SECTION 7.11

UNPAVED ROAD DUST
FARM ROADS

(Updated August 1997)

EMISSION INVENTORY SOURCE CATEGORY
Miscellaneous Processes / Road Dust

EMISSION INVENTORY CODES (CES CODES) AND DESCRIPTION
645-646-5400-0000 (47431) Unpaved Road Travel Dust - Farm Roads

METHODS AND SOURCES

This source category provides estimates of the entrained geologic particulate matter emissions that result from vehicular travel over unpaved roads on agricultural lands. The emissions result from the mechanical disturbance of the roadway and the vehicle generated air turbulence effects. This emission factor used is oriented towards dust emissions from light duty vehicle use, but the activity data do implicitly include some larger vehicle use for harvest and other operations. Table 1 summarizes the farm road particulate matter estimates.

OVERVIEW OF ESTIMATION METHODOLOGY

Dust emissions from unpaved road dust are computed by using an emission factor computed by averaging unpaved road dust emission measurements performed by the University of California, Davis (UCD), and the Desert Research Institute (DRI). Unpaved farm road vehicle miles traveled (VMT) are based on an estimate that, on average, each 40 acres of cultivated land receives 175 VMT per year.

EMISSIONS ESTIMATION METHODOLOGY

Emission Factor. The emission factor used for our estimates of geologic dust emissions from vehicular travel on unpaved roads is based on work performed by UC Davis,[1] and the Desert Research Institute.[2] The emission factor used for all unpaved roads statewide is 2.27 lbs PM_{10}/VMT. The derivation of this emission factor is provided in the ARB's unpaved road dust background document.[3] In summary, the emission factor is the average of 22 unpaved road dust emissions tests performed in the San Joaquin Valley for light duty truck traffic. Because the emission measurements were performed in California, this emission factor was used to replace the previous generic emission factor provided in U.S. EPA's AP-42 document.[4] The

new emission factor is slightly smaller than the factors derived with the AP-42 methodology.

This methodology directly computes PM_{10} emissions. The TSP emissions are PM_{10} x 1.64.[5]

Activity Data. For the purpose of estimating emissions, is assumed that the unpaved road dust emissions are primarily related to the vehicle miles traveled (VMT) on the roads. In 1976 an informal survey was made of several county agricultural commissioners in the San Joaquin Valley. They roughly estimated that each 40 acres of cultivated land receives approximately 175 vehicle passes per year on the unpaved farm roads.[6] This value is used in our emission estimates. The crop acreage data used to estimate the road dust emissions are from the California Department of Food and Agriculture summary of crop acreage harvested in 1993.[7,8] The acreage estimates do not include pasture lands because it is thought that the quantity of vehicular travel on these lands is minimal.

Table 1 summarizes the acreage, VMT, and emissions data for each county.

TEMPORAL ACTIVITY AND GROWTH

Daily activity on unpaved roads occurs primarily during daylight hours. Activity is assumed to be the same each day of the week. Monthly activity varies by county and is based on estimates of monthly rainfall in each county. This is to reflect that during wet months there is less unpaved road traffic, and there are also lower emissions per mile of road when the road soils have a higher moisture content. Table 2 shows the temporal profile for each county in California.

Unpaved road growth for farm roads is based on agricultural crop acreage or agricultural production. This value is set to zero for many counties.

ASSUMPTIONS AND LIMITATIONS

1. This methodology assumes that all unpaved farm roads in California emit the same levels of PM_{10} per VMT during all times of the year for all vehicles and conditions.

2. It is assumed that all unpaved farm roads in California receive 175 VMT per 40 acres per year for all crops and cultivational practices.

3. This methodology assumes that no controls are used on the roads included in this inventory.

4. It is assumed that the emission factors derived in the San Joaquin Valley are applicable to the rest of the State.

5. This methodology assumes that unpaved road travel associated with pasture lands is negligible.

CHANGES IN THE METHODOLOGY

There were several changes made to the unpaved farm road dust methodology for this update. They are:

- Use of a new unpaved road dust emission factor based on California test data.
- The acres of land in agricultural production were updated to reflect 1993 values.
- The VMT values were adjusted for raisins. Previously a value of 50 VMT per 40 acres of raisins or grapes was used. Based on a better understanding of raisin and grape growing practices, this value was replaced with the default value used for all of the other crops, which is 175 VMT/40 acres.
- The seasonal profile was updated to reflect the expected changes in emissions and VMT levels during wet months of the year.

COMMENTS AND RECOMMENDATIONS

Many items in this category could use improvement. Although expensive to develop, more region and season specific emission factors would help to improve the accuracy of the unpaved road dust particulate matter inventory. The VMT activity data is also very simplistic, and probably does not well represent actual unpaved farm road travel conditions for each major crop type. UC Davis is currently under contract to the Air Resources Board to develop improved vehicle activity data for unpaved roads.

