Estimating the Impacts of Agricultural Best Management Practices in the Maricopa County PM_{10} Non-Attainment Area

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ABSTRACT

On June 10, 1996, the U.S. Environmental Protection Agency (U.S. EPA) designated a portion of Maricopa County, Arizona, as a serious non-attainment area for particulate matter less than or equal to 10 micrometers in diameter (PM_{10}). Some previously unregulated sources that need to be addressed in future control plans include unpaved roads and parking lots, vacant lots, and agricultural sources. Arizona Department of Environmental Quality (ADEQ) initiated a study to quantify the impacts from implementing best management practices (BMPs) to control agricultural emissions in the Maricopa County PM_{10} Non-Attainment Area. Approximately 30 BMPs were identified by a governor-appointed committee. The Governor's Agricultural BMP Committee consists of representatives from local agricultural interests, ADEQ, Arizona Department of Agriculture, Natural Resources Conservation Service, and the University of Arizona Cooperative Extension. The Committee is currently developing a public education document and workshops to provide guidelines to farmers for implementing the BMPs.

The analysis conducted to determine the impacts of the BMPs on emissions generated by agricultural practices included a literature search to ascertain existing data pertaining to control efficiencies for BMPs. An implementation scenario was developed based on the BMPs most likely to be implemented, and their range of control efficiency. A 1995 base year design-day emissions inventory formed the basis of the impacts analysis. The impacts of BMPs were determined by applying the implementation scenario and other factors (e.g., anticipated amount of agricultural land to go out of production due to urbanization) to the design-day inventory to project emissions to the attainment year of 2006. Results show that a reduction in agricultural PM_{10} emissions of between 58% and 63% can be achieved through implementation of the BMP program in the Maricopa County PM_{10} Non-Attainment Area. The results of this analysis are documented in a technical support document that is currently undergoing public review.[1]

INTRODUCTION

On June 10, 1996, the U.S. EPA designated a portion of Maricopa County, Arizona, as a serious non-attainment area for PM_{10}. The Maricopa County PM_{10} Non-Attainment Area comprises approximately 2,880 square miles of Maricopa County. Some of the previously unregulated sources that need to be addressed in future control plans for PM_{10} include unpaved roads, unpaved parking lots, vacant lots, and agricultural sources. In two previous studies, the ADEQ examined the sources contributing to exceedances of the 24-hour PM_{10} National Ambient Air Quality Standard (NAAQS).[2,3] ADEQ's analyses included examination of monitoring data, estimation of emissions based on microscale field studies, and modeling of a design day of April 9, 1995.[2,3]

In a follow-on study that began in June, 2000, ADEQ assessed the emissions from agricultural practices and the impacts of agricultural BMPs for the Maricopa County PM_{10} Non-Attainment Area.[1] The focus was on agricultural emissions and implementation of BMPs for the April 1995 design day. The following agricultural emission sources were examined:

- Tillage and harvest: Any mechanical practice that disturbs cropland or crops on a commercial farm.
- Non-cropland: Any commercial farm land that is no longer used for agricultural production or areas that include private farm roads, ditch banks, equipment yards, storage yards, or well heads.
- Cropland: Land on a commercial farm that is producing or is planned for crop production.

The BMPs, determined through extensive work by ADEQ, the Governor's Agricultural BMP Committee, and other stakeholders, are summarized in Table 1.

ANALYSIS OF AGRICULTURAL BEST MANAGEMENT PRACTICES

In an effort to address agriculture's contribution to PM_{10} non-attainment in Maricopa County, the Governor's Agricultural Best Management Practices Committee was created by law in 1998 (Arizona Revised Statutes [A.R.S.] §49-457). The Committee identified BMPs that focus on feasible, effective, and common sense practices while minimizing negative impacts on local agriculture.[4]

Determination of Best Management Practices Impacts

The Arizona Administrative Register (A.A.R), Title 18, Chapter 2, §609-611 contains the rulemaking for the "Agricultural PM_{10} General Permit." The General Permit requires that any agricultural operation greater than 10 contiguous acres and located within the Maricopa County PM_{10} Non-Attainment Area must implement at least one BMP from each of the following categories: Tillage and Harvest, Non-Cropland, and Cropland. (The rule is not applicable to farms located on tribal lands.) Virtually all of the cropland in Maricopa County in production during 1995 was on farms greater than 10 acres.[5]

In order to quantify the emission reductions achievable from implementation of the General Permit, the following steps were followed:

1) The applicability of each BMP to each major crop grown in Maricopa County (i.e., cotton, wheat, barley, corn, alfalfa and other hay, vegetables, and citrus) was determined.
2) The BMPs were ranked based on the likelihood that they would be implemented by a farmer.
3) Control efficiencies (i.e., percentage reduction achievable) were determined through a literature search and by independent calculations, as necessary.

