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PARTICULATE CONTROL FOR FUGITIVE DUST

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PARTICULATE CONTROL FOR FUGITIVE DUST

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1.0 CONCLUSIONS

1. Fugitive dust sources are significant emitters of particulates in a majority of the AQCR's. Of the 150 AQCR's that do not meet the TSP standards, fugitive dust emissions exceed point source emissions in 139, or 92 percent. In fact, fugitive emissions are 10 times greater than point source emissions in 58, or 39 percent of the AQCR's.
2. In most cases, unpaved roads provide the largest source of particulate emissions in the AQCR's. Agricultural tilling and construction sources are also very important and in some cases are the largest emitters.
3. The reentrainment of particles from paved roads is a source of large quantities of particulates in many AQCR's.
4. Industrial sources of fugitive emissions are plentiful and can have a substantial impact on surrounding areas.
5. Fugitive dust sources can contribute significantly to the TSP burden of an entire AQCR as well as having an impact in a localized area.
6. The relationship between pollutant exposure and human health has been demonstrated. Increased hospitalization rates have been observed with increased particulate pollutant exposure.
7. More attention should be given to the control of fugitive dust emissions because of their contribution to ambient dust loadings.
8. Control effectiveness for fugitive sources is highly variable and depends on such things as type of control, characteristics of the source, local climatic conditions, and source activity.
9. Present control technology for unpaved roads, agricultural tilling, and construction activity is inadequate. Reducing the emissions from these activities by the amounts reported in the literature has only a small influence on fugitive emissions in most AQCR's.

2.0 RECOMMENDATIONS

2.1 AGRICULTURAL TILLING

Agricultural tilling has the potential to generate large amounts of particulate emissions, possibly including pesticide residues. Thus, an important source of potentially adverse health effects exists. A study to characterize this source is highly recommended. An initial procedure to follow may look like the following:

1. Arbitrarily select several agricultural sites and collect ambient air and soil samples for analysis.
2. Measure airborne concentration and respirable fraction.
3. Analyze samples for residual pesticide content.

If this initial program does show potentially adverse levels of pesticide residuals, a more detailed program such as the following would be recommended.

Stage 1 - (Approximately 3 months in duration)

1. Obtain data on types and quantities of agricultural pesticides used. Relate quantities to geographical use.
2. Relate types of pesticides to application patterns, both recommended and actual.

Stage 2 - (Approximately 3 years in duration)

1. Establish test plots where various pesticides can be applied to different types of soils. Physically isolate each plot from the effects of the other plots.
2. Design a sampling program using recommended sampling procedures, and periodically sample test plots for pesticide residues.
3. Analyze ambient air samples from around the test plots during tilling operations and characterize the collected particles for particle size, particle identity, and pesticide residue content. Relate pesticide residue content to particle type.

4. Perform bioassay tests using Level I Environmental Assessment procedures.
5. Relate the results to the population at risk.

2.2 CONSTRUCTION ACTIVITY

Construction activity has the potential to generate large amounts of fugitive dust. Along with the activity itself, the stripped land is subject to dusting from wind action. The possibility exists for hazardous emissions depending on the nature of the soil and rock that are being worked. The potential of the materal getting into surrounding water supplies by runoff is also present.

To study emissions from construction activity, the following guidelines may be used:

1. Examine excavation methods.
2. Evaluate the effectiveness and extent of use of current control techniques.
3. Design a sampling program for a detailed evaluation of controlled and uncontrolled emissions from various construction activities. At a minimum, evaluate excavation, scraping, hauling, other vehicle travel on roads, and blasting.
4. Evaluate the effectiveness and extent of use of methods to stabilize exposed sites.
5. Propose new control methods and examine their effectiveness and economic impact.
6. Examine data on construction activity sources to develop improved procedures for completing accurate emission inventories.

2.3 STOCKPILE AND WASTE HEAP DATA BASE

An examination of data from the NEDS file indicated that very little data on these types of emissions are included. A major study on cataloging these types of sources should be conducted. Large amounts of raw materials and wastes are piled each year. An inventory of these sources would require a major effort but could be beneficial to a number of studies.

2.4 UNPAVED ROADS

The data base on unpaved roads and parking lots should be refined by using more detailed and site specific data. A good start has been made on unpaved roads by using localized emission factors based on local characteristics (e.g., silt content) and local climatic factors (precipitation/evaporation index and number of dry days). However, better data on the local activity factors (vehicle miles) are needed. These data can be collected from State and local governmental agencies.

The control techniques for unpaved roads are inadequate. A detailed study of new control techniques should be initiated.

2.5 CONTROL TECHNIQUES FOR REENTRAINED STREET DUST

Recent studies have shown that reentrained dust from streets is a major contributor to the TSP loadings in urban areas. This source of dust pollution is usually not subject to any control. Street cleaning techniques have been found to be ineffective in most cases for reducing dust emissions from paved roads. However, the data are inconclusive, and more studies to test and develop new techniques are needed.

3.0 INTRODUCTION

Many Air Quality Control Regions (AQCR's) do not meet the primary and/or secondary standards for total suspended particulates (TSP). This project has made an estimate of the impact of fugitive dust emissions (i.e., nonducted emissions) on the TSP in these AQCR's. In making this estimate, the relationships between fugitive dust emissions and emissions from other sources were examined in each AQCR. The relationship of emissions to ambient concentrations was not explored except in a general fashion by examining published information on this relationship.

Existing control technology for fugitive dust sources was also examined. The effectiveness of control techniques applied to various sources was estimated. When possible, data on fractional efficiency of control were presented.

4.0 EMISSION SOURCES

The Air Quality Control Regions that do not meet the total suspended particulate standards were identified from a published report.[1] Emissions in each of these AQCR's were then examined to define relative importance for the various emission source categories.

4.1 AREA SOURCES

The emission sources examined were those over which man has some control. In most cases, these sources were classified as area sources by the National Emissions Data System (NEDS) and include dirt roads, landings and takeoffs from dirt airstrips, agricultural tilling, construction, open burning, slash fires, and coal refuse fires. In the case of the first four sources listed, the data were taken from an updated card file that used countywide emission factors and activity levels. The resultant emissions data are thought to be more accurate than the data that used nationwide emissions factors because they are corrected by local silt content, precipitation/evaporation indexes, and dry days per year.

Data on emissions from open burning, slash fires, and burning coal refuse piles also were obtained from NEDS. Of course, other area sources such as paved roads should also be considered in the area source calculations. However, data on these types of emissions could not be obtained on a nationwide basis.

The emissions from each of the above sources are presented in Table 1 for each of the AQCR's that do not meet the TSP standards. These are referred to as area source emissions. The emissions for AQCR's 244 and 246 are not tabulated due to a lack of data in NEDS. open burning contains emission data for residential, industrial, and commercial refuse burning. The data for coal refuse piles were generated using an emission factor of 10 kg/m^3 (17 lb/yd^3) and assuming that 5 percent of the pile burns each year.[2]

TABLE 1. AREA SOURCE EMISSIONS FROM AQCR'S THAT DO NOT MEET TSP STANDARDS

AQCR		AREA SOURCE EMISSIONS (10^3 tons/year)						
		Dirt Roads	Dirt LTO's	Agricultural Tilling	Open Burning[1]	Construction	Slash Fires	Coal Refuse[2]
3	East Alabama	53.8	0	1.3	2.6	30.8	0	0
4	Metropolitan Birmingham	94.7	0	3.3	5.0	86.7	0	Neg.
5	Mobile-Pensacola-Panama City-Southern Mississippi Interstate	271.6	0	15.1	4.4*	176.7	7.1	0
7	Tennessee River Valley-Cumberland Mountains Interstate	158.2	0.1	7.3	3.6	89.7	0	0
8	Cook Inlet	2.0	0.4	0.2	0	36.2	0	0
9	Northern Alaska	12.7	0.6	Neg.	0.5	13.0	0	0
11	Southeastern Alaska	0.9	Neg.	Neg.	0.1	8.2	0	0
12	Arizona-New Mexico-Southern Border Interstate	50.5	0.2	64.3	0.2	6.3	0	0
13	Clark-Mohave Interstate	5.6	0.3	164.4	0.1	22.5	0	0
14	Four Corners Interstate	179.1	0.3	50.4	0.3*	36.0	0.1	0
15	Phoenix-Tuscon	80.6	0.6	331.5	2.5	105.6	0	0
16	Central Arkansas	293.1	0	26.6	0.6	55.4	0	0
17	Metropolitan Ft. Smith Interstate	89.4	0	2.4	1.0	37.8	0	0
18	Metropolitan Memphis Interstate	29.1	Neg.	9.2	0.2	48.8	0	0
19	Monroe-El Dorado Interstate	79.6	Neg.	20.6	1.8	73.5	0	0
20	Northeast Arkansas	151.3	Neg.	100.4	0.4	29.3	0	0
22	Shreveport-Texarkana-Tyler Interstate	219.6	0.1	18.3	2.7	346.0	0	0
24	Metropolitan Los Angeles	184.7	0.7	182.8	9.3	2431.3	0	0
25	North Central Coast	43.7	Neg.	36.5	0.3	87.7	0	0
26	North Coast	66.9	Neg.	3.8	0.2	57.6	0	0
27	Northeast Plateau	16.9	Neg.	5.6	Neg.*	4.4	0	0
28	Sacramento Valley	115.7	0.3	43.0	1.1	331.6	0	0
29	San Diego	38.5	Neg.	11.4	1.2	346.0	0	0
30	San Francisco Bay Area	73.4	0.4	44.2	4.2	1210.5	0	0
31	San Joaquin Valley	225.9	0.1	402.4	1.5	380.9	0	0
32	South Central Coast	14.9	Neg.	25.4	0.1*	33.4	0	0
33	Southeast Desert	16.3	0.1	285.7	0.1*	14.8	0	0

TABLE 1. (cont'd)

