APPENDIX F

PM10 EMISSIONS

EXISTING FARM OPERATIONS

Existing Farm Operations

Particulate emissions from the farm were estimated for agricultural land preparation, travel on unpaved roads, and wind erosion. Approximately 750 acres are currently subject to recurrent cultivation practices (250 acres) and weed control disking (500 acres).

Farm access is provided by 9.5 miles of unpaved roads that are restricted to local traffic at reduced speeds. The remainder of the farm consists of field borders, vacant land, and a few residential sites, most of which are partly vegetated.

Land Preparation. PM_{10} emissions from tilling and weed control disking operations were calculated using the equation below (EPA 2001).

$$E = c * k * s^{0.6} * p * a$$

Where:

E = PM_{10} emissions (lbs per year)
c = constant of 4.8 lbs per acre-pass
k = dimensionless particle size multiplier (PM_{10} = 0.21)
s = percentage silt content of soil
p = number of tillage passes per year
a = total acreage

The average surface silt content of soil on the farm is 51 percent based on soil sampling conducted by Reclamation. Estimates of the number of passes for each crop type, projected cropping pattern, and acreages were obtained from the SXCA Farm (Worthey 2004). Annual PM_{10} tillage and disking emissions were then estimated by multiplying the calculated emission factor by the total number of crop-specific acre-passes related to tilling activities and a single pass for annual weed control (Table F-1). The annual PM_{10} emission from tilling is estimated to be 4,030 pounds (2 tons).

Table F-1. Estimated Annual PM_{10} Emissions for Agricultural Tilling.

Crop	Acres	Passes	Emission Factor	PM_{10} Emissions (lbs)
Alfalfa est.	31	2	10.66	661
Alfalfa hay	125	0	10.66	0
Sweet corn	13	6	10.66	831
Traditional squash	7	3	10.66	224
Tepary beans	32	4	10.66	1364
Pumpkins	7	3	10.66	224
Oat hay	35	2	10.66	726
			Total	4,030

Approximately 500 acres would be subject to annual weed suppression disking operations. This would produce a PM_{10} emission of 5,330 pounds (2.7 tons).

The total annual land preparation PM_{10} emission is estimated to be 9,380 pounds (4.7 tons).

Agricultural Wind Erosion. Emission factors for agricultural wind erosion are not available from EPA; therefore, wind-blown PM_{10} emissions were estimated using emission factors developed by the University of Nevada in wind tunnel testing of desert soils in Clark County, Nevada (James et al., 2000). The testing program examined PM_{10} emissions for different land use categories (i.e., disturbed vacant lands, native desert, and stabilized vacant land) based on wind speeds of 15 miles per hour (mph) or greater (Table F-2).

Table F-2. Emission Factors for Wind-blown Dust.

Emission Factor Types	PM_{10} Emission Factor (ton/acre/hour) by Wind Speed (mph)		
	15 – 19.9	20 – 24.9	25 -29.9
Disturbed Vacant Land	0.00495	0.00521	0.0064
Undisturbed Native Desert	0	0	0.00257
Stabilized Land	0.00042	0.00034	0.00019

The empirical evidence from wind tunnel test indicate that wind-derived fugitive dust emissions are more prevalent where desert soils have been destabilized by human activity or livestock. Under natural conditions, desert soils tend to form a mineral and organic crust that is somewhat resistant to wind erosion. Generally, undisturbed soil that has formed a crust has a limited reservoir of available fugitive dust and will only emit during the first hour of a high wind event (Macdougall 2002).

On most soils, relatively high threshold wind speeds are required to cause particles to become suspended in measurable airborne concentrations (Macdougall 2002). In Maricopa County, Arizona, exceedances of the PM_{10} NAAQS from wind-blown dust occurred when sustained hourly winds exceeded 15 mph. Pima County determined 15 mph to be a relevant minimum threshold wind speed for calculating PM_{10} emission totals from wind events within the NEAP action area (PDEQ 2001).

Wind-blown dust emissions from the farm were calculated for cultivated agricultural fields, fallow fields, farm roads, and miscellaneous disturbed land. For active agricultural fields, PM_{10} emissions are assumed to be negligible during periods when irrigated crops are present. Dust emissions were calculated for each land use category only for those periods when average hourly winds equaled or exceeded 15 mph. The emission estimates are based on emission factors derived from Table 10, using the following equation:

$$E = a * f * w$$

where:

$E = PM_{10}$ emissions (tons/year)
a = number of acres for the particular land category
f = wind speed-specific emission factor (tons/acre-hour)
w = number of hours of wind in stated range

Table F-3 provides an acreage estimate for irrigated land within the farm. The estimate is seasonally adjusted according to a typical crop mix and irrigation regime. Post irrigation agricultural acreage was determined by subtracting total irrigated acres for each month from the total cultivated acreage.

Table F-3. Estimate of Irrigated Acres by Month.

Month	Acres of Irrigated Crops							
	Alfalfa Est.	Alfalfa	Squash	Tepary Beans	Pumpkins	Sweet Corn	Oat Hay	Total
Jan							28	28
Feb							28	28
Mar	26	104	1	11		1	28	171
Apr	26	104	1	11		1	28	171
May	26	104	2			3		135
Jun	26	104	4	12	6	4		156
Jul	26	104	5	12	6	6		159
Aug	26	104	6	12	6	6		160
Sep	26	104	4		6	6		146
Oct							28	28
Nov	26						28	54
Dec	26						28	54

The acreage for "vacant" disturbed land was totaled for each month according to land use category (Table F-4). Only categories of land with no substantial plant cover were included. Roadside ditches and unused fields with minimal vegetation were listed as miscellaneous disturbed land.

