VOLUME III: CHAPTER 9

PESTICIDES - AGRICULTURAL AND NONAGRICULTURAL

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Emission Inventory Improvement Program

DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

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1

INTRODUCTION

This chapter is one of a series of documents developed to provide cost-effective, reliable and consistent approaches to estimating emissions for area source inventories. Multiple methods are provided in the chapters to accommodate needs of state agencies with different levels of available resources and skills; and different levels of needs for accuracy and reliability of their estimates. More information about the EIIP program can be found in Volume 1 of the EIIP series, *Introduction and Use of EIIP Guidance for Emissions Inventory Development.*

Throughout this chapter and other EIIP area source methods chapters, we stress that area source categories should be prioritized by the inventory planners so that resources can be spent on the source categories that are the largest emitters, most likely to be subject to regulations or are already subject to regulations, or require special effort because of some policy reason. Prioritization is particularly important for area source inventories, because in some cases, a difficult to characterize source category may contribute very little to overall emissions and attempting a high quality estimate for that source category may not be cost effective.

EIIP chapters are written for the state and local air pollution agencies, with their input and review. EIIP is a response to EPA's understanding that state and local agency personnel have more knowledge about their inventory area's activities, processes, emissions, and availability of information; and require flexible inventory methods to best use their sometimes limited resources. These EIIP area source chapters are written as a set of options presented to inventory professionals capable of using their own experience and judgement to apply the method that best fits their overall needs and constraints.

This chapter describes the procedures and recommended approaches for estimating emissions from pesticide applications. Section 2 of this chapter contains a general description of the pesticide applications category. Section 3 of this chapter provides an overview of available emission estimation methods. Section 4 presents the preferred emission estimation method for pesticide applications, while Section 5 presents alternative emission estimation techniques. Quality assurance/quality control are discussed in Section 6. Data coding procedures are discussed in Section 7, and Section 8 is the reference section.

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SOURCE CATEGORY DESCRIPTION

Pesticides are substances used to control nuisance weeds (herbicides), insects (insecticides), fungi (fungicides), and rodents (rodenticides). Pesticides can be broken down into three chemical categories: synthetics, nonsynthetics (petroleum products), and inorganics. Formulations of pesticides are made through the combination of the pest-killing material referred to as the active ingredient, and various solvents (which act as carriers for the pest-killing material) referred to as the inert ingredient. Both types of ingredients contain volatile organic compounds (VOC) that can potentially be emitted to the air either during application or as a result of evaporation. Pesticide applications can be broken down into two user categories: agricultural and nonagricultural (which includes municipal, commercial, and consumer). The criteria pollutant of concern from the application of pesticides is VOC.

Pesticides are used mainly for agricultural applications. Agricultural pesticides are a cost-effective means of controlling weed, insects, and other threats to the quality and yield of food production. Application rates for a particular pesticide may vary from crop to crop and region to region. Application of pesticides can be from the ground or from the air and pesticides can be applied as sprays, dusts, pellets, fogs, or through other dispersion techniques.

Nonagricultural applications are a smaller part of the inventory and include municipal, commercial, and consumer applications. Municipal applications cover state and possibly public institutions such as schools and hospitals, and public recreational areas. Municipal applications can include mosquito control and weed suppression by government agencies, pesticide application at parks, highway department use, utilities maintenance, and pesticide application at railroad right-of-ways. Commercial applications include applications to public and private golf courses and homeowner/business property (yards, dwellings, and buildings) by a commercial exterminator/lawn care service. Consumer applications include homeowner-applied insecticides (*e.g.*, flea and tick sprays, wasp and hornet sprays, lawn and garden insecticides), fungicides and nematicides (*e.g.*, wood preservatives, and mold and mildew retardants), and herbicides (*e.g.*, defoliant herbicides, swimming pool algicides, and aquatic herbicides). As with agricultural applications of pesticides, nonagricultural applications can be from the ground or from the air and pesticides can be applied as sprays, dusts, pellets, fogs, or through other dispersion techniques. Table 9.2-1 provides a summary of municipal usage of pesticides and the suggested organizations to contact for information on usage.

TABLE 9.2-1

MUNICIPAL USAGE OF PESTICIDES

Type of Use	Suggested Organizations to Contact
Publicly-Maintained Golf Courses	Public Parks Department
Public Parks	Public Parks Department
Public Institutions (grounds and gardens)	Public Parks Departments, Institution's Maintenance Departments
Mosquito/Other Pest Control	Public Health Department
Utility Right of Ways	Utility Companies
Roadways	State and Local Highway Departments

2.1 EMISSIONS SOURCES

Approximately 68 to 75 percent of pesticides used in the United States are applied to agricultural lands, both cropland and pasture (Baker and Wilkinson, 1990), (Aspelin *et. al.*, 1991). Of the remaining 25 to 32 percent, 7 to 8 percent are used privately for home and garden pests, and the remaining 18 to 24 percent are used for industrial, commercial, and government purposes.

A wide variety of solvents are used in pesticide formulations. In 1987, according to the Freedonia solvent marketing study, the United States consumed approximately 1,090 million pounds of pesticide formulations. This study estimated that these formulations contained about 570 million pounds of active ingredients and about 520 million pounds of solvents (Freedonia Group, 1989). Both the active ingredient and the solvent emit VOC either during and/or after application.

2.2.1 FACTORS INFLUENCING EMISSIONS

To use pesticides effectively, the most appropriate pesticide formulation, equipment, and application and treatment strategy must be determined. Table 9.2-2 summarizes the different formulations, equipment, and application strategies available. Each of these factors will influence the amount of VOC emitted by the pesticide application being investigated. Limited information is available on the effects of each of these factors on VOC emissions. However, it can be reasoned that solid formulations such as powders, dusts, and pellets will have lower VOC emissions than solutions, concentrates, and aerosols. In addition, pesticides that are applied by equipment that increases the surface area to which the pesticide is applied, such as compressed air sprayers and mist blowers, will have higher VOC emissions per unit of time than small hand dusters and sprayers. Finally, application strategies that increase the area over which the pesticide is applied, such as a broadcast application, will have higher VOC emissions than a strategy that applies the pesticide to a specific part of the plant to be treated, such as in a directed application. Currently there are no federal or state regulations limiting air emissions from pesticide applications.

TABLE 9.2-2

SUMMARY OF FORMULATIONS, EQUIPMENT, AND APPLICATION STRATEGIES

- Formulations
  - Emulsifiable Concentrate
  - Solution
  - Flowable
  - Wettable Powder
  - Dry Flowable
  - Soluble Powder
  - Ultra Low Volume Concentrate
  - Low Concentrate Solution
  - Aerosol
  - Invert Emulsion
  - Dust
  - Bait
  - Granule
  - Pellets
  - Micro Encapsulation
  - Water-soluble Packets
  - Impregnates
- Equipment
  - Hand Dusters
  - Rotary-type Hand Dusters
  - Knapsack Dusters
  - Power Dusters
  - Compressed Air Sprayers
  - Power Sprayers
  - Hand Sprayers
  - Knapsack Sprayers
  - Mist Blowers
- Applications/Treatments
  - Band
  - Basal
  - Broadcast
  - Directed
  - Sequential
  - Serial
  - Spot

3

OVERVIEW OF AVAILABLE METHODS

3.1 EMISSION ESTIMATION METHODS

There are several methods available for calculating emissions from pesticide applications. The method chosen is dependent on the type of application (agricultural or nonagricultural), available data, available resources, and the degree of accuracy required for the estimate. Also, selection of the appropriate estimation method depends on the relative significance of emissions from this source in the inventory area and the data quality objectives (DQOs) of the inventory plan. Refer to EIIP Volume VI, *Quality Assurance Procedures,* Sections 2.1 and 2.4 for discussions of inventory categories and DQOs.

This section discusses the methods available for calculating emission estimates from agricultural and nonagricultural pesticide applications and identifies the preferred method of calculation for each category. A discussion of the data elements needed for each method is provided.

3.2 AVAILABLE METHODS

3.2.1 VOLATILE ORGANIC COMPOUNDS

The VOC emitted from agricultural and nonagricultural pesticide applications are from the inert ingredients (*i.e.*, solvent carriers) and the volatile organic constituents of the active ingredients. These VOC are emitted during application and evaporate over time. There are several methods for estimating VOC emissions from both agricultural and nonagricultural application, depending on the data available and the information sought. Table 9.3-1 summarizes these methods. The preferred methods are discussed in Section 4 and alternative methods are discussed in Section 5.

Agricultural Pesticide Applications

Each method (with the exception of the per capita emission factor) requires information on the total area to which the pesticide is applied, the amount of active and inert ingredients in the pesticide, and the application rate. There are several approaches to estimating the amount of VOC emitted from this category, depending on the data available.

TABLE 9.3-1

PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS FROM PESTICIDE APPLICATIONS

Methods	Agricultural	Nonagricultural		
		Municipal	Commercial	Consumer
Preferred Method	Gather data from State Agricultural Departments to calculate emissions based on the pesticide applied, the formulation of the pesticide, and the total acres to which the pesticide is applied. The emission factors in this method are based on the vapor pressures of the active ingredients in the pesticides.	Survey State and local government agencies, highway departments, utility companies, and parks offices to gather information on the total acres and the amount of pesticide applied to those acres. The more information on the pesticide that can be found, the more accurate the emission estimate.	Survey commercial pesticide application companies to determine the pesticides used, the formulation of those pesticides, and the amount applied.	Use data from EPA's Consumer Products Survey.
Alternative Method 1	Gather data from State Agricultural Departments to calculate emissions based on the pesticide applied, the formulation of the pesticide, and the total acres to which the pesticide is applied. This method requires data on the VOC content of the active and inert ingredients in the pesticide.	Use a national per capita emission factor. Calculation is for all nonagricultural pesticide applications.	Use a national per capita emission factor. Calculation is for all nonagricultural pesticide applications.	
Alternative Method 2	Gather data from State Agricultural Departments to calculate emissions based on the pesticide applied, the formulation of the pesticide, and the total acres to which the pesticide is applied. This method uses a default for the amount of VOC present in the active ingredient to calculate the total emissions. Use this method if no pesticide-specific data are available.			
Alternative Method 3 (Volatility/ Biodegradability)	This method calculates emissions by taking into consideration the volatility and biodegradability of the pesticide. This method can only be used for semi-volatile pesticides and requires detailed information on the formulation of the pesticide. This is the preferred method if this level of information is available from a State Agricultural Department. Emissions are calculated by month.			
Alternative Method 4 (Top-Down Solvent Use)	Apportion national solvents consumption for this source category to counties.			

