Table 6-6. SO_2 emission factors for marine engines.

Engine Type	Fuel Sulfur Content	SO^2 (g/kW-hr)
Category 1		
<1000 hp	0.25%	1.29
>1000 hp	0.25%	1.25
Category 2 and 3		
Medium speed	0.25%/2.70%[a]	1.25/13.46[a]
Slow speed	2.70%	12.5

[a] The first value is for marine diesel oil, which is used in Category 2 engines, and the second value is for residual oil, which is used in Category 3 engines.

These emission factors can also be converted to fuel-based factors by dividing them by the fuel consumption rate for a given engine type. For example, the SO_2 emission factor for slow-speed Category 3 engines can be converted to a fuel basis as follows:

Fuel-based emission rate = (12.5 g/kW-hr / 195 g/kW-hr) * 1000 g/kg = 64.1 g/kg of fuel **(6-2)**

6.3.2 Acquisition of Activity Data

Emissions estimates were based primarily on bottom-up fuel usage data for inland river systems in the CENRAP region derived from the Tennessee Valley Authority (TVA) Barge Costing Model. This model was developed to estimate fuel usage by inland river segment for fuel tax purposes.[6] Inputs to the model include engine horsepower and trip characteristics for each vessel that travels on a given waterway segment in a given year. These data are used to estimate fuel consumption for each significant inland waterway segment in the United States.[7] The model uses these data to estimate total fuel consumption, total cargo transported, and average vessel horsepower by waterway segment. Each year, fuel consumption estimates are compared to actual tax receipts, and model errors have averaged only 1.5% per year since 1996.

For the GIWW, however, the TVA model does not provide a complete picture of fuel consumption, as "deep-draft" (oceangoing), harbor tugs, and other vessels not bound for an inland river system are not considered. For these vessels, emission estimates were prepared with work-based emission factors and the following types of activity data (U.S. Environmental Protection Agency, 1999a):

- The number of total trips to and from each port
- The total number of trips passing (but not stopping at) each port

[6] Some "segments" consist of an entire river, such as the Atchafalaya River in Louisiana. Longer rivers, such as the Mississippi, are broken up into multiple segments.
[7] The small rivers and tributaries not considered by the model account for only 1-3% of the total tonnage moved over inland waterways each year (Dager, 2004).

- Vessel characteristics for tugboats and transport ships operating in and through each port
- Speed and time-in-mode data for four operational modes: cruise, slow cruise, maneuvering, and hoteling (or docking)
- Engine load factors for each of the four operational modes listed above

Much of the necessary data on vessel trips can be obtained from the U.S. Army Corps of Engineers (USACE) Waterborne Commerce Statistics Center, which tracks vessel movements and characteristics, as well as barge trips and tonnage. The Maritime Administration of the Department of Transportation also maintains a U.S. waterway database that includes vessel names and ports/waterways visited.

Vessel characteristics, speeds, times-in-mode, and engine load data have been modeled for deep sea, river, and Great Lake ports in the United States in a two-volume report produced by ARCADIS on behalf of the EPA (U.S. Environmental Protection Agency, 1999a, d). These documents provide a detailed analysis of selected ports, as well as a method for extrapolating activity data from these "known" ports to other ports with similar characteristics. Several of the ports chosen for detailed analysis are located within the CENRAP region, including St. Louis, Baton Rouge, New Orleans, Plaquemines, South Louisiana, and Corpus Christi. The techniques described in these reports were used to produce a profile of vessel characteristics and operations for all ports in the CENRAP states. Also, some bottom-up surveys of selected port authorities and/or vessel operators were done to verify the assumptions made in creating these profiles.

6.3.3 Spatial Allocation

Emissions occurring in and around a deep sea or Great Lake port area were assigned to the county in which the port is located. If a port spanned multiple counties, the number of port terminals in each county was used to allocate maneuvering and hoteling emissions, and the length of the port area in each county was used to allocate emissions from cruise mode. Data on port terminals and their waterway locations are available from the USACE (2003a).

However, for inland river systems, fuel consumption must first be disaggregated into "in-port" and "underway" components. To accomplish this, fuel consumption at river ports in the CENRAP states was estimated with fuel-based emission factors described in Section 6.3.1 and port-specific data on vessel trips; and characteristics (as outlined in Section 6.3.2) were obtained from USACE data, EPA guidance documents, and surveys of port authorities. Once in-port fuel consumption was estimated, the values were subtracted from Barge Costing Model fuel consumption estimates for the river segment in question. The remaining fuel consumption was considered "underway" and allocated to counties based on the fraction of a river segment's length passing through each county. These county-level river segment fractions were derived from the GIS-based National Waterway Network database produced by the Bureau of Transportation Statistics (BTS).

6.3.4 Temporal Allocation

Monthly variations in vessel activity and fuel usage are significant (Dager, 2004). These seasonal variations are influenced by climate (the upper Mississippi is closed during winter) and by the types of commodity being moved (grain shipments, for example, primarily occur in April/May and September/October).

Fuel usage estimates produced by the Barge Costing Model are not currently available on a monthly basis. Therefore, monthly activity patterns were determined from the Lock Performance Monitoring System (LPMS) maintained by the USACE. This database provides USACE operators, planners, and managers with information on the use, performance, and characteristics of the USACE's national system of locks. The LPMS consists of data collected at most USACE-owned and/or -operated locks, including the number of vessels and barges locked, dates of lockages, and the type and tonnage of commodity carried (U.S. Army Corps of Engineers, 2003b). Statistics are published monthly for selected key locks, and these monthly data were used to generate a monthly activity profile for each inland river system, as well as the GIWW.

6.3.5 Data Preparation

Deliverables for this source category include the county-level emission estimates in both NIF 3.0 format and the IDA format used by the SMOKE emissions model. The temporal allocation profiles and cross-reference files used by SMOKE were also provided.

