AP42 Section: 13.2.1 Paved Roads

Title: Addendum to Emission Factor Documentation for AP-42, Sections 11.2.5 and 11.2.6

Paved Roads

EPA Contract 68-D2-0159

September 1997

# Addendum to Emission Factor Documentation for AP-42 Section 11.2.5 and 11.2.6 (Now 13.2.1)

## Paved Roads

## Final Report

For U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Factor and Inventory Group
Research Triangle Park, NC 27711

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EPA Contract 68-D2-0159
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NOTICE

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PREFACE

This report was prepared by Midwest Research Institute (MRI) for the Office of Air Quality Planning and Standards (OAQPS), U. S. Environmental Protection Agency (EPA), under Contract No. 68-D2-0159, Work Assignment No. 4-02. Mr. Ron Myers was the requester of the work.

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## 1.0 BACKGROUND DOCUMENTATION--PAVED ROADS SECTION 13.2.1

This document is an addendum to *Emission Factor Documentation for AP-42, Sections 11.2.5 and 11.2.6, Paved Roads*, EPA Contract No. 68-D0-0123, Assignment 44, dated March 8, 1993 and prepared for the Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency (EPA). Since the preparation of the 1993 document, the Fifth edition of AP-42 incorporated Sections 11.2.5, Paved Urban Roads, and 11.2.6, Industrial Paved Roads, into Section 13.2.1, Paved Roads. An update to AP-42 Section 13.2.1 is warranted to address the U. S. EPA's recent focus on particulate matter (PM) emissions less than 2.5 $\mu$m in aerodynamic diameter (PM-2.5) and to permit the reexamination of test information on public road surface silt loadings.

Information in this Addendum includes descriptions of the test reports used to develop the current emission factor equation in AP-42, Section 13.2.1; a narrative of the reexamination of the road surface silt loading data base; and a summary of changes included in the AP-42 Paved Road Section including the new emission factor equation multiplier for PM-2.5. The format for this Addendum is as follows: (a) Section 1.1 - Test Report Descriptions, (b) Section 1.2 - Revision of the Public Paved Road Silt Loading Default Values, (c) Section 1.3 - Summary of Changes to AP-42 Section 13.2.1, (d) Section 2 - a copy of the revised AP-42 Section 13.2.1, (e) Attachment 1 - Comments/Response Logs for external review comments on the March 8, 1993 Paved Road Background Document , (f) Attachment 2 - Public Paved Road Surface Loading AP-42 data base from March 8, 1993, and (g) Attachment 3 - New Silt Loading Data Set..

### 1.1 Section 1--Test Report Descriptions

Test reports containing data used to develop the paved road emission factor equation in the March 8, 1993, Paved Road Background Document, are discussed in the following subsections. Summary emission data and detailed test data from each of the four test reports are provided along with a brief description of each test site and test methodology.

Profiling methodologies are used for these test reports and include the following test parameters: (a) downwind test equipment should be located approximately 5 meters from the source, (b) background equipment should be located approximately 15 meters upwind of the source, (c) and no disturbances should exist immediately upwind or downwind of the testing location. For wind conditions to remain acceptable during an exposure profiling test, 5- to 10-minute averages of speed and direction are examined. If the mean wind direction moves out of an arc within 45 degrees of the line perpendicular to the road centerline for two consecutive averaging periods, testing is suspended. Similarly, if the mean wind speed falls outside the acceptable range (typically 4 to 20 mph) for two consecutive periods, testing is suspended. While sampling is suspended, mean wind speed and direction are still monitored. To restart a test, analogous criteria are used. That is to say, if the mean wind direction lies within 45 degree of the perpendicular for two consecutive averaging periods, testing can be reinitiated. Likewise, if the average wind speed falls in the acceptable range for two consecutive periods, sampling may resume.

When following standard testing methodologies some vehicle heights may exceed the height of the sampling equipment; however, the fact that the emissions originate at the road curve and the emission plume can be characterized as decreasing with height indicates the total plume can be estimated. Vehicle heights are not generally reported in the source test reports. Analyses for silt content of the road surface follow methodologies described in Appendix C.1 and Appendix C.2 of AP-42. Moisture content was reported for several of these paved road studies. Variations from the generally accepted test methodology stated above or any other nontraditional methodology are discussed within the individual test report reviews. Test reports were not down graded on their qualities ratings due to unreported data if it was not significant to the paved road emission factor equation development.

### 1.1.1 Reference 1 - Midwest Research Institute, Roadway Emissions Field Tests at US Steel's Fairless Works, for U.S. Steel Corporation, May 1990.

This testing program focused on paved and unpaved road PM emissions at an integrated iron and steel plant near Philadelphia, Pennsylvania, in November 1989. Exposure profiling was used to characterize emissions from two paved roads. Site C-1 was located along the main access route and had a mix of light- and medium-duty vehicles. Site E-2 was located near the southwest corner of the plant and the traffic consisted mostly of plant equipment.

Tests were conducted using a profiling array, with four sampling heights from 1.5 m to 6.0 m, for measuring the downwind mass flux of airborne PM. A high-volume sampler with a parallel-slot cascade impactor and a cyclone preseparator (cutpoint of 15 µmA) was employed to measure the downwind particle size distribution, and a standard high-volume sampler was utilized to determine the downwind mass fraction of total suspended particulate matter (TSP). The upwind (background) particle size distribution was determined with a high-volume cyclone/ impactor combination. Warm wire anemometers at two heights measured wind speed.

Eight tests were conducted at Site C-1 and four tests were conducted at Site E-2. The paved road test sites were considered uncontrolled. The road width, moisture content, and mean number of wheels were not reported. The test data are assigned an A rating. Table A1-1 presents summary information and Table A1-2 presents detailed test information. Warm wire anemometers at two heights measured wind speed.

### 1.1.2 Reference 2 - Midwest Research Institute, *Paved Road Particulate Emissions - Source Category Report*, for U.S. EPA, July 1984

This document reports the results of testing of paved roads conducted in 1980 at sites in Kansas City, MO, St. Louis, MO, Tonganoxie, KS, and Granite City, IL. Paved road test sites included commercial/industrial roads, commercial/residential roads, expressways, and a street in a rural town. The expanded measurement program reported in this document was used to develop emission factors for paved roads and focused on the following particle sizes: PM-15 (inhalable particulate matter [IP]), PM-10, and PM-2.5.

Total airborne PM emissions were characterized using an exposure profiler containing four sampling heads. High-volume samplers with size selective inlets (SSI) having a cutpoint of 15 µmA were used to characterize upwind and downwind PM-15 concentrations. A high-volume sampler with a SSI and a cascade impactor was also located downwind to characterize particle size distribution within the PM-15 component. Upwind and downwind standard high-volume samplers measured TSP concentrations. Warm wire anemometers at two heights measured wind speed.

A total of 19 paved road emission tests were conducted in four cities. These included four tests of commercial/industrial paved roads, ten tests of commercial/residential paved roads, four expressway tests, and one test of a street in a rural town. Additionally, as part of this study, 81 dust samples were collected in 12 cities. The mean number of vehicle wheels was not reported. The test data are assigned an A rating. Table A1-3 presents summary test data and Table A1-4 presents detailed test information.

TABLE A1-1. SUMMARY INFORMATION FOR REFERENCE 1

| Operation | Location | State | Test dates | No. of tests | TSP emission factor, lb/VMT | | PM-10 emission factor, lb/VMT | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Geom. mean | Range | Geom. mean | Range |
| Vehicle traffic | AU-X (Unpaved road) | PA | 11/89 | 2 | 0.61 | 0.39-0.96 | 0.16 | 0.14-0.18 |
| Vehicle traffic | Paved road | PA | 11/89 | 6 | 0.033 | 0.012-0.12 | 0.0095 | 0.0009-0.036 |
| Vehicle traffic | Paved road | PA | 11/89 | 4 | 0.078 | 0.033-0.30 | 0.022 | 0.0071-0.036 |

1 lb/VMT = 281.9 g/VKT.

TABLE A1-2. DETAILED INFORMATION FROM PAVED ROAD TESTS FOR REFERENCE 1

| Test runs | PM-10 emission factor, lb/VMT | Duration, min | Meterorology | | Vehicle characteristics | | | Silt loading, $g/m^2$ | Silt, % |
|---|---|---|---|---|---|---|---|---|---|
| | | | Temperature, °F | Mean wind speed, mph | No. of vehicle passes | Mean vehicle weight, ton | Mean vehicle speed[a] | | |
| AU-C-3 | 0.00497 | 103 | 50 | 12 | 836 | 5.5 | (27) | 0.42 | 10 |
| AU-C-4 | 0.0355 | 147 | 63 | 11 | 1057 | 6.0 | 25 | 0.52 | 12 |
| AU-C-5 | 0.0337 | 120 | 62 | 14 | 963 | 3.9 | 29 | 0.23 | 9.7 |
| AU-C-6 | 0.00816[c] | 187 | 39 | 14 | 685 | 6.2 | (27) | 0.23 | 8.6 |
| AU-C-7 | 0.000887 | 96 | 42 | 12 | 703 | 3.0 | (27) | 0.26 | 7.7 |
| AU-C-8 | 0.0174 | 218 | 40 | 15 | 779 | 2.0 | (27) | 0.15 | 9.9 |
| AU-E-1 | 0.00709 | 154 | 43 | 12 | 210 | 12 | 15 | 4.0 | 17 |
| AU-E-2 | 0.0234 | 89 | 44 | 13 | 373 | 5.1 | 16 | 4.0 | 17 |
| AU-E-3 | 0.0355 | 118 | 41 | 9.3 | 330 | 2.6 | (15) | 2.2 | 18 |
| AU-E-4 | 0.0199 | 130 | 41 | 9.3 | 364 | 2.6 | (15) | 1.3 | 15 |

[a]Value in parentheses is the average speed measured for test road during the field exercise.
[b]*Test conducted on a paved road surface vacuum-swept five times per week.*
[c]Mean TSP/TP or PM10/TP ratio applied.
1 lb/VMT = 281.9 g/VKT.
1 $g/m^2$ = 1.434 $gr/ft^2$

TABLE A1-3. SUMMARY INFORMATION FOR REFERENCE 2

| Operation | State | Test dates | No. of tests | PM-15 emission factor, lb/VMT | | PM-10 emission factor, lb/VMT | | PM-2.5 emission factor, lb/VMT | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Geom. mean | Range | Geom. mean | Range | Geom. mean | Range |
| Commercial/ Industrial | MO | 2/80 | 4 | 0.0078 | 0.0036 - 0.013 | 0.0068 | 0.0034 - 0.011 | 0.0045 | 0.0030 - 0.0063 |
| Commercial/ Residential | MO, IL | 2/80 | 10 | 0.0021 | 0.0006 - 0.012 | 0.0017 | 0.0004 - 0.0093 | 0.0011 | 0.0002 - 0.0037 |
| Expressway | MO | 5/80 | 4 | 0.0004 | 0.0002 - 0.0008 | 0.0004 | 0.0002 - 0.0007 | 0.0002 | 0.0001 - 0.0003 |
| Rural Town | KS | 3/80 | 1 | 0.031 | 0.031 | 0.025 | 0.025 | 0.005 | 0.005 |

1 lb/VMT = 281.9 g/VKT.

TABLE A1-4. DETAILED INFORMATION FOR PAVED ROAD TESTS FOR REFERENCE 2

| Category | Run test No. | PM-10 emission factor, lb/VMT | Duration, min. | Temp., °F | Mean wind speed, mph | Road width, ft | No. of vehicle passes | Mean vehicle speed, mph | Mean vehicle weight, tons | Silt loading, $g/m^2$ | Silt (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commercial/Industrial | M-1 | 0.0110 | 120 | 28 | 7.4 | 44 | 2,627 | 30 | 5.6 | 0.46 | 10.7 |
| Commercial/Industrial | M-2 | 0.00340 | 86 | 27 | 6.5 | 44 | 2,166 | 30 | 3.8 | 0.26 | 6.2 |
| Commercial/Industrial | M-3 | 0.00781 | 120 | 28 | 7.8 | 44 | 2,144 | 30 | 4.5 | 0.15 | 3.5 |
| Commercial/Industrial | M-9 | 0.00712 | 136 | 50 | 7.4 | 44 | 3,248 | 30 | 4.1 | 0.29 | 12.2 |
| Commercial/Residential | M-4 | 0.000400 | 240 | 38 | 7.8 | 36 | 2,763 | 35 | 2.1 | 0.43 | 18.8 |
| Commercial/Residential | M-5 | 0.00153 | 226 | 53 | 2.2 | 36 | 2,473 | 35 | 2.2 | 1.00 | 21.4 |
| Commercial/Residential | M-6 | 0.00304 | 281 | 35 | 5.6 | 36 | 3,204 | 30 | 2.1 | 0.68 | 21.7 |
| Commercial/Residential | M-13 | 0.00680 | 194 | 60 | 2.7 | 22 | 5,190 | 35 | 2.7 | 0.11 | 13.7 |
| Commercial/Residential | M-14 | 0.00301 | 178 | 55 | 9.2 | 22 | 3,940 | 35 | 2.7 | 0.079 | - |
| Commercial/Residential | M-15 | 0.00323 | 135 | 77 | 11.4 | 22 | 4,040 | 35 | 2.7 | 0.047 | 8.1 |
| Commercial/Residential | M-17 | 0.00582 | 150 | 75 | 4.0 | 40 | 3,390 | 30 | 2.0 | 0.83 | 5.7 |
| Commercial/Residential | M-18 | 0.000800 | 172 | 75 | 5.1 | 40 | 3,670 | 30 | 2.0 | 0.73 | 7.1 |
| Commercial/Residential | M-19 | 0.000390 | 488 | 70 | 2.7 | 20 | 5,800 | 30 | 2.4 | 0.93 | 8.6 |
| Expressway | M-10 | 0.000390 | 182 | 60 | 2.9 | 96 | 11,148 | 55 | 4.5 | 0.022 | - |
| Expressway | M-11 | 0.000700 | 181 | 56 | 8.7 | 96 | 11,099 | 55 | 4.8 | 0.022 | - |
| Expressway | M-12 | 0.000190 | 150 | 65 | 4.7 | 96 | 9,812 | 55 | 3.8 | 0.022 | - |
| Expressway | M-16 | 0.000530 | 254 | 70 | 4.0 | 96 | 15,430 | 55 | 4.3 | 0.022 | - |
| Rural Town | M-8 | 0.0247 | 345 | 50 | 4.7 | 30 | 1,975 | 20 | 2.2 | 2.50 | 14.5 |

1 lb/VMT = 281.9 g/VKT.
1 $g/m^2$ = 1.434 $gr/ft^2$

1.1.3 Reference 3 - Midwest Research Institute, *Size Specific Particulate Emission Factors for Uncontrolled Industrial and Rural Roads*, for U. S. EPA, January 1983

This document reports the results of testing conducted in 1981 and 1982 at industrial unpaved and paved roads and at rural unpaved roads. Unpaved industrial roads were tested at a sand and gravel processing facility in Kansas, a copper smelting facility in Arizona, and both a concrete batch and asphalt batch plant in Missouri. The study was conducted to increase the existing data base for size-specific PM emissions. The following particle sizes were of specific interest for the study: PM-15, PM-10, and PM-2.5.

Exposure profiling was utilized to characterize total PM emissions. Five sampling heads, located at heights of up to 5 m, were deployed on the profiler. A standard high-volume sampler and a high-volume sampler with an SSI (cutpoint of 15 µmA) were also deployed downwind. In addition, two high-volume cyclone/impactors were operated to measure particle size distribution. A standard high-volume sampler, a high-volume sampler with an SSI, and a high-volume cyclone/impactor were utilized to characterize the upwind TSP and PM-15 concentrations and the particle size distribution within the PM-15 fraction. Wind speed was monitored with warm wire anemometers.

A total of 18 paved road tests and 21 unpaved road tests are completed. The test data are assigned an A rating. Industrial paved road tests were conducted as follows: three unpaved road tests at the sand and gravel processing plant, three paved road tests at the copper smelting plant, four paved road tests at the asphalt batch facility, and three paved road tests at the concrete batch facility. The industrial road tests were considered uncontrolled and were conducted with heavy duty vehicles at the sand and gravel processing plant and with medium duty vehicles at the asphalt batch, concrete batch, and copper smelting plants. Table A1-5 presents summary test data and Table A1-6 presents detailed test information.

1.1.4 Reference 4 - Midwest Research Institute, *Iron and Steel Plant Open Source Fugitive Emission Control Evaluation*, for U. S. EPA, August 1983

This test report centered on the measurement of the effectiveness of different control techniques for PM emissions from fugitive dust sources in the iron and steel industry. The test program was performed at two integrated iron and steel plants, one located in Houston, Texas, and the other in Middletown, Ohio. Control techniques to reduce emissions from paved roads, unpaved roads, and coal storage piles were evaluated. For paved roads, control techniques included vacuum sweeping, water flushing, and flushing with broom sweeping. Particle emission sizes of interest in this study were total PM, PM-15, and PM-2.5.

The exposure profiling method was used to measure paved road particulate emissions at the Iron and Steel plants. For this study, a profiler with four or five sampling heads located at heights of 1 to 5 m was deployed. Two high-volume cascade impactors with cyclone preseparators (cutpoint of 15 µmA), one at 1 m and the other at 3 m, measured the downwind particle size distribution. A standard high-volume sampler and an additional high-volume sampler fitted with a SSI (cutpoint of 15 µmA) were located downwind at a height 2 m. One standard high-volume sampler and two high-volume samplers with SSIs were located upwind for measurement of background concentrations of TSP and PM-15.

Twenty-three paved road tests of controlled and uncontrolled emissions were performed. These included 11 uncontrolled tests, 4 vacuum sweeping tests, 4 water flushing tests, and 4 flushing and broom sweeping tests. For paved roads, this test report does not present vehicle speeds, mean number of wheels, or moisture contents. Because vehicle speeds and moisture content do not figure into the emission

TABLE A1-5. SUMMARY OF PAVED ROAD EMISSION FACTORS FOR REFERENCE 3

| Industrial category | Type | TP, lb/VMT | | PM-15, lb/VMT | | PM-10, lb/VMT | | PM-2.5, lb/VMT | |
|---|---|---|---|---|---|---|---|---|---|
| | | Geo. mean | Range | Geo. mean | Range | Geo. mean | Range | Geo. mean | Range |
| Asphalt Batching | Medium duty | 1.83 | 0.750-3.65 | 0.437 | 0.124-0.741 | 0.295 | 0.0801-0.441 | 0.130 | 0.0427-0.214 |
| Concrete Batching | Medium duty | 4.74 | 2.25-7.23 | 1.66 | 0.976-2.34 | 1.17 | 0.699-1.63 | 0.381 | 0.200-0.562 |
| Copper Smelting | Medium duty | 11.2 | 7.07-15.7 | 4.01 | 2.02-5.56 | 2.78 | 1.35-3.86 | 0.607 | 0.260-0.846 |
| Sand and Gravel Processing | Medium Duty | 5.50 | 4.35-6.64 | 1.02 | 0.783-1.26 | 0.633 | 0.513-0.753 | 0.203 | 0.194-0.211 |

1 lb/VMT = 281.9 g/VKT.

TABLE A1-6. DETAILED INFORMATION FOR PAVED ROAD TESTS FOR REFERENCE 3

| Run No. | Industrial category | Traffic | PM-10 emission factor, lb/VMT | Duration, min. | Mean wind speed, mph | Road width, ft | No. of vehicle passes | Vehicle characteristics: Mean vehicle weight, tons | Vehicle characteristics: No. of wheels | Vehicle characteristics: Mean vehicle speed, mph | Moisture content, % | Silt loading, $g/m^2$ | Silt, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Y-1 | Asphalt Batching | Medium Duty | 0.257 | 274 | 5.37 | 13.8 | 47 | 3.6 | 6 | 10 | 0.22 | 91 | 2.6 |
| Y-2 | Asphalt Batching | Medium Duty | 0.401 | 344 | 4.70 | 14.1 | 76 | 3.7 | 7 | 10 | 0.51 | 76 | 2.7 |
| Y-3 | Asphalt Batching | Medium Duty | 0.0801 | 95 | 6.04 | 14.1 | 100 | 3.8 | 6.5 | 10 | 0.32 | 193 | 4.6 |
| Y-4 | Asphalt Batching | Medium Duty | 0.441 | 102 | 5.59 | 14.1 | 150 | 3.7 | 6 | 10 | 0.32 | 193 | 4.6 |
| Z-1 | Concrete Batching | Medium Duty | 0.699 | 170 | 6.71 | 24.3 | 149 | 8.0 | 10 | 10 | a | 11.3 | 6.0 |
| Z-2 | Concrete Batching | Medium Duty | 1.63 | 143 | 9.84 | 24.9 | 161 | 8.0 | 10 | 15 | a | 12.4 | 5.2 |
| Z-3 | Concrete Batching | Medium Duty | 4.01 | 109 | 9.62 | 24.9 | 62 | 8.0 | 10 | 15 | a | 12.4 | 5.2 |
| AC-4 | Copper Smelting | Medium Duty | 3.86 | 38 | 8.72 | 34.8 | 45 | 5.7 | 7.4 | 10 | 0.43 | 287 | 19.8 |
| AC-5 | Copper Smelting | Medium Duty | 3.13 | 36 | 9.62 | 34.8 | 36 | 7.0 | 6.2 | 15 | 0.43 | 188 | 15.4 |
| AC-6 | Copper Smelting | Medium Duty | 1.35 | 33 | 4.92 | 34.8 | 42 | 3.1 | 4.2 | 20 | 0.53 | 400 | 21.7 |
| AD-1 | Sand and Gravel | Heavy Duty | 3.27 | 110 | 7.61 | 12.1 | 11 | 42 | 11 | 23 | a | 94.8 | 6.4 |
| AD-2 | Sand and Gravel | Heavy Duty | 0.753 | 69 | 5.15 | 12.1 | 16 | 39 | 17 | 23 | a | 63.6 | 7.9 |
| AD-3 | Sand and Gravel | Heavy Duty | 0.513 | 76 | 3.13 | 12.1 | 20 | 40 | 15 | 23 | a | 52.6 | 7.0 |

1 lb/VMT = 281.9 g/VKT.
1 $g/m^2$ = 1.434 $gr/ft^2$
a Not measured.

equation, the test data are assigned an A rating. Table A1-7 presents summary test data and Table A1-8 presents detailed test information. The PM-10 emission factors presented in Table A1-8 were calculated from the PM-15 and PM-2.5 data using logarithmic interpolation.