AQCR	Dirt Roads	Dirt LTO's	Agricultural Tilling	Open Burning	Construction	Slash Fires	Coal Refuse
	AREA SOURCE EMISSIONS (10^3 tons/year)						
35 Grand Mesa	46.6	Neg.	18.8	Neg.	17.6	0	0.1
36 Metropolitan Denver	14.3	0.3	27.9	0.2	130.3	0	0
37 Pawnee	43.0	0.1	159.9	Neg.	25.7	0	2.2
38 San Isabel	47.5	Neg.	23.7	0.1	36.6	0	24.2
42 Hartford-New Haven-Springfield Interstate	39.3	0	0.9	0.5*	193.0	0	0
43 New Jersey-New York-Connecticut Interstate	93.5	Neg.	1.7	9.8	1572.2	0	0
45 Metropolitan Philadelphia Interstate	61.4	Neg.	3.4	0	850.6	Neg.	0
47 National Capital Interstate	29.3	0	1.9	0.8	115.3	0	0
49 Jacksonville-Brunswick Interstate	156.7	Neg.	3.5	0.4*	149.2	17.5	0
52 West Central Florida	70.4	0	0.9	0.1*	148.8	11.6	0
55 Chattanooga Interstate	102.6	0	0.8	0.5	60.2	3.5	0
58 Savannah-Beaufort Interstate	49.7	0	1.3	1.2	36.4	2.3	0
60 Hawaii	*	0	8.1	0.7	64.5	22.2	0
61 Eastern Idaho	45.6	Neg.	140.7	0.7*	133.0	6.4	0
62 Eastern Washington-Northern Idaho Interstate	72.3	0.2	290.1	0.7*	153.1	Neg.	0
63 Idaho	104.5	0.1	208.7	0.8*	156.7	22.5	0
64 Metropolitan Boise	14.5	0.3	42.6	0.5*	164.5	0	0
65 Burlington-Keokuk Interstate	117.5	Neg.	51.7	2.0	69.2	0	0
67 Metropolitan Chicago Interstate	197.5	Neg.	30.0	9.2	944.8	0	0
69 Metropolitan Quad Cities Interstate	92.8	Neg.	48.1	2.8	62.9	0	Neg.
70 Metropolitan St. Louis Interstate	179.6	0	30.1	2.1*	198.4	0	0
73 Rockford-Janesville-Beloit Interstate	67.6	0	28.9	1.1	53.5	0	0
75 West Central Illinois	150.8	Neg.	70.5	1.7	94.5	0	0
77 Evansville-Owensboro-Henderson Interstate	90.0	Neg.	19.1	0.7	72.3	Neg.	0.2
78 Louisville Interstate	28.9	0	1.3	1.0	72.6	0	0
79 Metropolitan Cincinnati Interstate	77.3	0	7.8	2.4	200.7	Neg.	0
80 Metropolitan Indianapolis	85.7	Neg.	12.5	1.7	169.4	0	0
84 Wabash Valley	194.9	0	60.7	1.2	134.3	0	0

TABLE 1. (cont'd)

AQCR		AREA SOURCE EMISSIONS (10^3 tons/year) Dirt Roads	Dirt LTO's	Agricultural Tilling	Open Burning[1]	Construction	Slash Fires	Coal Refuse[2]
85	Metropolitan Omaha-Council Bluffs Interstate	29.3	0	16.6	1.0*	70.4	0.7	0
86	Metropolitan Sioux City Interstate	47.7	0	46.9	1.3*	16.9	Neg.	0
87	Metropolitan Sioux Falls Interstate	52.3	0	60.0	0.2	6.2	Neg.	0
88	Northeast Iowa	119.0	Neg.	50.4	3.9	40.0	Neg.	0
89	North Central Iowa	239.3	0	50.0	2.2	27.3	Neg.	0
91	Southeast Iowa	80.3	0	31.3	1.8	19.1	0	0
92	South Central Iowa	148.1	0	63.2	5.3	65.4	Neg.	0
94	Metropolitan Kansas City Interstate	66.2	0.2	17.1	3.1	133.6	0	0
95	Northeast Kansas	114.1	Neg.	34.8	2.2	44.6	0.8	0
96	North Central Kansas	105.8	0	101.4	2.4	31.9	2.2	0
97	Northwest Kansas	120.1	Neg.	308.1	1.2	19.3	0	0
101	Appalachian	110.4	Neg.	1.0	0.4	32.0	Neg.	66.7
102	Bluegrass	53.2	0	4.7	0.5	43.9	Neg.	0
103	Huntington-Ashland-Portsmouth-Ironton Interstate	106.8	0	6.8	0.6	72.3	Neg.	0
107	Androscoggin Valley Interstate	25.2	Neg.	1.2	0.5	36.4	0	0
109	Down East	12.8	Neg.	0.5	0.3	18.8	0	0
112	Central Maryland	7.4	0	1.7	0.1	4.7	0	0
113	Cumberland-Keyser Interstate	19.9	0	2.1	1.2*	7.7	0	1.7
115	Metropolitan Baltimore	40.6	Neg.	1.5	1.9	62.9	0	0
117	Berkshire	7.9	0	0.4	Neg.	4.7	0	0
118	Central Massachusetts	25.1	Neg.	0.3	0.1	13.9	0	0
119	Metropolitan Boston	31.4	0	0.2	0	62.1	0	0
120	Metropolitan Providence Interstate	71.2	0	0.6	1.9	39.1	0	0
121	Merrimac Valley-South New Hampshire Interstate	90.3	Neg.	0.7	0.9	77.4	0	0
123	Metropolitan Detroit-Port Huron	91.0	0	5.9	0.3	353.7	0	0
124	Metropolitan Toledo Interstate	42.3	0	7.3	0.9	89.4	0	0
126	Upper Michigan	149.6	Neg.	3.5	0.1	55.3	0	0

TABLE 1. (cont'd).

AQCR	Dirt Roads	Dirt LTO's	Agricultural Tilling	Open Burning[1]	Construction	Slash Fires	Coal Refuse[2]
	AREA SOURCE EMISSIONS (10^3 tons/year)						
128 Southeast Minnesota-La Crosse Interstate	246.9	0	119.9	1.0*	101.8	0	0
131 Minneapolis-St. Paul	55.9	0	8.8	0.1*	257.5	0	0
132 Northwest Minnesota	180.8	0	95.1	0.3*	48.5	0	0
133 Southwest Minnesota	111.3	0	101.8	0.1*	34.9	0	0
137 Northern Missouri	190.4	0.1	103.1	0.3*	58.0	0	0
140 Billings	41.3	Neg.	89.6	0.2	5.3	2.9	0
141 Great Falls	38.2	Neg.	159.4	0.6	4.6	1.3	0
142 Helena	44.0	Neg.	55.6	0.5	6.5	14.6	0
143 Miles City	70.2	0.1	202.1	0.5	3.1	1.5	0
144 Missoula	38.9	Neg.	13.7	0.4	6.9	15.1	0
145 Lincoln-Beatrice-Fairbury	42.7	0	21.8	0.1*	34.1	Neg.	0
146 Nebraska	326.7	Neg.	809.2	0.3*	98.8	0.1	0
147 Nevada	13.6	0.1	130.5	Neg.	2.6	Neg.	0
148 Northwest Nevada	33.7	Neg.	40.3	Neg.	7.9	0	0
151 Northeast Pennsylvania-Upper Delaware Valley Interstate	287.8	Neg.	12.4	0*	382.2	0	10.2
152 Albuquerque-Mid Rio	25.3	0	2.7	0.6	18.5	0	0
153 El Paso-Las Cruces-Alamogordo Interstate	86.5	0.1	75.2	0.5	96.7	0	0
155 Pecos-Permian Basin	58.3	Neg.	90.5	0.4	9.6	0	0
158 Central New York	93.0	Neg.	14.8	1.0	97.2	0	0
161 Hudson Valley	136.8	0.2	7.5	1.3	169.4	0	0
162 Niagara Frontier	39.8	Neg.	4.3	1.1	89.6	0	0
164 Southern Tier West	63.7	Neg.	11.8	0.5	47.6	0	0
173 Dayton	50.2	0	12.8	1.6	120.5	0	0
174 Greater Metropolitan Cleveland	0.8	Neg.	4.3	5.3	410.1	0	0
176 Metropolitan Columbus	0.5	Neg.	17.3	1.8	178.6	0	0.1
177 Northwest Ohio	7.2	0	37.8	0.9	81.5	0	0
178 Northwest Pennsylvania-Youngstown Interstate	246.2	0.1	9.3	1.0*	227.0	0	0
178 Parkersburg-Marietta Interstate	47.7	Neg.	2.0	0.3	46.3	0	Neg.

TABLE 1. (cont'd).

AQCR	AREA SOURCE EMISSIONS (10^3 tons/year) Dirt Roads	Dirt LTO's	Agricultural Tilling	Open Burning[1]	Construction	Slash Fires	Coal Refuse[2]
180 Sandusky	28.9	0.1	10.3	0.4	37.5	0	0
181 Stubenville-Wierton-Wheeling Interstate	52.0	Neg.	2.3	0.5	51.6	0	0.6
184 Central Oklahoma	70.8	0	30.4	1.0	124.7	0	0
186 Northeastern Oklahoma	135.2	0	14.8	2.4	128.5	0	0
187 Northwestern Oklahoma	81.4	Neg.	167.8	0.9	21.7	0	0
190 Central Oregon	78.3	Neg.	52.0	0.1	16.2	4.0	0
191 Eastern Oregon	108.3	Neg.	96.2	0.2	13.4	1.7	0
193 Portland Interstate	152.0	0.2	6.0	2.1	210.7	24.4	0
194 Southwest Oregon	61.3	Neg.	1.7	0.4	24.4	3.9	0
195 Central Pennsylvania	235.1	Neg.	13.7	0*	185.0	0	40.4
196 South Central Pennsylvania	228.5	0	16.5	0*	275.9	0	1.7
197 Southwest, Pennsylvania	300.4	Neg.	5.0	0*	472.5	0	112.3
205 Black Hills-Rapid City	21.4	Neg.	27.0	0.1	5.2	0	0
207 Eastern Tennessee-Southwestern Virginia Interstate	455.9	0	6.2	2.3	131.5	0	5.3
208 Middle Tennessee	126.3	Neg.	8.2	0.7	91.6	0	0
209 Western Tennessee	103.7	0	18.6	0.5	34.9	0	0
211 Amarillo-Lubbock	104.2	0.1	585.5	0.5	185.5	0	0
213 Brownsville-Laredo	37.9	Neg.	83.3	0.3	96.7	0	0
214 Corpus Christi-Victoria	51.8	0.1	75.3	0.4	201.3	0	0
215 Metropolitan Dallas-Forth Worth	87.1	Neg.	70.6	2.2	875.4	0	0
216 Metropolitan Houston-Galveston	87.2	0	25.8	1.9	1030.3	0	0
217 Metropolitan San Antonio	79.4	0.1	56.9	0.9	306.3	0	0
219 Utah	82.2	Neg.	108.6	0.2	34.5	0.5	0
220 Wasatch Front	35.5	0.1	16.9	Neg.	149.0	0.1	0
222 Central Virginia	54.8	Neg.	2.6	0.5	42.3	0	0
223 Hampton Roads	18.0	0	1.4	0.4	88.2	0	0
225 State Capital	26.5	0	1.6	0.5	58.2	0	0
226 Valley of Virginia	49.2	0	6.3	0.9	51.0	0	0
227 Northern Washington	51.1	Neg.	48.3	0.1	23.4	0.9	0

TABLE 1. (cont'd).