6.4 LOCOMOTIVES

Railroads can be separated into three class sizes. Class I railroads operate over a large geographic area, serve many states, and maintain fleets of locomotives that number from several hundred to several thousand. These railroads, while few in number, are responsible for about 93% of the annual fuel consumption of all railroads nationwide (U.S. Environmental Protection Agency, 1998d). Class II (or regional) railroads serve only a few states and typically operate about 30 to 200 locomotives. Class III (or local) railroads usually serve only one state and operate only a handful of locomotives. Locomotives in each of these classifications can be used for two types of operation: line haul and yard (or switching) activities. Line haul locomotives generally travel long distances, whereas yard locomotives only move railcars within a local railway yard. Some local railroads do not operate any line haul locomotives, but only provide switching services to other railroads. These "Switching and Terminal" railroads were treated as a fourth classification for emission estimation purposes.

Table 6-7 shows the total number of railroads operating in the entire CENRAP region by class (Association of American Railroads, 2004). Using the emission factors and activity data described in the following sections, emissions were estimated for all line haul and yard locomotives operated by one of these railroads.

Table 6-7. Railroads operating in the CENRAP region by class.

Railroad Class	Number of Railroads	Railroad Names
Class I	8	Amtrak Burlington Northern & Sante Fe Kansas City Southern Union Pacific Norfolk Southern CSX Transportation Canadian National Canadian Pacific/Soo Line
Class II	14	Chicago, Central & Pacific Dakota, Minnesota & Eastern Duluth, Missabe & Iron Range I & M Rail Link Iowa Interstate Kansas City & Oklahoma Kyle Missouri & Northern Arkansas Nebraska, Kansas & Colorado Northern Plains Red River Valley & Western South Kansas & Oklahoma Texas Mexican Texas Pacifico
Class III	80	Numerous
Switching & Terminal	33	Numerous

6.4.1 Emission Factors

Emissions from locomotives are calculated based on fuel consumption. The EPA has estimated average emissions rates for locomotives as grams of pollutant emitted per gallon of fuel consumed (g/gal) (U.S. Environmental Protection Agency, 1997). These emission factors vary by the age of the locomotive, as three separate sets of emissions standards have been adopted by the EPA (see **Table 6-8**).

Table 6-8. Locomotive emission factors by model year.

Locomotive Type	Model Year	Controls	Emission factors (g/gal)			
			HC	CO	NO^x	PM
Line haul	<1973	Uncontrolled	10	26.6	270	6.7
	1973-2001	Tier 0	10	26.6	178	6.7
	2002-2004	Tier 1	9.8	26.6	139	6.7
	>2004	Tier 2	5.4	26.6	103	3.6
Switch	<1973	Uncontrolled	21	38.1	362	9.2
	1973-2001	Tier 0	21	38.1	262	9.2
	2002-2004	Tier 1	21	38.1	202	9.2
	>2004	Tier 2	11	38.1	152	4.3

For Class I railroads, weighted emission factors were calculated based on locomotive fleet age distribution data available from the Bureau of Transportation Statistics (Bureau of Transportation Statistics, 2003a). The latest BTS locomotive fleet information indicates that 14% of Class I locomotives were built prior to 1973 and 86% were built from 1973 to 2001 (and are, therefore, subject to Tier 1 controls). At the time of data acquisition, no information was available on the number of locomotives built in 2002 that have entered the fleet; so for purposes of the 2002 inventory, it was assumed that the impact of Tier 1 controls is negligible. The weighted emission factors shown in **Table 6-9** were calculated based on the BTS fractions listed above.[8]

Table 6-9. Weighted emission factors for Class I locomotives.

Locomotive Type	Emission factors (g/gal)			
	HC	CO	NO_x	PM
Line haul	10	26.6	191	6.7
Switch	21	38.1	273	9.2

For Class II, Class III, and switching railroads, no specific information on fleet age distributions is readily available, and since these railroads use only about 5% of the fuel consumed by all railroads nationwide (U.S. Environmental Protection Agency, 1998d), a simple, conservative approach was applied. Because it is known that these smaller railroads tend to have an older fleet mix than Class I railroads (U.S. Environmental Protection Agency, 1992), uncontrolled emission factors were applied to all Class I, Class II, and switching railroads.

[8] For purposes of this calculation, it was assumed that fuel usage per locomotive does not vary with age, either due to fuel economy changes or the reduced usage of older locomotives.

6.4.2 Acquisition of Activity Data

Class I Railroads

Class I line haul locomotives, which operate over large geographic regions, do not burn all their fuel in the same area where the fuel was pumped. Therefore, total annual fuel consumption for each Class I railroad must be estimated at the state (or county) level in order to determine the amount of fuel consumed within the inventory area. Such estimates were made by calculating a system-wide fuel consumption index (expressed in gross ton-miles[9] per gallon or GTM/gal) for each railroad and applying that index to state-level traffic density data (U.S. Environmental Protection Agency, 1992). As a quality assurance check, Class I railroads were contacted individually to see if they track state or county-level fuel consumption data that could be compared to the estimated values.

The data needed to calculate a fuel consumption index can be obtained from the "R-1" reports all Class I railroads are required to file with the Surface Transportation Board (STB) each year. Schedule 755 of this report lists the annual traffic density in gross ton-miles for a given railroad, and Schedule 750 lists the total fuel consumption for line haul operations and switching operations. Copies of these schedules for all Class I railroads were obtained from the STB, and **Table 6-10** lists the 2002 traffic density and fuel consumption data for each Class I railroad operating in the CENRAP region.

Table 6-10. 2002 system-wide activity data for Class I railroads.

Railroad Name	Traffic Density (1000 ton-miles)	Fuel Consumption (gal)	
		Line Haul	Switching
Amtrak[a]	N/A	75,000,000	N/A
Burlington Northern and Sante Fe	958,862,994	1,091,248,247	57,434,118
Kansas City Southern	37,563,933	51,256,604	4,057,180
Union Pacific	1,085,700,525	1,176,963,998	137,902,327
Norfolk Southern	373,281,203	433,678,710	38,810,939
CSX Transportation	469,392,729	514,107,567	56,172,596
Canadian National	104,578,305	108,013,647	15,135,382
Canadian Pacific/Soo Line	45,426,616	42,198,000	3,060,000

[a] Amtrak does not file reports with the STB, so fuel consumption data for that railroad was obtained from the BTS (2003b).

