

## **APPENDIX 5 - Emission Calculations**



## EMISSION CALCULATIONS

### 1.0 Vehicle Tail Pipe and Tire-Wear Emissions

The PM-10 emissions factor for motor vehicle exhaust and tire-wear was determined by the California Air Resources Board (CARB) for Mono County. CARB's estimates were adjusted using traffic counts provided by Caltrans for the Mono Basin. The average daily traffic (ADT) figures are listed in Table 2-1.

#### Emission Rates for Mono County

Based on emission factors used by the California Air Resources Board, the estimated average daily PM-10 emissions for gas and diesel powered vehicles for the entire Mono County is 164 pounds per day. The methods of calculation and the calculations are presented in Tables 1-1 through Table 1-5. The following parameters are used in these tables and calculations:

- e = CARB emission factor per vehicle type
- er = emission rate per vehicle type =  
(e) [Mono County vehicle miles traveled/day  
(VMT/D) per vehicle type]
- Rv = ratio of Mono County VMT/D per vehicle type/  
total Mono County VMT/D
- VMT/D = (ADT) (m)
- ADT = average daily travel/highway
- m = number of miles/highway

Table 1-1			
PM-10 EMISSIONS (CARB's estimated daily average) Mono County			
Vehicle Type	Emission Factor (e)	Mono Miles	Emission Rates (e)
Light Duty Passenger	0.13 T/D	522,000 VMT/D	$5.0 \times 10^{-4}$ lbs/VMT
Light Duty Trucks	0.07 T/D	287,000 VMT/D	$4.9 \times 10^{-4}$ lbs/VMT
Medium Duty Trucks	0.02 T/D	69,000 VMT/D	$5.9 \times 10^{-4}$ lbs/VMT
Heavy Duty Diesel	0.14 T/D	58,000 VMT/D	$4.8 \times 10^{-4}$ lbs/VMT
TOTAL	0.36 T/D	936,000 VMT/D	

$$R_v = (\text{VMT/D per Vehicle Type}) / (\text{VMT/D Total})$$

Table 1-2			
$R_v$ Mono County			
Vehicle Type	Total VMT/D (Mono County)	VMT/D (per Vehicle Type)	$R_v$
Light Duty Passenger	936,000 VMT/D	522,000 VMT/D	0.558
Light Duty Trucks	936,000 VMT/D	287,000 VMT/D	0.307
Medium Duty Trucks	936,000 VMT/D	69,000 VMT/D	0.074
Heavy Duty Diesel	936,000 VMT/D	58,000 VMT/D	0.062

It is assumed that the same vehicle ratio is in effect for the Mono Basin as for the rest of Mono County.

Table 1-3  
**MONO BASIN  
 VEHICLE MILES TRAVELED / DAY**

Highway	Miles Mono Basin	ADT	VMT/D
395 outside Lee Vining	24	4000	96,000
395 inside Lee Vining	1	5400	5,400
120 East	16	400	6,400
120 West	10	2300	23,000
168	28	360	10,800
158 North	10	610	6,100
158 South	5	1450	7,250
<b>TOTAL</b>			<b>154,950</b>

VMT/D per Vehicle Type for Mono Basin = (VMT/D Total for Mono Basin) (R<sub>v</sub>)

Table 1-4  
**MONO BASIN  
 VEHICLE MILES TRAVELED**

Vehicle Types	(Total Mono Basin Miles) (R <sub>v</sub> )	Miles/vehicle type
Light Duty Passenger	(154,950 VMT/D) (0.558)	86,462 VMT/D
Light Duty Trucks	(154,950 VMT/D) (0.307)	47,570 VMT/D
Medium Duty Trucks	(154,950 VMT/D) (0.074)	11,466 VMT/D
Heavy Duty Diesel	(154,950 VMT/D) (0.062)	9,606 VMT/D

PM-10 emissions in pounds per day = (VMT/D per Vehicle Type for Mono Basin) ( e<sub>r</sub> )

