VOLUME III: CHAPTER 14

TRAFFIC MARKINGS

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Prepared by:
Eastern Research Group
Post Office Box 2010
Morrisville, North Carolina 27560-2010

Prepared for:
Area Sources Committee
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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Charles Mann, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency
Carolyn Lozo, California Air Resources Board
Kwame Agyei, Puget Sound Air Pollution Control Agency
Mike Fishburn, Texas Natural Resource Conservation Commission
Gwen Judson, Wisconsin Department of Natural Resource
George Leney, Allegheny County Health Department
Charles Masser, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency
Linda Murchison, California Air Resources Board
Sally Otterson, Washington Department of Ecology
Lee Tooly, Emission Factor and Inventory Group, U.S. Environmental Protection Agency
Jim Wilkinson, Maryland Department of the Environment

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INTRODUCTION

This chapter describes the procedures and recommended approaches for estimating emissions from traffic markings. Section 2 of this chapter contains a general description of the traffic marking category and an overview of available control technologies. Section 3 of this chapter provides an overview of available emission estimation methods. Section 4 presents the preferred emission estimation method for traffic markings, and Section 5 presents alternative emission estimation techniques. Quality assurance and control (QA/QC) procedures are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7, and Section 8 is the reference section.

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SOURCE CATEGORY DESCRIPTION

Traffic marking operations consist of marking of highway center lines, edge stripes, and directional markings and painting on other paved and nonpaved surfaces, such as markings in parking lots. Materials used for traffic markings include solvent-based paints, water-based paints, thermoplastics, preformed tapes, field-reacted materials, and permanent markers. Solvent-based formulations of alkyd resins or chlorinated rubber resins are the most commonly used traffic paints. This chapter focuses on applications of traffic paints that emit a significant quantity of volatile organic compounds (VOCs). The use of traffic paints is entirely an area source.

Traffic paints are applied by maintenance crews or by contractors during new road construction, resurfacing, and other maintenance operations. The method of application is usually a spray. The paints are subjected to harsher conditions than most other paints and must withstand wear from tires, rain, sun, and other environmental factors for a considerable period of time.

Solvent- and water-based paints have roughly the same durability, with both beginning to deteriorate about a year after their application. Both solvent- and water-based paints must be applied in dry conditions and at temperatures above 40°F. If applied properly, water-based paint is considered to be of better quality than solvent-based paint; however, application of water-based paint is more susceptible to weather constraints such as humidity. Plastic-based paints (i.e., thermoplastics, preformed tapes, and field-reacted systems) are more durable than either solvent- or water-based paints.

2.1 EMISSION SOURCES

VOC emissions result from the evaporation of organic solvents during and shortly after the application of the marking paint. Of the painting materials commonly used for traffic marking, three types emit VOCs in appreciable amounts:

- Nonaerosol traffic paint, water- and solvent-based: Solvent-based paints include aliphatic hydrocarbons, toluene, xylene, ketones, and chlorinated hydrocarbons. Water-based paints contain some organic solvent components, usually emulsions of glycols and alcohols; however, the VOC emissions are considerably lower than those from solvent-based paints.

- Aerosol marking paint, water- and solvent-based: These paints are used to apply stripes or markings to outdoor surfaces, such as streets, golf courses, athletic fields, or construction sites. Markings can be either temporary or permanent. Chapter 5, of this volume, *Consumer and Commercial Solvent Use*, page A-9, includes an emission factor of 0.0254 lb/person for the use of these products. Total annual emissions in the U.S. for this subcategory are estimated as 3,154 tons of reactive VOC per year. Emissions from these paints are **not included** in this chapter.

- Preformed tapes applied with adhesive primer: Emissions from traffic marking adhesives are included as part of Chapter 5, *Consumer and Commercial Solvent Use*, on page A-7, under the subcategory of "other adhesives." Emissions from these adhesives are **not included** in this chapter.

VOC emissions are negligible from application of some alternative paints including thermoplastics, preformed tapes with no adhesive primer, and two-component, field-reacted systems. In addition to the painting material used, VOCs from solvents utilized in cleaning the striping equipment should be quantified in the category.

2.2 FACTORS INFLUENCING EMISSIONS

2.2.1 PROCESS OPERATING FACTORS

Emissions from traffic marking vary depending on the marking material used and the frequency of application. Table 14.2-1 compares estimated annual VOC emissions for the different marking types. These emission factors account for traffic marking applications that take place either more frequently or less frequently than once a year, since a more durable marking material will effectively emit less because it needs to be applied less frequently. Climate conditions and paint durability, coupled with factors such as pavement type, traffic density, and position of the marking, will influence the frequency of application.

2.2.2 CONTROL TECHNIQUES

Because the use of organic solvents in traffic markings is the primary source of emissions, control techniques for this source category involve either product substitution or product reformulation. Alternative formulations include low-solvent-content coatings, water-based coatings, and plastic-based coatings. Because the performance requirements for different marking situations differ, and because these materials have different physical and chemical properties and a wide range of costs, different materials are advantageous for specific application situations. Table 14.2-2 lists the advantages and disadvantages of various traffic marking materials.

TABLE 14.2-1

COMPARISON OF ESTIMATED VOC EMISSIONS (EPA, 1988)

Marking Materials	Estimated VOC Emissions (lb/lane mile-yr)[a]
Solvent-based (non-aerosol)	69[b]
Water-based (non-aerosol)	13[c]
Thermoplastic	---[d]
Field-reacted	
Polyester	---[d]
Epoxy	0.25
Preformed Tapes	
Without adhesive primer	0
With adhesive primer	58[e]
Permanent Markers	0

[a] Mile refers to one 4-inch-wide solid stripe that is 1 mile long.

[b] Solvent-based paints typically consist of a resin, pigment, and various additives, all suspended in an organic solvent. The average VOC content for solvent-based paints listed in this reference is 3.15 lb/gal.