Also, as better data become available, crop specific VMT and road dust emissions could be estimated. It is also possible that, for limited regions, better unpaved road mileage estimates can be determined by using geographic information systems (GIS) based crop acreage maps and updated assumptions about the miles of unpaved agricultural roads.

SAMPLE CALCULATIONS

The instructions and associated table below provide an example of unpaved farm road dust for Yolo county.

Step 1: Cultivated Acres. From Table 1, input the crop acreage. This acreage is derived from the data used to develop the agricultural land preparation emissions estimates.[8] The crop acreage does not include pasture lands.

Step 2: VMT per Acre. Input the default vehicle miles traveled per acre. The current default value is 175 VMT/40 acres, which is 4.37 VMT/acre. Future inventories could

possibly use crop specific VMT estimates.

Step 3: Emission Factor. Input the unpaved road PM_{10} emission factor. The default ARB emission factor for unpaved roads is 2.27 lbs PM_{10}/VMT.

Step 4: Compute Emissions. Multiply the crop acres (Step 1) by the VMT/acre (Step 2) and the emission factor (Step 3) to compute the PM_{10} emissions. Divide by 2000 lbs/ton to compute annual tons. *Emissions = (Acres x VMT x EF)/2000*.

Estimating Unpaved Farm Road Dust Emissions in Yolo County

Step 1	Cultivated Acres	372
Step 2	VMT/Acre	10
Step 3	Emission Factor *(lbs PM_{10}/mile)*	2.27
Step 4	Emissions *(tons PM_{10}/year)*	1541

REFERENCES

1. Flocchini, Robert; et al. Evaluation of the Emission of PM_{10} Particulates from Unpaved Roads in the San Joaquin Valley, Final Report. University of California, Davis. Air Quality Group, Crocker Nuclear Laboratory. San Joaquin Valley Grant File #20960. April 1994.

2. John Gillies; et al. Effectiveness Demonstration of Fugitive Dust Control Methods for Public Unpaved Roads and Unpaved Shoulders on Paved Roads, Final Report. Desert Research Institute. DRI Document No. 68505200.1F1, for the California Regional Particulate Air Quality Study. December 1996.

3. Gaffney, Patrick. Entrained Dust from Unpaved Road Travel, Emission Estimation Methodology, Background Document. California Air Resources Board. September 1997.

4. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, AP-42, Section 11.2.1, Fourth Edition. September 1985.

5. Houck, J.E., Chow, J.C., Watson, J.G., et al. Determination of Particle Size Distribution and Chemical Composition of Particulate Matter from Selected Sources in California, Final Report. Desert Research Institute & OMNI Environmental. Prepared for California Air Resources Board. Agreement No. A6-175-32. June 30, 1989.

6. Bill Roddy, Fresno County Air Pollution Control District. Personal Communication. 1976.

7. California Agricultural Statistics Service. 1993 acreage extracted from agricultural commissioner's reports. Sacramento, CA. Phone (916) 654-1533.

8. Gaffney, P.H., Agricultural Land Preparation: Geologic Particulate Matter Emission Estimates, Background Document. California Air Resources Board. September 1997.

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Table 1
Unpaved Farm Roads -- Entrained Dust Emissions