Using these data, a fuel consumption index for each railroad was calculated by dividing the system-wide traffic density by the system-wide fuel usage. For example, the fuel consumption index for the Burlington Northern & Sante Fe (BNSF) railroad was calculated as follows:

$$FCI_{BNSF} = 958{,}862{,}994 \times 10^3 \text{ ton-miles} / 1{,}091{,}248{,}247 \text{ gal} = 878.7 \text{ ton-miles/gal} \qquad \textbf{(6-3)}$$

[9] Gross ton-miles include the weight of locomotives, freight cars, etc. rather than the weight of freight only.

State-level traffic density data were obtained from the Federal Railroad Administration (FRA), as Class I railroads are only required to report their traffic density to the STB on an aggregate (or national) basis. The FRA has a rail network model which is used to estimate traffic flows on specific rail lines, and the agency provided state-level traffic density data for all Class I railroads (Kedar, 2004). These data can be used in conjunction with the fuel consumption index calculations described above to estimate fuel usage by state for each Class I railroad. For example, FRA data show that the 2002 gross traffic density for the BNSF Railroad in Arkansas was 8090.66 million ton-miles. Fuel usage for this railroad in Arkansas can then be calculated as follows:

$$\text{Fuel Consumption} = 8090.66 \times 10^6 \text{ ton-miles} / 878.7 \text{ ton-miles/gal} = 9{,}207{,}696 \text{ gal} \qquad \textbf{(6-4)}$$

Class I switching emissions were also calculated based on fuel usage data gathered from Class I railroads or taken from R-1 reports. These data were disaggregated to the state level using procedures similar to those outlined above, with a fuel consumption index generated for each railroad by dividing the railroad's system-wide traffic density by the system-wide fuel usage for switching operations.

Class II and Class III Railroads

Emissions from Class II and III locomotives were calculated based on the amount of fuel consumed in the inventory area. However, these smaller railroad companies are not required to file R-1 reports with the STB, so the only source of fuel consumption information is the railroads themselves. Because there are only 14 Class II (regional) railroads operating in the CENRAP states, each one was surveyed to determine fuel usage by state. In cases where Class II railroads are unable or unwilling to provide data, an average fuel consumption index was calculated for railroads that did supply information and extrapolated to railroads with missing data. This fuel consumption index was based on the total miles of track operated by a railroad and the total carloads of freight transported each year—information gathered through annual surveys conducted by the Association of American Railroads (AAR).

A similar approach was used for Class III railroads. Surveying each of the 80 local railroads in the CENRAP states individually was not feasible within the scope of this project, so a sample of such railroads was contacted in each state. Again, a fuel consumption index was calculated from available data and used to estimate fuel usage for railroads that were not surveyed.

Switching and Terminal Railroads

For yard (or switching) locomotives, the EPA recommends an emission estimation method based on the number of yard locomotives operating within an inventory area. The EPA estimates that the average yard locomotive operates 24 hours per day, 365 days per year, and consumes 228 gallons of diesel fuel per day (U.S. Environmental Protection Agency, 1992). Yard locomotive emissions can be derived by multiplying the number of yard locomotives within the inventory area by this fuel usage factor and applying the switch locomotive emission factors previously cited. However, these assumptions indicate that the typical yard locomotive consumes over 80,000 gallons of fuel per year, and, while this figure may be appropriate for

busy Class I yard locomotives, it is almost certainly too high for local switching operations.[10] Therefore, fuel usage for switching railroads was calculated in a manner similar to that carried out for other Class III railroads. A sample of switching railroads was contacted to obtain annual fuel usage data, and a fuel consumption index was derived and applied to other railroads. This fuel consumption index was based on the number of yard locomotives and total miles of track operated, as well as the number of carloads of freight handled each year—information available from the AAR.

6.4.3 Spatial Allocation

For Class I railroads, emissions were apportioned to the county level by using the GIS-based National Rail Network produced by BTS. This network contains traffic density data[11] by railway segment and railroad classification, and the network can be overlaid with county boundaries to estimate the fraction of a given state's Class I rail traffic that passes through each county in that state. These fractions were used to disaggregate emissions from the state to the county level. Similarly, state-level emissions from switching operations were assigned to individual counties based on the number of railroad terminals[12] in a given county.

For Class II and III railroads, emission factors for line haul locomotives[13] were applied to statewide fuel usage estimates for Class II and III railroads, and emissions were apportioned to the county level using the Class II and III traffic density data contained in the National Rail Network. For Class III switching operations, emission factors for switching locomotives were applied to fuel usage estimates, and the emissions were apportioned to the county in which each railroad's yard is located.

6.4.4 Temporal Allocation

Movements of freight by rail occur 24 hours per day, 7 days per week, though there are slight variations across the months of the year (Kedar, 2004). The AAR produces an annual report that summarizes weekly carloads of freight shipped in the United States, and these weekly data were used to model monthly variations in locomotive activity (American Association of Railroads, 2003).

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[10] Preliminary data collected for Iowa show that two local switching railroads consume less than 10,000 gallons of diesel fuel per year each.

[11] Each rail segment is assigned to one of seven density groupings (for example, Group 2 represents densities ranging from 5.0 to 9.9 million GTM/mile). The average of each range will be used when apportioning traffic density to the county level.

[12] The BTS National Rail Network contains data on the locations of railroad terminals and junctions in each state.

[13] Class II and III railroads are not as likely as Class I railroads to operate their own switching engines or to track fuel by locomotive type. This assumption was also made by the EPA in a regulatory support document (U.S. Environmental Protection Agency, 1998d).

6.4.5 Quality Assurance

For Class I railroads, fuel consumption estimates by state from the FRA rail network model were cross-checked with other readily available estimates of railroad activity as a quality assurance check. For example, the state-level data published by the AAR list the total tons of freight transported through each state annually (Association of American Railroads, 2004). These data show that freight traffic in Nebraska is significantly higher in than any of the other CENRAP states, which corroborates initial fuel estimates performed for Class I railroads from available STB data.

For Class II and III railroads, survey data gathered in 2001 by the American Shortline and Regional Railroad Association (ASRRA) were used as a quality assurance check. This survey included questions related to fuel consumption; and while confidentiality concerns prevent the release of the actual database, a researcher with ASRRA provided an aggregate estimate of fuel consumed by all Class II and III railroads headquartered in CENRAP states for 2001 (Benson, 2004). This estimate of 50,000,000 gallons matches up very well with the results of the CENRAP inventory.