AQCR	Dirt Roads	Dirt LTO's	Agricultural Tilling	Open Burning[1]	Construction	Slash Fires	Coal Refuse[2]
	AREA SOURCE EMISSIONS (10^3 tons/year)						
228 Olympia-Northwest Washington	52.9	Neg.	0.7	0.3	78.7	3.8	0
229 Puget Sound	64.5	0.1	0.2	0.5	354.1	1.9	0
230 South Central Washington	60.6	Neg.	145.2	0.4	64.3	0.2	1.3
234 Kanawha Valley	53.9	0	0.3	0.1	46.6	0	32.1
237 Lake Michigan	104.5	0.1	33.0	1.2	45.4	0	0
238 North Central Wisconsin	59.1	0	11.6	0.4	16.0	0	0
239 Southeastern Wisconsin	55.3	0	8.4	3.9	74.6	0	0
240 Southern Wisconsin	69.9	0	38.2	0.7	30.7	0	0
243 Wyoming	75.6	0	97.3	Neg.	13.0	0.3	0

1. Includes residential, industrial, and commercial.
2. Emission factor of 17 lb/yd^3 - assume 1/20 burns per year

Neg. = Negligible < 0.5 x 10^3 tons/year

*Data missing or incomplete

The data for the dirt road emissions were calculated by multiplying the number of vehicle miles traveled by a local emission factor. The vehicle miles traveled were based on a nationwide population extrapolation of data from Kansas where an accurate accounting has been made. A discussion with EPA personnel indicated that a check of these data with results from St. Louis indicated that rural data were within approximately 50 percent while urban data could be as much as two orders of magnitude high.[3] For inclusion in Table 1, the computed values for dirt roads have been reduced by one order of magnitude. This reduction was arbitrarily selected.

Some reported data were incomplete or missing, and these occurrences are so noted by an asterisk.

4.2 INDUSTRIAL SOURCES

Some industrial sources have the potential to contribute significant fugitive dust emissions. A list of these sources is shown in Table 2.[4]

Within these industries, there may be many sources of fugitive emissions. Some of the most important include raw material and product piles, waste heaps, materials handling equipment, comminution equipment, furnaces, and dryers.

A search of the NEDS file provided data on the total emissions, number of industrial sources, and the percentage of the sources that are controlled in each of the AQCR's that do not meet the TSP standards. The data are presented in Table 4, columns 3, 8, and 9, respectively (Section 4.4 presents Table 4).

4.3 PAVED ROADS

One source of fugitive emissions has been virtually neglected until recently. Paved roads have been shown to be significant contributors to particulate emissions. A study conducted in Seattle's Duwamish Valley compared dust emissions from paved and unpaved roads to emissions from industry and other sources.[5] The results follow:

TABLE 2. INDUSTRIES THAT ARE CONSIDERED TO BE SIGNIFICANT SOURCES OF FUGITIVE EMISSIONS

Process Chemical Manufacturing

- TNT - open waste burning
- Fertilizer - ammonia nitrate
- Pesticides
- Asbestos - chemical

Process Food/Agriculture

- Alfalfa dehydrating
- Cotton ginning
- Grain terminals
- Grain terminals - country
- Grain processing
- Barley feed manufacture
- Other

Primary Metals

- Aluminum
- Metallurgical coke
- Copper
- Ferroalloys
- Iron
- Steel
- Lead
- Molybdenum
- Barium
- Gold
- Beryllium
- Mercury
- Zinc

Secondary Metals

- Aluminum
- Brass/Bronze
- Gray iron
- Lead
- Magnesium
- Steel foundry
- Zinc
- Malleable iron
- Nickel
- Zirconium

Process Mineral Products

- Asphalt concrete
- Brick
- Castable refractories
- Cement
- Ceramics/clays
- Concrete batching
- Coal cleaning
- Glass
- Gypsum
- Lime
- Mineral wool
- Phosphate rock
- Stone quarrying
- Salt mining
- Potash production
- Calcium borate
- Magnesium carbonate
- Sand and gravel
- Diatomaceous earth
- Asbestos
- Special materials - open pit
- Others

Wood Products

- Sulfate pulping
- Sulfite pulping
- Paperboard manufacturing
- Plywood/particle board
- Sawmill
- Furniture

Waste Disposal

- Government, commercial, institutional, and industrial open burning
- Sludge incineration
- Auto body burning
- Railcar burning

Source	Emissions (tons/yr)	Percent of Total Emissions
Heavy industry	1200	24.5
Vessels, trains, auto tailpipes, home heating	1000	20.4
Gravel roads (19 mi)	2100	42.9
Paved roads (110 mi)	600	12.2

Other data presented in this study showed that a car driven 12 km (7.5 mi) at 16 km/h (10 mph) on a wet gravel road picked up 36 kg (80 lb) of mud. Average pickup from dirt parking lots was 0.34 kg (0.74 lb) per vehicle. Thus, mud pickup from unpaved roads and parking lots can contribute significantly to the amount of material that is deposited on paved roads.

Another study examined the contribution of various sources including paved roads to the total particulate emissions in three counties in North Carolina.[6] The results are shown in Table 3.

TABLE 3. COMPARISON OF THE CONTRIBUTION OF SOURCE CATEGORIES TO TOTAL EMISSIONS IN THREE COUNTIES OF NORTH CAROLINA FOR 1973

	EMISSIONS BY SOURCE CATEGORY (% OF TOTAL EMISSIONS)		
Source	Mecklenburg County	Forsyth County	Guilford County
Point	74.0	8.7	9.6
Unpaved Roads	14.9	77.8	76.6
Paved Roads	5.6	7.2	6.8
Other Area Sources	5.5	6.3	7.0

Tire wear debris has been examined as a source of airborne particulate. One study estimated that this debris was a relatively minor source accounting for 2 to 3 percent of the suspended particulate associated with vehicles.[7]

4.4 THE MAGNITUDE OF THE EMISSION PROBLEM

To estimate the magnitude of the emission problem associated with fugitive dust, the emissions were compared to the total point source emissions for each of the AQCR's that did not meet either the primary or the secondary TSP standards. The results are shown in Table 4.

The data in this table were taken from several sources. The total point source emissions data (column 3) were taken from NEDS. The data for AQCR 119 and subsequent AQCR's were taken directly from the current NEDS file while the data for AQCR's 3 through 118 were taken from a report that listed 1973 data.[8] The reason for the different data sources was a computer problem that did not allow the acquisition of current data for the lower numbered AQCR's.

The total industrial source emissions data (column 4) were acquired from the current NEDS File. These are the total emissions from the industrial sources listed in Table 2 (i.e., those industries that have been identified as potentially significant sources of fugitive emissions).

The area source emissions (column 5) are totals from Table 1. Again, these data represent emissions from dirt roads, dirt LTO's, agricultural tilling, open burning, construction, slash fires, and coal refuse piles.

The annual emission densities (columns 6, 7, and 8) represent the emission data divided by the land area of the AQCR (column 3). The number of industrial sources (represented by the emissions from column 4) are listed in column 9 and were obtained from the current NEDS File. Column 10 presents data on the percentage of industrial sources currently controlled in each AQCR.

A simple analysis of the data in Table 4 shows the following results:

	Number of AQCR's	% of Total
Point Source > Area Source	9	6.7
Area > Point	139	92.0
Area 5 times greater than point	97	64.7
Area 10 times greater than point	58	38.7
Data Missing	2	1.3
Totals	150	100.0

TABLE 4. COMPARISON OF FUGITIVE EMISSIONS WITH TOTAL POINT SOURCE EMISSIONS

AQCR No.	Area (10^3 mi^2)	EMISSIONS (10^3 t/year)			ANNUAL EMISSIONS DENSITIES ($tons/mi^2$)			Number of Industrial Sources in AQCR	Industrial Sources Controlled (%)
		Total Point Source	Total Industrial Source	Total Area Source[1]	Point	Industrial	Area		
3	6.2	24.8	23.0	88.5	4.0	3.7	14.3	179	33.5
4	10.9	643.3	230.4	189.7	59.0	21.1	17.4	409	40.1
5	33.4	199.8	91.1	474.9*	6.0	2.7	14.2	1032	44.3
7	15.8	338.6	67.4	258.9	21.4	4.3	16.4	539	46.0
8	43.5	1.3	0.8	38.8	Neg.	Neg.	0.9	14	64.3
9	316.7	13.1	0.3	26.8	Neg.	Neg.	0.1	19	31.6
11	34.6	2.9	1.6	9.2	0.1	Neg.	0.3	18	38.9
12	20.9	36.8	41.9	121.5	1.8	2.0	5.8	91	82.4
13	30.8	76.2	79.0	192.9	2.5	2.6	6.3	94	78.7
14	99.1	36.3	8.9	266.2*	0.4	0.1	2.7	68	52.9
15	29.6	53.2	44.7	520.8	1.8	1.5	17.6	197	56.3
16	13.3	46.2	13.2	375.7	3.5	1.0	28.2	182	52.7
17	64.9	13.1	23.3	130.6	0.2	0.4	2.0	61	47.5
18	2.6	13.9	7.1	87.3	5.3	2.7	33.6	129	72.1
19	12.8	29.0	12.1	175.5	2.3	0.9	13.7	80	58.8
20	13.1	29.8	6.4	281.4	2.3	0.5	21.5	117	25.6
22	26.3	154.1	56.9	586.7	5.9	2.2	22.3	271	42.1
24	9.1	64.1	42.1	2808.8	7.0	4.6	308.7	742	50.5
25	19.7	5.3	2.3	168.2	0.3	0.1	8.5	81	66.7
26	15.5	18.3	18.2	128.5	1.2	1.2	8.3	273	24.5
27	12.6	8.3	5.2	26.9*	0.7	0.4	2.1	120	32.5
28	20.7	28.4	26.2	491.7	1.4	1.3	23.8	317	44.8
29	3.7	16.9	15.3	397.1	4.6	4.1	107.3	131	71.0
30	6.9	26.5	4.5	1332.7	3.8	0.7	193.1	167	57.5
31	30.8	101.2	46.9	1010.8	3.3	1.5	32.8	358	41.9
32	5.5	5.4	3.8	73.8*	1.0	0.7	13.4	49	55.1
33	30.5	80.5	42.3	317.0*	2.6	1.4	10.4	182	71.4
35	18.9	5.5	0.5	83.1	0.3	Neg.	4.4	20	100

TABLE 4. (cont'd).

