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Region IV
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Air

EPA

Florida
Oxidant SIP Assistan
Phase I
Volatile Organic Co
Emissions Inventory

EPA-904/9-79-029a

Florida Oxidant SIP Assistance
Phase I
Volatile Organic Compound Emissions Inventory

by

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

The 1977 Clean Air Act Amendments require state and local governments to develop revisions to the State Implementation Plan (SIP) for all areas where the National Ambient Air Quality Standards (NAAQS) have not been attained (nonattainment areas). The U.S. Environmental Protection Agency (EPA) has been mandated by Congress to enforce the attainment and maintenance of these NAAQS. In accordance with this mandate, the EPA has determined that the SIP for Florida is inadequate for oxidants.

There are nine counties in Florida that are currently exceeding the NAAQS for oxidants. Due to the formation process of oxidants, the development of abatement strategies for these areas requires a comprehensive base of information concerning the injection of volatile organic compounds (VOC) into the atmosphere.

Pacific Environmental Services, Inc. (PES) was contracted by EPA Region IV to assist the State of Florida in compiling and analyzing data needed for oxidant control strategies. PES' task was divided into three phases.

Phase I

- Prepare an extensive seasonalized VOC emissions inventory for seven of Florida's nine oxidant nonattainment areas for calendar year 1977
- Forecast the base year (1977) emissions to reflect calendar years 1982 and 1987

Phase II

- Assist in the preparation of Reasonably Available Control Technology (RACT) regulations for VOC point sources in all nine counties. Point sources are defined in this study as having the potential to emit 100 tons or more of VOC per year.

- Determine RACT emission reduction estimates
- Analyze current air quality data
- Provide technical and editorial assistance in assembling the total Florida SIP package. This subtask involves all pollutant nonattainment areas.

Phase III

- Prepare an inspection/maintenance (I/M) program for seven of the nine oxidant nonattainment counties in Florida

Table 1-1 presents the study area by county and by phase involvement.

Table 1-1. FLORIDA STUDY AREA (VOC NONATTAINMENT AREAS)

County	AQCR	Metropolitan Area	Phase Involvement
Broward	050	Fort Lauderdale	I, II, III
Dade	050	Miami	I, II, III
Duval	049	Jacksonville	I, II, III
Escambia	005	Pensacola	I[a], II
Hillsborough	052	Tampa Bay	II, III
Leon	049	Tallahassee	I[a], II
Orange	048	Orlando	I, II, III
Palm Beach	050	West Palm Beach	I, II, III
Pinellas	052	Tampa Bay	II, III

[a] County classified as rural nonattainment area; only point sources are considered in this phase

Phase I activities are discussed in the remainder of this report, whereas Phases II and III are discussed in subsequent documents (EPA 904/9-79-029b and EPA 904/9-79-029c, respectively).

1.2 EMISSIONS INVENTORY

An emissions inventory is a descriptive listing of air pollutants that provides the basis from which pollutant reduction strategies may be planned and evaluated. The present inventory considers VOC emissions from both point and area sources in four major categories: evaporative sources, fuel combustion, solid waste disposal, and mobile sources. A complete source list is presented in Table 1-2.

1.2.1 APPROACH AND RATIONALE

The PES project team initiated the VOC inventory by gathering the necessary background information according to techniques outlined in EPA guideline documents (References 1 through 10). Recognized VOC emitting sources were classified according to the "Summary Format for VOC" reported in Reference 1 and outlined in Table 1-2, and were then further qualified into area and point sources based on the criteria noted in Section 1.1.

For each specific VOC emitting activity, the chemical composition of the emissions was assessed to allow allocation into a two-level photochemical reactivity scheme. As with the total VOC (TVOC) emitted, the emissions in these classes were projected to 1982 and 1987, using accepted forecasting techniques, including those described in the EPA guideline document "Projecting County Emissions" (Reference 2). An attempt was also made to seasonalize VOC emissions activities to more closely relate the inventory to the oxidant season, which, for purposes of this study, was defined as April through September.

Table 1-2. SOURCES OF VOC EMISSIONS

I. EVAPORATIVE SOURCES

- A. Processing, storage, transportation, and marketing of petroleum products
  - 1. Refinery fugitives
  - 2. Miscellaneous refinery sources
  - 3. Oil and gas production fields
  - 4. Natural gas and natural gasoline processing plants
  - 5. Gasoline and crude oil storage
  - 6. Ship and barge transfer of gasoline and crude oil
  - 7. Bulk gasoline terminals
  - 8. Gasoline bulk plants
  - 9. Service station loading and unloading
- B. Industrial processes, surface coatings, and solvent use
  - 1. Processes
    - a. Organic chemical manufacture
    - b. Paint manufacture
    - c. Vegetable oil processing
    - d. Pharmaceutical manufacture
    - e. Plastic products manufacture
    - f. Rubber products manufacture
    - g. Textile polymers manufacture
  - 2. Surface coatings
    - a. Large appliances
    - b. Magnet wire
    - c. Automobiles
    - d. Cans
    - e. Metal coils
    - f. Paper
    - g. Fabric
    - h. Metal furniture
    - i. Wood furniture
    - j. Flat wood products
    - k. Other metal products
    - l. Auto refinishing
  - 3. Solvent use
    - a. Degreasing
    - b. Drycleaning
    - c. Graphic arts
    - d. Adhesives
- C. Architectural surface coatings
- D. Cutback asphalt

II. FUEL COMBUSTION

III. SOLID WASTE DISPOSAL

- A. Incineration
- B. Open burning

IV. MOBILE SOURCES

- A. On-highway vehicles
- B. Off-highway vehicles
- C. Railroads
- D. Aircraft
- E. Vessels

Finally, because of the project's stringent time constraints, estimating techniques for point sources were employed in some cases. Although the associated errors are thought to be relatively minor, caution should be taken in using point source data. For example, many lithographic printing facilities utilized an oil-based ink known only by its trade name. The users were unaware of its solvent content and the supplier considered this information to be proprietary. Therefore, an average solvent content had to be developed and employed. Another example is the many operations that have significant fugitive VOC emissions, such as a beer company in the study area that has product spillage losses during bottling and packaging operations. No time was allocated for a thorough investigation of these activities, so engineering estimates were made. Estimates were also made for those sources that failed to submit complete data.

1.2.2 DATA SOURCES

Data needed for the emissions inventory were developed partly from published literature and partly from sources engaged in activities that might produce VOC emissions. In addition, a large portion of the information was obtained directly from local, state, and Federal agencies; those that were especially helpful included:

<u>Local Government</u>

Broward County Environmental Quality Control Board
Dade County Environmental Resources Management
Duval County Department of Health, Welfare, and Bio-Environmental Services - Air Pollution Control
Palm Beach County Health Department

<u>State of Florida</u>

Department of Environmental Resources
Department of Transportation

Department of Commerce
Department of Revenue
University of Florida, Bureau of Economic and Business Research
State Energy Office

Federal Government

Environmental Protection Agency, Region IV
Department of Commerce, Bureau of Census
Department of the Interior, Bureau of Mines
Department of Labor, Bureau of Labor Statistics

Information concerning specific point sources was gathered through the use of questionnaires submitted to plant managers during source visits. Addresses for these contacts were obtained from existing point source inventories, augmented with information from National Business Lists, Inc., the Directory of Florida Manufacturers (Reference 11), local telephone directories, and information provided by local agencies.

1.2.3 REPORT ORGANIZATION

Four sections comprise the remainder of this report. A brief description of their contents is as follows:

- Section 2.0 contains a description of the study area, along with a discussion of general background information such as population, employment, land use, and projections of these activities.
- Section 3.0 contains an analysis of the photochemical reactivity profiles applied to the various source categories.
- Section 4.0 includes a detailed discussion of the methodologies used for the base year and projection years for each source category examined, complete with VOC emissions estimates.
- Section 5.0 presents the results of the study and recommendations for further evaluation.

To simplify data manipulation and provide the reader with a lucid view of the assessment procedures, most of the data contained in this report have been rounded to three significant figures. In some cases, it may appear that the data contained in various tables and sections do not "add up," but this supposed inaccuracy is due to the rounding process and does not affect the overall precision of the study.

2.0 DATA BASE AND PRELIMINARY ANALYSIS

2.1 AREA DESCRIPTION

Seven counties are encompassed by this VOC inventory, and are referred to collectively as "the study area" throughout this phase of the work. Figure 2-1 shows the geographic location of each county in the study area.

The seven counties, together with Hillsborough and Pinellas (which are included in Phases II and III of this study), comprise the major metropolitan areas of Florida. Table 2-1 illustrates their distribution by Air Quality Control Region (AQCR) and Standard Metropolitan Statistical Area (SMSA).

Table 2-1. THE STUDY AREA

County	AQCR	SMSA
Broward	050	Ft. Lauderdale-Hollywood
Dade	050	Miami
Duval	049	Jacksonville[a]
Escambia	005	
Leon	049	
Orange	048	Orlando[b]
Palm Beach	050	West Palm Beach-Boca Raton

[a] SMSA also includes Nassau, Baker, Clay, and St. Johns Counties

[b] SMSA also includes Seminole and Osceola Counties

Leon and Escambia Counties are not referred to in the remainder of this section because their assessment did not warrant use of the belowmentioned data base items. However, Leon and Escambia

Figure 2-1. Geographic Location of Each County

were examined for point sources, which are discussed in Section 4.0.

2.2 POPULATION DATA

PES made an assertive effort to obtain county base year population estimates and projections directly from the appropriate local agencies. However, examination of the data received revealed that these estimates were inconsistent. During a telephone conference call between the project principals (Reference 1), it was therefore agreed that PES would use the population estimates called out in the 1977 Florida Statistical Abstract (Reference 2). These population figures are shown in Table 2-2.

In several instances, the 1977-1982 and 1977-1987 population growth factors reflected in Table 2-2 were used to project VOC emissions; Table 2-2 should therefore be referred to throughout Section 4.0.

2.3 EMPLOYMENT DATA

As with the population estimates, PES solicited county base year employment estimates and projections from participating local agencies, but for the most part, these estimates were obtained from the State of Florida's Department of Commerce (References 3-7). However, a difficulty arose in determining employment data for Duval and Orange Counties. As pointed out in Table 2-1, the Jacksonville and Orlando SMSAs, which contain Duval and Orange Counties, respectively, also contain other counties not included in this study. Consequently, in order to estimate county employment totals, it was necessary to assume that the ratio of county to SMSA population reflects the ratio of county to SMSA employment. This analytical technique can be expressed as:

Table 2-2. POPULATION DATA FIGURES[a]

Year	Broward County	Dade County	Duval County	Orange County	Palm Beach County	Florida State
1970	620,100	1,267,800	528,900	344,300	349,000	6,791,400
1972	722,700	1,342,500	545,000	385,000	390,400	7,441,500
1973	769,400	1,373,600	558,800	408,400	428,000	7,845,100
1974	828,200	1,413,100	570,400	424,000	459,200	8,248,900
1975	876,300	1,438,000	578,300	424,600	477,800	8,485,200
1976	884,900	1,449,300	579,700	420,600	488,000	8,551,800
1977	914,900	1,462,600	584,800	427,700	504,100	8,728,100
1978	945,800	1,476,100	590,000	434,900	520,800	8,908,000
1980	1,026,000	1,525,500	608,900	460,400	565,200	9,432,000
1982	1,097,000	1,556,000	620,200	481,200	604,600	9,859,700
1985	1,212,900	1,602,800	637,500	514,200	668,800	10,538,000
1987	1,265,700	1,672,500	691,800	536,500	697,900	10,996,500
1990	1,349,200	1,782,900	782,100	571,900	744,000	11,722,000

[a] Refer to Reference 2. The figures which are underlined are interpolations.

$$E_{ci} = RE_{(SMSA)i} \qquad (1)$$

where

E_{ci} = total county employment in sector i (i=1, construction; i=2, industrial; i=3, manufacturing; i=4, commercial/institutional)

R = ratio of county to SMSA population

$E_{(SMSA)i}$ = total SMSA employment in sector i

Table 2-3 shows county construction and industrial employment figures, while Table 2-4 provides county totals for manufacturing and commercial/institutional employment.

2.4 LAND USE DATA

The data used to project county land use figures for 1982 and 1987 were obtained from local planning agencies (References 10-18), but in most cases, data were not supplied for the principal years of interest (1977, 1982, and 1987). Data for those years were therefore generated by means of exponential interpolation between two known and acceptable figures.

The projected increases in cropland harvested were used to arrive at the county agricultural equipment projections for 1982 and 1987 shown in Table 4-55. The following assumptions were made:

- Land use more accurately reflects the amount of agricultural equipment in use than do earnings, since agricultural employment tends to decrease as more acres fall under mechanized crop production.
- Increases in the use of agricultural equipment will be proportional to the projected increases in total acres of cropland harvested.

Table 2-3. CONSTRUCTION AND INDUSTRIAL EMPLOYMENT PROJECTIONS[a]

County / Year	Construction Employment (SIC 16)					Industrial Employment				
	Broward[b]	Dade[c]	Duval[d]	Orange[e]	Palm Beach[f]	Broward[b]	Dade[c]	Duval[d]	Orange[e]	Palm Beach[f]
1973	6,430	4,950	4,480	4,150	2,220					
1974	6,510	5,090	4,660	4,140	2,290	106,660	262,860	83,590	69,750	63,150
1977	6,770	5,530	4,720	4,120	2,500	116,840	285,900	86,840	76,340	70,600
1978	6,850	5,680	4,730	4,110	2,570	120,210	293,530	87,890	78,640	73,100
1982	7,190	6,250	4,820	4,120	2,840	133,230	323,100	92,120	87,440	82,490
1985	7,450	6,710	4,890	4,130	3,060	143,920	347,220	95,420	94,680	90,320
1987	7,630	7,040	4,930	4,140	3,220	151,520	364,290	97,690	99,840	95,950

[a] The figures which are underlined are interpolations

[b] Refer to Reference 3

[c] Refer to Reference 4

[d] Refer to Reference 5 and Equation 2-1

[e] Refer to Reference 6 and Equation 2-1

[f] Refer to Reference 7

Table 2-4. MANUFACTURING AND COMMERCIAL/INSTITUTIONAL EMPLOYMENT PROJECTIONS[a]

Year \ County	Manufacturing Employment						Commercial and Institutional Employment[j]					
	Broward[b]	Dade[c]	Duval[d]	Orange[e]	Palm Beach[f]	Florida State	Broward[b]	Dade[c]	Duval[d]	Orange[e]	Palm Beach[f]	Florida State
1974	29,010	93,160	26,250	21,430	20,870	369,000[g]	217,910	511,220	175,360	133,730	122,390	2,222,700[g]
1975						327,700[g]						
1977	32,630	104.080	26,930	23,330	22,930	355,900[h]	243,290	561,430	186,890	153,680	140,310	2,279,900[h]
1978	33,850	107,700	27,140	23,980	23,620	381,860	251,740	578,140	190,730	160,200	146,260	2,455,240
1980						439,600[i]						2,347,400[i]
1982	38,430	121,610	27,990	26,090	26,190	506,070	284,030	642,330	204,990	182,320	168,790	3,302,202
1985	42,260	133,210	28,650	27,790	28,300	625,090	310,930	695,110	216,380	200,900	187,940	4,124,170
1987	45,030	141,550	29,100	28,980	29,800	719,600	330,270	732,680	224,320	214,320	201,900	4,782,900

[a] The figures which are underlined are interpolations
[b] Refer to Reference 3
[c] Refer to Reference 4
[d] Refer to Reference 5 and Equation 2-1
[e] Refer to Reference 6 and Equation 2-1
[f] Refer to Reference 7
[g] Refer to Reference 2
[h] Refer to Reference 8
[i] Refer to Reference 9
[j] Includes transportation, communication, other utilities, wholesale, retail, finance, insurance, real estate, services, and governmental employment

2.5 EMISSIONS SUBJECT TO INVENTORY

The volatile organic compounds (VOC) to be inventoried, although commonly referred to as hydrocarbons, are not all hydrocarbons in the strict chemical sense. When referred to as "total hydrocarbons" (THC), various hydrocarbon derivatives containing oxygen, chlorine, and other elements beside hydrogen and carbon are included. For purposes of this study, TVOC is equivalent to THC as defined above, with the following qualification.

A volatile organic compound is defined as "any compound of carbon that has a vapor pressure greater than 0.1 millimeters of mercury (≈0.002 psia) at standard conditions, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate" (Reference 19).

The majority of VOC that are released into the atmosphere ultimately engage in photochemical oxidant formation processes. Some VOC are more reactive than others and therefore have a quicker, more localized impact on air quality. For this reason, VOC can be described by their propensity to undergo photochemical reactions. There have been various reactivity schemes developed that attempt to quantify this phenomenon. These schemes vary from the relatively simple two-level system of methane/nonmethane to more complex multiple-level schemes (References 20 and 21). As specified in the task assignment for the project, PES employed the two-level scheme described in Reference 22. This scheme is discussed in Section 3.0.

REFERENCE FOR SECTION 2.0

1. Telephone conference call with Ron McHenry, Region VI, EPA, Marty Kahel, Steve Smallwood, Florida DER and Bill LaFroos, Bill Mustard, Florida DOT, July 14, 1978

2. Florida Statistical Abstract 1977, Bureau of Economic and Business Research College of Business Administration, University of Florida

3. Florida Employment Directions 1974-1985, Fort Lauderdale-Hollywood SMSA

4. Florida Employment Directions 1974-1985, Miami SMSA

5. Florida Employment Directions 1974-1985, Jacksonville SMSA

6. Florida Employment Directions 1974-1985, Orlando SMSA

7. Florida Employment Directions 1974-1985, West Palm Beach-Boca Raton SMSA

8. Economic Report of the Governor, 1977 Economic Forecast, January 1977, (Reubin Askew)

9. Florida Employment Directions 1970-1980, Florida Department of Commerce, Division of Employment Security, Research and Statistics, February 1976

10. Telephone communication with Louis E. Watson, Broward County Agricultural Extension Director, July 27, 1978

11. Existing and future land use figures for Broward and Palm Beach Counties, Environmental Protection Agency, July 24, 1978

12. Land Use Characteristics: 1960-1970, Metropolitan Dade County, Dade County Environmental Resources Management, July 5 and July 17, 1978

13. Telephone communication with Roge Mehta, Deputy Director of Jacksonville Area Planning Board, July 27, 1978

14. Telephone communication with Harold Hill, Planner, Orange County Planning Department, July 27, 1978

15. Orange County Land Use figures, Department of Environmental Regulations, July 31, 1978

16. Telephone communication with Gary Hines, Palm Beach County Area Planning Board, July 26, 1978

17. Telephone communication with Clayton Hutchinson, Orange County Agricultural Extension Office, July 26, 1978

18. Communication with William P. Stone, Broward County Agricultural Extension Service, July 31, 1978

19. Regulatory Guidance for Control of Volatile Organic Compound Emissions From 15 Categories of Stationary Sources, GCA/Technology Division, Bedford, MA. Prepared for the U.S. Environmental Protection Agency, Chicago, IL, under Contract No. 68-02-2887, Work Assignment No. 3, April 1978

20. Trijonis, J.C. and Arledge, K.W., "Utility of Reactivity Criteria in Organic Emission Control Strategies for Los Angeles," TRW Environmental Services, Redondo Beach, CA. Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC, under Contract No. 68-02-1735, December 1975

21. Pittis, J.N., "Keys to Photochemical Smog Control," Environmental Science and Technology, Volume II, No. 5, May 1977

22. Workshop on Requirements for Nonattainment Area Plans, U.S. Environmental Protection Agency, March 1978

3.0 REACTIVITY ANALYSIS

3.1 INTRODUCTION

PES categorized the VOC emissions inventoried during this study into a two-level photochemical reactivity scheme: nonreactive and reactive, hereafter referred to as Class I and Class II, respectively (Reference 1). Class I contains organic compounds which EPA has exempted from control based on their inability to engage in photochemical oxidant formation processes. As pointed out in a recent EPA publication on nonattainment area plans (Reference 2), the compounds encompassed by the Class I reactivity level are methane, ethane, 1,1,1-trichloroethane (methyl chloroform), and trichlorotrifluoroethane (Freon 113). All other VOC are categorized as Class II.

Throughout this inventory, all VOC emissions resulting from the evaporation of organic products are considered to be 100 percent Class II, unless otherwise indicated. On the other hand, all VOC emissions originating from combustion activities required generation of reactivity profiles based on fuel type consumed. The following is a discussion of the methodologies employed by PES in developing these profiles.

3.2 COMBUSTION REACTIVITY PROFILES

Table 3-1 categorizes the combustion sources inventoried in this study by reactivity level, and should be referred to throughout Section 3.2.

Table 3-1. CATEGORIZATION OF ORGANIC EMISSIONS

Source of Emissions	Reactivity Level (Weight Percent) Class I	Class II	Reference
A. Mobile Sources, Exhaust			
1. Gasoline Powered			
a. LDV Uncontrolled	12	88	3,4
b. LDV Controlled	14	86	3,4
c. LD Equipment			
(1) 2-stroke } (2) 4-stroke }	12	88	PES
d. HDV Uncontrolled	7	93	6
e. HD Equipment	7	93	6
2. Diesel Powered			
a. LDV } b. LD Equipment } c. HDV } d. HD Equipment }	2	98	6
3. Aircraft			
a. Jet (kerosene type fuels)	3	97	6
b. Piston	12	88	6,PES
B. Fuel Combustion			
1. Residual Oil	11	89	8
2. Distillate Oil	11	89	PES
3. Natural Gas	55	45	6
4. Coal	15	85	PES
5. Waste Burning and Other Fires	38	62	6

3.2.1 MOBILE SOURCES, EXHAUST

3.2.1.1 Gasoline Powered

3.2.1.1.1 Light-Duty Vehicles, Controlled and Uncontrolled

Reference 3 provides detailed exhaust VOC breakdowns for a light-duty vehicle (LDV) under both controlled and uncontrolled conditions. Unfortunately, the breakdowns exclude the oxygenated species, e.g., aldehydes. This omission makes them inadequate for estimating the exhaust breakdown into the photochemical reactivity scheme. However, Reference 4 gives VOC exhaust data by chemical category, including the oxygenated compounds (aldehydes) for a range of vehicles, but does not give a chemical species breakdown. Therefore, both references were employed to determine the classifications of exhaust VOC for controlled and uncontrolled vehicles.

Methane was called out in Reference 4, while ethane was left as part of the general category of total parrafins. Since ethane is only 1 to 2 percent of the total nonoxygenated compounds (Reference 3), little error was incurred when PES assumed that Class I included only methane.

It bears mentioning that even though the reactivity profiles for uncontrolled and controlled LDV appear to be similar, the average reduction in TVOC emissions for the uncontrolled vehicles is 73 percent. Another point worthy of discussion concerns unleaded versus leaded gasoline. The authors of Reference 5 did an exhaust VOC emissions study with three different automobiles using unleaded and leaded 91-octane gasoline. Their findings showed that TVOC emissions were 8 percent higher with the leaded than with unleaded fuel. However, they indicated that the presence or absence of lead in gasoline had no significant effect on the profile of their seven-class reactivity scheme. It can be reasonably assumed that this also applies to the two-level reactivity scheme used in the present inventory.

3.2.1.1.2 Light-Duty Equipment

Based on engineering and chemical judgment, PES assumed that two- and four-stroke LD equipment have reactivity profiles similar to uncontrolled LDV.

3.2.1.1.3 Uncontrolled Heavy-Duty Vehicles and Heavy-Duty Equipment

The reactivity profiles for uncontrolled heavy-duty vehicles (HDV) and HD equipment were extracted directly from Reference 6.

3.2.1.2 Diesel-Powered

The weight percentages for diesel-powered mobile sources listed in Table 3-1 represent a composition of diesel engines. Two- and four-stroke engines were considered at a variety of loads and burning a variety of diesel fuels. It was therefore assumed that this reactivity profile pertains to all diesel-powered equipment, i.e., automobiles, trucks, and tractors.

3.2.2 AIRCRAFT

3.2.2.1 Jet

Data presented in Table 3-1 are assumed to be representative of gas turbine engines in general, since it is known that the composition of exhaust VOC does not tend to vary substantially from turbine to turbine (Reference 6), although the mass emission rate does vary (Reference 7). The reactivity profile takes into account a typical landing-takeoff cycle (LTO), i.e., taxi-idle, takeoff-climbout, and approach.

3.2.2.2 Piston

Since aircraft piston engines are fundamentally similar to gasoline-powered automobile engines and burn similar fuel, it is reasonable to assume that their reactivity profiles are also similar. Because aircraft engines are not subject to emission controls, the uncontrolled reactivity profile for automobiles is applied to this category.

3.2.3 FUEL COMBUSTION

3.2.3.1 Residual Oil

This emission profile is based on an assessment of utility boilers that burn residual oil. Utility boilers were selected because approximately 95 percent of all residual oil combustion occurs in boilers of this type (Reference 8). Reference 7 indicates that powerplants and the industrial and commercial institutional sectors have the same TVOC emission factor for their residual oil boilers. Therefore, due to the lack of other evidence, it can be inferred that all residual oil-burning boilers have the same general VOC breakdown for their combustion gases. Thus the reactivity profile shown in Table 3-1 can be reasonably applied to any boiler that uses residual oil as a fuel.

3.2.3.2 Distillate Oil

No information on the reactivity profile of distillate oil was available from outside sources, so the engineering judgement of PES personnel was used to conclude that the breakdown for distillate oil is roughly comparable to that for residual oil.

3.2.3.3 Natural Gas

This reactivity profile was taken from Reference 6, Section 3.2.3 and is intended to be a working estimate of the combustion of different types of organic fuels. References 9 and 10 both suggest using this breakdown for natural gas, which seems reasonable in light of the fact that incomplete combustion of natural gas, which is primarily methane, results in such species as methanol and formaldehyde (Class II).

3.2.3.4 Coal

As in the situation with distiallate oil, the best engineering judgment of PES personnel was used to arrive at the reactivity profile for coal.

3.2.3.5 Waste Burning and Other Fires

This reactivity profile is an estimation of the composition of the VOC emitted by this diverse category, taken from Reference 6, Section 3.2.4.