Nonagricultural Pesticide Applications

For nonagricultural pesticide applications, the methods require information on the total area to which the pesticide is applied, the amount of active and inert ingredients in the pesticide, and the application rate. If no information is available, total nonagricultural emissions can be calculated based on a per capita emission factor. The method used to calculate emissions depends on the type of nonagricultural application method being used (*i.e*., municipal, commercial, or consumer).

3.2.2 HAZARDOUS AIR POLLUTANTS

Hazardous air pollutant (HAP) emissions from this source are determined by the methods discussed above for VOC emissions. The emissions of each HAP are assumed to be proportional to the amount of HAP used in the pesticide formulation for which the emissions are being calculated.

3.2.3 NATIONAL SOLVENT USE APPORTIONED TO COUNTIES

An alternative method is a material balance top-down approach, starting with total national solvent consumption and apportioning it to counties. This method utilizes national annual solvents consumption for this source category, surrogates for spatial allocation to counties, a method to show growth (if national numbers not for inventory year), knowledge of regulations[1] and recycling and waste management policies.

3.3 DATA NEEDS

3.3.1 DATA ELEMENTS

The data elements needed to calculate emission estimates for pesticide applications depend on the methodology used for data collection and on the methodology used to estimate emissions. The data elements needed for each emission estimation technique are presented in Table 9.3-2.

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[1] State any assumptions made to include national/state/local regulations and the exact regulation applied. Clarify any issues related to regulation and control assumptions. The final emissions estimates are **highly** dependent on these assumptions, therefore they must be stated explicitly in all documentation.

TABLE 9.3-2

DATA ELEMENTS NEEDED FOR EACH METHOD

	Agricultural[a]					Nonagricultural[b]			
						Municipal[c]		Commercial[c]	
	Preferred	ALT 1	ALT 2	ALT 3	ALT 4[d]	Preferred	ALT 1	Preferred	ALT 1
Total acres	x	x	x	x		x			
Pesticide formulation									
Fraction active ingredient	x	x	x			x		x	
Fraction inert ingredient	x	x				x			
Fraction VOC in active ingredient		x				x		x	
Fraction VOC in inert ingredient	x	x				x			
Vapor pressure of active ingredient	x			x					
Amount of pesticide applied per acre	x	x	x	x		x		x	
Average temperature in month of application				x					
Relative humidity during month of application			x						
Water evaporation rate			x						
Vapor pressure of water at average temperature			x						
Area population							x		x
National solvents consumption for this source category					x				

TABLE 9.3-2

(CONTINUED)

	Agricultural[a]					Nonagricultural[b]			
						Municipal[c]		Commercial[c]	
	Preferred	ALT 1	ALT 2	ALT 3	ALT 4[d]	Preferred	ALT 1	Preferred	ALT 1
Surrogate data for spatial allocation to counties					x				
Growth indicators to adjust activity (if national numbers not for inventory year)					x				
Impact of regulations[a] on emissions					x				
Recycling and waste management					x				
Solvent content factor					x				

[a] ALT 1 for agricultural applications is the pesticide-specific volatile component of pesticide applied method.
ALT 2 for agricultural applications is the default volatile component of pesticide applied method.
ALT 3 for agricultural applications is the California Air Resources Board method.
[b] Consumer pesticide applications should use EPA's 1992 Consumer Products Survey to estimate emissions.
[c] ALT 1 for municipal applications is the use of national per capita emission factors.
ALT 1 for commercial applications is the use of national per capita emission factors.
[d] ALT 4 for agricultural applications is the national top-down solvent use method.

Adjustments to Emission Estimates

Adjustments to an emission estimate for pesticide applications may be necessary depending on the type of inventory being prepared. For an annual inventory, adjustments would be made to spatially allocate the emissions to the appropriate counties and any corrections for applicable regulations. Therefore, data will be needed on where the pesticide was used and the appropriate values for rule effectiveness and rule penetration, assuming regulations apply to pesticide applications in the study area. A seasonal inventory will require seasonal corrections as outlined in Section 5.8 of Volume I of *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone* (EPA-450/4-91-016, May 1991), herein referred to as the *Procedures* document. The correction assumes application through a nine month growing season, six days per week (EPA, 1991). No additional data are required to seasonally adjust an inventory (the default value of 1.3 can be used) unless the pesticide application is not equivalent to the assumptions in the *Procedures* document. Projecting emissions for pesticides requires data on the anticipated changes in the number of acres to which pesticides are being applied in the area of concern.

Information on seasonal activity of the agricultural pesticide usage can also be obtained from agricultural extension offices. Such information may include data on the standard schedules for pesticide and herbicide application and the type of crops grown during the inventory season.

Application of Controls

Historically, control of emissions from pesticide applications have been limited. The use of solid formulations, low volume spray equipment, and direct applications have the potential for reducing the amount of VOC emitted. No states have regulated air emissions from pesticide applications through the controls mentioned, however, these types of regulations are being developed. When considering the effect of these potential rules, both rule effectiveness and rule penetration should be applied to the emission estimate.

3.4 SPATIAL ALLOCATION

The spatial allocation of agricultural pesticide application emissions can be performed by using agricultural data from the State Agricultural Departments. To spatially allocate municipal applications, data should be obtained by surveying various state and local agencies and utility companies that are responsible for applying the pesticide to determine in which county the pesticide was applied. For commercial applications, a survey should be used to pinpoint the county in which the pesticide was used. Finally, for consumer applications, spatial allocation can be accomplished by using local population data.

3.5 TEMPORAL RESOLUTION

3.5.1 SEASONAL APPORTIONING

Emissions from all types of pesticide applications vary from season to season in most areas of the United States. Seasonal throughput or months of application information should be collected so that a seasonal adjustment can be calculated. Section 5.8 of the *Procedures* document contains information and instructions on the methods for calculating a seasonal adjustment factor.

3.5.2 DAILY RESOLUTION

Most agricultural pesticide applications occur either five or six days per week. Municipal and commercial applications also occur five or six days per week. Consumer pesticide applications can take place throughout the entire seven day week. Most pesticide applications, both agricultural and nonagricultural, occur during daylight hours.

3.6 PROJECTING EMISSIONS

Projecting emissions from agricultural and nonagricultural pesticide applications requires information on anticipated changes in the number of acres to which pesticides are applied. However, if no information is available, the inventorying agency can assume no changes to the number of acres treated.

4

PREFERRED METHOD FOR ESTIMATING EMISSIONS

4.1 AGRICULTURAL APPLICATIONS

The preferred method for estimating emissions from agricultural applications of pesticides uses the vapor pressure of the active ingredient to determine the appropriate emission factor, the amount of pesticide applied to an area, and the percent of the active ingredient in the pesticide applied. This method takes into consideration the method by which the pesticide is applied, the type of formulation, and the fact that volatilization is essentially complete within 30 days of application (EPA, 1996).

This method cannot be used for aerial applications. A major factor in losses by aerial application is drift, and neither equations nor experimental data are currently available to permit predictions of these losses or the development of emission factors.

The following procedures should be applied for non-aerial applications:

(1) Contact State Agricultural Departments to collect data on:

- The pesticides applied;
- The amount of pesticide applied by county/nonattainment area;
- Method of application;
- The active ingredient(s) in the pesticide applied;
- The vapor pressure of the active ingredient(s);
- The type of formulation;
- The percentage of inert ingredients in the pesticide applied; and
- The percentage of VOC in the inert ingredients.

Data on the formulations can be found in publications such as the *Farm Chemicals Handbook*[2] or from the National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, DC (USDA, 1992). If specific data can not be obtained from the state, Tables 9.4-1 through 9.4-4 provide active ingredients for many pesticides, vapor pressures for typical active ingredients, and average VOC content for the inert portion by formulation type.

(2) Calculate the emissions from the active ingredient of the pesticide applied.

$$E_1 = R \text{ x } A \text{ x } PA \text{ x } EF \qquad (9.4\text{-}1)$$

where:

E_1 = emissions from the active ingredient
R = pounds of pesticide applied per year per harvested acre
A = total harvested acres
PA = fraction active ingredient in the pesticide applied
EF = emission factor from Table 9.4-4 based on vapor pressure of active ingredient

3) Calculate emissions from the inert ingredients in the pesticide applied.

$$E_2 = R \text{ x } A \text{ x } PI \text{ x } PVI \qquad (9.4\text{-}2)$$

where:

E_2 = emissions from inert ingredients
R = pounds of pesticide applied per year per harvested acre
A = total harvested acres
PI = fraction inert ingredient in the pesticide applied
PVI = fraction VOC in the formulation from Table 9.4-3

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[2] The *Farm Chemicals Handbook* is published annually by Meister Publishing Company, Willoughby, OH.

TABLE 9.4-1

TRADE NAMES FOR SELECTED ACTIVE INGREDIENTS[a]

Trade Name[b]	Active Ingredient[c]
Insecticides	
AC 8911	Phorate
Acephate-met	Methamidophos
Alkron®	Ethyl Parathion
Alleron®	Ethyl Parathion
Aphamite®	Ethyl Parathion
Bay 17147	Azinphos-methyl
Bay 19639	Disulfoton
Bay 70143	Carbofuran
Bay 71628	Methamidophos
Benzoepin	Endosulfan
Beosit®	Endosulfan
Brodan®	Chlorpyrifos
BugMaster®	Carbaryl
BW-21-Z	Permethryn
Carbamine®	Carbaryl
Carfene®	Azinphos-methyl
Cekubaryl®	Carbaryl
Cekudifol®	Dicofol
Cekuthoate®	Dimethoate
CGA-15324	Profenofos
Chlorpyrifos 99%	Chlorpyrifos
Chlorthiepin®	Endosulfan

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Comite®	Propargite
Corothion®	Ethyl Parathion
Crisulfan®	Endosulfan
Crunch®	Carbaryl
Curacron	Profenofos
Curaterr®	Carbofuran
Cyclodan®	Endosulfan
Cygon 400®	Dimethoate
D1221	Carbofuran
Daphene®	Dimethoate
Dazzel®	Diazinon
Denapon®	Carbaryl
Devicarb®	Carbaryl
Devigon®	Dimethoate
Devisulphan®	Endosulfan
Devithion®	Methyl Parathion
Diagran®	Diazinon
Dianon®	Diazinon
Diaterr-Fos®	Diazinon
Diazajet®	Diazinon
Diazatol®	Diazinon
Diazide®	Diazinon
Dicarbam®	Carbaryl
Dicomite®	Dicofol

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Dimethogen®	Dimethoate
Dimet®	Dimethoate
Dizinon®	Diazinon
DPX 1410	Oxamyl
Dyzol®	Diazinon
E-605	Ethyl Parathion
Ectiban®	Permethryn
Endocide®	Endosulfan
Endosol®	Endosulfan
ENT 27226	Propargite
ENT27164	Carbofuran
Eradex®	Chlorpyrifos
Ethoprop	Ethoprop
Ethoprophos	Ethoprop
Ethylthiodemeton	Disulfoton
Etilon®	Ethyl Parathion
Fezudin	Diazinon
FMC-5462	Endosulfan
FMC-33297	Permethryn
Fonofos	Dyfonate
Force®	Tefluthrin
Fosfamid	Dimethoate
Furacarb®	Carbofuran
G-24480	Diazinon