In addition, the procedures outlined in the project QAPP were followed (Sullivan, 2004).

6.4.6 Data Preparation

Deliverables for this source category include the county-level emission estimates in both NIF 3.0 format and the IDA format used by the SMOKE emissions model. The temporal allocation profiles and cross-reference files used by SMOKE were also provided.

7. METHODS TO ESTIMATE EMISSIONS FOR SOURCES OF AGRICULTURAL FUGITIVE DUST

Agricultural operations, such as crop tilling, crop harvesting, or confined animal feeding operations (CAFOs), release emissions of geologic fugitive dust. This section describes the information sources and methods used to calculate county-level emissions of agricultural fugitive dust for the CENRAP region for calendar year 2002.

7.1 PRIORITIZATION

Emissions estimation methodologies and existing emission inventories for the CENRAP region and for other regions of the country were reviewed. The EPA's 1999 NEI includes particulate matter (PM) emissions for the CENRAP region for the following agricultural source categories, as illustrated in **Figure 7-1**: tilling, beef cattle feedlots, cotton ginning, and agricultural crop burning (U.S. Environmental Protection Agency, 2004b). The Western Regional Air Partnership (WRAP) projected emissions from the 1999 NEI to estimate 2002 agricultural PM emissions for the WRAP region (E.H. Pechan and Associates, 2004). The WRAP region's inventories indicated that agricultural tilling and beef cattle feedlots were the largest contributors to agricultural fugitive dust, followed by crop transport and cotton ginning, as illustrated in **Figure 7-2**. Other sources of agricultural PM emissions in the WRAP region included harvesting, crop burning, and other combustion sources.

In the NEI and WRAP inventories, agricultural tilling and CAFOs encompass more than 90% of the PM emissions from agricultural sources. Therefore, agricultural tilling and CAFOs were selected for bottom-up treatment. Emissions of PM_{10} and $PM_{2.5}$[14] for these source categories were estimated by acquiring bottom-up activity data and applying emission factors from EPA guidance or other literature. Activity data for agricultural tilling operations were gathered through a survey of county agricultural extension offices (Reid et al., 2004). Facility-specific population estimates for beef cattle feedlots and dairies were prepared previously (Coe and Reid, 2003).

[14] PM_{10} is PM of less than or equal to 10 microns (μm) aerodynamic matter. $PM_{2.5}$ is PM of less than or equal to 2.5 microns (μm) aerodynamic matter

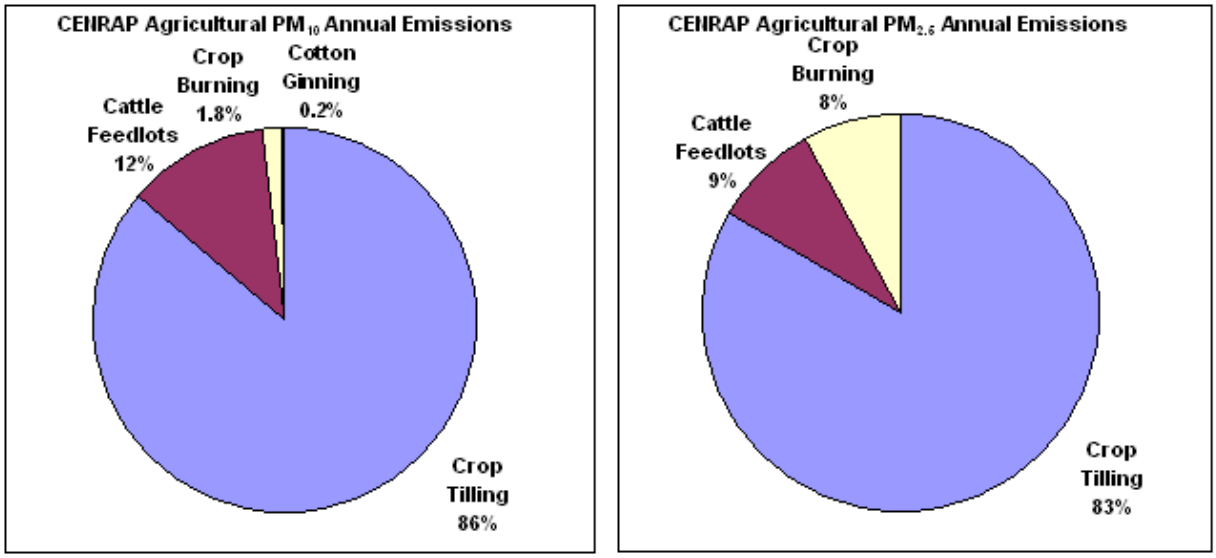

Figure 7-1. 1999 agricultural PM emissions for the CENRAP region.

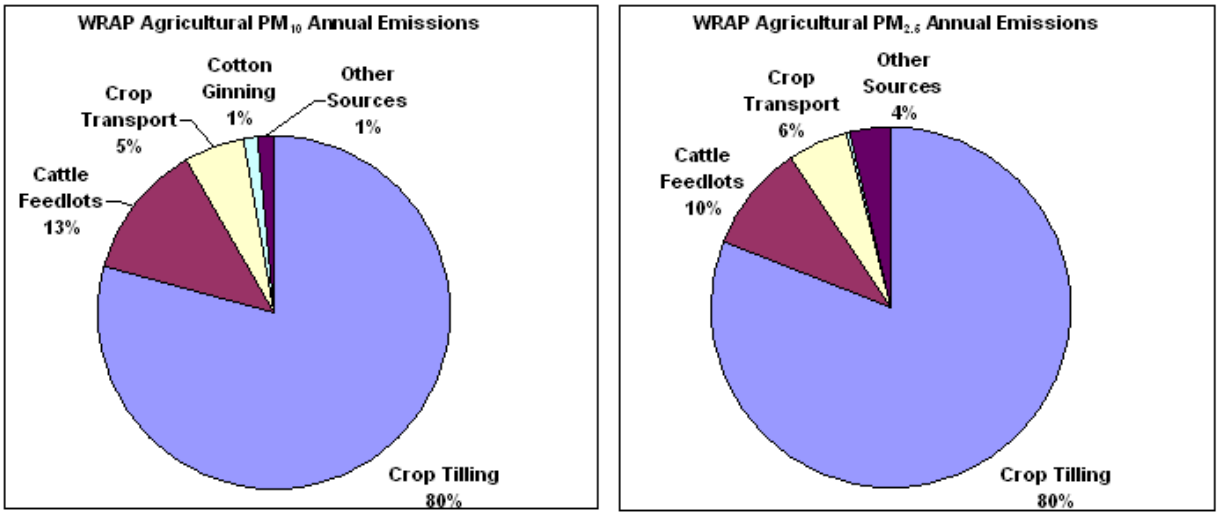

Figure 7-2. Projected 2002 agricultural PM emissions for the WRAP region.