REFERENCE FOR SECTION 3.0

1. Federal Register, Volume 42, No. 131, July 8, 1977, 35314-35316

2. Workshop on Requirements for Nonattainment Area Plans, U.S. EPA, March 1978

3. "1975 Ford Prototype, Detailed Hydrocarbon Emissions," received from Frank Black, U.S. Environmental Protection Agency, via Dr. Katherine Wilson, PES

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4.0 METHODOLOGY DEVELOPMENT AND VOC EMISSIONS ESTIMATES

4.1 INTRODUCTION

This section of the report provides detailed descriptions of the methodologies employed and the resulting VOC emissions estimates by source category inventoried. The presentation format adheres, in general, to that outlined in the "Summary Format for VOC" reported in Reference 1 and illustrated in Table 1-1.

Methodology development was based upon three primary sources of information, namely publications, governmental agencies, and information received directly from potential VOC emitting companies located in the study area. The latter source was relied on extensively in estimating VOC emissions from point sources and some of the larger area sources. Information extracted from publications and/or received from governmental agencies are addressed in detail in the appropriate source category, thereby requiring no further discussion at this point. However, since the acquisition and analysis of data received from potential VOC emitting sources represented a significant amount of effort, and since the results are mentioned throughout this report, the following provides an introductory discussion about the methodologies employed.

4.1.1 POINT SOURCE VISITS AND EVALUATION

As a starting point for this task, PES engineers prepared lists of potential VOC point sources by examining existing agency inventories (for the most part these inventories did not address VOC sources). Lists were augmented with information from National Business Lists, Inc., Directory of Florida Manufactures (Reference 2), local telephone directories, and from guidance provided by local air pollution control agencies. As an additional aid in preparing and prioritizing the lists, information reported in Reference 3 was used. This Reference identifies major Standard Industrial Classifications (SICs) associated with major VOC emitting sources, along with emission estimates based on employee population (refer to Table 4-1).

Because of stringent time constraints, a maximum 2 week data gathering period was allowed for each county. For the relatively small counties this proved to be sufficient time, but for large counties, such as Dade and Duval, more time was required because of the large number of potential point sources. Obviously, there was not enough time for extensive data collection and engineering analysis of each facility. Therefore, in some instances, generalized assumptions were made to allow source assessments which inadequate data would otherwise have prohibited.

Results of point source evaluations are presented in the appropriate evaporative source/categories. Appendix A contains a copy of the questionnaire that was used as a guide during facility visits.

4.1.2 IDENTIFICATION AND EVALUATION OF EVAPORATIVE AREA SOURCES

The identification and evaluation of evaporative area sources are difficult tasks in an emissions inventory. One of two approaches can be employed to resolve these difficulties: (1) identify and survey all potential sources, or (2) employ a generalized estimating method. Because of resource availability, time requirements, and the difficulty of obtaining a respectable return rate from a mail out survey, a generalized estimating approach was employed to determine most evaporative area source emissions.

Many large evaporative area sources were identified and evaluated during potential point source visits, as discussed earlier. To determine emissions from the remaining area sources, information from Reference 3 was again employed (refer to Table 4-1). Research into the use of data from similar studies (References 4 and 5) did

Table 4-1. ESTIMATED RANGES OF EVAPORATIVE VOC EMISSIONS PER EMPLOYEE WITHIN SELECTED SIC CATEGORIES

General 2-Digit SIC Categories	Specific 4-Digit SIC Categories	Emission Range (ton/yr/employee)
20 Food	Alcoholic beverages (2085)	0.075
21 Tobacco	Not surveyed	-------
22 Textiles	Coatings (2295), Non-wovens (2297), Dyeing (2231)	.563 - .89
23 Apparel	Not surveyed	-------
24 Lumber & Wood	Finished product (2435), (2492)	.024 - .07
25 Furniture & fixtures	SIC: (2511), (2514), (2521) (2522), (2542)	.08 - .24
26 Paper	Bags, box (2643), (2651), (2653), Coated papers (2641)	1.0 - 1.25
27 Printing	Newspaper publishing (2711) Comm. printing (2751), (2754)	.08 - .5
28 Chemicals	Organic chemical mfg. (2821), (2823), (2861), Chemical coating (2851), Specialty chemicals (2842), Carbon black (2895)	.32 - .357
29 Petroleum	All companies	.11 - 2.12
30 Rubber, plastic	Footwear (3021), Plastics (3041), (3069)	.16 - .256
31 Leather	Mfg. shoes (3149), Bags (3161), Personal goods (3172), Leather refinishing (3111)	.13
32 Stone, clay, etc.	Glass products (3221)	.03 - .092
33 Primary metal	Treating (3398), Tubing (3357)	.10 - .267
34 Fabricated metal	Screws (3451-2), Metal stampings (3469), Plating (3471), Tool mfg. (3423), (3429)	.19 - .281
35 Machinery	Industrial machines	.03 - .048
36 Electrical machinery	Devices (3643), Semicond. (3674)	.04 - .07
37 Transportation equipment	Boats (3732), (3731), Truck bodies (3711), 13, 14, 15)	.11 - .855
38 Instruments	Optical frames (3832) Precision instruments (3825)	.04 - .199
39 Miscellaneous manufacturing	Jewelry (3914-15), Toys (3944), Writing instr. (3951, 53)	.07 - .259
5171 Bulk terminals	All surveyed as point sources	-------

not warrant their use. Therefore, employee populations of the SIC numbers presented in Table 4-1 were received from Reference 2 and Bureau of Census information (Reference 6) and applied to average emission factors for each employee. Evaporative point source data were deleted from this total, thereby resulting in potential VOC emissions attributed to evaporative area sources. VOC SIC numbers were then distinguished by source category, i.e., industrial surface coating, industrial processes, degreasing, graphic arts, adhesives, etc. Each of these categories is discussed in subsequent sections. Although this approach is highly speculative in nature, it provided a means of estimating emissions in lieu of more substantive information.

4.2 PETROLEUM INDUSTRY

The petroleum industry can be divided into three broad categories: (1) petroleum production (i.e., oil wells) and transportation, (2) petroleum refining, and (3) transportation and marketing of finished petroleum products. A diagram depicting the flow of gasoline, which is the major petroleum product of concern, for these marketing operations and potential VOC emissions points is illustrated in Figure 4-1. Data on the petroleum industry's operations were collected by various means and are reported in the remainder of this section.

4.2.1 PRODUCTION AND REFINING

There are three petroluem operations encompassed by this category: petroleum refineries, oil and gas production fields, and natural gas/gasoline processing plants. After a careful review of the information sources to be discussed, none of these operations were found to occur in the study area.

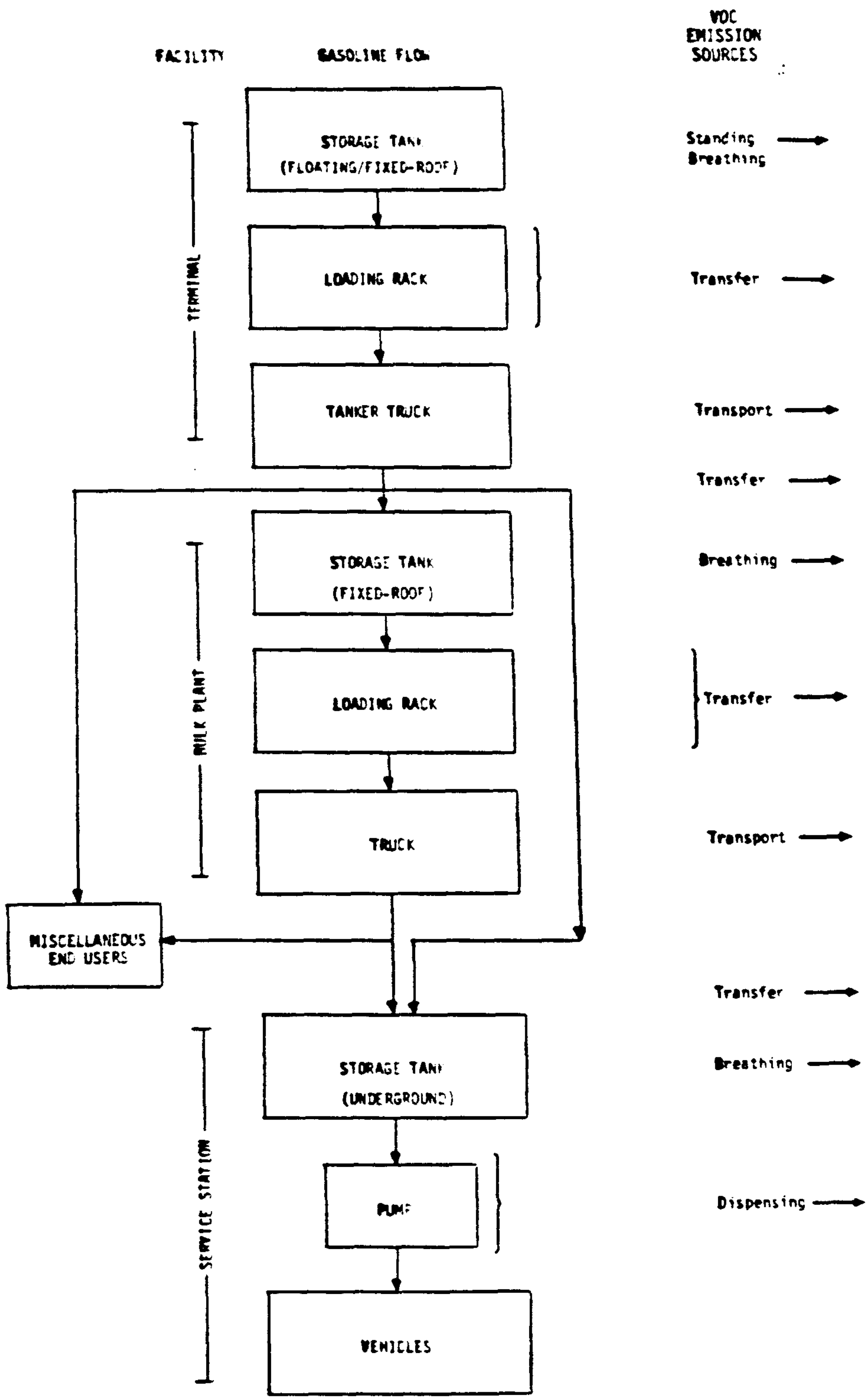

Figure 4-1. Gasoline Marketing Operations and Emission Sources

For the first activity, petroleum refineries, various source directories were reviewed, discussions held and lists obtained from local agencies, and the Oil and Gas Journal (Reference 7) was reviewed. As noted in the "Annual Refining Survey" of the Oil and Gas Journal, only one petroleum facility, (an asphalt plant) not located in the subject counties, exists in Florida.

PES has developed an oil field model (Reference 8) to calculate VOC emissions from oil and gas production. This model's data base contains information on all oil fields in the United States, and is capable of calculating emissions for four pollutants including hydrocarbons. After a careful review of the data base, no oil and gas fields were found in the subject counties.

The last activity that was not found in the subject counties was natural gas and natural gasoline processing plants. As with petroleum refineries, various source listings were reviewed and local agencies were contacted, but no activities were found.

4.2.2 SHIP AND BARGE TRANSFER OF GASOLINE AND CRUDE OIL

4.2.2.1 Base Year Analysis

Due to the nature of the data available, the base year for this section is 1976. Adjustment of the VOC emissions estimates to reflect 1977 is discussed in Section 4.2.2.2.

The point of origin for the marketing of petroleum products within a given area is the transportation phase of moving the products from the petroleum refinery to petroleum storage terminals. Inasmuch as there are no refineries in or around the study area and because the study area is primarily located along the East coast of Florida, the major modes of transport of both gasoline and crude oil are ocean-going tanker and barge.

VOC emissions associated with transport of this type are the result of evaporative losses during loading/unloading operations at marine terminals and of the transit losses between them. Since the study area ports are usually inbound to petroleum products, the losses due to vessel loading are of no consequence and, therefore, were not considered in this study.

Transit losses occur when VOC vapors are expelled from petroleum cargo tanks because of temperature and barometric changes. The TVOC emission rates that are characteristic of these losses were extracted from Reference 9 and are presented in Table 4-2.

Table 4-2. TVOC EMISSION FACTORS FOR SHIP AND BARGE TRANSFER OF PETROLEUM PRODUCTS

Petroleum Product	Transit[a]	Tanker Ballasting[b]
Crude Oil	1	.6
Gasoline	3	.8

[a] Expressed as pounds per week per thousand gallons transported

[b] Expressed as pounds per thousand gallons of cargo capacity ballasted

Because transit losses are computed in units of pounds per week per thousand gallons transported, the losses had to be adjusted to the time each vessel normally spends within county limits. At the time this report was prepared, PES was unable to obtain the average vessel stay for the ports in question. Therefore, as suggested by Reference 9, the average stay per vessel was assumed to be 3 days.

Table 4-3 reports the county throughputs for the petroleum products under study and the resulting VOC emissions estimates for transit losses based on the methodology described. These estimates are considered to be conservative because outbound vessels are assumed not to have petroleum products aboard. However, there are VOC emissions associated with the residual vapors left in the empty cargo tanks, which partially compensate for this overestimation.

The principal sources of losses that occur during unloading operations are the actual unloading of the product and the process of taking on ballast before leaving port.

During the unloading operation, the ships' manifolds are connected to shore by means of cargo hoses or hydraulic arms. Thus, the product is pumped directly from the cargo tank to onshore storage tanks. Since the transfer operation is essentially a closed system, the resulting VOC emissions are considered to be negligible.

Consequently, the major source of unloading emissions occur when the empty vessel takes on ballast before leaving port. During unloading of petroleum liquids, the air that is drawn into the emptying cargo tanks absorbs VOC evaporating from the liquid and tank surfaces. Prior to departing, several tanks are filled with sea water in order to maintain trim and stability while underway. As the ballast enters the tanks, it generates losses by displacing residual VOC vapors into the atmosphere through the tanks' vents and ullage cap. For this reason, the emission rate is dependent on the volume of ballast taken on. This fact is reflected in the TVOC emission factor reported in Table 4-2.

Vessels may ballast anywhere from 20 to 40 percent of cargo capacity before leaving port. For the ports in question, the total annual capacity for all petroleum carrying vessels using the

Table 4-3. VOC EMISSIONS ESTIMATES FROM THE SHIP AND BARGE TRANSFER OF GASOLINE AND CRUDE OIL, 1976

County	Throughput[a]		TVOC Emission Estimates[d]						
			Transit Losses			Unloading Losses			Grand Total
	Crude Oil	Gasoline	Crude Oil	Gasoline	Total	Crude Oil	Gasoline	Total	
Broward[a]	34.0	1,580,000[b]	NEG	1,020	1,020	NEG	632	632	1,650
Dade[b]	76.3	2,710	NEG	2	2	NEG	1	1	3
Duval	2,770	781,000	NEG	502	502	1	312	313	815
Orange[c]	---	---	---	---	---	---	---	---	---
Palm Beach	76.0	2,580	NEG	NEG	NEG	NEG	NEG	NEG	NEG

[a] Expressed in thousands of gallons per year. Refer to Reference 10

[b] Data provided by Broward County Environmental Quality Control Board

[c] No ports located in Orange County

[d] Expressed in tons per year and assumed to be 100 percent Class II

ports is unknown. Therefore, for purposes of this study, it was assumed that the total volume of gasoline and crude oil unloaded equals the total volume of ballast taken on. Using this rationale, the VOC emissions estimates for unloading operations are reported in Table 4-3. These emissions estimates are assumed to be 100 percent Class II.

4.2.2.2 Projections

Information necessary to accurately project the 1976 VOC emissions estimates to the inventory base year, 1977, and to the projection years 1982 and 1987 is unavailable at the present time. However, the draft report, Florida Water Port Systems Study (Reference 11), provided sufficient data on which to base the projections. This study supplies data on anticipated growth in the tonnage of cargo that will pass through Florida ports. PES adopted these projections because petroleum products represent a substantial proportion of the total cargo handled in the study area ports. Section 4.9.5.1.2 described in detail the growth rates extracted from this report, and Table 4-4 presents the results of their application to the 1976 figures.

Table 4-4. PROJECTED VOC EMISSIONS FROM SHIP AND BARGE TRANSFER OF GASOLINE AND CRUDE OIL[a]
(ton/year)

County	1977	1982	1987
Broward	1,690	1,880	2,090
Dade	4	4	6
Duval	832	923	1,020
Orange	N/A	N/A	N/A
Palm Beach	NEG	NEG	NEG

[a] Assumed to be 100 percent Class II

4.2.3 GASOLINE BULK PLANTS AND TERMINALS

4.2.3.1 Base Year Analysis

For purposes of this inventory, a gasoline terminal is defined as having a gasoline throughput of 20 thousand gallons per day or greater (Reference 12). At the terminal, gasoline is stored, transferred to tank trucks or rail cars, and subsequently delivered to gasoline bulk plants (intermediate wholesale outlets). From bulk plants, gasoline is transferred by tank trucks to service stations (large retail outlets) and commercial accounts (refer to Figure 4-1).

The sources of VOC emissions at bulk plants and terminals are storage and transfer operations. At bulk plants, transfer losses occur during the loading/unloading of gasoline into/out of tank trucks and rail cars. At gasoline terminals however, transfer losses are assumed to occur during loading operations only because most gasoline is received by pipeline from marine terminals (refer to Section 4.2.2).

During transfer operations, emissions from loading racks, tank trucks, and other handling processes occur. Loading racks consist mainly of shutoff valves, meters, relief valves, bypass plumbing, and loading arms.

Truck loading is accomplished by either topsplash fill or submerged fill (bottom or submerged fill pipe) through hatches, or by dry connections on top of trucks. Meetings with gasoline bulk plant and terminal personnel in the study area and communication with local agency personnel, revealed that the loading of truck or rail tanks is accomplished primarily by submerged fill, i.e., by top-submerged or bottom loading. Vapor recovery was not practiced in the study area during 1977. The CTG documents on gasoline bulk plants and terminals (References 12 and 13) and Reference 9 indicate that an appropriate emission factor for submerged filling is 5 pounds per 1,000 gallons of gasoline transferred.

Applying this emission factor to the total county 1977 gasoline throughput, derived from visits to the individual facilities and local agencies, resulted in the values presented in Table 4-5. These VOC emissions estimates are considered to be 100 percent Class II (refer to Section 3.0).

Table 4-5. ESTIMATED GASOLINE BULK PLANT AND TERMINAL THROUGHPUTS AND VOC EMISSIONS FROM TRANSFER OPERATIONS, 1977

County	Gasoline Throughput (10^3 gal/yr)	VOC Emissions[a]	Gasoline Throughput (10^6 gal/yr)	VOC Emissions[a]
Broward	365	1	1,550	3,880
Dade	0	0	0	0
Duval	840	2	996	2,490
Escambia	0	0	4	10
Orange	0	0	330	825
Palm Beach	NEG	NEG	0	0

[a] Expressed in tons per year and assumed to be 100 percent Class II

The losses attributed to storage of gasoline at these facilities are deferred to Section 4.2.5.

4.2.3.2 Projections

Information concerning projected throughputs for individual gasoline bulk plants and terminals was either unavailable or inadequate. Therefore, the base year emissions were projected using anticipated demand for gasoline nationwide. A detailed analysis of gasoline marketing trends and the resulting growth factors is presented in Section 4.2.4. Combining the growth factors with the emission data in Table 4-5 yields the projected VOC emissions in Table 4-6.

Table 4-6. PROJECTED VOC EMISSIONS FROM TRANSFER OPERATIONS AT GASOLINE BULK PLANTS AND TERMINALS[a]
(ton/yr)

County	1982	1987
Broward	3,830	3,620
Dade	0	0
Duval	2,460	2,320
Escambia	10	9
Orange	813	768
Palm Beach	0	0

[a] Assumed to be 100 percent Class II

4.2.4 SERVICE STATIONS

The primary retail gasoline distributor at the county level is the service station. At service stations or other gasoline retail outlets, e.g., auto repair garages and parking garages, gasoline is delivered to underground storage tanks and subsequently transferred to vehicle fuel tanks.

Estimates of VOC emissions originating from service station-type operations were based on the total gasoline throughput for all operations in the county. Emissions were computed by applying emission factors that represented typical processes (i.e., tank loading, spillage, and so on) to the throughput totals.

4.2.4.1 Base Year Analysis

PES contacted all local agencies involved in the study, as well as the Florida State Department of Revenue, in an effort to secure gasoline throughputs for each county in the study area. After examining all data received, PES concluded that the Department of Revenue's throughputs, which were based on gasoline sales, were the most reliable (Reference 14). These county totals are summarized in Table 4-7.

Table 4-7. THROUGHPUT AND VOC EMISSIONS ESTIMATES FROM GASOLINE SERVICE STATIONS, 1977

County	Gasoline Sales[a]	Total 1977 VOC Emissions[b]	Stage I Losses[b]	Stage II Losses[b]
Broward	446,500	4,310	2,140	2,170
Dade	651,600	6,290	3,130	3,160
Duval	301,200	2,910	1,450	1,460
Orange	270,300	2,610	1,300	1,310
Palm Beach	237,700	2,290	1,140	1,150

[a] Refer to Reference 14. Expressed in thousands of gallons per year

[b] Expressed in tons per year and assumed to be 100 percent Class II

Vehicle refueling and underground tank loading are the major sources of VOC emissions at service station-type operations. Breathing losses from underground tanks and spillage during vehicle refueling are other sources.

VOC emissions from refueling underground tanks are the result of displacing gasoline vapor-laden air from the storage tanks into the atmosphere. VOC emission rates for this operation are determined principally by type of fuel loading: splash filling, submerged filling, or vapor recovery submerged filling. Reference 4 noted that in the Tampa Bay Area (Hillsborough and Pinellas Counties), no vapor recovery system of any kind was currently in use. It also revealed that 70 percent of the service stations were equipped with submerged fill, while 30 percent were equipped with splash fill. In the absence of other data, PES elected to apply these characteristics directly to the counties in the study area. Employing the VOC emission factors for submereged and splash filling (Reference 9, AP-42), with the 70:30 ratio, yielded a weighted factor of 8.6 lb/1,000 gal throuhgput. The emission factor that accounts for underground storage tank breathing losses (Reference 9) was added to this value, resulting in a combined factor of 9.6 lb/1,000 gal throughput. This factor represents VOC emissions resulting from service station loading (Stage I) activities.

Emissions from vehicle refueling, like those from loading underground tanks, arise from displacement of VOC vapors during tank loading and from evaporation of gasoline which has been spilled or spit back during filling. Reference 9 estimated that VOC emission rates for these sources, defined as service station unloading losses (Stage II), were 9.0 and 0.7 lb/1,000 gal throughput, respectively.

Combining the TVOC emission factors for Stage I and Stage II activities with the county gasoline throughputs shown in Table 4-7 resulted in the county emission estimates also shown in Table 4-7. Finally, as described in Section 2.0, VOC emissions originating from gasoline marketing are considered to be 100 percent Class II reactivity level.

4.2.4.2 Projections

Because of the rapid obsolescence of gasoline marketing forecasts, PES conducted an automated literature search of several data bases in order to locate the most recent projections.

Among the sources reviewed were government documents (References 15 and 16), industrial publications (References 17, 18, and 19), and scientific publications (Reference 20). While these were not used as primary references, they did aid in developing an overall view of gasoline supply and demand.

The source selected to project gasoline marketing emissions was an Exxon publication entitled Energy Outlook, 1978-1990 (Reference 21). This study was the most recent projection of gasoline consumption, and seemed to be a logical extension of earlier studies and recent events.

Table 4-8 illustrates estimates and projections of national gasoline demand, along with rates of growth (decline). These rates were used to project base year VOC emissions to 1982 and 1987, the results of which are given in Table 4-9.

Table 4-8. U.S. GASOLINE CONSUMPTION ESTIMATES AND PROJECTIONS

Year	1977	1980	1982	1987	1990
Millions of barrels per day	7.2[a]	7.3[b]	7.1[c]	6.7[c]	6.5[b]
Rate of growth (1977-1982)	← .986 →				
Rate of growth (1977-1987)	← .931 →				

[a] Refer to Reference 19
[b] Refer to Reference 21
[c] Interpolated values

Table 4-9. PROJECTED GASOLINE SALES AND LOSSES FOR SERVICE STATIONS

County	1982				1987			
	Gasoline[a] Sales	Stage I Losses[b]	Stage II Losses[b]	Total VOC Emissions[b]	Gasoline[a] Sales	Stage I Losses[b]	Stage II Losses[b]	Total VOC Emissions[b]
Broward	440,200	2,110	2,140	4,250	415,200	1,990	2,020	4,010
Dade	642,500	3,080	3,120	6,200	606,700	2,910	2,940	5,850
Duval	297,000	1,430	1,440	2,870	280,400	1,350	1,360	2,710
Orange	266,500	1,280	1,290	2,570	251,600	1,210	1,220	2,430
Palm Beach	234,300	1,120	1,140	2,260	221,300	1,060	1,070	2,130

[a] Expressed in thousands of gallons per year

[b] Expressed in tons per year and assumed to be 100 percent Class II

4.2.5 PETROLEUM STORAGE

4.2.5.1 Base Year Analysis

Emissions resulting from the storage of gasoline, excluding gasoline service stations, and other petroleum products were estimated by use of a PES utility computer program referred to as TANK-1. TANK-1 employs the methodology described in Section 4.3 of Reference 9 (AP-42) to estimate breathing and working losses from petroleum product storage tanks. The following is a brief discussion of this program and the results it yielded. For a more detailed discussion, the reader is referred to Reference 75.

In addition to tank throughput data, the equations utilized by TANK-1 require three types of input parameters:

- Meteorological parameters
- Tank design parameters
- Petroleum liquid property parameters

If information for a particular tank parameter is missing, the program resorts to a default value to allow all calculations to be completed. The minimum data needed on each storage tank for TANK-1 to perform the calculations are tank capacity, tank roof type (floating or fixed), and petroleum product stored. It is also of great importance whether or not a vapor recovery system is present. PES was able to collect these data on each tank in the study area, as well as detailed tank design parameters, product parameters, and meteorological data, as a result of source visits and access to agency files. In most cases, default values were therefore not required.

Average meteorological conditions for July were used to calculate seasonal VOC emissions. These conditions are shown in Table 4-10.