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Gardentox®	Diazinon
Gearphos®	Methyl Parathion
Golden Leaf Tobacco Spray®	Endosulfan
Hexavin®	Carbaryl
Hoe 2671	Endosulfan
Indothrin®	Permethryn
Insectophene®	Endosulfan
Insyst-D®	Disulfoton
Karbaspray®	Carbaryl
Kayazinon®	Diazinon
Kayazol®	Diazinon
Kryocide®	Cryolite
Lannate® LV	Methomyl
Larvin®	Thiodicarb
Metafos	Methyl Parathion
Metaphos®	Methyl Parathion
Methomex®	Methomyl
Methyl	Methyl Parathion
Metiltriazotion	Azinphos-methyl
Nipsan®	Diazinon
Niran®	Ethyl Parathion
Nivral®	Thiodicarb
NRDC 143	Permethryn
Ortho 124120	Acephate

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Orthophos®	Ethyl Parathion
Panthion®	Ethyl Parathion
Paramar®	Ethyl Parathion
Paraphos®	Ethyl Parathion
Parathene®	Ethyl Parathion
Parathion	Methyl Parathion
Parathion	Ethyl Parathion
Parawet®	Ethyl Parathion
Partron M®	Methyl Parathion
Penncap-M®	Methyl Parathion
Phoskil®	Ethyl Parathion
Piridane®	Chlorpyrifos
Polycron®	Profenofos
PP 557	Permethryn
Pramex®	Permethryn
Prokil®	Cryolite
PT265®	Diazinon
Qamlin®	Permethryn
Rampart®	Phorate
Rhodiatox®	Ethyl Parathion
S276	Disulfoton
SD 8530	Trimethacarb
Septene®	Carbaryl
Sevin 5 Pellets®	Carbaryl

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Soprathion®	Ethyl Parathion
Spectracide®	Diazinon
SRA 5172	Methamidophos
Stathion®	Ethyl Parathion
Tekwaisa®	Methyl Parathion
Temik®	Aldicarb
Tercyl®	Carbaryl
Thimul®	Endosulfan
Thiodan	Endosulfan
Thiofor®	Endosulfan
Thiophos	Ethyl Parathion
Tricarnam®	Carbaryl
Trimetion®	Dimethoate
UC 51762	Thiodicarb
UC 27867	Trimethacarb
Uniroyal D014	Propargite
Yaltox®	Carbofuran
None listed	Dicrotophos
None listed	Terbufos
Herbicides	
A-4D	2,4-D
AC 92553	Pendimethalin
Acclaim	Fenoxaprop-ethyl
Acme MCPA Amine 4®	MCPA

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Aljaden®	Sethoxydim
Amiben®	Chloramben
Amilon®-WP	Chloramben
Amine®	MCPA
Aqua-Kleen®	2,4-D
Arrhenal®	DSMA
Arsinyl®	DSMA
Assure®	Quizalofop-ethyl
Avadex® BW	Triallate
Banlene Plus®	MCPA
Banvel®	Dicamba
Barrage®	2,4-D
Basagran	Bentazon
Bay 30130	Propanil
Bay DIC 1468	Metribuzin
Bay 94337	Metribuzin
Benefex®	Benefin
Benfluralin	Benefin
Bentazon	Bentazon
Bethrodine	Benefin
BH® MCPA	MCPA
Bioxone®	Methazole
Blazer®	Aciflurofen
Bolero®	Thiobencarb

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Border-Master®	MCPA
Brominex®	Bromoxynil
C-2059	Fluometuron
Cekuiron®	Diuron
Cekuquat®	Paraquat
Cekusima®	Simazine
CGA-24705	Metolachlor
Checkmate®	Sethoxydim
Chloroxone®	2,4-D
Classic®	Chlorimuron-ethyl
Clomazone	Clomazone
Command®	Clomazone
CP50144	Alachlor
Crisuron®	Diuron
Croprider®	2,4-D
Dacthal®	DCPA
Dailon®	Diuron
Depon®	Fenoxaprop-ethyl
Dextrone®	Paraquat
Di-Tac®	DSMA
Diater®	Diuron
DMA	DSMA
DMA-100®	DSMA
DPA	Propanil

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
DPX-Y6202	Quizalofop-ethyl
EL-110	Benefin
EL-161	Ethalfluralin
Emulsamine®	2,4-D
Esgram®	Paraquat
Excel®	Fenoxaprop-ethyl
EXP-3864	Quizalofop-ethyl
Expand®	Sethoxydim
Far-Go®	Triallate
Farmco Diuron®	Diuron
Farmco Atrazine Gesaprim®	Atrazine
Fervinal®	Sethoxydim
Ferxone®	2,4-D
Furore®	Fenoxaprop-ethyl
Fusilade 2000	Fluazifop-p-butyl
G-30027	Atrazine
G-34161	Prometryn
G-34162	Ametryn
Gamit®	Clomazone
Genate Plus®	Butylate
Glyphosate Isopropylamine Salt	Glyphosate
Goldquat® 276	Paraquat
Grasidim®	Sethoxydim
HerbAll®	MSMA

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Herbaxon®	Paraquat
Herbixol®	Diuron
Higalcoton®	Fluometuron
Hoe 002810	Linuron
Hoe-023408	Diclofop-methyl
Hoe-Grass®	Diclofop-methyl
Hoelon®	Diclofop-methyl
Illoxan®	Diclofop-methyl
Kilsem®	MCPA
Lasso®	Alachlor
Lazo®	Alachlor
Legumex Extra®	MCPA
Lexone® 4L	Metribuzin
Lexone® DF®	Metribuzin
Linorox®	Linuron
LS 801213	Aciflurofen
M.T.F.®	Trifluralin
Magister®	Clomazone
Mephanac®	MCPA
Merge 823®	MSMA
Methar® 30	DSMA
Mezopur®	Methazole
Monosodium methane arsenate	MSMA
Nabu®	Sethoxydim

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Option®	Fenoxaprop-ethyl
Oxydiazol	Methazole
Paxilon®	Methazole
Pillarquat®	Paraquat
Pillarxone®	Paraquat
Pillarzo®	Alachlor
Pilot®	Quizalofop-ethyl
Plantgard®	2,4-D
Pledge®	Bentazon
PP 005	Fluazifop-p-butyl
Primatol Q®	Prometryn
Probe	Methazole
Prop-Job®	Propanil
Propachlor	Propachlor
Prowl®	Pendimethalin
Rattler®	Glyphosate
RH-6201	Aciflurofen
Rodeo®	Glyphosate
Roundup®	Glyphosate
S 10145	Propanil
Sarclex®	Linuron
Saturno®	Thiobencarb
Saturn®	Thiobencarb
Scepter®	Imazaquin

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
SD 15418	Cyanazine
Sencor® 4	Metribuzin
Sencor® DF	Metribuzin
Shamrox®	MCPA
Sodar®	DSMA
Sonalan®	Ethalfluralin
Squadron®	Imazaquin
Squadron®	Pendimethalin
Strel®	Propanil
Surpass®	Vernolate
Targa®	Quizalofop-ethyl
Target MSMA®	MSMA
Telok®	Norflurazon
Tigrex®	Diuron
Total®	Paraquat
Toxer®	Paraquat
Trans-Vert®	MSMA
Tri-4®	Trifluralin
Tri-Scept®	Imazaquin
Tributon®	2,4-D
Trifluralina 600®	Trifluralin
Trinatox D®	Ametryn
Tritex-Extra®	Sethoxydim
Tunic®	Methazole

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Unidron®	Diuron
VCS 438	Methazole
Vegiben®	Chloramben
Vernam 10G	Vernolate
Vernam 7E	Vernolate
Vonduron®	Diuron
Weed-Rhap®	MCPA
Weed-B-Gon®	2,4-D
Weedatul®	2,4-D
Weedtrine-II®	2,4-D
Whip®	Fenoxaprop-ethyl
WL 19805	Cyanazine
Zeaphos®	Atrazine
Zelan®	MCPA
None listed	EPTC
None listed	Fomesafen
None listed	Molinate
None listed	Tridiphane
Other Active Ingredients	
A7 Vapam®	Metam Sodium
Aquacide®	Diquat
Avicol®	PCNB
Carbam (MAF)	Metam Sodium
Clortocaf Ramato®	Chlorothalonil

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Clortosip®	Chlorothalonil
Cotton Aide HC®	Cacodylic
De-Green®	Tribufos
DEF®	Tribufos
Deiquat	Diquat
Dextrone®	Diquat
E-Z-Off D®	Tribufos
Earthcide®	PCNB
Exotherm Termil®	Chlorothalonil
Folex®	Tribufos
Folosan®	PCNB
Fos-Fall A®	Tribufos
Karbation®	Metam Sodium
Kobutol®	PCNB
Kobu®	PCNB
Kypman® 80	Maneb
M-Diphar®	Maneb
Mancozin®	Mancozeb
Maneba®	Maneb
Manebe	Maneb
Manzate® 200	Mancozeb
Manzeb	Mancozeb
Manzin®	Mancozeb
Maposol®	Metam Sodium

TABLE 9.4-1 (CONTINUED)

Trade Name[b]	Active Ingredient[c]
Metam for the Acid	Metam Sodium
Moncide®	Cacodylic
Montar®	Cacodylic
Nemispor®	Mancozeb
Pentagen®	PCNB
Quintozene	PCNB
Rad-E-Cate® 25	Cacodylic
Reglon	Diquat
Riozeb®	Mancozeb
RTU® PCNB	PCNB
Sectagon® II	Metam Sodium
SMDC	Metam Sodium
Soil-Prep®	Metam Sodium
Sopranebe®	Maneb
Superman® Maneb F	Maneb
Terrazan®	PCNB
Tersan 1991®	Benomyl
TriPCNB®	PCNB
Tubothane®	Maneb
Weedtrine-D®	Diquat
Ziman-Dithane®	Mancozeb
None listed	Dimethipin
None listed	Ethephon
None listed	Thiadiazuron

[a] From *Farm Chemicals Handbook*. See the USDA publication on Agricultural Chemical Usage (USDA, 1992) for selected pesticides used on major field crops.

[b] From *Farm Chemicals Handbook*.

[c] Common names. See *Farm Chemicals Handbook* for chemical names.