After vacuum sweeping, emissions were reduced slightly more than 50 percent for two test runs and less than 16 percent for two test runs. Water flushing applied at 0.48 $gal/yd^2$ achieved emission reductions ranging from 30 percent to 70 percent. Flushing at 0.48 $gal/yd^2$ combined with broom sweeping resulted in emission reductions ranging from 35 percent to 90 percent.

TABLE A1-7. SUMMARY OF PAVED ROAD EMISSION FACTORS FROM REFERENCE 4

| Control method | Location | State | Test date | No. of tests | TP, lb/VMT | | PM-15, lb/VMT | | PM-2.5, lb/VMT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Geo mean | Range | Geo mean | Range | Geo mean | Range |
| None | A,D,F,J | OH | 7/80, 10/80, & 11/80 | 7 | 1.22 | 0.29-5.50 | 0.38 | 0.13-2.14 | 0.10 | 0.04-0.52 |
| Vacuum Sweeping | A | OH | 10/80 & 11/80 | 4 | 0.87 | 0.53-1.46 | 0.45 | 0.27-0.87 | 0.14 | 0.08-0.26 |
| Water Flushing | D,L | TX | 6/81 | 4 | 1.43 | 1.30-1.74 | 0.47 | 0.32-0.65 | 0.08 | 0.08-0.09 |
| Flushing & Broom Sweep | K,L,M | TX | 6/81 | 4 | 0.96 | 0.54-2.03 | 0.20 | 0.10-0.49 | 0.07 | 0.04-0.13 |
| None | L,M | TX | 6/81 | 4 | 3.12 | 0.83-5.46 | 0.92 | 0.31-1.83 | 0.26 | 0.06-0.62 |

1 lb/VMT = 281.9 g/VKT.

## TABLE A1-8. DETAILED INFORMATION FOR PAVED ROAD TESTS FROM REFERENCE 4

| Site | Test Run No. | Control method | PM-10 emission factor, lb/VMT | Duration, min. | Temp., °F | Mean wind speed, mph | No. of vehicle passes | Mean vehicle weight, tons | Silt loading, $g/m^2$ | Silt, % |
|---|---|---|---|---|---|---|---|---|---|---|
| A | F-34 | None | 0.536 | 62 | 90 | 4.2 | 79 | 28 | 2.79 | 16 |
| A | F-35 | None | 0.849 | 127 | 90 | 7.5 | 130 | 25 | 2.03 | 10.4 |
| A | F-36 | VS | 0.147 | 335 | 50 | 5.9 | 263 | 8.3 | 0.202 | 18.3 |
| A | F-37 | VS | 0.209 | 241 | 50 | 4.8 | 199 | 17 | 0.043 | 26.4 |
| A | F-38 | VS | 0.430 | 127 | 50 | 4.5 | 141 | 18 | 0.217 | 27.9 |
| A | F-39 | VS | 0.686 | 215 | 50 | 6.4 | 190 | 18 | 0.441 | 19.6 |
| D | F-61 | None | 1.35 | 108 | 40 | 11.0 | 93 | 40 | 17.9 | 21.0 |
| D | F-62 | None | 0.929 | 77 | 45 | 12.1 | 94 | 36 | 14.4 | 20.3 |
| D | F-74 | WF | 1.32 | 205 | 50 | 9.0 | 67 | 29 | 5.59 | 9.45 |
| F | F-27 | None | 0.357 | 91 | 100 | 9.5 | 158 | 14 | 17.7 | 35.7 |
| F | F-45 | None | 0.608 | 135 | 50 | 4.0 | 172 | 16 | 5.11 | 28.4 |
| J | F-32 | none | 0.144 | 259 | 90 | 5.8 | 301 | 14 | 0.117 | 13.4 |
| K | B-52 | FBS | 0.0946 | 60 | 90 | 2.9 | 119 | 12 | 7.19 | 34.3 |
| L | B-50 | FBS | 0.230 | 104 | 90 | 5.6 | 123 | 9.4 | 13.6 | 28.2 |
| L | B-51 | FBS | 0.435 | 93 | 90 | 4.2 | 127 | 11 | 13.6 | 28.2 |
| L | B-54 | WF | 0.268 | 101 | 90 | 5.4 | 118 | 10 | 3.77 | 22.6 |
| L | B-55 | WF | 0.575 | 82 | 90 | 8.5 | 98 | 11 | 6.29 | 19.6 |
| L | B-56 | WF | 0.398 | 61 | 90 | 6.3 | 118 | 9.2 | 2.40 | 11.2 |
| L | B-58 | None | 1.08 | 96 | 90 | 6.7 | 67 | 18 | 10.4 | 17.9 |
| M | B-53 | FBS | 0.161 | 81 | 90 | 5.3 | 72 | 20 | -- | 9.94 |
| M | B-57 | 0.554 | None | 101 | 90 | 3.6 | 68 | 12 | 2.32 | 6.45 |
| M | B-59 | 0.993 | None | 114 | 90 | 6.1 | 67 | 11 | 2.06 | 14.0 |
| M | B-60 | 1.18 | None | 112 | 90 | 5.0 | 50 | 12 | 3.19 | 13.5 |

[a]Average of 2+ values
[b]Sample used for more than 1 run.
[c]PM-10 emission factors were calculated from the PM-15 and PM-2.5 data using logarithmic interpolation.
VS = Vacuum sweeping; WF = Water flushing; FBS = Water flushing and broom sweeping; 1 lb/VMT = 281.9 g/VKT; 1 $g/m^2$ = 1.434 $gr/ft^2$

References for Section 1


1. *Roadway Emissions Field Tests at U.S. Steel's Fairless Works*, U.S. Steel Corporation, Fairless Hills, PA, USX Purchase Order No. 146-0001191-0068, May 1990.

2. *Paved Road Particulate Emissions—Source Category Report*, U. S. Environmental Protection Agency, Research Triangle Park, NC, EPA Contract No. 68-02-3158, Assignment 19, July 1984.

3. *Size Specific Particulate Emission Factors for Uncontrolled Industrial and Rural Roads*, U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA Contract No. 68-02-3158, Assignment 12, January 1983.

4. *Iron and Steel Plant Open Source Fugitive Emission Control Evaluation*, U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA Contract No. 68-02-3177, Assignment 4, August 1983.

5. *Emission Factor Documentation for AP-42, Sections 11.2.5 and 11.2.6—Paved Roads*, EPA Contract No. 68-D0-0123, Midwest Research Institute, Kansas City, MO, March 1993.

## 1.2 Revision of the Public Paved Road Silt Loading Default Values

During the preparation of the March 8, 1993 Paved Road Background Document[1], the available public road silt loading ("sL") values from test reports dated 1992 and earlier were assembled into a data base. Appendices C.1 and C.2 to AP-42 describe the sampling and analysis procedures, respectively, used to determine sL values. This "old" data set was originally presented as Appendix X in the March 8, 1993 background report. Subsequently, EPA requested that the sL data set be moved into the AP-42 Section. In response, MRI prepared the current Table 13.2.1-2. (An electronic version of the old sL data set has been supplied with this addendum.)

Although hundreds of public paved road sL measurements had been collected from 1980 until 1992 [2-10], the paved road sL data base was limited in its usefulness for various reasons:

1. Almost two-thirds of the available data had been collected in one state (Montana).

2. Only Montana had collected extensive data that addressed temporal variation of sL. While this provided very useful information on the annual cycle of silt loadings, the data were not generally transferable to most regions in the United States.

3. There had been no uniformity in either the sampling/analysis methods used to generate sL values or in schemes used to report roadway classifications. Similarly, the different sampling programs do not all report the necessary information to develop a coherent data set. For example, the following items are not always reported: whether the road is curbed; the posted speed limit; if surrounding land use would lead to trackout from unpaved shoulders or parking lots; or, if anti-skid materials were recently applied. These unknowns result from the lack of uniform reporting.

4. Examination of the data base did not reveal any meaningful relationship between silt loading and other variables (such as average daily traffic [ADT], road class, etc.). For example, a significant negative correlation was found between sL and ADT for roads with ADTs of 5,000 or more. However, on further investigation of that road class, it was found that there was a significant positive and a significant negative correlation over the first and second halves, respectively, of the calendar year.

5. There were strong reasons to suspect that the assembled data base was skewed towards high values:

- The majority of measurements were collected during the first calendar half (which was found to have substantially higher values than the second half).

- There was anecdotal information that at least some of the sampling programs focused on suspected trouble spots that were heavily loaded (such as after snow/ice storms, near construction sites, etc.).

Note that the assembled data base was composed of "point values" of silt loading. Here the term "point value" is used to denote samples collected at a specific point along a roadway and at a single point in time. In this sense, the term is contrasted with "composite" samples, for which increments from different roadways and/or from different times are aggregated in a single vacuum bag. The resulting composite sample thus represents a spatially or temporally averaged value of silt loading. At the time the data base was assembled, two sets of spatial averages were available –one set covering the South Coast Air Quality Management District (REF 11) and another from three study areas in Oregon (REF 12). Because of their composite nature, these measurements were not included in the data base assembled for the 1993 background document.

Although there were strong reasons to suspect that the assembled data base was biased towards high values, independent data were not available to confirm the suspicions. Since the time that the background document was prepared, a number of field sampling programs have been undertaken; the references that document these programs are shown in Table A1-9.

TABLE A1-9. PAVED ROAD SILT LOADING STUDIES SINCE THE 1993 BACKGROUND REPORT

| Reference | Study description |
|---|---|
| 13 | A characterization of control measures to reduce mud/dirt carryout onto paved roads from a construction site in Kansas City |
| 14 | Collection of late winter/early spring silt loadings in the Pocatello, Idaho area, emphasizing post-storm conditions |
| 15 | A yearlong study to define temporal variations of silt loading on roads in the Reno, Nevada area. |
| 16 | Collection of sets of spatially averaged silt loadings in four study areas of the desert southwest: South Coast, Coachella Valley, Las Vegas, Bakersfield |
| 17 | An ongoing study to track silt loading trends over a yearlong period in the Pocatello, Idaho area |

Note that the first two studies in Table A1-9 were directed to higher values of sL due to their focus on mud/dirt carryout and post-winter storm conditions. As such, results from these two studies were excluded from further consideration in revising the public road silt loading values. Data from the second Pocatello study (Reference 17) were not available at the time of this addendum.

Results from References 15 and 16, together with results from the composite samples in References 11 and 12 and the silt loading values from the recent PM-2.5/PM-10 study[18] for baseline road surface conditions (i.e., not immediately after road sanding), formed the basis for revising the default values for public paved road silt loading. An electronic version of the new sL data set has been supplied with this addendum. Table A1-10 presents summary statistics for the new data set.

TABLE A1-10. SUMMARY STATISTICS FOR RECENT PAVED ROAD SILT LOADING STUDIES

| | | Silt loading, $g/m^2$ | | | | |
|---|---|---|---|---|---|---|
| Data set | Sample size | Range | Geo. mean | Geo. std. dev. | Median | 90th percentile |
| High ADT[a] | 50 | 0.01 - 1.02 | 0.093 | 3.13 | 0.086 | 0.38 |
| Low ADT | 103 | 0.054 - 6.82 | 0.41 | 2.64 | 0.39 | 1.52 |
| Overall | 169[b] | 0.01 - 6.82 | 0.26 | 3.34 | 0.27 | 1.05 |

[a]In this context, high ADT refers to roadways with at least 5,000 vehicles per day.

[b]The overall data set includes 16 spatially average samples that included increments from both high and low ADT roads.

When the results in Table A1-10 are compared to those presented in Table 13.2.1-2 of AP-42, it becomes immediately apparent that the current default guidance in Section 13.2 leads to overly conservative values for silt loading. Values in the newer data set are roughly 5 times lower than those in the data set compiled for the 1993 background document. Consequently, it is recommended that AP-42 Table 13.2.1-2 be modified to include the (rounded) median values from Table A2-2 for "normal" conditions. However, the newer data set also indicates that substantially higher or lower than "normal" silt loadings may occur on public paved roads. As a result, it is further recommended that the modified AP-42 table present the former median values for the January-to-June period as suitable for use when estimates of elevated silt loading (e.g., after snow/ice controls or near trackout areas) are desired.

Additional revisions are recommended for default values for limited access roads. Reference 18 presents the results from not only baseline sampling, but also samples collected immediately after sanding an interstate highway in Denver:

Baseline: 0.0127 $g/m^2$
After sanding: 0.184 $g/m^2$

After averaging the baseline with the older data for limited access roads, the recommended default for limited access roads under "normal" conditions is 0.015 $g/m^2$. Furthermore, the section text has been revised to suggest a default value of 0.2 $g/m^2$ for short periods of time following the application of snow/ice controls (antiskid abrasives) to limited access roads.

References for Section 1.2


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2. Cowherd, Jr., and P. J. Englehart, *Paved Road Particulate Emissions*, EPA-600/7-84-077, U.S. Environmental Protection Agency, Cincinnati, OH, July 1984.

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4. *Street Sanding Emissions And Control Study*, PEI Associates, Inc., Cincinnati, OH, October 1989.

5. *Evaluation Of PM-10 Emission Factors For Paved Streets*, Harding Lawson Associates, Denver, CO, October 1991.

6. *Street Sanding Emissions And Control Study*, RTP Environmental Associates, Inc., Denver, CO, July 1990.

7. *Post-storm Measurement Results — Salt Lake County Road Dust Silt Loading Winter 1991/92 Measurement Program*, Aerovironment, Inc., Monrovia, CA, June 1992.

8. Written communication from Harold Glasser, Department of Health, Clark County (NV).

9. *PM-10 Emissions Inventory Data For The Maricopa And Pima Planning Areas*, EPA Contract No. 68-02-3888, Engineering-Science, Pasadena, CA, January 1987.

10. *Characterization Of PM-10 Emissions From Antiskid Materials Applied To Ice- And Snow-covered Roadways*, EPA Contract No. 68-D0-0137, Midwest Research Institute, Kansas City, MO, October 1992.

11. *Open Fugitive Dust PM10 Control Strategies Study*, South Coast Air Quality Management District Contract No. 90059, Midwest Research Institute, Kansas City, MO, July 1990.

12. *Oregon Fugitive Dust Emission Inventory*, EPA Contract No. 68-D0-0123, Work Assignment No. 24, Midwest Research Institute, Kansas City, MO, January 1992.

13. *Characterization of Mud/Dirt Carryout onto Paved Roads from Construction and Demolition Activities,* EPA Contract No. 68-D2-0159, Work Assignment No. I-04, Midwest Research Institute, Kansas City, MO, December, 1995.

14. Letter Report to Doug Cole, Idaho Operations Office, EPA Region 10, dated April 30, 1993, EPA Contract 68-D0-0123, Work Assignment II-76.

15. Personal communication with Andy Goodrich of Washoe County Department of Health, Reno, NV.

16. *Improvement of Specific Emission Factors (BACM Project No. 1)*, South Coast Air Quality Management District Contract No. 95040, Midwest Research Institute, Kansas City, MO, March 1996.

17. Personal communication with J. Light, c/o Bannock Planning Organization, Pocatello, ID.

18. *Fugitive Particulate Matter Emissions*, EPA Contract No. 68-D2-0159, Work Assignment No. 4-06, Midwest Research Institute, Kansas City, MO, April 1997.

1.3 Summary of Changes to AP-42 Section 13.2.1

Although the equation for particulate emissions from paved roads remains unchanged, the PM-2.5 multiplier has been updated based on findings in Reference 22. The PM-2.5 multiplier update is reflected in the list of particle size multipliers for the paved road equation. Also, the default silt loading (sL) values for public paved roads have been updated. Table 13.2.1-2 has been revised along with associated text to reflect this new analysis. The silt loading data base, formerly presented as Table 13.2.1-3, will only be available as an electronic file. (The new sL data set is also available as an electronic file.)

Section 13.2.1 follows with text removed from the old AP-42 version striked out and new text in bold. Although not shown here, no changes were made to Figure 13.2.1-1, and Figures 13.2.1-2 through 13.2.1-7 (showing the silt loading frequency distribution) have been removed from the AP-42 section.

**13.2.1 Paved Roads**

13.2.1.1 General

Particulate emissions occur whenever vehicles travel over a paved surface, such as a road or parking lot. **Particulate emissions from paved roads are due to direct exhaust from vehicles and resuspension of loose material on the road surface.** In general terms, **the resuspended** particulate emissions from paved roads originate from the loose material present on the surface. In turn, that surface loading, as it is moved or removed, is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and trackout from unpaved roads and staging areas. Figure 13.2.1-1 illustrates several transfer processes occurring on public streets.

Various field studies have found that public streets and highways, as well as roadways at industrial facilities, can be major sources of the atmospheric particulate matter within an area.[1-9] Of particular interest in many parts of the United States are the increased levels of emissions from public paved roads when the equilibrium between deposition and removal processes is upset. This situation can occur for various reasons, including application of snow and ice controls, carryout from construction activities in the area, and wind and/or water erosion from surrounding unstabilized areas. **In the absence of continuous addition of fresh material (through localized trackout or application of antiskid material), paved road surface loading should reach equilibrium values in which the amount of material resuspended matches the amount replenished. The equilibrium sL value depends upon numerous factors. It is believed that the most important factors are: mean speed of vehicles traveling the road; the average daily traffic (ADT); the number of lanes and ADT per lane; the fraction of heavy vehicles (buses and trucks); and the presence/absence of curbs, storm sewers and parking lanes.**

13.2.1.2 Emissions And Correction Parameters

Dust emissions from paved roads have been found to vary with what is termed the "silt loading" present on the road surface as well as the average weight of vehicles traveling the road. The term silt loading (sL) refers to the mass of silt-size material (equal to or less than 75 micrometers [μm] in physical diameter) per unit area of the travel surface.[4-5] The total road surface dust loading is that of loose material that can be collected by broom sweeping and vacuuming of the traveled portion of the paved road. The silt fraction is determined by measuring the proportion of the loose dry surface dust that passes through a 200-mesh screen, using the ASTM-C-136 method. Silt loading is the product of the silt fraction and the total loading, and is abbreviated "sL". Additional details on the sampling and analysis of such material are provided in AP-42 Appendices C.1 and C.2.

The surface sL provides a reasonable means of characterizing seasonal variability in a paved road emission inventory.[9] In many areas of the country, road surface loadings are heaviest during the late winter and early spring months when the residual loading from snow/ice controls is greatest. **As noted earlier, once replenishment of fresh material is eliminated, the road surface loading can be expected to reach an equilibrium value, which is substantially lower than the late winter/early spring value.**

13.2.1.3 Predictive Emission Factor Equations[10]

The quantity of dust emissions from vehicle traffic on a paved road may be estimated using the following empirical expression:

$$E = k\,(sL/2)^{0.65}\,(W/3)^{1.5} \qquad (1)$$

where:

E = particulate emission factor (having units matching the units of k)
k = base emission factor for particle size range and units of interest (see below)
sL = road surface silt loading (grams per square meter) ($g/m^2$)
W = average weight (tons) of the vehicles traveling the road

It is important to note that Equation 1 calls for the average weight of all vehicles traveling the road. For example, if 99 percent of traffic on the road are 2 Mg cars/trucks while the remaining 1 percent consists of 20 Mg trucks, then the mean weight "W" is 2.2 Mg. More specifically, Equation 1 is *not* intended to be used to calculate a separate emission factor for each vehicle weight class. Instead, only one emission factor should be calculated to represent the "fleet" average weight of all vehicles traveling the road.

The particle size multiplier (k) above varies with aerodynamic size range as ~~follows:~~ **shown in Table 13.2.1-1.** To determine particulate emissions for a specific particle size range, use the appropriate value of k **shown in Table 13.2.1-1.**.