Table 4-10. METEOROLOGICAL DATA ASSUMPTIONS FOR JULY

County	Average Temperature (°F)	Diurnal Temperature Change (°F)	Average Wind Speed
Broward	81.5	10.6	7.5
Dade	81.5	10.6	7.5
Duval	82.1	19.0	8.0
Escambia	82.0	16.0	7.7
Orange	82.1	19.0	8.0

To account for the variation in meteorological conditions throughout Florida, the state was divided into meteorological districts, the boundaries of which were selected so that the general methodology of each district was characterized by data recorded in that district. Thus each emission calculation was performed using meteorological data that corresponded to the district in which the specific tank was located.

As previously described, input for the tank design and petroleum liquid property parameters was obtained from the data compiled about each tank from source visits and access to agency files. The number of bulk plants, terminals, and other significant storage facilities found in the study are shown in Table 4-11. Where necessary, the default values used for the tank design parameters were based on tank design trends identified from TANK-1's extensive data files (refer to Reference 75). For the most part, the vapor pressure data acquired from the sources were not considered reliable, so all vapor pressures were taken from Reference 9 (AP-42). Table 4-12 lists vapor pressures that were used in the calculations for some of the more common petroleum liquids.

Table 4-11. NUMBER OF MAJOR PETROLEUM STORAGE FACILITIES IN THE STUDY AREA

County	Terminal	Bulk Plant	Other
Broward	15	1	2
Dade	0	0	8
Duval	13	1	6
Escambia	3	0	2
Orange	1	0	2
Palm Beach	0	--[a]	--[a]

[a] Small tank farms located at Palm Beach International Airport but assumed to have negligible emissions

Table 4-12. DEFAULT VALUES FOR PETROLEUM VAPOR PRESSURES[a]

Petroleum Liquid	True Vapor Pressure (at 70°F)
Gasoline	6.2
Kerosene	.011
Diesel fuel	.009
Fuel oil No. 2 (distillate oil)	.009
Fuel oil No. 6 (residual oil)	.00006
Commercial jet fuel	.011
Military jet fuel	1.6
Naptha	4.3

[a] Refer to Reference 9

Table 4-13 shows the results of applying TANK-1. All storage emissions associated with gasoline and crude oil are tabulated in the column entitled "Gasoline and Crude Oil." Losses from the remaining products (distillate oil, jet fuel, and so on) are shown in the column entitled "Other." It should be noted that TANK-1 is not capable of handling variable space or pressure tanks. For the few tanks of this type, VOC emissions were hand calculated according to Reference 9 and are included in Table 4-1.

Although some petroleum storage materials contained a small amount of Class I emissions such as crude oil, these were assumed to be negligible compared to overall storage VOC emissions. Thus, all VOC emissions from petroleum products were assumed to be Class II.

Table 4-13. ESTIMATED VOC EMISSIONS FROM STORAGE, 1977 (ton/yr)

County	Tank Storage Losses[a]		
	Gasoline and Crude Oil	Other	Total
Broward	2,340	401	2,740
Dade	7	241	242
Duval	3,400	900	4,300
Escambia	1,180	522	1,700
Orange	102	8	110
Palm Beach[b]	NEG	64	64

[a] Assumed to be 100 percent Class II

[b] Small tank farms located at Palm Beach International Airport. VOC emissions are considered to be negligible

4.2.5.2 Projections

Even though other materials are stored besides gasoline, there is a lack of available projection information for each petroleum material. Projected county storage emission totals were therefore developed using the approach discussed for gasoline growth in Section 4.2.3.3. The results of these projections are presented in Table 4-14.

Table 4-14. PROJECTED VOC EMISSIONS FROM PETROLEUM STORAGE
(ton/yr)

County	Total Petroleum Losses[a]	
	1982	1987
Broward	2,700	2,550
Dade	245	231
Duval	4,240	4,000
Escambia	1,680	1,580
Orange	108	102
Palm Beach	63	60

[a] Assumed to be 100 percent Class II

4.3 INDUSTRIAL PROCESSES

Various facilities in the study area have a main operation that can be defined as an industrial process. These industrial processes include but are not limited to the manufacture of:

- Organic chemicals
- Paint
- Plastic products

- Rubber products
- Textile polymers

All of these processes involve the use of organic solvents. The VOC emissions from these processes are the result of solvent evaporation, either deliberately, as in drying of finished fiber in textile polymer manufacturing, or unintentionally, as in the case of paint manufacturing.

4.3.1 BASE YEAR ANALYSIS

Table 4-15 summarizes the VOC emissions from all facilities involved in industrial processes in the study area.

Table 4-15. ESTIMATED VOC EMISSIONS FROM INDUSTRIAL PROCESSES, 1977[a]
(ton/yr)

County	Point Sources	Area Sources	Total
Broward	52	168	220
Dade	374	796	1,170
Duval	1,350	362	1,710
Escambia	1,900	-- [b]	1,900
Orange	219	95	314
Palm Beach	0	43	43

[a] All VOC emissions are considered to be 100 percent Class II

[b] Area sources in Escambia County were not addressed in this study

The point source estimates are the result of engineering analysis on data that PES collected during facility visits (refer to Section 4.1.1). The area source estimates resulted from applying the manufacturing employee evaporative TVOC emission factors, as discussed in Section 4.1.2.

4.3.2 PROJECTIONS

Area source industrial process VOC emissions were projected by the percentage increase/decrease forecast for manufacturing employment in the various counties (refer to Section 2.3). The point sources were projected on a case-by-case basis using information supplied by the appropriate facilities. These data are summarized in Table 4-16.

Table 4-16. PROJECTED VOC EMISSIONS FROM INDUSTRIAL PROCESSES[a]
(ton/yr)

County	1982	1987
Broward	275	335
Dade	1,400	1,650
Duval	1,740	1,750
Escambia[b]	1,930	1,950
Orange	291	301
Palm Beach	49	56

[a] All VOC emissions are considered to be 100 percent Class II

[b] Totals do not include area sources

4.4 INDUSTRIAL SURFACE COATING

Surface coating involves the application of decorative or protective materials in liquid or powder form to any of a number of substrates. These coatings normally include general solvent-type paints, varnishes, lacquers, and water-thinned paints. After application by one of a variety of methods, such as brushing, rolling, spraying, dipping, and flow coating, the surface is air and/or oven dried to remove the volatile solvents leaving the coated surface. Powder-type coatings can be applied to a hot surface or melted after application and caused to flow together. Other coatings can be applied normally, then polymerized by curing thermally with infrared or electron beam curing systems.

Industrial surface coating is employed in manufacturing the following products:

- Large appliances
- Magnet wire
- Automobiles
- Cans
- Metal coils
- Paper
- Fabric
- Metal furniture
- Wood furniture
- Flat wood products
- Other metal products

4.4.1 BASE YEAR ANALYSIS

Table 4-17 contains the base year emissions for industrial surface coatings. These emissions are the result of (1) point source visits by PES engineers and (2) the application of employee TVOC emission factors, as discussed in Section 4.1.

Table 4-17. ESTIMATED VOC EMISSIONS FROM INDUSTRIAL SURFACE COATING, 1977[a] (ton/yr)

County	Point Sources	Area Sources	Total
Broward	0	1,420	1,420
Dade	196	1,732	1,928
Duval	683	857	1,540
Escambia	0	--[b]	0
Orange	368	470	838
Palm Beach	26	385	411

[a] All VOC emissions are considered to be 100 percent Class II

[b] Area sources in Escambia County were not addressed in this study

4.4.2 PROJECTIONS

Table 4-18 contains projected VOC estimates for industrial surface coatings. As with industrial processes, these projections are the result of (1) projection information collected from each point source and (2) application of projected manufacturing estimates in the various counties, as presented in Section 2.3.

Table 4-18. PROJECTED VOC EMISSIONS FROM INDUSTRIAL SURFACE COATING[a] (ton/yr)

County	1982	1987
Broward	1,700	1,990
Dade	2,210	2,550
Duval	1,530	1,570
Escambia[b]	--	--
Orange	928	985
Palm Beach	494	561

[a] All VOC emissions are considered to be 100 percent Class II

[b] Totals do not include area sources

4.5 NONINDUSTRIAL SURFACE COATING

4.5.1 TRADE PAINTS

Paints, stains, varnishes, and other protective or decorative coatings sold to the public, paint contractors, institutions, and other nonindustrial sources through retail outlets are commonly referred to as trade paints. Trade paints include architectural surface coatings (ASC), automotive refinishing (AR), and miscellaneous nonindustrial surface coatings (MSC).

The VOC emissions originating from trade paints can be attributed to the quantities of paint used. Consequently, determinations of the total weight of the organic compounds contained in these coatings is equivalent to estimating VOC emissions from this source category.

4.5.1.1 National VOC Emissions Estimates

Data as to the quantity of trade paints consumed nationally during 1977 were not available at the time this report was prepared. However, U.S. Bureau of Census figures indicated that, over the past few years, trade paint sales have fluctuated around a relatively stable value (Reference 22). As a reasonable working estimate for 1977, the 1974 to 1976 national totals were therefore averaged, yielding a value of 467 million gallons of trade paint sold. This nationwide average was also used for 1982 and 1987, because all industry personnel contacted indicated that trade paint sales are expected to remain fairly constant in future years (Reference 23).

The types of trade paints (e.g., water-based) included in the 1974 to 1976 Bureau of Census sales totals were not specified. In order to determine the paint type distribution, annual reports prepared by the National Paint and Coatings Association (NPCA) were consulted (Reference 22). NPCA queried 86 major paint companies as to their paint sales during 1974, 1975, and 1976. Comparison of NPCA data with the Bureau of Census figures suggested that the NPCA surveys covered a consistent cross-section of the paint industry. It was therefore assumed that NPCA's ratios of water to organic solvent-based paints sold during these years represent reasonable working estimates.

Percentages of water and solvent-based trade paints for the baseline and projection years were obtained by linear regression, using NPCA's paint type distribution data for 1974 to 1976, yielding a correlation coefficient of -0.9996. The results of this analysis are presented in Table 4-19. Although the projected ratios are believed to be the best available, future technology and/or regulatory actions could alter these values.

Table 4-19. NATIONWIDE TRADE PAINT TYPE DISTRIBUTIONS (Percent)

Paint Type	1977	1982	1987
Water-based	58.9	68.9	78.8
Organic solvent-based	41.3	31.1	21.1

Thus, the total pounds of solvent contained in trade paints nationwide, which is synonymous with the VOC emissions estimate for this source category, can be expressed as:

$$S_N = T_N d(F_s f_s + F_w f_w) \tag{1}$$

where:

S_N = total pounds of solvents (VOC emissions) contained in trade paints sold annually nationwide

T_N = total gallons of trade paints sold nationwide (467×10^6 gal)

d = average density of solvents used in trade paints (7.21 lb/gal)

F_s = fraction of all trade paints sold annually that is organic solvent-based (refer to Table 4-19)

f_s = fraction of organic solvent-based trade paints that is organic solvent (.53)

F_w = fraction of all trade paints sold annually that is water-based (refer to Table 4-19)

f_w = fraction of water-based trade paints that is organic solvent (.035)

On the average, solvent-based trade paints contain 53 percent organic solvents by volume, while water-based paints contain 3.5 percent by volume (Reference 24). Table 4-20 presents typical organic solvents found in trade paints, along with their corresponding densities (Reference 25). As a working estimate, the average density of these solvents (7.21 lb/gal) was used to represent the various solvent species found in trade paints.

Table 4-20. TYPICAL SOLVENTS USED IN TRADE PAINTS

Solvent	Density (lb/gal)
n-Butyl Alcohol	6.76
Ethylene Glycol	9.28
Ethylene Glycol Monoethyl Ether ("Cellosolve")	7.72
Menthyl Ethyl Ketone (MED)	6.72
Mineral Spirits	6.54
Toluene	7.26
Turpentine	7.10
VM & P Naptha	6.27
Xylol	7.27
Average	7.21

Using this information in Equation 1 yielded the nationwide totals of organic solvents consumed via trade paints that are presented in Table 4-21. In effect, these figures represent the annual total VOC emissions estimates for trade paints.

Table 4-21. ESTIMATED VOC EMISSIONS FROM TRADE PAINTS NATIONWIDE (x 10^3 ton)

Year	Total	Trade Paint Type		
		ASC	AR	MSC
1977	403	330	52	21
1982	318	245	52	21
1987	235	162	52	21

As was pointed out in the beginning of this section, trade paints include ASC, AR, and MSC. In order to estimate the distribution of these subcategories, the annual NPCA reports were again consulted. Examination of the distribution data for 1974 through 1976 yielded an average ratio of 83.6 percent ASC, 11.7 percent AR, and 4.7 percent MSC. If it assumed that the ratio can be applied to the baseline and projection years and that all AR and MSC are organic solvent-based coatings, then Table 4-21 reports the distribution of trade paints by type nationwide.

4.5.1.2 County VOC Emissions Estimates

Apportioning of the annual nationwide VOC emissions estimates from trade paints (refer to Table 4-21) to the county level was based on the assumption that the per capita usage of trade paint is reasonably constant across geographical areas. The NPCA indicated that 21.0 percent of 1976 nationwide trade paint sales occurred in the South Atlantic region, which includes Delaware, Maryland, District of Columbia, Virgina, West Virginia, North Carolina, South Carolina, Georgia, and Florida. For purposes of this inventory, is was assumed that this value reflects 1977, and the projection years as well.

The VOC emissions originating from trade paints sold in each county in the study area can be expressed as:

$$E_{Ci} = E_{Ni}F_RP_{CR} \tag{2}$$

where:

- E_{Ci} = annual VOC emissions rate for trade paint type i in the county
- E_{Ni} = annual VOC emissions rate for trade paint type i in the nation (refer to Table 4-21)
- F_R = fraction of E_{Ni} that NPCA allocated to the South Atlantic region (.210)
- P_{CR} = ratio of county to South Atlantic region population

Linear regression analysis of annual population data for 1960 through 1976 (Reference 26) yielded South Atlantic population estimates for 1977, 1982, and 1987 of 34.6, 37.5, and 40.8 million, respectively. Using this information in Equation 2, along with projected population estimates for the counties in the study area, resulted in the VOC emissions estimates presented in Table 4-22. Trade paint emissions are considered to be 100 percent Class II.

4.6 OTHER SOLVENT USE

4.6.1 DEGREASING, GRAPHIC ARTS, ADHESIVES, AND OTHER SOLVENT USES

The use of nonaqueous solvents to clean and remove soils from metal surfaces which are to be electroplated, painted, repaired, inspected, assembled, or further machined is termed solvent metal cleaning or degreasing. A broad spectrum of organic solvents are available, such as petroleum distillates, chlorin-

Table 4-22. ESTIMATED VOC EMISSIONS FROM TRADE PAINTS BY COUNTY[a]
(ton/yr)

County	1977				1982				1987			
	Total	Trade Paint Type			Total	Trade Paint Type			Total	Trade Paint Type		
		ASC	AR	MSC		ASC	AR	MSC		ASC	AR	MSC
Broward	2,240	1,830	289	117	1,950	1,500	319	129	1,540	1,060	339	137
Dade	3,580	2,930	462	186	2,790	2,150	453	183	2,030	1,400	448	181
Duval	1,430	1,170	185	74	1,100	851	181	73	837	577	185	75
Orange	1,050	857	135	54	857	660	140	57	651	447	144	60
Palm Beach	1,230	1,010	159	64	1,080	830	176	71	844	582	187	75

[a] Assumed to be 100 percent Class II

ated hydrocarbons, ketones, alcohols, and blends of these solvents. Emissions originating from degreasing are the direct result of solvent evaporation during cleaning operations and handling of the solvents.

Graphic arts consist of five basic types of printing operations: letterpress, flexography, lithography, gravure, and screen printing. The industry includes the printing of newspapers, books, and magazines; floor and wall coverings; sheet metal; cans; and fabrics. The organic solvent content of printing inks may range from 1 to 70 percent, all of which is generally emitted directly into the atmosphere during the drying process.

Adhesives are used for joining surfaces in the assembly and construction of a large variety of products, such as pressure-sensitive tapes and labels, rubber products, and automobiles. Adhesives may be water-borne, organic solvent-borne, hot melt, or high solids. The organic solvent content of adhesives can be as high as 40 percent. As in graphic arts, virtually all of the organic solvent used in adhesives is emitted to the atmosphere when the adhesive dries.

The "other solvent users" classed under this heading are those facilities that PES identified during source visits as area sources that cannot be conveniently classified as degreasing, graphic arts, or adhesives operations.

4.6.1.1 Base Year Analysis

Base year point source emissions from degreasing, graphic arts, and adhesive activities were identified from source visits and subsequent evaluations. Area source emissions were developed, as discussed in Section 4.1, except for degreasing activities. Because degreasing solvents are utilized in a wide spectrum of manufacturing operations, service stations, households, and so on, and because no SIC number specifically addresses degreasing solvent consumption, an estimating approach was needed.

Two approaches were explored, both dependent upon national consumption rates. A relatively recent estimate of national degreasing VOC emissions is 770,000 tons per year (Reference 27). It was assumed that each of the counties in the study area contributed a proportional share to this national degreasing emissions total. An allocating parameter was therefore required. The first proportioning factor examined was based on population, and the second on manufacturing employees. Table 4-23 shows the results of applying these factors.

Table 4-23. ESTIMATED DEGREASING VOC EMISSIONS BASED ON POPULATION AND MANUFACTURING EMPLOYEES, 1977[a]
(ton/yr)

County	Population	Manufacturing Estimates
Broward	3,230	1,290
Dade	5,170	4,110
Duval	2,070	1,060
Orange	1,510	921
Palm Beach	1,780	905

[a] Expressed as TVOC

Since the inventory was directed toward selection of the more conservative (i.e., higher) estimate when in doubt as to the validity of different approaches to the same task, emissions based on population were used. Although these figures may appear high at first glance, they represent an average rate of 0.7

gallons per person per year. However, as discussed in Section 5.0, the degreasing category needs to be explored in more detail. It should also be noted that point source totals derived from source visits were subtracted from these values to obtain area source totals. Thus, the totals in Table 4-23 are a summary of area and point sources.

Table 4-24 presents estimated base year VOC emissions (area and point) from degreasing, graphic arts, adhesives, and other solvent users. It was assumed that the reactivity distribution for point sources, as identified from data collected during source visits, was representative of the entire category.

4.6.1.2 Projections

Base year emissions were projected to 1982 and 1987 on the basis of expected increases in manufacturing employment (refer to Section 2.3). Projected emissions are reported in Table 4-24.

4.6.2 DRYCLEANING

4.6.2.1 Base Year Analysis

Fabric cleaning in an essentially nonaqueous solvent is referred to as drycleaning. There are two broad groups of organic solvents used in the drycleaning industry: halogenated organic compounds and petroleum solvents. The halogenated organic compounds, principally perchlorethylene and trichlorotrifluoroethane, are referred to as synthetic solvents. Petroleum solvents are mixtures of compounds that are generally composed of approximately one-third parrafins, two-thirds cycloparrafins, and a few percent aromatics.

Essentially all of the drycleaning solvents consumed are evaporated directly into the atmosphere. Therefore, determination

Table 4-24. BASE YEAR AND PROJECTED VOC EMISSIONS FROM DEGREASING, GRAPHIC ARTS, ADHESIVES, AND OTHER SOLVENT USES (ton/yr)

County	1977			1982			1987		
	Class I	Class II	Total	Class I	Class II	Total	Class I	Class II	Total
Broward	646	3,530	4,180	761	4,050	4,810	891	4,690	5,580
Dade	1,030	8,040	9,070	1,200	9,730	10,900	1,400	11,200	12,600
Duval	414	2,320	2,730	430	2,160	2,590	447	2,230	2,680
Orange	302	1,340	1,640	338	1,490	1,830	375	1,660	2,030
Palm Beach	356	1,550	1,910	407	1,770	2,180	463	2,020	2,480

of the total solvent usage within a county will yield the VOC emissions estimate for this source category.

Without conducting a complete survey (i.e., questionnaire mailout to all companies within a subject area), the methods available for estimating solvent usage were incomplete. PES explored several methodologies in an effort to generate estimates. The method finally selected as the most reasonable is discussed in the following paragraphs.

The numbers of facilities in each county that were classified by SIC Codes 7215 ("Coin-Operated Laundries and Drycleaning"), 7216 ("Drycleaning Plants, Except Rug Cleaning"), and 7218 ("Industrial Laundries") were extracted from Bureau of Census data (Reference 6) and are summarized in Table 4-25. Even though these data represent 1975, it was felt that they would yield reasonable estimates that could then be projected to reflect 1977 estimates.

Table 4-25. DRYCLEANING FACILITIES IN STUDY AREA, 1975[a]

County	SIC Code		
	7215	7216	7218
Broward	49	58	3
Dade	101	110	10
Duval	56	65	3
Orange	32	45	5
Palm Beach	37	42	2

[a] Refer to Reference 6

Each facility recorded was further distinguished by the types of solvent used and the average throughput of fabric cleaned per year (References 28 and 29). These data are reported in Table 4-26.

Table 4-26. TYPICAL CHARACTERISTICS OF DRYCLEANING FACILITIES

Facility	Average Throughput[a]	Solvent Distribution[b]		TVOC Emission Factor[c]
		Percent	Type	
SIC 7215	16	94	Perc	110
		6	FC	4
SIC 7216	60	75	Perc	110
		23	Pet	230
		2	FC	4
SIC 7218	1,050	50	Perc	110
		50	Pet	230

[a] Expressed in units of thousands of pounds of fabric cleaned per year (Reference 28)

[b] Perc = Perchloroethylene, Pet = petroleum, FC = fluorcarbon (Reference 29)

[c] Expressed in pounds per thousand pounds of fabric processed (Reference 9)

EPA-recommended VOC emission factors (Reference 9) by type of plant and solvent used (refer to Table 4-26) were employed to compute emissions estimates from drycleaning in each county. The following equation was used to perform these calculations:

$$E = \sum_{i=1}^{3} \sum_{j=1}^{3} N_i T_i P_{ij} F_{ij} \qquad (3)$$

where

E = VOC emission rate in county

N_i = total number of facilities in the county classified as SIC Code i

T_i = average throughput of fabric processed in facility type i

P_{ij} = fraction of solvent used in plant type i that is of type j

F_{ij} = VOC emission factor for plant i using solvent type j

Assuming that the per capita consumption of these solvents within each county will remain fairly constant, VOC emissions totals were projected to 1977 using population trends from 1975 to 1977. The totals are reported in Table 4-27. It should be pointed out that the Duval Agency recently surveyed many of the drycleaning establishments in Duval County and calculated a per capita figure of 1.5 pounds. A followup investigation is planned for gathering data on the remaining sources. The results are of importance because the per capita estimate received from the approach described above resulted in a value of 1.8 pounds.

Finally, the reactivity profiles shown in Table 4-27 were developed by assuming that all drycleaning solvents are Class II except for Freon 113, which is Class I.

4.6.2.2 Projections

As with the projections of VOC emissions from 1975 to 1977, it was assumed that the per capita consumption of drycleaning solvents will remain relatively constant through 1987, and that no significant shift in percent distribution of solvent types will occur. Population increases were applied (refer to Section 2.3), and the results are presented in Table 4-27.

Table 4-27. BASE YEAR AND PROJECTED VOC EMISSIONS FROM DRYCLEANING (ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	566	NEG	566	679	NEG	679	783	NEG	783
Dade	1,450	1	1,450	1,540	1	1,540	1,650	1	1,650
Duval	586	NEG	586	621	NEG	621	693	NEG	693
Orange	659	NEG	659	741	NEG	741	827	NEG	827
Palm Beach	405	NEG	405	486	NEG	486	561	NEG	561

4.6.3 CUTBACK ASPHALT

4.6.3.1 Base Year Analysis

Asphalt pavements and surfaces are composed of asphalt and compacted aggregate. It is from the asphalt fraction that the VOC emissions originate.

Asphalt cement and liquified asphalts are the two most common types of asphalts. Asphalt cement is the semisolid residue from the distillation of crude oil, and therefore has little or no VOC associated with it.

Liquified asphalts are categorized as either cutback or emulsion. Cutback is asphalt cement that has been thinned, or "cut back," with volatile petroleum products such as heavy residual oil, kerosene-type solvents, or heavy naphtha. Emulsions are produced by combining asphalt cement and water with an emulsifying agent such as soap. Cutbacks emit VOC during the curing process, whereas emulsions emit almost no VOC.

Cutback asphalt is divided into three broad categories based on curing properties: slow cure or road oils (SC), medium cure (MC), and rapid cure (RC). The 1975 national sales breakdown for these three categories and corresponding TVOC emission factors are presented in Table 4-28.

Table 4-28. 1975 NATIONAL SALES BREAKDOWN OF CUTBACK ASPHALT AND TVOC EMISSION FACTORS[a]

Category	National Sales Breakdown[b]	Emission Factors[c]
Rapid Cure (RC)	26.5	.204
Medium Cure (MC)	49.3	.209
Slow Cure (SC)	24.2	.078

[a] Refer to Reference 30

[b] Expressed as percentage of total sold

[c] Expressed in tons of TVOC per ton of asphalt

Information as to the annual tonnage of cutback asphalt used in the study area were received from both state and county agencies, but the quality of the data varied considerably. Table 4-29 summarizes the state and county totals. Based on information gathered by PES, it was assumed that the tonnage of asphalt consumed in the county is the sum of totals reported by the state and county agencies (which is also reflected in Table 4-29). In most cases, the figures received by PES were given in terms of gallons per year, so an average density of 7.8 lb/gal (Reference 30) was used to convert to tons per year.

Table 4-29. CUTBACK ASPHALT CONSUMPTION BY COUNTY, 1977
(ton/yr)

County	Cutback Used		
	State Data[a]	County Data	Total
Broward	190	5,012[c]	5,202
Duval	287	22,000[d]	22,287
Orange	382	280[b]	662
Palm Beach	95	0	95

[a] Reference 31

[b] References 32 and 33

[c] Reference 34 (1976 figures assumed to reflect 1977)

[d] Reference 35

Where the distribution of cutback asphalt was not indicated, the national pattern was assumed (refer to Table 4-28). The resultant breakdown is shown in Table 4-30.