4) An implementation scenario was developed based on the BMPs most likely to be implemented.

Applicability of BMPs by Crop Type

The applicability of the BMPs by crop type was identified by the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS).[6] Some factors impacting BMP applicability include technical feasibility and crop switching (e.g., a farmer switching between cotton and small grain might employ different BMPs in different years).

Ranking of BMPs

Members of the agricultural community were asked to rank each BMP within each category on a scale from 1 to 10 from most-likely to least-likely to be implemented. Some factors impacting the likelihood of implementation are economic feasibility and the ability to achieve the greatest amount of PM_{10} reduction. Also, an important factor that would impact a farmer's decision to implement specific BMPs is whether or not they own their land. A farmer who leases land is less likely to implement a permanent BMP, such as artificial wind barriers, than a farmer who owns land. The potential significance of this factor is demonstrated by the fact that in 1997, approximately 70% of farmland acreage in Maricopa County was operated by a part owner or tenant, versus approximately 30% of land that was operated by an owner.[6]

Control Efficiency Determination

Relevant documents obtained from ADEQ, NRCS, and other sources (e.g., U.S. EPA guidance documents) were reviewed and control efficiencies applicable to the subject BMPs were recorded. When no control efficiency information could be found in the literature for the BMPs with a ranking of "1" (most likely to be implemented), additional research and/or calculations were performed in order to quantify a control efficiency, or range of control efficiency, of the specific BMP. An exception to this is that no data were found in the literature pertaining to control efficiency for two BMPs ranked "1": chemical irrigation and manure application; thus, these BMPs could not be included in the implementation scenario described below.

Implementation Scenario

The implementation scenario establishes a basis for estimating the emission reductions expected to be achieved through compliance with the General Permit. Since a farmer can select from a list of BMPs for each category, it cannot be determined with certainty which specific BMPs will actually be implemented. However, knowing the most likely BMPs to be implemented (i.e., ranked "1") and the control efficiency or range of control efficiencies associated with each of those BMPs, the percentage of emission reduction can be estimated.

Table 2 summarizes the implementation scenario selected for this analysis that includes all the BMPs having a ranking of "1" for which a control efficiency can be determined. The implementation scenario assumes that any farmer will implement only one BMP from each category. The net control efficiencies are the product of the (maximum, minimum, or mid-point) control efficiencies, the compliance factor, and the relevancy factor for each BMP by crop type. (Note that Table 2 shows the mid-point net control efficiency.) These net control efficiencies are used in the calculation of projected emissions for 2006 and the overall emissions reductions.

The assumed compliance factor for each BMP is 80% (i.e., the product of the U.S. EPA default compliance rate of 80% and the estimated percentage of cropland within the non-attainment area that is on farms at least 10 acres in size [99.8%]). Relevancy factors are the estimate of the percentage of all farmers (or acreage), by crop, who are expected to implement a given BMP. For example, it is assumed that emissions attributable to tillage of cotton acreage will be controlled by "Combining Tractor Operations" (23%), "Limited Activity During High Wind Events" (47%), and "Multi-Year Crops" (30%). These estimates were determined by first estimating the relevancy of the multi-year crop BMP. Based on information provided by Maricopa County farmers, and analysis of crop data statistics, it was determined that the cotton, wheat, barley, and corn acreage in Maricopa County decreased by an annual rate of approximately 8% between 1995 and 1999.[7] Furthermore, it was determined that this decrease was attributable to land going out of production (approximately 4% per year), switching to alfalfa (approximately 3% per year), and other factors.

Based on this trend, the "relevancy" of the multi-year crop BMP (i.e., replacing cotton, wheat, barley, and corn with 3-5 year alfalfa) was estimated as 30% for the period 1995 to 2006. Since the relevancy of the other applicable BMPs would total 70% (i.e., 100% minus 30%), and "Limited Tilling on During High Wind Events" is twice as likely to be implemented than "Combining Tractor Operations," the relevancy of these two BMPs would be 23% and 47%, respectively.

