BALTIMORE REGIONAL ENVIRONMENTAL IMPACT STUDY

Technical Memorandum No. 3
Air Quality Analysis

Alan M. Voorhees & Associates, Inc.

BALTIMORE
REGIONAL
ENVIRONMENTAL
IMPACT
STUDY

TECHNICAL MEMORANDUM NO. 3

AIR QUALITY ANALYSIS

Prepared for

THE INTERSTATE DIVISION FOR BALTIMORE CITY

By

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March 1974

PREFACE

This memorandum, the third of a series of seven technical memoranda on the Baltimore Regional Environmental Impact Study (BREIS) prepared for the Interstate Division for Baltimore City (IDBC), describes the assumptions, methodology, and findings for air quality analysis.

The other technical memoranda are:

- 1 -- Socioeconomic and Land Use Analysis
- 2 -- Travel Simulation and Traffic Analysis
- 4 -- Water Resource and Solid Waste Analysis
- 5 -- Noise Analysis
- 6 -- Analysis of Environmentally Sensitive Areas
- 7 -- Summary Analysis and Evaluation

In addition to IDBC, the Baltimore Regional Planning Council and the Maryland Department of Transportation, including the Mass Transit Administration, have been active participants in the study. Other agencies which have assisted in the project include:

- Maryland Department of Health and Mental Hygiene, Bureau of Air Quality Control
- Maryland Department of Natural Resources
- Maryland Department of State Planning
- Baltimore City, Department of Planning
- Baltimore City, Department of Transit and Traffic
- Baltimore City, Department of Health
- U.S. Federal Highway Administration
- U.S. Environmental Protection Agency

Undertaking the effort was a multidisciplinary team consisting of Alan M. Voorhees & Associates, Inc., with overall responsibility for the study, in conjunction with:

- Environmental Systems Laboratory -- Noise Analysis
- Jason M. Cortell and Associates, Inc. -- Environmentally Sensitive Areas

- Economics Research Associates -- Economic Analysis
- Dr. David Marks, Resource Analysis, Inc. -- Water Resources & Solid Waste
- Dr. Gerhard Israel, University of Maryland -- Meteorology

TABLE OF CONTENTS

Preface		iii
List of Figures		vii
List of Tables		xi
Chapter		Page
I.	BACKGROUND	I-3
	Study Organization and Plan	I-6
	Description of Alternatives	I-8
	General Assumptions and Definitions	I-11
	Study Results	I-11
II.	OVERVIEW	II-1
III.	INTRODUCTION	III-1
IV.	GENERAL APPROACH	IV-1
	Regional vs. Selected Corridor Analysis of Air Quality	IV-1
	Air Pollutants Investigated	IV-2
	Generation of Data Base	IV-2
	Methodology for Comparison of Alternatives	IV-9
	Evaluation Criteria	IV-15
V.	INVENTORY OF EXISTING EMISSIONS AND AIR QUALITY DATA	V-1
	Ambient Air Quality	V-1
	Carbon Monoxide	V-1
	Oxidants	V-11
	Nitrogen Oxides	V-18
	Particulate Matter	V-18
	Comparison to Air Quality Criteria	V-18
	Overview	V-20
	Carbon Monoxide	V-20
	Hydrocarbons and Photochemical Oxidants	V-21
	Nitrogen Dioxide	V-21
	Particulate Matter	V-21
	Stationary Source Emissions	V-22
	Mobile Source Emissions	V-24
	Composite Emissions	V-24

Table of Contents (continued)

VI.	PROJECTED EMISSIONS AND AIR QUALITY	VI-1
	Projected Stationary Source Emissions	VI-1
	Mobile Source Emissions	VI-2
	Composite Emissions	VI-14
	Air Quality Projections	VI-21
	Comparison to Criteria	VI-49
	REFERENCES	R-1
	APPENDICES	A-1

LIST OF FIGURES

Figure		Page
I-1	Baltimore 3-A System	I-2
I-2	Environmental Impact Statements (EIS) on 3-A System	I-4
I-3	BREIS-Process for Evaluation of Alternatives	I-7
I-4	Study Area -- Baltimore Regional Environmental Impact Study	I-9
I-5	BMATS Study Area	I-12
II-1	Carbon Monoxide Emissions in BMATS Area	II-4
II-2	Hydrocarbon Emissions in BMATS Area	II-5
II-3	Nitrogen Oxide Emissions in BMATS Area	II-6
III-1	Process for Air Quality and Emissions Analysis	III-2
V-1	Location of Air Quality Sampling Stations and Receptor Sites	V-3
V-2	Surface Weather Map, November 6, 1972	V-8
V-3	Windrose for Elevated CO Concentrations in Baltimore	V-9
V-4	Average Daily CO Cycle for Days with a High Pressure System	V-10
V-5	Daily Cycle of the Average Oxidant Concentration at AIRMON 1 and 2, Map-July, 1972, for Days when AIRMON 2 Exceeded the Maximum 1-Hour Concentration	V-13
V-6	Total Monthly Hours Oxidant Concentrations in Excess of Standards (0.08 ppm) Baltimore AIRMON Station 1, 1972	V-15
V-7	Total Monthly Hours Oxidant Concentrations in Excess of Standards (0.08 ppm) Baltimore AIRMON Station 2, 1972	V-15
V-8	Windrose During Hours when Maximum 1-Hour Oxidant Concentration is Exceeded at AIRMON 2	V-17
V-9	Air Pollutant Emissions by Sources and Jurisdictions BREIS Study Area--1971	V-31

List of Figures

Figure		Page
VI-1	Projected Changes in Total Motor Vehicle Emissions in BMATS Area	VI-13
VI-2	Location of Air Quality Sampling Stations & Receptor Sites	VI-23
VI-3	Comparison of Maximum Predicted Carbon Monoxide Concentrations at Six Receptor Sites with Maximum Measured Concentrations--Hourly Averages	VI-26
VI-4	Comparison of Predicted and Observed Maximum 8-Hour Carbon Monoxide Concentrations at Six Receptor Sites	VI-27
VI-5	Typical Daily Variations in Carbon Monoxide Levels During Periods with Adverse Meteorological Conditions--as Measured and as Predicted by Dispersion Model	VI-28
VI-6	Grid System Map for Baltimore Region	VI-30
VI-7	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 1--Existing, 1970	VI-32
VI-8	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 3--Complete 3-A, 1980	VI-33
VI-9	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 4--3-A System less Ft. McHenry Crossing, 1980	VI-34
VI-10	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 5--No 3-A, 1980	VI-35
VI-11	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 6--Complete 3-A and GDP Improvements, 1995	VI-36
VI-12	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 7--No 3-A, All GDP Improvements, 1995	VI-37
VI-13	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 8--Complete 3-A, No GDP Improvements, 1995	VI-38

List of Figures, Continued

Figure		Page
VI-14	Predicted Urban Background Concentrations of Carbon Monoxide for Alternative 9--No GDP Improvements, No 3-A System, 1995	VI-39
VI-15	Daily Variation in Carbon Monoxide Concentrations Predicted for the Receptor Site with Highest CO Levels--1970, 1980, 1995	VI-42
VI-16	Required Hydrocarbon Emission Control as a Function of Oxidant Concentration	VI-45

LIST OF TABLES

Table		Page
I-1	Transportation Alternatives for Baltimore Regional Environmental Impact Study	I-10
II-1	Summary of Existing Air Quality--Baltimore Region	II-2
II-2	Maximum Predicted Regional Pollutant Concentrations	II-3
IV-1	National Primary and Secondary Ambient Air Quality Standards	IV-3
IV-2	Emission Factors for 1970	IV-5
IV-3	Emission Factors for 1980	IV-6
IV-4	Emission Factors for 1995	IV-7
IV-5	Generalized Hourly Traffic Factors in the Balitimore Region.	IV-5
V-1	Maximum 1-Hour Average Carbon Monoxide Concentrations	V-4
V-2	Maximum 8-Hour Average Carbon Monoxide Concentrations	V-5
V-3	Eight-Hour Maximum CO-Concentration--Baltimore AIRMON Stations (1972)	V-7
V-4	1-Hour Oxidant Concentrations over 0.08 ppm-- Baltimore AIRMON Stations (1972)	V-14
V-5	Summary of existing Air Quality--Baltimore Region	V-19
V-6	Emissions from Stationary Point and Area Sources by Jurisdiction--Metropolitan Baltimore Region (1971)	V-23
V-7	1970 Motor Vehicle Emissions--Baltimore Metropolitan Study Area (BMATS)	V-25
V-8	Comparison of Mobile Source Emission Totals for BMATS Area (1970))	V-26
V-9	Carbon Monoxide Emissions in Baltimore Region (1971)	V-27
V-10	Hydrocarbon Emissions in Baltimore Region (1971)	V-28
V-11	Nitrogen Oxide Emissions in Baltimore Region (1971)	V-29
V-12	Sulphur Dioxide Emissions in Baltimore Region (1971)	V-30
V-13	Suspended Particulate Emissions in Baltimore Region (1971)	V-33

List of Tables, Continued

Table		Page
VI-1	Growth Factors for Existing Point Sources by SIC Group	VI-3
VI-2	Growth Factors for Stationary Area Source Categories	VI-4
VI-3	Emission Reductions for Area Source Categories Under Control Regulations	VI-5
VI-4	Projected Motor Vehicle Emissions of Carbon Monoxide	VI-6
VI-5	Projected Motor Vehicle Emissions of Hydrocarbons	VI-7
VI-6	Projected Motor Vehicle Emissions of Oxides of Nitrogen	VI-9
VI-7	Projected Motor Vehicle Emissions of Particulate Matter	VI-10
VI-8	Total VMT in BMATS Study Area by Alternative	VI-12
VI-9	Projected Motor Vehicle Emissions, Ton/Day, 1978 (1980 Alternative 3 Traffic	VI-15
VI-10	Traffic Growth Factors for Transportation Source Categories	VI-16
VI-11	Projected Emissions of Carbon Monoxide	VI-17
VI-12	Projected Emissions of Hydrocarbons	VI-18
VI-13	Projected Emissions of Oxides of Nitrogen	VI-19
VI-14	Projected Emissions of Particulate Matter	VI-20
VI-15	Correlation of the Results of CO Model with Measured CO Concentrations	VI-25
VI-16	Predicted Maximum One-Hour CO Concentrations at Selected Receptor Points	VI-43
VI-17	Summer Weekday Non-Methane Hydrocarbon Emissions	VI-45
VI-18	Existing and Projected 6 to 9 a.m. Summer Hydrocarbon Emissions by Alternative	VI-47
VI-19	Maximum Base Period and Predicted Regional Pollutant Concentrations	VI-48
VI-20	Summary of Indexes of Air Quality Degradation	VI-52

I. BACKGROUND

This study, initiated in the spring of 1973, was the culmination of a series of events related to transportation systems planning and highway construction that had occurred over a number of years in the Baltimore region. The following brief statement outlines the events leading up to the study to provide a context within which the results of the study should be reviewed.

The highway system which is the subject of this study was defined in a previous comprehensive study of the Interstate plan in Baltimore by Urban Design Concepts Associates, (1) as well as in several other planning studies that preceded it. (2) This system, shown in Figure I-1, is known as the 3-A system. It was adopted in 1969 by the Baltimore Planning Commission and subsequently approved by the Regional Planning Council (RPC) for inclusion in the General Development Plan. The 3-A system consists of several segments of I-70N, I-83, I-95, the I-395 and I-170 spurs, and City Boulevard, an arterial link not on the Federal Interstate System. In the spring of 1973, the following portions of the system were complete:

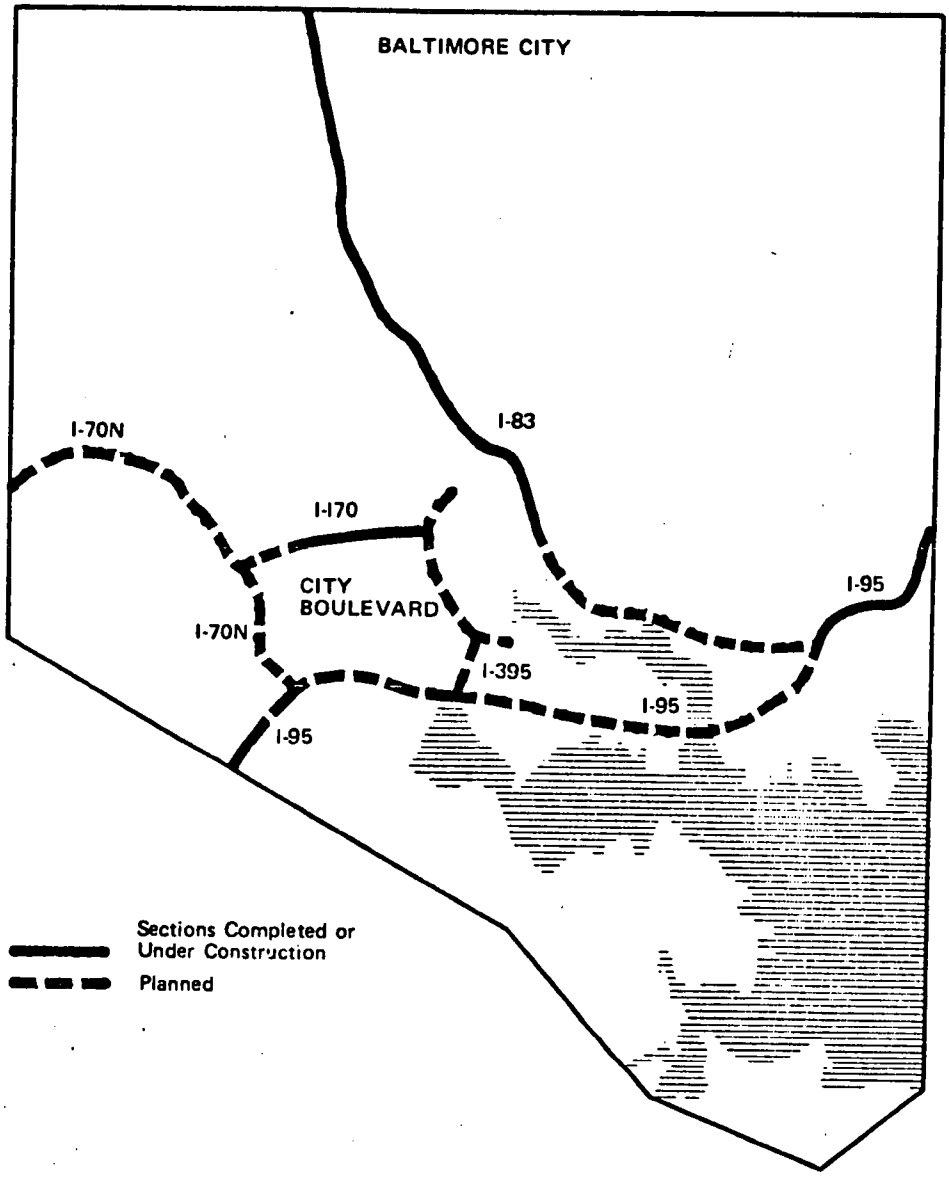
- I-70N was constructed to the City line
- I-95 was constructed to Caton Avenue just inside the City line on the south and was under construction on the east side in the vicinity of the Harbor Tunnel Thruway to O'Donnell Street
- I-83 (Jones Falls Expressway) was constructed on the north to a point near Eager Street.

In addition, several other segments had received design approval.

With the passage of the National Environmental Policy Act of 1969 (NEPA), many of the environmental concerns which had been expressed by various groups in the Baltimore region received official recognition. Section 102(2)(C) of this act requires a detailed statement for any proposed federal action affecting the environment, including:

- The environmental impact of the proposed action
- Any adverse environmental effects which cannot be avoided should the proposal be implemented

Figure I-1. Baltimore 3A System



- The relationships between the local short-term uses of man's environment and the maintenance of long-term productivity

- Any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented

For federal highway construction, these requirements were reinforced by provisions of the Federal-aid Highway Act of 1970 (Section 136), the Department of Transportation Act as amended (Section 4(f)), the Clean Air Act Amendments of 1970, and the Historic Preservation Act of 1966. The Federal Highway Administration (FHWA), in its Policy and Procedures Memorandum 90-1, has directed that these provisions be fulfilled by highway agencies for each highway construction project.

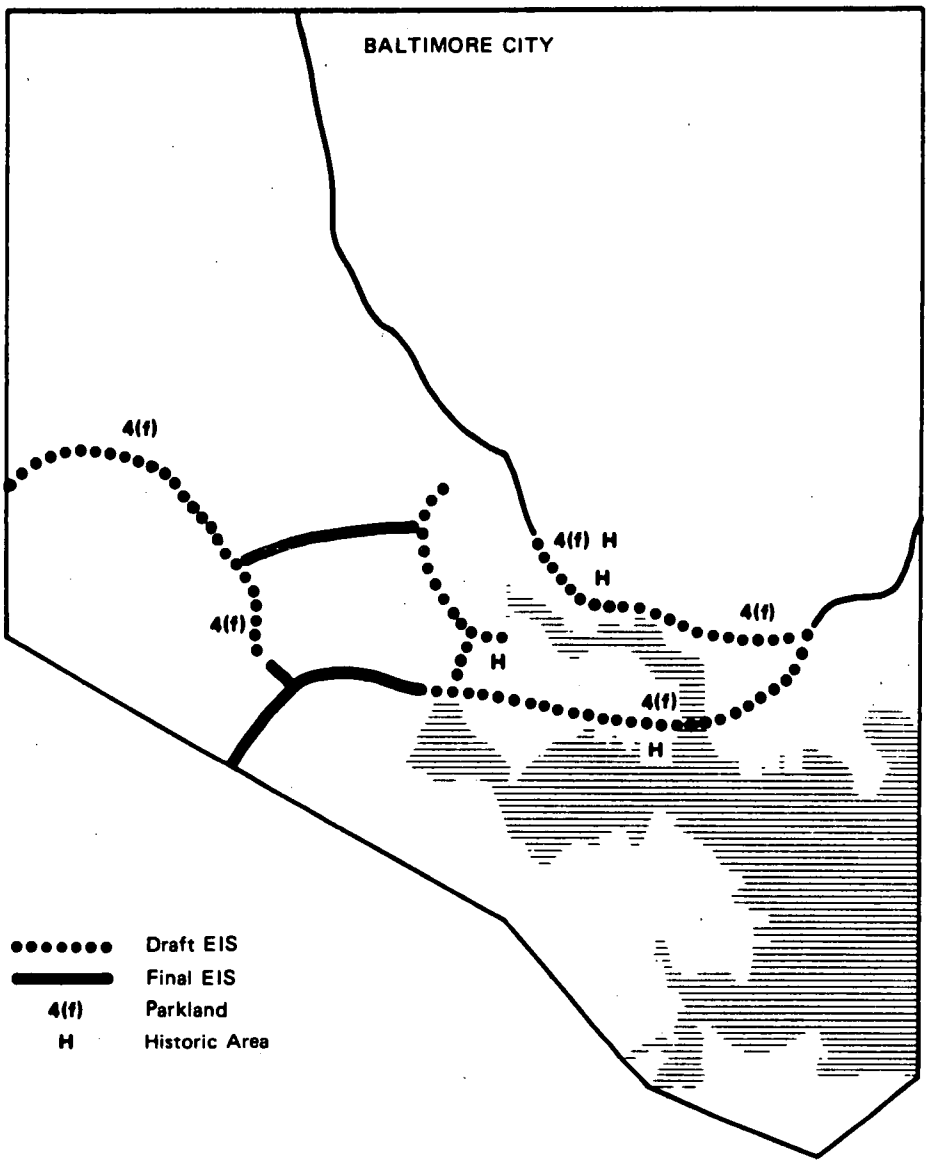
In response to these new requirements, the Maryland Department of Transportation (MdDOT) has submitted a draft environmental impact statement (EIS) for each segment of the 3-A system as it reached the location and design approval stage. The segments of the 3-A system for which environmental impact statements have been prepared are shown in Figure I-2.

However, a citizen suit was filed in 1972 against the U.S. Department of Transportation (Movement Against Destruction (MAD) vs. Volpe) charging that the 3-A system as a whole represented a significant federal action and that a regional environmental impact statement should be filed in addition to separate statements for each facility. Another question, relating to the Franklin-Mulberry Corridor (I-170) asserted that the EIS process had not been sufficient to meet NEPA and other federal requirements. Rights-of-way had been purchased in this corridor, and the City would be required to return over $5 million to FHWA if construction on this segment did not begin by June 30, 1973.

Two other cases (Sierra Club, Inc. vs. Volpe and Lukowski vs. Volpe), also questioning the adequacy of the EIS process, were then pending in the courts. It was agreed that the relevant portions of all these cases would be heard concurrently on April 16, 1973.

As a result of this hearing, the court found on June 22, 1973 that "the applicable law does not require that an environmental impact statement be prepared for the 3-A system as such." Further, "components of the 3-A system are not necessarily so interdependent as to require the construction of all the 3-A system or none of it." The court continued that:

Figure I-2. Environmental Impact Statements (EIS) on 3A System



It may be wise for the city, state and federal authorities to prepare in the near future a statement which considers those environmental impacts that should be determined with respect to the entire configuration, or major portions thereof. Such a statement would be included in one or more of the EISs which will have to be prepared in the future for other sections of the highways in the 3-A system and which will, of course, also include and consider those environmental impacts that should properly be determined section by section or road by road. (3)

As a result of this decision, construction began in the disputed section of the Franklin-Mulberry Corridor on June 22, 1973.

Concurrent with the legal contest, the U.S. Environmental Protection Agency (EPA) was stressing the need for a regional environmental analysis for the 3-A system. In September 1972, based on a series of discussions, a consensus agreement between EPA and FHWA was reached. This agreement provided in part:

- For all remaining segments of the 3-A system under environmental review neither PS&E (plans, specifications and estimates) approval nor further right-of-way approval would be granted by FHWA until a regional impact consideration statement was prepared and circulated to FHWA, EPA, the U.S. Department of Transportation, and the Maryland Department of Health and Mental Hygiene, Bureau of Air Quality Control (BAQC).

- That the regional impact consideration statement will address those regional issues, identified by EPA in its various reviews, that cannot be addressed on a project basis and will include as a minimum:

  1. Cumulative (regional) air pollution impact of the various stages of completion of the currently envisioned 3-A system (including the MTA system) in the years 1978, 1980, 1985, and 1990.

  2. A detailed discussion of possible modifications to the proposed system to mitigate air pollution problems. The effect of these changes on land use and local traffic patterns should be discussed. These modifications should include the options of:

- Increased highway access to the MTA system
- Impact of elimination of various segments of the 3-A system
- Optimization of construction scheduling to minimize saturation of local street systems
- Impact of the no-build-alternative

It is in response to these actions and the desire of regional and local agencies to understand the socioeconomic, traffic, and environmental implications of the 3-A plan that the study presented in this series of reports is directed.

STUDY ORGANIZATION AND PLAN

The study was programmed for completion in approximately six months. The conduct of the study, under the direction of the Interstate Division for Baltimore City (IDBC), was a joint effort by the consultant team and other regional and local agencies. Some of the work for this study was accomplished by RPC and MdDOT, with assistance from AMV, as part of the "3-C" (cooperative, comprehensive, and continuing) planning process element of the Unified Transportation Planning Program in the Baltimore region.

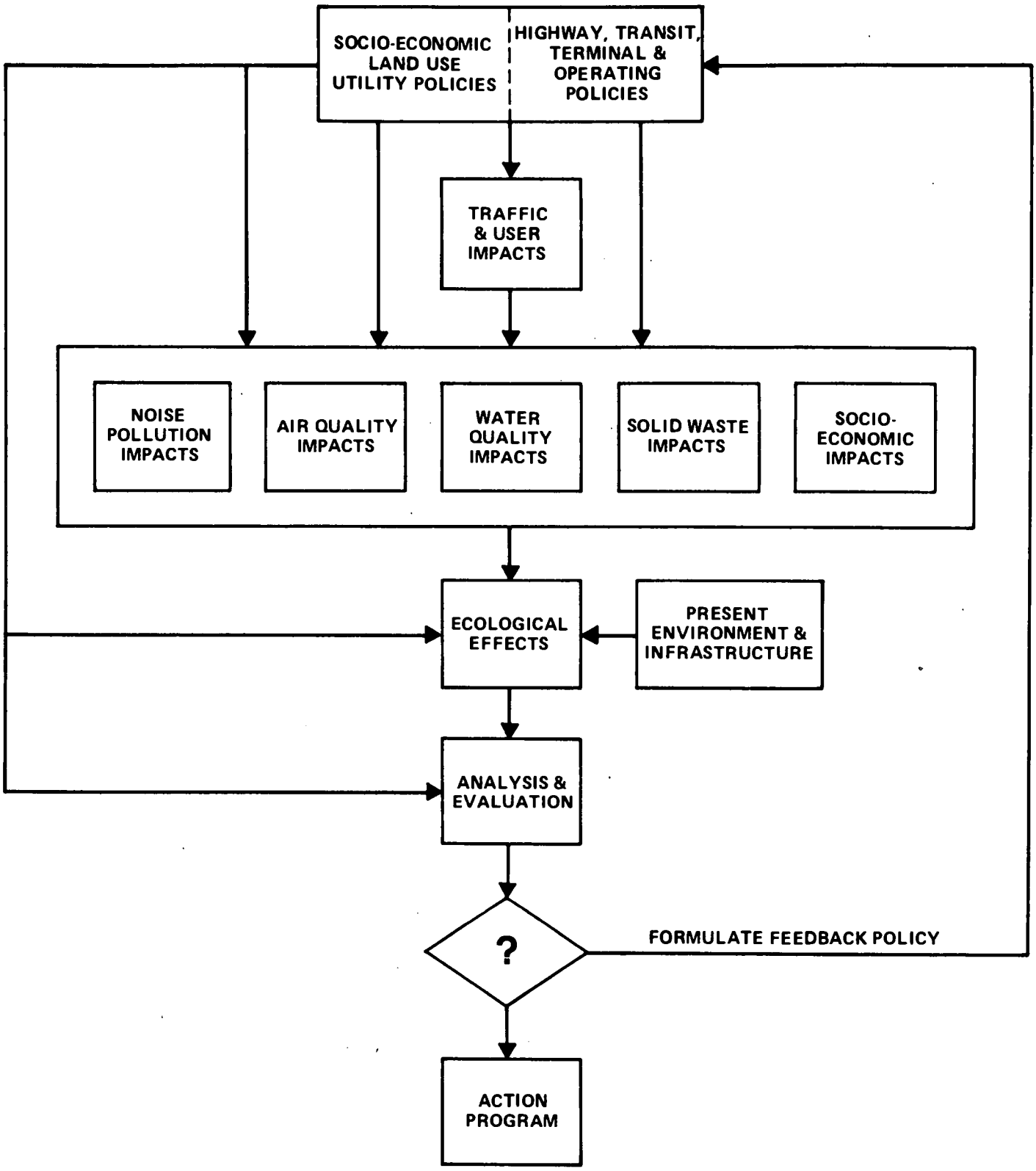
The study process outlined in Figure I-3 was directed toward the measurement of several regional environmental features through which the examination of the estimated future impacts that the 3-A system would have on:

- Socioeconomic and land use factors
- Traffic and travel demand
- Air quality
- Noise pollution
- Water resources and solid waste
- Ecologically sensitive areas

To provide a basis for determining the extent to which future environmental conditions were related to the 3-A system as opposed to other factors, such as growth in population, the environmental consequences of several alternative transportation systems, including a "no-build" option, were also studied. These alternatives were devised jointly by the various agencies associated with the study, both as alternatives to the 3-A system and as a basis for determining the regional environmental consequences of major

Figure I-3.

BREIS-PROCESS FOR EVALUATION OF ALTERNATIVES



components of that system. These alternatives were selected to isolate various conditions and assess their impact on the region. One of the significant features of this procedure is that land use and socioeconomic activity policies were varied separately for each transportation alternative studied. This permitted an assessment of the predicted effects of changes in urbanization due to transportation policy on the region and demonstrates the interrelationships between transportation and land use.

The study area includes the jurisdictions represented in the RPC -- Baltimore City, and Baltimore, Anne Arundel, Carroll, Harford, and Howard Counties, as shown in Figure I-4. A comprehensive General Development Plan (GDP), which includes a land use pattern element, was adopted for the region in December 1972. It includes the full 3-A system, numerous freeways and other highways outside the City of Baltimore, and a regional rapid transit system comprised of six major lines. This plan serves as one alternative and is the basis for the examination of alternative transportation and land use assumptions for future years.

DESCRIPTION OF ALTERNATIVES

The transportation and land-use alternatives studied consist of three systems for 1980 and four systems for 1995. These alternative systems are shown in Table I-1 and are briefly described below. A tear-out copy of Table I-1, which can be used as a reference while reading this report, can be found at the end of Chapter I.

Originally the study plan included a 1978 system for analysis based on the premise that all of the 3-A system except the Fort McHenry bypass could be completed by 1978; however, since the Phase I rapid transit lines would not be completed until 1980 and since revisions to contemplated construction schedules by IDBC have made the 1978 date meaningless, this was eliminated in favor of analyzing the no-build system in 1995. RPC and MdDOT will continue the analysis for 1978, if necessary.

Phase I rapid transit will consist of 28 miles of rail running northwest to Owings Mills and south to Glen Burnie. All 1980 alternatives include the Phase I rapid transit; all 1995 alternatives are based on the GDP and include the full 6-legged rapid transit system, as well as an augmented bus system.

The differences among the 1980 alternatives are related to the 3-A system--in Alternative 3 the full 3-A system is assumed to be completed; in Alternative 4 the 3-A system will be completed except for the Fort McHenry Crossing; and only existing Interstate facilities or those under construction were

Figure I-4. Study Area—Baltimore Regional Environmental Impact Study

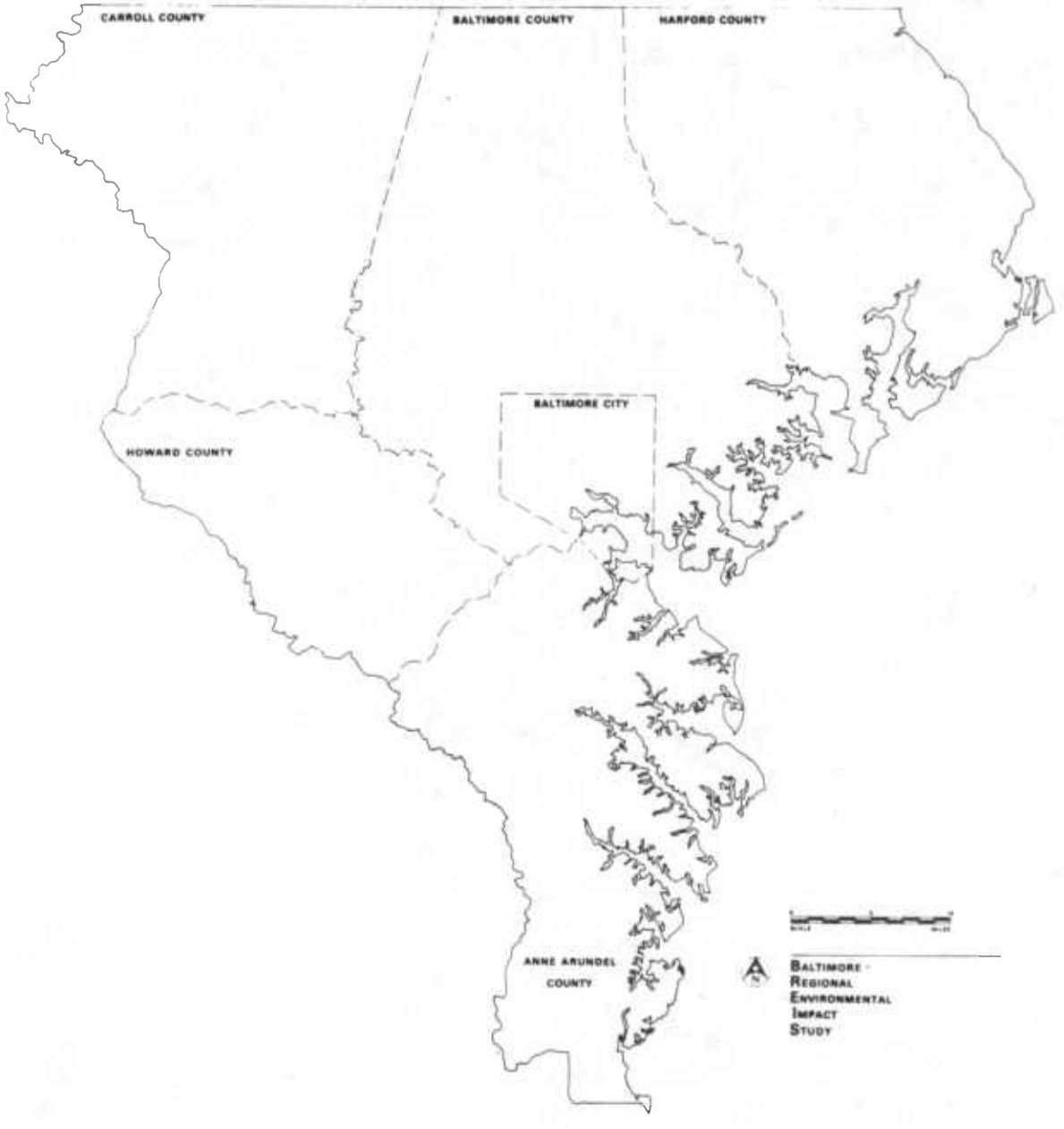


Table I-1.

TRANSPORTATION ALTERNATIVES FOR BALTIMORE REGIONAL ENVIRONMENTAL IMPACT STUDY

ALTERNATIVE	YEAR	HIGHWAY ASSUMPTION		RAPID TRANSIT ASSUMPTION
		3-A INTERSTATE	OTHER HIGHWAYS	
1	1970	Existing	Existing	None
*2	1978	Existing and Programmed	Existing and Programmed	Phase I
3	1980	Complete	Existing and Programmed	Phase I
4	1980	Partial	Existing and Programmed	Phase I
5	1980	Existing and under construction	Existing and Programmed	Phase I
6	1995	Complete	GDP	GDP
7	1995	Existing and under construction	GDP	GDP
8	1995	Complete	Existing and under construction	GDP
9	1995	Existing and under construction	Existing and under construction	GDP

*Eliminated in favor of Alternative 9.

assumed in Alternative 5. Other programmed highway improvements which were assumed to be operational by 1980 include the Northwest Freeway and the Outer Harbor Crossing which is part of the Baltimore Beltway (I-695). The John F. Kennedy Expressway (I-95) northeast of Baltimore has been widened since 1970.

In 1995, the differences concern not only the 3-A, but also other planned GDP highway improvements. Examples include, in addition to those completed in 1980, construction of the Perring Freeway northeast of the City; upgrading and extension of U.S. 29 and the southern portion of Maryland Route 3; and widening of other facilities including U.S. 40, the Baltimore-Washington Parkway, U.S. Route 1, the Arundel Freeway, and Hilton Street in Baltimore City.

Alternative 6 includes the completed 3-A system and other GDP highway improvements while Alternative 7 includes GDP improvements with the exception of the 3-A system. Alternative 8 includes the 3-A, but no other GDP highway improvements except those under construction. Alternative 9 does not include either the 3-A or other GDP highway improvements except those under construction.

GENERAL ASSUMPTIONS AND DEFINITIONS

A number of assumptions have been made jointly by IDBC and the study team throughout the conduct of this study. Those which relate to specific areas are stated and described in the appropriate technical memorandum. One general assumption is that no special transportation control strategies to reduce air pollution, except Federal Motor Vehicle Controls, are represented in any of the alternatives. At the time of the study no State Implementation Plan to reduce mobile source emissions in the Baltimore region had been formally adopted.

For purposes of analysis the region was divided into 94 Regional Planning Districts (RPDs) and the urbanized area was further divided into 498 transportation zones. The transportation analysis is concentrated within the area comprising the 1964 Baltimore Metropolitan Area Transportation Study (BMATS) as shown in Figure I-5.

STUDY RESULTS

The purpose for the Baltimore Regional Environmental Impact Study has been outlined in the preceding discussion. The role of the study in the region has been stated in the U.S. District Court decision of June 22, 1973 (3):

Figure I-5. BMATS Study Area

The study has developed into a future planning tool for RPC and Maryland DOT. Many state agencies, such as State Planning, State Health, City Planning and City Health, in addition to RPC and Maryland DOT, will have a use for the study when completed. It will be a data base and data resource document that can be used for possibly setting future transportation policies and other policies within the Baltimore Metropolitan region.

The study results will be framed to answer the following broad questions:

- What were the regional environmental problems in 1970?
- Will there be regional environmental problems in the short-term (1980) with the 3-A system? Without the 3-A system?
- Will there be regional environmental problems in the long-term (1995) with the 3-A system? Without the 3-A system? With the GDP highway plan?
- What are the regional differences between alternatives?
- What regional effects can be attributed to the 3-A system?
- Is there a need for further study?

LIST OF REFERENCES -- CHAPTER I

1. Urban Design Concept Associates, "Transportation, Environmental, and Cost Summary -- An Evaluation of Three Concepts for Expressway Routes in Baltimore City," 1968. (Supported by a series of reports on route segments).

2. Wilbur Smith and Associates, "Baltimore Metropolitan Area Transportation Study," 1964.

   Alan M. Voorhees & Associates, Inc., "Travel Forecasting and Patronage Estimates for Baltimore Region Rapid Transit System," July, 1968.

   Alan M. Voorhees & Associates, Inc., "Update of Patronage, Revenue, and Operating Costs for Phase I, Baltimore Rapid Transit System," January, 1971.

3. Movement Against Destruction v. Volpe, Civil N. 72-1041-M (D. Md., filed June 22, 1973).

TRANSPORTATION ALTERNATIVES FOR BALTIMORE REGIONAL ENVIRONMENTAL IMPACT STUDY

ALTERNATIVE	YEAR	HIGHWAY ASSUMPTION		RAPID TRANSIT ASSUMPTION
		3-A INTERSTATE	OTHER HIGHWAYS	
1	1970	Existing	Existing	None
*2	1978	Existing and Programmed	Existing and Programmed	Phase I
3	1980	Complete	Existing and Programmed	Phase I
4	1980	Partial	Existing and Programmed	Phase I
5	1980	Existing and under construction	Existing and Programmed	Phase I
6	1995	Complete	GDP	GDP
7	1995	Existing and under construction	GDP	GDP
8	1995	Complete	Existing and under construction	GDP
9	1995	Existing and under construction	Existing and under construction	GDP

*Eliminated in favor of Alternative 9.

II. OVERVIEW

Baltimore air quality is sufficiently degraded to cause the metropolitan area to become one of 58 out of 247 air quality control regions in the United States whose ambient air quality exceeded standards for oxidants, carbon monoxide, or nitrogen dioxide. The federal ambient air quality standards and the current (1972) levels of air quality in the Baltimore region are shown in Table II-1. For purposes of coming into compliance with ambient air quality standards by 1977, the Baltimore region, according to EPA calculation procedures, must reduce morning peak period (6-9 a.m.) hydrocarbon emissions, which contribute to the formation of photochemical oxidants, by 70 percent or 40.4 tons per day, from 1972 levels. Carbon monoxide emissions must be reduced by 57 percent, or 967 tons per day.

By 1980 and 1995, air pollution levels in the Baltimore region will be influenced by changes in several principal factors: source controls on vehicular and stationary sources, land use and development plans, and transportation policy. These in turn, will be affected by the State Air Quality Implementation Plan for the Baltimore region. Based on the study, it can be concluded that (see Table II-2):

- By 1980 and 1995 the Baltimore region will meet the carbon monoxide ambient air quality standards. Primary and secondary standards for particulates will be met in 1980, but growth may cause marginal violations of the secondary standard by 1995. The nitrogen dioxide air quality standard will also be met in 1980 and will possibly be marginally exceeded in 1995.

