Yuma Maintenance Plan
Technical Support Document

Demonstration of Attainment

AIR QUALITY DIVISION
ARIZONA DEPARTMENT OF
ENVIRONMENTAL QUALITY

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CHAPTER 1 – INTRODUCTION

1.1 Yuma's Ambient PM_{10} Record and Regulatory History

The U. S. Environmental Protection Agency (EPA), via the Clean Air Act, has established health standards for airborne particulate matter. The standards are for particles with an aerodynamic diameter of 10 microns and smaller, otherwise know as PM_{10}. The two averaging periods for these PM_{10} standards are 24 hours and annual. Their numerical values are expressed in a weighted mass of particles per volume of air, the units being described as micrograms per cubic meter (µg/m^3). The two standards are 150 µg/m^3 for a 24 hour period, and 50 µg/m^3 for an annual period.

Monitoring for PM_{10} began in Yuma in 1985, and has continued through the present. The monitoring data presented in Figures 1-1 and 1-2 and in Table 1-1 show that exceedances of both the annual and 24-hour standards occurred through the early 1990s, but since then the standards have been met.

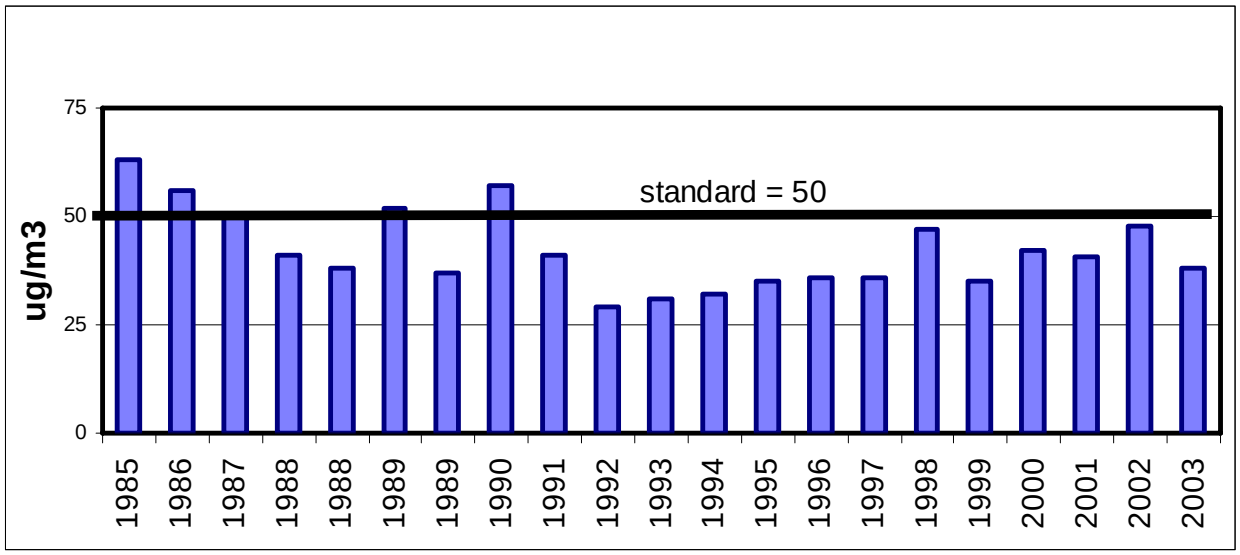

Figure 1-1. PM_{10} Annual Averages in Yuma (µg/m^3)

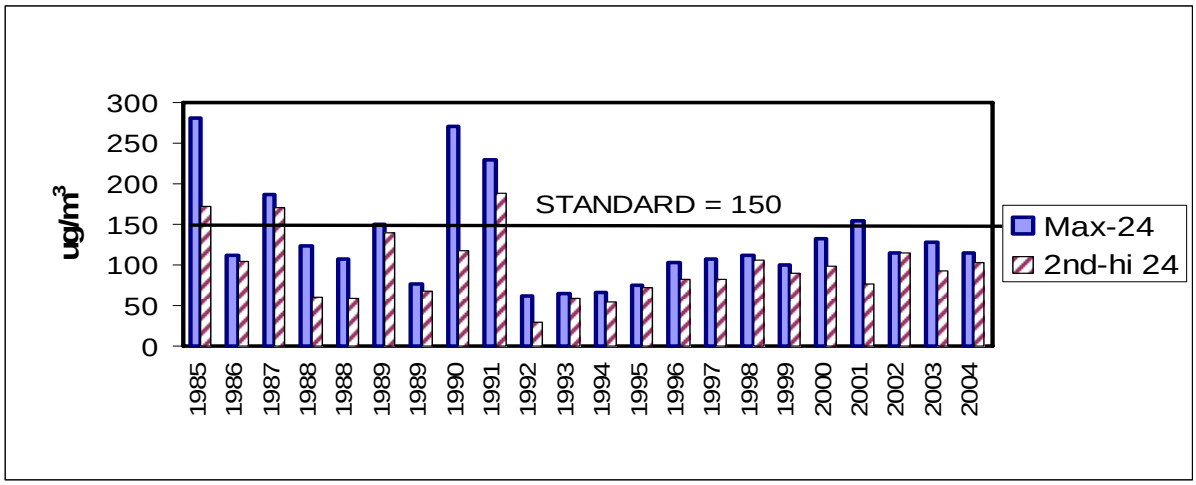

Figure 1-2. Maximum and Second-Highest 24-Hour PM_{10} Averages in Yuma (excludes the August 18, 2002 exceedance of 170 µg/m^3 flagged as a natural event)

Table 1-1. PM_{10} Concentrations in Yuma: Annual Statistics in µg/m^3

Year	Annual Average	Max-24-Hr	2nd-hi 24-Hr	Address
1985	**63**	**281**	**172**	201 S. 2nd Ave
1986	**56**	112	105	201 S. 2nd Ave
1987	50	**187**	**170**	201 S. 2nd Ave
1988	41	123	60	1485 2nd Ave
1988	38	108	59	201 S. 2nd Ave
1989	**52**	150	139	201 S. 2nd Ave
1989	37	77	67	1485 2nd Ave
1990	**57**	**270**	118	1485 2nd Ave
1991	41	**229**	**188**	201 S. 2nd Ave
1992	29	62	30	2795 Ave B
1993	31	65	59	2795 Ave B
1994	32	66	54	2795 Ave B
1995	35	75	72	2795 Ave B
1996	36	103	83	2795 Ave B
1997	36	108	83	2795 Ave B
1998	47	112	106	2795 Ave B
1999	35	100	90	Juvenile Center
2000	42	132	99	Juvenile Center
2001	41	154	77	Juvenile Center
2002*	48	115	115	Juvenile Center
2003	38	127	93	Courthouse
2004	40	114	103	Courthouse

* excludes the August 18, 2002 exceedance of 170 µg/m^3 flagged as a natural event

A few details in Table 1-1 need to be explained. Bold values exceed an air quality standard. In 1988 and 1989, monitoring was conducted at two sites. The table and the figures show the data for both. The 154 µg/m^3 concentration in 2001 is not considered an exceedance of the 24-hour standard of 150 µg/m^3. An

exceedance is defined as 155 µg/m^3 or greater, to account for the precision of the instrument. On August 18, 2002, a 24-hour concentration of 170 µg/m^3 was recorded. Subsequent analysis showed that the extremely windy and dry conditions of that date qualified it as a "natural exceptional event." Through a Natural Events Action Plan (NEAP), Somerton, the City of Yuma, and Yuma County have agreed to apply the Best Available Control Measures (BACM) to the contributing PM_{10} emission sources in return for having the concentration removed from the compliance record. The data of 2002 in Table 1-1 reflect its removal.

The overall PM_{10} trends shown in the figures and table depict elevated, above-standard concentrations in the mid 1980s and early 1990s, followed by a long period of uninterrupted compliance with the standards. Because of the PM_{10} violations in the 1980s, the western area of Yuma County was designated a moderate PM_{10} nonattainment area by the 1990 Clean Air Act Amendments. ADEQ completed a state implementation plan (SIP) for the Yuma Moderate PM_{10} Nonattainment Area in 1991 and updated the plan in 1994. As a result of several years of measured attainment with the air quality standards for PM_{10} , ADEQ began working with the stakeholders in July 2001 to develop a request to EPA to redesignate Yuma from non-attainment to attainment. This request requires a "maintenance plan" that demonstrates that the control measures in effect will assure compliance with the standards for at least ten years. It also requires that the most recent three years of monitoring data meet the standards.

In the designation of the PM_{10} nonattainment area, discussed above, the "nonattainment area" consisted of the western portion of Yuma County shown in Figure 1-3. This area can be considered the "Yuma air quality planning area." When controls to reduce PM_{10} emissions are discussed (Chapter 3), these controls apply to this nonattainment area. Within this area, in the central portion of the City of Yuma, PM_{10} monitoring has been and is being conducted. References to "Yuma PM_{10} monitoring" refer, in 1999, to the data collected at the Juvenile Center. In the technical work for this Maintenance Plan, both the emissions inventory and the air quality modeling were conducted for a larger area in western Yuma County. Also shown in Figure 1-3, this "modeling domain" included portions of California and Baja California del Norte, Mexico. In the emissions and air quality modeling sense, the term "Yuma" refers to this entire modeling domain. In summary, then, the term "Yuma" is used in three ways in this document:

1. The "Yuma air quality planning area" -- roughly the area east of the Colorado River, west of the Gila Mountains, and north of Sonora, Mexico, and as far north as the La Paz County line – is the area in which PM_{10} emission controls have been enacted.

2. The "Yuma PM_{10} monitoring area' is that portion of central Yuma in which PM_{10} monitoring has been conducted: namely, the locations given in Table 1-1.

3. The "Yuma PM_{10} modeling domain" is a larger area that includes nearly all of the nonattainement area, but also includes portions of Baja and California. This large rectangular area was chosen for both the emissions and air quality modeling conducted as part of this Maintenance Plan.

In this technical support document (TSD) to the Maintenance Plan, two aspects of Yuma PM_{10} are explained. First, in Section 1-3, the monitoring record for 2002, 2003, and 2004 is presented and shows that the standards are being met. Second, in Chapter 2, the technical analysis that demonstrates attainment ten years into the future is presented. Following that is a discussion of the various air pollution controls and their effects on emissions and ambient air quality. The remainder of this introduction describes the nature of PM_{10} and discusses the 2002 - 2004 ambient record.

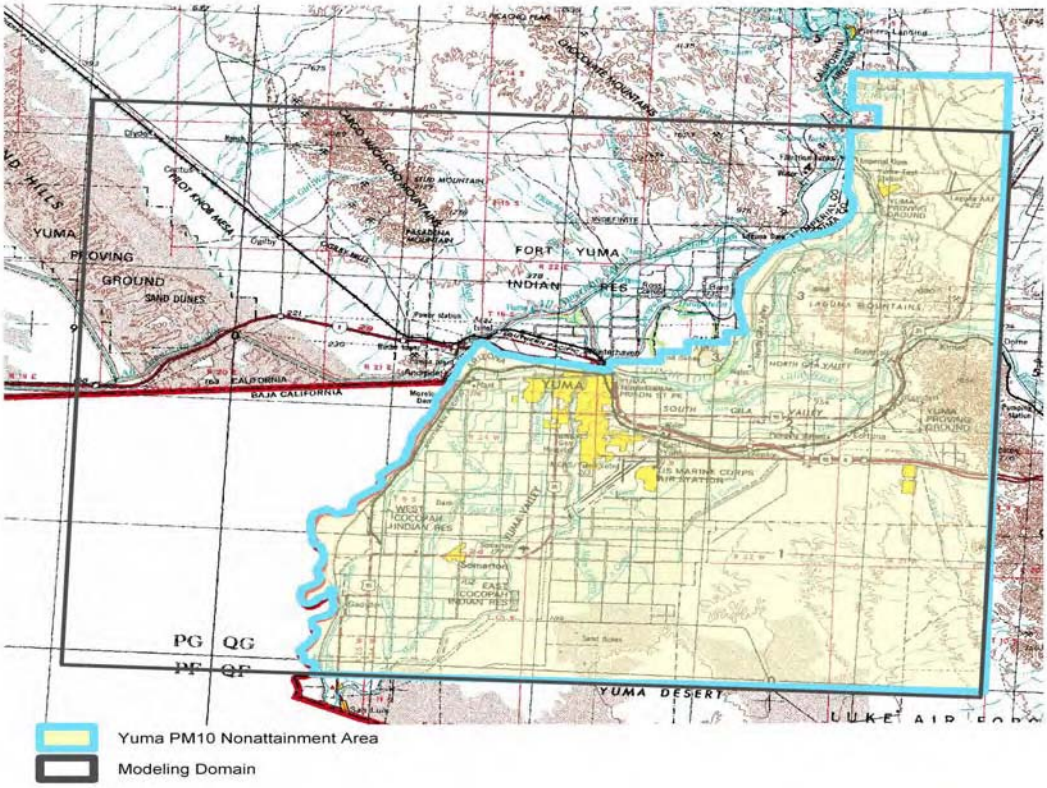

Figure 1-3. Yuma PM_{10} Nonattainment Area and the Modeling Domain for the 2005 PM_{10} Maintenance Plan

1.2 The General Nature of Particulate Matter

Particulate matter is a collective term describing small solid or liquid particles that vary considerably in size, geometry, chemical composition and physical properties. Produced by both natural processes (pollen and wind erosion) and human activity (soot, fly ash, and dust from paved and unpaved roads), particulates contribute to visibility reduction, pose a threat to public health and cause economic damage through soil disturbance. PM_{10} is particulate matter 10 microns and smaller, and it can be divided into two size fractions: coarse and fine. Some fine particulates (2.5 microns and smaller, or "$PM_{2.5}$") are formed by the condensation of vapors or by their subsequent growth through coagulation or agglomeration. Others are emitted directly from the sources, either by combustion or from mechanical grinding of soils. Coarse particulates (2.5 to 10 microns) are formed through mechanical processes such as the grinding of matter and the atomization of liquids. Fine particulates can also be classified as primary – produced within and emitted from a source with little subsequent change – or secondary – formed in the atmosphere from gaseous emissions.

Secondary particulate nitrates and sulfates, for example, form in the atmosphere from the oxidation of sulfur dioxide and nitric oxide, which are two gases. In contrast, most atmospheric carbon is primary, having been emitted directly from combustion sources, although some of the organic carbon in the aerosol is secondary, having been formed by the complex photochemistry of gaseous volatile organic compounds.

The size, shape and chemical composition of particulates determine their health effects. Particles larger than 10 microns are deposited in the upper respiratory tract. Particles from 2.5 to 10 microns are inhalable and are deposited in the upper parts of the respiratory system. Particles smaller than 2.5 microns are respirable and are deposited in the pulmonary tissues. Particles in the size range of 0.1 to 2.5 microns are most efficiently deposited in the alveoli, where their effective toxicity is greater than larger particles because of the higher relative content of toxic heavy metals, sulfates and nitrates. Epidemiological studies have shown causal relationships between particulates and excess mortality, aggravation of bronchitis, and, in children, small, reversible changes in pulmonary function. Acidic aerosols have been linked to the inability of the upper respiratory tract and pulmonary system to remove harmful particles.

Coarse particulate emissions are mostly geological and are dominated by dusts from three activities: re-entraining dust from paved roads, driving on unpaved roads and earthmoving associated with construction. Soil dust from these sources and others contribute more than 70 percent of the coarse particulates in Arizona. On days with winds in excess of 15 miles per hour, wind erosion of soil contributes to this loading.

Concentrations of particulates tend to be higher in the late fall and winter, when atmospheric dispersion is at a seasonal low. PM_{10} maximum concentrations can occur in any season, provided nearby sources of coarse particulates are present or when strong and gusty winds suspend soil disturbed by human activities. Hourly concentrations of particulates tend to peak during the hours of the worst dispersion, which is from sunset to mid-morning.

Urban PM_{10} concentrations are the sum of two parts: the part generated by local emissions and the part that would be present without any human activity whatsoever. This second part is called the background concentration. In over three decades of monitoring throughout the State, annual PM_{10} concentrations from pristine to polluted urban are as follows:

	$\mu g/m^3$
Desert or plateau background	10
Urban fringe	20 – 30
General urban	30 – 45
Urban with elevated concentrations	45 – 55

Urban with serious problems	55 – 80

Any demonstration of attainment has to account for this background concentration, which cannot be reduced by local air pollution controls. In the technical analysis of Chapter 2, there is an extensive discussion of how background PM_{10} concentrations were calculated for the various study dates of the base year of 1999. Unless documented controls are applied to these background concentrations, they remain constant from the base to the future year.

1.3 Yuma PM_{10} Concentrations in 2002 – 2004

What follows is an examination of the ambient monitoring records for PM_{10} in Yuma in 2002, 2003, and 2004, to show that these data meet all Clean Air Act standards. A successful request for designation from non-attainment to attainment depends on two findings:

1. That air quality in the future meets the standards (addressed in Chapter 2), and

2. That the most recent three years of monitoring meet the standards.

The three-year ambient record, shown in Table 1-2, demonstrates that the standards are met. Aspects of specific concentrations are discussed below the table.

Table 1-2. Yuma PM_{10} Concentrations 2002 – 2004

2002			2003			2004		
Date	**Original**	**Duplicate**	**Date**	**Original**	**Duplicate**	**Date**	**Original**	**Duplicate**
1/02/02	*46*		1/3/03	23		1/4/04	9	
1/8/02	*46*		1/9/03	43		1/10/04	20	
1/14/02	*46*		1/15/03	21		1/16/04	53	
1/20/02	*46*		1/21/03	46		1/22/04	11	
1/26/02	45	41	1/27/03	37		1/28/04	32	
2/1/02	25	17	2/2/03	**0, c**		2/3/04	36	
2/7/02	91	91	2/8/03	36		2/9/04	21	
2/13/02	115	116	2/14/03	27		2/15/04	49	
2/19/02	43	45	2/20/03	24		2/21/04	18	
2/25/02	63	79	2/26/03	14		2/27/04	30	
3/3/02	19	24	3/4/03	26		3/4/04	14	
3/9/02	42	49	3/10/03	42		3/10/04	2	
3/15/02	47	53	3/16/03	44		3/16/04	64	
3/21/02	101	111	3/22/03	31		3/22/04	73	
3/27/02	33	34	3/28/03	19		3/28/04	51	
4/2/02	42	56	4/3/03	29		4/3/04	9	
4/8/02	35	39	4/9/03	39		4/9/04	*125*	
4/14/02	30	34	4/15/03	22		4/15/04	26	
4/20/02	29	39	4/21/03	58		4/21/04	77	
4/26/02	93	111	4/27/03	28		4/27/04	30	
5/2/02	38		5/3/03	52		5/3/04	43	
5/8/02	125	55	5/9/03	39		5/9/04	35	
5/14/02	63	61	5/15/03	80		5/15/04	41	
5/20/02	113	**212, a**	5/21/03	63		5/21/04	42	
5/26/02	23	26	5/27/03	64		5/27/04	*125*	
6/1/02	51	49	6/2/03	31		6/2/04	48	

Table 1-2. Yuma PM_{10} Concentrations 2002 – 2004								
2002			**2003**			**2004**		
Date	**Original**	**Duplicate**	**Date**	**Original**	**Duplicate**	**Date**	**Original**	**Duplicate**
6/7/02	54	32	6/8/03	14		6/8/04	47	
6/13/02	92	96	6/14/03	41		6/16/04	29	
6/19/02			6/20/03	63		6/25/04	*125*	
6/25/02			6/26/03	53		6/26/04	*125*	
7/1/02			7/2/03	16		7/2/04	40	31
7/7/02	2	17	7/8/03	15		7/8/04	39	31
7/13/02	6		7/14/03	59		7/14/04	32	
7/19/02			7/20/03	50		7/20/04	31	32
7/25/02	32		7/26/03	55		7/26/04	46	25
7/31/02			8/1/03	29		7/31/04		37
8/6/02	44		8/7/03	65		8/1/04		
8/12/02	28		8/13/03	37		8/7/04	36	57
8/18/02	**170, b**		8/19/03	34		8/13/04	114	55
8/24/02	69		8/25/03			8/19/04	103	46
8/30/02	111		8/31/03	16		8/25/04	56	31
9/5/02	51		9/6/03	18		8/31/04	54	66
9/11/02	27		9/12/03	30		9/6/04	37	59
9/17/02	51		9/18/03	49		9/12/04	53	90
9/23/02	23		9/24/03	11		9/18/04	55	50
9/29/02	16		9/30/03	23		9/24/04	88	
10/5/02			10/6/03	38		9/30/04	47	
10/11/02	55		10/12/03	**0, d**		10/6/04	65	57
10/17/02	61		10/15/03	26		10/12/04	44	43
10/23/02	48		10/18/03	41		10/18/04	44	43
10/29/02	39		10/24/03	71		10/24/04	22	
11/4/02	47		10/30/03	**127, e**		10/30/04	21	19
11/10/02	18		11/5/03	47		11/5/04	53	49
11/16/02	24		11/11/03	29		11/11/04	25	26
11/22/02	46		11/17/03	29		11/17/04		
11/28/02			11/23/03	10		11/23/04	19	23
12/4/02	24		11/29/03	19		11/29/04	16	
12/10/02	25		12/5/03	38		12/1/04		28
12/16/02	41		12/11/03	93		12/5/04	15	15
12/22/02	16		12/17/03	10		12/11/04	18	20
12/28/02	21		12/23/03	16		12/17/04	26	26
			12/29/03	**0, f**		12/23/04	52	37
						12/29/04	23	23

Table 1-2. Yuma PM_{10} Concentrations 2002 – 2004								
2002			2003			2004		
Date	**Original**	**Duplicate**	**Date**	**Original**	**Duplicate**	**Date**	**Original**	**Duplicate**
Average Q1	53.8	< 75%		30.9			32.2	
Average Q2	60.6	67.5		45.0			61.8	
Average Q3	38.3	< 75%		33.8			55.4	
Average Q4	35.7			42.4			31.6	
Average (year)	47.1			38.0			45.2	
Std. Dev.	29.87	43.77		21.87			30.72	
n Samples	53	24		58			58	
Minimum	2	17		10			2	
Maximum	125	212		127			*125*	90
2nd High	115	116		93			*125*	66
3rd High	113	111		80			*125*	59
4th High	111	111		71			*125*	57
5th High	101	96		65			114	55

a -- May 20, 2002, duplicate value of 212 was validated, but doesn't count towards compliance

b -- Aug 18, 2002 value of 170 deleted (NEAP day)

c -- Feb 2, 2003 value of 0 set to "no data"

d -- October 12, 2003 value of 0 set to "no data"

e -- October 30, 2003 value of 127 has been attributed to smoke from Southern California wildfires

f – December 29, 2003 value of 0 set to "no data"

Italicized concentrations are substituted values for missing data.

No collocated samples were taken from 8/6/2002 through 7/1/2004.

Dichot samplers were moved from the Yuma Juvenile Center to the Courthouse 6/13/2002

Both dichots were replaced with one Partisol sampler 8/6/2002.

A second Partisol sampler was added for precision/accuracy 7/2/2004

As the footnotes indicate, a few anomalously low values have been deleted: it's unreasonable to suppose that PM_{10} concentrations averaged for 24 hours in southwest Arizona would be lower than 5 µg/m3. Nonetheless, all the nonzero values have been kept with the zero values set to "no data."

The maximum values also merit some discussion. First, the August 18, 2002, concentration of 170 µg/m^3, flagged in EPA's Air Quality System database, was the result of an unusually violent and persistent dust storm and has been treated under the Natural Events Action Plan. Second, the 212 µg/m^3 from the duplicate sampler on May 20, 2002, was examined and found to be valid. Paired with a value from the original sampler of 113 µg/m^3, this higher, above-standard value does not count towards compliance because it is not the primary sampler. Third, the 127 µg/m^3 on October 30, 2003, was the result of transported smoke from Southern California wildfires. All other maxima and second through fifth highest values are within the standard of 150 µg/m^3. The annual averages are all under the 50 µg/m^3, and their

three-year average, used for compliance with the standard, is 43.4 µg/m^3.

The last two footnotes require some explanation. A “dichot” sampler is a filter-based PM_{10} instrument that measures two approximate size fractions: particles smaller than 2.5 microns, and particles between 2.5 and 10.0 microns. Most of the Yuma PM_{10} measurements have been made with dichots. The “Partisol” sampler is a filter-based PM_{10} instrument that measures only one size fraction: particles 10 microns and smaller.

Finally, the italicized concentrations are substituted values. When fewer than 12 samples have been validated for each quarter, then the highest concentration in the past three years for that quarter is substituted for the missing values. The two cases evident in the table are the first quarter of 2002, in which the value of 46 µg/m^3 has been substituted; and the second quarter of 2004, in which 125 µg/m^3 has been substituted.

CHAPTER 2 – DEMONSTRATION OF ATTAINMENT

2.1 Introduction

While demonstrating attainment of an air quality standard is conceptually simple, it remains a data-intensive and computationally complex exercise. In the case of Yuma PM_{10}, the demonstration is eased considerably by the ambient monitoring record, which already shows attainment. What also needs to be demonstrated, however, is that this clean air will last ten years into the future, despite the anticipated growth of the community. This exercise consists of several steps, each one described in the following sections of this chapter:

- Choose several dates, called design days, from the base year 1999 to study, taking into account a variety of different meteorological conditions and all the seasons (Section 2.2).

- Build inventories of emissions for the base year 1999 and the future year 2016, and convert these inventories into a numerical format compatible with an air quality model (Section 2.3).

- For each design day, calculate the background PM_{10} concentrations. These are the concentrations that would have occurred had there been no anthropogenic emissions from within the Yuma modeling domain (Section 2.4).

- Simulate the PM_{10} concentrations of the base year with an air quality model. This model provides predicted concentrations based on the emissions and specific meteorological conditions of each design day (Section 2.5).

- Simulate the PM_{10} concentrations of the future year 2016, with the future year emissions and the base year meteorological conditions (Section 2.6).

- Attainment is demonstrated for the base and future years when the base-year measured concentrations and the concentrations predicted for 2016 are within the standard (Section 2.7).

2.2 Design Days for 1999, the Base Year

PM_{10} monitoring is generally conducted with a filter-based instrument, permanently mounted at a site. This instrument is typically run every sixth day, midnight to midnight, to give about sixty 24-hour averages each year. PM_{10} concentrations for the base year 1999 are shown in Table 2-1. Yuma's monitoring that year was done with two collocated samplers. Data from the "original" sampler was found to be invalid for the second half of the year. The annual average was 37 µg/m^3; the highest 24-hour average was 102 µg/m^3 (standards are 50 µg/m^3 and 150 µg/m^3).

Table 2-1. Yuma PM_{10} Concentrations for 1999 (24-Hour Averages in µg/m^3)

Date	Original	Duplicate	Date	Original	Duplicate
1/6/99	45	45	7/5/99	43	71
1/12/99	55	48	7/11/99	40	44
1/18/99	45	40	7/17/99	19	
1/24/99	35	33	7/23/99		24
1/30/99	35	34	7/29/99		
2/5/99			8/4/99		
2/11/99	19	19	8/10/99		26
2/17/99	61	58	8/16/99		35
2/23/99	28	29	8/22/99		27
3/1/99	64	65	8/28/99		18
3/7/99	28	17	9/3/99		88
3/13/99	38	40	9/9/99		37
3/19/99			9/15/99		38
3/25/99	17	18	9/21/99		34
3/31/99	102	74	9/27/99		28
4/6/99	20	22	10/3/99		31
4/12/99	20	17	10/9/99		67
4/18/99	19	22	10/15/99		47
4/24/99	22	21	10/21/99		43
4/30/99	36	36	10/27/99		37
5/6/99	24	34	11/2/99		65
5/12/99	27	31	11/8/99		32
5/18/99	31	36	11/14/99		46
5/24/99	32	34	11/20/99		50
5/30/99	21	30	11/26/99		54
6/5/99	26	28	12/2/99		15
6/11/99	42	45	12/8/99		46
6/17/99	19	22	12/14/99		35
6/23/99	43	44	12/20/99		19
6/29/99		42	12/26/99		19

The design days chosen, given in Table 2-2, represent all the seasons and a variety of meteorological conditions.

Table 2-2. PM_{10} Design Days for 1999				
Date	PM_{10} ($\mu g/m^3$) Original	PM_{10} ($\mu g/m^3$) Duplicate	Day of Week	Meteorological Conditions and Emissions
1/12/99	55	48	Tuesday	Low Winds, Agricultural Tillage
3/31/99	102	74	Wednesday	High Winds
5/30/99	21	30	Sunday	Low Winds
6/23/99	43	44	Wednesday	Low Winds
7/17/99	19		Saturday	Low Winds
11/8/99		32	Monday	Low Winds
12/8/99		46	Wednesday	Low Winds, Agricultural Tillage

These dates cover both low and high winds, two of the three highest recorded concentrations, and a wide range of low to moderate concentrations, as shown in Figure 2-1.

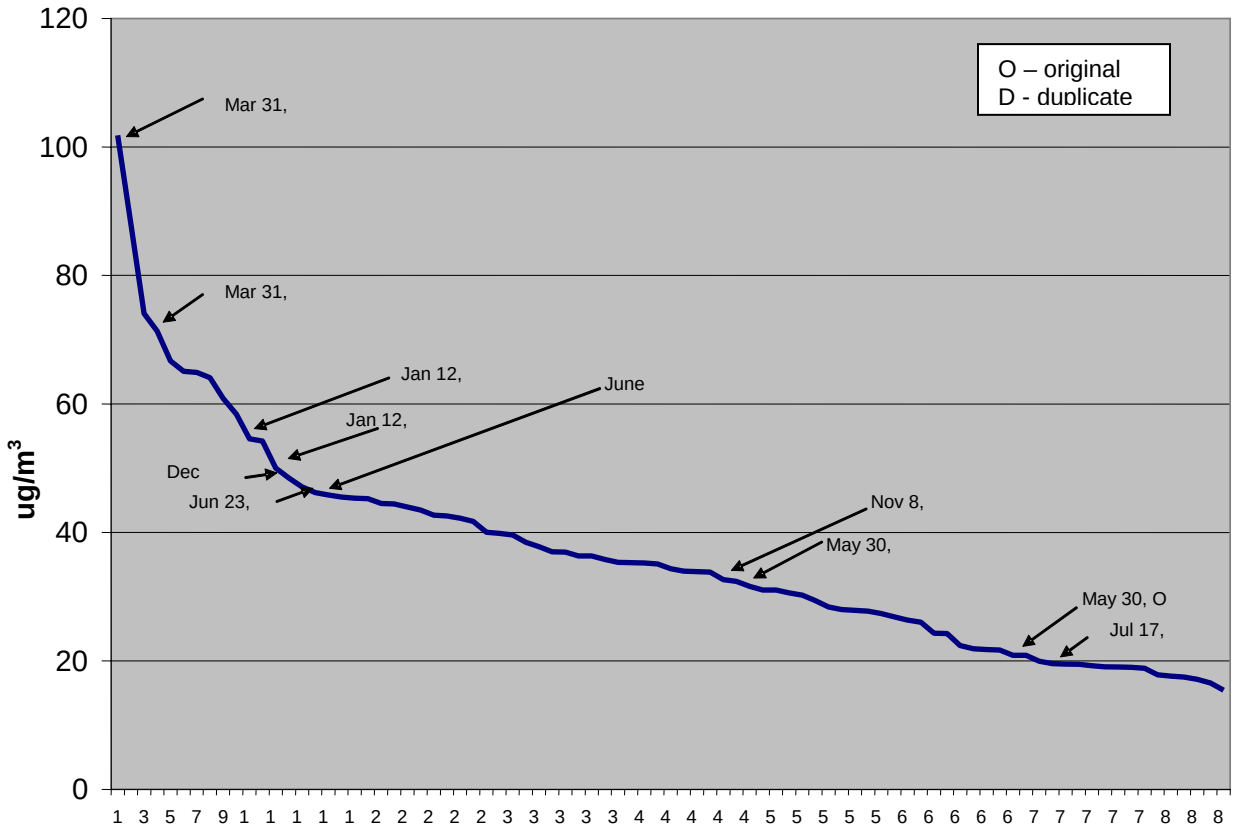

Figure 2-1. Yuma PM_{10} Concentrations for 1999 in $\mu g/m^3$, Plotted from Highest to Lowest, with Design Days Indicated

2.3 Emissions Inventory

2.3.1 Findings from the Inventory

A complete inventory of PM_{10} emissions for the Yuma area was constructed, based on a defined study area, also known as the "modeling domain", shown in Figure 2-2. As discussed later in this section, the PM_{10} emissions inventory for modeling covers eight different dates in 1999 and 2016. The domain footprint is illustrated in this figure and covers 2464 km^2 (945 square miles), with the city of Yuma located near the center of the domain. The domain is a rectangle aligned east and west, with 14 grids in the east-west direction and 11 grids in the north-south direction. Each grid is a square 4 kilometers on a side. This emissions inventory domain is also the modeling domain, discussed further in sections 2.3.2 and 2.5.

Details of the calculations may be found in Appendix A, E. H. Pechan & Associates, Inc. -- the contractor's report. On-road mobile source calculations, referenced in the Pechan report, are given in Appendix E. This inventory has undergone some revisions, principally in windblown emissions from vacant agricultural fields and general building and road construction. These revisions are presented in Appendix F. What follows are a summary table and two figures to illustrate the findings, which reflect these revisions. Table 2-3 gives the 1999 and 2016 annual PM_{10} emissions by source category. As windblown emissions dominate, Figure 2-3a shows the distribution of emissions on low-wind days by source category. The dominant source categories are unpaved roads, road construction, agricultural tilling, and reentrained dust from paved roads. Windblown dust emissions (Figure 2-3b) are dominated by vacant agricultural fields, unpaved agricultural roads, and miscellaneous disturbed areas.

Table 2-3. Yuma PM_{10} Emissions for 1999 and 2016, Revised			
Source Category	**Annual tons of PM_{10}**		
	1999	**2016**	**% Change***
Windblown Dust	**70,981**	**68,377**	3.7
Unpaved Roads - Re-entrained Dust	**10,174**	**5,532**	45.6
Agricultural Tilling	3,572	3,572	0.0
Paved Roads	3,419	5,839	-70.8
General Building Construction	**955**	**1,558**	-63.0
Road Construction	**901**	**1,427**	-58.3
Lawn & garden	**129**	**207**	-60.0
Stationary Sources	77	119	-54.5
Agricultural and Prescribed Burning	41	34	16.2
Railroad Locomotives	17	15	11.8
Agricultural Cultivation and Harvesting	16	16	0.0
Light Commercial Vehicles (Nonroad)	**16**	**16**	0.0
Aircraft	16	16	-5.8
ATVs	**3.6**	**5.9**	-63.0
Unpaved Airstrips	1	1	-10.0
Total	**90,319**	**86,735**	4.0

% Change: Positive values are decreases in emissions;
Negative values are increases in emissions.

***Note:** The following categories in bold have been revised from the original inventory: windblown dust, unpaved roads, general building construction, and road construction. Three other categories in bold were added to the inventory: lawn & garden, light commercial vehicles, and ATVs.

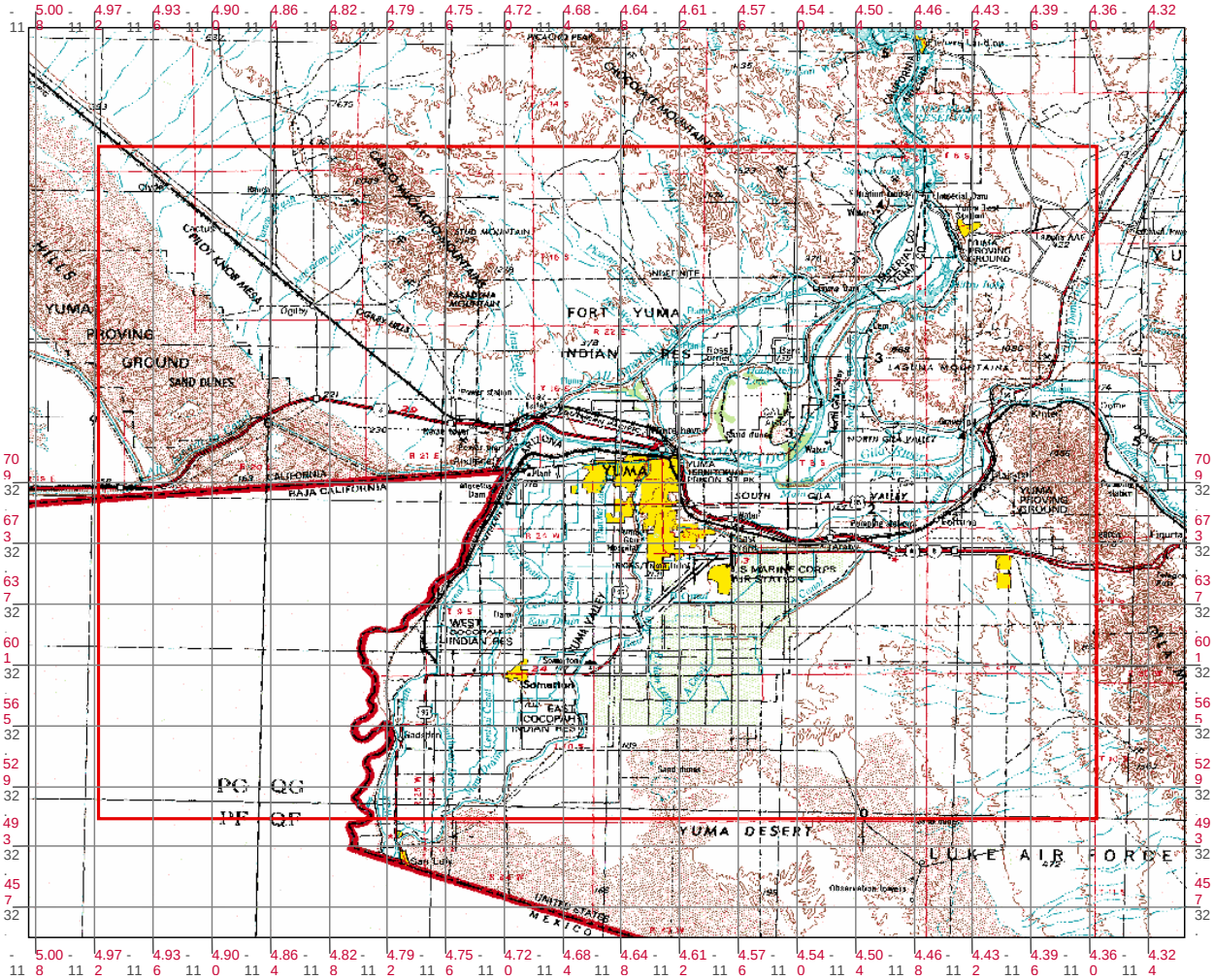

Figure 2-2. Yuma PM_{10} Emissions and Air Quality Modeling Domain (Orange Rectangle)

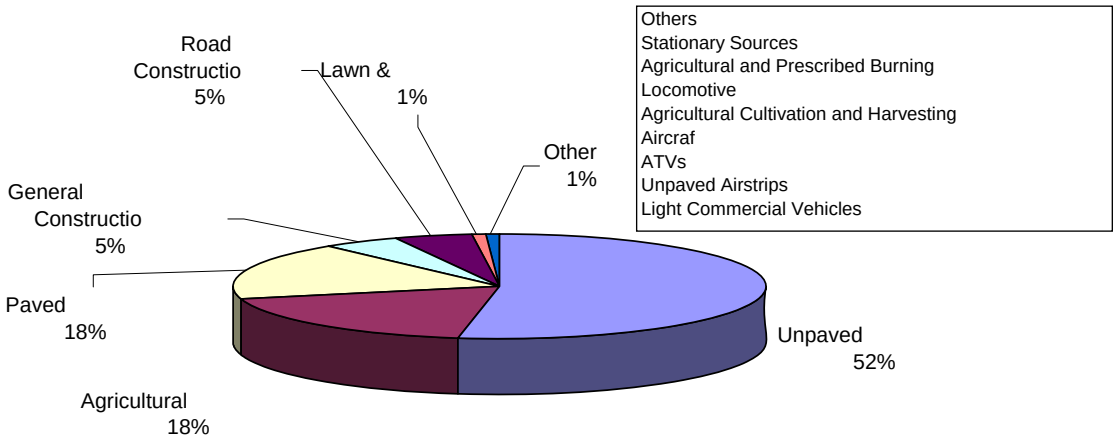

Figure 2-3a. Distribution of 1999 Yuma PM_{10} Emissions Low-Wind Days

The windbown dust category was divided into six categories, as shown in Table 2-4 and Figure 2-4, with vacant agricultural fields, miscellaneous disturbed areas, and unpaved agricultural roads accounting for 94% of the windblown PM_{10} emissions. The wide differences between the surface area of each category and the annual emissions reflect the variable potential of the different land surfaces to produce windblown dust emissions.

Table 2-4. Windblown PM_{10} Emissions

Source Category	Acres	Tons/Yr
Vacant Agricultural Fields	18,100	6,584
Miscellaneous Disturbed Areas	26,000	33,996
Unpaved Agricultural Roads	17,000	22,160
Urban Disturbed Areas	4,100	5,442
Alluvial Plains	141,000	2,517
Native Desert	74,300	282

Agricultural statistics come directly from the emissions inventory and reflect the modeling area, which is much larger than the nonattainment area. Non-citrus acreage in the nonattainment area is 60,000 acres (See Appendix C).

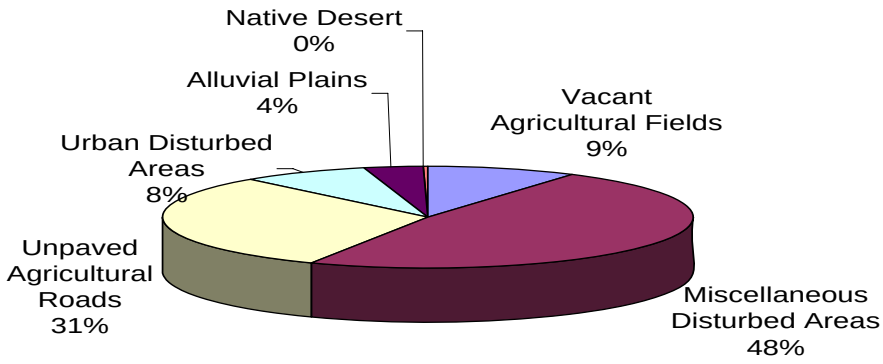

Figure 2-3b. 1999 Yuma PM_{10} Windblown Dust Emissions

2.3.2 Additional Aspects of the Emissions Inventory

This section discusses aspects of the emissions inventory not covered in the Pechan report.

The PM_{10} emissions inventory for modeling, developed for the Yuma study area, covered eight days each for the years 1999 and 2016 (Table 2-5). The inventory was completed before the air quality design dates were chosen. Therefore, these emission inventory dates do not match the chosen air quality dates exactly. The emission inventory date was matched with the most appropriate air quality date, based on season, day-of-week, and presence or absence of agricultural emissions and windblown emissions.

Including design dates with high wind speeds, (see Table 2-2 on page 2-3) was done for the simple reason that these are among the most difficult to show compliance with the standards. For the high-wind day, the emissions fed into the air quality model had windblown emissions for only those hours with average wind speeds in excess of 15 miles per hour. This is the threshold wind speed for dust resuspension. Through this approach, high-wind design dates were chosen which had the right windblown emissions from the inventory on an hourly basis.

Table 2-5. Study Dates for the Emissions Inventory

Julian Day	Calendar Date
99015	Friday, January 15, 1999
99017	Sunday, January 17, 1999
99105	Thursday, April 15, 1999
99107	Saturday, April 17, 1999
99196	Thursday, July 15, 1999
99198	Saturday, July 17, 1999
99288	Friday, October 15, 1999
99290	Sunday, October 17, 1999
16015	Tuesday, January 15, 2016
16020	Sunday, January 20, 2016
16105	Monday, April 15, 2016
16110	Saturday, April 20, 2016
16196	Monday, July 15, 2016
16201	Saturday, July 20, 2016
16288	Tuesday, October 15, 2016
16293	Sunday, October 20, 2016

Pechan, the emissions inventory contractor, used a 4-kilometer (km) by 4-km grid, as shown in Figure 2-2, emission estimates, and support information to develop the modeling inventory. Additional data sources include ADEQ-developed land use data and contacts with local stakeholders. Note that this PM_{10} study area includes all of urbanized and agricultural Yuma, as well as portions of Baja, Mexico and Imperial County, California.

Pechan received 1999 emissions data for Imperial County from the California Air Resources Board. Since these data were for all of Imperial County, Pechan reviewed the data to determine which sources were likely to be within the study area portion of that county. For the Imperial County emissions Pechan retained a 14-digit Source Category Code (SCC) similar to those in the original CARB data. For Yuma County sources, a 10-digit SCC has been assigned to all sources. For emissions from the Mexico portion of the study area, Pechan used a 12-digit SCC. The only source categories for which the conventions described above do not hold are the windblown dust categories. These emission estimates were developed from land use of the entire study area. Therefore, the 10-digit SCCs that were assigned to windblown dust apply to emissions for all three areas within the study area.

Two modeling files were developed that contain the hourly emissions data for each year, 1999 and 2016. The format for these files is provided in Table 2-6. Details on the temporal allocation for each source category can be found in Appendix A.

Table 2-6. Source Categories Included with the Yuma Modeling

Source Category	Description	Spatial Surrogate	Notes
2103000000	National Defense - Yuma Proving Ground Boilers	Yuma Proving Ground Grid Cells (Built-up Area)	
2200000110	On-Road Vehicles: Interstate - Yuma County	Yuma County I-8 Road Length	Includes re-entrained dust and tire and brake wear.
2200000110	On-Road Vehicles: Interstate Ramps - Yuma County	Yuma County I-8 Road Length	Includes re-entrained dust and tire and brake wear.
2200000130	On-Road Vehicles: Principle Arterials - Yuma County	Urban and Rural Primary Road Length	Includes re-entrained dust and tire and brake wear.
2200000130	On-Road Vehicles: Minor Arterials - Yuma County	Urban and Rural Primary Road Length	Includes re-entrained dust and tire and brake wear.
2200000135	On-Road Vehicles: Urban Collectors - Yuma County	Urban Secondary Road Length	Includes re-entrained dust and tire and brake wear.
2200000135	On-Road Vehicles: Local - Yuma County	Urban Secondary Road Length	Includes re-entrained dust and tire and brake wear.
2200000170	On-Road Vehicles: Rural Major Collectors - Yuma County	Rural Secondary Road Length	Includes re-entrained dust and tire and brake wear.
2200000170	On-Road Vehicles: Rural Minor Collectors - Yuma County	Rural Secondary Road Length	Includes re-entrained dust and tire and brake wear.
2200000170	On-Road Vehicles: Local Roads - Yuma County	Rural Secondary Road Length	Includes re-entrained dust and tire and brake wear.
2275001000	Aircraft: Yuma MCAS	Runway Location	
2275001010	Aircraft: Yuma Proving Ground	Runway Location	
2275020000	Aircraft: Yuma International Airport	Runway Location	

Table 2-6. Source Categories Included with the Yuma Modeling			
Source Category	**Description**	**Spatial Surrogate**	**Notes**
2275050000	Aircraft: U.S. Border Patrol	Runway Location (same as YIA)	
2275085001	Unpaved Airstrips - Somerton Airstrip	Coordinates = 32 degrees 35.90' N, 114 degrees 39.91' W.	No emissions data for Imperial or MX.
2275085002	Unpaved Airstrips - Pierce Aviation	Coordinates = 32 degrees 39.27' N, 114 degrees 42.68' W.	
2285002000	Railroads - Yuma County	Yuma Co. RR Track Length	
2296000000	Unpaved Roads - Re-entrained Dust: Yuma County	Yuma County Urban Area Land Use (500) - ADEQ Shape File	
2300000000	Miscellaneous Manufacturing	Yuma County Urban Area Land Use (500) - ADEQ Shape File	
2311010001	General Building Construction - Yuma County	Locations of Warehouse and New Home Construction in 1999	
2311010002	General Building Construction - City of Yuma	Yuma City Limits	
2311010003	General Building Construction - Somerton	Somerton Town Limits	
2311030001	Road Construction - Somerton	Somerton Town Limits	No emissions data for Imperial or MX.
2311030002	Road Construction - City of Yuma	Yuma City Limits	
2311030003	Road Construction - Yuma County	County Paved Road Lengths (excl. City of Yuma, Somerton, and I-8)	
2311030004	Road Construction - ADOT	Yuma County I-8 Road Length	
2325000000	Miscellaneous Mining & Quarrying	Yuma County Urban Area Land Use (500) - ADEQ Shape File	
2730100260	Yuma Study area Windblown Dust - Vacant Agricultural Fields	Agricultural Crops Landuse (260) - ADEQ Shape File	
2730100265	Yuma Study area Windblown Dust - Unpaved Agricultural Roads	Agricultural Crops Landuse (260) - ADEQ Shape File	
2730100290	Yuma Study area Windblown Dust - Misc. Disturbed Areas	Miscellaneous Disturbed Area Land Use (290) - ADEQ Shape File	
2730100295	Yuma Study area Windblown Dust - Urban Disturbed Areas	Miscellaneous Disturbed Area Land Use (295) - ADEQ Shape File	Disturbed areas within the City of Yuma.
2730100390	Yuma Study area Windblown Dust - Natural Desert Area	Natural Desert Area Land Use (390) - ADEQ Shape File	
2730100440	Yuma Study area Windblown Dust - Alluvial Plain and Channels	Alluvial Fan Stream Channels Landuse (440) - ADEQ Shape File	Includes all alluvial land uses (410, 430, 440)
2801000005	Harvest Operations - Cotton	Yuma Co. Agricultural Crops Land Use (260) - ADEQ Shape File	
2801001003	Tilling - Cotton	Yuma Co. Agricultural Crops Land Use (260) - ADEQ Shape File	
2801002003	Tilling - Barley	Yuma Co. Agricultural Crops Land Use (260) - ADEQ Shape File	
2801003003	Tilling - Hay	Yuma Co. Agricultural Crops Land Use (260) - ADEQ Shape File	
2801004003	Tilling - Wheat	Yuma Co. Agricultural Crops Land Use (260) - ADEQ Shape File	
2801005003	Tilling - Vegetables	Yuma Co. Agricultural Crops Land Use (260) - ADEQ Shape File	
2801006003	Tilling - Corn	Yuma Co. Agricultural Crops Land Use (260) - ADEQ Shape File	
2801100000	Yuma County - Yuco Cotton Gin	Coordinates = 32 degrees 42.27' N, 114 degrees 27.73' W.	