7.2 AGRICULTURAL CROP TILLING

EPA's guidance for estimating PM emissions from agricultural crop tilling involves combining a constant emission factor with county-level activity data, including the silt content of surface soils, the number of tillings performed in a year for each crop type, and the acres of each crop type (U.S. Environmental Protection Agency, 2001, 2004c). For conservational tillage practices, such as no till, mulch till, and ridge till, the number of tillings performed in a year is reduced proportionally according to information provided by the Conservation Information

Technology Center (CTIC) (U.S. Environmental Protection Agency, 2004c; Conservation Technology Information Center, 2004). Emissions from agricultural crop tilling are calculated according to Equation 6-1.

$$E = c \times k \times s^{0.6} \times p \times a \qquad \textbf{(6-1)}$$

E represents the PM emissions in units of pounds per year, and *c* equals the constant emission factor of 4.8 lbs/acre-tilling. A dimensionless particle size multiplier, *k*, is applied to calculate either PM_{10} (k=0.21) or $PM_{2.5}$ (k=0.042). The silt content of the soil, *s*, is defined as the mass fraction of particles smaller than 0.75 µm diameter found in soil to a depth of 10 cm, expressed as a percent. The other activity data include *p*, which represents the number of tillings or passes that are performed in a year for each crop type, and *a*, which represents the acres of land tilled for each crop type. In summary, the methodology requires the following information, at county level, as activity data:

- The number of tillings per year by crop.
- The conservational tilling practices.
- The silt content of soils.
- The acres of land planted by crop type .

The EPA's Emissions Inventory Improvement Program suggests that local data for the number of tillings per year for each crop type and the temporal distribution of tilling activities are desirable (U.S. Environmental Protection Agency, 2004c). A survey of tilling practices was conducted by contacting county agricultural extension offices throughout the CENRAP region (Reid et al., 2004). Questionnaires were designed to elicit information about the types of crops in each respondent's county and the tilling practices for each crop type. The survey results were analyzed and extrapolated for each of the CENRAP states to estimate the number of tillings per year by crop type, the temporal distributions of temporal tilling activities, and the prevalences of conservational tilling practices.

The EPA National Air Pollutant Emission Trends Procedures Document provides a cross-reference table with silt contents for various soil types (U.S. Environmental Protection Agency, 1998b). The State Soil Survey Geographic Database (STATSGO) produced by the Natural Resources Conservation Service of the United States Department of Agriculture was used to determine soil types at the county level (National Resources Conservation Service, 1994). County-level silt contents were determined by using the EPA Procedures Document to cross-reference silt contents with STATSGO soil types.

County-level acreages of grown crops were prepared previously (Reid et al., 2004). These acreages were based on 2002 National Agricultural Statistics Service (NASS) data.

7.3 CATTLE FEEDLOTS AND DAIRIES

The open surfaces of the pens and/or the manure pack are sources of fugitive dust at cattle feedlots and dairies. The major difference between cattle feedlots and dairies is the proportion of time that herds are in contact with the manure pack, which tends to limit fugitive

dust emissions at dairies to levels much lower than those of beef cattle feedlots (Goodrich et al., 2002).

EPA guidance specifies an emission factor equal to 17 tons of PM_{10} per thousand head of feeding cattle per year (or 93 lbs PM_{10} per thousand head per day), and an assumption that 15% of PM_{10} is emitted as $PM_{2.5}$ (U.S. Environmental Protection Agency, 2004a). However, a literature review indicated that the EPA's guidance results in greatly overestimated emission inventories (Flocchini and James, 2001; Goodrich et al., 2002). Two recent studies performed by the University of California at Davis and Texas A&M University yielded emission factors of 28.9 lbs PM_{10} per thousand head per day (Flocchini and James, 2001) and 19 lbs PM_{10} per thousand head per day (Goodrich et al., 2002) for beef cattle at feedlots. The midpoint—24 lbs PM_{10} per thousand head per day—was selected and used to estimate emissions of PM_{10} for beef cattle feedlots in the CENRAP region. In addition, an emission factor of 4.4 lbs PM_{10} per thousand head per day was selected for use in estimating emissions for dairies. This emission factor is based on sampling conducted at a single central Texas dairy in the summer of 2002 (Goodrich et al., 2002), and is therefore highly uncertain. However, it is the best and most reasonable emission rate that could be identified at this time.

Facility-specific population estimates for beef cattle feedlots and dairies were prepared previously (Coe and Reid, 2003). These population estimates were based primarily on facility-specific animal populations and species available from National Pollutant Discharge Elimination System (NPDES).

No information was identified that could be used to develop temporal patterns for this source category. However, emissions are likely to vary because climate conditions and animal husbandry practices vary seasonally and diurnally.

7.4 DATA PREPARATION

Deliverables for this source category include the county-level emission estimates in both NIF 3.0 format and the IDA format used by the SMOKE emissions model. The temporal allocation profiles and cross-reference files used by SMOKE were also provided.

8. PREPARATION OF INVENTORIES AND DATA FILE SYSTEMS FOR DELIVERY

8.1 ON-ROAD MOBILE SOURCES

Activity data, MOBILE6-ready input files, temporal profiles and cross-references used by SMOKE, and MOBILE6 command files were prepared to allow an independent third party to run MOBILE6 within SMOKE. These deliverables permitted CENRAP to prepare hourly meteorological inputs, estimate emissions, and prepare gridded emission inventories for any 2002 time period. In addition, STI ran MOBILE6 within SMOKE, estimated annual emissions for on-road mobile sources, and prepared NIF 3.0 emission inventories for the entire CENRAP region.