TABLE 9.4-2

VAPOR PRESSURES OF SELECTED ACTIVE INGREDIENTS[a]

Active Ingredient	Vapor Pressure (mm Hg at 20 to 25°C)
1,3-Dichloropropene	29
2,4-D acid	8.0×10^{-6}
Acephate	1.7×10^{-6}
Alachlor	1.4×10^{-5}
Aldicarb	3.0×10^{-5}
Aldoxycarb	9×10^{-5}
Amitraz	2.6×10^{-6}
Amitrole (aminotriazole)	4.4×10^{-7}
Atrazine	2.9×10^{-7}
Azinphos-methyl	2.0×10^{-7}
Benefin (benfluralin)	6.6×10^{-5}
Benomyl	$< 1.0 \times 10^{-10}$
Bifenox	2.4×10^{-6}
Bromacil acid	3.1×10^{-7}
Bromoxynil butyrate ester	1.0×10^{-4}
Butylate	1.3×10^{-2}
Captan	8.0×10^{-8}
Carbaryl	1.2×10^{-6}
Carbofuran	6.0×10^{-7}
Chlorobenzilate	6.8×10^{-6}
Chloroneb	3.0×10^{-3}
Chloropicrin	18
Chlorothalonil	1.0×10^{-3} (estimated)
Chlorpyrifos	1.7×10^{-5}
Clomazone (dimethazone)	1.4×10^{-4}
Cyanazine	1.6×10^{-9}
Cyromazine	3.4×10^{-9}

TABLE 9.4-2 (CONTINUED)

Active Ingredient	Vapor Pressure (mm Hg at 20 to 25°C)
DCNA (dicloran)	1.3×10^{-6}
DCPA (chlorthal-dimethyl; Dacthal®)	2.5×10^{-6}
Diazinon	6.0×10^{-5}
Dichlobenil	1.0×10^{-3}
Dicofol	4.0×10^{-7}
Dicrotofos	1.6×10^{-4}
Dimethoate	2.5×10^{-5}
Dinocap	4.0×10^{-8}
Disulfoton	1.5×10^{-4}
Diuron	6.9×10^{-8}
Endosulfan	1.7×10^{-7}
EPTC	3.4×10^{-2}
Ethalfluralin	8.8×10^{-5}
Ethion	2.4×10^{-6}
Ethoprop (ethoprophos)	3.8×10^{-4}
Fenamiphos	1.0×10^{-6}
Fenthion	2.8×10^{-6}
Fluometuron	9.4×10^{-7}
Fonofos	3.4×10^{-4}
Isofenphos	3.0×10^{-6}
Lindane	3.3×10^{-5}
Linuron	1.7×10^{-5}
Malathion	8.0×10^{-6}
Methamidophos	8.0×10^{-4}
Methazole	1.0×10^{-6}
Methiocarb (mercaptodimethur)	1.2×10^{-4}
Methomyl	5.0×10^{-5}

TABLE 9.4-2 (CONTINUED)

Active Ingredient	Vapor Pressure (mm Hg at 20 to 25°C)
Methyl parathion	1.5×10^{-5}
Metolachlor	3.1×10^{-5}
Metribuzin	$< 1.0 \times 10^{-5}$
Mevinphos	1.3×10^{-4}
Molinate	5.6×10^{-3}
Naled	2.0×10^{-4}
Norflurazon	2.0×10^{-8}
Oxamyl	2.3×10^{-4}
Oxyfluorfen	2.0×10^{-7}
Parathion (ethyl parathion)	5.0×10^{-6}
PCNB	1.1×10^{-4}
Pendimethalin	9.4×10^{-6}
Permethrin	1.3×10^{-8}
Phorate	6.4×10^{-4}
Phosmet	4.9×10^{-7}
Profenofos	9.0×10^{-7}
Prometon	7.7×10^{-6}
Prometryn	1.2×10^{-6}
Propachlor	2.3×10^{-4}
Propanil	4.0×10^{-5}
Propargite	3.0×10^{-3}
Propazine	1.3×10^{-7}
Propoxur	9.7×10^{-6}
Siduron	4.0×10^{-9}
Simazine	2.2×10^{-8}
Tebuthiuron	2.0×10^{-6}
Terbacil	3.1×10^{-7}
Terbufos	3.2×10^{-4}

TABLE 9.4-2 (CONTINUED)

Active Ingredient	Vapor Pressure (mm Hg at 20 to 25°C)
Thiobencarb	2.2×10^{-5}
Thiodicarb	1.0×10^{-7}
Toxaphene	4.0×10^{-6}
Triallate	1.1×10^{-4}
Tribufos	1.6×10^{-6}
Trichlorfon	2.0×10^{-6}
Trifluralin	1.1×10^{-4}
Triforine	2.0×10^{-7}

[a] From Wauchope, *et al.*, 1992. Vapor pressures of other pesticide active ingredients can also be found there.

TABLE 9.4-3

AVERAGE VOC CONTENT OF PESTICIDE INERT INGREDIENT PORTION, BY FORMULATION TYPE[a]

Formulation Type	Average VOC Content Of Inert Portion (wt. %)
Oils	66
Solution/liquid (ready to use)	20
Emulsifiable concentrate	56
Aqueous concentrate	21
Gel, paste, cream	40
Pressurized gas	29
Flowable (aqueous) concentrate	21
Microencapsulated	23
Pressurized liquid/sprays/foggers	39
Soluble powder	12
Impregnated material	38
Pellet/tablet/cake/briquette	27

TABLE 9.4-3 (CONTINUED)

Formulation Type	Average VOC Content Of Inert Portion (wt. %)
Wettable powder	25
Dust/powder	21
Dry flowable	28
Granule/flake	25
Suspension	15
Paint/coatings	64

[a] Written communication from California Environmental Protection Agency, Department of Pesticide Regulation, Sacramento, CA, to D. Safriet, U.S. Environmental Protection Agency, Research Triangle Park, NC. December 6, 1993.

TABLE 9.4-4
UNCONTROLLED EMISSION FACTORS FOR PESTICIDE ACTIVE INGREDIENTS[a]
(METRIC AND ENGLISH UNITS)

EMISSION FACTOR RATING: E

Vapor Pressure Range (mm Hg at 20° to 25°C)[b]	Emission Factor[c]	
	kg/Mg	lb/ton
Surface application		
(SCC 24-61-800-001)		
1×10^{-4} to 1×10^{-6}	350	700
$>1 \times 10^{-4}$	580	1,160
Soil incorporation		
(SCC 24-61-800-002)		
$<1 \times 10^{-6}$	2.7	5.4
1×10^{-4} to 1×10^{-6}	21	42
$>1 \times 10^{-4}$	52	104

[a] Factors are functions of application method and vapor pressure. SCC = Source Classification Code.
[b] See Wauchope *et al.*, 1992 for vapor pressures of specific active ingredients.
[c] Based on Jury, *et al.*, 1983a, Jury, *et al.*, 1983b, Jury, *et al.*, 1984a, Jury, *et al.*, 1984b, and Midwest Research Institute, 1994. Expressed as equivalent weight of active ingredients volatilized/unit weight of active ingredients applied.

(4) Calculate the total emissions

$$E = E_1 + E_2 \qquad (9.4\text{-}3)$$

where:

E = total emissions from pesticide applied during the 30 day period
E_1 = emissions from active ingredient
E_2 = emissions from inert ingredients

The 30-day period was chosen because (1) most pesticides volatilize within 30 days of application and (2) there are very few data available on pesticide volatilization based on field application studies with sampling times greater than 30 days.

Example 9.4-1 Farmco Atrazine Gesaprim® is surface applied to the soil surrounding corn at an annual rate of 3.5 lbs/year/acre. There are 15,000 acres of corn in the area.

From Table 9.4-1, Gesaprim®'s active ingredient is atrazine, with a vapor pressure (from Table 9.4-2) of 2.9 x 10^{-7} mm Hg at 20° to 25°C. The pesticide is an emulsifiable concentrate that is 52 percent active ingredient and 48 percent inert ingredient. From Table 9.4-4, the emission factor is 700 lb/ton and from Table 9.4-3, the VOC content of the inert portion of emulsifiable concentrates is 56 percent.

E_1 = 3.5 lbs/year/acre x 15,000 acres x 1 ton/2000 lbs x 0.52 x 700 lb/ton = 9,555 lbs/year

E_2 = 3.5 lbs x 15,000 acres x 0.48 x 0.56 = 14,112 lbs/year

4.2 NONAGRICULTURAL APPLICATIONS

4.2.1 MUNICIPAL

The preferred method for estimating emissions from municipal applications of pesticides involves using a survey to collect data on the pesticide use and total acreage. The following procedures should be followed:

(1) Survey state and local government agencies, state and local highway departments, local utility companies, and state and local park offices to determine:

- The amount of pesticides applied per acre;
- Total acres (parks, right-of-ways, etc.);
- The pesticides applied to those acres;
- The percent active and inert ingredients in the pesticides applied;
- The VOC content of the active and inert ingredients; and
- Times of year in which the pesticide was applied.

(2) Calculate a pesticide-specific VOC content for each pesticide that is applied in the study area.

$$PVP = (PA \times PVA) + (PI \times PVI) \qquad (9.4\text{-}4)$$

where:

PVP = pounds VOC per pound of pesticide applied
PA = fraction active ingredient in the pesticide applied
PVA = fraction VOC in the active ingredient of the pesticide applied
PI = fraction inert ingredient in the pesticide applied
PVI = fraction VOC in the inert ingredient of the pesticide applied

(3) Using the pesticide-specific VOC content developed with equation 9.4-4, calculate the total emissions.

$$\text{Total emissions} = PVP \times R \times A \times ER \qquad (9.4\text{-}5)$$

where:

PVP = pounds VOC per pound of pesticide applied
R = pounds of pesticide applied per year per acre
A = total acres
ER = evaporation rate (typically 0.9) (Wiens, 1977)

The seasonal adjustment factor should be calculated based on the information in Section 5.8 of the *Procedures* document.