Table 4-30. 1977 CUTBACK ASPHALT CONSUMPTION BY CATEGORY, 1977
(ton/yr)

County	Rapid Cure	Medium Cure	Slow Cure	Total
Broward[a]	5,060	94	46	5,200
Duval	5,910	11,000	5,400	22,300
Orange	175	326	160	622
Palm Beach	25	47	23	95

[a] Ratio provided by Broward County Environmental Quality Control Board

The breakdown shown in Table 4-30 was then applied to the relevant emission factors, yielding the county cutback asphalt emissions shown in Table 4-31. Due to the nature of the solvents used to thin asphalt cement, these VOC emissions are 100 percent Class II.

Table 4-31. ESTIMATED VOC EMISSIONS FROM CUTBACK ASPHALT, 1977
(ton/yr)

County	VOC Emissions[a]
Broward	481
Dade[b]	401
Duval	3,922
Orange	116
Palm Beach	17

[a] 100 percent Class II emissions
[b] Refer to Reference 76

4.6.3.2 Projections

All of the agencies contacted were queried as to the future use of cutback in their area, e.g., in road construction activities. It was generally agreed that such projections have a great deal of uncertainty associated with them, but most agencies indicated that cutback asphalt will be phased out with emulsified asphalt. However, no one was able to provide quantitative data concerning the projection years. For these reasons, cutback asphalt VOC emissions were assumed to remain constant through 1987.

4.7 STATIONARY SOURCE FUEL COMBUSTION

4.7.1 UTILITIES

There are nine significant electrical power plants currently operating in the study area. Table 4-32 provides a list of these utility plants.

Table 4-32. MAJOR POWER GENERATING PLANTS IN THE STUDY AREA

County	Utility
Broward	Florida Power and Light - Lauderdale
	Florida Power and Light - Port Everglades
Dade	Florida Power and Light - Turkey Point
Duval	Jacksonville Electric Authority - Kennedy
	Jacksonville Electric Authority - Southside
	Jacksonville Electric Authority - Northside
Orange	Orlando Utility
	Reedy Creek
Palm Beach	Florida Power and Light - Riviera

Since TVOC emission factors for electrical productions depend on the amount and type of fuel burned, PES engineers visited each of the major power companies to acquire necessary fuel data and projection information on each power plant. Analysis of the fuel data on each plant and application of the appropriate TVOC emission factors from Reference 9, Tables 1.3-1 and 1.4-1, resulted in the VOC emission estimates by reactivity class that are presented in Table 4-33.

Projections were based on information reported in 10 year study plans provided by the major power companies and/or on analysis of projected utility use in the State of Florida (References 38, 77, and 78). It should be noted that a number of sites in Florida, including a few in the study area, are currently under consideration for construction of new power plants. However, because these decisions have not yet been made, no plants were projected for the study area. Also, it was assumed that the ratio of fuel types burned will remain relatively constant. Although these assumptions may change in the future, their impact on this relatively small VOC emissions source category is not expected to be significant. The results of these analyses are presented in Table 4-33.

4.7.2 OTHER FUEL COMBUSTION SOURCES

Stationary fuel source combustion is divided into three sectors: residential, commercial/institutional (C/I), and industrial. These categories are further defined by the type of fuels used, e.g., natural gas.

References 51 and 79 suggest estimating VOC emissions originating from these sources by apportioning Bureau of Mines' state fuel totals to each county based on the distribution of correlative variables (e.g., population). The level of effort associated with obtaining the necessary economic and demographic information (e.g., number of hospital beds per county) is not in proportion either with the low level of VOC emissions associated with this source or with the relatively small differences that result from using less sophisticated techniques. For these reasons, PES elected to use modified forms of the simplified methodologies described in Reference 39.

Table 4-33. BASE YEAR AND PROJECTED VOC EMISSIONS FROM POWER GENERATING PLANTS (ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	146	23	123	184	29	155	225	36	189
Dade	117	13	104	160	17	143	200	22	178
Duval	216	24	192	304	33	271	280	31	249
Orange[a]	78	9	69	78	9	69	0	0	0
Palm Beach	55	18	37	68	22	46	82	27	55

[a] The Orlando utility will be shutting down operations before 1987

4.7.2.1 Statewide VOC Emissions

After researching available fuel consumption data, PES decided to use Florida State Energy Office (FSEO, Reference 38) fuel consumption estimates. These estimates are prepared for each fuel type and sector and are presented in Table 4-34.

Table 4-34. FLORIDA FUEL CONSUMPTION ESTIMATES, 1977[a]

Sector	Fuel Oils (10^4 bbl)		Natural Gas (10^9 cf)
	Residual	Distillate	
Residential	0	212	17.7
Commercial/ Institutional	93.8	652	41.6
Industrial	1,180	345	72.3

[a] Reference 38; excluding powerplants

VOC emissions estimates from the combustion of the fuels shown in Table 4-34 can be expressed as:

$$E_{ij} = S_{ij}f_i \qquad (4)$$

where

E_{ij} = annual state TVOC emission rate from fuel type i in sector j

S_{ij} = annual state consumption rate of fuel type i in sector j

f_i = TVOC emission factor for fuel type i

The TVOC emission factor (f_i) for both types of fuel oil in all three sectors is 1 pound per thousand gallons of fuel consumed (Reference 3). The TVOC emission factors for natural gas combustion are 8 pounds per million cubic feet of gas consumed in the residential and C/I sectors, and 3 pounds per million cubic feet of gas consumed in the industrial sector (Reference 3).

The results of the calculations utilizing equation 4 are shown in Table 4-35.

Table 4-35. ESTIMATED VOC EMISSIONS FROM FUEL COMBUSTION IN FLORIDA, 1977[a] (ton/yr)

Sector	Fuel Oils		Natural Gas	Total
	Residual	Distillate		
Residential	N/A	45	71	116
C/I	20	137	166	323
Industrial	248	72	108	428

[a] Excluding powerplants

4.7.2.2 County VOC Emissions

4.7.2.2.1 Residential Sector

To generate a working estimate of emissions attributable to residential fuel combustion, AEROS Volume II (Reference 39) suggested apportioning the state fuel total to the county by the number of dwelling units using that type of fuel. For the residential sector, dwelling units are defined as structures containing fewer than 20 units. The 1970 Census of Housing (Reference 40) is the most recent publication that provides adequate housing data for application of the AEROS methodology. Because of the age of the census data and the dynamic nature of residential housing, a methodology had to be developed that made optimum use of the available data.

The following relationship summarizes the methodology that PES used to estimate emissions from fuel combustion in the residential sector:

$$C_{Ri} = r_1 S_{Ri} P_{CS} H_{CS} + r_2 S_{Ri} P_{CS} \quad (5)$$

where

C_{Ri} = annual VOC emissions rate from combustion of fuel type i in the county's residential sector

r_1 = fraction of fuel type i used for space heating (refer to Table 4-36)

S_{Ri} = annual VOC emissions rate from combustion of fuel type i in the state's residential sector (refer to Table 4-35)

P_{CS} = ratio of county to state population

H_{CS} = ratio of county to state heating degree days

r_2 = fraction of fuel type i not used for space heating (equal to $1 - r_1$)

In developing this methodology, it was assumed that the county to state population ratio is a reasonable representation of the dwelling unit ratio (as previously defined). In addition, to compensate for the temperature gradients across the state, a temperature-related parameter, H_{CS}, was introduced. This parameter was applied only to fuel used for space heating. Table 4-36 shows PES' assumptions as to the impact of this parameter on each fuel type.

Table 4-36. FRACTION DISTRIBUTION OF THE RESIDENTIAL SECTOR SPACE-HEATING PARAMETER

Parameter	Fuel Type	
	Distillate Oil	Natural Gas
r_1	1.00	0.20
r_2	0.00	0.80

The results of utilizing these data in equation 5, along with the reactivity analysis are shown in Table 4-37. The totals for the different VOC classes were estimated by multiplying the emissions totals by the compositional fractions for each fuel type from Table 3-1 and then summing.

Table 4-37. ESTIMATED VOC EMISSIONS FROM RESIDENTIAL FUEL COMBUSTION, 1977 (ton/yr)

County	TVOC	Class I	Class II
Broward	7	3	4
Dade	11	5	6
Duval	9	3	6
Orange	5	2	3
Palm Beach	5	2	3

4.7.2.2.2 Commercial-Institutional Sector

Equation 6 summarizes the methodology used to estimate emissions from fuel combustion in the commercial-institutional sector.

$$C_{Ci} = c_1 S_{Ci} E_{CS} H_{CS} + c_2 S_{Ci} E_{CS} \qquad (6)$$

where

- C_{Ci} = annual VOC emissions rate from combustion of fuel type i in the county's C/I sector
- c_1 = fraction of fuel type i used for space heating (refer to Table 4-38)
- S_{Ci} = annual VOC emissions rate from combustion of fuel type i in the state's C/I sector (refer to Table 4-35)
- E_{CS} = ratio of county to state employment in the C/I sector
- H_{CS} = ratio of county to state annual heating degree days
- c_2 = fraction of fuel type i not used for space heating (equal to $1 - c_1$)

AEROS (Reference 39) recommended that state fuel totals for this sector be apportioned to the counties according to population. PES, however, preferred employment in this sector as an indicator of fuel use distribution. (Equation 6 reflects this viewpoint.) In addition, a "heating degree days" parameter was incorporated to account for fuel allocated for space heating. The same reasoning that was applied to the residential sector was used for this sector as well. Table 4-38 presents PES' assumptions as to the impact of the space-heating parameter on each fuel type.

Table 4-38. FRACTION DISTRIBUTION OF THE COMMERCIAL-INSTITUTIONAL SECTOR SPACE-HEATING PARAMETER

Parameter	Fuel Type		
	Residual Oil	Distillate Oil	Natural Gas
c_1	1.00	1.00	0.50
c_2	0.00	0.00	0.50

The results of using these data in equation 6 are shown in Table 4-39. The totals for the two VOC classes were generated by multiplying the TVOC emission totals by the compositional fraction for each fuel type indicated in Table 3-1 and then summing.

Table 4-39. ESTIMATED VOC EMISSIONS FROM COMMERCIAL AND INSTITUTIONAL FUEL COMBUSTION, 1977 (ton/yr)

County	TVOC	Class I	Class II
Broward	15	6	9
Dade	32	15	17
Duval	36	11	25
Orange	21	7	14
Palm Beach	10	4	6

4.7.2.2.3 Industrial Sector

The state's industrial fuel totals were apportioned to the counties in the study area by assuming that fuel use is proportional to the number of manufacturing employees per county (SICs

20 to 29). Applied to emissions, this allocating procedure can be expressed as:

$$C_{Iij} = S_{Iij}E_{CS} \qquad (7)$$

where

C_{Iij} = annual VOC emissions rate from combustion of fuel type i in the county's industrial sector

S_{Iij} = annual statewide VOC emissions rate from the combustion of fuel type i in the industrial sector (refer to Table 4-35)

E_{CS} = ratio of county to state employment in the industrial sector

No parameter was included to account for space heating because nearly all of the fuel consumed in this sector is used for process operations.

Using the appropriate data in equation 7 yielded the annual county emissions estimates given in Table 4-40. Again, the reactivity profiles for the various fuel types from Table 3-1 were applied to the TVOCs.

Table 4-40. ESTIMATED VOC EMISSIONS FROM INDUSTRIAL FUEL COMBUSTION, 1977
(ton/yr)

County	TVOC	Class I	Class II
Broward	40	10	30
Dade	126	28	98
Duval[a]	651	243	408
Orange	28	7	21
Palm Beach[b]	1,195	445	750

[a] Two sources, St. Regis Paper Company and Alton Box Board Co., burn a considerable amount of wood/bark in their boilers. Reference 2 emission factors were applied. TVOC for both facilities equaled 619 tons

[b] A significant amount of bagasse is utilized as fuel for sugar cane production. Total fuel consumption was derived from source information and Reference 2 emission factors applied. Fuel burning occurs October through February. TVOC for the year equaled 1,167 tons

4.7.2.3 Projections

Projections of VOC emissions from fuel combustion sources, exclusive of utilities, were made according to predicted fuel usage for each of the sectors by FSEO (Reference 38). FSEO reports projections for 1978, 1980, 1985, and 1990. Therefore a linear interpretation was employed for 1982 and 1987 values. The resultant projection factors by fuel type and sector are shown in Table 4-41. Projected VOC emissions are presented in Table 4-42, along with a breakdown by reactivity class.

Table 4-41. GROWTH FACTORS FOR PROJECTED FUEL USAGE[a]

Fuel Type	Residential		Commercial/ Institutional		Industrial	
	1982	1987	1982	1987	1982	1987
Distillate Oil	.173	.320	.119	.286	.480	.799
Residual Oil	N/A	N/A	.289	.442	.200	.304
Natural Gas	.286	.605	.252	.463	.020	-.012

[a] Developed from Reference 38

4.8 SOLID WASTE DISPOSAL

Solid waste disposal includes two sources, onsite incineration and open burning. The first approach that was explored to determine VOC emissions attributed to these sources was dependent on the availability and completeness of state or local agency solid waste permit files. However, this information was not complete for any county, so PES based its approaches on other available data supplied by local air pollution control agencies and other agencies in the study area (Reference 41 through 49).

4.8.1 ONSITE INCINERATION

4.8.1.1 Base Year Analysis

Incineration of solid waste is more common in some counties of the study area than others, and is prohibited in Broward County (Reference 41). Where it is common, many types of incinerators are used, e.g., municipal, industrial, and pathological. Pollution control devices installed on the incinerators vary. Some counties require controls like afterburners and multiple chambers, which considerably reduce the quantity of emissions released into the

Table 4-42. BASE YEAR AND PROJECTED STATIONARY SOURCE FUEL COMBUSTION VOC EMISSIONS[a] (ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	62	19	43	259	52	207	310	62	248
Dade	169	48	121	365	74	291	427	83	344
Duval[b]	696	257	439	1,020	294	722	1,000	297	708
Orange	54	16	38	142	28	114	73	22	51
Palm Beach[b]	1,210	451	759	1,300	485	811	1,320	493	824

[a] Excluding powerplants

[b] The VOC emissions resulting from the point sources indicated in Table 4-40 were projected based on information collected during source visits

atmosphere. Other counties have no control requirements at all. Consequently, the methods used to determine VOC emissions from incineration of solid waste varied from county to county, depending upon on the information available.

The number of incinerators in each county, types of controls, and yearly throughput were needed to calculate the emissions for each county. Data collected by PES were incomplete, so for some counties, the values needed were calculated by making the following assumptions:

- The amount of solid waste incinerated in a county varied yearly as the population in that county varied.
- EPA-recommended emission factors were used (Reference 9).
- Incinerators specified as having multiple chambers or afterburners, and those for which pollution controls are unknown, were categorized as "Industrial/Commercial Multiple Chamber," with an emission factor of 3 lb/ton (refer to Table 4-43).

Table 4-43. TVOC EMISSION FACTORS FOR INCINERATORS (lb/ton burned)

Incinerator Type	Emission Factor (lb/ton)
Municipal	
Multiple chamber, uncontrolled	1.5
Industrial/commercial	
Multiple chamber	3
Single chamber	15
Flue-fed (modified)	3
Domestic single chamber	
Without primary burner	100
With primary burner	2
Sludge (after scrubber)	1

Combining the information gathered by PES with the appropriate TVOC emission factors from Table 4-43 resulted in the TVOC emission estimates shown in Table 4-44, which also includes the total tonnage of solid waste incinerated in each county.

Table 4-44. ESTIMATED VOC EMISSIONS FROM INCINERATORS, 1977

County	Solid Waste Incinerated (Ton/Yr)	VOC Emissions (Ton/Yr)
Broward	143,866[a]	108
Dade	86,331[b]	73
Duval	3,907[c]	4
Orange	27,219[d]	18
Palm Beach	-- [e]	19

[a] Personal communication from Mr. Gary D. Carlson, Broward County Environmental Quality Control Board, June 27, 1978

[b] Personal communication with Mr. Robert Johns, Environmental Resources Management, Metropolitan Dade County, August 1, 1978

[c] Projection based on 1976 information supplied by the Department of Environmental Regulations, June 30, 1978

[d] Personal communication with Mr. Charles M. Collins, Department of Environmental Regulations, Air and Solid Waste Engineering, August 7, 1978

[e] Information supplied by the Palm Beach County Air Pollution Control Division of Environmental Science and Engineering, June 28, 1978. Did not include the amount of solid waste incinerated. The calculated VOC emissions, however, were given

4.8.1.2 Projections

Projections from 1977 to 1982 and 1987 were generated from base year data and projected population increases in each county. (Refer to Table 4-45.) The reactivity profile for "Waste Burning

Table 4-45. BASE YEAR AND PROJECTED VOC EMISSIONS ESTIMATES FROM INCINERATORS (ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	108	41	67	--[a]	--[a]	--[a]	--[a]	--[a]	--[a]
Dade	73	28	45	80	30	50	86	33	53
Duval	4	2	2	5	2	3	5	2	3
Orange	18	7	11	20	8	12	23	9	14
Palm Beach	19	7	12	23	9	14	26	10	16

[a] Incineration is prohibited in Broward County (Reference 41). Data shows that the Fort Lauderdale incinerator was still operating in 1977. The incinerator will not be used in subsequent years

and Other Fires" from Table 3-1 was used to generate the totals in the various VOC classes.

4.8.2 OPEN BURNING

4.8.2.1 Base Year Analysis

County and state regulations limit the types of open burning allowed in each county. Information on the burning allowed as well as estimates of the amount burned in a given year were obtained from appropriate state and county governmental agencies (References 41 through 49).

The types of controlled open burning that are allowed vary from county to county and include foliage burns to help prevent wildfires, land clearing, agricultural fires, and other miscellaneous fires requiring permits. Open burning of municipal refuse is not allowed in any of the counties. For purposes of this inventory, uncontrolled open burning includes forest fires (wildfires), dumpsite fires (accidental burning of refuse material by spontaneous combustion or by other means), illegal dumpster fires, and structural fires.

There were differences in the terminology used by each county in reporting open burning activities. These differences caused some difficulty in interpreting what the activity included. For example, the term "legal fires" included prescribed burning in some cases and land clearing in others.

Estimates of VOC emissions from the various open burning categories are presented in Table 4-46. To generate the totals in the two VOC classes, the reactivity profile for "Waste Burning and Other Fires" from Table 3-1 was used. Appendix B contains example calculations.

Table 4-46. ESTIMATED VOC EMISSIONS FROM OPEN BURNING, 1975
(ton/yr)

Source	County				
	Broward	Dade	Duval	Orange	Palm Beach
Forest Fires					
Wildfires	115	1,390	368	1,140	950
Prescribed burning	781	665	850	-- [a]	-- [a]
Agricultural					
Sugar field	--	--	--	--	11,200
Brush	--	145	23	--	--
Land Clearing	--	--	--	--	1,620
Legal fires	--	--	--	1,820	--
Dumpsites	--	106	--	--	--
Dumpsters	--	--	4	--	--
Structural	28	597	189	174	206
Total	924	2,903	1,434	3,134	13,976
Class I	352	1,100	546	1,190	5,310
Class II	572	1,800	888	1,944	8,666

[a] Could not be determined from the data made available by the State of Florida Division of Forestry, August 21, 1978. Assumed to be included in other open burning activities, i.e., legal fires, land clearing

Concerning the data in Table 4-46, is should be noted that Broward County supplied calculated emissions utilizing assumptions that differed from those of the other subject counties (refer to Appendix B). For Dade County, 1976 estimates were provided, so it was necessary to make projections for 1977, based on land use and population changes. In Duval County, only the number of brush and dumpster fires were available, with no method of determining acres or pounds burned (Reference 44). It was therefore necessary to make some assumptions based on other data for Duval County to determine VOC emissions (refer to Appendix B).

For structural fires, it was assumed that an average of four structural fires per thousand people occur annually (Reference 50).

Reference 50 recommends applying the TVOC emission factor for open burning of municipal solid waste to structural fires. This emission factor, taken from Reference 3, is 30 pounds per ton of material burned. Combining this information yielded a TVOC emission factor of 204 pounds per structural fire. Utilizing this emission factor with the estimated number of structural fires resulted in the VOC emissions estimates shown in Table 4-46. However, Broward County calculations were completed by county personnel using different emission factor assumptions (refer to Appendix B).

Finally, due to incomplete data, agricultural burning was reported only for Palm Beach County. EPA has changed the fuel loading factor and emission factors to specifically depict Florida sugarcane conditions (Reference 52). Refer to Appendix B for calculations.

4.8.2.2 Projections

Projections from 1977 to 1982 and 1987 were generated from the base year data, projected land use changes, and projected population increases (refer to Section 2.0). The projected emissions are presented in Table 4-47.

4.9 MOBILE SOURCES

4.9.1 HIGHWAY VEHICLES (Methodology Description Provided by FDOT)

In order to obtain highway vehicle emissions, the adopted or accepted MPO vehicle miles of travel (VMT) for the base year and plan year were "straight line" interpolated to provide VMT for 1977, 1982, and 1987. To expand these numbers to annual totals, a factor of 320 was applied. Local traffic was also added, as shown in Table 4-48. The standard vehicle mix for urban travel was input to MOBILE 1; the average of 19.6 mph was used for vehicle speed, and an average statewide temperature of 75°F was applied.

Table 4-47. PROJECTED VOC EMISSIONS FROM OPEN BURNING
(ton/yr)

	County/Year									
	Broward		Dade		Duval		Orange		Palm Beach	
Source	1982	1987	1982	1987	1982	1987	1982	1987	1982	1987
Forest fires										
Wildfires	115[a]	115[a]	1,300	1,250	338	310	1,110	1,096	925	882
Prescribed burning	781[a]	781[a]	623	598	780	715	--	--	--	--
Agricultural										
Sugar field	--	--	--	--	--	--	--	--	11,200[b]	11,200[b]
Brush	--	--	136	131	24	27	--	--	--	--
Land clearing	--	--	--	--	--	--	--	--	1,400	1,220
Legal fires	--	--	--	--	--	--	1,680	1,560	--	--
Dumpsites	--	--	113	121	--	--	--	--	--	--
Dumpsters	--	--	--	--	5	5	--	--	--	--
Structural	33	38	635	682	253	282	196	219	247	285
Total	929	934	2,807	2,782	1,400	1,339	2,988	2,869	13,772	13,587
Class I	353	355	1,067	1,057	532	509	1,135	1,090	5,233	5,163
Class II	576	579	1,740	1,725	868	830	1,853	1,779	8,539	8,424

[a] Information on future land use for Broward County supplied by EPA July 24, 1978 indicated no increase in the following land use categories: parks and recreation, and undeveloped. It was assumed that forested acreage was included in these categories. Therefore, emissions from controlled and uncontrolled forest fires remained constant

[b] Data provided by Palm Beach County APCD

The nonmethane MOBILE 1 emission factors are presented in Table 4-49. These factors were applied to the VMT, and hydrocarbon emissions were obtained.

Table 4-48. LOCAL VEHICLE MILES OF TRAVEL (VMT) FACTORS[a]

Urban Area	Percent		
	1977	1982	1987
Broward	N/A	N/A	N/A
Dade	7.1	6.8	6
Duval	15	15	15
Escambia	15	15	15
Leon	15	15	15
Orange	10	10	10
Palm Beach	10.5	9.5	8.5

[a] Table provided by FDOT

PES prepared Table 4-50 which summarizes VMT per day and Class II emissions per year for each subject county. Appendix C contains the highway vehicles worksheets received by FDOT.

4.9.2 OFF-HIGHWAY VEHICLES

Six area source categories are classified as off-highway mobile sources: agricultural equipment, construction equipment, industrial equipment, motorcycles, lawn and garden equipment, and snowmobiles.

The EPA's recommended methodologies (Reference 57) were used as a guide in estimating the VOC emissions originating from each category. In some cases, deviations from these methodologies were necessary for optimum utilization of the available data. Moreover, sim-

Table 4-49. MOBILE 1 EMISSION FACTORS FOR USE IN HYDROCARBON EMISSION INVENTORY[a]

*NON-METH HC EMISSION FACTORS INCLUDE EVAP. HC EMISSION FACTORS

		VEH. TYPE: LDV LDT1 LDT2 HDG HDD MC
CAL. YEAR: 1977	TEMP: 75.0(F)	0.803/0.058/0.058/0.045/0.031/0.005
REGION: 49-STATE	19.6:19.6/19.6/19.6 MPH (19.6)	20.6/ 27.3/ 20.6

COMPOSITE EMISSION FACTORS (GM/MILE)

	LDV	LDT1	LDT2	HDG	HDD	MC	ALL MODES
NON-METH HC:	6.91	7.72	11.22	28.13	4.39	11.01	8.11
EXHAUST CO:	61.55	66.02	80.92	274.51	20.88	36.29	71.44
EXHAUST NO :	3.15	3.20	5.28	10.71	20.78	0.13	4.15

		VEH. TYPE: LDV LDT1 LDT2 HDG HDD MC
CAL. YEAR: 1982	TEMP: 75.0(F)	0.803/0.058/0.058/0.045/0.031/0.005
REGION: 49-STATE	19.6:19.6/19.6/19.6 MPH (19.6)	20.6/ 27.3/ 20.6

COMPOSITE EMISSION FACTORS (GM/MILE)

	LDV	LDT1	LDT2	HDG	HDD	MC	ALL MODES
NON-METH HC:	3.66	5.17	8.02	20.65	4.47	5.70	4.80
EXHAUST CO:	38.04	56.87	70.65	261.03	28.23	21.72	50.67
EXHAUST NO :	2.15	2.44	3.86	9.51	20.27	0.42	3.17

		VEH. TYPE: LDV LDT1 LDT2 HDG HDD MC
CAL. YEAR: 1987	TEMP: 75.0(F)	0.803/0.058/0.058/0.045/0.031/0.005
REGION: 49-STATE	19.6:19.6/19.6/19.6 MPH (19.6)	20.6/ 27.3/ 20.6

COMPOSITE EMISSION FACTORS (GM/MILE)

	LDV	LDT1	LDT2	HDG	HDD	MC	ALL MODES
NON-METH HC:	1.98	3.30	4.71	12.18	3.34	1.33	2.71
EXHAUST CO:	20.47	40.20	50.18	166.44	27.76	6.97	30.06
EXHAUST NO :	1.64	1.97	2.59	8.15	13.56	0.25	2.37

[a] Table provided by FDOT

Table 4-50. CLASS II VOC EMISSIONS FROM HIGHWAY VEHICLES

County	VMT/Day			Class II Emissions (ton/yr)		
	1977	1982	1987	1977	1982	1987
Broward[a]	12,424,000	N/A	N/A	43,190	33,665	23,666
Dade	18,898,097	21,843,076	24,788,055	57,859	38,609	25,119
Duval	10,192,435	12,258,748	14,325,062	33,507	23,871	15,728
Orange	7,829,041	9,481,038	11,130,634	24,618	17,655	11,713
Palm Beach	8,800,333	11,433,000	14,063,667	27,797	21,194	14,614

[a] Information for 1976 supplied by the Broward County Environmental Quality Control Board due to incomplete 1977 data; growth factors for projections of VMT/day were not available. Received September 18, 1978

plifying assumptions pertaining to area apportionment of national or state equipment or of corresponding VOC emissions totals were employed where inadequate information prohibited computations that were in the scope of this inventory.