Table 2-6. Source Categories Included with the Yuma Modeling			
Source Category	**Description**	**Spatial Surrogate**	**Notes**
2801500001	Yuma Co. Agricultural Burning: Bermuda Grass	Yuma Co. Agricultural Crops Landuse (260) - ADEQ Shape File	
2801500002	Yuma Co. Agricultural Burning: Wheat	Yuma Co. Agricultural Crops Landuse (260) - ADEQ Shape File	
2801500003	Yuma Co. Agricultural Burning: Citrus	Yuma Co. Agricultural Crops Landuse (260) - ADEQ Shape File	
300000000001	Mexico Agricultural Burning - Wheat/Sudan Grass	Mexico Crop Land	
350000000001	Mexico Wheat Tilling	Mexico Agricultural Crops Land Use (260) - ADEQ Shape File	
350000000002	Mexico Vegetables Tilling	Mexico Agricultural Crops Land Use (260) - ADEQ Shape File	
500000000000	On-Road Vehicles: Mexico Hwy 2	MX Hwy 2 Road Length	Includes re-entrained dust and tire and brake wear.
500000000010	On-Road Vehicles: Other Mexico Paved Roads	Mexico Portion of the Study area	Includes re-entrained dust and tire and brake wear.
62060000000000	Agricultural: Imperial Co. Harvest Operations	Imperial Co. Crops Land Use (260) - ADEQ Shape File	
62060000000000	Agricultural: Imperial Co. Agricultural Tilling	Imperial Co. Crops Land Use (260) - ADEQ Shape File	
62060000000000	Agricultural: Farm Equipment	Imperial Co. Crops Land Use (260) - ADEQ Shape File	
62060000000010	Agricultural: Food and Ag. Industrial Processes	Imperial Co. Crops Land Use (260) - ADEQ Shape File	
62060000000010	Agricultural: Food and Ag. Boilers	Imperial Co. Crops Land Use (260) - ADEQ Shape File	
64564000000000	Unpaved Roads - Re-entrained Dust: Imperial County	Imperial Co. Misc. Disturbed Land Use (290) - ADEQ Shape File	
67066202620000	Imperial County Agricultural Burning Emissions - Total	Imperial County Crop Land	
70000000000000	On-Road Vehicles: Imperial County	Urban and Rural Primary Road Length	Includes re-entrained dust and tire and brake wear.
82082012100000	Railroads - Imperial County	Imperial Co. RR Track Length	

2.3.3. Converting the Contractor's Inventory into Model-Ready Format

This section explains how the contractor's inventory had to be modified to make it ready for the air quality modeling.

Although Pechan had developed the emissions inventory to be "model ready", further work was necessary to enable the ISCST-3 model to read the input values. ISC is limited to an eight character name for the source category. Since the source categories were Source Category Codes (SCC) values and many exceeded the eight character limit, a new system for nomenclature had to be developed. Ultimately, each SCC was modified to reflect the source category location and type while utilizing only four digits. This was achieved by replacing the SCC numbers with alpha numeric codes like AA12, where AA was the source category and 1 = X coordinate and 2 = Y coordinate. This system allowed the modeler to (somewhat more easily then using numbers alone) turn on and off specific source categories in specific locations. This step was necessary in that not only did it provide source category names that ISC could understand, but it also provided more control for the modeler. Because the emissions inventory was unified, it was somewhat difficult to conduct source category contribution modeling without these modifications to the nomenclature.

In addition to the formatting modifications, some changes were made to the modeling days provided. Pechan built the inventory using the days described in Table 2-4. The Yuma air quality modeling work paired each inventory with the most appropriate design day, based on the season, day of week, and presence or absence of agricultural activity. For example, the Pechan inventory day of Friday, January 15, 1999, was used for the design date of December 8, 1999. This matching of the inventory day with the air quality date illustrates how the most appropriate inventory was paired with the air quality observation and modeling date.

Additional details on the modeling inventory not covered by Pechan include:

- For each source category, Pechan included a value for the initial vertical dimension ($S_{z\text{-init}}$) required by ISC3 (i.e., the initial vertical height of the plume before horizontal advection begins). All of the $S_{z\text{-init}}$ assignments were made using engineering judgment. For area sources, this value is given by the vertical dimension divided by 4.3 for sources elevated above the ground and by the vertical dimension divided by 2.15 for sources emanating from the ground surface. The "engineering judgment" comes into play in knowing whether the source is better characterized as coming from the surface or from above the surface, and in having a reasonable idea of what the initial vertical dimension of the plume is. Initial vertical dimensions in the Yuma PM_{10} modeling ranged from 0 to 3 meters, as shown in the Table 2-7.

Table 2-7. Initial Vertical Dimensions of Emission Sources

Emission Source Category	$S_{z\text{-init}}$* (Meters)
On-Road Vehicles Paved & Unpaved	0-1
Aircraft	1-2
Railroads	1-3
Ag Burning	0
Ag Food/Industrial Boilers	0
Windblown -- All Categories	0

*$S_{z\text{-init}}$: the initial vertical dimension of a plume

- For windblown dust emissions, March 31 was selected as the high-wind modeling day, because its PM_{10} concentrations were the highest of the year. For 2016, Pechan assumed that winds would occur on March 31 with the same frequency and magnitude. As for other 1999 days with high winds, there were three days with one or more hours of an average hourly wind speed in excess of 15 miles per hour, and 41 days whose maximum instantaneous wind speed exceeded this value. March 31 was the most severe and had the highest PM_{10} concentrations. In the selection of the seven design dates it is important to have dates throughout the concentration range, including all four seasons, as well as to include a high-wind day. As explained later in this chapter, the modeling for the high wind day was unsuccessful and the day had to be dropped from the analysis. Figure 2-1 illustrates that the choice extends from the highest to the lowest concentrations. Given the frequency of winds high enough to resuspend dust – three days out of 365 in 1999 – modeling a single high wind day was sufficient.

  Limiting the high-wind analysis to the single day with the highest PM concentrations was necessary and sufficient. First, it allowed for a greater effort in modeling the kinds of anthropogenic emissions that were more easily controlled than wind-blown emissions. These would include dust from construction of roads and home sites, dust from unpaved roads, both agricultural and municipal, and dust from paved roads. These are the emissions which, on a day to day basis, need to be controlled to meet air quality standards. Second, the choice of a single high-wind day eliminated some difficult simulations necessary to produce concentrations reasonable when compared to the measurements. As discussed later in this chapter, the modeling system – emissions of windblown dust pegged to an hourly average wind speed of 15 miles per hour, driving an air quality dispersion model – was unable to produce realistic PM_{10} concentrations under these high wind conditions. Third, attempting to simulate similar conditions without extensive applied research would have been unproductive. This research would better quantify the land surfaces associated with windblown emissions, would elicit the temporal decay curves that arise from the depletion of upwind suspendable dust in a multi-hour wind event, and, perhaps, would invoke deposition algorithms in a more effective way. As such research was beyond the scope of this project, a single high-wind day was modeled. Finally, since the monitored PM concentration for the day modeled was more than 30% below the PM_{10} 24-hour National Ambient Air Quality Standard (NAAQS), modeling additional windy days with lower PM_{10} concentrations add no value to the effort of demonstrating attainment of the NAAQS.

- Pechan evaluated new emissions data for sand dunes. These tests, on sand dunes near Owens Dry Lake, CA, suggest that threshold wind speeds in excess of 35 mph are needed to generate significant PM_{10} emissions from sand dunes. The surface winds evaluated for the Yuma Study area in 1999 did not exceed 30 mph (Yuma Valley AZMET station). Therefore, no emissions were assigned to sand dunes in 1999 or 2016.

- During 1999, agricultural burning in the Bard/Winterhaven area of Imperial County was limited to 50 acres of alfalfa and 4 acres of tree trimmings. All burning was conducted in August of that year; hence, no Imperial County agricultural burning emissions appear in the modeling inventory.

- Pechan estimated Mexican on-road vehicle emissions from information provided by ADEQ. ADEQ provided estimates of roadway length for Mexican Highway 2 and other paved roads, as well as the number of vehicles using these roads each day (10,0000 vehicles on Highway 2 and 3,000 on other paved roads). Pechan found that Mexican Highway 2 fell outside of the study area boundaries. Therefore, these emissions were left out of the modeling inventory. ADEQ's estimate for other paved roads (217 miles) was used to estimate VMT. For 1999, the estimated Mexican on-road emissions were 935 tons from paved roads within the study area. For other paved roads, the emission factors corresponding to major collectors in Yuma County were used. To estimate 2016 emissions, the growth in VMT was estimated from VMT growth estimated for Yuma County. Hence, the on-road Mexican emissions are based on emission factors for a U.S. fleet and do not reflect emissions from a potentially dirtier Mexican fleet. This disparity makes little difference, it should be pointed out, because of the small contribution of tailpipe emissions in the whole of the monitoring domain and the even smaller contribution from those in Baja.

- Vehicle miles traveled (VMT) and emission factor information used by Pechan in building the inventory are included as two reports in Appendix E.

- The 50% reduction in unpaved road emissions from the base to the future year in the Pechan emission inventory is based upon stated assumptions in the two Lima and Associates reports (Appendix C). These assumptions were made in consultation with the Yuma Planning Organization, for whom the reports were written. A reasonable check on this rate of progress would be to determine the dirt roads paved and the emissions reduced in 1999 – 2004. This information is contained in Chapter 3, "Controls," but the paving projects are part of a diverse mix of dust reduction efforts. Table 2-8, which presents this unpaved road paving and emissions information, shows that from 2000 through 2004, unpaved road emissions have been reduced by about 8% each year. This pace is about twice as fast as the assumption of a 50% reduction in unpaved road emissions between 1999 and 2016 built into the inventory (at an 8% rate, the 2016 unpaved road total would be about 2500 tons, as opposed to the roughly 10,000 tons in 1999 and 5,000 tons in 2016).

- The vehicle miles traveled (VMT) growth rates from 1999 to 2013 and from 2013 to 2016 are described in the second Lima and Associates report that is in Appendix E.

- The suitability of either 1999 or 2005 as a "base year" for the maintenance plan is discussed in Appendix D. Basically the years are equivalent because neither the PM_{10} concentrations nor the emission totals change appreciably in this period.

Table 2-8. Unpaved Roads Paved in 2000 – 2004, with Emission Reductions

Agency	Miles	Tons/Year	%
City of Yuma	8.72	2011	
Somerton	6.16	837	
Yuma County	1.75	345	
Yuma County Water Users	2.50	345	
Marine Corps Air Station	1.33	1.4	
Developers	12.00	306.6	
Yuma, Yuma County, Somerton	1.54	78.7	
Total (2000 - 2004)	34.00	3924.7	
Annual Average	6.8	784.94	
Unpaved Road Total (Pechan)		10183	
Annual as % of Unpaved Road Total			**7.7**

Figures 2-4 and 2-5 are emissions density plots for two days in 1999. Figure 2-4 is a day in which there were no windblown dust emissions in the inventory, while Figure 2-5 is a day in which windblown dust emissions occur. Notice the difference in the scales and density saturation between the two maps. The high wind day has a majority of the domain covered with cells that have a density of 10,000 to 300,000 g/m² PM_{10}, while the low wind day is mostly dominated by lower density cells ranging from 1,000 to 60,000 g/m² PM_{10}. The emission totals for high wind days are roughly five times the PM_{10} emissions on the low wind days. A higher emission density throughout the domain for the high wind day, as compared to the low, would be expected. It's still easy to see that on a low-wind day the domain is dominated by light emission densities except for the area along the I-8 corridor.

Another notable difference in the maps can be seen in their upper right corners. The low wind map has light

emission densities (none greater than 30,000 g/m²), while the high wind day has quite dense emissions, with values as high as 600,000 g/m². This difference can be attributed to the dominance of windblown emissions for those cells. This makes sense, given that a majority of this area consists of miscellaneous disturbed ground surfaces associated with the Yuma Proving Grounds and would not materially affect local emissions unless wind speeds exceeded the resuspension threshold. This threshold was exceeded on the April 15, 1999, high-wind day, but not on the January 15, 1999, low-wind day: hence, the difference in these two maps.

Recommendations for future improvement to the Yuma Study area inventory follow:

- *Improve spatial allocation of agricultural emissions:* Pechan investigated the use of survey information from the U.S. Bureau of Reclamation (USBR) on the location of various crop types in Yuma and Imperial Counties (those using Colorado River water for irrigation). Unfortunately, less than 8,000 acres had survey data (including fallow and vacant fields), representing less than 5% of the Yuma-Imperial crop land. Stakeholders may be able to shed light on which portions of the study area agricultural lands are used to raise certain crop types. Important crop types include citrus, wheat, cotton, and vegetables. In the current inventory, emissions for agricultural tilling, harvesting, and burning operations are spread over the entire county-level crop land use area; and

- *Gather additional information to estimate Mexican emissions:* Missing source categories include unpaved roads and open burning (e.g. household waste). Incorporate refined data to estimate on-road emissions, including emission factors for a Mexican fleet.

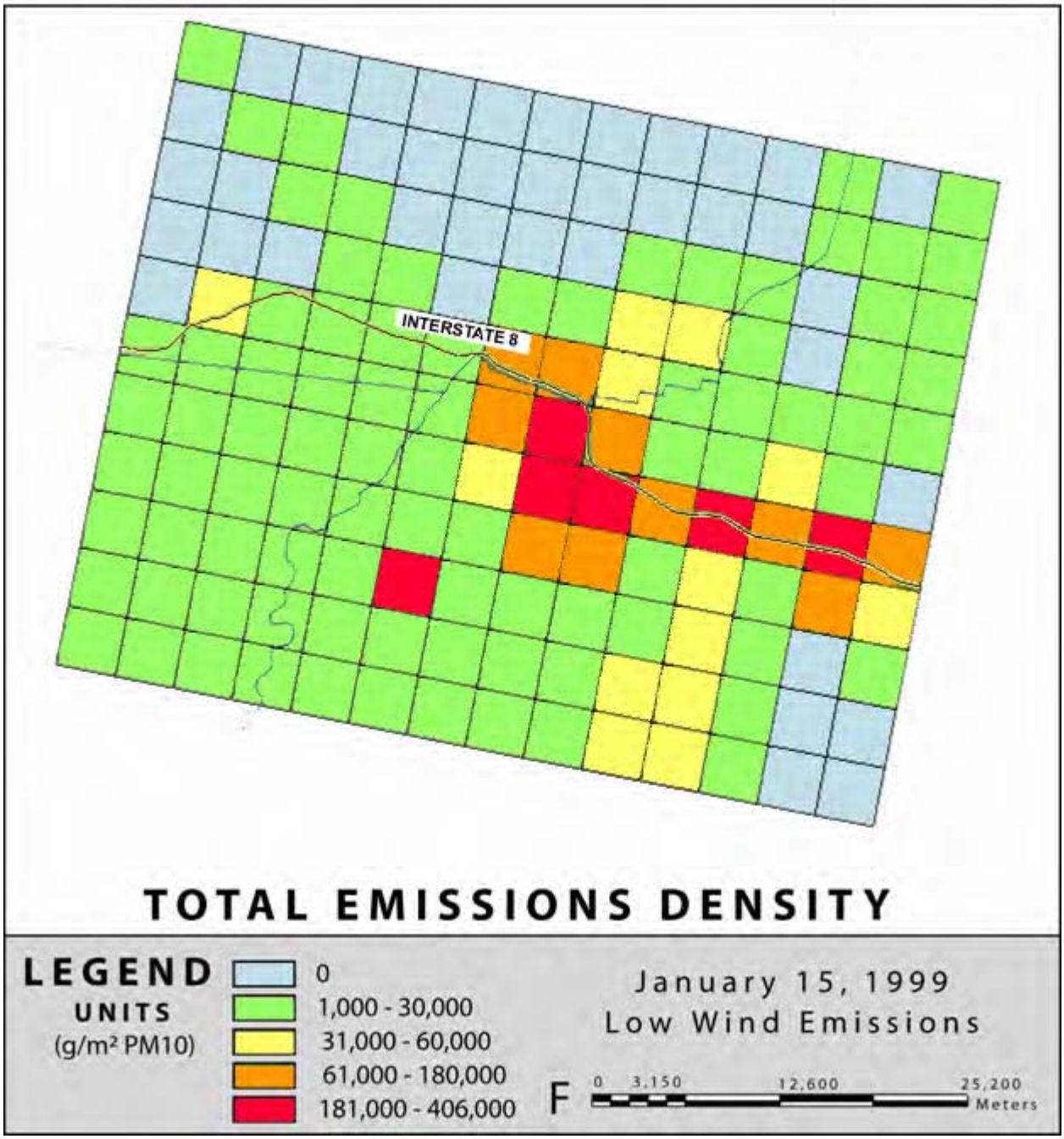

Figure 2-4. Distribution of 1999 Yuma PM_{10} Low Wind Emissions

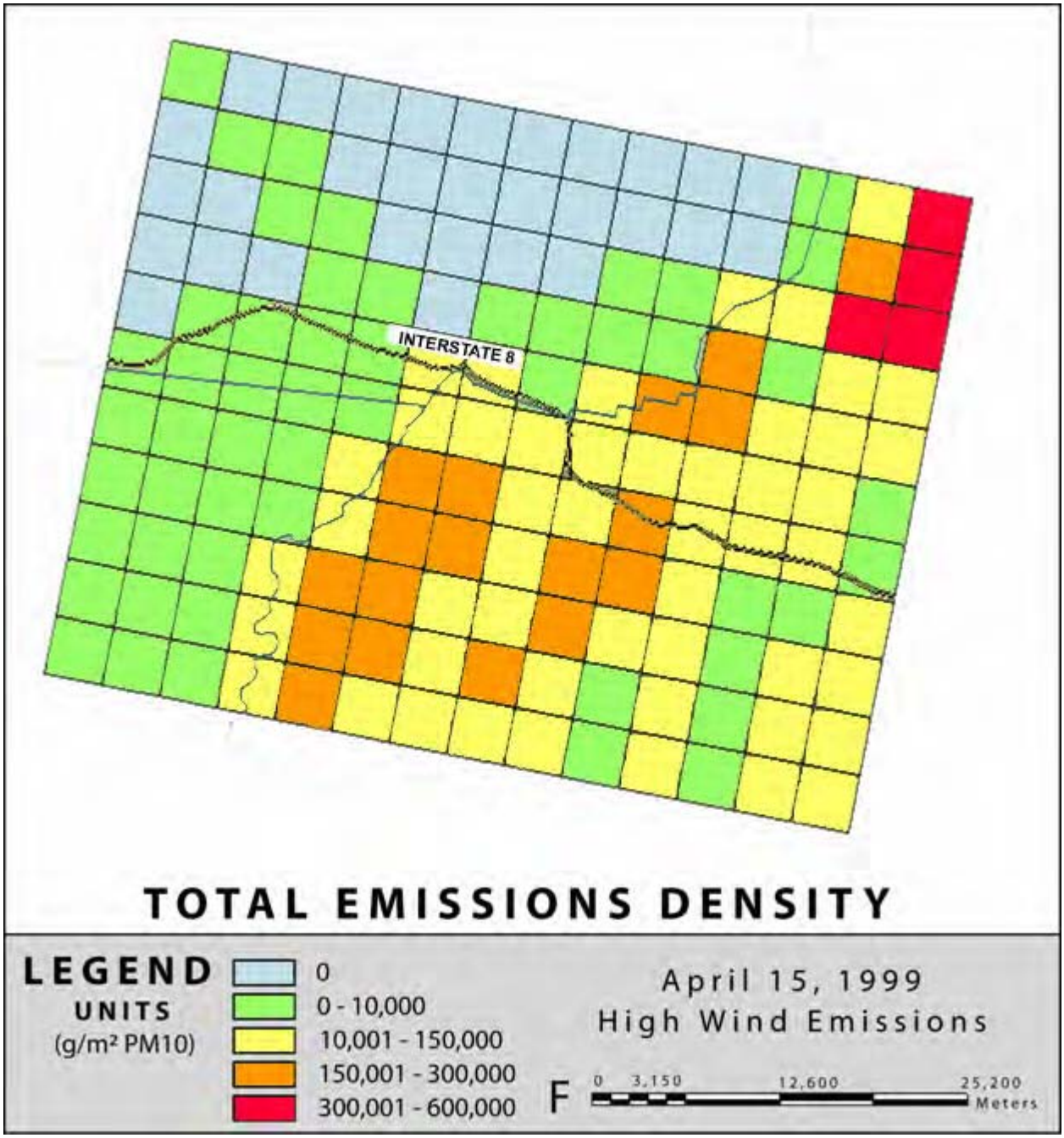

Figure 2-5. Distribution of 1999 Yuma PM_{10} High Wind Emissions

2.4 Background Concentrations

2.4.1 Introduction

Background concentrations of an air pollutant are those concentrations that would be measured in the total absence of any anthropogenic emissions in a particular study area. Outside of any study area both anthropogenic and natural emissions give rise to background concentrations. The Yuma PM_{10} background concentrations arise from both natural and anthropogenic sources in Mexico, California, and other parts of Arizona. These concentrations are transported into Yuma and are considered that part of the total aerosol that is not subject to reduction through local controls.

A slightly different way of looking at this phenomenon would be to imagine a small study area in the heart of a large city with dense emissions of air pollutants. The study area would have emissions that are a small fraction (say 1%) of the city's total. The objective would be to determine how effective reductions of "local emissions" inside the study area would be in lowering local air pollution levels. To achieve this goal, the air pollution arising from the rest of the city's emissions would have to be measured, since the city-wide concentrations would be transported into the study area. These measurements could be done at the boundaries of the study area and would be called "background concentrations." The relationship between local emissions and local concentrations within the study area could be quantified through an inventory of emissions and an air quality model. When this was finished, however, the background concentrations from the rest of the city would have to be taken into account. If the proposed controls were strictly local – that is, within the study area – then it is apparent that with background concentrations kept constant, the local controls would have little effect.

In the technical work for this Yuma PM_{10} maintenance plan, the study area is rather large: 56 x 44 kilometers. In simulating PM_{10} concentrations with a numerical model, it is the "local emissions", those coming from human activities (and high winds) within the modeling domain, that determine its simulations of PM_{10} concentrations. Nonetheless, PM_{10} concentrations prevail outside this modeling domain; they result from both natural and anthropogenic emissions outside the modeling domain; but are transported into it. These "outside" or "background" PM_{10} concentrations contribute to the locally generated concentrations. They have to be accounted for in assessing the air quality in Yuma.

To quantify the Yuma background concentrations, monitored PM_{10} concentrations from outside the Yuma modeling domain, mixing heights, wind speeds and directions, and the hourly distribution of background PM_{10} concentrations were all brought to bear. The calculated background concentrations are added to those predicted by the model, which are based entirely on local Yuma emissions. This sum of concentrations coming from the emissions within the modeling domain plus background PM_{10} concentrations – otherwise known as the "total prediction" -- can then be compared with the measurements.

Accounting for that portion of the PM_{10} concentration, whether measured or modeled, that does not result from emissions within the study area is crucial to predicting accurate outcomes. No amount of emission reductions within the Yuma modeling domain will diminish those PM_{10} concentrations originating from elsewhere. Calculating these imported concentrations allows one to accurately relate the Yuma emissions to the Yuma PM_{10} concentrations. Having this accurate relationship ensures that reductions in the local Yuma emissions will be translated into realistic predictions of air quality, fully accounting for that portion of the PM_{10} concentration – the "background" concentration --- that is independent of and unaffected by local controls.

2.4.2 Data Sources

Ambient PM_{10} monitoring data for the design days was available in 24-hour averages from several locations, all of which were brought into the background calculations (Figure 2-6). The Yuma PM_{10} concentrations were measured with dichotomous samplers, which give separate measurements for fine (particles less than 2.5 microns) and coarse (2.5 – 10 microns) particulates. Hourly PM_{10} concentration profiles were available from Green Valley, Arizona and Calexico, California. Wind speed and direction were available from several sites in the Yuma vicinity. Mixing heights were calculated from the upper air observations in Tucson. These

monitoring sites, presented in Table 2-9, provided the information to produce hourly and 24-hour PM_{10} background concentrations as described below.

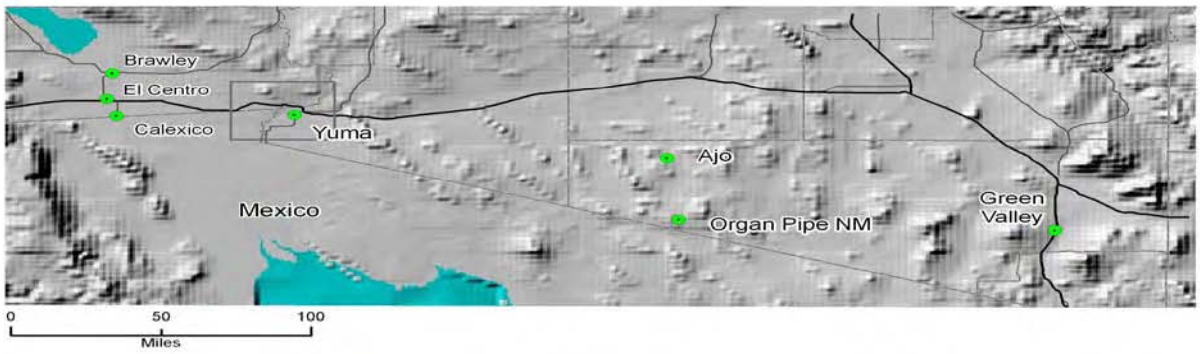

Figure 2-6. Background PM_{10} Sites in the Vicinity of Yuma, Arizona

Table 2-9. Measurement Sites in the Background Calculations Particulate Matter (PM)			
$PM_{2.5}$ and $PM_{2.5-10}$ (24-Hour Averages)	**PM_{10} (24-Hour Averages)**	**PM_{10} Hourly**	**Wind Speed And Direction**
Yuma	Yuma		Yuma
		Green Valley	Many Others
Organ Pipe	Organ Pipe	Calexico, CA	
Ajo			
El Centro, CA			
Brawley, CA			

2.4.3 Overview of PM_{10} Background Calculations

The calculation of background concentrations for Yuma is a multi-step process that accounts for wind direction, wind speed, mixing heights, and gravitational settling of fine and coarse PM. This accounting has to be done on an hourly basis, even though most of the PM measurements are 24-hour average integrated samples.

The hourly PM_{10} concentrations at the various sites in the Yuma vicinity were calculated by applying the urban or rural (Calexico or Green Valley) percent distribution curve to the particular 24-hour PM_{10} average at the site. Hourly wind speeds and directions were used to establish reasonable transport paths. The numerical value of the outlying hourly concentration was not mapped directly onto the Yuma perimeter. Instead, these concentrations were reduced to account for the deposition of the coarse particles. A more sophisticated approach would have included the injection of PM_{10} emissions into the air parcel as it was transported towards Yuma. This approach was not taken because it would have required the use of a dispersion or puff model such as CALPUFF. Furthermore, the trajectory paths from the Imperial Valley and from south-central Arizona overlie land surfaces with minimal human activity.

A slightly different way to look at this method is as follows. First, an hourly PM_{10} concentration from an outlying, background monitor is calculated. Second, instead of assuming that this concentration would be present after transport to the Yuma perimeter, this outlying concentration is reduced to account for the large particle settling or “deposition” that occurs during transport.

An additional complication – not dealt with in this method – concerns obstructions from elevated terrain that affect the transport of PM emissions. Including such terrain effects would have been much too complex for the scope of this study, so flat terrain is assumed. The following sections explain the steps of these calculations.

2.4.4 Hourly PM_{10} Concentrations

The first step in calculating the composite background PM concentration is to obtain the mean hourly percent contribution of PM for any given day per season. These sites were chosen to represent both urban, high-emission areas (Calexico) and rural, and near pristine conditions (Green Valley). The Green Valley site, operated by Pima County, is in what can arguably be called a background area. Green Valley, Arizona, 25 miles south of Tucson, has had annual PM_{10} concentrations from 1989 through 2003 averaging 17 $\mu g/m^3$, with a high of 21 and low of 14 $\mu g/m^3$. These values are higher than the pristine conditions of Organ Pipe National Monument, which averages 10 $\mu g/m^3$, but are either lower than or about equal to other somewhat remote Sonoran desert sites. The Green Valley site is representative of rural, southern Arizona PM_{10} concentrations that are influenced by neither adjacent urban emissions nor by strong, near-field localized emissions. Of all the Arizona sites with continuous PM_{10} records, nearly all of which are in metropolitan Phoenix and Tucson, Green Valley stands out as the most remote with the lowest concentrations.

Using continuous PM_{10} records from Tapered Element Oscillating Microbalance (TEOM) instruments from Calexico (1999) and Green Valley (2001), the hourly percent contribution was calculated (Eq. 1).

Seasonal % Hourly PM = (Total Seasonal Hourly PM / Total Daily PM Seasonal Mass) * 100
(Eq.1)

The total seasonal hourly PM was divided by the total daily PM seasonal mass and multiplied by 100 to yield the mean seasonal hourly percent PM. In other words, on a season-by-season basis, for each hour of the day, the hourly total of PM_{10} concentrations is divided by the daily total. This result multiplied by 100% gives the percentage of PM_{10} that each hour contributes to the daily total.

An example follows. The “total daily PM annual mass” (for the Phoenix Supersite, for 1998) is 712.9 ug/m3. The lowest hourly concentration was 22.9, and the highest, 42.2 ug/m3. Considering a single hour, hour 23, the “Total Hourly PM” is 42.2 ug/m3. Dividing the “Total Hourly PM” of 42.2 by the “Total Daily PM Mass” of 712.9 gives the “Percent Hourly PM of 5.5%. In Figure 2-7, the hour-by-hour variation of PM_{10} concentrations and of the “Percent of Hourly PM” are shown together. Though these figures are for an entire year, the same method applies to a single month or season.

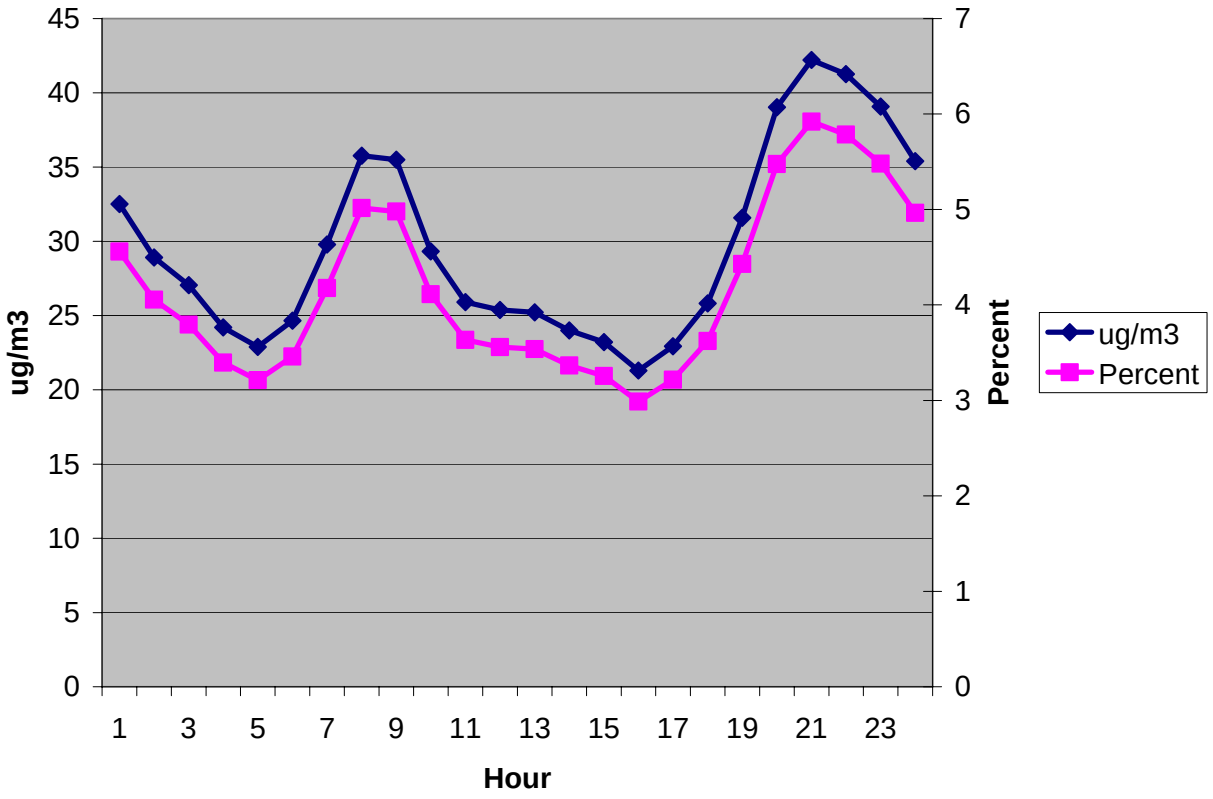

Figure 2-7. PHX Supersite: Hourly Averages in ug/m3 and the Hourly Percentage of the Daily PM_{10}

In the hourly percentage PM curves for the urban and rural sites (Figures 2-8 and 2-9), notice the flatness of the Green Valley hourly curves, in contrast with the Calexico pattern, which has both a pronounced morning and a late afternoon/evening peak. These two patterns are consistent with a near-pristine background site, whose local emissions approach zero, and with a high-emission urban site, whose localized emissions are much stronger and which tend to vary throughout the day in concert with human activities, principally, but by no means entirely, vehicular traffic.

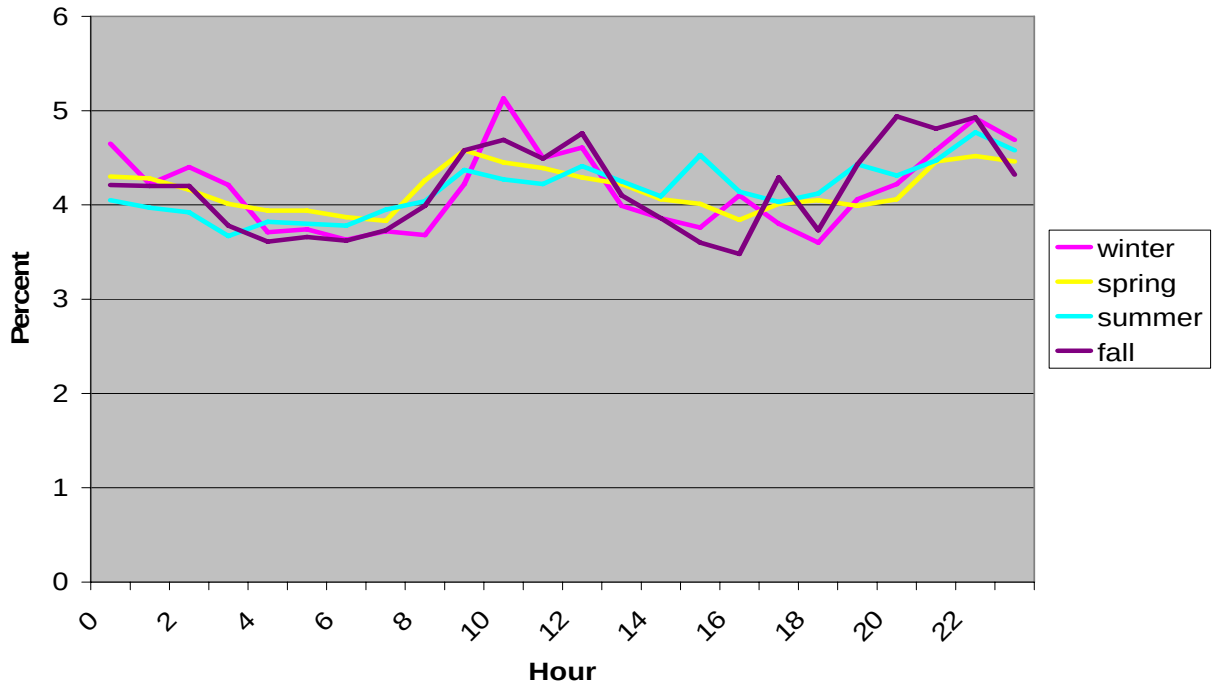

Figure 2-8. PM_{10} Hourly Profile of Remote Desert Sites, Based on Green Valley, AZ

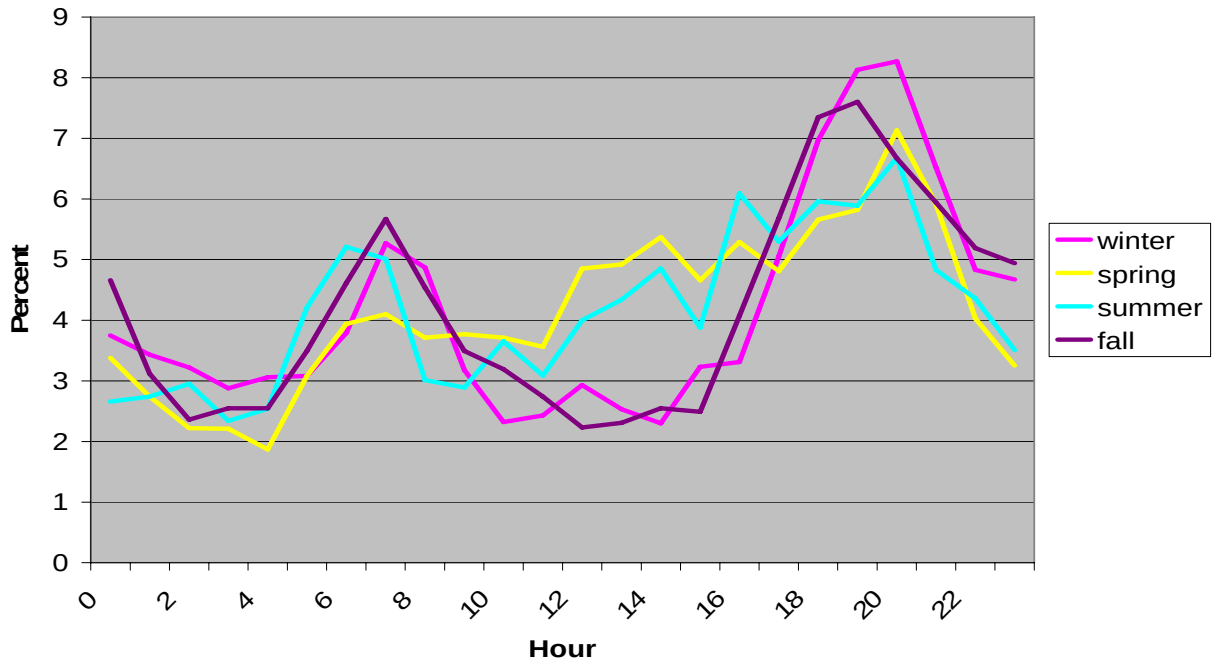

Figure 2-9. PM_{10} Hourly Profile from Urban Desert Sites with Considerable Agricultural and Vehicular Emissions, Based on Calexico, CA

2.4.5 Regional Contribution to Background PM

The contribution to background PM_{10} in Yuma uses wind direction, wind speed, and mixing heights in the composite estimation process. The wind direction is used to identify which source sector contributes for that hour. For example, if the wind direction is out of the south to the west, then the hourly pattern was based on the PM measurements from Calexico. All other sectors were based on Green Valley. Thus, the regional composite PM background concentration – on an hourly basis -- is the 24-hour concentration recorded at a background site, multiplied by the hourly percent value from either the Calexico or Green Valley sectors. If the wind for a given hour was from the west, then the 24-hour PM average from an Imperial Valley site for that specific sampling date would be multiplied by the percent contribution for the given hour from Calexico (Eq. 2) to yield the hourly PM concentration. These hourly concentrations, as explained below, were treated further to account for particle settling.

Hourly PM = 24-hour Average * Seasonal Hourly Percentage (Eq. 2)

2.4.6 Adjusting the Hourly PM Concentration for Deposition During Transport to Yuma

The deposition of particulate matter is a well known phenomenon, with higher deposition rates associated with coarser particles. By PM_{10} being divided into fine and coarse fractions (less than 2.5 microns for "fine" and 2.5 – 10 microns for "coarse"), appropriate deposition rates, and thus removal rates, can be assigned to the two particle size fractions. In their transport towards Yuma from these outlying regions, the particulates are reduced by a simple deposition method. This method consists of reducing the coarse fraction of remote ambient PM_{10} that reaches Yuma. This method takes into account the mixing height and wind speed and therefore transport time of the air parcel. In doing so, it reduces the transported concentrations and thus lowers the background concentration. As discussed previously, it does not attempt to incorporate fresh PM_{10} emissions along the transport paths, which are largely moving over undisturbed desert.

Consider an elevated PM_{10} concentration in Calexico or Brawley, consisting roughly of two thirds coarse, geological particles emitted by some "fugitive dust" activity, such as tilling or driving on unpaved roads. The bulk of these coarse, fugitive emissions, emitted at ground level, will "fall out" of a transported air parcel on its way to Yuma. This method reduces that portion of the coarse particles unlikely to remain suspended in the air during transport to Yuma. Table 2-10 gives both the outlying PM_{10} concentrations and the Yuma background concentrations derived from them.

Table 2-10. Calculated Background PM_{10} Concentrations

Date	Upwind PM_{10}	Winds		Calculated Background PM ($\mu g/m^3$)			Yuma PM_{10}	Back-ground %*
		Speed	Dir.	$PM_{2.5}$	$PM_{2.5-10}$	PM_{10}		
12 Jan	40-60	Low	SSE-WSW	7.1	8.2	15.3	52	30
31 Mar	40-60	High	WNW	10.1	14.4	24.5	88	28
30 May	20-120	Low	SW,NW	10.5	20.7	31.3	26	123
23 Jun	30-50	High	SSW-SSE	10.2	21.4	31.6	44	73
17Jul	25-40	Low	WNW-NNW	10.5	17.9	28.4	19	150
8 Nov	25	Low	WNW	5.9	7.6	13.6	32	43
8 Dec	30-40	Low	NNW	6.8	7.2	14.0	46	30

*%: the background concentration as a percentage of Yuma PM_{10}. The average of the two concentrations was used where available.

This table illustrates that the upwind PM_{10} concentrations have been reduced substantially. This reduction comes through applying a simple model that expresses deposition as a function of particle size (fine or coarse), transport time, and mixing height. The degree of deposition was based on the transport time (i.e. wind speed and distance to the Yuma perimeter), on mixing height, and on the size distribution of PM_{10}. Based on ambient sampling in many sites throughout the state, and understanding that in rural areas the primary source of ambient particulates is geological, one third of the PM_{10} is assigned to the 0 – 2.5 micron range and two thirds of PM_{10} is assigned to the 2.5 – 10 micron range. On an hour by hour basis, then, the PM_{10} in the air parcel on its trajectory towards Yuma was depleted in accordance with the methods described in "Methodology For Estimating Fugitive Windblown And Mechanically Resuspended Road Dust Emissions Applicable for Regional Scale Air Quality Modeling", Western Governors Association Contract No. 30203-9, R. Countess et al, April 2001. Given the wide range of wind speeds and mixing heights, this deposition method depleted the monitored PM_{10} concentrations from five to 85% on an hourly basis.

Table 2-9 contains some perplexing results: for example, why should the background be equal on a low-wind day (May 30) and high-wind day (June 23)? The upwind concentrations on the low wind day of May 30 ranged from 20 to 120 ug/m3, depending on wind direction. The higher concentrations, in the Imperial Valley, were transported by westerly winds into Yuma. On June 23 the upwind concentrations were much lower, ranging from 30 to 50 ug/m3. Faster transport winds decreased the amount of deposition and delivered the same 31-32 ug/m3 to Yuma as on the low-wind day.

2.4.7 Results of Background Calculations

These calculations yielded reasonable background values for five of the seven design days (Table 2-8). For May 30 and July 17, however, the calculated background concentrations exceeded the Yuma measurements. While this is not an impossibility, it does defy the logic of the entire background exercise. The Yuma concentrations on these two days were extremely low: 21 and 30 $\mu g/m^3$ on May 30 and 19 $\mu g/m^3$ on July 17. Concentrations in the surrounding areas were apparently higher than in Yuma, as calculated by this method.

Part of the anomalously high background concentrations on the two dates could be that the same sources are contributing to both 'background' concentrations and concentrations in Yuma. The distances involved argue against large contributions to Yuma PM_{10} from these outlying sources. The background sites of Palo Verde (107 miles), Ajo (102 miles), and El Centro (65 miles) are too distant from Yuma to make major contributions to its PM_{10} loading. In addition, the Ajo and Palo Verde sites lie east of Yuma, which puts them predominantly downwind due to prevailing daytime westerly and southwesterly winds. As Tables 2-10 and 2-11 show, however, the contributions are on the order of 30% with, on occasion, even higher contributions possible. Sources in the immediate vicinity of these background monitors, as well as sources between them and Yuma, do contribute to both concentrations.

The rationale for using Organ Pipe background on the two days when the calculated values exceeded those in Yuma is that this site is the most pristine, most isolated, monitoring site and it has the lowest PM_{10} concentrations in southern Arizona. That two of the seven background calculations gave illogical values suggests what is already known: that on a particular day there is much about emission patterns and transport that we simply don't know. Concentrations of this magnitude that approach pristine background levels are always more difficult to simulate and, in this background calculation method, prove to be intractable with the surrounding higher concentrations

In place of these calculated values, the 24-hour average PM_{10} concentrations from Organ Pipe National Monument for these two dates have been substituted. These final background values and the percentage they comprise of the Yuma concentrations are shown in Table 2-12.

Table 2-11. Calculated Background PM_{10} Concentrations							
Date	Winds	Measured Yuma PM_{10} ($\mu g/m^3$)		Calculated Background PM_{10} ($\mu g/m^3$)			
		Original	Duplicate	$PM_{2.5}$	$PM_{2.5-10}$	PM_{10}	%*
1/12/99	Low	55	48	7.1	8.2	15.3	29.7
3/31/99	High	102	74	10.1	14.4	24.5	27.8
5/30/99	Low	21	30	10.5	20.7	31.3	122.7
6/23/99	High	43	44	10.2	21.4	31.6	72.6
7/17/99	Low	19		10.5	17.9	28.4	149.5
11/8/99	Low		32	5.9	7.6	13.6	42.5
12/8/99	Low		46	6.8	7.2	14.0	30.4

(May 30 and July 17 are shown with their calculated values, which exceed Yuma's monitored concentrations.)

*%: Background concentration as a percentage of Yuma PM_{10}. The average of the two concentrations was used where available.

Table 2-12. Final Adjusted Background PM_{10} Concentrations							
Date	Winds	Yuma PM_{10} ($\mu g/m^3$)		Background PM_{10} ($\mu g/m^3$)			
		Original	Duplicate	$PM_{2.5}$	$PM_{2.5-10}$	PM_{10}	%*
1/12/99	Low	55	48	7.1	8.2	15.3	29.7
3/31/99	High	102	74	10.1	14.4	24.5	27.8
5/30/99	Low	21	30	**5.9**	**8.1**	**14.0**	53.8
6/23/99	High	43	44	10.2	21.4	31.6	72.6
7/17/99	Low	19		**5.7**	**8.5**	**14.2**	73.7
11/8/99	Low		32	5.9	7.6	13.6	42.5
12/8/99	Low		46	6.8	7.2	14.0	30.4

(Background values for May 30 and July 17 have been set equal to the concentrations measured at Organ Pipe National Monument on these dates.)

*%: Background concentration as a percentage of Yuma PM_{10}. The average of the two concentrations was used where available.

** 24-Hour average Organ Pipe National Monument $PM_{2.5}$, $PM_{2.5-10}$, and PM_{10} concentrations substituted for calculated values, which exceeded the measured PM_{10} concentrations in Yuma

2.5 Model Simulations for the Base Year

PM10 concentrations in Yuma, Arizona were simulated using the Industrial Source Complex Short Term (Version-3) – ISCST-3. This numerical model is a steady-state Gaussian dispersion model that has been approved by the U.S. Environmental Protection Agency and has a long history of applications in both the industrial and urban settings. The modeling domain consisted of an array of 4000 x 4000 meter grids, with a total of 154 grids covering the city of Yuma and the vicinity.

Yuma was modeled using the urban parameter for ISCST-3 with flat terrain, a unified emissions file, and the regulatory default modeling option. As for "flat" versus "complex" terrain, the area is flat enough to use the "flat" designation within the Industrial Source Complex (ISC) model. Near the northwest corner of the domain, the Cargo Muchacho Mountains (2129 feet, maximum elevation) and in the far eastern part of the domain, the Gila Mountains (3156 feet, maximum elevation) provide considerable topographical relief. This compares with elevations in the Yuma, Baja valley that range from 120 to 200 feet. Neither of these mountain ranges is in an area that produces any emissions, and being on the perimeter of the modeling domain, they don't materially affect transport in the generally broad, flat Colorado River Valley. If the concern had been predicted concentrations on these mountain peaks, then the complex terrain algorithms of ISC could have been invoked. Since they were not of concern, the flat terrain algorithms sufficed to simulate PM_{10} concentrations within the valley.