AQCR No.	Area (10^3 mi^2)	EMISSIONS (10^3 t/year) Total Point Source	Total Industrial Source	Total Area Source[1]	ANNUAL EMISSIONS DENSITIES (tons/mi^2) Point	Industrial	Area	Number of Industrial Sources in AQCR	Industrial Sources Controlled (%)
36	5.0	24.7	5.0	173.0	4.9	1.0	34.6	91	94.5
37	15.7	9.7	0.5	230.9	0.6	Neg.	14.7	20	80.0
38	17.0	142.5	9.8	132.1	8.4	0.6	7.8	64	96.9
42	3.5	38.4	9.8	233.7*	11.0	2.8	66.8	103	35.0
43	5.0	65.2	42.5	1677.2	13.0	8.5	335.4	657	73.8
45	4.5	200.1	104.0	915.4	44.5	23.1	203.4	398	65.6
47	2.3	37.8	15.2	147.3	16.4	6.6	64.0	128	87.5
49	23.9	70.7	10.1*	327.3*	3.0	0.4*	13.7	*	*
52	7.9	54.6	3.6	160.5*	6.9	0.5	20.3	48	79.2
55	5.9	53.2	19.1	167.6	9.0	3.2	28.4	179	81.0
58	6.0	55.9	1.0	90.9	9.3	0.2	15.2	17	47.1
60	6.4	41.8	13.5	95.5*	6.5	2.1	14.9	79	72.2
61	18.7	11.1	2.0	326.4*	0.6	0.1	17.5	50	74.0
62	19.4	19.3	6.4	516.4*	1.0	0.3	26.6	167	65.9
63	55.0	8.8	2.9	493.3*	0.2	0.1	9.0	77	45.5
64	1.6	2.0	4.3	222.4*	1.3	2.7	139.0	34	61.8
65	7.1	169.1	40.4	240.4	23.8	5.7	33.9	160	37.5
67	6.0	322.3	333.9	1181.5	53.7	55.7	196.9	507	61.5
69	4.9	44.8	7.5	206.6	9.1	1.5	42.2	155	54.2
70	6.5	111.5	94.5	410.2*	17.2	14.5	63.1	280	47.1
73	3.4	11.4	4.9	122.2	3.4	1.4	35.9	47	29.8
75	9.4	81.0	20.7	317.5	8.6	2.2	33.8	78	5.1
77	5.6	61.2	21.5	182.3	10.9	3.8	32.6	121	42.1
78	0.9	154.0	62.0	103.8	171.1	68.9	115.3	393	70.5
79	3.8	200.3	17.8	288.2	52.7	4.7	75.8	60	36.7
80	3.0	29.7	25.2	269.3	9.9	8.4	89.8	102	68.6
84	10.2	134.6	49.2	391.1	13.2	4.8	38.3	176	67.6
85	1.5	35.6	1.1	88.7*	23.7	0.7	59.1	107	53.3

TABLE 4. (cont'd).

AQCR No.	Area (10^3 mi^2)	EMISSIONS (10^3 t/year) Total Point Source	Total Industrial Source	Total Area Source[1]	ANNUAL EMISSIONS DENSITIES ($tons/mi^2$) Point	Industrial	Area	Number of Industrial Sources in AQCR	Industrial Sources Controlled (%)
86	3.2	8.1	5.6	112.8*	2.5	1.8	35.3	25	40.0
87	3.1	6.0	2.4	118.7	1.9	0.8	38.3	48	37.5
88	7.1	69.1	4.7	213.3	9.7	0.7	30.0	108	75.9
89	8.4	45.5	33.4	318.8	5.4	4.0	38.0	99	73.7
91	5.2	6.1	0.4	132.5	1.2	0.1	25.5	34	47.1
92	10.0	50.7	23.0	282.0	5.1	2.3	28.2	190	51.1
94	4.2	56.4	25.6	86.6	13.4	6.1	20.6	242	56.6
95	8.6	26.2	22.6	196.5	3.0	2.6	22.8	169	49.1
96	11.6	21.1	3.3	243.7	1.8	0.3	21.0	38	34.2
97	19.7	15.6	0.1	448.7	0.8	Neg.	22.8	34	32.4
101	7.7	241.3	193.9	210.5	31.3	25.2	27.3	112	20.5
102	4.3	26.8	1.5	102.3	6.2	0.3	23.8	85	35.3
103	8.1	164.6	41.0	186.5	20.3	5.1	23.0	188	43.6
107	9.1	26.1	22.0	63.3	2.9	2.4	7.0	237	33.8
109	7.6	9.7	6.6	32.4	1.3	0.9	4.3	159	17.0
112	0.7	2.3	0.9	13.9	3.3	1.3	19.9	59	81.4
113	1.8	111.6	1.5	32.6*	62.0	0.8	18.1	87	79.3
115	2.2	42.1	7.8	106.9	19.1	3.5	48.6	213	61.5
117	0.9	1.2	0.6	13.0	1.3	0.7	14.4	25	12.0
118	1.5	9.4	4.8*	39.4	6.3	3.2*	26.3	*	*
119	2.9	6.0	3.2	93.7	2.1	1.1	32.3	11	18.2
120	2.5	5.0	1.9	112.8	2.0	0.8	45.1	5	60.0
121	5.2	3.0	2.0	169.3	0.6	0.4	32.6	8	12.5
123	2.6	70.2	21.5	450.9	27.0	8.3	173.4	32	21.9
124	1.5	35.1	1.8	139.9	23.4	1.2	93.3	12	50.0
126	25.7	131.2	62.4	208.5	5.1	2.4	8.1	21	52.4
128	21.4	54.3	1.9	369.6*	2.5	0.1	17.3	8	75.0
131	2.8	25.3	*	322.3*	9.0	*	115.1	*	*

TABLE 4. (cont'd).

AQCR No.	Area (10^3 mi^2)	EMISSIONS (10^3 t/year): Total Point Source	Total Industrial Source	Total Area Source[1]	ANNUAL EMISSIONS DENSITIES (tons/mi^2): Point	Industrial	Area	Number of Industrial Sources in AQCR	Industrial Sources Controlled (%)
132	27.2	20.5	*	324.7*	0.8	*	11.9	*	*
133	11.9	18.2	*	248.1*	1.5	*	20.8	*	*
137	24.0	70.4	49.1	351.9*	2.9	2.0	14.7	57	24.6
140	25.6	3.9	*	139.3	0.2	*	5.4	*	*
141	23.8	0.4	*	204.1	Neg.	*	8.6	*	*
142	28.1	11.9	11.3	121.2	0.4	0.4	4.3	12	83.3
143	47.4	6.2	*	277.5	0.1	*	5.9	*	*
144	19.1	11.3	8.6	75.0	0.6	0.5	3.9	9	55.6
145	2.8	7.9	3.4	98.7*	2.8	1.2	35.3	4	25.0
146	72.1	89.6	56.9	1235.1*	1.2	0.8	17.1	283	2.1
147	91.6	37.2	37.2	146.8	0.4	0.4	1.6	20	70.0
148	9.4	1.3	1.2	81.9	0.1	0.1	8.7	7	100
151	11.2	110.8	66.5	692.6*	9.9	5.9	61.8	72	50.0
152	5.2	24.3	24.3	47.1	4.7	4.7	9.1	18	16.7
153	40.9	15.1	13.1	259.0	0.4	0.3	6.3	23	43.5
155	23.5	30.2	30.1	158.8	1.3	1.3	6.8	46	50.0
158	8.8	74.8	*	206.0	8.5	*	23.4	*	*
161	8.0	26.6	5.5	315.2	3.3	0.7	39.4	9	77.8
162	1.6	2.0	0.3	134.8	1.3	0.2	84.3	1	100
164	6.0	32.6	*	123.6	5.4	*	20.6	*	*
173	2.7	35.9	7.6	185.1	13.3	2.8	68.6	11	63.6
174	3.5	150.1	79.5	420.5	42.9	22.7	120.1	55	36.4
176	4.0	20.0	5.5	198.3	5.0	1.4	49.6	11	18.2
177	6.5	18.4	2.0	127.4	2.8	0.3	19.6	12	41.7
178	12.2	169.5	45.6	483.6*	13.9	3.7	39.6	77	39.0
179	3.5	92.0	64.5	96.3	26.3	18.4	27.5	4	100
180	2.0	193.3	109.6	77.2	96.7	54.8	38.6	21	71.4
181	2.5	256.1	64.3	107.0	102.4	25.7	42.8	62	27.4

TABLE 4. (cont'd).

AQCR No.	Area (10^3 mi^2)	EMISSIONS (10^3 t/year) Total Point Source	Total Industrial Source	Total Area Source[1]	ANNUAL EMISSIONS DENSITIES (tons/mi^2) Point	Industrial	Area	Number of Industrial Sources in AQCR	Industrial Sources Controlled (%)
184	7.2	1.1	0.9	226.9	0.2	0.1	31.5	2	50.0
186	10.6	40.7	16.6	280.9	3.8	1.6	26.5	14	42.9
187	16.3	0.8	0.8	271.8	0.1	0.1	16.7	7	0
190	25.5	5.2	0.5	150.6	0.2	Neg.	5.9	4	25.0
191	40.6	14.6	0.5	219.8	0.4	Neg.	5.4	2	100
193	19.7	28.4	12.9	395.4	1.4	0.7	20.1	42	73.8
194	12.6	9.3	2.3	91.7	0.7	0.2	7.3	13	61.5
195	10.3	121.4	45.3	474.2*	11.8	4.4	46.0	42	35.7
196	5.1	88.0	45.5	522.6*	17.3	8.9	102.5	42	54.8
197	6.6	191.3	36.5	890.2*	29.0	5.5	134.9	75	50.7
205	12.6	6.7	3.0	53.7	0.5	0.2	4.3	17	88.2
207	15.9	179.4	53.2	601.2	11.3	3.3	37.8	75	61.3
208	13.0	141.7	4.1	226.8	10.9	0.3	17.4	14	7.1
209	9.8	7.5	4.1	157.7	0.8	0.4	16.1	12	66.7
211	38.2	31.1	10.6	875.8	0.8	0.3	22.9	18	33.3
213	9.6	1.6	0.8	218.2	0.2	0.1	22.7	2	0
214	16.3	14.4	8.1	328.9	0.9	0.5	20.2	14	78.6
215	15.2	43.9	28.2	1035.3	2.9	1.9	68.1	50	50.0
216	12.3	38.5	11.2	1145.2	3.1	0.9	93.1	34	44.1
217	28.7	19.4	14.4	443.6	0.7	0.5	15.5	27	37.0
219	38.1	9.4	6.9	226.0	0.2	0.2	5.9	7	100
220	10.5	30.4	22.2	201.6	2.9	2.1	19.2	28	67.9
222	19.3	48.1	28.6	100.2	2.5	1.5	5.2	33	57.6
223	1.6	15.6	1.8	108.0	9.8	1.1	67.5	13	69.2
225	3.9	18.1	6.4	86.7	4.6	1.6	22.2	15	60.0
226	8.6	225.5	146.5	107.4	26.2	17.0	12.5	82	73.2
227	16.0	7.7	5.2	123.8	0.5	0.3	7.7	7	57.1
228	12.2	12.0	2.7	136.4	1.0	0.2	11.2	10	70.0

TABLE 4. (cont'd).

AQCR No.	Area (10^3 mi^2)	EMISSIONS (10^3 t/year) Total Point Source	Total Industrial Source	Total Area Source[1]	ANNUAL EMISSIONS DENSITIES (tons/mi^2) Point	Industrial	Area	Number of Industrial Sources in AQCR	Industrial Sources Controlled (%)
229	6.2	11.0	4.3	421.3	1.8	0.7	68.0	19	47.4
230	12.6	15.2	1.2	272.0	1.2	0.1	21.6	6	66.7
234	1.2	32.0	0.3	133.0	26.7	0.3	110.8	2	100.0
237	10.3	68.6	3.8	184.2	6.7	0.4	17.9	16	56.3
238	12.1	48.3	11.3	87.1	4.0	0.9	7.2	27	70.4
239	2.6	63.0	7.5	142.2	24.2	2.9	54.7	9	66.7
240	6.8	3.4	0.7	139.5	0.5	0.1	20.5	4	25.0
243	60.6	14.8	2.7	186.2	0.2	Neg.	3.1	10	40.0

1. Includes dirt roads, dirt LTO's, agricultural filling, open burning, construction, slash fires, and coal refuse fires.