Example 9.4-2 Assume County X has 1,000 acres of park land and 300 acres of other municipal land. Pesticide A is applied to 1,100 acres (900 acres of park land plus 200 acres of municipal land), and is 47 percent active ingredient (90 percent VOC) and 53 percent inert ingredient (60 percent VOC). Pesticide A is applied at 1.5 lbs per acre per year. Using Equations 9.4-4 and 9.4-5, emissions for County X are calculated as follows:

PVP = (0.47 x 0.90) + (0.53 x 0.60) = 0.741 lbs VOC per lb Pesticide A

Total emissions = 0.741 lb VOC/lb Pesticide A x 1.5 lbs Pesticide A/acre/yr x 1,100 acres x 0.9

Total emissions = 1,100 lb VOC/yr = 0.55 tons VOC/yr

The *Procedures* document assumes that the inert ingredient (solvent carrier) in the pesticide is 1.45 times the active ingredient (the amount of which can be found for most pesticides). Therefore, 2.45 times the active ingredient has the potential to be emitted as a VOC. The method in the *Procedures* document also assumes that 2 to 5 pounds of pesticide are applied per year per acre (average of 3.5 pounds of pesticide per year per acre). This range was derived from national pesticide use data, and can be used as a default or a check for the specific application rate, if necessary. Therefore, where the survey does not provide enough detail, the defaults of 2.45 pounds of VOC per pound of active ingredient and an average of 3.5 pounds of pesticide per year per acre can be used. However, at a minimum, the survey must provide information on the amount of active ingredients in the pesticides applied. Equation 9.4-6 shows the calculation used in this approach.

$$\text{Total emissions} = R \times PA \times PVP \times A \times ER \tag{9.4-6}$$

where:

R = pounds of pesticide applied per year per acre (in this approach, R = 3.5 pounds of pesticide per year, per acre)
PA = fraction active ingredient in the pesticide
PVP = pounds VOC per pound of active ingredient (in the approach, PVP = 2.45 pounds of VOC per pound of active ingredient)
A = total acres
ER = evaporation rate (typically 0.9) (Wiens, 1977)

Example 9.4-3 Again, assume County X has 1,100 acres of park and municipal land. However, while the survey did not provide any information on the application rate, it did indicate that 41 percent of the pesticide is active ingredient. Using default assumptions (2.45 pounds VOC per pound active ingredient and 3.5 pounds pesticide applied per year per acre), the calculation of total emissions is as follows:

Total emissions = 3.5 lb pesticide/yr/acre x 0.41 lbs active ingredient/lb pesticide x 2.45 lb VOC/lb active ingredient x 1,100 acres x 0.9

Total emissions = 3,481 lb VOC/yr = 1.74 tons VOC/yr

4.2.2 COMMERCIAL

The preferred method for estimating emissions from commercial applications of pesticides is to conduct a survey to gather information on each commercial pesticide application company. The following procedure should be used:

(1) Survey commercial pesticide application companies (exterminators and lawn care services) to determine the pesticides used, the formulation of the pesticides (indicating the active and inert ingredients), and the total amount applied in a given period.

(2) Calculate total emissions based on the information gathered in Step (1).

$$\text{Total emissions} = R \times PA \times PVA \times ER \qquad (9.4\text{-}7)$$

where:

R = pounds of pesticide applied per year
PA = fraction active ingredient in the pesticide applied
PVA = fraction VOC in the active ingredient or 2.45 pounds VOC per pound of active ingredient
ER = evaporation rate (typically 0.9) (Wiens, 1977)

If R is given in gallons, it will be necessary to convert to pounds by multiplying by the density of the pesticide. The density of the pesticide should be available from the manufacturer.

Example 9.4-4 An area surveys commercial pesticide application companies and determines that 1,500 gallons of pesticide X are used to eliminate fleas and ticks and 10,000 pounds of pesticide Y are used for lawn weed control. Pesticide X is 50 percent active ingredient. Pesticide Y is 45 percent active ingredient. Pesticide X has a density of 7.2 pounds per gallon. Using the Equation 9.4-7, total emissions are calculated as follows:

Total emissions of X = 1,500 gal/yr x 7.2 lbs/gal x 0.5 lbs active ingredient/lb pesticide x 2.45 lbs VOC/lb active ingredient x 0.9

Total emissions of X = 11,907 lbs VOC/yr = 5.95 tons VOC/yr

Total emissions of Y = 10,000 lbs/yr x 0.45 lbs active ingredient/lb pesticide x 2.45 lbs VOC/lb active ingredient x 0.9

Total emissions of Y = 9,923 lbs VOC/yr = 4.96 tons VOC/yr

Total emissions for area = 11,907 lbs VOC/yr + 9,923 lbs VOC/yr = 21,830 lbs VOC/yr = 10.9 tons VOC/yr

4.2.3 CONSUMER

Limited information is available on consumer use of pesticides. In 1992, EPA conducted a consumer/commercial products survey to determine the number of products, the sales of those products, and the VOC content of the products. From these data, EPA calculated estimates of emissions for specific product categories in pounds per 10,000 people and in tons for nonattainment areas. Chapter 5 of this volume titled *Consumer and Commercial Solvent Use* includes per capita emission factors for pesticide application. However, these per capita factors are based on a wide range of uses including consumer, municipal, and commercial. Multiplying the emission factor by the population yields total pesticides applied. Subtracting municipal and commercial use (using any of the methods described in this chapter) yields estimates of consumer usage.

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5

ALTERNATE METHODS FOR ESTIMATING EMISSIONS

5.1 AGRICULTURAL APPLICATIONS

5.1.1 PESTICIDE-SPECIFIC VOLATILE COMPONENT OF PESTICIDE APPLIED

This alternative method for estimating emissions from agricultural applications of pesticides uses a pesticide-specific volatile component of the pesticide, total acreage, and application rate. The following procedures should be followed:

(1) Collect data on:

- The total harvested acreage by crop in the study area;
- The pesticides used for each crop;
- The time of year when the pesticide is typically applied to the crop. If the application time is not during the inventory season, it may not be necessary to estimate emissions for that pesticide;
- The application rate of each pesticide for each crop; and
- The percent active and inert ingredients and the VOC contents of each ingredient for each pesticide used.

Some states may gather this information periodically, mainly on an annual basis. In addition, many states publish an annual handbook which contains suggested pesticides for a particular crop and suggested application rates. When this information is not already compiled, it can be collected from other sources. Acreage by crop data can be found in the following sources:

- The Department of Commerce Bureau of Census publication *Census of Agriculture*[2] includes county level harvested acres by crop and other data that can be helpful in estimating emissions. However, the *Census of Agriculture* is published at 5 year intervals for years ending in "2" and "7" and may not be available for the inventory year. Inventory preparers will need to decide whether the data in this publication is suitable for their inventory area.

- The United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS)[3] maintains county statistics on production for major crops and farm acreage.

- State agricultural departments and state commerce departments may also compile the acreage of major crops in each county.

Although detailed information about the type of pesticide used, the time of application and the pesticide-specific application rate for each county's crops may not be available, reasonable estimates can be made based on local recommended practices. It is best to identify crops that have either high rates of pesticide use or are the most significant crops in the area, so that inventory personnel can focus their efforts on crops that are the most significant sources of emissions in their area. Local agricultural extension agents can discuss the typical pesticide treatment, application time, and application rate. Agricultural chemical suppliers can discuss the recommended practices for the major crops in an area. State universities with agricultural schools also can be contacted for recommended pesticide usage practices. When several counties in an inventory area have similar crops, only one contact may be necessary to collect data on all of the crops and pesticides.

Agricultural extension agents, agricultural chemical suppliers, and agricultural university experts may also be sources of information about total VOC content of the pesticides used in the area.

(2) Calculate the pesticide-specific VOC content of the pesticide applied.

$$PVP = (PA \times PVA) + (PI \times PVI) \qquad (9.5\text{-}1)$$

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[2] The *Census of Agriculture* is published every 5 years by the U.S. Department of Commerce, Bureau of Census, Washington, D.C. Information about the Census can also be found on the Bureau of Census Website at: http://www.census.gov/.

[3] At the time of this writing, NASS maintains a World Wide Web site at: http://www.usda.gov.nass/. Links are available to state offices. NASS can also be contacted through the NASS Information Hotline at: 1-800-727-9540.

where:

PVP = pounds VOC per pound of pesticide applied
PA = fraction active ingredient in the pesticide applied
PVA = fraction VOC in the active ingredient in the pesticide applied
PI = fraction inert ingredient in the pesticide applied
PVI = fraction VOC in the inert ingredient in the pesticide applied

(3) Using the pesticide-specific VOC content developed in Step (2), calculate the total emissions.

$$\text{Total emissions} = PVP \times R \times A \times ER \qquad (9.5\text{-}2)$$

where:

PVP = pounds VOC per pound of pesticide applied
R = pounds of pesticide applied per year per harvested acre
A = total harvested acres
ER = evaporation rate (typically 0.9) (Wiens, 1977)

This procedure would be followed for each pesticide and each crop for which it is used.

<u>Example 9. 5-1</u> Pesticide A is applied to corn at an annual rate of 3.8 lbs/year/acre. There are 2,100 acres of corn in the area. Pesticide A is 47 percent active ingredient (90 percent VOC) and 53 percent inert ingredient (60 percent VOC).

Using the above equations, total emissions from Pesticide A applied to corn in this area are calculated as follows:

PVP = (0.47 x 0.90) + (0.53 x 0.60) = 0.741 lbs VOC/lb Pesticide A applied

Total emissions = 0.741 lbs VOC/lb Pesticide A x 3.8 lbs Pesticide A/yr/acre x 2,100 acres x 0.9

Total emissions = 5,322 lbs VOC/yr = 2.7 tons VOC/yr

5.1.2 DEFAULT VOLATILE ORGANIC COMPONENT OF PESTICIDE APPLIED

Another alternative method for estimating emissions is to use a default for the VOC content of the pesticide. This method also requires the use of total acreage and application rate. The following procedures should be followed:

(1) Contact State Agricultural Departments to collect data on:

- The total harvested acreage by crop in the county/nonattainment area;
- The pesticides used for each crop;
- The application rate of each pesticide for each crop; and
- The percent active ingredient for each pesticide used.

(2) Calculate the total emissions using the information gathered in Step (1). The *Procedures* document assumes that the inert ingredient (solvent carrier) in the pesticide is 1.45 times the active ingredient (the amount of which can be found for most pesticides) (EPA, 1991). Therefore, 2.45 times the active ingredient has the potential to be emitted as a VOC. The following equation is the same as the equation for the preferred method; however, a default VOC content of 2.45 pounds VOC per pound active ingredient is assumed in place of the pesticide-specific VOC content (PVP).

$$\text{Total emissions} = A \times R \times I \times ER \times 2.45 \text{ pounds VOC/pound active ingredient} \quad (9.5\text{-}3)$$

where:

A = total harvested acres
R = pounds of pesticide applied per year per harvested acre
I = pounds of active ingredient per pound of pesticide
ER = evaporation rate (typically 0.9) (Wiens, 1977)

Again, this procedure would be followed for each pesticide and each crop for which it is used.

Example 9.5-2 Assume an area has 800,000 acres of corn and 2.9 lbs of pesticide are applied per year per harvested acre. The pesticide contains 0.8 lbs of active ingredient (AI) per lb of pesticide (P).