Table 1-5 VEHICLE TAIL PIPE & TIRE-WEAR EMISSIONS		
Vehicle Type	(Mono Miles/Vehicle Type) ( e <sub>r</sub> )	Emissions (lb/D)
Light Duty Passenger	(86,462) (5.0 x 10 <sup>-4</sup> lbs/VMT)	42.2
Light Duty Trucks	(47,570) (4.9 x 10 <sup>-4</sup> lbs/VMT)	23.3
Medium Duty Trucks	(11,466) (5.9 x 10 <sup>-4</sup> lbs/VMT)	66.5
Heavy Duty Diesel	(9,600) (4.8 x 10 <sup>-4</sup> lbs/VMT)	46.1
TOTAL		163.7

Annual PM-10 Emission

$$(76.3 \text{ Kg/D}) (365 \text{ D/yr}) = 27,839 \text{ Kg/yr}$$

$$(27,839 \text{ Kg/yr}) (907.2 \text{ Tons/Kg}) = 30.7 \text{ Tons/yr}$$

24 - Hour PM-10 Emission

From the emission totals from the previous page the 24-hour PM-10 emission total was calculated to be 76.3 Kg/D.

**2.0 Road Cinders Emission**

The following equation and assumptions necessary for its calculation are based upon the Town of Mammoth Lakes General Plan and a Caltrans study of road cinders used in Mammoth Lakes.

$$e = 2.28 (sL/0.5)^{0.75} \text{ (grams/VKT)}$$

Given:

Unit Weight of Cinders, loose = 68 lbs/ ft<sup>3</sup>

Silt Content (< 200 mesh or 75 microns) = 0.02 before use, 0.08 after use on roads

Assumption:

Cinders of average diameter of 1/16" (1.6 mm) are spread evenly on the road and they cover 1/4th of the surface area.

Silt Loading:

Volume of cinders spread on road = (0.0016 m)(m<sup>2</sup>)/4 m<sup>2</sup> = 0.0004 m<sup>3</sup>/m<sup>2</sup>

Street Loading Mass = (0.0004 m<sup>3</sup>/m<sup>2</sup>)(68 lb/ft<sup>3</sup>)(454 g/lb)(3.28 ft/m)<sup>3</sup> = 436 g/m<sup>2</sup>

Silt Loading Before Use (sL) = (436 g/m<sup>2</sup>)(0.02) = 8.7 g/m<sup>2</sup>

Emission Calculation

$$e = 2.28 \left( \frac{sL}{0.5} \right)^{0.8} \quad (\text{grams/VKT})$$

$$e = 2.28 \left( \frac{8.7}{0.5} \right)^{0.8}$$

$$e = 22.4 \text{ g/VKT}$$

Annual PM-10 Emission

$$PM_{10} = ( e ) (VKT) (n)$$

*n* = number of cinder applications/month

*VKT* = (VMT) (1.61 km/mile)

*VMT* = (ADT) (*m*)

*m* = number of miles/highway

*ADT* = average daily travel/highway

The Average Daily Travel (ADT) is the California Department of Transportation's designation for the average number of vehicle miles on a particular highway per day. This is combined with the number of times per day cinders are applied and the number of applications per month. The calculations for the estimation of the road cinder emission are shown in Table 2-1. An example calculation from Table 2-1 involving October, 1992 would be:

$$PM_{10} = ( e ) (VKT) (n)$$

*ADT* = average daily travel/highway = 4341 miles

*m* = number of miles/highway = 24 miles [US 395]

*VMT* = (*ADT*) (*m*) = (4341) (24) = 104,328 miles

*VKT* = (*VMT*) (1.61 km/mile) = (104,328 miles) (1.62 km/miles) = 167,968 km

*n* = number of cinder applications/month = (12)

*PM*<sub>10</sub> = ( 22.4 g/*VKT* ) (167,968 km) (12) (1 kg/1000 g) = 45,150 kg

The calculations for the Mono Basin are summarized in Table 2-1

#### 24 - Hour PM-10 Emission

The 24 - Hour Design Day was May 8, 1991. No road cinders were used on that day, therefore there were no road cinder emissions on that day.