[c] Water-based paints typically consist of latex emulsions which also include some organic solvent. The average VOC content for water-based paints listed in this reference is 0.76 lb/gal.

[d] Negligible.

[e] Adhesive primers for tapes are included in Chapter 5, *Consumer and Commercial Solvent Use*.

TABLE 14.2-2

ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE TRAFFIC MARKING MATERIALS (EPA, 1988)

Marking Material	Advantages	Disadvantages
Solvent-based Paints	Low initial cost Good dry-night visibility Short drying times available Good equipment availability Well-established technology No pavement-type limitations	High VOC emissions Short life Poor wet-night visibility
Water-based Paints	Low VOC emissions Low initial cost Good dry-night visibility Easy to adapt from solvent-based formulations Easy cleanup No pavement-type limitations	Poor wet-night visibility Short life Weather restrictions for application
Thermoplastics	Negligible VOC emissions Long life Good night visibility (wet & dry) 100 percent solids	High initial cost High application temperature Reduced durability on Portland cement More difficult application than for paint
Preformed Tapes	No VOC emissions if adhesive primer is not used Long life Little or no application equipment needed Excellent material safety 100 percent solids	High VOC emissions if primer is used Very high initial cost Variable night visibility
Field-reacted Systems	Negligible VOC emissions Long life Moderate initial cost Essentially 100 percent solids Good night visibility	Polyester type adheres poorly to Portland cement Special application equipment needed
Permanent Markers	Negligible VOC emissions Long life Excellent night visibility (wet & dry)	High initial cost Poor durability in snowplow areas

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OVERVIEW OF AVAILABLE METHODS

3.1 EMISSION ESTIMATION METHODOLOGIES

Several methodologies are available for calculating emissions from traffic markings. The method used is dependent upon the degree of accuracy required in the estimate, available data, and available resources.

This section presents the methods available for calculating emission estimates from traffic markings and identifies the preferred calculation method. The data elements needed for each method are also discussed.

3.2 AVAILABLE METHODOLOGIES

3.2.1 VOLATILE ORGANIC COMPOUNDS

The VOCs released into the air by traffic marking application are from the evaporation of the VOCs contained in the coating. Determining the amount of the VOCs in coatings should provide a good estimate of the VOC emitted by this source category. There are four approaches to estimating the amount of VOC emitted from this source category:

Preferred Method: Survey of traffic marking use in the inventory area;

Alternative Method 1: Emissions based on Manufacturing Census data on paint production, Federal Highway Administration data, and the national average per gallon emission factor;

Alternative Method 2: Lane miles emission factor; and

Alternative Method 3: Per capita usage and the national average per gallon emission factor.

The preferred method is the best approach for emissions estimation because it will most accurately reflect the actual use, seasonal application, and content of traffic coatings in the inventory area and, if requested in the survey, will include cleanup solvent estimates. If required by the inventory, the level of detail provided by this method allows for greater accuracy in VOC as well as hazardous air pollutant (HAP) emissions estimation and control strategy modeling.

The alternative approaches do not provide the same level of detail as does the survey method in terms of the specific amounts and types of paints used in the inventory area. This means that information on the use of water- versus solvent-based coatings, or the amount and type of cleanup solvents used is not available when the alternative methods are used. Alternative Method 3 in particular does not take into account variability among regions, but will take into account the variability of usage at the national level from year to year. The alternative methods are best used if controls are limited or nonexistent and no further controls are anticipated for the source category.

3.2.2 HAZARDOUS AIR POLLUTANTS

HAP emissions for this category can be estimated using two methods:

- Surveying traffic marking use in the inventory area; or
- Applying speciation profiles to the VOC emissions estimate, obtained by using either the preferred or alternative methods for VOCs.

The survey method is the preferred method, because it will provide the most accurate information on coating usage and HAP content of the coatings used. The effect of VOC controls on HAP emissions will also be apparent when using this method.

Speciation profiles can be used as an alternate approach when conducting a detailed survey is not practical. Although specific profiles will be provided in Section 5, updated or local speciation profiles should be used when available.

3.3 DATA NEEDS

3.3.1 DATA ELEMENTS

The data elements used to calculate emission estimates for this category will depend on the methodology used for data collection. The data elements necessary for an emission calculation that should be requested in a survey of state and county highway departments include:

- Product type;
- Product amount distributed by type (gallon) for the inventory period;
- Product density (pounds per gallon);

- VOC and HAP content of each product, or solvent content by type, and VOC percentage of solvents (weight percent) for each product;
- Information on the amount and type of cleanup solvent; and
- Information on disposal of unused products.

If an emission factor method is used, the following data elements are needed depending on the chosen method: national or local coating usage, statistics for highway maintenance spending, national and local population, number of lane miles in the inventory area, and a VOC emission factor and HAP speciation profiles (both provided in Section 5). Emission factors may be developed at the national or state level or representative sample subsection, then apportioned to the inventory level.

3.3.2 APPLICATION OF CONTROLS

Because the use of controls will affect the VOC or HAP content of the coating itself, a survey of coating usage and VOC or HAP content, or development of an emission factor from recent usage data, will reflect controls that are in place. Because a reformulation or substitution represents an irreversible process change and, thus, a reduction in emissions, rule effectiveness can be assumed to be 100 percent for that coating type.

Rule penetration will be based on the weighted percentage of coatings within the inventory area that are affected by the rule.

3.3.3 SPATIAL ALLOCATION

Spatial allocation is used in two cases in the preparation of an area source inventory: (1) to allocate emissions or activity to the county level and (2) to allocate county-level emission estimates or activity to a modeling grid cell. Allocation of emissions or activity to the county level is addressed in the discussion of each preferred or alternative method.