AGRICULTURAL EMISSIONS FOR 1995

The basis for quantifying the impacts of the agricultural BMPs is a baseline PM_{10} emissions inventory of agricultural farmland and related activities. Since the BMPs are aimed primarily at addressing violations of the 24-hour PM_{10} NAAQS, it was necessary to estimate emissions on a daily basis. The specific design-day selected for this analysis was April 9, 1995. This design-day is consistent with days selected for analysis in ADEQ's Microscale Study and the Maricopa Association of Governments (MAG's) SIP and related documents.[2,3,8]

Emissions Estimation Methodology

For purposes of using existing emission estimation techniques (EETs), the agricultural emission categories were subdivided into the following separate emission-generating activities:

- Tillage;
- Harvest;
- Wind erosion of cropland;
- Wind erosion of non-cropland (e.g., agricultural aprons and unpaved roads); and
- Travel on unpaved agricultural roads.

Since the data used in application of these EETs were available only at the county-level for Maricopa County, it was necessary to adjust the EET equations for the fraction of Maricopa County farmland that lies within the PM_{10} non-attainment area. This factor, "F", was determined to be 0.6276.[8,9]

<u>Tillage</u>

Tillage emissions for the 1995 design-day were estimated using the tillage emission factor equation in Section 9.1 of AP-42.[10] An average soil silt content for agricultural land in Maricopa County was determined based on soil texture data that were obtained from the Soil Survey Geographic (SSURGO) Database located on the NRCS website (http://www.tw.nrcs.usda.gov). Only SSURGO tables for central Maricopa County were used. The associated acreage was obtained from the comp table and the soil texture for each portion was obtained from the layer table. Only the first layer of soil data was used in this calculation.

Using the soil texture triangle and recommendations of NRCS staff, relevant silt contents were assigned by the soil texture classification. For example, if the soil texture was equal to “SL” (for sandy loam), a silt content of 30% was assigned.[11] Finally, an average soil silt content of 35.2% for agricultural land was calculated based on the proportion of land with a given soil silt content. This value is considerably higher than the EPA default value of 18% which was used in the ADEQ Microscale Study.[2,3]

Tillage emissions were then estimated by multiplying the calculated emission factor by the total number of crop-specific acre-passes related to tilling activities. The annual number of tillage acre-passes per acre by crop type was obtained from the University of Arizona Cooperative Extension.[12] The crop-specific number of tilled acres in 1995 was obtained from Arizona Agricultural Statistics Report.[7] Daily emissions were estimated by crop type using estimates of tillage days per year.[12] The crop- and activity-specific periods were used to determine the fraction of tilling activity occurring on the April 9 design day.

The tilling activity over a given period was assumed to follow a normal distribution with activity levels peaking towards the middle of the period. Following this normal distribution, a tilling period can be divided into 5 segments: (i.e., 17%, 11%, 44%, 11%, and 17%) where each segment represents a percentage of the number of days in the period. The percentage of tilling activity occurring during each segment was assumed to be 10%, 20%, 40%, 20%, and 10%, respectively.[12] Once the activity bins were determined, then the bin containing the April 9 design day was used to calculate the fraction of tilling activity on that day. The tilling activity on April 9 was calculated to be 1% of the total tilling activities.

Next, crop-specific periods of activity were used to determine the fractional activity on April 9. It should be noted that of the most frequently planted crops, only tillage of alfalfa was determined not to have occurred on the design day of April 9, 1995. Tilling activity for fall crops (e.g., fall lettuce, cantaloupe, and honeydew melons) were also assumed to be zero.

Harvest

Harvest emissions were estimated using crop-specific emission factors for cotton[13], and wheat and barley.[10] Emission factors are only available for these three crops grown in Maricopa County. As with the tillage EET, the number of harvested acres by crop was obtained from the Arizona Agricultural Statistics Report.[7] To convert the annual emissions to daily emissions, estimates of the number of harvest days per year for cotton, wheat, and barley were also obtained from the Agricultural Statistics Report.[7] However, based on this report, none of the three crops covered in this emission inventory were harvested in April. Therefore, the design-day PM_{10} emissions from crop harvesting were set equal to zero.

Wind Erosion

Wind erosion emissions were estimated for three different classes of agricultural land: cropland, non-cropland/unpaved roads, and non-cropland/other areas. The most commonly used wind erosion emission factor equation is based on a modified version of the soil erodibility equation developed by the U.S. Department of Agriculture and is in the following form:[14]

Equation (1) $EF = 0.0125 \times I \times C \times K \times LN \times VN$

where

EF = PM_{10} emission factor (tons/acre/year);
0.0125 = fraction of suspended particles that are PM_{10};

I	=	soil erodibility (tons/acre/year);
C	=	climatic factor (unitless);
K	=	surface roughness factor (unitless);
LN	=	unsheltered field width factor (unitless); and
VN	=	vegetative cover factor (unitless).