Using the equation above, total emissions are calculated as follows:

Total emissions = 800,000 acres x 2.9 lbs P/acre x 0.8 lbs AI/lb P x 2.45 lbs VOC/lb AI x 0.9

Total emissions = 4,092,480 lbs VOC/yr = 2,046 tons VOC/yr

The method in the *Procedures* document assumes that 2 to 5 lbs of pesticide are applied per year per harvested acre (average of 3.5 lbs of pesticide per year per harvested acre). This range was derived from national pesticide use data, and can be used as a default or a check for the specific application rate, if necessary.

5.1.3 VOLATILITY/BIODEGRADABILITY METHOD

The final alternative method for calculating emissions takes into consideration the volatility and the biodegradability of the pesticide (CARB, 1991). The data that are used in the methodology are available through the California Department of Food and Agriculture's Pesticide Use Report. The methodology classifies pesticides into the following four categories:

- Very low volatility pesticides;
- High volatility pesticides;
- Semi-volatile pesticides that are highly absorbed; and
- Semi-volatile pesticides that are highly biodegradable.

Table 9.5-1 provides a list of highly absorbed and highly biodegradable semi-volatile pesticides. For those pesticides with very low volatility (vapor pressure less than 10^{-7} mm Hg), the pesticide is assumed not to volatilize and therefore has no emissions associated with its application (Li, 1981). For those pesticides that are highly volatile (vapor pressure greater than 0.3 mm Hg), the amount of pesticide that is applied is assumed to equal the total emissions from that pesticide because it will completely evaporate within a month of the application (Seiber, *et al.*, 1983).

TABLE 9.5-1

SEMI-VOLATILE PESTICIDES[a]

Highly Adsorbed Pesticides[b]		
Azinphosmethyl	Fenac	Picloram
Chlordane	Fluchloralin	Tebuthiuron
Chloroxuron	Heptachlor	
Dichlobenil	Nitralin	
Highly Biodegradable Pesticides[c]		
Alachlor	Bentazon	IPC (Propham)
Amitrole	Bromoxynil Octanoate	Monocrotophos
Ammonium Ethyl Carbamoylphosphonate	Dalapon	Propanil
Barban	Eptam	2-4-D

[a] Data in this table has been drawn from Matsumura and Murti, 1982; Wangern, 1983; Verschueren, 1983; Weed Science Society of America, 1979; and Worthing, 1979.

[b] Pesticides that persist for one year or more and are not considered to undergo biological degradation.

[c] Pesticides that undergo complete biodegradation within 30 days and are not considered subject to sequestration. Assume loss due to biodegradation will be 30 percent per month.

Special calculation procedures were developed for the semi-volatile pesticides. Figure 9.5-1 is a flow chart of the process. Due to pesticide applications being reported in acres as well as other units (such as gallons), equations exist for each type of application units (this does not affect the process as outlined in Figure 9.5-1).

$$\text{For acreage applications, emissions during application} = A_1 - A_2 \qquad (9.5\text{-}4)$$

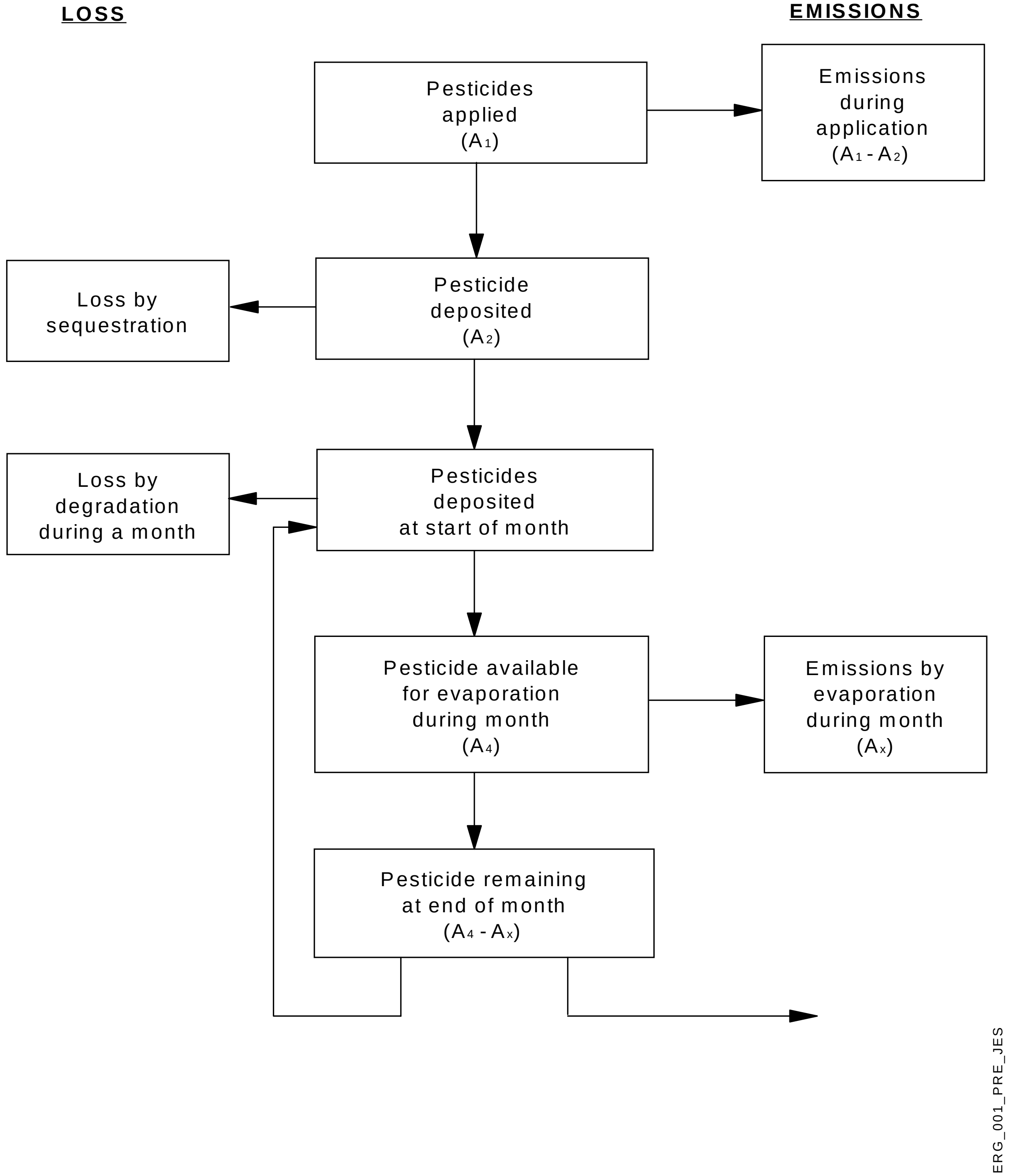

FIGURE 9.5-1

FLOWCHART OF EMISSIONS ESTIMATION METHOD FOR SEMI-VOLATILE PESTICIDES

where:

A_1 = total pesticide applied per acre
A_2 = total pesticide deposited per acre

To calculate A_2, use the following equation:

$$A_2 = A_1 \times (1 - [4.625 \times (\log P_i + 7) \times (0.0024 \times T^2) \times 0.01] \qquad (9.5\text{-}5)$$

where:

P_i = vapor pressure of pesticide i (mm Hg at 20°C)
T = average temperature in the month of application (°C)

It is assumed that 2 percent of the amount of pesticide deposited is lost by sequestration and that an additional 4 percent of the remaining amount of pesticide (after sequestration) is lost by biodegradation. Therefore, the calculation of those losses is as follows:

$$A_3 = (1 - 0.02) \times A_2 \qquad (9.5\text{-}6)$$

where:

A_3 = remaining pesticide per acre after sequestration
A_2 = total pesticide deposited per acre

$$A_4 = (1 - 0.04) \times A_3 \qquad (9.5\text{-}7)$$

where:

A_4 = remaining pesticide per acre after loss by biodegradation
A_3 = remaining pesticide per acre after sequestration

In order to calculate the emissions on a monthly basis, the maximum monthly evaporation rate must be calculated. The Hartley Equation is used to calculate the maximum monthly evaporation rate as follows (Hartley, 1969):

$$E_p = [E_A/(1-RH)] \times [(P_i \times M_i^{0.5})/(P_w \times M_w^{0.5}) \qquad (9.5\text{-}8)$$

where:

E_p = the maximum evaporation rate of compound i in lbs/acre during the month p (E_p is calculated for each month)
E_A = adjusted water evaporation rate in lbs/acre
RH = average relative humidity during the month p (in percent)
P_i = vapor pressure of compound i at cited temperature (mm Hg)
M_i = molecular weight of compound i
P_w = vapor pressure of water at cited temperature (mm Hg)
M_w = molecular weight of water

E_A is equal to 0.73 x E, 0.40 x E, and 0.70 x E for applications to vegetated land, soil surfaces, and water surfaces, respectively. E is equal to the inches of water evaporated times 226,600 pounds per inch of water on one acre.

The monthly emissions from the deposited pesticide are calculated by the following equation:

$$k \times t = 2.303 \times \log[A_4/(A_4 - A_x)] \quad (9.5\text{-}9)$$

where:

k = rate constant
t = time in days
A_4 = remaining pesticide after loss by biodegradation in lbs per acre
A_x = pounds of pesticide evaporated per acre in any month for time t

This is an iterative process starting with t=1 and solving for k. The calculation of monthly emissions would continue by calculating the losses and following the steps outlined above until A_x is less than 0.1 pounds per acre or 12 months have passed since the application. The calculation is best illustrated with an example (see Example 9.5-3).

5.2 NONAGRICULTURAL APPLICATIONS

The alternative method for estimating emissions is through the use of national per capita emission factors for nonagricultural pesticide uses provided in Chapter 5 of this volume, titled "Consumer and Commercial Solvent Use."

Example 9.5-3 Assume that an area applies mineral oil as an insecticide to nectarines. The vapor pressure of mineral oil is 7.4 x 10^{-6} mm Hg, and its molecular weight is 327. Assume that 182 pounds of the insecticide are applied in February on 23 acres of nectarines. The average temperature in February is 10.28°C, with a relative humidity of 75 percent and a water evaporation rate of 2.46 inches. The vapor pressure of water is 17.535 mm Hg, and its molecular weight is 18.