* Data missing or incomplete

As a further illustration of the magnitude of these area source emissions, examine the effect of cutting them in half. Even with this, area source emissions in 129, or 86 percent of the AQCR's are still greater than the total point source emissions.

4.5 IMPACT OF EMISSIONS ON TSP

The evaluation of the impact of emissions on air quality requires a complicated, site-specific calculation that is beyond the scope of this report. Therefore, this report must concentrate on published results to evaluate fugitive dust impacts.

In a recent paper describing the impact of fugitive emissions on TSP, it was stated that in a large industrial city whose TSP loading was influenced by fugitive emissions, the TSP on an annual basis averaged 25 $\mu g/m^3$ higher than industrial areas not influenced by fugitive emission sources.[9] This paper also stated that the results from 20 sites in five heavily industrialized cities indicated that fugitive emissions increased TSP by 10 $\mu g/m^3$.

In discussions with various EPA personnel, it was brought out that fugitive dust emissions from dirt roads have a relatively minor effect on TSP. This statement was based on the assumption that the particle size of the dust from dirt roads is such that most particles fall out of the air within short distances from the dirt roads and that most dirt roads are located in rural areas away from the sampling stations. However, the study performed in Seattle showed that 27 percent of the dust from vehicles traveling over dirt roads at 32 km/h (20 mph) was suspendable (less than 10 μm in size), while 41 percent was suspendable at 48 km/h (30 mph).[5]

Further evidence of the substantial impact of fugitive dust emissions comes from Massachusetts. An item appearing in a weekly publication reported that the air of southeastern Massachusetts had been declared a hazard to public health and that 80 percent of the particulates came from windblown sand and road dirt.[10] A followup discussion with Massachusetts officials indicated that the episodes occurred during the winter months and were the result of the reentrainment of sand that was used for vehicle skid control.[11]

A study of air quality maintenance areas in North Carolina found that the emissions inventories for particulate matter in several counties did not provide enough emissions to account for the ambient air quality measurements obtained in urban areas.[6] The study concluded that paved roads contributed the substantial amount of emissions necessary to make up the difference in TSP observations in urban sections. To account for this difference, the emission factor that was based on the Seattle study[5] was raised by a factor of 2.3 for Mecklenburg County where vacuum street cleaning is used and by 3.5 for Forsyth and Guilford Counties where no vacuum street cleaning is used. As a result, an acceptable calibration of the Air Quality Display Model (AQDM) was achieved.

The data on both emission quantities and impact of emissions on TSP imply a strong relationship between fugitive dust emissions and nonattainment in many AQCR's. It must be emphasized that the precision and reliability of the data base used for this analysis is unknown, basically because of the inconsistencies in sampling, testing, and recording methodologies used throughout the network. However, NEDS is the only data base available for a study of this type. Therefore, the approach has been to rely on a comparison of relative magnitudes and not on an exact quantification of each piece of data.

4.6 PROJECTIONS OF FUTURE EMISSION TRENDS FOR MAJOR FUGITIVE DUST SOURCES

The projections of future emissions from unpaved roads, agricultural tilling, and construction are difficult because of the lack of sufficient past data. Linear regressions were performed on data for earth road mileage built by State highway departments,[12] acreages of harvested crops,[13] and constant dollar value of new construction put in place.[14]

The projections, based on 1960 to 1970 data, show that by late 1979 no new unpaved roads will be built by State highway departments. Of course, this type of projection creates its own inconsistencies because obviously, unpaved roads will continue to be built. In addition, it is difficult to project the trend in vehicle activity on unpaved roads and the paving of unpaved roads.

The projection of acreages of harvested crops was based on consecutive yearly data from 1965 to 1974. The projection shows an increase in acreage of 4 percent from 1975 to 1980 and an increase of about 8 percent from 1975 to 1985.

The projection of construction activity is based on value of new construction in place. This is difficult to relate to construction acres but is the best information available. The data show a 25 percent increase from 1975 to 1980 and a 43-percent increase from 1975 to 1985.

5.0 CONTROL TECHNIQUES

Fugitive dust can emanate from a variety of sources that require a multitude of different emission control alternatives. In many cases, control techniques are applicable to a variety of sources in different industries.

To discuss controls, this section will examine the application of control methods to different sources, estimate their relative effectiveness, and comment on their limitations. The results of this effort are presented in Tables 5 through 12. This is followed by a discussion of the major types of control.

5.1 PHYSICAL STABILIZATION

Physical stabilization methods can be used for controlling fugitive dust from inactive waste heaps, unpaved roads, and other sites. Physical stabilization requires the covering of the exposed surface with a material that prevents the wind from disturbing the surface particles.

Common physical stabilizer materials for inactive waste heaps and steep slopes include rock, soil, crushed or granulated slag, bark, wood chips, and straw that are harrowed into the top few inches of the material.[15] For dirt roads, paving is a common practice. However, paving is expensive and, in most cases, must be preceded by roadbed buildup and improvement to prevent overdriving by vehicle operators. Other methods of physical stabilization of these sources include covering with elastomeric films, asphalt, wax, tar, oil, pitch, and other cover materials.

Very little information is available on the effectiveness of physical control methods. One reference cites an 85-percent control efficiency with paving and right-of-way improvement on dirt roads.[16] This control efficiency is dependent on how much dirt is brought onto the road and later reentrained by passing vehicles.

TABLE 5. FUGITIVE DUST CONTROL METHODS FOR AGRICULTURAL SOURCES

Source	Type of Control	Relative Estimated Effectiveness*	Remarks or Restrictions
Fields	Wind Breaks	VP	
	Chemical Stabilizers	P	Possible interactions w/ plants. May be restrictive due to cost - temp.
	Crop Plantings	F	May be restrictive due to cost and lack of markets for off-season crops.
Spraying & Dusting of Pesticides & Fertilizers	Liquifaction	F to G	May be restrictive due to cost or inconvenience of changing to liquified sprays. After the pesticides dry, they may be subject to dusting.
Agricultural Activity	Wet Suppression	F	Continual turnover leads to low efficiency of control. Additional problems include the possible short supply of water and the inability of cultivating equipment to carry enough water.
Orchard Heaters			No effective control

* Abbreviations used in this column for Tables 5 through 12 are:

VP = very poor

P = poor

F = fair

G = good

TABLE 6. FUGITIVE DUST CONTROL METHODS FOR TRANSPORTATION SOURCES

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Unpaved Roads	Wet Suppression	VP	Temporary
	Stabilization	P	Temporary
	Paving	G	Cost--without improvement of road leads to psychological over-driving
	Speed Reduction	Variable	
Paved Roads	Washing	P	Costly, temporary
	Vacuuming	P	Costly, temporary
Transport of Fines by Truck or Train	Wetting	P	Temporary only
	Covering (tarps)	F	
	Enclosure	G	Problems occur during loading and unloading and from leakage. Also costly.
Off-Highway Travel	None		
Road Shoulders	Stabilization	F	
	Vegetation	G	

TABLE 7. FUGITIVE DUST CONTROL FOR MATERIALS HANDLING SOURCES

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Conveyors, Elevators, and Feeders	Sprays at transfer points	F	Can use water or water plus a surfactant. Cannot be used where wet product is intolerable to later process steps.
	Foam sprays	F to G	
	Enclosure of transfer points and exhaust	F	Could be costly
	Complete enclosure and exhausting to control device	G	Costly--must be ducted to control device.
	Scraper	F	Used to remove sticking material from belt. Effective in combination with other controls.
In-Plant Hauling	Wetting	F	Wetting of transported material is a temporary control but is effective for short hauls.
	Stabilization	F to G	Not cost effective for short hauls.
Loading and Unloading	Enclosure	F	
	Exhausting	G	Costly
Railcar or truck	Enclosure or hooding of hatches	P to F	
	Reduction of fall distance	P to F	By use of rock ladders, telescoping chutes, etc.
	Wet Suppression	F	Only applicable if wet product can be tolerated.
	Pneumatic System	G	Costly
Barge or Ship	Tarpaulins over holds	P to F	May establish a positive pressure in hold. Therefore, venting may be needed.
	Reduction of fall distance	P to F	Still causes disturbance of surface. Depending on material, could become clogged.

continued

TABLE 7. (cont'd)

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Barge or Ship (cont'd)	Canopy with exhaust	F to G	Requires a control device--costly.
	Enclosure and exhaust of receiving hoppers	F to G	Requires a control device--costly.
	Enclosure of receiving hoppers	F	
Bagging	Enclosure of operation	F	May lead to problems of equipment abrasion due to retained dust--requires periodic cleaning.
	Exhausting of enclosure	F to G	Extra cost for control
Stacking of Products	Reduction of fall distance	P to F	Use of telescoping chutes, rock ladders, hinged-boom conveyors, etc.
	Wet Suppression	P to F	Temporary only
	Enclosure	G	May not be feasible due to type or amount of material.
Waste Disposal Handling	Wet Material	G	May be impractical due to type of material or disposal area. May present additional problems such as solubilization of metals, etc.
	Covered or enclosed hauling system	F	Costly
Dumping	Sprays	P to F	
	Enclosure	F	May be impractical

TABLE 8. FUGITIVE DUST CONTROL FOR STOCKPILES AND WASTE DISPOSAL HEAPS

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Stockpiles	Wetting	P	Continuous operations on stockpiles preclude effective control.
	Stabilization	P	Same as wetting
	Enclosure	F to G	May not be practical for all types of operations.
	Wind Screen	VP	
	Separation of fines that are sent to enclosed areas	F	Extra cost
Waste Disposal Heaps	Wetting	P	Temporary only
	Stabilization	P to F	Efficiency depends on type of material, type of stabilizer, etc. Temporary
	Vegetation	F to G	May be expensive due to cost of pretreating (fertilizing, etc.).
	Physical Stabilization	F to G	
Coal Refuse Pile Fires	Wetting	VP	No effective control
	Trenching	VP	No effective control
	Covering, etc.	VP	No effective control

TABLE 9. FUGITIVE DUST CONTROL METHODS FOR MINING OPERATIONS

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Overburden Removal	Wetting	VP	Continuous activity negates effective control
Drilling	Water, foam or surfactant injection	F to G	
	Hooding and collection system	G	Baghouses are common controls--costly.
Blasting	Wetting	VP	No effective control
	Water ampul steming	VP	No effective control
	Proper technique	P	No effective control
Excavating and Loading	Wetting	P	Continual disturbance precludes effective control

TABLE 10. FUGITIVE DUST CONTROL FOR SOLIDS BENEFICIATION SOURCES

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Crushing	Wetting	P to F	Depends on type of product and crusher. Wetting can cause clogging.
	Enclosure	F	Can have problems due to abrasion of equipment by enclosed particles.
	Hooding and ducting to control device	F to G	Efficiency depends on type and design of control and associated equipment.
Screening	Wetting	P	Wetting can cause clogging of fine screens. Not applicable for materials that require low moisture for subsequent process steps.
	Housing or enclosure	P to F	May increase maintenance charges due to abrasion of screens. Periodic cleaning necessary.
	Hooding and ducting to control device	F to G	Costly--may add significant cost per unit of product, especially in high volume, low price industries such as crushed stone.
Classifying	Enclosure and ducting	F	
	Wet Classification	G	Only applicable if material can be wet for next steps.
	Closed pneumatic system	G	Applicability depends on material

TABLE 11. FUGITIVE DUST CONTROL FOR CONSTRUCTION SOURCES

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Excavating	Wetting	VP to P	Continual working precludes effective control.
Heaping of Excavated Materials	Wetting Stabilizing	P F to G	Temporary only Stabilizing with a binder is an effective control method that is applicable to short term heaping of excavated material.
Vehicle Travel	See Unpaved Roads (Table 7)		
Demolition	None		Demolition may cause high, short-term exposure to asbestos from bulding materials.