Table 2-1

**ANNUAL PM<sub>10</sub> EMISSION ESTIMATES FOR  
ROAD CINDERS**

			US 395	CA 167	CA 158	PM10 Total (Kg)
		(miles)	24	25	6	
Date	Oct. 92	ADT	4347	360	1450	52810
Days Cindered	6	VMT	104328	9000	8700	
Times Cindered/Day	2	VKT	167968	14490	14007	
Cinder Applications/Month	12	PM10 (kg)	45150	3895	3765	
Date	Nov-92	ADT	2632	360	1450	69994
Days Cindered	12	VMT	63168	9000	8700	
Times Cindered/Day	2	VKT	101700	14490	14007	
Cinder Applications/Month	24	PM10 (kg)	54674	7790	7530	
Date	Dec-92	ADT	2628	360	1450	89547
Days Cindered	12	VMT	63072	9000	8700	
Times Cindered/Day	3	VKT	101546	14490	14007	
Cinder Applications/Month	36	PM10 (kg)	81887	3895	3765	
Date	Jan-93	ADT	1164	360	1450	43929
Days Cindered	12	VMT	27936	9000	8700	
Times Cindered/Day	3	VKT	44977	14490	14007	
Cinder Applications/Month	36	PM10 (kg)	36269	3895	3765	
Date	Feb-93	ADT	1732	360	1450	61628
Days Cindered	12	VMT	41568	9000	8700	
Times Cindered/Day	3	VKT	66924	14490	14007	
Cinder Applications/Month	36	PM10 (kg)	53968	3895	3765	
Date	Mar-93	ADT	2242	360	1450	54233
Days Cindered	12	VMT	53808	9000	8700	
Times Cindered/Day	2	VKT	86631	14490	14007	
Cinder Applications/Month	24	PM10 (kg)	46573	3895	3765	
Date	Apr-93	ADT	3217	360	1450	41073
Days Cindered	6	VMT	77208	9000	8700	
Times Cindered/Day	2	VKT	124305	14490	14007	
Cinder Applications/Month	12	PM10 (kg)	33413	3895	3765	
1992 - 1993 Winter Total:			PM10 =	413214 Kg		
			PM10 =	455 Tons		

### 3.0 Annual PM-10 Emission Estimates for Residential Wood Burning Devices

Emissions for each wood burning device was calculated using the following equation:

$$PM_{10} \text{ emissions per device} = (e) (Mass_{wood})$$

$$\begin{aligned} Mass_{wood} &= (\text{number of cords}) (800 \text{ kg/cord}) \quad \text{Jeffery, Pinion Pine} \\ e &= 8.1 \text{ g/kg certified wood stoves} \\ e &= 14.0 \text{ g/kg fireplaces} \\ e &= 15.0 \text{ g/kg conventional wood stoves, fireplace inserts} \end{aligned}$$

#### Annual PM-10 Emission

Jeffery and Pinon are the predominant wood types burned in the Mono Basin. A density for these wood types was estimated to be 10 kg/ft<sup>3</sup> based on data for Ponderosa Pine. Given that a cord is 80 ft<sup>3</sup> of wood per cord, the density of Jeffrey and Pinon Pine is 800 kg/cord.

The total number of wood burning devices within the Mono Basin was calculated using the same ratio of wood burning devices calculated for the Mammoth Lakes study. The ratio of fireplaces to wood burning stoves is 1:3 in Mammoth Lakes and is assumed to be the same for the Mono Basin. As per the 1990 Census there are 979 residents in the Mono Basin. This is 18.9% of the residents in the unincorporated areas of Mono County. There are 2009 occupied housing units in the county therefore (18.9%)(2009) = 380 housing units in the Mono Basin. With the ratio of fireplaces to wood burning stoves being 1:3 the number of fireplaces would be (380)(1/3) = 127. This means that there are 380 - 127 = 253 wood burning stoves. This assumes a worst case scenario with every residence having either a fireplace or a wood burning stove. Based on these assumptions and relevant calculations, the total annual PM<sub>10</sub> emissions, as seen in Table 3-1, for wood burning devices in the Mono Basin is 18.3 Tons/yr.

Table E 3-1  
**ANNUAL PM<sub>10</sub> EMISSION ESTIMATES  
 FOR RESIDENTIAL WOOD COMBUSTION**

Wood Burning Device	Emission Factor	Cords	Cord Density	Units	Total Emission (Mg)
Fireplace	14.0	0.8	800 kg/cord	127	1.4
Wood Stove	15.0	4.0	800 kg/cord	253	15.2
<b>TOTAL</b>					<b>16.6</b>
<b>TOTAL (16.6 Mg) (1000 kg/Mg) (1/907.2 kg/Tons) = 18.3 Tons</b>					

#### 24-Hour PM-10 Emission

It is assumed that there was little to no residential wood combustion on May 8, 1991. Therefore, like road cinders, residential wood combustion will not be a contributing factor for the 24-Hour Design Day PM-10 emission estimates.