To estimate annual emissions, CENRAP's MM5 meteorological inputs for the months of January and July 2002 were used. Annual emissions were estimated from the average of the emission inventories for January and July 2002.[15] In addition, although SMOKE/MOBILE6 can be used to calculate emissions from refueling, these emissions are better allocated spatially and temporally if they are calculated separately from MOBILE6 runs. Therefore, refueling emissions were not included in the CENRAP emission inventory.

8.2 NON-ROAD MOBILE SOURCES

Revised activity data files and fuels characteristics, formatted for use with NONROAD, were prepared to allow an independent third party to run NONROAD and estimate emissions. In addition, STI ran the latest version of NONROAD (NONROAD 2004), estimated annual emissions for non-road mobile sources, and prepared NIF 3.0 and IDA-formatted emission inventories for the entire CENRAP region. The temporal allocation profiles and cross-reference files used by SMOKE were also provided. Emissions for locomotives and commercial marine vessels were estimated externally to the NONROAD model, which does not treat these sources, and were prepared in NIF 3.0 and IDA formats.

8.3 SOURCES OF AGRICULTURAL FUGITIVE DUST

STI estimated annual emissions for sources of agricultural fugitive dust, and prepared NIF 3.0 and IDA-formatted emission inventories for the entire CENRAP region. For agricultural tilling dust, the temporal allocation profiles and cross-reference files used by SMOKE were also provided.

[15] Test runs were also completed using representative temperatures for April and October to determine the potential effects on the annual average; however, the effects of including four months in the annual average were negligible.

9. REFERENCES

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APPENDIX A

CENTRAL STATES REGIONAL AIR PLANNING ASSOCIATION (CENRAP) PLEASURE CRAFT STUDY

Central States Regional Air Planning Association (CENRAP) Pleasure Craft Study

Final Report

Prepared for

Sonoma Technology, Inc.

Project 1031

July 2004

Prepared by

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Appendix D: Waterway Maps
Appendix E: Data Files (CD-ROM)

Final Report

Overview

Population Research Systems (PRS), LLC, a subsidiary of Freeman, Sullivan & Co., conducted the Pleasure Craft Survey for the Central States Regional Air Planning Association (CENRAP) Study in July 2004 on behalf of Sonoma Technologies, Inc. The project, which was sponsored by CENRAP, was designed to quantify air pollutant emissions from pleasure craft activities in the states of Nebraska, Kansas, Oklahoma, Arkansas, Texas, Iowa, Minnesota, Missouri and Louisiana.

Sonoma Technology, Inc. and PRS collaborated closely on the development of the mail survey instrument (Appendix B) used for this project. PRS was responsible for printing and mailing of the mail survey, the personalized cover letter (Appendix C), four-color state waterway maps as well as for programming of the telephone recruitment screener used by the PRS computer-assisted telephone interviewing (CATI) laboratory.

All project files and an electronic copy of this report can be found on the enclosed CD-Rom in Appendix D.

Methods

A. Sample

PRS purchased commercially available sample of registered boat owners in the target states from Dunhill International. Altogether 17,454 records of boat owners were loaded into the CATI system, 2,000 randomly drawn records per state. The only exception was Oklahoma, were the total number of available and loaded sample points was 1,454 records. Out of all records, 16,878 records were attempted, and 577 were not attempted, since some state quota cells were filled

without calling all available records. Table 1. shows the number of sample points available per state.

Table 1. Number of loaded sample points per CENRAP state

STATE	Frequency
AR	2,000
IA	2,000
KS	2,000
LA	2,000
MN	2,000
MO	2,000
NE	2,000
OK	1,454
TX	2,000
Total	17,454

B. Telephone Recruit and Survey Package Mailing

Potential participants for the Pleasure Craft Study were recruited over the phone in a brief 10 minute interview (Appendix A).

Respondents were recruited from May 20, 2004 through June 10, 2004. All recruits were conducted by trained PRS CATI laboratory interviewers on weekdays between 5:00 PM and 9:00 PM Central Standard Time. At a respondent's request, PRS also scheduled callback appointments outside of these interviewing hours.

A maximum of four call attempts were made to each sample point and no refusal conversions were used to convince eligible respondents to participate in the study.

Once a respondent agreed to participate, a survey package containing a personalized letter, a pen-and-paper survey, waterway map(s) for the state respondent is using motorized watercraft, a business reply envelope and a safety whistle on a floating lanyard as incentive were mailed.

About two weeks after the initial survey mailing, a reminder postcard was sent to respondents who had not yet returned their surveys.

C. Results

PRS recruited 1,387 respondents for the mail survey, and 979 completed surveys were returned. Table 2 shows the distribution of recruits and returned surveys per state, as well as the respective

percentage of response rate per state. The response rate varied between 67.4% and 77.1% and averaged at a return rate of 70.6%.

Table 2. Number of recruits and completed interviews per state

STATE	recruited	returned	%
AR	158	111	70.3%
IA	153	118	77.1%
KS	160	107	66.9%
LA	153	105	68.6%
MN	160	115	71.9%
MO	157	113	72.0%
NE	152	110	72.4%
OK	135	91	67.4%
TX	159	109	68.6%
Totals	**1387**	**979**	**70.6%**

APPENDIX A

TELEPHONE RECRUIT SCREENER

CENRAP Boating Study, Project 1031
Telephone Recruitment Script

INTRO1
Hello, my name is <interviewer>, may I speak with <insert fname, lname>?
1. On the phone (skpto INTRO3)
2. No, respondent is coming to the phone (skpto INTRO2)
3. No, respondent is not at home (schedule callback)
4. No such person (skpto TERM1)

INTRO2
Hello, my name is <interviewer> and I'm calling on behalf of CENRAP, the Central States Regional Air Planning Association. CENRAP is an organization of states, tribes, federal agencies, and other interested parties that studies and addresses air pollution, regional haze and visibility issues. Your state is participating in CENRAP and as such, you have been randomly selected to participate in an important air quality study. (Skpto INTRO4)

INTRO3
Hi, I'm calling on behalf of CENRAP, the Central States Regional Air Planning Association. CENRAP is an organization of states, tribes, federal agencies, and other interested parties that studies and addresses air pollution, regional haze and visibility issues. Your state is participating in CENRAP and as such, you have been randomly selected to participate in this important air quality study.