Similar to the method used to determine soil silt content, the erodibility were obtained from the layer table of the SSURGO database. An average soil erodibility was then calculated based on the portion of area associated with individual erodibility factors. As before, only central Maricopa County tables were used in this evaluation. The average erodibility factor obtained in this fashion was 65.4 tons/acre/year which compares favorably with the value of 63.6 tons/acre/year used in the ADEQ Microscale Study.[2,3]

An annual climatic factor ("C") accounts for the effect of wind speed and soil moisture (precipitation and temperature) on wind erosion. An annual climatic factor of 0.318 was adapted from the Revised MAG 1999 Serious Area PM_{10} Plan.[8] Other studies have indicated that the climatic factor can be lowered by as much as 30% if the effects of soil cloddiness (from irrigation) and the actual amount and frequency of irrigation are taken into account.[13,15] Therefore, a more thorough investigation of irrigation effects on the climatic factor is advisable in future versions of the agricultural PM_{10} emissions inventory. Nevertheless, a climatic factor of 0.318 was considered conservatively acceptable for this agricultural PM_{10} emissions inventory.

For calculating PM_{10} emissions caused by wind erosion of cropland, the surface roughness factor, K, accounts for the resistance of wind blowing over ridges, furrows, or large clods in a field, and is influenced by crop type. Crop-specific values for K, LN, and VN were obtained from U.S. EPA guidance.[14]

For calculating PM_{10} emissions caused by wind erosion of unpaved agricultural roads, the values of K = 1, LN = 0.32, and VN = 1 were used.[13] The values for VN and K, respectively, reflect the lack of vegetative cover and the absence of ridges and furrows expected on unpaved roads. Although the wind angle on roads varies constantly, it is reasonable to assume that over the long term, wind direction is equally distributed for all roads. With this assumption, the value of LN becomes only a function of the product $I \times K$ (= $65.4 \times 1 = 65.4$) and is equal to 0.32.[14] Non-cropland agricultural aprons are areas of farmland that are no longer suitable, or not intended for, growing crops. These areas could include staging and turn-around areas. The same values of K = 1, LN = 0.32, and VN = 1 were therefore used for these other non-cropland areas.

After the emission factor was calculated, annual PM_{10} emissions were estimated for each of the subject areas by multiplying the wind erosion emission factor times the number of acres of cropland or non-cropland (acres). The acres were determined as follows:

- Cropland: From the Arizona Agricultural Statistics Report.[7]
- Non-cropland: From surveys of selected farmers as a fraction of cropland areas.[16] The survey results indicated that non-cropland areas as a fraction of cropland areas for cotton, wheat, and alfalfa crops were 0.02, 0.008, and 0.002, respectively. The surveys did not include information on any other crops. Consequently, the value of 0.008 for wheat was also used as a representative value for the remaining crops. The unpaved road areas around cotton, wheat, and alfalfa fields were reportedly 1500, 1200, and 1800 square feet per acre of farm, respectively. The value of 1200 square foot per acre for wheat was again used as a representative value for all remaining crops.

The same methodology used in the development of the Revised MAG 1999 Serious Area PM_{10} Plan[8] was used to calculate the PM_{10} emissions from wind erosion on the April 9 design day. The underlying assumption used in this methodology is that wind erosion is caused when wind speeds in excess of 15 miles per hour (mph) are prevailing. In 1995, there were a total of 37 hours with a wind speed greater than 15 mph. Therefore, the average hourly emission rate was calculated by dividing the annual emissions by 37. Then, to calculate the emissions for the design day, the hourly emission rate was multiplied by 7, the number of hours with wind speed greater than 15 mph on April 9.

Travel on Unpaved Agricultural Roads

Re-entrained dust emissions from unpaved agricultural roads for the 1995 design-day were estimated using the emission factor equation located in Section 13.2.2 of AP-42.[10] Emissions were estimated based on activity data obtained for three different types of vehicles: pick-up trucks, heavy-duty trucks, and tractors.

A default soil silt content of 12% was used.[10] This value is based on calculating the mean silt content for dirt roads, with silt contents varying between 1.6% and 67%. A limited survey of Maricopa County farmers was conducted with the assistance of the Maricopa County Farm Bureau in order to determine farm vehicle activity data (i.e., mean vehicle speeds, vehicle weights, and number of wheels), and unpaved road parameters (frequency and distance of travel and size of typical unpaved areas).[16] The mean values for S, W, and w were calculated for both the maximum and average number of vehicle miles traveled (VMT) by each vehicle type. The parameter values estimated based on maximum VMT were used to calculate emissions for crops harvested in April, whereas the parameters estimated based on average VMT were used to calculate emissions for the remaining crops.