The U.S. Environmental Protection Agency (EPA) maintains the guideline on air quality models. This guideline provides the agency's guidance on the regulatory applicability of air quality dispersion models in the review and preparation of new source permits and State Implementation Plan (SIP) revisions. The regulatory default option selected in this modeling work conforms to the EPA guideline for SIP modeling - 40 CFR part 51, while the urban and flat terrain settings best reflect the conditions of the Yuma area. Contributions to overall PM10 in the domain were predicted for a 24-hour average using separate, day-specific, emission files consisting of seven design days in 1999 and in 2016. Each day was modeled individually and comparisons were made between the 1999 ISC results and results for each corresponding day in 2016. The Yuma Juvenile Center was used as a reference point within the domain and is the location of the PM_{10} sampler. Data from this sampler were compared to modeling results for each day.

2.5.1 Model Simulations for the Base Year 1999

After some modifications to the contractor inventory, described in section 2.3.2, the hourly emission files were modeled with the day-specific meteorological files to generate day specific 24-hour average predictions for PM_{10}. Table 2-13 illustrates these results. As previously discussed, the air quality date was matched with the closest inventory date that had the weekend/weekday right, the presence or absence of agricultural tillage, and, for one date, the presence of windblown dust. The elevated PM_{10} concentrations on March 31st were caused by high winds above the dust resuspension threshold. Additional discussion of this modeling date is in section 2.5.2. Although the overall model performance was satisfactory, it did over predict the measured concentration for each of the seven dates, as shown in Table 2-14 and Figure 2-10. The over predictions ranged from 1.8 to 3.2: that is, the model plus background concentrations were from 1.8 to 3.2 times higher than the measured PM_{10}

Table 2-13. Illustrates the 1999 PM_{10} Results at the Yuma Juvenile Center

Actual 1999 Met & Air Quality Day	1/12/99	3/31/99	5/30/99	6/23/99	7/17/99	11/8/99	12/8/99
Pechan Inventory Day	1/15/99	4/15/99	4/17/99	7/15/99	7/17/99	10/15/99	1/15/99
PM_{10} (µg/m³)	**148**	**138**	**48**	**67**	**46**	**60**	**85**

Table 2-14. PM_{10} Modeling Predictions versus Observations at the Yuma Juvenile Center							
	Observations			Predictions			
Date	#1	#2	Average	Model	Back ground	Total	Total/ Average
12 Jan 99	45	55	51	148	15	163	3.20
31 Mar 99	74	102	88	93	25	118	1.85
30 May 99	30	21	26	48	14	62	2.38
23 Jun 99	44	43	44	67	32	99	2.24
17 Jul 99	19		19	46	14	60	3.16
8 Nov 99	32		32	60	14	74	2.30
8 Dec 99	46		46	85	14	99	2.15

The output files generated were also used to create day-specific PM_{10} concentration maps for the Yuma domain. Such concentration maps are Figure 2-11 (a low-wind concentration field), and Figure 2-12 (a high-wind PM_{10} concentration field).

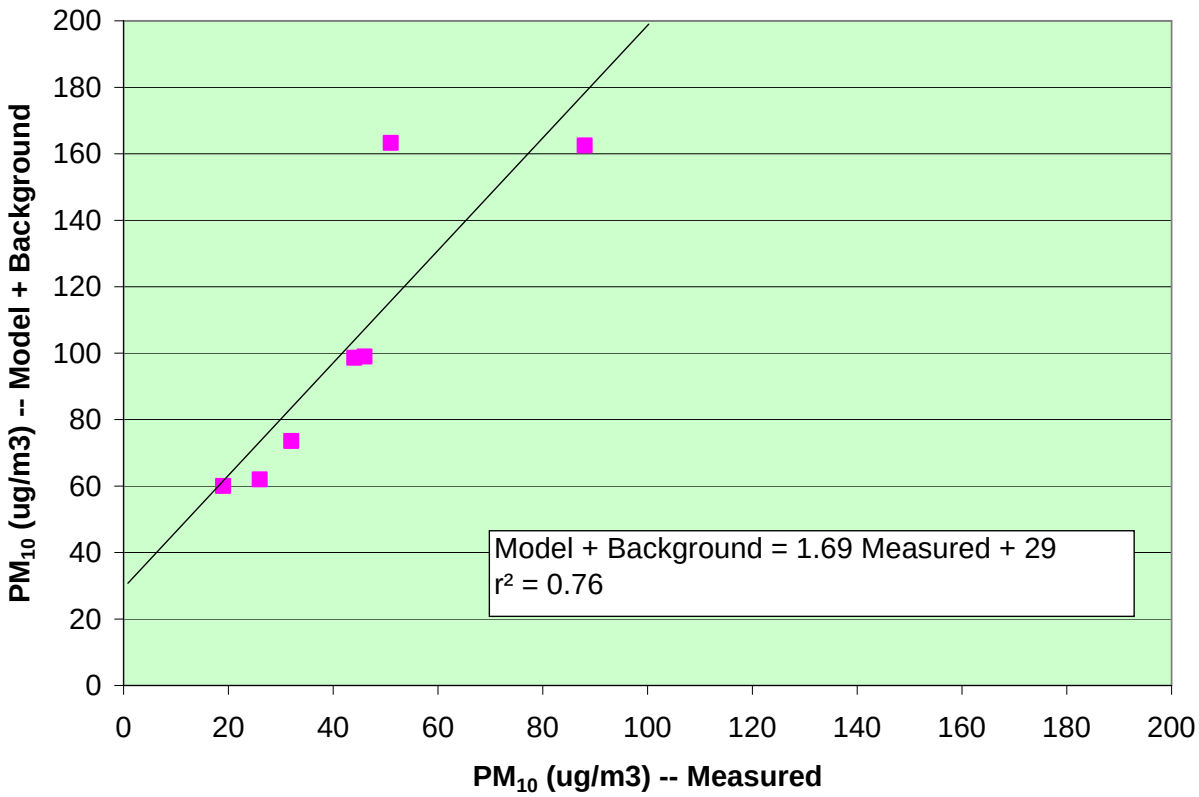

Figure 2-10. Total Prediction (Model + Background) versus Observations of PM_{10} in 1999 – in an X-Y Scatter Plot

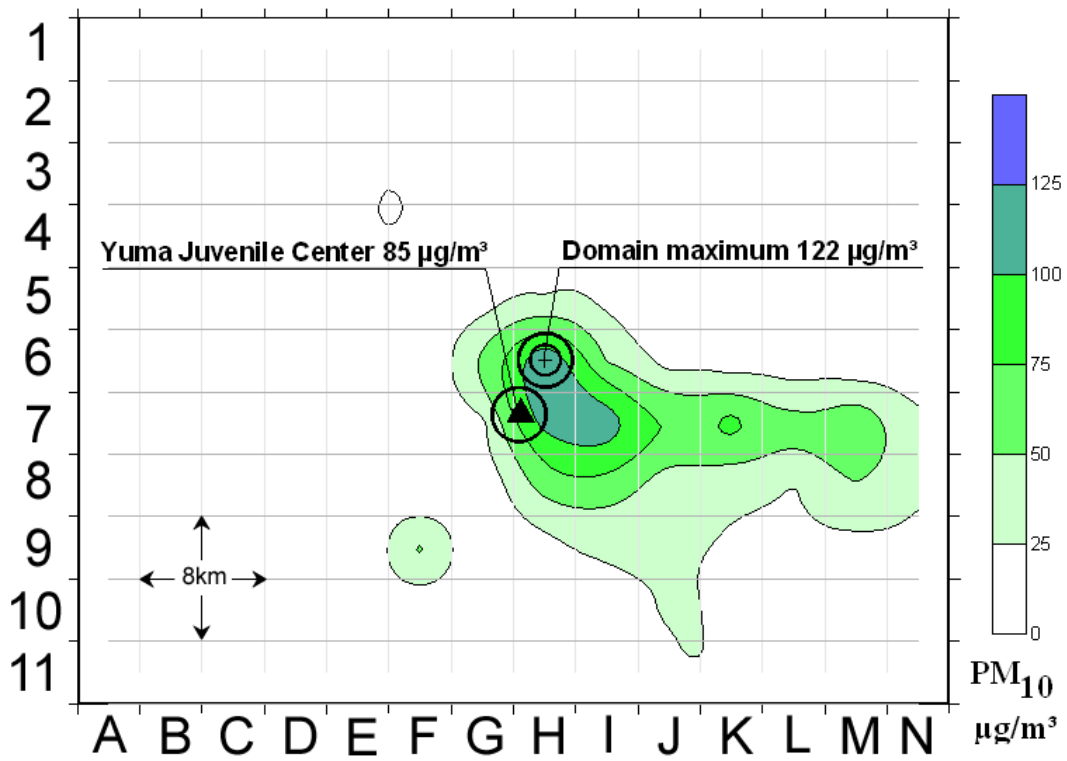

Figure 2-11. Illustrates the December 8, 1999, PM_{10} Results for the Yuma Domain

In Figure 2-11, the low-wind day, the predicted concentrations in the 25 to 50 µg/m^3 range in cell 9F can be attributed to construction emissions: road and general building construction in Somerton. These emissions are evidently high enough to produce these localized concentrations above the 0 to 25 µg/m^3 range. Figure 2-12 shows the PM_{10} concentration distribution on the high-wind day. The highest predicted concentrations are on the order of 800 ug/m3, much higher than is realistic. This eventually led to dropping this date from the analysis, as discussed in the next section.

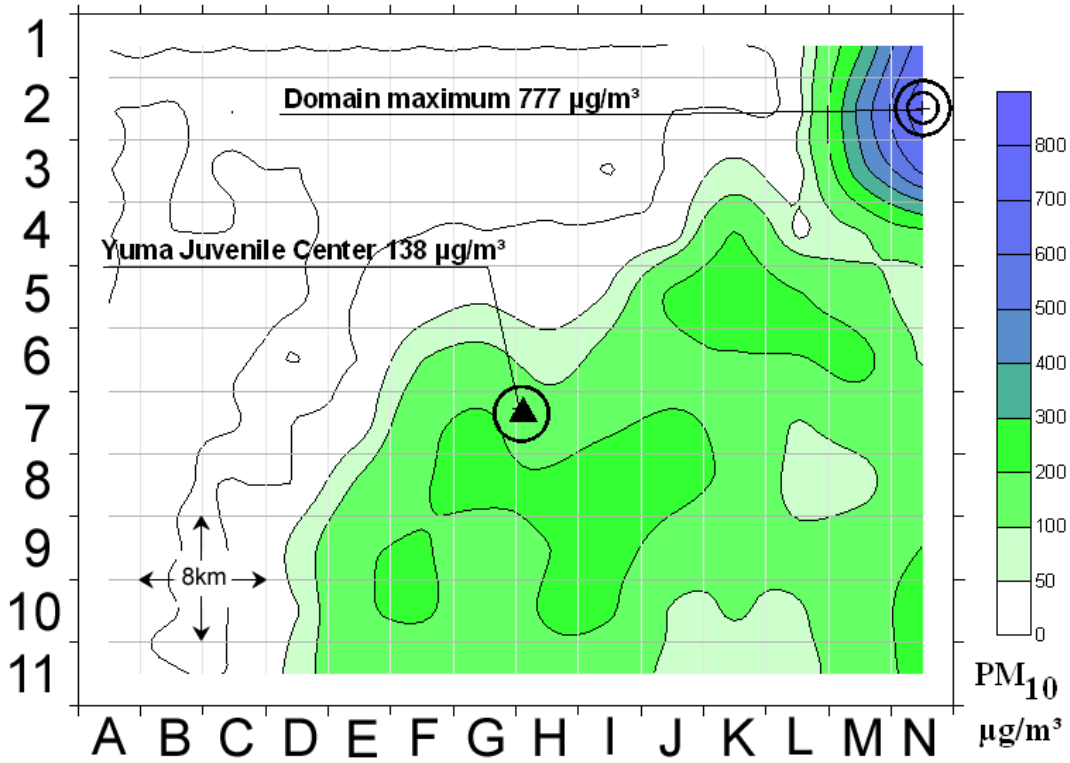

Figure 2-12. Illustrates the March 31, 1999, PM_{10} Results for the Yuma Domain

2.5.2 High-Wind Day Modeling

Numerous sensitivity tests and discussions with EPA Region 9 staff were conducted in the wake of the high-wind day modeling of March 31, 1999, for which the model produced extreme over-predictions. These over-predictions at the monitoring site were tolerable (138 µg/m^3 for the model, 25 µg/m^3 for background, versus a pair of observations of 74 and 102 µg/m^3). Maximum predicted concentrations anywhere in the domain ranged from 300 to nearly 800 µg/m^3. The tests included a limited application of the ISC deposition algorithm, zeroing out emissions in grids near and upwind of the monitor, and adjusting the mixing height. Neither the deposition algorithm nor the mixing height adjustments had any considerable effect on the model output. Zeroing out the emissions, provided the grids were close enough and upwind of the monitor, lowered the predicted concentrations. These sensitivity tests are described in Appendix B.

An attempt was made to derive a semi-empirical relationship between monitored PM_{10} and periods of six to eight hours of high wind speeds. The rationale behind this work lay in a phenomenon called "reservoir depletion." In this phenomenon dust from most land surfaces is resuspended by turbulent winds in large amounts in the first hour or two, but, as the suspendable particles on the surface are depleted, the concentrations of PM_{10} begin to decrease, and do so rapidly. TEOM concentrations of PM_{10} from the Douglas Cemetery and wind speeds taken there in 1999 were examined for several long-duration high-wind events. Although some depletion was observed, there was no consistent pattern and the PM_{10} concentrations seldom fell to near-background levels even by the sixth or seventh hour. The depletion phenomenon fails to occur when the surface dust reservoir is infinite. The classic example of an infinite reservoir is the alluvial surface material of an arroyo or river bottom. In the Douglas site, given the land clearance, road dragging, and vehicular traffic on dirt roads along the border, the land surface might have acted as an infinite reservoir, as well.

A thorough literature search revealed that numerous investigators in laboratory, wind tunnel, and field experiments had attempted to quantify reservoir depletion as an influence on windblown dust concentrations. At this stage, however, the relationships remain qualitative: what's lacking is a firm empirical basis by which to reduce emissions in the latter stages of a multi-hour high wind event. Despite all the effort in modeling PM_{10} concentrations on March 31, 1999, satisfactory answers were never obtained. For the reasons given in the following discussion, this date was dropped from the supporting technical work for the Yuma Maintenance Plan.

If meteorological conditions are so severe as to be classified as "exceptional", then the high concentrations of PM_{10} can be flagged, compliance with the ambient air quality standards is excused, and the community then begins to apply the Best Available Control Measures to those sources contributing to the exceptional concentration. The conditions of March 31, 1999, are exceptional, or fall just short of exceptional, depending on which set of National Weather Service (NWS) winds one uses, since there are differences between what is archived in the ADEQ records and what is archived in the Web site of the NWS. Discussions based on both sets of data are presented below. In one set, the date does qualify; in the other, it narrowly misses. Whether it is considered officially "exceptional" may not be as important as it was extraordinarily windy.

The measured 24-hour average PM_{10} concentrations at the collocated monitors on March 31, 1999, were 74 and 102 µg/m^3. A trough and frontal passage brought west-northwesterly winds of 20 to 30 miles per hour from 1300 through 2300 hours. Visibility was as low as four to five miles from 1300 to 1600, with blowing dust reported at the National Weather Service station. Hourly average wind speeds are given in Table 2-15. Wind speeds in the two sets of archived data differ significantly, with the result that the first set (Set A) has a 24-hour average wind speed just below the criterion for an exceptional event, while the second set (Set B), has a high enough 24-hour average wind speed for the day to qualify.

Table 2-15. March 31, 1999 Meteorological Records from the Yuma National Weather Service				
		NWS-A	NWS-B	
	Direction	Speed	Speed	Visibility
Hour	(Degrees)	(mph)	(mph)	(Miles)
1	290	13	12	7
2	290	12	14	7
3	300	14	12	7
4	320	12	10	7
5	300	10	8	7
6	300	8	7	7
7	310	7	6	7
8	320	6	9	7
9	300	9	13	7
10	290	13	16	7
11	290	16	17	7
12		**16.5**	**21**	7
13	300	17	25	5
14	300	25	29	5
15	290	29	29	4
16	280	29	29	4
17		**29**	31	7
18	290	29	20	7
19	280	20	20	7
20	300	20	28	7
21	290	28	24	7
22	290	24	24	7
23	290	24	23	7
24	300	23	29	7
	Maximum	29	31	7.00
	Average	18.06	19.00	6.58

The missing observations of wind speed for 1200 and 1700 hours have been interpolated.

According to the May 2000 natural events technical document, a day qualifies as exceptional (and is therefore eligible for flagging and treatment through a Natural Events Action Plan), if it meets either the first two or the first and last three of the following five tests.

1. Three hours must have average wind speeds in excess of 15.7 mph. This date had 14 consecutive hours with wind speeds above this value, which, together, averaged 23.5 mph. This date qualifies.

2. The 24-hour average wind speed is equal to or greater than the 99.9th percentile value, which for Yuma, is 18.6 mph. With Set A, this date falls just short of that (18.1 versus 18.6 mph). For Set B, however, the 19.0 mph average exceeds the 99.9th percentile and the day qualifies.

3. If the 24-hour average wind speed is less than the 99.9th percentile value, does it exceed the 97th percentile value, which for Yuma is 13.6 mph? This date qualifies under this criterion, which keeps it as a qualifying date, provided it can meet the rainfall tests (#4 and/or #5).

4. For a date that passes #1 and #3 but fails #2, the rainfall records are brought to bear. The first rain test is the rainfall in the 60 days before the event, which must be less than the 99th percentile. For Yuma, that figure is 0.00 inches, but in the 60 days before March 31, 1999, the rainfall was 0.42 inches. The date fails this test.

5. For dates failing the 60-day rainfall test, a second rainfall test is invoked that concerns the prior October-March period, which, again, must have rainfall less than the 99th percentile. For Yuma, this figure is 0.20 to 0.28 inches, depending on the station chosen. Rainfall in the October-March period before the March 31, 1999, date was 0.65 inches. The date fails this test.

Of the five tests, a date qualifies if it passes the first two tests, but this date fails the second test with Set A of the wind speed data. With Set B of the wind speed data, the date does qualify as exceptional. If Set A is used, the date then has to pass the third test and one of the two rainfall tests. March 31, 1999, with Set A of the wind speed data, does meet the third test, but ultimately fails because it doesn't pass either of the rainfall tests.

It should be pointed out that these wind speed and rainfall criteria are extremely strict. The fact that the fourth (and fifth) tests do not account for monsoon and other strong frontal conditions that have winds strong enough to overwhelm BACM even if accompanied or followed by rain is one of the reasons why these technical criteria were revised and expanded in 2005. In any case, the meteorology on that date was extraordinary, if not officially exceptional, with its 14 consecutive hours of winds that averaged 24 mph, well above the dust resuspension threshold of 15.7 mph. That the date meets the 24-hour average wind speed criterion and therefore qualifies as exceptional with one set of wind data, but falls just short with the other set, is less important than realizing that wind speeds of this sustained duration are seldom encountered in Yuma.

The exceptional events criteria of February 2005 expand considerably on the earlier version, to account for long range transport of dust (or smoke) under moderate or light winds, and to account for either regional high-wind events or short-lived thunderstorms. Criteria are also spelled out to classify an event as a regional exceptional event, one whose size is large enough to transport blowing dust into an airshed, and whose out-of-airshed emissions are great enough to cause a PM_{10} exceedance (or elevation) and overwhelm Reasonably Available Control Measures (RACM) or Best Available Control Measures (BACM). These criteria adopt a more holistic approach to classifying events as exceptional, employing weight-of-evidence methods. Although March 31, 1999, would not appear to qualify as a regional exceptional event, based on the PM_{10} concentrations recorded in Yuma and vicinity, given in Table 2-16, it may still qualify as "exceptional" through the weight of evidence approach.

Table 2-16. PM_{10} Observations for March 31, 1999

Monitoring Site	PM_{10}
Brawley	33
El Centro	39
Westmoreland	50
Niland	50
Calexico	292
Yuma, original	**102**

Table 2-16. PM_{10} Observations for March 31, 1999	
Monitoring Site	**PM_{10}**
Yuma, duplicate	**74**
Ajo	41
Organ Pipe	16
Nogales	37
Mexicali-Cobach	<353
Mexicali-CBTIS	<103
Mexicali-UABC	<160
Mexicali-Progresso	<420

All values are 24-hour PM_{10} concentrations in µg/m^3 for March 31, 1999; all come from filter-based instruments except Calexico. The "less than sign" (<) figures for the four Mexicali sites arise from the lack of available daily sampling data. For these sites for 1999, only the four highest values and their dates were available. None of the values occurred on March 31, 1999, so all that is known about the PM_{10} on this date is that it is less than the fourth-highest value in the summary report. None of the downwind monitoring sites, east of Yuma, shows any elevation. Only one of the five upwind sites in the Imperial Valley – Calexico – has an elevated 24-hour PM_{10} concentration. Its peak concentration and its moderate late afternoon and evening concentrations are inconsistent with the timing of the high winds in Yuma (Figure 2-13).

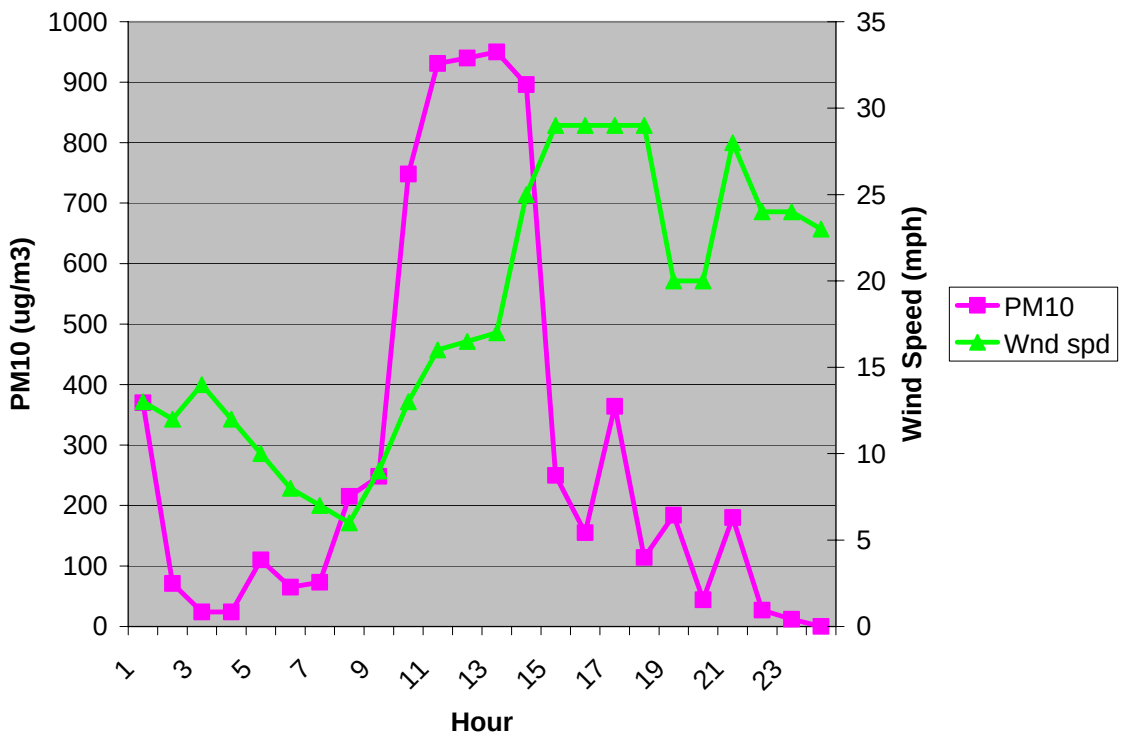

Figure 2-13. March 31, 1999, Wind Speeds from Yuma and Hourly PM_{10} from Calexico

All of this suggests that the blowing dust observed in Yuma on March 31, 1999 was more localized than regional. While the technical criteria include closer examination of meteorology, attribution to emission sources, and the contribution from regional natural sources, the spatial distribution and magnitude of the PM_{10} concentrations on this date do not lend themselves to a regional explanation. The concentrations in the

Imperial Valley and southern Arizona were rather low, ranging from 33 to 41 µg/m^3, in contrast to Yuma's 74 and 102 µg/m^3. Calexico was the lone monitoring site with elevated PM_{10} concentrations, averaging 292 µg/m^3 for the 24 hours. The Imperial Valley sites are all within a circle of ten miles radius. Ten miles south of El Centro, Calexico would seem to have been influenced by close-in sources that were absent in the Imperial Valley. Yuma is 55 miles east of Calexico. Although the elevated Yuma concentrations were undoubtedly related to the extremely high Calexico ones, a pattern of regionally elevated values, from the Imperial Valley, through Yuma, and to points east, is simply not there. Thus, this date does not fit in well with the regional exceptional event hypothesis.

Even though the date may or may not qualify as an exceptional event, either local or regional, a number of arguments can be made to exclude it from the modeling analysis in the Yuma Maintenance Plan. These arguments are based on the inability of both the emissions and air quality models to adequately simulate the measured concentrations, as well as on there being no regulatory issues that would be resolved by including this date in the modeling.

The first consideration is the actual wind speeds used in the modeling for the Yuma PM_{10} Maintenance Plan, versus the official National Weather Service (NWS) measurements. Presented in Table 2-17, the NWS measured wind speeds are considerably higher than those used in the model, which come from the AZMET station called Yuma Mesa.

Table 2-17. Wind Speeds on March 31, 1999

Hour	Wind Speed (mph)	
	National Weather Service (10 m Height)	**Yuma-Mesa (3 m Height)**
1	13	2.9
2	12	4.0
3	14	4.9
4	12	3.6
5	10	4.3
6	8	3.1
7	7	2.7
8	6	3.6
9	9	8.7
10	13	13.6
11	16	13.2
12	**16.5**	13.4
13	17	13.9
14	25	14.8
15	29	15.0
16	29	17.9
17	**29**	18.3
18	29	14.5
19	20	15.2
20	20	15.7
21	28	15.9
22	24	14.8
23	24	17.7
24	23	13.9
n>=15	14	7
Max	29	18.34
Average	18.06	11.06

With a wind speed threshold of 15.7 mph or greater for causing windblown emissions, the model had seven hours with these windblown emissions, as opposed to the 14 hours had the NWS measurements been used. The Yuma Mesa site has a lower anemometer height (three as opposed to 10 meters), and is somewhat shielded with vegetation and citrus, unlike the open areas of the Marine Corps Air Station with its NWS anemometer. Maximum concentrations predicted from the NWS wind speeds would have been on the order of 1600 $\mu g/m^3$ for a 24-hour PM_{10} average, in contrast to the 777 $\mu g/m^3$ predicted from the Yuma Mesa wind speeds. By selecting the lower wind speeds from the Yuma-Mesa site for the modeling, Assessment staff were cognizant of the modeling difficulties and were trying to minimize them.

The second consideration is the inherent uncertainty of the emissions modeling. Satellite images were examined for division into six land surface types. This technology is advanced enough that it does an adequate job for all large-scale surface features. The 4x4 kilometer grids employed in the emissions/air quality model were then assigned the corresponding amount of each land surface type, and an emission factor in grams per meter squared per second was assigned commensurate with the area of the erodible land surface. The problem here is not with the image work, but, rather, what emission factor to assign that accurately reflects the wind-driven mass flux from soil surfaces of variable erodibility, of variable soil moisture, and with variable threshold wind speeds for resuspension. Additional uncertainty is introduced by this simple scheme because it has no way to account for either the depletion of erodible particles from the upwind surface or for their deposition and accretion onto the same surface from high-wind advection further upwind. Another simplification in the emissions modeling is the lack of any dependence on wind speed. Higher winds above the threshold will generate more dust emissions, but in this work, the emissions are a constant value for any hour with the threshold wind speed or above. Accurate simulations based on emissions modeling with these uncertainties are difficult to achieve.

The third consideration concerns the dispersion modeling. Can a Gaussian plume model such as the Industrial Source Complex be expected to produce believable simulated concentrations under such turbulent conditions? Can it adequately account for deposition (this was not even attempted, except for some sensitivity tests)? In its area source configuration, used exclusively in the Yuma analysis, the model effectively takes a 4x4 kilometer grid of uniform emissions and disperses it downwind toward the receptors. Given that emissions throughout a 16 square kilometer area are seldom, if ever, uniform, then the model begins with a handicap even before dispersion takes place.

Predicted 24-hour PM_{10} concentrations on this date were 163 $\mu g/m^3$ at the monitor, where the observations were 74 and 102 $\mu g/m^3$. These figures and the rest in this discussion are the model output plus the background concentration of 25 $\mu g/m^3$. Considering the entire domain, the predictions ranged from 54 to 802 $\mu g/m^3$. Table 2-18 summarizes the predictions.

Table 2-18. PM_{10} Predictions for March 31, 1999	
Range	**Percent**
>400	7.7
300-400	7.7
200-300	35.9
150-200	16.7
<150	32.1
>150	67.9

Two thirds of the predictions are above the standard of 150 µg/m^3; 15% of the predictions are higher than the highest monitored concentration in the historical record (281 µg/m^3). While the precise degree of over prediction is only known at the monitor receptor, the maximum predicted concentration of 802 µg/m^3 and the percentage of predictions greater than 300 µg/m^3 suggest that

a) The windblown emissions were simply too high and the dispersion model was faithfully simulating them; or

b) The windblown emissions were accurate but the dispersion model was over predicting in these turbulent conditions; or

c) The emissions were over estimated and the dispersion model was over predicting.

Whichever the case, the net result is a set of simulated 24-hour PM_{10} concentrations that is inconsistent with the historical record, cannot be verified by the monitoring network, and cannot support maintenance of the air quality standard.

A fourth consideration is the lack of monitoring data in the Yuma PM_{10} modeling domain: one monitoring site in 154 grids of 4x4 kilometers. Reasonable agreement between the model and the measurements at the monitoring site does not even begin to suggest that in other grids with variable emissions similar performance would be obtained. For example, there is not a way to verify the elevated concentrations predicted by the model in the northeast corner of the domain (Yuma Proving Grounds) for the March 31, 1999, design date.

A fifth consideration is that in over 20 years of PM_{10} monitoring in Yuma, no 24-hour concentration on the order of 800 µg/m^3 has ever been recorded. The annual high and second-high 24-hour average PM_{10} concentrations from 1985 through 2003 are shown in descending order in Figure 2-14.

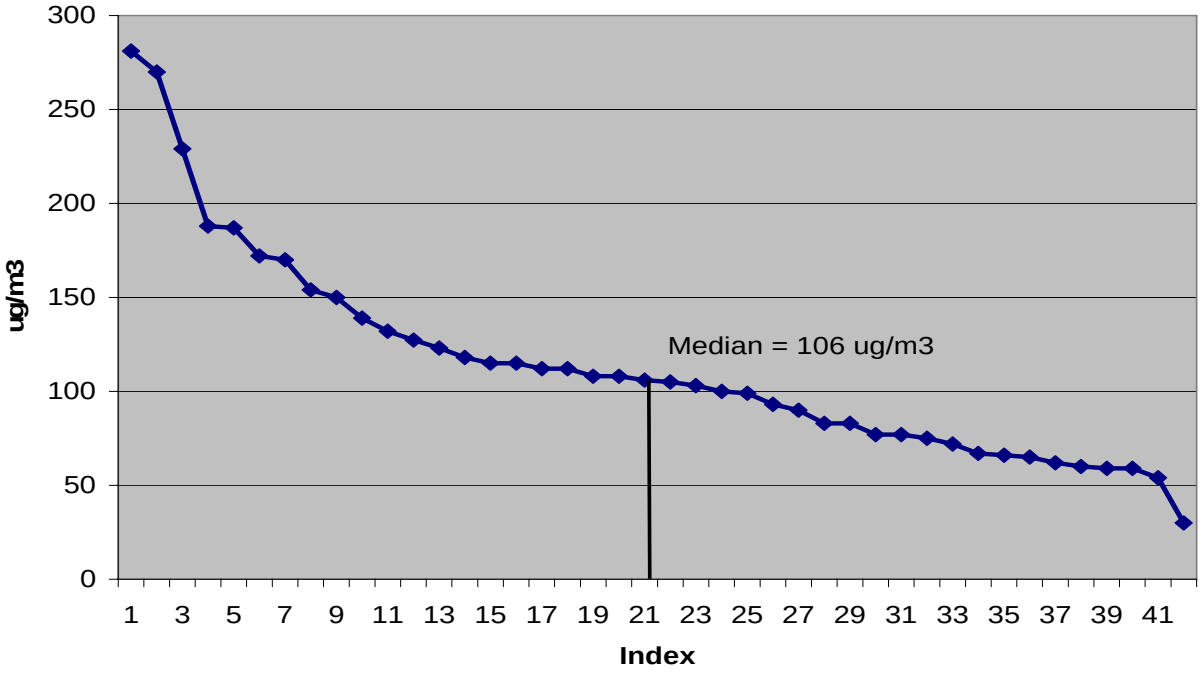

Figure 2-14. Yuma PM_{10} Concentrations: Annual Highs and Second-Highs from 1985 through 2003, Arranged in Descending Order

The top ten values from this figure are shown in Table 2-19 and reveal the following two features of these extreme PM_{10} concentrations:

1. The highest concentrations have remained below 300 µg/m^3, and have not approached the predicted maximum of 802 µg/m^3 from the modeling.

2. With one exception – 2001 -- these highest 24-hour PM_{10} concentrations all occurred 15 to 20 years ago.

Table 2-19. Yuma 24-Hour Average PM_{10} Concentrations: 1985 -2003: the Ten Highest Annual Maximum or Second-Highest Concentrations	
Year	**PM_{10} (ug/m3)**
1985	281
1990	270
1991	229
1991	188
1987	187
1985	172
1987	170
2001	154
1989	150
1989	139

Given the random paths that violent summer thunderstorms take, and given the somewhat more homogeneous wind fields associated with the passage of dry cold fronts (e.g. March 31, 1999), monitoring at a fixed site in north-central Yuma could reasonably be expected to record in 20 years at least a few elevated PM_{10} concentrations considered as domain-wide maxima. If this is the case, then these maxima are in the 200 – 300 µg/m^3 bracket, which is well below the model-predicted maximum of 800 µg/m^3.

The sixth consideration concerns the magnitude of the observations on March 31, 1999 – 74 and 102 µg/m^3. Although these were the highest 24-hour PM_{10} concentrations of 1999 – and formed the rationale for modeling that date -- they were still well within the 24-hour PM_{10} standard. In a Maintenance Plan analysis, then, these concentrations do not in and of themselves compel modeling.

The seventh consideration is that the extremely high and persistent winds of March 31, 1999 – which averaged 24 mph for a 14-hour period – would have overwhelmed the benefits of Best Available Control Measures.

The eighth and last consideration is that this modeling is unnecessary to select additional control strategies, which has already been done for the Natural Events Action Plan (NEAP) analysis for August 18, 2002.

Modeling PM_{10} concentrations for the Yuma PM_{10} modeling domain for this particular high-wind design day, March 31, 1999, has proven to be intractable. Successful simulations would seem to depend on a large scale field research study in which the relationships between soil surface type, moisture content, silt content, wind speed threshold, depletion and accumulation phenomena, and resultant concentrations could be empirically determined. Such a study would be far beyond the scope of this Maintenance Plan and its schedule, and thus that research is out of the question for now. Instead, based on the preceding arguments, the high-wind day modeling day of March 31, 1999 has been removed from the Yuma Maintenance Plan.

2.5.3. Model Predictions throughout the Domain

The discussions of the last two subsections concern the model-simulated PM_{10} concentrations at a particular point in Yuma: i.e. at the monitoring site located at the Yuma Juvenile Center. While model performance is necessarily limited to the location of the monitoring site, the larger picture of how PM_{10} concentrations are distributed across the modeling domain of Yuma is more important. The Clean Air Act requires that all points within an airshed meet the air quality standards. This section demonstrates that the PM_{10} standards are met throughout the Yuma area.

The simulated concentrations throughout the domain, shown graphically in Figures 2-9 and 2-15, shed some light on how elevated PM_{10} concentrations are distributed throughout the Yuma area on a high-wind and low-

wind day. For the low-wind day of December 8, 1999, the measured concentration was 46 µg/m^3; the model-predicted concentration at the monitor was 85 µg/m^3; and the maximum prediction anywhere in the domain was 122 µg/m^3. On that day the highest predicted concentrations and the domain maximum were concentrated in three grid cells (total area of 48 square kilometers) immediately to the northeast and east of the monitor. This close proximity of the monitor with the predicted maximum suggests that under low-wind conditions the model adequately places the highest concentrations in the region near the monitor.

The maximum predicted PM_{10} concentrations anywhere in the domain are now examined in light of the over-predictions at the monitoring site. Table 2-20 begins with the observation ("Obs") of the 24-hour average PM_{10} concentration at the Juvenile Center. On its right is the calculated background value ("Back") from Section 2.4. Because background PM_{10} comes from outside of the Yuma area, it is subtracted from the observation ("Obs – Back"). This difference – the observation with the background subtracted – can then be compared with the ISC model prediction. Dividing this difference by the prediction gives the decimal fractions in the "Ratio" column. For those total predicted concentrations (model plus background) within the standard of 150 µg/m^3, these fractions are not used. Instead, the model prediction plus the background goes into the far right column called "normalized maximum."

For those predictions that would be above the standard, the fractions are multiplied by the value of the predicted maximum anywhere in the domain (next to last column), with the background added back in to give the "Normalized Maximum". These concentrations are the highest anywhere in the modeling domain. They account for both the background concentration and for the degree of over-prediction by the modeling system. More importantly, these normalized maximum, domain-wide PM_{10} concentrations, reflect the distribution and magnitude of PM_{10} emissions throughout the Yuma area. This set of predicted concentrations demonstrates that all of the Yuma airshed complies with the 24-hour PM_{10} standard, not just the Juvenile Center.

Table 2-20. Domain-Wide PM_{10} Concentrations in Yuma, Based on ISC Model Predictions at the Juvenile Center and Throughout the Domain

Date	Yuma Juvenile Center					Anywhere in the Modeling Domain	
	Obs	Back	Obs - Back	ISC Model Prediction	Ratio (Obs –Back) to Prediction	ISC Predicted Maximum	Normalized Maximum (with Back-Ground)
1/12	51	15	36	148	0.24	195	62
5/30	26	14	12	48	0.25	78	92
6/23	44	32	12	67	0.18	97	129
7/17	19	14	5	46	0.11	69	83
11/8	32	14	18	60	0.30	100	114
12/8	46	14	32	85	0.38	122	136

Notes:

Obs	Observation or measurement of PM_{10}
Back	Background PM_{10} concentration (calculated)
Obs – Back	Difference of the two
Ratio	(Observation minus Background) divided by the model prediction

Normalized Maximum — Highest predicted PM_{10} in the domain, normalized for the model over-prediction, and with background added in.

(All values are calculated or measured PM_{10} concentrations in µg/m3 averaged for 24 hours.)

This compliance is shown for the six low-wind days. For the six low-wind days the normalized domain maxima vary from 62 to 136 µg/m^3, within the 150 µg/m^3 standard. el predictions and those predictions that resulted from the emissions rollback described

2.6 Model Simulations for the Projected Year 2016

For the 2016 air quality predictions, Pechan built a set of 2016 emissions files. These files were adjusted and modeled in the same fashion as the 1999 files and generated the PM_{10} predictions of Table 2-21. Figure 2-15 illustrates the low-high wind simulation of December 8, 2016, while Figure 2-18 illustrates high-wind simulation for March 31, 2016.

Table 2-21. Illustrates the 2016 PM_{10} Results at the Yuma Juvenile Center

Actual Met & Air Quality Day	1/12/99	3/31/99	5/30/99	6/23/99	7/17/99	11/8/99	12/8/99
Pechan Inventory Day	1/15/99	4/15/99	4/17/99	7/15/99	7/17/99	10/15/99	1/15/99
PM_{10} (µg/m³)	**107**	**28**	**48**	**49**	**28**	**37**	**61**

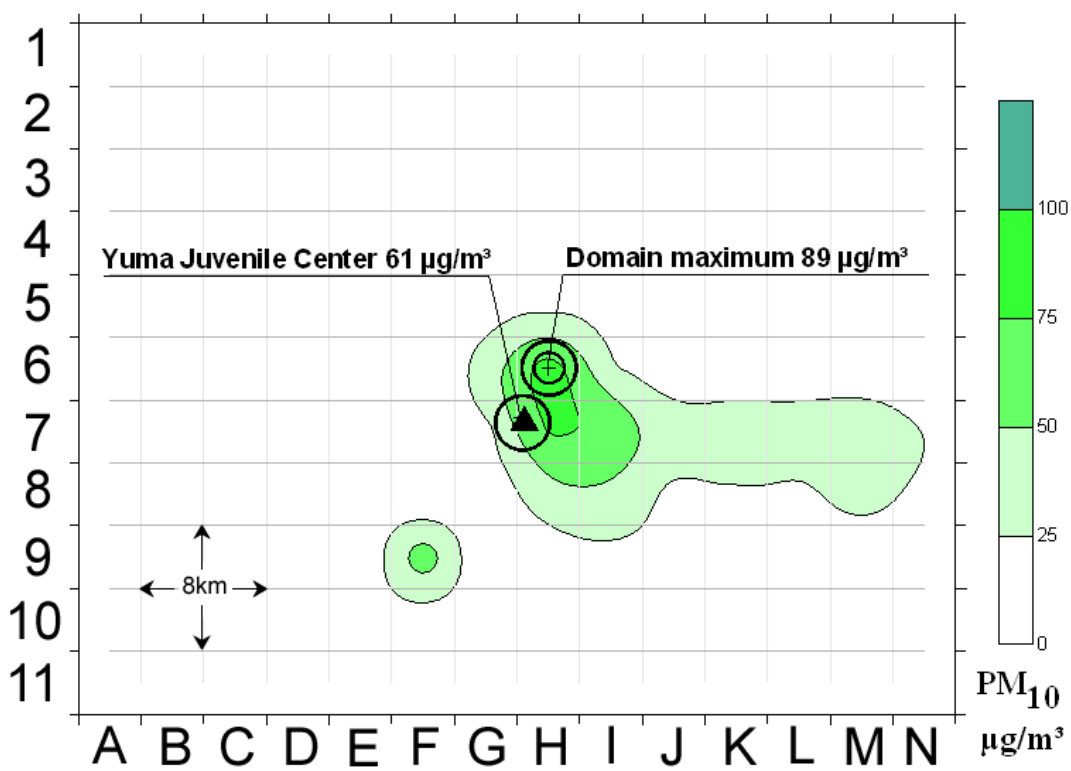

Figure 2-15. Illustrates the December 8, 2016 PM_{10} Results for the Yuma Domain

2.7 Demonstration of Attainment

Attainment in 2016 is shown by examining the 1999 observations, calculating the ratio of the 2016 to 1999 total predictions, and applying these ratios to the base year observations. All of these figures, except the ratios, have been assembled in Table
2-22.

Table 2-22. PM_{10} Concentrations in 1999 and 2016 in Yuma: Observations and Model Results

Date	1999: Observations & Model Results				2016: Model Results	
	Average Observation	Model Prediction	Background	Total Prediction	Model Prediction	Total Prediction
1/12/99	51	148	15	163	107	122
5/30/99	26	48	14	62	48	62
6/23/99	44	67	32	101	49	81
7/17/99	19	46	14	60	28	42
11/8/99	32	60	14	74	37	51
12/8/99	46	85	14	99	61	75

In Table 2-23, the 2016 predicted concentrations are shown in the far right column. These values are merely the 1999 observation less the background, multiplied by the ratio of the 2016 model prediction to the 1999 model prediction, and then with the background added back in. The background is independent of the Yuma emissions profile and is assumed to remain constant between 1999 and 2016. The logic requires that this background be subtracted from the observation, and the model prediction ratio between 2016 and 1999 be applied to this difference. After this ratio is applied to the "local concentration", i.e. the measured PM_{10} less the background – the background needs to be added back in.

As an example, January 12 has a 24-hour average PM_{10} measurement of 51 µg/m^3. Subtracting the background of 15 µg/m^{3}gives 36 µg/m^3. This 36 µg/m^3 can be considered the PM_{10} concentration generated by local Yuma emissions. The air quality dispersion model responds only to local emissions. For 2016 the model prediction is 107 µg/m^3. The 1999 model prediction is 148 µg/m^3. Their ratio is (107/148) = 0.72. This ratio multiplied by 36 µg/m^3 gives 26 µg/m^3. Adding the background to this value gives the 2016 predicted concentration of 41 µg/m^3.

Table 2-23. Yuma PM_{10} Concentrations for 2016							
Date	1999			Model Predictions		Ratio (2016/1999) Model Predictions	2016 Calculated PM_{10}
	Obs	Back	Obs –Back	2016	1999		
1/12/99	51	15	36	107	148	0.72	41
5/30/99	26	14	12	48	48	1.00	26
6/23/99	44	32	12	49	67	0.73	41
7/17/99	19	14	5	28	46	0.61	17
11/8/99	32	14	18	37	60	0.62	25
12/8/99	46	14	32	61	85	0.72	37
Avg	43.7	18.3				0.76	

Notes: (Units are $\mu g/m^3$)
Obs is the observation: 24-hour average PM_{10} at the Yuma Juvenile Center
Back is the background concentration
Obs – Back is the background subtracted from the observation

The concentrations in this table demonstrate that Yuma air quality over a ten-year horizon will remain well in compliance with the 24-hour PM_{10} standards. Similar arguments can be invoked for the annual standard. The base-year annual PM_{10} average was 37.0 $\mu g/m^3$. This average is based on 56 sampling days, 29 of which had both the original and duplicate samples taken. Based on the background and model predictions for the seven design dates of 1999, this annual average is expected to decrease slightly by 2016 – to 32 $\mu g/m^3$. The necessary calculations for this exercise are illustrated in Table 2-24.

Table 2-24. Demonstration of Attainment for the Annual PM_{10} Standard in 2016 in Yuma		
Line #	Description	Statistic
1	Average PM_{10} : 6 Design Days 1999 ($\mu g/m^3$)	36.3
2	Average PM_{10} : 6 Background Concentrations ($\mu g/m^3$)	17.1
3	Average: 6 Background as a Fraction of Observations	0.47
4	Average: 6 2016/1999 Model Prediction Ratio	0.73
5	1999 Annual Average PM_{10} (Juvenile Center) ($\mu g/m^3$)	37.0
6	1999 Average Background Value ($\mu g/m^3$) [line 3 x line 5]	15.5
7	1999: Annual Average – Average Background ($\mu g/m^3$) [line 5-6]	21.5
8	2016 local PM_{10} ($\mu g/m^3$) [line 7 x line 4]	15.8
9	2016 Annual Average ($\mu g/m^3$) [line 8 + line 6]	31.3

An examination of annual PM_{10} averages before and after 1999 reveals that this method would predict attainment in 2016 for the range of concentrations in the most recent ten years. The base year of the study – 1999 – is in no way unique or unusual (Table 2-25 and Figure 2-16).

Table 2-25. Yuma PM_{10} Annual Averages: 1985 - 2004	
Year	**Annual Average**
1985	**63**
1986	**56**
1987	50
1988	41
1988	38
1989	**52**
1989	37
1990	**57**
1991	41
1992	29
1993	31
1994	32
1995	35
1996	36
1997	36
1998	47
1999	35
2000	42
2001	41
2002	48
2003	38
2004	40

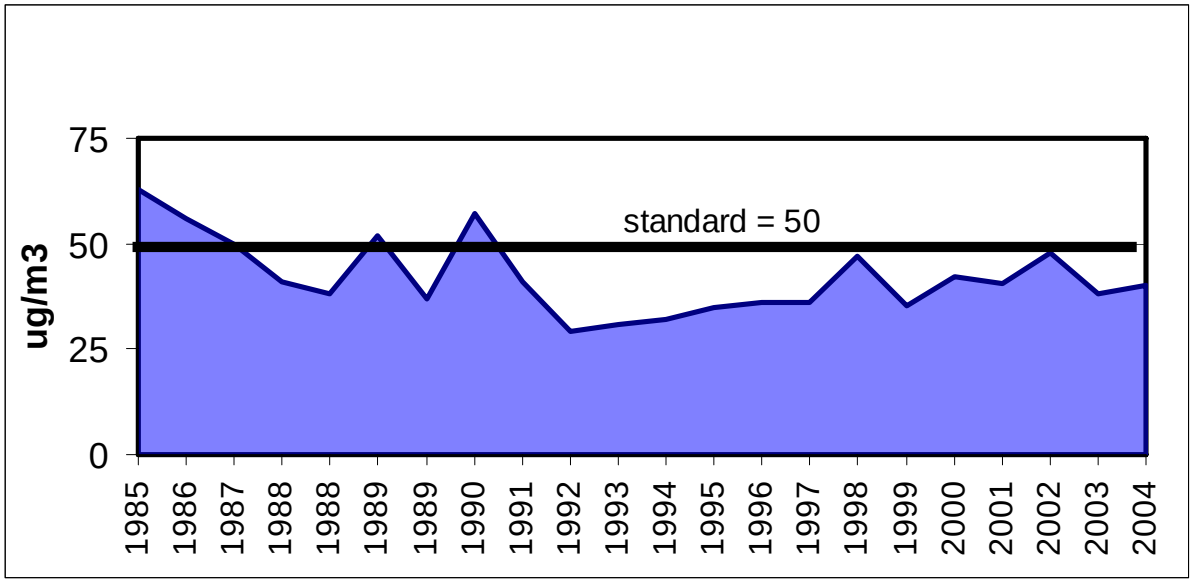

Figure 2-16. Annual PM_{10} Averages for Yuma: 1985 - 2004

2.8 Summary of Attainment Demonstration

- Six representative design dates from 1999 were chosen to include all the seasons, to include days with agricultural tillage, and to include the highest measured PM_{10} concentrations on low-wind days.