- By 1980 and 1995 the Baltimore region will exceed the guidelines for hydrocarbons (non-methane) in spite of significant decreases in pollutant concentrations from their 1970 levels.

- According to the projections, photochemical oxidant standards will be exceeded slightly in 1980 and attained by 1995.

- By 1980 and 1995 projected pollutant levels in all categories will differ only slightly among the alternatives. Figures II- 1 through II-3 show projections of air pollution emissions for carbon monoxide, hydrocarbons, and nitrogen oxides. These figures show the results for each alternative in ascending order of expected capital cost. Contributions from mobile sources are shaded in the figures.

Table II - 1

SUMMARY OF EXISTING AIR QUALITY - BALTIMORE REGION
(1972 Data)

Pollutant	Averaging Time	Sampling Station: AIRMON 1 (1)	AIRMON 2 (2)	Riviera Beach (3)	Linthicum (4)	Towson (5)	Essex (6)	National Air Quality Standard
Carbon Monoxide (ppm)	1-hour maximum	12	14	14	14	11	21	
	2nd high 1-hour	10	13	13	13	10	20	35 ppm
	8-hour maximum	7	10	10	9	8	17	
	2nd high 8-hour	7	8	9	9	8	16	9 ppm
Non-Methane Hydrocarbons (ppm)	3-hour maximum (6-9 am)	2.1	2.8	--	--	--	--	0.24 ppm
Nitrogen Dioxide (ppm)	annual arithmetic mean	0.05*	0.06*	--	--	--	--	0.05 ppm
Photochemical Oxidants (ppm)	1-hour maximum	0.12	0.21	--	--	--	--	
	2nd high 1-hour	0.11	0.20	--	--	--	--	0.08 ppm
Particulate Matter ($\mu g/m^3$)	24-hour maximum	not collected	not collected	261	165	225	213	primary-- 260 $\mu g/m^3$ secondary-- 150 $\mu g/m^3$
	annual geometric	not collected	not collected	60	63	60	75	primary-- 75 $\mu g/m^3$ secondary-- 60 $\mu g/m^3$

* Standard measurement method has been changed. Concentrations by new method would be lower.

Table II - 2

MAXIMUM PREDICTED REGIONAL POLLUTANT CONCENTRATIONS

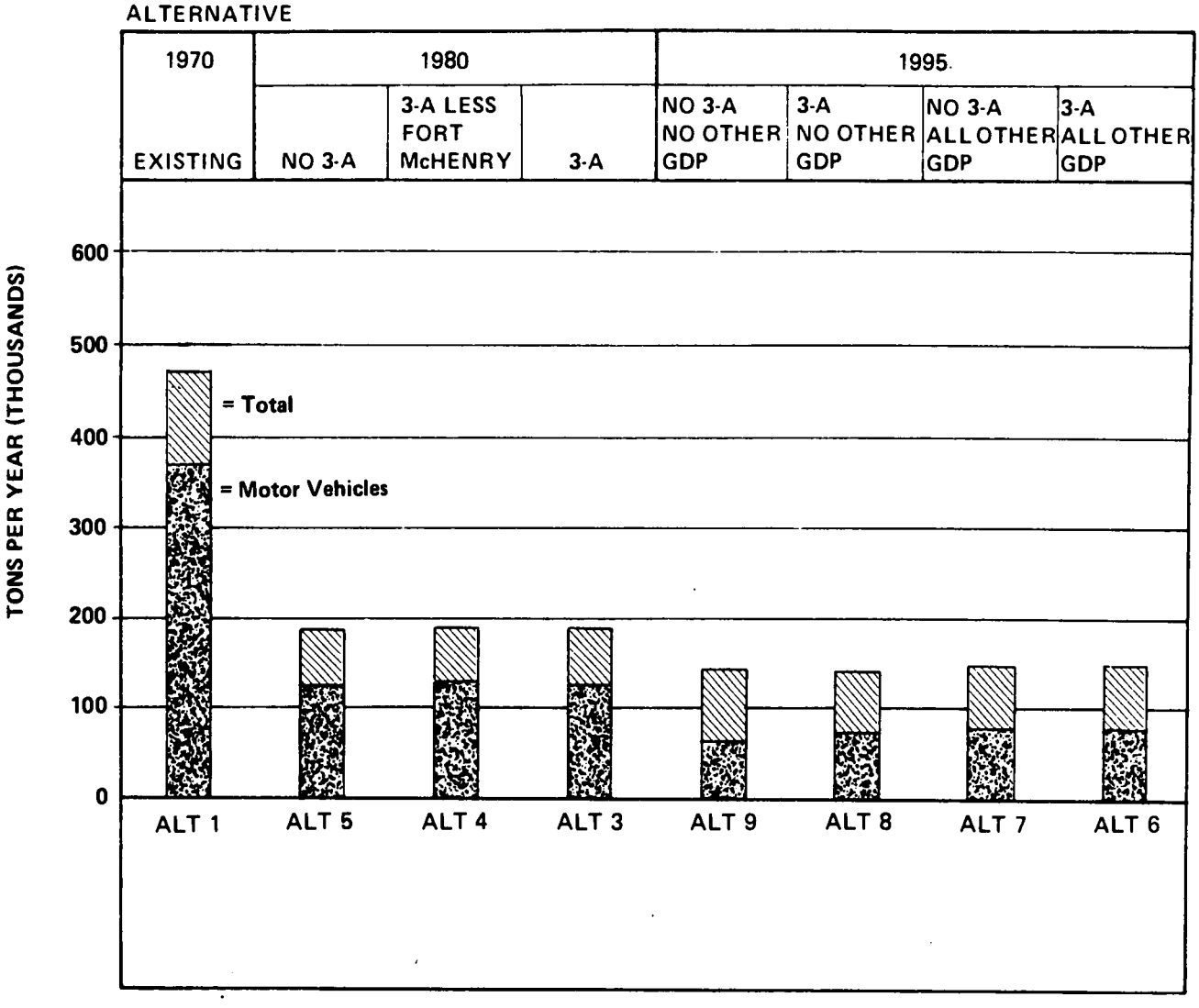
Pollutant	Averaging Time	1980			1995				National Air Quality Standard
		Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or GDP Improvements	
Carbon Monoxide (ppm)	1-hour maximum	11.1	11.1	10.8	6.4	6.5	7.4	7.2	35 ppm
	8-hour maximum	7.4	7.4	7.2	4.3	4.4	5.0	4.8	9 ppm
Non-Methane Hydrocarbons (ppm)	3-hour maximum (6-9 a.m.)	1.1	1.1	1.1	1.0	1.0	1.0	0.9	0.24 ppm
Photochemical Oxidants (ppm)	1-hour maximum	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.08 ppm
Nitrogen Dioxide (ppm)	annual arithmetic mean	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.05 ppm
Particulate Matter ($\mu g/m^3$)	annual geometric mean	59.0	59.0	59.0	63.0	63.0	63.0	63.0	primary-- 75 $\mu g/m^3$ secondary-- 60 $\mu g/m^3$

* All predicted values based on 1972 air quality data collected at AIRMON 1 and 2 stations. A new standard method for NO_x measurement may change the observed levels at these stations.

** Proportional model calculations assume the 123 $\mu g/m^3$ arithmetic mean at the maximum site used in the implementation plan and a 40 $\mu g/m^3$ background. Conversion to geometric mean was with the assumption that the geometric standard deviation equals 1.6.

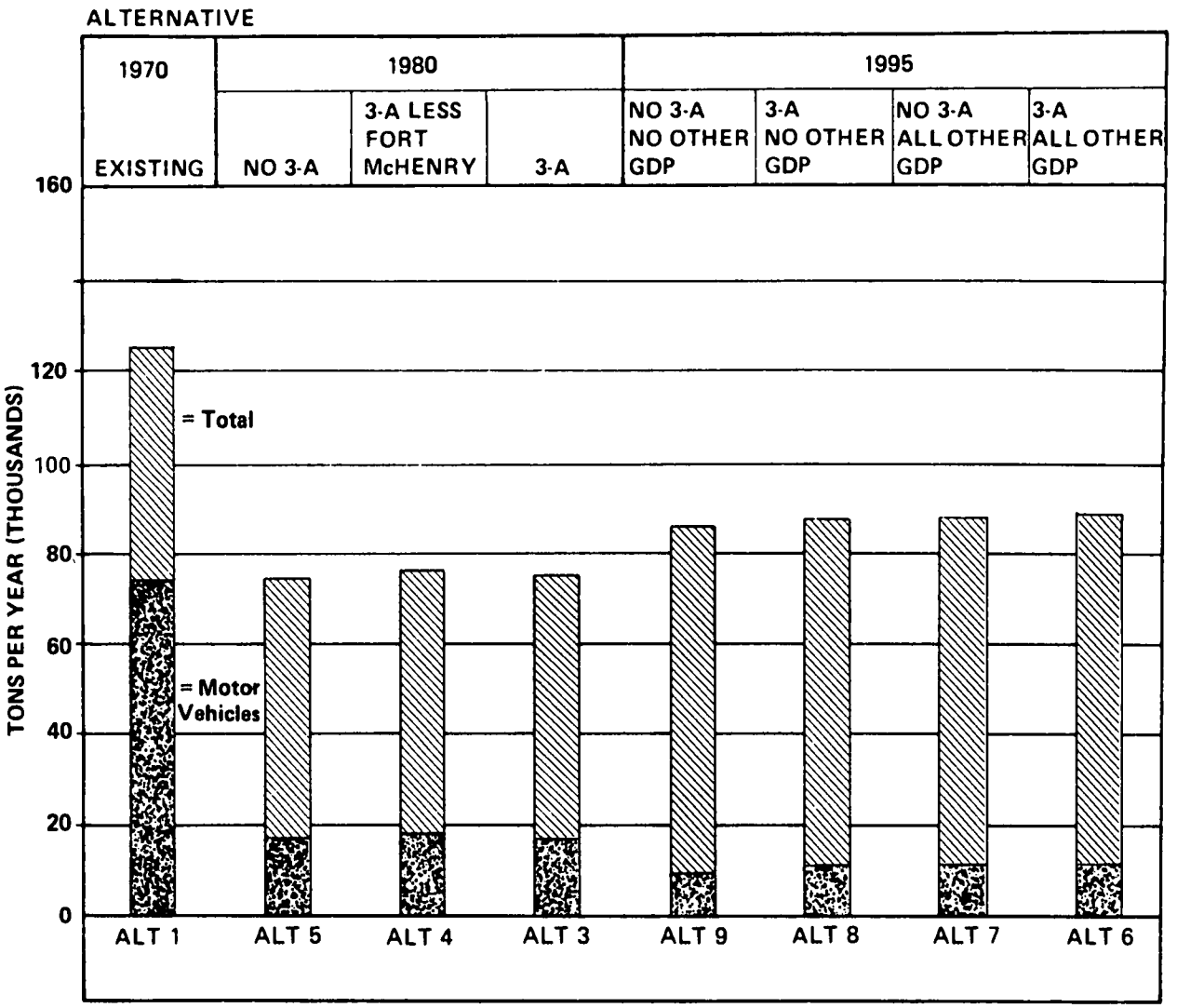
Note: Does not include estimates of the effects of transportation control strategies and controls on certain stationary sources issued after September, 1973.

FIGURE II-1
CARBON MONOXIDE EMISSIONS IN BMATS AREA



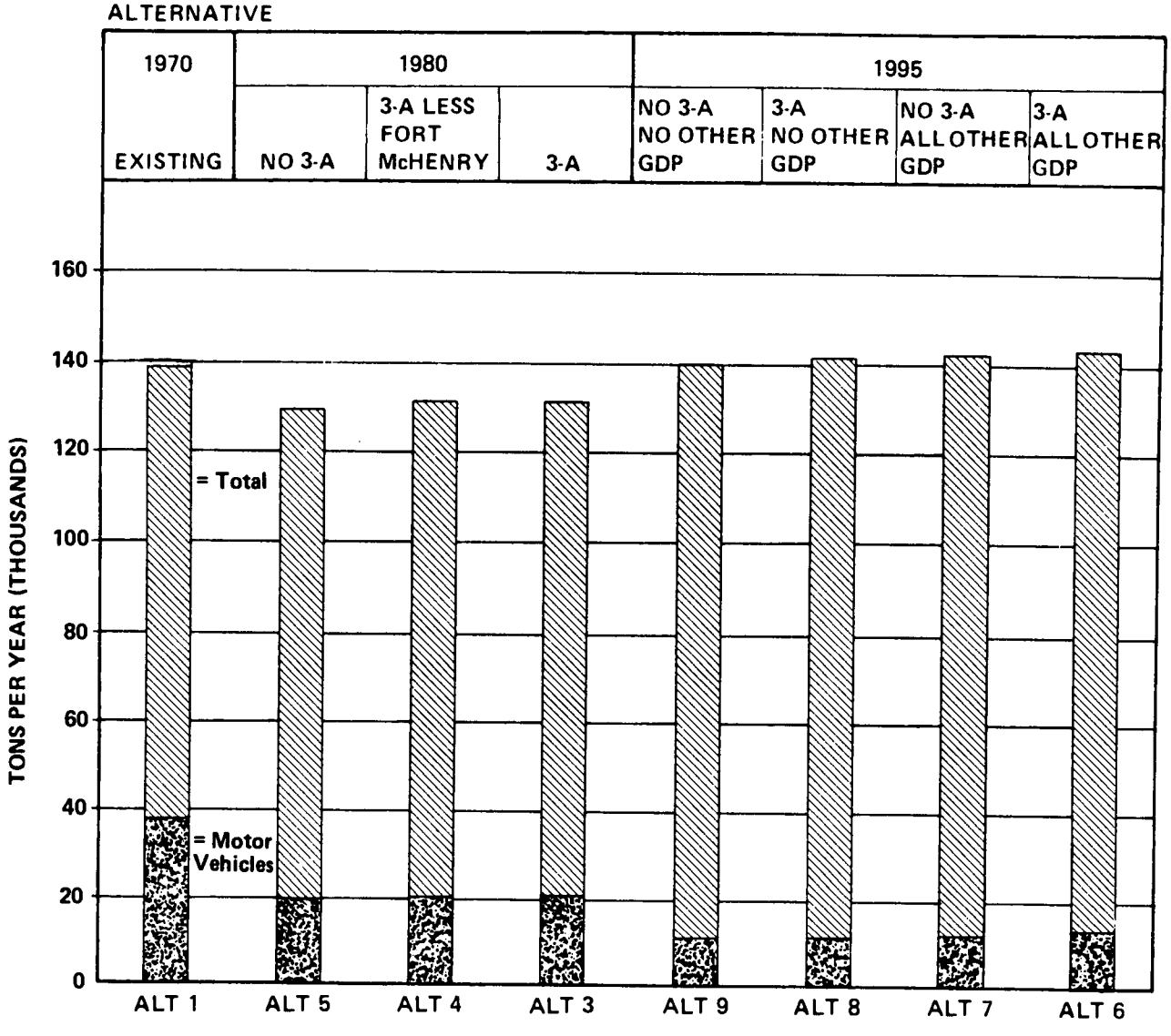
Note: Does not include estimates of the effects of transportation control strategies and controls on certain stationary sources issued after September 1973.

FIGURE II-2
HYDROCARBON EMISSIONS IN BMATS AREA



Note: Does not include estimates of the effects of transportation control strategies and controls on certain stationary sources issued after September 1973.

FIGURE II-3
NITROGEN OXIDE EMISSIONS IN BMATS AREA



Note: Does not include estimates of the effects of transportation control strategies and controls on certain stationary sources issued after September 1973.

- Reductions in motor vehicle emissions are expected to be of such a magnitude that 1980 and 1995 air pollution levels will be caused chiefly by stationary and non-vehicular sources. Emissions from such sources are not significantly affected by the proposed transportation networks.

The following discussion expands these conclusions for each of the pollutants:

- Carbon Monoxide -- Neither the 1-hour maximum standard (35 parts per million, or ppm) nor the 8-hour maximum standard (9 ppm) is projected to be exceeded in 1980 or 1995 under any of the transportation alternatives. Highest future year concentrations for the 1-hour standard are estimated at 11.1 ppm in 1980 and 7.4 ppm in 1995. The projected levels are 7.4 ppm and 5.0 ppm, respectively, as compared with a standard of 9 ppm for 8 hours.

- Non-methane Hydrocarbons -- In 1980 and 1995, projected maximum hydrocarbon concentrations of 1.1 and 1.0 ppm, respectively, during the 6-9 a.m. period exceed the 0.24 ppm guideline value. The 6-9 a.m. period is the significant one for hydrocarbons, as research has indicated that the hydrocarbons emitted in this morning period contribute most to the afternoon build-up of oxidant levels. However, even with the hydrocarbon guideline being exceeded, oxidant standards were found to be met or only marginally exceeded. The total percentage reduction in 6-9 a.m. hydrocarbon emissions by 1980 and 1995 amounts to a range of 61 to 67 percent for the alternatives examined. This contrasts with the annual hydrocarbon emission totals which are reduced by only about 40 percent in 1980 and 30 percent in 1995.

- Photochemical Oxidants -- Photochemical oxidant concentrations are projected to decline from their present 1-hour maximum high of .21 ppm to .09 ppm by 1980 and to further decline to .08 ppm for all alternatives by 1995. This level of oxidants matches the EPA standard, also .08 ppm. (The 6-9 a.m. summer hydrocarbon emissions data reported in Table VI-18 and used in the photochemical oxidant analysis was taken from the Maryland Bureau of Air Quality Control charts shown in Appendix E. This does not include estimated reductions in emissions for 1980 and

1995 from gasoline storage and handling which results from stationary source regulations issued subsequent to the study period. Had this reduction in hydrocarbon emissions been considered in the analysis for this technical memorandum, the air quality standard of .08 ppm for all 1980 alternatives would have been achieved. The Bureau of Air Quality Control values for gasoline storage and handling emissions were not included in this memorandum because they were part of stationary and transportation source control regulations promulgated after the analysis for the Technical Memorandum.)

- Nitrogen Dioxide -- The annual arithmetic mean level for NO_2 is presently .06 ppm. By 1980, the level is estimated to fall to .05 ppm for all alternatives. The NO_2 level is predicted to rise to .06 in 1995, again for all alternatives. All alternatives, therefore, appear to have a NO_2 level that is approximately equal to the .05 ppm EPA standard. The amount of NO_2 emissions contributed by highway transportation is projected to decline from the base 32 percent to 16 percent in 1980 and about 8 percent in 1995.

- Particulate Matter -- The projected annual geometric mean of particulate matter concentration for 1980 indicates no violation of either the primary or secondary air quality standards (primary: 75 $\mu g/m^3$; secondary: 60 $\mu g/m^3$. The level in that year for all alternatives is expected to be 59 $\mu g/m^3$. By 1995, however, the particulate level is expected to be 63 $\mu g/m^3$ for all alternatives, a level that slightly exceeds the secondary standard. Particulates from highway transportation amount to only 3 percent of the existing regionwide total. In 1980 and 1995 the proportion is anticipated to be 4 percent under all alternatives.

In addition to conformance with standards, air quality degradation was also examined. A decline in environmental quality, or degradation, would be signaled by upward changes in certain indices of air quality. If total tons of emissions or maximum levels of concentration of any air pollutant rise, there has been a degradation of air quality. Compared with present conditions on a regional basis, as shown in Figures II-1 through II-3, there appears to be no degradation, but rather improvement in all pollutant categories for all alternatives. A low point is reached in 1980, after which there is moderate degradation by 1995 for NO_2, HC, and particulates, compared with the figures attained for 1980. CO emissions will be less than base year levels for all alternatives.

In summary, from an air pollution viewpoint, building the 3-A system versus doing nothing appears to have little effect on the air pollution levels. After 1980 there will be no violation of the carbon monoxide air quality standard. However, there will continue to be a violation of the hydrocarbon guideline level primarily due to the growth in stationary rather than mobile source pollution, and as a consequence, predicted violation of the photochemical oxidant standard for some period of time between 1980 and 1995. These findings hinge, however, on effective implementation of Federal motor vehicle emission controls for new vehicles. None of the findings in this study include the effects of the Transportation Control Plan promulgated by the Environmental Protection Agency for the Baltimore region on December 12, 1973, or the state regulations for stationary source control of October 3, 1973.

A subsequent technical memorandum is being prepared which will include the effects of both the stationary source controls and transportation control strategies issued after September 1973. These controls may be expected to reduce pollutant levels below those shown in this technical memorandum.

III. INTRODUCTION

The general approach taken in the analysis of air quality in the Baltimore region was to inventory the extent of the 1970 air quality problem, forecast the extent of the problem in 1980 and 1995 as related to the alternatives for building the 3-A system and other regional highway improvements, and to describe projected air pollution effects on people and land use and their relation to various evaluation criteria. The process used to perform this evaluation is described in Figure III-1.

The air quality analysis examined six air pollutants known to have adverse impacts on man and his environment and for which the U.S. Environmental Protection Agency (EPA) has established ambient air quality standards:

- Carbon monoxide (CO)
- Hydrocarbons (HC)
- Oxidants (O_x)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Particulate matter

To first define the 1970 air quality problem, data on current ambient air quality levels were obtained from various City and state sampling stations. Emissions data on stationary sources were identified by location, type, and amount of air pollutants being generated. The stationary source data provided the basis for estimating "background" pollution levels to which mobile source emissions are superimposed in diffusion model analyses to arrive at overall estimated ambient air quality.

Base year (1970) mobile source emissions were derived from the vehicle miles of travel (VMT) estimates developed in the travel simulation phase of the study and input to the emissions model adapted from the Maryland Bureau of Air Quality Control (BAQC) procedures. Mobile source emissions and stationary source emissions were then combined for a regional emissions total.

Emissions were similarly estimated for the seven 1980 and 1995 alternative transportation networks and their associated land use plans, using projected traffic and stationary source data and appropriate emission factors for each alternative.

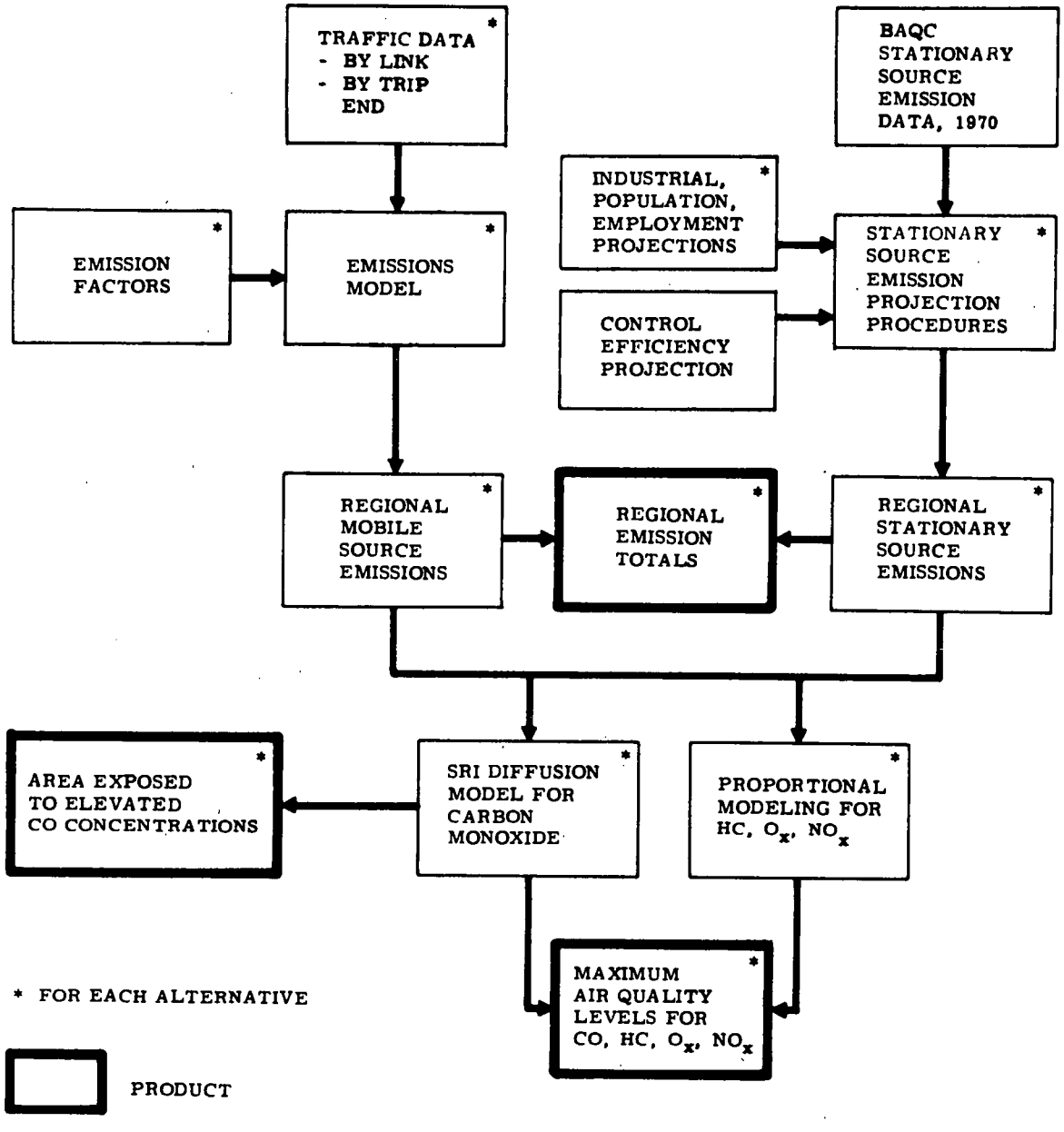


FIGURE III-1. PROCESS FOR AIR QUALITY AND EMISSIONS ANALYSIS

As noted in Chapter I, no transportation control strategy programs other than the Federal Motor Vehicle Control Program and its assumed effects in terms of automotive emissions have been included in this analysis.

At the time the study was being conducted, the BAQC had proposed to EPA a program of transportation control strategies for inclusion in the State Implementation Plan for the Baltimore Intrastate Air Quality Control Region. The plan, however, had not been formally adopted and was subject to review and change; therefore, no assumptions regarding the possible effects on travel, and thus on emissions, have been made for future years. (In December 12, 1973, EPA promulgated a Transportation Control Plan for the Baltimore Air Quality Control Region; the effects of these strategies will be summarized in a subsequent technical memorandum.)

It should also be noted that although the 1978 Alternative 2 was dropped from the overall analysis, a test of the 1978 emission rates on the 1980 networks and traffic was completed and is described in Chapter V.

In order to estimate regional air quality for each of the alternatives, the Stanford Research Institute (SRI) APRAC-IA urban diffusion model was used for carbon monoxide; the projection of future oxidant, hydrocarbon, nitrogen oxide, and particulate levels was completed by use of proportional modeling techniques. (Due to the extremely small contribution of mobile sources to regional levels of sulfur oxides and the uncertainty of emission rates, analysis of this pollutant was not carried out for future year alternatives).

The results of the above analyses were used to examine the impacts of future year levels of air pollution on people and land use. National ambient air quality standards established by EPA were used to evaluate the air quality consequences of the alternatives under study. For the pollutants examined, the National Standards are the same as for the State of Maryland.

This technical memorandum is comprised of seven parts. Chapter I described the background for the entire Baltimore Regional Environmental Impact Study (BREIS). Chapter II presented an overview of the findings in the air quality analysis. This chapter is followed by a description of the general approach used (Chapter IV). An inventory of existing emissions and air quality data is continued in Chapter V. Chapter VI is a discussion of the projected emissions and air quality for the future year alternatives. The appendices contain background information for the air quality analysis portion of the study.

IV. GENERAL APPROACH

This chapter describes the overall approach to the regional air quality analysis and the methodology used to perform the analysis.

REGIONAL VS. SELECTED CORRIDOR ANALYSIS OF AIR QUALITY

The regional analysis applied in this study is designed to test the effects of alternative highway plans and policies in the Baltimore region. This approach complements the more usual analysis of localized impacts created by a single facility.

Air quality analysis for a regionwide transportation network differs from the selected corridor analysis usually undertaken in environmental impact assessments. The points of major difference may be summarized:

- A corridor analysis is specific, localized, and detailed. A regional analysis is broad, areawide, and general.

- Generally, a corridor analysis deals only with mobile sources, namely, the vehicular traffic moving over the main roadway(s) in the study corridor. Background air pollution from all other sources is added in as a given, while in the regional analysis significant changes in land use, as well as traffic changes, are analyzed.

A regional analysis accounts for all sources of air pollution and treats them spatially (geographic location). This is accomplished by modeling the location and projected changes in:

- "Point" sources, such as factories, incinerators, institutions that emit major quantities of air pollution

- "Area" sources, which are constituted of many individual sources such as residential units, whose total contribution of air pollution when linked together (as from home heating plants) is significant when cumulated over a wide geographic area

- "Line" sources, such as major highways

When taken in combination, pollution from the point, area, and line sources represent the total regionwide air pollution emissions which relate directly to the quantities of pollutants measured by air quality monitoring stations located at various points throughout the region.

There are also differences between the way traffic patterns are included in each type of analysis. The corridor approach, therefore, is more likely to identify localized high concentrations of pollutants, or "hot spots." A regional analysis, however, does not provide the detailed spatial resolution for prediction of pollution and is not intended to yield accurate information on a micro-scale basis, but it will produce regional contours of pollution concentrations which can demonstrate the effects of alternative transportation plans.

AIR POLLUTANTS INVESTIGATED

As noted in the introduction, the major air pollutants investigated are:

- Carbon monoxide (CO)
- Hydrocarbons (non-methane HC)
- Oxidants (O_x)
- Nitrogen oxides (NO_x)
- Sulfur oxides (SO_x)
- Particulates

EPA has established national ambient air quality standards for these pollutants. Primary standards relate to health; secondary standards relate to welfare. The State of Maryland has also set standards for these pollutants, which for mobile sources are identical to the Federal standards. These standards are listed in Table IV-1. A brief description of the adverse effects of these pollutants may be found in Appendix A.

The standards for several of these pollutants are for short exposure times, and in the case of hydrocarbons, the standard is for a specific time of day. These time-dependent relationships were considered in the analysis of projected air quality.

GENERATION OF DATA BASE

The measurement and projection of air pollution levels require four basic input parameters:

Table IV - 1

NATIONAL PRIMARY AND SECONDARY
AMBIENT AIR QUALITY STANDARDS

Pollutant	Type of Standard	Averaging Time	Frequency Parameter	Concentration $\mu g/m^3$	Concentration ppm
Carbon monoxide (CC)	Primary and secondary	1 hr	Annual maximum[a]	40,000	35
		8 hr	Annual maximum	10,000	9
Hydrocarbons (nonmethane) (HC)	Primary and secondary	3 hr (6 to 9 am)	Annual maximum	160[b]	0.24[b]
Nitrogen dioxide (NO_2)	Primary and secondary	1 yr	Arithmetic mean	100	0.05
Photochemical oxidants (O_x)	Primary and secondary	1 yr	Annual maximum	160	0.08
Particulate matter	Primary	24 hr	Annual maximum	260	--
		24 hr	Annual geometric mean	75	--
	Secondary	24 hr	Annual maximum	150	--
		24 hr	Annual geometric mean	60[c]	--
Sulfur dioxide (SO_2)	Primary	24 hr	Annual maximum	365	0.14
		1 hr	Arithmetic mean	80	0.03
	Secondary	3 hr	Annual maximum	1,300	0.5
		24 hr	Annual maximum	260[d]	0.1[d]
		1 hr	Arithmetic mean	60	0.02

[a] Not to be exceeded more than once per year.

[b] As a guide in devising implementation plans for achieving oxidant standards.

[c] As a guide to be used in assessing implementation plans for achieving the annual maximum 24-hour standard.

[d] As a guide to be used in assessing implementation plans for achieving the annual arithmetic mean standard.

Source: Environmental Protection Agency,
National Primary and Secondary Ambient Air
Quality Standards, 1971, Federal Register 36: 8186-8201, April, 1971

- Emission factors
- Emission sources
- Meteorology
- Geography and topography

In addition, base year air quality readings are required for proportional roll-back procedures.

Mobile Source Emission Factors

Emission factors are measures of the rate at which various sources emit a given pollutant. When multiplied by the number of similar sources emitting the pollutant in a given area and cumulated for all sources in the area within a certain time period, the total amount of that pollutant emitted can be determined.

Emission factors are affected by a number of variables. For mobile (transportation) sources, the variables include traffic speeds, mode of vehicle operation, and vehicle mix (age and type of vehicles). Traffic speeds influence engine operating efficiency and the degree to which fuel is burned, the amount and type of gases created, and the amount of unburned residues emitted. Mode of operation includes starting, stopping, length of trip, and whether the trip is mostly stop-start or constant speed running. These parameters influence the amount of pollutants emitted. Finally, vehicle mix is important. Automobiles and other light duty vehicles, including trucks up to 6,000 pounds gross vehicle weight (GVW), emit pollutants at different rates than trucks over 6,000 pounds GVW and other heavy duty vehicles. In addition, pollution emission rates change with engine deterioration as a result of age and with the progressive adaptation of more refined emission control technology to the vehicle fleet year by year.

For this study, emission factors for mobile sources were adapted from those proposed by the Maryland Bureau of Air Quality Control (BAQC), using Environmental Protection Agency vehicle test data. The BAQC values and underlying EPA data are based on extensive tests of existing vehicles and projections of future emission rates expected as emission standards are met by automobile manufacturers.

The pollutants for which air pollution emission factors were developed are carbon monoxide, hydrocarbons, nitrogen oxides, and particulates. Three sets of factors were developed to be representative of the years under investigation--1970, 1980, and 1995. These factors are summarized in Tables IV-2, IV-3, and IV-4.

Table IV - 2

EMISSION FACTORS FOR 1970

Pollutant	Vehicle Type	Running Emissions gm/mile	Cold Start Emissions gm/cold start	Hot Soak Emissions gm/stop
CO	LDV	$56.42C_1$ [a]	52.72 [a]	—
	HDV	$123.23C_1$ [b]	104.26 [b]	—
HC	LDV	$5.23C_1+1.43$ [a]	5.28 [a]	22.22 [a]
	HDV	$15.21C_1+3.21$ [b]	12.68 [b]	22.50 [b]
NO_x	LDV	$5.43C_2$ [a]	—	—
	HDV	$9.38C_2$ [b]	—	—
Particulates	LDV	0.30 [c]	—	—
	HDV	0.74 [c]	—	—

Speed Correction Factors (Dimensionless):

$C_1 = 5.06S^{-0.55}$

$C_2 = 0.56S^{0.20}$, where S = average speed, in mph.

gm = grams

LDV = Light duty vehicles (less than 6000 lbs.)

HDV = Heavy duty vehicles

Sources:

(a) Maryland Bureau of Air Quality Control. Method for Estimating Light Duty Vehicle Emission on a Sub-Regional Basis. Technical Memorandum 73-107, April 1973.

(b) U.S. Environmental Protection Agency. An Interim Report on Motor Vehicle Emission Estimation. Revised, January 1973.

(c) U.S. Environmental Protection Agency. Compilation of Air Pollution Emission Factors. Revised, February 1972, AP-42.

Table IV - 3

EMISSION FACTORS FOR 1980

Pollutant	Vehicle Type	Running Emissions gm/mile	Cold Start Emissions gm/cold start	Hot Soak Emissions gm/stop
CO	LDV	$8.90C_3$[a]	18.84[a]	---
	HDV	$117.93C_3$[b]	98.27[b]	---
HC	LDV	$1.02C_3$[a]	2.47[a]	2.57[a]
	HDV	$12.73C_3$[b]	10.37[b]	9.05[b]
NO_X	LDV	$1.80C_4$[a]	---	---
	HDV	$9.22C_4$[b]	---	---
Particulates	LDV	0.10[c]	---	---
	HDV	0.70[c]	---	---

Speed Correction Factors (Dimensionless):

$C_3 = 1.56\ S^{-0.15}$

$C4 = 0.52\ S^{0.22}$, where S = average speed, in mph.

gm = grams

LDV = Light duty vehicles (less than 6000 lbs.)

HDV = Heavy duty vehicles

Sources:

(a) Maryland Bureau of Air Quality Control. Method for Estimating Light Duty Vehicle Emission on a Sub-Regional Basis. Technical Memorandum 73-107, April 1973.

(b) U.S. Environmental Protection Agency. An Interim Report on Motor Vehicle Emission Estimation. Revised, January 1973.

(c) U.S. Environmental Protection Agency. Compilation of Air Pollution Emission Factors. Revised, February 1972, AP-42.

Table IV - 4

EMISSION FACTORS FOR 1995

Pollutant	Vehicle Type	Running Emissions gm/mile	Cold Start Emissions gm/cold start	Hot Soak Emissions gm/stop
CO	LDV	2.22[a]	6.70[a]	---
	HDV	117.00[b]	97.50[b]	-----
HC	LDV	0.34[a]	0.87[a]	1.50[a]
	HDV	11.70[b]	9.75[b]	6.00[b]
NO_X	LDV	0.76[a]	---	---
	HDV	9.20[b]	---	---
Particulates	LDV	0.10[c]	---	---
	HDV	0.69[c]	---	---

gm = grams

LDV= Light duty vehicles (less than 6000 lbs.)

HDV = Heavy duty vehicles

Sources:

(a) Maryland Bureau of Air Quality Control. Method for Estimating Light Duty Vehicle Emission on a Sub-Regional Basis. Technical Memorandum 73-107, April 1973.

(b) U.S. Environmental Protection Agency. An Interim Report on Motor Vehicle Emission Estimation. Revised, January 1973.

(c) U.S. Environmental Protection Agency. Compilation of Air Pollution Emission Factors. Revised, February 1972, AP-42.

The change from 1975 to 1976 of the required date for motor vehicle emission standards for CO and HC has been considered in the development of the emission factors used in this study. However, the later relaxation of the NO_x emission standard from 1976 to 1977 has not been included. The present study was already beyond emission factor development stage when this second change occurred.

The basic procedure was the same as that employed by Maryland BAQC. See Appendix B for further discussion. It differs from Federal EPA methodology by assigning a portion of the average per-mile emissions to account for cold starts and hot soak. ("Hot soak" is the release of vapors from unburned gasoline still in the engine pan when the ignition is cut off.)

Based on additional testing, a few of the low-mileage (new car) emission rates used by BAQC to calculate their model-year emission factors have been updated by EPA. In conjunction with BAQC staff, it was decided that the updated values would not be used in this study. The primary reason was to keep emission calculations consistent and comparable with those done by the BAQC. These changes were only for pre-1972 model years, and therefore will not significantly influence the emission factors for 1980 and 1995. The net effect of the updated values on regionwide CO, HC, and NO_x emission estimates for 1970 would be to reduce the estimates by 15 to 20 percent.

Separate factors for heavy duty vehicles (HDV) were developed. Low mileage emission rates for individual model years were taken from a 1973 EPA data source (4). The procedure for estimating HDV trip-end emissions was the same as for light duty vehicles (LDV)--a value of 10 percent of standard trip emissions was assumed for cold starts. Hot soak emissions were taken to be the same as evaporation losses as shown in EPA emission factors. (4)

The difference in emission rates from vehicles traveling at the same average speed on city streets (start/stop) compared to emissions on freeways (constant speed) was investigated thoroughly. Although directly comparable test data are not yet available to make this analysis, it appears that the error introduced by using a single emission factor for both conditions is not significant. This is because the speed correction factor already reflects the lower variation in speeds for travel at the higher average speeds associated with freeway travel. The speed correction factor was converted into a continous function to permit efficient computer calculation of emissions for each highway link.