Emissions during application
A_2 = 182/23 x (1 - [(4.625) x (log 7.4E^{-6} + 7) x (0.0024) x (10.28^2) x (0.01)]) (9.5-5)
A_2 = 7.74 lbs/acre deposited

A_1 - A_2 = 182/23 -178/23 = 0.17 lbs/acre emitted during application (9.5-4)

Loss by sequestration
A_3 = (1 - 0.02)(7.74) = 7.6 lbs/acre deposited after sequestration (9.5-6)

Loss by biodegradation
A_4 = (1 - 0.04)(7.6) = 7.3 lbs remaining after loss by biodegradation (9.5-7)

Maximum evaporation rate
E_p = [(0.73 x 2.46 x 226,600)/(1-0.75)] x [(7.4 x 10^{-6} x $327^{0.5}$)/(17.535 x $18^{0.5}$)] (9.5-8)
E_p = 2.93 lbs/acre

Monthly emissions

solve for k at t = 1 day

A_4 = 7.3 lbs/acre
A_x = 2.93 lbs/acre/30 days = 0.0976667

k x 1 = 2.303 log [7.3/(7.3 - 0.0976667)] (9.5-9)
k = 0.0134717

then solve for A_x
0.0134717 x 30 = 2.303 log [7.3/(7.3 - A_x)]
7.3/(7.3 - A_x) = antilog (0.1754889)
A_x = 2.426 lbs/acre during the month

Therefore the total emissions in February are:
Total emissions = (A_1 - A_2) + A_x x acres
Total emissions = 4 + 2.426 x 23 = 59.8 lbs

To determine whether to continue the calculation of monthly emissions, determine the remaining pesticide that is available for the next month as follows:

A_4 - A_x = 7.3 - 2.426 = 4.874 lbs/acre, which is greater than 0.1 lbs/acre, therefore the calculation is continued for the month of March following the same procedure as outlined above.

5.3 METHOD FOR ALL USERS: TOP-DOWN SOLVENT USE METHOD

Another alternative type of methodology involves the estimation of national solvents consumption, spatial allocation of consumption to counties, and application of local control regulations. Estimation of national consumption is based on a material balance approach, since this is the best way of ensuring that the inventory covers all solvents emissions. A detailed description and application of this method with emission calculations can be found in (*reference project report*). The steps required for this method are:

- Estimate solvents consumption for this source category at the national level. These data can be obtained from solvents industries studies (*reference project report*).
    - Apply growth indicator, if national solvent consumption data from industry studies are not available for the target inventory year:
        - Use national solvent consumption projections for the target inventory year from industry studies, or extrapolate between past and future years that span the target inventory year, using data obtained from the same national solvent consumption data from industry studies.
        - Use BEA estimates of future employment and Census projections of population to project solvent use from national solvent consumption data from industry studies for previous years.
- Estimate county-level solvents consumption (S) from national data in the same proportions as employment for this source category. The following equation is used to allocate national consumption to counties:

$$S_{cty} = S_{nat} * F_{nat,\ cty} \qquad (9.5.10)$$

where:

S_{cty} = County solvent consumption

S_{nat} = National solvent consumption

$F_{nat,\ cty}$ = Spatial allocation factor for the county: the ratio of employment in the county to nationwide employment

Note: Employment data at a county level are available in the County Business Patterns database (U.S. DOC).

- Incorporate the effects of national, state, and local regulations[1] into spatial allocation to counties. On the state/local level, stricter controls in some states/counties than in others has the effect of moving some of the solvent emission from the more highly controlled counties/states into other counties/states. (*Reference project report*).

  - Estimate the extent of recycling and waste management practices in the source category.

- Subtract out point source solvent use, using the method described in Section 3.2.2. Point sources should be accounted for, and subtracted out from, the solvent consumption that is allocated to the county level. Point source solvent consumption for the category may be determined from the emission factor(s) used or from other underlying consumption data if available. Otherwise, the point source activity (solvent consumption) may be assumed equal to point source (uncontrolled) emissions, and that proportion subtracted from the total county solvent consumption.

- The emission factor used in converting solvents to VOC[2] emissions is complete conversion of consumption to emission (2000 lbs solvent/ton VOC) adjusted for controls/regulations,[1] recycling and waste management, and processes that consume solvents with no emissions. For activity data in terms of product/coating consumption, emission factors account for the amount of solvent in the product/coating by including a solvent content factor.

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[1] State any assumptions made to include national/state/local regulations and the exact regulation applied. Clarify any issues related to regulation and control assumptions. The final emissions estimates are **highly** dependent on these assumptions, therefore they must be stated explicitly in all documentation.

[2] The solvents consumption information is identified by solvent chemical and type of source. Some of the solvents chemicals are HAPs, and one could follow a similar process as the above method (which estimates VOC not individual chemicals to obtain estimates for some HAPs.

6

QUALITY ASSURANCE/ QUALITY CONTROL

Data collection and handling for this source category should be planned and documented in the Quality Assurance Plan. When using survey methods, the survey planning and data handling should also be documented. Refer to the discussion of survey planning and survey QA/QC in Chapter 1, *Introduction to Area Source Emission Inventory Development*, of this volume, and Volume VI, *Quality Assurance Procedures*, of the Emission Inventory Improvement Program (EIIP) series. Potential pitfalls when developing emission estimates by using a survey for this category are data gaps due to surveys not returned; unanswered or misunderstood survey questions; inappropriate assumptions used to compensate for missing information or scaling up the survey sample; errors in compiling the returned survey information; and calculation errors, which can include unit conversion errors, and data handling errors.

6.1 EMISSION ESTIMATE QUALITY INDICATORS

The Data Attribute Rating System (DARS) has been developed as a tool to rate emission inventories. A description of the system and the EIIP recommendations for its use can be found in Appendix F of EIIP Volume VI, *Quality Assurance Procedures.* The following discussion uses the DARS rating system as a way to compare the estimation approaches presented in this chapter and analyze their strengths and weaknesses.

For agricultural pesticide emission estimates, the third alternative method gives higher Data Attribute Rating System (DARS) scores, but requires more effort than the other methods. The preferred method for agricultural pesticide gives the next highest DARS scores.

The lowest potential DARS score assigned to any of the methods is assigned to the preferred method for consumer pesticide use. The method recommends using the pesticide use portion of the emission factor from Chapter 5 of this volume, *Consumer and Commercial Solvent Use*, for consumer pesticide use. However, this factor has been developed for consumer and commercial (which includes municipal) users and must be corrected by subtracting the estimated municipal and commercial emissions in order to estimate consumer pesticide use only. The alternative method for municipal, commercial, and consumer pesticide use recommends using the unadjusted pesticide use emission factor from Chapter 5 of this volume to estimate emissions for all of these users. It is more suitable in this case, and has a higher DARS score. Another advantage of using this alternative method is that it is a straightforward and economical approach.

6.1.2 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

The DARS scores for each method are summarized in Tables 9.6-1 through 9.6-7. A range of scores is provided for the methods because the implementation of these methods can vary. The higher scores assume that reliable data were collected specifically for the inventory area and time period, and few, if any, assumptions or generalizations have been made in the data gathered. All scores assume that satisfactory QA/QC measures are performed and no significant deviations from good inventory practices have been made. If these assumptions are not met, new DARS scores should be developed according to the guidance provided in Appendix F of EIIP Volume VI.

The preferred method for agricultural pesticide use is to collect detailed data on pesticide usage and type, and estimate emissions based on the pesticide formulation vapor pressure and application method. DARS scoring for this method is shown in Table 9.6-1. The preferred method for municipal and commercial pesticide use and the first alternative method for agricultural pesticide use collect information on the amount of active and inert ingredients and assume a standard emission rate. DARS scores for these sources are shown in Tables 9.6-2 and 9.6-3. The second alternative method for agricultural pesticide use is similar to the first alternative method, but uses a default proportion of active to inert ingredients. DARS scores for the second alternative method for agricultural pesticides are shown in Table 9.6-4. In each of these methods, the approach is similar, but the method of calculating emissions becomes more generalized and consequently, DARS scores for the emission factor become lower. The third alternative method for agricultural pesticide use collects detailed data on pesticide usage and type, and estimates emissions based on the pesticide formulation vapor pressure, local temperatures, and reductions from sequestration and biodegradation. The DARS scores for this method are shown in Table 9.6-5.

The preferred method for consumer pesticide use calculates emissions from the per capita pesticide usage factor provided in Chapter 5 of this volume for all municipal, commercial, and consumer pesticide use, and then subtracts the estimated emissions from commercial and municipal users collected by survey. Because the preferred method for municipal and commercial pesticide use is based on local survey data, it will provide an estimate that reflects local usage. If these emission estimates are significantly different from the national average (which is inherent in the pesticide usage factor in Chapter 5), then using the surveyed estimates for municipal and commercial pesticide use to adjust the consumer estimate will skew the estimate for consumer pesticide use in a manner that is opposite from the most likely local consumption level.

TABLE 9.6-1

PREFERRED: AGRICULTURAL PESTICIDE USE

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5 - 0.5	0.3 - 0.9	0.15 - 0.45
Source Specificity	0.6 - 0.8	0.4 - 0.9	0.24 - 0.72
Spatial Congruity	0.7 - 0.8	0.7 - 1	0.49 - 0.8
Temporal Congruity	0.5 - 0.8	0.7 - 0.9	0.35 - 0.72
Composite Scores	0.58 - 0.73	0.53 - 0.93	0.31 - 0.67

TABLE 9.6-2

PREFERRED: MUNICIPAL AND COMMERCIAL PESTICIDE USE

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.3 - 0.4	0.3 - 0.6	0.09 - 0.24
Source Specificity	0.5 - 0.7	0.3 - 0.6	0.15 - 0.42
Spatial Congruity	0.6 - 0.7	0.6 - 0.9	0.36 - 0.63
Temporal Congruity	0.5 - 0.5	0.7 - 0.9	0.35 - 0.45
Composite Scores	0.48 - 0.58	0.48 - 0.75	0.24 - 0.44

TABLE 9.6-3

ALTERNATIVE 1: AGRICULTURAL PESTICIDE USE

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.3 - 0.4	0.3 - 0.6	0.09 - 0.24
Source Specificity	0.5 - 0.7	0.3 - 0.6	0.15 - 0.42
Spatial Congruity	0.6 - 0.6	0.6 - 0.9	0.36 - 0.54
Temporal Congruity	0.5 - 0.5	0.7 - 0.9	0.35 - 0.45
Composite Scores	0.48 - 0.55	0.48 - 0.75	0.24 - 0.41

TABLE 9.6-4

ALTERNATIVE 2: AGRICULTURAL PESTICIDE USE

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.3	0.3 - 0.6	0.09 - 0.18
Source Specificity	0.5	0.5 - 0.7	0.25 - 0.35
Spatial Congruity	0.6	0.6 - 0.9	0.36 - 0.54
Temporal Congruity	0.5	0.7 - 0.9	0.35 - 0.45
Composite Scores	0.48	0.53 - 0.78	0.26 - 0.38

TABLE 9.6-5

ALTERNATIVE 3: AGRICULTURAL PESTICIDE USE

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.5 - 0.5	0.3 - 0.9	0.15 - 0.45
Source Specificity	0.7 - 0.8	0.7 - 0.9	0.49 - 0.72
Spatial Congruity	0.7 - 0.8	0.7 - 1	0.49 - 0.8
Temporal Congruity	0.8 - 0.8	0.7 - 0.9	0.56 - 0.72
Composite Scores	0.68 - 0.73	0.6 - 0.93	0.42 - 0.67

TABLE 9.6-6

PREFERRED: CONSUMER PESTICIDE USE

Attribute	Scores		
	Factor	**Activity**	**Emissions**
Measurement	0.3	0.6	0.18
Source Specificity	0.5	0.5	0.25
Spatial Congruity	0.5	0.5	0.25
Temporal Congruity	0.6	0.9	0.54
Composite Scores	0.48	0.63	0.31

TABLE 9.6-7

ALTERNATIVE 1: MUNICIPAL, COMMERCIAL, AND CONSUMER PESTICIDE USE

Attribute	**Scores**		
	Factor	**Activity**	**Emissions**
Measurement	0.3	0.6	0.18
Source Specificity	0.7	0.5	0.35
Spatial Congruity	0.6	0.9	0.54
Temporal Congruity	0.6	0.9	0.54
Composite Scores	0.55	0.73	0.40

The unadjusted per capita emission factor is also recommended as the first alternative method for municipal, commercial and consumer pesticide use. A discussion of QA/QC for the per capita method can be found in Chapter 5 of this volume, but the DARS scores for the use of the per capita pesticide factor have been compiled for the preferred consumer method and the first alternative municipal, commercial, and consumer method, and are shown in Tables 9.6-6 and 9.6-7.