- An inventory of PM_{10} emissions was constructed that included all known sources. This inventory was adapted for use in a numerical model.

- This numerical model, called Industrial Source Complex Short Term (ISC), then simulated PM_{10} concentrations for the six design days, based on the emissions in the inventory and meteorological measurements specific to the design day.

- Background concentrations of PM_{10} were calculated from measurements and transport paths from monitors in the Yuma vicinity.

- When background plus model concentrations were compared with measurements at the Yuma Juvenile Center, the modeling system consistently over-predicted the PM_{10} measurements.

- Accounting for these over-predictions, and with a 2016 inventory of emissions, compliance with the PM_{10} standards can be shown at the monitoring site.

- Given the maximum predicted PM_{10} concentrations anywhere in the modeling domain, and again accounting for the over-predictions and for the background, compliance with the standards can be shown throughout the Yuma area through 2016.

- In summary, both the ambient record of the past several years and the modeling exercise described in this chapter, demonstrate attainment of the 24-hour and annual PM_{10} standards from 1999 to 2016 at the Yuma Juvenile Center. This same state of attainment has been shown to prevail throughout the Yuma area by utilizing the spatial distribution of PM_{10} concentrations provided by the ISC model.

CHAPTER 3 – YUMA PM_{10} MAINTENANCE PLAN TSD -- CONTROLS

3.1 Controls to Reduce PM

Controls to reduce PM_{10} emissions have been carried out in Yuma at least since the early 1990's and, no doubt, before. At present, Yuma is officially in nonattainment for PM_{10}, although a redesignation request by the Arizona Department of Environmental Quality is underway. As part of this redesignation an emissions and air quality modeling analysis was conducted, with 1999 as the base year and 2016 as the future year. To be eligible for attainment status, Yuma had to have no violations in the ambient monitoring record for 2002, 2003, and 2004 (there were none, nor were there any in 2005). Also, a demonstration that PM_{10} concentrations would remain within standards by 2016 was necessary (this was part of the technical analysis).

This chapter documents specific controls to reduce PM_{10} emissions in Yuma after the base year of 1999 and through 2016. The controls consist of a variety of projects such as paving unpaved roads and parking lots, watering unpaved roads, chemically stabilizing unpaved roads, and controlling access to the canal roads. A complete list of such projects is given below.

Paving unpaved roads
Watering unpaved roads
Chemically stabilizing unpaved roads
Installing curbs and sidewalks
Paving alleys
Street sweeping
Applying magnesium chloride to unpaved roads
Reducing unauthorized traffic on canal roads by barricades, signs, and patrolling
Reducing authorized traffic on canal roads by stocking fish, pipelining
Controlling dust on open areas with vehicular traffic

PM_{10} emissions reduced through these projects have been calculated with standard emission factors and estimates of vehicular traffic. The average annual reduction from these projects in 2000 through 2004 was 1466 tons, eight percent of the annual anthropogenic total.

In this accounting, emission reductions are not carried over from year to year. For example, an unpaved road being paved in one year gets emission reduction credit for that year only, not the years after completion of the project. Some of the larger reductions in 2000 and 2001 were unpaved road and unpaved shoulder watering by Somerton (1532 and 2188 tons, respectively). Paving unpaved roads by the City of Yuma in 2000 and 2001 accounts for 42 and 218 tons, respectively. Of the 104 projects reported, the average emission reduction was 75 tons, but the size varied from 0.02 to 1247 tons. Table 3-1 gives the emission reductions of PM_{10} for each governmental entity for 2000 through 2004.

Table 3-1. Yuma Area PM_{10} Emission Reductions by Year and Agency

Agency	2000	2001	2002	2003	2004
City of Yuma	114	430	103	111	109
City of Somerton	584	677	996	1393	1376
Yuma County	27	351	55	254	19
Yuma County Water Users	99	107	85	198	203
Marine Corps Air Station	0.06	0.02	0.00	2.80	2.70
Immigration/Naturalization	7	7	7	7	7
Total	831	1571	1247	1966	1717

The future year reductions from these dust control projects are assumed to be the average of 2000 – 2004, which is 1466 tons per year. Figure 3-1 and Table 3-2 show what contribution each type of project made to the total reduction of emissions.

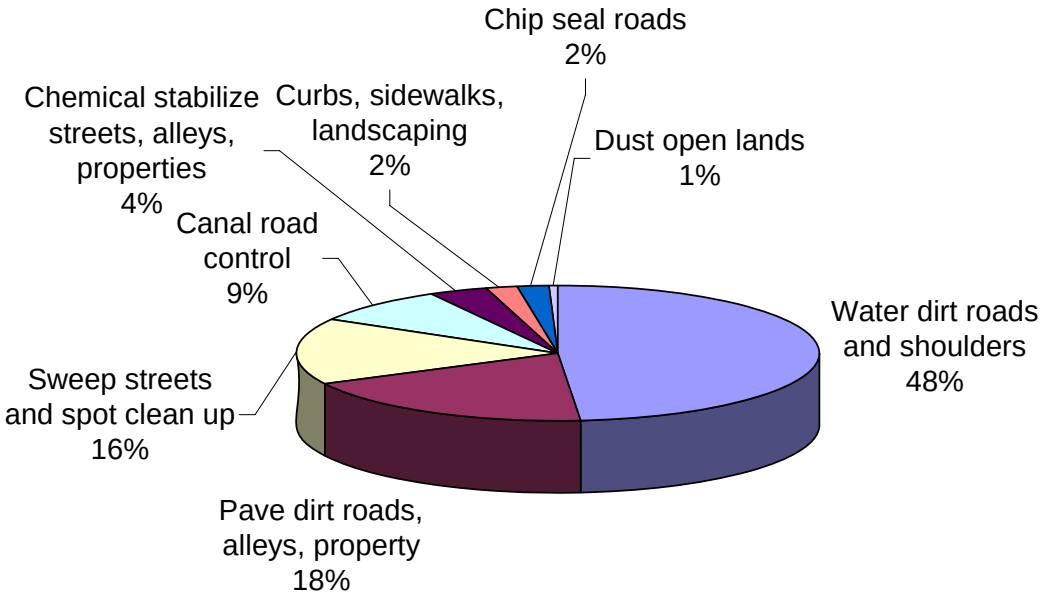

Figure 3-1. PM_{10} Emission Reductions by Project Type

Table 3-2. PM_{10} Emission Reductions by Project Type	
Type of Project	**Tons/Yr**
Water Dirt Roads and Shoulders	3808
Pave Dirt Roads, Alleys, Property	1476
Sweep Streets and Spot Clean Up	1242
Canal Road Control	672
Chemical Stabilize Streets, Alleys, Properties	288
Curbs, Sidewalks, Landscaping	159
Chip Seal Roads	134
Control Dust on Open Lands	52

To put these numbers into context, it is useful to consult the inventory. All of these measures except the last one concern PM_{10} emissions from unpaved roads, unpaved shoulders, and paved roads. PM_{10} emissions from paved and unpaved roads amount to about 13,000 tons per year, meaning that on an annual basis, the paving and stabilization measures carried out in Table 3-1 are providing an emission reduction in the PM_{10} from roadways of about 12%. Except for the emission factors, these reductions are estimates calculated independent of the inventory. Although their values may better be viewed more qualitatively than quantitatively, however they are viewed, their impact is substantial.

Another fruitful way to understand these emission reductions is to compare them with the progress made from 1991, the year of the first nonattainment area plan, through 1999. This comparison is given by project type in Table 3-3 and shows that the rate of progress in 2000-2004 is nearly twice that of the earlier period.

Table 3-3. PM_{10} Emission Reductions for Two Periods in Yuma (Tons per Year)		
Project Type	**1991-99**	**2000-04**
Paving & Chip Seal Unpaved Roads	618	322
Watering Unpaved Roads	248	762
Open Burning	195	371
Street & Runway Sweeping	3	248
Canal Roads Control	8	134
Chemically Stabilize Unpaved Roads	9	58
Dust Control On Construction Projects	4	5
Dust Control On Open Land	0	10
Stabilizing Unpaved Lots	0	2
Overall Reduction (TPY)	1,085	1,913

A complete list of the emission reduction projects in 2000 – 2004 is given in Table 3-4.

Table 3-4. 2000-2004 Yuma Area Implemented Control Measures and PM_{10} Emission Reductions (Tons per Year)								
Agency	**Projects**	**Year**	**Tons**	**2000**	**2001**	**2002**	**2003**	**2004**
City of Yuma	Pave unpaved roads	2000	42	5.74 mi				
		2001	21.8		2.98 mi			
	Pave unpaved alleys	2000	3.5	0.83 mi				
		2001	3.5		0.83 mi			
	Paving unpaved vacant land		1.1				6835 sq yds	
	Chemically stabilize	2001	4.1		1.0 mi			
	Unpaved roads	2002						
		2003	19.5				44287 yds	
		2004	39.0					88575 yds
	Watering shoulder	2001	6.3		5436' of 8' shoulder			
	Street sweeping	2000	64	17128 mi				
	Paved roads	2001	64		171218 mi			
		2002	64			17128 mi		
		2003	64				17128 mi	
		2004	64					17128mi
		2005	64	17128 mi				
	Install curbs & sidewalks	2000	8	0.63 mi				
		2001	122		10.14 mi			
	Landscaping median	2000	0	5.74 mi				
	Magnesium chloride on							
	Alleys	2003	3.8				87930 sq yds	
		2004	3.8					87930 sq yds
	City property	2003	1.9				63852 sq yds	
		2004	1.9					63852 sq yds
City of Somerton	Water unpaved roads	2000	511	400 mi				

Table 3-4. 2000-2004 Yuma Area Implemented Control Measures and PM_{10} Emission Reductions (Tons per Year)								
Agency	**Projects**	**Year**	**Tons**	**2000**	**2001**	**2002**	**2003**	**2004**
		2001	511		400 mi			
		2002	None rptd					
		2003	1247				1211 mi	
		2004	1247					1211 mi
	Water unpaved Shoulders	2000	0.1	1820 mi				
		2001	0.1		1820 mi			
	Street sweeping	2000	66.5	1376 mi				
		2001	158.,8		3286 mi			
		2002	139.6			2888 mi		
		2003	128.7				2662 mi	
		2004	123.1					2548 mi
		2005	141.0	2918 mi				
	Pave unpaved roads							
		2002	830			4.5 mi		
	Weekly cleanup of paved roads, mud, trackout, spills	2000	3.6	52				
		2001	3.6		52			
		2002	3.6			52		
		2003	3.6				52	
		2004	3.6					52
	Pave unpaved lots(ft2)							
		2002	6.41			505,440		
	Install curbs (mi)							
		2002	5.5			0.5 mi		
	Landscape shoulders (mi)							
		2002	11.0			1.0 mi		
		2003	13.7				1.25 mi	
		2004	2.7					0.25 mi
Yuma County	Paved/stabilized unpaved roads							
		2001	173		0.75 mi			

Table 3-4. 2000-2004 Yuma Area Implemented Control Measures and PM_{10} Emission Reductions (Tons per Year)								
Agency	**Projects**	**Year**	**Tons**	**2000**	**2001**	**2002**	**2003**	**2004**
		2003	231				1.0 mi	
	Chip/sealed	2001	138		0.75 mi			
	Magnesium chloride on							
	Unpaved roads	2000	17	56.2 mi				
		2001	17		56.2 mi			
		2004	19					64 mi
	Street Sweeping							
		2000	10	100 mi				
		2001	23		200 mi			
		2002	36			300 mi		
		2003	23				200 mi	
		2004	19					175 mi
Immigration and Naturalization Service	Water drag roads	2000	7.1	18 mi				
		2001	7.1		18. mi			
		2002	7.1			18 mi		
		2003	7.1				18 mi	
		2004	7.1					18 mi
Yuma County Water Users Association								
		2000	3.35	Restock				
	Stock 8,420 white amur fish/year	2001	3.35		Restock			
		2002	3.35			Restock		
		2003	3.35				Restock	
		2004	3.35					Restock
	Pipelined 1 mile							
		2000	4.0	2 mi				
		2002	1.6			0.8 mi		
		2003	1.0				0.5 mi	
	Maintain 350 "No Trespassing" signs & 50 barricades							
		2000	10	Enforcement				
		2001	10		Enforcement			

Table 3-4. 2000-2004 Yuma Area Implemented Control Measures and PM_{10} Emission Reductions (Tons per Year)								
Agency	**Projects**	**Year**	**Tons**	**2000**	**2001**	**2002**	**2003**	**2004**
	Patrol & water unpaved canal roads	2000	82	400 mi				
		2001	82		400 mi			
		2002	82			400 mi		
		2003	82				400 mi	
		2004	82					400 mi
	3 mi posted/barricaded	2001	4.2		3 mi			
	Paved 2.5 mi		5.0		2.5 mi			
	1.5 mi fenced off		2.1		1.5 mi			
	Abandoned 3/8 mi	2003	1.3				2.6	
	Lined 8 mi of canal	2004	8.9					17.8
N. Gila Irrigation District	20 miles posted	1999	0					
Unit B Irrigation District	3 mi posted/barricaded	1999	0					
Bureau of Reclamation	Water 960 miles of canal banks	2003	108				960 mi	
		2004	108					960 mi
Marine Corps Air Station	Remove 26 gas Vehicles	2000	0.06	0.06				
	Remove 15 gas Scooters	2001	0.02		0.02			
	Pave 140329 ft2 roadway						1.4	1.4
	Pave 102112 ft2 parking	half in 2003					0.2	0.2
	Sweeping 717,221 yd2	half in 2004						

Table 3-4. 2000-2004 Yuma Area Implemented Control Measures and PM_{10} Emission Reductions (Tons per Year)								
Agency	**Projects**	**Year**	**Tons**	**2000**	**2001**	**2002**	**2003**	**2004**
	runway							
	Sweeping 388,952 yd2 taxiway							
	Sweeping 401,090 yd2 aprons and 121,380 yd2 other							
	Sweeping Totals		1.1/Year					
	Stabilize desert	0.1					4200 ft^2	
	Stabilize 22500 ft2 desert							
Tons Reduced by Year				921	1661	1347	2082	1819

The other type of control measure being considered in the PM_{10} Maintenance Plan is called a contingency measure. These measures are invoked if PM_{10} concentrations exceed 95% of the standards: that is, if the 24-hour average is 143 µg/m^3 or greater; and the annual average is 48 µg/m^3 or greater. Three such measures are given in Table 3-5, along with their annual PM_{10} emission reductions. These measures are particularly well suited as contingencies, as the agencies involved would be able to accelerate their paving and stabilizing above their normal rate.

Table 3-5. Yuma PM_{10} Contingency Measures with their Annual Emission Reductions

Contingency Measure	Details	Tons/Year
Pave unpaved roads	City of Yuma: 0.44 mile/year City of Somerton: 0.1 mile/year Yuma County: 1.0 mile/year	78.7*
Chemically stabilize unpaved roads twice a year	City of Yuma: 10 miles City of Somerton: 30 miles Yuma County: 60 miles	2,555
Adopt 20% opacity rule for fugitive dust	All road and building construction sites in the nonattainment area	149
Total		2,783

* For each paved mile with 500 vehicles per day

3.2 Effect of Controls on PM_{10} Concentrations

In the construction of the emissions inventory for 2016, Pechan, the contractor, relied on the best estimates of community growth, of emission factor change, and of committed control measures. For example, unpaved road vehicle miles traveled was figured to decline from 98,000 miles per day in 1999 to 64,000 in 2016. These future estimates of PM_{10} emissions were used in the air quality modeling for 2016 to predict future concentrations. As shown in Table 2-23, the ISC model predictions for 2016 are on average 24% lower than the 1999 concentrations (the 2016/1999 average ratio was 0.76). The future concentrations reflect the degree of PM_{10} emission controls from paving but not from other activities such as watering, chemical stabilization, and so forth. Excluding these reductions from the air quality modeling for 2016 introduces an element of conservatism in its estimates. Had they been included, then the estimated future concentrations would have been even lower.

CHAPTER 4 – YUMA PM_{10} MAINTENANCE PLAN TSD – CONCLUSIONS

- Yuma has been officially designated as nonattainment for the PM_{10} standards since the early 1990s.

- Monitoring of PM_{10} concentrations in Yuma since 1985 demonstrates that the annual PM_{10} standard has been met since 1991 and that the 24-hour standard has been met since 1992.

- Monitoring conducted in 2002 – 2004 shows that the most recent three years also comply with these standards.

- The single PM_{10} exceedance in recent years occurred because of an unusually turbulent dust storm on August 18, 2002 (The 24-hour average PM_{10} concentration was 170 µg/m^3, above the standard of 150 µg/m^3). The winds were strong enough to qualify the date as a "Natural Exceptional Event." The Yuma community has considered the necessary measures called "Best Available Control Measures (BACM) and intends to enact them by August 2005 through its Natural Events Action Plan. These efforts will eliminate this exceedance from the compliance record, and enable the 2002 – 2004 clean air record to go forward in the Maintenance Plan revision to the State Implementation Plan.

- The objective of this maintenance plan revision to the State Implementation Plan is to obtain from EPA Region 9 the official designation of "attainment' of the PM_{10} standards to reflect the actual air quality.

- The analyses described in this Technical Support Document form the basis of this maintenance plan. The following conclusions summarize this work, whose principal purpose is to demonstrate that the standards have been achieved in 2002 – 2004 and that they will continue to be met in 2016.

- The emissions inventory constructed for this project shows that the main sources of PM_{10} are as follows:

  For windblown dust:

Vacant agricultural fields	51%,
Miscellaneous disturbed areas	26%, and
Unpaved agricultural roads	17%.

  For PM_{10} emissions on low-wind days:

Unpaved roads	42%,
Road construction	28%,
Agricultural tillage	15%, and
Reentrained dust from paved roads	14%.

- These emissions, mapped into a study area of 35 x 27 miles, divided into squares four kilometers on a side with Yuma at the center, were put into a numerical air quality model called Industrial Source Complex. With the emissions went meteorological measurements for seven design days in 1999, the base year.

- The air quality model produced simulated PM_{10} concentrations at the Yuma Juvenile Center, the PM_{10} monitoring site, and throughout the domain.

- The model consistently over-predicted the observed concentrations.

- The model-predicted concentrations result from anthropogenic emissions within the Yuma modeling domain. Another component adds to these concentrations, namely, the background concentrations. Background is the level of air pollution that would prevail without any emissions from the Yuma

modeling domain. The background concentrations were calculated from measurements made outside of Yuma and from transport considerations.

- The sum of the background and model-predicted concentrations equals the modeling-system prediction, and it was these concentrations that were ultimately compared with the measurements.

- Three modeling procedures were employed to demonstrate attainment everywhere in the study area and in 2016:

    1. Scaling of emissions downward on the high-wind day;

    2. Applying the ratio of the total predicted to the measured concentration to the highest predicted value in the study area; and

    3. Predicting the future concentrations by starting with the 1999 observations, and multiplying them by the ratio of the 2016 to 1999 total predictions.

- Numerous control measures to reduce PM_{10} emissions have been implemented and documented by Yuma-area agencies. Adoption of Best Available Control Measures will keep the PM_{10} air quality within standards in Yuma throughout the maintenance period of 2005 – 2016 and beyond.

APPENDIX A.

1999 and 2016 Emission Estimates For the Yuma, Arizona PM_{10} Nonattainment Area Maintenance Plan: Pechan Final Report

1999 AND 2016 EMISSION ESTIMATES FOR THE YUMA, ARIZONA PM_{10} NONATTAINMENT AREA MAINTENANCE PLAN

FINAL REPORT

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ACRONYMS AND ABBREVIATIONS

ADEQ	Arizona Department of Environmental Quality
ARB	Air Resources Board
AZMET	Yuma Mesa Meteorological Station
CTIC	Conservation Tillage Information Center
DEQ	Department of Environmental Quality
EF	emission factor
EGAS	Economic Growth Analysis System
EPA	U.S. Environmental Protection Agency
FOFEM	First Order Fire Effects Model
GIS	Geographic Information System
lbs	pounds
LTO	landing and takeoff
mph	miles per hour
NAAQS	National Ambient Air Quality Standard
NEI	National Emissions Inventory
Pechan	E.H. Pechan & Associates, Inc.
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
REMI	Regional Economics Model, Inc.
SCS	Arizona Soil Conservation Service
tpy	tons per year
VMT	vehicle miles traveled
YMPO	Yuma Metropolitan Planning Organization

The Yuma, Arizona area was designated nonattainment for particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}) on November 15, 1990 by operation of law, but has not violated the National Ambient Air Quality Standard (NAAQS) since 1991. Arizona Department of Environmental Quality (ADEQ) has initiated a process to prepare a maintenance plan that requests redesignation to attainment, and describes how the area will maintain that status for the next ten years. In preparing this plan, ADEQ hired E.H. Pechan & Associates, Inc. (Pechan) to develop estimates of PM_{10} emissions for the area. This report is a technical support document that describes the methods used to estimate 1999 and 2016 PM_{10} emissions for the Yuma area. The study area is defined to be the Yuma PM_{10} Nonattainment Area, as designated by the U.S. Environmental Protection Agency (EPA).

EPA produces a National Emissions Inventory (NEI) every three years for counties in the United States. The most recent NEI completed for Yuma County at the time ADEQ began this study was in 1999. Consequently, the base year for this study is 1999. The projection year (2016) was selected to meet the EPA requirement that there be a maintenance plan demonstrating that the PM_{10} NAAQS will still be met 10 years after the area is redesignated as an attainment area by EPA.

The starting point for the 1999 inventory preparation was Version 1.0 of EPA's NEI, which contains PM_{10} emission estimates for Yuma County. Pechan, with input from ADEQ and the Yuma area stakeholders, identified the emission source categories for which there was limited confidence in the NEI estimates or the NEI did not contain estimates for the category.

This report describes the local data and emission estimation methods used to develop 1999 and 2016 PM_{10} emission estimates for Yuma. Emission estimates for any PM_{10} source categories not explicitly described in this report are taken from the 1999 NEI (Version 1.0). For most source categories, this report describes emission estimates only for the Yuma County portion of the Yuma Study Area (which includes portions of Imperial County, California and Baja California Norte, Mexico). Emission estimates for the rest of the Yuma Study Area for use in air quality modeling are described in separate documentation submitted to ADEQ (Pechan, 2003).

A. AGRICULTURAL AND PRESCRIBED BURNING

Estimates of PM_{10} emissions from agricultural burning were calculated using the following equation:

$$E = a * f * e$$

where :

E = PM_{10} emissions (tons/year);
a = acres burned per year;
f = fuel loading factor (tons/acre);
e = emission factor (pounds [lbs] PM_{10}/ton of material burned).

Estimates of the average annual acreage burned (from May 1998 to present) in Yuma County for the following crops were derived from information submitted by the Yuma Rural/Metro Fire Department: bermuda grass, wheat stubble, citrus, jojoba, artichoke, and sugar cane. However, estimates for burning of jojoba, artichoke, and sugar cane were excluded from emissions in the nonattainment area because burning of these crops occurs outside of the nonattainment area. Some burning of wheat stubble occurs outside the nonattainment area; therefore, the wheat stubble acreage burned (4,851.5) was multiplied by the ratio of nonattainment acreage (28,783 acres) to total county acreage (38,783 acres) to obtain the nonattainment area wheat stubble acreage burned.

The majority of burned acres are comprised of citrus and wheat stubble. Therefore, estimates were focused on developing appropriate emission factors for these two crops. The emission factor (EF) and fuel loading for wheat stubble were taken from an August 2000 California Air Resources Board (ARB) memo on agricultural burning emission factors (Shimp, 2000). This memo contains recommendations for emission factors and fuel loading factors for the burning of various agricultural residues. For some residues, newer test data than those used to develop the AP-42 emission factors were used to develop revised emission factors (for the remaining residues, AP-42 factors were used). Fuel loading factors in the California ARB memo are still taken primarily from AP-42. The citrus (orange, lemon) emission factor was taken from Section 2.5 of AP-42 (Table 2.5-5). The average emission factor and fuel loading from the California ARB memo were used for bermuda grass.

The Yuma Rural/Metro Fire Department was contacted to determine the months in which burning occurs, so that the annual emissions can be temporally allocated. Bermuda grass and wheat were reported to be burned in June, and all other activity is assumed to occur throughout the year (Foster, 2002). Emission estimates and supporting data for 1999 are summarized in Table 1a. Projected activity data and emissions for 2013 are provided in Table 1b. Information for 2013 activity levels was obtained from the Yuma stakeholders and documented in a May 2002 memorandum (Wrona, 2002). For the purposes of estimating 2016 emissions, the same 2013 activity levels are assumed. Also for the 2016 projected emission estimates, Bureau of Land Management 2013 prescribed burning activity levels (100 acres) are assumed to be appropriate for 2016. For these prescribed burns, fuel loading and emission factor information was taken from recent EPA guidance for wildland fires (EC/R, 2002). This information corresponds to default values used in the First Order Fire Effects Model (FOFEM) for grasslands and shrubs.

B. AGRICULTURAL TILLING

PM emissions from agricultural tilling were calculated using the equation below (EPA, 2001a):

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

where:

E = PM emissions (lbs/year);
c = constant of 4.8 lbs/acre-pass;

k = dimensionless particle size multiplier (PM_{10} = 0.21);
s = silt content of soil (mass fraction of particles smaller than 75 μm diameter found in soil to a depth of 10 centimeters) (percentage);
p = number of passes/year;
a = number of acres.

Table 1a
1999 Yuma County Nonattainment Area PM_{10} Emissions from Agricultural Burning

Crop	Acres[1]	Fuel Loading (ton/acre)	Emission Factor (lbs PM10/ton)	Emissions (tons per year [tpy])	Comments
Bermuda Grass	202	2.0	15.9	3.2	EF and Fuel Loading Source - ARB "Grasslands": Average of Field Crops (Shimp, 2000).
Wheat	3601	1.9	10.6	36.3	EF and Fuel Loading Source - Shimp (2000); Nonattainment area acreage estimated as total burned acreage (4,851.5) x ratio of nonattainment area acreage (28,783) to county acreage (38,783).
Citrus	415	1.0	5.9	1.2	EF and Fuel Loading Source - AP-42; no correction made to acreage estimate; according to Farm Service Agency, most of citrus is in the nonattainment area.
Jojoba[2]	0	2.0	15.9	0	EF and Fuel Loading Source - Shimp (2000): Average of Field Crops.
Artichoke[2]	0	2.0	15.9	0	EF and Fuel Loading Source - Shimp (2000): Average of Field Crops.
Sugar Cane[2]	0	2.0	15.9	0	EF and Fuel Loading Source - Shimp (2000): Average of Field Crops.
BLM Prescribed Burns	0	0.3	25.3	0	No activity in 1999. EF and Fuel Loading Source - EC/R (2002).
Totals	**4,218**			**40.7**	

NOTE: [1]Acreage is annual average from May 1998 to present: Data from Rural/Metro Fire Department. [2] All burn activity occurs outside of the non-attainment area.

Table 1b
Projected 2016 PM_{10} Emissions

Crop	Fuel Loading (ton/acre)	EF (lbs PM10/ton)	Acres*	Emissions (PM_{10} tpy)
Bermuda Grass	**2.0**	**15.9**	**200**	**3.2**
Wheat	**1.9**	**10.6**	**3,000**	**30.2**
Citrus	**1.0**	**5.9**	**100**	**0.3**
Jojoba	**2.0**	**15.9**	**0**	**0**
Artichoke	**2.0**	**15.9**	**0**	**0**
Sugar Cane	**2.0**	**15.9**	**0**	**0**
BLM Prescribed Burns	**0.3**	**25.3**	**100**	**0.4**
Totals			**3,400**	**34.1**

NOTE: *Acres burned estimates for 2013 were provided by the Rural/Metro Fire Department. 2013 activity levels are assumed to be representative of 2016 activity levels.

The surface soil silt content (83 percent) was estimated from the Yuma-Wellton Soil Survey from the Arizona Soil Conservation Service (SCS, 1980). The typical range of silt content on Yuma County crop lands was 75-90 percent. Estimates of the number of passes for all crops, except cotton, were obtained from the University of Arizona Cooperative Extension (Zerkoune, 2002). The number of passes for cotton was estimated based on Conservation Tillage Information Center (CTIC) conservation use estimates. The 1999 crop acreage, for all crops except wheat, was estimated based on data from the 1997 Census of Agriculture and information provided by the University of Arizona Cooperative Extension. Wheat acreage was provided by the Farm Service Agency. A summary of this information is provided in Table 2a.

Table 2a
1999 and 2016 Yuma County Agricultural Tilling PM_{10} Emission Estimates

Crop	Acres	Passes	Emissions (tpy)	Months	Comments
Cotton	27,972	5	999.0	March	Number of passes estimated based on CTIC estimate.
Barley	2,313	2	33.0	Dec-Jan	
Hay	9,000	3	192.9	Oct-Nov	University of Arizona Cooperative Extension office - tilling done once every 5 years - total acreage of 45,000 divided by 5 to get an annual average.
Wheat	28,800	2	411.4	Dec-Mar	Acreage from Farm Service Agency.
Vegetables	86,329	3	1,849.9	Aug-Dec	
Corn	4,000	3	85.7	Jan-Feb	
Totals	158,414		3,572.0		Same acreage estimated for 2013 (Wrona, 2002).

The months in which tilling occurs for each crop were provided by University of Arizona Cooperative Extension (Zerkoune, 2002) and the Yuma County Farm Bureau (Allen, 2002). This information can be used to temporally allocate the emissions. Acreage estimates, number of passes, and the typical months when tilling is performed for each major crop type were reviewed with a representative of the Farm Services Agency (Grissom, 2002). The total number of acres is higher than the total estimated 1999 crop acreage for Yuma County (126,000), since the effects of double-cropping are taken into account.

For 2013, stakeholders estimated that there would be similar activity (i.e., acreage) for all of the crops listed in Table 2a above (Wrona, 2002). 2016 activity levels are assumed to be the same as estimated for 2013. Hence, agricultural tilling emissions are not expected to change significantly between 1999 and 2016.

In addition to tilling, cultivation and harvesting operations also produce PM_{10} emissions. Emissions data for cultivation and harvesting are limited. Pechan did identify

some information on cotton and grain harvesting from AP-42 and California ARB's area source methods. These data were used to develop emission estimates for those two crops, as shown in Table 2b below. Since the activity does not change between 1999 and 2016, the emission estimates are the same for these two years.

Table 2b
1999 and 2016 Agricultural Cultivation and Harvesting Emissions

Crop	Acres	EF (lbs/acre)	PM_{10} Emissions (tpy)	Months	Comments
Cotton	27,972	1.12	15.6	Sep-Jan	Harvesting EF from California ARB Area Source Methods Section 7.5
Barley	2,313	0.00	0.000		No EF available.
Hay	9,000	0.00	0.000		No EF available.
Wheat	28,800	0.00262	0.038	May-Jul	EF for $PM_{7.0}$ from AP-42 Section 9.3.2 for harvesting/truck loading/field transport.
Vegetables	86,329	0.00	0.000		No EF available.
Corn	4,000	0.00	0.000		No EF available.
Totals	158,414		15.7		

For cotton harvesting, emission factors vary by almost 2 orders of magnitude between AP-42 and California ARB's area source method (0.041 lbs/acre in AP-42 versus 1.12 lbs/acre in California ARB's method; California ARB, 1997). Since the California ARB EF is based on 1995 test data (compared to 1977 data for AP-42), it was selected for use in the Yuma PM_{10} emission estimates. The AP-42 data were also provided as $PM_{7.0}$, instead of PM_{10}.

For wheat harvesting, the AP-42 $PM_{7.0}$ emission factor was used for estimating PM_{10} emissions for Yuma County.

C. WIND-BLOWN DUST

Wind-blown PM_{10} emissions were calculated for the following land use categories: alluvial plain and channels, agricultural crop lands, agricultural unpaved roads, native desert, urban disturbed areas, and miscellaneous disturbed areas (e.g., construction areas outside of the City of Yuma). Major revisions were made later by ADEQ to two categories: agricultural crop lands and agricultural unpaved roads. These revisions are presented in Appendix F of the Technical Support Document. Emissions for the Imperial sand dunes were also assessed. Recent test data from sand dunes near Owens Lake, California indicates that significant emissions are only likely to occur when the threshold wind speed of about 35 miles per hour (mph) is reached (Nickling and Brown, 2001). No winds exceeding 30 mph were recorded by the Yuma Valley meteorological station in 1999. Hence, 1999 emissions for sand dunes were assumed to be negligible.

For agricultural lands, it was assumed that PM_{10} emissions are negligible during seasons when crops are present. Hence, emissions were only estimated during seasons when agricultural tilling occurs (estimates of vacant land by season are provided below). Emissions from a particular land use category are calculated using the following equation:

$$E = a*f_1*w_1 + a*f_2*w_2+a*f_3*w_3$$

where:

$E = PM_{10}$ emissions (tons/year);
a = number of acres for the particular land use type;
f_1= the wind speed-specific emission factor for the land use type (ton/acre-hour); and
w_1 = the number of hours of wind in range 1.

Emission factors were taken from a recent University of Nevada, Las Vegas wind tunnel testing program in Clark County, Nevada (James et al., 2000). For different land use types (disturbed vacant lands, native desert, and stabilized vacant land), wind speed-specific emission factors were provided. Table 3 shows the assignment of these emission factors to the land use categories in the Yuma Study Area. The wind speed ranges are 15-19.9 miles per hour (mph), 20-24.9 mph, and 25-29.9 mph. Hence, the threshold wind speeds found in the Las Vegas testing are consistent with the 15 mph threshold found in the Phoenix Microscale Study (Sedlacek, 1999). The emission factors are provided in Table 3 below.

Table 3
Emission Factors for Windblown Dust

Emission Factor Types	PM_{10} EF (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
Native Desert	0	0	0.00257
Stabilized Land	0.00042	0.00034	0.00019

For agricultural fields with vegetation, it was assumed that there were no emissions. Seasonal emissions were calculated for each land use category. Annual emissions were calculated by summing across all land use categories and all seasons. Because the number of acres of vacant agricultural land varies by season, the total acreage of agricultural land was multiplied by the following percentages, based on months for agricultural tilling: Fall = 35 percent; Winter = 40 percent; Spring = 10 percent; Summer = 10 percent. No refinement of these estimates from stakeholders was received by Pechan.

Table 4 provides Yuma Study Area acreage estimates for the land uses of interest (Sedlacek, 2002), as well as the emission factor types that were used to estimate PM_{10} emissions. ADEQ developed acreage estimates for the various types of land use with input from stakeholders. Hence, emission estimates were developed for the entire Yuma Study Area, not just Yuma County. Vacant agricultural acreage by season was assumed to be the

same in the Imperial County and Mexico portions of the Study Area. For unpaved agricultural roads, ADEQ sampled several areas throughout the Study Area from satellite imagery to derive a factor (0.0815) to estimate the portion of agricultural land that was unpaved roads versus crop land.

A specific land use category for Urban Disturbed Areas (Code 295) was created to estimate emissions within the urbanized portions of the City of Yuma. This specific category allowed for more accurate characterization of the reductions in emissions associated with the 2013 reduction in disturbed area acres within the City of Yuma. This same 2013 reduction in disturbed area was assumed to be representative of 2016.

Table 4
1999 Yuma Study Area Acreage Estimates by Land Use Category and Emission Factor Type

Land Use Category	Land Use Code	Acres	Emission Factor Type
Alluvial Plain and Channels	440	141,227	Stabilized Land
Native Desert	390	74,252	Native Desert
Vacant Agricultural Fields *	260	180,825	Disturbed Vacant
Unpaved Ag Roads *	260	16,798	Disturbed Vacant
Urban Disturbed Areas	295	4,125	Disturbed Vacant
Miscellaneous Disturbed Areas	290	25,770	Disturbed Vacant

* These acreages and their emissions have been revised by ADEQ and may be found in Appendix F of the Technical Support Document.

The number of hours of wind in each wind speed range was determined using 1999 average hourly wind speed data from the Yuma Valley AZMET station. Previous analyses by ADEQ had shown that, of the three stations in and around Yuma, this station had the highest number of hours above the 15 mph threshold. All days with measurable precipitation were removed from the data, since rain dramatically reduces the amount of wind-blown dust. To estimate the number of hours in each wind speed range, the number of *wind events* was also determined. Consecutive hours of wind over the threshold value of 15 mph were considered one *wind event*. A summary of the wind data used for estimating 1999 emissions is provided in Table 5.

Table 5
1999 Wind Speed Data for Yuma County

Season	No. of Wind Events*	Disturbed Land			Native & Stabilized Land		
		No. Hours (15-19.9 mph)	No. Hours (20-24.9 mph)	No. Hours (25-29.9 mph)	No. Hours (15-19.9 mph)	No. Hours (20-24.9 mph)	No. Hours (25-29.9 mph)
Fall	8	46	25	2	7	1	0
Winter	16	80	12	1	14	2	0
Spring	13	68	9	0	13	0	0
Summer	6	16	4	0	6	0	0

NOTE: *Wind events are used with native and stabilized land categories; the sum of hours for all wind speed ranges equal the number of wind events.

For native and stabilized lands, emissions are calculated using the number of wind events. This method is based on the assumption that after a short period of high winds on native and stabilized lands, most of the dust capable of being entrained by the wind has already been removed (i.e., the limited reservoir theory). The number of wind events is equal to the total number of hours above each of the wind speed thresholds, as shown in Table 5. Hence, emissions are assumed to occur only during the first hour of each wind event. For disturbed land, it is assumed that there is an unlimited reservoir of suspendable material. Therefore, the total number of hours of wind in each wind speed range was used in calculating emissions for disturbed land. In addition to the data shown in Table 5, there were several hours in the Fall and Winter of 1999 that exceeded the 25 mph threshold for native desert (these hours were part of the same wind events shown in Table 5). These hourly exceedances were used to estimate emissions for natural desert areas in 1999. Emission estimates are provided in Table 6a.

Table 6a
1999 Yuma Study Area PM_{10} Emission Estimates for Windblown Dust

Land Use Category	Acres	Emissions by Season (tons)				Total Annual (PM_{10} tons)
		Fall	Winter	Spring	Summer	
Alluvial Plain and Channels	141,227	463	926	771	356	2,517
Native Desert	74,252	191	191	0	0	382
Vacant Agricultural Fields *	180,825	23,464	33,628	6,934	1,809	65,835
Unpaved Agricultural Roads *	16,798	6,228	7,810	6,442	1,680	22,160
Urban Disturbed Areas	4,125	1,529	1,918	1,582	413	5,442
Miscellaneous Disturbed Areas	25,770	9,554	11,981	9,883	2,578	33,996
	Totals	41,430	56,453	25,612	6,836	130,331

* These emissions have been revised by ADEQ and may be found in Appendix F of the Technical Support Document.

Emission estimates for 2016 are provided in Table 6b. It was assumed that the winds in 2016 would be similar to those observed in 1999. The only significant change in the activity data (acreage estimates) between 1999 and 2016 was the reduction of urban disturbed acreage; hence, the emission estimates for the entire Study Area are very similar. A small amount of agricultural land is lost to urban development in 2016.

Table 6b
2016 Yuma Study Area PM_{10} Emission Estimates for Windblown Dust

Land Use Category	Acres	Emissions by Season (tons)				Total Annual (PM_{10} tons)
		Fall	Winter	Spring	Summer	
Alluvial Plain and Channels	141,227	463	926	771	356	2,517
Native Desert	74,252	191	191	0	0	382
Vacant Agricultural Fields *	179,048	23,234	33,297	6,866	1,791	65,188
Unpaved Agricultural Roads *	16,633	6,167	7,733	6,379	1,664	21,942
Urban Disturbed Areas	2,290	849	1,065	878	229	3,021
Miscellaneous Disturbed Areas	25,770	9,554	11,981	9,883	2,578	33,996
	Totals	40,458	55,193	24,777	6,618	127,046

* These emissions have been revised by ADEQ and may be found in Appendix F of the Technical Support Document.

D. UNPAVED ROADS - RE-ENTRAINED DUST

The most recent suggested revision of the AP-42 section for unpaved roads (13.2.2 Unpaved Roads) contains two new emission factor equations, one for industrial unpaved roads and one for publicly accessible unpaved roads (Muleski, 2001). The equation for publicly accessible unpaved roads was believed to be more representative of the Yuma Nonattainment Area; therefore, the emission factor was calculated using the following equation:

$$E = \frac{k\left(s/12\right)^{0.97}\left(S/30\right)^{0.46}}{\left(M/0.5\right)^{0.23}}$$

where:

E = size specific emission factor (lbs/vehicle miles traveled [VMT]);
k = 1.8
s = surface material silt content (%);
S = mean vehicle speed (mph); and
M = surface material moisture content (percentage).

A silt material silt content of 7.5 percent was determined from a soil sample taken from a dirt road in Yuma County (Catlin, 2002). A surface material moisture content representative of Arizona (1 percent) was used. The average vehicle speed was assumed to be 10 mph, based on tractor travel on unpaved roads in the Yuma area (Lima & Associates, 2000). It should be noted that the above equation has been modified slightly in EPA's publicized draft version of the documentation of this equation. Primarily, the exponents have been rounded to 1 decimal place in the EPA version.

VMT data and the mean vehicle speed were obtained from the PM_{10} emissions analysis conducted as part of the Yuma Metropolitan Planning Organization (YMPO) Model and Air Quality Conformity Analysis project. The report indicates that the 1999 unpaved road daily VMT, calculated using TransCAD GIS-based modeling software, is 98,864 miles (Lima & Associates, 2000). The projected daily unpaved road VMT for 2016 is 64,240 miles. This value was estimated by calculating the annual growth rate between 2013 and 2025 unpaved road VMT projections (Lima & Associates, 2002). This annual growth rate of 6.1 percent per year was then used to estimate three additional years of growth from 2013.

Unpaved road reentrained dust emissions were corrected for the effects of precipitation, as proposed in the suggested revisions to AP-42. Corrected monthly emission factors were calculated using the following equation:

$$E_{corr} = E\left(\frac{N - p}{N}\right)$$

where:

E_{corr} = monthly emission factor corrected for precipitation effects;
E = the uncorrected emission factor;
N = number of days in the month; and
p = number of days in the month with > 0.01 inches of rain.

Precipitation data from 1999 was obtained from the Yuma Mesa Meteorological Station (AZMET, 1999). The number of days with greater than 0.01 inches of rain for each month in 1999 is shown in Table 7. The same precipitation data was used for the 2016 calculations. Table 8 shows the monthly PM_{10} emission factors and resulting PM_{10} emission estimates for 1999 and 2016.

Table 7
Number of Days with >0.01 in. of Rain at Yuma Mesa Meteorological Station in 1999

Month	No. of Days
January	0
February	2
March	0
April	4
May	0
June	2
July	2
August	2
September	2
October	0
November	0
December	0

Table 8
Monthly PM_{10} Emission Factors and Emissions for Unpaved Roads

Month	Monthly Emission Factor	1999 Emissions (tons)	2016 Emissions (tons)
January	0.5869	899	584
February	0.5478	754	490
March	0.5869	899	584
April	0.5086	754	490
May	0.5869	899	584
June	0.5478	812	528
July	0.5478	841	547
August	0.5478	841	547
September	0.5478	812	528
October	0.5869	899	584
November	0.5869	870	566
December	0.5869	899	584
Total		10,183 *	6,617 *

* These emissions have been revised by ADEQ and may be found in Appendix F of the Technical Support Document.

In developing inputs for air quality modeling, unpaved road emissions were broken out into two subcategories: emissions from unpaved public roads; and emissions from agricultural roads. The emissions for unpaved public roads is assumed to be 15% of the total (i.e. 15% of the unpaved road travel occurs on unpaved public roads), while the remaining 85% of emissions occur from agricultural roads (Ramos, 2003).

E. PAVED ROADS - RE-ENTRAINED DUST, EXHAUST, AND TIRE WEAR

Emission factors for paved roads were calculated using a combination of the AP-42 paved road emission factor equation and EPA's PART5 and MOBILE6.1 models. The following equation is from Section 13.2.1 of AP-42 (EPA, 2001b):

$$E = 7.3\left(\frac{sL}{2}\right)^{0.65}\left(\frac{W}{3}\right)^{1.5}$$

where:

E = size specific emission factor (g/VMT);
sL = road surface silt loading (g/m^2); and
W = average vehicle weight in tons.

An average vehicle weight of 3 tons, the national average, was used. Road surface silt loading values were taken from two sources. The surface silt loadings for arterials, rural collectors, and local roads were determined from soil samples taken from various roads in the Yuma area by ADEQ in January 2002 (Catlin, 2002). Laboratory analysis of the samples was performed by Kleinfelder, Inc. The silt loadings were reported as silt percentages, and were converted to g/m^2 using the following equation:

$$sL = \frac{S \bullet \left(w_{b\&s} - w_b\right)}{A}$$

where:

S = the silt content in percent
$w_{b\&s}$ = the weight of the bag and sample in grams
w_b = the weight of the bag in grams
A = the area vacuumed in m^2

The results of the silt measurements are shown in Table 9. The result of the first rural minor collector sample was removed because it is unusually high compared to the second sample and the silt loading from an earlier analysis (0.24 g/m^2). In addition, the laboratory analysis noted that the material in this sample contained some asphaltic bituminous material that melted when heated. This had an effect on the laboratory's ability to reclaim the material for an accurate dry weight. Silt loadings for interstates and urban collectors were taken from the previous analysis (Lima & Associates, 2000). Table 10 shows the silt loadings used for each of the 9 road types.

Table 9
2002 Silt Loading Measurements (g/m^2)

Road Type	Sample 1	Sample 2	Sample 3	Average
Principal arterial	0.32	0.28	-	0.30
Local paved	1.21	0.17	1.16	0.85
Rural minor collector	2.47	0.70	-	0.70

Table 10
Silt Loadings (g/m^2) by Road Type

Road Type	Silt Loading (g/m^2)
Interstate	0.04
Principal Arterials	0.30
Minor Arterials	0.30
Rural Major Collectors	0.70
Rural Minor Collectors	0.70
Urban Collectors	0.24
Local Roads	0.85
Interstate Ramps	0.04
Local	0.85

The AP-42 equation above encompasses reentrained road dust, brake wear, tire wear, and vehicle exhaust, based on the empirical relationship that existed at the time the emission factor equation was developed. Thus, the AP-42 equation produces emission factors that are higher than would be accounted for by today's vehicles that have lower PM10 exhaust emission factors due to lower emission standards. In addition, the 2016 exhaust emission PM10 emission factors will be even lower due to the Tier 2 emission standards and the heavy duty vehicle emission standards. EPA is currently revising the AP-42 equation to exclude the exhaust portion of the paved road emissions from this equation. For this analysis, EPA's PART5 model was used to obtain the reentrained road dust, brake wear, and tire wear portions of the paved road emission factors (EPA, 1995). As part of the PART5 output, the paved road reentrained road dust plus brake wear emission factors are available. These emission factors are shown in Table 11. Also, based on the PART5 output, the brake wear accounts for 0.013 grams per mile in all of the PART5 emission factors. Table 11 also shows the PART5 tire wear emission factor. This value does not change by road type or year. MOBILE6.1, another EPA model, was used to calculate 1999 and 2016 exhaust emission factors (EPA, 2002). The MOBILE6.1 exhaust emission factors account for Tier 2 emission standards and 2007 heavy duty emission standards that are not incorporated in PART5. These exhaust emission factors are shown in Table 11. However, MOBILE6.1 does not include reentrained road dust emission factors, while both PART5 and MOBILE6.1 use the same information for calculating brake wear and tire wear emission factors. Therefore, the PART5 emission factors for fugitive dust and brake and tire wear, and the MOBILE6.1 *exhaust* emission factors were used to calculate emission factors, because they are more representative of the 1999 and 2016 vehicle populations.

Daily VMT estimates were obtained from the PM_{10} emissions analysis prepared by Lima & Associates for the Arizona Department of Transportation and the YMPO (Lima & Associates, 2000). VMT for each roadway type was estimated using TransCAD GIS based modeling software. Lima & Associates projected 2013 and 2025 daily VMT on paved roads (Lima & Associates, 2002). Daily VMT estimates were not available for 2016 for this analysis. Therefore, the average annual growth rate was calculated for each road type from 2013 to 2025. Three years of growth at this annual growth rate were then applied to the 2013 VMT by road type to estimate 2016 average daily VMT on paved roads. The 1999,

Table 11
1999 and 2016 PM_{10} Paved Road Emission Factors by Road Type

Roadway Type	Speed (mph)	Silt Loading (g/m^2)	AP-42 Equation, 1999 & 2016 (includes Reentrained Dust, Brake Wear, Tire Wear, and Exhaust)	PART5 1999 and 2016 Paved Road Reentrained Dust plus Brake Wear Emission Factor (g/mi)	PART5 1999 and 2016 Tire Wear Emission Factor (g/mi)	1999 MOBILE6.1 PM_{10} Exhaust Emission Factor (g/mi)	2016 MOBILE6.1 PM10 Exhaust Emission Factor (g/mi)	1999 Total Paved Road PM_{10} Emission Factor (includes Reentrained Dust, Tire Wear, Brake Wear, and Exhaust)	2016 Total Paved Road PM_{10} Emission Factor (includes Reentrained Dust, Tire Wear, Brake Wear, and Exhaust)
Interstate	55	0.04	0.57	0.37	0.009	0.064	0.011	0.443	0.390
Principal Arterials	42	0.3	2.13	1.92	0.009	0.064	0.011	1.993	1.940
Minor Arterials	40	0.3	2.13	1.92	0.009	0.064	0.011	1.993	1.940
Rural Major Collectors	45	0.7	3.69	3.49	0.009	0.064	0.011	3.563	3.510
Rural Minor Collectors	46	0.7	3.69	3.49	0.009	0.064	0.011	3.563	3.510
Urban Collectors	35	0.24	1.84	1.64	0.009	0.064	0.011	1.713	1.660
Local Roads	35	0.85	4.19	3.98	0.009	0.065	0.011	4.054	4.000
Interstate Ramps	35	0.04	0.57	0.37	0.009	0.064	0.011	0.443	0.390
Local	20	0.85	4.19	3.98	0.009	0.065	0.011	4.054	4.000

NOTES: Emission factors are in grams per mile.