Allocation of emission estimates or activity to a modeling grid cell level can be done using one of three potential spatial surrogates, shown below in order of preference:

1. Use detailed information about the number of lane miles within each grid cell, or a group of grid cells. This information may be available from inventory personnel involved in estimating mobile source emissions or from county or state departments of transportation.

2. Use other land use data, if land use can be generalized to estimate the number of lane miles. This information is usually available through county planning departments.

3. Use population data, available from the U.S. Census Bureau.

3.3.4 TEMPORAL RESOLUTION

Seasonal Apportioning

Traffic marking use is influenced by the seasons, since spreading and drying characteristics for many paints are dependent on temperature. Solvent-based traffic paints are usually applied only when the temperature of the road surface is 50°F or higher. Best results from water-based paints are achieved when they are applied when air temperature is 50°F or higher and there is low humidity. The preferred method for seasonal apportioning is to survey state or local highway departments. Because it can be assumed that seasonal usage is similar among all users in the area, the survey sample can be small. If a survey is not practical, the seasonal activity factor for the ozone season is 1.3 or 33 percent of annual activity (EPA, 1991). See Chapter 1 of this volume, *Introduction to Area Source Emission Inventory Development* for more information about using seasonal activity factors and seasonal apportioning.

Daily Resolution

Traffic marking application typically takes place 5 days a week during the active season.

3.3.5 PROJECTING EMISSIONS

A discussion about developing growth factors and projecting emission estimates can be found in Section 4 of Chapter 1 of this volume, *Introduction to Area Source Emission Inventory Development*. Projecting emissions for this source category will take two variables into account, the change in activity (e.g., road miles painted, or gallons of paint used) and the change in the formulations of paints and other marking materials used, which will determine the emission factor that is used. Projected emission estimates may need to be calculated differently in the two following cases:

Case 1: There are no controls and thus there is no change in the emission factor; and

Case 2: There are controls in place for traffic markings, and emission reductions are reflected in the emission factor.

Each case uses a different projection equation. If there are no controls and no changes in the emission factor, projected emissions are calculated using the following equation:

$$EMIS_{PY} = ORATE_{BY} * EMF * GF \quad (14.3\text{-}1)$$

where:

$EMIS_{PY}$	=	Projection year emissions
$ORATE_{BY}$	=	Base year activity rate
EMF	=	Emission factor
GF	=	Growth factor

For Case 2, where controls are reflected in the emission factor, the equation would be:

$$EMIS_{PY} = ORATE_{BY} * EMF_{PY} * \left[\frac{\left(200 - RP_{PY} \right)}{100} \right] * GF \quad (14.3\text{-}2)$$

where:

EMF_{PY}	=	Projection year emission factor
RP_{PY}	=	Projection year rule penetration (%)

Tools for the development and use of growth factors are discussed in Chapter 1 of this volume.

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PREFERRED METHOD FOR ESTIMATING EMISSIONS

The preferred method for calculating emission estimates from traffic markings is to conduct a survey of marking use by state and county highway departments, and city road maintenance departments. The highway and road maintenance departments are responsible for the predominant part of traffic coatings applied. Records should be accessible and information should be sufficiently detailed to calculate VOC and HAP emissions. This section provides an outline for preparing and using a traffic markings survey, and calculating emission estimates from the information collected.

Survey planners are asked to refer to Section 2.1 of this chapter, Emission Sources, before developing any survey. There are three types of traffic markings that have appreciable emissions, traffic paints, aerosol traffic markings, and traffic tapes that use an adhesive primer. Of those three, the traffic aerosols and traffic tape adhesives are discussed in Chapter 5 of this document, *Consumer and Commercial Solvent Use*. A survey of traffic markings may include the use of traffic tapes and possibly the use of aerosols, but if the survey results for those products are used, then estimated emissions for the aerosol and adhesive subcategories of the consumer products source category will need to be reduced to avoid double counting of emissions. However, information about the proportion of adhesives or aerosol products that can be attributed to traffic marking uses is not available.

Drawbacks to the survey method are that not all highway and maintenance departments may keep records of coating usage. If highway and maintenance departments do not keep these records, then using this method is not practical. Also, a survey of highway and maintenance departments will not include markings used for parking lots by private contractors unless the contractors are also surveyed. However, it is unlikely that a survey of contractors would be as reliable as that of government highway departments for a number of reasons. First, the response rate will likely be lower; second, they may not keep as complete or as detailed records; and third, a contractor will do work over county or state boundaries and may not be able to estimate coating use for just the inventory area. However, a national-level survey of traffic coating end users shows that government highway departments are using 95 percent of the traffic coatings in the United States (EPA, 1993).

The final drawback to this method is that a well-planned, well-run survey requires more time, effort and expense than a top-down approach. Inventory preparers must judge whether the costs of this approach are outweighed by the benefit of having an estimate that is more specific to the inventory area and time period.

Costs and labor efforts are highest for the first time that a regional or local survey of traffic marking use is performed. Subsequent updates to the survey may be done using fewer samples at much less cost. In the years following the baseline survey, updates on coating usage may be all that is needed. Periodically, information on changes in formulations, methods of application, and the percentages of different types of coatings used will be needed to accurately estimate emissions.

Surveys for area sources are specifically discussed in Volume I of the Emission Inventory Improvement Program (EIIP) series and in Chapter 1 of this volume. A survey of state and county highway departments will consist of: (1) survey planning, (2) survey preparation, (3) survey distribution, (4) survey compilation and scaling, and (5) emission estimation. Discussion of these steps follows.

4.1 SURVEY PLANNING

During the planning phase, the following issues should be addressed:

- Survey data quality objectives (DQOs) should be identified, and how the DQOs will be realistically reached specified.

- The survey recipients and data needs must be identified.

    - Information from the state and county levels may cover an area larger or smaller than the inventory area. Should scaling be needed for survey results, identify an available scaling surrogate (e.g., number of lane miles, population).