4.9.2.1 Agricultural Equipment

4.9.2.1.1 Base Year Analysis

The population of the agricultural equipment by county is documented in the U.S. Census of Agriculture (Reference 55). This reference supplies equipment population data on farm tractors, self-propelled (S-P) combines, pick-up (P-U) balers, and field forage (FF) harvesters. The most recent edition of this reference was published in 1974. In order to adjust these data to reflect 1977 totals, growth in agricultural land use (Reference 56), was assumed to represent growth in equipment totals from 1974 to 1977. This adjustment is reflected in Table 4-51.

Table 4-52 reports the TVOC emission factors for agricultural equipment (Reference 9). Crankcase and evaporative emissions from diesel engines were considered to be negligible (Reference 9).

These emission factors are the result of test data which were assumed to represent actual field applications. Annual usage rates were also estimated from survey data, or by analyzing the type and amount of crop acreage for which the equipment was used. Table 4-53 summarizes annual usage rates and other pertinent information (References 9, 57, and 58).

Annual TVOC emission factors for different equipment categories were determined by combinig the hourly emission factors with the annual usage rates; these factors are reported in Table 4-54.

Table 4-51. 1977, 1982, AND 1987 AGRICULTURAL EQUIPMENT TOTALS

Year	Equipment Type	County				
		Broward	Dade	Duval	Orange	Palm Beach
1977	Tractors	441	1,487	378	1,272	2,152
	S-P Combines	0	3	0	0	6
	PU Balers	5	4	37	19	8
	FF Harvesters	5	10	11	15	11
	Misc. HD	124	402	102	343	581
	Misc. LD	225	859	298	1,080	526
	Class 1-5 Farms	150	573	378	719	351
1982	Tractors	293	1,392	433	1,174	1,868
	S-P Combines	0	3	0	0	6
	PU Balers	3	4	42	18	7
	FF Harvesters	4	9	12	14	10
	Misc. HD	82	376	117	317	505
	Misc. LD	149	804	341	997	457
	Class 1-5 Farms	100	536	227	664	304
1987	Tractors	195	1,338	493	1,084	1,623
	S-P Combines	0	3	0	0	5
	PU Balers	2	3	48	16	6
	FF Harvesters	2	9	14	13	8
	Misc. HD	55	361	133	292	438
	Misc. LD	99	773	389	920	397
	Class 1-5 Farms	66	515	259	613	265

Table 4-52. TVOC EMISSION FACTORS
(g/unit/hr)

Source	Diesel Tractors	Gasoline Tractors	HD Diesel Nontractor	HD Gasoline Nontractor
Exhaust	77.8	128.0	38.6	143.0
Crankcase	NEG	26.0	Neg.	28.6
Evaporative	NEG	15.6 g/unit/yr	Neg.	16.0 g/unit/yr

Table 4-53. ANNUAL USAGE RATES AND EQUIPMENT BREAKDOWNS

Equipment Category	Estimated Annual Usage (hr)	Percent Diesel Powered	Percent Gasoline Powered	Percent Motorized
Tractors				
Diesel	490	100	---	100
Gasoline	291	---	100	100
Nontractors				
S-P Combines	73	50	50	100
P-U Balers	24	100	---	50
FF Harvesters	120	---	100	10
Misc. HD	50	50	50	100
Misc. LD	50	---	100	100

Table 4-54. ANNUAL TVOC EMISSION FACTORS (kg/unit/hr)

Equipment Category	Diesel	Gasoline		
	Exhaust	Exhaust	Evaporative	Crankcase
Tractor	38.1	37.2	15.6	7.6
S-P Combine	2.8	10.4	16.0	2.1
P-U Baler	0.9	N/A	N/A	N/A
FF Harvester	N/A	17.2	16.0	3.4
Misc. HD	1.9	7.2	16.0	1.4
Misc. LD[a]	N/A	1.2	0.3	0.2

[a] Based on emission rates for LD industrial engines; refer to Table 4-65

The following equation was used to compute county VOC emissions for the three general equipment categories:

$$E_{ci} = \sum_{j=1}^{N} f_{ij} e_{ij} m_j n_{cj} \qquad (8)$$

where

- E_{ci} = county TVOC emission estimate for equipment class i (e.g., HD diesel)
- f_{ij} = TVOC emission factor for equipment type j (e.g., tractors) in equipment class i (refer to Table 4-54)
- e_{ij} = fraction of equipment type j that is in equipment class i (refer to Table 4-53)
- m_j = fraction of equipment type j that is motorized (refer to Table 4-53)
- n_{cj} = county population of equipment type j (refer to Table 4-51)
- N = number of equipment types j that are in equipment class i

The ratio of gasoline to diesel-powered tractors was determined to be 62 percent diesel and 38 percent gasoline for 1977 (Reference 4). This information yielded the VOC emissions shown in Table 4-55.

4.9.2.1.2 Projections

Emission calculations for the projection years were computed in a similar fashion. The 1977 equipment totals were updated, as well as the diesel to gasoline tractor ratios, yielding equipment totals for 1982 and 1987. These estimates are presented in Table 4-55. It was estimated that diesel tractors will comprise 81 percent of the tractor population in 1982 and 90 percent in 1987

Table 4-55. 1977, 1982, AND 1987 ESTIMATES OF VOC EMISSIONS FROM AGRICULTURAL EQUIPMENT (ton/yr)

Year	Emissions Source		County				
			Broward	Dade	Duval	Orange	Palm Beach
1977	Exhaust Emissions	HD Diesel	11.6	39.1	10.0	33.5	56.7
		HD Gasoline	7.4	24.8	6.3	21.2	35.9
		LD Gasoline	0.3	1.1	0.4	1.4	0.7
	Crankcase and Evaporative Emissions		5.6	18.8	4.8	16.3	26.9
	Total		25	84	22	72	120
1982	Exhaust Emissions	HD Diesel	10.1	47.8	14.9	40.3	64.1
		HD Gasoline	2.6	12.4	3.9	10.4	16.6
		LD Gasoline	0.2	1.1	0.5	1.3	0.6
	Crankcase and Evaporative Emissions		2.3	10.9	3.4	9.3	14.3
	Total		15	72	23	61	96
1987	Exhaust Emissions	HD Diesel	7.4	51.0	18.8	41.3	61.9
		HD Gasoline	1.0	7.0	2.6	5.6	8.4
		LD Gasoline	0.1	1.0	0.5	1.2	0.5
	Crankcase and Evaporative Emissions		1.1	7.4	2.8	6.1	8.6
	Total		10	66	25	54	80

(Reference 4). Projected emission totals are displayed in Table 4-55, while Table 4-56 shows emissions by reactivity class.

Table 4-56. 1977, 1982, AND 1987 ESTIMATED VOC EMISSIONS FROM AGRICULTURAL EQUIPMENT BY REACTIVITY CLASS (ton/yr)

County	1977		1982		1987	
	Class I	Class II	Class I	Class II	Class I	Class II
Broward	1	24	1	14	1	9
Dade	5	79	4	68	4	62
Duval	1	21	1	22	1	24
Orange	4	68	3	58	3	54
Palm Beach	6	114	5	91	5	75

4.9.2.2 Lawn and Garden Equipment

4.9.2.2.1 Base Year Analysis

Table 4-57 indicates the types of motorized equipment included in this category and the relative abundance of each type nationwide. In the absence of more specific information, the same relative equipment distribution has been assumed to apply to the study area, except for snowthrowers.

There are, unfortunately, no reliable estimates of the current lawn and garden engine population for 1977. Registrations are not required, and there is no satisfactory sales or production information available. In addition, PES was not able to secure reliable statistics concerning engine displacement or type. However, estimates have been made in recent years which provide sufficient groundwork from which to make a 1977 estimate.

Table 4-57. LAWN AND GARDEN EQUIPMENT

Engine Application	Percentage of Total (Nationwide)
Riding mower	9
Walking mower	74
Garden tractor	4
Motor tiller	5
Snowthrower	4
Other lawn and garden equipment	4

Two types of gasoline-powered small utility engines are typically used in lawn and garden equipment: the four-stroke and the two-stroke. Estimates of the 1968 nationwide population of these types of engines are shown in Table 4-58. It was assumed that equipment populations have grown at a rate of 6 percent per year since that time (Reference 57) which yielded the 1977 equipment populations also shown in Table 4-58.

Table 4-58. ESTIMATED NATIONWIDE POPULATION OF LAWN AND GARDEN EQUIPMENT, EXCLUDING SNOWTHROWERS[a]
(millions of units)

Engine Type	1968[b]	1977	Percent of Total
Four-stroke	34.8	58.8	93.6
Two-stroke	2.4	4.0	6.4
Total	37.2	62.8	100.0

[a] Snowthrowers represent approximately 4 percent of the national total

[b] Refer to Reference 57

Apportionment of the national equipment totals to the counties in the study area was achieved by use of the following relationship:

$$P_C = P_N R \qquad (9)$$

where

P_C = population of lawn and garden equipment in the county

P_N = population of lawn and garden equipment in the nation (refer to Table 4-58)

R = ratio of county to national single-unit housing structures

Equation 9 assumes that a direct relationship exists between the number of lawn and garden engines in a given area and the number of single-unit housing structures in that area. This supposition was made on the strength of the exceptionally good agreement between the two parameters at the national level (Reference 57).

To obtain 1977 estimates for county housing data, national housing data for 1970 and 1976 were obtained from the 1970 Census of Housing (Reference 59) and the 1976 Annual Housing Survey (Reference 60). By assuming a linear growth pattern, the 1977 national total of single-unit structural houses was estimated to be 54.8 million. This represents a national growth rate of 1.17 percent from 1970 to 1977, which was assumed to apply to county housing totals as well, as Table 4-59 shows. The results of using this data in equation 9 are presented in Table 4-60.

Table 4-59. ESTIMATED NUMBERS OF SINGLE-UNIT HOUSING STRUCTURES IN THE STUDY AREA (thousands of units)

County	1970[a]	1977
Broward	150	176
Dade	253	296
Duval	131	153
Orange	89.0	104
Palm Beach	84.7	99.1

[a] Refer to Reference 59

Table 4-60. LAWN AND GARDEN COUNTY EQUIPMENT TOTALS, 1977
(thousands of units)

County	Equipment Population
Broward	202
Dade	339
Duval	175
Orange	119
Palm Beach	114

The following formula was used to compute the VOC emissions originating annually from lawn and garden equipment. Emission factors for this category are given in Table 4-61.

$$E_C = P_C R \sum_{i=1}^{3} f_i P_{Ni} \qquad (10)$$

where

E_C = county TVOC emission estimate for lawn and garden equipment

P_C = population of lawn and garden equipment in the county (refer to Table 4-60)

R = ratio of county to national annual mean freeze-free days

f_i = TVOC emission factor (exhaust plus evaporative) for engine type i (refer to Table 4-58)

P_{Ni} = national population of lawn and garden equipment with engine type i (refer to Table 4-58)

Table 4-61. TVOC EMISSION FACTORS FOR LAWN AND GARDEN EQUIPMENT[a]
(kg/unit/yr)

Pollutant	Engine Type	
	Four-Stroke	Two-Stroke
TVOC		
Exhaust	1.6	14.7
Evaporative	.1	.1

[a] Refer to References 9 and 57

Table 4-61 gives nationwide average TVOC emission factors for the two engine types under study. These emission factors are based on:

1. A composite of test results on typical engines used in this source category operating under normal workloads.
2. The assumption that the annual usage of the equipment is 50 hours per unit per year nationwide.
3. The assumption that the annual usage is spread over an operating year of 213 days, which is the average of the mean number of freeze-free days per year (days when the minimum temperature is freater than 32°F) for all counties nationwide (Reference 57).
4. Crankcase emissions are considered to be negligible.

The results of employing the appropriate data in equation 10 are summarized in Table 4-62. The totals for the various VOC classes were generated by combining each of the emissions totals (based on distribution of exhaust to evaporative TVOC emission factors) with the appropriate compositional fractions and summing for each VOC class.

Table 4-62. 1977 LAWN AND GARDEN EQUIPMENT EMISSIONS BY REACTIVITY CLASS (ton/yr)

County	TVOC	Class I	Class II
Broward	969	93	877
Dade	1,642	157	1,485
Duval	849	81	768
Orange	578	55	522
Palm Beach	549	52	497

4.9.2.2.2 Projections

As discussed in the previous section, county VOC emissions from lawn and garden equipment are proporational to county equipment totals. Base year equipment totals were computed from recent housing data. Projected equipment totals were to be computed from the projected number of single-unit housing structures, but this information was not available, so projected population was assumed to adequately represent the increase or decrease in housing units. This assumption implies that average housing densities and the percent singly-family homes will not vary significantly from the pattern of recent years.

Projected lawn and garden emissions are displayed in Table 4-63.

Table 4-63. PROJECTED VOC EMISSIONS FROM LAWN AND GARDEN EQUIPMENT
(ton/yr)

County	1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	1,163	112	1,051	1,341	129	1,212
Dade	1,747	168	1,579	1,878	180	1,698
Duval	900	86	814	1,065	102	963
Orange	650	62	588	725	70	655
Palm Beach	659	63	596	761	73	688

4.9.2.3 Industrial Equipment

4.9.2.3.1 Base Year Analysis

The point of origin for calculating VOC emissions estimates for this category was the national population of industrial equipment for calendar year 1974, which are shown in Table 4-64.

Table 4-64. NATIONAL INDUSTRIAL EQUIPMENT POPULATION ESTIMATES, 1974
(thousands of units)

Engine Type	Equipment Population
HD[a] Diesel	417[b]
HD Gasoline	990[b]
LD[a] Gasoline	2,105[c]

[a] HD = heavy-duty; LD = Light-duty
[b] Refer to Reference 58
[c] Refer to Reference

The VOC emissions were first calculated for 1974, then projected to the base year, 1977.

Apportionment of the national industrial equipment total to the counties in question was based on examining employment data in the industrial sector. Mining (SIC codes 10-14), manufacturing (SIC codes 20-39), and wholesale trade (SIC codes 50-51) were selected as industrial indicators. Using the county employment data from Section 2.3 along with the 1974 Bureau of the Census national employment figure of 25.0 million (Reference 80) yielded the equipment totals shown in Table 4-66. The apportioning technique assumed that the engine type distribution for the counties was that observed for the nation.

County emissions estimates were calculated by use of the following equation. The emission factors employed are presented in Table 4-65.

$$E_C = P_C \sum_{i=1}^{3} \sum_{j=1}^{3} t_i f_{ij} \qquad (11)$$

where

E_C = county TVOC emission estimate for industrial equipment

P_C = population of industrial equipment in the county (refer to Table 4-66)

t_i = fraction of P_C that is of equipment type i (refer to Table 4-64)

f_{ij} = TVOC emission factor for equipment type i, source j, i.e., exhaust (refer to Table 4-65)

Table 4-65. TVOC EMISSION FACTOR FOR INDUSTRIAL EQUIPMENT (kg/yr per unit)

Pollutant	HD Diesel Engines[a]	HD Gasoline Engines[a]	LD Gasoline Engines[b]
TVOC			
Exhaust	43.7	57.3	1.17
Evaporative	--[c]	18.6	.29
Crankcase	--[c]	11.5	.23[d]

[a] Refer to Reference 58

[b] Refer to Reference

[c] Evaporative and crankcase VOC emissions from diesel engines are considered to be negligible (Reference 4)

[d] Crankcase TVOC is assumed to be 20 percent of the exhaust TVOC (Reference 58, page 92)

The TVOC estimates that resulted from these calculations are shown in Table 4-66.

Table 4-66. ESTIMATES OF INDUSTRIAL EQUIPMENT AND VOC EMISSIONS, 1974

County	Equipment Total	TVOC (ton/yr)
Broward	5,930	202
Dade	20,800	708
Duval	6,890	235
Orange	4,330	148
Palm Beach	3,800	129

4.9.2.3.2 Projections

Industrial employment projections from Section 2.3 were utilized to represent growth in the use of industrial equipment. Application of these data yielded two emissions totals shown in Table 4-67. Amounts in the various VOC classes were determined by multiplying each of the 1974 emission totals (not shown) by the appropriate compositional fraction, summing for each VOC class, and then forecasting to the projection years.

4.9.2.4 Heavy Construction Equipment

4.9.2.4.1 Base Year Analysis

Table 4-68 presents national heavy construction equipment totals by type for calendar year 1973. Because these are the most recent estimates of this kind, emissions from this source category were computed for 1973 and then projected to 1977.

The first step in the analysis was the allocation of the national equipment totals to the various counties in the study area. Apportionment was based on the ratio of county to national employment in the heavy construction sector (SIC code 16; employment data extracted from Section 2.3 and Reference 80). Table 4-69 summarizes the resulting county equipment totals. The national equipment mix was assumed to apply directly to each county.

Table 4-70 reports the TVOC emission factors which correspond to each of the equipment types under consideration. To apply these emission factors to the county equipment totals, it was necessary to first estimate the distribution of gasoline- to diesel-powered equipment in each category. Based on the reported emission factors and information presented in Reference 58, it was determined that five of the categories are strictly diesel-powered while the other five contain a mix. The following paragraph gives an account of the approach PES took to ascertain these distributions.

Table 4-67. PROJECTED VOC EMISSIONS FROM INDUSTRIAL EQUIPMENT (ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	221	13	208	252	15	237	287	17	269
Dade	771	47	724	871	53	818	982	60	922
Duval	244	15	237	259	16	243	274	17	257
Orange	161	10	151	184	11	173	211	13	198
Palm Beach	145	9	136	169	10	159	197	12	185

Table 4-68. NATIONAL HEAVY CONSTRUCTION EQUIPMENT TOTALS, 1973[a]

Equipment Type	Equipment Total
Tracklaying tractors	197,000
Tracklaying shovel loaders	86,000
Motor graders	95,300
Scrapers	27,000
Off-highway trucks	20,800
Wheel loaders	134,000
Rollers	81,600
Wheel dozers	2,700
Miscellaneous	100,000
Total	1,181,400

[a] Refer to Reference 57

Table 4-69. HEAVY CONSTRUCTION EQUIPMENT TOTALS BY COUNTY, 1973

County	Equipment Total
Broward	10,100
Dade	14,300
Duval	6,300
Orange	6,900
Palm Beach	4,840

Reference 58 contains 1973 estimates of nationwide evaporative VOC emissions from each equipment category. In forming these estimates, the authors of Reference 58 assumed that evaporative emissions from diesel-powered equipment are negligible, thereby attributing the total tonnage of evaporative emissions to gasoline-powered equipment. By applying the evaporative emission factors shown in Table 4-70 to the evaporate emissions totals, the number of gasoline-powered equipment in each affected category was determined. Comparing these totals with those in Table 4-68 yielded the desired distributions. The results of this technique are recorded in Table 4-70.

To simplify data manipulation, composite TVOC emission factors were computed for the two major equipment categories, namely HD diesel and HD gasoline. The factors from Table 4-70 were weighted to reflect the 1973 national equipment distribution and the corresponding fuel use ratios. For convenience and because their reactivity profiles are assumed to be similar, evaporative and crankcase emissions were summed and are denoted herein as "evaporative." The composite emission factors are displayed in Table 4-71.

Finally, county VOC emissions estimates were made by weighting the composite TVOC emission factors by the national distribution of HD diesel to HD gasoline equipment and then combining these factors with the county equipment totals. The results are reported in Table 4-72.

4.9.2.4.2 Projections

The 1973 VOC emissions from Table 4-72 were multiplied by the growth in construction employment (SIC code 16) to project emissions to 1977, 1982, and 1987. It was assumed that the ratio of diesel- to gasoline-powered equipment and the distribution of

Table 4-70. HEAVY CONSTRUCTION EQUIPMENT FUEL USE DISTRIBUTIONS AND TVOC EMISSION FACTORS

	Equipment Distribution by Fuel Type[a]		TVOC Emission Factors[b]			
			Diesel	Gasoline		
Equipment Type	Gasoline	Diesel	Exhaust	Exhaust	Crankcase	Evaporative
Tracklaying tractor	--	100	52.6	--	--	--
Wheel tractor	15.4	84.6	49.7	121	24.1	22.9
Wheel dozer	--	100	211	--	--	--
Scraper	--	100	568	--	--	--
Motor grader	7.6	92.4	20.5	154	30.8	24.9
Wheel loader	30.0	70.0	96.6	275	54.9	33.9
Tracklaying loader	--	100	16.0	--	--	--
Off-highway truck	--	100	396	--	--	--
Roller	69.2	30.8	18.3	205	41.1	20.9
Miscellaneous	25.0	75.0	71.4	254	50.7	25.4

[a] Expressed as percentage of total equipment population. Refer to text

[b] Expressed in kilogram per unit per year. Refer to Reference 9

Table 4-71. COMPOSITE TVOC EMISSION FACTORS FOR HEAVY CONSTRUCTION EQUIPMENT (kg/unit/yr)

Equipment Type	TVOC Emission Factor
HD diesel	
Exhaust	73.5
HD gasoline	
Exhaust	194.9
Evaporative[a]	63.9

[a] Includes crankcase emissions

Table 4-72. ESTIMATED VOC EMISSIONS FROM HEAVY CONSTRUCTION EQUIPMENT, 1973 (ton/yr)

County	VOC Emissions
Broward	1,148
Dade	1,625
Duval	716
Orange	785
Palm Beach	550

equipment types would not change significantly before 1987. Table 4-73 presents the projected VOC emissions from this category by reactivity class.

4.9.2.5 Off-Highway Motorcycles

4.9.2.5.1 Base Year Analysis

In determining the VOC emissions impact from vehicles of this type, the crucial problem was estimating the number of motorcycles that participate in off-highway activities. State registration data were not helpful because not all motorcycles used off-highway are registered. Therefore, state motorcycle population estimates, which indlude both on- and off-highway vehicles, were extracted from a report issued by the Motorcycle Industry Council, Inc. (MIC, Reference 63). Table 4-74 shows MIC's 1976 population and off-highway usage estimates for three classes of motorcycles.

The 4 percent not accounted for in the off-highway category were assumed to belong to serious racing enthusiasts and so were not considered to be trail bikes.

The following equation was used to estimate county total off-highway unit equivalents, hereafter referred to as O/H motorcycles:"

$$N_C = R_C \sum_{i=1}^{3} n_i t_i \qquad (12)$$

where

N_C = estimated county O/H motorcycles

R_C = ratio of the county to state population, 1976

n_i = estimated state total of all motorcycles in class i, e.g., street

t_i = fraction of time motorcycles in class i are ridden off-highway

Table 4-73. PROJECTED VOC EMISSIONS FROM HEAVY CONSTRUCTION EQUIPMENT (ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	1,210	76	1,136	1,284	81	1,206	1,363	86	1,280
Dade	1,815	114	1,704	2,050	129	1,925	2,310	146	2,169
Duval	753	47	707	769	48	722	788	50	740
Orange	778	49	731	779	49	731	781	49	733
Palm Beach	618	39	580	702	44	659	795	50	747

For resulting county O/H motorcycle totals, refer to Table 4-78.

Table 4-74. POPULATION AND OFF-HIGHWAY USE OF MOTORCYCLES, 1976[a]

Motorcycle Class	Street[b]	Dual-Purpose[c]	Off-Highway[d]
Florida Population	129,300	100,200	58,800
Off-Highway Usage[e]	13	55	96

[a] Refer to Reference 63

[b] Street motorcycles are certified by the manufacturer as being in compliance with the Federal Motor Safety Standards (FMVSS), and are designed primarily to be ridden on public roads

[c] Dual-pupose motorcycles are also certified by the manufacturers as being in compliance with the FMVSS, and are designed to be ridden both on public roads and nonpublic roads (trails, dirt, paths, and so on)

[d] Off-highway motorcycles are not certified to be in compliance with the FMVSS, and are designed exclusively for nonpublic roads. These are the motorcycles least likely to be registered

[e] National average. Expressed as percent of total time ridden off-highway

Table 4-75 gives estimated percent distribution of motorcycles used off-highway by engine displacement and type, while Table 4-76 tabulates the TVOC emission factors for the various motorcycle engines under consideration. The annual emission rates are for exhaust pollutants only. (Data and methodology required to estimate evaporative emissions are given later in this section.)

Table 4-75. ESTIMATED PERCENT DISTRIBUTIONS OF MOTORCYCLES USED OFF-HIGHWAY BY ENGINE DISPLACEMENT AND TYPE[a]

Engine Displacement (cc)	Total	Two-Stroke	Four-Stroke
Up to 100	46	54	46
101 to 190	25	81	19
191 to 250	16	84	16
Above 251	13	60	40

[a] Refer to Reference 64

Table 4-76. EXHAUST TVOC EMISSION FACTORS[a]

Engine Displacement (cc)	Stroke	TVOC[b]
Up to 100	2	4.5
101 to 190	2	14
191 to 250	2	38
Above 251	2	75
Up to 100	4	1.6
101 to 190	4	3.6
191 to 250	4	7.1
Above 251	4	14

[a] Refer to Reference 57

[b] Expressed in units of kilograms per unit per year

Due to the spectrum of motorcycle engine displacements and types, a weighted TVOC emission factor was developed to simplify data manipulations. The following equation was used to perform this task (Reference 57):

$$E_{ex} = \sum_{i=1}^{4}\sum_{j=1}^{2} d_i s_j f_{ij} \qquad (13)$$

where

E_{ex} = weighted exhaust TVOC emission factor

d_i = fraction of total motorcycle population that is of engine displacement i

s_j = fraction of engine displacement i's population that is of stroke type j

f_{ij} = exhaust TVOC emission factor for engine displacement i and stroke type j

Using data from Table 4-75 and 4-76 in equation 13 resulted in a weighted exhaust TVOC emission factor of 16.3 kilograms per unit per year.