AIR BASIN	COUNTY	Cultivated Acreage*	Annual VMT	PM_{10} (tons/yr)	TSP (tons/yr)
GBV	ALPINE	0	0	0	0
	INYO	4915	21503	24	39
	MONO	8985	39309	45	74
LC	LAKE	23067	100918	115	189
LT	EL DORADO	400	1751	2	3
	PLACER	2615	11439	13	21
MC	AMADOR	5850	25594	29	48
	CALAVERAS	1992	8715	10	16
	EL DORADO	2936	12844	15	25
	MARIPOSA	1123	4913	6	10
	NEVADA	234	1024	1	2
	PLACER	15949	69777	79	130
	PLUMAS	4365	19097	22	36
	SIERRA	4365	19097	22	36
	TUOLUMNE	373	1632	2	3
NC	DEL NORTE	1470	6431	7	11
	HUMBOLDT	1896	8295	9	15
	MENDOCINO	15865	69409	79	130
	SONOMA	44798	195990	222	364
	TRINITY	500	2188	2	3
NCC	MONTEREY	308623	1350226	1533	2513
	SAN BENITO	59311	259486	295	484
	SANTA CRUZ	20464	89530	102	167
NEP	LASSEN	77482	338984	385	631
	MODOC	85521	374154	425	697
	SISKIYOU	119333	522082	593	972
SC	LOS ANGELES	5636	24656	28	46
	ORANGE	15628	68373	78	128
	RIVERSIDE	80277	351210	399	654
	SAN BERNARDINO	31373	137256	156	256
SCC	SAN LUIS OBISPO	128193	560844	637	1044
	SANTA BARBARA	101961	446079	506	830
	VENTURA	109458	478879	544	892
SD	SAN DIEGO	68915	301503	342	561
SED	IMPERIAL	505314	2210749	2509	4113
	KERN	262391	1147962	1303	2136
	LOS ANGELES	8453	36984	42	69
	RIVERSIDE	130977	573026	650	1066
	SAN BERNARDINO	12814	56062	64	105
SF	ALAMEDA	12176	53270	60	98
	CONTRA COSTA	34177	149524	170	279
	MARIN	2524	11043	13	21
	NAPA	34144	149380	170	279
	SAN FRANCISCO	5	22	0	0
	SAN MATEO	7474	32699	37	61
	SANTA CLARA	251739	1101358	1250	2049
	SOLANO	40857	178751	203	333
	SONOMA	28641	125305	142	233
SJV	FRESNO	1193552	5221790	5927	9716
	KERN	557582	2439420	2769	4539
	KINGS	501949	2196027	2492	4085
	MADERA	300669	1315427	1493	2448
	MERCED	474155	2074428	2354	3859
	SAN JOAQUIN	520885	2278872	2587	4241
	STANISLAUS	365343	1598376	1814	2974
	TULARE	767080	3355975	3809	6244
SV	BUTTE	187725	821297	932	1528
	COLUSA	275747	1206393	1369	2244
	GLENN	224520	982275	1115	1828
	PLACER	7582	33173	38	62
	SACRAMENTO	133440	583800	663	1087
	SHASTA	31525	137922	157	257
	SOLANO	163430	715005	812	1331
	SUTTER	251588	1100698	1249	2048
	TEHAMA	54756	239558	272	446
	YOLO	341722	1495034	1697	2782
	YUBA	67779	296533	337	552
	TOTALS	9106588	39841323	45220	74131

*Does not include pasture lands.

PM Fraction: PM_{10} = TSP x 0.61 (TSP Emissions = PM_{10}/0.61)