Daily re-entrained unpaved road dust emissions were then estimated by combining the calculated emission factor with VMT estimates for agricultural roads.

Results

The 1995 design-day emissions estimates for agricultural sources are summarized in Table 3. These results show that cropland wind erosion was the most significant source of agricultural PM_{10} emissions on the April 1995 design day with 3,042,794 lbs (87.8% of the total). Non-cropland wind erosion was the next largest contributor to overall agricultural emissions with 325,895 lbs (9.4% of the total), comprising wind erosion of unpaved roads (203,886 lbs) and wind erosion of other areas (122,009 lbs). The remaining 2.8% of PM_{10} emissions are caused by tillage activities and dust re-entrainment on unpaved roads. These estimates are reasonable, especially considering the limited activity data that were available to calculate the emissions. More accurate estimates can be obtained if more accurate and detailed activity data are obtained through additional survey efforts.

AGRICULTURAL EMISSIONS FOR 2006

Understanding and estimating the impact on daily PM_{10} emissions is the overall objective of this TSD. Using data collected through the literature search, and through discussions with experts in Maricopa County, a control scenario was developed along with estimates of control efficiencies for each BMP comprising the scenario. These BMPs were then applied to the 1995 emissions to estimate the overall emission reductions expected through compliance with the Agricultural PM_{10} General Permit by 2006.

Emissions Estimation Methodology

The methodology for projecting the 1995 design-day emissions to the year 2006 involved three steps:

1) The net control efficiency range (i.e., minimum, maximum, mid-point) expected from implementation of each BMP by crop was determined. (See Table 2 for a summary of the mid-point net control efficiencies).
2) The percentage of agricultural land going out of production by 2006 was determined to be approximately 37% (i.e., the corresponding land use factor is 0.6265) based on information obtained from MAG.[9]
3) The mid-point net control efficiency for each BMP by crop, and the percentage of land going out of production by 2006 were applied to the design-day estimates to estimate year 2006 emissions.

Results

The 2006 projected emissions estimates for agricultural sources are summarized in Table 4. As the table shows, cropland wind erosion is the most significant source of PM_{10} emissions on a daily basis for 2006 (81.9% of the total). Wind erosion of non-cropland is the next most significant source (14.8% of the total).

CONCLUSIONS

Table 5 summarizes the emission reductions expected through compliance with the General Permit. The total reduction was calculated by adding the reduction expected from agricultural lands going out of production (i.e., approximately 37% of the daily emissions) to the range of BMP reductions. The range of BMP reductions were estimated by applying the BMP net control efficiencies (i.e., minimum, maximum, and mid-point) to the daily emissions for the crops subject to that BMP (minus the 37% reduction attributable to land going out of production). An overall emission reduction of 60.3% from the 1995 design-day emission is predicted based upon the mid-point BMP reduction.

Some significant issues and assumptions that influenced the 1995, 2006 emissions estimates, and 2006 emission reduction estimates are as follows:

- Tillage emissions are significantly influenced by the estimates of number of days of tilling. The estimate of tilling days by crop was based on detailed information provided by the University of Arizona Cooperative Extension and the Arizona Agricultural Statistics Report are believed to result in the most accurate estimate of tilling emissions available.[7,12]
- Very limited survey data were used to estimate the activity data for input into the unpaved road re-entrainment emissions and wind erosion from non-cropland emissions equations.
- The wind erosion estimates developed using U.S. EPA’s equation do not consider the effects of soil irrigation and resulting “cloddiness” as a deterrent to wind erosion. Based on recent research by ARB, this approach can overestimate the climatic factor, and thus the emissions, by as much as 30%.[15]
- The implementation scenario includes a set of BMPs that were selected based on their likelihood for implementation. Actual reductions may be more or less than those quantified on Table 5.

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Table 1. Summary of agricultural best management practices for the Maricopa County PM_{10} Non-Attainment Area.