INTRO4
This telephone interview will take only a few minutes and I can assure you that I am not selling anything. We are conducting a study about recreational boating activities and are interested in learning more about how people use their watercrafts. All of your answers will be confidential and not used for any purpose other than this research.

Q1
Do you own a motorized sailboat, a personal watercraft such as a Jet-Ski or Waverunner or a power boat?
1. Yes
2. No (skpto TERM1)
8. Don't know/Refused (skpto TERM1)

Q2
Do you own more than one watercraft?
1. Yes
2. No (skpto Q5)
8. Don't know/Refused

Q3
What types of watercrafts do you own? Do you own… *(multiple choice, click all that apply)*
1. Powerboats
2. Motorized sail boats
3. Personal watercrafts
8. Don't know/Refused

Q4
Which of your watercrafts do you use the most?

1. Powerboat
2. Motorized sail boat
3. Personal watercraft
8. Don't know/Refused

Q5
Did you use your (primary) watercraft in the past year?

1. Yes
2. No
8. Don't know/Refused (IF answers = 2 skpto TERM1)

Q6
In which states did you use your <Insert Answer from Q4 here> in the past year?
(multiple choice, click all that apply)

1. Arkansas
2. Iowa
3. Kansas
4. Louisiana
5. Minnesota
6. Missouri
7. Nebraska
8. Oklahoma
9. Texas
10. Don't know/Refused

Q7

We would like to invite you to fill out a short paper survey regarding your boating activities with your watercraft you have used most in the past year, the <Insert Answer from Q5 here>. We would mail you the survey with a business reply envelope, and as a Thank-you gift you will also receive a Kwik Tex Safety whistle with floating Lanyard for your watercraft keys. May I have your address to send you the brief mail survey?

1. Yes
2. No, not interested (skpto TERM1)
3. Not sure (call back)

Q8

What is your mailing address?
Name:
Address:
City: / State: / Zip:

END1

Thank you very much for your participation in this important air quality study. You will receive the survey together with a business reply envelope and the boating key chain in the next 1-2 weeks in the mail. Please use the provided return envelope to send us back the filled out survey. You do not have to pay for postage. Do you have any other questions about this?

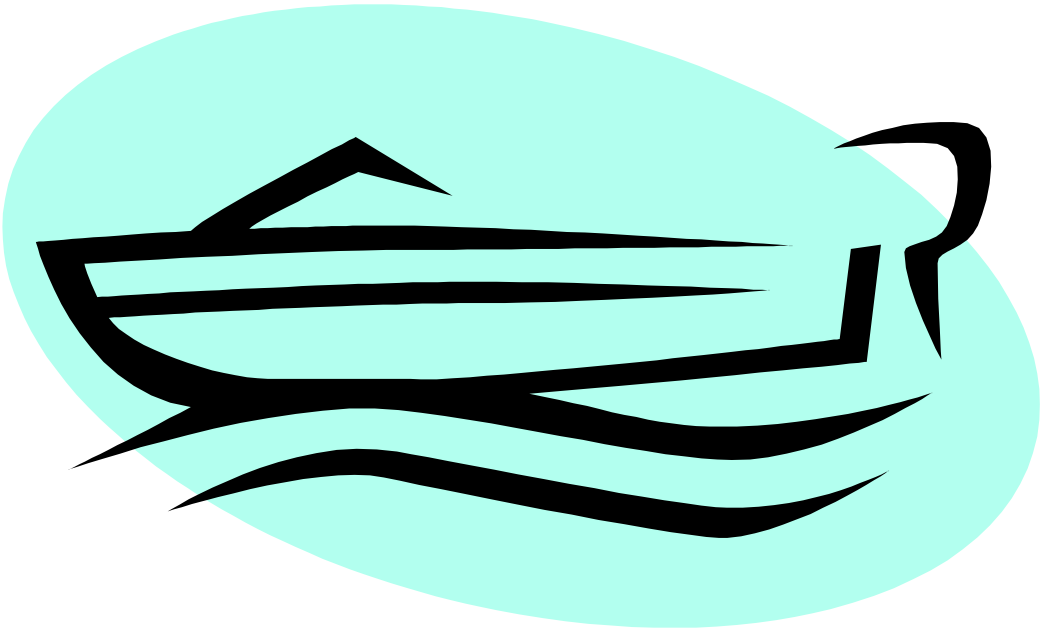
TERM1
Then these are all the questions I have for you. Thank you for your time. Good bye.

APPENDIX B

MAIL SURVEY INSTRUMENT

put sticker w/ boat type here
fscid

PLEASURE CRAFT SURVEY



1. Check the one category, which best describes your registered boat.

- ❑ 1 Sailboat with engine
- ❑ 2 Personal Water Craft (Jetski, Waverunner, etc.)
- ❑ 3 Power boat (bassboat, speedboat, houseboat, etc.)

2. Which category below describes your primary propulsion engine?

(*Do not describe any secondary propulsion used for low speed trolling and fishing.)*

- ❑ 1 Two-Stroke Gasoline Engine (requires gasoline and oil fuel mixture)
- ❑ 2 Four-Stroke Gasoline Engine (has an oil sump and dipstick)
- ❑ 3 Diesel (either 2 or 4 Stroke; requires diesel fuel)

3. Which one of the following is the primary propulsion type for your boat?
(Include auxiliary motors for sailboats, but do not include secondary motors for low speed trolling or fishing.)

- ❑ 1 Outboard
- ❑ 2 Inboard
- ❑ 3 Personal Water Craft Jet (Jetski engine, Waverunner engine, etc.)
- ❑ 4 Other (please specify): _____

4. What is the horsepower for this boat's primary engine?
(If unsure, you might want to check the specifications in the owner's manual. Otherwise, give your best estimate.)