2013, and 2025 VMT, as well as the calculated annual growth rates between 2013 and 2025, and the estimated 2016 VMT are all shown in Table 12.

As with unpaved roads, the paved road reentrained dust emission factors were corrected for the effects of precipitation. Monthly emission factors for paved roads were calculated using a similar method as that used for unpaved roads. Precipitation is assumed to affect paved roads half as much as unpaved roads; therefore, the following equation is used:

$$E_{corr} = E\left(\frac{N - 0.5\,p}{N}\right)$$

where:

E_{corr} = monthly emission factor corrected for precipitation effects;
E = the uncorrected emission factor;
N = number of days in the month; and
p = number of days in the month with > 0.01 inches of rain.

Emission factors adjusted for precipitation effects were then calculated by month and road type. Only the fugitive dust portion of the emission factor was adjusted for precipitation effects. No adjustments were applied to the brake wear, tire wear, or exhaust portions of the emission factors. The resulting monthly emission factors by road type are shown in Tables 13 and 14 for 1999 and 2016, respectively. Monthly VMT was estimated by month and road type by multiplying the average daily VMT values by the number of days in each month for each road type. The monthly emission factors were then multiplied by the monthly VMT for each road type. The emission results are shown in Table 13 for 1999 and in Table 14 for 2016.

F. ROAD CONSTRUCTION

Construction emissions are estimated using two basic construction parameters, the acres of land disturbed by the construction activity and the duration of the activity. Data on the actual acres disturbed by road construction are generally not available, so a surrogate is used. The 1999 NEI emission estimation methods for road construction use the following miles to acres conversions by roadway type:

- Interstate, urban and rural; Other arterial, urban – 15.2 acres/mile
- Other arterial, rural – 12.7 acres/mile
- Collectors, urban – 9.8 acres/mile
- Collectors, rural – 7.9 acres/mile

Table 12
1999 and 2016 Daily VMT by Road Type

Road Type	1999 Daily VMT (miles per day)	2013 Daily VMT (miles per day)	2025 Daily VMT (miles per day)	Average Annual Growth Rate from 2013 to 2025	Estimated 2016 Daily VMT (miles per day)
Interstate	541,163	866,379	986,872	1.09%	895,048
Principal Arterials	860,715	1,564,166	1,768,187	1.03%	1,612,851
Minor Arterials	672,408	1,137,824	1,443,793	2.00%	1,207,626
Rural Major Collectors	91,129	198,520	289,087	3.18%	218,077
Rural Minor Collectors	448,640	870,923	1,028,207	1.39%	907,831
Urban Collectors	139,709	232,904	271,676	1.29%	242,045
Local Roads	4,841	17,387	21,204	1.67%	18,271
Interstate Ramps	50,581	84,437	94,825	0.97%	86,922
Local Paved	889,680	1,361,490	1,678,386	1.76%	1,434,610
Total	3,698,866	6,334,030	7,582,237		6,623,281

NOTES: The 1999 Daily VMT estimates are from Lima & Associates, 2000. The 2013 and 2025 Daily VMT estimates are from Lima & Associates, 2002.

Table 13
1999 Paved Road Emission Factors by Month and Road Type and Emissions by Road Type

Month	No. of Days with >0.01 inches of precip.	Interstate	Principal Arterial	Minor Arterial	Rural Major Collector	Rural Minor Collector	Urban Collector	Local Roads	Interstate Ramps	Local Paved	Total Paved Roads
Jan	0	0.443	1.993	1.993	3.563	3.563	1.713	4.054	0.443	4.054	
Feb	2	0.430	1.924	1.924	3.438	3.438	1.654	3.912	0.430	3.912	
Mar	0	0.443	1.993	1.993	3.563	3.563	1.713	4.054	0.443	4.054	
Apr	4	0.419	1.865	1.865	3.331	3.331	1.604	3.789	0.419	3.789	
May	0	0.443	1.993	1.993	3.563	3.563	1.713	4.054	0.443	4.054	
Jun	2	0.431	1.929	1.929	3.447	3.447	1.658	3.921	0.431	3.921	
Jul	2	0.431	1.931	1.931	3.450	3.450	1.660	3.926	0.431	3.926	
Aug	2	0.431	1.931	1.931	3.450	3.450	1.660	3.926	0.431	3.926	
Sep	2	0.431	1.929	1.929	3.447	3.447	1.658	3.921	0.431	3.921	
Oct	0	0.443	1.993	1.993	3.563	3.563	1.713	4.054	0.443	4.054	
Nov	0	0.443	1.993	1.993	3.563	3.563	1.713	4.054	0.443	4.054	
Dec	0	0.443	1.993	1.993	3.563	3.563	1.713	4.054	0.443	4.054	
Average Daily VMT (miles/day)		541,163	860,715	672,408	91,129	448,640	139,709	4,841	50,581	889,680	3,698,866
Annual Emissions (tons)		95	677	529	128	631	95	8	9	1,424	3,595

Table 14
2016 Paved Road Emission Factors by Month and Road Type and Emissions by Road Type

Month	No. of Days with >0.01 inches of precip.	Interstate	Principal Arterial	Minor Arterial	Rural Major Collector	Rural Minor Collector	Urban Collector	Local Roads	Interstate Ramps	Local Paved	Total Paved Roads
Jan	0	0.390	1.940	1.940	3.510	3.510	1.660	4.000	0.390	4.000	
Feb	2	0.377	1.874	1.874	3.390	3.390	1.603	3.863	0.377	3.863	
Mar	0	0.390	1.940	1.940	3.510	3.510	1.660	4.000	0.390	4.000	
Apr	4	0.366	1.812	1.812	3.278	3.278	1.551	3.735	0.366	3.735	
May	0	0.390	1.940	1.940	3.510	3.510	1.660	4.000	0.390	4.000	
Jun	2	0.378	1.876	1.876	3.394	3.394	1.605	3.867	0.378	3.867	
Jul	2	0.378	1.878	1.878	3.397	3.397	1.607	3.872	0.378	3.872	
Aug	2	0.378	1.878	1.878	3.397	3.397	1.607	3.872	0.378	3.872	
Sep	2	0.378	1.876	1.876	3.394	3.394	1.605	3.867	0.378	3.867	
Oct	0	0.390	1.940	1.940	3.510	3.510	1.660	4.000	0.390	4.000	
Nov	0	0.390	1.940	1.940	3.510	3.510	1.660	4.000	0.390	4.000	
Dec	0	0.390	1.940	1.940	3.510	3.510	1.660	4.000	0.390	4.000	
Average Daily VMT (miles/day)		895,048	1,612,851	1,207,626	218,077	907,831	242,045	18,271	86,922	1,434,610	6,623,281
Annual Emissions (tons)		138	1,238	927	303	1,261	159	29	13	2,271	6,340

The number of miles of highway constructed in 1999 and 2013 projections, shown in Table 15, were provided by local officials. Activity in 2016 is assumed to be equivalent to the 2013 projected activity. The type of roadways constructed was not available; therefore, 9.8 acres/mile was assumed for all roads.

Table 15
1999 and 2016 Miles of Roadway Constructed and PM_{10} Emissions

Location	1999 Miles of Roadway Constructed	1999 Emissions (tons)	2016 Miles of Roadway Constructed	2016 Emissions (tons)
Somerton	2.52	1,383	0	0
City of Yuma	7.2	3,951	11.1	6,092
Yuma Co.	1.9	384	3.6	2,634
ADOT	0.7	1,043	4.8	1,976
Total		6,761		10,702

* These emissions have been revised by ADEQ and may be found in Appendix F of the Technical Support Document.

Emissions were calculated using the total acres disturbed, the PM_{10} emission factor of 0.42 tons/acre/month, and the activity duration, estimated to be 12 months. Adjustments were made to the PM_{10} emissions to account for conditions in Yuma including correction parameters for soil moisture level and silt content (MRI, 1999). The corrected emissions were calculated using the following equation:

$$E_{corr} = E\left(24/PE\right)\left(s/9\right)$$

where:

E_{corr} = emissions corrected for soil moisture and silt content;
E = uncorrected emissions;
PE = PE index (moisture level); and
s = surface silt content (percentage).

Soil moisture levels were estimated using precipitation-evaporation values from Thornthwaite's PE Index. The PE value for Yuma County is 6. A silt content value of 40 percent was used. This value was used to calculate 1999 NEI emissions for Yuma County and was determined by comparing the U.S. Department of Agriculture surface soil map with the county map.

G. GENERAL BUILDING CONSTRUCTION

This category includes residential building (housing) construction and commercial building construction. Housing construction PM_{10} emissions were calculated using an emission factor of

0.032 tons PM_{10}/acre/month, the number of housing units constructed, a units-to-acres conversion factor, and the duration of construction activity. The duration of construction activity is assumed to be 6 months (MRI, 1999). The equation for calculating emissions from residential construction is:

$$\text{Emissions} = (0.032 \text{ tons } PM_{10}/\text{acre/month}) * B * f * m$$

where:

B = number of single- or two-family homes constructed;
f = buildings-to-acres conversion factor; and
m = duration of construction activity in months.

Apartment construction emissions were computed separately using an emission factor that is more representative of emissions from apartment building construction (0.11 tons PM_{10}/acre/month). A 12-month duration is assumed for apartment construction. The same emission factor and duration were used for warehouse construction.

The total acres disturbed by construction is estimated by applying conversion factors to the housing start data for each category as follows:

- Single family - 1/4 acre/building
- Two family - 1/3 acre/building
- Apartment - ½ acre/building or 1/20 acre/unit

These conversion factors were used unless they were larger than 1999 average lot sizes reported by local officials. Average lot size was used for all Yuma County buildings and City of Yuma single family houses and duplexes. The warehouse average lot size of 7 acres provided by the City of Yuma seemed excessively large, and there were no acres per building conversion factors available for warehouses. Therefore, the average warehouse lot size provided by Yuma County was also used for the 8 warehouses constructed in the City of Yuma.

The number of single-family, two-family, and apartment buildings and warehouses constructed in 1999 and 2013 projections were provided by Somerton, Yuma, and Yuma County officials. The data provided by Somerton combined single-family and two-family data; therefore, all units were assumed to be single-family buildings. The number of single family houses, duplexes, and warehouses constructed in 1999 and 2013 projections and the acre/unit used for each is shown in Table 16. Activity in the 2016 projection year is assumed to be the same as projected for 2013. 1999 and 2016 emission estimates in tons per year (tpy) for building construction are given in Table 17.

Table 16
1999 and 2013 Housing Starts and Acres/Unit Conversions

		1999		2013	
	Unit Type	No. of Units	Acres/Unit	No. of Units	Acres/Unit
Yuma Co.	single family	370	0.25	370	0.25
	warehouses	8	1.30	8	1.30
City of Yuma	single family	251	0.184	1533	0.184
	duplex	2	0.184	6	0.184
	apartment	44	0.05	111	0.05
	warehouses	8	1.30	7	1.30
Somerton	single family	393	0.25	393	0.25
	apartment	84	0.05	84	0.05

Table 17
1999 and 2016 PM_{10} Emission Estimates for Building Construction

Area	Unit Type	1999 Emissions (tons)	2016 Emissions (tons)
Yuma Co.	single family	11.1	11.1
	warehouses	14.8	14.8
City of Yuma	single family	5.51	33.8
	duplex	0.04	0.13
	apartment	1.82	9.16
	warehouses	14.8	13.0
Somerton	single family	3.24	3.24
	apartment	2.48	2.48
Totals		53.8 *	87.7 *

* These emissions have been revised by ADEQ and may be found in Appendix F of the Technical Support Document.

H. AIRCRAFT

The basic method for estimating emissions for this category involves determining aircraft fleet make-up and level of activity and this is matched with the appropriate emission factors by aircraft type to estimate daily or annual emissions. Aircraft emission estimates focus on emissions that occur close enough to the ground to affect ground-level concentrations. Aircraft

operations within this layer are defined as landing and takeoff (LTO) cycle. The five specific operating modes in an LTO are:

- Approach
- Taxi/idle-in
- Taxi/idle-out
- Takeoff
- Climbout

The following PM_{10} emission factors were used for calculating emissions (EPA, 1992).

Air Taxi: 0.60333 pounds/LTO
Military Aircraft: 0.60333 pounds/LTO

Air taxi refers to small aircraft used for scheduled service carrying passengers and/or freight.

LTO information was provided by the U.S. Border Patrol, the Marine Corps Air Station, the Yuma Proving Ground, and Yuma International Airport, shown in Table 18. The number of flights per day is expected to decrease at Yuma International Airport between 1999 and 2013 due to a decrease in the number of passengers to the Yuma market and the subsequent increased fares to Yuma. The 2013 estimates provided by the sources above are assumed to be representative of 2016 activity.

Table 18
1999 and 2016 LTO Data and Emission Estimates for Yuma Airports

Airport	1999 Daily LTOs	1999 Emissions (tons)	2016 Daily LTOs	2016 Emissions (tons)
U.S. Border Patrol	**2**	**0.22**	**6**	**0.66**
Marine Corp Air Station	**60**	**6.60**	**69**	**7.60**
Yuma Proving Ground	**54**	**5.95**	**54**	**5.95**
Yuma Intl. Airport	**25**	**2.75**	**20**	**2.20**
Total		**15.5**		**16.4**

I. UNPAVED AIRSTRIPS

PM_{10} emissions from unpaved airstrips were estimated using the same equation as was used for unpaved roads. The soil silt content and moisture content were assumed to be 3 percent and 1 percent, respectively. An average speed of 40 mph was used, and the length of one LTO was assumed to be 1 mile. The number of flights per week for the two unpaved airstrips in the Yuma nonattainment area, shown in Table 19, was provided by local officials. The number of LTOs estimated by these officials for 2013 is assumed to be representative of activity in 2016.

Table 19
1999 and 2016 LTO Data and Emissions for Unpaved Airstrips

	1999			2016		
Airstrip	**Flights per Week**	**Average Annual LTOs**	**Emission (lbs)**	**Flights per Week**	**Average Annual LTOs**	**Emission (lbs)**
Somerston	**7-10**	**442**	**202**	**15**	**780**	**356**
Pierce Aviation	**70-80**	**3,900**	**1,781**	**70-80**	**3,900**	**1,781**
Total		**4,342**	**1,982**		**4,680**	**2,137**

J. STATIONARY SOURCES

1999 PM_{10} emissions for 5 categories of stationary sources, shown in Table 20, were provided by ADEQ. 2016 emissions were calculated by applying a growth factor to the 1999 emissions. The growth factors were based on industry sector constant dollar output projections from Regional Economics Model, Inc. (REMI) economic models incorporated into Version 4.0 of the Economic Growth Analysis System (EGAS) (Pechan, 2001). Table 21 shows the 1999 and 2016 REMI data for each sector. The growth factors, the ratio of 2016 output to 1999 output, are also shown in Table 21. The growth factor for manufacturing stationary sources was calculated by summing the REMI data for REMI sectors 1 (lumber and wood products), 3 (stone, clay, and glass products), 16 (paper and allied products), and 18 (chemical and allied products).

Table 20
1999 and 2016 PM_{10} Stationary Source Emissions

Sector	1999 Emissions (tons)	2016 Emissions (tons)
Support activities for agriculture	**10**	**14**
Utilities	**50**	**73**
Manufacturing	**6**	**11**
National Security	**1**	**1**
Rock Products	**10**	**20**
Total	**77**	**119**

Table 21
1999 and 2016 REMI Data and Growth Factors

Sector	REMI Sector	1999 REMI Data	2016 REMI Data	2016 Growth Factor
Support activities for agriculture	**49**	**0.656**	**0.893**	**1.361**
Utilities	**30**	**1.883**	**2.740**	**1.455**
Manufacturing	**1,3,16, and 18**	**3.839**	**10.267**	**1.877**
National Security	**52**	**4.608**	**4.800**	**1.042**
Rock Products	**3**	**1.631**	**3.291**	**2.018**

K. RAILROAD LOCOMOTIVES

The 1999 NEI estimates that railroad locomotives contribute 17 tpy of PM_{10} in the Yuma Nonattainment Area. Estimation methods are described in the Trends Procedures Document (EPA, 2001a). Future year activity changes affecting emission estimates are based on earnings projections for Railroad Transportation.

In January 1997, EPA proposed draft locomotive emission standards to control emissions of oxides of nitrogen, volatile organic compounds, carbon monoxide, PM, and smoke from newly manufactured and remanufactured diesel-powered locomotives and locomotive engines. In December 1997, EPA promulgated the locomotive emission standards (EPA, 1997). The locomotive standards are to be implemented in three phases, depending on the manufacture date. Tier 0 applies to the remanufacturing of locomotives and locomotive engines manufactured from 1973 through 2001. Tier I applies to the original manufacture and remanufacturing of locomotives and locomotive engines manufactured from 2002 through 2004. Tier II applies to the original manufacture and remanufacturing of locomotives and locomotive engines manufactured in 2005 and later. When fully phased-in by 2040, EPA estimates that the rule will achieve a 46 percent reduction in PM emissions. Emission estimates for 1999 and 2016 are shown in Table 22 below.

L. SUMMARY

Table 22 summarizes the 1999 and 2016 PM_{10} emissions by source category for the Yuma area. These source categories are listed in the same order that they appear in this report. With the exception of windblown dust, the emission estimates summarized in Table 22 are for the Yuma County portion of the nonattainment area. In total, 2016 emissions are expected to be at the same level that they were in 1999. The largest PM_{10} emission reductions between 1999 and

2013 come from paving unpaved roads, and through reducing the acreage that is susceptible to windblown dust. These PM_{10} emission reductions are offset by increased PM_{10} emissions resulting from increased travel on paved roads and more road construction occurring in 2016 than in 1999. Agriculture-related PM_{10} emissions are expected to remain steady during the study period.

Table 22
Yuma PM_{10} Nonattainment Area Emissions Summary - 1999 and 2016[1]

	1999 Annual Emissions (tons)	2016 Annual Emissions (tons)
Agricultural and Prescribed Burning	**40.7**	**34.1**
Agricultural Tilling	**3,572**	**3,572**
Agricultural Cultivation and Harvesting	**15.7**	**15.7**
Windblown Dust	**130,331 ***	**127,046 ***
Unpaved Roads - Re-entrained Dust	**10,183 ***	**5,537 ***
Paved Roads	**3,419**	**5,839**
Road Construction	**6,761 ***	**10,702 ***
General Building Construction	**53.8 ***	**87.7 ***
Aircraft	**15.5**	**16.4**
Unpaved Airstrips	**1.0**	**1.1**
Stationary Sources	**77**	**119**
Railroad Locomotives	**17**	**15**
Total	**154,487 ***	**152,985 ***

[1]With the exception of windblown dust, all emission estimates are for the Yuma County portion of the nonattainment area.

* These emissions have been revised by ADEQ and may be found in Appendix F of the Technical Support Document.

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APPENDIX A. PART5 Output Files

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Interstate    :Scenario Desc
Particle Size Cutoff 10.00 Microns              Altitude:  500. Ft.                Driving:  Transient RFG:No
Cal. Year: 1999                                 I/M Program: No                    Region:   Low                All
  Veh. Type:  LDGV   LDGT1   LDGT2    HDGV     MC     LDDV    LDDT   2BHDDV  LHDDV   MHDDV   HHDDV   BUSES    Veh.
Veh. Speeds:  55.0    55.0    55.0    55.0    55.0    55.0    55.0    55.0    55.0    55.0    55.0    55.0    55.0
    VMT Mix: 0.6173  0.1883  0.0853  0.0310  0.0064  0.0017  0.0012  0.0126  0.0013  0.0161  0.0357  0.0032
Composite Emission Factors (g/mi)
 Exhaust PM: 0.013   0.018   0.025   0.112   0.020   0.213   0.244   0.188   0.857   0.719   0.827   0.699   0.065
 Brake:      0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013
 Tire:       0.008   0.008   0.008   0.012   0.004   0.008   0.008   0.008   0.012   0.012   0.036   0.008   0.009
 Total PM:   0.056   0.069   0.076   0.190   0.046   0.264   0.302   0.271   0.981   0.864   1.022   0.861   0.119

Fugitive Dust: Unpaved Roads Fleet Average  598.24 g/mi (as calculated in AP42 Vol 1 9/88)*
                 Paved Roads Fleet Average    0.57 g/mi (as calculated in draft AP42 Vol 1 3/93)*
               Unpaved Roads Fleet Average  598.04 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and
                                                         tire-wear emissions)**
                 Paved Roads Fleet Average    0.37 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe
                                                         and tire-wear emissions)**

*  Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

 Paved Road Silt:  0.04 (g/m^2)                              Fleet average vehicle weight:   6000
 Unpaved Silt:  4.3%                                         Fleet average number of wheels:  4
 Precipitation Days:   20 >0.01 in. (per year)

                                                                                                                  All
  Veh. Type:  LDGV   LDGT1   LDGT2    HDGV     MC     LDDV    LDDT   2BHDDV  LHDDV   MHDDV   HHDDV   BUSES    Veh.
Gas. SO2:
   (g/mi) :  0.078   0.104   0.105   0.186   0.033   0.108   0.132   0.215   0.345   0.421   0.509   0.494   0.113
Principal Art :Scenario Desc
Particle Size Cutoff 10.00 Microns              Altitude:  500. Ft.                Driving:  Transient RFG:No
Cal. Year: 1999                                 I/M Program: No                    Region:   Low                All
  Veh. Type:  LDGV   LDGT1   LDGT2    HDGV     MC     LDDV    LDDT   2BHDDV  LHDDV   MHDDV   HHDDV   BUSES    Veh.
Veh. Speeds:  42.0    42.0    42.0    42.0    42.0    42.0    42.0    42.0    42.0    42.0    42.0    42.0    42.0
    VMT Mix: 0.6173  0.1883  0.0853  0.0310  0.0064  0.0017  0.0012  0.0126  0.0013  0.0161  0.0357  0.0032
Composite Emission Factors (g/mi)
 Exhaust PM: 0.013   0.018   0.025   0.112   0.020   0.213   0.244   0.188   0.857   0.719   0.827   0.699   0.065
 Brake:      0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013   0.013
 Tire:       0.008   0.008   0.008   0.012   0.004   0.008   0.008   0.008   0.012   0.012   0.036   0.008   0.009
 Total PM:   0.056   0.069   0.076   0.190   0.046   0.264   0.302   0.271   0.981   0.864   1.022   0.861   0.119

Fugitive Dust: Unpaved Roads Fleet Average  456.84 g/mi (as calculated in AP42 Vol 1 9/88)*
                 Paved Roads Fleet Average    2.13 g/mi (as calculated in draft AP42 Vol 1 3/93)*
```

```
              Unpaved Roads Fleet Average  456.63 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and
                                                        tire-wear emissions)**
                Paved Roads Fleet Average    1.92 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe
                                                        and tire-wear emissions)**

*  Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

 Paved Road Silt:  0.30 (g/m^2)                                Fleet average vehicle weight:   6000
 Unpaved Silt:  4.3%                                           Fleet average number of wheels:  4
 Precipitation Days:   20 >0.01 in. (per year)
```

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2: (g/mi) :	0.078	0.104	0.105	0.186	0.033	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

```
Minor Arterial:Scenario Desc
Particle Size Cutoff 10.00 Microns              Altitude:  500. Ft.                Driving:  Transient RFG:No
Cal. Year: 1999                                 I/M Program: No                    Region:   Low
```

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Veh. Speeds:	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
VMT Mix:	0.6173	0.1883	0.0853	0.0310	0.0064	0.0017	0.0012	0.0126	0.0013	0.0161	0.0357	0.0032	
Composite Emission Factors (g/mi)													
Exhaust PM:	0.013	0.018	0.025	0.112	0.020	0.213	0.244	0.188	0.857	0.719	0.827	0.699	0.065
Brake:	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Tire:	0.008	0.008	0.008	0.012	0.004	0.008	0.008	0.008	0.012	0.012	0.036	0.008	0.009
Total PM:	0.056	0.069	0.076	0.190	0.046	0.264	0.302	0.271	0.981	0.864	1.022	0.861	0.119

```
Fugitive Dust: Unpaved Roads Fleet Average  435.08 g/mi (as calculated in AP42 Vol 1 9/88)*
                 Paved Roads Fleet Average    2.13 g/mi (as calculated in draft AP42 Vol 1 3/93)*
               Unpaved Roads Fleet Average  434.88 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and
                                                        tire-wear emissions)**
                 Paved Roads Fleet Average    1.92 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe
                                                        and tire-wear emissions)**

*  Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

 Paved Road Silt:  0.30 (g/m^2)                                Fleet average vehicle weight:   6000
 Unpaved Silt:  4.3%                                           Fleet average number of wheels:  4
 Precipitation Days:   20 >0.01 in. (per year)
```

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2: (g/mi) :	0.078	0.104	0.105	0.186	0.033	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

```
Rural Maj Col :Scenario Desc
Particle Size Cutoff 10.00 Microns              Altitude:  500. Ft.                Driving:  Transient RFG:No
Cal. Year: 1999                                 I/M Program: No                    Region:   Low
```

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	Veh.
Veh. Speeds:	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
VMT Mix:	0.6173	0.1883	0.0853	0.0310	0.0064	0.0017	0.0012	0.0126	0.0013	0.0161	0.0357	0.0032	
Composite Emission Factors (g/mi)													
Exhaust PM:	0.013	0.018	0.025	0.112	0.020	0.213	0.244	0.188	0.857	0.719	0.827	0.699	0.065
Brake:	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Tire:	0.008	0.008	0.008	0.012	0.004	0.008	0.008	0.008	0.012	0.012	0.036	0.008	0.009
Total PM:	0.056	0.069	0.076	0.190	0.046	0.264	0.302	0.271	0.981	0.864	1.022	0.861	0.119

Fugitive Dust: Unpaved Roads Fleet Average 489.47 g/mi (as calculated in AP42 Vol 1 9/88)*
Paved Roads Fleet Average 3.69 g/mi (as calculated in draft AP42 Vol 1 3/93)*
Unpaved Roads Fleet Average 489.26 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and tire-wear emissions)**
Paved Roads Fleet Average 3.49 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe and tire-wear emissions)**

* Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

Paved Road Silt: 0.70 (g/m^2)
Unpaved Silt: 4.3%
Precipitation Days: 20 >0.01 in. (per year)

Fleet average vehicle weight: 6000
Fleet average number of wheels: 4

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2: (g/mi) :	0.078	0.104	0.105	0.186	0.033	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

Rural Min Col :Scenario Desc
Particle Size Cutoff 10.00 Microns Altitude: 500. Ft. Driving: Transient RFG:No
Cal. Year: 1999 I/M Program: No Region: Low

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Veh. Speeds:	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0
VMT Mix:	0.6173	0.1883	0.0853	0.0310	0.0064	0.0017	0.0012	0.0126	0.0013	0.0161	0.0357	0.0032	
Composite Emission Factors (g/mi)													
Exhaust PM:	0.013	0.018	0.025	0.112	0.020	0.213	0.244	0.188	0.857	0.719	0.827	0.699	0.065
Brake:	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Tire:	0.008	0.008	0.008	0.012	0.004	0.008	0.008	0.008	0.012	0.012	0.036	0.008	0.009
Total PM:	0.056	0.069	0.076	0.190	0.046	0.264	0.302	0.271	0.981	0.864	1.022	0.861	0.119

Fugitive Dust: Unpaved Roads Fleet Average 500.35 g/mi (as calculated in AP42 Vol 1 9/88)*
Paved Roads Fleet Average 3.69 g/mi (as calculated in draft AP42 Vol 1 3/93)*
Unpaved Roads Fleet Average 500.14 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and tire-wear emissions)**
Paved Roads Fleet Average 3.49 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe and tire-wear emissions)**

* Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

Paved Road Silt: 0.70 (g/m^2)
Unpaved Silt: 4.3%
Precipitation Days: 20 >0.01 in. (per year)

Fleet average vehicle weight: 6000
Fleet average number of wheels: 4

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2: (g/mi) :	0.078	0.104	0.105	0.186	0.033	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

Urban Collect :Scenario Desc
Particle Size Cutoff 10.00 Microns — Altitude: 500. Ft. — Driving: Transient RFG:No
Cal. Year: 1999 — I/M Program: No — Region: Low

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Veh. Speeds:	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
VMT Mix:	0.6173	0.1883	0.0853	0.0310	0.0064	0.0017	0.0012	0.0126	0.0013	0.0161	0.0357	0.0032	
Composite Emission Factors (g/mi)													
Exhaust PM:	0.013	0.018	0.025	0.112	0.020	0.213	0.244	0.188	0.857	0.719	0.827	0.699	0.065
Brake:	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Tire:	0.008	0.008	0.008	0.012	0.004	0.008	0.008	0.008	0.012	0.012	0.036	0.008	0.009
Total PM:	0.056	0.069	0.076	0.190	0.046	0.264	0.302	0.271	0.981	0.864	1.022	0.861	0.119

Fugitive Dust: Unpaved Roads Fleet Average 380.70 g/mi (as calculated in AP42 Vol 1 9/88)*
Paved Roads Fleet Average 1.84 g/mi (as calculated in draft AP42 Vol 1 3/93)*
Unpaved Roads Fleet Average 380.49 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and tire-wear emissions)**
Paved Roads Fleet Average 1.64 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe and tire-wear emissions)**

* Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

Paved Road Silt: 0.24 (g/m^2)
Unpaved Silt: 4.3%
Precipitation Days: 20 >0.01 in. (per year)

Fleet average vehicle weight: 6000
Fleet average number of wheels: 4

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2: (g/mi) :	0.078	0.104	0.105	0.186	0.033	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

Local Roads :Scenario Desc
Particle Size Cutoff 10.00 Microns — Altitude: 500. Ft. — Driving: Transient RFG:No
Cal. Year: 1999 — I/M Program: No — Region: Low

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Veh. Speeds:	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
VMT Mix:	0.6173	0.1883	0.0853	0.0310	0.0064	0.0017	0.0012	0.0126	0.0013	0.0161	0.0357	0.0032	
Composite Emission Factors (g/mi)													
Exhaust PM:	0.013	0.018	0.025	0.112	0.020	0.213	0.244	0.188	0.857	0.719	0.827	0.699	0.065
Brake:	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Tire:	0.008	0.008	0.008	0.012	0.004	0.008	0.008	0.008	0.012	0.012	0.036	0.008	0.009

Total PM:	0.056	0.069	0.076	0.190	0.046	0.264	0.302	0.271	0.981	0.864	1.022	0.861	0.119

Fugitive Dust: Unpaved Roads Fleet Average 380.70 g/mi (as calculated in AP42 Vol 1 9/88)*
Paved Roads Fleet Average 4.19 g/mi (as calculated in draft AP42 Vol 1 3/93)*
Unpaved Roads Fleet Average 380.49 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and tire-wear emissions)**
Paved Roads Fleet Average 3.98 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe and tire-wear emissions)**

* Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

Paved Road Silt: 0.85 (g/m^2)
Unpaved Silt: 4.3%
Precipitation Days: 20 >0.01 in. (per year)

Fleet average vehicle weight: 6000
Fleet average number of wheels: 4

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2: (g/mi) :	0.078	0.104	0.105	0.186	0.033	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

Interst Ramps :Scenario Desc
Particle Size Cutoff 10.00 Microns
Altitude: 500. Ft.
Driving: Transient RFG:No
Cal. Year: 1999
I/M Program: No
Region: Low

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Veh. Speeds:	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
VMT Mix:	0.6173	0.1883	0.0853	0.0310	0.0064	0.0017	0.0012	0.0126	0.0013	0.0161	0.0357	0.0032	
Composite Emission Factors (g/mi)													
Exhaust PM:	0.013	0.018	0.025	0.112	0.020	0.213	0.244	0.188	0.857	0.719	0.827	0.699	0.065
Brake:	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Tire:	0.008	0.008	0.008	0.012	0.004	0.008	0.008	0.008	0.012	0.012	0.036	0.008	0.009
Total PM:	0.056	0.069	0.076	0.190	0.046	0.264	0.302	0.271	0.981	0.864	1.022	0.861	0.119

Fugitive Dust: Unpaved Roads Fleet Average 380.70 g/mi (as calculated in AP42 Vol 1 9/88)*
Paved Roads Fleet Average 0.57 g/mi (as calculated in draft AP42 Vol 1 3/93)*
Unpaved Roads Fleet Average 380.49 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and tire-wear emissions)**
Paved Roads Fleet Average 0.37 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe and tire-wear emissions)**

* Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

Paved Road Silt: 0.04 (g/m^2)
Unpaved Silt: 4.3%
Precipitation Days: 20 >0.01 in. (per year)

Fleet average vehicle weight: 6000
Fleet average number of wheels: 4

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2:													

(g/mi) :	0.078	0.104	0.105	0.186	0.033	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

Local :Scenario Desc: fi
Particle Size Cutoff 10.00 Microns Altitude: 500. Ft. Driving: Transient RFG:No
Cal. Year: 1999 I/M Program: No Region: Low

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Veh. Speeds:	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
VMT Mix:	0.6173	0.1883	0.0853	0.0310	0.0064	0.0017	0.0012	0.0126	0.0013	0.0161	0.0357	0.0032	
Composite Emission Factors (g/mi)													
Exhaust PM:	0.013	0.016	0.024	0.112	0.020	0.213	0.244	0.188	0.857	0.719	0.827	0.699	0.064
Brake:	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Tire:	0.008	0.008	0.008	0.012	0.004	0.008	0.008	0.008	0.012	0.012	0.036	0.008	0.009
Total PM:	0.056	0.067	0.075	0.190	0.046	0.264	0.302	0.271	0.981	0.864	1.022	0.861	0.118

Fugitive Dust: Unpaved Roads Fleet Average 217.54 g/mi (as calculated in AP42 Vol 1 9/88)*
Paved Roads Fleet Average 4.19 g/mi (as calculated in draft AP42 Vol 1 3/93)*
Unpaved Roads Fleet Average 217.34 g/mi (as calculated in AP42 Vol 1 9/88, minus tailpipe and tire-wear emissions)**
Paved Roads Fleet Average 3.98 g/mi (as calculated in draft AP42 Vol 1 3/93, minus tailpipe and tire-wear emissions)**

* Includes fleet average tailpipe, tire-wear and brake-wear emissions.
** Includes fleet average brake-wear emissions.

Paved Road Silt: 0.85 (g/m^2)
Unpaved Silt: 4.3%
Precipitation Days: 20 >0.01 in. (per year)

Fleet average vehicle weight: 6000
Fleet average number of wheels: 4

Veh. Type:	LDGV	LDGT1	LDGT2	HDGV	MC	LDDV	LDDT	2BHDDV	LHDDV	MHDDV	HHDDV	BUSES	All Veh.
Gas. SO2:													
(g/mi) :	0.078	0.104	0.105	0.186	0.032	0.108	0.132	0.215	0.345	0.421	0.509	0.494	0.113

APPENDIX B. MOBILE6.1 Input and Output Files

```
MOBILE6.1 Calendar Year 1999

MOBILE6 INPUT FILE :

DAILY OUTPUT       :
AGGREGATED OUTPUT  :
PARTICULATES       :

RUN DATA           :
>



>SCENARIO: 1, Interstate
SCENARIO RECORD    : Interstate
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 55 Freeway
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 2, Principal Arterials
SCENARIO RECORD    : Principal Arterials
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 42.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 3, Minor Arterials
SCENARIO RECORD    : Minor Arterials
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 40.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 4, Rural Major Collectors
SCENARIO RECORD    : Rural Major Collectors
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
```

```
AVERAGE SPEED      : 45.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 5, Rural Minor Collectors
SCENARIO RECORD    : Rural Minor Collectors
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 46.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 6, Urban Collectors
SCENARIO RECORD    : Urban Collectors
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 35.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 7, Local Roads
SCENARIO RECORD    : Local Roads
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
VMT BY FACILITY    : FV3.FV
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 8, Interstate Ramps
SCENARIO RECORD    : Interstate Ramps
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
VMT BY FACILITY    : FV4.FV
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 9, Local
SCENARIO RECORD    : Local
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
```

```
VMT BY FACILITY    : FV3.FV
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 1
SCENARIO RECORD    : Temperature Test
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 55.0 Freeway
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 20. 30.
FUEL RVP           : 7.0

>SCENARIO: 1
SCENARIO RECORD    : RVP Test
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 1
DIESEL SULFUR      : 500.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 55.0 Freeway
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 13.0


END OF RUN         :


* # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
* Interstate
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # # # # # #

                            Calendar Year:  1999
                                    Month:  Jan.
               Gasoline Fuel Sulfur Content:  300. ppm
                 Diesel Fuel Sulfur Content:  500. ppm
                       Particle Size Cutoff: 10.00 Microns
                           Reformulated Gas:  No
       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
               GVWR:                <6000     >6000     (All)
                         ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
   VMT Distribution:    0.5138    0.2687    0.0919              0.0356    0.0015    0.0017    0.0804    0.0064    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
              GASPM:    0.0046    0.0060    0.0171    0.0088    0.0904    ------    ------    ------    0.0205    0.0089
            ECARBON:    ------    ------    ------    ------    ------    0.2259    0.1177    0.3860    ------    0.0316
            OCARBON:    ------    ------    ------    ------    ------    0.0637    0.1693    0.1900    ------    0.0157
                SO4:    0.0044    0.0062    0.0064    0.0063    0.0077    0.0059    0.0095    0.0320    0.0009    0.0074
   Total Exhaust PM:    0.0090    0.0122    0.0236    0.0151    0.0981    0.2955    0.2965    0.6080    0.0214    0.0635
              Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
```

```
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0088    0.0080    0.0080    0.0261    0.0040    0.0095
          Total PM:    0.0295    0.0327    0.0441    0.0356    0.1195    0.3161    0.3170    0.6467    0.0379    0.0855
               SO2:    0.0689    0.0808    0.1159    0.0897    0.1784    0.1129    0.1819    0.4568    0.0329    0.1115
               NH3:    0.0996    0.0959    0.0892    0.0942    0.0451    0.0068    0.0068    0.0270    0.0113    0.0890
 ------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Principal Arterials
* File 1, Run 1, Scenario 2.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                              Calendar Year:  1999
                                      Month:  Jan.
              Gasoline Fuel Sulfur Content:  300. ppm
                Diesel Fuel Sulfur Content:  500. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

      Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                       ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:    0.5138    0.2687    0.0919              0.0356    0.0015    0.0017    0.0804    0.0064    1.0000
 ------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
              Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:    0.0046    0.0060    0.0171    0.0088    0.0904    ------    ------    ------    0.0205    0.0089
           ECARBON:    ------    ------    ------    ------    ------    0.2259    0.1177    0.3860    ------    0.0316
           OCARBON:    ------    ------    ------    ------    ------    0.0637    0.1693    0.1900    ------    0.0157
               SO4:    0.0044    0.0062    0.0064    0.0063    0.0077    0.0059    0.0095    0.0320    0.0009    0.0074
  Total Exhaust PM:    0.0090    0.0122    0.0236    0.0151    0.0981    0.2955    0.2965    0.6080    0.0214    0.0635
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0088    0.0080    0.0080    0.0261    0.0040    0.0095
          Total PM:    0.0295    0.0327    0.0441    0.0356    0.1195    0.3161    0.3170    0.6467    0.0379    0.0855
               SO2:    0.0689    0.0808    0.1159    0.0897    0.1784    0.1129    0.1819    0.4568    0.0329    0.1115
               NH3:    0.0996    0.0959    0.0892    0.0942    0.0451    0.0068    0.0068    0.0270    0.0113    0.0890
 ------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Minor Arterials
* File 1, Run 1, Scenario 3.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                              Calendar Year:  1999
                                      Month:  Jan.
              Gasoline Fuel Sulfur Content:  300. ppm
                Diesel Fuel Sulfur Content:  500. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

      Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                       ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:    0.5138    0.2687    0.0919              0.0356    0.0015    0.0017    0.0804    0.0064    1.0000
 ------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
```

```
              Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:    0.0046    0.0060    0.0171    0.0088    0.0904    ------    ------    ------    0.0205    0.0089
           ECARBON:    ------    ------    ------    ------    ------    0.2259    0.1177    0.3860    ------    0.0316
           OCARBON:    ------    ------    ------    ------    ------    0.0637    0.1693    0.1900    ------    0.0157
               SO4:    0.0044    0.0062    0.0064    0.0063    0.0077    0.0059    0.0095    0.0320    0.0009    0.0074
  Total Exhaust PM:    0.0090    0.0122    0.0236    0.0151    0.0981    0.2955    0.2965    0.6080    0.0214    0.0635
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0088    0.0080    0.0080    0.0261    0.0040    0.0095
          Total PM:    0.0295    0.0327    0.0441    0.0356    0.1195    0.3161    0.3170    0.6467    0.0379    0.0855
               SO2:    0.0689    0.0808    0.1159    0.0897    0.1784    0.1129    0.1819    0.4568    0.0329    0.1115
               NH3:    0.0996    0.0959    0.0892    0.0942    0.0451    0.0068    0.0068    0.0270    0.0113    0.0890
 ------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Rural Major Collectors
* File 1, Run 1, Scenario 4.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                            Calendar Year:  1999
                                    Month:  Jan.
              Gasoline Fuel Sulfur Content:  300. ppm
                Diesel Fuel Sulfur Content:  500. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                        ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:    0.5138    0.2687    0.0919              0.0356    0.0015    0.0017    0.0804    0.0064    1.0000
 ------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
              Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:    0.0046    0.0060    0.0171    0.0088    0.0904    ------    ------    ------    0.0205    0.0089
           ECARBON:    ------    ------    ------    ------    ------    0.2259    0.1177    0.3860    ------    0.0316
           OCARBON:    ------    ------    ------    ------    ------    0.0637    0.1693    0.1900    ------    0.0157
               SO4:    0.0044    0.0062    0.0064    0.0063    0.0077    0.0059    0.0095    0.0320    0.0009    0.0074
  Total Exhaust PM:    0.0090    0.0122    0.0236    0.0151    0.0981    0.2955    0.2965    0.6080    0.0214    0.0635
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0088    0.0080    0.0080    0.0261    0.0040    0.0095
          Total PM:    0.0295    0.0327    0.0441    0.0356    0.1195    0.3161    0.3170    0.6467    0.0379    0.0855
               SO2:    0.0689    0.0808    0.1159    0.0897    0.1784    0.1129    0.1819    0.4568    0.0329    0.1115
               NH3:    0.0996    0.0959    0.0892    0.0942    0.0451    0.0068    0.0068    0.0270    0.0113    0.0890
 ------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Rural Minor Collectors
* File 1, Run 1, Scenario 5.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                            Calendar Year:  1999
                                    Month:  Jan.
              Gasoline Fuel Sulfur Content:  300. ppm
                Diesel Fuel Sulfur Content:  500. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No
```

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
GVWR:		<6000	>6000	(All)						
VMT Distribution:	0.5138	0.2687	0.0919		0.0356	0.0015	0.0017	0.0804	0.0064	1.0000
Composite Emission Factors (g/mi):										
Lead:	0.0000	0.0000	0.0000	0.0000	0.0000	------	------	------	0.0000	0.0000
GASPM:	0.0046	0.0060	0.0171	0.0088	0.0904	------	------	------	0.0205	0.0089
ECARBON:	------	------	------	------	------	0.2259	0.1177	0.3860	------	0.0316
OCARBON:	------	------	------	------	------	0.0637	0.1693	0.1900	------	0.0157
SO4:	0.0044	0.0062	0.0064	0.0063	0.0077	0.0059	0.0095	0.0320	0.0009	0.0074
Total Exhaust PM:	0.0090	0.0122	0.0236	0.0151	0.0981	0.2955	0.2965	0.6080	0.0214	0.0635
Brake:	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125
Tire:	0.0080	0.0080	0.0080	0.0080	0.0088	0.0080	0.0080	0.0261	0.0040	0.0095
Total PM:	0.0295	0.0327	0.0441	0.0356	0.1195	0.3161	0.3170	0.6467	0.0379	0.0855
SO2:	0.0689	0.0808	0.1159	0.0897	0.1784	0.1129	0.1819	0.4568	0.0329	0.1115
NH3:	0.0996	0.0959	0.0892	0.0942	0.0451	0.0068	0.0068	0.0270	0.0113	0.0890

```
* # # # # # # # # # # # # # # # # # # # # # # # # # # # #
* Urban Collectors
* File 1, Run 1, Scenario 6.
* # # # # # # # # # # # # # # # # # # # # # # # # # # # #

                            Calendar Year:  1999
                                    Month:  Jan.
              Gasoline Fuel Sulfur Content:  300. ppm
                Diesel Fuel Sulfur Content:  500. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No
```

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
GVWR:		<6000	>6000	(All)						
VMT Distribution:	0.5138	0.2687	0.0919		0.0356	0.0015	0.0017	0.0804	0.0064	1.0000
Composite Emission Factors (g/mi):										
Lead:	0.0000	0.0000	0.0000	0.0000	0.0000	------	------	------	0.0000	0.0000
GASPM:	0.0046	0.0060	0.0171	0.0088	0.0904	------	------	------	0.0205	0.0089
ECARBON:	------	------	------	------	------	0.2259	0.1177	0.3860	------	0.0316
OCARBON:	------	------	------	------	------	0.0637	0.1693	0.1900	------	0.0157
SO4:	0.0044	0.0062	0.0064	0.0063	0.0077	0.0059	0.0095	0.0320	0.0009	0.0074
Total Exhaust PM:	0.0090	0.0122	0.0236	0.0151	0.0981	0.2955	0.2965	0.6080	0.0214	0.0635
Brake:	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125
Tire:	0.0080	0.0080	0.0080	0.0080	0.0088	0.0080	0.0080	0.0261	0.0040	0.0095
Total PM:	0.0295	0.0327	0.0441	0.0356	0.1195	0.3161	0.3170	0.6467	0.0379	0.0855
SO2:	0.0689	0.0808	0.1159	0.0897	0.1784	0.1129	0.1819	0.4568	0.0329	0.1115
NH3:	0.0996	0.0959	0.0892	0.0942	0.0451	0.0068	0.0068	0.0270	0.0113	0.0890

```
* # # # # # # # # # # # # # # # # # # # # # # # # # # # #
* Local Roads
* File 1, Run 1, Scenario 7.
* # # # # # # # # # # # # # # # # # # # # # # # # # # # #
```

```
                          Calendar Year:  1999
                                  Month:  Jan.
              Gasoline Fuel Sulfur Content:  300. ppm
                Diesel Fuel Sulfur Content:  500. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

      Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                         ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:     0.5138    0.2687    0.0919              0.0356    0.0015    0.0017    0.0804    0.0064    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
              Lead:     0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:     0.0046    0.0060    0.0171    0.0088    0.0904    ------    ------    ------    0.0205    0.0089
           ECARBON:     ------    ------    ------    ------    ------    0.2259    0.1177    0.3860    ------    0.0316
           OCARBON:     ------    ------    ------    ------    ------    0.0637    0.1693    0.1900    ------    0.0157
               SO4:     0.0060    0.0068    0.0069    0.0068    0.0067    0.0059    0.0095    0.0320    0.0018    0.0084
  Total Exhaust PM:     0.0106    0.0128    0.0240    0.0157    0.0971    0.2955    0.2965    0.6080    0.0222    0.0645
             Brake:     0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:     0.0080    0.0080    0.0080    0.0080    0.0088    0.0080    0.0080    0.0261    0.0040    0.0095
          Total PM:     0.0311    0.0333    0.0446    0.0362    0.1185    0.3161    0.3170    0.6467    0.0388    0.0865
               SO2:     0.0684    0.0806    0.1158    0.0896    0.1787    0.1129    0.1819    0.4568    0.0326    0.1112
               NH3:     0.0996    0.0959    0.0892    0.0942    0.0451    0.0068    0.0068    0.0270    0.0113    0.0890
 ---------------------------------------------------------------------------------------------------------------------------

* # # #
```

```
                NH3:    0.0996    0.0959    0.0892    0.0942    0.0451    0.0068    0.0068    0.0270    0.0113    0.0890
 ------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # #
* Local
* File 1, Run 1, Scenario 9.
* # # # # # # # # # # # # # # # # # # # # # # # # #

                              Calendar Year:  1999
                                      Month:  Jan.
               Gasoline Fuel Sulfur Content:  300. ppm
                 Diesel Fuel Sulfur Content:  500. ppm
                       Particle Size Cutoff: 10.00 Microns
                           Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
               GVWR:                <6000     >6000     (All)
                          ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
   VMT Distribution:    0.5138    0.2687    0.0919              0.0356    0.0015    0.0017    0.0804    0.0064    1.0000
 ------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
              GASPM:    0.0046    0.0060    0.0171    0.0088    0.0904    ------    ------    ------    0.0205    0.0089
            ECARBON:    ------    ------    ------    ------    ------    0.2259    0.1177    0.3860    ------    0.0316
            OCARBON:    ------    ------    ------    ------    ------    0.0637    0.1693    0.1900    ------    0.0157
                SO4:    0.0060    0.0068    0.0069    0.0068    0.0067    0.0059    0.0095    0.0320    0.0018    0.0084
   Total Exhaust PM:    0.0106    0.0128    0.0240    0.0157    0.0971    0.2955    0.2965    0.6080    0.0222    0.0645
              Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
               Tire:    0.0080    0.0080    0.0080    0.0080    0.0088    0.0080    0.0080    0.0261    0.0040    0.0095
           Total PM:    0.0311    0.0333    0.0446    0.0362    0.1185    0.3161    0.3170    0.6467    0.0388    0.0865
                SO2:    0.0684    0.0806    0.1158    0.0896    0.1787    0.1129    0.1819    0.4568    0.0326    0.1112
                NH3:    0.0996    0.0959    0.0892    0.0942    0.0451    0.0068    0.0068    0.0270    0.0113    0.0890
 ------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # #
* Temperature Test
* File 1, Run 1, Scenario 10.
* # # # # # # # # # # # # # # # # # # # # # # # # #