    - In some cases, highway departments in several counties will arrange to purchase paint and will contract with a private contractor to have the painting done. During survey planning, this sort of situation should be identified, an allocation approach will need to be defined, and data should be collected for it.

    - When counties in the inventory area include extensive state or national parks, military bases, or very large commercial properties which arrange for their own traffic marking, the maintenance offices for these areas may

need to be surveyed. However, these areas may not need to be surveyed if the facility already reports traffic marking activities as part of a point source inventory, or the amount of traffic marking at the facility is proportionally small in comparison to the activity in the rest of the county.

- If the usage of different types of coatings and solvents is known to be consistent from county to county, a standard profile of product types can be developed and the survey need only collect the total amount of coatings and solvents used per county.

- Data handling needs specific to this survey must be identified.

- Survey QA/QC methods must be delineated and implemented.

The survey package should include a cover letter explaining the program, the survey form, a list of definitions and a postage-paid return envelope. Both state and county highway departments may need to be surveyed in order to collect information needed for the traffic markings category. Additional disposal information may be collected as part of a waste disposal or recycling category. The portion of emissions that correspond to recycled or discarded traffic coating materials from the disposal or recycling category should be subtracted from the emission estimate for traffic marking. This is necessary to avoid double counting.

4.2 SURVEY PREPARATION

A survey may be planned to collect either a detailed amount of data or only the minimum amount needed for to estimate emissions. The minimum amount of information needed to calculate an emission estimate is the number of gallons of solvent-based and water-based traffic paints used in the inventory area or inventory county. The national averages of VOCs for solvent-based and water-based traffic coatings can be multiplied by the number of gallons of each coating type to estimate emissions. National averages of VOC content for types of coatings have been prepared by the National Paint and Coatings Association (NPCA) (EPA, 1993) shown in Table 14.4-1.

A more detailed survey will request:

- Product type, including thinning and cleanup solvents;

- Product amount used by type (gallon);

- Product density (pound per gallon);

- Estimates of the proportion of products used during the inventory season; and

- VOC or solvent content of each product type (pounds per gallon or weight percent) for a VOC inventory, or, for a HAP inventory, HAP or solvent content of each product type (pounds per gallon or weight percent).

Survey preparers should clearly define the time period that the survey information is being collected for. A request for annual data, for instance, should specify the range of months to avoid confusion between fiscal and calendar years. It is preferable to collect data specific to the inventory period, but for periods less than 12 months, usage will probably have to be apportioned by the inventory preparer.

If the survey results need to be scaled to a different spatial scale, or are expected to be adjusted for future inventories, factors that may be useful to adjust the survey information may also be collected. For example, the road miles or lane miles within the county that the department is responsible for could be requested from that department. Road miles or lane miles may also be available from mobile emissions inventory preparers. Then, a county-specific emission factor based on the number of road miles or lane miles can be developed and used in future inventories.

TABLE 14.4-1

EMISSION FACTORS FOR TRAFFIC MARKINGS (EPA, 1993)[a]

Coating Type	VOC Content (lb/gal)
Water-based coatings	0.72
Solvent-based coatings	3.64
National average, water- and solvent-based	3.36

[a] Data are based on a 1991 survey.

The advantages of the more detailed approach are that the inventory developed is more specific to the locality, and the information collected can be more readily projected to inventories for subsequent years.

Instructions for using the survey form are provided on the survey cover page, shown in Figure 14.4-1. As shown in Table 14.4-2, respondents must first estimate the annual amount of coatings as the amount stocked and VOC weight percent or pounds per gallon used in coatings, less waste disposed of off-site or unused. For HAP inventories, material safety data sheets (MSDS) for each product should be requested. This information can be combined with the

coating and solvent density to yield the pounds of product used in a given year. HAP weight-percent information can be derived from the MSDS provided with each coating.

An alternative survey-based method for a HAP inventory would use a representative sample of the HAP contents for each product type, applied to a more complete inventory of traffic marking types and usage.

4.3 SURVEY DISTRIBUTION

This method requires contact with every transportation department that uses traffic coatings in the inventory area. Surveys can be distributed by mail, or the information can be collected through a telephone survey. Initial contacts and follow-up contacts may also be undertaken as part of the survey to answer any questions. Survey distribution issues are discussed in Chapter 1 of this volume.

4.4 SURVEY COMPILATION AND SCALING

Survey compilation and scaling issues are discussed in Volume I of this series. Completed surveys will result in information that includes many types of coatings and multiple pollutants, so compilation of this information will require planning for data transfer and data management. Efficient transfer to the data handling system will benefit from inventory planner's consideration of the data transfer step during the design of the survey.

QC checks should be performed during this phase of the work (see Volume VI for QA/QC methods). Incoming surveys should be checked for errors such as potential unit conversion errors or misidentification of products or chemicals. Survey information should be checked for reasonableness. Compiled survey information should also be subject to similar checks. Survey recipients may need to be recontacted in order to correct any errors.

Name of Highway Department: _____

Street Address: _____

City: _____

Contact Person/Phone Number: _____

The purpose of this survey is to collect information about the amounts of traffic paints used so that estimates of air pollution from the traffic paints can be made. Please enter the following information on the attached form.

1. List the product types stocked in year _____. Product types should include all traffic coatings and any solvents used for thinning or cleanup in association with them.

2. Provide the weight percent of VOCs for each product or, if it is available, provide the amount of VOCs, as pounds per gallon of product. Please clearly mark the entry as a percent (%) or pounds per gallon (lb/gal).

3. If the entry in Column B is weight percent, provide the specific gravity of the product.

4. Provide the amount, in gallons, of each product stocked.

5. Subtract from the products listed under Column A any coating or solvent that was disposed of off-site (Column E), lost as waste (spills, etc.) in Column F, or portions that were unused (Column G). If only the total amounts of these losses are known, split the total between the different products.