Table 2
Seasonal Profile for Unpaved Road Dust Emissions

Basin	Co #	County	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GBV	2	ALPINE	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	14	INYO	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	26	MONO	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
LC	17	LAKE	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
LT	9	EL DORADO	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	31	PLACER	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
MC	3	AMADOR	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	5	CALAVERAS	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	9	EL DORADO	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	22	MARIPOSA	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	29	NEVADA	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	31	PLACER	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	32	PLUMAS	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	46	SIERRA	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	55	TUOLUMNE	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
NC	8	DEL NORTE	0.021	0.029	0.032	0.074	0.087	0.151	0.166	0.178	0.080	0.106	0.050	0.025
	12	HUMBOLDT	0.021	0.029	0.032	0.074	0.087	0.151	0.166	0.178	0.080	0.106	0.050	0.025
	23	MENDOCINO	0.021	0.029	0.032	0.074	0.087	0.151	0.166	0.178	0.080	0.106	0.050	0.025
	49	SONOMA	0.021	0.029	0.032	0.074	0.087	0.151	0.166	0.178	0.080	0.106	0.050	0.025
	53	TRINITY	0.021	0.029	0.032	0.074	0.087	0.151	0.166	0.178	0.080	0.106	0.050	0.025
NCC	27	MONTEREY	0.021	0.029	0.032	0.074	0.087	0.151	0.166	0.178	0.080	0.106	0.050	0.025
	35	SAN BENITO	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	44	SANTA CRUZ	0.014	0.017	0.025	0.046	0.059	0.169	0.228	0.224	0.046	0.115	0.044	0.013
NEP	18	LASSEN	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	25	MODOC	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	47	SISKIYOU	0.024	0.022	0.023	0.084	0.093	0.151	0.151	0.151	0.151	0.082	0.040	0.031
SC	19	LOS ANGELES	0.010	0.012	0.015	0.100	0.120	0.081	0.135	0.135	0.135	0.134	0.100	0.024
	30	ORANGE	0.010	0.012	0.015	0.100	0.120	0.081	0.135	0.135	0.135	0.134	0.100	0.024
	33	RIVERSIDE	0.052	0.088	0.084	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.074
	36	SAN BERNARDINO	0.052	0.088	0.084	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.074
SCC	40	SAN LUIS OBISPO	0.020	0.023	0.022	0.071	0.069	0.126	0.159	0.159	0.132	0.104	0.078	0.036
	42	SANTA BARBARA	0.015	0.020	0.020	0.087	0.066	0.127	0.137	0.128	0.145	0.130	0.087	0.037
	56	VENTURA	0.010	0.012	0.015	0.100	0.120	0.081	0.135	0.135	0.135	0.134	0.100	0.024
SD	37	SAN DIEGO	0.010	0.012	0.015	0.100	0.120	0.081	0.135	0.135	0.135	0.134	0.100	0.024
SED	13	IMPERIAL	0.052	0.088	0.084	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.074
	15	KERN	0.042	0.044	0.029	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.087	0.057
	19	LOS ANGELES	0.010	0.012	0.015	0.100	0.120	0.081	0.135	0.135	0.135	0.134	0.100	0.024
	33	RIVERSIDE	0.052	0.088	0.084	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.074
	36	SAN BERNARDINO	0.052	0.088	0.084	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.088	0.074
SF	1	ALAMEDA	0.014	0.017	0.025	0.046	0.059	0.169	0.228	0.224	0.046	0.115	0.044	0.013
	7	CONTRA COSTA	0.014	0.017	0.025	0.046	0.059	0.169	0.228	0.224	0.046	0.115	0.044	0.013
	21	MARIN	0.014	0.017	0.025	0.046	0.059	0.169	0.228	0.224	0.046	0.115	0.044	0.013
	28	NAPA	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	38	SAN FRANCISCO	0.014	0.017	0.025	0.046	0.059	0.169	0.228	0.224	0.046	0.115	0.044	0.013
	41	SAN MATEO	0.014	0.017	0.025	0.046	0.059	0.169	0.228	0.224	0.046	0.115	0.044	0.013
	43	SANTA CLARA	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	48	SOLANO	0.014	0.017	0.025	0.046	0.059	0.169	0.228	0.224	0.046	0.115	0.044	0.013
	49	SONOMA	0.021	0.029	0.032	0.074	0.087	0.151	0.166	0.178	0.080	0.106	0.050	0.025
SJV	10	FRESNO	0.030	0.033	0.026	0.099	0.121	0.121	0.121	0.121	0.121	0.104	0.058	0.046
	15	KERN	0.042	0.044	0.029	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.087	0.057
	16	KINGS	0.039	0.035	0.028	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.093	0.060
	20	MADERA	0.030	0.033	0.026	0.099	0.121	0.121	0.121	0.121	0.121	0.104	0.058	0.046
	24	MERCED	0.029	0.023	0.026	0.110	0.094	0.110	0.110	0.110	0.110	0.110	0.110	0.055
	39	SAN JOAQUIN	0.024	0.026	0.025	0.080	0.096	0.138	0.138	0.138	0.138	0.103	0.051	0.043
	50	STANISLAUS	0.028	0.028	0.029	0.092	0.080	0.121	0.121	0.121	0.121	0.115	0.098	0.047
	54	TULARE	0.028	0.032	0.021	0.104	0.115	0.121	0.121	0.121	0.121	0.121	0.058	0.039
SV	4	BUTTE	0.024	0.029	0.026	0.069	0.078	0.099	0.209	0.209	0.115	0.075	0.037	0.030
	6	COLUSA	0.020	0.022	0.025	0.077	0.099	0.153	0.153	0.153	0.133	0.105	0.034	0.027
	11	GLENN	0.017	0.025	0.023	0.074	0.060	0.147	0.147	0.147	0.133	0.123	0.075	0.029
	31	PLACER	0.009	0.022	0.023	0.054	0.090	0.170	0.170	0.170	0.170	0.050	0.032	0.041
	34	SACRAMENTO	0.023	0.021	0.022	0.086	0.105	0.153	0.153	0.153	0.153	0.074	0.035	0.024
	45	SHASTA	0.024	0.022	0.023	0.084	0.093	0.151	0.151	0.151	0.151	0.082	0.040	0.031
	48	SOLANO	0.023	0.026	0.023	0.068	0.076	0.185	0.185	0.185	0.096	0.079	0.030	0.024
	51	SUTTER	0.023	0.021	0.022	0.086	0.105	0.153	0.153	0.153	0.153	0.074	0.035	0.024
	52	TEHAMA	0.023	0.026	0.023	0.068	0.076	0.185	0.185	0.185	0.096	0.079	0.030	0.024
	57	YOLO	0.016	0.020	0.021	0.076	0.086	0.155	0.155	0.155	0.149	0.108	0.039	0.021
	58	YUBA	0.021	0.020	0.021	0.055	0.067	0.144	0.178	0.178	0.178	0.069	0.045	0.023