To calculate a weighted composite emission factor for evaporative VOC emissions from off-highway mototcycle use, riding season in days and estimated fuel tank volumes by engine size were required. For each county in the study area, the riding season was determined by the following criteria (Reference 57):

- Nationwide, the average riding season was assumed to be from March through November (275 days).
- Any remaining months with an average normal temperature less that 38°F were converted to days and subtracted from the average riding season.

The required county temperature data were extracted from the Local Climatological Data (Reference 65). All of the counties in the study area have riding seasons of 275 days. Average fuel tank volumes by engine displacement are shown in Table 4-77.

Table 4-77. ESTIMATED VOLUME OF FUEL TANKS[a]

Engine Displacement (cc)	Tank Volume (liters)
Up to 100	7.6
101 to 190	9.5
191 to 250	11.4
Above 251	15.2

[a] Refer to Reference 57

The formula used to compute a weighted emission factor for evaporative TVOC was:

$$E_{Ce} = S_C f_e \sum_{i=1}^{4} V_i d_i \qquad (14)$$

where

E_{Ce} = weighted evaporative TVOC emission factor for county

S_C = county O/H motorcycle riding season (expressed as days per year)

f_e = evaporative TVOC emission factor (0.53 grams per liter tank volume per day, Reference 57)

V_i = average fuel tank volume for a motorcycle with engine displacement i

d_i = fraction of total O/H motorcycles that are of engine displacement i

Using the appropriate data from Tables 4-75 and 4-77 in equation 14 resulted in a TVOC emission factor of 1.4 kilograms per unit per year for all the counties in the study area.

In addition to evaporative emissions, consideration was also given to crankcase emissions. Crankcase emissions for four-stroke engines are 0.60 grams per mile, while those from two-stroke engines are considered negligible because most two-stroke engines employ crankcase induction (Reference 9). Using 4,000 miles per year as an estimate of motorcycle travel (Reference 9), along with the fact that 34 percent of off-highway motorcycles are four-stroke (refer to Table 4-76), yielded a TVOC emission factor of 0.8 kilograms per unit per year.

Since the reactivity profiles of evaporative and crankcase VOC emissions are assumed to be similar, they were added together and are referred to hereafter as "evaporative." This yielded a TVOC emission factor of 2.2 kilograms per unit per year for a riding season of 275 days.

TVOC emissions for each county were computed by combining the O/H motorcycle totals (refer to Table 4-78) with the weighted exhaust TVOC emission factor (16.3 kilograms per unit per year) and the evaporative TVOC emission factor (2.2 kilograms per unit per year). The results appear in Table 4-78. Amounts in the various VOC classes were determined by multiplying each of the emission totals by the appropriate compositional fraction (refer to Table 3-1) and summing for each VOC class.

Table 4-78. ESTIMATED VOC EMISSIONS FROM OFF-HIGHWAY MOTORCYCLES, 1976 (ton/yr)

County	O/H Motorcycle Population	TVOC	Class I	Class II
Broward	13,900	281	25	256
Dade	22,100	446	40	406
Duval	8,540	172	15	157
Orange	6,260	126	11	115
Palm Beach	8,210	166	15	151

4.9.2.5.2 Projections

Off-highway motorcycle use was projected on the basis of population trends in each county. In doing so, it was assumed that:

- The proportion of the population who engage in off-highway motorcycling will remain constant from 1976 to 1987.
- Engine type and other vehicle specifications will be represented by the 1976 mix.
- The riding seasons in the various counties will not change significantly.

Forecasted VOC emissions are reported in Table 4-79.

4.9.3 RAIL EMISSIONS (Methodology Description Provided by FDOT)

The percentage of locomotive miles of travel in Florida was taken as a percentage of the total locomotive miles of travel systemwide. This information was obtained from the 1977 R-1 reports for each rail system operating in Florida. Total system fuel was obtained from the same report, and fuel consumption was then prorated to Florida. Total statewide mileage of track was

Table 4-79. PROJECTED VOC EMISSIONS FROM OFF-HIGHWAY MOTORCYCLES (ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	290	26	264	348	31	317	401	36	365
Dade	450	40	410	479	43	436	515	46	469
Duval	174	16	158	184	16	168	206	18	189
Orange	128	11	117	145	13	132	161	14	147
Palm Beach	171	15	156	205	18	187	237	21	216

also obtained from the R-1 and prorated by county by FDOT's Railroad Planning Unit. Fuel consumption was then assigned by county. The amount of switching activity was also noted (in cases of heavy switching, the fuel consumed by that company in the county in question was doubled). Fuel consumption was totaled and combined with rail operation TVOC emission factors from Reference 9 to produce VOC rail emissions. A growth factor of -1.3 percent per year for 1970 to 1977 was obtained from American Association of Railroads data.

Table 4-80 summarizes base year and projected rail operation VOC emissions by reactivity class. These summaries were prepared by PES.

4.9.4 AIRCRAFT EMISSIONS (Methodology Description Provided by FDOT)

Landing-takeoff cycles were obtained from Florida's Aviation System Plan and were interpolated to provide counts for the specific years in question. For general aviation airports that had no aircraft mix, the national general aviation mix was assumed. For commercial operations, the vehicle mix for spring 1977 was obtained from the Airline Guide. There was no projection of vehicle mix into the future. There are two exceptions: Palm Beach International Airport figures represent those in the airport's "Environmental Impact Assessment Report," and vehicle mixes were provided by the Dade County Environmental Resources Management Office for Dade County airports.

Military operations were exceptionally hard to obtain. For military activity at civilian airports, the estimated mix is shown in Appendix D. At those bases where an "Air Installation Compatible Use Zone" (AICUZ) study was available, the aircraft mix of the Air Quality Section was used. No projections of military activity are possible so none were provided.

Table 4-80. ESTIMATED VOC EMISSIONS FROM RAILROAD OPERATIONS, 1977, 1982, AND 1987

County	1977 Fuel Consumed[a]	VOC Emissions[b]								
		1977			1982			1987		
		TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	2,979	140	3	137	133	3	130	123	3	120
Dade	3,280	154	3	151	144	3	141	134	3	131
Duval	3,067	144	3	141	135	3	132	126	2	124
Orange	961	45	1	44	42	1	41	39	1	38
Palm Beach	1,907	90	2	88	84	2	82	78	2	76

[a] Expressed in thousands of gallons per year

[b] Expressed in tons per year

Total VOC emissions were obtained from Reference 9 per LTO cycle. No allowance was made for taxi time because the time allowed by the factors was considered appropriate by FDOT's Aviation Planning Unit.

PES developed county airport summary tables (Appendix D) from individual airport summary sheets provided by FDOT. These tables summarize VOC emissions by aircraft class and type for each reported airport in a subject county. Tables 4-81 and 4-82 summarize county VOC emissions by engine type and reactivity class, respectively.

4.9.5 VESSELS

Vessels are separated into two distinct categories: ocean-going and recreational boating. The methodologies for determining fuel consumption were based upon the information presented in Reference 39. Ocean-going vessels (distillate oil-fired motorships and residual oil-fired steamships) are discussed in Section 4.9.5.1, while recreational boats (predominantly gasoline users) are discussed in Section 4.9.5.2.

4.9.5.1 Ocean-Going Vessels

4.9.5.1.1 Base Year Analysis

Due to insufficient up-to-date information, the base year analysis for ocean-going vessels was made for 1976, and then projected to 1977. Emission calculations for vessels were based upon two components: fuel consumption while sitting at dockside (hoteling) and fuel consumption while underway. The authors of References 39 and 66 assumed that only vessels with a draft of 18 feet or greater operate their boilers/engines while at dockside.

Table 4-81. ESTIMATED VOC EMISSIONS FROM AIRCRAFT BY ENGINE TYPE (ton/yr)

County	1977			1982			1987		
	Jet	Piston	Helicopter	Jet	Piston	Helicopter	Jet	Piston	Helicopter
Broward	657[a]	523[a]	0.2[a]	1,095	198	5	1,198	223	6
Dade[b]	5,630	431	7	6,249	473	10	6,765	494	10
Duval	1,757	166	69	1,827	87	169	1,964	107	169
Orange	298	21.4	1	375	38	1	462	53	3
Palm Beach	301	49	1	456	76	2.1	639	155	4

[a] Information for 1976 supplied by Broward County Environmental Quality Control Board due to incomplete 1977 data; received September 18, 1978

[b] Homestead Air Force Base total emissions were only given. To determine the jet/piston/helicopter breakdown, 1976 aircraft emission information supplied by Dade County Environmental Resources Management, July 5, 1978, was used

Table 4-82. ESTIMATED VOC EMISSIONS FROM AIRCRAFT, 1977, 1982, AND 1987

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	1,180[a]	82[a]	1,097[a]	1,299	58	1,241	1,427	64	1,363
Dade	6,068	221	5,847	6,732	245	6,487	7,269	263	7,009
Duval	1,992	80	1,912	2,083	81	2,002	2,240	88	2,152
Orange	320	12	308	414	16	398	518	20	498
Palm Beach	351	15	336	534	23	511	798	38	760

[a] Information for 1976 supplied by the Broward County Environmental Quality Control Board due to incomplete 1977 data. Received September 18, 1978

The average in-port stay for vessels with a draft of 18 feet or greater is generally 3 days (Reference 39). While at dockside, References 39 and 66 assumed that residual oil-fired steamships consume 1,900 gallons of oil per day, and that distillate oil-fired motorships consume 660 gallons of oil per day. After further investigation, it was found that motorships take their main propulsion engines out of service and either generate power from auxiliary diesel engines located aboard or use shoreside power. Steamships, on the other hand, rarely shut down their plants because to do so would be complicated and time-consuming. While operating their boilers at reduced loads in port, steamships receive power from shoreside connections to provide the supplemental electricity and steam necessary to satisfy their needs.

The number of vessels entering and leaving the ports in the counties in the study area was obtained from Reference 67, which also denoted the types of vessels using the various ports: self-propelled passenger and dry cargo ships, tankers, tugboats or towboats, and non-self-propelled dry cargo ships and tankers. For each port within the study area, the number of vessels entering and leaving that are 18 feet in draft and greater and the estimated number of days each such vessel spends in that port are shown in Table 4-84.

Vessel days at dockside must be allocated to residual and distillate oil users. To do this, 1976 estimates of fuel oil sales for vessel use (bunkering) in Florida were obtained from Reference 68. These estimates of fuel oil sold in each state were then converted to vessel days (VDS), as suggested by References 39 and 66. The equation used to calculate vessel days is as follows:

$$VDS_i = F_{si}/r_i \qquad (15)$$

where

VDS_i = total VDS for fuel oil i statewide

F_{si} = annual statewide fuel sales for fuel oil i

r_i = fuel consumption rate for fuel oil i while hoteling (600 gallons per day per vessel for distillate oil, and 1,900 gallons per day per vessel for residual oil)

The total possible VDS in the state (distillate VDS plus residual VDS) was determined, and from this and the individual totals the distributions of the two vessel types were calculated. Table 4-83 reports the fuel oil sales by states and the corresponding distribution of distillate and residual VDS. These percentages should only be considered working estimates because the distillate fuel taken on by vessels of less than 18 feet draft has not been taken into account. To compensate for these vessels would require estimating their fuel use for the entire state, which is outside of the scope of this study.

Table 4-83. FUEL OIL SALES AND IN-PORT VESSEL DAYS (VDS) DISTRIBUTION FOR FLORIDA, 1976

Fuel Sale ($\times 10^3$ gal)		VDS Distribution (Percent)	
Distillate	Residual	Distillate	Residual
730	2,840	42.5	57.5

The fuel consumption rates for each port in the study area were computed by use of the following equation:

$$H_{ij} = VDS_j t_i r_i \tag{16}$$

where

H_{ij} = annual hoteling fuel consumption rate of fuel type i in port/harbor j

VDS_j = total annual vessel days in port/harbor j

t_i = fraction of VDS that is of fuel type i

r_i = fuel consumption rate for fuel oil i while hoteling (equation 15)

The results of employing equation 16 are shown in Table 4-84.

The calculation of underway fuel consumption resulting from vessel movement within ports and through channels has become a complex apportioning process. The methodology suggested by Reference 39 is based on determining in-port fuel oil for the entire state, then deducting that amount from the estimated fuel oil sales for the state. This value is then apportioned to each of the ports or waterways, based on the tonnage of cargo handled in these areas. This method requires that in-port fuel consumption for all counties in the state be computed. However, it does not take into account the fuel that is taken on in port and consumed in the open sea, where the resulting emissions have no impact on the counties. Therefore, a new method of estimating underway fuel consumption for a limited number of counties within a state was developed. The methodology that was used to estimate underway fuel consumption was based on determining the annual underway mileage within each county and then applying underway fuel consumption rates.

Each county's underway mileage was estimated by the following method. The mileages of each shipping lane within each county in

Table 4-84. IN-PORT VESSEL DAYS AND IN-PORT FUEL CONSUMPTION, 1976

County	Port	Vessels 18 ft Entering Port	Days in Port	Fuel Consumption (x10^3 gal)	
				Distillate	Residual
Broward	Port Everglades Harbor	752	2,256	632	2,464
Dade	Miami Harbor	1,227	3,681	1,032	4,022
	Intracoastal Waterway, Miami to Key West	0	0	0	0
	Miami River			0	0
	Intracoastal Waterway, Jacksonville to Miami	0	0		
Duval	Jacksonville Harbor	1,432	4,296	1,205	4,693
	St. Johns River, Jacksonville to Lake Larney	0	0	0	0
	Intracoastal Waterway, Jacksonville to Miami	0	0	0	0
	Atlantic Intracoastal Waterway between Norfolk, Va., and St. Johns River, Jacksonville	0	0	0	0
Orange	No ports	-	-	-	-
Palm Beach	Palm Beach Harbor	41	123	34.4	135

the study area, as identified by Reference 67, were estimated using the best available maps, which range in scale from 1 mi = 0.36 in to 1 mi = 0.05 in. When a shipping lane bordered more than one political jurisdiction, the mileage was apportioned to the counties according to their shoreline mileage along the particular waterway. The numbers of vessels traveling these lanes were also recorded by type and draft (Reference 67). Combining the number of vessel trips with the mileage of each shipping lane and then totaling for each county yielded the annual vessel mileages shown in Table 4-85.

Estimates of underway fuel consumption required allocations of the vessel mileage estimates to motorships and steamships. It was assumed that vessels of less than 18 feet draft were strictly distillate oil users, i.e., that they are all motorships (Reference 39). For vessels of 18 feet and greater in draft, the underway mileage was distributed between residual and distillate oil, as described in equation 15, except that the fuel consumption rates are 16.5 and 38 gallons per mile for distillate oil-fired motorships and residual oil-fired steamships, respectively (Reference 39). The percentage distributions of the two fuel types were calculated in the same manner as those for hoteling. The calculated percent ratios of distillate oil to residual oil are 37.3 to 62.7 for Florida. Applying this information to the county underway vessel mileage shown in Table 4-85 results in the fuel consumption rates also shown in Table 4-85.

Emissions for vessels were based upon the emission factors shown in Table 4-86 (Reference 9). These factors are dependent upon operating mode, i.e., hoteling (dockside) and cruise (underway). The factor for distillate motorships hoteling was established by assuming that distillate oil-fired ships run auxilliary generators at dockside with a rated output of 500 kw (Reference 69). Also, PES assumed that a 50 percent load is a reasonable average for generator electrical output at dockside. These were the best estimates PES could make after contacting several industry sources (References 69 through 71).

Table 4-85. UNDERWAY FUEL CONSUMPTION, 1976

County	Vessel Mileage		Fuel Consumption ($\times 10^3$ gal)	
	≥18 ft Draft	<18 ft Draft	Distillate	Residual
Broward	3,564	17,020	349	98.3
Dade	14,920	2,939,000	56,000	412
Duval	119,900	1,796,000	35,000	3,309
Orange[a]	N/A	N/A	--	--
Palm Beach	205	28,480	543	5.63

[a] No waterways or ports located in Orange County

Table 4-86. TVOC EMISSION FACTORS FOR OCEAN-GOING VESSELS[a] (pounds per thousand gallons)

Vessel Type	Mode	TVOC Emission Factor
Motorship	Hoteling	82
	Underway	50
Steamship	Hoteling	3.2
	Underway	.7

[a] Refer to Reference 9, Tables 3.2.3-1, 3.2.3-2, and 3.2.3-4

The following equation was used to compute the county TVOC emissions originating from ocean-going vessels:

$$E_C = \sum_{i=1}^{2}\sum_{j=1}^{2} C_{Cij} f_{ij} \qquad (17)$$

where

E_C = county TVOC emissions estimate

C_{Cij} = fuel consumption by county for operating mode i, vessel type j (refer to Tables 4-84 and 4-85)

f_{ij} = TVOC emission factor for mode i, vessel type j

Table 4-87 presents VOC emissions from ocean-going vessels in each county in the study area.

Table 4-87. ESTIMATED VOC EMISSIONS FROM OCEAN-GOING VESSELS, 1976 (ton/yr)

County	TVOC
Broward	39
Dade	1,448
Duval	932
Orange	N/A
Palm Beach	15

4.9.5.1.2 Projections

Information needed to accurately project the 1976 emissions to 1977, 1982, and 1987 was unavailable. Therefore, after a review of available existing data, PES used a draft entitled "Florida Waterport Systems Study" (Reference 11), which provides projections for the amount of cargo to pass through Florida ports in 1980, 1985, and 1990. The amounts projected for the ports in the study area are shown in Table 4-88.

The FDOT (publisher of Reference 11) was unable to provide an accurate accounting of the commodities included in their projection analysis for the years 1980, 1985, and 1990, so PES could not utilize 1976 Waterborne Commerce data to develop a growth rate from 1976 to 1980. To be consistent with the assumptions made in Reference 11, PES therefore used the annual growth rate arrived at for 1980 to 1985 for both its 1977 and 1982 emission projections. These growth rates were applied to the emission figures given in Table 4-87; Table 4-89 presents the results.

The totals presented in Table 4-89 were then broken down by reactivity level. Both residual and distillate oil combustion have the same reactivity profile (11 percent nonreactive, Class I; 89 percent reactive, Class II). This profile was applied to the calculated emission totals; the results are given in Table 4-89.

4.9.5.2 Recreational Boating

4.9.5.2.1 Base Year Analysis

This category includes small pleasure craft operated on lakes, rivers, and the ocean. Most of these craft are powered by outboard motors, but inboard-outdrives using gasoline are also considered in the study.

To quantify the amount of VOC emissions contributed by recreational boating activities, it was necessary to determine the amount of gasoline used in each county by recreational boats. To accomplish this task, fuel consumption within the State of Florida

Table 4-88. PROJECTED CARGO TONNAGE AND ANNUAL GROWTH RATES FOR EACH IN THE STUDY AREA

County	Port	1980 (1,000 short ton)	1985 (1,000 short ton)	1990 (1,000 short ton)	1980-1985 Growth Rate[a]	1985-1990 Growth Rate[a]
Broward	Port Everglades	11,850	13,183	14,592	2.2	2.1
Dade	Miami Harbor	3,907	5,459	7,152	6.9	5.6
Duval	Jacksonville Harbor	14,497	16,645	18,498	2.1	2.1
Orange	--	--	--	--	--	--
Palm Beach	Palm Beach Harbor	2,368	3,304	3,440	6.9	0.8

[a] Expressed in percentage per year

Table 4-89. PROJECTED VOC EMISSIONS FROM VESSEL ACTIVITY BY REACTIVITY LEVELS
(ton/yr)

County	1977			1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	40	4	36	44	5	40	49	5	44
Dade	1,550	170	1,380	2,160	238	1,920	2,840	312	2,530
Duval	952	105	847	1,060	116	940	1,170	129	1,040
Orange	--	--	--	--	--	--	--	--	--
Palm Beach	16	2	14	22	2	20	23	3	21

was calculated and then allocated to the various counties included in the study area.

Reference 1 suggested the National Air Data Branch (NADB) method for calculating the amount of fuel consumed in the states by gasoline-powered vessels. The initial step was to ascertain the number of registered pleasure craft in Florida (Reference 72). These vessels were then categorized as inboard or outboard boats.

The Florida Department of Registered Boating (Reference 73) provided PES with information to categorize the boats as either inboard or outboard. Of the total number of registered boats in the state, 66,783 are powered by inboard motors while 356,945 are powered by outboard motors. This gives a percentage breakdown of 16 percent inboard to 84 percent outboard in the state. These percentages were then applied to the county pleasure craft totals, thus yielding the number of inboard and outboard boats by county. Table 4-90 gives the state and county boat registration figures and the number of inboard and outboard boats registered for each county.

Table 4-90. REGISTERED INBOARD AND OUTBOARD RECREATIONAL BOATS, 1977

County	Registered Boats	
	Inboard	Outboard
Broward	3,785	19,870
Dade	6,187	32,481
Duval	3,628	19,045
Orange	2,994	15,718
Palm Beach	2,978	15,632

The next step in the NADB method was to calculate annual inboard and outboard fuel consumption. County fuel consumption by boat type can be expressed as:

$$G_{Ci} = n_{Ci} r_i k(10) \tag{18}$$

where

G_{Ci} = annual rate of gasoline consumption by boat type i in the county

n_{Ci} = total number of small craft of type i registered in the county

r_i = fuel consumption rate for boat type i

k = climatic factor

Small craft powered by inboard out-drives were included with inboards to estimate fuel use. Reference 39 reports fuel consumption factors of 3 and 1.5 gallons per hour for inboards and outboards, respectively. The "k" factor was a climatic factor which accounted for a longer pleasure boating season in warmer areas. For the purposes of this study, "k" represented the number of months during the year which had a mean temperature that exceeded 55°F (Reference 57). Reference 65 was used to determine the monthly mean temperature for all of the counties situated within the study area. All of the counties have a "k" factor of 12 except for Duval, which has a value of 11. For the resulting gasoline consumption rates, refer to Table 4-91.

Table 4-91. ESTIMATES OF FUEL CONSUMPTION BY RECREATIONAL BOATS AND RESULTING VOC EMISSIONS, 1977

County	Gasoline Consumption[a]		VOC Emissions[b]		
	Inboard	Outboard	TVOC	Class I	Class II
Broward	1,363	3,577	2,030	243	1,780
Dade	2,227	5,847	3,310	397	2,910
Duval	1,197	3,142	1,780	214	1,570
Orange	1,078	2,829	1,600	192	1,410
Palm Beach	1,072	2,814	1,590	191	1,400

[a] Expressed in thousands of gallons per year
[b] Expressed in tons per year

Equation 19 illustrates the method of calculating annual county TVOC emissions:

$$E_C = \sum_{i=1}^{2} r_i f_i \qquad (19)$$

where

E_C = annual rate of exhaust TVOC emissions for recreational boating in the county

r_i = annual rate of fuel consumption for boat type i

f_i = exhaust TVOC emission factor for boat type i

The applicable TVOC emission factors are 86 pounds per 1,000 gallons for inboard craft and 1,100 pounds per 1,000 gallons for outboard craft (Reference 9). The results of these calculations are shown in Table 4-91. These totals were then distributed by reactivity level. Because recreational small craft have light-duty engines, the reactivity profile for two- and four-stroke LD equipment (listed under gasoline-powered mobile sources in Table 3-1) was used.

The TVOC emission factors used to compute the emissions take into account the scrubbing action of the water into which much of the exhaust emitted by small craft is expelled. However, the reactivity profile for light-duty engine exhaust does not reflect the effects of this scrubbing on pollutants such as aldehydes. Therefore, the emissions distributions can only be considered rough working estimates.

Only exhaust gases from small-craft motors were considered in this inventory. Crankcase and evaporative emissions were assumed to be negligible on the basis of available information and engineering judgment.

4.9.5.2 Projections

The projected VOC emissions for each county within the study area were based upon their respective anticipated population growth/decline for 1982 and 1987 (refer to Section 2.2). The results are shown in Table 4-92.

Table 4-92. PROJECTED VOC EMISSIONS FROM RECREATIONAL BOATING (ton/yr)

County	1982			1987		
	TVOC	Class I	Class II	TVOC	Class I	Class II
Broward	2,430	291	2,140	2,800	336	2,470
Dade	3,520	423	3,100	3,790	454	3,330
Duval	1,890	227	1,660	2,100	253	1,850
Orange	1,800	216	1,590	2,010	241	1,770
Palm Beach	1,910	229	1,680	2,210	265	1,940

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5.0 RESULTS AND RECOMMENDATIONS

5.1 SUMMARY OF EMISSIONS

A summary of estimated Class II VOC emissions for the base year is given in Table 5-1. Totals are shown for each of the source categories listed in the "Summary Format for VOC" (Reference 1). As expected, a brief analysis of Table 5-1 shows that the largest contribution of Class II emissions is highway vehicles, which accounted for 60 percent of the total emissions and more than half of the emissions in each county. The next largest category was storage, transportation, and marketing of petroleum products. This group accounted for over one-third of Class II stationary emissions in the study area. Emissions attributed to this group were significantly higher in Broward and Duval Counties because of the centralized marketing activities (gasoline bulk plants and terminals) located there. Petroleum refineries, which can be a significant VOC source, were not found in the study area.

Projected 1982 and 1987 Class II emissions for stationary and mobile sources are presented by the "Summary Format for VOC" (Reference 1) in Tables 5-2 and 5-3, respectively. Emissions are also summarized for stationary and mobile sources in the base year and projected years in Table 5-4. Emissions presented in these tables reflect the most recent projection information available both from publications and directly from the sources. As indicated in Tables 5-1 and 5-3, 1987 Class II emissions from highway sources will be reduced by approximately 50 percent. This reduction is attributed to the continued implementation of a Federal Motor Vehicle Control Program. Conversely, these tables show a 1987 increase in Class II emissions from stationary sources of 2 percent.