The above equation is based on a regression analysis of numerous emission tests, including 65 tests for PM-10.[10] Sources tested include public paved roads, as well as controlled and uncontrolled industrial paved roads. No tests of "stop-and-go" traffic were available for inclusion in the data base. The equations retain the quality rating of A (B for PM-2.5), if applied within the range of source conditions that were tested in developing the equation as follows:

| | |
|---|---|
| Silt loading: | 0.02 - 400 $g/m^2$ |
| | 0.03 - 570 grains/square foot ($ft^2$) |
| Mean vehicle weight: | 1.8 - 38 megagrams (Mg) |
| | 2.0 - 42 tons |
| Mean vehicle speed: | 16 - 88 kilometers per hour (kph) |
| | 10 - 55 miles per hour (mph) |

To retain the quality rating for the emission factor equation when it is applied to a specific paved road, it is necessary that reliable correction parameter values for the specific road in question be determined. **With the exception of limited access roadways, which are difficult to sample, the collection and use of site-specific sL data for public paved road emission inventories are strongly recommended**. The field and laboratory procedures for determining surface material silt content and surface dust loading are summarized in Appendices C.1 and C.2. In the event that site-specific values

**Table 13.2.1-1.** PARTICLE SIZE MULTIPLIERS FOR PAVED ROAD EQUATION

| Size range[a] | Multiplier k[b] | | |
|---|---|---|---|
| | g/VKT | g/VMT | lb/VMT |
| PM-2.5[c] | ~~2.1~~ | ~~3.3~~ | ~~0.0073~~ |
| | **1.1** | **1.8** | **0.0040** |
| PM-10 | 4.6 | 7.3 | 0.016 |
| PM-15 | 5.5 | 9.0 | 0.020 |
| PM-30[cd] | 24 | 38 | 0.082 |

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.

[b] Units shown are grams per vehicle kilometer traveled (g/VKT), grams per vehicle mile traveled (g/VMT), and pounds per vehicle mile traveled (lb/VMT). **The muliplier k includes unit conversions to produce emission factors in the units shown for the indicated size range from the mixed units required in Equation 1.**

[c] **Ratio of PM-2.5 to PM-10 taken from Reference 22.**

[c d] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

cannot be obtained, an appropriate value for an industrial road may be selected from the mean values given in Table 13.2.1-2, but the quality rating of the equation should be reduced by 1 level.

~~With the exception of limited access roadways, which are difficult to sample, the collection and use of site-specific sL data fr public paved road emission inventories are strongly recommended. Although hundreds of public paved road sL measurements have been made since 1980,[8, 14-21] uniformity has been lacking in sampling equipment and analysis techniques, in roadway classification schemes, and in the types of data reported.[10] The assembled data set (described below) does not yield any readily identifiable, coherent relationship between sL and road class, average daily traffic (ADT), etc., even though an inverse relationship between sL and ADT had been found for a subclass of curbed paved roads in urban areas.[8] The absence of such a relationship in the composite data set is believed to be due to the blending of data (industrial and nonindustrial, uncontrolled, and controlled, and so on). Further complicating any analysis is the fact that, in many parts of the country, paved road sL varies greatly over the course of the year, probably because of cyclic variations in mud/dirt carryout and in use of anti-skid materials. For example, repeated sampling of the same roads over a period of 3 calendar years at 4 Montana municipalities indicated a noticeable annual cycle. In those areas, silt loading declines during the first 2 calendar quarters and increases during the fourth quarter.~~

~~Figure 13.2.1-2 and Figure 13.2.1-3 present the cumulative frequency distribution for the public paved road sL data base assembled during the preparation of this AP-42 section.[10] The data base includes samples taken from roads that were treated with sand and other snow/ice controls. Roadways are grouped into high- and low-ADT sets, with 5000 vehicles per day being the approximate cutpoint. Figure 13.2.1-2 and Figure 13.2.1-3, respectively, present the cumulative frequency distributions for high- and low-ADT roads.~~

~~In the absence of site-specific sL data to serve as input to a public paved road inventory, conservatively high emission estimates can be obtained by using the following values taken from the~~

~~figures. For annual conditions, the median sL values of 0.4 g/m$^2$ can be used for high-ADT roads (excluding limited access roads that are discussed below) and 2.5 g/m$^2$ for low-ADT roads. Worst-case loadings can be estimated for high-ADT (excluding limited access roads) and low-ADT roads, respectively, with the 90th percentile values of 7 and 25 g/m$^2$. Figure 13.2.1-4, Figure 13.2.1-5, Figure 13.2.1-6, and Figure 13.2.1-7 present similar cumulative frequency distribution information for high- and low-ADT roads, except that the sets were divided based on whether the sample was collected during the first or second half of the year. Information on the 50th and 90th percentile values is summarized in Table 13.2.1-2.~~

~~Table 13.2.1-2 (Metric Units). PERCENTILES FOR NONINDUSTRIAL SILT LOADING (g/m$^2$) DATA BASE~~

| ~~Averaging Period~~ | ~~High-ADT Roads~~ | | ~~Low-ADT Roads~~ | |
|---|---|---|---|---|
| | ~~50$^{th}$~~ | ~~90th~~ | ~~50th~~ | ~~90th~~ |
| ~~Annual~~ | ~~0.4~~ | ~~7~~ | ~~2.5~~ | ~~25~~ |
| ~~January-June~~ | ~~0.5~~ | ~~14~~ | ~~3~~ | ~~30~~ |
| ~~July-December~~ | ~~0.3~~ | ~~3~~ | ~~1.5~~ | ~~5~~ |

**During the preparation of the background document (Reference 10), public road silt loading values from 1992 and earlier were assembled into a data base. This data base is available as __________. Although hundreds of public paved road sL measurements had been collected, there was no uniformity in sampling equipment and analysis techniques, in roadway classification schemes, and in the types of data reported. Not surprisingly, the data set did not yield a coherent relationship between sL and road class, average daily traffic (ADT), etc., even though an inverse relationship between sL and ADT has been found for a subclass of curbed paved roads in urban areas. Further complicating the analysis is the fact that, in many parts of the country, paved road sL varies greatly over the course of the year, probably because of cyclic variations in mud/dirt carryout and in use of anti-skid materials. Although there were strong reasons to suspect that the assembled data base was skewed towards high values, independent data were not available to confirm the suspicions.**

**Since the time that the background document was prepared, new field sampling programs have shown that the assembled sL data set is biased high for "normal" situations. Just as importantly, however, the newer programs confirm that substantially higher than "normal" silt loadings can occur on public paved roads. As a result, two sets of default values are provided in Table 13.2.1-2, one for "normal" conditions and another for worst-case conditions (such as after winter storm seasons or in areas with substantial mud/dirt trackout). The newer sL data base is available as ____________.**

The range of sL values in the data base for normal conditions is 0.01 to 1.0 for high-ADT roads and 0.054 to 6.8 for low-ADT roads. Consequently the use of a default value from Table 13.2.1-2 should be expected to yield only an order-of-magnitude estimate of the emission factor. Public paved road silt loadings are dependent upon: traffic characteristics (speed, ADT, and fraction of heavy vehicles); road characteristics (curbs, number of lanes, parking lanes); local land use (agriculture, new residential construction) and regional/seasonal factors (snow/ice controls, wind blown dust). As a result, the collection and use of site-specific silt loading data is highly recommended.

Table 13.2.1-2 (Metric Units). RECOMMENDED DEFAULT SILT LOADING ($g/m^2$) VALUES FOR PUBLIC PAVED ROADS[a]

| | High ADT roads[b] | Low ADT roads |
|---|---|---|
| Normal conditions | 0.1 | 0.4 |
| Worst-case conditions[c] | 0.5 | 3 |

[a] Excluding limited access roads. See discussion in text. 1 $g/m^2$ is equal to 1.43 $grains/ft^2$

[b] High ADT refers to roads with at least 5,000 vehicles per day.

[c] For conditions such as post-winter-storm or areas with substantial mud/dirt carryout.

~~In the event that sL values are taken from any of the cumulative frequency distribution figures, the quality ratings for the emission estimates should be downgraded 2 levels.~~

**In the event that default sL values are used the quality ratings for the equation should be downgraded 2 levels.**

~~As an alternative method of selecting sL values in the absence of site-specific data, users can review the public (I. e., nonindustrial) paved road sL data base presented in Table 13.2.1-3 and can select values that are appropriate for the roads and seasons of interest. Table 13.2.1-3 presents paved road surface loading values together with the city, state, road name, collection date (samples collected from the same road during the same month are averaged), road ADT if reported, classification of the roadway, etc. Recommendation of this approach recognizes that end users of AP-42 are capable of identifying roads in the data base that are similar to roads in the area being inventoried. In the event that sL values are developed in this way, and that the selection process is fully described, then the quality ratings for the emission estimates should be downgraded only 1 level~~.

Limited access roadways pose severe logistical difficulties in terms of surface sampling, and few sL data are available for such roads. Nevertheless, the available data do not suggest great variation in sL for limited access roadways from 1 part of the country to another. For annual conditions, a default value of ~~0.02~~ **0.015** $g/m^2$ is recommended for limited access roadways.[9,22] Even fewer of the available data correspond to worst-case situations, and elevated loadings are observed to be quickly depleted because of high ADT rates. A default value of ~~0.1~~ **0.2** $g/m^2$ is recommended for short periods of time following application of snow/ice controls to limited access roads.[22]

13.2.1.4 Controls[6,~~22~~ 23]

Because of the importance of the surface loading, control techniques for paved roads attempt either to prevent material from being deposited onto the surface (preventive controls) or to remove from the travel lanes any material that has been deposited (mitigative controls). Regulations requiring the covering of loads in trucks, or the paving of access areas to unpaved lots or construction sites, are preventive measures. Examples of mitigative controls include vacuum sweeping, water flushing, and broom sweeping and flushing. It is particularly important to note that street sweeping of gutters and curb areas may actually increase the silt loading on the traveled portion of the road. Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions.

In general, preventive controls are usually more cost effective than mitigative controls. The cost-effectiveness of mitigative controls falls off dramatically as the size of an area to be treated increases. The cost-effectiveness of mitigative measures is also unfavorable if only a short period of time is required for the road to return to equilibrium silt loading condition. That is to say, the number and length of public roads within most areas of interest preclude any widespread and routine use of mitigative controls. On the other hand, because of the more limited scope of roads at an industrial site, mitigative measures may be used quite successfully (especially in situations where truck spillage occurs). Note, however, that public agencies could make effective use of mitigative controls to remove sand/salt from roads after the winter ends.

Because available controls will affect the sL, controlled emission factors may be obtained by substituting controlled silt loading values into the equation. (Emission factors from controlled industrial roads were used in the development of the equation.) The collection of surface loading samples from treated, as well as baseline (untreated), roads provides a means to track effectiveness of the controls over time.

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## 2.0 PROPOSED AP-42 SECTION 13.2.1

The proposed AP-42 Section for paved roads is presented on the following pages as it would appear in the document.

## 13.2.1 Paved Roads

### 13.2.1.1 General

Particulate emissions occur whenever vehicles travel over a paved surface, such as a road or parking lot. Particulate emissions from paved roads are due to direct exhaust from vehicles and resuspension of loose material on the road surface. In general terms, particulate emissions from paved roads originate from the loose material present on the surface. In turn, that surface loading, as it is moved or removed, is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and trackout from unpaved roads and staging areas. Figure 13.2.1-1 illustrates several transfer processes occurring on public streets.

Various field studies have found that public streets and highways, as well as roadways at industrial facilities, can be major sources of the atmospheric particulate matter within an area.[1-9] Of particular interest in many parts of the United States are the increased levels of emissions from public paved roads when the equilibrium between deposition and removal processes is upset. This situation can occur for various reasons, including application of snow and ice controls, carryout from construction activities in the area, and wind and/or water erosion from surrounding unstabilized areas. In the absence of continuous addition of fresh material (through localized trackout or application of antiskid material), paved road surface loading should reach equilibrium values in which the amount of material resuspended matches the amount replenished. The equilibrium sL value depends upon numerous factors. It is believed that the most important factors are: mean speed of vehicles traveling the road; the average daily traffic (ADT); the number of lanes and ADT per lane; the fraction of heavy vehicles (buses and trucks); and the presence/absence of curbs, storm sewers and parking lanes.

### 13.2.1.2 Emissions And Correction Parameters

Dust emissions from paved roads have been found to vary with what is termed the "silt loading" present on the road surface as well as the average weight of vehicles traveling the road. The term silt loading (sL) refers to the mass of silt-size material (equal to or less than 75 micrometers [µm] in physical diameter) per unit area of the travel surface.[4-5] The total road surface dust loading is that of loose material that can be collected by broom sweeping and vacuuming of the traveled portion of the paved road. The silt fraction is determined by measuring the proportion of the loose dry surface dust that passes through a 200-mesh screen, using the ASTM-C-136 method. Silt loading is the product of the silt fraction and the total loading, and is abbreviated "sL". Additional details on the sampling and analysis of such material are provided in AP-42 Appendices C.1 and C.2.

The surface sL provides a reasonable means of characterizing seasonal variability in a paved road emission inventory.[9] In many areas of the country, road surface loadings are heaviest during the late winter and early spring months when the residual loading from snow/ice controls is greatest. As noted earlier, once replenishment of fresh material is eliminated, the road surface loading can be expected to reach an equilibrium value, which is substantially lower than the late winter/early spring value.

13.2.1.3 Predictive Emission Factor Equations[10]

The quantity of dust emissions from vehicle traffic on a paved road may be estimated using the following empirical expression:

$$E = k\,(sL/2)^{0.65}\,(W/3)^{1.5} \qquad (1)$$

where:

E = particulate emission factor (having units matching the units of k)
k = base emission factor for particle size range and units of interest (see below)
sL = road surface silt loading (grams per square meter) ($g/m^2$)
W = average weight (tons) of the vehicles traveling the road

It is important to note that Equation 1 calls for the average weight of all vehicles traveling the road. For example, if 99 percent of traffic on the road are 2 Mg cars/trucks while the remaining 1 percent consists of 20 Mg trucks, then the mean weight "W" is 2.2 Mg. More specifically, Equation 1 is *not* intended to be used to calculate a separate emission factor for each vehicle weight class. Instead, only one emission factor should be calculated to represent the "fleet" average weight of all vehicles traveling the road.

The particle size multiplier (k) above varies with aerodynamic size range as shown in Table 13.2.1-1. To determine particulate emissions for a specific particle size range, use the appropriate value of k shown in Table 13.2.1-1.

Table 13.2-1.1. PARTICLE SIZE MULTIPLIERS FOR PAVED ROAD EQUATION

| Size range[a] | Multiplier k[b] | | |
|---|---|---|---|
| | g/VKT | g/VMT | lb/VMT |
| PM-2.5[c] | 1.1 | 1.8 | 0.0040 |
| PM-10 | 4.6 | 7.3 | 0.016 |
| PM-15 | 5.5 | 9.0 | 0.020 |
| PM-30[d] | 24 | 38 | 0.082 |

[a] Refers to airborne particulate matter (PM-x) with an aerodynamic diameter equal to or less than x micrometers.

[b] Units shown are grams per vehicle kilometer traveled (g/VKT), grams per vehicle mile traveled (g/VMT), and pounds per vehicle mile traveled (lb/VMT). The muliplier k includes unit conversions to produce emission factors in the units shown for the indicated size range from the mixed units required in Equation 1.

[c] Ratio of PM-2.5 to PM-10 taken from Reference 22.

[d] PM-30 is sometimes termed "suspendable particulate" (SP) and is often used as a surrogate for TSP.

The above equation is based on a regression analysis of numerous emission tests, including 65 tests for PM-10.[10] Sources tested include public paved roads, as well as controlled and uncontrolled industrial paved roads. No tests of "stop-and-go" traffic were available for inclusion in the data base. The equations retain the quality rating of A (B for PM-2.5), if applied within the range of source conditions that were tested in developing the equation as follows:

| | |
|---|---|
| Silt loading: | 0.02 - 400 $g/m^2$ |
| | 0.03 - 570 grains/square foot ($ft^2$) |
| Mean vehicle weight: | 1.8 - 38 megagrams (Mg) |
| | 2.0 - 42 tons |
| Mean vehicle speed: | 16 - 88 kilometers per hour (kph) |
| | 10 - 55 miles per hour (mph) |

To retain the quality rating for the emission factor equation when it is applied to a specific paved road, it is necessary that reliable correction parameter values for the specific road in question be determined. With the exception of limited access roadways, which are difficult to sample, the collection and use of site-specific sL data for public paved road emission inventories are strongly recommended. The field and laboratory procedures for determining surface material silt content and surface dust loading are summarized in Appendices C.1 and C.2. In the event that site-specific values cannot be obtained, an appropriate value for an industrial road may be selected from the mean values given in Table 13.2.1-2, but the quality rating of the equation should be reduced by 1 level. Also, recall that Equation 1 refers to emissions due to freely flowing (not stop-and-go) traffic.

During the preparation of the background document (Reference 10), public road silt loading values from 1992 and earlier were assembled into a data base. This data base is available as __________. Although hundreds of public paved road sL measurements had been collected, there was no uniformity in sampling equipment and analysis techniques, in roadway classification schemes, and in the types of data reported. Not surprisingly, the data set did not yield a coherent relationship between sL and road class, average daily traffic (ADT), etc., even though an inverse relationship between sL and ADT has been found for a subclass of curbed paved roads in urban areas. Further complicating the analysis is the fact that, in many parts of the country, paved road sL varies greatly over the course of the year, probably because of cyclic variations in mud/dirt carryout and in use of anti-skid materials. Although there were strong reasons to suspect that the assembled data base was skewed towards high values, independent data were not available to confirm the suspicions.

Since the time that the background document was prepared, new field sampling programs have shown that the assembled sL data set is biased high for "normal" situations. Just as importantly, however, the newer programs confirm that substantially higher than "normal" silt loadings can occur on public paved roads. As a result, two sets of default values are provided in Table 13.2.1-2, one for "normal" conditions and another for worst-case conditions (such as after winter storm seasons or in areas with substantial mud/dirt trackout). The newer sL data base is available as __________.

Table 13.2.1-2 (Metric Units). RECOMMENDED DEFAULT SILT LOADING ($g/m^2$) VALUES FOR PUBLIC PAVED ROADS[a]

| | High ADT roads[b] | Low ADT roads |
|---|---|---|
| Normal conditions | 0.1 | 0.4 |
| Worst-case conditions[c] | 0.5 | 3 |

[a] Excluding limited access roads. See discussion in text. 1 $g/m^2$ is equal to 1.43 grains/$ft^2$

[b] High ADT refers to roads with at least 5,000 vehicles per day.

[c] For conditions such as post-winter-storm or areas with substantial mud/dirt carryout.

The range of sL values in the data base for normal conditions is 0.01 to 1.0 for high-ADT roads and 0.054 to 6.8 for low-ADT roads. Consequently the use of a default value from Table 13.2.1-2 should be expected to yield only an order-of-magnitude estimate of the emission factor. Public paved road silt loadings are dependent upon: traffic characteristics (speed, ADT, and fraction of heavy vehicles); road characteristics (curbs, number of lanes, parking lanes); local land use (agriculture, new residential construction) and regional/seasonal factors (snow/ice controls, wind blown dust). As a result, the collection and use of site-specific silt loading data is highly recommended. In the event that default sL values are used, the quality ratings for the equation should be downgraded 2 levels.

Limited access roadways pose severe logistical difficulties in terms of surface sampling, and few sL data are available for such roads. Nevertheless, the available data do not suggest great variation in sL for limited access roadways from 1 part of the country to another. For annual conditions, a default value of 0.015 $g/m^2$ is recommended for limited access roadways.[9,22] Even fewer of the available data correspond to worst-case situations, and elevated loadings are observed to be quickly depleted because of high ADT rates. A default value of 0.2 $g/m^2$ is recommended for short periods of time following application of snow/ice controls to limited access roads.[22]

### 13.2.1.4 Controls[6,23]

Because of the importance of the surface loading, control techniques for paved roads attempt either to prevent material from being deposited onto the surface (preventive controls) or to remove from the travel lanes any material that has been deposited (mitigative controls). Regulations requiring the covering of loads in trucks, or the paving of access areas to unpaved lots or construction sites, are preventive measures. Examples of mitigative controls include vacuum sweeping, water flushing, and broom sweeping and flushing. It is particularly important to note that street sweeping of gutters and curb areas may actually increase the silt loading on the traveled portion of the road. Redistribution of loose material onto the travel lanes will actually produce a short-term increase in the emissions.

In general, preventive controls are usually more cost effective than mitigative controls. The cost-effectiveness of mitigative controls falls off dramatically as the size of an area to be treated increases. The cost-effectiveness of mitigative measures is also unfavorable if only a short period of time is required for the road to return to equilibrium silt loading condition. That is to say, the number and length of public roads within most areas of interest preclude any widespread and routine use of mitigative controls. On the other hand, because of the more limited scope of roads at an industrial site, mitigative measures may be used quite successfully (especially in situations where truck spillage occurs). Note, however, that public agencies could make effective use of mitigative controls to remove sand/salt from roads after the winter ends.

Because available controls will affect the sL, controlled emission factors may be obtained by substituting controlled silt loading values into the equation. (Emission factors from controlled industrial roads were used in the development of the equation.) The collection of surface loading samples from treated, as well as baseline (untreated), roads provides a means to track effectiveness of the controls over time.

### References For Section 13.2.1


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2. R. Bohn, *et al.*, *Fugitive Emissions From Integrated Iron And Steel Plants*, EPA-600/2-78-050, U. S. Environmental Protection Agency, Cincinnati, OH, March 1978.

3. C. Cowherd, Jr., *et al.*, *Iron And Steel Plant Open Dust Source Fugitive Emission Evaluation*, EPA-600/2-79-103, U. S. Environmental Protection Agency, Cincinnati, OH, May 1979.