6. Attach copies of the Material Safety Data Sheets (MSDSs) for all of the products listed *(for HAP inventories)*.

FIGURE 14.4-1. SURVEY REQUEST FORM FOR TRAFFIC MARKINGS STATE AND COUNTY HIGHWAY DEPARTMENTS

TABLE 14.4-2

TRAFFIC MARKINGS DATA REQUEST FORM[a]

A Product Type	B Product VOC Weight Percent or Pounds/Gallon	C Specific Gravity of Product[b]	D Amount Stocked in year	E Amount Disposed of Off-site	F Amount Lost as Waste	G Amount Unused	Amount Used = D - (E + F + G)

[a] Volume of product expressed gallons unless otherwise noted.
[b] The specific gravity of the product is needed only if VOC content of the product is in weight percent.

Depending on the recipients to the survey, results may need to be either scaled up for all counties in the inventory area or scaled down to the inventory area. In either case, a scaling factor should have been identified in the planning phase, and any necessary requests for information from the survey respondents included on the survey form. Refer to Sections 3.3.3 Spatial Allocation, and 3.3.4 Temporal Resolution for more information about allocation and scaling factors for this source category.

4.5 EMISSION ESTIMATION

Emission estimation calculations involve determining emissions of the pollutant(s) of interest, and then the application of any necessary spatial or temporal adjustments. Because the application of traffic markings is defined as an area source, there should not be a need to subtract point source emission estimates from the total. Emission estimate calculations from the information collected by survey require the following steps:

If pounds of VOC per gallon are not available, then emissions are calculated as follows:

- Multiply the specific gravity of the product by 8.34 lb/gal, the density of water, to get the product density.

$$\text{Product Density} = \left(\begin{array}{c} \text{Specific Gravity} \\ \text{of the Product} \end{array} \right) * 8.34 \qquad (14.4\text{-}1)$$

- Multiply the gallons of product used by the density to yield the pounds of each product used.

$$\begin{array}{c} \text{Pounds of} \\ \text{Product} \end{array} = \begin{array}{c} \text{Gallons} \\ \text{of Product} \end{array} * \begin{array}{c} \text{Product} \\ \text{Density} \end{array} \qquad (14.4\text{-}2)$$

- For a VOC inventory, multiply the VOC weight percent by the pounds of product for each coating or cleaning solvent. For a HAP inventory, identify the HAP components from the coating MSDS and multiply the weight percent of each HAP by the pounds of product for the coating or cleaning solvent.

$$\text{Pollutant Emissions (lb)} = \text{Pounds of Product} * \text{Pollutant Weight \%} \qquad (14.4\text{-}3)$$

Emissions for each product type should be calculated separately.

If pounds of VOCs per gallon for each product type is available, then VOCs are calculated as:

$$\text{VOC Emissions (lb)} = \text{Amount of Product (gal)} * \text{VOCs per Gallon (gal)} \qquad (14.4\text{-}4)$$

Emissions for each product type should be calculated separately.

Example 4-1

In this example, information on the pounds of VOCs per gallon of each type of coating used in one county has been collected. The data collected and calculation for the total amount of VOCs emitted for the county is shown below:

Example traffic coating usage for one county:

- 10,000 gallons yellow traffic paint; solvent-based, 3.21 lb VOCs/gal
- 1,560 gallons white traffic paint; solvent-based, 3.26 lb VOCs/gal
- 6,324 gallons yellow traffic paint; water-based, 0.54 lb VOCs/gal
- 7,610 gallons white traffic paint; water-based, 0.69 lb VOCs/gal

The calculation will be:

VOC Emissions from Traffic Coatings = [(10,000 gal * 3.21 lb/gal) + (1.560 gal * 3.26 lb/gal) + (6,324 gal * 0.54 lb/gal) + (7,610 gal * 0.69 lb/gal)]

= 45,852 lb VOC

Example 4-2

In this example, the HAP emissions from one paint type are calculated from the HAP volume percent for that paint type and the HAP density. Representative HAP volume percents and densities are shown in Table 14.4-3.

Emissions for carbon tetrachloride from traffic paint used in an area would be calculated:

Carbon tetrachloride emissions = 10,000 gal * 0.009 % * 12.19 (lb/gal)

= 10.97 lb

Emissions from each HAP from each type of paint are calculated as they are above, then summed to get the total for all paint types.

Spatial allocation of emissions to individual counties or other inventory area units can be done by proportioning emissions with a surrogate factor. Potential surrogate factors, in order of preference, are lane mile data, land use data, or population.

Temporal allocation may be necessary if the inventory requires seasonal or daily emission estimates, and is discussed in Section 3 of this chapter.

TABLE 14.4-3

HAP SPECIES PROFILES FOR TRAFFIC MARKINGS (EPA, 1993)[a]

HAP	Volume Percent (%)	Density (lb/gal)
Carbon tetrachloride	0.009	12.19
Cumene	0.002	7.19
Ethylbenzene	0.009	7.24
Ethylene glycol	0.086	9.31
Glycol ethers	0.040	7.01
Methyl ethyl ketone	1.514	6.89
Methyl isobutyl ketone	0.002	6.71
Methyl methacrylate	0.044	7.84
Naphthalene	0.002	9.55
Propylene oxide	0.115	6.93
Styrene	0.277	7.55
Toluene	6.914	7.23
Xylenes (mixed isomers)	0.499	7.18

[a] Data based on a 1991 survey.
[b] These volume percent factors are based on the amounts of each HAP component in a sales-weighted average traffic paint.

5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

This section provides an outline for developing and using emission factors as alternative methods for calculating emissions from traffic markings. Procedures for using the three alternative methods described in Section 3 are provided in the following discussion.

