**FUGITIVE DUST FROM UNPAVED ROADS**

***a. Source Category Description***

Fugitive dust emissions from unpaved road traffic were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL emissions.

For this source category, the following SCC was assigned:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCC** | **SCC Level 1** | **SCC Level 2** | **SCC Level 3** | **SCC Level 4** |
| 2296000000 | Mobile Sources | Unpaved Roads | All unpaved Roads | Total: Fugitives |

Uncontrolled unpaved road emissions were calculated at the county level by roadway type for the year 2014. This was done by multiplying the county/roadway class unpaved road vehicle miles traveled (VMT) by the appropriate unpaved road emission factor. Next, control factors were applied to the unpaved road emissions in PM10 nonattainment and maintenance area counties. Emissions by roadway class were then totaled to the county level and adjusted for meteorological conditions. Emissions were then summed to the state level and distributed based on census rural and “like-rural” populations for reporting in the NEI. The following provides further details on the emission factor equation, determination of unpaved road VMT, and controls.

***b. Emission Factor Equation***

Re-entrained road dust emissions for unpaved roads were estimated using paved road VMT and the emission factor equation from AP-421:

E = [k × (s/12)1 × (SPD/30)0.5] / (M/0.5)0.2 - C

Where k and C are empirical constants given in Table 1, with:

E = unpaved road dust emission factor (lb/VMT)

k = particle size multiplier (lb/VMT)

s = surface material silt content (%)

SPD = mean vehicle speed (mph)

M = surface material moisture content (%)

C = emission factor for 1980’s vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

The uncontrolled emission factors without precipitation corrections are in the worksheet “Emission Factor Calculations” by county and roadway class.

Values used for the particle size multiplier and the 1980’s vehicle fleet exhaust, brake wear, and tire wear are provided in Table 1, and come from AP-421 defaults.

Average State-level unpaved road silt content values, developed as part of the 1985 NAPAP Inventory, were obtained from the Illinois State Water Survey2. Silt contents of over 200 unpaved roads from over 30 States were obtained. Average silt contents of unpaved roads were calculated for each sate that had three or more samples for that State. For States that did not have three or more samples, the average for all samples from all States was used as a default value. The silt content values are by State and identifies if the values were based on a sample average or default value.

**Table 1:** Constants for Unpaved Roads re-entrained dust emission factor equation1

|  |  |  |
| --- | --- | --- |
| **Constant** | **PM25-PRI/PM25-FIL** | **PM10-PRI/PM10-FIL** |
| k (lb/VMT) | 0.18 | 1.8 |
| C | 0.00036 | 0.00047 |

Table 2 lists the speeds modeled on the unpaved roads by roadway class. These speeds were determined based on the average speeds modeled for onroad emission calculations and weighted to determine a single average speed for each of the roadway classes. The roadway class “Urban collector” with an average speed of 20 mph was split into two sub-categories, “Urban major collector” and “Urban minor collector”, to correspond to the roadway types found in the 2014 VMT data.

**Table 2:** Speeds modeled by roadway type on Unpaved Roads3

|  |  |
| --- | --- |
| **Unpaved Roadway Type** | **Speed (mph)** |
| Rural Minor Arterial | 39 |
| Rural Major Collector | 34 |
| Rural Minor Collector | 30 |
| Rural Local | 30 |
| Urban Other Principal Arterial | 20 |
| Urban Minor Arterial | 20 |
| Urban Major Collector | 20 |
| Urban Minor Collector | 20 |
| Urban Local | 20 |

The value of 0.5 percent for M was chosen as the national default as sufficient resources were not available at the time the emissions were calculated to determine more locally-specific values for this variable.

***c. Activity Data***Total annual VMT estimates by county and roadway class were derived from a 2014 MOVES run providing county-level estimates of total (paved and unpaved) VMT by road type. Unpaved VMT was calculated by multiplying total VMT in each county by a census region-level ratio of unpaved VMT to total VMT.