Particulate emission factors for LDV were taken directly from Table III-1 of EPA's February 1972 *Compilation of Emission Factors*. (13) This reference also contains emission factors for heavy duty diesel vehicles. These factors are independent of speed. However, no particulate factors have been published for heavy duty gasoline-powered vehicles, and therefore, a value of 0.685 gm/ mile was proposed, based on an adjustment of the EPA particulate emission factor for LDV and the relative gasoline consumption rates for the two vehicle classes. The two factors (for gasoline-powered and diesel-powered HDV) were then combined on a weighted basis to yield a single 1970 HDV emission factor of 0.74 gm/mile. The weighting factors used were derived from earlier work in the Baltimore region which estimates heavy duty gasoline vehicles at 9.9 percent and heavy duty diesel (road) vehicles at 1.2 percent of total VMT. (8) The corresponding HDV emission factors in 1980 and 1995 become 0.70 and 0.69 gm/mile.

Other Data

The other data required--emission sources, meteorology, and geography--and their application to the analysis are described in Chapters V and VI.

METHODOLOGY FOR COMPARISON OF ALTERNATIVES

The alternatives were compared by three methods: (1) total annual tonnage of emissions of pollutants into the region, (2) the maximum expected pollutant concentrations in the region, and (3) the extent of area and people exposed to elevated pollutant concentrations.

Emissions Modeling Overview

Air pollutant emissions from mobile sources were estimated as the total of: (1) emissions from individual links of the network, (2) contributions from residual vehicle miles of travel (VMT) not on major traffic links, and (3) emissions associated with vehicle trip-ends (cold start and hot soak emissions). Necessary traffic volume and trip-end data for each alternative were available from the travel simulation portion of the study and were multiplied by appropriate factors of emissions per vehicle mile and per trip-end to obtain the emission values assigned to each link and regional planning district (RPD). Derivation of the emission factors, the key to the accuracy of this procedure, is explained in the preceding section, "Generation of Data Base." Emissions were projected by multiplying the appropriate emission factor by the applicable VMT or trip-end data. See Appendix C for equations used for CO, HC, NO_x, and particulates.

The above procedure for estimating total regional emissions for each alternative from disaggregated traffic data was employed for several reasons:

- Vehicular emission rates are greatly influenced by the vehicle's speed. The speed function can be considered more accurately on an individual link basis than with aggregated VMT totals.

- Calculation of vehicular emissions at the link and RPD levels permits a more accurate analysis of the spatial distribution of pollutants in the region.

- Estimation of trip-end emissions separately from running emissions becomes increasingly important for post-1975 vehicles, for which half of the total trip emissions of carbon monoxide and hydrocarbons are expected to occur within the first two minutes after startup.

- Separation of running and trip-end emissions makes the present analysis more comparable with previous mobile source studies done by the Maryland Bureau of Air Quality Control.

With one preliminary modification, the outputs of the traffic network models for each alternative were directly usable in calculating air pollutant emissions. This modification was the reduction in number of individual links considered in the emission calculations from approximately 6,000 in the detailed traffic network to the 1,200 with highest traffic volumes. Data for the eliminated links were aggregated for calculation purposes by RPD as residual traffic. Residual traffic also includes intrazonal traffic. Approximately 60 percent of the total VMT were still associated with individual links in this reduced network.

The 24-hour average simulated speed for each link or RPD (for residual traffic) was then input into the appropriate equations to calculate the speed correction factor for each pollutant. These equations are shown in the footnotes to Tables IV-2, IV-3, and IV-4. These were next multiplied with emission factors per vehicle mile and the VMT for the link or RPD to get the daily emissions of each pollutant. The final step was summation of individual link and residual emission data to get emission subtotals. In addition to separate totals for link/residual traffic emissions, emission data for light duty vehicles (LDV), heavy duty vehicles (HDV), and inside Beltway/outside Beltway were also calculated and summed separately. Emissions for areas outside BMATS were factored.

Trip-end emissions, the third component of the mobile source emission estimating procedure, were calculated as the product of the appropriate emission factor times the number of trip-ends per day aggregated by RPD. The number of trip-ends was determined from node data in the traffic network model. One-half of all trip origins were assumed to be cold starts, while all trip destinations were assumed to have hot soaks.

Since the estimated vehicle emissions for each alternative were calculated directly from the traffic simulation outputs using emission factors specific for the forecast years and for vehicles in the Baltimore area, they should reflect differences both in total emission levels and in regional distribution of emissions between alternatives. Comparison of emissions for different alternatives--especially with Alternative 1 (1970), for which concurrent air quality data are available--is the most direct evaluation of the relative air pollution impact of the alternatives.

In order to estimate traffic volumes for a given hour, 24-hour emissions were factored using typical curves of diurnal traffic distribution by link type which were developed from empirical data. Distributions were formulated for roads inside and outside the Beltway due to significant observed differences in pattern. These hourly traffic factors are shown in Table IV-5.

The table was derived from sample traffic counts provided by the Maryland Department of Transportation at various locations throughout the region for five highway types: freeways, primary arterials, minor arterials, major collectors, and residential streets. For each classification type a sample was included from the central business district (CBD), as well as from each of the four primary compass directions.

The substantial lack of uniformity in the data is indicative of the importance of localized traffic generation and distribution characteristics, which are influenced primarily by land use composition. Thus, while characteristic morning and afternoon peak periods are generally evidenced, their magnitude and duration vary considerably from location to location.

The freeway routes, high volume limited access facilities, are characterized by a fairly sustained flow rate between 8 a.m. and 6 p.m., with only minor peaks during morning and evening rush hours. This generalization is particularly valid for locations outside the Baltimore Beltway. For the Beltway and internal locations, morning and evening peaks are more pronounced.

Table IV - 5

GENERALIZED HOURLY TRAFFIC FACTORS IN THE BALTIMORE REGION

Hour Ending	Percent of ADT in Given Hour					
	Freeways and Primary Arterials		Secondary Streets			
	Beltway and Internal	Outside Beltway	Minor Arterials	Major Collectors	Residential	Average
1 a.m.	1.5	2	1	1.5	2	1.5
2	1	1.5	1	1	1	1
3	.5	1.5	.5	.5	.5	.5
4	.5	1	.5	.5	.5	.5
5	.5	1	.5	.5	.5	.5
6	2	1.5	1.5	1	1	1
7	5.5	2.5	4	2	3.5	3.5
8	7.5	5	7	5	5	6
9	5.5	5	7	6	6.5	6.5
10	4.5	5	4.5	4.5	5	4.5
11	4.5	5.5	4.5	4	5.5	4.5
12 noon	5	5.5	5	4.5	5.5	5
1 p.m.	5.5	5.5	5.5	5	5.5	5.5
2	5.5	5.5	5	4.5	5.5	5
3	6	5.5	5.5	5	6	5.5
4	7	6.5	7	6	6.5	6.5
5	8	7	9	9.5	8.5	9
6	7	6.5	8.5	8.5	8	8.5
7	5	6	6	7	5.5	6
8	4.5	5.5	5	6	5	5.5
9	4	4.5	4	5.5	4	4.5
10	3.5	4	3	5	3.5	3.5
11	3	3.5	2.5	4	3	3
12 mid.	2.5	3	2	3	2.5	2.5

Primary arterials demonstrate a rapid increase in traffic flow rate during the morning rush. Typically, the flow rate continues to increase gradually through the morning and afternoon, reaching a peak during the evening rush period, whereupon it gradually decays until the next morning rush. Notable exceptions were found in two high-volume arterials--Orleans Street in the CBD which shows marked morning and afternoon peaks, and Maryland Route 151 which also demonstrates a smaller peak in late evening, probably coincident with shift schedules at Sparrows Point.

Minor arterials, major collectors, and residential streets generally follow a pattern in which morning and afternoon peaks are quite pronounced, with evening peaks significantly greater than morning peaks.

The vehicle mix input factor is determined by averaging the emission factors for each year group, weighted by the number of vehicles on the road from that group. Vehicle age was derived from BAQC data.

A more technical description of the methodology for converting traffic data for use in the emissions model and sample equations used in the emissions model may be found in Appendix C.

Atmospheric Modeling Overview

In order to convert air pollutant emissions to air quality measures, two procedures were used--for carbon monoxide a computer diffusion model was employed, while for HC, oxidants, NO_x and particulates a proportional modeling technique was applied.

CO Diffusion Model -- The Stanford Research Institute (SRI) APRAC-1A diffusion model for CO computes the pollutant concentration at any point within a city or metropolitan area. Inasmuch as the major source for CO is motor vehicles, the SRI model has capability for predicting intraurban diffusion from freeway, arterial, and feeder street sources. The model offers a choice of three calculations:

- Synoptic -- hourly concentrations over time at specified locations (receptor sites)
- Climatological -- frequency of occurrence of predicted higher concentrations
- Grid point -- concentrations at various locations in a geographical grid.

The grid point and synoptic versions of the model were used for this study. The model application is described in more detail in Appendix B.

The grid point version of the model can only report rooftop, or urban background, CO concentrations because of its macroscale view of regional pollution levels. In the present study, it was used to identify areas with potentially high ground-level concentrations for further investigation with the synoptic version of the model. Three hundred and seventy sites were used in the grid-point model.

After the potential CO hot spots on a regional scale were identified, hour-by-hour ground-level CO concentrations were obtained with the synoptic version at roadside locations on the traffic link in each hot spot area with the highest traffic volume. The most adverse meteorological conditions possible were specified so that the resulting CO concentrations would be representative of annual maximum values. The 8-hour CO values predicted with the synoptic version (ground-level, source-oriented) could then be considered the maximum levels occurring anywhere in the region during the year. They could then be compared with the air quality standards to determine compliance status for the different alternatives.

Other Pollutants -- The proportional model or "rollback" technique was used to project air quality for HC, NO_x, oxidants, and particulates. In this procedure it is assumed that decreases or increases in the pollutant emission density over a defined area will result in a directly proportional change in the ambient concentrations of the pollutant in that area. The implied relationship between emissions and air quality is expressed by the following equation:

$$\frac{A_2 - B}{A_1 - B} = \frac{E_2}{E_1}$$

where:

A_1 = existing air quality at the location having the highest measured or estimated concentration in the area

A_2 = predicted maximum air quality concentration

B = background concentration

E_1 = existing (1972) emission density

E_2 = predicted emission density at the time of A_2

For hydrocarbons and NO_x, a background of zero is assumed.

While proportional reduction is the least sophisticated modeling procedure, it appears to be the best available technique presently accepted by EPA to estimate future concentrations of HC, NO_x, and particulates for this study. The first two of these pollutants, HC and NO_x, are reactive once emitted into the atmosphere and therefore cannot be successfully modeled with the atmospheric dispersion equations employed with more stable gases such as carbon monoxide. Models which attempt to simulate the atmospheric chemical reactions which lead to photochemical oxidant formation as well as the dispersion have not been validated for any metropolitan areas other than Los Angeles. Proportional modeling is the best available procedure for predicting hydrocarbon and nitrogen oxide concentrations.

Although more accurate and elaborate models are available for particulates, such an analysis was not thought to be warranted because of the insignificant differences in particulate emission densities between the alternatives under investigation.

EVALUATION CRITERIA

The evaluation of air pollution effects in the Baltimore region is examined with reference to two measures--emissions and air quality. The criterion for evaluation of forecast emissions is the total weight of emissions. Criteria used in the evaluation of ambient air quality in this study include: (1) the ambient air quality standards set by the Environmental Protection Agency (EPA) under the Clean Air Act of 1970, (2) the degree of degradation of air that may be expected to occur under alternative transportation programs over the study period, (3) the amount of human exposure to air pollution, and (4) the relationship of pollutant levels to sensitive receptors, as defined below.

Air Quality Standards

In response to requirements of the Clean Air Act of 1970 the Environmental Protection Agency has promulgated ambient air quality standards for the pollutants considered in this study. These have been shown in Table IV-1.

The analysis for future years in this study is designed to assess whether and to what degree the alternative transport plans will cause ambient air quality standards to be exceeded.

Degradation

The decline in air quality is examined in terms of air pollution indices over time. The unit of measure used to evaluate the degree of degradation is total tons of emissions by pollutant for each alternative.

Human Exposure

The impact on the population at large is evaluated by delineating the areas where ambient air quality standards are predicted to be exceeded and summing the total resident population within the areas so affected.

For purposes of comparing alternatives, the resident and employment population of the area where background concentrations of CO exceed 2.0 ppm are given as the indication of human exposure. This level was specified because of the CO diffusion model showed at least this urban background concentration during periods when the model indicated street-level concentrations exceeding the air quality standard.

Sensitive Receptors

Some groups in the population--such as school children, the elderly and the ill--maybe more severely affected by air pollution. These groups are the first and most likely to suffer ill effects from pollution levels which exceed standards. Consideration is given, therefore, to the numbers of persons in these categories that will be exposed to potentially harmful levels of air pollution under the various transportation alternatives being considered.

The impact of air pollutants on sensitive natural and human receptors is determined by specific measures of impact as follows:

- Total number of schools and students within the area where air quality standards may be exceeded.
- Total number of hospitals and hospital beds within the area where air quality standards may be exceeded.
- Total acres of open space within the area where air quality standards may be exceeded.

Impact measures for each of the above receptors are calculated for the area where background CO concentrations equal or exceed 2.0 ppm.

V. INVENTORY OF EXISTING EMISSIONS AND AIR QUALITY DATA

This chapter describes the base condition--the state of air quality in the Baltimore region in the 1970-72 period. This period was selected as representative of the base year, 1970, for the study Alternative 1. It was necessary to select this more extensive base period because of the lack of air quality data for 1970. Most of the base information is derived from 1972 readings, as this was the calendar year from which the best information was available. The results of air quality monitoring by stations of the state and local governments are listed and analyzed. The recorded levels of air pollution are compared to air quality standards to determine the extent to which they are being exceeded.

Stationary and mobile source emissions are examined in detail to determine their major origins by source and jurisdiction. The two emission types are combined to reveal the composite emission totals for each pollutant expressed by weight. From this base, it is possible to compare future year emission levels to determine the trends likely to occur and their meaning for health and welfare issues related to air quality in the Baltimore region.

Ambient Air Quality Data

Baltimore air quality in the base year of 1970 was sufficiently degraded to cause the metropolitan area to become one of 58 out of 247 Air Quality Control Regions in the United States whose ambient air exceeded air quality standards for oxidants, carbon monoxide, or nitrogen dioxide. In Baltimore's case, standards for the first two, CO and oxidants, were exceeded. (14)

For purposes of coming into compliance with ambient air quality standards by 1977, the Baltimore region, according to EPA calculation procedures, must reduce daily morning peak hour (6 - 9 a.m.) hydrocarbon emissions (contributing to oxidant formation) by 70 percent, or 40.4 tons per day from 1972 levels. Carbon monoxide emissions must be reduced by 57 percent, or 967 tons per day. (7) The following discussion describes ambient air quality data in Baltimore as it has been found from monitoring in the base period.

Carbon Monoxide

According to the Environmental Protection Agency statement released July 11, 1973, "health standards for carbon monoxide pollution in Baltimore are exceeded *virtually every working day*, specifically 233 times in 1972." (7)

Data on present CO levels in the Baltimore area are available from two sources:

- The Metropolitan Baltimore Air Quality Stations (MBAQS), a network of 10 monitoring stations spread throughout the Baltimore region (four in Baltimore City, three each in Baltimore County and Anne Arundel County) that have operated since 1965. (8)

- The Statewide Air Monitoring System (AIRMON) that has two stations in the City of Baltimore that began operation in March 1972. AIRMON 1 is located at Green and Lombard Streets, southwest of downtown; AIRMON 2 is at Calvert and 22nd Streets, north of the central business district (CBD). These stations are shown in Figure V-1. (8)

Because of its longer period of operation, more data are available from the MBAQS network on CO levels in the Baltimore region. From 1968 to 1971 the four Baltimore City stations recorded maximum 24-hour average levels in the 20 to 30 ppm range. The six county stations had maximum days that averaged about 10 to 15 ppm.

Maximum 1-hour average concentrations reported from MBAQS stations ranged from 17 to 62 ppm, with the station 1-hour averages generally in proportion to their maximum 24-hour values. While the 1-hour national primary air quality standard of 35 ppm was exceeded at the Baltimore City stations in the 3 preceding years, no violations of the standard were reported in 1971. Although 8-hour average levels were not summarized in the 1968-70 period examination of the data by BAQC revealed that violation of the 8-hour average standard was frequent, according to a report to EPA prepared by GCA Corporation in late 1972. (8)

The most recent calendar 1972 1-hour figures reported by the MBAQS and AIRMON networks, summarized in Table V-1 show that the 1-hour standard was never exceeded. However, several stations reported a number of 8-hour average levels above the 9 ppm standard, as shown in Table V-2. Highest recorded 8-hour average levels reached 17 ppm, almost double the maximum level specified by the national standards.

Analysis of this data indicates consistencies in meteorological conditions correlated with high CO concentrations--CO levels are highest in the fall and winter months and during the morning traffic rush hour (7 - 9 a.m.) and the late evening and overnight period (7 p.m. to 5 a.m.) (8). (Reasons for the unexpected phenomenon of an overnight persistence of high CO levels are discussed below).

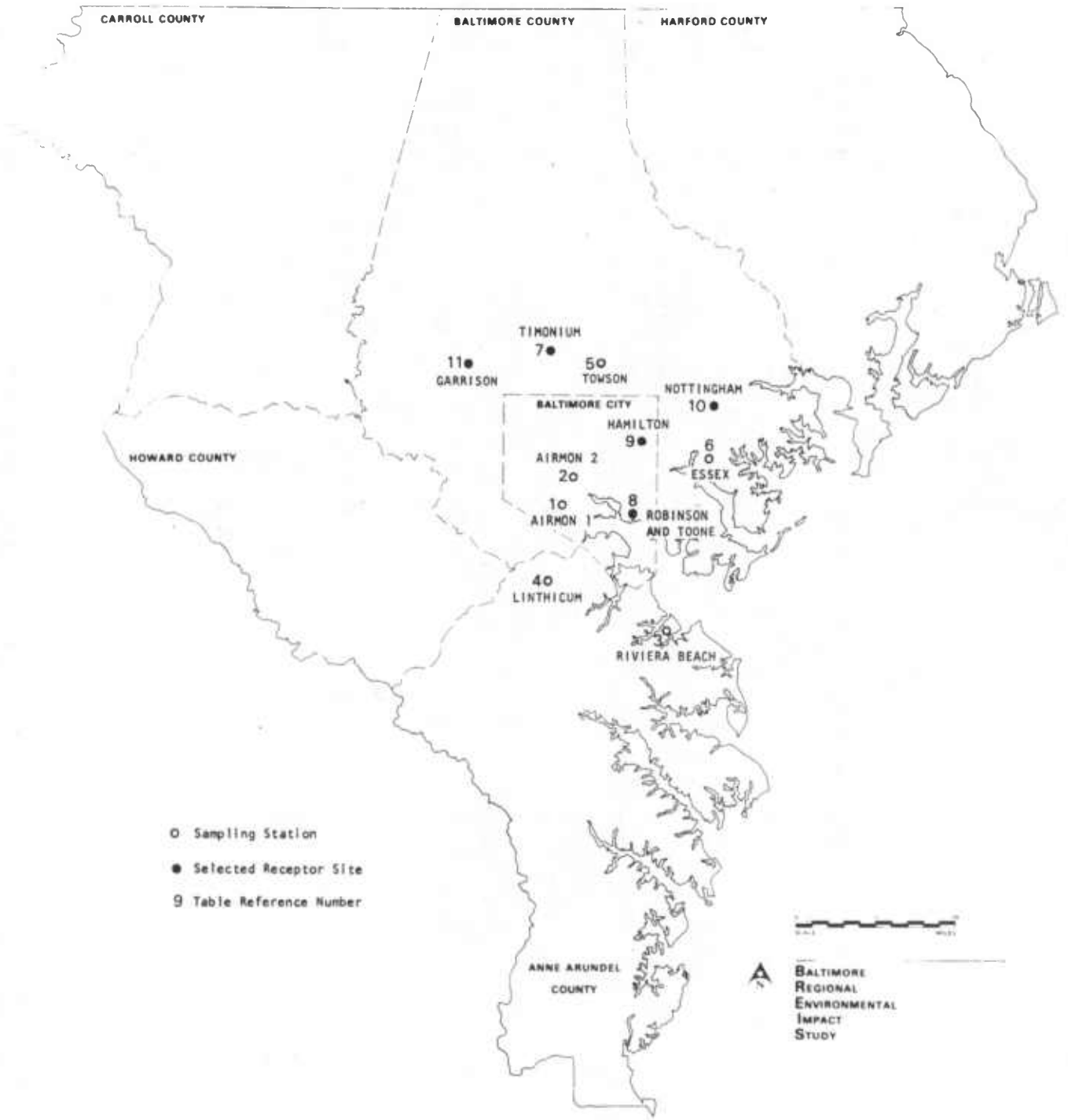


FIGURE V-1. LOCATION OF AIR QUALITY SAMPLING STATIONS AND RECEPTOR SITES

Table V - 1

MAXIMUM 1-HOUR AVERAGE
CARBON MONOXIDE CONCENTRATIONS

1972 Baltimore Area

	Maximum High (ppm)	Date	Hour	Second High (ppm)	Date	Hour
AIRMON 1	12	10/27/72	7- 8 a.m.	10	4/29/72	3- 4 a.m.
					5/19/72	9-10 a.m.
					10/02/72	10-11 p.m.
					10/21/72	12 p.m.-2 a.m.
					11/02/72	4- 5 p.m.
AIRMON 2	14	10/27/72	7- 8 a.m.	13	12/06/72	11-12 a.m.
					12/21/72	1- 2 p.m.
Riviera Beach	14	10/23/72	6- 7 a.m.	13	10/23/72	7- 8 a.m.
Linthicum	14	1/10/72	9-10 a.m.	13	1/20/72	9-10 a.m.
					2/01/72	9-10 a.m.
					10/27/72	8- 9 a.m.
Towson	11	2/01/72	9-10 a.m.	11	4/06/72	8- 9 a.m.
Essex	21	1/20/72	7- 8 a.m.	20	2/29/72	8- 9 a.m.
					11/24/72	11-12 p.m.
					11/25/72	12 p.m.-1 a.m.

Source: Metropolitan Baltimore Air Quality Stations (MBAQS) and Statewide Air Monitoring System (AIRMON) data, 1972.

Table V - 2

MAXIMUM 8-HOUR AVERAGE
CARBON MONOXIDE CONCENTRATIONS

1972 Baltimore Area

	Maximum High (ppm)	Date	8-hour Period	Second High (ppm)	Date	8-hour Period
AIRMON 1	7	10/02-3/72	9 p.m.- 5 a.m.	7	10/07/72	12 p.m.- 8 a.m.
AIRMON 2	10	12/04-5/72	5 p.m.- 1 a.m.	8	3/30/72	12 p.m.- 8 p.m.
Riviera Beach	10	10/23/72	2 a.m.-10 a.m.	9	10/06-7/72	6 p.m.- 2 a.m.
Linthicum	9	10/27-8/72	5 p.m.- 1 a.m.	9	11/03-4/72	6 p.m.- 2 a.m.
Towson	8	2/19/72	11 a.m.- 7 p.m.	8	12/06/72 12/07/72 12/08/72	12 a.m.- 8 p.m. 3 p.m.-11 p.m. 12 p.m.- 8 a.m.
Essex	17	11/24-5/72	7 p.m.- 3 a.m.	16	12/03/72	4 p.m.-12 p.m.

Source: Metropolitan Baltimore Air Quality Stations (MBAQS) and Statewide Air Monitoring System (AIRMON) data, 1972.

The tabulation in Table V-3 shows that 77 percent of the cases where an 8-hour CO average of 5.9 ppm (an arbitrary minimum value used for evaluation) was exceeded at one of the AIRMON stations occurred during the fall season (October-December 1972). AIRMON Station 2 shows, on the average, a 25 percent higher maximum 8-hour level than AIRMON 1.

The high CO levels occurred in about 75 percent of the cases (except for March 29 and 30 and December 6 and 8) under a meteorological situation that is characterized by a high pressure system that is aligned along the Appalachian ridge, with its center covering the Baltimore area. Figure V-2 is a copy of the daily 7:00 a.m. weather map for November 6, 1972, which is characteristic for general conditions which are conducive to elevated or high CO levels.

This meteorological situation is associated with:

1. Clear skies (zero cloud cover)
2. Prevailing winds from WNW to WSW direction as shown by the windrose in Figure V-3
3. Low wind velocities with average velocity of v=4 knots
4. A ground inversion at Sterling, Virginia, indicated by the rawinsonde at 7:00 a.m. with an inversion height ranging from 200-400 m.

The remaining 4 days (March 29 and 30, and December 6 and 8) are characterized by a quasi-stationary front in the Baltimore area, which stabilizes the air near the ground due to the inflow of cold air.

Figure V-4 shows the average daily CO cycle for AIRMON 1 and 2 for days where the 8-hour maximum CO concentration exceeds 5.9 ppm. Several features are evident:

- AIRMON 1 and 2 show a very similar daily variation with a sharp peak at about 7:00 a.m. during the morning rush hour and a second, wider peak between 8 p.m. and midnight
- Both peaks are slightly more pronounced at AIRMON 2, which probably reflects the heavier traffic density in the downtown business district during the rush hours
- AIRMON 1 is located SSW of AIRMON 2 and might be less influenced by the downtown area during the prevailing westerly winds.

TABLE V-3

EIGHT-HOUR MAXIMUM CO-CONCENTRATION
Baltimore AIRMON Stations
1972

Date	AIRMON 1 (ppm)	AIRMON 2 (ppm)
3/29/72	3	7
3/30/72	5	8
4/13/72	4	6
7/18/72	4	6
10/2/72	7	6
10/3/72	6	5
10/11/72	6	5
10/20/72	4	6
10/21/72	6	3
10/26/72	4	6
10/27/72	6	6
11/6/72	3	7
11/7/72	7	6
11/25/72	5	6
12/3/72	6	10
12/6/72	5	7
12/8/72	5	8

SOURCE: AIRMON Data Recordings of CO Levels, March-December 1972.

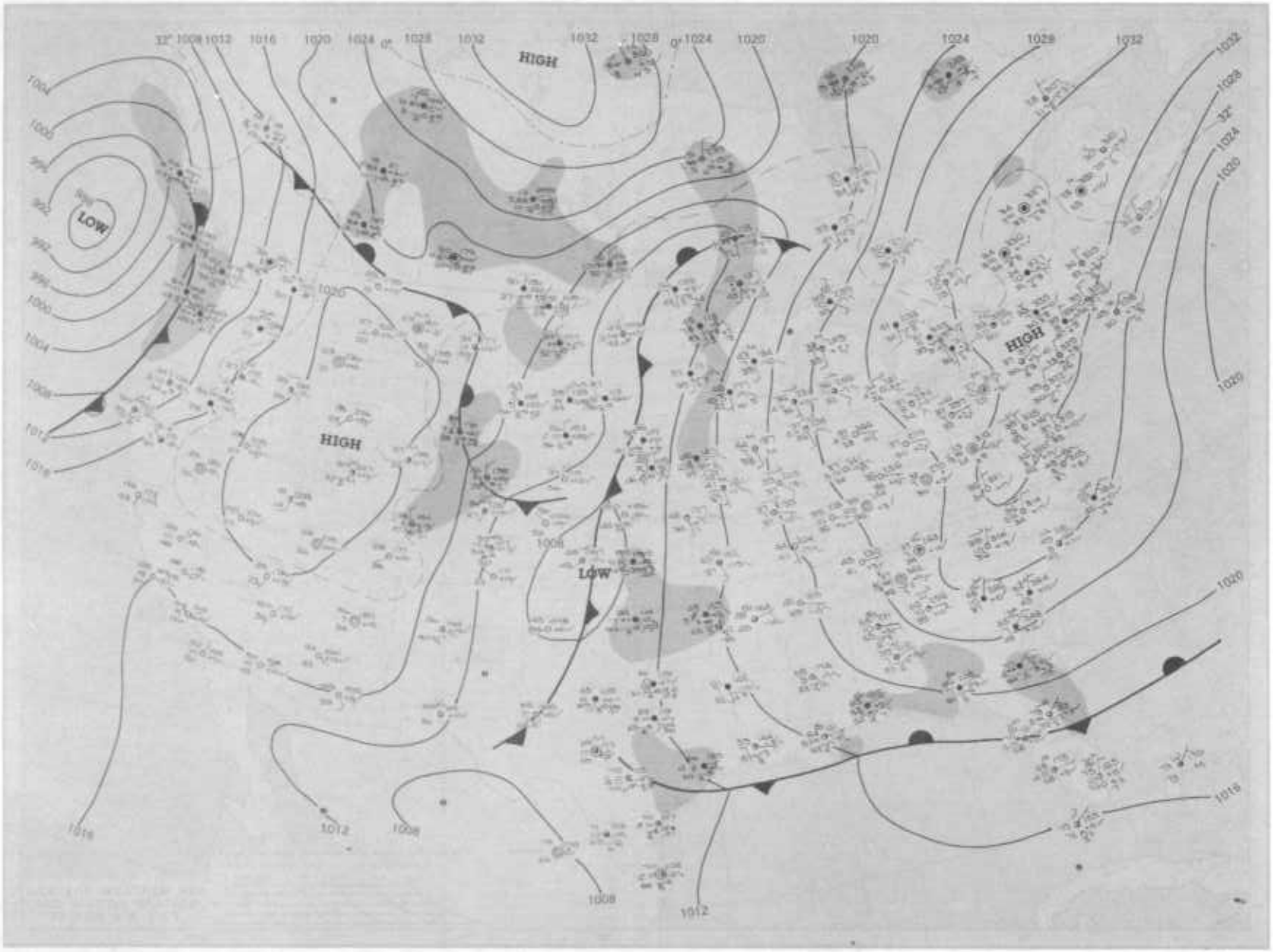


FIGURE V-2. SURFACE WEATHER MAP, NOVEMBER 6, 1972, 7 A.M. EST

SOURCE U.S. DEPARTMENT OR COMMERCE

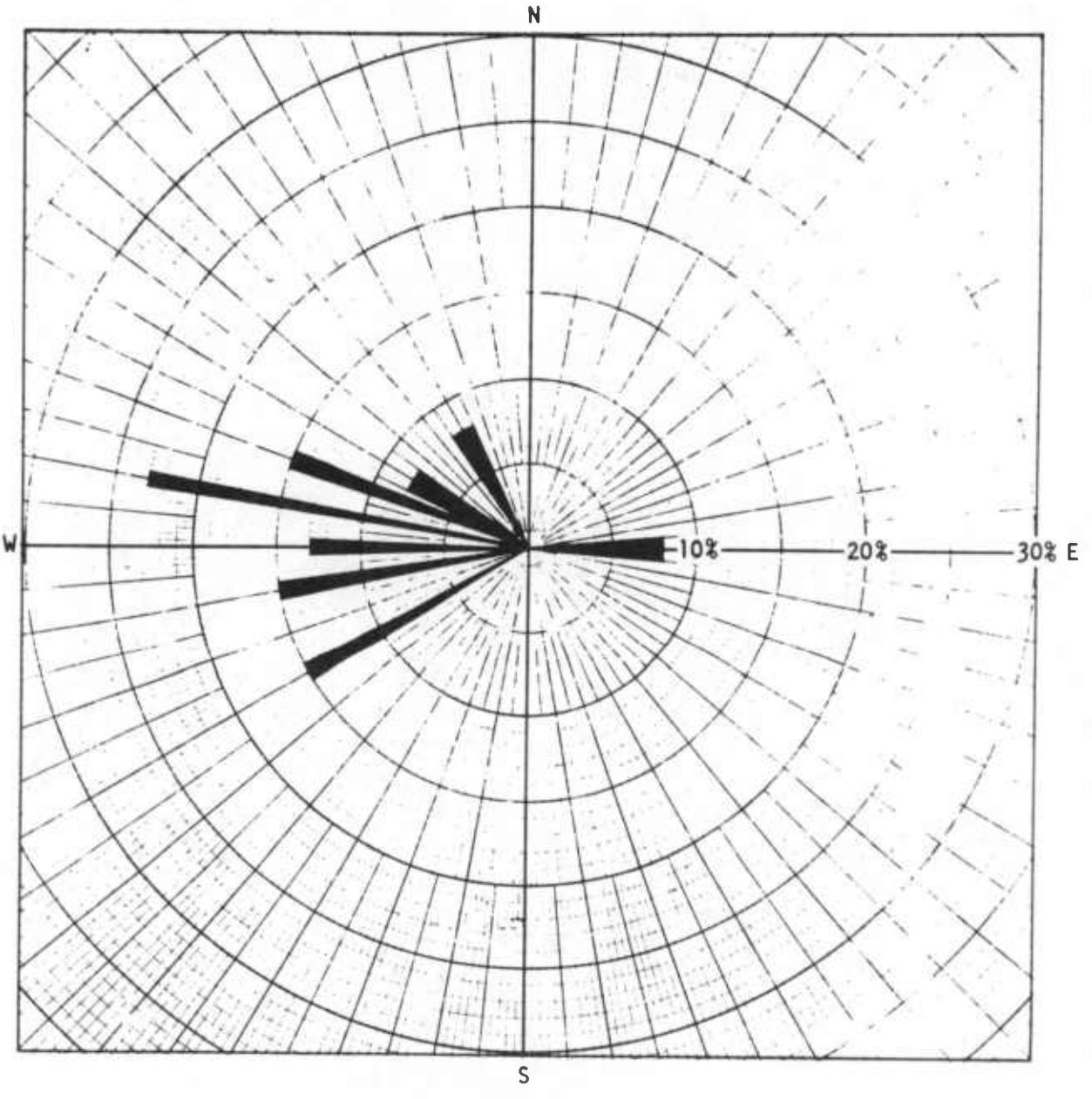


FIGURE V-3. WINDROSE FOR ELEVATED CO CONENTRATIONS IN BALTIMORE

SOURCE: BALTIMORE LOCAL CLIMATOLOGICAL DATA, U.S. DEPARTMENT OF COMMERCE.

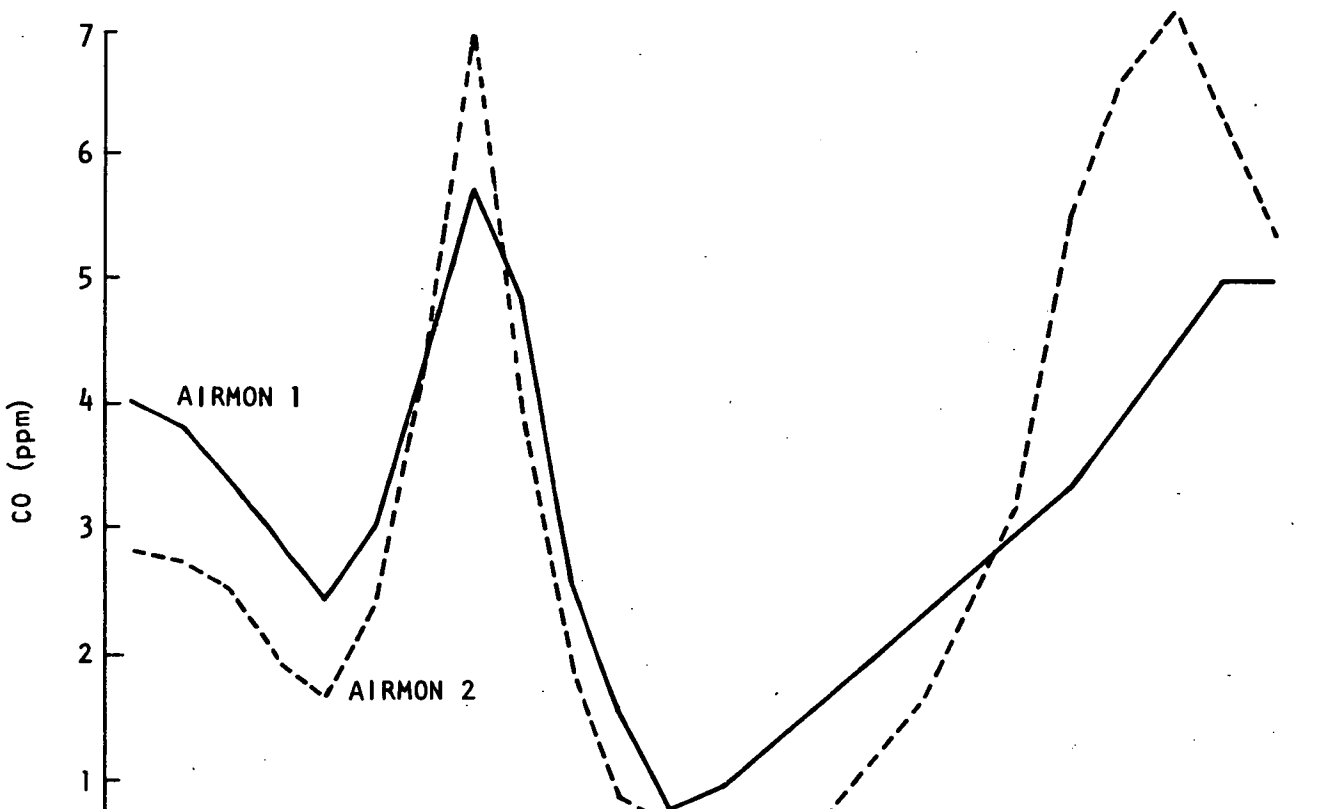


FIGURE V-4. AVERAGE DAILY CO CYCLE FOR DAYS WITH A HIGH PRESSURE SYSTEM

SOURCE AIRMON DATA RECORDINGS OF CO LEVELS, 1972.

The prevailing meteorological situation causes strong radiation cooling in the evening, which starts stabilizing the air near the ground about one hour before sunset. During the night, the City air is probably close to isothermal, topped by a low level inversion. The CO level in the City during the evening and night hours is probably determined by two factors--the traffic and removal by inflow of cleaner air from the surrounding suburbs.

Since CO is chemically very stable in the atmosphere, the CO concentration in a fixed volume of air will steadily increase with continuing CO emissions into the volume. This may explain the steady increase of the CO concentration during the evening hours as long as traffic continues. Later, during the night, the CO concentration decreases slowly as cleaner air moves into to the City. This mechanism would also explain why AIRMON 2 shows a sharper evening peak with higher absolute CO values than AIRMON 1 and why the two stations show very similar values between midnight and 4:00 a.m. Also, as noted above, AIRMON 2 is probably influenced by the increased traffic in the business district during the evening hours. Its CO concentration, however, decreases later as cleaner air flows in after the main traffic ceases.

The morning rush hour starts before the air over the City becomes destabilized by the radiational heating after sunrise. Increased ventilation and vertical mixing during the morning and early afternoon reduces the CO concentration in the City air rapidly and causes the pronounced minimum at both stations during the daytime hours.

During the summer months the CO concentrations are much lower due to earlier sunrise and later sunset, which enhance mixing during the morning and evening rush hours.

Oxidants

Standards for photochemical oxidant pollution in Baltimore were exceeded at least 119 hours in 1972 at the AIRMON 2 monitoring station and several times at the AIRMON 1 station, both on the fringe of the Baltimore CBD.

Although there is sufficient data to satisfy EPA that an oxidant problem exists and that standards are being violated, the photochemical oxidant problem in the Baltimore region is beset by uncertainty both as to the location and degree of the problem.

Part of the uncertainty arises from the lack of good data with which to measure the problem. The 10 MBAQS stations have oxidant measurements

taken by using grab samples which are analyzed by the phenolphthalein wet chemistry method, which is not an approved equivalent to the preferred chemiluminescence reference method. The two AIRMON stations have reference method oxidant instruments and methane instruments with which to provide accepted oxidant measurements. The AIRMON stations have, however, collected such data only since March 1972.