4. C. Cowherd, Jr., *et al.*, *Quantification Of Dust Entrainment From Paved Roadways*, EPA-450/3-77-027, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 1977.

5. *Size Specific Particulate Emission Factors For Uncontrolled Industrial And Rural Roads*, EPA Contract No. 68-02-3158, Midwest Research Institute, Kansas City, MO, September 1983.

6. T. Cuscino, Jr., *et al.*, *Iron And Steel Plant Open Source Fugitive Emission Control Evaluation*, EPA-600/2-83-110, U. S. Environmental Protection Agency, Cincinnati, OH, October 1983.

7. J. P. Reider, *Size-specific Particulate Emission Factors For Uncontrolled Industrial And Rural Roads*, EPA Contract 68-02-3158, Midwest Research Institute, Kansas City, MO, September 1983.

8. C. Cowherd, Jr., and P. J. Englehart, *Paved Road Particulate Emissions*, EPA-600/7-84-077, U. S. Environmental Protection Agency, Cincinnati, OH, July 1984.

9. C. Cowherd, Jr., and P. J. Englehart, *Size Specific Particulate Emission Factors For Industrial And Rural Roads*, EPA-600/7-85-038, U. S. Environmental Protection Agency, Cincinnati, OH, September 1985.

10. *Emission Factor Documentation For AP-42, Sections 11.2.5 and 11.2.6 — Paved Roads*, EPA Contract No. 68-D0-0123, Midwest Research Institute, Kansas City, MO, March 1993.

11. *Evaluation Of Open Dust Sources In The Vicinity Of Buffalo, New York*, EPA Contract No. 68-02-2545, Midwest Research Institute, Kansas City, MO, March 1979.

12. *PM-10 Emission Inventory Of Landfills In The Lake Calumet Area*, EPA Contract No. 68-02-3891, Midwest Research Institute, Kansas City, MO, September 1987.

13. *Chicago Area Particulate Matter Emission Inventory — Sampling And Analysis*, Contract No. 68-02-4395, Midwest Research Institute, Kansas City, MO, May 1988.

14. *Montana Street Sampling Data*, Montana Department Of Health And Environmental Sciences, Helena, MT, July 1992.

15. *Street Sanding Emissions And Control Study*, PEI Associates, Inc., Cincinnati, OH, October 1989.

16. *Evaluation Of PM-10 Emission Factors For Paved Streets*, Harding Lawson Associates, Denver, CO, October 1991.

17. *Street Sanding Emissions And Control Study*, RTP Environmental Associates, Inc., Denver, CO, July 1990.

18. *Post-storm Measurement Results — Salt Lake County Road Dust Silt Loading Winter 1991/92 Measurement Program*, Aerovironment, Inc., Monrovia, CA, June 1992.

19. Written communication from Harold Glasser, Department of Health, Clark County (NV).

20. *PM-10 Emissions Inventory Data For The Maricopa And Pima Planning Areas*, EPA Contract No. 68-02-3888, Engineering-Science, Pasadena, CA, January 1987.

21. *Characterization Of PM-10 Emissions From Antiskid Materials Applied To Ice- And Snow-Covered Roadways*, EPA Contract No. 68-D0-0137, Midwest Research Institute, Kansas City, MO, October 1992.

22. *Fugitive Particulate Matter Emissions*, EPA Contract No. 68-D2-0159, Work Assignment No. 4-06, Midwest Research Institute, Kansas City, MO, April 1997.

23. C. Cowherd, Jr., *et al.*, *Control Of Open Fugitive Dust Sources*, EPA-450/3-88-008, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1988.

24. Written communication from G. Muleski, Midwest Research Institute, Kansas City, MO, to R. Myers, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 30, 1997.

**Attachment 1**

**Comment/Response Log for March 8, 1993, Paved Road Background Document**

## RESPONSE TO COMMENTS MADE IN ATTACHMENTS TO WILLIAM R. BARNARD LETTER OF MAY 12, 1993
## PAVED ROADS

| COMMENT | RESPONSE |
|---|---|
| 1. Page 2-2, 1st paragraph, sentence that starts "In addition..." change from "can be often heavily loaded" to "can often be..."<br><br>Page 2-2, In definitions of equation 2-1, change "s=surface material content silt" to read "surface material silt content"<br><br>Page 2-4, 1st paragraph at the top, sentence that begins "The industrial road augmentation factor..." change "was included to take into account for..." to "was included to account for..." | 1 These all address typographical errors or recommended wording changes to the background document. Changes will be made in any revision to the background document. |
| 2. Although I know that you are simply "quoting" AP-42, it is very confusing to the reader that in equation 2-1, s = surface material silt content and L = surface material loading, but in equation 2-3, sL = road surface silt loading and has the same units as L alone in equation 2-1. | 2. MRI agrees that the use of "sL" and the combination of "s" and "L" can prove confusing. Because the revised AP-42 section will replace all three paved road equations currently contained in Sections 11.2.5 and 11.2.6, "sL" will be used in only one sense thus eliminating any confusion. |
| 3. I would suggest moving most of section 3 forward (to become section 2) and would place section 2 as the new section 3. It would seem more logical to have a general description of the ratings system prior to summarizing the existing information, including the current ratings for current AP-42 emission factors. I also think that sections 3.0 and 3.1 would be better "tagged" onto the end of section 2 and the remaining current section 3 moved to section 2 as indicated above. | 3. MRI will consider the merit of reorganizing the background document prior to any revision to the report. |
| 4. In the discussion on page 2-6, the indication is that the reformulated emission factor will include data using controls. Although a rationale is given for this, I strongly question the wisdom of this approach. If controlled and uncontrolled information is used to generate the emission factor, then it becomes extremely difficult to perform any control strategy analyses for SIP purposes using an emission factor that may already incorporate some level of control. There is virtually no data on how much the various control options for paved roads reduce silt content (which is the information needed with the new approach), while there is limited data on overall control efficiency. Although I know that most of the control approaches are aimed at reducing the silt loading, what happens if you are wrong and the silt loading is not really the controlling factor for paved road emissions? | 4. MRI firmly believes that the approach employed in the background document is "best" in the sense that the approach<br>• addresses confusion that may result from having two or more different paved road models might be used to estimate emissions in various size ranges from roads at a single facility, municipality, etc.<br>• recognizes the very dynamic nature of silt loading in that emissions are reduced substantially (i.e., "controlled") through rainfall. To a very real extent, a truly "uncontrolled" paved road would have to be completely sheltered from the direct rain and water runoff.<br>• provides the regulatory and regulated communities a cost-effective means (through relatively inexpensive surface sampling) to evaluate seasonal variations in emissions and the efficiency of control programs<br>• recognizes that there is a far larger data base in which efficiency is tied to reduction in silt loading rather than reduction in the emission factor<br>With reference to the potential for mistaking the importance of silt loading, please see discussion on page 4-20. As stated there, the most notable features about the correlation matrix are the high degree of interdependence between (i) emisison factor; (ii) speed: and (iii) silt loading; and, the low degree of interdependence between (a) silt loading and weight and (b) weight and speed. The selection of combination (a) over combination (b) is explained at the bottom of page 4-20. |

RESPONSE TO COMMENTS MADE IN ATTACHMENTS TO WILLIAM R. BARNARD LETTER OF MAY 12, 1993
PAVED ROADS (continued)

| COMMENT | RESPONSE |
|---|---|
| 5. I think another criteria should be added to all reviews and AP-42 chapter development efforts. All primary source reports should contain sufficient information and data so that all data reduction procedures and/or calculations can be verified. Frequently, even when information has been given in fugitive emission factor development reports, the data cannot be used to give reproducible results using the data reduction/calculation methods presented.<br><br>Section 2, page 2-6 next to last paragraph indicates that previous test data were included in the reexamination and that no distinction was made between public and industrial roads or controlled/uncontrolled tests. However, on page 3-2, the top paragraph indicates that "earlier controlled industrial road test data were reexamined in addition to new data." Which is it? In section 4, it looks like all data were reviewed. Be consistent. | 5. Please see the discussion in response 6 regarding independent calculation of exposure profiling test results.<br><br>MRI does not see the two statements as contradictory; however, there may be some confusion about the meaning of terms such as "reexamined" or "reviewed". The background document does not make any hard and fast distinctions between terms such as "considered," "(re)examined," or "reviewed." Simply put, data are first examined -- or equivalently, "reviewed" or "considered" -- to decide from which data emission factors will be developed. New data (from test reports I, II and III) were examined. In addition, MRI reconsidered field test results that had been available during the earlier updates of this section (in 1983 and, to a lesser extent, 1987) but not used (because of the "controlled" nature of the surface) to develop an emission factor. The reasons for including the controlled tests in the current update are described in the background document and in the previous response. |

| COMMENT | RESPONSE |
|---|---|
| 6. Page 3-2, item #2 in the section 3-2 list. What do EPA method 5 front-half and back-half have to do with fugitives? A better example of incompatible methods should be found.<br><br>A great deal of the discussion on upwind-downwind tends to deal with drawbacks to using this method. However, it can be utilized with standardized, wind tunnel certified sampling devices and really requires little more meteorological data than exposure profiling (wind speed and direction vs. wind speed). Equal time should be devoted towards drawbacks/uncertainties associated with exposure profiling.<br><br>For instance, the samplers used for exposure profiling have never been wind tunnel certified for size cutpoints to the best of my knowledge (i.e., never published). Also, I have never been able to successfully duplicate the "spatial integration of measurements" even when data and example calculations have been provided.<br><br>In the case of PM-10, how can you truly estimate the visual extent of the plume to insure that at least 90% is captured? I believe that visually estimating the extent of 10 micron particles (mainly invisible) would be extremely difficult.<br><br>Finally, the discussion of exposure profiling should discuss the relative error (as was done for upwind-downwind).<br><br>The overall tone of the discussion tends to sound "heavy-handed" and biased towards the method that MRI developed rather than an objective presentation of the two methodologies which is what an objective review should do. | 6. This text is drawn verbatim from the EPA guideline document for development of AP-42 sections. MRI will revise this passage to better reflect the particulars involved with paved road testing procedures in any new version of the background document.<br><br>It is important to recall that exposure profiling represents a sampling approach rather than any specific type of sampler. In other words, "standardized, wind tunnel certified samplers" can (and have been) used in exposure profiling programs. The reviewer is quite right in stating that upwind/downwind (UW/DW) approach requires little more meteorlolgical data than exposure profiling. As a matter of fact, MRI requires that wind direction be monitored throughout any exposure profiling test.<br><br>The important distinction to be drawn between the UW/DW and the exposure profiling methods involves how data are used to characterize the source. The background document discusses basic limitations of using uncalibrated dispersion models to estimate emission strength. Beyond the relatively simple discussion presented in the background document, UW/DW suffers other fundamental limitations. For example, traffic on many roads is too low to pose a steady, uniformly emitting line source as required in dispersion models. A better representation would view the source as a series of discrete moving point source.<br><br>Even assuming the source is reasonably steady in nature, the modeled line source/wind geometry does not necessarily properly account for dispersion from the moving point sources. As the plume is released, dispersion occurs in all three cartestian coordinate directions. Only dispersion in the direction parallel to the plume centerline would be negligible. Depending on the direction a vehicle is traveling, an oblique wind would appear to "dilute" or "concentrate" the plume as seen by the UW/DW samplers. Correction for each plume depends upon the magnitude and direction of the wind relative to vehicle velocity vector. In other words, if two vehicles passed in opposite directions at the same time, one plume would be concentrated and the other diluted.<br><br>Because the exposure profiling approach focuses on the mass flux through a plane, concentration/dilution issues are not a concern. As noted earlier, standardized samplers can be and have been readily used in the exposure profiling arrays. Because of the interest in total particulate and size-specific factors, MRI has traditionally used directional samplers operated isokinetically, together with aerodynamic particle sizing instruments. (In addition to manufacturer tests for the cascade impactors, the cyclone preseparator has been wind tunnel tested. Results are reported in Baxter et al 1986.)<br><br>The Southern Research Institute (SoRI) collaborative study (Pyle and McClain 1986) examined many issues associated with exposure profiling. The authors duplicated MRI's and four other organization's calculations from 11 test runs on a "simulated" unpaved road. In addition, SoRI investigated potential errors associated with isokinetic tracking, different particle sizing approaches, maximum sampling height, spatial integration schemes, etc. |

RESPONSE TO COMMENTS MADE IN ATTACHMENTS TO WILLIAM R. BARNARD LETTER OF MAY 12, 1993
PAVED ROADS (continued)

| COMMENT | RESPONSE |
|---|---|
| 7. Page 3-9, next to last sentence says, "sin specific source parameters" should say "in specific source parameters"<br><br>Page 3-11, top of page "virtual point source missions" should be "virtual point source emissions" | 7. These changes will be made to any subsequent version of the background document. |
| 8. On page 3-11, one of the criteria used for evaluating emission factor data is "industry representativeness." Why are we concerned about industry representativeness as a criteria in developing a new emission factor when the new emission factor is to be reflective of emissions from any paved road, regardless of whether industrial or public? | 8. As stated above, this text is drawn verbatim from the EPA guideline document. The passage will be revised in any subsequent version of the background document. |
| 9. Page 4-7, 1st full paragraph indicates that the Test Report I does not fully meet the minimum requirements for upwind-downwind sampling (i.e., a minimum of 4 samplers).<br><br>The description of the sampling set-up says that even when 6 samplers were used they were set up identically with one at 20 m and a pair at 5 m on each side of the road. This means 3 samplers on upwind side at 2 distances and 3 on downwind at 2 distances. On page 3-10, next to last paragraph, the minimum test requirements for upwind-downwind are stated as 1 device upwind (satisfied here by 3 at 2 distances) and the others at 2 downwind (satisfied here by the 5 m and 20 m distances) and 3 crosswind. The requirement for crosswind distances is waived for line sources. A paved road is a line source, thus this report does meet the minimum requirements for sampling and should be included in the analysis. | 9. MRI mistakenly stated in the background document that "neither" sampling configuration met minimum requirements. Only the <u>second</u> configuration (described on page 4-4) failed to meet minimum requirements because the sources tested were not truly line sources. Instead, the halves of each road segment were considered separately. Test Report I did not explain how far samplers were separated from the end of segments nor did it describe any attempt to prevent tracking of material from one segment to another. (See, for example, Figure 2-3 of Test Report I.) Thirty-two of the 69 emission tests used the second configuration. |
| 10 In the discussion of Test Report II, the text indicates that only 1 particle size device is used to determine a PM-10 emission factor. Are the investigators really sure that there is no variability in the distribution of the PM-10 concentration (flux) with height? Unpaved road studies performed as part of NAPAP indicate otherwise. | 10. Test Report II's use of single height for particle sizing measurements resulted from the limited number of devices available. MRI has found in numerous past studies and one would certainly expect the PM-10 fraction to increase with height in the plume. To at least partially account for this, the single height was selected to approximate the height in a dust plum at which half the mass emissions pass above and half below. |
| 11. Figure 4-3 is really a table. | 11. MRI called this a "figure" because it is a photocopy of two different outputs from a computer program. No change is planned. |
| 12. Table 4-5, the multiple $R^2$ for PM-15 = .765, but "Figure" 4-3 indicates it should be .772. | 12. To ensure that the different size fractions had functional forms similar to that for PM-10, all final models were "forced" to have the same exponents for silt loading and weight. Thus, the ℓn-transformed emission factors were regressed against the term<br><br>$0.65 \ln sL + 1.5 \ln W$<br><br>with the line-of-fit forced to pass through the origin to determine the final form. The lower $R^2$ results from the fact that the final factor is not "best" in an independent least-squares sense. |

| COMMENT | RESPONSE |
|---|---|
| 13. Based upon the discussion above concerning inclusion of Test Report I and due to the fact that it was considered good enough for validation, what would the emission factor equation look like if that data was included? | 13. Inclusion of the Test Report I data could be expected to lower the exponent for "sL" for the PM-10 equation from 0.65 to approximately 0.5. At a summer 1992 meeting with the commentor, Chuck Masser, Tom Pace, and Robin Dunkins, we discussed how, the discussion in Zimmer 1991 notwithstanding, Test Report I emission rates exhibited a strong dependence on silt loading. (Figure 4-2 of the background document clearly shows this.) It is also important to recall that primary reason for not including Test Report I data was that only PM-10 factors were available. |
| 14. On page 4-23, the validation results indicate that at least 50% of the data are outside the factor of 3 range. Does this mean that the factor of 2 used for rating (see Table 3-1) is unrealistic for rating emission factors and that a more appropriate lower end would be 3 rather than 2? | 14. Page 4-23 states that "a little over half" of the quasi-independent values are within a factor of 3. This certainly does not indicate that "at least 50% ... are outside" that range. A rough scaling of Figure 4-4 on page suggests that approximately 57% ≈ 60% are within a factor of 3.<br><br>Table 3-1 pertains to single-valued emission factors. The quality ratings for predictive equations are assigned following the scheme presented in Table 3-2. |
| 15. Why is the equation on the first page of the proposed new section 11.2.x different from the new one derived in the report (equation on page 4-22). Specifically, why is sL divided by 2 and W by 3? Why doesn't the equation on page 4-22 have an equation number as earlier equations did? | 15. The background document discusses a "working" form for the model. By that is meant all emission factors are measured in g/VMT, all silt loadings are in g/m², and so on. For example, in order to be exactly precise, one must either<br><br>• consider silt loading and weight "nondimensionalized" by implicit division by 1 g/m² and 1 ton respectively<br><br>or<br><br>$\frac{g \cdot m^{1.3}}{g^{0.65} \cdot tons^{1.5} \cdot veh\text{-}mile} = \frac{g^{0.35} \cdot m^{1.3}}{tons^{1.5} \cdot veh\text{-}mile}$<br><br>The working versions of models are used to establish properties of candidate emission factors. On the other hand, once a factor has been selected, the AP-42 section must present a final product. In the AP-42 sections, nondimensionalization occurs through the explicit division by the "default" values of 2 g/m² and 3 tons. Furthermore, k is expressed in a variety of compatible units.<br><br>One can readily verify that all working and final expressions result in the same emission factor for the same input values.<br><br>An equation number will be added on page 4-22 in any subsequent version of the background document. |

References

Baxter, T. E. et al. 1986. "Calibration of Cyclone for Monitoring Inhalable Particles," Journal of Environmental Engineering, 112, 3, pp. 468-478.

Pyle, B. E. and J. D. McCain 1986. Critical Review of Open Source Particulate Emission Measurements -- Part II: Field Comparison. Work Assignment 002, EPA Contract 68-02-3936. February 1986.

Zimmer, R. A. 1991."Evaluation of PM10 Emission Factors for Paved Streets." Harding Lawson and Associates report for the Regional Air Quality Council (Denver). October 1991.