Table F-4. Land Use Categories.

Month	Acres of Land				
	Highly Disturbed		Stable		Undisturbed
	Cultivated - Post Irrigation and Disked Fallow	Roads/ Facilities[1]	Undisturbed Fallow	Field Borders/ Ditches/Dikes	Native Desert
January	722	12	209	87	18
February	722	12	209	87	18
March	579	12	209	87	18
April	579	12	209	87	18
May	615	12	209	87	18
June	594	12	209	87	18
July	591	12	209	87	18
August	590	12	209	87	18
September	604	12	209	87	18
October	722	12	209	87	18
November	696	12	209	87	18
December	696	12	209	87	18

[1] Includes farm maintenance and equipment storage area.

Annual emissions were derived by summing the acreages of all nonirrigated land use categories according to month. Acreages were multiplied by the number of hours of wind in each speed range at or above the 15 mph threshold and the appropriate emission factor. Average hourly wind speed was determined using data from the Tucson AZMET station. No average hourly wind speed in excess of 24.9 mph was recorded by the AZMET station. Emission estimates are provided in Table F-5.

Table F-5. Annual Emission Estimates for Agricultural Wind Erosion.

Month	Land Type (Acres)			Wind Event (Hours)*		Total PM_{10} Emission (tons)
	Highly Disturbed	Stable	Native Desert	15 – 19.9 mph (EFD = 0.00495) (EFS = 0.00042)	20 – 24.9 mph (EFD = 0.00521) (EFS = 0.00034)	
January	734	296	18	2	1	11.4
February	734	296	18	7	1	30.2
March	591	296	18	10		29.4
April	591	296	18	8		23.5
May	627	296	18	1		3.2
June	606	296	18	2		6.2
July	603	296	18	2		6.2
August	602	296	18	2		6.2
September	614	296	18	5		15.8
October	734	296	18	2		7.5
November	708	296	18	1		3.6
December	708	296	18	9		32.7
					Total	175.9

* Based on 5-year average (1998 to 2002)
EFD=emission factor for disturbed land
EFS= emission factor for stable land
The emission factor for undisturbed native desert is 0 at wind speeds ≤ 24.9 mph.

Unpaved Roads. The EPA has developed an AP-42 equation for assessing particulate emissions for travel on unpaved roads (EPA 2003). Various ranges of source conditions from actual road tests were used in developing the equation, including mean vehicle speed (5 to 55 mph), mean number of wheels (4 to 7), and surface silt content (1.2 to 35 percent). Also factored into the equation is a mitigation expression for moisture input from precipitation.

The following AP-42 equation is used to estimate PM_{10} emissions per vehicle mile traveled (VMT) under existing conditions:

$$E_{ext} = \frac{k(s/12)^1(S/30)^{0.5}}{(M/0.5)^{0.2}} - C\,[(365 - p)/365]$$

where:

E_{ext} = emission factor (lbs/VMT), extrapolated for natural mitigation
k = particle size multiplier for PM_{10} (= 1.8)
s = surface material silt content (= 51 percent)
W = mean vehicle weight (13.4 tons)
M = surface material moisture content under dry conditions (= 1 percent)
S = mean vehicle speed (15 mph)
C = emission factor for 1980s vehicle fleet exhaust (0.00047)
p = number of days with > 0.01 inches of rain (=40)

Road surfaces consist of compacted soils with high silt content (approximately 51 percent). A surface material moisture content representative of Arizona was used. Total annual distance traveled by vehicles on unpaved roads is estimated to be 7,065 miles. Five-year average precipitation data for 1998 to 2002 was obtained from the Tucson AZMET station

(AZMET 2003).

Vehicle travel on unpaved roads was estimated to contribute 14.8 tons of PM_{10} annually.

Harvest. PM_{10} fugitive dust emission factors for harvest operations are not available from EPA. The UC Davis has quantified harvest emission factors for three crops (cotton, wheat, and almonds) based on field emissions testing of agricultural activities. Table F-6 shows the emission factors developed by UC Davis.

Table F-6. Harvest Emission Factors.

Activity	Emission Factor (lbs PM_{10}/acre pass)
Cotton Harvest	3.4
Almond Harvest	40.8
Wheat Harvest	5.8

Using the UC Davis emission factors, the California Air Resources Board applied an adjustment factor to estimate the relative dustiness of harvesting other crops (Gaffney and Yu 2003). PM_{10} emissions per acre were calculated by dividing the base factor with the adjustment factor. Total PM_{10} harvest emissions are estimated to be 943 pounds (0.5 tons) (Table F-7).

Table F-7. Harvest Emission Factor (EF) Assignments and Total Annual Harvest Emissions for San Xavier Farm Crops.

Crop	Acres	Harvest EF Base Factor	Harvest EF Adjustment	PM_{10} Emissions/Acre (lbs)	Number Harvest Passes/Year	Annual PM_{10} Emissions (lbs)
Alfalfa est.	31	0	1	0	28 [1]	0
Alfalfa hay	125	0	1	0	28 [1]	0
Sweet corn	13	3.4 (Cotton)	2	1.7	1	22
Traditional squash	7	0	0	0	1	0
Tepary beans	32	3.4 (Cotton)	2	1.7	2	109
Pumpkins	7	0	0	0	1	0
Oat hay	35	5.8 (Wheat)	1	5.8	4	812
					Total	943

1. Alfalfa harvest consists of four passes per cutting, seven cuts per year (personal communication Bill Worthey, Farm Manager 2004).