The measurements taken by the MBAQS stations show maximum oxidant levels at or just below the .08 ppm standard at all but one station. The exception shows a relatively high reading of .115 ppm. Since this station shows high readings for other pollutant measures, this is not necessarily an anomoly. The station (Riviera Beach) is located southeast of the central business district and the harbor industrial area and likely reflects the emission generating potential of these two areas. Based on the MBAQS readings of oxidant levels generally within standards, the State's original implementation plan concluded the 1-hour oxidant standard would be met in 1975 through the Federal Motor Vehicle Control Program and stationary source controls.

The AIRMON stations have been operating only long enough to record oxidant levels for the 1972 summer season. Oxidant levels were found to be appreciably higher than the top measurement obtained at the MBAQS stations.

During the period of June through September 1972, the one hour maximum oxidant concentration of .08 ppm was exceeded at AIRMON 2 on 27 days with a maximum of .21 ppm; the standard was exceeded at AIRMON 1 on six days, with an hourly maximum of .12 ppm. The ratio of the maximum one hour oxidant concentration at AIRMON 2, C_{OX2}, to the maximum one hour oxidant concentration at AIRMON 1, C_{OX1}, for the days where AIRMON 2 exceeded .08 ppm, was determined from the BAQC data to be:

$$\frac{C_{OX2}}{C_{OX1}} = 1.6 \pm .2$$

Figure V-5 shows the average diurnal oxidant concentration at both stations for the cases where AIRMON 2 exceeded the 1-hour standards.

Data on 1-hour oxidant concentrations on days when levels exceeded .08 ppm at the AIRMON Stations is contained in Table V-4. The number of hours in 1972 when oxidant concentrations exceeded standards at each AIRMON station are shown in the accompanying graphs, Figures V-6 and V-7.

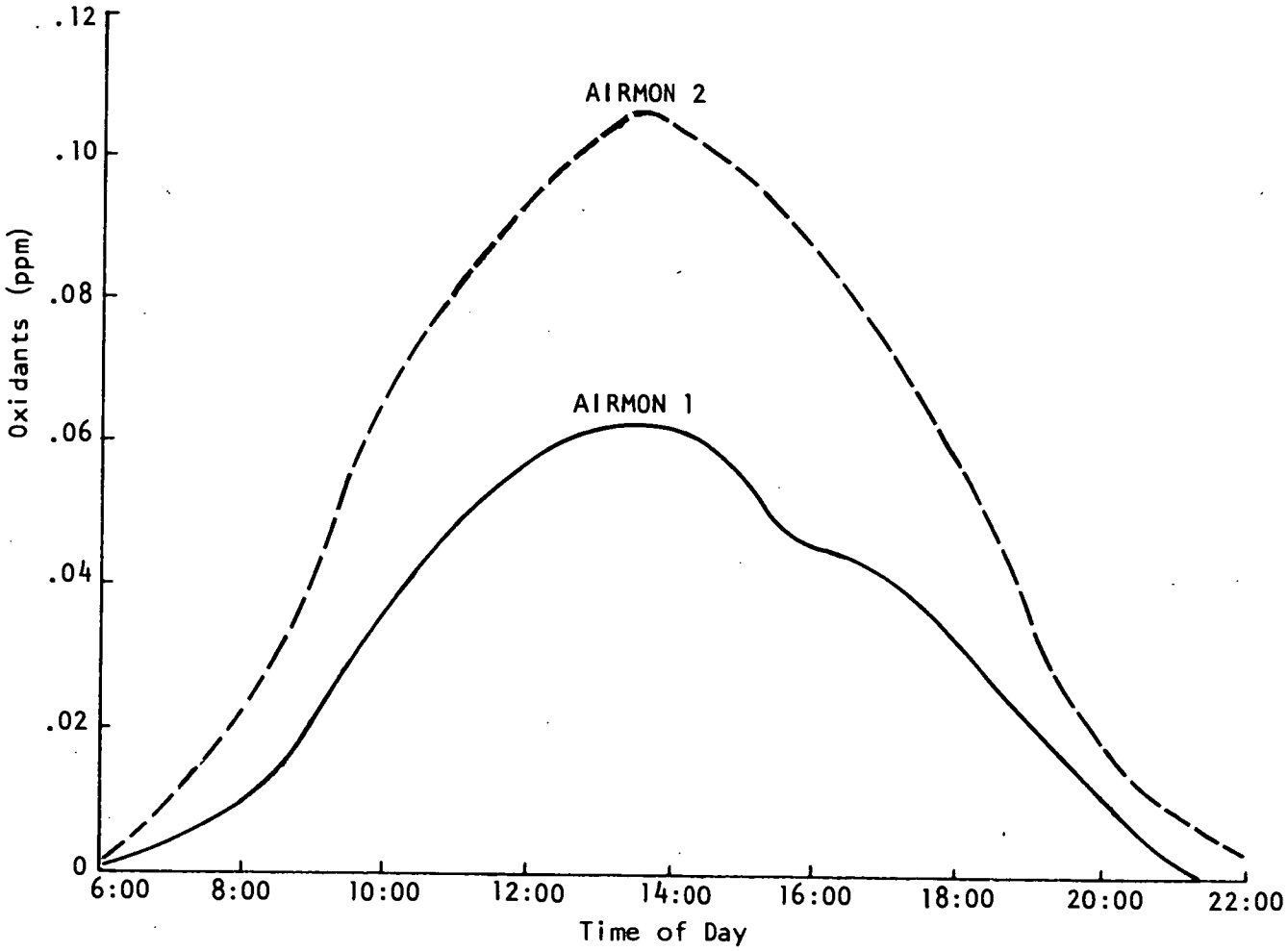


FIGURE V-5. DAILY CYCLE OF THE AVERAGE OXIDANT CONCENTRATION AT AIRMON 1 AND 2, MAY-JULY, 1972, FOR DAYS WHEN AIRMON 2 EXCEEDED THE MAXIMUM 1-HOUR CONCENTRATION

SOURCE: AIRMON DATA RECORDINGS OF OXIDANT LEVELS, 1972.

Table V - 4

1-HOUR OXIDANT CONCENTRATIONS OVER 0.08 PPM
BALTIMORE AIRMON STATIONS - 1972

	Date 1972	Maximum One-Hour Concentration	Time of Day Exceeded	Hours Exceeded
AIRMON 1				
(Green & Lombard Sts.)	June 4	0.09	2pm- 3pm	1
	July 2	0.10	2pm- 4pm	2
	July 14	0.11	12am- 3pm	3
	July 17	0.10	12am- 1pm	1
	July 19	0.10	12am- 3pm	3
	Aug. 26	0.12	1pm- 4pm	3
AIRMON 1 TOTAL				13
AIRMON 2	May 18	0.09	2pm- 3pm	1
(Calvert & 22nd St.)	May 22	0.13	12am- 3pm	3
	May 23	0.09	2pm- 4pm	2
	May 24	0.13	11am- 7pm	8
	June 3	0.11	11am- 6pm	7
	June 4	0.14	10am- 5pm	7
	June 16	0.10	12am- 1pm	1
	June 30	0.11	11am-12am	1
	July 11	0.12	12am- 1pm	1
	July 14	0.19	11am- 3pm	4
	July 15	0.10	11am- 1pm	2
	July 16	0.10	11am- 3pm	4
	July 17	0.12	11am-11pm	12
	July 18	0.12	1pm- 2pm	1
	July 19	0.20	9am- 6pm	9
	July 20	0.12	10am-11pm	13
	July 21	0.11	11am-11pm	12
	Aug. 11	0.09	2pm- 3pm	1
	Aug. 12	0.13	12am- 5pm	5
	Aug. 26	0.21	11am- 5pm	6
	Aug. 27	0.09	12am- 2pm	2
	Sept. 1	0.12	12am- 3pm	3
	Sept. 7	0.09	5pm- 6pm	1
	Sept. 8	0.15	10am- 5pm	7
	Sept. 16	0.09	1pm- 2pm	1
	Sept. 17	0.09	4pm- 5pm	1
	Sept. 26	0.11	12am- 4pm	4
AIRMON 2 TOTAL				119

Source: AIRMON Data Recording of Oxidant Levels, 1972.

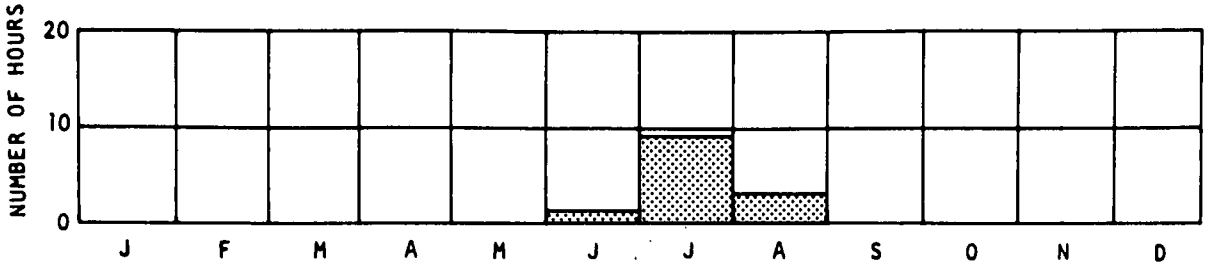


FIGURE V-6. TOTAL MONTHLY HOURS OXIDANT CONCENTRATIONS IN EXCESS OF STANDARDS (0.08 PPM) BALTIMORE AIRMON STATION 1, 1972

SOURCE: AIRMON DATA RECORDINGS OF OXIDANT LEVELS, 1972.

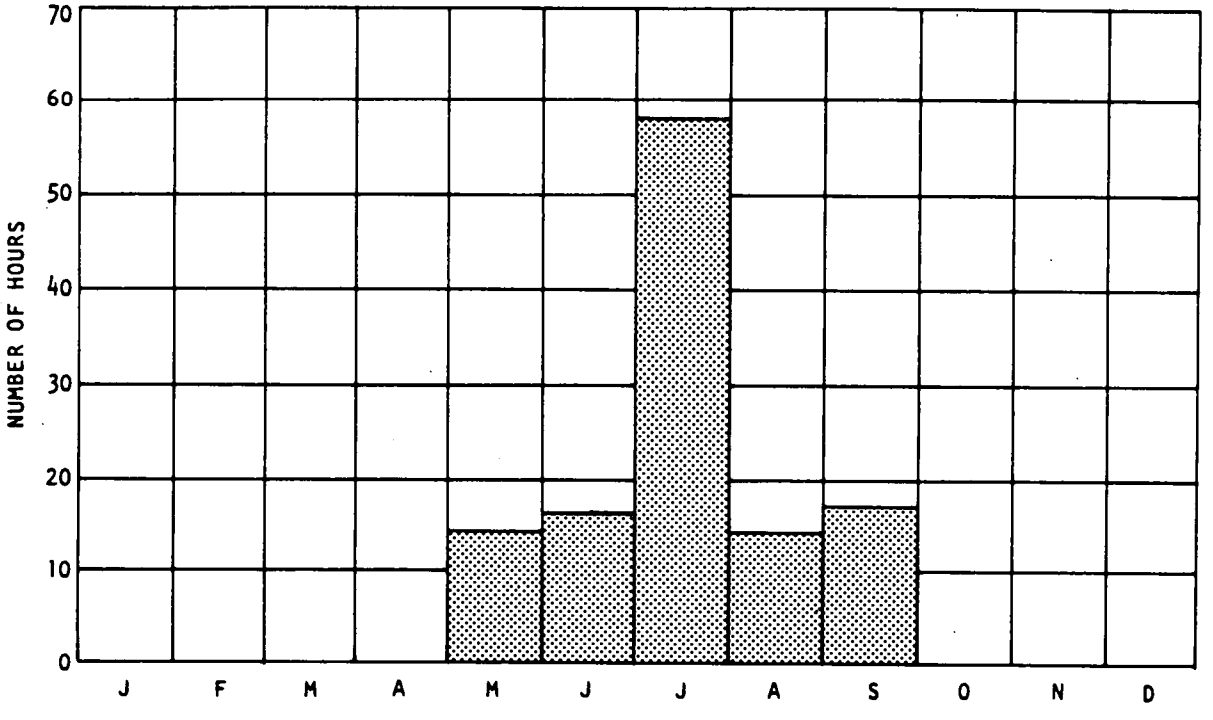


FIGURE V-7. TOTAL MONTHLY HOURS OXIDANT CONCENTRATIONS IN EXCESS OF STANDARDS (0.08 PPM) BALTIMORE AIRMON STATION 2, 1972

SOURCE: AIRMON DATA RECORDINGS OF OXIDANT LEVELS, 1972

Since the data have been measured by an accepted method there is no reason to doubt their validity. High oxidant levels are found under high pressure stagnation conditions with 65 percent of the wind-frequency coming out of the SSW to WSW sector (see Figure V-8). Oxidants are not directly emitted from automobiles but are formed by chemical reaction from emissions of nitrogen oxides and hydrocarbons in the presence of sunlight. The oxidant concentration results from a dynamic equilibrium between the rate of formation in the presence of light and the rate of consumption by chemical processes. As expected, with increasing light intensity in the morning, the oxidant level increases to reach its maximum between noon and 1:00 p.m. As the sun angle and the amount of primary pollutants decrease in the afternoon, there is a decrease in oxidant level.

The question arises why oxidant readings at AIRMON 2 differ so much from those at AIRMON 1. Again, this seems to be related to the meteorology of the area. The highest oxidant levels are expected to be found downwind from the location of highest emissions. AIRMON 1 and 2 are approximately two miles apart, Station 2 being located in a northeasterly direction of Station 1. For the prevailing winds (Figure V-8) AIRMON 2 is located about 2 miles downwind from Station 1 with the main downtown business district between them. Higher oxidant values, therefore, are to be expected at AIRMON 2 compared to AIRMON 1, which agrees well with the actual measurements. Even higher oxidant values downwind from AIRMON 2 cannot be ruled out.

Examination of the graphs of the data in Figure V-6 and V-7 leads to the following generalized conclusions:

- The oxidant problem is a warm weather phenomenon, the data showing its occurrence only in the months from May to September.
- Oxidant levels in excess of standards are not spread evenly throughout the region as shown by the number of hours in excess of standards being considerably greater at AIRMON 2 than at AIRMON 1.
- Correlation between readings at the two AIRMON stations is good for conditions with high oxidant levels.
- Existing maximum oxidant levels in Baltimore exceed the air quality standard by more than 160 percent.

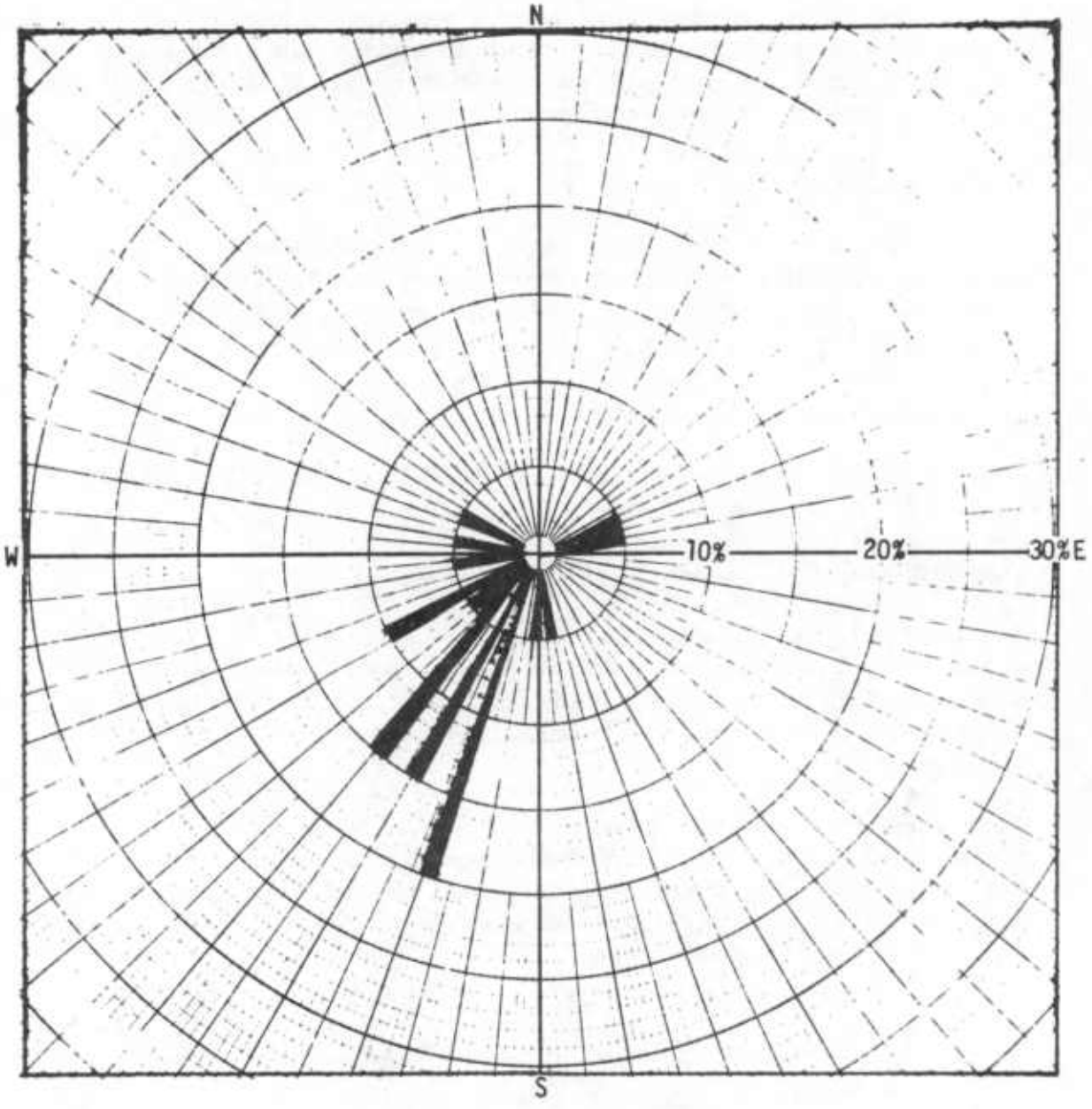


FIGURE V-8. WINDROSE DURING HOURS WHEN MAXIMUM 1-HOUR OXIDANT CONCENTRATION IS EXCEEDED AT AIRMON 2

SOURCE: BALTIMORE LOCAL CLIMATOLOGICAL DATA, U.S. DEPARTMENT OF COMMERCE

- Detailed examination of the measurements and prevailing meteorological conditions revealed a consistent and expected correlation between oxidant concentrations and certain weather conditions: high sunlight intensity, clear skies or few clouds, high temperatures and low wind speeds.

Nitrogen Oxides

Current data on oxides of nitrogen readings are not discussed in detail in this memorandum as the sampling procedures which had been used have come under question by the EPA, and are not useful for consideration at this time. The data are, however, shown in Table V-5.

Particulate Matter

Particulate readings are collected at the MBAQS stations; 1972 readings provide the data shown in Table V-5.

COMPARISON TO AIR QUALITY CRITERIA

As required by the Federal Clean Air Act of 1970, national primary and secondary ambient air quality standards have been established for carbon monoxide (CO), hydrocarbons (HC), nitrogen dioxide (NO_x), photochemical oxidants (O_x), and particulate matter. (9) The current standards are listed in Table V-1.

To determine the status of Baltimore regional air quality with respect to these standards, a comparison was conducted between the standards and the air quality readings taken at various monitoring stations in the Baltimore region, in central city and in suburban areas. Readings at six stations were considered:

1. AIRMON 1 -- Green and Lombard Streets, Baltimore City
2. AIRMON 2 -- Calvert and 22nd Streets, Baltimore City
3. MBAQS -- Riviera Beach
4. MBAQS -- Linthicum
5. MBAQS -- Towson
6. MBAQS -- Essex

The locations of these stations are mapped in Figure V-1. Data from other sampling stations was not considered valid for several reasons:

Table V - 5

SUMMARY OF EXISTING AIR QUALITY - BALTIMORE REGION
(1972 Data)

Pollutant	Averaging Time	Sampling Station: AIRMON 1 (1)	AIRMON 2 (2)	Riviera Beach (3)	Linthicum (4)	Towson (5)	Essex (6)	National Air Quality Standard
Carbon Monoxide (ppm)	1-hour maximum	12	14	14	14	11	21	
	2nd highest 1-hour	10	12	13	13	10	20	35 ppm
	8-hour maximum	7	10	10	9	8	17	
	2nd highest 8-hour	7	8	9	9	8	16	9 ppm
Non-Methane Hydrocarbons (ppm)	3-hour maximum (6-9 am)	2.1	2.8	---	---	---	---	0.24 ppm
Nitrogen Dioxide (ppm)	annual arithmetic mean	0.05 *	0.06 *	---	---	---	---	0.05 ppm
Photochemical Oxidants (ppm)	1-hour maximum	0.12	0.21	---	---	---	---	
	2nd highest 1-hour	0.11	0.20					0.08 ppm
Particulate Matter ($\mu g/m^3$)	24-hour maximum	not collected	not collected	261	165	225	213	primary-- 260 $\mu g/m^3$ secondary 150 $\mu g/m^3$
	annual geometric mean	not collected	not collected	60	63	60	75	primary-- 75 $\mu g/m^3$ secondary-- 60 $\mu g/m^3$

Source: MBAQS and AIRMON Data; EPA (Standards).

- Baltimore City has determined that excess moisture had invalidated the readings.

- Independent samples taken at some of the sites recorded significantly lower CO levels.

- Readings did not follow normal diurnal variations as related to meteorology or normal traffic flow patterns.

The maximum reading for 1972 was extracted from the records of each station along with the second highest reading in cases where national standards specify the standard is not to be exceeded more than once a year. Accordingly, the comparison demonstrates whether the standards are being exceeded in the Baltimore region and, if so, by how much. Exceeding the standard at even one station is sufficient to place the Baltimore region in violation of EPA regulations and to require implementation of pollution control strategies. It is noted that the State Implementation Plan for the Baltimore Intrastate Air Quality Control Region cites a maximum 8-hour CO value of 21 ppm. This reading, however, was recorded in 1971 at one of the stations subsequently found to show invalid measurements as noted above. For this reason, the more accurate 1972 data was used as shown in Table V-5.

Table V-5, Summary of Existing Air Quality, displays the appropriate readings for each station. The table also lists, in the right-hand column, the relevant national air quality standard for comparison purposes. Inspection of the table reveals the following findings and conclusions regarding Baltimore regional air quality.

Overview

The present air quality in the Baltimore region exceeds the national air quality standards in all five categories of air pollutants examined.

Carbon Monoxide

The 1-hour maximum standard is not violated at any of the stations. Second highest 1-hour levels fall in the 10-20 ppm range, well below the 35 ppm national standard. The highest 1-hour level is 21 ppm.

The monitoring station with the highest CO readings exceeded the 8-hour maximum standard by 78 percent. Considering the highest 8-hour maximum for the stations in question, three of the six stations recorded CO levels in excess of standards with one additional borderline case.

Hydrocarbons and Photochemical Oxidants

Hydrocarbon concentrations at AIRMON stations 1 and 2 exceeded the 3-hour (6-9 a.m.) maximum standard of .24 ppm by a factor of approximately 10. The highest recorded readings at AIRMON 1 and 2 in 1972 were 2.1 ppm and 2.8 ppm respectively.

Reliable photochemical oxidant readings taken at the two Baltimore AIRMON stations during their first year of operation, April 1972-1973, showed 1-hour maximum oxidant standards of .08 ppm were exceeded at both stations. AIRMON 1 and 2 had high readings for the year of .12 ppm and .21 ppm respectively. The second highest 1-hour levels were only slightly less: .11 ppm at AIRMON 1 and .20 ppm at AIRMON 2. Hence, the most severe oxidant level recorded is over twice the national air quality standards.

Nitrogen Dioxide

Nitrogen dioxide levels at the two sampling locations equal or marginally exceed the national air quality standard of .05 ppm annual arithmetic mean. Nitrogen dioxide readings at the AIRMON stations averaged out to .05 ppm at AIRMON 1 and .06 ppm at AIRMON 2 during 1972. As previously mentioned, the standard method of measurement has been changed for NO_2.

Particulate Matter

National primary air quality standards for particulate matter are met or exceeded only marginally in Baltimore. Secondary standards are exceeded at several monitoring stations by significant amounts.

The 24-hour maximum primary standard of 260 $\mu g/m^3$ is exceeded only at Riviera Beach among the six selected stations examined. There, a marginal reading of 261 $\mu g/m^3$ was attained in 1972. All four stations for which particulate data was available exceeded the 150 $\mu g/m^3$ secondary standard, with maxima ranging from 165 to 261 $\mu g/m^3$. The annual geometric mean primary standard of 75 $\mu g/m^3$ was matched at one station; exceeded at none. The secondary annual geometric mean standard of 60 $\mu g/m^3$ was exceeded at two of the four stations with readings of 63 and 75; matched at the remaining two stations that recorded averages of 60 $\mu g/m^3$.

STATIONARY SOURCE EMISSIONS

The majority of the large stationary sources in the Baltimore metropolitan region consists of industrial processors, power plants, and institutions. Emissions are generated by both fuel combustion and manufacturing processes. Total emissions from stationary point sources with annual emissions of a single pollutant in excess of 100 tons and area sources, broken down by county, are shown in Table V-6.

Over 90 percent of stationary source air pollutant emissions in all categories except hydrocarbons originate from point sources. In the Baltimore region, 66 percent of HC emissions originate from point sources. This is significant to the extent that non-methane hydrocarbons can contribute to the formation of photochemical oxidants, although no severe health effects are directly attributable to most hydrocarbons.

Carbon monoxide from stationary sources is generated primarily in Baltimore City (55 percent) and Baltimore County (42 percent); together they account for 97 percent of all regional emissions of CO from stationary sources.

Baltimore City is also highest in percent of regional emissions of hydrocarbons from stationary sources, its share being 58 percent. Most of the remainder is divided between Baltimore County (20 percent) and Anne Arundel County (18 percent).

Oxides of nitrogen emissions from stationary sources are heaviest in Baltimore County (48 percent), reflecting its heavy industrialization. With respect to NO_x, the remainder comes from Baltimore City (25 percent), Anne Arundel County (26 percent), and 1 percent from Harford County. The greater share of regional stationary source sulfur dioxide emissions is also found in Baltimore County (51 percent), again a function of its heavy industrial sector. Baltimore City (23 percent) and Anne Arundel County (25 percent) account for most of the remainder.

Particulate emissions from stationary sources come primarily from Baltimore County, with 66 percent of the total. Baltimore City has 17 percent, followed by Anne Arundel and Carroll Counties, both having 7 percent. The percentage of regional emissions in all categories of pollutants produced in Carroll, Howard and Harford Counties is negliable with the one exception of suspended particulates in Carroll County mentioned above.

Table V - 6

EMISSIONS FROM STATIONARY POINT AND AREA SOURCES
BY JURISDICTION
METROPOLITAN BALTIMORE REGION 1971

Emissions in Tons/Year

		CO	Percent	HC	Percent	NO_x	Percent	SO_2	Percent	Particulates	Percent
Baltimore City:	Point	38,743	54	16,675	39	20,744	22	46,490	21	14,074	17
	Area	363	1	8,090	19	2,424	3	3,336	2	260	0
Baltimore County:	Point	28,924	40	5,116	12	43,091	45	108,668	50	54,926	65
	Area	1,603	2	3,525	8	2,583	3	2,101	1	1,080	1
Anne Arundel County:	Point	878	1	5,781	14	23,814	25	51,873	24	5,481	6
	Area	758	1	1,621	4	1,134	1	1,082	1	510	1
Carroll County:	Point	23	0	282	1	312	0	1,039	0	5,812	7
	Area	307	0	469	1	107	0	112	0	76	0
Howard County:	Point	0	0	9	0	164	0	428	0	1,572	2
	Area	80	0	177	0	202	0	223	0	81	0
Harford County:	Point	380	1	226	1	937	1	1,759	1	313	1
	Area	262	0	630	1	351	0	365	0	180	0
			100		100		100		100		100
Total All Jurisdictions BREIS Study Area:		72,321		42,601		95,863		217,476		84,365	
Point Source as percent of total:			95		66		93		97		97

Source: Maryland Bureau of Air Quality Control, Table 1-10,"Large Stationary Sources, Metropolitan Baltimore Region," Baltimore: October 15, 1971.

MOBILE SOURCE EMISSIONS

The results of the 1970 pollutant emission calculations for individual links, residual traffic, and trip end emissions are summarized in Table V-7. They are subtotaled for traffic inside and outside the Beltway, and also for LDV and HDV running emissions, cold starts, and evaporation.

These calculations indicate that about 6 percent of the emissions, and hence, a smaller percentage of the VMT, are from HDV. Cold start and hot soak emissions are relatively greater inside the Beltway than outside, probably due to more trip ends in this area. Overall, 12.8 percent of carbon monoxide and 6.8 percent of hydrocarbon emissions are from cold starts. Twenty-six percent of hydrocarbon emissions are from evaporation (hot soak), since most of the vehicles on the road in 1970 did not have controls to reduce carburetor evaporation losses.

The emissions totals in the BMATS area using this link-specific method compare very well with 1970 emission estimates for the same BMATS study area prepared by the Bureau of Air Quality Control. The corresponding values from the two different data bases are shown in Table V-8. The same set of emission factors was used in both cases, but BAQC generated trip end data by interpolating 1962 and 1980 forecast trip ends and approximated VMT and average speeds with the Koppelmann Model, a less sophisticated model than those used in the present investigation. The lower CO and hydrocarbon and higher NO_x totals by the link specific method indicate that predicted average speeds are higher in the new traffic simulations than with the Koppelmann Model.

COMPOSITE EMISSIONS

The aggregate of all existing emissions, mobile and stationary, for the region are contained in Tables V-9 through V-13. The percentage of the total regional air pollution contributed by each source and jurisdiction is illustrated by the pie charts in Figure V-9.

Carbon Monoxide -- Highway transportation, at 82 percent, is by far the largest contributor to the region's carbon monoxide levels. The jurisdictions in which the carbon monoxide problem predominates are Baltimore City and Baltimore County which, together, account for 71 percent of the total carbon monoxide released in the region.

Hydrocarbons -- Highway transportation again produces the largest share (63 percent) of regional air pollution from hydrocarbons, though to a

Table V - 7

1970 MOTOR VEHICLE EMISSIONS
BALTIMORE METROPOLITAN STUDY AREA (BMATS)

	Pollutant Emissions, Tons/Day			
	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides	Suspended Particulates
Inside Beltway				
LDV Running Emissions	502.5	74.7	57.4	3.0
HDV Running Emissions	23.5	4.4	2.5	0.2
Cold Starts	92.1	9.8	----	---
Evaporation (Hot Soak)	---	38.0	----	---
TOTAL Inside Beltway	618.1	126.9	59.9	3.2
Outside Beltway				
LDV Running Emissions	331.0	50.7	42.0	2.1
HDV Running Emissions	24.4	4.6	2.7	0.2
Cold Starts	37.0	4.0	---	---
Evaporation (Hot Soak)	---	15.1	---	---
TOTAL Outside Beltway	392.4	74.4	44.7	2.3
Total Motor Vehicle Emissions in BMATS Area	1,010.5	201.3	104.6	5.5
Total Annual Motor Vehicle Emissions in BMATS Area in Tons/Year (365 day year)	368,833	73,475	38,179	2008

Table V - 8

COMPARISON OF MOBILE SOURCE EMISSION TOTALS
FOR BMATS AREA - 1970

	Regional Total		BREIS Total
	BREIS Value	BAQC Value	BAQC Total
VMT/day in millions	17.84	16.69	1.07
Pollutants in tons per year			
Carbon Monoxide	368,832	413,076	.89
Hydrocarbon	73,475	88,514	.83
Oxides of Nitrogen	38,179	37,449	1.02
Particulate Matter	2,008	n.a.	---

Table V - 9

CARBON MONOXIDE EMISSIONS IN BALTIMORE REGION
1971
(in tons/year)

Source	Baltimore City	Baltimore County	Anne Arundel County	Carroll County	Howard County	Harford County	Total
Mobile Sources							
Highway	163,926	159,372	72,856	18,214	13,660	27,321	455,349
Other Transportation	972	1,200	25,253	70	61	110	27,666
Stationary Sources							
Point	38,743	28,924	878	23	0	380	68,948
Area	363	1,603	758	307	80	262	3,373
TOTALS	204,004	191,099	99,745	18,614	13,801	28,073	555,336

Source: Maryland State Department of Health and Mental Hygiene, Environmental Health Administration, Bureau of Air Quality Control. Plan for the Implementation of the Ambient Air Quality Standards of the Metropolitan Baltimore Intrastate Air Quality Control Region, May 1972.

Table V - 10

HYDROCARBON EMISSIONS IN BALTIMORE REGION
1971
(in tons/year)

Source	Baltimore City	Baltimore County	Anne Arundel County	Carroll County	Howard County	Harford County	Total
Mobile Sources							
Highway	30,841	32,655	14,513	3,628	3,629	5,443	90,709
Other Transportation	409	449	9,386	17	14	25	10,300
Stationary Sources							
Point	16,675	5,116	5,781	282	9	226	28,089
Area	8,090	3,525	1,621	469	177	630	14,512
TOTALS	56,015	41,745	31,301	4,396	3,829	6,324	143,610

Source: Maryland State Department of Health and Mental Hygiene, Environmental Health Administration, Bureau of Air Quality Control. Plan for the Implementation of the Ambient Air Quality Standards of the Metropolitan Baltimore Intrastate Air Quality Control Region, May 1972.

Table V - 11

NITROGEN OXIDE EMISSIONS IN BALTIMORE REGION

1971

(in tons/year)

Source	Baltimore City	Baltimore County	Anne Arundel County	Carroll County	Howard County	Harford County	Total
Mobile Sources							
Highway	16,026	16,969	7,542	1,885	1,885	2,828	47,135
Other Transportation	233	1,697	4,169	73	63	116	6,351
Stationary Sources							
Point	20,744	43,091	23,814	312	164	937	89,062
Area	2,424	2,583	1,134	107	202	351	6,801
TOTALS	39,427	64,340	36,659	2,377	2,314	4,232	149,349

Source: Maryland State Department of Health and Mental Hygiene, Environmental Health Administration, Bureau of Air Quality Control. Plan for the Implementation of theAmbient Air Quality Standards of the Metropolitan Baltimore Intrastate Air Quality Control Region, May 1972.

Table V - 12

SULFUR DIOXIDE EMISSIONS IN BALTIMORE REGION

1971
(in tons/year)

Source	Baltimore City	Baltimore County	Anne Arundel County	Carroll County	Howard County	Harford County	Total
Mobile Sources							
Highway	934	1,079	439	110	97	170	2,829
Other Transportation	995	1,351	4,488	14	11	20	6,879
Stationary Sources							
Point	46,490	108,668	51,873	1,039	428	1,759	210,257
Area	3,336	2,101	1,082	112	223	365	7,219
TOTALS	51,755	113,199	57,882	1,275	759	2,314	227,184

Source: Maryland State Department of Health and Mental Hygiene, Environmental Health Administration, Bureau of Air Quality Control. Plan for the Implementation of the Ambient Air Quality Standards of the Metropolitan Baltimore Intrastate Air Quality Control Region, May 1972.

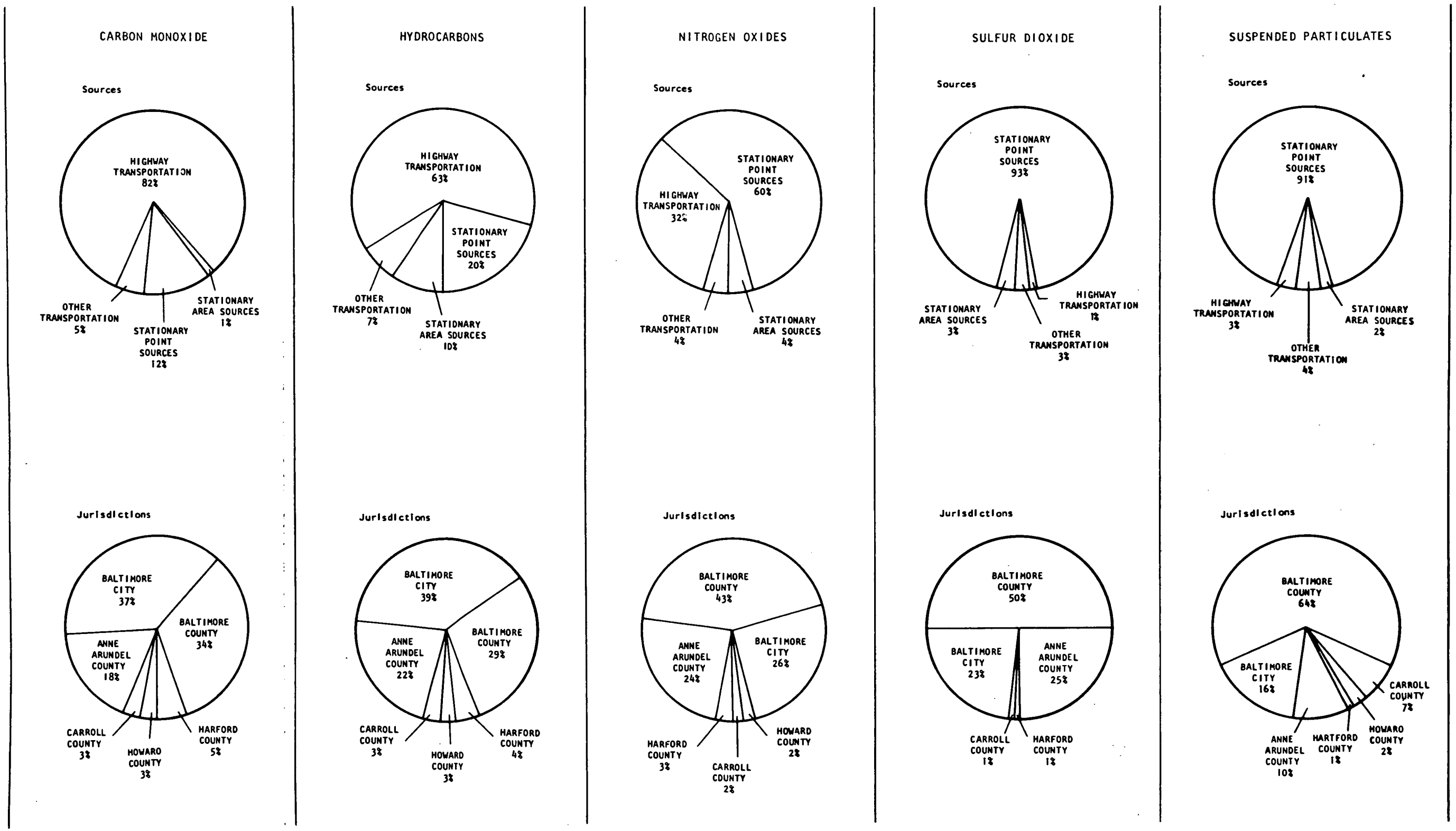


FIGURE V-9. AIR POLLUTANT EMISSIONS BY SOURCES AND JURISDICTIONS BREIS STUDY AREA—1971

Table V - 13

SUSPENDED PARTICULATE EMISSIONS IN BALTIMORE REGION
1971
(in tons/year)

Source	Baltimore City	Baltimore County	Anne Arundel County	Carroll County	Howard County	Harford County	Total
Mobile Sources							
Highway	217	1,384	597	163	136	216	2,713
Other Transportation	264	316	2,697	7	5	10	3,299
Stationary Sources							
Point	14,074	54,926	5,481	5,812	1,572	313	82,178
Area	260	1,080	510	76	81	180	2,187
TOTALS	14,815	57,706	9,285	6,058	1,794	719	90,377

Source: Maryland State Department of Health and Mental Hygiene, Environmental Health Administration, Bureau of Air Quality Control. Plan for the Implementation of the Ambient Air Quality Standards of the Metropolitan Baltimore Intrastate Air Quality Control Region, May 1972.

lesser degree than for carbon monoxide. Stationary point sources at 20 percent are the second largest contributor. Especially significant in the latter category are industrial solvent usage and gasoline loading facilities where hydrocarbons result from evaporation of solvents and gasoline, respectively.