TABLE 12. FUGITIVE DUST CONTROL OF MISCELLANEOUS SOURCES

Source	Type of Control	Relative Estimated Effectiveness	Remarks or Restrictions
Roof Monitors	Ducting to control device	F to G	Effectiveness depends on type of material and type of control
Open Burning	None		
Incineration	Control Device	F to G	Costly
Cooling Tower Drift			No effective control

5.2 WET DUST SUPPRESSION

Wet suppression of dust using either water or water plus a wetting agent can be employed for temporary control of fugitive dust from agricultural activity, cattle feedlots, unpaved roads, transport of raw materials or products, materials handling and benefiication, stockpiles, waste heaps, and mining and construction activities. The temporary nature of wet suppression restricts its usefulness. In cases when there is continual activity at the source, the suppressive must be repeatedly applied to be useful. This is due to the continual exposure of dry surfaces to climatic elements and is applicable to agricultural activity, unpaved roads, and stockpiles.

Water has proven to be a poor suppressive due to its high surface tension. The high surface tension interferes with the wetting, spreading, and penetrating necessary for effective suppression.

Surface tension can be reduced by the addition of wetting agents. These agents increase the effectiveness of wet suppression by:[17]

1. allowing particles to penetrate the water droplet, and thus exposing a larger water surface;
2. agglomerating particles in the droplet;
3. increasing the number of droplets per unit volume, the surface area, and the contact potential through increased efficiency of atomization; and
4. causing the liquid to wet faster and deeper and spread farther.

In addition to being a temporary control measure, wet dust suppression cannot be used where either the product or the next stage of processing will not tolerate a wet product. Examples of these instances include grain processing and certain beneficiation processes that require dry classification. Drying steps can be taken but present additional environmental problems as well as added costs.

The wet suppression of dust is usually accomplished by spraying the water either with or without a surfactant onto the surface of the exposed material. For many mining and construction roads and other surfaces, this is usually done by a special truck equipped with a tank for the liquid and a series of spray nozzles in the front and back. For the transport of products and raw materials, the carrier vehicle is usually passed under a series of spray bars where the liquid is dispersed onto the surface of the material. For materials handling and beneficiation sources, nozzles located at transfer points and at equipment intakes spray the liquid on the material. For stockpiles, nozzles spray the liquid onto either the pile or the material as it is being transferred. For feedlots, a spray system is also appropriate.

The application of wet dust suppression to many fugitive dust sources is not feasible. These sources include agricultural activity, unpaved roads, and waste heaps. Reasons for the infeasibility include the potential shortages of water, magnitude of source, lack of suitable equipment for transporting and dispersing water, and the temporary nature of the control method.

In recent years, a new wet dust suppression system has been introduced. The use of foam systems has become an important dust suppression method. Foam systems have been successfully applied to both hard rock drilling operations and transfer points of conveyors.[18,19] These systems have advantages over untreated water in that they increase the wettability, thus requiring a smaller supply of wetting fluid, and in the case of drilling operations, they prevent overinjection of water into the hole which in turn can cause collaring of the bit and decreased penetration rates.

Data on the control efficiency of wet dust suppression is minimal. One reference cited as much as 80 percent control for cattle feedlots, but this is very much dependent on soil conditions, local climatic conditions, number of cattle, activity level, and many other things.[16] This same reference reported efficiencies of 30 to 67 percent for highly disturbed to nondisturbed storage piles, and efficiencies of 0 to 70 percent for construction site watering.[16]

Observations made by this author in several North Carolina granite quarries have shown substantially reduced emissions from processing plants, haulage roads, and drilling rigs using wet dust suppression with surfactants.[17]

Control efficiencies from drilling storage piles and construction sites will depend on many factors, including type of material and percentage of fines, local climatic conditions, type of equipment being used, moisture, and activity rate.

A recent study has examined the use of water sprays and foam on materials handling processes.[19] At a coal chain feeder-to-conveyor transfer point with a 3-ft material drop, water controlled 70 percent of the emissions while the foam spray controlled 91 percent. These numbers represent control with a spray under the belt as well as at the transfer point. Under-the-belt sprays were shown by this report to be effective in controlling dust at conveyor transfer points when used in conjunction with transfer point sprays.

5.3 CHEMICAL STABILIZATION

Chemical stabilization requires the use of binding materials that, upon drying, bind with surface particles to form a protective crust. It acts in much the same way as physical controls by isolating the surface from climatic factors and is often used in combination with vegetative stabilization. Applications of chemical stabilization are found on agricultural fields, unpaved roads, waste heaps, and excavation heaps.

Evaluations of the suitability of various chemical stabilizing materials have been reported in the literature. In one study evaluating the cost and effectiveness of 34 stabilizers,[20] the evaluation criteria were cost, prevention of wind erosion, effect on plant germination and growth of tomatoes and beans, and ease of application. Those stabilizers that proved effective for reducing wind erosion from the piles for 180, 120, and 60 days are ranked by cost in Tables 13, 14, and 15.

A later report presented the results of the Bureau of Mines tests on 70 different chemicals.[21] Water and wind erosion tests were performed in the laboratory on applications of these chemicals to various types of mill tailings. The more effective chemicals of those tested are listed below in order of their relative effectiveness based upon the cost required to stabilize 1 yd^2.[19] Long-term effectiveness to wind erosion was not measured. The results of their ranking follow.

TABLE 13. MATERIALS THAT REDUCED SOIL LOSS FOR 180 DAYS RANKED BY 1971 COST

Product	Manufacturer	Nonerosion Rate (per acre)	1971 Cost ($)	Ranked by Effectiveness
Elvanol 50-42	E. I. du Pont	13 lb	8.20	6
Technical Protein Colloid 5-V	Swift & Co.	108 lb	34.60	5
Geon 652	Goodrich Chemical	17 gal	51.20	8
Aquatain	Larutan Corp.	68 gal	172.50	7
ORTHO Soil Mulch	Chevron Chemical	681 gal	242.20	1
Anionic Asphalt Emulsion	Phillips Petroleum	1226 gal	436.70	3
AGRI-MULCH	Douglas Oil	954 gal	445.70	4
Soil Erosion Control Resin Adhesive Z-3876	Swift & Co.	571 gal	1,159.90	2

TABLE 14. MATERIALS THAT REDUCED SOIL LOSS FOR 120 DAYS RANKED BY 1971 COST

Product	Manufacturer	Nonerosion Rate (per acre)	1971 Cost ($)	Ranked by Effectiveness
Elvanol 50-42[a]	E. I. du Pont	13 lb	8.20	9*
Polyco 2460[b]	Borden Chemical	17 gal	26.90	8
Technical Protein Colloid 5-V	Swift & Co	108 lb	34.60	3
Polyco 2605[c]	Borden Chemical	17 gal	40.80	10*
Geon 652	Goodrich Chemical	17 gal	51.20	7
Curasol AE	American Hoechst	42 gal	89.70	11**
Gantrez ES-3351	GAF[d]	17 gal	103.10	12**
Aquatain	Larutan Corp.	68 gal	172.50	5
ORTHO Soil Mulch	Chevron Chemical	681 gal	242.20	4
Anionic Asphalt Emulsion	Phillips Petroleum	1226 gal	436.10	2
AGRI-MULCH	Douglas Oil	954 gal	445.70	6
Soil Erosion Control Resin Adhesive Z-3876	Swift & Co.	571 gal	1,159.90	1

[a]Discontinued. [b]Replaced by Polyco 2445. [c]Replaced by Polyco 2607.

[d]Originally General Analine & Film Co. *Tie. **Tie.

TABLE 15. MATERIALS THAT REDUCED SOIL LOSS FOR 60 DAYS RANKED BY 1971 COST

Product	Manufacturer	Nonerosion Rate (per acre)	1971 Cost ($)	Effectiveness
Elvanol 71-30	E. I. du Pont	13 lb	6.90	8
CMC-7-H	Hercules Inc.	11 lb	7.30	20
Elvanol 50-42[a]	E. I. du Pont	13 lb	8.20	6
WICALOID Latex 7035 (AD)	Wica Chemical	17 gal	14.40	14*
Polyco 2460[b]	Borden Chemical	17 gal	26.90	18
SBR Latex S-2105[a]	Shell Chemical	17 gal	27.40	13
CMC-7-M	Hercules Inc.	43 lb	28.40	16**
Technical Protein Colloid 5-V	Swift & Co.	108 lb	34.60	12
COHEREX	Golden Bear Oil[c]	170 gal	34.60	5
Polyco 2605[d]	Borden Chemical	17 gal	40.80	9
Gantrey An-119	GAF[e]	40 lb	43.60	11
Geon 652	Goodrich Chemical	17 gal	51.20	17**
Curasol AE	American Hoechst	42 gal	89.70	7
Gantrez ES-3351	GAF[e]	17 gal	103.10	19
Aquatain	Larutan Corp.	68 gal	172.50	15*
ORTHO Soil Mulch	Chevron Chemical	681 gal	242.20	3
Anionic Asphalt Emulsion	Phillips Petroleum	1223 gal	436..0	2
AGRI-MULCH	Douglas Oil Co.	954 gal	445.70	4
Soil Erosion Control Resin Adhesive Z-3876	Swift & Co.	571 gal	1,159.90	1
Experimental	Ashland Oil Co.	51 gal	?	10

[a]Discontinued.

[b]Replaced by Polyco 2445.

[c]Now Witco Chemical, Golden Bear Division.

[d]Replaced by Polyco 2607.

[e]Originally General Analine & Film Co.

*Tie. **Tie.