                              Calendar Year:  1999
                                      Month:  Jan.
               Gasoline Fuel Sulfur Content:  300. ppm
                 Diesel Fuel Sulfur Content:  500. ppm
                       Particle Size Cutoff: 10.00 Microns
                           Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
               GVWR:                <6000     >6000     (All)
                          ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
   VMT Distribution:    0.5138    0.2687    0.0919              0.0356    0.0015    0.0017    0.0804    0.0064    1.0000
 ------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
              GASPM:    0.0046    0.0060    0.0171    0.0088    0.0904    ------    ------    ------    0.0205    0.0089
            ECARBON:    ------    ------    ------    ------    ------    0.2259    0.1177    0.3860    ------    0.0316
```

OCARBON:	------	------	------	------	------	0.0637	0.1693	0.1900	------	0.0157
SO4:	0.0044	0.0062	0.0064	0.0063	0.0077	0.0059	0.0095	0.0320	0.0009	0.0074
Total Exhaust PM:	0.0090	0.0122	0.0236	0.0151	0.0981	0.2955	0.2965	0.6080	0.0214	0.0635
Brake:	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125
Tire:	0.0080	0.0080	0.0080	0.0080	0.0088	0.0080	0.0080	0.0261	0.0040	0.0095
Total PM:	0.0295	0.0327	0.0441	0.0356	0.1195	0.3161	0.3170	0.6467	0.0379	0.0855
SO2:	0.0689	0.0808	0.1159	0.0897	0.1784	0.1129	0.1819	0.4568	0.0329	0.1115
NH3:	0.0996	0.0959	0.0892	0.0942	0.0451	0.0068	0.0068	0.0270	0.0113	0.0890

```
* # # # # # # # # # # # # # # # # # # # # # # # # # # # #
* RVP Test
* File 1, Run 1, Scenario 11.
* # # # # # # # # # # # # # # # # # # # # # # # # # # # #
```

Calendar Year: 1999
Month: Jan.
Gasoline Fuel Sulfur Content: 300. ppm
Diesel Fuel Sulfur Content: 500. ppm
Particle Size Cutoff: 10.00 Microns
Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
GVWR:		<6000	>6000	(All)						
	------	------	------	------	------	------	------	------	------	------
VMT Distribution:	0.5138	0.2687	0.0919		0.0356	0.0015	0.0017	0.0804	0.0064	1.0000

Composite Emission Factors (g/mi):

Lead:	0.0000	0.0000	0.0000	0.0000	0.0000	------	------	------	0.0000	0.0000
GASPM:	0.0046	0.0060	0.0171	0.0088	0.0904	------	------	------	0.0205	0.0089
ECARBON:	------	------	------	------	------	0.2259	0.1177	0.3860	------	0.0316
OCARBON:	------	------	------	------	------	0.0637	0.1693	0.1900	------	0.0157
SO4:	0.0044	0.0062	0.0064	0.0063	0.0077	0.0059	0.0095	0.0320	0.0009	0.0074
Total Exhaust PM:	0.0090	0.0122	0.0236	0.0151	0.0981	0.2955	0.2965	0.6080	0.0214	0.0635
Brake:	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125
Tire:	0.0080	0.0080	0.0080	0.0080	0.0088	0.0080	0.0080	0.0261	0.0040	0.0095
Total PM:	0.0295	0.0327	0.0441	0.0356	0.1195	0.3161	0.3170	0.6467	0.0379	0.0855
SO2:	0.0689	0.0808	0.1159	0.0897	0.1784	0.1129	0.1819	0.4568	0.0329	0.1115
NH3:	0.0996	0.0959	0.0892	0.0942	0.0451	0.0068	0.0068	0.0270	0.0113	0.0890

MOBILE6.1 Calendar Year 2016

```
MOBILE6 INPUT FILE :
>Arizona--Yuma PM10 Exhaust--2016

DAILY OUTPUT       :
AGGREGATED OUTPUT  :
PARTICULATES       :

RUN DATA           :
>
```

```
>SCENARIO: 1, Interstate
SCENARIO RECORD    : Interstate
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 55 Freeway
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 2, Principal Arterials
SCENARIO RECORD    : Principal Arterials
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 42.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 3, Minor Arterials
SCENARIO RECORD    : Minor Arterials
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 40.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 4, Rural Major Collectors
SCENARIO RECORD    : Rural Major Collectors
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 45.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 5, Rural Minor Collectors
SCENARIO RECORD    : Rural Minor Collectors
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 46.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0
```

```
>SCENARIO: 6, Urban Collectors
SCENARIO RECORD    : Urban Collectors
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 35.0 Arterial
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 7, Local Roads
SCENARIO RECORD    : Local Roads
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
VMT BY FACILITY    : FV3.FV
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 8, Interstate Ramps
SCENARIO RECORD    : Interstate Ramps
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
VMT BY FACILITY    : FV4.FV
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 9, Local
SCENARIO RECORD    : Local
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
VMT BY FACILITY    : FV3.FV
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 7.0

>SCENARIO: 1
SCENARIO RECORD    : Temperature Test
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 55.0 Freeway
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 20. 30.
FUEL RVP           : 7.0
```

```
>SCENARIO: 1
SCENARIO RECORD    : RVP Test
CALENDAR YEAR      : 2016
EVALUATION MONTH   : 1
DIESEL SULFUR      : 15.
PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV PMDDR1.CSV PMDDR2.CSV
AVERAGE SPEED      : 55.0 Freeway
PARTICLE SIZE      : 10.0
MIN/MAX TEMP       : 64. 92.
FUEL RVP           : 13.0


END OF RUN         :


*************************************************************************
* MOBILE6.2.01 (31-Oct-2002)                                            *
* Input file: AZDEQ_16.IN (file 1, run 1).                              *
*************************************************************************

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Interstate
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                              Calendar Year:  2016
                                      Month:  Jan.
               Gasoline Fuel Sulfur Content:   30. ppm
                 Diesel Fuel Sulfur Content:   15. ppm
                       Particle Size Cutoff: 10.00 Microns
                           Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                         ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
   VMT Distribution:    0.3001    0.4252    0.1450              0.0358    0.0003    0.0021    0.0863    0.0052    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
              GASPM:    0.0040    0.0038    0.0039    0.0038    0.0185    ------    ------    ------    0.0205    0.0042
            ECARBON:    ------    ------    ------    ------    ------    0.0157    0.0116    0.0441    ------    0.0038
            OCARBON:    ------    ------    ------    ------    ------    0.0044    0.0167    0.0229    ------    0.0020
                SO4:    0.0002    0.0004    0.0004    0.0004    0.0019    0.0002    0.0003    0.0009    0.0001    0.0005
   Total Exhaust PM:    0.0042    0.0042    0.0043    0.0043    0.0204    0.0203    0.0286    0.0680    0.0206    0.0105
              Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
               Tire:    0.0080    0.0080    0.0080    0.0080    0.0086    0.0080    0.0080    0.0258    0.0040    0.0095
           Total PM:    0.0248    0.0248    0.0249    0.0248    0.0416    0.0408    0.0492    0.1064    0.0371    0.0326
                SO2:    0.0068    0.0088    0.0115    0.0095    0.0164    0.0029    0.0056    0.0132    0.0033    0.0092
                NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ---------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Principal Arterials
* File 1, Run 1, Scenario 2.
```

```
* # # #
```

```
                SO2:    0.0068    0.0088    0.0115    0.0095    0.0164    0.0029    0.0056    0.0132    0.0033    0.0092
                NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ---------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Rural Major Collectors
* File 1, Run 1, Scenario 4.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                             Calendar Year:  2016
                                     Month:  Jan.
               Gasoline Fuel Sulfur Content:   30. ppm
                 Diesel Fuel Sulfur Content:   15. ppm
                       Particle Size Cutoff: 10.00 Microns
                           Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
               GVWR:                <6000     >6000     (All)
                         ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
   VMT Distribution:    0.3001    0.4252    0.1450              0.0358    0.0003    0.0021    0.0863    0.0052    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
              GASPM:    0.0040    0.0038    0.0039    0.0038    0.0185    ------    ------    ------    0.0205    0.0042
            ECARBON:    ------    ------    ------    ------    ------    0.0157    0.0116    0.0441    ------    0.0038
            OCARBON:    ------    ------    ------    ------    ------    0.0044    0.0167    0.0229    ------    0.0020
                SO4:    0.0002    0.0004    0.0004    0.0004    0.0019    0.0002    0.0003    0.0009    0.0001    0.0005
   Total Exhaust PM:    0.0042    0.0042    0.0043    0.0043    0.0204    0.0203    0.0286    0.0680    0.0206    0.0105
              Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
               Tire:    0.0080    0.0080    0.0080    0.0080    0.0086    0.0080    0.0080    0.0258    0.0040    0.0095
           Total PM:    0.0248    0.0248    0.0249    0.0248    0.0416    0.0408    0.0492    0.1064    0.0371    0.0326
                SO2:    0.0068    0.0088    0.0115    0.0095    0.0164    0.0029    0.0056    0.0132    0.0033    0.0092
                NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ---------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Rural Minor Collectors
* File 1, Run 1, Scenario 5.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                             Calendar Year:  2016
                                     Month:  Jan.
               Gasoline Fuel Sulfur Content:   30. ppm
                 Diesel Fuel Sulfur Content:   15. ppm
                       Particle Size Cutoff: 10.00 Microns
                           Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
               GVWR:                <6000     >6000     (All)
                         ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
   VMT Distribution:    0.3001    0.4252    0.1450              0.0358    0.0003    0.0021    0.0863    0.0052    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
              GASPM:    0.0040    0.0038    0.0039    0.0038    0.0185    ------    ------    ------    0.0205    0.0042
```

```
           ECARBON:    ------    ------    ------    ------    ------    0.0157    0.0116    0.0441    ------    0.0038
           OCARBON:    ------    ------    ------    ------    ------    0.0044    0.0167    0.0229    ------    0.0020
               SO4:    0.0002    0.0004    0.0004    0.0004    0.0019    0.0002    0.0003    0.0009    0.0001    0.0005
   Total Exhaust PM:    0.0042    0.0042    0.0043    0.0043    0.0204    0.0203    0.0286    0.0680    0.0206    0.0105
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0086    0.0080    0.0080    0.0258    0.0040    0.0095
          Total PM:    0.0248    0.0248    0.0249    0.0248    0.0416    0.0408    0.0492    0.1064    0.0371    0.0326
               SO2:    0.0068    0.0088    0.0115    0.0095    0.0164    0.0029    0.0056    0.0132    0.0033    0.0092
               NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ----------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Urban Collectors
* File 1, Run 1, Scenario 6.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                             Calendar Year:  2016
                                     Month:  Jan.
              Gasoline Fuel Sulfur Content:   30. ppm
                Diesel Fuel Sulfur Content:   15. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                         ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
   VMT Distribution:    0.3001    0.4252    0.1450              0.0358    0.0003    0.0021    0.0863    0.0052    1.0000
 ----------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
              Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:    0.0040    0.0038    0.0039    0.0038    0.0185    ------    ------    ------    0.0205    0.0042
           ECARBON:    ------    ------    ------    ------    ------    0.0157    0.0116    0.0441    ------    0.0038
           OCARBON:    ------    ------    ------    ------    ------    0.0044    0.0167    0.0229    ------    0.0020
               SO4:    0.0002    0.0004    0.0004    0.0004    0.0019    0.0002    0.0003    0.0009    0.0001    0.0005
   Total Exhaust PM:    0.0042    0.0042    0.0043    0.0043    0.0204    0.0203    0.0286    0.0680    0.0206    0.0105
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0086    0.0080    0.0080    0.0258    0.0040    0.0095
          Total PM:    0.0248    0.0248    0.0249    0.0248    0.0416    0.0408    0.0492    0.1064    0.0371    0.0326
               SO2:    0.0068    0.0088    0.0115    0.0095    0.0164    0.0029    0.0056    0.0132    0.0033    0.0092
               NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ----------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # # #
* Local Roads
* File 1, Run 1, Scenario 7.
* # # # # # # # # # # # # # # # # # # # # # # # # # #

                             Calendar Year:  2016
                                     Month:  Jan.
              Gasoline Fuel Sulfur Content:   30. ppm
                Diesel Fuel Sulfur Content:   15. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
```

```
              GVWR:                <6000     >6000     (All)
                       ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:    0.3001    0.4252    0.1450              0.0358    0.0003    0.0021    0.0863    0.0052    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:   0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:    0.0037    0.0037    0.0038    0.0037    0.0190    ------    ------    ------    0.0205    0.0040
           ECARBON:    ------    ------    ------    ------    ------    0.0157    0.0116    0.0441    ------    0.0038
           OCARBON:    ------    ------    ------    ------    ------    0.0044    0.0167    0.0229    ------    0.0020
               SO4:    0.0005    0.0006    0.0006    0.0006    0.0013    0.0002    0.0003    0.0009    0.0002    0.0006
  Total Exhaust PM:    0.0043    0.0043    0.0044    0.0043    0.0203    0.0203    0.0286    0.0680    0.0207    0.0105
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0086    0.0080    0.0080    0.0258    0.0040    0.0095
          Total PM:    0.0248    0.0248    0.0249    0.0248    0.0415    0.0408    0.0492    0.1064    0.0372    0.0326
               SO2:    0.0067    0.0088    0.0115    0.0095    0.0166    0.0029    0.0056    0.0132    0.0033    0.0092
               NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ---------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # #
* Interstate Ramps
* File 1, Run 1, Scenario 8.
* # # # # # # # # # # # # # # # # # # # # # # # # #

                            Calendar Year:  2016
                                    Month:  Jan.
              Gasoline Fuel Sulfur Content:   30. ppm
                Diesel Fuel Sulfur Content:   15. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

      Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                       ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:    0.3001    0.4252    0.1450              0.0358    0.0003    0.0021    0.0863    0.0052    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:   0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:    0.0040    0.0038    0.0039    0.0038    0.0185    ------    ------    ------    0.0205    0.0041
           ECARBON:    ------    ------    ------    ------    ------    0.0157    0.0116    0.0441    ------    0.0038
           OCARBON:    ------    ------    ------    ------    ------    0.0044    0.0167    0.0229    ------    0.0020
               SO4:    0.0002    0.0004    0.0004    0.0004    0.0019    0.0002    0.0003    0.0009    0.0001    0.0005
  Total Exhaust PM:    0.0042    0.0042    0.0043    0.0043    0.0204    0.0203    0.0286    0.0680    0.0206    0.0105
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0086    0.0080    0.0080    0.0258    0.0040    0.0095
          Total PM:    0.0248    0.0248    0.0249    0.0248    0.0416    0.0408    0.0492    0.1064    0.0371    0.0326
               SO2:    0.0068    0.0088    0.0115    0.0095    0.0164    0.0029    0.0056    0.0132    0.0033    0.0092
               NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ---------------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # #
* Local
* File 1, Run 1, Scenario 9.
* # # # # # # # # # # # # # # # # # # # # # # # # #

                            Calendar Year:  2016
```

```
                                   Month:  Jan.
              Gasoline Fuel Sulfur Content:   30. ppm
                Diesel Fuel Sulfur Content:   15. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No

      Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                        ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:    0.3001    0.4252    0.1450              0.0358    0.0003    0.0021    0.0863    0.0052    1.0000
 ---------------------------------------------------------------------------------------------------------------------------
 Composite Emission Factors (g/mi):
               Lead:    0.0000    0.0000    0.0000    0.0000    0.0000    ------    ------    ------    0.0000    0.0000
             GASPM:    0.0037    0.0037    0.0038    0.0037    0.0190    ------    ------    ------    0.0205    0.0040
           ECARBON:    ------    ------    ------    ------    ------    0.0157    0.0116    0.0441    ------    0.0038
           OCARBON:    ------    ------    ------    ------    ------    0.0044    0.0167    0.0229    ------    0.0020
               SO4:    0.0005    0.0006    0.0006    0.0006    0.0013    0.0002    0.0003    0.0009    0.0002    0.0006
  Total Exhaust PM:    0.0043    0.0043    0.0044    0.0043    0.0203    0.0203    0.0286    0.0680    0.0207    0.0105
             Brake:    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125    0.0125
              Tire:    0.0080    0.0080    0.0080    0.0080    0.0086    0.0080    0.0080    0.0258    0.0040    0.0095
          Total PM:    0.0248    0.0248    0.0249    0.0248    0.0415    0.0408    0.0492    0.1064    0.0372    0.0326
               SO2:    0.0067    0.0088    0.0115    0.0095    0.0166    0.0029    0.0056    0.0132    0.0033    0.0092
               NH3:    0.1017    0.1017    0.1017    0.1017    0.0451    0.0068    0.0068    0.0270    0.0113    0.0925
 ---------------------------------------------------------------------------------------------------------------------------

* # # #
```

```
* # # # # # # # # # # # # # # # # # # # # # # # # # # #
* RVP Test
* File 1, Run 1, Scenario 11.
* # # # # # # # # # # # # # # # # # # # # # # # # # # #