The jurisdictions most adversely affected by existing hydrocarbon emissions are Baltimore City, Baltimore County and Anne Arundel County in descending order of approximately 40, 30, and 20 percent respectively. Hydrocarbon emissions in Baltimore City and Baltimore County alone comprise about 70 percent of the total.

Nitrogen Oxides -- The nitrogen oxide problem is mainly caused by stationary point sources (60 percent). Highway transportation, however, generates a significant (32 percent) share of nitrogen oxide emissions. As previously, Baltimore City and County combined contain approximately 70 percent of the NO_x sources. Anne Arundel County follows with 23 percent.

Sulfur Dioxide -- Sulfur dioxide (SO_2), the result of fuel burning and process emissions, is almost entirely (93 percent) the product of stationary point sources such as industrial plants, power plants, and large institutions. Highway transportation accounts for an insignificant 1 percent of total regional SO_2 emissions. Therefore, sulfur dioxide was elimated from further analysis in this study. It is recognized that an electrified rapid rail transit system could result in the generation of additional SO_2 in the region as a consequence of its power requirements. In this study the rapid transit was a constant for the 1980 and 1995 periods. The power source for the rapid transit has not been determined.

Baltimore County sources generate 50 percent of regional sulphur dioxide emissions. The balance is nearly evenly divided between Anne Arundel (25 percent) and Baltimore City (23 percent).

Suspended Particulates -- An insignificant 3 percent of suspended particulates emanate from highway transportation sources. Primary contributor to the particulate volume is stationary point sources (91 percent). Suspended particulates thus do not form a significant criterion for the evaluation of regional highway alternatives in the region.

The particulate emissions are heaviest in Baltimore County (64 percent) with Baltimore City, Anne Arundel County and Carroll County dividing most of the remainder: 16 percent, 10 percent, and 7 percent, respectively. Baltimore County exceeds the City's particulate emissions level by a factor of 4, pointing to the existence of some large particulate sources in the county.

VI. PROJECTED EMISSIONS AND AIR QUALITY

This chapter describes the results of projecting future emissions and air quality in the Baltimore region based on the transportation system and land use alternatives analyzed in this study. Models described in Chapter IV were used to arrive at estimates of future pollution levels under the various 1980 and 1995 alternatives.

Major variables used in projecting mobile source emissions included simulated traffic volumes and link speeds of the alternative systems, the number of projected vehicle trip ends (to measure cold start and hot soak emissions), future-year emission factors assuming compliance with federal requirements, mix of vehicles by type, and degree of emission control. Stationary source emission levels are also projected using various industry and population estimates which are consistent with the particular transportation alternative being analyzed.

The combination of mobile and stationary source emission totals provided a basis for determining air quality projections for the seven land use and transportation system alternatives under study. Air quality in 1980 and 1995 was compared to various criteria to determine the impacts of the alternatives and to permit their ranking as a basis for evaluation of regional impacts.

Again, it should be noted that the effects of the control strategies promulgated in October and December 1973 are not included in this analysis.

PROJECTED STATIONARY SOURCE EMISSIONS

Future stationary source emissions for the 1980 and 1995 alternatives were projected by a two-step procedure--first, emission reductions that will occur in the future to bring various sources into compliance with existing regulations were accounted for by assigning the allowable rate to each source, or source category (for area sources), or a lower emission rate if the source was committed to such a reduction. Second, the emissions, assuming fully controlled rates were then expanded by a growth factor to represent increased emissions associated with production increases.

Emissions for point sources were projected individually to 1980 and 1995 by review of Maryland Bureau of Air Quality Control source files to ascertain allowable emissions, followed by application of a growth

factor based on the Standard Industrial Classification (SIC) group of the source. Growth factors for the different SIC groups are summarized in Table VI-1. Because this projection methodology for point source emissions is independent of the traffic and land use variations between alternatives, the projected emissions for all 1980 and all 1995 alternatives are the same.

Area source emissions were projected by source category. Residential fuel combustion and waste disposal emissions were increased in proportion to population growth for each alternative, while industrial/commercial fuel combustion emissions were projected according to anticipated increases in total employment. Emission reduction factors were also assigned by source category to represent the impact of regulations on area source emissions. The growth and control factors used are summarized in Tables VI-2 and VI-3, respectively.

MOBILE SOURCE EMISSIONS

Mobile source emissions were projected for each of the seven transportation alternatives studied for 1980 and 1995. The techniques used are described in the earlier section entitled, "Emissions Modeling Overview."

The resultant emissions projections are shown in Tables VI-4 through VI-7. Mobile source emissions by pollutant in tons per day are classified by location (inside or outside the Beltway), type of vehicle (LDV or HDV), and mode of operation (running or cold starts). Examination of the tables and comparison of the data between alternatives and time periods yields the following observations for the BMATS study area:

Carbon monoxide mobile source emissions (Table VI-4) for the 1980 alternatives differ only slightly among the alternatives; there are relatively greater differences among alternatives in 1995, however. Alternative 6 with the full 3-A and GDP highway improvements will yield approximately 21.8 more tons per day than Alternative 9 (no 3-A or GDP improvements). The greatest volume of pollutants are produced outside the Beltway in 1995 in Alternatives 6 and 7, which both include the completion of all GDP facilities.

Hydrocarbon emissions from mobile sources (Table VI-5) do not vary significantly among alternatives for either 1980 and 1995; the difference is in the order of 3 tons per day in each period. In 1980, Alternative 4 (3-A without Ft. McHenry Crossing) produces the most hydrocarbon emissions. In 1995, Alternative 6 yields the highest HC as it did CO.

Table VI - 1

GROWTH FACTORS FOR EXISTING POINT SOURCES BY SIC GROUP*

Industry	SIC Code	1975 to 1980 Growth	1975 to 1995 Growth
Food & Kindred Products	2000	1.137	1.658
Textile Mill Products	2200	1.060	1.197
Apparel & Other Fabric Products	2300	1.167	1.764
Lumber Products & Furniture	2400/2500	1.224	2.039
Paper & Allied Products	2600	1.226	2.248
Printing & Publishing	2700	1.181	1.976
Chemicals & Allied Products	2800	1.241	2.429
Petroleum Refining	2900	1.129	1.574
Rubber & Plastics Products	3000	Use Values for All Mfg.	
Leather Products	3100	Use Values for All Mfg.	
Stone, Clay & Mineral Products	3200	1.150	1.420
Primary Metals	3300	1.119	1.612
Fabricated Metals	3400	1.228	2.220
Machinery, Excluding Electrical	3500	1.226	2.255
Electrical Machinery	3600	1.317	2.826
Motor Vehicles & Equipment	3700	1.292	2.188
Other Transportation Equipment	3800	1.059	1.588
Other Manufacturing	3900	1.184	1.992
All Manufacturing	2000-3999	1.193	2.007
Hospitals	8060	1.262**	2.049**
Other Health Institutions	8063/9242	1.306**	2.229**
Penitentiaries	9225	1.211**	1.845**
Public and Private Colleges	8221	1.233**	1.933**
Military Installations	9171	1.083	1.599
Civilian Government	9100	1.267	2.440
Wholesale Trade	5000	1.236	2.279

SOURCES:

* Economic Projections for Air Quality Control Regions. U.S. Department of Commerce, Office of Economics. June, 1970.

** National Statistics Adjusted to Baltimore SMSA: The U.S. Economy in 1980, A Summary of BLS Projections, Bulletin 1673, U.S. Department of Labor, Bureau of Labor Statistics (1970).

Table VI - 2

SUMMARY GROWTH FACTORS FOR STATIONARY AREA SOURCE CATEGORIES

(BMATS AREA)

Alternative	Growth in Population - Related Source Categories	Growth in Employment-Related Source Categories
3. 1980-Complete 3-A	1.14	1.14
4. 1980-3-A, Less Ft. McHenry Crossing	1.14	1.14
5. 1980-No 3-A	1.13	1.13
6. 1995-Complete 3-A and GDP Improvements	1.39	1.43
7. 1995-No 3-A, All other GDP Improvements	1.34	1.39
8. 1995-Complete 3-A, No Other GDP Improvements	1.36	1.41
9. 1995-No 3-A, No Other GDP Improvements	1.30	1.35

Table VI - 3

EMISSION REDUCTIONS FOR AREA SOURCE CATEGORIES
UNDER CONTROL REGULATIONS

Source Category	Percent Reduction Due to Control Regulations	
	Particulate	Hydrocarbons
Open Burning	100	100
Residential/Commercial Coal Combustion	100	100
Industrial Oil Combustion	50	0
Residential Oil Combustion	0	0
Natural Gas Combustion	0	0
Industrial Process Losses and Solvent Usage	0	26
Gasoline Storage	0	17

Table VI - 4

PROJECTED MOTOR VEHICLE EMISSIONS OF CARBON MONOXIDE, TONS/DAY
BMATS STUDY AREA

Emission Source	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, no Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Inside Beltway							
LDV Running Emissions	113.7	113.9	112.2	34.5	32.6	35.2	32.7
HDV Running Emissions	31.1	31.6	31.3	38.6	37.7	39.0	37.8
Cold Starts	38.5	38.5	37.8	16.5	15.7	17.4	16.6
Subtotal	183.3	184.0	181.3	89.6	86.0	91.6	87.1
Outside Beltway							
LDV Running Emissions	100.7	101.0	101.3	38.7	37.7	30.4	29.2
HDV Running Emissions	40.0	37.1	37.3	50.7	50.2	43.9	43.0
Cold Starts	19.1	22.2	22.3	11.9	11.8	10.2	9.8
Subtotal	159.8	160.3	160.9	101.3	99.7	84.5	82.0
Total CO Motor Vehicle Emissions	343.1	344.3	342.2	190.9	185.7	176.1	169.1

Table VI - 5

PROJECTED MOTOR VEHICLE EMISSIONS OF HYDROCARBONS, TONS/DAY
BMATS STUDY AREA

Emission Source	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Inside Beltway							
LDV Running Emissions	12.8	13.9	13.0	5.1	4.8	5.7	4.9
HDV Running Emissions	3.3	3.4	3.4	3.9	3.8	3.9	3.8
Cold Starts	5.0	5.0	4.9	2.2	2.1	2.3	2.2
Evaporation (Hot Soak)	5.2	5.1	5.1	3.2	3.1	3.4	3.2
Subtotal	26.3	27.4	26.4	14.4	13.8	15.3	14.1
Outside Beltway							
LDV Running Emissions	11.3	13.1	11.4	6.1	5.2	4.7	5.0
HDV Running Emissions	4.0	4.0	4.0	5.1	5.0	4.4	4.3
Cold Starts	2.9	2.9	2.9	1.6	1.6	1.4	1.3
Evaporation (Hot Soak)	2.9	3.0	3.0	2.4	2.3	2.0	1.9
Subtotal	21.1	23.0	21.3	15.2	14.1	12.5	12.5
Total Hydrocarbon Motor Vehicle Emissions	47.4	50.4	47.7	29.6	27.9	27.8	26.6

Oxides of nitrogen mobile source emissions (Table VI-8) are projected to be lowest for those alternatives which do not include the 3-A System--Alternatives 5, 7, and 9. There is virtually no difference among the 1980 alternatives. The 1995 emissions outside the Beltway differ considerably among alternatives; however, Alternatives 8 and 9, which do not include GDP improvements in the area outside the Beltway, produce the least NO_x.

Particulate emissions from motor vehicles are low, and exhibit little differentiation among alternatives in either 1980 or 1995.

The difference in mobile source pollutant levels produced by the various alternatives in a given time period is insignificant when scaled against total pollutant emissions. The greatest difference in any pollutant category found among alternatives in a given year was no more than 7 percent of the total annual emissions of the least polluting alternative.

When more vehicles on the road are equipped with emission control devices in future years, running emissions will, of course, decline due to these controls. Emissions from cold starts may be expected to assume a greater relative importance as a source of air pollution since the existing and proposed control devices, such as catalytic converters must come up to a high temperature before becoming effective; thus, an engine being started is essentially uncontrolled. This suggests that in future years pollution hot spots may occur in concentrated parking areas, including residential areas, where cold starts occur in large numbers. (16) It should be again noted that no assumptions regarding inspection and maintenance or retrofit of on-the-road vehicles have been made in developing these figures and that the dates for controlled vehicles were assumed to be 1976 for CO and HC, and 1977 for NO_x.

From the data in the preceding tables it may be observed that the no-build alternatives appear to generate less pollution of all types than the alternatives that include some or all of the proposed regional highway system, especially in 1995.

In general, this may be accounted for by four considerations:

- Lack of a complete highway system induces less economic and population growth with concomitant reduction in number of autos and vehicle miles of travel.

- Absence of the traffic generating propensity of new highway facilities produces fewer vehicle miles traveled.

Table VI - 6

PROJECTED MOTOR VEHICLE EMISSIONS OF OXIDES OF NITROGEN, TONS/DAY
BMATS STUDY AREA

Emission Source	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Inside Beltway							
LDV Running Emissions	26.4	26.2	24.9	11.8	11.1	12.0	11.2
HDV Running Emissions	3.0	3.0	2.8	3.0	3.0	3.1	3.0
Subtotal	29.4	29.2	27.7	14.8	14.1	15.1	14.2
Outside Beltway							
LDV Running Emissions	23.6	23.7	23.7	13.3	12.9	10.4	10.0
HDV Running Emissions	3.4	3.5	3.5	4.0	3.9	3.5	3.4
Subtotal	27.0	27.2	27.2	17.3	16.8	13.9	13.4
Total NO_x Motor Vehicle Emissions	56.4	56.4	54.9	32.1	30.9	29.0	27.6

Table VI - 7

PROJECTED MOTOR VEHICLE EMISSIONS OF PARTICULATE MATTER, TONS/DAY
BMATS STUDY AREA

Emission Source	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Inside Beltway							
LDV Running Emissions	1.4	1.3	1.3	1.6	1.5	1.6	1.5
HDV Running Emissions	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Subtotal	1.6	1.5	1.5	1.8	1.7	1.8	1.7
Outside Beltway							
LDV Running Emissions	1.2	1.2	1.2	1.7	1.7	1.4	1.3
HDV Running Emissions	0.2	0.2	0.2	0.3	0.3	0.2	0.3
Subtotal	1.4	1.4	1.4	2.0	2.0	1.6	1.6
Total Particulate Motor Vehicle Emissions	3.0	2.9	2.9	3.8	3.7	3.4	3.3

- Existence of few outlying and radial highways restricts urban expansion and encourages more centrally oriented development where trip-lengths are shorter..

- Residential development which is reoriented toward the denser urban center generates more travel by transit, resulting in fewer highway vehicle miles of travel.

In contrast, in the no-build alternatives (Alternatives 5 and 9), higher emission levels result from lower speeds. Systems that include larger amounts of expressway mileage show less pollution per vehicle mile of travel because of greater engine efficiency and less pollution at higher speeds attainable on limited access roadways. The total VMT in the BMATS area for each alternative is shown in Table VI-8 for comparative purposes.

The mobile source data in Tables VI-4 through VI-7 and the comparable 1970 emissions data have been plotted for analysis in Figure VI-1. While the spread in emissions among highway alternatives in each time period is small, there are significant differences between time periods. Specifically, there is a large decline in mobile source emission levels from 1970 to 1980 and a lesser, but continued decline between 1980 and 1995. The emission curves have been plotted using the known data points in 1980 and 1995, but are estimated to bottom out about 1985. It has been assumed that by 1985 only 5 percent of the pre-1975 partially-controlled highway vehicles will still be in service; thus, practically the entire highway fleet will be controlled by that year. Assuming no further reduction in vehicle emission levels would be technologically achieved, the continued growth in the almost totally controlled vehicle population begins to draw the curve upward again. In the case of particulate emissions, 1995 levels are predicted to rise above 1980 levels. However, the 1995 particulate air quality problem from motor vehicles is likely to be less than that of 1980 in spite of a higher total daily tonnage since an expanded urban area will distribute the pollutants more widely, thereby reducing the degree of concentration at any given point. (11)

1978 Mobile Source Emissions

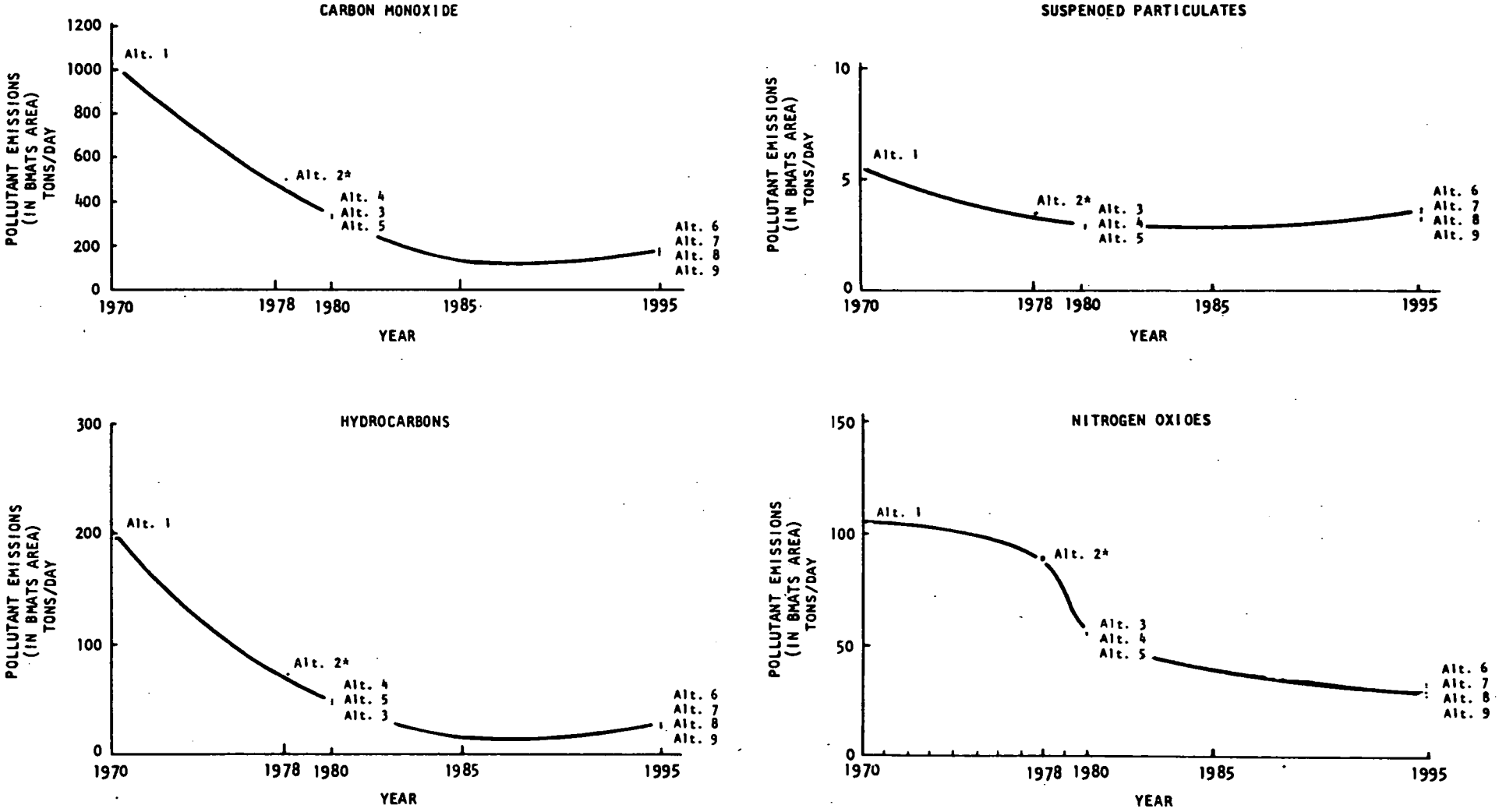
Although the 1978 Alternative 2 was dropped from this analysis, as stated in Chapter I, an analysis of projected mobile source emissions was completed for this phase of the study. To do this, 1978 emission rates were applied to 1980 projected travel. The traffic and land use base was the same as that for 1980 Alternative 3, (i.e., the 3-A system

Table VI - 8

TOTAL VMT IN BMATS STUDY AREA BY ALTERNATIVE

Alternative	Vehicle - Miles of Travel (VMT) Per 24 Hours, in millions
1970 - Alternative 1 - Existing	17.842
1980 - Alternative 3 - Complete 3-A	25.977
1980 - Alternative 4 - 3-A, Less Ft. McHenry Crossing	26.000
1980 - Alternative 5 - No 3-A	25.642
1995 - Alternative 6 - Complete 3-A and GDP Improvements	34.146
1995 - Alternative 7 - No 3-A, All other GDP Improvements	32.826
1995 - Alternative 8 - Complete 3-A, No other GDP Improvements	30.217
1995 - Alternative 9 - No 3-A, No other GDP Improvements	28.599

Source: Baltimore Regional Environmental Impact Study, Technical Memorandum No. 2, Traffic and Travel Analysis, March 1974.



*1978 Emissions Based On 1980 Alternative 3 Traffic.

FIGURE VI-1. PROJECTED CHANGES IN TOTAL MOTOR VEHICLE EMISSIONS IN BMATS AREA

would be completed as would all other existing and programmed highways). This also assumes completion of the Phase I rapid transit system. *No transportation control strategies are assumed*. The purpose of this analysis is to assess the effects of motor vehicle emission controls in the intervening years. The projected emissions are shown in Table VI-9. When plotted on the curves of emissions by year in Figure VI-1, these points fall close to the curve for CO, HC, and particulates. For NO_x, however, the point is far above the curve, indicating that the curve actually has a much sharper break after the introduction of the controlled vehicle in 1977. In an effort to control carbon monoxide and hydrocarbons, engine modifications on "partially controlled vehicles" actually result in a higher emission factor in the 1969-1975 period than for 1968 vehicles. Thus, the curve of emissions versus time is smooth and downward sloping for partially controlled vehicles for CO and HC, but it tends to drop sharply for NO_x after 1977.

Other Mobile Source Emissions

Emissions from other transportation sources--trains, ships, aircraft, and off-road vehicles--have been forecast for 1980 and 1995 by a method analogous to that employed for stationary sources. The growth factors for each source category and references for the values are shown in Table VI-10. The only emission rate reduction assumed to result from control of any of these mobile sources is a 72 percent reduction in particulates from aircraft, as a result of the smokeless combustion cannister retrofitted in 1970 through 1973.

COMPOSITE EMISSIONS

Projections of emissions from both mobile and stationary sources were combined to obtain the composite total for each pollutant and by alternative. The resulting totals by source category and for the BMATS study area are contained in Tables VI-11 through VI-14.

From these tables it may be observed that:

- As motor vehicle emission controls reduce the total percentage of pollution generated from mobile sources in 1980 and 1995, the relative share generated by stationary and other transportation sources tends to rise. This differential could be larger if inspection and maintenance or retrofit are employed. Thus, motor vehicle emissions tend to become less important in determining air quality.

Table VI - 9

PROJECTED MOTOR VEHICLE EMISSIONS, TONS/DAY
1978 (1980 ALTERNATIVE 3 TRAFFIC)
BMATS AREA

	Pollutant			
	CO	HC	NO_X	Particulates
Inside Beltway				
LDV Running Emissions	183.1	19.1	42.9	1.3
HDV Running Emissions	29.2	3.5	3.5	0.2
Cold Starts	54.0	6.8	----	---
Evaporation	-----	11.6	----	---
Subtotal	266.3	41.0	46.4	1.5
Outside Beltway				
LDV Running Emissions	161.9	17.0	39.0	1.2
HDV Running Emissions	35.0	4.3	4.0	0.2
Cold Starts	31.0	3.9	----	---
Evaporation	-----	6.7	----	---
Subtotal	227.9	31.9	43.0	1.4
Total Motor Vehicle Emissions	494.2	72.9	89.4	2.9

Table VI - 10

TRAFFIC GROWTH FACTORS
FOR TRANSPORTATION SOURCE CATEGORIES

Source Category	1971 to 1980 Growth	1971 to 1995 Growth	Reference
Trains	1.00	1.00	Communication with B&O Railroad Traffic Dept., 7/16/73
Ships	1.164	1.427	Adapted from Projection for "Four Alternative Strategies Document," MBAQC, 1973.
Aircraft	1.425	2.56	Raney, J. L., and G. D. Kittredge. Measurement and Control of Air Pollution from Aircraft and Other Off-Highway Propulsion Systems, EPA, 1970.
Off-Road Vehicles	1.164	1.427	Adapted from Projection for "Four Alternative Strategies Document," MBAQC, 1973

Table VI - 11

PROJECTED EMISSIONS OF CARBON MONOXIDE, TONS/YEAR
BMATS STUDY AREA

Source Category	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Mobile							
Motor Vehicle	125,250	125,650	124,930	69,680	67,730	64,290	61,720
Other Transportation	13,630	13,630	13,630	15,990	15,990	15,990	15,990
Stationary							
Point	40,630	40,630	40,630	51,080	51,080	51,080	51,080
Area	8,920	8,920	8,850	11,030	10,720	10,880	10,410
Total	188,430	188,830	188,040	147,780	145,520	142,240	139,200
	PERCENTAGES						
Mobile							
Motor Vehicles	66	66	66	47	47	45	44
Other Transportation	7	7	7	11	11	11	11
Stationary							
Point	22	22	22	35	35	36	37
Area	5	5	5	7	7	8	8
Total	100	100	100	100	100	100	100

Table VI - 12

PROJECTED EMISSIONS OF HYDROCARBONS, TONS/YEAR
BMATS STUDY AREA

Source Category	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Mobile							
Motor Vehicles	17,310	18,390	17,390	10,780	10,160	10,140	9,710
Other Transportation	14,920	14,920	14,920	25,130	25,130	25,130	25,130
Stationary							
Point	23,430	23,430	23,430	28,310	28,310	28,310	28,310
Area	19,160	19,160	18,990	23,680	23,000	23,360	22,360
Total	74,820	75,900	74,730	87,900	86,600	86,940	85,510
	PERCENTAGES						
Mobile							
Motor Vehicles	23	24	23	12	12	12	11
Other Transportation	20	20	20	29	29	29	30
Stationary							
Point	31	31	31	32	33	32	33
Area	26	25	26	27	26	27	26
Total	100	100	100	100	100	100	100

Table VI - 13

PROJECTED EMISSIONS OF OXIDES OF NITROGEN, TONS/YEAR
BMATS STUDY AREA

Source Category	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Mobile							
Motor Vehicles	20,600	20,580	20,030	11,710	11,300	10,570	10,000
Other Transportation	9,160	9,160	9,160	12,190	12,190	12,190	12,190
Stationary							
Point	92,790	92,790	92,790	108,100	108,100	108,100	108,100
Area	7,800	7,800	7,730	9,640	9,370	9,500	9,100
Total	130,350	130,330	129,710	141,640	140,960	140,360	139,390
	PERCENTAGES						
Mobile							
Motor Vehicles	16	16	15	8	8	7	7
Other Transportation	7	7	7	9	9	9	9
Stationary							
Point	71	71	72	76	77	77	77
Area	6	6	6	7	6	7	7
Total	100	100	100	100	100	100	100

Table VI - 14

PROJECTED EMISSIONS OF PARTICULATE MATTER, TONS/YEAR
BMATS STUDY AREA

Source Category	1980			1995			
	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Mobile							
Motor Vehicle	1,090	1,080	1,070	1,400	1,350	1,260	1,190
Other Transportation	2,390	2,390	2,390	3,340	3,340	3,340	3,340
Stationary							
Point	13,760	13,760	13,760	16,940	16,940	16,940	16,940
Area	8,960	8,960	8,890	11,090	10,780	10,930	10,470
Total	26,200	26,190	26,110	32,770	32,410	32,470	31,940
	PERCENTAGES						
Mobile							
Motor Vehicles	4	4	4	4	4	4	4
Other Transportation	9	9	9	10	10	10	10
Stationary							
Point	53	53	53	52	52	52	53
Area	34	34	34	34	34	34	33
Total	100	100	100	100	100	100	100

- The proportion of particulate emissions generated by motor vehicles remains a constant 4 percent for all alternatives. In addition, because of the relative insignificance of particulate emissions from motor vehicles they are not a factor in determining regional air quality. Particulates are well dispersed throughout the region and thus are not a valid criterion for choice among the alternative highway systems at the regional level.

- Stationary sources show gains in the amount of pollution produced in all categories between 1980 and 1995. Growth of industry and population overshadow further reductions from regulatory controls and technologies.

- Other transportation modes, whose growth matches that of the economy and population, are predicted to produce an increasing total amount of pollutant emissions.

AIR QUALITY PROJECTIONS

Air quality was projected using the methodologies described in Chapter IV.

Projections of air quality related to carbon monoxide were carried out with the aid of the Stanford Research Institute's (SRI) APRAC-IA Urban Diffusion Model Computer Program. The model, its theory, operation, and computer program are fully explained in the SRI manual. (17) A brief description is contained in Appendix B.

The SRI model was chosen for use in modeling Baltimore regional carbon monoxide levels based on three considerations:

- It is the only model that had the capability of modeling CO urban background levels on a regional scale.

- The model is not only able to project background CO pollution, but also to develop street canyon or localized concentrations as well.

- The model was developed under contract to the U.S. Environmental Protection Agency and is approved for use by EPA. The model has been demonstrated in tests made in San Jose, California and St. Louis, Missouri, and is endorsed by the Federal Highway Administration.

Validation was accomplished by comparing simulated CO levels at the sites of six sampling stations with concentrations which were actually measured at those points. The stations, whose locations are shown in Figure VI-2, were AIRMON 1, AIRMON 2, Riviera Beach, Linthicum, Towson, and Essex. First, a 24-hour period with high measured CO levels was selected, and meteorological data for that specific period was obtained from the National Weather Records Center and from the Friendship Airport Weather Station. This meteorological data and 1970 traffic data were then input to the synoptic version of SRI model, and estimated hourly CO values were produced for each of the six stations.

Comparison of hourly measured and predicted values did not indicate an acceptable correlation. With available data, it could not be determined whether the excessive variations were due to traffic and/or meteorological inputs to the model, or to the relationship between the sampling station receptor site and nearby streets specified for the model.

Dimensions for the local street configuration which were input to the model are presented below:

- Sampling height -- 4.5 meters
- Street canyon (building) height -- 38.6 meters
- Width of street canyon (twice the distance from the roadway center to the sampler) --
  AIRMON 1 = 85 meters
  AIRMON 2 = 50 meters
  Riviera Beach = 100 meters
  Linthicum = 350 meters
  Towson = 300 meters
  Essex = 200 meters

It was observed that the maximum levels predicted by the model at the six sites and their measurements were closely related. Therefore, a more generalized set of meteorological data descriptive of periods with high CO levels regionally was constructed using the findings of the meteorological analysis described in Chapter V, Figures V-2 and V-3. This generalized data was thought to be more compatible with the average annual traffic data employed.

The SRI model was then rerun, and the resulting concentrations were compared with maximum measured 1972 (base period) 1-hour CO concentrations

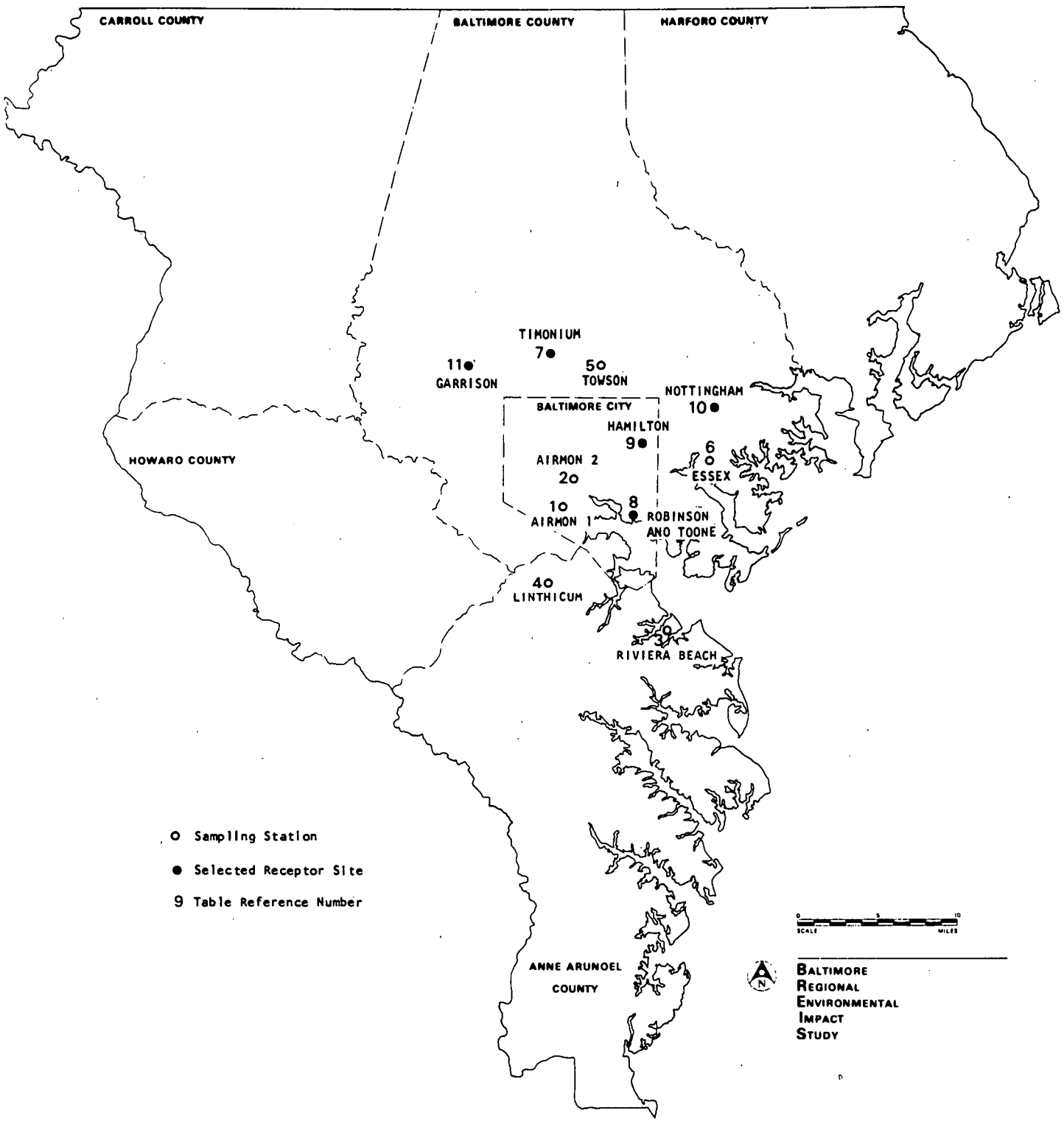


FIGURE VI-2. LOCATION OF AIR QUALITY SAMPLING STATIONS AND RECEPTOR SITES

at the six stations. This comparison is shown in Table VI-15. Since the model predicted that maximum CO levels would occur during the afternoon rush hour and observed maximum hourly CO levels generally occurred during the morning rush hour, the two periods were considered separately in this correlation procedure, as shown in Figure VI-3.

The afternoon maximum CO levels show the best correlation. The model appears to under-predict the morning maximum concentrations by a fairly consistent amount that could be overcome by using a correction factor.

Evaluation of the model's capability to predict maximum 8-hour CO concentrations was also undertaken, since the 8-hour values are more critical than hourly concentrations from the standpoint of achievement of air quality standards. The comparison of measured and predicted maximum 8-hour values is shown in Figure VI-4. The accuracy of the model for this averaging time appears to be comparable with its accuracy for hourly concentrations.

It was concluded that the SRI model was reasonably accurate and that the correlation between predicted and observed maximum CO levels was good enough to proceed with the projections. Measured and predicted diurnal CO curves at a typical site are shown in Figure VI-5. The difference in shape between the two curves reveals why the correlation between hourly values for the entire 24-hour period was not acceptable. The model showed afternoon CO levels peaking during the rush hour and then falling off sharply, while it was noted that actual Baltimore CO levels continued to rise and sustain a late evening plateau, falling off only after 10 p.m. Possible reasons for this phenomenon were discussed in Chapter V.

Another apparent anomoly is the higher morning peak in Baltimore. According to the model, the higher peak of the day should occur during the afternoon traffic rush. In order to scale up the model's prediction for the morning peak to obtain a figure more nearly matching measured values, a factor of 1.62 was used, based on the slope of the line of best fit in the validation procedure (See Figure VI-3) This factor was used to correct the projections obtained from the model for the morning peak in 1980 and 1995.