#### **4.0 Unpaved Roads**

There are 319 miles of roads within the Mono Basin National Forest Scenic Area. Of these 319 miles, 32 are paved. Additionally there are approximately 135 other unpaved road miles located outside of the scenic area but within the Mono Basin. This brings the number of unpaved road miles within the Mono Basin to 422 miles. The soil type from the region is mixed rock; generally granitic in the south western, western, and northern portions of the basin. In the southern and eastern regions the soil is primarily aerial ash and cinder deposit. The equation for calculating the emissions factor for unpaved roads is as follows:

$$\text{Emissions Factor } e = k (1.7) \left( \frac{s}{12} \right) \left( \frac{S}{48} \right) \left( \frac{W}{2.7} \right)^{0.7} \left( \frac{w}{4} \right)^{0.5} \left( \frac{365 - p}{365} \right) \text{ Kg/VKT}$$

where: k = particle size multiplier  
s = silt content of road surface material (%)  
S = mean vehicle speed (Km/hr)  
W = mean vehicle weight (Mg)  
w = mean number of wheels  
p = number of days with at least 0.254mm (0.01") of precipitation

From the data in Appendix 3 it was determined that the number of days that precipitation was at least 0.01 inches averaged 61 days per year. From Table 11.2.1-3 of AP-42 the particle size multiplier was determined to be k = 0.36. The silt content was determined from table 11.2.1-1 to average 5.0. The mean vehicle speed was estimated to be 32.2 Km/hr (20 mph). The mean vehicle weight was estimated to be 2.7 Mg or 6000 pounds and the mean number of wheels per vehicle was assigned to be 4. This resulted in the following equation:

$$e = (0.36) (1.7) \left(\frac{5.0}{12}\right) \left(\frac{40.23}{48}\right) \left(\frac{2.7}{2.7}\right)^{0.7} \left(\frac{4}{4}\right)^{0.5} \left(\frac{365 - 61}{365}\right) \text{ Kg/VKT}$$

$$e = 0.178 \text{ Kg/VKT}$$

In 1986, 46,398 visitor days were recorded for the scenic area. That same year the Inyo National Forest had  $6.04 \times 10^6$  visitor days. In 1992 the Inyo National Forest had  $8.38 \times 10^6$  visitor days. This yields  $(8.38/6.04) \times (46,398) = 64,373$  visitor days visiting the scenic area in 1992. Assuming 3 visitors per car, this means that 21,458 vehicles/year traveled in the scenic area. Assuming that 95% of these vehicles drive only the 1.5 miles (1.6 km) to the South Tufa, this leaves 1072 vehicles/year driving on the remaining 421 miles (678Km).

### Annual PM-10 Emission

Based on the above set of assumptions this means that:

$$PM_{10} = (\text{number of vehicles/year}) (\text{VKT}) (e)$$

where: VKT = [vehicle miles traveled (VMT)] (1.61Km/mile)

$$\begin{aligned} PM_{10} &= (1072 \text{ vehicles/year}) (678\text{Km}) (0.178 \text{ Kg/VKT}) = 129,000 \text{ Kg/year} \\ &= (20386 \text{ vehicles/year}) (1.6\text{Km}) (0.178 \text{ Kg/VKT}) = \underline{5,800 \text{ Kg/year}} \\ &\qquad\qquad\qquad \text{Total} \qquad\qquad\qquad 134,800 \text{ Kg/year} \end{aligned}$$

$$(134,800 \text{ Kg}) (1 \text{ Ton}/907.2 \text{ Kg}) = 149 \text{ Tons/year}$$

24 - Hour PM-10 Emission

Based on the annual PM-10 emission of 134,800 Kg/year:

$$(134,800 \text{ Kg/year}) (1 \text{ year}/365 \text{ days}) = 378 \text{ Kg/day}$$