5.1 VOLATILE ORGANIC COMPOUNDS

5.1.1 ALTERNATIVE ONE: NATIONAL TRAFFIC PAINT SALES AND NPCA EMISSION FACTOR

This method uses NPCA per gallon emission factors multiplied by traffic paint usage values that are specific to the inventory year, but are apportioned from the national level to the county level in two steps. The national to state apportioning step proportions the amount of traffic paint by the dollars spent on roads and highways in the inventory state. This information is available in Federal Highway Administration reports, and is well suited as a surrogate for apportioning. The apportioning approach of using dollars spent will reflect differences between states in the number of lane miles in each state that the states have to maintain, differences in the types of roads in each state, and variations between states in the levels of maintenance for roads. The federal report does not provide this information for individual counties, so apportioning from the state to the county level requires another surrogate. Paved lane miles or population are used in this method because they are easily available, but other surrogates, such as state-generated, per-county highway maintenance spending, or vehicle registration numbers can be used to calculate a per-county estimate of traffic paint used.

The advantage to this method is that most of the information needed for the calculations should be relatively simple to collect and manage. The disadvantage is that the estimate will not include cleanup emissions (although thinning is included in the NPCA emission factor), and the usage numbers will not be as specific as those from the survey method.

The steps needed to use the first alternative method are as follows:

- Determine the amount of U.S. traffic paint usage for the inventory year. Use data from the U.S. Census Bureau, Report MA28F-Paint and Allied Products.[a] Table 14.5-1 is an example report.

- Apportion the national traffic paint usage to the state level based on spending for highway maintenance. The Federal Highway Administration publishes *Highway Statistics* annually.[b] Table HF-2, Total Disbursements for Highways, All Units of Governments, in the *Highway Statistics* publication will have the necessary information.

- Apportion the state estimate of traffic paint usage to the county level using either the proportion of the number of county paved lane miles to the number of state paved lane miles, or by the proportion of county to state population. Using paved lane miles as a surrogate is the preferred approach.

- If information is available on the proportion of solvent- versus water-based coatings for the state or county, those proportions can be used to develop a local emission factor from the NPCA solvent- and water-based coating factors in Table 14.4-1. Otherwise, the national average emission factor for both types of coatings from the NPCA survey should be used. The equation for calculating emissions is:

$$\text{VOC Emissions} = \begin{matrix}\text{NPCA Emission} \\ \text{Factor (lb/gal)}\end{matrix} * \begin{matrix}\text{County Traffic} \\ \text{Paint Usage (gal)}\end{matrix} \qquad (14.5\text{-}1)$$

Example 5-1 shows the calculation for a typical county.

5.1.2 ALTERNATIVE METHOD TWO: LANE MILES EMISSION FACTOR

This method uses an emission factor for lane miles of road painted paired with local data. The emission factors are from a 1988 Control Technology Center (CTC) report (EPA, 1988). Emission factors for solvent- and water-based traffic paints, and for lane

[a] Total national coating usage is compiled by the Bureau of the Census, Report MA28F-Paint and Allied Products, available from the U.S. Census Bureau, Department of Commerce, Washington, D.C.

[b] Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

TABLE 14.5-1

QUALITY AND VALUE OF SHIPMENTS OF PAINT AND ALLIED PRODUCTS: 1994 AND 1993 (QUANTITY IN THOUSANDS OF GALLONS; VALUE IN THOUSANDS OF DOLLARS)[a]

Product Code	Product Description	1994 Quantity	1994 Value	1993 Quantity	1994 Value
2851	Paint and allied products [b]	1,103,693	14,140,288	1,228,531	13,538,654
28513 11	Traffic marking paints (all types, shelf goods and highway department	33,898	202,810	29,515	174,154

[a] Source: U.S. Bureau of the Census Report MA28F-Paint and Allied Products.

[b] Represents total shipments for those establishments producing paint and allied products that have 20 or more employees. These establishments represent approximately 95 percent of the total value of shipments for Standard Industrial Classification (SIC) industry 2851, paint, varnishes, lacquers, enamels, and allied products based on relationships observed in the 1992 Census of Manufactures preliminary report.

Example 5-1:

U.S. traffic paint sales totaled 29,515,000 gallons in 1993 (see Table 14.5-1). According to the Federal Highway Administration's annual *Highway Statistics* report, Table HF-2, total disbursements on roads and highways was $62,351,345,000, and State A spent $1,115,435,000. Gallons of traffic paint are apportioned from the national level to state level by:

State A Traffic Paint Usage = [$1,115,435,000/$62,351,345,000] * 29,515,000 gallons

= 528,009 gallons

The amount of traffic paint is apportioned from the state to the county level using population for County B and State A (77,055 and 6,386,600 people, respectively):

County B Traffic Paint Usage = [77,055/6,386,600] * 528,009 gallons

= 6,370 gallons

In this case, no information is available about the proportions of solvent- versus water-based paints used in the inventory area, so the national average emission factor provided in Table 14.4-1 should be used. VOC emissions are calculated for County B by:

County B VOC Emissions from Traffic Paints = 6,370 gallons paint * 3.36 lb/gal

= 21,403 lb VOCs

= 10.7 tons VOCs

miles painted or total lane miles are shown in Table 14.5-2. If the number of lane miles that were actually painted in the inventory year are available, a more specific estimatecan be made using the factor for emissions per lane miles painted, in units of pounds per mile. If only the total lane miles in the inventory area are available, then emission estimates can be estimated using the factor for typical annual emissions, in units of pounds per mile and year. Lane miles painted data may be available from state and county highway departments. Total lane miles data should be available from state and county highway departments, or from air agency mobile inventory preparers.

The emission factors for solvent-based paints should be used if there is no information about whether solvent- or water-based paints are used. This will result in the most conservative estimate. However, the preferred approach is to gather information about the proportions of solvent-based versus water-based paint if at all possible. State or local rules may determine the type of paint or other marking type that can be used within an area, or a small telephone survey of a subset of highway departments may be used to define the proportions of paint type.