A consistent relationship between the morning and afternoon peaks is important since the height and duration of the peak period is used to

TABLE VI - 15

CORRELATION OF THE RESULTS OF CO MODEL
WITH MEASURED CO CONCENTRATIONS - 1972

Station	Time Period	1-Hour Maximum Predicted ppm	1-Hour Maximum Observed ppm	Predicted Values as a Percent of Observed	
				a.m. percent	p.m. percent
AIRMON (1)	a.m.	9.3	12 10	78	127
	p.m.	12.7	10		
AIRMON (2)	a.m.	9.0	14 12	64	103
	p.m.	12.3	12		
Rivera Beach (3)	a.m.	7.8	14 13	56	105
	p.m.	10.5	10		
Linthicum (4)	a.m.	9.7	14 13	69	121
	p.m.	13.3	11		
Towson (5)	a.m.	6.0	11	55	82
	p.m.	8.2	10		
Essex (6)	a.m.	10.2	21	49	70
	p.m.	13.9	20		
Average				62	101

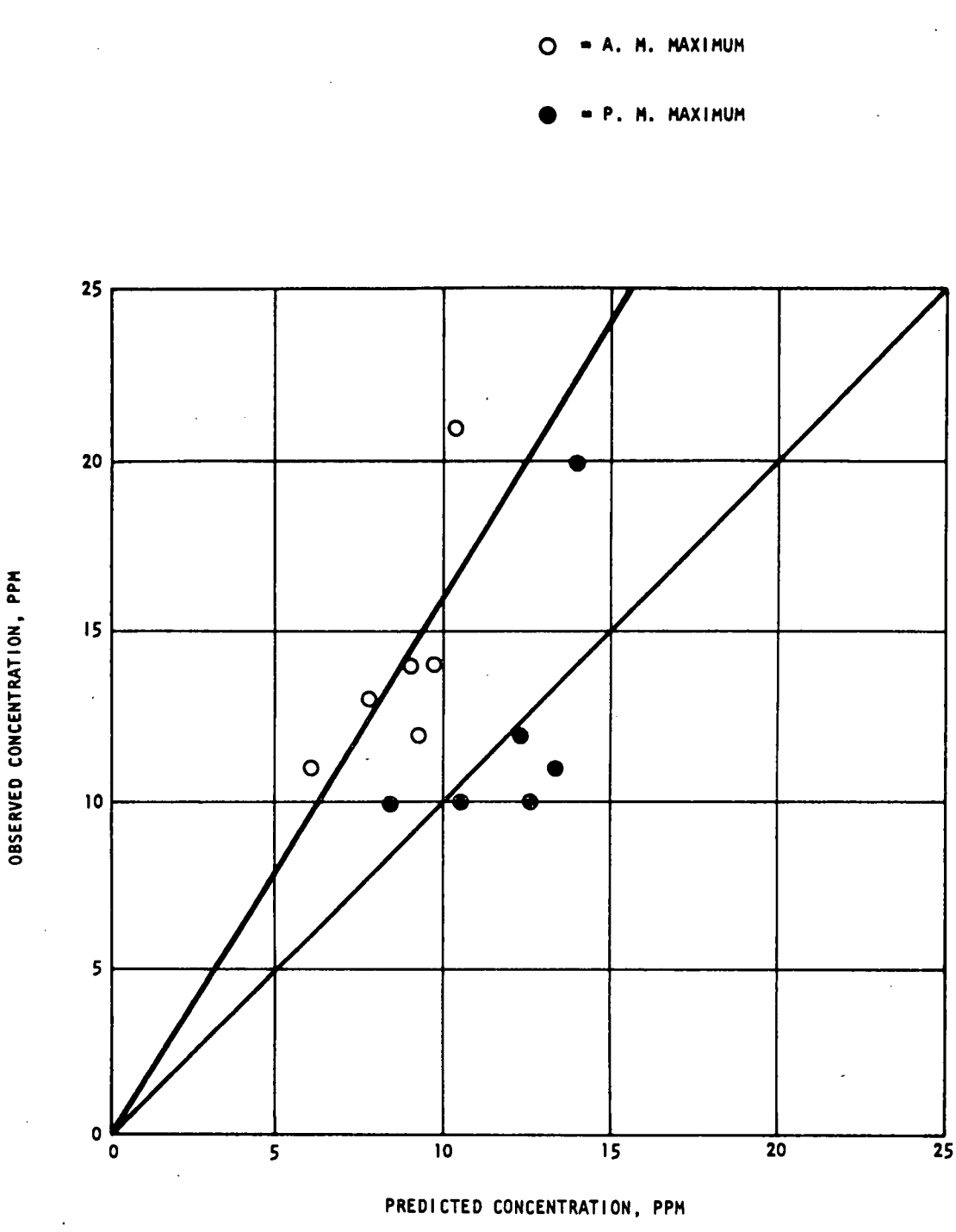


FIGURE VI-3. COMPARISON OF MAXIMUM PREDICTED CARBON MONOXIDE CONCENTRATIONS AT SIX RECEPTOR SITES WITH MAXIMUM MEASURED CONCENTRATIONS–HOURLY AVERAGES

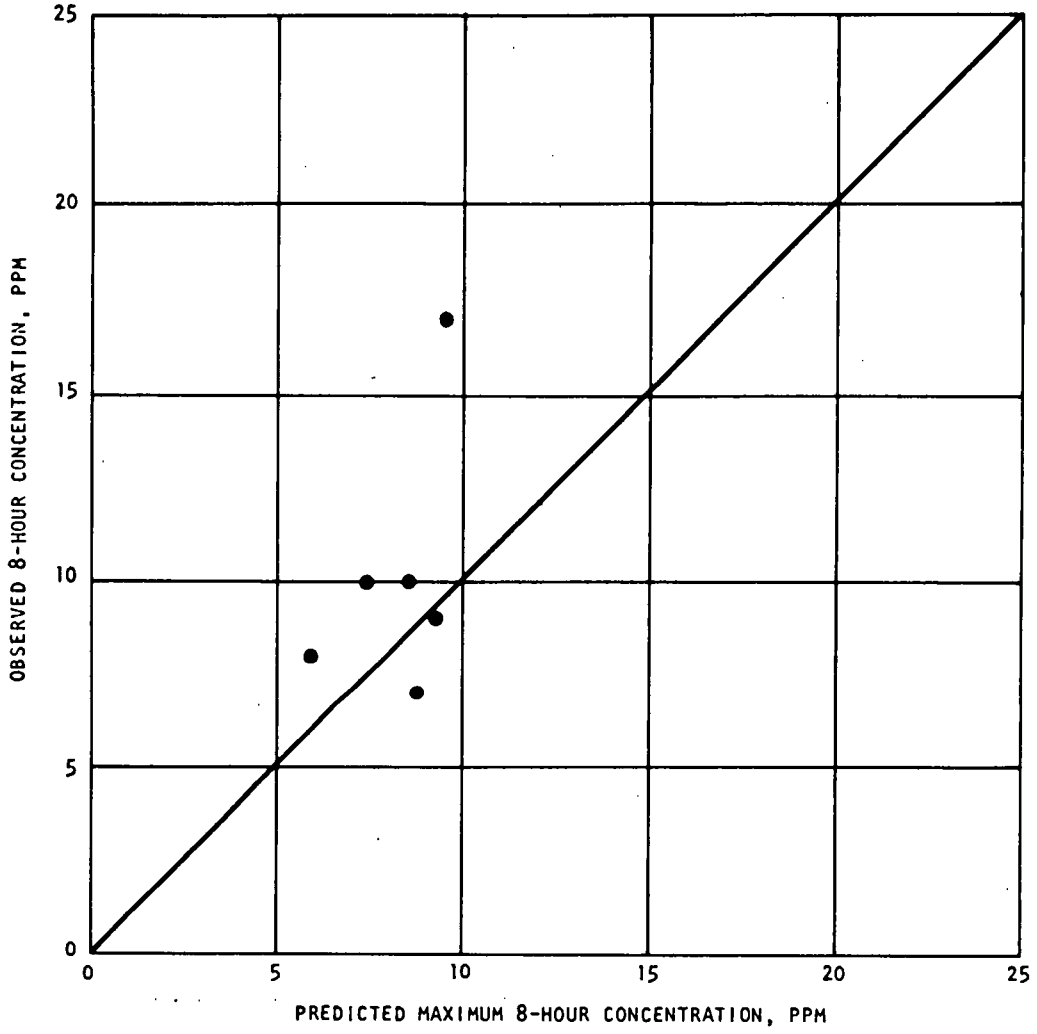


FIGURE VI-4. COMPARISON OF PREDICTED AND OBSERVED MAXIMUM 8-HOUR CARBON MONOXIDE CONCENTRATIONS AT SIX RECEPTOR SITES

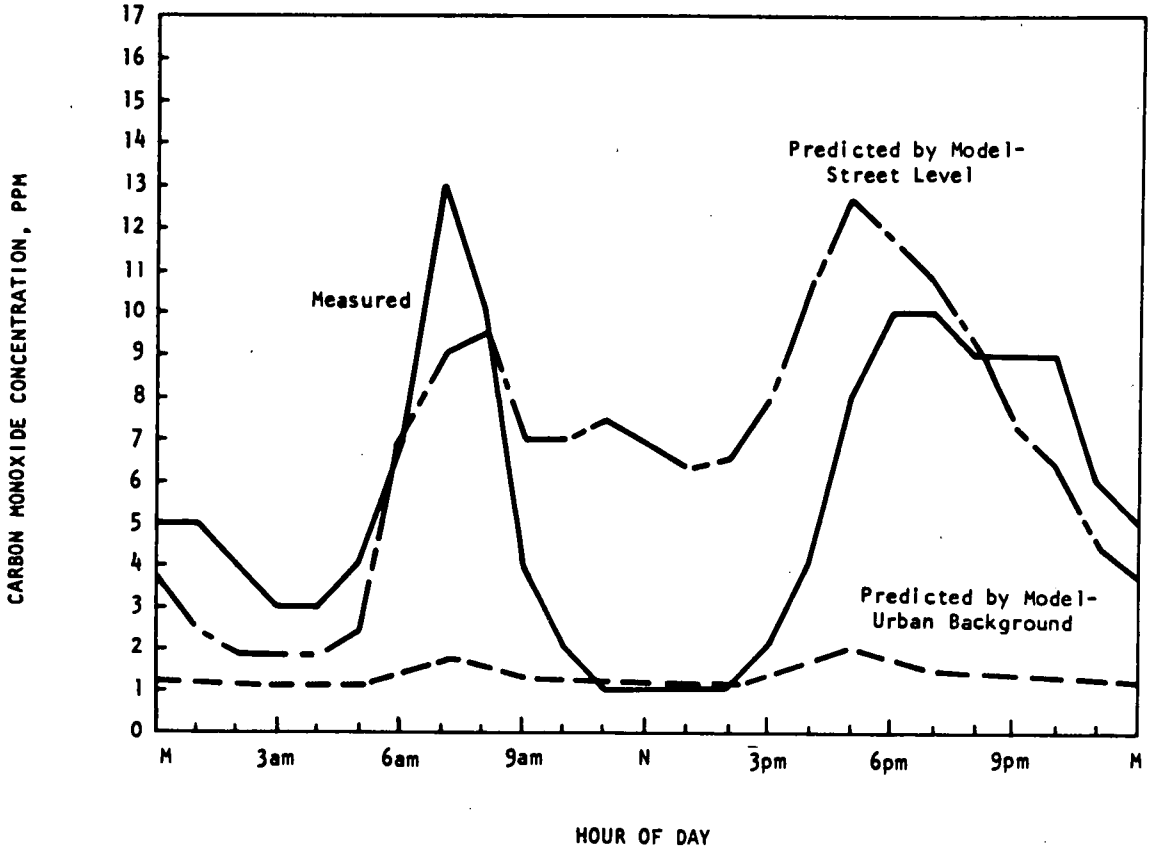


FIGURE VI-5. TYPICAL DAILY VARIATIONS IN CARBON MONOXIDE LEVELS DURING PERIODS WITH ADVERSE METEOROLOGICAL CONDITIONS—AS MEASURED AND AS PREDICTED BY DISPERSION MODEL

determine the 8-hour average for CO. The extended afternoon/evening peak is probably a significant factor in the fact that Baltimore is exceeding the 8-hour maximum CO standard.

Also shown in Figure VI-5 is the line resulting from the synoptic modeling of urban background levels of CO--the more uniform level of CO pollution away from highways extending regionwide. The predicted CO concentrations, using the street canyon model, include the background (rooftop) CO levels. The urban background levels extend over wider areas than the street level CO emissions, which result primarily from traffic sources in a relatively confined corridor. It is this urban background concentration that is geographically distributed by the grid point version of the SRI model.

The grid point version of the SRI model is only capable of predicting urban background levels, because the scale of the region prohibits showing CO concentrations around highways and major emissions sources and their rapid fall-off with distance away from the sources. Such concentrations would appear too minuscule at the regional scale to be adequately mapped.

The grid point version shows the worst predicted CO background conditions, which were simulated by using the adverse meteorological conditions described in Chapter V and the hour of the day shown by the synoptic version to produce the highest CO levels. However, the values obtained represent roof-top concentrations and not the higher levels associated with street level measurements. To obtain street level estimates, the synoptic model was again employed to analyze street canyon conditions at points on the grid model that appeared to be hot spots of urban background levels, on the assumption that these would also represent regional street level maxima.

The grid point version of the SRI model includes emissions contributed by stationary sources from their respective locations within the region. Mobile source emissions are represented in the model as line sources. Emission rates are calculated by the model internally from input data on vehicle miles of travel by vehicle types on major highway links, the average speed appropriate to each link, location and number of trip ends, and appropriate emission factors, as described in Chapter IV.

A grid is overlaid on the study area to establish receptor points at regular intervals throughout the study area. A map of the BREIS region, overlaid with the grid system used in this study, appears in Figure VI-6.

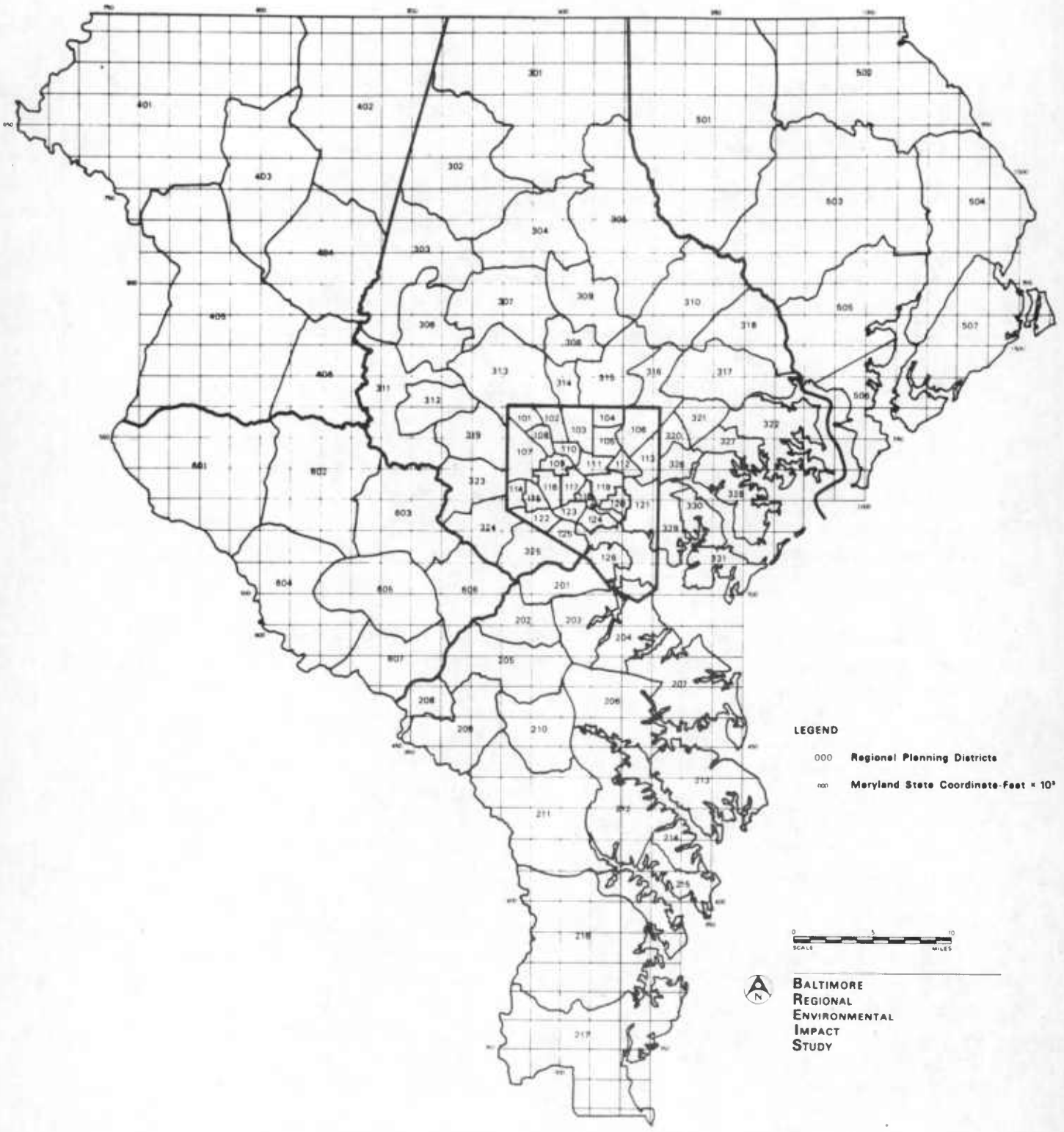


FIGURE VI-6. GRID SYSTEM MAP FOR BALTIMORE REGION

When the model is run on the computer, downwind CO emissions from all sources are cumulated at the receptor points using a Gaussian plume effect. Thus, the model attempts to duplicate the natural processes of CO buildup and movement as determined by meteorological conditions. The CO levels calculated by the model for each receptor point in the grid can be distributed geographically and contour mapped to show areas over which similar values exist.

The results of the grid version of the SRI model are contained in Figures VI-7 through VI-14, showing predicted urban background concentrations of CO for all alternatives.

Maximum concentrations are highest in Alternative 1 (1970) and decrease over time, as evidenced in the 1980 and 1995 alternatives. This trend agrees with that found for total emissions, as discussed in the preceding section.

By contrast, the extent of the area having a definite level (1.0 ppm) of CO urban background concentration broadens in later years. Moving out in the 1980 alternatives, the 1.0 ppm level covers nearly the entire region in 1995 as population, commerce and industry disperse to the suburbs. No major differences in CO levels between alternatives appear at the regional scale.

Highest CO urban background concentrations occur in locations that appear reasonable in light of what is known concerning land use, heavy traffic areas and the effects of prevailing winds: The 1970 peaks appear: (1) in the vicinity of Owings Mills, possibily due to the effect of congested U.S. Route 140; (2) in the vicinity of the intersection of I-83 and the Beltway; (3) in a somewhat triangular area covering most of the eastern Baltimore area--Dundalk, Edgemere, and Essex.

Within this triangle, particularly high background CO levels, including peaks of up to 3.00 ppm, are found in an area northeast of Baltimore. This area encompasses five major highways in close proximity--JFK Memorial Highway, Pulaski Highway, U.S. Route 1, Baltimore Beltway, and the Windlass Freeway. The confluence of major highways and considerable industrial development in the area appear to contribute to the peak CO concentration in the region. Also contributing to this situation is the fact that this area is located east of the Baltimore CBD. Prevailing winds from the west during adverse meteorological periods cumulate CO from the CBD with that being generated east of the city center, building up the higher levels via the plume effect. This effect is generally visible as the elongation

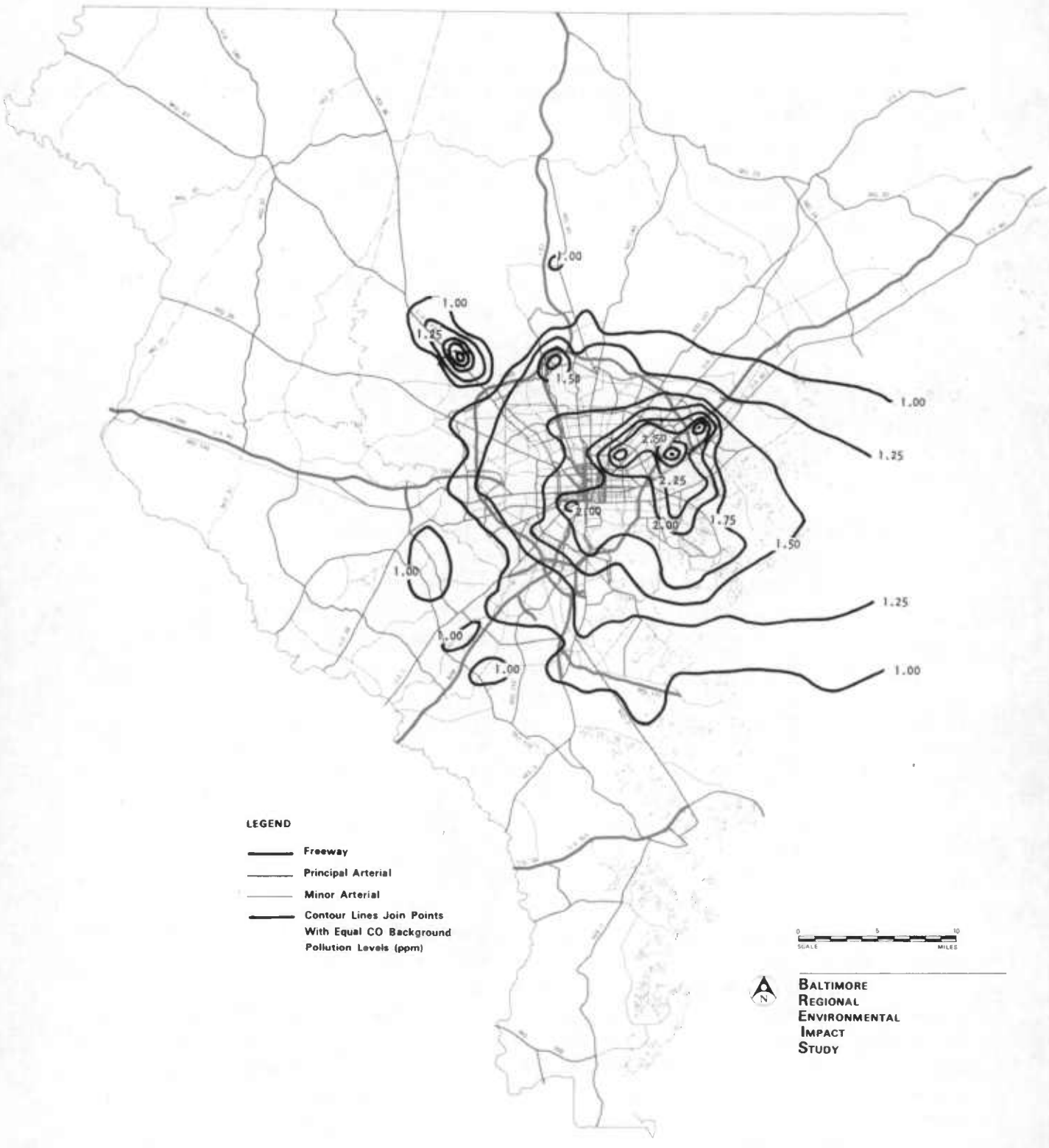
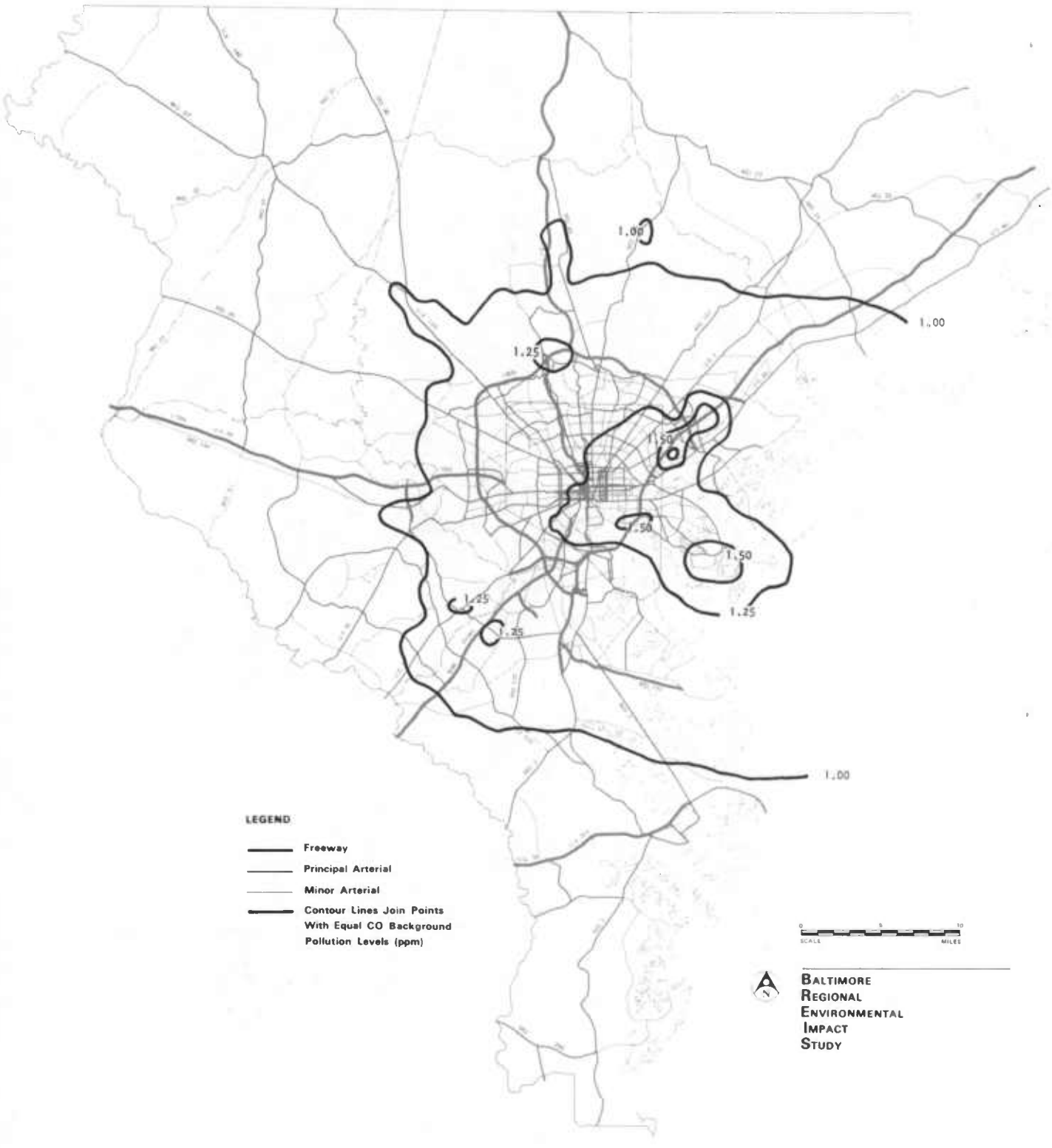


FIGURE VI-7. PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE (PPM) FOR ALTERNATIVE 1—EXISTING—1970



PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE FOR ALTERNATIVE 3–COMPLETE 3-A-1980

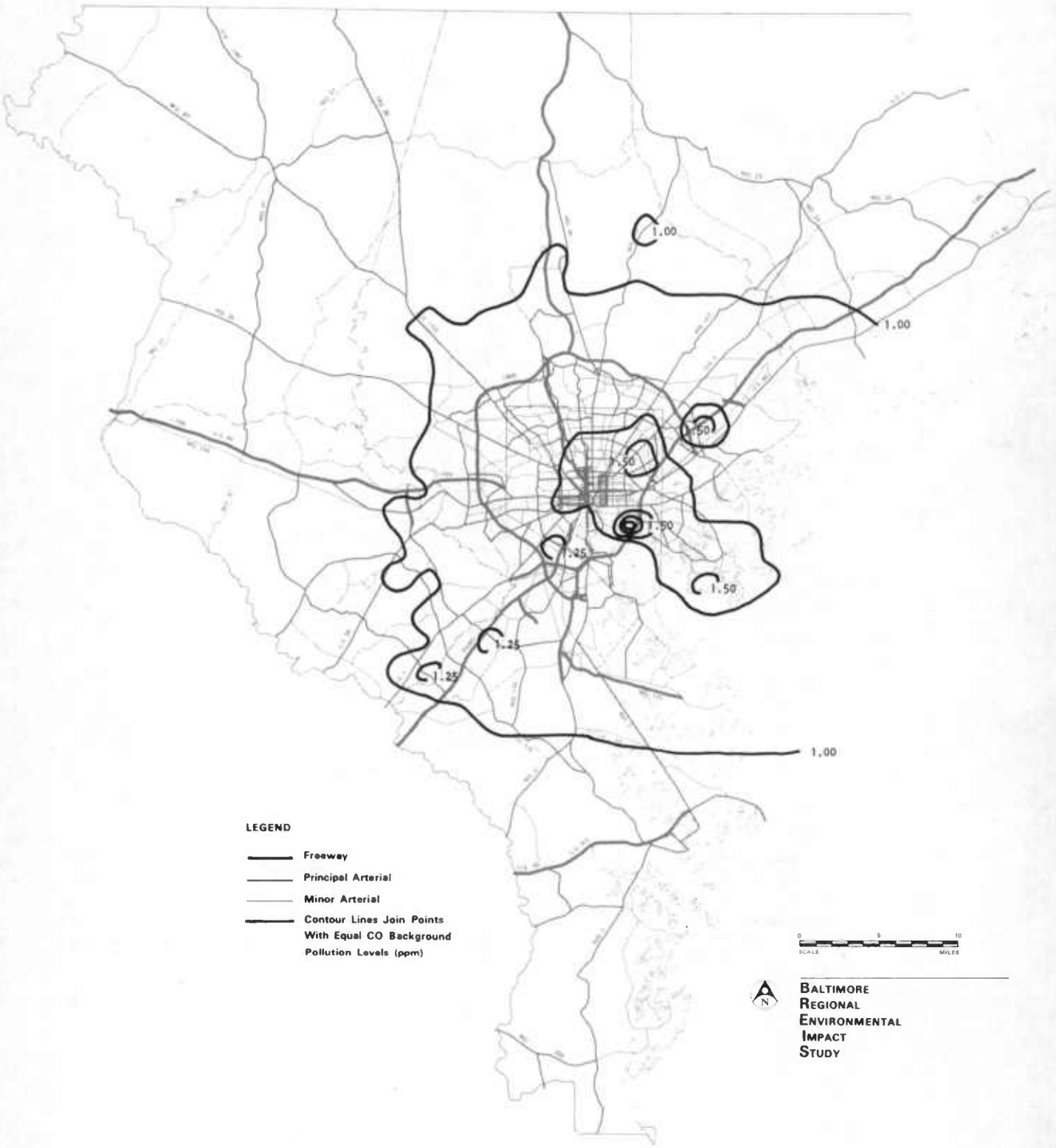


FIGURE VI-9. PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE (PPM) FOR ALTERNATIVE 4–3-A SYSTEM LESS FT. McHENRY CROSSING–1980

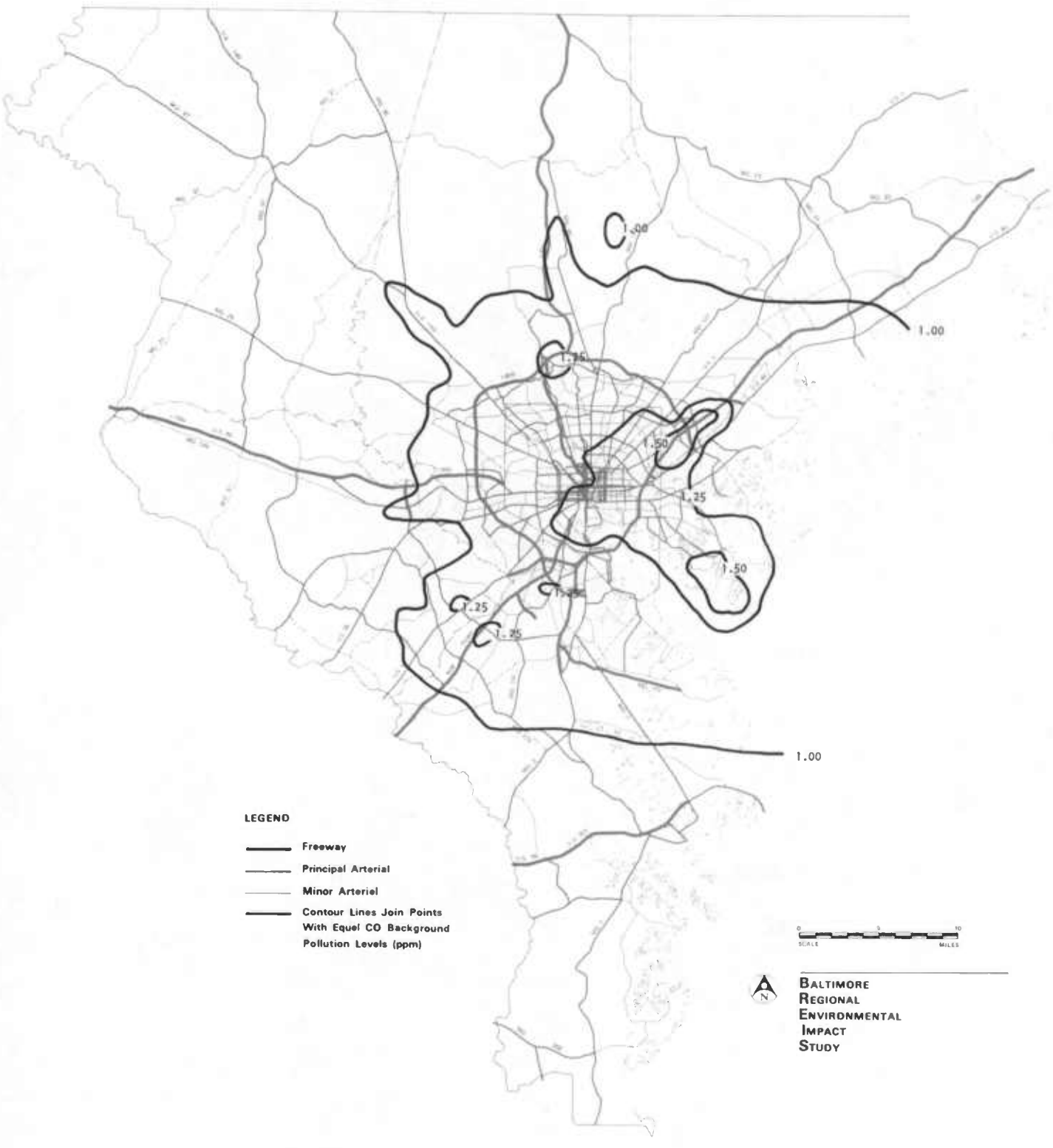


FIGURE VI-10. PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE (PPM) FOR ALTERNATIVE 5—NO 3-A-1980

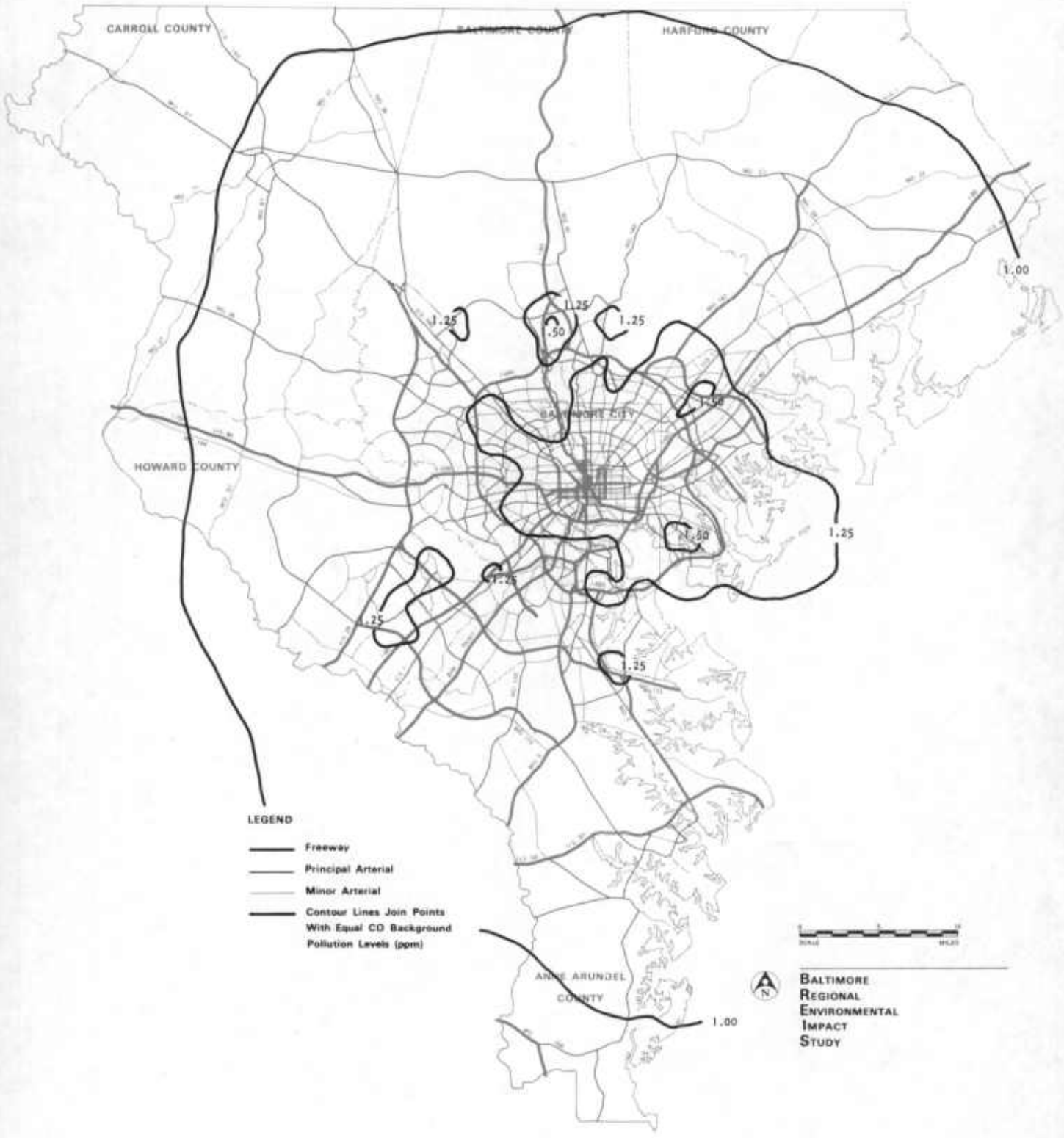


FIGURE VI-11. PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE (PPM) FOR ALTERNATIVE 6—COMPLETE 3-A AND GDP IMPROVEMENTS-1995

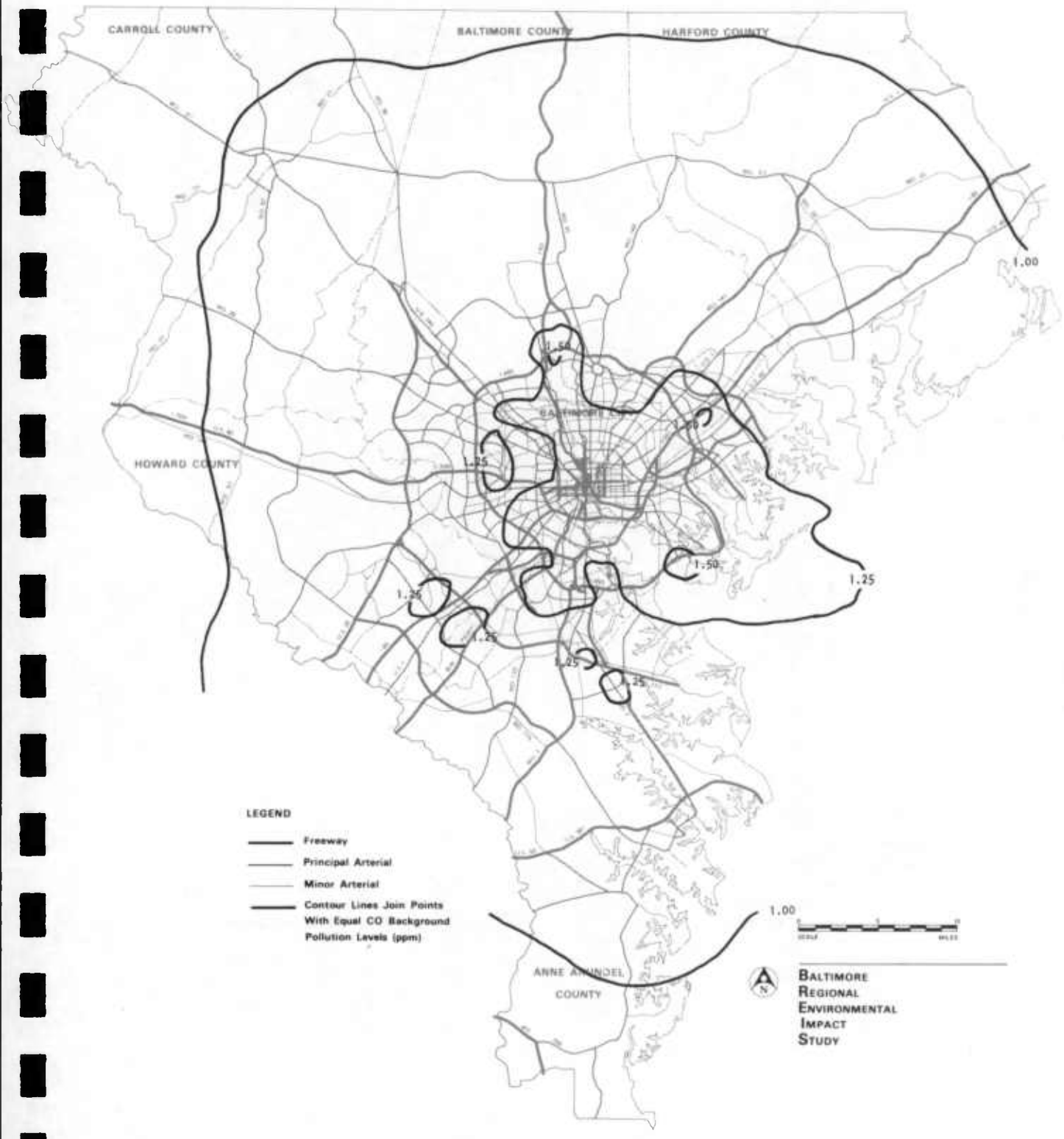


FIGURE VI-12. PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE FOR ALTERNATIVE 7—NO 3-A, ALL GDP IMPROVEMENTS-1995