1. COHEREX - good wind resistance at coverage of 240 gal/acre at cost of $65/acre, good water-jet resistance at cost of $650/acre.
2. Calcium, sodium, ammonium lignosulfonates - effective stabilizers at coverage of 2400 lb/acre at cost of $130 to $170/acre.
3. Compound SP-400, Soil Gard, and DCA-70 - wind and water resistant surfaces at coverage of 55, 90, and 50 gal/acre, respectively. Cost of about $130/acre.
4. Cement and milk of lime - effective stabilization at costs of about $190/acre.
5. Paracol TC 1842 - effective stabilizer at cost of about $250/acre.
6. Pamak WTP - effective at cost of $250/acre.
7. Petroset SB-1 - effective at cost of $250/acre.
8. Potassium silicate (SiO_2 to K_2O ratio of 2.5) - effective at $450 to $950/acre.
9. PB-4601 - effective at $500/acre.
10. Cationic neoprene emulsion and Rezosol - effective at $500/acre.
11. Dresinol TC 1843 - effective at $500/acre.
12. Sodium silicates (SiO_2 to Na_2O ratios of 2.4 to 2.9 to 1) - effective at about $200/acre, with calcium chloride additive, amount of sodium silicate was reduced.

One reference has estimated control efficiencies of chemical stabilization on a number of sources.[16] Examples of these estimates are as follows:

Source	Efficiency (%)
Unpaved roads	50
Construction - completed cuts and fills	80
Agricultural fields	40
Tailings piles	80
Continuous spray of aggregate as it is piled	90
Cattle feedlots	40

The effectiveness of chemical stabilization of unpaved roads would seem to be extremely variable based on the amount of traffic. Heavy traffic would tend to break up the surface crust, pulverize particles, and eject them into the atmosphere in much the same manner as if the road were untreated. Likewise, with cattle feedlots, the effectiveness would seem to be heavily dependent on the activity in the feedlot. It would seem that continuous spraying of aggregate as it is piled could be highly variable depending on such things as the quantity of fines in the mix, type of stone, etc. In addition, the activity level of the storage pile is also important.

5.4 VEGETATIVE STABILIZATION

Vegetation can be effectively used to stabilize a variety of exposed surfaces. In many cases, modifications must be made to the surface or the surrounding terrain before effective stabilization can occur (e.g., fertilization, pH modification, and slope reduction).

Vegetative stabilization for the control of fugitive dust is restricted to inactive areas where the vegetation will not be mechanically disturbed once it is started. These sources can include refuse piles (coal and mineral) and road shoulders.

5.4.1 Coal Refuse Piles

Coal mining and preparation usually produce both fine and coarse waste materials. These materials consist of low grade coal, ash, carbonaceous and pyritic shale, slate, clay, and sandstone.[23]

The principal problems encountered in the vegetative stabilization of coal refuse piles occur as a result of the acidic nature of the wastes and from the slopes of the piles' sides. Thus, chemical or physical treatment of the piles' components must be accomplished prior to effective stabilization. Chemical treatment usually involves the addition of a soil neutralizing material such as agricultural limestone. Other materials such as fly ash, mined phosphate rock, and treated municipal sewage sludge have also been used.[23] Even with a neutralization pretreatment, it is recommended that acid-tolerant vegetative species be used for stabilization because the sulfide materials in the waste can oxidize to acid sulfates and thus lower the pH of the soils.

Physical treatment of the piles usually involves such things as the burying of high pyritic materials, covering the spoils with a layer of topsoil, or grading to reduce slopes of the piles.[23] A good premining restoration plan can be effective for efficient physical treatment methods.

Many species of plants have been used for the stabilization of coal mine refuse piles. Table 16 shows species used for this purpose and coded comments on their use.[23] For a detailed discussion of these plants and their uses refer to reference 23.

TABLE 16. SPECIES USED FOR MINE-SPOIL REVEGETATION[23]

Vegetation	East	Midwest	West
GRASSES			
Alkali Sacaton			Alk,D,S
Bahiagrass	+W		
Bermudagrass	++W,D,S		+W,D,S
Bluegrass	*C		+C
Bluestem	*		
Bottlebrush Squirreltail			N
Bromegrass (field, smooth)	+R,T	+	+D
Deertongue	+A		
Fescue	++	++	+
Foxtail			+C
Grama (blue, sideoats)			+D
Indian	*		
Indian Ricegrass			*
Millett	+R,T,W		
Needlegrass			*
Oatgrass (tall)	+	*	
Orchardgrass	+	++	+C
Povertygrass	N		
Prairie Sandreed Grass			+
Redtop	+C,T	+T	
Reed Canarygrass	*	+	*
Rye	+W		
Ryegrass	+C,R,T	+C,R,T	*C,R,T
Sand Dropseed			*
Sheep Sorrell	*		
Sorghum	+T		
Switchgrass	+W	+A	
Timothy	*		
Weeping Lovegrass	++A,R,W	++A,R,W	++A,R,W
Wheat		*T	
Wheatgrass	*		++Alk,D,S
Wildrye			*D

continued

TABLE 16. (cont'd)

Vegetation	East	Midwest	West
LEGUMES			
Alfalfa	+	++	+D
Birdsfoot Trefoil	++C	++C	+C
Cicer Milkvetch			*
Clover (red, white)	*		
Crownvetch	++C	+	
Flatpea	+A,C		
Kudzu	*	*	
Lespedeza (Sericea, Kobe, Korean)	++A	++A	
Narrowleaf Trefoil	+		
Sweetclover	+Alk		+D
SHRUBS AND VINES			
Arrowwood	+		
Black Chokeberry	+		
Bladder Senna	*		
Bristly Locust	++A,R	++A,R	
Buffaloberry			+Alk,S
Coralberry		*	
Greasewood			+Alk,D,S
Honeysuckle	+	+	+D
Indigobush	+A	+A	
Japanese Fleeceflower	*		
Juniper			*
Matrimony Vine			+Alk,D,S
Multiflora Rose	*		
Olive (autumn, Russian)	++A,Alk,R	+A	++Alk,D,S
Rabbitbrush			+D,W
Russian Thistle			N
Sagebrush (big)			+Alk,D,S
Saltbush			+Alk,D,S
Sassafras	N		
Scotch Broom	+A,W	+W	
Shadscale			+D,N
Silky Dogwood	+		
Sumac (fragrant, shining, skunkbush, smooth)	+A	+	++Alk,D,S

continued

TABLE 16. (cont'd)

Vegetation	East	Midwest	West
TREES			
Ailanthus		-	
Alder (black)	++A,R	++A,R	
Apple	*C		
Ash (green, white)	*	+	
Aspen	N		N,C
Austrian Pine	*A	*	
Bald Cypress	-		
Birch (gray, river, white)	+A		
Black Cherry	*A	*	*
Black Locust	++A,R	++A,R	
Black Walnut	*	*	
Caragana			+D
Cedar (red)		+	
Chestnut Oak	*	*	
Cottonwood	+	++	*
Crabapple	*		
Dogwood	*		
Douglas Fir	-		N,C
Elm (Siberian)		*	+D,S,Alk
Hazelnut	-		
Jack Pine	+A,C	+A	
Japanese Black Pine	*		
Larch (European, Japanese)	+ (Japanese)		
Loblolly Pine	++W	++A,W	
Longleaf Pine	*W		
Maple (red, silver, sugar)	+A	*A	
Mugho Pine	+A		
Oak (bur, chestnut, red, white)	+A (red)	+	
Osage Orange		+	
Pitch Pine	*A	*	
Ponderosa Pine	-	-	*D
Poplar (hybrid, yellow)	++	+	
Redbud	*	+	
Red Pine	+A,C	+A,C	
Scotch Pine	+	+	*D
Shortleaf Pine	+	*	
Spanish Pine	*		

continued

TABLE 16. (cont'd)

Vegetation	East	Midwest	West
Spruce (Norway, red, white)	-	*	
Sweetgum	+	+	
Sycamore	++	++	
Virginia Pine	+A	+	
White Pine	+	*	
Willow (tall)	N	+	*
Yucca	+D		

+ - Recommended
++ - Highly Recommended
* - Used
- - Failed
A - Recommended for acidic spoils (pH less than 5.5)
Alk - Recommended for alkaline spoils
C - Recommended for cooler climates
D - Recommended for dry regions (less than 18 inches (46 cm) of precipitation per year)
N - Native or volunteer plant, not necessarily recommended
R - Recommended for rapid stabilization and erosion control
S - Recommended for saline spoils
T - Temporary or short-lived crop
W - Recommended for warmer climates
Blank - No information

5.4.2 Mineral Refuse Piles

Mineral mining and beneficiation produce wastes in the form of overburden, gangue, and tailings. Overburden and gangue do not usually present problems to vegetative stabilization. However, tailings can present varied and extreme problems due to a deficiency of nutrients, saline or toxic properties, and variable pH.[23]

Most tailings stabilization is accomplished by first covering the waste with a layer of topsoil and then by establishing a vegetative cover. Without the topsoil cover, vegetation usually requires the assistance of other wind erosion preventatives such as mulches, chemical coatings, rapidly established plant covers, and watering.[23] However, even with these aids, stabilization of many mineral wastes has not been effective. Table 17 shows some plant species that have been used on various mineral tailings piles.[23] Most species are very site-specific with small changes in topography, climate, and tailings composition affecting their growth success.