RESPONSE TO COMMENTS MADE IN ATTACHMENTS TO WILLIAM R. BARNARD LETTER OF MAY 12, 1993
CONSTRUCTION ACTIVITIES

| COMMENT | RESPONSE |
|---|---|
| Specific comments | |
| 1. On page v, there is a superscript 8 in the Section 3.3 line of the Table of Contents.<br><br>On page vi, there is a superscript in #2-3 line of Tables list | 1. These all address typographical errors or recommended wording changes to the background document. These changes will be made in any subsequent version of the background document. |
| 2. As with the Paved Roads document, I'd probably flip-flop Sections 2 and 3, although the reason for switching them is less compelling in this document, since there are few if any references to the previous AP-42 emission factor quality rating. | 2. MRI will consider the merit of reorganizing the background document prior to any revision to the report. |
| Comments on Section 2 | |
| 3. Page 2-1 In the discussion of the number of construction industries, you list 2.0 million, instead of 2 million. The decimal point implies some level of significant figures. Is that level really there? | 3. Reference 1 in the background document should not be the Statistical Abstract but rather the 1987 Census of Construction Industries. This will be corrected in any revision. The 1987 Census uses the expression "nearly 2.0 million construction establishments." Any subsequent version of the background document will incorporate that phrasing. |
| 4. Unless total value of business done is the way that Statistical Abstract describes the information presented on page 2-1 and 2-2, I'd say total revenue. | 4. The Statistical Abstract reports "value of construction [contract]." The Census of Construction Industries uses the term "value of construction work." Subsequent version of the background document will use "value of construction work." |
| 5. Page 2-5 "unpaved travel rates"? - middle of last paragraph | 5. This is a typographical error and should read "travel routes." The change will be made in a subsequent revision to the background document. |
| Comments on Section 3 | |
| 6. I think another criteria should be added to all reviews and AP-42 chapter development efforts. All primary source reports should contain sufficient information and data so that all data reduction procedures and/or calculations can be verified. Frequently, even when information has been given in fugitive emission factor development reports, the data cannot be used to give reproducible results using the data reduction/calculation methods presented. | 6. Please see response 6 in the paved road comment log regarding independent calculation of exposure profiling test results. |
| 7. Page 3-1 near the bottom. The 1987 Censu s of Construction Industries, United States Summary is *listed as reference 1, however, reference 1 is the* Statistical Abstract of the U.S. for 1992. | 7. As noted in response 3, Reference 1 should read<br><br>*U.S. Department of Commerce, Bureau of the Census.* "*1987 Census of Construction Industries.*" Geographic Area Series, CC87-A-10. Washington, D. C. October 1990. |
| 8. Page 3-6, change "unless the plume can be draw..." to "unless the plume can be drawn"<br><br>Page 3-9, next to last sentence change "when characterize source conditions" to "which characterize source conditions" | 8. These changes will be made in any subsequent version of the background document. |

## RESPONSE TO COMMENTS MADE IN ATTACHMENTS TO WILLIAM R. BARNARD LETTER OF MAY 12, 1993 CONSTRUCTION ACTIVITIES (continued)

| COMMENT | RESPONSE |
|---|---|
| Comments on Section 4 | |
| 9. All discussions of reviewed emission factors should clearly delineate whether the emission factor being discussed is for TSP or PM-10.<br><br>Page 4-5, last paragraph, says that upwind-downwind sampling was used to determine TSP emission factors in Table 4-2, but the table caption says they are PM-10 emission factors. | 9. The background document will be reviewed to identify points where PM10/TSP could be confused.<br><br>The entries are in fact PM-10 emission factors based on Referernce 12's reanalysis of TSP emission factors contained in Test Report III. Statements will be corrected in any subsequent version of the background document. |
| 10. Page 4-6, last sentence of first paragraph, says that a minimum of 4 samplers are required but on Page 3-11 the minimum number is specified as 5. | 10. MRI does not see the two statements as contradictory. Page 3-11 calls for "at least five ... with one device located upwind." Consequently at least 4 should be deployed downwind. Page 4-6 states that "two samplers ... were used downwind rather than the minimum of four." |
| 11. Page 4-6, last paragraph before section 4.2.2, either give it a B or a C rating. Probably deserves a C | 11. MRI agrees that "C" is appropriate. |
| 12. In the revised section for AP-42, the discussion concerning equation 1 indicates that the emission factor can be used for PM-10, but this is a TSP emission factor. No discussion is provided to indicate what factor should be applied to provide PM-10 emission estimates. | 12. The intention in the revised AP-42 section is to allow readers to use Equation (1) to not only estimate TSP emissions but also to <u>conservatively</u> estimate PM-10 emissions. The discussion on page 11.2.4-2 recognizes that this approach may result in too high a PM-10 estimate and recommends estimating emissions on the basis of component operations. |

COMMENTS MADE IN MAY 24, 1992, LETTER FROM DOUGLAS P. COLLINS, IDAHO DEQ PAVED ROADS

| COMMENT | RESPONSE |
|---|---|
| The 90th percentile, as a worst case scenario, appears to overestimate emissions, especially if used to generate a daily total emission rate. To assume that all streets, on any day, would be carrying a 90th percentile silt loading seems unlikely. | MRI agrees that it is highly unlikely that all roads in an area will be at the 90th percentile at once. As noted in the AP-42 section and the comments below, sL values specific to the site and situation of interest would be preferred. |
| The temporal scale of January to June, and July to December, does not reflect annual increase and decrease of silt loadings in Idaho. Increased silt loadings from the application of anti skid materials starts with the first significant snow fall, usually in November, and lasts until about April, when many road departments mechanically remove excess road debris. | During the preparation of the AP-42 Section, MRI considered using different groupings, such as winter/spring vs. summer/fall or November-through-March vs. April-through-October. The other grouping schemes all failed to adequately account for differences seen in the sL values; furthermore, the other schemes called for a subjective decision -- such as: When does "winter" begin at a specific site? -- or failed to take into account weather patterns during a particular sampling year -- such as: Was November 1991 particularly snowy or warm? Because the sL data base was a secondary objective in the program, project resources were insufficient to devote much effort in resolving weather patterns. Consequently, calendar year halves were selected to avoid subjective decisions. |
| Not all counties in Idaho require vehicle weights to be recorded with the title or registration. Therefore it is a best guess as to what the average vehicle weight might be. Some guidelines, references, or suggested values, or range of values would be helpful. | For most public roads with "normal" mixes of cars, trucks and buses, one can probably expect the average weight not vary outside the range of 2.0 to 2.5 tons. |
| The preferred method for determining silt loading value is to collect your own representative samples. Appendices, in the past, have addressed how to take and analyze the samples, but do not provide a methodology to set up a sampling study. A methodology that lays out guidelines on the number of sites, number of samples, precision and accuracy, QA/QC, meterological considerations, and other parameters needed to conduct an adequate road silt sampling project would be of help. These guidelines could address both larger studyies for determining specific silt loading values, an a limited study for trying to narrow down the options presented in using the 50th to 90th percentile used in the revised AP-42. | MRI agrees that some sort of "case study" would be quite useful to the regulatory community. The current version of Appendix D to AP-42 is necessarily vague on where and how many samples should be collected and even on the type of equipment to be used in sampling, because site-specific considerations may affect decisions. A case study that considered<br>• three different size cities (e.g., Phoenix, Reno, and Pocatello)<br>and,<br>• and 2 or 3 levels of effort (for example, a two-month long program for $10,000 versus a multiyear program for $70,000).<br>would be of great practical benefit. |
| Use of the public paved road sL data base (not yet provided) would seem to be a good intermediate choice between getting site specific data and using the the revised AP-42 values, providing the selection criteria used can adequately reflect the area of interest. Selection information might include: the amount of anti-skid material used, percent of silt in anti skid material, average number of applications per season, application equipment used, application rate, and the size and location of the area where the data was collected. | At present, the revised paved road section recognizes that end users of AP-42 are the most capable in selecting roads in the data base that are similar to roads of interest in their jurisdictions. Although site-specific sL values would be most preferred, MRI believes that the new approach represents an improvement. |
| When compared to the current AP-42 section in use, selecting a winter time silt loading value from the revised section feels more comfortable. The 50th to 90th percentile range appears to accurately reflect the range of silt loadings that can be found on Idaho roads, and even though the value range is fairly large, it does let you know when you are in the ball park. | MRI agrees. |

## COMMENTS MADE IN MAY 27, 1992, LETTER FROM GARY NEUROTH, ARIZONA DEQ PAVED ROADS

| COMMENT | RESPONSE |
|---|---|
| The "MRI accepted" data base contains little, if any, data for relatively high volume, high speed roads typically found in urban areas. For example, roads with daily traffic volumes over 10,000 with speeds over 35 mph. | Figures 1 and 2 compare the speed/silt loading ranges in the AP-42 data base and data from the PEI Denver study (Test Report I in the background document). As can be seen, the AP-42 data contains slightly more tests within the range of the PEI data.<br><br>This is not to say that the current paved road emission factor data base does not suffer from certain limitations. As MRI has pointed out, the present paved road emission factor models do not explicitly reference characteristics that are likely to influence emission levels, such as<br><br>• Vehicle mix -- It is likely that particulate matter emission levels are higher for roads/areas where diesel and/or poorly maintained older vehicles are prevalent. At present, however, neither the current Section 11.2.5 or Section 11.2.6 $PM_{10}$ emission factor distinguishes between roads with different vehicle mixes. The recommended revision, on the other hand, at least partially accounts for vehicle mix by the inclusion of the "weight term." Still, no direct distinction is made for different diesel/gasoline ratios, etc.<br>• Vehicle speed -- As the comment points out, it is likely that, all other factors being equal, high ADT roads should have different emission characteristics than low ADT roads. However, both the AP-42 and the PEI baseline data bases show a very strong interrelationship between silt loading and vehicle speed. Thus, the effects of high-speed (and, by inference, high-ADT) are at least partially accounted for by the inclusion of silt loading as an input parameter. (Also, please see the response to comment 4 in the log for the letter from Pechan and Associates.<br>• Traffic flow characteristics -- The AP-42 paved road data base and all current or revised emission factor models apply only to freely flowing traffic; no provision is made for the presumably higher emissions due to stop-and-go traffic. |
| As you are probably aware, the Federal Highway Administration is presentaly funding research conducted by Desert Research Institute (DRI) to characterize emissions from paved roads. My staff is currently assisting DRI conducting roadside testing in Scottsdale, Arizona. In October 1993, our Department plans to conduct roadside $PM_{10}$ sampling at several locations in the Phoenix metro area using a 3-dimensional sampling array similar to the MRI configuration. I've enclosed a copy of our proposed study plan, which I believe has two inherent advantages that promise to yield a better data base than that used to derive the AP-42 emission factors for urban areas: (1) saqmpling will be conducted on roads selected to represent a majority of the urban VMT (2) $PM_{10}$ samples will be collected continuously using Tapedred Element Oscillating Microbalance (TEOM) samplers which will provide a larger number of data points with shorter averaging times allowing tighter specification on variables such as wind and traffic. | In light of the above response, MRI certainly recognizes the need for additional field investigation. Furthermore, MRI also recognizes the need that, as new information becomes available, the paved road emission factor should be evaluated in terms of its performance in estimatin<br><br>• evaluated in terms of its performance in estimating independent emissions data<br>• reformulated, as needed, depending upon the results of the evaluation |

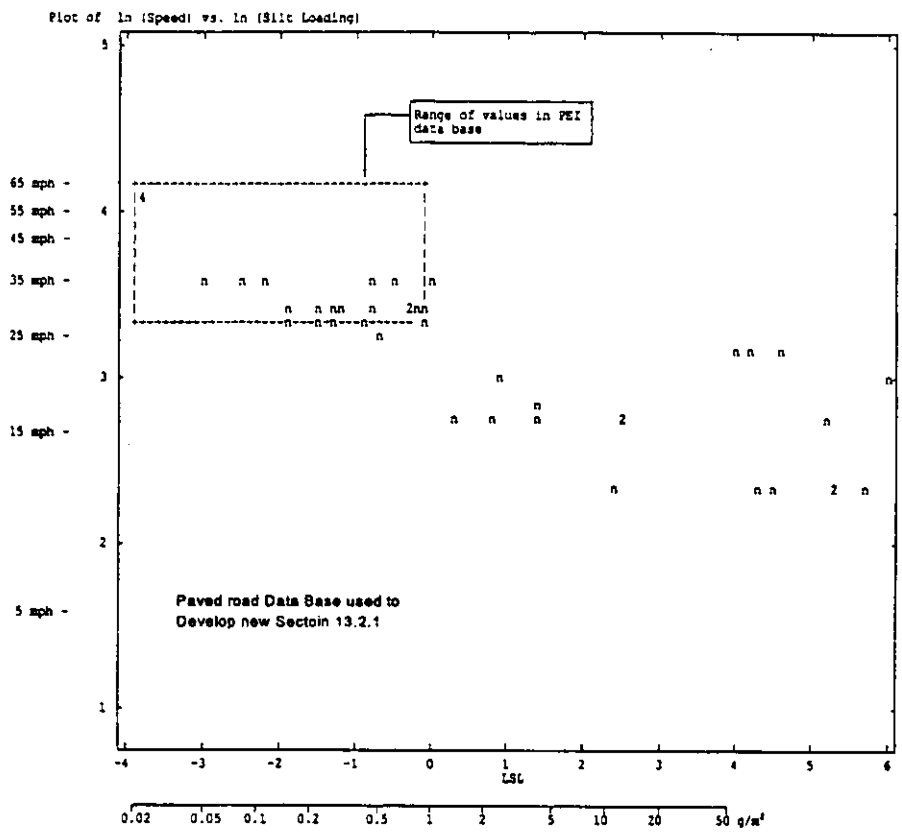


Figure 1. PLOT OF AVERAGE VEHICLE SPEED vs. SILT LOADING IN THE AP-42 PAVED ROAD EMISSION FACTOR DATA BASE (Fully logarithmic)

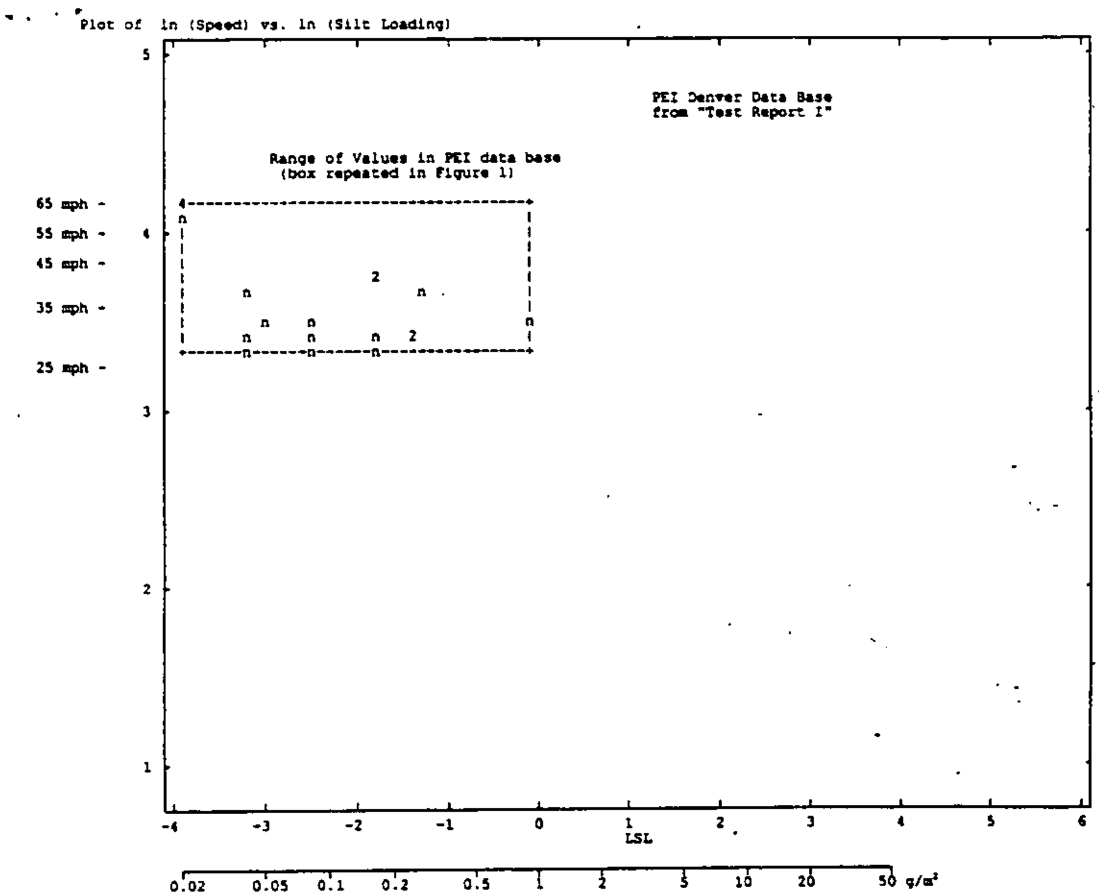


Figure 2. PLOT OF AVERAGE VEHICLE SPEED vs. SILT LOADING IN THE PEI BASELINE EMISSION FACTOR DATA BASE (Fully logarithmic)

**Attachment 2.**

**Public Paved Road Surface Loading**
**Presented as Appendix X in March 8, 1993**
**Paved Road Background Document**

TABLE A2-1. PUBLIC PAVED ROAD SURFACE LOADING DATA BASE (DETAILED INFORMATION)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| The following data from | | Reference 1 | | | | | | | |
| MT | Billings | ----- | Rural | Apr-78 | 50 | 0.6 | 18.5 | 3.4 | |
| MT | Billings | Yellowstone | Residential | Apr-78 | 115 | 0.5 | 14.3 | 3.5 | |
| MT | Missoula | Bancroft | Residential | Apr-78 | 4000 | 8.4 | 33.9 | 24.9 | |
| MT | Butte | 1st St | Residential | Apr-78 | 679 | 24.6 | 10.6 | 232.4 | |
| MT | Butte | N Park Pl | Residential | Apr-78 | 60 | 103.7 | 7 | 1480.8 | |
| MT | Billings | Grand Ave | Collector | Apr-78 | 6453 | 1.6 | 19.1 | 13.05 | 2 samples, range: 1.0 - 2.2 |
| MT | Billings | 4th Ave E | Collector | Apr-78 | 3328 | 7.7 | 7.7 | 99.5 | |
| MT | Missoula | 6th St | Collector | Apr-78 | 3655 | 26 | 62.9 | 6 | |
| MT | Butte | Harrison | Arterial | Apr-78 | 22849 | 1.9 | 5 | 37.3 | |
| MT | Missoula | Hiway 93 | Arterial | Apr-78 | 18870 | 1.9 | 55.9 | 3.3 | |
| MT | Butte | Montana | Arterial | Apr-78 | 13529 | 0.8 | 6.6 | 11.9 | |
| MT | East Helena | Thurman | Residential | Apr-83 | 140 | 13.1 | 4.3 | 305.2 | |
| MT | East Helena | 1st St | Local | Apr-83 | 780 | 4 | 13.6 | 29 | |
| MT | East Helena | Montana | Collector | Apr-83 | 2700 | 8.2 | 9.4 | 86.6 | |
| MT | East Helena | Main St | Collector | Apr-83 | 1360 | 4.7 | 8.4 | 55.3 | |
| MT | Libby | 6th | Local | Mar-88 | 1310 | ----- | 14.8 | ----- | |
| MT | Libby | 5th | Local | Mar-88 | 331 | ----- | 16.5 | ----- | |
| MT | Libby | Champion Int So g | Collector | Mar-88 | 800 | ----- | 27.5 | ----- | |
| MT | Libby | Mineral Ave | Collector | Mar-88 | 5900 | 7 | 16 | 43.5 | |
| MT | Libby | Main Ave btwn 6th | Collector | Mar-88 | 536 | 61 | 20.4 | 299.2 | |
| MT | Libby | California | Collector | Mar-88 | 4500 | ----- | 12.1 | ----- | |
| MT | Libby | US 2 | Arterial | Mar-88 | 10850 | ----- | 12.3 | ----- | |
| MT | Butte | Garfield Ave | Residential | Apr-88 | 562 | 2.1 | 10.9 | 19.3 | |
| MT | Butte | Continental Dr | Arterial | Apr-88 | 5272 | 0.9 | 10.1 | 8.8 | |
| MT | Butte | Garfield Ave | Residential | Jun-89 | 562 | 1 | 8.7 | 11.2 | |
| MT | Butte | So Park Ave | Residential | Jun-89 | 60 | 2.8 | 10.9 | 25.5 | |
| MT | Butte | Continental Dr | Arterial | Jun-89 | 5272 | 7.2 | 3.6 | 197.6 | |
| MT | East Helena | Morton St | Local | Aug-89 | 250 | 1.7 | 6.8 | 24.6 | |
| MT | East Helena | Main St | Collector | Aug-89 | 2316 | 0.7 | 4.1 | 17 | |
| MT | East Helena | US 12 | Arterial | Aug-89 | 7900 | 2.1 | 12.5 | 16.5 | |
| MT | Columbia Fall | 7th St | Residential | Mar-90 | 390 | ----- | 9.5 | ----- | |
| MT | Columbia Fall | 4th St | Residential | Mar-90 | 400 | 18.8 | 14.3 | 131.5 | |
| MT | Columbia Fall | 3rd Ave | Residential | Mar-90 | 50 | ----- | 14.3 | ----- | |
| MT | Columbia Fall | 4th Ave | Residential | Mar-90 | 1720 | ----- | 5.4 | ----- | |

TABLE A2-1. (continued)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| MT | Columbia Fall | CF Forest | Local | Mar-90 | 240 | ----- | 16.3 | ----- | |
| MT | Columbia Fall | 12th Ave | Collector | Mar-90 | 1510 | ----- | 8.8 | ----- | |
| MT | Columbia Fall | 3rd St | Collector | Mar-90 | 1945 | ----- | 7 | ----- | |
| MT | Columbia Fall | Nucleus | Collector | Mar-90 | 4730 | 15.4 | 10 | 153.9 | |
| MT | Columbia Fall | Plum Creek | Collector | Mar-90 | 316 | ----- | 6.2 | ----- | |
| MT | Columbia Fall | 6th Ave | Collector | Mar-90 | 1764 | ----- | 4.2 | ----- | |
| MT | Columbia Fall | US 2 | Arterial | Mar-90 | 13110 | 2.7 | 18.7 | 14.6 | |
| MT | East Helena | Morton | Residential | Jul-90 | 250 | 1.6 | 17 | 9.3 | |
| MT | East Helena | Main St | Collector | Jul-90 | 2316 | 5.6 | 10.6 | 52.5 | |
| MT | East Helena | US 12 | Arterial | Jul-90 | 7900 | 3.2 | 15.4 | 20.9 | |
| MT | Columbia Fall | 4th Ave | Local | Aug-90 | 400 | 1.5 | 4 | 37.7 | |
| MT | Libby | Main Ave 4th & | Collector | Aug-90 | 530 | 2.4 | 17.9 | 13.2 | |
| MT | Columbia Fall | Nucleus | Collector | Aug-90 | 5730 | 0.8 | 5.3 | 16 | |
| MT | Columbia Fall | US 2 | Arterial | Aug-90 | 13039 | 0.2 | 7 | 2.9 | |
| MT | East Helena | Morton | Local | Oct-90 | 250 | 3.4 | 10.2 | 33.6 | |
| MT | East Helena | Main | Collector | Oct-90 | 2316 | 4.5 | 5.6 | 81.3 | |
| MT | East Helena | US 12 | Arterial | Oct-90 | 7900 | 0.6 | 13.9 | 4.3 | |
| MT | Columbia Fall | Nucleus | Collector | 11/6/90 | 5670 | 5.2 | 13.5 | 38 | |
| MT | Columbia Fall | US 2 | Arterial | 11/6/90 | 15890 | 1.7 | 24.1 | 7.2 | |
| MT | Libby | US 2 | Arterial | 12/8/90 | 10000 | 21.5 | 9.6 | 223.9 | |
| MT | Libby | Main Ave 4th & | Collector | 12/9/90 | 530 | 13.6 | 27.1 | 50.3 | |
| MT | Butte | Texas | Collector | 12/13/90 | 3070 | 1 | 15.4 | 6.4 | |
| MT | East Helena | King | Local | Jan-91 | 75 | 1 | 3.4 | 30.6 | |
| MT | East Helena | Prickly Pear | Local | Jan-91 | 425 | 12 | 1.8 | 666.5 | |
| MT | East Helena | Morton | Local | Jan-91 | 250 | 14.1 | 3.5 | 402.3 | |
| MT | East Helena | Main St | Collector | Jan-91 | 2316 | 36.7 | 12.1 | 303.4 | |
| MT | East Helena | US 12 | Arterial | Jan-91 | 7900 | 0.8 | 14 | 5.6 | |
| MT | Thompson Fall | Preston | Local | 1/23/90 | 920 | 9.2 | 9.9 | 93 | |
| MT | Thompson Fall | Highway 200 | Collector | 1/23/90 | 5000 | 33.3 | 27.2 | 122.2 | |
| MT | East Helena | Seaver Park Rd | Local | Feb-91 | 150 | 21.6 | 7.1 | 304.7 | |
| MT | East Helena | New Lake Helena D | Collector | Feb-91 | 2140 | 19.2 | 9 | 213.4 | |
| MT | East Helena | Porter | Collector | Feb-91 | 850 | 74.4 | 7.7 | 966.8 | |
| MT | Libby | Main Ave 4th & | Collector | 2/14/91 | 530 | 33.3 | 18.7 | 178.2 | |
| MT | Libby | US 2 | Arterial | 2/17/91 | 10000 | 69.3 | 21 | 330.3 | |
| MT | Butte | Texas | Collector | 2/21/91 | 3070 | 1.2 | 11 | 10.9 | |