Scores for these methods are presented as ranges to allow for variability in data collection and the use of assumptions. The upper range of scores can be used as long as survey responses are complete and few assumptions have been made. However, assumptions about the pesticides used in an area, the volatility of a pesticide, or the proportion of volatile organic compounds (VOC) to the amount of active ingredients will result in lower scores. Temporal congruity DARS scores may need to be lowered if emissions are estimated for a longer or shorter time period than the inventory time period, and the estimates are apportioned to the inventory time period without adjustment for variations in usage or temperature. When using these methods, inventory preparers are cautioned to consider the feasibility of the methods and the detail necessary to develop an estimate that merits the higher score.

DARS scoring attributes were originally developed for rating emission factor-based methods (EIIP Volume VI, Appendix F). When applying DARS scores to methods that use more than emission and activity factors in the calculation, it is useful to review which DARS attribute covers which part of the emission estimation method. For the methods described in this chapter, the DARS attributes reflect the following qualities:

- Measurement -- The quality and reliability of the data used as variables in the emission estimation equation. For this source category, this attribute is used to show how well the method (material balance) takes all the potential variables affecting emission rates into account;

- Source Specificity -- The specificity of the equation to the actual emission process, the choices of variables used or not used in the emission estimation equation, or the use of surrogate variables in the equation;

- Spatial Congruity -- The variability in emissions that may be introduced by local climate, terrain, or other environmental factors, and the scaling of data used in the emission estimation equations for the inventory area; and

- Temporal Congruity -- The specificity of the method and the data used in the method to the temporal scale of the inventory.

6.1.3 SOURCES OF UNCERTAINTY

Another way to evaluate the emission estimates is to examine the associated uncertainty. For estimates derived from survey data, the uncertainty can be quantified (see Chapter 4 of Volume VI of the EIIP series). Statistics needed to quantify the uncertainty of emissions derived by the per capita emission factor method are incomplete. Please refer to Chapter 5 of this volume, *Consumer and Commercial Solvent Use*, for further discussion of the uncertainties associated with the use of these emission factors.

There are a number of sources of uncertainty in estimating emissions from this source category. Emissions from pesticide use depend on variables such as the amounts and types of pesticides used, application method, the timing of the application relative to the inventory period, and meteorology. Data collection alone for this number of variables is likely to be a source of uncertainty. The preferred method for consumer pesticide use, which adjusts a national average per capita emission factor with the estimated emissions from municipal and commercial use surveys, is affected by the associated uncertainty of both the emission factor and the surveys of commercial and municipal pesticide usage.

The preferred emission estimation methods for agricultural, municipal, and commercial pesticide emissions, and the third alternative method for agricultural pesticide emissions are based on the actual amount and types of pesticides used, and include more of the potential variables in their respective emission estimation equations. These methods can be viewed as being the least uncertain of the methods presented here. The remaining alternative methods have increasingly uncertain results as more and more assumptions are made.

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7

DATA CODING PROCEDURES

The inventory preparer should check the EPA website (http://www.epa.gov/ttn/chief/) for the latest information (codes) available to characterize emission estimates from agricultural and non-agricultural pesticides. A complete list of Source Classification Codes (SCC) can be retrieved at http://www.epa.gov/ttn/chief/codes/. Table 9.7-1 lists the applicable SCCs for agricultural and non-agricultural pesticides.

Available codes and process definitions influence and help guide the preparation of emission estimates for this category. Data transfer formats should be taken into account when an inventory preparer plans for data collection, calculation, and inventory presentation. Consistent categorization and coding will result in greater continuity between emission inventories for use in regional and national scale analyses.

7.1 NECESSARY DATA ELEMENTS

If the category emissions data will be transferred to EPA for incorporation into the national criteria and toxics air pollutant inventory, specific data transfer formats are acceptable. The acceptable data transfer format(s) are described and available for download at http://www.epa.gov/ttn/chief/net/. The acceptable data transfer formats contain the data elements necessary to complete the data set for use in regional or national air quality and human exposure modeling. The inventory preparer should review the area source portion of the acceptable file format(s) to understand the necessary data elements. The EPA describes its use and processing of the data for purposes of completing the national inventory, in its Data Incorporation Plan, also located at http://www.epa.gov/ttn/chief/net/.

TABLE 9.7-1

AREA AND MOBILE SOURCE CATEGORY CODES FOR AGRICULTURAL AND NONAGRICULTURAL PESTICIDES APPLICATIONS

Process Description	Source Category Code
Pesticide Application: Herbicides - Corn	24-61-850-001
Pesticide Application: Herbicides - Apples	24-61-850-002
Pesticide Application: Herbicides - Grapes	24-61-850-003
Pesticide Application: Herbicides - Potatoes	24-61-850-004
Pesticide Application: Herbicides - Soybeans	24-61-850-005
Pesticide Application: Herbicides - Hay and Grain	24-61-850-006
Pesticide Application: Herbicides - Misc. Agricultural Use	24-61-850-009
Pesticide Application: Other Pesticides - Corn	24-61-850-051
Pesticide Application: Other Pesticides - Apples	24-61-850-052
Pesticide Application: Other Pesticides - Grapes	24-61-850-053
Pesticide Application: Other Pesticides - Potatoes	24-61-850-054
Pesticide Application: Other Pesticides - Soybeans	24-61-850-055
Pesticide Application: Other Pesticides - Hay and Grain	24-61-850-056
Pesticide Application: Other Pesticides - Misc. Agricultural Use	24-61-850-099
Pesticide Application: Nonagricultural Use	24-61-870-999

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REFERENCES

Aspelin, A.L., A.H. Grube, and V. Kibler. 1991. *Pesticide Industry Sales and Usage: 1989 Market Estimates*. U.S. Environmental Protection Agency, H-7503. Washington, D.C.

Baker, Scott R., and C. F. Wilkinson, Eds. 1990. Advances in Modern Environmental Toxicology, Volume XVII - The Effects of Pesticides on Human Health. Princeton Scientific Publishing Co., Inc., Princeton, NJ.

CARB. 1991. *Methods for Assessing Area Source Emissions in California*. California Air Resources Board, Emission Inventory Branch, Sacramento, California.

EPA. 1996. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition*, AP-42. U.S. Environmental Protection Agency, (GPO 055-000-00251-7). Research Triangle Park, NC.

EPA. 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Volume I: General Guidance for Stationary Sources*. U.S. Environmental Protection Agency, EPA-450/4-91-016. Research Triangle Park, North Carolina.

Hartley, G.S. 1969. *Evaporation of Pesticides*. Advanced Chemistry Series. American Chemical Society. 86:115.

Jury, W.A., *et al*. 1993. Use of Models for Assessing Relative Volatility, Mobility, and Persistence of Pesticides and Other Trace Organics in Soil Systems. *Hazard Assessment Of Chemicals: Current Developments*, 2:1-43.

Jury, W.A., *et al*. 1984. Behavior Assessment Models For Trace Organics In Soil: II. Chemical Classification And Parameter Sensitivity. *Journal of Environmental Quality* 13(4):567-572.

Jury, W.A., *et al*. 1984. Behavior Assessment Models For Trace Organics In Soil: III. Application Of Screening Model. *Journal of Environmental Quality* 13(4):573-579.

Jury, W.A., *et al*. 1983. Behavior Assessment Models For Trace Organics In Soil: I. Model Description. *Journal of Environmental Quality* 12(4):558-564.

Li, Ming-Yu. 1981. *Recommendations for the Future Use of the Pesticide Use Report Data to Estimate the Hydrocarbon Emissions Resulting From Pesticide Applications in California*. Prepared for California Air Resources Board under Contract Number A0-050-54.

Matsumura, F. and G.R. Krishma Murti, Editors. 1982. *Biodegradation of Pesticides*. Premium Press, New Jersey.

Midwest Research Institute. 1994. Emission Factor Documentation For AP-42 Section 9.2.2, Pesticide Application. EPA Contract No. 68-D2-0159. Kansas City, MO. September 1994.

Seiber, James, J. Woodward and Y. Kim. 1983. *Evaporation of Petroleum Hydrocarbon Pesticides Under Controlled and Field Conditions*. Prepared for California Air Resources Board under Contract Number A1-037-32 by the Department of Environmental Toxicology, University of California, Davis.

The Freedonia Group, Inc. 1989. *Industry Study #264 - Solvents*, Cleveland, OH.

Wagner, S.L. 1983. *Clinical Toxicology of Agricultural Chemicals*. Noyes Data Corporation. New Jersey.

Wauchope, R.D., *et al*. 1992. The SCS/ARS/CES Pesticide Properties Database for Environmental Decision-making. *Review of Environmental Contamination and Toxicology*. Springer-Verlag. New York.

Weed Science Society of America. 1979. *Herbicide Handbook*.

Wiens, F.J., *Reactive Organic Gas Emissions from Pesticide Use in California*. California Air Resources Board, Report No. PD-777-002. Sacramento, California.

Worthing, C.R. Editor. 1979. *The Pesticide Manual*. British Crop Protection Council. London, England.

USDA. 1992. *Agricultural Chemical Usage: 1991 Field Crops Summary*. U.S. Department of Agriculture, Washington, DC.

Verschueren, K. 1983. *Handbook of Environmental Data on Organic Chemicals*. Van Nastrand Reinhold Company. New Jersey.