Table 3 lists the census region-level ratios. These ratios were calculated based on the sum of the unpaved VMT in each census region in the EPA dataset calculated for the 2011 NEI divided by the sum of the total VMT in each census region. The origin of the unpaved/total split from the 2011 NEI was from data from FHWA from 1996 (the last year these data were available).4

**Table 3.** Unpaved Ratios by Census Region and Road Type

| **Region** | **FHWA Road Type** | **Unpaved Ratio** |
| --- | --- | --- |
| Midwest Region | Rural Interstate | 0.00E+00 |
| Midwest Region | Rural Local | 2.70E-01 |
| Midwest Region | Rural Major Collector | 7.18E-03 |
| Midwest Region | Rural Minor Arterial | 0.00E+00 |
| Midwest Region | Rural Minor Collector | 5.82E-02 |
| Midwest Region | Rural Other Freeways and Expressways | 0.00E+00 |
| Midwest Region | Rural Other Principal Arterial | 0.00E+00 |
| Midwest Region | Urban Interstate | 0.00E+00 |
| Midwest Region | Urban Local | 8.99E-02 |
| Midwest Region | Urban Major Collector | 3.88E-03 |
| Midwest Region | Urban Minor Arterial | 4.72E-04 |
| Midwest Region | Urban Minor Collector | 1.73E-01 |
| Midwest Region | Urban Other Freeways and Expressways | 0.00E+00 |
| Midwest Region | Urban Other Principal Arterial | 0.00E+00 |
| Northeast Region | Rural Interstate | 0.00E+00 |
| Northeast Region | Rural Local | 4.08E-02 |
| Northeast Region | Rural Major Collector | 1.29E-04 |
| Northeast Region | Rural Minor Arterial | 0.00E+00 |
| Northeast Region | Rural Minor Collector | 1.09E-03 |
| Northeast Region | Rural Other Freeways and Expressways | 0.00E+00 |
| Northeast Region | Rural Other Principal Arterial | 0.00E+00 |
| Northeast Region | Urban Interstate | 0.00E+00 |
| Northeast Region | Urban Local | 3.03E-03 |
| Northeast Region | Urban Major Collector | 3.71E-06 |
| Northeast Region | Urban Minor Arterial | 0.00E+00 |
| Northeast Region | Urban Minor Collector | 1.74E-04 |
| Northeast Region | Urban Other Freeways and Expressways | 0.00E+00 |
| Northeast Region | Urban Other Principal Arterial | 0.00E+00 |
| South Region | Rural Interstate | 0.00E+00 |
| South Region | Rural Local | 1.72E-01 |
| South Region | Rural Major Collector | 1.61E-03 |
| South Region | Rural Minor Arterial | 0.00E+00 |
| South Region | Rural Minor Collector | 1.63E-02 |
| South Region | Rural Other Freeways and Expressways | 0.00E+00 |
| South Region | Rural Other Principal Arterial | 0.00E+00 |
| South Region | Urban Interstate | 0.00E+00 |
| South Region | Urban Local | 3.17E-02 |
| South Region | Urban Major Collector | 9.23E-04 |
| South Region | Urban Minor Arterial | 3.12E-04 |
| South Region | Urban Minor Collector | 1.49E-02 |
| South Region | Urban Other Freeways and Expressways | 0.00E+00 |
| South Region | Urban Other Principal Arterial | 0.00E+00 |
| West Region | Rural Interstate | 0.00E+00 |
| West Region | Rural Local | 3.03E-01 |
| West Region | Rural Major Collector | 7.03E-03 |
| West Region | Rural Minor Arterial | 0.00E+00 |
| West Region | Rural Minor Collector | 1.23E-01 |
| West Region | Rural Other Freeways and Expressways | 0.00E+00 |
| West Region | Rural Other Principal Arterial | 0.00E+00 |
| West Region | Urban Interstate | 0.00E+00 |
| West Region | Urban Local | 6.13E-02 |
| West Region | Urban Major Collector | 3.26E-04 |
| West Region | Urban Minor Arterial | 1.20E-04 |
| West Region | Urban Minor Collector | 3.24E-03 |
| West Region | Urban Other Freeways and Expressways | 0.00E+00 |
| West Region | Urban Other Principal Arterial | 0.00E+00 |

***d. Emissions***

County level PM emissions were calculated by multiplying the county unpaved VMT (by road type) by the emission factors calculated in section b and summing based on county and urban/rural classification.