TABLE A2-1. (continued)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| MT | Butte | Harrison | Arterial | 2/21/91 | 22849 | 2.9 | 7.9 | 36.6 | |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | 2/24/91 | 2653 | 30.5 | 24.8 | 122.9 | |
| MT | Kalispell | Main | Arterial | 2/24/91 | 14730 | 17.4 | 20.4 | 85.2 | |
| MT | Thompson Fall | Preston | Local | 2/25/91 | 920 | 35.7 | 17.9 | 199.6 | |
| MT | Thompson Fall | Highway 200 | Collector | 2/25/91 | 5000 | 66.8 | 17.8 | 375.3 | |
| MT | Helena | Montana | Arterial | Mar-91 | 21900 | 15.4 | 6.2 | 248.3 | |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | 3/9/91 | 2653 | 39.1 | 29.1 | 134.5 | |
| MT | Columbia Fall | Nucleus | Collector | Mar-91 | 5670 | 30.1 | 17 | 174.6 | 2 samples, range: 0.8 - 0.8 |
| MT | Kalispell | Main | Arterial | 3/9/91 | 14730 | 17.6 | 24.7 | 71.4 | |
| MT | Thompson Fall | Preston | Local | Mar-91 | 920 | 4.4 | 8.3 | 51 | 2 samples, range: 2.8 - 5.9 |
| MT | Thompson Fall | Highway 200 | Collector | Mar-91 | 5000 | 4.3 | 15.5 | 28.9 | 2 samples, range: 1.0 - 7.5 |
| MT | Libby | Main Ave 4th & | Collector | Mar-91 | 530 | 14.8 | 33.1 | 44.9 | 2 samples, range: 13.5 - 16.1 |
| MT | Libby | US 2 | Arterial | Mar-91 | 11963 | 20 | 19.5 | 111.9 | 3 samples, range: 11.4 - 32.4 |
| MT | East Helena | Morton | Local | Apr-91 | 250 | 4.3 | 8.8 | 48.7 | |
| MT | East Helena | US 12 | Arterial | Apr-91 | 7900 | 0.5 | 8.7 | 5.7 | |
| MT | Thompson Fall | Preston | Local | Apr-91 | 920 | 1.2 | 15.7 | 6.3 | 4 samples, range: 0.3 - 4.0 |
| MT | Thompson Fall | Highway 200 | Collector | 4/4/91 | 5000 | 2 | 13.4 | 14.7 | 2 samples, range: 1.1 - 2.2 |
| MT | Libby | Main Ave 4th & | Collector | Apr-91 | 530 | 3.5 | 44 | 7.8 | 2 samples, range: 2.5 - 4.4 |
| MT | Libby | US 2 | Arterial | Apr-91 | 12945 | 11.8 | 20.5 | 57.2 | 4 samples, range: 1.2 - 22.9 |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | 4/14/91 | 2653 | 15.1 | 37.1 | 40.9 | |
| MT | Columbia Fall | Nucleus | Collector | Apr-91 | 5670 | 9 | 19.8 | 47.6 | |
| MT | Kalispell | Main | Arterial | 4/14/91 | 14730 | 13 | 44.5 | 29.4 | |
| MT | Columbia Fall | Nucleus | Collector | May-91 | 5670 | 2.4 | 17.5 | 15.9 | 4 samples, range: 1.3 - 3.8 |
| MT | Columbia Fall | US 2 | Arterial | May-91 | 14712 | 5.5 | 20.7 | 24.8 | 5 samples, range: 1.5 - 14.2 |
| MT | Libby | Main Ave 4th & | Collector | 5/19/91 | 530 | 1.7 | 31 | 5.7 | |
| MT | Libby | Main Ave 4th & | Collector | 6/27/91 | 530 | 1.7 | 24.3 | 7.1 | |
| MT | Libby | US 2 | Arterial | 6/27/91 | 10000 | 3.8 | 12.6 | 30.6 | |
| MT | East Helena | Morton | Local | Jul-91 | 250 | 1.7 | 11.4 | 15.3 | |
| MT | East Helena | Main | Collector | Jul-91 | 2316 | 8.8 | 11 | 79.7 | |
| MT | Thompson Fall | Preston | Local | 7/9/91 | 920 | 10.9 | 11 | 98.7 | |
| MT | Thompson Fall | Highway 200 | Collector | 7/9/91 | 5000 | 2.1 | 8.1 | 25.9 | |
| MT | Helena | Montana | Arterial | 7/17/91 | 21900 | 0.9 | 4.7 | 19.4 | |
| MT | Butte | Texas | Collector | 7/26/91 | 3070 | 2.5 | 28.2 | 8.9 | |
| MT | Butte | Harrison | Arterial | 7/26/91 | 22849 | 1.6 | 28.2 | 5.8 | |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | 8/3/91 | 2653 | 5.8 | 23 | 25.3 | |

TABLE A2-1. (continued)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| MT | Kalispell | Main | Arterial | 8/3/91 | 14730 | 4 | 21 | 19.3 | |
| MT | Columbia Fall | US 2 | Arterial | 8/11/91 | 15890 | 0.1 | 5.6 | 2.3 | |
| MT | Missoula | Russel btwn 4th & | Road | 8/30/91 | 5270 | 1.6 | 8.3 | 19.3 | |
| MT | East Helena | US 12 | Arterial | 8/30/91 | 7900 | 7 | 20.5 | 34.3 | |
| MT | Butte | Texas | Collector | 10/3/91 | 3070 | 1 | 17.7 | 5.4 | |
| MT | Butte | Harrison | Arterial | 10/3/91 | 22849 | 2.1 | 23.1 | 9.1 | |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | 10/6/91 | 2653 | 10 | 31.3 | 31.9 | |
| MT | Kalispell | Main | Arterial | 10/6/91 | 14730 | 4.3 | 27.7 | 15.7 | |
| MT | East Helena | Morton | Local | 10/16/91 | 250 | 1.8 | 31 | 5.9 | |
| MT | East Helena | Main St | Collector | 10/16/91 | 2316 | 1.6 | 20.5 | 7.7 | |
| MT | East Helena | US 12 | Arterial | 10/16/91 | 7900 | 1 | 6.7 | 14.9 | |
| MT | Columbia Fall | Nucleus | Collector | 10/20/91 | 5670 | 1.9 | 13.9 | 13.3 | |
| MT | Columbia Fall | US 2 | Arterial | 10/20/91 | 15890 | 1.2 | 11.3 | 10.2 | |
| MT | Kalispell 3r | d btwn Main & 1 | Collector | 11/6/91 | 2653 | 2.2 | 12.3 | 17.8 | |
| MT | Kalispell | Main | Arterial | 11/28/91 | 14730 | 2.7 | 8.6 | 30.8 | |
| MT | Thompson Fall | Preston | Local | 12/17/91 | 920 | 4 | 18.1 | 22.5 | |
| MT | Thompson Fall | Highway 200 | Collector | 12/17/91 | 5000 | 1.5 | 13.2 | 11.6 | |
| MT | Butte | Texas | Collector | 2/2/92 | 3070 | 19.1 | 11.6 | 164.5 | |
| MT | Butte | Harrison | Arterial | 2/2/92 | 22849 | 8.3 | 12 | 69.3 | |
| MT | East Helena | Morton | Local | 2/3/92 | 250 | 78.3 | 9.5 | 824.7 | |
| MT | Libby | W 4th St | Local | 2/3/92 | 350 | 36.3 | 56.3 | 64.5 | |
| MT | Libby | Main Ave 4th & | Collector | 2/3/92 | 530 | 10.7 | 49.9 | 21.4 | |
| MT | East Helena | Main St | Collector | 2/3/92 | 2316 | 57.9 | 14.8 | 391 | |
| MT | Columbia Fall | Nucleus | Collector | 2/3/92 | 5670 | 29.2 | 20.1 | 145.4 | |
| MT | Columbia Fall | US 2 | Arterial | Feb-92 | 12945 | 51.3 | 32.2 | 143.1 | 2 samples, range: 13.0 - 89.5 |
| MT | East Helena | US 12 | Arterial | 2/3/92 | 7900 | 2.9 | 14.3 | 20.7 | |
| MT | Thompson Fall | Preston | Local | 2/22/92 | 920 | 0.5 | 18 | 2.6 | |
| MT | Thompson Fall | Highway 200 | Collector | 2/22/92 | 5000 | 1.2 | 14.6 | 8.1 | |
| MT | Kalispell | 3rd btwn 2nd & 3r | Local | 3/15/92 | 450 | 40.2 | 11.9 | 338 | |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | 3/15/92 | 2653 | 81.1 | 37.3 | 217.3 | |
| MT | Kalispell | Main | Arterial | 3/15/92 | 14730 | 16.5 | 32.1 | 51.3 | |
| MT | Thompson Fall | Preston | Local | Apr-92 | 920 | 0.43 | 14.9 | 3.2 | |
| MT | Thompson Fall | Highway 200 | Collector | Apr-92 | 5000 | 0.8 | 18.2 | 4.7 | 3 samples, range: 0.4 - 1.0 |
| MT | Kalispell | 3rd btwn 2nd & 3r | Local | 4/26/92 | 450 | 20.9 | 45.8 | 45.5 | |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | 4/26/92 | 2653 | 19.2 | 50.9 | 37.7 | |

TABLE A2-1. (continued)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| MT | Kalispell | Main | Arterial | 4/26/92 | 14730 | 10.7 | 33.5 | 32.1 | |
| MT | Kalispell | 3rd btwn 2nd & 3r | Local | May-92 | 450 | 8.3 | 35.6 | 23.5 | 3 samples, range: 6.6 - 10.3 |
| MT | Kalispell | 3rd btwn Main & 1 | Collector | May-92 | 2653 | 8.5 | 32.4 | 25.8 | 3 samples, range: 6.3 - 11.4 |
| MT | Kalispell | Main | Arterial | May-92 | 14730 | 5.1 | 23.6 | 21.7 | 3 samples, range: 3.8 - 5.9 |
| MT | Libby | W 4th St | Local | 5/11/92 | 350 | 13.4 | 56.5 | 23.7 | |
| MT | Libby | Main Ave 4th & | Collector | 5/11/92 | 530 | 5.6 | 58.9 | 9.4 | |
| MT | Libby | US 2 | Arterial | May-92 | 12945 | 10.4 | 25.6 | 29.4 | |
| MT | East Helena | Morton | Local | 5/15/92 | 250 | 6.9 | 6.7 | 103 | |
| MT | East Helena | Main St | Collector | 5/15/92 | 2316 | 6.4 | 10.2 | 62.8 | |
| MT | East Helena | US 12 | Arterial | 5/15/92 | 7900 | 1.2 | 6.9 | 17 | |
| MT | Columbia Fall | Nucleus | Collector | 5/25/92 | 5670 | 1 | 21.7 | 4.5 | |
| MT | Missoula | Inez btwn 4th & 5 | Local | 6/4/92 | 500 | 1 | 17.4 | 5.6 | |
| MT | Missoula | Russel btwn 3rd & | Collector | 6/4/92 | 5270 | 15.2 | 14 | 108.4 | |
| MT | Missoula | 3rd btwn Prince & | Arterial | 6/4/92 | 12000 | 2 | 13.1 | 15.7 | |
| | | | | | | | | | |
| The following data from | | Reference 2 & 3 | | | | | | | |
| CO | Denver | E. Colfax | Principal Arte | Mar-89 | 1994 * | 0.21 | 2 | 19.9 | 4 samples, range: 0.04-0.47 |
| CO | Denver | E. Colfax | Principal Arte | Apr-89 | 2228 * | 0.73 | 1.7 | 106.7 | 18 samples, range: 0.08-1.78 |
| CO | Denver | York St | Principal Arte | Apr-89 | 780 * | 0.86 | 1.2 | 74.8 | 2 samples, range: 0.83 - 0.89 |
| CO | Denver | E. Belleview | Principal Arte | Apr-89 | ----- | 0.07 | 4.2 | 2 | 3 samples, range: 0.03-0.09 |
| CO | Denver | I-225 | Expressway + | Apr-89 | 4731 * | 0.02 | 3.6 | 0.4 | 3 samples, range: 0.01-0.02 |
| CO | Denver | W. Evans | Principal Arte | May-89 | 1905 * | 0.76 | 1.9 | 74 | 11 samples, range: 0.03 - 2.24 |
| CO | Denver | W. Evans | Principal Arte | Jun-89 | 1655 * | 0.71 | 1.2 | 66.1 | 12 samples, range: 0.07 - 3.34 |
| CO | Denver | E. Louisiana | Minor Arterial | Jun-89 | 515 * | 0.14 | 4.66 | 3.5 | 5 samples, range: 0.08 - 0.24 |
| | | | | | | | | | |
| The following data from | | Reference 4 & 3 | | | | | | | |
| CO | Denver | E. Louisiana | Minor Arterial | Jan-90 | ----- | 1.44 * | ----- | ----- | 6 samples, range: 0.12-2.0 |
| CO | Denver | E. Jewell Ave | Collector + | 1/24/90 | ----- | 2.24 * | ----- | ----- | |
| CO | Denver St | ate Highway 36 | Expressway + | 1/30/90 | ----- | 0.56 * | ----- | ----- | 2 samples, range: 0.56 - 0.56 |
| CO | Denver St | ate Highway 36 | Expressway + | 2/1/90 | ----- | 1.92 * | ----- | ----- | 4 samples, range: 1.92-1.92 |
| CO | Denver | W. Evans Ave | Principal Arte | 2/3/90 | ----- | 1.64 * | ----- | ----- | 2 samples, range: 1.64-1.64 |

TABLE A2-1. (continued)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| CO | Denver | E. Mexico St | Local + | 2/7/90 | ----- | 2.58 * | ----- | ----- | 3 samples, range: 2.58 - 2.58 |
| CO | Denver | E. Colfax Ave | Principal Arte | Feb-90 | ----- | 0.09 * | ----- | ----- | 16 samples, range: 0.02 - 0.17 |
| CO | Denver St | ate Highway 36 | Expressway + | Mar-90 | ----- | ----- | ----- | ----- | 7 samples |
| CO | Denver E. | Louisiana Ave | Minor Arterial | 3/10/90 | ----- | ----- | ----- | ----- | 3 samples |
| CO | Denver | W. Evans Ave | Principal Arte | Mar-90 | ----- | 1.27 * | ----- | ----- | 5 samples, range: 0.07 - 3.38 |
| CO | Denver | W. Colfax Ave | Principal Arte | Mar-90 | ----- | 0.41 * | ----- | ----- | 21 samples, range: 0.04 - 2.61 |
| CO | Denver | Parker Rd | Local + | Apr-90 | ----- | 0.05 * | ----- | ----- | 6 samples, range: 0.01 - 0.11 |
| CO | Denver | W. Byron Pl | Principal Arte | Apr-90 | ----- | 0.3 * | ----- | ----- | 6 samples, range: 0.21 - 0.35 |
| CO | Denver | E. Colfax Ave | Principal Arte | 4/18/90 | ----- | 0.21 * | ----- | ----- | |
| | | | | | | | | | |
| The following data from | | Reference 5 | | | | | | | |
| UT | Salt Lake Cou | 700 East | Arterial | * | 42340 | 0.137 | 11.5 | 1.187 | 4 samples, range: 0.107-0.162 |
| UT | Salt Lake Cou | State St | Collector | * | 27140 | 0.288 | 17 | 1.692 | 4 samples, range: 0.212-0.357 |
| UT | Salt Lake Cou | I-80 | Freeway | * | 77040 | 0.023 | 21.4 | 0.1 | 5 samples, range: 0.011 - 0.034 |
| UT | Salt Lake Cou | I-15 | Freeway | * | 146180 | 0.096 | 23.5 | 0.419 | 6 samples, range: 0.078 - 0.126 |
| UT | Salt Lake Cou | 400 East | Local | * | 5000 | 1.967 | 4.07 | 46.043 | 14 samples, range: 0.177 - 5.772 |
| | | | | | | | | | |
| The following data from | | Reference 6 | | | | | | | |
| NV | Las Vegas | Lake Mead | Major | 7/15/87 | ----- | 0.81 | 12.4 | 6.51 | |
| NV | Las Vegas | Perliter | Local | 7/15/87 | ----- | 2.23 | 31.2 | 7.14 | |
| NV | Las Vegas | Bruce | Collector | 7/15/87 | ----- | 1.64 | 26.1 | 6.3 | |
| NV | Las Vegas | Stewart | Major | 9/29/87 | ----- | 0.38 | 24 | 1.63 | 3 samples, range: 0.24 - 0.46 |
| NV | Las Vegas | Ambler | Local | 9/29/87 | ----- | 1.38 | 23 | 6.32 | 3 samples, range: 0.64 - 2.00 |
| NV | Las Vegas | 28th St | Collector | 9/29/87 | ----- | 0.52 | 15.8 | 3.4 | 3 samples, range: 0.51 - 0.54 |
| NV | Las Vegas | Lake Mead | Major | 10/7/87 | ----- | 0.19 | 14.9 | 1.26 | 2 samples, range: 0.17 - 0.20 |

TABLE A2-1. (continued)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| NV | Las Vegas | Perliter | Local | 10/7/87 | ----- | 1.5 | 31.9 | 4.76 | 2 samples, range: 1.48 - 1.52 |
| NV | Las Vegas | Bruce | Collector | 10/7/87 | ----- | 0.9 | 24.1 | 3.74 | 2 samples, range: 0.76 - 1.03 |
| | | | | | | | | | |
| The following data from | | Reference 7 | | | | | | | |
| AZ | Phoenix | Broadway | Arterial | * | ----- | 0.127 | 12.2 | 1.071 | |
| AZ | Phoenix | South Central | Arterial | * | ----- | 0.085 | 5 | 1.726 | |
| AZ | Phoenix | Indian School & 2 | Arterial | * | ----- | 0.035 | 3.1 | 1.021 | |
| AZ | Glendale | 43rd & Vista | Arterial | * | ----- | 0.042 | 3.9 | 1.049 | |
| AZ | Glendale | 59th & Peoria | Arterial | * | ----- | 0.099 | 8.2 | 1.183 | |
| AZ | Mesa | Mesa Drive | Arterial | * | ----- | 0.099 | 8.9 | 1.085 | |
| AZ | Mesa | E. McKellips & Ol | Arterial | * | ----- | 0.014 | 17 | 0.092 | |
| AZ | Phoenix | 17th & Highland | Collector | * | ----- | 0.028 | 13.4 | 0.232 | |
| AZ | Mesa | 3rd & Miller | Collector | * | ----- | 0.07 | 11.8 | 0.627 | |
| AZ | Phoenix | Avalon & 25th | Collector | * | ----- | 0.528 | 11.1 | 4.79 | |
| AZ | Phoenix | Apache | Collector | * | ----- | 0.282 | 6.4 | 4.367 | |
| AZ | Phoenix | 28th St & E. G | Collector | * | ----- | 0.035 | 2.3 | 1.479 | |
| AZ | Pima County | 6th Ave | Collector | * | ----- | 1.282 | 6.417 | 19.961 | |
| AZ | Pima County | Speedway Blvd | Arterial | * | ----- | 0.401 | 8.117 | 4.937 | |
| AZ | Pima County | 22nd St | Arterial | * | ----- | 0.028 | 16.529 | 0.176 | |
| AZ | Pima County | Amklam Rd | Collector | * | ----- | 0.014 | 5.506 | 0.197 | |
| AZ | Pima County | Fort Lowel Rd | Arterial | * | ----- | 0.113 | 3.509 | 3.268 | |
| AZ | Pima County | Oracle Rd | Arterial | * | ----- | 0.014 | 1.556 | 0.725 | |
| AZ | Pima County | Inn Rd | Arterial | * | ----- | 0.021 | 18.756 | 0.127 | |
| AZ | Pima County | Orange Grove | Arterial | * | ----- | 0.162 | 21.989 | 0.725 | |
| AZ | Pima County | La Canada | Arterial | * | ----- | 0.106 | 3.975 | 2.571 | |
| | | | | | | | | | |
| The following data from | | Reference 8 | | | | | | | |
| KS | Kansas City | 7th | Arterial | Feb-80 | ----- | 0.29 | 6.8 | 4.2 | 3 samples, range: 0.15 - 0.46 |
| MO | Kansas City | Volker | Arterial | Feb-80 | ----- | 0.67 | 20.1 | 3.5 | 3 samples, range: 0.43 -1.00 |
| MO | Kansas City | Rockhill | Arterial | Feb-80 | ----- | 0.68 | 21.7 | 3.3 | |
| KS | Tonganoxie | 4th | Collector | Mar-80 | ----- | 2.5 | 14.5 | 17.1 | |
| KS | Kansas City | 7th | Arterial | Mar-80 | ----- | 0.29 | 12.2 | 2.4 | |
| MO | St. Louis | I-44 | Expressway | May-80 | ----- | 0.02 | ----- | ----- | 4 samples, range: 0.02 |