TABLE 17. SPECIES RECOMMENDED FOR MINERAL TAILINGS RECLAMATION[23]

Vegetation	East	Midwest	West
GRASSES			
Bahiagrass	D,P,W		
Barley			+Cu: Alk,S
Bentgrass (fine)			+
Bermudagrass			+Cu
Bluegrass			*U: C
Bromegrass		*Fe	+Cu: C
Buffel Grass	*P		+Cu: Alk,S
Fescue	*Fe	+Fe	+Cu: C
Indian Ricegrass			*O
Milomaize (see Sorghum)		*Fe	*Cu
Pangolagrass			*Al
Pubescent Wheatgrass			++O
Quack Grass			-Cu
Rye			*Cu
Ryegrass	*Fe: R,T		+Cu: C,T
Saltgrass			-Cu
Sorghum	*P		+Al, Cu: W
Switchgrass	*P		
Timothy		*Fe	
Weeping Lovegrass	++V: R		++Cu
Wheat			+Cu
Wheatgrass			++Cu,U,V: Alk,S
Wildrye (Russian)			+Cu: D
LEGUMES			
Alfalfa		+Fe, Cu	+Cu
Birdsfoot Trefoil		+Fe	+Cu: D,S
Clover	+P		
Sweetclover		+Fe	+Cu, V

continued

TABLE 17. (cont'd)

Vegetation	East	Midwest	West
TREES, SHRUBS, AND VINES			
Alder	+Fe		
Aspen			+Mo: C
Austrian Pine			*
Birch	+Fe: Alk		
Black Locust	+Fe	*Fe	
Blue Palo Verde			+Cu: Alk,D,S
Bristlecone Pine	+Fe		
Bristly Locust			+Cu
Cacti			+Cu: D,W
Caragana			+Cu
Cottonwood			+Cu
Creosote Bush			+Cu: Alk,D,S
Datura			+Cu: Alk,D,S
Desert Broom			+Cu: Alk,D,S
Desert Encelia			+Cu: Alk,D,S
Desert Tobacco			+Cu: Alk,D,S
Desert Willow			+Cu: Alk,D,S
Douglas Fir			-
Eucalyptus			+Cu: N,S
Greasewood			-Cu
Hopseed Bush			+Cu: Alk,D,S
Isenberg Bush			+Al
Jack Pine	+Fe		
Japanese Black Pine	+Fe		
Juniper			+Cu,Mo
Kochia			+Cu
Mesquite			+Cu: Alk,D,S
Myrtle			+Al
New Mexico Forestiera			+O
New Mexico Locust			++O
Olive (Russian)			+Cu,O
Peru Pepper			+Cu: Alk,D
Poplar (hybrid)	++Fe		+Al,Cu
Rabbitbrush			+Cu: Alk,D,S
Red Pine		+Fe	
Ruby Sheepbush			+Cu: Alk,S
Russian Thistle			+Cu
Sagebrush (big)			+Cu: Alk,S
Saltbush			+Cu: Alk,D,S

continued

TABLE 17. (cont'd)

Vegetation	East	Midwest	West
Scouring Rush		Cu: N	
Shortleaf Pine	+Fe		
Spruce (Engelmann)			+Mo: C
Tamarisk			+Cu: Alk,S

\+ - Recommended
++ - Highly recommended
* - Used
\- - Failed
Al - Bauxite spoils
Alk - Recommended for alkaline spoils
C - Recommended for cooler climates
Cu - Copper tailings
D - Recommended for dry regions (less than 18 in. of precipitation per year)
Fe - Iron ore tailings
Mo - Molybdenum tailings
N - Native or volunteer plant, not necessarily recommended
O - Oil shale
P - Phosphate spoils
R - Recommended for rapid stabilization and erosion control
S - Recommended for saline spoils
T - Temporary or short-lived crop
U - Uranium spoils
V - Vanadium spoils
W - Recommended for warmer climates

Copper Tailings--

The establishment of vegetation on copper tailings is very site-specific. Even with piles in the same general geographic area, it is often difficult to establish the same type of vegetation.

In the western United States, copper tailings have been stabilized with vegetation. In most cases, maintenance in the form of liming, fertilizing, and irrigating after planting is required. However, at Magma, Utah, a form of permanent vegetative stabilization seems to have been established with natural vegetation invading the pile.[23]

Uranium Tailings--

Uranium tailings in Colorado have been stabilized using sweet brome, sweetclover, cereal rye, barley, alfalfa, and various wheatgrasses.[23] There has been very little invasion by natural species, and continual maintenance is required.

Iron Tailings--

The vegetative stabilization of iron tailings in Pennsylvania and Minnesota has been relatively successful. Initial stabilization with grasses and legumes followed by the planting of woody plants seems to have been successful.[23] Invasion by native vegetation heightens the propspect of a permanent, maintenance-free stabilization site.

Other Metallic Tailings--

In most cases, plants tolerant to specific conditions must be applied to metallic tailings piles. Some success has been demonstrated with varieties of grasses on gold mining slimes and sands; some species of grasses have been found to be tolerant to lead and zinc; but little long-term success has been demonstrated with rye on molybdenum tailings.[23]

5.4.3 Control Efficiency

The control efficiency of vegetative stabilization should vary considerably with differences in the amount and type of cover established on the tailings piles. One report estimates a control efficiency of from 50 to 80 percent.[16] This estimate was made using the wind erosion equation and is not based on a measured efficiency. This same report estimates a 93-percent reduction in windblown emissions with a combined chemical/vegetative stabilization program.

It would seem reasonable to assume that these control efficiencies could be achieved. In fact, efficiencies of 100 percent should be approached with complete vegetative covering on some sources.

5.5 OTHER CONTROL METHODS

Numerous other control methods are available for various sources of fugitive emissions. Some of the most important include speed reduction on unpaved roads, street cleaning of paved roads, reduction of fall distances for materials handling, and enclosure, hooding, and ducting.

5.5.1 Speed Reduction

Reducing the speed of vehicles traveling over unpaved roads has been shown to reduce the dust emissions from such travel. A reduction in vehicle speed reduces both the pulverization of road material and the turbulent wake of the vehicle. A well-quoted source has shown the following results from vehicle travel at various speeds on dirt roads (Table 18).[18]

TABLE 18. EFFECT OF SPEED REDUCTION ON EMISSIONS

Average Vehicle Speed (mph)	Dust Emissions (lb/vehicle mile)	Emissions Compared to Those at 40 mph (%)
40	2.50	100.0
35	1.47	58.8
25	0.70	28.0
15	0.48	19.2

In another report, the results of a study in Seattle's Duwamish Valley have shown comparatively higher emissions.[5] In addition, this study showed significant reductions in the quantities of suspendable particulates with speed reduction. The results are shown in Table 19.

TABLE 19. EFFECT OF SPEED REDUCTION ON EMISSIONS IN SEATTLE'S DUWAMISH VALLEY

Vehicle Speed (mph)	Total Emissions (lb/vehicle mile)	Suspendable Emissions (lb/vehicle mile)	Total Emissions Compared to Those at 30 mph (%)	Suspendable Emissions Compared to Those at 30 mph (%)
30	22.2	9	100.0	100.0
20	7.0	2	31.5	22.2
10	3.5	0.5	15.8	0.1

5.5.2 Street Cleaning

With the recent interest on reentrained dust from paved roads as a source of air pollution, attention has been focused on street cleaners as dust control devices. Essentially three types of cleaners are now in use: broom sweepers, flushers, and vacuum and regenerative air sweepers. Their effectiveness has not been overwhelmingly demonstrated. Streetside samples have shown concentration reductions but regional samplers have shown no reductions.

Broom sweeping has been shown to reduce the average concentration of dust in one study but has been shown to be ineffective in two others.[24] It has been estimated that this type of sweeper picks up 20 percent of the material below 140 μm.[25] Also, while recovering this paltry amount of material, the sweeper can actually generate air pollution by stirring up the dust and by moving the material from the curbs into the middle of the road where it can be reentrained by passing vehicles.

Flushing showed significant particulate reduction in two studies and no effect in two other studies. In a fifth study, flushing showed no reduction in the average monthly concentration but did show reduction on days when flushing took place.[24]

Vacuum and regenerative air sweepers have been shown to be ineffective.[24]

Two studies on mud carryover control showed substantial reductions in particulate concentrations.[24] These studies involved manual cleaning at a construction site egress and strip paving and oiling of unpaved parking lots, roads, and shoulders on an areawide basis.

5.5.3 Reduction of Fall Distances

During the transfer of dusty materials from a conveyor or stacker to another location such as another conveyor or a stockpile, the separation of the fine materials from the large materials can be caused by wind and/or the falling action of the material. A simple method to reduce dusting from these operations is to reduce the fall distances by using hinged-boom conveyors, rock ladders, telescoping chutes, lowering wells, or other devices.[17] The hinged-boom conveyor can raise or lower the conveyor belt and, thus, reduce the fall distance at the transfer point. Rock ladders allow the material to fall small distances in a step-like fashion. By reversing the direction of travel on successive steps, the momentum that the material receives from the previous fall and the dusting are reduced.

Telescoping chutes carry the material from the discharge point to the receiving point. Thus, the material is not exposed. Lowering wells, or perforated pipes, allow material to flow out of the pipe above the pile surface. The dusting from the impact of the falling material is retained inside the pipe, and the material is protected from wind action.

5.5.4 Enclosure

Simple enclosure of a fugitive dust source is an effective control method in some cases. It has been applied to a number of sources including storage of products, loading and unloading operations, product bagging operations, and classification operations. In process operations, periodic cleaning is necessary and may preclude application.

The enclosure of sources without providing adequate exhaust is not applicable to sources where abrasive materials are handled. This is especially true in hard rock processing plants where a high quartz content of the rock abrades the equipment. Enclosure is also not applicable to sources whose dust would present the danger of explosion such as in many grain handling operations.

5.5.5 Exhaust Systems

Many process sources of fugitive dust emissions can be controlled by the use of exhaust systems in combination with full or partial enclosure or full- or partial-coverage hoods and the associated ducting. Examples of sources amenable to this type of control include materials handling (i.e., conveyors, elevators, feeders, loading and unloading, product bagging, and stockpiling), solids beneficiation (i.e., crushing, screening, and other classifying), mining operations (i.e., drilling), and others (i.e., furnaces and dryers).

Complete enclosure of conveyors, elevators, or feeders has been practiced. Another alternative is to enclose the transfer points. Hoods as well as enclosures can be used on many loading and bagging operations.

For solid beneficiation processes, both enclosures and hoods are used. For drilling operations, enclosure of the drill hole and ducting to a baghouse mounted on the drill rig is used.[17]

Effectiveness of control is highly variable and dependent on many variables. Efficiencies of 90 percent and greater are considered appropriate. For example, 90 percent efficiency is attainable on the enclosure of BOF furnaces.[26]

No attempt has been made to provide detailed descriptions of ventilation practices. However, several excellent references are available on this subject (see references 27 and 28).

5.6 EFFECT OF FUGITIVE EMISSION REDUCTION ON AQCR'S

To examine the effects of fugitive dust emissions reduction on total AQCR emissions, emissions from unpaved roads, agricultural tilling, and construction were reduced by appropriate measures reported in the literature. The reductions used were 50 percent for unpaved roads (see Section 5.3 for chemical stabilization effectiveness), 40 percent for agricultural tilling (see Section 5.3), and 30 percent for construction (see Section 5.2).

The results of the emissions reduction are shown in the following summary:

	Before Emissions Reduction	After Emissions Reduction
Total number of AQCR's not meeting TSP Standards	150	150
Point > Area	9	17
Area > Point	139	131
Area 5x > Point	97	68
Area 10x > Point	58	38
Data Missing	2	2

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16. ABSTRACT

The report gives results of a study of particulate control for fugitive dust. Study results indicate that many Air Quality Control Regions (AQCRs) do not meet ambient air standards for particulates. In a majority of these ACQRs, the emissions from fugitive dust sources are higher than those from nonfugitive sources. In most cases, unpaved roads provide the greatest amount of emissions. Agricultural tilling and construction activity also contribute substantial amounts. The reentrainment of particles from paved roads also provides large quantities in urban areas. The study concludes that present control strategies for fugitive sources are inadequate. Even with reductions in fugitive emissions of 50% for unpaved roads, 40% for agricultural tilling, and 30% for construction, most of the 150 AQCRs that exceeded total suspended particulate standards will still probably exceed them. In addition, area sources will still dominate all other emissions sources. Thus, more effective control measures must be developed.

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