                            Calendar Year:  2016
                                    Month:  Jan.
              Gasoline Fuel Sulfur Content:   30. ppm
                Diesel Fuel Sulfur Content:   15. ppm
                      Particle Size Cutoff: 10.00 Microns
                          Reformulated Gas:  No
```

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV	LDDT	HDDV	MC	All Veh
GVWR:		<6000	>6000	(All)						
VMT Distribution:	0.3001	0.4252	0.1450		0.0358	0.0003	0.0021	0.0863	0.0052	1.0000
Composite Emission Factors (g/mi):										
Lead:	0.0000	0.0000	0.0000	0.0000	0.0000	------	------	------	0.0000	0.0000
GASPM:	0.0040	0.0038	0.0039	0.0038	0.0185	------	------	------	0.0205	0.0042
ECARBON:	------	------	------	------	------	0.0157	0.0116	0.0441	------	0.0038
OCARBON:	------	------	------	------	------	0.0044	0.0167	0.0229	------	0.0020
SO4:	0.0002	0.0004	0.0004	0.0004	0.0019	0.0002	0.0003	0.0009	0.0001	0.0005
Total Exhaust PM:	0.0042	0.0042	0.0043	0.0043	0.0204	0.0203	0.0286	0.0680	0.0206	0.0105
Brake:	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125
Tire:	0.0080	0.0080	0.0080	0.0080	0.0086	0.0080	0.0080	0.0258	0.0040	0.0095
Total PM:	0.0248	0.0248	0.0249	0.0248	0.0416	0.0408	0.0492	0.1064	0.0371	0.0326
SO2:	0.0068	0.0088	0.0115	0.0095	0.0164	0.0029	0.0056	0.0132	0.0033	0.0092
NH3:	0.1017	0.1017	0.1017	0.1017	0.0451	0.0068	0.0068	0.0270	0.0113	0.0925

APPENDIX B.

Sensitivity Testing

Introduction

In response to over predicted values by the Industrial Source Complex short term version 3 model (ISC) for the Yuma PM_{10} modeling, several sensitivity tests were made. These tests, described below, were necessary to better understand the model's behavior with changes to various input parameters and to ideally uncover the reasons for the over predictions. Although these tests did not reveal the causes of the over predictions, they did add to the Division's understanding of the model's behavior in its Yuma applications.

The PM_{10} concentrations in Yuma were simulated using the ISC model with flat terrain and the regulatory default modeling option. This numerical model is a steady-state Gaussian dispersion model that has been approved by the U.S. Environmental Protection Agency and that has a long history of applications in both the industrial and urban settings. The regulatory default option selected in this modeling work conforms to the EPA guideline for SIP modeling - 40 CFR part 51, while the urban and flat terrain settings best reflect the conditions seen in Yuma.

The ISC Model and its Area Source Calculations

Although the ISC model is typically applied to stack emissions, it also has computational routines to simulate emissions from area and volume sources. Given the lack of large, significant stack emission sources in Yuma, the model was applied entirely with area sources. Each cell or gird, described below, was treated as a single area source, meaning, that on an hourly basis, the emissions from all the activities within the grid were spread evenly throughout its area. The ISC model treats area sources in the following way, as described in the user's guide.

The ISC Short Term area source model is based on a numerical integration over the area in the upwind and crosswind directions of the Gaussian point source plume equation. Individual area sources may be represented as rectangles with aspect ratios (length/width) of up to 10 to 1. In addition, the rectangles may be rotated relative to a northsouth and east-west orientation. The effects of an irregularly shaped area can be simulated by dividing the area source into multiple areas. Note that although the size and shape of the individual area sources may vary; the only requirement is that each area source must be a rectangle. As a result, an irregular area source can be represented by a smaller number of area sources than if each area had to be a square shape. Because of the flexibility in specifying elongated area sources up to an aspect ratio of about 10 to 1, the ISCST area source algorithm may also be useful for modeling certain types of line sources.
In the Yuma modeling, since square grids were used uniformly throughout the domain, the above considerations of gird shape do not come into play.

The ground-level concentration at a receptor located downwind of all or a portion of the source area is given by a double integral in the upwind (x) and crosswind (y) directions as:

$$\chi = \frac{Q_A K}{2\pi u_s} \int_x \frac{VD}{\sigma_y \sigma_z} \left\{ \int_y \exp[-0.5\{y/\sigma_y\}^2] dy \right\} dx \qquad \text{(Eq 1)}$$

where:

Q_A = area source emission rate (mass per unit area per unit time)

K = units scaling coefficient

V = vertical term

D = decay term as a function of x

U_S = wind speed in meters per second

σ_y = horizontal (or “lateral”) dispersion coefficient

σ_z = vertical dispersion coefficient

The Vertical Term is given by other equations, with the effective emission height, h_e, being the physical release height assigned by the user. In general, h_e should be set equal to the physical height of the source of emissions above local terrain height. For example, in the Yuma case, these effective emission heights varied from 0 to 5 meters. Sensitivity tests described below include varying this parameter.

Since the ISCST algorithm estimates the integral over the area upwind of the receptor location, receptors may be located within the area itself, downwind of the area, or adjacent to the area. However, since σ_z goes to 0 as the downwind distance goes to 0, the plume function is infinite for a downwind receptor distance of 0. To avoid this singularity in evaluating the plume function, the model arbitrarily sets the plume function to 0 when the receptor distance is less than 1 meter. As a result, the area source algorithm will not provide reliable results for receptors located within or adjacent to very small areas, with dimensions on the order of a few meters across. In these cases, the receptor should be placed at least 1 meter outside of the area.

For the Yuma case, this constraint on receptors does not apply, since the grids are large – 4km x 4km, and the receptors are at the center points of all the grids,

except for the monitoring location, which is close to the center. The point here is that the Yuma receptor arrangement is fully consistent with the limits of the model's area source dispersion treatment.

In Equation 1 the integral in the lateral (i.e., crosswind or y) direction is solved analytically as follows:

$$\int_y \exp\left[-0.5\ \{y/\sigma_y\}^2\right] dy = \mathrm{erfc}\{y/\sigma_y\} \qquad \text{(Eq. 2)}$$

where erfc is the complementary error function.

In Equation 1 the integral in the longitudinal (i.e., upwind or x) direction is approximated using certain, well-tested numerical methods. Specifically, the ISCST model estimates the value of the integral, I, as a weighted average of previous estimates, using a scaled down extrapolation as follows:

$$I = \int_x \frac{VD}{\sigma_y \sigma_z}\ \mathrm{erfc}\ \{y/\sigma_y\}\ dx = I_{2N} + \frac{(I_{2N} - I_N)}{3} \qquad \text{(Eq. 3)}$$

where the integral term refers to the integral of the plume function in the upwind direction, and I_N and I_{2N} refer to successive estimates of the integral using a trapezoidal approximation with N intervals and 2N intervals. The number of intervals is doubled on successive trapezoidal estimates of the integral. The model also performs a Romberg integration by treating the sequence I_k as a polynomial in k. The model uses a set of three criteria to determine whether the process of integrating in the upwind direction has "converged." The calculation process will be considered to have converged, and the most recent estimate of the integral used, if any of the following conditions is true:

1) If the number of "halving intervals" (N) in the trapezoidal approximation of the integral has reached 10, where the number of individual elements in the approximation is given by $1 + 2^{N-1} = 513$ for N of 10;

2) If the extrapolated estimate of the real integral (Romberg approximation) has converged to within a tolerance of 0.0001 (i.e., 0.01 percent), and at least 4 halving intervals have been completed; or

3) If the extrapolated estimate of the real integral is less than 1.0E-10, and at least 4 halving intervals have been completed.

The first condition essentially puts a time limit on the integration process, the second condition checks for the accuracy of the estimate of the integral, and the third condition places a lower threshold limit on the value of the integral. The result of these numerical methods is an estimate of the full integral that is essentially equivalent to, but much more efficient than, methods employed in earlier models.

The complexities of the model's area source dispersion calculations notwithstanding, the important point to realize here is that its application for simulating Yuma PM_{10} concentrations is consistent with all the constraints of the mathematics. The one possible exception is the size of the area source grid. The 4x4 kilometer grids are four times as large as the largest recommended 2x2 km surface area. As a sensitivity test described below demonstrates, this larger size made no difference in model performance.

The Yuma Modeling Domain and the Monitoring Location Cell

The modeling domain includes the city of Yuma, Arizona and spans 56 kilometers east and west, and 44 kilometers north and south. (The origin in UTM coordinates is 692220E and 3598883N). Each cell within the domain measures 4 kilometers by 4 kilometers, providing a total of 154 cells. Each cell was given a specific name ranging from 1A (Top left corner) to 11N (bottom right corner). The cell designations were incorporated into the Source ID naming structure and provided a means for ISC to model identical emission types with separate locations. The emissions of greatest importance for the sensitivity testing are in the cell where the PM_{10} sampler is located, cell 7H.

Since the first sensitivity test showed that the emissions from cell 7H contribute a majority of the overall concentration at the monitor, the following sensitivity tests chiefly involve the 7H sources. Limiting the sensitivity tests to this cell provided a reasonable representation of how the model would perform throughout the entire domain while keeping the workload to a manageable level.

The design day used for all sensitivity tests was January 12, 1999, with local meteorological data and with an emissions inventory from January 15, 1999. The emissions inventory included agricultural tilling emissions. The observed PM_{10} concentration for January 12, 1999, in cell 7H at the monitor, was 52 µg/m³ (the average of 55 and 48 µg/m3). The ISC model calculated a PM_{10} concentration of 148 µg/m³ for this location. Since the model's predicted concentrations are based only on emissions within the modeling domain, background concentrations are not a consideration for these tests.

Test #1: Only Emissions within Cell 7H – the Monitoring Location

To better understand how local emissions influenced the model results, the model input file for hourly emission rates was modified to use only the emissions of cell 7H (only source-id's with a 7H in the name). The predicted PM_{10} concentration at the monitor was 125 µg/m³ of PM_{10} for a 24-hour average. This value is 85% of the PM_{10} concentration at the monitor from emissions from the entire domain (125/148 x 100% = 84.5%). This result implies that 85% of the total predicted concentration at the monitor can be attributed to only those emission sources within cell 7H. The emissions from the other 153 cells of the domain contribute but 15% to this predicted concentration.

Test #2: Zero Emissions in Cell 7H (Usual Emissions Outside 7H)

To verify the previous scenario, the emissions from cell 7H were zeroed out, keeping all other emissions in the domain. This test was done to ensure that the sum of the concentrations from emissions outside 7H and inside 7H equaled the overall predicted PM_{10} concentration at the monitor from all of the domain's emissions. The results were 21.9 µg/m³ for zero emissions in 7H, 125.9 µg/m³ for only emissions in 7H, and 147.7 µg/m³ for the entire domain, in excellent agreement with the original prediction of all emissions in a single run of 148 ug/m3.

Test #3: Re-Entrained Dust from Paved Roads Divided by 4 in Cell 7H

Recent work involving re-entrained dust from *paved roads* suggests that past inventory calculations for this source category may have been overestimated by as much as a factor of four. This scenario -- dividing the paved road re-entrained dust emissions in 7H by four -- resulted in a PM_{10} concentration of 118.2 µg/m³. This decrease of 20% from the base case inventory shows the importance of this source category in Yuma in general and in the vicinity of the monitor, in particular. It does not lower the prediction to the desired concentration range of 40 – 50 µg/m3.

Test #4: Increase Vertical Dimension of Emissions by 10

Szinit is an optional parameter for ISC. Szinit describes the initial vertical dimension of a particular source in meters. The ISC manual describes Szinit as an option whereby the emission source may be "turbulently mixed near the source, - and therefore occupy some initial depth". By increasing this Szinit value, the model-predicted PM_{10} concentration was reduced. However, for this test and the following (x100 meters) this condition may be somewhat unrealistic. Pechan and Associates Inc., provided Szinit parameters for all of the sources in the inventory and had values ranging from 0 to 5 meters. As one can see, multiplying the Szinit by 10 times the initial value would artificially dilute the emissions from the source by spreading them vertically up to (in this case) 50 meters in height. The result for this model run was 87 µg/m³ PM_{10}.

Test #5: Increase Vertical Dimensions of Emissions by 100

Similar to the sensitivity test above, the Szinit value was increased by 100 times the initial value. The result for this model run was 47 µg/m³ PM_{10}.

Test #6: Model Runs with 4km by 4km vs. 2km by 2km Grids

An additional test was run to better understand the model's use of a larger than normal grid area. The emissions inventory had been calculated for grid dimensions of 4km by 4km. However, ISC generates a warning flag for grid sizes greater than 2km by 2km. After the repeated over predictions, it was necessary to investigate the impact of using a grid 4 times larger (in area) than what the model had been designed to use.

A generic emissions inventory was built for a single 4km by 4km grid. This inventory consisted of a single source ID with 24 hourly emission rates. The model was run with the identical conditions of January 12, 1999, with the exception of the inventory; hence, the calculated value should not be compared to the actual value. This model run was simply a base for comparison to the next "fine grid" run. The result for this model run was 1.73 µg/m³.

Like the above run, the same inventory was used, but with the 4x4 km grid divided into four smaller 2x2km grids. The inventory was divided (not reduced, since we are dealing with a rate per unit area) among the four new source locations. The result for this model run was 1.73 µg/m³. Identical results with the larger and smaller grids proved that the larger grid, although beyond the model's recommended size, was performing the same as the smaller grid.

Test #7: The Deposition Algorithm

The purpose of this test was to investigate the effect of enabling dry deposition, within the ISCST-3 (ISC) framework on the predicted PM10 concentration for the Yuma, AZ modeling domain. The specific issue addressed was the over prediction of PM_{10} on the high wind day of March 31, 1999. The thought was that by enabling the model to deposit the larger particles to the earth's surface, the airborne concentrations of PM_{10} would decrease.

Dry deposition effects for particles are treated using a resistance formulation in which the deposition velocity is the sum of the resistances to pollutant transfer within the surface layer of the atmosphere, plus a gravitational settling term. These deposition calculations require a modification to both the ISC model input file and the ISC meteorology input file. The ISC input file requires the mass mean diameter (microns), particle density (gm/cm3) and the mass fraction for each particle size category modeled. The ISC input test file was built for Yuma on the high-wind day of March 31 and used seven particle size bins from 1 to 10 microns, with the majority of the particles residing in the larger 5 to 10 micron

range. That is to say, the mass fraction was more heavily weighted to larger particles, as one would expect for windblown dust (Table B-2). These fractions were derived from measurements of coarse and fine particulates in the Salt River PM_{10} area of southwest Phoenix, and reflect an aerosol dominated by coarse, geological particles.

Table B-2. Mass Fractions Employed in the Deposition Simulations

Diameter (Microns)	Mass Fraction
0.5	0.05
1.5	0.1
2.5	0.25
3.5	0.1
5.5	0.2
8.5	0.2
10	0.1

The particle density was held constant at 1.3 g/cc for all particle sizes – a fair accounting of the various values for dry earth of different kinds, which ranges from 1.0 to 1.5 g/cc. The meteorological input file required a surface roughness length (cm) friction velocity (m/s) and the Monin-Obukhov length (m). The friction velocity and Monin-Obukhov length were provided by a meteorological preprocessor, while the surface roughness was estimated. Results showed a small reduction in the predicted PM_{10} concentration from the standard runs where physical removal or dry deposition was not used. Invoking the deposition algorithm caused a near ten-fold increase in processing time. Given the requirements in processing time compared to the small reduction observed in the predicted concentration, a choice was made to discontinue use of the deposition feature.

Conclusions

Results of these sensitivity tests are summarized in Figure 1.0. These tests demonstrated the importance of local emissions on the predicted concentration: 85% of the PM_{10} concentration at the monitor could be attributed to emissions from within the monitor's 4x4 km grid. The tests also showed that re-entrained dust emissions from traffic on paved roads was an important contributor and that reducing these emissions by a factor of four would lower the model's prediction by about 20%. The model also proved sensitive to increasing the vertical height of the emissions, although the heights tested were too high to be realistic. Perhaps most importantly, the tests demonstrated that the 4x4 km grid size was not artificially skewing the model results. The model proved to be insensitive to

the deposition algorithm on the high-wind day. The tests did not provide an explanation of the model's over predictions.

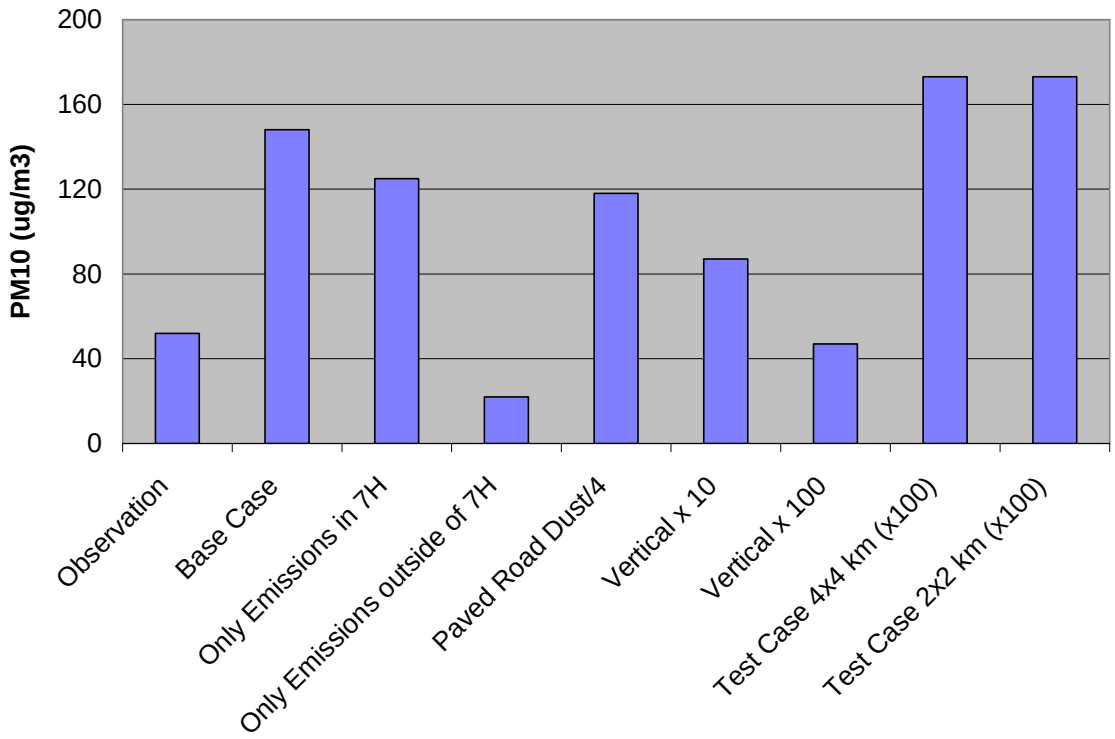

Figure 1.0 Results from the Sensitivity Tests

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APPENDIX C.

PM_{10} Emission Reductions from Agricultural Best Management Practices (AgBMPs) in the Yuma PM_{10} Nonattainment Area

Appendix C.

PM_{10} Emission Reductions from Agricultural Best Management Practices (AgBMPs) in the Yuma PM_{10} Nonattainment Area

Summary

Agricultural Best Management Practices (AgBMPs), already being carried out in Maricopa County, began in the Yuma PM_{10} nonattainment area in June - August 2005. Based on the Maricopa AgBMPs and their emission reductions; examining the differences between the mix of crops in the two counties; and with reviews by the Yuma farming community; the application of AgBMPs in the Yuma nonattainment area will reduce agricultural emissions by 19.1%, or six tons per day.

Introduction

In June 2001 the combined efforts of Maricopa County farmers, the Arizona Department of Environmental Quality (ADEQ), and its contractors led to a "Technical Support Document for Quantification of Agricultural Best Management Practices", URS Corporation and Eastern Research Group, June 8, 2001. This document explained the various best management practices to reduce agricultural dust, and calculated their percentage reductions of PM_{10} emissions. On June 1, 2005, AgBMPs became effective in the Yuma nonattainment area. By August 1, 2005, farmers in the PM_{10} nonattainment area of Yuma County were required to implement the AgBMP regulations. This paper addresses the question of how suitable these emission reductions based on Maricopa County crops and farming practices are for the Yuma area. In considering the potential reductions from the AgBMPs in both counties, the regulations state that each farmer shall employ one BMP in each of three categories: tillage and harvest, non-cropland (unpaved roads), and cropland (wind erosion). All of the calculated emission reductions from the technical support document are based on this use of the AgBMPs.

In an effort to get Yuma redesignated from nonattainment to attainment for PM_{10}, ADEQ has carried out a comprehensive emissions and air quality modeling analysis as part of a PM_{10} Maintenance Plan for submittal to EPA Region 9. This analysis showed that the PM_{10} concentrations in Yuma in 1999, which met the air quality standards, will remain in attainment through 2016. As part of this analysis, an ADEQ contractor prepared an inventory of all PM_{10} emissions, including agricultural, for the Yuma Area. This study area was considerably larger than the Yuma PM_{10} nonattainment area, but was much smaller than all of Yuma County (See Figure 1).

In this paper, three stages are necessary to calculate emission reductions in the Yuma nonattainment area. First, agricultural statistics by crop will be given for all of Yuma County, since smaller breakdowns are not available. A comparative analysis of the crop types and AgBMP applicability in Maricopa and Yuma Counties will be presented. Second, the PM_{10} emissions from the Yuma PM_{10} Maintenance Plan study area will be

examined, especially for the agricultural sector. Third, a Yuma emissions analysis based on the implementation of AgBMPs will be given for the PM_{10} nonattainment area.

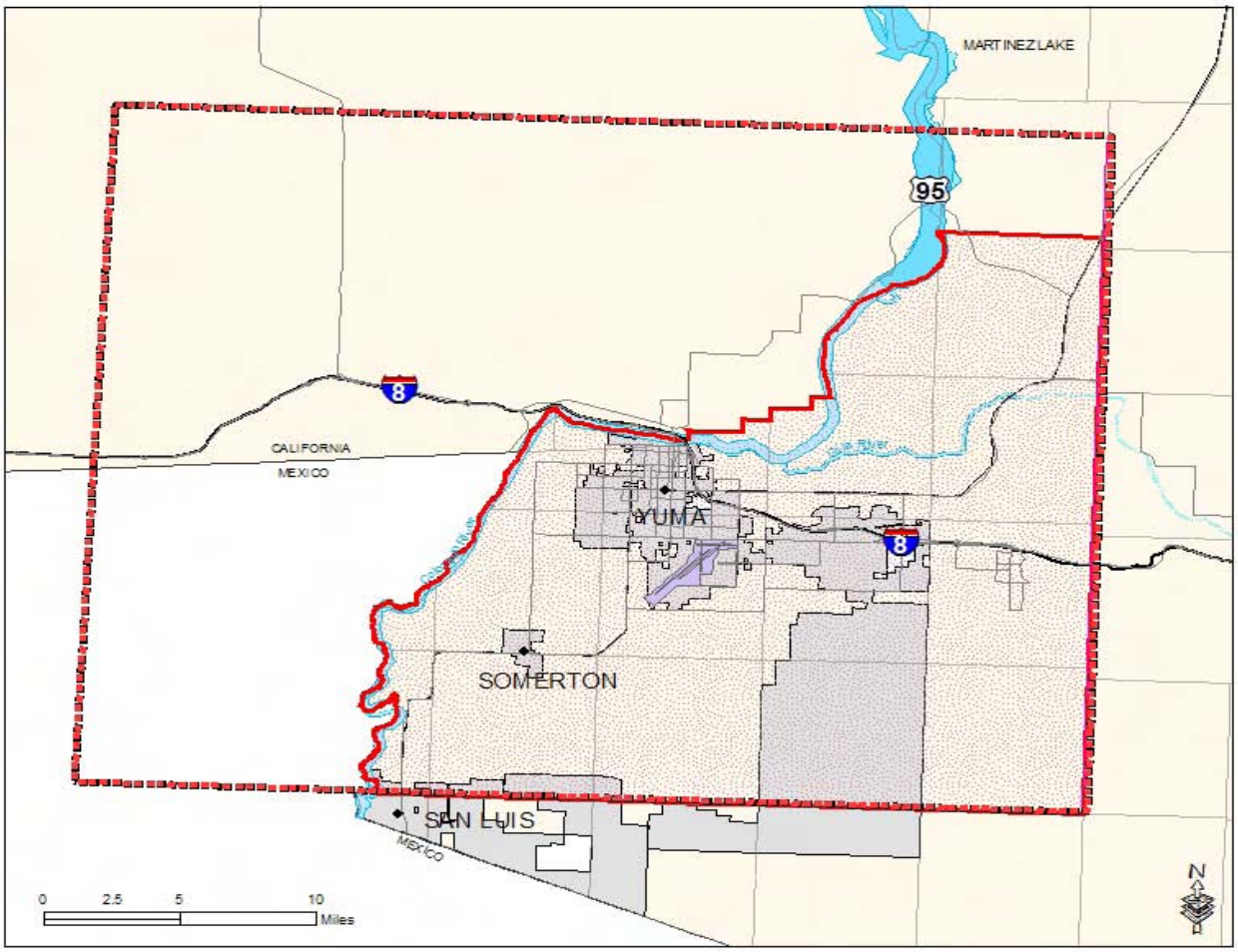


Figure 1.

Yuma PM10 Study Area for the Maintenance Plan

Yuma PM10 Nonattainment Boundary

Prep: NLC 07/25/05

Crops

To apply the Maricopa AgBMPs to Yuma County, a primary consideration is the mix of crops in the two counties. The "Statewide Economic Study 2002 – Arizona's Agricultural Sector", M. L. Nadelhoffer, University of Arizona, July 2002 gives the harvested acres by crop for all counties of the state for 2000. Table 1 presents these data for Maricopa and Yuma Counties. Figures 1-3 show these data as bar and pie charts.

Table 1. Harvested Acres by Crop in Maricopa and Yuma Counties In 2000

Crop	Acres			Percentage by Crop		
	Maricopa	Yuma		Maricopa	Yuma	M/Y*
Cotton	84,300	26,600		36.4	11.9	3.1
All Hay	72,600	50,000		31.3	22.3	1.4
Vegetables	26,300	83,500		11.3	37.2	0.3
All Wheat	16,700	40,400		7.2	18.0	0.4
Citrus	11,600	17,600		5.0	7.8	0.6
Barley	11,200	1,000		4.8	0.4	10.8
Potatoes	6,500	0		2.8	0.0	
Grapes	2,000	0		0.9	0.0	
Corn for Grain	600	4,000		0.3	1.8	0.1
Total	231,800	223,000		100.0	100.0	

*M/Y: Maricopa acreage divided by the Yuma acreage per crop

Although the total harvested acreages in the two counties are nearly the same, important differences arise in the individual crops. Maricopa has three times as much cotton, 11 times as much barley, and considerably more hay and grapes as does Yuma. Crops with more acreage in Yuma than Maricopa include vegetables (3.2 times), wheat (2.4 times), citrus (1.5 times), and corn for grain (6.7 times). The distribution of field crops between the two counties has significant differences, although the percentage of citrus plus grapes is similar (5.9% for Maricopa and 7.8% for Yuma).

Figure 1. Harvested Acres by Crop in 2000 in Maricopa and Yuma Counties

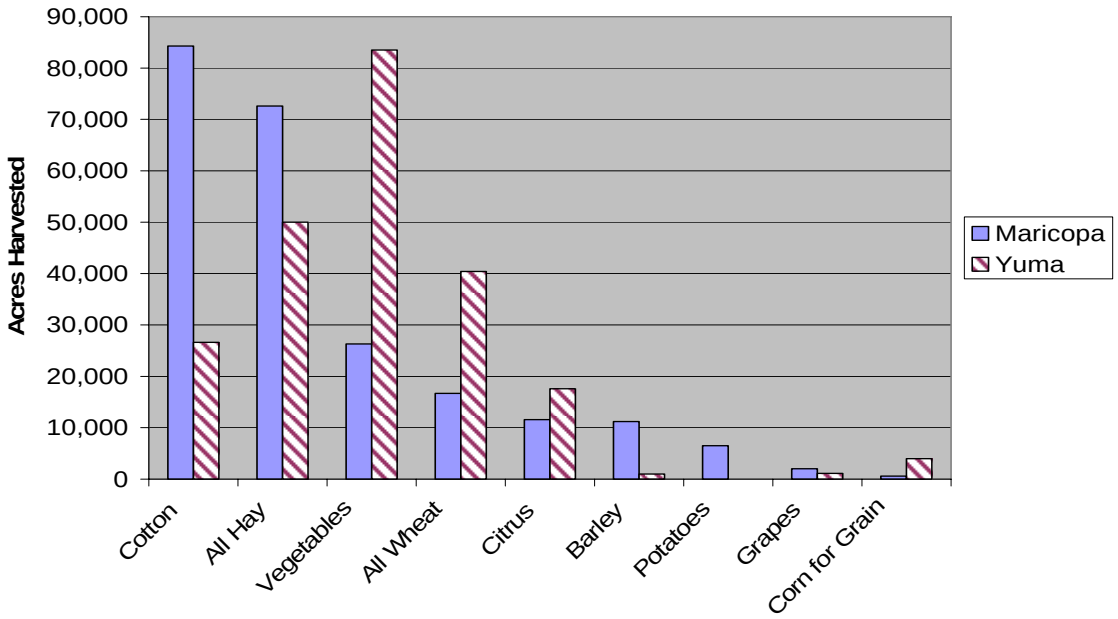


Figure 2. Crop Distribution in Maricopa County in 2000

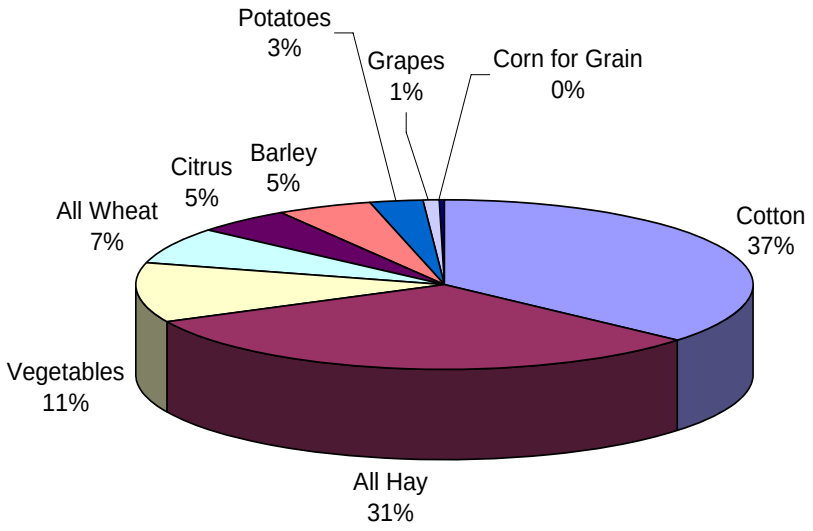
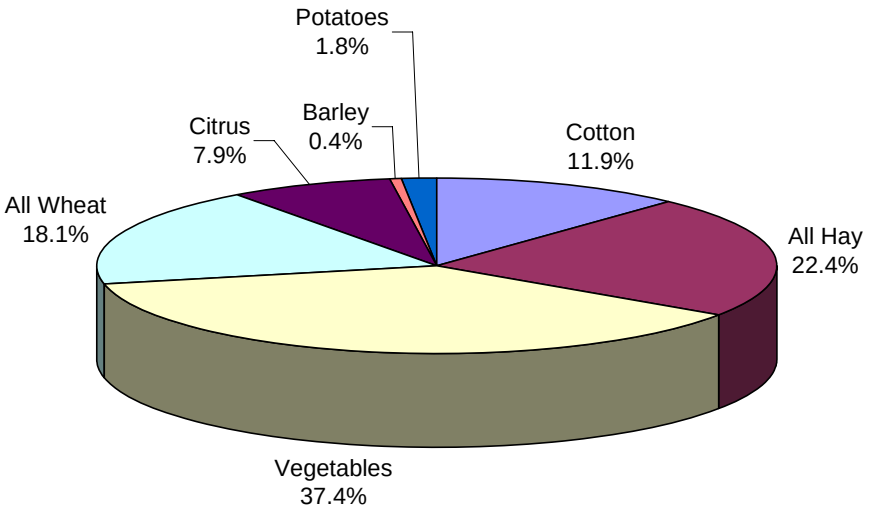


Figure 3. Crop Distribution in 2000 in Yuma County



Crops and BMPs in the Two Counties

Crop differences and farming practices between the two counties affect how well the Maricopa AgBMPs would apply to Yuma County. The Maricopa AgBMP Technical Support Document (Chapter 2) addresses the applicability of the BMPs on a crop-by-crop basis. This applicability by crop, shown in Table 3a, has been adapted to Yuma County after discussions with the Yuma agricultural community. The BMPs presented in these tables were determined through a survey of Maricopa County farmers to be those most likely to be implemented. The complete list of the Yuma BMPs, which is much longer, is shown as Table 2. In the remainder of this paper, only the subset of BMPs most likely to be implemented will be considered.

Table 2. Yuma Area Agricultural Best Management Practices

Tillage and Harvest

0 Bed row spacing
0 Chemical irrigation
0 Combining tractor operations
0 Conservation irrigation
0 Conservation tillage
0 Equipment modification
0 GPS tractor or implement management
0 Limited activity during a high wind event
0 Multi-year crop
0 Night farming
0 Planting based on soil moisture
0 Reduced harvest activity
0 Reduced tillage system
0 Tillage based on soil moisture
0 Timing of a tillage operation
0 Transgenic crops

Non-Cropland

0 Access restriction
0 Aggregate cover
0 Artificial wind barrier
0 Critical area planting
0 Manure application
0 Reduce vehicle speed
0 Synthetic particulate suppressant
0 Track-out control system
0 Tree, shrub, or windbreak planting
0 Watering

Cropland

0 Artificial wind barrier
0 Cover crop
0 Cross-wind ridges
0 Cross-wind strip-cropping
0 Cross-wind vegetative strips
0 GPS tractor or implement management
0 Manure application
0 Mulching
0 Multi-year crop
0 Permanent cover
0 Planting based on soil moisture
0 Residue management
0 Sequential cropping
0 Surface roughening
0 Tree, shrub, or windbreak planting

Table 3a. Yuma County AgBMP Applicability by Crop								
Category	**BMP**	**BMPs with "x" Are Applicable for the Crop**						
		Cotton	**Wheat**	**Barley**	**Corn**	**Hay**	**Veggies**	**Citrus**
Tillage	Combing Tractor Operations	x	x	x	x	x	X	x
	Limiting Activity In High Winds	x	x	x	x	x	X	x
	Multi-Year Crops							
Unpaved Roads	Restrict Access	x	x	x	x	x	X	x
	Reduce Speed	x	x	x	x	x	X	x
	Wind Erosion							
Wind Erosion	Multi-Year Crops							
	Residue Management	x	x	x	x		x	x
	Timing of Tillage	x	x	x	x		x	
	Planting Based on Soil Moisture	x	x	x	x		X	

In the next two tables, 3b and 3c, the acreages that are suitable for the specific BMPs are given for the two counties.

Table 3b. Maricopa County Crop Acreages Suitable for BMPs								
Category	**BMP**	**Acreages Suitable for BMPs**						
		Cotton	**Wheat**	**Barley**	**Corn**	**Hay**	**Veggies**	**Citrus**
Tillage	Combing Tractor Operations	84,300	16,700	11,200	600		26,300	11,600
	Limiting Activity In High Winds	84,300		11,200	600	72,600	26,300	11,600
	Multi-Year Crops	84,300	16,700	11,200	600			
Unpaved Roads	Restrict Access	84,300		11,200	600	72,600	26,300	11,600
	Reduce Speed	84,300	16,700	11,200	600	72,600	26,300	11,600
	Wind Erosion							
Wind Erosion	Multi-Year Crops	84,300	16,700	11,200	600			
	Residue Management	84,300		11,200	600			
	Timing of Tillage	84,300		11,200	600			
	Planting Based on Soil Moisture	84,300		11,200	600		26,300	

Table 3c. Yuma County Crop Acreages Suitable for BMPs								
Category	**BMP**	**Acreages Suitable for BMPs**						
		Cotton	**Wheat**	**Barley**	**Corn**	**Hay**	**Veggies**	**Citrus**
Tillage	Combing Tractor Operations	26,600	40,400	1,000	4,000	50,000	83,500	17,600
	Limiting Activity In High Winds	26,600	40,400	1,000	4,000	50,000	83,500	17,600
	Multi-Year Crops							
Unpaved Roads	Restrict Access	26,600	40,400	1,000	4,000	50,000	83,500	17,600
	Reduce Speed	26,600	40,400	1,000	4,000	50,000	83,500	17,600
	Wind Erosion							
Wind Erosion	Multi-Year Crops							
	Residue Management	26,600	40,400	1,000	4,000		83,500	17,600
	Timing of Tillage	26,600	40,400	1,000	4,000		83,500	
	Planting Based on Soil Moisture	26,600	40,400	1,000	4,000		83,500	

The next two tables, 3d/3e, combine the crop information and BMP suitability with the emission reductions. In each table, the column headings are:

Acres	The total harvested acreage from all crops suitable for a specific BMP.
Fraction of Acreage	The fraction that this acreage comprises of the total harvested acres.
Reduction %	This figure is taken directly from the Maricopa Technical Support Document and is the emission reduction percentage for each BMP.
Potential Reduction (lbs/day)	The reduction obtained by applying the “Reduction %” to base case emissions from the category. This base-case emissions figure is from the Pechan inventory and applies to the PM_{10} study area.
Actual Reduction (lbs/day)	The reduction obtained by applying the fraction of acreage to the potential reduction.
Realized %	The total actual reduction is expressed as a percent of the total potential reduction.

Table 3d. Maricopa County BMPs with Emission Reductions							
Category	**BMP**	**Harvested Acres**	**Fraction of Acreage**	**Reduction %**	**Potential Reduction (lbs/day)**	**Actual Reduction (lbs/day)**	**Realized %**
	Total Crop Acreage	231,800					
Tillage	Combing Tractor Operations	159,200	0.69	5.32	2,910	1,999	
	Limiting Activity In High Winds	231,800	1.00	6.26	3,423	3,423	
	Multi-Year Crops	112,800	0.49	8.14	4,450	2,165	
Unpaved Roads	Restrict Access	231,800	1.00	0.38	156	156	
	Reduce Speed	231,800	1.00	10.48	4,357	4,357	
	Wind Erosion						
Wind Erosion	Multi-Year Crops	112,800	0.49	11.82	359,556	174,969	
	Residue Management	112,800	0.49	6.02	183,068	89,086	
	Timing of Tillage	112,800	0.49	5.05	153,810	74,848	
	Planting Based on Soil Moisture	139,100	0.60	2.76	83,897	50,345	
Total					795,627	401,349	50.4

Table 3e. Yuma County BMPs with Emission Reductions							
Category	**BMP**	**Harvested Acres**	**Fraction of Acreage**	**Reduction %**	**Potential Reduction (lbs/day)**	**Actual Reduction (lbs/day)**	**Realized %**
	Total Crop Acreage	223,000					
Tillage	Combing Tractor Operations	223,000	1.00	5.32	1,042	1,042	
	Limiting Activity In High Winds	223,000	1.00	6.26	1,226	1,226	
	Multi-Year Crops	0	0.00	0	1,593	0	
Unpaved Roads	Restrict Access	223,000	1.00	0.38	178	178	
	Reduce Speed	223,000	1.00	10.48	4,972	4,972	
	Wind Erosion	0	0.00	0.00	0	0	
Wind Erosion	Multi-Year Crops	0	0.00	0	42,627	0	
	Residue Management	173,000	0.78	6.02	21,704	16,837	
	Timing of Tillage	155,400	0.70	5.05	18,235	12,707	
	Planting Based on Soil Moisture	155,400	0.70	0.67	9,946	6,931	
Total					101,523	43,894	43.2

These two tables contain calculations in four steps:

1. Calculate the total acreage suitable for each BMP,

2. Express this acreage as a fraction of the total harvested acres,

3. Calculate potential emission reductions as if all of the acreage were suitable for each BMP, and

4. Finally, reduce this figure by the actual fraction of acreage that is suitable for the BMP.

The two "realized % reductions", one for each county, from Tables 3d & 3e, merely give an indication of how effective the AgBMPs are likely to be. Maricopa County has a 50.4% realized emission reduction total; Yuma County's is 43.2%. These figures need to be interpreted in a relative sense: i.e. the mix of crops in Maricopa is slightly more suitable for AgBMP reductions than in Yuma.

Additional remarks on the two tables, which may shed some light on the results, are as follows:

- The actual emission reductions depend on the acreage and on the BMP-specific reduction percentage obtained from the Maricopa AgBMP technical analysis. These BMP percentages are based on the nature of the emissions and its control, and account for each farmer carrying out a single BMP in each of the three categories. Because these BMP reduction percentages already factor in the rule of one BMP in each of three categories, they can be applied more than once across the same acreage without double counting.

- The highest emissions and greatest emission reductions are in the wind erosion category. For example, the actual reductions in Maricopa County in this category are 32 times the reductions from tillage and unpaved roads combined.

- The reduction percentages themselves vary by more than a factor of ten: from 0.38% to 11.82%.

- Maricopa's larger realized emission reductions come from having a higher fraction of its total acreage being suitable for wind erosion BMPs than Yuma's (0.49 vs. 0.31 for three of the four BMPs).

This comparison shows that Maricopa and Yuma Counties can achieve similar emission reductions with comparable applications of BMPs. These sets of reductions are substantial, and, on a percentage basis, are comparable for the two counties.

Yuma PM_{10} Nonattainment Area Emissions and Expected Reductions from the AgBMPs

What remains is to apply the appropriate emission reduction percentages for each BMP to the agricultural activities in the Yuma PM_{10} nonattainment area. This will begin with agricultural emissions from the larger PM_{10} study area, which will be factored down to the nonattainment area. Then, the emission reduction percentages from the Maricopa AgBMP analysis will be applied to the Yuma nonattainment area.

The emissions for the larger PM_{10} study area come directly from the contractor's report: "1999 and 2016 Emission Estimates for the Yuma, Arizona PM_{10} Nonattainment Area Maintenance Plan – Final Report", Pechan, June 2003. Despite its title, these emissions are for the larger PM_{10} study area, which includes agricultural lands in Baja California and to a lesser extent, in California. Agricultural acreage in the nonattainment area comes from a 1996 crop/citrus map produced by the Arizona Department of Agriculture. The citrus acres on this map amounted to 26,000, more than the 17,600 for the entire county from the 2000 survey by the University of Arizona. The latter figure is used in the following table. The ratio of agricultural acres in the nonattainment area to the larger study area – 0.595 – was applied to the other categories of vacant agricultural fields and agricultural roads to obtain values for the nonattainment area. The relevant acres and emissions are given in Table 4. The vacant agricultural fields' acreage is greater than the agricultural acres because it represents the total acreage through the four seasons that is "vacant", i.e. lacks a growing crop.

Table 4. Yuma Area Agricultural Acreages and PM_{10} Emissions for the Larger PM_{10} Study Area and the PM_{10} Nonattainment Area

Agricultural Emission Source	PM_{10} Study Area		Non-Attainment Area	
	Acres	PM_{10} Emissions (Tons/Yr)	Acres	PM_{10} Emissions (Tons/Yr)
Harvested Acres (non-citrus)	158,414	3,588	60,192	1,363
Vacant Ag Fields	179,048	65,188	13,844	5,040
Ag Roads -- Windblown	16,633	21,942	1,480	1,952
Ag Roads -- Vehicular		4,073		2,425

Before AgBMP reductions are calculated from these emissions, a few observations are in order.

- First, although there apparently is no specific AgBMP to address wind erosion from unpaved farm roads in the original Maricopa AgBMPs (see page 4-5, footnote "f"), other discussions in the Maricopa Technical Support Document of

non-cropland BMPs include watering of roads to reduce vehicular dust, Whatever the exact status of the Maricopa AgBMPs in watering farm roads, certainly both vehicular and windblown dust would be reduced by this practice. In Yuma County vegetable growing areas the unpaved roads are watered during the six-month planting and harvesting season. Reductions of both vehicular and windblown emissions will be accounted for in this analysis, despite the fact that there may be no official BMP for this activity as it affects windblown emissions.

- Second, the PM_{10} emissions from vehicles on unpaved farm roads for the PM_{10} study area came originally from an estimate that 85% of the vehicle miles traveled (VMT) on unpaved roads in the study area take place on agricultural roads. This estimate comes from Lima & Associates, a contractor employed by the Yuma Metropolitan Planning Organization. In the nonattainment area, however, Yuma farmers estimate that most of the vehicle miles traveled on unpaved roads is on county roads, not farm roads. In this analysis 60% of the VMT is assigned to county roads.

  In addition the mileage of unpaved roads in the nonattainment area is also much lower than one calculated from the emission inventory. This revised estimate is based on the service area within the nonattainment area from the three irrigation districts, which provide water for a nominal total of 94,000 acres. Adjusting for roads, urban areas, and homes scattered throughout the rural area, this net acreage is reduced to 74,000 acres. The accepted figure of 2% is applied to a net acreage to calculate the area devoted to roads and canals. The nonattainment area acreage for roads, then, is 1480 acres, down about five-fold from inventory-based calculations of 9,000 acres.

- Third, “Vacant Ag Fields” refers to those fields that do not have actively growing vegetation. In the calculations for the PM_{10} emissions inventory, this amount varies by season: fall, 35%, winter, 40%; spring and summer, 10%. In discussions with Yuma farmers, however, these percentages were deemed to be unrealistically high, in large part, because of the double cropping of cotton with wheat or vegetables. The Yuma farming community has explained that any typical double-cropped acreage actually lies fallow for only ten days after the initial soil preparation for the second crop. This ten-day period occurs after the laser leveling but before irrigation is applied to form a crust that remains undisturbed until planting. This practice reduces the windblown dust potential from fallow fields by 90% from the emission inventory.

- Fourth, the conversion of agricultural land to residential and commercial uses within the nonattainment area has not been accounted for. If this conversion since 1996 has been substantial, then the acreage and emission figures of Table 4, and, hence, the AgBMP benefits, are upper bounds. For a more definitive tracking of agricultural emissions from 1999 to 2016 – the base and future years of the PM_{10} Maintenance Plan – the retirement of agricultural lands within the nonattainment area needs to be tabulated and extrapolated.

Results of the final calculations are given in Table 5. The PM_{10} nonattainment area emissions are multiplied by the BMP reduction percentage to give the tons reduced for each BMP. These percentage reductions already account for the premise that each farmer will carry out one BMP in each category. Agricultural emissions are reduced by 19.1% through the AgBMP program, with an emission reduction of about 2000 tons per year, or six tons per day.

Table 5. Yuma PM_{10} Nonattainment Area Agricultural Emission Reductions through AgBMPs

Category	AgBMP	PM_{10} Emissions (Tons/Yr)	AgBMP Reduction %	PM_{10} Emissions Reductions (Tons/Yr)	Notes
Tillage and Harvest	Combing tractor operations	1,363	5.32	73	
	Limiting activity in high winds		6.26	85	
	Multi-year crops		0.00	0	1
Unpaved Roads Vehicular Traffic	Restrict access	1,617	0.38	6	
	Reduce speed		10.48	169	
	Watering vegetable crop roads	800	37.50	300	
Unpaved Roads Wind Erosion	Watering vegetable crop roads	1,952	37.50	732	2
Wind Erosion	Multi-year crops	5,040	0.00	0	1
	Residue management		6.02	303	
	Timing of tillage		5.05	255	
	Planting based on soil moisture		2.76	139	
Emissions (tons/year)		10,772		2,062	
Percentage Reduction				19.1	
Reduction (tons/day)				5.7	

Notes:

1. Multi-year crops mean converting from an annual (wheat) to a long-term crop (hay), a rare conversion in Yuma.
2. Although not a BMP for windblown emissions, watering dirt roads in vegetable areas is common and its benefits in reducing windblown emissions are taken here.

From the foregoing discussion one may draw two conclusions:

1. Carrying out AgBMPs will reduce agricultural emissions of PM_{10} in Yuma; and

2. The potential reductions are more or less equally divided among the four categories of tillage, vehicular traffic on unpaved roads, wind erosion from unpaved roads, and wind erosion from vacant agricultural fields. Consequently, no single category or BMP would appear to be dominant in reducing Yuma agricultural emissions.

APPENDIX D.

Yuma PM_{10} Maintenance Plan Technical Analysis: The Suitability of 1999 as the Base Year

The Suitability of 1999 as the Base Year

Introduction

Emissions and air quality modeling work in the Yuma Maintenance Plan has used three different inventory years so far: 1999, 2013, and 2016. Delays in the plan necessitated that the future year be changed from 2013 to 2016 to have a ten-year period after filing. This appendix puts forth quantitative and qualitative arguments that either 1999 or 2005 would be equally acceptable as a base year, at such time that the complete 2005 monitoring record becomes available.

Emissions

Emissions by source category from the 1999 and 2016 inventories have been interpolated to give 2005 emissions. The source categories have been divided into windblown dust and anthropogenic emissions. The figures from the inventory, and the 2005 interpolations, are given in Table 1. Inventory figures are also shown in Figures 1 and 2.

Table 1. Yuma PM_{10} Emissions for 1999, 2005, and 2016

Windblown PM_{10} Emissions	**Annual Tons of PM_{10}**			**Percent Change**	
	1999	**2005**	**2016**	**99-05**	**99-16**
Vacant Ag Fields	65,835	65,607	65,188	0.35	0.98
Misc Disturbed Area	33,996	33,996	33,996	0.00	0.00
Unpaved Ag Roads	22,160	22,083	21,942	0.35	0.98
Urban Disturbed Area	5,442	4,588	3,021	15.70	44.49
Alluvial Plains	2,517	2,517	2,517	0.00	0.00
Native Desert	282	317	382	-12.52	-35.46
Total	130,232	129,108	127,046	0.86	2.45

Anthropogenic PM_{10} Emissions	**Annual Tons of PM_{10}**			**Percent Change**	
	1999	**2005**	**2016**	**99-05**	**99-16**
Agricultural And Prescribed Burning	40.7	38.4	34.1	5.72	16.22
Agricultural Tilling	3,572	3,572.0	3,572	0.00	0.00
Agricultural Cultivation And Harvesting	15.7	15.7	15.7	0.00	0.00
Unpaved Roads - Re-Entrained Dust	10,183	8,543.2	5,537	16.10	45.63
Paved Roads	**3,419**	**4,273.1**	**5,839**	**-24.98**	-70.78
Road Construction	**6,761**	**8,151.9**	**10,702**	**-20.57**	-58.29
General Building Construction	**53.8**	**65.8**	**87.7**	**-22.24**	-63.01
Aircraft	15.5	15.8	16.4	-2.05	-5.81
Unpaved Airstrips	1	1.0	1.1	-3.53	-10.00
Stationary Sources	**77**	**91.8**	**119**	**-19.25**	-54.55
Railroad Locomotives	17	16.3	15	4.15	11.76
Total	24,156	24,785	25,939	-2.61	-7.38

Figure 1. Yuma Windblown Emissions in Tons per Year for 1999

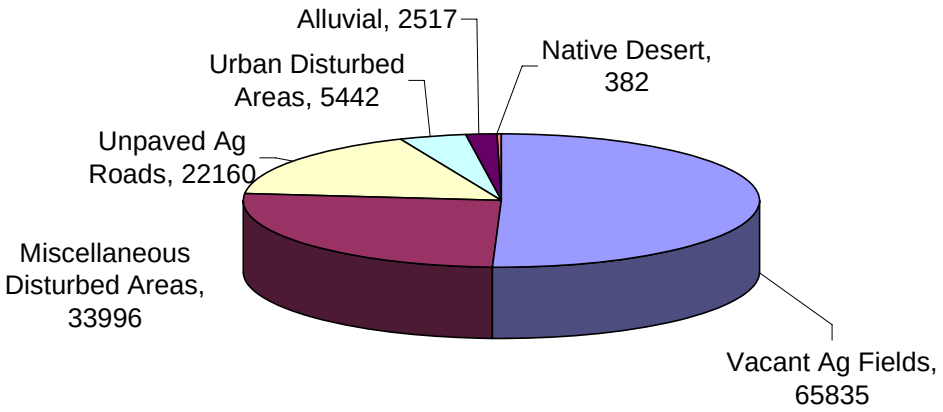
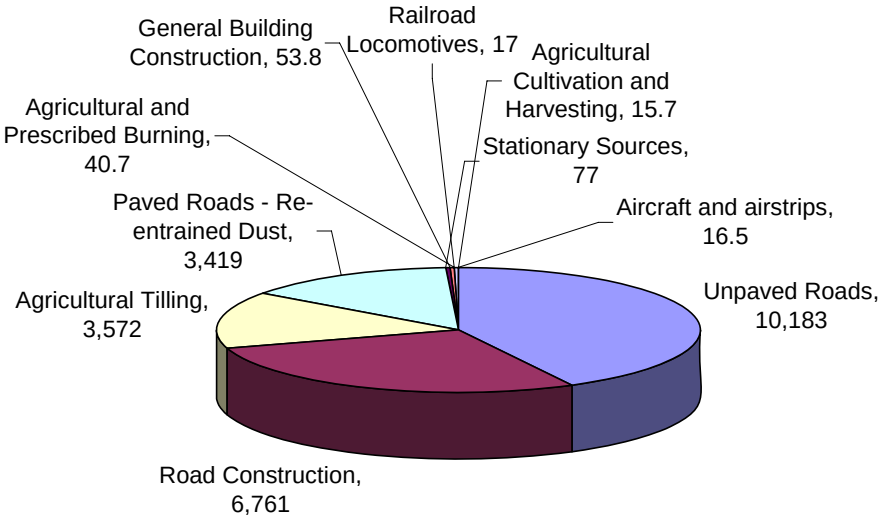
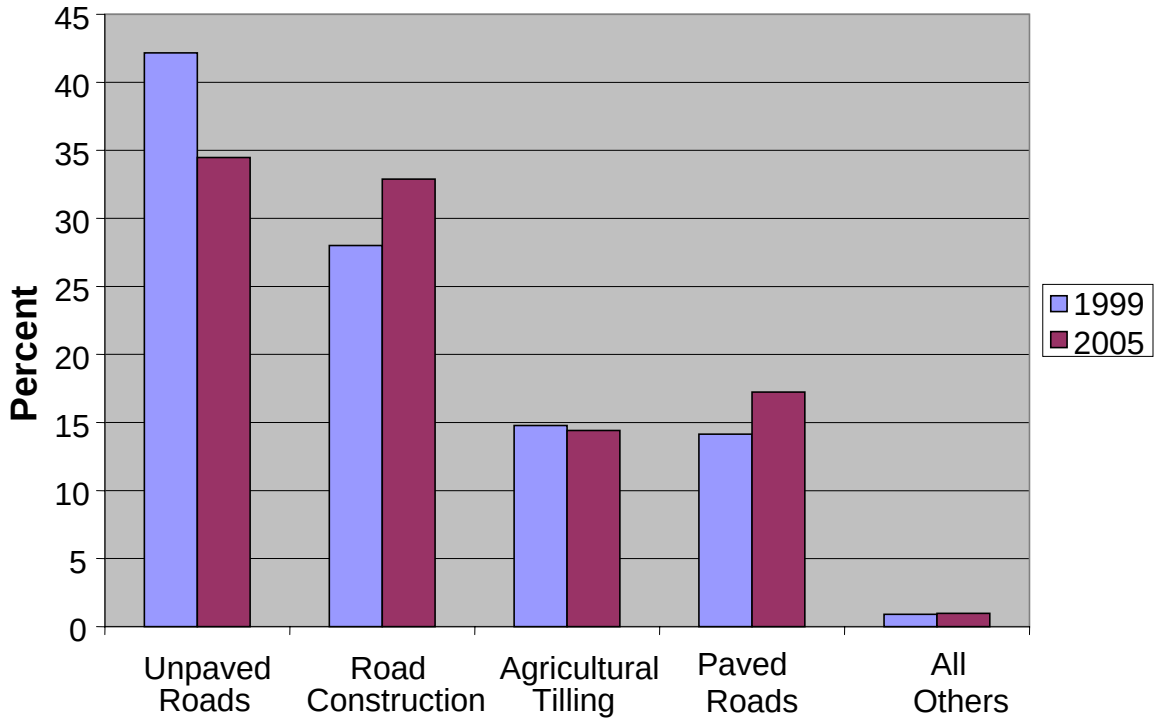


Figure 2. Yuma Anthropogenic Emissions in Tons per Year for 1999



With the inventory figures as a basis, the differences between 1999 and future years will now be examined. Windblown emissions of PM_{10} remain fairly constant, with a one percent decrease from 1999 to 2005 and a 2.5 percent decrease by 2016. Although most of the source categories in the anthropogenic emissions either decrease or remain constant, four categories, only two of which have numeric importance, increase from their 1999 totals. These increases, from 1999 to 2005, are paved road emissions (plus 25%) and road construction (plus 21%). Overall anthropogenic emissions increase 2.5% from 1999 to 2005. For those source categories which do change from 1999 to 2005, it's worth noting that their overall contributions to anthropogenic emissions remain roughly the same (Figure 3). This near equality in the anthropogenic source categories between the two years would suggest, that despite the increases in paved road and road construction emissions, the overall mix of anthropogenic sources remains pretty much the same. From a strict emissions standpoint, the 1999 and 2005 inventories are roughly equivalent.

Figure 3. Yuma PM_{10} Anthropogenic Emission Source Category Contributions in 1999 and 2005 (in Percent)



PM_{10} Concentrations

Another way to evaluate the two years is to consider the ambient record. Any major shifts or changes would cast doubt on the suitability of 1999 as a base year for modeling. PM_{10} concentrations from 1999 through 2004 certainly show some changes, but no consistent trend, and no changes that are statistically significant. In the following series of charts, the annual averages (Figure 4), the full day-to-day time series (Figure 5), the multiple annual time series (Figure 6), and the multiple annual ranked concentrations ordered from maximum to minimum (Figure 7) shed considerable light on how representative the 2004-5 conditions are of 1999.

Figure 4. Yuma PM_{10} Annual Averages

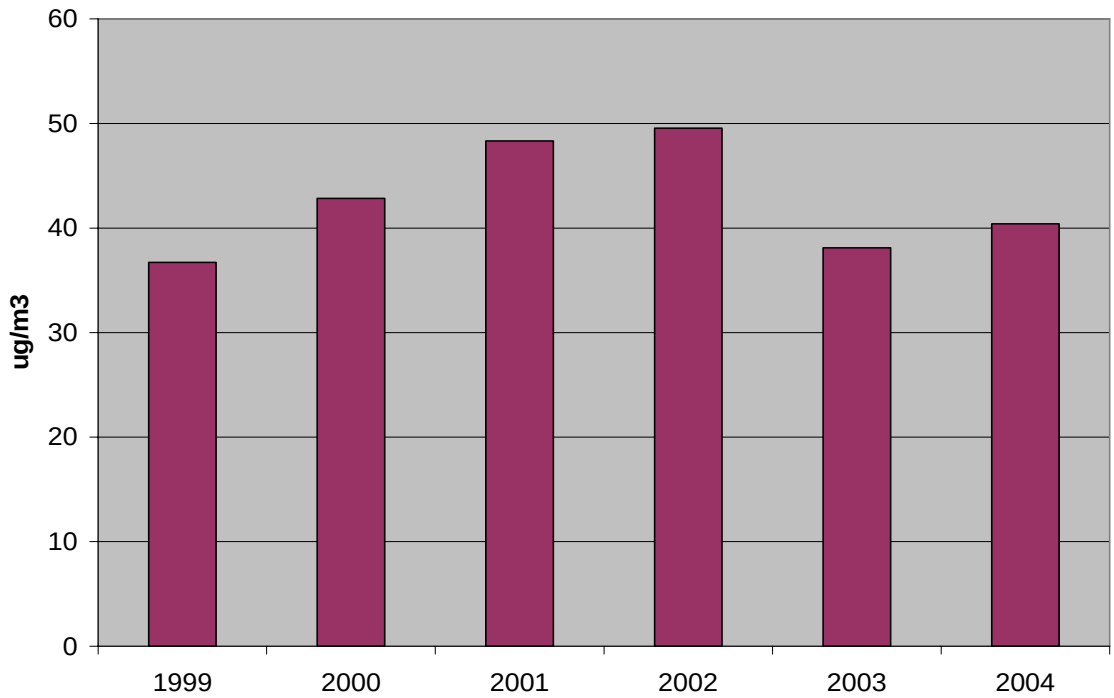
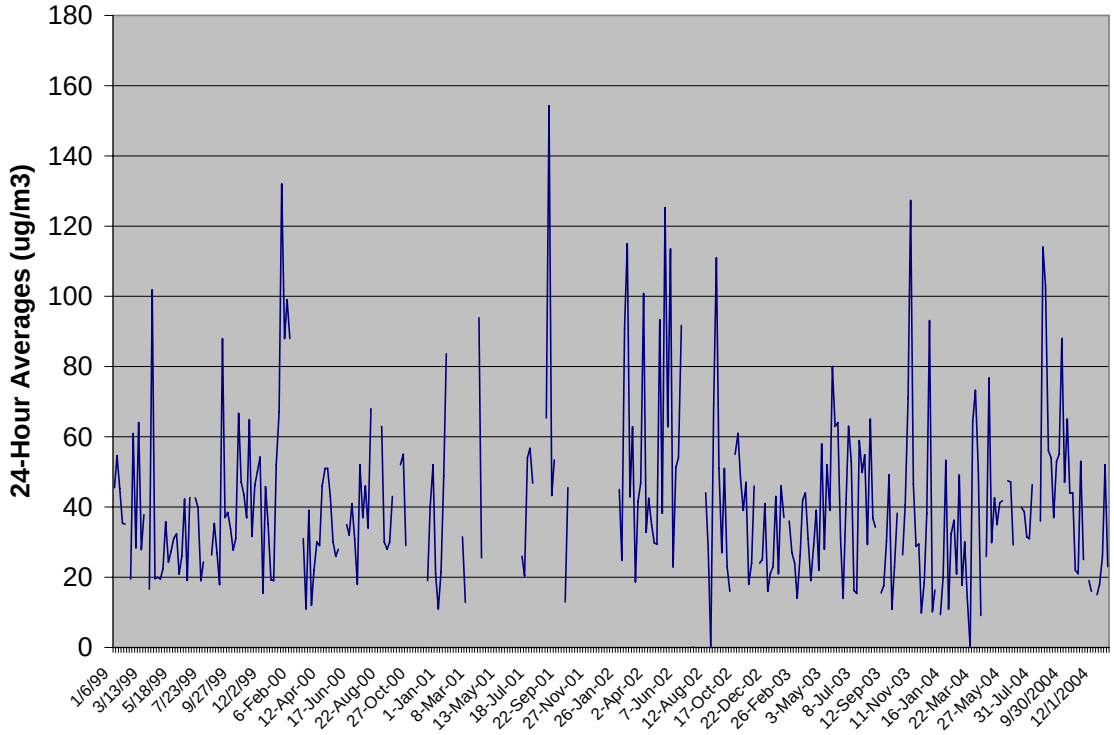


Figure 5. Yuma PM_{10} Concentrations from Every Sixth Day Sampling: 1999 – 2004



Note that the highest concentration of 154 µg/m^3 is not an exceedance, since rounding conventions dictate that exceedances begin at 155 µg/m^3.

Figure 6. Yuma PM_{10} 24-Hour Averages for Years 1999 – 2004

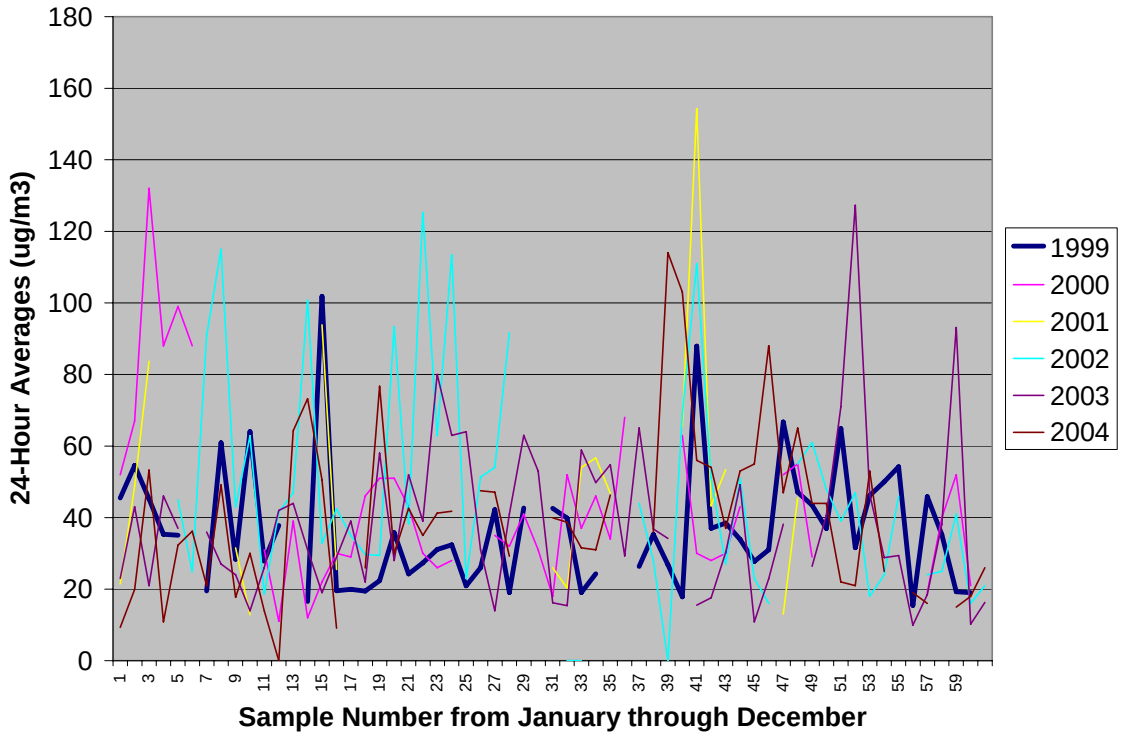
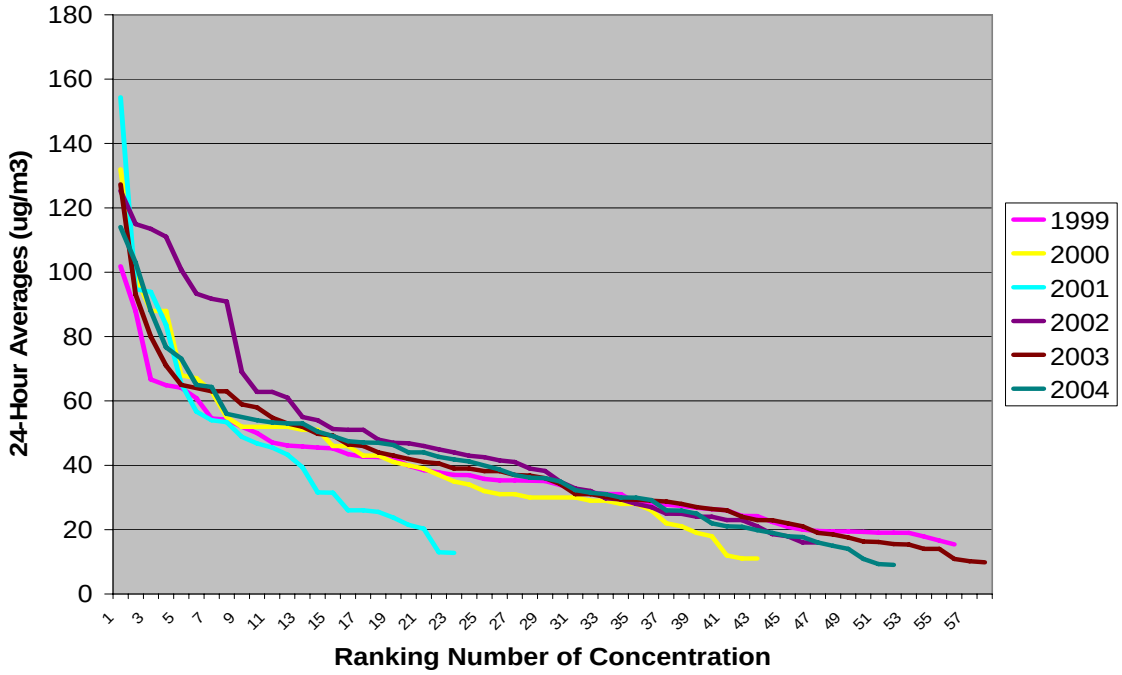


Figure 7. Yuma PM_{10} 24-Hour Averages for 1999 – 2004, with Concentrations Shown in Rank Order



Although subtle differences are readily apparent, it's difficult to claim that 1999 is somehow vastly different from the other years. When the 1999 annual average of 36.73 µg/m^3 is compared statistically with the other five years, only one combination was statistically different (Table 2).

Table 2. Statistical Comparison of the 1999 Annual Average PM_{10} Concentrations with the other Years

Years	Average (µg/m^3)	Standard Deviation	t Statistic	t Critical at 95%	Same or Different
1999 - 2000	42.84	24.34	1.391	2.000	Same
1999 - 2001	48.34	32.99	1.597	2.052	Same
1999 - 2002	49.55	29.08	2.643	2.000	Different
1999 - 2003	38.11	21.89	0.372	2.000	Same
1999 - 2004	40.39	22.30	0.942	2.000	Same

Notes: The t statistic must be greater than the critical value to say that the two years differ. This is the case for 2002 compared with 1999, but not the others.

The average and standard deviation for 1999 are 36.73 and 17.44 µg/m^3.

The method employed, a two-tailed t-statistic with unequal variances, accounts for the number of samples, their degree of variability, and the annual means. Only one year of the five, 2002, differed significantly from 1999, suggesting, as did the emissions, that the 1999 – 2004 concentration profiles in Yuma have been more or less constant and that the 1999 inventory is suitable for the maintenance plan.

Nature of the Modeling

In the Yuma TSD, the dispersion modeling of 1999 and 2016 PM_{10} concentrations was done in the following way. For several different design dates, simulated concentrations were produced based on the 1999 meteorology and emissions. Similar concentrations were produced with the 2016 emissions. The relative change in these simulated concentrations, applied to the measured concentrations of 1999, was used to project the 2016 concentrations. These future concentrations were no higher than their 1999 counterparts, and were all well within the 24-hour standard. Table 2-13 from the TSD, reprinted below as Table 3, illustrates how these 2016 predictions depend not only on the simulated concentrations, but also on their ratio to the 1999 measured concentrations. This table shows that concentrations in 2016 are predicted to range from 13 to 85 ug/m3, well within the standard. Choosing a base year with a slightly higher emissions density and/or slightly higher measured concentrations would not materially alter this outcome.

Table 3. Yuma PM_{10} Concentrations for 1999 and 2016					
Date	1999		2016 Total Prediction	Ratio of Predictions (2016/1999)	2016 Calculated PM_{10}
	Observation	Total Prediction			
12 Jan	51	163	122	0.75	38
31 Mar	88	118	114	0.97	85
30 May	26	62	62	1.00	26
23 Jun	44	99	81	0.82	36
17 Jul	19	60	42	0.70	13
8 Nov	32	74	51	0.69	22
8 Dec	46	99	75	0.76	35

(Units are µg/m3)

Concentration-Emission Ratios

Another way to understand this independence of base year is to examine the ratio of the highest measured concentrations with the emissions. If this ratio is more or less constant through the years in question, then all of the years are equivalent. In this comparison only the emissions from the two source categories that increase are considered: paved roads and road construction. Their increase of 22% is interpolated through the period 1999 – 2004. For each year, the five highest PM_{10} concentrations are divided by the emissions. For each year the range of concentration to emission ratios is within the bounds of 5 – 12, with some slight variations, of course.

This wide of a range, in itself, does not support constancy. But, looking at the entire set of ratios, and invoking a single year, 2001, as being unusual, the ratios are rather stable. Excluding 2001, we have the following ranges exhibiting a fair degree of stability:

High	9.2 – 12.4
2nd	8.3 -- 9.3
3rd	6.6 -- 8.3
4th	5.9 -- 8.3
5th	5.4 – 6.4.

The year 2001 doesn't fit in with the others because its second through fifth highest concentrations of PM10 are so much higher than the other years. For example, the fifth highest value in 2001 is 101 ug/m3: the highest in the other four years is considerably lower, at 73 ug/m3.

This set of ratios demonstrates that for these two important emission sources, which figure prominently in concentrations recorded at the monitor (agricultural

and dirt road emissions are much further away), there's no discernable trend from 1999 to 2004. There is some variability in year-to-year ratios, to be sure, especially with 2001 included. But even with 2001 in the mix, there is no upward or downward trend.

Shown in Table 4, these relatively constant ratios from year to year mean that predicted concentrations from an emissions-air quality model will not vary much from year to year. The constant ratios also mean that the fundamental relationship between emissions and PM_{10} concentrations in Yuma has remained the same from 1999 through 2004. Using predictions from any of the years, including 2005, would result in similar attainment findings for 2016.

In the choice of a base year for the Yuma PM10 Maintenance Plan, 1999 has been used in the various technical analyses, but 2005 has been shown to be equivalent. If emission budgets, control strategies, or any other considerations argue for 2005 as the base year, then this year will suffice. Because of its equivalency with 1999 in its emissions and PM10 concentrations, discussed in this paper, there would be no need to construct a new inventory from scratch and redo the air quality modeling work.

Table 4. PM_{10} Concentrations and Concentration-Emission Ratios						
PM_{10} Concentrations	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Average (year)	36.7	42.8	48.3	49.6	38.1	40.4
n of Samples	55	43	23	47	58	52
Maximum	102	132	125	127	127	114
2nd High	88	99	115	93	93	103
3rd High	67	88	113	80	80	88
4th High	65	88	111	71	71	77
5th High	64	68	101	65	65	73
Emissions (Tons/Yr)						
Anthropogenic	24,156					24,785
Roads + Const	10,180	10,629	11,078	11,527	11,976	12,425
Concentration/Emissions Ratios (x 1000)						
Maximum	10.0	12.4	11.3	11.0	10.6	9.2
2nd High	8.6	9.3	10.4	8.1	7.8	8.3
3rd High	6.6	8.3	10.2	6.9	6.7	7.1
4th High	6.4	8.3	10.0	6.2	5.9	6.2
5th High	6.3	6.4	9.1	5.6	5.4	5.9

Conclusions

Both 1999 and 2005 (or any year in between) are suitable base years for the Yuma PM_{10} modeling of the maintenance plan. Examination of emissions, ambient concentrations, and inferred model predictions shows that any year between 1999 and 2004, and by inference, 2005, would give similar results. These results, given in detail in the TSD, demonstrate that attainment is shown by a wide margin in 2016 with 1999 as a base year. This finding would not be changed by remodeling with any of the years 2000 – 2005.

APPENDIX E.

Lima & Associates:
Vehicle Particulate Emissions Analysis
And Associated Tables

VEHICLE PARTICULATE EMISSIONS ANALYSIS

Prepared for

ARIZONA DEPARTMENT OF TRANSPORTATION
TRANSPORTATION PLANNING DIVISION