TABLE A2-1. (continued)

| STATE | CITY | STREET | CLASS | DATE | ADT | SILT LOADING (g/m*m) | SILT % | TOTAL LOADING (g/m*m) | SILT LOADING SUMMARY |
|---|---|---|---|---|---|---|---|---|---|
| MO | St. Louis | Kingshighway | Collector | May-80 | ----- | 0.08 | 10.9 | 0.7 | 3 samples, range: 0.05 - 0.11 |
| IL | GraniteCity | 24th | Arterial | May-80 | ----- | 0.78 | 6.4 | 12.3 | 2 samples, range: 0.73 - 0.83 |
| IL | GraniteCity | Benton | Collector | May-80 | ----- | 0.93 | 8.6 | 10.8 | |
| | | | | | | | | | |
| The following data from | | Reference 9 | | | | | | | |
| MN | Duluth | US53north | Highway | 3/19/92 | 5000 | 0.23 | 28 | 1.94 | 8 samples, range: 0.04 - 0.77 |
| MN | Duluth | US53south | Highway | 2/26/92 | 5000 | 0.24 | 13.4 | 2.3 | 5 samples, range: 0.05 - 0.37 |
| | | | | | | | | | |
| The following data from | | Reference 10 | | | | | | | |
| CO | Aspen | Aspen | Local | 3/18/92 | ----- | 3.56 * | 24 | 14.81 | * Samples said to be wet sieved |
| CO | Aspen | Aspen | Collector | 3/30/92 | ----- | 12.05 * | 24 | 50.23 | |
| CO | Aspen | Aspen | Collector | 4/1/92 | ----- | 5.97 * | 21.1 | 29.16 | 8 samples, range: 2.65 - 9.10 |
| CO | Aspen | Highway 82 | Major Arterial | 4/6/92 | ----- | 6.1 * | 12 | 50.08 | 2 samples, range: 4.55 - 7.65 |
| CO | Aspen | Knollwood | Local | 4/1/92 | ----- | 7.9 * | 8 | 96.01 | 2 samples, range: 5.21 - 10.59 |
| CO | Aspen | Main | Major Arterial | 4/2/92 | ----- | 7.68 * | 21.7 | 35.9 | 3 samples, range: 5.58 - 9.30 |
| CO | Aspen | Maroon Creek Rd | Minor Arterial | 3/30/92 | ----- | 2.07 * | 9 | 23.03 | |
| CO | Aspen | Maroon Creek Rd | Minor Arterial | 4/1/92 | ----- | 2.78 * | 8.9 | 30.35 | 7 samples, range: 0.96 - 6.41 |
| CO | Aspen | South Mill | Collector | 4/1/92 | ----- | 9.05 * | 25 | 36.21 | |
| | | | | | | | | | |
| | | | | | | | | | |

"-----" denotes missing information.

TABLE A2-2. PUBLIC PAVED ROAD SURFACE LOADING DATA BASE

| STATE | CLASS | DATE | ADT | SL | SILT | TL | # SAMPLES |
|---|---|---|---|---|---|---|---|
| MT | 1 | Apr-78 | 50 | 0.6 | 18.5 | 3.4 | 1 |
| MT | 2 | Apr-78 | 115 | 0.5 | 14.3 | 3.5 | 1 |
| MT | 2 | Apr-78 | 4000 | 8.4 | 33.9 | 24.9 | 1 |
| MT | 2 | Apr-78 | 679 | 24.6 | 10.6 | 232.4 | 1 |
| MT | 2 | Apr-78 | 60 | 103.7 | 7 | 1480.8 | 1 |
| MT | 3 | Apr-78 | 6453 | 1.6 | 19.1 | 13.05 | 2 |
| MT | 3 | Apr-78 | 3328 | 7.7 | 7.7 | 99.5 | 1 |
| MT | 3 | Apr-78 | 3655 | 26 | 62.9 | 6 | 1 |
| MT | 4 | Apr-78 | 22849 | 1.9 | 5 | 37.3 | 1 |
| MT | 4 | Apr-78 | 18870 | 1.9 | 55.9 | 3.3 | 1 |
| MT | 4 | Apr-78 | 13529 | 0.8 | 6.6 | 11.9 | 1 |
| MT | 2 | Apr-83 | 140 | 13.1 | 4.3 | 305.2 | 1 |
| MT | 5 | Apr-83 | 780 | 4 | 13.6 | 29 | 1 |
| MT | 3 | Apr-83 | 2700 | 8.2 | 9.4 | 86.6 | 1 |
| MT | 3 | Apr-83 | 1360 | 4.7 | 8.4 | 55.3 | 1 |
| MT | 5 | Mar-88 | 1310 | . | 14.8 | . | 1 |
| MT | 5 | Mar-88 | 331 | . | 16.5 | . | 1 |
| MT | 3 | Mar-88 | 800 | . | 27.5 | . | 1 |
| MT | 3 | Mar-88 | 5900 | 7 | 16 | 43.5 | 1 |
| MT | 3 | Mar-88 | 536 | 61 | 20.4 | 299.2 | 1 |
| MT | 3 | Mar-88 | 4500 | . | 12.1 | . | 1 |
| MT | 4 | Mar-88 | 10850 | . | 12.3 | . | 1 |
| MT | 2 | Apr-88 | 562 | 2.1 | 10.9 | 19.3 | 1 |
| MT | 4 | Apr-88 | 5272 | 0.9 | 10.1 | 8.8 | 1 |
| MT | 2 | Jun-89 | 562 | 1 | 8.7 | 11.2 | 1 |
| MT | 2 | Jun-89 | 60 | 2.8 | 10.9 | 25.5 | 1 |
| MT | 4 | Jun-89 | 5272 | 7.2 | 3.6 | 197.6 | 1 |
| MT | 5 | Aug-89 | 250 | 1.7 | 6.8 | 24.6 | 1 |
| MT | 3 | Aug-89 | 2316 | 0.7 | 4.1 | 17 | 1 |
| MT | 4 | Aug-89 | 7900 | 2.1 | 12.5 | 16.5 | 1 |
| MT | 2 | Mar-90 | 390 | . | 9.5 | . | 1 |
| MT | 2 | Mar-90 | 400 | 18.8 | 14.3 | 131.5 | 1 |
| MT | 2 | Mar-90 | 50 | . | 14.3 | . | 1 |
| MT | 2 | Mar-90 | 1720 | . | 5.4 | . | 1 |

TABLE A2-2. (continued)

| STATE | CLASS | DATE | ADT | SL | SILT | TL | # SAMPLES |
|---|---|---|---|---|---|---|---|
| MT | 5 | Mar-90 | 240 | . | 16.3 | . | 1 |
| MT | 3 | Mar-90 | 1510 | . | 8.8 | . | 1 |
| MT | 3 | Mar-90 | 1945 | . | 7 | . | 1 |
| MT | 3 | Mar-90 | 4730 | 15.4 | 10 | 153.9 | 1 |
| MT | 3 | Mar-90 | 316 | . | 6.2 | . | 1 |
| MT | 3 | Mar-90 | 1764 | . | 4.2 | . | 1 |
| MT | 4 | Mar-90 | 13110 | 2.7 | 18.7 | 14.6 | 1 |
| MT | 2 | Jul-90 | 250 | 1.6 | 17 | 9.3 | 1 |
| MT | 3 | Jul-90 | 2316 | 5.6 | 10.6 | 52.5 | 1 |
| MT | 4 | Jul-90 | 790 | 3.2 | 15.4 | 20.9 | 1 |
| MT | 5 | Aug-90 | 400 | 1.5 | 4 | 37.7 | 1 |
| MT | 3 | Aug-90 | 530 | 2.4 | 17.9 | 13.2 | 1 |
| MT | 3 | Aug-90 | 5730 | 0.8 | 5.3 | 16 | 1 |
| MT | 4 | Aug-90 | 13039 | 0.2 | 7 | 2.9 | 1 |
| MT | 5 | Oct-90 | 250 | 3.4 | 10.2 | 33.6 | 1 |
| MT | 3 | Oct-90 | 2316 | 4.5 | 5.6 | 81.3 | 1 |
| MT | 4 | Oct-90 | 7900 | 0.6 | 13.9 | 4.3 | 1 |
| MT | 3 | 11/6/90 | 5670 | 5.2 | 13.5 | 38 | 1 |
| MT | 4 | 11/6/90 | 15890 | 1.7 | 24.1 | 7.2 | 1 |
| MT | 4 | 12/8/90 | 10000 | 21.5 | 9.6 | 223.9 | 1 |
| MT | 3 | 12/9/90 | 530 | 13.6 | 27.1 | 50.3 | 1 |
| MT | 3 | 12/13/90 | 3070 | 1 | 15.4 | 6.4 | 1 |
| MT | 5 | Jan-91 | 75 | 1 | 3.4 | 30.6 | 1 |
| MT | 5 | Jan-91 | 425 | 12 | 1.8 | 666.5 | 1 |
| MT | 5 | Jan-91 | 250 | 14.1 | 3.5 | 402.3 | 1 |
| MT | 3 | Jan-91 | 2316 | 36.7 | 12.1 | 303.4 | 1 |
| MT | 4 | Jan-91 | 7900 | 0.8 | 14 | 5.6 | 1 |
| MT | 5 | 1/23/91 | 920 | 9.2 | 9.9 | 93 | 1 |
| MT | 3 | 1/23/91 | 5000 | 33.3 | 27.2 | 122.2 | 1 |
| MT | 5 | Feb-91 | 150 | 21.6 | 7.1 | 304.7 | 1 |
| MT | 3 | Feb-91 | 2140 | 19.2 | 9 | 213.4 | 1 |
| MT | 3 | Feb-91 | 850 | 74.4 | 7.7 | 966.8 | 1 |
| MT | 3 | 2/14/91 | 530 | 33.3 | 18.7 | 178.2 | 1 |
| MT | 4 | 2/17/91 | 10000 | 69.3 | 21 | 330.3 | 1 |

TABLE A2-2. (continued)

| STATE | CLASS | DATE | ADT | SL | SILT | TL | # SAMPLES |
|---|---|---|---|---|---|---|---|
| MT | 3 | 2/21/91 | 3070 | 1.2 | 11 | 10.9 | 1 |
| MT | 4 | 2/21/91 | 22849 | 2.9 | 7.9 | 36.6 | 1 |
| MT | 3 | 2/24/91 | 2653 | 30.5 | 24.8 | 122.9 | 1 |
| MT | 4 | 2/24/91 | 14730 | 17.4 | 20.4 | 85.2 | 1 |
| MT | 5 | 2/25/91 | 920 | 35.7 | 17.9 | 199.6 | 1 |
| MT | 3 | 2/25/91 | 5000 | 66.8 | 17.8 | 375.3 | 1 |
| MT | 4 | Mar-91 | 21900 | 15.4 | 6.2 | 248.3 | 1 |
| MT | 3 | 3/9/91 | 2653 | 39.1 | 29.1 | 134.5 | 1 |
| MT | 3 | Mar-91 | 5670 | 30.1 | 17 | 174.6 | 2 |
| MT | 4 | 3/9/91 | 14730 | 17.6 | 24.7 | 71.4 | 1 |
| MT | 5 | Mar-91 | 920 | 4.4 | 8.3 | 51 | 2 |
| MT | 3 | Mar-91 | 5000 | 4.3 | 15.5 | 28.9 | 2 |
| MT | 3 | Mar-91 | 530 | 14.8 | 33.1 | 44.9 | 2 |
| MT | 4 | Mar-91 | 11963 | 20 | 19.5 | 111.9 | 3 |
| MT | 5 | Apr-91 | 250 | 4.3 | 8.8 | 48.7 | 1 |
| MT | 4 | Apr-91 | 7900 | 0.5 | 8.7 | 5.7 | 1 |
| MT | 5 | Apr-91 | 920 | 1.2 | 15.7 | 6.3 | 4 |
| MT | 3 | 4/4/91 | 5000 | 2 | 13.4 | 14.7 | 2 |
| MT | 3 | Apr-91 | 530 | 3.5 | 44 | 7.8 | 2 |
| MT | 4 | Apr-91 | 12945 | 11.8 | 20.5 | 57.2 | 4 |
| MT | 3 | 4/14/91 | 2653 | 15.1 | 37.1 | 40.9 | 1 |
| MT | 3 | Apr-91 | 5670 | 9 | 19.8 | 47.6 | 1 |
| MT | 4 | 4/14/91 | 14730 | 13 | 44.5 | 29.4 | 1 |
| MT | 3 | May-00 | 5670 | 2.4 | 17.5 | 15.9 | 4 |
| MT | 4 | 50 | 14712 | 5.5 | 20.7 | 24.8 | 5 |
| MT | 3 | 5/19/91 | 530 | 1.7 | 31 | 5.7 | 1 |
| MT | 3 | 6/27/91 | 530 | 1.7 | 24.3 | 7.1 | 1 |
| MT | 4 | 6/27/91 | 10000 | 3.8 | 12.6 | 30.6 | 1 |
| MT | 5 | Jul-91 | 250 | 1.7 | 11.4 | 15.3 | 1 |
| MT | 3 | Jul-91 | 2316 | 8.8 | 11 | 79.7 | 1 |
| MT | 5 | 7/9/91 | 920 | 10.9 | 11 | 98.7 | 1 |
| MT | 3 | 7/9/91 | 5000 | 2.1 | 8.1 | 25.9 | 1 |
| MT | 4 | 7/17/91 | 21900 | 0.9 | 4.7 | 19.4 | 1 |
| MT | 3 | 7/26/91 | 3070 | 2.5 | 28.2 | 8.9 | 1 |

TABLE A2-2. (continued)

| STATE | CLASS | DATE | ADT | SL | SILT | TL | # SAMPLES |
|---|---|---|---|---|---|---|---|
| MT | 4 | 7/26/91 | 22849 | 1.6 | 28.2 | 5.8 | 1 |
| MT | 3 | 8/3/91 | 2653 | 5.8 | 23 | 25.3 | 1 |
| MT | 4 | 8/3/91 | 14730 | 4 | 21 | 19.3 | 1 |
| MT | 4 | 8/11/91 | 15890 | 0.1 | 5.6 | 2.3 | 1 |
| MT | 3 | 8/3/91 | 5270 | 1.6 | 8.3 | 19.3 | 1 |
| MT | 4 | 8/3/91 | 7900 | 7 | 20.5 | 34.3 | 1 |
| MT | 3 | 10/3/91 | 3070 | 1 | 17.7 | 5.4 | 1 |
| MT | 4 | 10/3/91 | 22849 | 2.1 | 23.1 | 9.1 | 1 |
| MT | 3 | 10/6/91 | 2653 | 10 | 31.3 | 31.9 | 1 |
| MT | 4 | 10/6/91 | 14730 | 4.3 | 27.7 | 15.7 | 1 |
| MT | 5 | 10/16/91 | 250 | 1.8 | 31 | 5.9 | 1 |
| MT | 3 | 10/16/91 | 2316 | 1.6 | 20.5 | 7.7 | 1 |
| MT | 4 | 10/16/91 | 7900 | 1 | 6.7 | 14.9 | 1 |
| MT | 3 | 10/20/91 | 5670 | 1.9 | 13.9 | 13.3 | 1 |
| MT | 4 | 10/20/91 | 15890 | 1.2 | 11.3 | 10.2 | 1 |
| MT | 3 | 11/6/91 | 2653 | 2.2 | 12.3 | 17.8 | 1 |
| MT | 4 | 11/28/91 | 14730 | 2.7 | 8.6 | 30.8 | 1 |
| MT | 5 | 12/17/91 | 920 | 4 | 18.1 | 22.5 | 1 |
| MT | 3 | 12/17/91 | 5000 | 1.5 | 13.2 | 11.6 | 1 |
| MT | 3 | 2/2/92 | 3070 | 19.1 | 11.6 | 164.5 | 1 |
| MT | 4 | 2/2/92 | 22849 | 8.3 | 12 | 69.3 | 1 |
| MT | 5 | 2/3/92 | 250 | 78.3 | 9.5 | 824.7 | 1 |
| MT | 5 | 2/3/92 | 350 | 36.3 | 56.3 | 64.5 | 1 |
| MT | 3 | 2/3/92 | 530 | 10.7 | 49.9 | 21.4 | 1 |
| MT | 3 | 2/3/92 | 2316 | 57.9 | 14.8 | 391 | 1 |
| MT | 3 | 2/3/92 | 5670 | 29.2 | 20.1 | 145.4 | 1 |
| MT | 4 | Feb-92 | 12945 | 51.3 | 32.2 | 143.1 | 2 |
| MT | 4 | 2/3/92 | 7900 | 2.9 | 14.3 | 20.7 | 1 |
| MT | 5 | Feb-92 | 920 | 0.5 | 18 | 2.6 | 1 |
| MT | 3 | 2/22/92 | 5000 | 1.2 | 14.6 | 8.1 | 1 |
| MT | 5 | 3/15/92 | 450 | 40.2 | 11.9 | 338 | 1 |
| MT | 3 | 3/15/92 | 2653 | 81.1 | 37.3 | 217.3 | 1 |
| MT | 4 | 3/15/92 | 14730 | 16.5 | 32.1 | 51.3 | 1 |
| MT | 5 | Apr-92 | 920 | 0.43 | 14.9 | 3.2 | 1 |

TABLE A2-2. (continued)

| STATE | CLASS | DATE | ADT | SL | SILT | TL | # SAMPLES |
|---|---|---|---|---|---|---|---|
| MT | 3 | Apr-92 | 5000 | 0.8 | 18.2 | 4.7 | 3 |
| MT | 5 | 4/26/92 | 450 | 20.9 | 45.8 | 45.5 | 1 |
| MT | 3 | 4/26/92 | 2653 | 19.2 | 50.9 | 37.7 | 1 |
| MT | 4 | 4/26/92 | 14730 | 10.7 | 33.5 | 32.1 | 1 |
| MT | 5 | May-92 | 450 | 8.3 | 35.6 | 23.5 | 3 |
| MT | 3 | May-92 | 2653 | 8.5 | 32.4 | 25.8 | 3 |
| MT | 4 | May-92 | 14730 | 5.1 | 23.6 | 21.7 | 3 |
| MT | 5 | 5/11/92 | 350 | 13.4 | 56.5 | 23.7 | 1 |
| MT | 3 | 5/11/92 | 530 | 5.6 | 58.9 | 9.4 | 1 |
| MT | 4 | May-92 | 12945 | 10.4 | 25.6 | 29.4 | 1 |
| MT | 5 | 5/15/92 | 250 | 6.9 | 6.7 | 103 | 1 |
| MT | 3 | 5/15/92 | 2316 | 6.4 | 10.2 | 62.8 | 1 |
| MT | 4 | 5/15/92 | 7900 | 1.2 | 6.9 | 17 | 1 |
| MT | 3 | 5/25/92 | 5670 | 1 | 21.7 | 4.5 | 1 |
| MT | 5 | 6/4/92 | 500 | 1 | 17.4 | 5.6 | 1 |
| MT | 3 | 6/4/92 | 5270 | 15.2 | 14 | 108.4 | 1 |
| MT | 4 | 6/4/92 | 12000 | 2 | 13.1 | 15.7 | 1 |
| CO | 6 | Mar-89 | 1994 | 0.21 | 2 | 19.9 | 4 |
| CO | 6 | Apr-89 | 2228 | 0.73 | 1.7 | 106.7 | 18 |
| CO | 6 | Apr-89 | 780 | 0.86 | 1.2 | 74.8 | 2 |
| CO | 6 | Apr-89 | . | 0.07 | 4.2 | 2 | 3 |
| CO | 7 | Apr-89 | 4731 | 0.02 | 3.6 | 0.4 | 3 |
| CO | 6 | May-89 | 1905 | 0.76 | 1.9 | 74 | 11 |
| CO | 6 | Jun-89 | 1655 | 0.71 | 1.2 | 66.1 | 12 |
| CO | 8 | Jun-89 | 515 | 0.14 | 4.66 | 3.5 | 5 |
| CO | 8 | Oct-90 | . | 1.44 | . | . | 6 |
| CO | 3 | 1/24/90 | . | 2.24 | . | . | 1 |
| CO | 7 | 1/30/90 | . | 0.56 | . | . | 2 |
| CO | 7 | 2/1/90 | . | 1.92 | . | . | 4 |
| CO | 6 | 2/3/90 | . | 1.64 | . | . | 2 |
| CO | 5 | 2/7/90 | . | 2.58 | . | . | 3 |
| CO | 6 | Feb-90 | . | 0.9 | . | . | 16 |
| CO | 7 | Mar-90 | . | . | . | . | 7 |
| CO | 8 | 3/10/90 | . | . | . | . | 3 |