Tillage and Harvest	Non-Cropland	Cropland
Chemical irrigation	Access restriction	Artificial wind barrier
Combining tractor operations	Aggregate cover	Cover crop
Equipment modification	Artificial wind barrier	Cross-wind ridges
Limited activity during a high wind event	Critical area planting	Cross-wind strip-cropping
Multi-year crop	Manure application	Cross-wind vegetative strips
Planting based on soil moisture	Reduced vehicle speed	Manure application
Reduced harvest activity	Synthetic particulate suppressant	Mulching
Reduced tillage system	Track-out control system	Multi-year crop
Tillage based on soil moisture	Tree, shrub, or windbreak planting	Permanent cover
Timing of tillage operation	Watering	Planting based on soil moisture
		Residue management
		Sequential cropping
		Surface roughening
		Tree, shrub, or windbreak planting

Table 2. Scenario for implementation of the agricultural PM_{10} general permit in the Maricopa County PM_{10} Non-Attainment Area.

Summary		Net Control Efficiency by Applicable Crop (%)						
Category	**BMP**	**Cotton**	**Wheat**	**Barley**	**Corn**	**Alfalfa/Hay**	**Vegetables**	**Citrus**
Tillage	Combining Tractor Operations	7.9	7.9	7.9	7.9	N/A	11.2	11.2
	Limited Activity During High-Wind Events	9.3	9.3	9.3	9.3	20.0	13.2	13.2
	Multi-Year Crops	15.8	15.8	15.8	15.8	N/A		
Harvest	Combining Tractor Operations	17.0	33.9	33.9	33.9	N/A	33.9	33.9
	Reduced Harvest Activity	20.0	N/A			39.9	N/A	
Non-Cropland	Access Restriction	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Reduced Vehicle Speed	16.8	16.8	16.8	16.8	16.8	16.8	16.8
Cropland	Multi-Year Crops	23.9	23.9	23.9	23.9	N/A		
	Residue Management	12.2	18.3	18.3	12.2			
	Timing of Tilling Operations	10.2	15.4	15.4	10.2			
	Planting Based on Soil Moisture	5.6	N/A		5.6			

N/A= Not applicable.

Table 3. Results of 1995 design-day emissions estimates of agricultural sources.

Category	Activity	Design-Day Emissions (lbs/day)	Percentage of Total
Tillage and Harvest	Tillage	54,667	1.6%
	Harvest	0	0%
Non-Cropland	Wind Erosion	325,895	9.4%
	Unpaved Road Travel	41,561	1.2%
Cropland	Wind Erosion	3,042,794	87.8%
Total		**3,464,917**	**100.0%**

Table 4. Results of 2006 design-day projected emissions estimates of agricultural sources.

Category	Activity	Projected Emissions (lbs/day)	Percentage of Total
Tillage and Harvest	Tillage	23,467	1.7%
	Harvest	0	0.0%
Non-Cropland	Wind Erosion	204,186	14.8%
	Travel on Unpaved Roads	21,528	1.6%
Cropland	Wind Erosion	1,126,101	81.9%
Total		**1,375,282**	**100.0%**

Table 5. Summary of design-day emission reductions achievable through compliance with the agricultural PM_{10} general permit.

Category	Activity	Total Design-Day Emissions (lbs/day)	Land Use Reduction[a] (lbs/day)	BMP Implementation Scenario: BMP	BMP Implementation Scenario: BMP Reduction[b]	Total Reduction[c] (lbs/day)
Tillage and Harvest	Tillage	54,667	20,416	Combining Tractor Operations	2,910	31,200
				Limited Activity During High-Wind vents	3,423	
				Multi-Year Crops	4,450	
	Harvest	0	0	Combining Tractor Operations	0	0
				Reduced Harvest Activity		
Non-Cropland	Unpaved Road Travel	41,561	15,521	Access Restriction	156	20,034
				Reduced Vehicle Speed	4,357	
	Wind Erosion	325,895	121,709	N/A[d]		121,709
Cropland	Wind Erosion	3,042,794	1,136,362	Multi-Year Crops	359,556	1,916,693
				Residue Management	183,068	
				Timing of Tilling Operations	153,810	
				Planting Based on Soil Moisture	83,897	
Total		**3,464,917**	**1,294,008**		**795,627**	**2,089,636**

Notes:

[a] Land Use Reduction = (design-day emissions) × (1 - land use factor of 0.62654).
[b] BMP Reduction = (design-day emissions for BMP-applicable crops) × (land use factor of 0.62654) × (net control efficiency).
[c] Total Reduction = (Land Use Reduction) + (BMP Reduction).
[d] No BMPs applicable to non-cropland wind erosion were included in the implementation scenario.

N/A= Not applicable.

KEYWORDS

Agricultural Sources
Best Management Practices
PM
Emission Inventory