}_{10} \text{ emissions (tons)} \times 2000 \text{ lbs/ton} \div 365 \text{ days} \\
 &= 56.99 \text{ tons PM}_{10}/\text{yr} \times 2000 \text{ lbs/ton} \div 365 \text{ days} \\
 &= 312.3 \text{ lbs PM}_{10}/\text{day}
 \end{aligned}$$

Table 4.12–4. Typical daily emissions (in lbs/day) from locomotives in Maricopa County.

Locomotive type	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
BNSF Class I haul line	44.8	38.8	1,776.8	107.5	2.8
UP Class I haul line	312.3	270.6	12,386.5	749.4	19.8
BNSF yard/switch operations	27.4	26.0	1,093.2	49.3	1.3
UP yard/switch operations	22.8	21.6	908.9	41.0	1.1
Amtrak	0.7	0.6	27.7	1.7	0.0
Totals:	407.9	357.7	16,193.1	948.9	25.0

Table 4.12–5. Typical daily emissions (in lbs/day) from locomotives in the PM₁₀ nonattainment area.

Locomotive type	PM ₁₀	PM _{2.5}	NO _x	SO _x	NH ₃
BNSF Class I haul line	19.8	17.2	786.6	47.6	1.3
UP Class I haul line	138.2	119.8	5,483.5	331.8	8.8
BNSF yard/switch operations	27.4	26.0	1,093.2	49.3	1.3
UP yard/switch operations	22.8	21.6	908.9	41.0	1.1
Amtrak	0.0	0.0	0.0	0.0	0.0
Totals:	208.2	184.7	8,272.2	469.7	12.4

4.13 Summary of all nonroad mobile source emissions

Table 4.13–1 summarizes annual and daily emissions of PM₁₀, PM_{2.5}, NO_x, SO_x and NH₃ from nonroad mobile sources in Maricopa County respectively. Table 4.13–2 shows annual and typical daily emissions for these pollutants for 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	39.21	38.03	386.34	5.95	0.73	251.4	243.8	2,476.5	38.2	4.7
Airport ground support	16.50	15.70	467.82	14.71		90.4	86.0	2,563.4	80.6	
Commercial	119.34	114.47	1,449.72	17.32	23.18	765.0	733.8	9,293.1	111.0	148.6
Construction & mining	1,354.26	1,311.26	16,016.62	287.07	31.22	8,681.1	8,405.5	102,670.7	1,840.2	200.1
Industrial	110.02	107.01	3,316.67	26.63	79.21	705.2	686.0	21,260.7	170.7	507.7
Lawn & garden	178.22	165.18	843.10	9.53	21.21	1,226.0	1,135.4	5,882.8	64.1	155.5
Pleasure craft	11.33	10.45	70.58	0.71	1.49	152.5	140.7	950.0	9.5	20.1
Railway maintenance	1.20	1.16	9.27	0.14	0.02	8.3	8.1	64.2	1.0	0.1
Recreational	42.29	38.95	59.99	0.68	1.97	361.4	332.9	512.7	5.8	16.8
Aircraft	173.48	125.05	3,029.37	233.60		950.6	685.2	16,599.3	1,280.0	
Locomotives	74.45	65.28	2,955.24	173.18	4.57	407.9	357.7	16,193.1	948.9	25.0
Totals:	2,120.29	1,992.56	28,604.72	769.51	163.58	13,599.9	12,815.2	178,466.6	4,550.0	1,078.7

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	18.83	18.26	185.46	2.86	0.35	120.7	117.0	1,188.9	18.3	2.2
Airport ground support	16.50	15.70	467.82	14.71		90.4	86.0	2,563.4	80.6	
Commercial	118.48	113.65	1,439.36	17.20	23.01	759.5	728.5	9,226.7	110.2	147.5
Construction & mining	1,356.40	1,313.34	16,042.02	287.52	31.27	8,694.9	8,418.8	102,833.5	1,843.1	200.4
Industrial	109.23	106.25	3,292.98	26.44	78.64	700.2	681.1	21,108.8	169.5	504.1
Lawn & garden	178.50	165.44	844.44	9.54	21.24	1,227.9	1,137.2	5,892.2	64.2	155.8
Pleasure craft	8.60	7.94	53.59	0.54	1.13	115.8	106.9	721.4	7.2	15.2
Railway maintenance	1.20	1.17	9.29	0.14	0.02	8.3	8.1	64.3	1.0	0.1
Recreational	8.89	8.19	12.61	0.14	0.41	76.0	70.0	107.8	1.2	3.5
Aircraft	157.68	114.15	2,929.27	225.69		864.0	625.5	16,050.8	1,236.7	
Locomotives	38.01	33.70	1,509.67	85.72	2.26	208.2	184.7	8,272.2	469.7	12.4
Totals:	2,012.32	1,897.78	26,786.52	670.50	158.33	12,866.0	12,163.8	168,029.9	4,001.8	1,041.4

4.14 Quality assurance procedures

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

4.15 References

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