TABLE A2-2. (continued)

| STATE | CLASS | DATE | ADT | SL | SILT | TL | # SAMPLES |
|---|---|---|---|---|---|---|---|
| CO | 6 | Mar-90 | . | 1.27 | . | . | 5 |
| CO | 6 | Mar-90 | . | 0.41 | . | . | 21 |
| CO | 5 | Apr-90 | . | 0.05 | . | . | 6 |
| CO | 6 | Apr-90 | . | 0.3 | . | . | 6 |
| CO | 6 | 4/18/90 | . | 0.21 | . | . | 1 |
| UT | 4 | . | 42340 | 0.137 | 11.5 | 1.187 | 4 |
| UT | 3 | . | 27140 | 0.288 | 17 | 1.692 | 4 |
| UT | 9 | . | 77040 | 0.023 | 21.4 | 0.1 | 5 |
| UT | 9 | . | 146180 | 0.096 | 23.5 | 0.419 | 6 |
| UT | 5 | . | 5000 | 1.967 | 4.07 | 46.043 | 14 |
| NV | 10 | 7/15/87 | . | 0.81 | 12.4 | 6.51 | 1 |
| NV | 5 | 7/15/87 | . | 2.23 | 31.2 | 7.14 | 1 |
| NV | 3 | 7/15/87 | . | 1.64 | 26.1 | 6.3 | 1 |
| NV | 10 | 9/29/87 | . | 0.38 | 24 | 1.63 | 3 |
| NV | 5 | 9/29/87 | . | 1.38 | 23 | 6.32 | 3 |
| NV | 3 | 9/29/87 | . | 0.52 | 15.8 | 3.4 | 3 |
| NV | 10 | 10/7/87 |  | 0.19 | 14.9 | 1.26 | 2 |
| NV | 5 | 10/7/87 | . | 1.5 | 31.9 | 4.76 | 2 |
| NV | 3 | 10/7/87 | . | 0.9 | 24.1 | 3.74 | 2 |
| AZ | 4 | . | . | 0.127 | 12.2 | 1.071 | 1 |
| AZ | 4 | . | . | 0.085 | 5 | 1.726 | 1 |
| AZ | 4 | . | . | 0.035 | 3.1 | 1.021 | 1 |
| AZ | 4 | . | . | 0.042 | 3.9 | 1.049 | 1 |
| AZ | 4 | . | . | 0.099 | 8.2 | 1.183 | 1 |
| AZ | 4 | . | . | 0.099 | 8.9 | 1.085 | 1 |
| AZ | 4 | . | . | 0.014 | 17 | 0.092 | 1 |
| AZ | 3 | . | . | 0.028 | 13.4 | 0.232 | 1 |
| AZ | 3 | . | . | 0.07 | 11.8 | 0.627 | 1 |
| AZ | 3 | . | . | 0.528 | 11.1 | 4.79 | 1 |
| AZ | 3 | . | . | 0.282 | 6.4 | 4.367 | 1 |
| AZ | 3 | . | . | 0.035 | 2.3 | 1.479 | 1 |
| AZ | 3 | . | . | 1.282 | 6.417 | 19.961 | 1 |
| AZ | 4 | . | . | 0.401 | 8.117 | 4.937 | 1 |
| AZ | 4 | . | . | 0.028 | 16.529 | 0.176 | 1 |

TABLE A2-2. (continued)

| STATE | CLASS | DATE | ADT | SL | SILT | TL | # SAMPLES |
|---|---|---|---|---|---|---|---|
| AZ | 3 | . | . | 0.014 | 5.506 | 0.197 | 1 |
| AZ | 4 | . | . | 0.113 | 3.509 | 3.268 | 1 |
| AZ | 4 | . | . | 0.014 | 1.556 | 0.725 | 1 |
| AZ | 4 | . | . | 0.021 | 18.756 | 0.127 | 1 |
| AZ | 4 | . | . | 0.162 | 21.989 | 0.725 | 1 |
| AZ | 4 | . | . | 0.106 | 3.975 | 2.571 | 1 |
| KS | 4 | Feb-80 | . | 0.29 | 6.8 | 4.2 | 3 |
| MO | 4 | Feb-80 | . | 0.67 | 20.1 | 3.5 | 3 |
| MO | 4 | Feb-80 | . | 0.68 | 21.7 | 3.3 | 1 |
| KS | 3 | Mar-80 | . | 2.5 | 14.5 | 17.1 | 1 |
| KS | 4 | Mar-80 | . | 0.29 | 12.2 | 2.4 | 1 |
| MO | 7 | May-80 | | 0.02 | . | . | 4 |
| MO | 3 | May-80 | | 0.08 | 10.9 | 0.7 | 3 |
| IL | 4 | May-80 | | 0.78 | 6.4 | 12.3 | 2 |
| IL | 3 | May-80 | | 0.93 | 8.6 | 10.8 | 1 |
| MN | 11 | 3/19/92 | 5000 | 0.23 | 28 | 1.94 | 8 |
| MN | 11 | 2/26/92 | 5000 | 0.24 | 13.4 | 2.3 | 5 |
| CO | 5 | 3/18/92 | | 3.56 | 24 | 14.81 | 1 |
| CO | 3 | 3/30/92 | . | 12.05 | 24 | 50.23 | 1 |
| CO | 3 | 4/1/92 | . | 5.97 | 21.1 | 29.16 | 8 |
| CO | 10 | 4/6/92 | . | 6.1 | 12 | 50.08 | 2 |
| CO | 5 | 4/1/92 | | 7.9 | 8 | 96.01 | 2 |
| CO | 10 | 4/2/92 | . | 7.68 | 21.7 | 35.9 | 3 |
| CO | 8 | 3/30/92 | . | 2.07 | 9 | 23.03 | 1 |
| CO | 8 | 4/1/92 | . | 2.78 | 8.9 | 30.35 | 7 |
| CO | 3 | 4/1/92 | . | 9.05 | 25 | 36.21 | 1 |

**Attachment 3**

**New Silt Loading Data Set Used to Develop Revised Default Silt Loading Values**

TABLE A3-1. NEW PUBLIC PAVED ROAD SILT LOADING DATA SET

| State | Reference | Location | Date | Silt loading, g/m2 | ADT | Posted speed limit | Road/Comments |
|---|---|---|---|---|---|---|---|
| NV | BACM11 | Las Vegas | Apr-95 | 0.084 | LOW | NA | Composite of 4 roads of the same class |
| NV | BACM11 | Las Vegas | Jun-95 | 0.097 | LOW | NA | Repeat sample of above roads |
| NV | BACM11 | Las Vegas | Apr-95 | 0.052 | HIGH | NA | Composite of 4 roads of the same class |
| NV | BACM11 | Las Vegas | Jun-95 | 0.033 | HIGH | NA | Repeat sample of above roads |
| NV | BACM12 | Las Vegas | Jun-95 | 1.270 | LOW | NA | Composite of 4 roads of the same class |
| NV | BACM12 | Las Vegas | Jun-95 | 0.029 | HIGH | NA | Composite of 4 roads of the same class |
| NV | BACM13 | Las Vegas | Jun-95 | 0.280 | LOW | NA | Composite of 4 roads of the same class |
| NV | BACM13 | Las Vegas | Jun-95 | 0.200 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM21 | South Coast | Apr-95 | 0.184 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM21 | South Coast | Jun-95 | 0.054 | LOW | NA | Repeat sample of above roads |
| CA | BACM21 | South Coast | Apr-95 | 0.012 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM21 | South Coast | Jun-95 | 0.015 | HIGH | NA | Repeat sample of above roads |
| CA | BACM22 | South Coast | Jun-95 | 0.170 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM22 | South Coast | Jun-95 | 0.011 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM23 | South Coast | Jun-95 | 0.140 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM23 | South Coast | Jun-95 | 0.046 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM31 | Bakersfield | Apr-95 | 0.520 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM31 | Bakersfield | Jul-95 | 0.190 | LOW | NA | Repeat sample of above roads |
| CA | BACM31 | Bakersfield | Apr-95 | 0.054 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM31 | Bakersfield | Jul-95 | 0.015 | HIGH | NA | Repeat sample of above roads |
| CA | BACM32 | Bakersfield | Jul-95 | 0.940 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM32 | Bakersfield | Jul-95 | 0.051 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM33 | Bakersfield | Jul-95 | 0.410 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM33 | Bakersfield | Jul-95 | 0.039 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM41 | Coachella Valley | Apr-95 | 2.040 | LOW | NA | Composite of 4 roads of the same class, visible trackout signs present |
| CA | BACM41 | Coachella Valley | Jul-95 | 0.420 | LOW | NA | Repeat sample of above roads |
| CA | BACM41 | Coachella Valley | Apr-95 | 0.027 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM41 | Coachella Valley | Jul-95 | 0.037 | HIGH | NA | Repeat sample of above roads |
| CA | BACM42 | Coachella Valley | Jul-95 | 0.350 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM42 | Coachella Valley | Jul-95 | 0.082 | HIGH | NA | Composite of 4 roads of the same class |
| CA | BACM43 | Coachella Valley | Jul-95 | 0.200 | LOW | NA | Composite of 4 roads of the same class |
| CA | BACM43 | Coachella Valley | Jul-95 | 0.030 | HIGH | NA | Composite of 4 roads of the same class |

TABLE A3-1. (continued)

| State | Reference | Location | Date | Silt loading, g/m2 | ADT | Posted speed limit | Road/Comments |
|---|---|---|---|---|---|---|---|
| CA | SCAQMD | South Coast | Mar-90 | 0.117 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.236 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.720 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.207 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.438 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.139 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.180 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.348 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.112 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.283 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 1.830 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.907 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| CA | SCAQMD | South Coast | Mar-90 | 0.260 | MIXED | NA | Composite of 10 to 12 roads within a 5 km x 5 km area |
| OR | LAGRD | La Grande | May-91 | 0.770 | MIXED | NA | Composite of 10 to 12 roads within the inventory area |
| OR | KFALLS | Klamath Falls | May-91 | 0.370 | MIXED | NA | Composite of 10 to 12 roads within the inventory area |
| OR | GRPASS | Grants Pass | May-91 | 0.810 | MIXED | NA | Composite of 10 to 12 roads within the inventory area |
| NV | RENO | Reno | Jan-95 | 0.520 | 2778 | 25 | Purina |
| NV | RENO | Reno | Feb-95 | 0.810 | 2778 | 25 | Purina |
| NV | RENO | Reno | Mar-95 | 0.400 | 2778 | 25 | Purina |
| NV | RENO | Reno | Apr-95 | 0.690 | 2778 | 25 | Purina |
| NV | RENO | Reno | May-95 | 0.890 | 2778 | 25 | Purina |
| NV | RENO | Reno | Jun-95 | 0.910 | 2778 | 25 | Purina |
| NV | RENO | Reno | Jul-95 | 0.550 | 2778 | 25 | Purina |
| NV | RENO | Reno | Aug-95 | 1.520 | 2778 | 25 | Purina |
| NV | RENO | Reno | Sep-95 | 0.920 | 2778 | 25 | Purina |
| NV | RENO | Reno | Oct-95 | 0.290 | 2778 | 25 | Purina |
| NV | RENO | Reno | Nov-95 | 0.390 | 2778 | 25 | Purina |
| NV | RENO | Reno | Dec-95 | 0.330 | 2778 | 25 | Purina |
| NV | RENO | Reno | Jan-95 | 0.300 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Feb-95 | 0.100 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Mar-95 | 0.330 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Apr-95 | 0.270 | 511 | 25 | Lonetree |
| NV | RENO | Reno | May-95 | 0.200 | 511 | 25 | Lonetree |

TABLE A3-1. (continued)

| State | Reference | Location | Date | Silt loading, g/m2 | ADT | Posted speed limit | Road/Comments |
|---|---|---|---|---|---|---|---|
| NV | RENO | Reno | Jun-95 | 0.120 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Jul-95 | 0.120 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Aug-95 | 0.120 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Sep-95 | 0.090 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Oct-95 | 0.130 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Nov-95 | 0.170 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Dec-95 | 1.050 | 511 | 25 | Lonetree |
| NV | RENO | Reno | Jan-95 | 0.260 | 1978 | 25 | Forest |
| NV | RENO | Reno | Feb-95 | 0.160 | 1978 | 25 | Forest |
| NV | RENO | Reno | Mar-95 | 0.100 | 1978 | 25 | Forest |
| NV | RENO | Reno | Apr-95 | 0.180 | 1978 | 25 | Forest |
| NV | RENO | Reno | May-95 | 0.250 | 1978 | 25 | Forest |
| NV | RENO | Reno | Jun-95 | 0.140 | 1978 | 25 | Forest |
| NV | RENO | Reno | Jul-95 | 0.190 | 1978 | 25 | Forest |
| NV | RENO | Reno | Aug-95 | 0.110 | 1978 | 25 | Forest |
| NV | RENO | Reno | Sep-95 | 0.280 | 1978 | 25 | Forest |
| NV | RENO | Reno | Oct-95 | 0.160 | 1978 | 25 | Forest |
| NV | RENO | Reno | Nov-95 | 0.110 | 1978 | 25 | Forest |
| NV | RENO | Reno | Dec-95 | 0.110 | 1978 | 25 | Forest |
| NV | RENO | Reno | Jan-95 | 0.230 | 1978 | 25 | Forest |
| NV | RENO | Reno | Feb-95 | 1.310 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Mar-95 | 0.420 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Apr-95 | 2.890 | 2155 | 25 | Freeport |
| NV | RENO | Reno | May-95 | 0.330 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Jun-95 | 0.720 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Jul-95 | 0.810 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Aug-95 | 1.030 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Sep-95 | 0.850 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Oct-95 | 0.420 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Nov-95 | 0.910 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Dec-95 | 0.680 | 2155 | 25 | Freeport |
| NV | RENO | Reno | Jan-95 | 1.510 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Feb-95 | 6.820 | 1578 | 25 | Cashill |

TABLE A3-1. (continued)

| State | Reference | Location | Date | Silt loading, g/m2 | ADT | Posted speed limit | Road/Comments |
|---|---|---|---|---|---|---|---|
| NV | RENO | Reno | Mar-95 | 0.630 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Apr-95 | 0.480 | 1578 | 25 | Cashill |
| NV | RENO | Reno | May-95 | 0.340 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Jun-95 | 0.340 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Jul-95 | 0.270 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Aug-95 | 0.140 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Sep-95 | 0.150 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Oct-95 | 0.190 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Nov-95 | 0.430 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Dec-95 | 0.550 | 1578 | 25 | Cashill |
| NV | RENO | Reno | Feb-95 | 5.090 | 509 | 25 | Ralston |
| NV | RENO | Reno | Mar-95 | 2.100 | 509 | 25 | Ralston |
| NV | RENO | Reno | Apr-95 | 1.340 | 509 | 25 | Ralston |
| NV | RENO | Reno | May-95 | 1.630 | 509 | 25 | Ralston |
| NV | RENO | Reno | Jun-95 | 1.630 | 509 | 25 | Ralston |
| NV | RENO | Reno | Jul-95 | 2.170 | 509 | 25 | Ralston |
| NV | RENO | Reno | Aug-95 | 1.730 | 509 | 25 | Ralston |
| NV | RENO | Reno | Sep-95 | 2.250 | 509 | 25 | Ralston |
| NV | RENO | Reno | Oct-95 | 0.790 | 509 | 25 | Ralston |
| NV | RENO | Reno | Nov-95 | 1.120 | 509 | 25 | Ralston |
| NV | RENO | Reno | Dec-95 | 1.000 | 509 | 25 | Ralston |
| NV | RENO | Reno | Jan-95 | 0.240 | 2396 | 25 | Mayberry |
| NV | RENO | Reno | Apr-95 | 0.200 | 2396 | 25 | Mayberry |
| NV | RENO | Reno | Jul-95 | 0.220 | 2396 | 25 | Mayberry |
| NV | RENO | Reno | Oct-95 | 0.320 | 2396 | 25 | Mayberry |
| NV | RENO | Reno | Jan-95 | 0.110 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Feb-95 | 0.860 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Mar-95 | 0.340 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Apr-95 | 0.460 | 5135 | 25 | Patriot |
| NV | RENO | Reno | May-95 | 0.710 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Jun-95 | 0.230 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Jul-95 | 0.400 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Aug-95 | 0.370 | 5135 | 25 | Patriot |

TABLE A3-1. (continued)

| State | Reference | Location | Date | Silt loading, g/m2 | ADT | Posted speed limit | Road/Comments |
|---|---|---|---|---|---|---|---|
| NV | RENO | Reno | Sep-95 | 0.520 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Oct-95 | 0.450 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Nov-95 | 0.550 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Dec-95 | 0.460 | 5135 | 25 | Patriot |
| NV | RENO | Reno | Jan-95 | 0.630 | 5135 | 25 | W. 4th |
| NV | RENO | Reno | Apr-95 | 1.020 | 5135 | 25 | W. 4th |
| NV | RENO | Reno | Jul-95 | 0.380 | 5135 | 25 | W. 4th |
| NV | RENO | Reno | Oct-95 | 0.280 | 5135 | 25 | W. 4th |
| NV | RENO | Reno | Jan-95 | 0.140 | 10170 | 35 | Mill |
| NV | RENO | Reno | Apr-95 | 0.290 | 10170 | 35 | Mill |
| NV | RENO | Reno | Jul-95 | 0.140 | 10170 | 35 | Mill |
| NV | RENO | Reno | Oct-95 | 0.200 | 10170 | 35 | Mill |
| NV | RENO | Reno | Jan-95 | 0.170 | 10521 | 45 | Vista |
| NV | RENO | Reno | Apr-95 | 0.190 | 10521 | 45 | Vista |
| NV | RENO | Reno | Jul-95 | 0.090 | 10521 | 45 | Vista |
| NV | RENO | Reno | Oct-95 | 0.080 | 10521 | 45 | Vista |
| NV | RENO | Reno | Jan-95 | 0.050 | 14441 | 45 | N. McCarran |
| NV | RENO | Reno | Apr-95 | 0.050 | 14441 | 45 | N. McCarran |
| NV | RENO | Reno | Jul-95 | 0.020 | 14441 | 45 | N. McCarran |
| NV | RENO | Reno | Oct-95 | 0.010 | 14441 | 45 | N. McCarran |
| NV | RENO | Reno | Jan-95 | 0.400 | 15566 | 50 | Kietzke-G |
| NV | RENO | Reno | Apr-95 | 0.250 | 15566 | 50 | Kietzke-G |
| NV | RENO | Reno | Jul-95 | 0.080 | 15566 | 50 | Kietzke-G |
| NV | RENO | Reno | Oct-95 | 0.250 | 15566 | 50 | Kietzke-G |
| NV | RENO | Reno | Jan-95 | 0.210 | 17425 | 25 | Prater |
| NV | RENO | Reno | Apr-95 | 0.070 | 17425 | 25 | Prater |
| NV | RENO | Reno | Jul-95 | 0.040 | 17425 | 25 | Prater |
| NV | RENO | Reno | Oct-95 | 0.110 | 17425 | 25 | Prater |
| NV | RENO | Reno | Jan-95 | 0.110 | 17854 | 40 | S. McCarran |
| NV | RENO | Reno | Apr-95 | 0.250 | 17854 | 40 | S. McCarran |
| NV | RENO | Reno | Jul-95 | 0.160 | 17854 | 40 | S. McCarran |
| NV | RENO | Reno | Oct-95 | 0.330 | 17854 | 40 | S. McCarran |
| NV | RENO | Reno | Jan-95 | 0.470 | 25199 | 40 | Kietzke-P |

TABLE A3-1. (continued)

| State | Reference | Location | Date | Silt loading, g/m2 | ADT | Posted speed limit | Road/Comments |
|---|---|---|---|---|---|---|---|
| NV | RENO | Reno | Apr-95 | 0.530 | 25199 | 40 | Kietzke-P |
| NV | RENO | Reno | Jul-95 | 0.210 | 25199 | 40 | Kietzke-P |
| NV | RENO | Reno | Oct-95 | 0.200 | 25199 | 40 | Kietzke-P |
| NV | PM2.5 Study | Reno | Jun-96 | 0.082 | HIGH | 45 | Virginia, North of Parr |
| NC | PM2.5 Study | Raleigh | May-96 | 0.060 | HIGH | 45 | Western (3600 block) |

NA = not applicable; shown for composite samples from several roads