The equation used to calculate emissions using these emission factors is:

$$\begin{matrix}\text{Inventory Area} \\ \text{Emissions from} \\ \text{Traffic Paints}\end{matrix} = \begin{matrix}\text{Emission Factor} \\ \text{(lb/lane mile)}\end{matrix} * \begin{matrix}\text{Traffic Lane} \\ \text{Miles Painted}\end{matrix} \qquad (14.5\text{-}2)$$

If the lane mile data are available, this method has the advantage of being easy to use. However, the method does not take into account any region-specific use of lower-emitting coatings, such as water-based coatings or thermoplastic tapes. Using the typical annual emissions factor with total lane miles also will not reflect area-specific repainting schedules.

TABLE 14.5-2

LANE MILE VOC EMISSION FACTORS (EPA, 1988)

Traffic Paint Type	Typical Expected Life (years)	VOC Emissions Per Lane Mile Painted (lb/mile)	Typical Annual VOC Emissions (lb/mile-year)[a]
Solvent-based	0.75	52	69
Water-based	1.0	13	13

[a] Mile refers to one 4-inch-wide stripe that is 1 mile long.

5.1.3 ALTERNATIVE METHOD THREE: PER CAPITA EMISSION FACTOR

This method is a simplified version of Alternative Method One. A national average usage factor of gallons per person is developed from U.S. Census data for the inventory year. The per capita usage factor is multiplied by the NPCA per-gallon emission factor to calculate emissions. The steps needed for this method are:

- Collect the necessary data: National traffic paint sales data, in gallons, from U.S. Census Report MA28F-Paint and Allied Products, national population and inventory area population figures for the inventory year, and the NPCA per-gallon emission factor.

- Develop a national average per capita usage factor:

$$\text{National Per Capita Usage (gal/person)} = \text{National Traffic Paint Usage (gallons)} / \text{National Inventory Year Population} \quad (14.5\text{-}3)$$

- Multiply the usage factor, the NPCA per gallon emission factor, and the inventory area population to get the inventory area emission estimate:

$$\text{ıtory Area sions from fic Paints} = \text{National Per Capita Usage Factor (gal/person)} * \text{NPCA Emission Factor (lb/gal)} * \text{Inventory Popula} \quad (14.5\text{-}4)$$

The advantage of this method is that all of the information needed is easily obtained and the calculations are simple. If this source category is a low priority in the inventory and no controls are planned, this could be an appropriate method. However, limitations to this method are: population is not the most accurate surrogate for traffic coatings because it does not take into account the region-specific use of lower-emitting coatings, and the activity will not reflect whether an area has a higher or lower level of maintenance.

5.2 HAZARDOUS AIR POLLUTANTS

HAP emissions are calculated by multiplying the county traffic paint usage amount by the HAP volume percent (Table 14.4-3). The equation for this calculation is:

$$\text{VOC Emissions} = \text{County Traffic Paint Usage} * \text{HAP Volume \%} * \text{HAP Density} \quad (14.5\text{-}5)$$

See Example 14.5-1 for an example calculation.

If Alternative Method Two is used, assume that 16 gallons of traffic paint of either type are used for every lane mile counted (EPA, 1988).

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6

QUALITY ASSURANCE/QUALITY CONTROL

When using the preferred method, the survey planning, sample design, and data handling should be planned and documented in the inventory QA/QC plan. Refer to the discussion of survey planning and survey QA/QC in Chapter 1 of this volume.

Data handling for the survey data and for data collected for the alternate methods should also be planned and documented in the inventory QA/QC plan and do not involve any category-specific issues. Please consult EIIP Volume VI on inventory QA/QC for more information.

6.1 EMISSION ESTIMATE QUALITY INDICATORS

Surveys are theoretically the most accurate approach for estimating emissions, but also are the most expensive. Advantages to using surveys are that region- or area-specific information about the amount and type of traffic markings used will be collected. Markings surveyed will more precisely reflect the regulations for VOCs that are in place in the inventory area. Emissions of HAPs can be calculated based on the specific types of coatings in use in the area. The level of detail that is possible to collect with a survey is not available when using the alternative methods.

The preferred method gives higher quality estimates than any of the alternative methods, but requires significantly more effort. The level of effort required to calculate emissions using either of the alternative methods ranges from 8 to 40 hours. Conducting a survey of state, county, and city highway departments requires between 60 to 150 hours depending on the size of inventory region and the desired level of detail of the survey. However, the resultant increase in the quality may justify this expenditure of resources, especially if this category is believed to be a significant contributor to emissions or is subject to regulations. Emissions from traffic markings are typically among the top 15 area sources of VOCs and HAPs in urban areas.

6.1.1 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

The DARS scores for each method are summarized in Tables 14.6-1, 14.6-2, 14.6-3, and 14.6-4. A range of scores is given for the preferred method and first alternative method to reflect variability in survey techniques. A range of scores for spatial congruity is also given for the

second alternative method to account for the use of either the more specific lane miles painted activity or less specific total miles painted. In the case of the first alternative method, use of more specific apportioning surrogates and more specific information about the types of paint used in the area will improve the scores. All scores assume that good QA/QC measures are performed and that no significant deviations from the prescribed methods 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 gives higher DARS scores than any of the alternative methods. The alternative method DARS scores range between 0.51 and 0.33, and the preferred method's DARS scores are between 0.85 and 0.73. The preferred method scores higher on all attributes than the alternative methods.

Among the alternative methods, lane miles and an emission factor use the most locally specific surrogate activity factor and consequently has the higher activity composite score for the alternative methods.