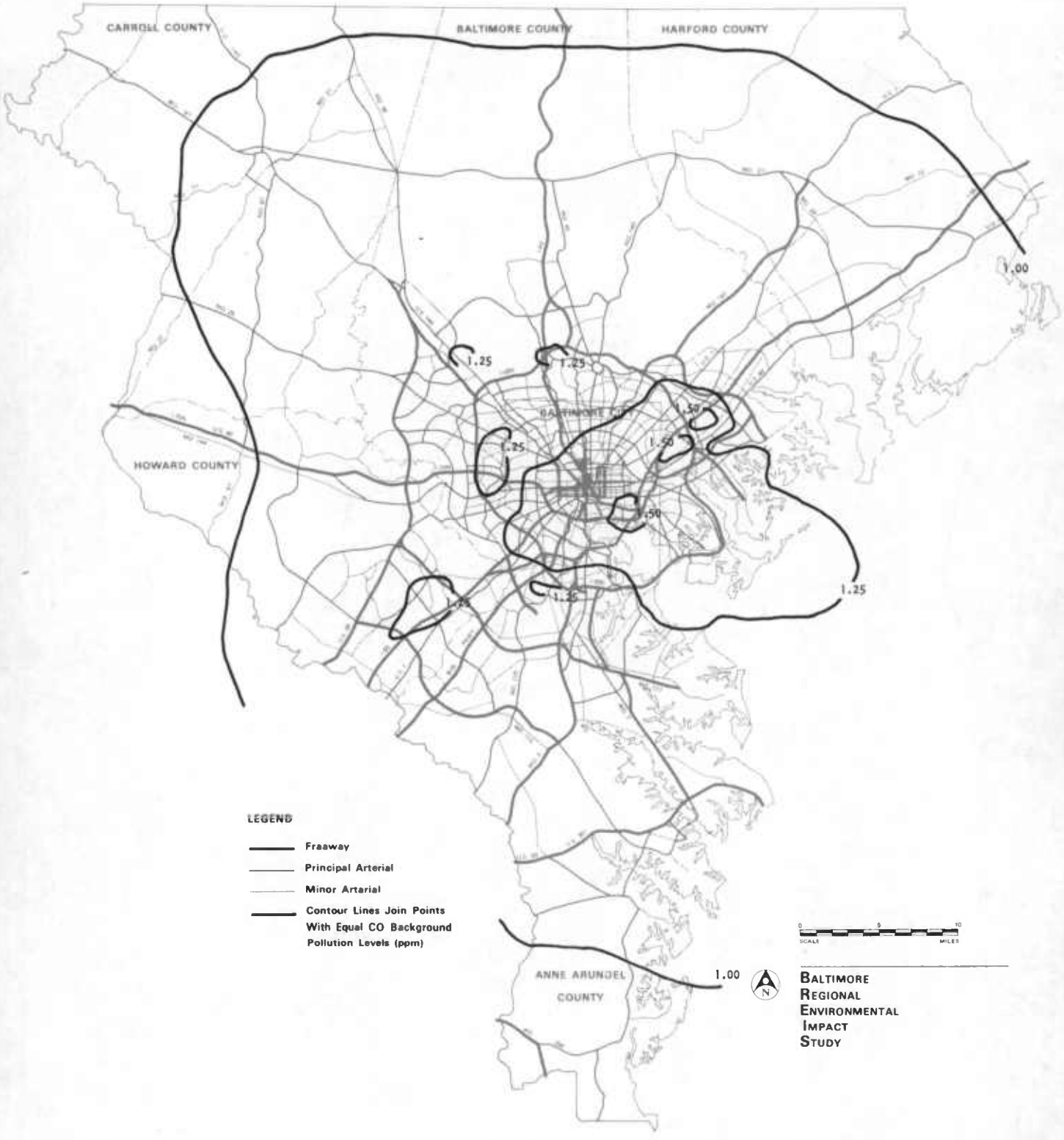


FIGURE VI-13. PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE (PPM) FOR ALTERNATIVE 8–COMPLETE 3-A, NO GDP IMPROVEMENTS-1995

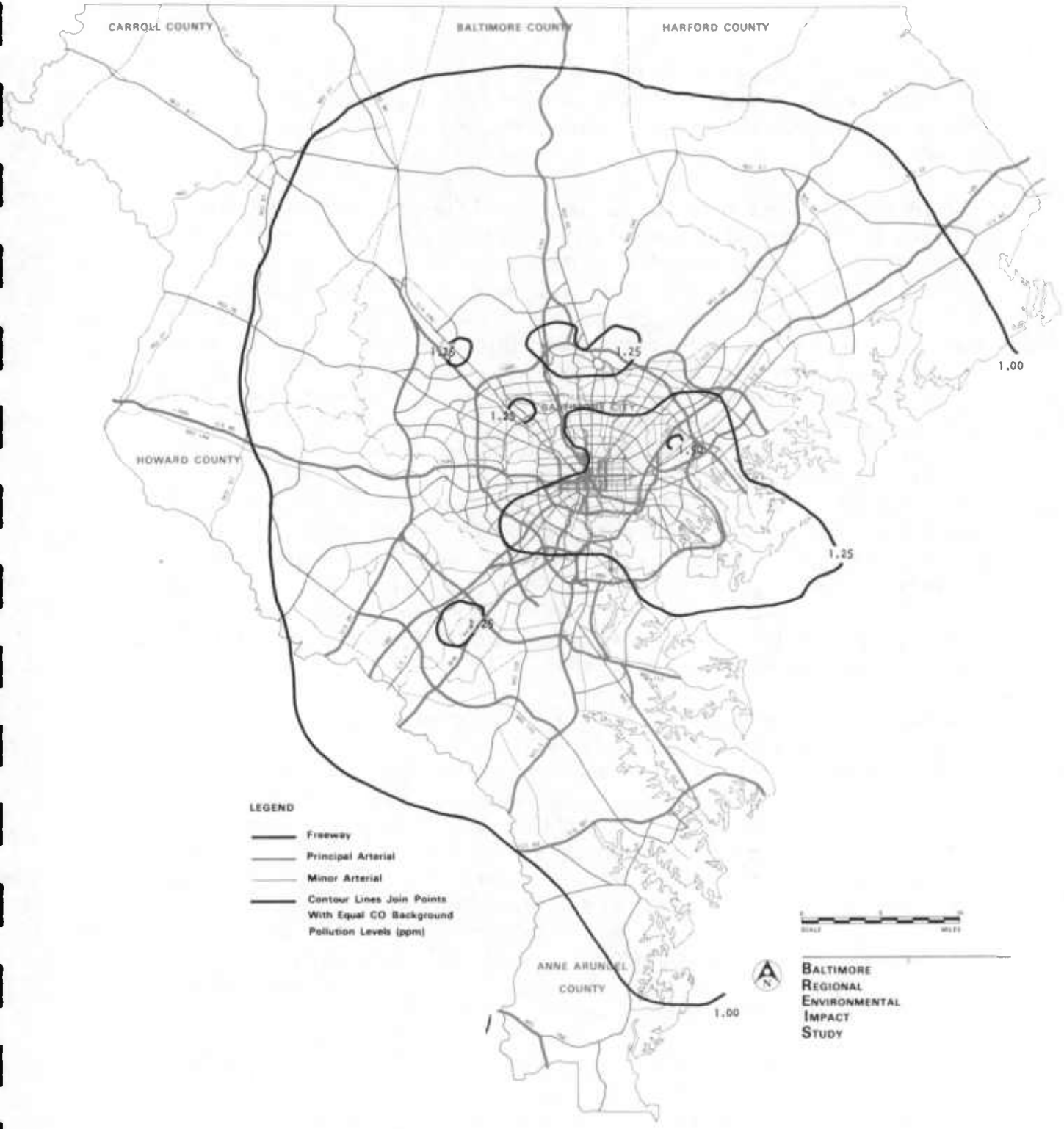


FIGURE VI-14. PREDICTED URBAN BACKGROUND CONCENTRATIONS OF CARBON MONOXIDE PPM FOR ALTERNATIVE 9—NO GDP IMPROVEMENTS, NO 3-A SYSTEM-1995

of the urban CO plume toward the east and out over Chesapeake Bay. Prevailing winds from the west also account for the slight off-set of CO concentrations easterly of their apparent sources visible in the contour maps.

The 1980 alternatives show similar patterns of CO concentrations. The 1.0 contour has expanded over a broader area than was covered in 1970, while the peak levels and number of peak hot spots have been reduced. The top CO concentration projected, 2.00 ppm, occurs in only one area in Alternative 4 (3-A without Ft. McHenry Crossing); concentrations in the 1.50 range, are more common. As in 1970, the heaviest concentration appears to cover eastern Baltimore, Dundalk, and Edgemere. Lack of the Ft. McHenry crossing in Alternative 4 appears to generate the high 2.00 ppm peak on the approaches to the existing Harbor Tunnel as the traffic bottleneck there is of sufficient magnitude to affect regional air quality. There is no significant difference in the location or peaks of CO concentration between Alternative 3 (complete 3-A system) and Alternative 5 (no 3-A system) in 1980. This suggests that the reduction in CO levels due to higher speeds under the 3-A system is offset by the higher traffic volumes the system generates. On the other hand, lower speeds and higher CO levels in Alternative 5 are balanced by the reduced traffic due to lack of new capacity. Thus, the two extremes tend to produce nearly equivalent amounts and patterns of background CO.

The 1995 alternatives show few significant differences. The base 1.0 ppm level has expanded to encompass almost the entire BMATS area as a result of urban expansion. CO levels at the center of the metropolitan area in 1995 show peak concentrations no higher than 1.50 ppm, down from a 1980 high of 2.00 ppm and half of the 1970 peak of 3.00 ppm. Highest 1995 CO concentrations appear in pockets over the interchanges of major expressways and in heavily industrialized areas. In this respect, Dundalk and the Harbor Tunnel Thruway and I-95 corridors show up strongly, especially in Alternatives 6 and 8, which both incorporate the complete 3-A system. Alternative 9, the "null," which includes neither the 3-A system nor other GDP improvements has only one small 1.50 ppm peak in the vicinity of the I-95/Beltway intersection.

A rather uniform concentration of 1.25 ppm appears to cover the area from central Baltimore eastward to Chesapeake Bay and down the Patapsco peninsula in all 1995 alternatives. Inasmuch as maximum 1995 urban background concentration CO levels are one-half or less than those of 1970, there does not appear to be a CO problem under any alternative.

The synoptic version of the SRI model was run for selected points with highest concentrations on the grid point maps in order to show the maximum street level CO projections for comparison with air quality standards. The selected receptor sites shown in Figure VI-2 are those with the highest identifiable CO levels for 1970, 1980, and 1995.

The results of the synoptic model runs are shown in Figure VI-15 and Table VI-16. The curves appear similar in shape due to the use of identical meteorological data and percentage of traffic by hour data. Variables were the emission factors and traffic volumes in the representative years. The curves confirm the conclusions previously drawn:

- In 1970, CO concentrations are above the 8-hour average 9 ppm primary standard for a sufficient length of time and at sufficiently high levels to cause violation of the standard.

- By 1980, decline in emissions due to motor vehicle controls is sufficient to bring CO levels within the 8-hour primary standard.

- By 1995, CO levels are about half the 1970 levels and fall well within the standard.

The SRI model projections for maximum concentrations were compared with projected maximum CO concentrations predicted by the proportional, or rollback method, described in Chapter IV. For the three 1980 alternatives, proportional reduction indicated that a 1-hour maximum of 8.4 ppm and an 8-hour maximum of 6.8 ppm would be attained, whereas the CO model predicted concentrations of approximately 11.0 and 7.4, respectively. Thus, the distribution of emissions in the dispersion model resulted in significantly higher pollution levels, or a more conservative estimate of expected improvements in air quality.

A similar comparison of model-predicted values with results of rollback calculations for the 1995 alternatives did not produce the same findings. The 1-hour concentrations from the model were generally higher, but its 8-hour averages were lower than those from rollback. None of the four pairs of data points differed by more than 1 ppm, with the net result that the two methods of predicting air quality produced equivalent values of 1995 air quality.

To project the future year levels of the remaining pollutants--hydrocarbons, oxidants, nitrogen oxides, and particulates--the bulk proportional model

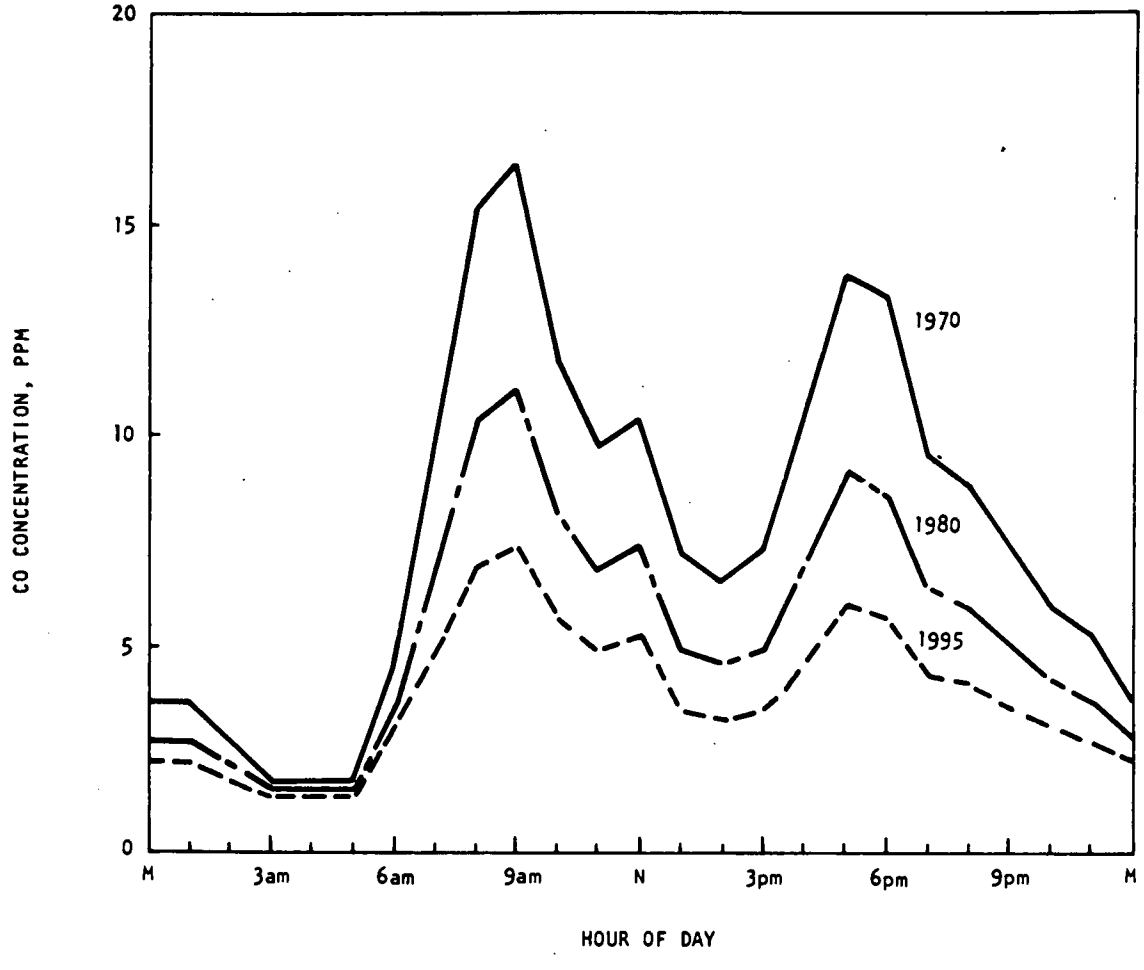


FIGURE VI-15. DAILY VARIATION IN CARBON MONOXIDE CONCENTRATIONS PREDICTED FOR THE RECEPTOR SITE WITH HIGHEST CO LEVELS*—1970, 1980, AND 1995

*ESSEX (6) IN 1970; NOTTINGHAM (10) IN 1980 AND 1995

Table VI - 16

PREDICTED MAXIMUM ONE-HOUR CO CONCENTRATIONS
AT SELECTED RECEPTOR POINTS

Year/Alternative \ Receptor	AIRMON 1 (1)	AIRMON 2 (2)	Riviera Beach (3)	Linthicum (4)	Towson (5)	Timonium (7)	Robinson & Toone (8)	Hamilton (9)	Nottingham (10)	Garrison (11)
	Maximum One-Hour CO Concentration, ppm*									
1980 - Alternative 3 - Complete 3-A	4.3	3.9	3.0	8.2	5.4	7.7	5.8	5.9	11.1	4.5
1980 - Alternative 4 - 3-A, less Ft. McHenry Crossing	4.5	4.2	3.3	7.0	5.4	7.7	7.4	6.0	11.0	3.7
1980 - Alternative 5 - No 3-A	4.9	4.9	3.2	8.3	5.8	8.4	6.2	6.2	10.8	4.7
1995 - Alternative 6 - Complete 3-A and GDP Improvements	3.3	2.9	3.4	5.5	4.1	4.8	3.6	3.6	6.4	3.2
1995 - Alternative 7 - No 3-A, All GDP Improvements	3.4	3.0	3.0	5.6	4.3	4.8	4.4	3.5	6.5	2.8
1995 - Alternative 8 - Complete 3-A, No GDP Improvements	3.2	2.9	2.6	3.0	4.1	5.4	3.9	3.7	7.4	3.8
1995 - Alternative 9 - No 3-A, No GDP Improvements	3.4	3.1	2.4	3.0	4.2	5.2	4.4	3.6	7.2	3.7

* Predicted maximum 8-hour CO centrations are all in the range of 58 to 67 percent of the maximum one-hour concentrations. This uniformity results from the use of identical meterological data for all alternatives and similar patterns of percent of total daily traffic by hour input for all roadways in the study area.

was used. The characteristics of the pollutants and the state-of-the-art does not permit their modeling on a geographic basis in the manner carried out for carbon monoxide.

The bulk proportional model is based on the concept that future year air quality levels are proportional to emissions by weight in that year, as compared to existing air quality levels and emissions in the present. Therefore, future air quality levels are to present levels as future emissions are to present emissions. Thus, future air quality can be estimated, using the three known factors--present air quality, present emissions, and estimates of future emissions.

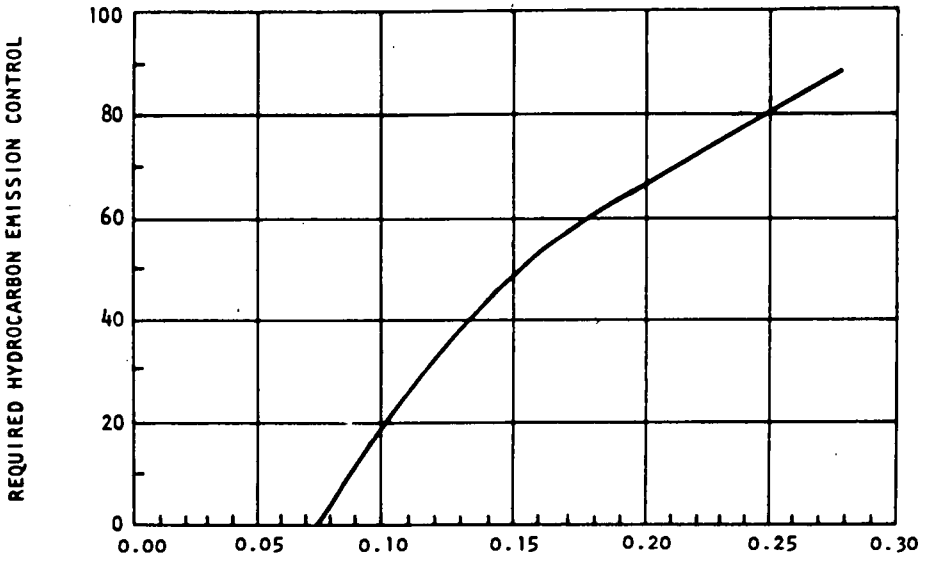
Future maximum oxidant concentrations cannot be estimated directly from a proportional reduction in emissions, since they are formed in the atmosphere instead of being emitted. However, an empirical relationship between atmospheric oxidant levels and relative hydrocarbon emissions has been established. This relationship, shown in Figure VI-16, has been employed to predict the oxidant levels reported in Table VI-19.

Hydrocarbon emissions for the proportional model are those emitted during the 6-9 a.m. period rather than the annual totals used for the other pollutants. The air quality standard for HC is for this 6-9 a.m. period and, more importantly, these are the emissions that are assumed to contribute to the formation of photochemical oxidants.

Table VI-17 shows the percent of daily HC emissions from each source category that are estimated to occur in the 6-9 a.m. period during the summer months. These percentages were applied to the total HC emissions in tons projected for 1980 and 1995 under the various alternatives as shown in Table VI-18. Table VI-18 also indicates the diminishing role of automotive sources in producing 6-9 a.m. HC levels. Motor vehicles are responsible for 77 percent of 1970 levels; this drops to a maximum of 49 percent in 1980 and falls further to 32 percent in 1995.

Estimates of the maximum regional pollutant concentrations predicted for each future-year alternative are shown in Table VI-19. National air quality standards are also shown in the same table for comparison to the projected pollutant levels. Comparison may also be made to Table V-5 for contrast with 1970 (Alternative 1) pollutant concentration levels. The highest 1972 values have been shown in Table VI-19 to show this comparison.

Carbon Monoxide -- Carbon monoxide 1-hour maximum levels are predicted to decline. In the worst case, 1980 1-hour concentrations will decrease



Note: Assumes no Hydrocarbon or Oxidant background

FIGURE VI-16. REQUIRED HYDROCARBON EMISSION CONTROL AS A FUNCTION OF OXIDANT CONCENTRATION*

*SOURCE: "EPA REGULATIONS FOR PREPARATION OF IMPLEMENTATION PLAN," FEDERAL REGISTER, VOLUME 36, NO. 67, WEDNESDAY, AUGUST 14, 1971

TABLE VI - 17

1972 SUMMER WEEKDAY NON-METHANE HYDROCARBON EMISSIONS OCCURING IN THE 6-9 AM PERIOD

BALTIMORE REGION

Source Category	Total Annual Tons Per Year 1970/1971 [1]	Total Annual Tons Per Year 1972 [2]	Summer-Weekday 6-9 am Tons Per Day 1972	6-9 am Period as Percent Average Daily [2] Emissions 1972
Power Plants	1,601	1,800	0.62	12.5
Refuse	753	450	0.15	12.5
Heating	664	980	0.00	0
Trains & Ships	3,113	3,200	1.10	12.5
Aircraft	8,452	2,500	0.92	12.5
Industrial Process Heating	966	2,100	0.72	12.5
Solvent Usage	22,842	25,000	5.72	8.3
Automotive	155,690	97,000	66.40	25.0
Gasoline Storage and Handling	15,573	17,000	3.90	8.3
Miscellaneous Gasoline Usage	277	4,000	0.35	3.1
Total	209,931	154,130	79.86	

Source:

[1] 1970 Emissions, State Implementation Plan

[2] Maryland Bureau of Air Quality Control. Four Alternative Strategies Document, Developed for the Transportation Control Implementation Plan submitted to the Environmental Protection Agency, January 1973.

Table VI - 18

EXISTING AND PROJECTED 6 to 9 a.m. SUMMER HYDROCARBON EMISSIONS
BMATS AREA, BY ALTERNATIVE, TONS/3 HRS.

Source Category	1970*	1980			1995			
	Alternative 1 Existing	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Power Plants	0.60	0.65	0.65	0.65	0.71	0.71	0.71	0.71
Industrial Process Heating	0.69	0.78	0.78	0.78	0.95	0.95	0.95	0.95
Solvent Usage	5.75	4.09	4.09	4.09	4.10	4.10	4.10	4.10
Gasoline Storage and Handling	3.57	4.31	4.32	4.26	5.67	5.45	5.02	4.75
Motor Vehicles	50.33	11.85	12.60	11.93	7.40	6.98	6.9	6.65
Other Transportation	3.82 0.25	3.05	3.05	3.05	4.33	4.33	4.33	4.33
Total, Tons/3 Hrs.	65.01	24.84	25.60	24.87	23.30	22.60	22.20	21.63
Percent Contributed by Automotive, 6-9 a.m.	77.4	47.7	49.2	48.0	31.8	30.8	31.3	30.7
Percent Reduction in HC Emissions, 6-9 a.m. from 1970	---	61.8	60.6	61.7	64.2	65.1	65.9	66.7

* Source: Maryland Bureau of Air Quality Control and Table VI-17

Table VI - 19

MAXIMUM BASE PERIOD AND PREDICTED REGIONAL POLLUTANT CONCENTRATIONS

Pollutant	Averaging Time	1970	1980			1995				
		Alternative 1 Existing	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements	National Air Quality Standard
Carbon Monoxide (ppm)	1-hour maximum	21.0	11.1	11.0	10.6	6.4	6.5	7.4	7.2	35 ppm
	8-hour maximum	17.0	7.4	7.4	7.2	4.3	4.4	5.0	4.8	9 ppm
Non-Methane Hydrocarbons (ppm)	3-hour maximum	2.6	1.1	1.1	1.1	1.0	1.0	1.0	0.9	0.24 ppm
Photochemical Oxidants (ppm)	1-hour maximum	0.21	0.09	0.09	0.09	0.06	0.06	0.06	0.08	0.08 ppm
Nitrogen Dioxide (ppm)	annual arithmetic mean	0.06	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.05 ppm
Particulate Matter ($\mu g/m^3$)	annual geometric mean	75	59	59	59	63	63	63	63	primary-- 75 $\mu g/m^3$ secondary-- 60 $\mu g/m^3$

* All predicted values based on 1972 air quality data collected at AIRMON 1 and 2 stations. A new standard method of NO_x measurement may change the observed levels at these stations.

** Proportional model calculations assume the 123$\mu g/m^3$ arithmetic mean at the maximum site used in the implementation plan and a 40$\mu g/m^3$ background. Conversion to geometric mean was with the assumption that the geometric standard deviation equals 1.6.

Note: Does not include estimates of the effects of transportation control strategies and controls on certain stationary sources issued after September 1973.

by one-half and 1995 by two-thirds below 1970 levels. The 8-hour maximum levels show a similar relationship: 1970--17 ppm; 1980--7.4 ppm; and 1995--5 ppm.

Non-methane Hydrocarbons -- Three-hour maximum (6-9 a.m.) hydrocarbons levels will be less than 40 percent of their present 2.8 ppm levels by 1980 and 1995, standing at 1.1 ppm in 1980 and 1.0 ppm in 1995.

Photochemical Oxidants -- Photochemical oxidant levels are expected to drop from their present high of .21 ppm to .09 ppm in 1980 and .08 ppm in 1995, a reduction of 57 to 62 percent from their present level. (The 6-9 a.m. summer hydrocarbon emissions data reported in Table IV-18 and used in the photochemical oxidant analysis was taken from the Maryland Bureau of Air Quality Control charts shown in Appendix E. This does not include estimated reductions in emissions for 1980 and 1995 from gasoline storage and handling which results from stationary source regulations issued subsequent to the study period. Had this reduction in hydrocarbon emissions been considered in the analysis for this technical memorandum, the air quality standard of .08 ppm for all 1980 alternatives would have been achieved. The Bureau of Air Quality Control values for gasoline storage and handling emissions were not included in this memorandum because they were part of stationary and transportation source control regulations promulgated after the analysis for the Technical Memorandum.)

Nitrogen Dioxide -- The annual arithmetic mean in nitrogen dioxide is projected to fall from the existing high of .06 ppm to .05 ppm in 1980 and rise to .06 ppm in 1995. The air quality data used as the base in the proportional model for nitrogen dioxide, however, was measured by a method (Saltzman) no longer considered valid. The figures for nitrogen dioxide are therefore likely to be higher than actual levels.

Particulates -- Particulate levels of the six sites investigated showed a high annual geometric mean of 75 $\mu g/m^3$ at present. This figure is predicted to fall to 59 $\mu g/m^3$ in 1980 and to rise to 63 $\mu g/m^3$ in 1995. The highest value reported in the Baltimore Air Quality Control Region for suspended particulates was 123 $\mu g/m^3$ arithmetic mean, the value used in the implementation plan. This value was used in the proportional model calculations because of its ready availability and correspondence with previous work. A background of 40 $\mu g/m^3$ was used, and conversion to geometric mean was with the assumption that the geometric standard deviation equaled 1.6. This simple analysis should not be construed to update or modify the calculations performed by the Bureau of Air Quality Control in their implementation plan. In any case, as previously discussed, particulate emissions from motor vehicles comprise a negligible fraction of the regional totals, thereby negating its significance as a criterion for evaluation of alternative highway systems.

COMPARISON TO CRITERIA

Evaluation of the air quality implications of the various alternative Baltimore regional transportation alternatives, (Alternatives 3-9), involves examining projected air quality in terms of four sets of criteria: (1) EPA ambient air quality standards; (2) the degree of air quality degradation; (3) human exposure to pollution; and (4) the exposure of sensitive receptors.

Ambient Air Quality Standards

The relationship of air pollutant concentrations to EPA air quality standards is shown in Table VI-19. From these results it may be concluded that:

- Regional air quality in Baltimore will meet EPA ambient air quality standards for carbon monoxide in 1980 and 1995. Primary and secondary standards for particulates will be met in 1980, but growth may cause marginal violations of the secondary standard by 1995.

- According to the projections, photochemical oxidant standards will be exceeded slightly in 1980 and attained by 1995.

- The region will exceed the guidelines for hydrocarbons in 1980 and 1995 in spite of significant decreases in pollutant concentrations from their 1970 levels.

- Nitrogen dioxide concentrations are projected to be slightly below the standard in the forecast years.

- Projected pollutant levels in all categories differ only slightly among the alternatives in 1980 and 1995.

- Reductions in motor vehicle emissions are expected to be of such magnitude that the sources generating the 1980 and 1995 levels that exceed standards are largely stationary, area and non-vehicular transportation sources. Emissions from such sources are not significantly affected by the proposed transportation alternatives.

Carbon Monoxide -- Neither the 1-hour maximum standard (35 ppm) nor the 8-hour maximum standard (9 ppm) is projected to be exceeded in 1980 or 1995 under any alternatives. Highest future year concentrations for the 1-hour standards are estimated at 11.1 ppm in 1980 and 7.4 ppm in 1995. For the 8-hour standard the levels are 7.4 ppm and 5.0 ppm, respectively.

Non-methane Hydrocarbons -- Maximum hydrocarbon concentrations of 1.1 ppm in 1980 and 1.0 ppm in 1995 during the 6-9 a.m. period exceed the 0.24 ppm guidelines. The 6-9 a.m. period is the significant one for hydrocarbons as research has indicated that the HC emitted in this morning period contributes most to the afternoon buildup of oxidant levels. If oxidant levels are within standards, the HC level may be immaterial, as no adverse effects have been confirmed for HC at the level of the guidelines. The total percentage reduction in HC from present levels amounts to a range of 61 percent to 67 percent for all alternatives in both time periods.

Photochemical Oxidants -- Photochemical oxidant concentrations are projected to decline from their present 1-hour maximum high of .21 ppm to .09 ppm by 1980 and to further decline to .08 ppm for all alternatives in 1995. This level of oxidants matches the EPA standard, which is also .08. Again, this does not account for certain stationary source controls which may reduce the oxidant levels further.

Nitrogen Dioxide -- The annual arithmetic mean level for NO_2 is presently .06 ppm. By 1980, the level is estimated to fall to .05 ppm for all alternatives. The NO_2 level is predicted to rise slightly to 0.55 in 1995, again for all alternatives. All alternatives, therefore, appear to have a NO_2 level that is approximately equal to the .05 ppm EPA standard. The amount of NO_2 emissions contributed by highway transportation is projected to decline from the base year 32 percent to 16 percent in 1980 and about 8 percent in 1990.

Particulate Matter -- The projected annual geometric mean of particulate matter concentration for 1980 indicates no violation of either the primary or secondary air quality standards (primary: 75 $\mu g/m^3$; secondary: 60 $\mu g/m^3$). The level in that year for all alternatives is expected to be 59 $\mu g/m^3$. By 1990, however, the particulate level is expected to be 63 $\mu g/m^3$ for all alternatives, a level that slightly exceeds the secondary standards. Particulates from highway transportation amount to only 3 percent of the existing regionwide total. In 1980 and 1990, the proportion is anticipated to be 4 percent under all alternatives. In either case, the motor vehicle contribution appears insignificant.

Degradation

A decline in environmental quality, or "degradation," would be signaled by upward changes in certain indexes of air quality. If total tons of emissions or maximum levels of concentration of any air pollutant rise, there has been a degradation of air quality or the environment.

Table VI-20 summarizes the data from previous tables in this memorandum. Its purpose is to examine the degradation issue to determine whether there will be degradation and, if so, which pollutants and to what degree.

Table VI - 20

SUMMARY OF INDEXES OF AIR QUALITY DEGRADATION

Degradation Index	1970	1980			1995			
	Alternative 1 Existing	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Total Tons of Emissions Per Year (in Thousands)								
CO	555.30	188.40	188.80	188.00	147.80	145.50	142.20	139.20
NO_2	149.30	130.30	130.30	129.70	141.60	140.90	140.40	139.40
HC	143.60	74.80	75.90	74.70	87.90	86.80	88.90	85.50
Particulates	90.30	26.20	28.20	28.10	32.80	32.40	32.50	31.90
Maximum Air Pollution Levels Projected								
CO (ppm)-8 Hr. Maximum	17.0	7.4	7.4	7.2	4.3	4.4	5.0	4.8
NO_2 (ppm)	.06	.05	.05	.05	.06	.06	.08	.08
HC (ppm)	2.80	1.1	1.1	1.1	1.0	1.0	1.0	.9
O_x (ppm)	.21	.09	.09	.09	.08	.08	.08	.08
Particulates ($\mu g/m^3$)	75.0	59.0	59.0	59.0	63.0	63.0	63.0	83.0

Compared with present conditions, there is no degradation but rather improvement in all pollutant categories for all alternatives. A low point in all indexes is reached in 1980, after which there is moderate degradation from 1980 to 1995 in indexes for NO_2, HC, and particulates compared with the figures attained for 1980. CO shows constant improvement in all alternatives and time periods.

Human Exposure

Estimates of human exposure to levels of carbon monoxide that exceed ambient air quality standards were obtained by measuring the total residential and employment population in the area where mapped background levels were at the 2.0 ppm level. This level of background seems to correspond with a total street level concentration of 9.0 ppm or more, 8-hour ambient air quality standard for CO.

The area of the Baltimore region wherein 1970 or existing background CO concentrations exceed 2.0 ppm is shown in Figure VI-7. The total resident population in the area where standards are exceeded is approximately 216,000; the total employment population in the same area is approximately 60,000 persons. The actual exposure to persons in the area depends on employment patterns, but may be estimated at about 240,000 persons.

Similar estimates of human exposure levels for oxidants is not applicable at this level of analysis since oxidants are a regional phenomenon.

Inspection of contour maps for urban background concentration levels of CO for the 1980 and 1995 highway system alternatives (Figures VI-8 through VI-14) reveals only a minor concentration in 1980 of 2.0 ppm or greater at this scale of analysis. However, there are likely to be localized concentrations of CO which will require further analysis with respect to human exposure levels.

Sensitive Receptors

The measurement of the numbers of sensitive receptors--school children, the elderly and ill--exposed to levels of CO in excess of ambient air quality standards was carried out in the same manner as the analysis for human exposure above. The numbers of schools and school children, hospitals and hospital beds in the area of the total region where urban background concentrations of CO exceed 2.0 ppm were estimated.

In Alternative 1 (Existing 1970) where urban background concentration levels of CO exceeding 2.0 ppm were found, sensitive receptors are exposed in the following approximate numbers in the Baltimore region:

Total schools	33
Total students	66,100
Total hospitals	3
Total hospital beds	800

Examination of the contour maps of CO urban background concentrations for the remaining time periods (1980 and 1995) and Alternatives (3-9) reveals only one instance of concentrations of 2.0 ppm or greater. (See Figures VI-8 through VI-14).

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APPENDICES

Appendix A	Health Effects of Air Pollution	A-1
Appendix B	Description of APRAC-1A Urban Diffusion Model	A-4
Appendix C	Conversion of Traffic Data	A-7
Appendix D	Correspondence Related to Development of Emission for Automotive Sources--Baltimore Regional Environmental Impact Study--1973	A-13
Appendix E	Hydrocarbon Emissions	A-40

APPENDIX A

HEALTH EFFECTS OF AIR POLLUTION

The following discussion briefly describes the adverse effects on health and materials of the pollutants examined in the BREIS study. More detailed information may be found in references listed in the bibliography.

The pollutants discussed are:

- Carbon monoxide (CO)
- Hydrocarbons (HC)
- Oxidants (O_x)
- Oxides of nitrogen (NO_x)
- Oxides of sulfur (SO_x)
- Particulates

All of these pollutants have been found to have negative effects on human health, plant life, or materials. A Congressional staff report generalized their effects as follows:

> There is strong evidence that air pollution is associated with a number of respiratory ailments. These include: (1) non-specific infectious upper respiratory disease, (2) chronic bronchitis, (3) chronic constrictive ventilatory disease, (4) pulmonary emphysema, (5) bronchial asthma, and (6) lung cancer. (1)
>
> Most common materials are adversely affected by pollution. Metals corrode, fabrics weaken and fade, leather weakens and becomes brittle, rubber cracks and loses its elasticity, paint discolors, concrete and building stone discolor and erode, glass is etched, and paper becomes brittle. (1)

Other U.S. Government reports relate, more specifically, the effects of each pollutant:

> Carbon Monoxide -- Concentrations of 30 ppm carbon monoxide for more than four hours under controlled conditions will tie up approximately 5 percent of the body's hemoglobin, producing measurable impairment of physiological functions, such as vision and psycho-motor performance. Concentrations higher than 30 ppm carbon

monoxide are frequently observed in urban traffic. There are reports which indicate that lower levels of carboxyhemoglobin can produce measurable effects on cognitive and psychomotor perfomance. (2)

Hydrocarbons -- Certain hydrocarbon derivatives emitted in automobile exhaust may have carcinogenic effects on lung tissue, but the evidence is inconclusive. The primary concern with these emissions is their indirect effect through participation in the photochemical reactions which lead to the formation of oxidants. Plant damage, eye and respiratory tract irritation and reduced visibility are all associated with the formation and prevalence of photochemical oxidants. (2)

Nitrogen Oxides -- Oxides of nitrogen are major participants in photochemical oxidant reactions. Ozone and peroxyacyl nitrates (PAN), in addition to nitrogen dioxide, are oxidizing agents resulting from automotive exhausts which are found in the atmosphere. These substances are associated with eye irritation, odor, and respiratory effects of photochemical smog. Ozone, the peroxyacyl nitrates, and a number of organic oxidants associated with automotive emissions have been identified as the responsible agents for damage to food, forage, and ornamental crops in most of the major metropolitan areas of the United States. Cash crop losses related to air pollution are estimated to be on the order of $6-$10 million annually in California alone. Ozones and other oxidants in photochemical smog attack many materials, including rubber, textiles, and dyes. (2)

Sulfur Oxide -- Considerable evidence points to the fact that sulfur oxide pollution very likely contributes to the development of and aggravates existing respiratory disease in humans. (3)

Particulates (particularly lead compounds) -- Lead is known to be toxic to humans, but the concentrations required for this effect, either in the body or in the environment, have occurred only in isolated cases, usually as a result of occupational hazards. Lead also has some effects which produce no overt symptons. It interferes with the maturation and development of red blood cells, allegedly affects liver and kidney functions, and disturbs enzyme activity. But neither these nor other bodily disturbances caused by lead have been detected in the general population to date. Epidemiological studies adequate to detect these effects, should they exist, have not been carried out. (2)

While research is continuing into the extent and nature of the precise effects of air pollution on health, plants, materials, and the atmosphere, sufficient evidence as to its negative effects has accumulated to warrant the present attempts to measure, predict and control it. Ambient air quality standards have been set by agencies at all levels of government, but most notably by the U.S. Environmental Protection Agency. The Federal 1970 Clean Air Act requires the states to propose the implementation plans for meeting the standards by 1975 (1977 in some cases).