***e. Controls***

The controls assumed for unpaved roads varied by PM10 nonattainment area classification and by urban and rural areas. On urban unpaved roads in moderate PM10 nonattainment areas, paving of the unpaved road was assumed and a control efficiency of 96 percent and a rule penetration of 50 percent were applied. Controls were not applied to rural unpaved roads in moderate nonattainment areas. Chemical stabilization, with a control efficiency of 75 percent and a rule penetration of 50 percent, was assumed for rural areas in serious PM10 nonattainment areas. A combination of paving and chemical stabilization, with a control efficiency of 90 percent and a rule penetration of 75 percent, was assumed for urban unpaved roads in serious PM10 nonattainment areas. In counties currently at maintenance status, controls were assumed based on the severity (moderate or serious) of their prior nonattainment status. Some counties had multiple partial areas with differing levels of nonattainment. In these cases, controls were assumed to be applied based on the most serious level of nonattainment found within a given county.

Note that the controls were applied at the county level, and the controls differ by urban vs. rural roadway class. In the final emissions table, the emissions for all roadway classes were summed to the county level. Therefore, the emissions at the county level can represent several different control effectiveness and rule penetration levels. However, the control efficiency and rule penetration values were reported in the Controlled Emissions worksheet at the county level for urban and rural roadways separately.

***f. Meteorological Adjustment***

After controls were applied, emissions were summed to the county level and converted to tons in order for the meteorological adjustment to be applied. The meteorological adjustment accounts for the fact that in some cases roads will be wet after it rains and therefore will result in significantly lower emissions. The county-level meteorological adjustment factors were developed by EPA based on the ratio of the unadjusted NEI2014 version 1 emissions to the adjusted emissions in each county after the emissions were processed to create the SMOKE flat files. The county-level meteorological adjustment is a number between 0 and 1 that is multiplied by the estimated emissions.

***g. Emissions Redistribution Procedure***

Unpaved roads are generally not located in urban centers, such as New York City or Chicago, so emissions were redistributed away from these areas to reflect this. Emissions were summed to the state-level and redistributed back to the county level based on the proportion of county to state rural and “like-rural” population, according to the 2010 Census. “Like-rural” population is defined as the population of urbanized areas and urban clusters with population densities’ equal to or less than the maximum rural population density value for all counties in the US.

***h. Changes from 2011 Methodology***

The methodology described above contains several adjustments from the methodology used to compose the 2011 version. This is due in part to differences in data sources used to compile the inventory. In 2014, VMT was obtained from a MOVES run instead an NMIM run and separated in paved and unpaved values based on census-region level ratios. Emissions were also redistributed based on rural and “like-rural” county population.

***i. Puerto Rico and US Virgin Islands Emissions Calculations***

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory’s activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are “EACH”.

***j. References***

1. United States Environmental Protection Agency, Office of Air Quality Planning and Standards. “Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.2, Unpaved Roads.” Research Triangle Park, NC. January 2011.
2. W. Barnard, G. Stensland, and D. Gatz, Illinois State Water Survey, “Evaluation of Potential Improvements in the Estimation of Unpaved Road Fugitive Emission Inventories,” paper 87-58.1, presented at the 80th Annual Meeting of the APCA. New York, New York. June 21-26, 1987
3. United States Environmental Protection Agency, Clearinghouse for Inventories & Emissions Factors. “[2011 National Emissions Inventory, version 2 Technical Support Document](https://www.epa.gov/air-emissions-inventories).” Research Triangle Park, NC. August 2015. (accessed May 2019)
4. Federal Highway Administration, “[Highway Statistics 1996, Table HM-67](https://www.fhwa.dot.gov/ohim/1996/text/roads.html).” 1996..