6.1.2 SOURCES OF UNCERTAINTY

The uncertainty of the emission estimates developed through the preferred method can be quantified (see QA Procedures, Volume VI, Chapter 4). However, the statistics needed to quantify the uncertainty of the alternative methods are incomplete. Activity for the alternative methods is based on the use of surrogates: highway maintenance spending and population for the first alternative method, lane miles for the second alternative method, and population for the third alternative method. Actual paint use is expected to vary in relation to these surrogates, but is not defined.

The emission factors that are used in the alternative methods are also expected to vary by region. Factors that cause regional variation are climate, traffic density, and driving patterns all of which result in variations in wear, maintenance schedules, rules affecting the materials used for traffic markings, and lack of information about unused paints or the use of cleanup solvent use. Identifying the types of paints or other marking materials used in the inventory region so that a more specific factor can be developed will reduce variability, as will the development of locally specific activity factors.

TABLE 14.6-1

PREFERRED METHOD DARS SCORES: SURVEY OF STATE AND COUNTY HIGHWAY DEPARTMENTS COATING USE IN THE INVENTORY REGION

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5 - 0.6[a]	0.8 - 1.0	0.40 - 0.60
Source Specificity	0.9 - 1.0	0.9 - 1.0	0.81 - 1.0
Spatial	1.0	0.9 - 1.0	0.90 - 1.0
Temporal	0.9	0.9	0.81
Composite Scores	0.83 - 0.88	0.88 - 0.98	0.73 - 0.85

[a] Score assumes emissions are calculated using mass balance calculation of VOC content. If a VOC emission factor used or speciated to get HAPs, the score should be lowered.

TABLE 14.6-2

ALTERNATIVE METHOD 1 DARS SCORES: ACTIVITY APPORTIONED FROM THE INVENTORY YEAR NATIONAL LEVEL APPLIED TO NPCA 1991 EMISSION FACTORS

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5[a]	0.6	0.30
Source Specificity	0.8	0.5 - 0.7	0.40 - 0.56
Spatial	0.5 - 0.7	0.8	0.40 - 0.56
Temporal	0.7	0.9	0.63
Composite Scores	0.60 - 0.65	0.70 - 0.75	0.43 - 0.51

[a] Score assumes total VOC factor is used; if this is speciated to get HAPs, score should be lowered.

TABLE 14.6-3

ALTERNATIVE METHOD 2 DARS SCORES: LANE MILES APPLIED TO 1988 CTC EMISSION FACTORS

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5[a]	0.6	0.30
Source Specificity	0.6	0.6	0.36
Spatial	0.5-0.7	0.9	0.45-0.63
Temporal	0.5	0.9	0.45
Composite Scores	0.52	0.75	0.39-0.44

[a] Score assumes total VOC factor is used; if this is speciated to get HAPs, score should be lowered.

TABLE 14.6-4

ALTERNATIVE METHOD 3 DARS SCORES: ACTIVITY APPORTIONED BY POPULATION AND APPLIED TO NPCA 1991 EMISSION FACTORS

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5[a]	0.6	0.30
Source Specificity	0.8	0.3	0.24
Spatial	0.5	0.3	0.15
Temporal	0.7	0.9	0.63
Composite Scores	0.6	0.53	0.33

[a] Score assumes total VOC factor is used; if this is speciated to get HAPs, score should be lowered.

7

DATA CODING PROCEDURES

This section describes the codes available to characterize traffic marking emission estimates. Consistent categorization and coding will result in greater uniformity between inventories. Inventory planning for data collection calculations and inventory presentation should take the data formats presented in this section into account. Available codes and process definitions may impose constraints or requirements on the preparation of emission estimates for this category.

7.1 PROCESS AND CONTROL CODES

The source category process codes for traffic marking operations are shown in Table 14.7-1. These codes are derived from the EPA's Aerometric Information Retrieval System (AIRS) Area and Mobile Source (AMS) source category codes (EPA, 1994). The control codes for use with AMS are shown in Table 14.7-2. The "099" control code can be used for miscellaneous control devices that do not have a unique identification code. The "999" code can be used for a combination of control devices where only the overall control efficiency is known.

Typically, the source category code for "total: all solvent types, traffic markings" will be used. Low-solvent or water-based coatings will be the control method, so either control device code 101 or 103 will be used.

TABLE 14.7-1

AIRS AMS CODES FOR TRAFFIC MARKINGS

Process Description	AMS Code
Total: All Solvent Types	24-01-008-000
Acetone	24-01-008-030
Butyl Acetate	24-01-008-055
Butyl Alcohols: All Types	24-01-008-060
n-Butyl Alcohol	24-01-008-065
Isobutyl Alcohol	24-01-008-070
Diethylene Glycol Monobutyl Ether	24-01-008-125
Diethylene Glycol Monoethyl Ether	24-01-008-130
Diethylene Glycol Monomethyl Ether	24-01-008-135
Ethyl Acetate	24-01-008-170
Ethylene Glycol Monoethyl Ether (2-Ethoxyethanol)	24-01-008-200
Ethylene Glycol Monomethyl Ether (2-Methoxyethanol)	24-01-008-210
Ethylene Glycol Monobutyl Ether (2-Butoxyethanol)	24-01-008-215
Glycol Ether: All Types	24-01-008-235
Isopropanol	24-01-008-250
Methyl Ethyl Ketone	24-01-008-275
Methyl Isobutyl Ketone	24-01-008-285
Special Naphthas	24-01-008-370
Solvent — General	24-01-008-999
Xylenes	N/A[a]

[a] N/A = No AMS source code assigned.

TABLE 14.7-2

AIRS CONTROL DEVICE CODES

Control Device	Code
Process Modification — Low-Solvent Coatings	101
Process Modification — Powder Coatings	102
Process Modification — Water-Borne Coatings	103
Miscellaneous Control Device	099
Combination Control Efficiency	999

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8

REFERENCES

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