_____ hp

5. What year was your engine manufactured?
(If unsure, you might want to find the model year in the owner's manual.)

_____ A (enter year)

- ❑ 1 Not sure, but probably before 1997
- ❑ 2 Not sure, but probably 1997 or later
- ❑ 3 Don't know

6a. **Typically, how often do you use your boat during the following seasons?**
(Please choose the answer that best matches your boat usage.)

Winter (Dec - Feb):

- ❑ 1` Practically never
- ❑ 2 1 time per week or less
- ❑ 3 2-3 times per week
- ❑ 4 4-5 times per week
- ❑ 5 6 times per week
- ❑ 6 Practically every day

Spring (Mar – May):

- ❑ 7 Practically never
- ❑ 8 1 time per week or less
- ❑ 9 2-3 times per week
- ❑ 10 4-5 times per week
- ❑ 11 6 times per week
- ❑ 12 Practically every day

6b. **Summer (Jun - Aug):**

- ❑ 1` Practically never
- ❑ 2 1 time per week or less
- ❑ 3 2-3 times per week
- ❑ 4 4-5 times per week
- ❑ 5 6 times per week
- ❑ 6 Practically every day

Fall (Sep – Nov):

- ❑ 7 Practically never
- ❑ 8 1 time per week or less
- ❑ 9 2-3 times per week
- ❑ 10 4-5 times per week
- ❑ 11 6 times per week
- ❑ 12 Practically every day

7. **How often did you use your boat <u>during the past week</u>?**

- ❑ 1` Never
- ❑ 2 1 time
- ❑ 3 2 times
- ❑ 4 3 times
- ❑ 5 4 or more times

8a. **During each of the following seasons, what percentage of your boat trips occur on weekdays vs. weekends?**
(Please choose the answer that best matches your boat usage.)

Winter (Dec - Feb):

	Weekday	Weekend
❑ 1	0%	100%
❑ 2	25%	75%
❑ 3	50%	50%
❑ 4	75%	25%
❑ 5	100%	0%

Spring (Mar – May):

	Weekday	Weekend
❑ 6	0%	100%
❑ 7	25%	75%
❑ 8	50%	50%
❑ 9	75%	25%
❑ 10	100%	0%

8b. **Summer (Jun - Aug):**

	Weekday	Weekend
❑ 1	0%	100%
❑ 2	25%	75%
❑ 3	50%	50%
❑ 4	75%	25%
❑ 5	100%	0%

Fall (Sep – Nov):

	Weekday	Weekend
❑ 6	0%	100%
❑ 7	25%	75%
❑ 8	50%	50%
❑ 9	75%	25%
❑ 10	100%	0%

9a. **Typically, how many hours is the engine operating <u>per trip</u> when you use your boat during the following seasons?**
(Please choose the answer that best matches your boat usage.)

Winter (Dec - Feb):

- ❑ 1` More than 8 hours
- ❑ 2 6 – 8 hours
- ❑ 3 4 – 6 hours
- ❑ 4 2 – 4 hours
- ❑ 5 0 – 2 hours

Spring (Mar – May):

- ❑ 6 More than 8 hours
- ❑ 7 6 – 8 hours
- ❑ 8 4 – 6 hours
- ❑ 9 2 – 4 hours
- ❑ 10 0 – 2 hours

9b. **Summer (Jun - Aug):**

- ❑ 1` More than 8 hours
- ❑ 2 6 – 8 hours
- ❑ 3 4 – 6 hours
- ❑ 4 2 – 4 hours
- ❑ 5 0 – 2 hours

Fall (Sep – Nov):

- ❑ 6 More than 8 hours
- ❑ 7 6 – 8 hours
- ❑ 8 4 – 6 hours
- ❑ 9 2 – 4 hours
- ❑ 10 0 – 2 hours

10a. At what time do you typically launch your boat during the following seasons?

Winter (Dec - Feb):

- ❑ 1` Before 8:00 AM
- ❑ 2 8:00 AM – 11:00 AM
- ❑ 3 11:00 AM – 1:00 PM
- ❑ 4 1:00 PM – 4:00 PM
- ❑ 5 After 4:00 PM

Spring (Mar – May):

- ❑ 6` Before 8:00 AM
- ❑ 7 8:00 AM – 11:00 AM
- ❑ 8 11:00 AM – 1:00 PM
- ❑ 9 1:00 PM – 4:00 PM
- ❑ 10 After 4:00 PM

10b. Summer (Jun - Aug):

- ❑ 1` Before 8:00 AM
- ❑ 2 8:00 AM – 11:00 AM
- ❑ 3 11:00 AM – 1:00 PM
- ❑ 4 1:00 PM – 4:00 PM
- ❑ 5 After 4:00 PM

Fall (Sep – Nov):

- ❑ 6` Before 8:00 AM
- ❑ 7 8:00 AM – 11:00 AM
- ❑ 8 11:00 AM – 1:00 PM
- ❑ 9 1:00 PM – 4:00 PM
- ❑ 10 After 4:00 PM

11. When your boat engine is in operation, what percentage of time is typically spent at the following power settings? (Please circle an answer for each setting; answers should sum to 100%).

Example: 30
+ 60
+ 10 = **100%**

Near Idle/Low Throttle →	0	10	20	30	40	50	60	70	80	90	100 %	
Mid-throttle →	0	10	20	30	40	50	60	70	80	90	100 %	
Full throttle →		0	10	20	30	40	50	60	70	80	90	100 %
Total:				**100%** (of time when engine is in operation)								

12. Please estimate the amount of fuel you use in your boat <u>each year</u>.

Number of gallons purchased:

- ❑ 1` More than 300 gallons
- ❑ 2 200 – 300 gallons
- ❑ 3 100 – 200 gallons
- ❑ 4 50 – 100 gallons
- ❑ 5 Less than 50 gallons

13. In which counties do you typically operate your boat? (Use the county codes printed on the enclosed Waterways Map and choose up to three counties.)

County Code 1: _____

County Code 2: _____

County Code 3: _____

Thank you for your cooperation.
Please use the provided business reply envelope to mail back the survey to

Population Research Systems
100 Spear St., 17th Floor
San Francisco, CA 94105

No postage necessary!