Table 5-1. COUNTY SUMMARIES OF CLASS II VOC EMISSIONS, 1977 (ton/yr)

Source Category	Source	Broward	Dade	Duval	Orange	Palm Beach	Total
Petroleum refineries	Refinery fugitives (leaks)	0	0	0	0	0	0
	Miscellaneous sources	0	0	0	0	0	0
	Other	0	0	0	0	0	0
Storage, transportation and marketing of petroleum products	Oil and gas production fields	0	0	0	0	0	0
	Natural gas and natural gasoline processing plants	0	0	0	0	0	0
	Gasoline and crude oil storage[a]	2,340	7	3,400	102	NEG	5,850
	Ship and barge transfer of gasoline and crude oil	1,690	4	830	0	0	2,500
	Bulk gasoline terminals[b]	3,880	0	2,490	825	0	7,200
	Gasoline bulk plants[c]	1	0	2	0	0	3
	Service station loading (Stage I)	2,140	3,130	1,450	1,300	1,140	9,160
	Service station unloading (Stage II)	2,170	3,160	1,460	1,310	1,150	9,250
	Other	401	241	900	8	64	1,610
Industrial processes	Organic chemical manufacture	0	32	382	0	0	414
	Paint manufacture	41	227	67	22	17	374
	Vegetable oil processing	0	0	0	0	0	0
	Pharmaceutical manufacture	0	0	0	0	0	0
	Plastic products manufacture	6	13	17	274	0	310
	Rubber products manufacture	22	163	10	1	0	196
	Textile polymers manufacture	2	176	4	0	0	182
	Other	149	561	1,130	17	26	1,880
Industrial surface coating	Large appliances	0	0	0	0	0	0
	Magnet wire	3	4	0	12	0	19
	Automobiles	168	60	77	26	44	375
	Cans	0	0	116	76	0	192
	Metal coils	0	0	0	0	0	0
	Paper	79	0	337	303	2	721
	Fabric	0	0	0	0	0	0
	Metal furniture	56	201	6	11	2	276
	Wood furniture	21	188	14	17	12	252
	Flat wood products	0	0	69	1	0	70
	Other metal products	327	661	352	68	109	1,520
	Other	768	814	573	324	242	2,720
Nonindustrial surface coating	Architectural coatings	1,830	2,930	1,170	857	1,010	7,800
	Auto refinishing	289	462	185	135	159	1,230
	Other	117	186	74	54	64	495
Other solvent use	Degreasing	2,580	2,580	1,660	1,210	1,420	9,450
	Drycleaning	566	1,450	586	659	405	3,670
	Graphic arts	908	2,360	508	128	128	4,030
	Adhesives	0	376	0	0	0	376
	Cutback asphalt	481	401	3,920	116	17	4,940
	Other	42	2,720	156	0	0	2,920
Other miscellaneous sources	Fuel combustion	166	225	631	107	796	1,900
	Solid waste disposal	67	45	2	11	12	137
	Forest, agricultural, and other open burning	572	1,800	888	1,940	8,660	13,900
Total Class II Emissions From Stationary Sources		21,900	25,200	23,500	9,910	15,500	90,000
Mobile sources	Highway vehicles	43,200	57,900	33,500	24,600	27,800	187,000
	Off-highway vehicles	2,510	4,400	1,890	1,590	1,480	11,900
	Rail	137	151	141	44	88	561
	Aircraft	1,100	5,850	1,910	308	336	9,500
	Vessels	1,820	4,290	2,420	1,410	1,410	11,400
Total Class II Emissions From Mobile Sources		48,800	72,600	39,900	28,000	31,100	220,000
Grand Total of Class II Emissions		70,700	97,800	63,400	37,900	46,600	316,000

[a] Includes all storage facilities except those at service stations
[b] Emissions from loading tank trucks and rail cars
[c] Emissions from storage and transfer operations

Table 5-2. COUNTY SUMMARIES OF CLASS II VOC EMISSIONS, 1982 (ton/yr)

Source Category	Source	Broward	Dade	Duval	Orange	Palm Beach	Total
Petroleum refineries	Refinery fugitives (leaks)	0	0	0	0	0	0
	Miscellaneous sources	0	0	0	0	0	0
	Other	0	0	0	0	0	0
Storage, transportation and marketing of petroleum products	Oil and gas production fields	0	0	0	0	0	0
	Natural gas and natural gasoline processing plants	0	0	0	0	0	0
	Gasoline and crude oil storage[a]	2,310	7	3,350	100	NEG	5,770
	Ship and barge transfer of gasoline and crude oil	1,880	4	923	0	NEG	2,810
	Bulk gasoline terminals[b]	3,830	0	2,460	813	0	7,100
	Gasoline bulk plants[c]	1	0	2	0	0	3
	Service station loading (Stage I)	2,110	3,080	1,430	1,280	1,120	9,020
	Service station unloading (Stage II)	2,140	3,120	1,440	1,290	1,140	9,130
	Other	395	238	887	8	63	1,590
Industrial processes	Organic chemical manufacture	0	37	512	0	0	549
	Paint manufacture	48	269	68	25	19	429
	Vegetable oil processing	0	0	0	0	0	0
	Pharmaceutical manufacture	0	0	0	0	0	0
	Plastic products manufacture	7	15	18	246	0	286
	Rubber products manufacture	26	190	10	1	0	227
	Textile polymers manufacture	2	257	4	0	0	263
	Other	192	636	1,130	19	30	2,010
Industrial surface coating	Large appliances	0	0	0	0	0	0
	Magnet wire	4	5	0	13	0	22
	Automobiles	198	69	80	29	0	376
	Cans	0	0	69	94	50	213
	Metal coils	0	0	0	0	0	0
	Paper	93	0	348	339	2	782
	Fabric	0	0	0	0	0	0
	Metal furniture	66	235	6	12	2	321
	Wood furniture	25	219	15	19	14	292
	Flat wood products	0	0	NEG	1	0	1
	Other metal products	385	759	429	78	124	1,780
	Other	952	920	587	343	302	3,100
Nonindustrial surface coating	Architectural coatings	1,500	2,150	851	660	830	5,990
	Auto refinishing	319	453	181	140	176	1,270
	Other	129	183	73	57	71	513
Other solvent use	Degreasing	3,040	3,010	1,730	1,350	1,620	10,800
	Drycleaning	679	1,540	621	741	486	4,070
	Graphic arts	949	2,640	275	143	150	4,160
	Adhesives	0	538	0	0	0	538
	Cutback asphalt	481	401	3,920	116	17	4,940
	Other	63	3,540	156	0	0	3,760
Other miscellaneous sources	Fuel combustion	362	434	993	183	857	2,830
	Solid waste disposal	0	50	3	12	14	79
	Forest, agricultural, and other open burning	576	1,740	868	1,850	8,540	13,600
Total Class II Emissions From Stationary Sources		22,800	26,800	23,400	9,960	15,600	98,600
Mobile sources	Highway vehicles	33,700	38,600	23,900	17,700	21,200	268,000
	Off-highway vehicles	2,820	4,830	1,970	1,680	1,690	13,000
	Rail	130	141	132	41	82	526
	Aircraft	1,240	6,490	2,000	398	511	10,600
	Vessels	2,180	5,020	2,600	1,590	1,700	13,100
Total Class II Emissions From Mobile Sources		40,000	55,100	30,600	21,400	25,200	172,000
Grand Total of Class II Emissions		62,800	81,900	54,000	31,400	40,800	271,000

[a] Includes all storage facilities except those at service stations
[b] Emissions from loading tank trucks and rail cars
[c] Emissions from storage and transfer operations

Table 5-3. COUNTY SUMMARIES OF CLASS II VOC EMISSIONS, 1987 (ton/yr)

Source Category	Source	Broward	Dade	Duval	Orange	Palm Beach	Total
Petroleum refineries	Refinery fugitives (leaks)	0	0	0	0	0	0
	Miscellaneous sources	0	0	0	0	0	0
	Other	0	0	0	0	0	0
Storage, transportation and marketing of petroleum products	Oil and gas production fields	0	0	0	0	0	0
	Natural gas and natural gasoline processing plants	0	0	0	0	0	0
	Gasoline and crude oil storage[a]	2,180	7	3,170	94	NEG	5,4[illegible]
	Ship and barge transfer of gasoline and crude oil	2,090	6	1,020	0	NEG	3,120
	Bulk gasoline terminals[b]	3,620	0	2,320	768	0	6,710
	Gasoline bulk plants[c]	1	0	2	0	0	3
	Service station loading (Stage I)	1,990	2,910	1,350	1,210	1,060	8,520
	Service station unloading (Stage II)	2,020	2,940	1,360	1,220	1,070	8,610
	Other	373	224	838	8	60	1,500
Industrial processes	Organic chemical manufacture	0	44	513	0	0	557
	Paint manufacture	57	304	69	27	22	479
	Vegetable oil processing	0	0	0	0	0	0
	Pharmaceutical manufacture	0	0	0	0	0	0
	Plastic products manufacture	8	18	18	252	0	296
	Rubber products manufacture	30	222	11	1	0	264
	Textile polymers manufacture	2	337	4	0	0	343
	Other	238	722	1,130	21	34	2,150
Industrial surface coating	Large appliances	0	0	0	0	0	0
	Magnet wire	4	5	0	15	0	24
	Automobiles	232	73	83	32	57	477
	Cans	0	0	69	94	0	163
	Metal coils	0	0	0	0	0	0
	Paper	109	0	360	376	2	847
	Fabric	0	0	0	0	0	0
	Metal furniture	77	273	6	14	2	372
	Wood furniture	29	253	15	21	16	334
	Flat wood products	0	0	NEG	1	0	0
	Other metal products	451	869	431	85	142	1,980
	Other	1,090	1,070	601	347	342	3,440
Nonindustrial surface coating	Architectural coatings	1,060	1,400	577	447	582	4,070
	Auto refinishing	339	448	185	144	187	1,300
	Other	137	181	75	60	75	528
Other solvent use	Degreasing	3,570	3,510	1,790	1,500	1,850	12,200
	Drycleaning	783	1,650	693	827	561	4,510
	Graphic arts	1,040	2,930	275	159	170	4,570
	Adhesives	0	700	0	0	0	700
	Cutback asphalt	481	401	3,920	116	17	4,940
	Other	84	4,040	156	0	0	4,280
Other miscellaneous sources	Fuel combustion	437	522	957	51	879	2,850
	Solid waste disposal	0	53	3	14	16	86
	Forest, agricultural, and other open burning	579	1,720	830	1,780	8,420	13,300
Total Class II Emissions From Stationary Sources		23,100	27,800	22,800	9,680	15,600	9[illegible],000
Mobile sources	Highway vehicles	23,700	25,100	15,700	11,700	14,600	90,800
	Off-highway vehicles	3,140	5,320	2,120	1,790	1,910	14,300
	Rail	120	131	124	38	76	489
	Aircraft	1,360	7,010	2,150	498	760	11,800
	Vessels	2,510	5,860	2,890	1,770	1,960	11,800
Total Class II Emissions From Mobile Sources		30,800	43,400	23,000	15,800	19,300	132,000
Grand Total of Class II Emissions		53,900	71,200	45,800	25,500	34,900	23[illegible],000

[a] Includes all storage facilities except those at service stations
[b] Emissions from loading tank trucks and rail cars
[c] Emissions from storage and transfer operations

Table 5-4. PROJECTED STATIONARY AND MOBILE SOURCE CLASS II VOC EMISSIONS (ton/yr)

Source Category	(1977)	1982	1987
Broward County			
Stationary Sources	21,900	22,800	23,100
Mobile Sources	48,800	40,000	30,800
TOTAL	70,700	62,800	53,900
Dade County			
Stationary Sources	25,200	26,800	27,800
Mobile Sources	72,600	55,100	43,400
TOTAL	97,800	81,900	71,200
Duval County			
Stationary Sources	23,500	23,400	22,800
Mobile Sources	39,900	30,600	23,000
TOTAL	63,400	54,000	45,800
Orange County			
Stationary Sources	9,910	9,960	9,680
Mobile Sources	28,000	21,400	15,800
TOTAL	37,900	31,400	25,500
Palm Beach County			
Stationary Sources	15,500	15,600	15,600
Mobile Sources	31,100	25,200	19,300
TOTAL	46,600	40,800	34.900

This is apparent because no stationary source emission reductions contingent upon the implementation of control measures prescribed by Control Technique Guidelines (CTG) documents were made. Estimates of emission reductions from the implementation of these control measures were made in Phase II activities of this contract.

5.2 EMISSION ESTIMATE SCHEDULING

As discussed earlier, a number of assumptions were made in the evaluation of various source categories because of time constraints during the study. An aggressive pursuit of pertinent source data could not be made for some sources due to this time element. For example, a large shipyard in Duval County refused to submit requested data; VOC estimates from the Duval Agency showed approximately 360 tons per year being emitted but the actual figure could be much higher. The only data gathering method apparently available to determine precise quantities of emissions from the many activities located at the shipyard was through the "Section 114" process. However, this process required more time than was available for this study. Control strategy development for this source was therefore not possible.

There were also many sources whose personnel could not answer necessary technical questions. This was typified, as discussed earlier, by the many lithographic printing facilities that utilized oil-based ink known only by its trade name. Since the suppliers considered this information to be proprietary, an assumption had to be made regarding the ink's solvent content.

Finally, to better quantify emissions attributed to various area source categories (e.g., drycleaning, degreasing) an extensive, time consuming survey needs to be conducted, as dis- in the subsequent section.

5.3 RECOMMENDATIONS

There are a number of areas which will require further investigation to help define VOC emission estimates. The first area which should be addressed are point sources for which complete data was not received. This information is extremely important when applying emissions reduction strategies.

Another area requiring further investigation is drycleaning. There is much speculation in the subject counties, especially those in southern Florida, that drycleaning emissions are considerably lower than the old AP-42 (Reference 2) per capita figure of 2.0 pounds because of the relatively tropical climate in Florida. Broward County personnel, for example, have suggested that a 0.167 per capita figure be employed. Because of the lack of specific information, this study employed an approach based upon average throughput per type of drycleaning plant located in each county (Refer to Section 4.6.2). Reflected values were considerably higher than 0.167. An aggressive questionnaire survey is required therefore to obtain better estimates. Such a survey is presently being conducted in Duval County, which will help define drycleaning emission estimates there.

As discussed in Section 4.6.1.1, degreasing activities also require further attention. No method was available to quantify degreasing emissions other than national apportioning techniques. Total degreasing consumptions were received during source visits, but these values are not all-inclusive. A random survey of area source categories is required to verify results from the national approach.

Moreover, to seasonalize solid waste burning, further investigation is required to determine the time of year these activities are conducted. As an example, most forest-control burning is conducted during Florida's winter season, but the exact amount could not be ascertained. Information supplied from Broward County indicated that all forest-controlled burning was from September through April. Contact with the Florida Division of Forestry could not resolve this issue.

Finally, an extensive survey will be required in the study areas to help quantify evaporative area source emissions. During source visits, PES covered as many potential sources as time allowed, but because of the large number of these sources, only a small percentage were evaluated. Although a significant portion of emissions attributed to area sources are small, a few source categories emit enough emissions to warrant investigation, especially for control strategy development. When area sources are not investigated, exaggerated emissions may result. This is sometimes caused by overinflated emission factors or by assigning employee emissions for a manufacturing SIC number, which actually may consist only of a storage warehouse for that SIC code. Conversely, emissions may be underestimated because evaporative sources listed in the guideline documents are not surveyed (Reference 3).

REFERENCES FOR SECTION 5.0

1. Workshop on Requirements for Nonattainment Area Plans, U.S. EPA, March 1978

2. "Compilation of Air Pollutant Emission Factors," Second Edition, Publication No. AP-42, U.S. EPA, Research Triangle Park, N.C. 27711, April 1973

3. "Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds," Volume 1, U.S. EPA, December 1977 (EPA 450/2-77/028)

APPENDIX A

SURVEY QUESTIONNAIRE

Figure A-1 is a copy of the questionnaire used by PES engineers as part of the interview phase of the plant visits described in Section 4.1.1. The engineering analysis of the facilities was not based solely on the data gathered by the questionnaire; rather, questionnaire data were augmented by plant flow diagrams, logs of various process variables, control device characteristics, and source test data wherever possible.

The questionnaire also provided an effective data gathering tool when plant personnel did not have the appropriate information at hand. In these cases, the questionnaire was left with the plant engineer for subsequent mailing to PES.

I. GENERAL INFORMATION

Date____________________

1. Company Name:______________________________

   Plant Address:______________________________

   City:________________ Zip Code:______ County:__________

   Nearest Cross Street:______________________________

   Mailing Address (if different than above):____________________

   City:________________ Zip Code:________

2. Person to contact about form:______________________________

   Telephone:________________ Title:____________________

3. Year for which the data represents:__________

4. Approximate number of employees:________

5. Nature of business (SIC   ):______________________________

   ____

6. Normal operating schedule:

   _______ hrs/day   _______ days/wk   _______ wks/yr

7. Seasonal operation:

   Dec to Feb ______%   June to Aug ______%

   Mar to May ______%   Sept to Nov ______%

8. Anticipated growth of company (percentage increase (+) or decrease (-) based on the year for which the data are gathered)

   1982 ______%   Other ______ ______%

   1987 ______%   ______ ______%

9. Briefly indicate the changes in the use of VOC and/or fuels between 1977 and the years 1975 and 1976. In addition, indicate any control equipment that has been added since 1975.

   ____

   ____

   ____

   ____

   ____

10. Describe how these data were collected, e.a., phone, plant visit, etc.

____

____

11. Briefly describe the visit to the plant.

IIa. TECHNICAL DATA

1. Materials being coated (newspapers, books, cartons, cans, etc.): ____________________

2. Process information:

Source No.*	Indicate Printing Process (Letterpress, Lithographic, Gravure, Screen, etc.)	Indicate Type of Ink (solvent based, oil based, water based, etc.)	Annual Amount of Ink Used (lbs/yr)	Amount of solvent in ink as received from supplier, % by weight	Solvents Added to Inks	
					Type**	Amount, Gal/Yr.

3. Type** and amount of solvent used for surface preparation, dilution and cleaning not included above:

Type__________________, Amount (Gal/Yr)__________________

Type__________________, Amount (Gal/Yr)__________________

4. Type** and amount of solvent returned to supplier for disposal or reprocessing.

Type__________________, Amount (Gal/Yr)__________________

Type__________________, Amount (Gal/Yr)__________________

5. Do you have any air pollution control equipment in use? YES_________ NO_________
If YES, please complete the next page.

*A source is an individual or number of similar printing machines, dryers, etc. It should correspond to the Source No. in Section IIb, Air Pollution Control Equipment, if applicable.

**Isopropyl Alcohol, Ethanol, Propanol, Naptha/Mineral Spirits, Toluene, MEK, other (specify).

IIb. AIR POLLUTION CONTROL EQUIPMENT

Instructions:

1. A number should be assigned to each piece of equipment that emits hydrocarbons or to a number of similar units that are vented to a common stack. The Source No. below should correspond to the section previously filled out. If similar equipment have different control equipment please separate the source number as: a, b or c. (Example: 101a, 101b, 101c).
2. Identify the process or operation from which hydrocarbons are emitted. For example, dry cleaner, degreasing tank, spray booth, reactor, etc. If more than one unit is emitting to a common stack, specify the number of units.
3. Identify the hydrocarbon control method used such as afterburners, scrubbers, carbon adsorption, condensers, etc.
4. Indicate approximate efficiency if known.

	Source No.	Process or Operation	Hydrocarbon Control Equipment	Efficiency of Control Equipment
EXAMPLE	99	Flexographic	Afterburner	98%

III. DEGREASING OPERATIONS

1. Type of degreasing: [ ] Cold solvent cleaning
   [ ] Vapor degreasing

2. Type and amount of solvent used in degreasing operation.

a. Stoddard	________(Gal/Yr)	d. Methylene chloride	________(Gal/Yr)
b. 1,1,1-Trichloroethane (Chlorothene VG)	________(Gal/Yr)	e. Trichloroethylene	________(Gal/Yr)
		f. Other (specify)	________(Gal/Yr)
c. Perchloroethylene	________(Gal/Yr)	g. Other (specify)	________(Gal/Yr)

3. Suppliers of Solvent

   Name: ________________ Trade Name of Solvent: ________________
   Address: ________________

   Name: ________________ Trade Name of Solvent: ________________
   Address: ________________

4. Waste solvent disposal method (Please check appropriate method or methods used for the disposal of waste solvents).

   a. Discharged into sewer [ ]
   b. Reclaimed by salvager [ ]
   c. Commercial disposal [ ]
   d. Incinerator [ ]
   e. Other (specify) ________________

5. Specify the type and amount of each solvent returned for reprocessing or disposal to salvager, if applicable.

   Type ________________ Amount ________ (Gal/Yr)
   Type ________________ Amount ________ (Gal/Yr)

6. Is any air pollution control used in conjunction with degreasing operations?

   YES ________ NO ________

   If YES, enter appropriate information in Section IV, Part IVc.

IVa. TECHNICAL DATA

1. Brief description of process: ______________________________

2. Process information:

Source No*	Indicate Process or Operation: Spray, Dip, Roller, Brush, Mixing, Saturation, Lamination, Other (Specify)	Type of Coating*	Amount of Coating (Gal/Yr)	Density of Coating (lb/gal)	Amount of Solvent in Coating as Received from Supplier, % by weight	Solvent Added to Coating	
						Type***	Amount (Gal/Yr)

3. Type*** and amount of solvent used for surface preparation, dilution, and cleaning not included above:

Type ______________, Amount ______________ (Gal/Yr)

Type ______________, Amount ______________ (Gal/Yr)

4. Type*** and amount of each solvent returned for reprocessing or disposal to collector.

Type ______________, Amount ______________ (Gal/Yr)

Type ______________, Amount ______________ (Gal/Yr)

5. Is any air pollution control equipment used in conjunction with these operations? YES ______ NO ________

If Yes, please complete Section IVb.

*A source is an individual or similar pieces of equipment such as spray booths, tanks, dryers, etc. It should correspond to the Source No. in Section V.

**Paint, varnish/shellac, lacquer, enamel, primer, adhesives, ink, polyurethanes, other (specify).

***Acetone, isopropyl alcohol, MEK, butyl acetate, cellosolve, toluene, naptha, mineral spirits, xylene, other (specify).

IVb. BULK SOLVENT STORAGE

Please complete the following information for each storage tank greater than 5,000 gallons capacity

Tank No.	Solvent Type	Capacity (Gal)	Annual Throughput (Gal/Yr)	Type of Fill and Control Equipment*	Type of Tank

*Submerged fill, splash fill, return vent line, adsorber.
**Underground, fixed-roof, floating-roof, etc.

IIIc. AIR POLLUTION CONTROL EQUIPMENT

Instructions:

1. A number should be assigned to each piece of equipment that emits hydrocarbons or to a number of similar units that are vented to a common stack. The Source No. below should correspond to the sections previously filled out. If similar equipment have different control equipment please separate the source number as: a, b or c. (Example: 101a, 101b, 101c).
2. Identify the process or operation from which hydrocarbons are emitted. For example, dry cleaner, degreasing tank, spray booth, reactor, etc. If more than one unit is emitting to a common stack, specify the number of units.
3. Identify the hydrocarbon control method used, such as afterburners, scrubbers, carbon adsorption, condensers, etc.
4. Indicate approximate efficiency if known.

	Source No.	Process or Operation	Hydrocarbon Control Equipment	Efficiency of Control Equipment
Example	99	Paint Mixing Tank	Adsorber	80%

V. PETROLEUM STORAGE OPERATIONS

Va. BULK STORAGE TANK INFORMATION

	Item No.	Data / Tank Identification No.	020A (EXAMPLE)
		STORED PRODUCT INFORMATION	
Minimum Data	1.*	Product stored; crude oil, gasoline (specify or true reid vapor pressure), jet naptha (JP-4), etc.	Jet Fuel (JP-4)
	2.	Throughput for the year 1977 (gals/yr)	630,000,000
		TANK INFORMATION	
	3.	Tank capacity (gals) at °C	10,500,000 /50
	4.	Type of tank: e.g., fixed roof, floating roof, variable vapor space, pressure, horizontal, spherical, etc.	Floating roof
	5.	If tank is floating roof: a) Type of roof: Double deck/pontoon/other (describe) b) Type of seal: Single/double/other (describe) c) Type of construction: Riveted/welded/other (describe)	 a) Pontoon b) Double c) Welded
	6.	Is tank underground or above ground? (If underground, proceed to question 14.)	Above ground
	7.	a) Tank diameter (ft-inches) b) Tank height (ft-inches) c) For cone roof tanks: Height of cone above rim of tank (ft-inches)	100-0 45-6 3-2
	8.	Tank shape: cylindrical/spherical/other (describe)	Cylindrical
	9.	Tank material of construction: Steel/fiberglass/steel-gunite lined/other (describe)	Steel
	10.	Tank paint color: White/aluminum/light grey/medium grey/other (describe)	Aluminum
	11.	Tank condition: Good/fair/poor	Fair
	12.	Seal condition: Good/fair/poor	Poor
	13.	Is tank equipped with a vapor recovery system? If yes, describe.	No
	14.	Date tank installed	February, 1964

*If more than one product is stored in a tank at different times, use a separate column.

Specify total number of fixed-roof tanks at this facility:__________

Specify total number of floating-roof tanks at this facility:__________

Specify total number of pressure tanks at this facility:__________

V. PETROLEUM STORAGE OPERATIONS (CONTINUED)

Va. BULK STORAGE TANK INFORMATION (continued)

Tank Identification Number

Item No.					
	STORED PRODUCT INFORMATION				
1.					
2.					
	TANK INFORMATION				
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					

V. PETROLEUM STORAGE OPERATIONS (CONTINUED)

Vb. LOADING/UNLOADING INFORMATION

Item No.	Data \ Product Transferred*	(EXAMPLE) Gasoline		
1.	Amount transferred (loading) gals/yr	450,000		
2.	Amount transferred (unloading) gals/yr	600,000		
3.	Amount transferred (pipe line) gals/yr	None		
4.	Bulk Temperature of the product, °F	63		
5.	Type of loading: Vessel, barge, truck, other (specify)	Truck		
6.	Type of filling: Submerged, splash top, filling, bottom filling, other (specify)	Submerged		
7.	If submerged fill is used, what approximate percent is the fill pipe submerged	60%		
8.	Is loading/unloading operation equipped with vapor recovery or other pollution control system (specify)	Yes (Vapor recovery system)		
9.	Efficiency of vapor collection system	70%		
10.	Provide additional information which might be helpful for evaluation	-----------		

*Crude oil, gasoline, naptha jet fuel (JP-4), kerosene, distillate fuel, other (specify name)

V. PETROLEUM STORAGE OPERATIONS (CONCLUDED)

Vb. LOADING/UNLOADING INFORMATION (continued)

Item No.	Tank Identification Number				
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

VI. DRYCLEANING OPERATIONS

1. Amount of clothes cleaned per year, if known = ______________ tons.

2. Type of operation.

   ☐ Transfer or ☐ Dry to Dry

3. What type of business does your operation handle?

   ☐ Commercial ☐ Industrial

   ☐ Coin-Op ☐ Other (Specify)______________________

4. Type and amount of solvent cleaner used per year (1976) and supplier's name and address.

TYPE OF SOLVENT	QUANTITY PURCHASED (GALLONS PER YEAR)	SUPPLIER'S NAME AND MAILING ADDRESS
Petroleum (Stoddard, 140°F)		
Perchloroethylene		
Freon 113		
Other (Specify)		

5. Amount of solvent returned to supplier or collector for reprocessing or disposal, if applicable. Specify type of solvent if more than one type is used.