MPOs/COGs AIR QUALITY POLICY AND LOCAL PROGRAMS SECTION
AND
YUMA METROPOLITAN PLANNING ORGANIZATION

Lima & Associates
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1. INTRODUCTION

This Working Paper documents the particulate matter (PM_{10}) emissions analysis conducted as part of the Yuma Metropolitan Planning Organization (YMPO) Model and Air Quality Conformity Analysis project. The emissions analysis was conducted for the YMPO nonattainment area.

The analysis was performed using a variety of software tools. The TransCAD traffic forecasting microcomputer software was used to estimate the vehicle-miles traveled (VMT) on the transportation system network. TransCAD, PC ARC/INFO, and ArcView softwares were used extensively to gather, analyze, and manage roadway network data; to gather and manage socioeconomic data; and to compute daily emissions by functional classification.

OVERVIEW OF VEHICLE PARTICULATE ANALYSIS

The objective for this PM_{10} air quality analysis was to determine the average daily amount of PM_{10} emitted due to vehicular traffic on the highway network. The individual steps for conducting the technical analysis were as follows:

A. Define Geographical Scope and Analysis Parameters

B. Collect Demographic, Roadway Network, and Traffic Data

C. Estimate Traffic Volumes, Vehicle-Miles Traveled (VMT), and Vehicle Speeds

D. Estimate Emissions Factors

E. Calculate Particulate Emissions

The final product of the analysis was the total yearly vehicle particulate emissions generated in the modeling domain.

ORGANIZATION OF THE WORKING PAPER

This section presents an overview of the analysis approach. The next section describes the development of the modeling domain, and highway current and future networks. Vehicle activity is discussed in the third section. The fourth section discusses the calculation of PM_{10} emissions and presents the results of the analysis. The final section presents a summary and conclusion.

2. GEOGRAPHICAL SCOPE AND ANALYSIS PARAMETERS

The initial step of the air quality analysis involved defining its spatial extent or modeling domain. Once this was determined, information about the transportation system was inventoried so that an accurate travel demand model could be developed. The inventory was also necessary to determine PM_{10} emissions rates for the various types of roadway facilities. Finally, the planning scenarios were defined for the base and future years.

DEFINITION OF MODELING DOMAIN

The modeling domain is the area that covers all of the land use activities that contribute to PM_{10} air pollution in the nonattainment area. This domain should include transportation facilities and other land use facilities, such as power plants, mines, quarries, and major construction sites. The domain should conform with analyses performed by other agencies.

This domain encompasses the modeling domain used in the analysis for the PM_{10} State Implementation Plan for the Yuma non attainment area. A grid of 1 km by 1 km cells was developed for the Yuma non attainment area, but was not used in this project. Figure 2-1 shows the modeling domain used for this study and the transportation system network used for the base year analysis

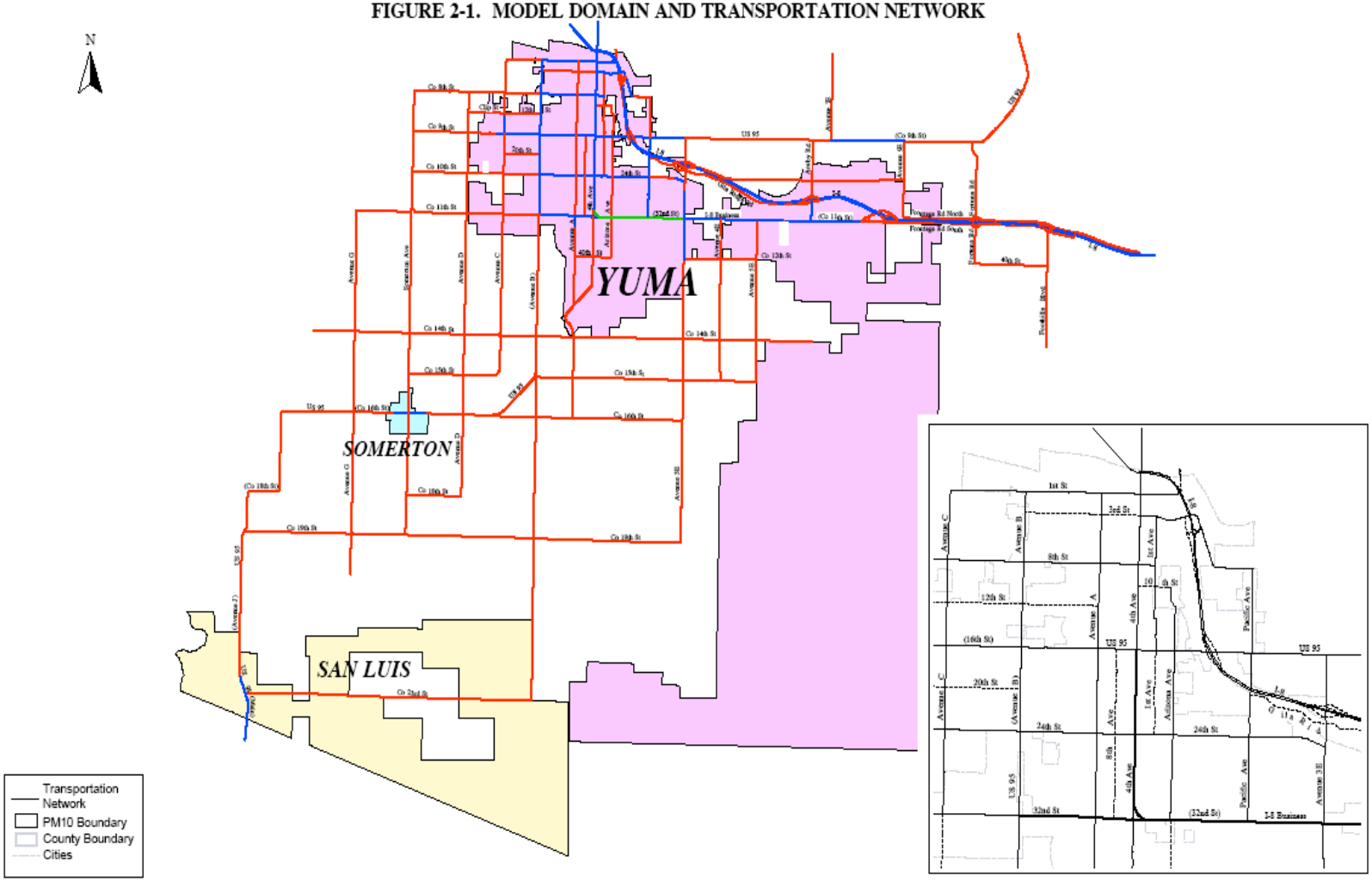
ROADWAY NETWORK

In order to develop an accurate representation of PM_{10} emissions from vehicular traffic, an inventory of all highways, roads, and streets was performed using street maps, aerial photographs, ERSI TIGER line files, and field data. A TransCAD travel demand model was then created from that inventory. Unpaved roads were identified, since they are assigned a different PM_{10} emission factor than paved roads. The unpaved roads were located using data provided by YMPO and Yuma County personnel.

TransCAD Model Network

A new travel demand model was developed for this project using TransCAD GIS based modeling software. The model was used to estimate current and future traffic volumes on the transportation network links. The TransCAD network, as mentioned above, is a schematic representation of the study area's highway transportation system. The TranscCAD model network should be spatially accurate so that emissions can be correctly distributed into grid cells if pollutant dispersion modeling is to be implemented. Future TransCAD network links were created to represent planned improvements to the highway transportation system based on transportation plans.

FIGURE 2-1. MODEL DOMAIN AND TRANSPORTATION NETWORK



Off-Network Links

Travel demand model networks only include “major roads” such as freeways, expressways, arterials, and some collector streets. However, local streets usually make up a large portion of the transportation system, and as many as 15 percent of the regional VMT is due to vehicle trips made on local streets. An inventory was performed on all local streets in the region to obtain relevant information, such as their location and surface type.

Accounting for future off-network links presented a problem, since it is difficult to determine where and how many local roads will be built in future years. The construction of local streets is dependent upon private residential development, and it is not usually included in regional transportation plans. As a result, local street links were not created for future years. Instead, the vehicle activity for local roads, calculated as VMT, was extrapolated for future years. The methodology of VMT estimations for future “offnetwork” links is presented in the next section.

Analysis Scenarios

The major objective of an emissions analysis is to compare the impact of improvements upon the transportation system in future planning horizons. This particular study analyzes only existing and one future horizon year. Therefore, the analysis were for the years 1998 (base year) and 2025. The exercise was conducted to compare the current with the future emission status.

3. VEHICLE MILES TRAVELED AND SPEED

The measure of vehicle activity that affects the amount of particulates being emitted daily is daily vehicle miles traveled or VMT. For a specific link representing a roadway or street in the transportation system the daily VMT is:

$$VMT_{link} = VOL_{link} * LENGTH_{link}$$

where:

VMT_{link} = daily vehicle miles traveled for a specific link
VOL_{link} = total daily volume on a specific link
$LENGTH_{link}$ = total length of specific link in miles

The TransCAD travel demand model was used to estimate traffic volumes on network links based on socioeconomic activity and network structure. These estimated volumes were used to calculate VMT on the links using the above equation for all of the links in the network.

This VMT calculation was then adjusted due to the difference between the model local roadway mileage and the actual local roadway mileage. The model local roadway mileage is 136 miles and the actual local roadway mileage is approximately 780 miles. In addition, vehicle trips only travel a portion of the roadway, not its entire length as the above calculation assumes. For this study 30% of VMT on local paved roads and 15% of VMT on local unpaved roads was used in the analysis.

VMT Estimations for Off-Network Links

As mentioned previously, the local streets and roads in the regional transportation network were not represented in the TransCAD model. Therefore, a different approach was required to estimate the VMT on these links. This involved estimating the VMT per mile for each local link in a traffic analysis zone (TAZ), based on its length and the number of vehicle trip-ends generated within the TAZ. The link VMT for local roads was using the following expression:

$$VMT_{i,n} = \left(T_n / \sum L\right) * \left(L_{i,n}\right)^2$$

where:

$VMT_{i,n}$ = daily vehicle miles traveled for link *I* within TAZ *n*
T_n = total number of trip-ends generated in TAZ *n*
L = total length of all links in TAZ *n* in miles
$L_{i,n}$ = length of link *I* within TAZ *n* in miles

The VMT for future off-network links could not be estimated by the foregoing expression, since it is difficult to estimate the future construction of local roads. However, a simple linear regression analysis revealed that a relation exists between the VMT and the number of dwelling units in a TAZ. The results indicated that, on an average, the VMT for a TAZ increased by 1.22 for an increase in one dwelling unit. Therefore, the increase in VMT for a specific TAZ in a future year was 1.22 times the number of dwelling units added to the TAZ from the base year until the future year. The VMT of the TAZ for each future year was estimated by adding the increase in VMT, due to development, to the "base year" TAZ VMT. For this, it was assumed that the "added" VMT is a result of the construction of paved roads, since most new housing developments have paved streets.

For example, suppose a TAZ is planned to have 300 more dwelling units in the year 2025. The increase of VMT between the years 1998 and 2025 is 300 times 1.22 equals 366. Assuming the base year VMT for this TAZ is 1200, the total VMT for the TAZ in 2025 is 1566.

Average Vehicle Speed

Vehicle speeds are required to compute the vehicle particulate emissions on paved and unpaved roads. The transportation model was used to compute road link speeds and also average speed for each facility type. However, as noted, transportation models do not typically include unpaved roads. Therefore, vehicle speeds on unpaved roads must be estimated based on field observed speeds or assumed speeds based on facility type and traffic volume. In this project a speed of 10 mph was used on all unpaved roads.

4. ESTIMATE OF VEHICLE PARTICULATE EMISSION FACTORS

Once VMT data have been determined, vehicle particulate emission factors must be developed to calculate the emissions based on vehicle activity. Emission factors are defined as the amount of pollutant emitted, usually expressed in grams per vehicle mile traveled. Vehicle particulate emission factors take into consideration vehicle tailpipe, brake and tire wear emissions, and the re-entrained dust which is kicked up by vehicles passing over roadways. The EPA has developed a methodology for determining the emission factors described below. PART5, a computer program developed to determine emission factors and which is available from the EPA, is also described below.

AP-42 METHODOLOGY FOR DETERMINING EMISSION FACTORS

Emission factors can be developed from the equations presented in Section 13.2 *of The Compilation of Air Pollutant Emission Factors* (AP-42). These empirically derived equations are used to calculate fleet average vehicle gram per mile emission factors.

Emission Factors for Paved Roads

The equation used to compute emission factors for paved roads is as follows:

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

where:

E = particulate emission factor (g/VMT)
k = base emission factor for particle size range (7.3 for PM_{10})
sL = road surface silt loading (grams per square meter) (g/m^2)
W = average vehicle weight in tons

The base emission factor, k, is a value that is dependent upon the particle size cutoff. Since current particulate air quality standards are concerned with particulate matter with a diameter of less than 10 microns, the particle size cutoff is 10. Therefore, the base emission factor will always be 7.3 for PM10, which is obtained from the AP-42 manual.

The road surface silt loading, sL, is a measurement of the amount of silt on paved roads and is measured in grams per square meter. It is highly recommended that field measurements be made based on procedures summarized in Appendix C of the AP-42 manual. However, if field measurements are not available, the analyst can refer to a data base in the AP-42 manual of silt loadings measured in various locations in the U.S.

The third variable in the above equation is the average vehicle weight in tons, W. This can be determined from traffic data or data from weighing stations. The default value is 3 tons, which is based on a national average.

Emission Factors for Unpaved Roads

The equation used to compute emission factors for unpaved roads is as follows:

$$E = 5.9k(s/2)(S/30)(W/3)^{0.7}(w/4)^{0.5}(365 - p/365)$$

where:

E = particulate emission factor in pounds per VMT (lb/VMT)
(this can be converted to g/VMT by multiplying by 453.59)
k = particle size multiplier (0.36 for PM_{10})
s = silt content of road surface material
S = mean vehicle speed in miles per hour
W = mean vehicle weight in tons
w = mean number of wheels
p = number of days per year with at least 0.01 inches of precipitation

The particle size multiplier, k, is a value that is dependent upon the particle size cutoff. As mentioned above, most analyses are concerned with particulate matter of 10 micrometers or less due to the requirements of national air quality standards. Therefore, the base emission factor for PM10 will always be 0.36, as obtained from the AP-42 manual. The emission factor would be 0.095 for PM2.5, which corresponds to a particle size cutoff of 2.5.

The road surface silt loading, s, is a measurement of the silt content of unpaved roads and is measured as a percentage. It is highly recommended that field measurements be made based on procedures summarized in Appendix C of the AP-42 manual. However, if field measurements are not available, the analyst can refer to a database in the AP-42 manual of silt content percentages measured at various locations in the U.S.

Average vehicle speed, S, can be measured from the field or calculated from a travel demand model. If data on vehicle speeds are not available, the national average default of 19.6 mph can be used.

The average vehicle weight in tons, W, can be determined from vehicle classification data. The national average default value is 3 tons.

The average number of wheels, *w*, for each vehicle can be based on vehicle classification data. It should usually be 4 wheels per vehicle, which is the national average. However, this value can be increased for dirt roads that have high volumes of truck traffic.

The amount of dust kicked up by motor vehicles traveling on dirt roads is highly dependent upon the amount of rainfall in the analysis area. The number of days per year with at least 0.01 inches of precipitation, p, can be obtained from a weather almanac or a chart from the AP-42 manual. This value ranges from about 18 to 65 in Arizona.

PART5 MODEL

The EPA's PART5 model, based on the AP-42 methodology, can be used to compute particle emission factors in grams per mile (g/mi) from on-road automobiles, trucks, and motorcycles for particle sizes of 1 - 10 microns. The particulate matter includes exhaust particulate components, brake and tire wear, and re-entrained road dust. It is important to note that PART5 requires a significant amount of data that is used to separately compute emissions for vehicle tailpipe, brake and tire wear emissions, and re-entrained dust. However, the analyst generally only needs to compute the total emissions factor and will not need this detailed information. Therefore, it is recommended the AP-42 equations be used directly.

ASSIGNING EMISSION FACTORS TO ROADWAYS

Usually the emission factors calculated for paved and unpaved roads can be applied to all such facilities in the roadway network. This assumes that inputs from the emission factor equations are regional averages and best represent the entire network as a whole. However, it may be necessary to assign different emission factors to different roadways based on their unique characteristics such as silt loading on paved roads, or silt percentages, average vehicle weights, or average vehicle speeds on unpaved roads.

Not all roadways have the same silt loading because of access to cleared areas and unpaved roads, lack of curbs and gutters, lack of street sweeping services, etcetera. In such cases, where differences in the amount of silt loading on various roadways is large,

it may be appropriate to collect silt loading from various sites. For example, a field inventory can be taken of which paved facilities can be classified as “paved clean” and “paved dirty”. Then, silt loading values can be determined for the facilities depending upon whether they are “clean” or “dirty”. As a result, two different emission factors can represent each type of roadway. Likewise, not all unpaved roadways have the same silt percentages. Therefore, it may be necessary to assign different emission factors to different types of unpaved roads if their silt percentages vary significantly. It is also important to note that the emissions factors for unpaved roads are significantly higher than those for paved roads.

The vehicle mix may not be the same for all facilities, thus, the average vehicle weight may vary. In cases where facilities serve high percentages of trucks, it may be necessary to assign separate emission factors based on higher average vehicle weights. Also, in cases where average vehicle speeds vary significantly for unpaved roads, it might be appropriate to develop multiple emission factors.

5. VEHICLE PARTICULATE EMISSIONS

Once the VMT and emission factors have been determined PM_{10} emissions were calculated by facility type. For this analysis it was necessary to total the VMT for each facility type to determine the emissions for each type of facility. Total vehicle particulate emissions are expressed in imperial tons. For the analysis the emissions was calculated by simply multiplying the facility type VMT by its assigned emission factor. For conformity analyses, it was necessary to sum the entire emissions for all the roadways within the modeling domain.

The following assumptions were made to perform the PM_{10} emissions calculations:

- Fifty percent of all unpaved roads in 1998 will be converted to paved roads by 2025

- The future VMT for a TAZ increases by 1.22 per added dwelling unit

PARTICULATE EMISSIONS BY ROADWAY FUNCTIONAL CLASS

PM_{10} emission factors were used to compute PM_{10} emissions on both an aggregate and disaggregate basis. For example, the VMT for local roads were aggregated for the entire region. Therefore, the regional emissions due to paved local roads was the product of the regional VMT and the emissions factor. The disaggregate approach was employed for calculating emissions from TransCAD based on facility type for non local roadways. For this, the emissions were calculated by facility type, which involved multiplying the facility type VMT by the facility type emission factor. The facility type emissions were then summed to compute the regional total emissions. This breakdown by facility type allows one to determine which types of facilities contribute most to particulate emissions. Table 5-1 summarizes the vehicular PM_{10} emissions estimate for the 1998 base year while Tables 5-2 and 5-3 present the vehicular PM_{10} emissions for future scenarios.

TABLE 5-1. PM_{10} EMISSIONS ESTIMATE FOR 1999				
Facility Type	**Daily VMT (miles)**	**Speed Used**	**Factor (kg/mi)**	**Total (kg/day)**
Interstate	541,163	55	0.00037	180.5
Principal Arterials	860,715	42	0.00037	327.7
Minor Arterials	672,408	40	0.00062	405.7
Rural Major Collectors	91,129	45	0.00164	137.4
Rural Minor Collectors	448,640	46	0.00164	709
Urban Collectors	139,709	35	0.00164	243.4
Local Roads	4,841	35	0.00306	22.4
Interstate Ramps	50,581	35	0.00037	17.3
Local Paved	889,680	20	0.00306	3,012.90
Local Unpaved	98,864	10	0.10857	8,699.50
DAILY TOTALS	**3,797,729**			**13,755.80**
	PM_{10} Emissions (tons/day)			**15.13**
	PM_{10} Emissions (tons/year)			**5,522.90**

TABLE 5-2. PM_{10} EMISSIONS ESTIMATE – NO BUILD				
Facility Type	**Daily VMT (miles)**	**Speed Used**	**Factor (kg/mi)**	**Total (kg/day)**
Interstate	1,209,501.00	55	0.00037	447.5
Principal Arterials	1,683,746.00	42	0.00037	623
Minor Arterials	1,311,500.00	40	0.00062	813.1
Rural Major Collectors	254,544.00	45	0.00164	417.5
Rural Minor Collectors	1,214,593.00	45	0.00164	1,991.90
Urban Collectors	278,038.00	30	0.00164	456
Local Roads	14,722.00	35	0.00306	45
Interstate Ramps	105,413.00	35	0.00037	39
Local Paved	1,451,574.30	20	0.00306	4,441.80
Local Unpaved	186,597.30	10	0.10857	20,258.90
DAILY TOTALS	**7,710,228.60**			**29,533.7**
	PM_{10} Emissions (tons/day)			**32.49**
	PM_{10} Emissions (tons/year)			**11,857.80**

TABLE 5-3. PM_{10} EMISSIONS ESTIMATE FOR 2025				
Facility Type	**Daily VMT (miles)**	**Speed Used**	**Factor (kg/mi)**	**Total (kg/day)**
Interstate	986,872.00	55	0.00037	365.1
Principal Arterials	1,768,187.00	42	0.00037	654.2
Minor Arterials	1,443,793.00	40	0.00062	895.2
Rural Major Collectors	289,087.00	45	0.00164	474.1
Rural Minor Collectors	1,028,207.00	46	0.00164	1,686.30
Urban Collectors	271,676.00	35	0.00164	445.5
Local Roads	21,204.00	35	0.00306	64.9
Interstate Ramps	94,825.00	35	0.00037	35.1
Local Paved	1,678,386.90	20	0.00306	5,135.90
Local Unpaved	109,618.50	10	0.10857	11,901.30
DAILY TOTALS	**7,691,856.40**			**21,657.5**
	PM_{10} Emissions (tons/day)			**23.82**
	PM_{10} Emissions (tons/year)			**8,695.50**

6. SUMMARY AND CONCLUSIONS

PM_{10} emissions were estimated for the Yuma nonattainment area using a TransCAD travel demand model and GIS applications. The estimates were made for three planning scenarios: current conditions (1998), no build (1998 network with 2025 socioeconomic data) and future conditions (2025 network and socioeconomic data). The estimates assumed that 50 percent of the unpaved roads in the nonattainment area will be paved by the year 2025. Table 6-1 summarizes the PM_{10} emissions estimated for each planning scenario.

TABLE 6-1. PM_{10} EMISSIONS SUMMARY

Scenario	Year	PM_{10} Emissions (tons/year)
1	1998	5,522.9
2	No Build	11,857.8
3	2025	8,695.5

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1999 PM10 Emissions from Unpaved Roads

Annual (tons) ***10,589***
Average Daily (tons) ***29.01***

Month	Days/Month	Silt content (%)	Mean vehicle speed (mi/hr)	Surface moisture content (%)	Days with >0.01 inches of prec.	Emission factor (lbs/mi)	Daily VMT	CE	RP	Monthly Emissions (lbs)
Jan	31	7.5	10	1	0	0.5869	98,864			1,798,719
Feb	28	7.5	10	1	2	0.5869	98,864			1,624,649
Mar	31	7.5	10	1	0	0.5869	98,864			1,798,719
Apr	30	7.5	10	1	4	0.5869	98,864			1,740,696
May	31	7.5	10	1	0	0.5869	98,864			1,798,719
Jun	30	7.5	10	1	2	0.5869	98,864			1,740,696
Jul	31	7.5	10	1	2	0.5869	98,864			1,798,719
Aug	31	7.5	10	1	2	0.5869	98,864			1,798,719
Sep	30	7.5	10	1	2	0.5869	98,864			1,740,696
Oct	31	7.5	10	1	0	0.5869	98,864			1,798,719
Nov	30	7.5	10	1	0	0.5869	98,864			1,740,696
Dec	31	7.5	10	1	0	0.5869	98,864			1,798,719

Annual Emissions (tons) **10,589**

1999 PM10 Emissions from Paved Roads

Annual (tons) ***3,712***
Average Daily (tons) ***10.17***

Road Type	Base emission factor for PM10	Silt loading (g/m^2)*	Average vehicle weight (tons)	Emission factor w/o precip. Effects (g/mi)	Daily VMT	CE	RP
Interstate	7.3	*0.04*	3	0.5741	541,163		
Principal Arterial	7.3	0.3	3	2.1271	860,715		
Minor Arterial	7.3	0.3	3	2.1271	672,408		
Rural Major Collector	7.3	0.7	3	3.6895	91,129		
Rural Minor Collector	7.3	0.7	3	3.6895	448,640		
Urban Collector	7.3	*0.24*	3	1.8399	139,709		
Local Roads	7.3	0.85	3	4.1858	4,841		
Interstate Ramps	7.3	*0.04*	3	0.5741	50,581		
Local Paved	7.3	0.85	3	4.1858	889,680		

*Numbers in italic are from previous silt loading measurements

Emission Factors with Precipitation Effects (g/mi)

Month	Days with >0.01 inches of prec.	Interstate	Principal Arterial	Minor Arterial	Rural Major Collector	Rural Minor Collector	Urban Collector	Local Roads	Interstate Ramps	Local Paved
Jan	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Feb	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Mar	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Apr	4	0.4976	1.8435	1.8435	3.1976	3.1976	1.5946	3.6277	0.4976	3.6277
May	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Jun	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Jul	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Aug	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Sep	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Oct	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Nov	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Dec	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858

1999 PM10 Emissions from Paved Roads (*continued*)

Controlled PM 10 Monthly Emissions (lbs), including fugitive dust, tire wear, and exhaust.

Month	Days/Month	Interstate	Principal Arterial	Minor Arterial	Rural Major Collector	Rural Minor Collector	Urban Collector	Local Roads	Interstate Ramps	Local Paved	Total
Jan	31	21,233	125,123	97,749	22,978	113,126	17,568	1,385	1,985	254,510	655,656
Feb	28	17,900	105,480	82,403	19,371	95,366	14,810	1,167	1,673	214,555	552,725
Mar	31	21,233	125,123	97,749	22,978	113,126	17,568	1,385	1,985	254,510	655,656
Apr	30	17,809	104,942	81,983	19,272	94,880	14,734	1,161	1,665	213,460	549,905
May	31	21,233	125,123	97,749	22,978	113,126	17,568	1,385	1,985	254,510	655,656
Jun	30	19,178	113,014	88,289	20,755	102,178	15,867	1,251	1,793	229,880	592,206
Jul	31	19,818	116,782	91,232	21,446	105,584	16,396	1,293	1,852	237,543	611,946
Aug	31	19,818	116,782	91,232	21,446	105,584	16,396	1,293	1,852	237,543	611,946
Sep	30	19,178	113,014	88,289	20,755	102,178	15,867	1,251	1,793	229,880	592,206
Oct	31	21,233	125,123	97,749	22,978	113,126	17,568	1,385	1,985	254,510	655,656
Nov	30	20,548	121,087	94,596	22,237	109,476	17,001	1,340	1,921	246,300	634,506
Dec	31	21,233	125,123	97,749	22,978	113,126	17,568	1,385	1,985	254,510	655,656
Total		240,415	1,416,716	1,106,767	260,175	1,280,874	198,910	15,680	22,471	2,881,714	**7,423,723**
									Annual Total, tons		**3,712**

2013 PM10 Emissions from Unpaved Roads

Annual (tons) ***5,758***
Average Daily (tons) ***15.78***

Month	Days/Month	Silt content (%)	Mean vehicle speed (mi/hr)	Surface moisture content (%)	Days with >0.01 inches of prec.	Emission factor (lbs/mi)	Daily VMT	CE	RP	Monthly Emissions (lbs)
Jan	31	7.5	10	1	0	0.5869	53,758			978,068
Feb	28	7.5	10	1	2	0.5869	53,758			883,416
Mar	31	7.5	10	1	0	0.5869	53,758			978,068
Apr	30	7.5	10	1	4	0.5869	53,758			946,517
May	31	7.5	10	1	0	0.5869	53,758			978,068
Jun	30	7.5	10	1	2	0.5869	53,758			946,517
Jul	31	7.5	10	1	2	0.5869	53,758			978,068
Aug	31	7.5	10	1	2	0.5869	53,758			978,068
Sep	30	7.5	10	1	2	0.5869	53,758			946,517
Oct	31	7.5	10	1	0	0.5869	53,758			978,068
Nov	30	7.5	10	1	0	0.5869	53,758			946,517
Dec	31	7.5	10	1	0	0.5869	53,758			978,068
								Annual Emissions (tons)		**5,758**

2013 PM10 Emissions from Paved Roads

Annual (tons) ***6,360***
Average Daily (tons) ***17.43***

Road Type	Base emission factor for PM10	Silt loading (g/m^2)*	Average vehicle weight (tons)	Emission factor w/o precip. Effects (g/mi)	Daily VMT	CE	RP
Interstate	7.3	*0.04*	3	0.5741	866,379		
Principal Arterial	7.3	0.3	3	2.1271	1,564,166		
Minor Arterial	7.3	0.3	3	2.1271	1,137,824		
Rural Major Collector	7.3	0.7	3	3.6895	198,520		
Rural Minor Collector	7.3	0.7	3	3.6895	870,923		
Urban Collector	7.3	*0.24*	3	1.8399	232,904		
Local Roads	7.3	0.85	3	4.1858	17,387		
Interstate Ramps	7.3	*0.04*	3	0.5741	84,437		
Local Paved	7.3	0.85	3	4.1858	1,361,491		

*Numbers in italic are from previous silt loading measurements

Emission Factors with Precipitation Effects (g/mi)

Month	Days with >0.01 inches of prec.	Interstate	Principal Arterial	Minor Arterial	Rural Major Collector	Rural Minor Collector	Urban Collector	Local Roads	Interstate Ramps	Local Paved
Jan	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Feb	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Mar	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Apr	4	0.4976	1.8435	1.8435	3.1976	3.1976	1.5946	3.6277	0.4976	3.6277
May	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Jun	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Jul	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Aug	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Sep	2	0.5358	1.9853	1.9853	3.4435	3.4435	1.7172	3.9067	0.5358	3.9067
Oct	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Nov	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858
Dec	0	0.5741	2.1271	2.1271	3.6895	3.6895	1.8399	4.1858	0.5741	4.1858

2013 PM10 Emissions from Paved Roads (*continued*)

Controlled PM 10 Monthly Emissions (lbs), including fugitive dust, tire wear, and exhaust.

Month	Days/Month	Interstate	Principal Arterial	Minor Arterial	Rural Major Collector	Rural Minor Collector	Urban Collector	Local Roads	Interstate Ramps	Local Paved	Total
Jan	31	33,994	227,385	165,407	50,057	219,605	29,286	4,974	3,313	389,481	1,123,501
Feb	28	28,657	191,688	139,440	42,199	185,130	24,689	4,193	2,793	328,337	947,124
Mar	31	33,994	227,385	165,407	50,057	219,605	29,286	4,974	3,313	389,481	1,123,501
Apr	30	28,511	190,710	138,728	41,984	184,185	24,563	4,172	2,779	326,661	942,292
May	31	33,994	227,385	165,407	50,057	219,605	29,286	4,974	3,313	389,481	1,123,501
Jun	30	30,704	205,380	149,400	45,213	198,353	26,452	4,493	2,992	351,789	1,014,776
Jul	31	31,727	212,226	154,380	46,720	204,965	27,334	4,642	3,092	363,516	1,048,601
Aug	31	31,727	212,226	154,380	46,720	204,965	27,334	4,642	3,092	363,516	1,048,601
Sep	30	30,704	205,380	149,400	45,213	198,353	26,452	4,493	2,992	351,789	1,014,776
Oct	31	33,994	227,385	165,407	50,057	219,605	29,286	4,974	3,313	389,481	1,123,501
Nov	30	32,897	220,050	160,071	48,443	212,521	28,342	4,813	3,206	376,917	1,087,260
Dec	31	33,994	227,385	165,407	50,057	219,605	29,286	4,974	3,313	389,481	1,123,501
Total		384,894	2,574,580	1,872,831	566,778	2,486,498	331,596	56,317	37,512	4,409,930	**12,720,936**
										Annual Total, tons	**6,360**

YUMA 2016 NOBUILD PARTICULATE MATTER (PM10) CONFORMITY ANALYSIS

Facility Type	Daily VMT(miles)	Daily VHT	Modeled Speed	Speed Used	Silt Loading	Factor(kg/mi)	Total(kg/day)
Interstate	742,246.00	15,099.00	49.16	55.00	0.040	0.000370	274.6
Principal Arterials	1,585,503.00	52,097.00	30.43	42.00	0.300	0.001920	3,044.2
Minor Arterials	1,024,853.00	47,819.00	21.43	40.00	0.300	0.001920	1,967.7
Rural Major Collectors	87,818.00	2,721.00	32.27	45.00	0.700	0.003490	306.5
Rural Minor Collectors	704,204.00	23,829.00	29.55	46.00	0.700	0.003490	2,457.7
Urban Collectors	222,015.00	13,487.00	16.46	35.00	0.240	0.001640	364.1
Local Roads	11,423.00	383.00	29.83	35.00	0.850	0.003980	45.5
Interstate Ramps	72,340.00	4,407.00	16.41	35.00	0.040	0.000370	26.8
Local paved	1,415,962.75			20.00	0.850	0.003980	5,635.5
Local unpaved	176,541.30			10.00	0.850	0.108570	19,167.1
DAILY TOTALS	**6,042,906.05**	**159,842.00**					**33,289.6**
					PM10 Emissions (tons/day)		**36.62**
					PM10 Emissions (tons/year)		**13,365.8**

7.97

YUMA 2016 PARTICULATE MATTER (PM10) CONFORMITY ANALYSIS

Facility Type	Daily VMT(miles)	Daily VHT	Modeled Speed	Speed Used	Silt Loading	Factor (kg/mi)	Total (kg/day)
Interstate	662,471.00	12,659.00	52.33	55.00	0.040	0.000370	245.1
Principal Arterials	1,466,306.00	41,539.00	35.30	42.00	0.300	0.001920	2,815.3
Minor Arterials	1,007,532.00	32,696.00	30.82	40.00	0.300	0.001920	1,934.5
Rural Major Collectors	166,904.00	3,834.00	43.53	45.00	0.700	0.003490	582.5
Rural Minor Collectors	870,323.00	23,261.00	37.42	46.00	0.700	0.003490	3,037.4
Urban Collectors	247,995.00	8,699.00	28.51	35.00	0.240	0.001640	406.7
Local Roads	8,133.00	232.00	35.06	35.00	0.850	0.003980	32.4
Interstate Ramps	63,083.00	2,206.00	28.60	35.00	0.040	0.000370	23.3
Local paved	1,510,851.00			20.00	0.850	0.003980	6,013.2
Local unpaved	100,856.76			10.00	0.850	0.108570	10,950.0
DAILY TOTALS	**6,104,454.76**	**125,126.00**					**26,040.4**
					PM10 Emissions (tons/day)		**28.64**
					PM10 Emissions (tons/year)		**10,455.2**

APPENDIX F.

Revisions to the Yuma PM_{10} Emissions Inventory (November 2006)

Revisions to the Yuma PM10 Emissions Inventory (July 2006)

The PM10 emissions inventory for Yuma, assembled by E. H. Pechan, released as “1999 and 2016 Emission Estimates for the Yuma, Arizona PM10 Nonattainment Area Maintenance Plan”, June 2003, and presented as Appendix A of this Technical Support Document, has been revised as described below. Certain categories were recalculated, a few new categories were added, and the emission totals are now presented for both the larger study area and the nonattainment area.

Original 1999 and 2016 Emission Inventories

The following are the contractor’s emission estimates as given in the above report (Table F-1). Estimates for 2005 were interpolated from the 1999 and 2016 totals.

Table F-1. Yuma Study Area PM10 Emissions – Contractor Inventory

Source Category	Annual tons of PM10		
	1999	2005	2016
Agricultural and Prescribed Burning	40.7	38.4	34.1
Agricultural Tilling	3,572	3,572	3,572
Agricultural Cultivation and Harvesting	15.7	15.7	15.7
Windblown Dust	130,331	129,172	127,046
Unpaved Roads - Re-entrained Dust	10,183	8,543	5,537
Paved Roads	3,419	4,273	5,839
Road Construction	6,761	8,152	10,702
General Building Construction	53.8	65.8	87.7
Aircraft	15.5	15.8	16.4
Unpaved Airstrips	1.0	1.0	1.1
Stationary Sources	77	92	119
Railroad Locomotives	17	16	15
Total	154,487	153,957	152,985

Unpaved Roads

The original work did not account for the constant that needs to be subtracted in the primary AP-42 emission factor equation for unpaved roads.

$E = [k[s/12]^{0.97} x[S/30]^{0.46}]/[M/0.5]^{0.23}] - C$, where

E = Particulate emission factor in pounds per mile

k = Particle size multiplier = 1.8

s = road surface silt loading

S = speed in miles per hour

M = surface moisture content in percent

C = Emission factor for 1980's vehicle fleet exhaust, break wear, and tire wear

The constant "C" has the value of 0.2119 grams per mile, while typical values of moisture content, speed, and silt content for southern Arizona yield an unpaved road emission factor of 250 grams per mile. Correcting for this factor can be done by multiplying an emission total by 0.999152 (Table F-2).

Table F-2. Original and Revised Unpaved Road Emissions

Source Category	Annual tons of PM10		
	1999	2005	2016
Original Unpaved Roads	10,183	8,543	5,537
Revised Unpaved Roads	10,174	8,536	5,532

Paved Roads

The contractor used MOBILE6.1 and the AP-42 equation for reentrained dust to estimate these emissions. The more recent version MOBILE6.2 has the same emission factors for exhaust, brake, and tire wear as the earlier version. The contractor did subtract the constant C, 0.2119 grams per mile, as laid out in current EPA guidance. These emission factors used by the contractor are current, so the emissions need no revision.

Windblown Dust – Vacant Agricultural Fields and Agricultural Roads

Emissions from vacant agricultural fields have been reduced by 90%. The contractor had estimated that from 10 to 40% of agricultural fields were vacant, depending on the season. In talks with Yuma area farmers and conservation agents, however, it was learned that the typical Yuma farm field is "vacant" – unirrigated, unplanted, and susceptible to wind erosion – only ten days per year. This leads to a 90% reduction in windblown emissions from these fields

For windblown dust from agricultural unpaved roads, the contractor applied a factor of 0.0815 to the total agricultural acreage to estimate unpaved road acreage. Staff from the Farm Service Agency in Yuma have stated that a more realistic figure is 0.02. Windblown emissions from agricultural unpaved roads have been recalculated with this figure.

The original inventory figures for windblown dust are given in Table F-3.

Table F-3. Windblown Emissions – Contractor Inventory

Windblown Dust Category	1999	2005	2016
Vacant Ag Fields	65,835	65,607	65,188
Miscellaneous Disturbed Area	33,996	33,996	33,996
Unpaved Ag Roads	22,160	22,083	21,942
Urban Disturbed Area	5,442	4,588	3,021
Alluvial Plains	2,517	2,517	2,517
Native Desert	382	317	382
Total	130,332	129,108	127,046

The revised figures, in which the "Vacant Ag Fields" windblown emissions have been lowered by 90%, and in which the unpaved agricultural road acreage is based on a 0.02 figure, are given in Table F-4.

Table F-4. Windblown Emissions – With Revised Vacant Ag Fields and Unpaved Ag Roads

Windblown Dust Category	1999	2005	2016
Vacant Ag Fields	**6,584**	**6,561**	**6,519**
Miscellaneous Disturbed Area	33,996	33,996	33,996
Unpaved Ag Roads	**4,179**	**4,164**	**4,138**
Urban Disturbed Area	5,442	4,588	3,021
Alluvial Plains	2,517	2,517	2,517
Native Desert	382	382	382
Total	**53,100**	**52,208**	**50,573**

Since the contributing sources of the 2002 Natural Events Action Plan (NEAP) were based on the original inventory, there is some question whether an inventory change of this magnitude would change the importance of sources for the Best Available Control Measures analysis of the NEAP. The answer to this question, with the exception of the vacant fields and unpaved agricultural roads categories, is no, as explained in the following section.

Yuma PM10 Maintenance Plan: Consistency with the Natural Events Action Plan's Contributing Sources in Light of the Reduction of Windblown Dust Emissions from Vacant Agricultural Land and Unpaved Agricultural Roads

Introduction

The Yuma PM10 monitor recorded an exceedance of 170 ug/m3 for a 24-hour average on August 18, 2002. The day qualified as an exceptional event and a Natural Events Action Plan (NEAP) was carried out. As part of this plan, Best Available Control Measures (BACM) were considered for all the contributing sources. These sources were identified through emissions and air quality modeling. Two of the major contributors, windblown dust from vacant agricultural fields and windblown dust from unpaved agricultural roads, were later found to be over estimated. The contractor building the emissions inventory had assumed that agricultural fields would be "vacant" or "fallow" in the following amounts: 35% in the fall, 40% in winter, 10% in spring and summer. In meetings with Yuma farmers and agricultural agents in 2005, however, Assessment Staff learned that these were large over estimates. Instead of these high percentages, the Yuma farming community stated that on average, each field was fallow, unirrigated, unplanted, and susceptible to wind erosion for ten days a year. Calculations then showed that on an annual basis, the emissions from vacant agricultural fields needed to be reduced by 90%. For windblown dust from agricultural unpaved roads, the contractor applied a factor of 0.0815 to the total agricultural acreage to estimate unpaved road acreage. Staff from the Farm Service Agency in Yuma have stated that a more realistic figure is 0.02. Windblown emissions from agricultural unpaved roads have been recalculated with this figure. This paper reexamines the contributing sources identified in the NEAP in light of these inventory corrections.

Results

In the following discussion, the "contributions" are those from a particular kind of emissions source to the model-predicted concentration averaged 24 hours at the Yuma Juvenile Center PM10 monitor. The net modeled concentration can be broken down into its component parts, each part from a different emission source. Correcting the contribution from windblown emissions from vacant agricultural fields and unpaved agricultural roads can be done in at least two ways. Their contributions can be reduced, and the other categories increased

proportionately such that the new modeled total concentration equals the old one. The other way is to simply leave the contributions from the other sources as they were, changing only the vacant agricultural fields and unpaved agricultural roads contributions. Results from both ways are shown below: they produce similar distributions of contributions, as shown by the percentages in Table F-6.

Table F-5. Contributing Sources to Yuma PM10 on August 18, 2002, micrograms per cubic meter

SOURCE	ORIGINAL	REVISION 1	REVISION 2
PAVED ROADS	23.6	33.7	23.6
WIND – AG. FIELDS	15.2	1.5	1.5
WIND - MISC. DIST AREAS	13.7	19.6	13.7
WIND - UNPAVED AG. ROADS	12.9	2.4	2.4
WIND - URBAN DIST AREAS	9	12.9	9
CONSTRUCTION	7.9	11.3	7.9
UNPAVED ROADS	1.4	2.0	1.4
AIRCRAFT	0.5	0.7	0.5
OTHERS	0.3	0.4	0.3
WIND - ALLUVIAL	0.1	0.1	0.1
TOTAL	84.6	84.6	60.4

Revision 1: 90% reduction of vacant ag fields and reduction of unpaved ag roads; other categories increased.

Revision 2: 90% reduction of vacant ag fields and reduction of unpaved ag roads; other categories unchanged

Table F-6. Contributing Sources to Yuma PM10 on August 18, 2002, Percentages

SOURCE	ORIGINAL	REVISION 1	REVISION 2
PAVED ROADS	27.9	39.8	39.1
WIND – AG. FIELDS	18.0	1.8	2.5
WIND - MISC. DIST AREAS	16.2	23.1	22.7
WIND - UNPAVED AG. ROADS	15.2	2.8	4.0
WIND - URBAN DIST AREAS	10.6	15.2	14.9
CONSTRUCTION	9.3	13.3	13.1
UNPAVED ROADS	1.7	2.4	2.3
AIRCRAFT	0.6	0.8	0.8
OTHERS	0.4	0.5	0.5
WIND - ALLUVIAL	0.1	0.2	0.2
TOTAL	100.0	100.0	100.0

Although the percentages between the two revisions are nearly equal, each one produces a distribution that is considerably different from the original. All of the more major contributing sources increase their share of the modeled concentration. The important contributing sources of the NEAP can now be compared with those from this inventory revision (Table F-7).

Table F-7. Contributing Sources to Yuma PM10 from the NEAP and with the Revision to Windblown Emissions from Vacant Agricultural Fields and Unpaved Agricultural Roads

Sources from the NEAP	%	Sources with the Revision	%
PAVED ROADS	27.9	PAVED ROADS	39.8
WIND – AG. FIELDS	17.9	WIND - MISC. DIST AREAS	23.1
WIND - MISC. DIST AREAS	16.2	WIND - URBAN DIST AREAS	15.2
WIND - UNPAVED AG. ROADS	15.3	CONSTRUCTION	13.3
WIND - URBAN DIST AREAS	10.6	WIND - UNPAVED AG. ROADS	2.8
CONSTRUCTION	9.3	UNPAVED ROADS	2.4
UNPAVED ROADS	1.6	WIND – AG. FIELDS	1.8
AIRCRAFT	0.6	AIRCRAFT	0.8
OTHERS	0.4	OTHERS	0.5
WIND - ALLUVIAL	0.1	WIND - ALLUVIAL	0.2

The top six from the NEAP are paved roads, windblown ag fields, windblown miscellaneous disturbed area, windblown unpaved ag roads, windblown urban disturbed areas, and construction. In the revision, the top four are paved roads, windblown miscellaneous disturbed areas, windblown urban disturbed areas, and construction, with windblown ag fields and unpaved ag roads decreasing to less than three percent each. With these revisions the relative contributions from agricultural fields and unpaved agricultural roads decreases, while the relative contribution from the other source categories increases. The three principal anthropogenic sources -- paved roads, construction, and unpaved roads – retain the same order with the revision as in the original NEAP work. Since the NEAP Best Available Control Measures concentrated on the anthropogenic sources, and since the revised contributions from these three sources is of the same order, albeit with higher percentages, the revisions in the emission inventory do not conflict with the anthropogenic contributions determined in the NEAP.

General Building Construction

These emissions were calculated without corrections for moisture and silt content. For moisture, the factor in the equation is (24/PE), where the PE value of 6 should have been used. This increases the emissions by 4.0. The silt adjustment factor is (s/9), where s is the silt content in percentage. The silt value of 40% should have been used, increasing the emissions by (40/9) = 4.44. With

these two adjustments, the emissions are increased by about a factor of 16, as shown in Table F-8.

Table F-8. Original and Revised General Building Construction Emissions

Source Category	Annual tons of PM10		
	1999	2005	2016
General Building Construction-original	53.8	65.8	87.7
General Building Construction-revised	955.5	1,168.0	1,557.6

Road Construction

Road construction emissions did factor in both the moisture and silt content, but appeared to have applied a monthly emission factor to annual construction totals. These emissions have been recalculated, as shown below in the two tables. The original estimates were too high by factors of three to 20. The following equation was used.

$E_{cor} = Ef * (24/Mf) * (s/9)$, where

E_{cor} = corrected emissions

E_f = emission factor of 0.42 tons/acre/month

M_f = moisture factor, (PE), for Yuma, 6

s = silt content in percent, for Yuma, 40%

Table F-9. Revised Road Construction Emissions -- 1999

	Revised Calculations for 1999						From Inventory	
Agency	Miles/Yr	Acres/Mi	Acres/Yr	Acres/Mon	Tons/Mon	Tons/Year	Tons/Yr	Calc/Inv
Somerton	2.52	9.8	24.7	2.1	15.37	**184**	1383	0.13
City of Yuma	7.2	9.8	70.6	5.9	43.90	**527**	3951	0.13
Yuma County	1.9	9.8	18.6	1.6	11.59	**139**	384	0.36
ADOT	0.7	9.8	6.9	0.6	4.27	**51**	1043	0.05
Total	12.32	9.8	120.7	10.1	75.12	**901**	6761	0.13

Table F-10. Revised Road Construction Emissions -- 2016

	Revised Calculations for 2016						From Inventory	
Agency	Miles/Yr	Acres/Mi	Acres/Yr	Acres/Mon	Tons/Mon	Tons/Year	Tons/Yr	Calc/Inv
Somerton	0	9.8	0.0	0.0	0.00	**0**	0	NA
City of Yuma	11.1	9.8	108.8	9.1	67.69	**812**	6092	0.13
Yuma County	3.6	9.8	35.3	2.9	21.95	**263**	2634	0.10
ADOT	4.8	9.8	47.0	3.9	29.27	**351**	1976	0.18
Total	19.5	9.8	191.1	15.9	118.91	**1427**	10702	0.13

ATV Emissions

Emissions from all-terrain vehicles (ATVs) do not appear in the PM10 emissions inventory prepared by Pechan. As one of the chief forms of recreation around Yuma is driving these vehicles over the desert and dunes, this omission was unfortunate but not terribly important. Here's why.

Generally, off-road vehicles are not used in paved, urbanized areas such as the majority of the land within the boundaries of the Yuma PM10 air quality planning area. Instead, these vehicles are used in outlying, unpaved areas such as the Ehrenburg Bowl Off-Highway Vehicle Recreation Area near Blythe, Arizona, in La Paz County and the Imperial Sand Dunes Recreation Area approximately 20 miles west of Yuma in California. Certainly some ATV activity takes place in the more remote areas of the Yuma planning area, especially along the Yuma Mesa along the slopes of the Gila Mountains.

For this discussion only, we assume that all of the ATV activity takes place within the planning area. This assumption leads to a large over estimate of the PM10 emissions from this source. Even with this erroneous excess, the ATV emissions are still a small part of the larger emissions picture. For example, calculations from a bottoms-up approach suggest that the ATV emissions – both exhaust and resuspended dust – are less than one percent of the anthropogenic total. This low percentage contribution is confirmed by the National Emissions Inventory. Consequently, their omission from the inventory has little consequence. Their omission from the air quality modeling has even less, even for the simulations of the 24-hour average PM10 concentrations.

ADEQ concludes that emissions from this small percentage of mobile sources in the Yuma PM10 planning area would not contribute to nonattainment or interfere with attainment of the PM10 NAAQS in the Yuma air quality planning area in the next 10 years.

Table F-11 presents the statistics.

Table F-11. ATV Activity Data and Emissions

Activity Data for Yuma Area ATVs

Item	Statistic	E-factor	Emissions
		g/mile	tons/yr
ATVs In Yuma County	8400		
Days Per Year Of Use	40		
Mileage To And From Area	80		
Mileage Of Offroad Use Per Day	10		
Onroad Mileage Per Year	26,880,000	0.06	1.61
Offroad Mileage Per Year	3,360,000	0.6	2.02

Roadway Emissions (Tons/Year)

	1999	2016
Unpaved Roads	**10,174**	**5,532**
Paved Roads	3,419	5,839
Anthropogenic Inventory Total	19,319	18,331

ATV Contributions in %	1999	2016
ATVs % of unpaved roads	0.020	0.024
ATVs % of paved roads	0.047	0.028
ATVs % of anthropogenic inventory	0.019	0.020

National Emissions Inventory Yuma PM10 Emissions	(Tons/Year)
ATV 2-stroke exhaust	0.03
ATV 4-stroke exhaust	0.32
Exhaust total	0.35
Fugitives	2.02
Total	2.37

Pechan Inventory Totals	1999	2016
Anthropogenic Inventory Total	19,319	18,331
ATVs % of Anthropogenic Inventory	0.012	0.013

Lawn and Garden Emissions

Emissions from lawn and garden equipment were estimated by using the fraction of the Maricopa County PM10 emissions that are lawn and garden, and applying the fraction to the Yuma inventory. The Maricopa County figures come from "Cap-and-Trade Oversight Committee – Final Report", January 16, 2004.

Table F-12. Lawn and Garden Emissions

	1999	2005	2016
MC lawn/garden emissions (tons/yr)	127	155.2	207
MC total emissions	83,375		
fraction of MC that is lawn/garden	0.0015		
Yuma PM10 emissions total	72,438		
Yuma lawn and garden (tons/yr)	**110**	**135**	**180**

Light Commercial Vehicles In the Offroad Category

Light commercial vehicles in the nonroad sector are small nonroad trucks, forklifts, small tractors and loaders used in construction; forklifts and small industrial riding sweepers, and various kinds of small farm vehicles such as riding mowers. To calculate these emissions for Yuma, two inventories were consulted: 2004 California statewide inventory, and the Maricopa County cap and trade inventory. Precise accounting for these vehicles had not been done in the nonroad inventories: Emissions from the various horsepower categories in the California inventory were assumed to be ten percent from these vehicles. The fraction of nonroad engines from these light commercial vehicles in the California inventory was applied to the nonroad total in the Maricopa inventory. The Maricopa fraction of light commercial vehicles was then applied to the Yuma PM10 inventory.

Table F-13. Calculations for Light Commercial Vehicle Emissions

California Statewide Inventory	Tons/Day	Fraction Vehicles	Vehicles Tons/day
Offroad Engine Total	16.01		
2-Srk < 25 Hp	0.07	0.1	0.007
4-Strk < 25 Hp	0.41	0.1	0.041
4-Strk > 25 Hp	0.46	0.1	0.046
Sum Light Commercial	0.94		0.094
Fraction Of Total Nonroad	0.006		
Maricopa PM10 Inventory (Cap Trade)			
Total	83375		
Commercial Equipment	141	0.1	14.1
Fraction Com	0.0002		
Total Offroad	2608		
Lt Comm Veh	15.31		
Fraction	0.0002		
Yuma Total	72,438		
Yuma light commercial vehicles	13.30		

Yuma PM10 Inventory – Revised

Table F-14 is the revised inventory, with those categories in bold being the ones that were revised or added. These figures are for the entire Yuma study area.

Table F-14. Yuma Study Area PM10 Emissions -- Revised

Source Category	Annual tons of PM10		
	1999	2005	2016
Windblown Dust	**53,100**	**52,208**	**50,573**
Unpaved Roads - Re-entrained Dust	**10,174**	**8,536**	**5,532**
Agricultural Tilling	3,572	3,572	3,572
Paved Roads	3,419	4,273	5,839
General Building Construction	**955**	**1,168**	**1,558**
Road Construction	**901**	**1,087**	**1,427**
Lawn & garden	**110**	**135**	**180**
Stationary Sources	77	92	119
Agricultural and Prescribed Burning	41	38	34
Railroad Locomotives	17	16	15
Agricultural Cultivation and Harvesting	16	16	16
Light Commercial Vehicles (Nonroad)	13	13	13
Aircraft	16	16	16
ATVs	**3.6**	**4.4**	**5.9**
Unpaved Airstrips	1	1	1
Total	**72,416**	**71,175**	**68,901**

Note: bold figures are revisions or additions to the original inventory of Table F-1

Nonattainment Area Emissions

Emission density plots by source category were examined to estimate the fraction of emissions occurring in the nonattainment area (Table F-15). These fractions were applied to the emissions from the entire study area to estimate the nonattainment area emissions.

Table F-15. Percentage of Emissions of the Entire Study Area Which Come From the Nonattainment Area, by Source Category

Source Category	Percent in Nonattainment Area
Windblown Dust	97
Unpaved Roads - Re-entrained Dust	95
Agricultural Tilling	90
Paved Roads	95
General Building Construction	99
Road Construction	99
Lawn & Garden	99
Stationary Sources	99
Agricultural and Prescribed Burning	98
Railroad Locomotives	60
Agricultural Cultivation and Harvesting	90
Aircraft	99
ATVs	99
Unpaved Airstrips	99

Table F-16. Yuma PM10 Emissions in the Nonattainment Area – Revised

Source Category	Annual tons of PM10		
	1999	2005	2016
Windblown Dust	**51,241**	**50,380**	**48,803**
Unpaved Roads - Re-entrained Dust	**9,666**	**8,109**	**5,256**
Agricultural Tilling	3,215	3,215	3,215
Paved Roads	3,248	4,059	5,547
General Building Construction	**946**	**1,156**	**1,542**
Road Construction	**892**	**1,076**	**1,413**
Lawn & garden	**109**	**134**	**178**
Stationary Sources	76	91	118
Agricultural and Prescribed Burning	40	38	33
Railroad Locomotives	10	10	9
Agricultural Cultivation and Harvesting	14	14	14
Light commercial vehicles	**13**	**13**	**13**
Aircraft	15	16	16
ATVs	**4**	**4**	**6**
Unpaved Airstrips	1	1	1
Total	**69,491**	**68,316**	**66,163**

Bold figures are revisions or additions to the inventory of Table F-1; all figures reflect emissions only from the nonattainment area.