   ________________ gallons per year.

VII. FUEL COMBUSTION OPERATIONS

1. Please provide the following information for each combustion unit for the calendar year 1977 (DO NOT INCLUDE FUEL USED IN VEHICLES.)

Item No.	Type of Furnace/ Boiler etc	Design Capacity (10^6 Btu/Hr)	Type of Fuel	Amount of Fuel Per Year	Units (Gal., MCF, etc)	Remarks
1						
2						
3						

2. Approximate Percent Seasonal Operation:

Unit No.	Hours/Day	Days/Week	Months/yr or seasonal
1.			
2.			
3.			
4.			

3. Control Equipment:

   a. Type of Unit ______________________.

   b. Overall Efficiency ________________.

4. Fuel Usage

   a. Increase/Decrease Yr__________.

   b. Switching fuels to __________in 19_______.

APPENDIX B

SAMPLE CALCULATIONS FOR OPEN BURNING

SAMPLE CALCULATIONS FOR OPEN BURNING

BROWARD COUNTY

Forest Fires

Uncontrolled (1977)

1,066 acres[a] x 9 ton/acre[b] = 9,590 ton burned

$$\frac{9{,}590 \text{ ton} \times 24 \text{ lb HC/ton}^{c}}{2{,}000 \text{ lb/ton}} = \underline{\underline{115}} \text{ ton HC/yr}$$

Controlled (1977)

18,103 acres[d] x 4.5 ton/acre[e] = 82,188 ton burned

$$\frac{82{,}188 \text{ ton} \times 19 \text{ lb HC/ton}^{f}}{2{,}000 \text{ lb/ton}} = \underline{\underline{781}} \text{ ton HC/yr}$$

DADE COUNTY

Forest Fires

Controlled Foliage and Uncontrolled (1977)

$$\frac{2{,}225 \text{ ton HC}^{g}}{506{,}057 \text{ acres}} (1976)^{h} = \frac{2{,}196 \text{ ton HC}}{499{,}409 \text{ acres}} (1977)$$

DUVAL COUNTY

Forest Fires (1977)

Wildfires

3,403 acres burned[i] x 9 ton/acre = 30,627 ton burned

$$\frac{30{,}627 \text{ ton} \times 24 \text{ lb HC/ton}}{2{,}000 \text{ lb/ton}} = \underline{\underline{368}} \text{ ton HC/yr}$$

DUVAL COUNTY (Continued)

Prescribed Burning (1977)

$$\frac{\text{6,146 acres}^{j} \text{ burned in Duval County in 1976 from wildfires}}{\text{9,555 acres burned in District 7* in 1976 from wildfires}}$$

= 0.64

69,144[k] authorized acres burned in 1977 in District 7
x 0.64
44,252 authorized acres burned in Duval County in 1977

44,252 acres x 3.2[L] ton/acre = 141,606 ton burned

$$\frac{\text{141,606 ton x 12 lb HC/ton}^{m}}{\text{2,000 lb/ton}} = \underline{\underline{850}} \text{ ton HC/yr}$$

Brush Fires (1977)

$$\frac{\text{3,403 forest acres burned}}{\text{257,165 total forested acres}^{n}} = 0.013$$

88,883[o] x 0.013 = 1,176 acres burned

1,176 x 3.2 ton/acre = 3,764 ton burned

$$\frac{\text{3,764 ton x 12 lb HC ton}}{\text{2,000 lb/ton}} = \underline{\underline{23}} \text{ ton HC/yr}$$

Dumpster Fires (1977)

$$\frac{\text{487 ton apartment trash burned/yr}^{p}}{\text{1,387 apartment buildings}^{q}} = \text{0.35 ton trash/apartment building/yr}$$

Assume 1 trash bin per apartment building

Assume 0.35 ton trash burned per trash bin fire

850 fires x 0.35 ton = 296 ton burned

$$\frac{\text{296 x 30 lb HC/ton}}{\text{2,000 lb/ton}} = \underline{\underline{4}} \text{ ton HC/yr}$$

* State of Florida, Division of Forestry, designated area that includes Duval, Clay, and Nassau Counties

ORANGE COUNTY

Forest Fires

10,583 acres[t] x 9 ton/acre = 95,247 ton burned

$$\frac{95{,}247 \text{ ton} \times 24 \text{ lb HC/ton}}{2{,}000 \text{ lb/ton}} = \underline{\underline{1{,}143}} \text{ ton HC/yr}$$

Legal Fires

95,000 acres[u] x 3.2 ton/acre = 304,000 ton/yr

$$\frac{304{,}000 \text{ ton} \times 12 \text{ lb HC/ton}}{2{,}000 \text{ lb/ton}} - \underline{\underline{1{,}824}} \text{ ton HC/yr}$$

PALM BEACH COUNTY

Forest Fires

8,797 acres[v] x 9 ton/acre = 79,173 ton burned

$$\frac{79{,}173 \text{ ton} \times 24 \text{ lb HC/ton}}{2{,}000 \text{ lb/ton}} = 950 \text{ ton HC/yr}$$

Agricultural Fires

Sugar Cane Field

254,000 acres[w] x 5.5 ton/acre[x] = 1,397,000 ton burned

$$\frac{1{,}397{,}000 \text{ ton} \times 16 \text{ lb HC/ton}^{y}}{2{,}000 \text{ lb/ton}} = \underline{\underline{11{,}176}} \text{ ton HC/yr}$$

Land Clearing

14,950 acres[z] x 9 ton/acre = 134,550 ton burned

$$\frac{134{,}550 \text{ ton} \times 24 \text{ lb/ton}}{2{,}000 \text{ lb/ton}} = \underline{\underline{1{,}615}} \text{ ton HC/yr}$$

REFERENCES FOR APPENDIX B

[a] Broward County Environmental Quality Control Board, Gary Carlson, June 27, 1978

[b] EPA-recommended fuel loading factor for forest fires, Southern region, EPA Publication No. AP-42; Broward County calculation

[c] EPA-recommended emission factor for unspecified forest residues, Broward County calculation

[d] Broward County Environmental Quality Control Board, Gary Carlson, June 27, 1978

[e] Fuel loading factor for heavy saw grass, Broward County Environmental Quality Control Board, Gary Carlson, June 27, 1978

[f] EPA-recommended emission factor for grasses, calculation by Broward County Environmental Quality Control Board

[g] Foliage and Forest Fire for 1976, HC emission, from Metropolitan Dade County, Environmental Resources Management, July 5, 1978

[h] Land use projection for Agricultural and Open Space. Based on information supplied by Environmental Resources Management, July 17, 1978

[i] Personal communication with Mike Schnegenburger, State of Florida Division of Forestry, September 25, 1978

[j] Communication with the Department of Environmental Regulation, June 30, 1978

[k] Communication with Stan Withrow, Division of Forestry, August 21, 1978

[L] Fuel loading factor for unspecified weeds, EPA Publication No. AP-42

[m] EPA-recommended emission factor for unspecified weeds, EPA Publication No. AP-42

[n] Projection based on information from Roge Mehta, Deputy Director, Jacksonville Area Planning Board, July 27, 1978

[o] Miscellaneous Undeveloped land; projected from data supplied by the Jacksonville Area Planning Board, August 8, 1978

[p] Tons of solid waste burned in one year from apartment buildings in Duval County, Department of Environmental Regulations, June 30, 1978

[q] *Florida Statistical Abstract, 1977*, Bureau of Economic and Business Research, College of Business Administration, University of Florida

[r] Personal communication with Lt. Hurst, Jacksonville Fire Marshall's Office, August 10, 1978

[s] EPA-recommended HC emission factor for open burning of municipal refuse, EPA Publication No. AP-42

[t] Personal communication with Charles Collins, Department of Environmental Regulations, Air and Solid Waste Engineering August 7, 1978

[u] Estimate based on numbers supplied by Charles Collins, Department of Environmental Regulations, Air and Solid Waste Engineering, August 7, 1978

[v] Telephone communication with Mr. Maynard, State of Florida Division of Forestry, August 1978

[w, x, y, z] Telephone communication with Mike Martin, Palm Beach County Health Department, Division of Environmental Science and Engineering Air Pollution Control, September 26, 1978

APPENDIX C

HIGHWAY VEHICLES WORKSHEETS
(Provided by FDOT)

HYDROCARBON EMISSION INVENTORY

HIGHWAY VEHICLES

Broward County

VMT/DAY	YEAR

*Indicates adopted MPO counts

VEHICLE MIX	%	ton/yr 1977	ton/yr 1982	ton/yr 1987
Light Duty Vehicles			20,704	1,868
Light Duty Trucks[1]			2,121	1,680
Light Duty Trucks[2]			3,266	2,390
Heavy Duty Gas			6,564	4,781
Heavy Duty Diesel			976	899
Motor Cycles			34	48
TOTAL				

EMISSION TOTALS

______ ton/yr 1977	33,665 ton/yr 1982
23,666 ton/yr 1987	

Temperature 75° F.

Average Speed 19.6 MPH

HYDROCARBON EMISSION INVENTORY

HIGHWAY VEHICLES

Dade County

VMT/DAY	YEAR
17,720,106	1975*
18,898,097	1977
21,843,076	1982
24,788,055	1987
32,445,000	2000*

*Indicates adopted MPO counts

VEHICLE MIX	%	ton/yr 1977	ton/yr 1982	ton/yr 1987
Light Duty Vehicles	80.3	39615	24185	14736
Light Duty Trucks[1]	5.8	3197	1575	1774
Light Duty Trucks[2]	5.8	4646	3828	2532
Heavy Duty Gas	4.5	9037	7647	5055
Heavy Duty Diesel	3.1	971	1140	960
Motor Cycles	.5	393	234	62
TOTAL	100			

EMISSION TOTALS

57,859 ton/yr (1977)

38,609 ton/yr (1982)

25,119 ton/yr (1987)

Temperature 75° F.

Average Speed 19.6 MPH

HYDROCARBON EMISSION INVENTORY

HIGHWAY VEHICLES

Duval County

VMT/DAY	YEAR
6,473,072	1968*
10,192,435	1977
12,258,748	1982
14,325,062	1987
19,697,476	2000*

*Indicates adopted MPO counts

VEHICLE MIX	%	ton/yr 1977	ton/yr 1982	ton/yr 1987
Light Duty Vehicles	80.3	22941	14615	9239
Light Duty Trucks[1]	5.8	1851	1491	1112
Light Duty Trucks[2]	5.8	2690	2313	1586
Heavy Duty Gas	4.5	5234	4621	3166
Heavy Duty Diesel	3.1	563	689	602
Motor Cycles	.5	228	142	39
TOTAL	100			

EMISSION TOTALS

33,507 ton/yr 1977

23,871 ton/yr 1982

15,728 ton/yr 1987

Temperature 75° F.

Average Speed 19.6 MPH

HYDROCARBON EMISSION INVENTORY

HIGHWAY VEHICLES

Escambia County

VMT/DAY	YEAR
2,680,000	1970*
4,302,133	1977
5,460,800	1982
6,619,466	1987
9,632,000	2000*

*Indicates adopted MPO counts

VEHICLE MIX	%	ton/yr 1977	ton/yr 1982	ton/yr 1987
Light Duty Vehicles	80.3	9683	6510	4269
Light Duty Trucks[1]	5.8	782	665	514
Light Duty Trucks[2]	5.8	1136	1031	733
Heavy Duty Gas	4.5	2208	2059	1472
Heavy Duty Diesel	3.1	237	307	278
Motor Cycles	.5	95	63	18
TOTAL	100			

14,141 ton/yr (1977)

10,636 ton/yr (1982)

7,284 ton/yr (1987)

EMISSION TOTALS

Temperature 75° F.

Average Speed 19.6 MPH

HYDROCARBON EMISSION INVENTORY

HIGHWAY VEHICLES

LEON County

VMT/DAY	YEAR
2,325,469	1977
2,939,594	1982
3,308,069	1985*
3,553,719	1987
3,150,445	2000*

*Indicates adopted MPO counts

VEHICLE MIX	%	ton/yr 1977	ton/yr 1982	ton/yr 1987
Light Duty Vehicles	80.3	5234	3505	2291
Light Duty Trucks[1]	5.8	425	357	275
Light Duty Trucks[2]	5.8	613	554	392
Heavy Duty Gas	4.5	1193	1108	790
Heavy Duty Diesel	3.1	128	165	148
Motor Cycles	.5	52	34	10
TOTAL	100			

7,642 ton/yr
1977

5,723 ton/yr
1982

3,876 ton/yr
1987

EMISSION TOTALS

Temperature 75° F.

Average Speed 19.6 MPH

HYDROCARBON EMISSION INVENTORY

HIGHWAY VEHICLES

Orange County

VMT/DAY	YEAR
5,517,925	1970*
7,829,041	1977
9,481,038	1982
11,130,634	1987
12,121,113	1990*

*Indicates adopted MPO counts

VEHICLE MIX	%	ton/yr 1977	ton/yr 1982	ton/yr 1987
Light Duty Vehicles	80.3	16856	10812	6867
Light Duty Trucks[1]	5.8	1360	1103	826
Light Duty Trucks[2]	5.8	1977	1711	1178
Heavy Duty Gas	4.5	3845	3415	2367
Heavy Duty Diesel	3.1	413	506	446
Motor Cycles	.5	167	105	29
TOTAL	100			

24,618 ton/yr (1977)

17,655 ton/yr (1982)

11,713 ton/yr (1987)

EMISSION TOTALS

Temperature 75° F.

Average Speed 19.6 MPH

HYDROCARBON EMISSION INVENTORY

HIGHWAY VEHICLES

Palm Beach County

VMT/DAY	YEAR
8,274,000	1976*
8,800,333	1977
11,433,000	1982
14,063,667	1987
20,906,000	2000*

*Indicates adopted MPO counts

VEHICLE MIX	%	ton/yr 1977	ton/yr 1982	ton/yr 1987
Light Duty Vehicles	80.3	19033	12977	8558
Light Duty Trucks[1]	5.8	1535	1324	1030
Light Duty Trucks[2]	5.8	2232	2054	1470
Heavy Duty Gas	4.5	4342	4103	2949
Heavy Duty Diesel	3.1	467	611	571
Motor Cycles	.5	198	125	36
TOTAL	100			

27,797 ton/yr (1977)

21,194 ton/yr (1982)

14,614 ton/yr (1987)

EMISSION TOTALS

Temperature 75° F.

Average Speed 19.6 MPH

APPENDIX D

AIRPORT SUMMARY TABLES
(Summarized from information provided by FDOT)

Table D-1. BROWARD COUNTY

Aircraft Class	Aircraft Type	Engines per Aircraft	1976 VOC Emissions by Airport (lb/yr)[a] Hollywood Fort Lauderdale	Perry	Executive
Jumbo Jet	1. Boeing 747	4	-	-	-
	2. Lockheed L-1011	3	160,000 (L-1011 and DC-10)	-	-
	3. McDonnell Douglas DC-10	3		-	-
Long Range Jet	1. Boeing 707	4	660,000 (707 and DC-8)	-	-
	2. McDonnell Douglas DC-8	4		-	-
Medium Range Jet	1. Boeing 727	2.75 (Av)	372,800 (727, 757 and DC-9)	-	-
	2. Boeing 757				
	3. McDonnell Douglas DC-9				
Turboprop	1.	2	-	-	-
	2.	4	-	-	-
Business Jet	1.	2.1	67,000	-	34,400
General Aviation Piston	1.	1	24,000	35,600	32,400
	2.	2	33,600	6,200	7,600
	3.	4	262,400	-	-
Piston Transport	1.	2.25 (Av)	634,600	-	-
Helicopter	1.	1	-	-	-
	2.	2	400	-	-
Military Jet (Specify)	1.	1	-	-	-
	2.	2	-	-	-
	3.	3	-	-	-
	4. Turboprop	4	19,200	-	-
Military Piston (Specify)	1.	1	9,800	-	-
	2.		-	-	-
		Total	2,244,400	41,800	74,400

[a] Information for 1976 supplied by Broward County Environmental Quality Control Board due to incomplete 1977 data; received September 18, 1978

Table D-2. DADE COUNTY

Aircraft Craft	Aircraft Type	Engines per Aircraft	1977 VOC Emissions by Airport (lb/yr)								
			Burrs	Chalks Seaplane	Dade Collier	Homestead AFB	Homestead GA	Miami International	New Tamiami	Opa Locka	Richard's Field
Jumbo Jet	1. Boeing 747	4	-	-	15,713	-	-	47,238	-	-	-
	2. Lockheed L-1011	3	-	-	92,488	-	-	277,647	-	-	-
	3. McDonnell Douglas DC-10	3	-	-	92,488	-	-	277,647	-	-	-
Long Range Jet	1. Boeing 707	4	-	-	331,660	-	-	4,319,738	-	-	-
	2. McDonnell Douglas DC-8	4	-	-	-	-	-	3,130,887	-	-	-
Medium Range Jet	1. Boeing 727	3	-	-	24,415	-	-	529,575	-	20,352	-
	2. Boeing 737	2	-	-	69	-	-	1,470	-	5,225	-
	3. McDonnell Douglas DC-9	2	-	-	6,037	-	-	132,393	-	13,968	-
Turboprop	1.	2	-	162,800[a]	443	-	-	14,203	1,837	26,004	-
	2.	4	-	-	4,669	-	-	13,108	-	78,346	-
Business Jet	1.	2	-	-	886	-	-	46,483	1,192	60,800	-
General Aviation Piston	1.	1	200	-	215	-	18,700	329	56,477	47,154	200
	2.	2	-	-	-	-	6,600	19,317	18,388	28,170	-
Helicopter	1.	1	-	-	-	-	-	839	608	12,937	-
	2.	2	-	-	-	-	-	-	-	-	-
Military Jet (Specify)	1.	1	-	-	437	NA	-	1,057	-	22,129	-
	2.	2	-	-	437	NA	-	1,063	-	22,134	-
	3. DC-3	2	-	-	109,198	-	-	504,517	20,441	-	-
	4.	3	-	-	-	-	-	-	-	-	-
	5. DC-6	4	-	-	-	-	-	42,024	-	623,117	-
Military Piston (Specify)	1.	2	-	-	3,611	NA	-	7,242	-	23,419	-
	2.	4	-	-	28,907	NA	-	23,174	-	343,536	-
		Total	200	162,800	711,673	420,000	25,300	9,389,951	98,943	1,327,291	200

[a] Grumman (Piston)

Table D-3. DUVAL COUNTY

Aircraft Class	Aircraft Type	Engines Per Aircraft	1977 VOC Emissions By Airport (lb/yr) Cecil Field	Craig	Herlong	Jacksonville International	Jacksonville Naval Air Station	Mayport	OLF Whitehouse
Jumbo Jet	1. Boeing 747	4	-	-	-	-	-	-	-
	2. Lockheed L-1011	3	-	-	-	33,379.2	-	-	-
	3. McDonnell Douglas DC-10	3	-	-	-	-	-	-	-
Long Range Jet	1. Boeing 707	4	-	-	-	-	-	-	-
	2. McDonnell Douglas DC-8	4	-	-	-	75,190	-	-	-
Medium Range Jet	1. Boeing 727	3	-	-	-	227,695.65	-	-	-
	2. Boeing 737	2	-	-	-	2,234.4	-	-	-
	3. McDonnell Douglas DC9	2	-	-	-	55,570.9	-	-	-
Turboprop	1.	2	-	7,290.6	-	18,800.7	-	-	-
	2.	4	-	-	-	13,224	-	-	-
Business Jet	1.	2	-	615.6	-	27,720	-	-	-
General Aviation Piston	1.	1	-	25,465.8	20,197	8,848.4	-	-	-
	2.	2	-	9,091.6	5,611.2	7,971.2	-	-	-
Helicopter	1.	1	-	980.46	936	1,248	-	-	-
	2.	2	-	-	-	-	55,042	276,159	-
Military Jet (Specify)	1.	1	844,794.75	-	-	15,888	54,366.75	-	534,978.75
	2.	2	549,625.5	-	-	15,888	271,833.75	163,100.25	355,137.5
	3.	3	-	-	-	-	-	-	-
	4. Turboprop	4	-	-	-	69,600	197,100	-	-
Military Piston (Specify)	1.	2	-	-	-	4,080	-	-	-
	2.	4	-	-	-	57,120	-	-	-
		TOTAL	1,394,420	43,444	26,744	634,458	578,343	439,259	870,116

Table D-4. ORANGE COUNTY

Aircraft Class	Aircraft Type	Engine Per Aircraft	1977 VOC Emissions by Airport (lb/yr)							
			Eure Brothers	Herndon	Longcoy	Maguire	MacDonald	Orlando Jetport	Potter	Tri-City (Proposed 1982)
Jumbo Jet	1. Boeing 747	4	-	-	-	-	-	-	-	-
	2. Lockheed L-1011	3	-	-	-	-	-	122,793	-	-
	3. McDonnell Douglas DC-10	3	-	-	-	-	-	45,018	-	-
Long Range Jet	1. Boeing 707	4	-	-	-	-	-	-	-	-
	2. McDonnell Douglas DC-8	4	-	-	-	-	-	-	-	-
Medium Range Jet	1. Boeing 727	3	-	-	-	-	-	257,603	-	-
	2. Boeing 737	2	-	-	-	-	-	156,369	-	-
	3. McDonnell Douglas DC-9	2	-	-	-	-	-	-	-	-
Turboprop	1.	2	-	7,157	-	234	-	5,423	-	-
	2.	4	-	-	-	-	-	-	-	-
Business Jet	1.	2	-	1,080	-	-	-	-	-	-
General Aviation Piston	1.	1	417	26,891	512	3,444	1,668	-	1,668	-
	2.	2	146	6,163	175	1,109	584	-	58	-
Helicopter	1.	1	14	1,329	16	115	109	-	5	-
	2.	2	-	-	-	-	-	-	-	-
Military Jet (Specify)	1.	1	-	-	-	-	-	-	-	-
	2.	2	-	-	-	-	-	-	-	-
	3.	3	-	-	-	-	-	-	-	-
	4. Turboprop	4	-	-	-	-	-	-	-	-
Military Piston (Specify)	1.	2	-	-	-	-	-	-	-	-
	2.	4	-	-	-	-	-	-	-	-
		TOTAL	577	42,620	703	4,902	2,361	587,206	1,731	-

Table D-5. PALM BEACH COUNTY

Aircraft Class	Aircraft Type	Engines Per Aircraft	1977 VOC Emissions By Airport (lb/yr)									
			Belle Glade	Boca Raton	Chem	Duda	Flying Cow	North Palm Beach	Palm Beach Glades	Palm Beach International	Palm Beach Park	South Palm Beach
Jumbo Jet	1. Boeing 747	4	-	-	-	-	-	-	-	-	-	-
	2. Lockheed L-1011	3	-	-	-	-	-	-	-	171,727	-	-
	3. McDonnell Douglas DC-10	3	-	-	-	-	-	-	-	-	-	-
Long Range Jet	1. Boeing 707	4	-	-	-	-	-	-	-	165,129	-	-
	2. McDonnell Douglas DC-8	4	-	-	-	-	-	-	-	-	-	-
Medium Range Jet	1. Boeing 727	3	-	-	-	-	-	-	-	167,793	-	-
	2. Boeing 737	2	-	-	-	-	-	-	-	-	-	-
	3. McDonnell Douglas DC-9	2	-	-	-	-	-	-	-	35,729	-	-
Turbo-prop	1.	2	-	550	-	-	-	-	550	34,427	4,455	-
	2.	4	-	-	-	-	-	-	-	-	-	-
Business Jet	1.	2	-	-	-	-	-	-	-	12,899	-	-
General Aviation Piston	1.	1	1,432	10,905	200	200	200	-	5,356	23,156	25,211	-
	2.	2	482	5,540	-	-	-	-	2,452	3,404	9,280	-
Heli-copter	1.	1	616	130	-	-	-	-	-	818	260	-
	2.	2	-	-	-	-	-	-	-	-	-	-
Military Jet (Specify)	1.	1	-	-	-	-	-	-	-	3,972	-	-
	2.	2	-	-	-	-	-	-	-	3,972	-	-
	3.	3	-	-	-	-	-	-	-	-		
	4. *Turboprop*	4	-	-	-	-	-	-	-	172,853	-	-
Military Piston (Specify)	1.	2	-	-	-	-	-	-	-	1,020	-	-
	2.	4	-	-	-	-	-	-	-	14,294	-	-
		TOTAL	2,530	17,125	200	200	200	-	8,358	811,193	39,206	-

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(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

EPA Project Officer: Ron McHenry

16. ABSTRACT

This report presents a discussion of the methodologies employed and results obtained from a detailed and comprehensive "Level 3" VOC emissions inventory. The study area consists of seven urban and two rural ozone nonattainment areas in the State of Florida. The study was performed as part of a three phase project to help prepare revisions to the Florida SIP as a result of the Clean Air Act Amendments of 1977.

For the base year, 1977, onsite visits were made to all potential VOC point sources to acquire necessary data. For area sources, the latest state-of-the-art methodologies were employed. Base year emissions were seasonalized and a reactivity profile applied. Also, emissions were projected to reflect the years 1982 and 1987.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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