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1. U.S. Congress, Senate, "A Study of Pollution--Air," A Staff Report to the Committee on Public Works, 88th Congress, 1st Session, September 1963.

2. Panel on Electrically Powered Vehicles, The Automobile and Air Pollution: A Program for Progress, Part I, Washington: U.S. Department of Commerce, 1967.

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APPENDIX B

DESCRIPTION OF APRAC-1A URBAN DIFFUSION MODEL

The APRAC-1A diffusion model for carbon monoxide (CO) was developed by the Stanford Research Institute to simulate CO concentrations that result primarily from multiple line sources distributed over an urban area. Diffusion calculations are made for sources that fall within a $22\text{-}1/2^{\circ}$ angular sector that extends 32 km upwind from each specified receptor point. This cone-shaped area is divided into nine segments spaced at increasing intervals away from the receptor point. The segments, which are at different locations for each change in wind direction or receptor point, may be thought of as overlaying a fixed traffic network for the urban area.

Traffic links or portions thereof which fall within each segment are identified by a model subroutine based on grid coordinates of the links and receptor. Emissions from each identified link are calculated in another subroutine, and the emissions are summed by segment. The model can accommodate up to 1200 traffic links and up to 625 receptor points, so the need for computerization is obvious.

Intraurban diffusion is then estimated with a Gaussian plume diffusion formulation, with the contribution from each segment calculated separately. The contributions from all nine segments are summed to produce the total intraurban CO concentration at a given receptor point. The Gaussian diffusion equation uses inputs of area emission rate, transport wind speed, atmospheric stability, and downwind distance to the receptor.

The diffusion subroutine also has the capability of switching to a "box model" to calculate the concentrations resutling from the distant segments if input meteorological data indicates that there is a limited mixing depth (inversion) for the time period being simulated. The box model assumes that the CO has a uniform vertical concentration throughout the mixing depth after it has been transported a sufficient distance. The subroutine switches to the box model formulation whenever it indicates higher concentrations than the Gaussian diffusion equation.

Diffusion of extraurban emissions, which has a very minor effect on reported concentrations, is also handled by a box model equation. CO from extraurban sources is estimated from input data on annual consumption of fuel to a distance of 1000 km in each of 16 compass-point sectors away from the center of the city. A single value of CO contributed by extraurban sources

for each day is then calculated by a subroutine using the prevaling wind direction for that day to select the upwind sector.

Traffic simulation in the model is by input of the average daily traffic volume on each link and a code number to describe the type of road, e.g., Interstate, four-lane divided, primary arterial, etc. The hourly distribution of traffic on the road, average speeds, peak/non-peak characteristics, and weeday/weekend characteristics are provided by type of road.

Emission rates for each vehicle-mile are calculated from an equation of the form:

$$E = aS^{-b}$$

where:

S = average vehicle speed on a link

a and b= constants for each year that reflect the characteristics of the emission control devices and mix of old and new model cars

Total hourly emissions on a link are then determed in the subroutine by multiplying the emission rate by the link's hourly traffic volume and its length in miles. Emissions of CO from stationary sources are considered along with traffic on minor streets (not included in the 1200 links) as secondary emissions. These are summed for subareas, either rectangular grids or other specified districts, then input as area sources located by their centroids.

The output of the model may be requested in any of three formats:

- Synoptic -- produces hour-by-hour concentrations for any specified length of time at up to ten different receptor sites. This version also includes a street-canyon subroutine which computes the CO contribution from the nearest road separately from the overall urban emissions and reports both ground-level and rooftop (urban background) CO concentrations.

- Climatological -- reports frequency of occurrence of higher concentrations at up to ten receptor sites if an extended time period is modeled.

- Grid point -- indicates concentrations at up to 625 different locations (in a grid array) throughout the urban area for a single one-hour period. By varying the spacing of the receptor grid, either the entire urban area can be investigated for distribution of concentrations or a smaller subarea can be examined with finer resolution. The grid point model only reports rooftop (urban background) concentrations.

The theory of the model, its operating feature, and data requirements are explained in detail in the User's Manual. (1)

(1) Mancuso, R.L. and F. L. Ludwig, User's Manual for the APRAC-1A Urban Diffusion Model Computer Program, Stanford Research Institute, Contract CAPA-3-68(1-69). Menlo Park, California, September 1972, 119 p.

APPENDIX C

CONVERSION OF TRAFFIC DATA

A system of data analysis computer programs was created in order to determine air quality and noise pollution for the alternative networks for the Baltimore region. Figure C-1 contains the system flow of data from the final capacity network output to the link data summaries by regional planning district (RPD) and link classification.

Rather than modify the existing pollution modeling programs to accept the Federal Highway Administration (FHWA) formatted network tapes, it was determined that existing computer programs could be utilized. The first of these programs was ANALHR. This program extracted only the necessary data used later by the various pollution models and link summary programs. The program eliminated the duplication of link data inherited by the FHWA network and formatted the data so that it was easily understandable. The second program used was NETGEN which produced data that was input to both the air and noise models and link summaries. Table C-1 contains the information of the data record used for link summaries and noise pollution analysis.

For the SRI air pollution model, link data information was punched on cards for further processing. Only the primary routes and freeways were considered because of link capacity limitations of the SRI model. There were three user subroutines compiled with NETGEN. These subroutines contained different environmental emission factors for each design year and were used in the CO emissions model.

The last data analyzing program executed was the AVADDR program. This program summarizes the various link attributes shown in Table C-1.

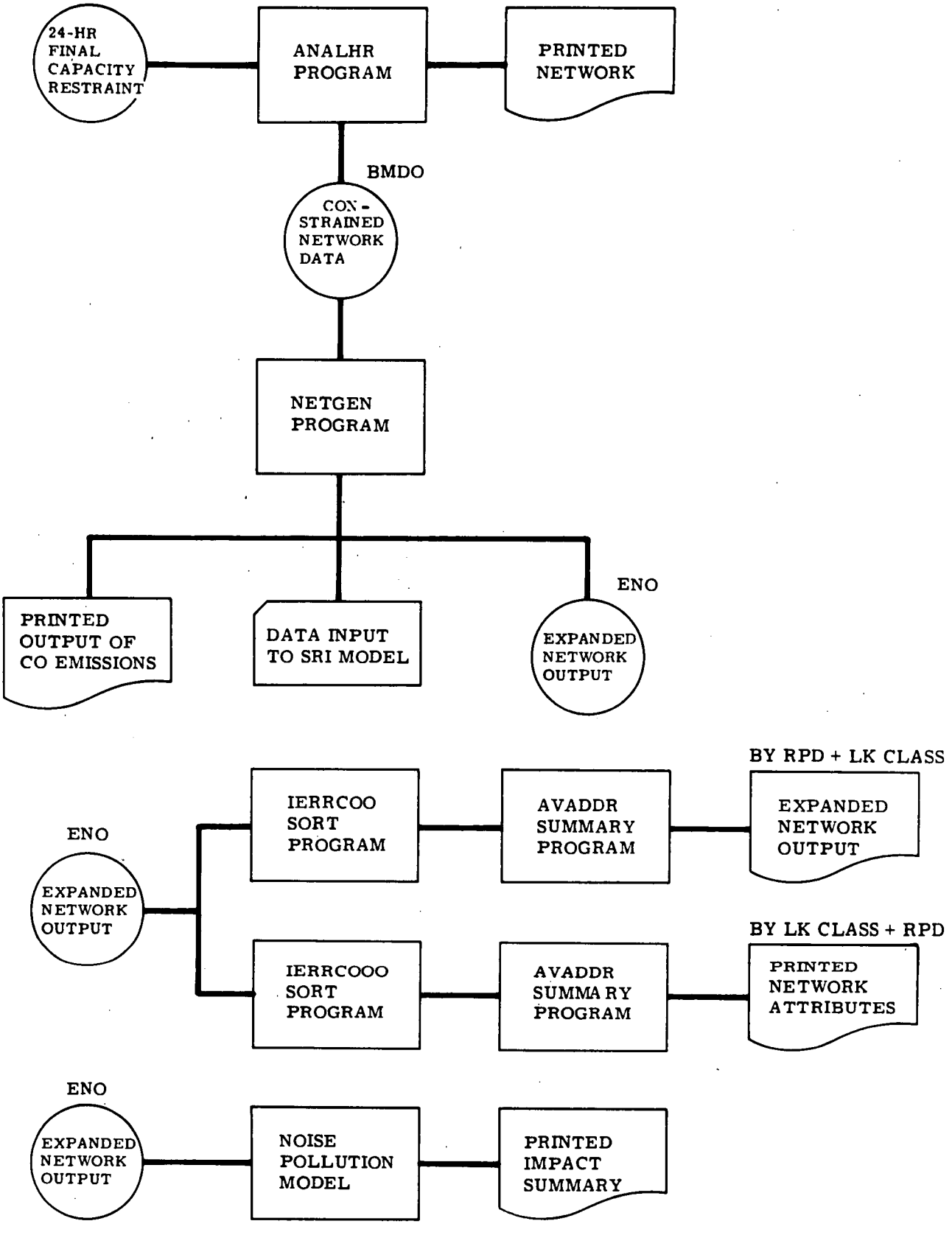

FIGURE C-1. SYSTEM FLOW FOR CONVERSION OF TRAFFIC DATA FOR AIR AND NOISE ANALYSIS

TABLE C-1

(INPUT TO NOISE AND AIR POLLUTION MODELS)

OUTPUT OF NETGEN

Data Record

Item	Cols.	Contents
1	1- 8	A-Node
2	9- 16	B-Node
3	17- 24	Administration Class *
4	25- 32	Functional Class **
5	33- 40	Adjacent Land Use ***
6	41- 48	Link Location (RPD)
7	49- 56	Route Number
8	57- 64	Hourly Capacity (Service C A-B)
9	65- 72	Hourly Capacity (Service C B-A)
10	73- 80	Width A-B Ft.
11	81- 88	Width B-A Ft.
12	89- 96	Speed (Level C) (10's)
13	97-104	Dist A-B Link Length (100's)
14	105-112	HDV-ADT (A-B) 24 Hr.
15	113-120	HDV-ADT (B-A) 24 Hr.
16	121-128	LDV-ADT (A-B) 24 Hr.
17	129-136	LDV-ADT (B-A) 24 Hr.
18	137-144	Auto-ADT (A-B) 24 Hr.
19	145-152	Auto-ADT (B-A) 24 Hr.
20	153-160	HDV-ADT (A-B) PP
21	161-168	HDV-ADT (B-A) PP
22	169-176	LDV-ADT (A-B) PP
23	177-184	LDV-ADT (B-A) PP
24	185-192	Auto-ADT (A-B) PP
25	193-200	Auto-ADT (B-A) PP

Item	Columns	Contents
26	201-208	X-COORDINATE - A NODE
27	209-216	Y-COORDINATE - A NODE
28	217-224	VMT-AUTO PEAK (Non-Directional)
29	225-232	VMT-HDV PEAK
30	233-240	VMT-LDV PEAK
31	241-248	VHR-AUTO PEAK
32	249-256	VHR-HDV PEAK
33	257-264	VHR LDV PEAK
34	265-272	VMT-AUTO 24HR
35	273-280	VMT-HDV 24HR
36	281-288	VMT-LDV 24HR
37	289-296	VHT-AUTO 24HR
38	297-304	VHT-HDV 24 HR
39	305-312	VHT-LDV 24 HR
40	313-320	AVE-PEAK SPEED A-B
41	321-328	AVE-PEAK SPEED B-A
42	329-336	AVE-24HR SPEED A-B
43	337-344	AVE-24HR SPEED B-A
44	345-352	X-COORDINATE-B NODE
45	353-360	Y-COORDINATE-B NODE

* 1 = Toll
2 = Interstate
3 = State Primary
4 = State Secondary
5 = Local

** 1 = Freeway
2 = Major Arterial
3 = Minor Arterial
4 = Collectors
5 = Off Ramps
6 = On Ramps
9 = Centroid Connectors

*** 10 = High CBD
20 = Medium Fringe
30 = Outlying Busines
40 = Rural

1970 EMISSION EQUATIONS

$$\text{Total } CO_{1970} = 56.42 \sum_{\text{link}=1}^{n} (VMT_i^{LDV})(C1_i) + 123.23 \sum_{\text{link}=1}^{n} (VMT_i^{HDV})(C1_i)$$

$$+ 56.42 \sum_{RPD=1}^{70} (VMT_i^{LDV})(C1_i) + 123.23 \sum_{RPD=1}^{70} (VMT_i^{HDV})(C1_i)$$

$$+ 52.72 \frac{\text{LDV trip ends}}{2} + 104.26 \frac{\text{HDV trip ends}}{2}$$

$$\text{Total } HC_{1970} = 5.23 \sum_{\text{link}=1}^{n} (VMT_i^{LDV})(C1_i) + 15.21 \sum_{\text{link}=1}^{n} (VMT_i^{HDV})(C1_i)$$

$$+ 5.23 \sum_{RPD=1}^{70} (VMT_i^{LDV})(C1_i) + 15.21 \sum_{RPD=1}^{70} (VMT_i^{HDV})(C1_i)$$

$$+ 27.50 \frac{\text{LDV trip ends}}{2} + 35.18 \frac{\text{HDV trip ends}}{2}$$

$$\text{Total } NO_{x_{1970}} = 5.43 \sum_{\text{link}=1}^{n} (VMT_i^{LDV})(C2_i) + 9.38 \sum_{\text{link}=1}^{n} (VMT_i^{HDV})(C2_i)$$

$$+ 5.43 \sum_{RPD=1}^{70} (VMT_i^{LDV})(C2_i) + 9.38 \sum_{RPD=1}^{70} (VMT_i^{HDV})(C2_i)$$

$$\text{Particulate}_{1970} = 0.30 \left(\sum VMT_{\text{links}}^{LDV} + \sum VMT_{RPD}^{LDV}\right) + 0.74 \left(\sum VMT_{\text{links}}^{HDV} + \sum VMT_{RPD}^{HDV}\right)$$

where:

VMT^{LDV} = Vehicle Miles of Travel for Light Duty Vehicles

VMT^{HDV} = Vehicle Miles of Travel for Heavy Duty Vehicles

Speed correction factors (dimensionless):

$$C1_i = 5.06 \, (\text{Speed}^{(-.55)})$$

$$C2_i = .56 \, (\text{Speed}^{(10.20)})$$

1980 EMISSION EQUATIONS

$$\text{Total CO}_{1980} = 8.90 \sum_{\text{link}=1}^{n} (\text{VMT}_i^{\text{LDV}})(C1_i) + 117.93 \sum_{\text{link}=1}^{n} (\text{VMT}_i^{\text{HDV}})(C1_i)$$

$$+ 8.90 \sum_{\text{RPD}=1}^{70} (\text{VMT}_i^{\text{LDV}})(C1_i) + 117.93 \sum_{\text{RPD}=1}^{70} (\text{VMT}_i^{\text{HDV}})(C1_i)$$

$$+ 18.84 \frac{\text{LDV trip ends}}{2} + 98.27 \frac{\text{HDV trip ends}}{2}$$

$$\text{Total HC}_{1980} = 1.02 \sum_{\text{link}=1}^{70} (\text{VMT}_i^{\text{LDV}})(C1_i) + 12.73 \sum_{\text{link}=1}^{70} (\text{VMT}_i^{\text{HDV}})(C1_i)$$

$$+ 1.02 \sum_{\text{RPD}=1}^{70} (\text{VMT}_i^{\text{LDV}})(C1_i) + 12.73 \sum_{\text{RPD}=1}^{70} (\text{VMT}_i^{\text{HDV}})(C1_i)$$

$$+ 5.04 \frac{\text{LDV trip ends}}{2} + 19.42 \frac{\text{HDV trip ends}}{2}$$

$$\text{Total NO}_{x_{1980}} = 1.80 \sum_{\text{link}=1}^{n} (\text{VMT}_i^{\text{LDV}})(C2_i) + 9.22 \sum_{\text{link}=1}^{n} (\text{VMT}_i^{\text{HDV}})(C2_i)$$

$$+ 1.80 \sum_{\text{RPD}=1}^{70} (\text{VMT}_i^{\text{LDV}})(C2_i) + 9.22 \sum_{\text{RPD}=1}^{70} (\text{VMT}_i^{\text{HDV}})(C2_i)$$

$$\text{Particulate}_{1980} = 0.10 \left(\sum \text{VMT}_{\text{links}}^{\text{LDV}} + \sum \text{VMT}_{\text{RPD}}^{\text{LDV}}\right) + 0.70 \left(\sum \text{VMT}_{\text{links}}^{\text{HDV}} + \sum \text{VMT}_{\text{RPD}}^{\text{HDV}}\right)$$

where:

VMT^{LDV} = Vehicle Miles of Travel for Light Duty Vehicles

VMT^{HDV} = Vehicle Miles of Travel for Heavy Duty Vehicles

Speed correction factors (dimensionless):

$$C1_i = 5.06 \, (\text{Speed}^{(-.55)})$$

$$C2_i = .56 \, (\text{Speed}^{(10.20)})$$

1995 EMISSION EQUATIONS

$$\text{Total } CO_{1995} = 2.22 \sum_{\text{link}=1}^{n} (VMT_i^{LDV})(C1_i) + 117.00 \sum_{\text{link}=1}^{n} (VMT_i^{HDV})(C1_i)$$
$$+ 2.22 \sum_{RPD=1}^{70} (VMT_i^{LDV})(C1_i) + 117.00 \sum_{RPD=1}^{70} (VMT_i^{HDV})(C1_i)$$
$$+ 6.70 \frac{\text{LDV trip ends}}{2} + 97.50 \sum_{RPD=1}^{80} \frac{\text{HDV trip ends}}{2}$$

$$\text{Total } HC_{1995} = .34 \sum_{\text{link}=1}^{70} (VMT_i^{LDV})(C1_i) + 11.70 \sum_{\text{link}=1}^{70} (VMT_i^{HDV})(C1_i)$$
$$+ .34 \sum_{RPD=1}^{70} (VMT_i^{LDV})(C1_i) + 11.70 \sum_{RPD=1}^{70} (VMT_i^{HDV})(C1_i)$$
$$+ 2.37 \frac{\text{LDV trip ends}}{2} + 15.95 \frac{\text{HDV trip ends}}{2}$$

$$\text{Total } NO_{x_{1995}} = .76 \sum_{\text{link}=1}^{n} (VMT_i^{LDV})(C2_i) + 9.20 \sum_{\text{link}=1}^{n} (VMT_i^{HDV})(C2_i)$$
$$+ .76 \sum_{RPD=1}^{70} (VMT_i^{LDV})(C2_i) + 9.20 \sum_{RPD=1}^{70} (VMT_i^{HDV})(C2_i)$$

$$\text{Particulate}_{1995} = 0.10 \left(\sum VMT_{\text{links}}^{LDV} + \sum VMT_{RPD}^{LDV}\right) + .69 \left(\sum VMT_{\text{links}}^{HDV} + \sum VMT_{RPD}^{HDV}\right)$$

where:

VMT^{LDV} = Vehicle Miles of Travel for Light Duty Vehicles

VMT^{HDV} = Vehicle Miles of Travel for Heavy Duty Vehicles

Speed correction factors (dimensionless):

$$C1_i = 5.60 \, (\text{Speed}^{(-.55)})$$
$$C2_i = .56 \, (\text{Speed}^{(10.20)})$$

APPENDIX D

Correspondence Related to Development of Emission Factors for Automotive Sources -- Baltimore Regional Environmental Impact Study -- 1973

AMV

MEMORANDUM

TO: Distribution DATE: May 3, 1973

FROM: Ken Axetell KA JOB: 357

SUBJECT: Development of Emission Factors for Automotive Sources

---

This memo explains the procedure used to develop air pollution emission factors for estimating automotive source emissions for BRTIS. The pollutants of concern are carbon monoxide, hydrocarbons, nitrogen oxides, and particulates. Three sets of factors were developed, to be representative of the years under investigation--1970, 1980, and 1995. These factors are summarized in Tables 1, 2, and 3.

The basic procedure was the same as that employed by Maryland BAQC. It differs from Federal EPA methodology by assigning a portion of the average per-mile emissions to trip ends to account for cold starts and hot soak. Readers are referred to an attached BAQC memo by Mr. Don Andrew for additional detail. This modification was sanctioned by Mr. David Kircher, an EPA engineer who has done much of their work on mobile source emission factors, in a phone call of April 24. A letter request to the EPA Region III Office to approve the procedure has not been answered to date.

A few of the low-mileage (i.e., new car) emission rates used by BAQC to calculate their model-year emission factors have been updated by EPA, based on additional testing. In conjunction with BAQC staff, it was decided that the updated values would not be used in this study. The primary reason was to keep emission calculations consistent and comparable with those done by the BAQC. These changes were only for pre-1972 model-years, and therefore will not influence the emission factors for 1980 or 1995. The net effect of the updated values on regionwide CO, HC, and NO_x emission estimates for 1970 would be to reduce the estimates by 15 to 20 percent.

Separate factors for heavy duty vehicles (HDV) were developed. Low-mileage emission rates for individual model years and the distribution of HDV by model year were taken from the EPA publication, "An Interim Report on Motor Vehicle Emission Estimation," January, 1973. The procedure for split-out of trip end emissions was the same as for LDV (a value of 10 percent of standard trip emissions was assumed.)

The difference in emission rates from vehicles on city streets compared to emissions on freeways at the same average speed (start-and-stop versus constant speed travel) was investigated thoroughly. Although directly comparable test data are not yet available to make this analysis, it appears that the error introduced by using a single emission factor for both conditions is not significant. This is because the speed correction factor already reflects the lower variation in speeds for travel at the higher average speeds associated with freeway travel.

The speed correction factor has been converted into a continuous function to permit efficient computer calculation of emissions for each highway link. However, these expressions are equivalent to those in Table XI of the BAQC memo.

Particulate emission factors for LDV were taken directly from EPA's Compilation of Emission Factors (February, 1972 edition), Table 3-1. Note that they are independent of speed. Since no particulate factors have been published for heavy duty gasoline powered vehicles, the diesel-powered HDV factor of 1.18 grams/mile for 1970 was considered for use. The factor for 1970 would be about 1 gram/mile under the assumption that particulate emission rates are proportional to average gasoline consumption rates (4 miles/gallon for HDV and 12.5 for LDV). Therefore, the value of 1.18 has been used because of this close agreement.

KA:mmi

Distribution: S. Bellomo
S. Liff
C. Zellner
F. Spielberg
D. Wagner
W. Ockert
P. Lebron

TABLE 1

EMISSION FACTORS FOR 1970

Pollutant	Vehicle Type	Running Emissions gm/mile	Cold Start Emissions gm/cold start	Hot Soak Emissions gm/stop
CO	LDV	$56.42\ C_1$	52.72	–
	HDV	$123.23\ C_1$	104.26	–
HC	LDV	$6.66\ C_1$	5.28	22.22
	HDV	$18.42\ C_1$	12.68	22.50
NO_x	LDV	$5.43\ C_2$	–	–
	HDV	$9.38\ C_2$	–	–
PART.	LDV	0.30	–	–
	HDV	1.18	–	–

Speed Correction Factors (Dimensionless):

$C_1 = 5.06\ S^{-0.55}$

$C_2 = 0.55\ S^{0.20}$, where S = average speed, in mph

TABLE 2

EMISSION FACTORS FOR 1980

Pollutant	Vehicle Type	Running Emissions gm/mile	Cold Start Emissions gm/cold start	Hot Soak Emissions gm/stop
CO	LDV	$8.90\ C_3$	18.84	–
	HDV	$117.93\ C_3$	98.27	–
HC	LDV	$1.02\ C_3$	2.47	2.57
	HDV	$12.73\ C_3$	10.37	9.05
NO_x	LDV	$1.80\ C_4$	–	–
	HDV	$9.22\ C_4$	–	–
PART.	LDV	0.10	–	–
	HDV	0.85	–	–

Speed Correction Factors (Dimensionless):

$$C_3 = 1.56\ S^{-0.15}$$

$$C_4 = 0.52\ S^{0.22}, \quad \text{where S = average speed, in mph}$$

TABLE 3

EMISSION FACTORS FOR 1995

Pollutant	Vehicle Type	Running Emissions gm/mile	Cold Start Emissions gm/cold start	Hot Soak Emissions gm/stop
CO	LDV	2.22	6.70	–
	HDV	117.00	97.50	–
HC	LDV	0.34	0.87	1.50
	HDV	11.70	9.75	6.00
NO_x	LDV	0.76	–	–
	HDV	9.20	–	–
PART.	LDV	0.10	–	–
	HDV	0.74	–	–

BUREAU OF AIR QUALITY CONTROL
TECHNICAL MEMORANDUM

Method for Estimating Light Duty Vehicle Emission on a Sub-Regional Basis

Division of Engineering

State of Maryland
Department of Health and Mental Hygiene
Environmental Health Administration
610 N. Howard Street
Baltimore, Maryland 21201
April 1973

BAQC-TM 73-107

I. INTRODUCTION

It is well known that motor vehicle emissions are directly related to engine operating parameters. To date all attempts to develop an emission model based upon these parameters have been unsuccessful. The only model currently available for use is based on an average vehicle--average trip--average emission concept and is suitable only for estimating emission inventories for large areas over which the average values are assumed to apply.

The vast majority of vehicle emission data available today is made up of data collected by EPA during its new vehicle certification program and by the California Air Resources Board as part of its surveillance program. These data are normally presented as a single value of grams/mile for the CVS and 7-mode test cycle respectively.

This memorandum outlines the procedure developed by the Bureau as a means to extend the value of the existing data bank. The procedure separates emissions into these categories: cold start, running, and hot soak. With this separation the running emissions become more link specific as they are independent of trip length and cold start and hot soak emissions may be assigned to complex point sources.

II. DISCUSSION

HOT SOAK EMISSIONS (HYDROCARBONS)

Hot soak emissions are measured and reported on a per test basis. They are then divided[1] by the 7.5 miles represented by the CVS test cycle and the resulting grams per mile is added to the exhaust emission grams per mile for a composite trip emission value. This procedure over estimates the hot soak emissions if the true trip is greater than the average of 7.5 miles and under estimates if it is less. The Bureau procedure uses the hot soak emission as the were measured-grams/test, with the test being synonymous with trip end. As there are two trip ends per trip, the hot soak emissions become the product of grams/trip end and the number of trip ends divided by two.

COLD START EMISSIONS (HYDROCARBONS AND CARBON MONOXIDE)

The cold start emissions are those emissions associated with a cold engine and/or a cold or inactive catalyst if the vehicle is so equipped. These emissions have become increasingly important with the development of catalyst systems that require the achievement of light-off temperatures before they will control exhaust emissions. GM[2] has reported

(1) Federal Regulations, February 10, 1970

(2) "Progress and Programs in Automotive Emissions Control", a progress report by General Motors to EPA, March 12, 1971

values for a 1975 catalyst equipped prototype and a 1970 production vehicle. The first 2 minutes of the federal constant volume sampling test procedure, CVS-I produced 50% and 21% respectively of the total emissions collected over the 23 minute cycle.

The first two minutes of a trip are associated with engine warm up and driving on local streets, parking lots, and garages prior to entry into traffic controlled areas. Separating the CVS-I emission data into that collected during the first two minutes and the final 21 minutes would, for example, provide emissions associated with the activities that generate trips (starts) and with the actual travel portion of the trip (running emissions).

It was assumed that the GM data applied to 1975 and later vehicles and 1968 thru 1971 vehicles. By linear interpolation a value of 35% was assigned to 1972 thru 1979. Because of the very large total emission from uncontrolled vehicles it was conservatively estimated that for these vehicles only 10% of the total emissions were emitted during the first 2 minutes.

There are no NO_x emissions associated with cold engine operation. Therefore, they are included only as running emissions.

III. USE OF DATA

The data supplied in Tables I thru XI are used as indicated in equations 1 thru 4. For commuter traffic (i.e., 6--9 a.m.) it may be desirable to use the population distribution of Table IV for the model distribution by age, y in equations 2, 3, and 4. For non-commuter or 24 hour trip generations it may be desirable to use the weighted travel distribution from the same table. This will depend upon the sensitivity of the trip generation model to these two categories.

TOTAL EMISSIONS

$$E_t = E_r + E_c + E_h$$

WHERE:

E_r = running emissions

E_c = cold start emissions

E_h = hot soak emissions

RUNNING EMISSIONS

$$E_r = \sum_{y=0}^{13} M_y \cdot R_y$$

WHERE:

y = calendar year +1 minus model year

M_y = (VMT) (model distribution by age, y)

R_y = running emission factor for age, y

RUNNING EMISSION FACTOR

R_y = (exhaust emission factor) (deterioration factor) (speed correction factor) + (blow-by)

COLD START EMISSIONS

$$E_c = \sum_{y=0}^{13} C_y \cdot \text{(model distribution by age, y)} \text{ (trip ends/2)}$$

WHERE:

C_y = cold start emission factor for age, y

HOT SOAK EMISSIONS

$$E_h = \sum_{y=0}^{13} H_y \cdot \text{(model distribution by age, y)} \text{ (trip ends/2)}$$

WHERE:

H_y = hot ~~start~~ soak emission factor for age, y

Table I

Age Distribution by Vehicle Age for Maryland and the United States

	MARYLAND[1]		UNITED STATES[2]			
			Passenger Vehicles		Passenger Vehicles & Trucks	
Age in Years	Simple	Percent Cummulative	Simple	Percent Cummulative	Simple	Percent Cummulative
<1	4.6	100	7.8	100.0	7.7	100
1-2	13.1	95.4	11.6	92.2	11.4	92.3
2-3	12.7	82.3	11.0	80.6	10.6	80.9
3-4	11.4	69.6	9.8	69.6	9.5	70.3
4-5	10.0	58.2	10.6	59.8	10.2	60.8
5-6	10.2	48.2	10.6	49.2	10.0	50.6
6-7	9.8	38.0	8.8	38.6	8.4	40.6
7-8	8.0	28.2	7.8	29.8	7.4	32.2
8-9	6.6	20.2	6.3	22.0	6.0	24.8
9 & over	13.6	13.6	15.7	15.7	18.8	18.8

by

(1) From registration figures as of June 7, 1971, furnished by Motor Vehicle Administration, Department of Transportation. (Excluding motorcycles)

(2) For year 1970, from 1971 Automobile Facts and Figures, Automobile Manufacturers Association.

Table II

Registration of Light Duty Vehicles by Age, Area III

Percent

Age	Simple	Cumulative
<1	4.1	100.0
1-2	11.8	95.9
2-3	11.5	84.1
3-4	10.5	72.6
4-5	9.3	62.1
5-6	9.5	52.8
6-7	9.2	43.3
7-8	7.7	34.1
8-9	6.5	26.4
9-10	6.0	79.9
10-11	5.0	13.9
11-12	4.0	8.9
12 and over	4.9	4.9

Table III

Average Miles Traveled by Model Year (1)

Year	Miles Traveled
1	13,200
2	12,000
3	11,000
4	9,600
5	9,400
6	8,700
7	8,600
8	8,100
9	7,300
10	7,000
11	5,700
12 &	4,500

(1) "Relationship of Passenger Car Age and Other Factors to Miles Driven" US. Dept. of Commerce, Bureau of Public Roads (ages 3-11 modified).

Table IV

Percent Total Light Duty Vehicle Miles Traveled Each Calendar Year by Model Year for State of Maryland Area III

Calendar Year +1 Minus Model Year	Avg. Miles[1] Traveled Per Vehicle	Population Distribution %	Weighed Travel	Travel Distribution %
0	3,300	4.1	135	1.5
1	12,900	11.8	1522	16.9
2	11,750	11.5	1351	14.9
3	10,650	10.5	1118	12.4
4	9,550	9.3	888	9.8
5	9,225	9.5	876	9.7
6	8,675	9.2	798	8.8
7	8,475	7.7	653	7.2
8	7,900	6.5	514	5.7
9	7,225	6.0	434	4.8
10	6,675	5.0	334	3.7
11	5,200	4.0	208	2.3
12 & greater	4,500	4.9	221	2.4

(1) Cars less than one year old travel an annual rate of 13,200/year - assuming new car sales for October, November and December only, the actual miles traveled are 1/4 x 13,200 = 3,300 miles.

TABLE V

Running Hydrocarbon Deterioration Factors
For Gasoline Engine Light Duty Vehicles(1)

Model Year	Years in Service(2)									
	0	1	2	3	4	5	6	7	8	9 & older
1967 & earlier	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1968	1.00	1.12	1.18	1.21	1.23	1.26	1.28	1.30	1.32	1.35
1969	1.00	1.10	1.16	1.18	1.21	1.23	1.25	1.28	1.29	1.31
1970 - 74	1.00	1.05	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.26
1975(3)	1.00	1.45	1.95	2.40	2.76	3.14	3.46	3.79	4.07	4.42
1976 & later(3)	1.00	1.45	1.95	2.40	2.76	3.14	3.46	3.79	4.07	4.42

(1) Based on State of California surveillance data as compiled by EPA

(2) Calendar year +1 minus model year

(3) National Academy of Sciences, "Semiannual Report by the Committee on Motor Vehicle Emissions of the National Academy of Sciences to the Environmental Protection Agency", January 1, 1972

TABLE VI

Running Carbon Monoxide Deterioration Factors
For Gasoline Engine Light Duty Vehicles(1)

Model Year	Years in Service(2)									
	0	1	2	3	4	5	6	7	8	9 & older
1967 & earlier	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1968	1.00	1.24	1.35	1.41	1.47	1.53	1.58	1.63	1.67	1.72
1969	1.00	1.42	1.53	1.59	1.63	1.68	1.71	1.75	1.79	1.82
1970 - 74	1.00	1.18	1.32	1.38	1.40	1.44	1.47	1.50	1.51	1.55
1975(3)	1.00	1.34	1.77	2.14	2.42	2.73	2.99	3.26	3.48	3.77
1976 & later	1.00	1.34	1.77	2.14	2.42	2.73	2.99	3.26	3.48	3.77

(1) Based on State of California surveillance data as compiled by EPA

(2) Calendar year +1 minus model year

(3) National Academy of Sciences, "Semiannual Report by the Committee on Motor Vehicle Emissions of the National Academy of Sciences to the Environmental Protection Agency", January 1, 1972

TABLE VII

Nitrogen Oxides Deterioration Factors
For Gasoline Engine Light Duty Vehicles(1)

Model Year	Years in Service(2)									
	0	1	2	3	4	5	6	7	8	9 & older
1972 & earlier	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1973 - 75	1.00	1.11	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26
1976 & later(3)	1.00	1.34	1.77	2.14	2.42	2.73	2.99	3.26	3.48	3.77

(1) Based on State of California surveillance data as compiled by EPA

(2) Calendar year +1 minus model year

(3) National Academy of Sciences, "Semiannual Report by the Committee on Motor Vehicle Emissions of the National Academy of Sciences to the Environmental Protection Agency", January 1, 1972

TABLE VIII

Low Mileage Hydrocarbon Emission Factors for Gasoline Engine Light Duty Vehicles

Model Year	Hydrocarbon			
	Running		Cold Start gm/start	Hot Start gm/stop
	Exhaust gm/mile	Blow-by gm/mile		
1967 & earlier	7.00	4.1(1)	5.60	22.50
1968 thru 1971	2.45	0.0	4.90	22.50(2)
1972 thru 1974	1.75	0.0	7.10	1.50
1975 & later	.12	0.0	.87	1.50

(1) 0.80 in 1966 & 67

(2) 3.80 in 1971

TABLE IX

Low Mileage Carbon Monoxide Emission Factors for
Gasoline Engine Light Duty Vehicles

Model Year	Carbon Monoxide	
	Running gm/mile	Cold Start gm/start
1967 & earlier	71.10	59.30
1968 thru 1971	22.40	44.90
1972 thru 1974	12.30	50.00
1975 & later	.90	6.70

TABLE X

Low Mileage NO_x Emission Factors for Gasoline Engine Light Duty Vehicles

Model Year	Running gm/mile
1967 & earlier	4.8
1968	5.6
1969 thru 1970	6.4
1971 thru 1972	6.0
1973 thru 1975	2.3
1976 & later	0.31

TABLE XI

Average Trip Speed
Correction Factor(1)

Model Year	Miles/Hour	CO	HC	NO_x
1967 & earlier	15	1.14	1.14	1.0
	60	.48	.48	1.0
1968 thru 1969	15	1.14	1.14	0.90
	60	.60	.60	1.53
1970 thru 1971	15	1.14	1.14	0.80
	60	.60	.60	1.62
1972 thru 1974	15	1.10	1.10	0.80(2)
	60	.60	.60	2.57
1975 & later	15	1.00	1.00	1.0(3)
	60	1.00	1.00	1.0

(1) When plotted on log-log paper will be a straight line. Assumed valid for speeds of 6 thru 60 mph.

(2) NO_x 1972 values same as 1971

(3) 1976 & later

April 30, 1973

Mr. Felipe Lebron
Head, Modelling Section
Bureau of Air Quality Control
Baltimore, Maryland 21201

Re: Technical Memorandum: Method for Estimating Light Duty Vehicle Emissions on a Sub-Regional Basis

Dear Mr. Lebron:

We have reviewed your transmittal of April 17, 1973, referenced above. It is our understanding that this memorandum represents the approach that the Bureau recommends A.M. Voorhees use in the IDBC 3-A contract.

We have reviewed your transmittal with Region III staff and with the staff of the Office of Air Programs in Durham. We recognize that many of the issues addressed in the memorandum have not been definitively resolved by EPA. However, in the absence of a final determination, we believe that it is important that the A.M. Voorhees' Study be internally consistent with the methodology utilized by the Bureau of Air Quality in its State Air Implementation Plans.

Based on the above, we approve the methodology for the study described in the April 17, 1973 transmittal. If the Administrator of EPA requires that the methodology of the State Air Implementation Plan be changed prior to promulgation, we will work closely with you to minimize the disruptive effect this decision could have on the A.M. Voorhees' Study.

Sincerely yours,

Robert J. Blanco, P.E.
Chief
Environmental Impact Branch

cc: W. [illegible],
I. [illegible],
L. [illegible],
W. Ockert, RPC

APPENDIX E

HYDROCARBON EMISSIONS

Table E-1

EXISTING AND PROJECTED 6-9 A.M. SUMMER HYDROCARBON EMISSIONS
BMATS AREA, BY ALTERNATIVE, TONS/3 HRS.
BUREAU OF AIR QUALITY CONTROL DATA

Source Category	1970*	1980			1995			
	Alternative 1 Existing	Alternative 3 Complete 3-A	Alternative 4 3-A less Ft. McHenry Crossing	Alternative 5 No 3-A	Alternative 6 Complete 3-A and GDP Improvements	Alternative 7 No 3-A, All Other GDP Improvements	Alternative 8 Complete 3-A, No Other GDP Improvements	Alternative 9 No 3-A or other GDP Improvements
Power Plants	0.60	0.65	0.65	0.65	0.71	0.71	0.71	0.71
Industrial Process Heating	0.69	0.78	0.78	0.78	0.95	0.95	0.95	0.95
Solvent Usage	5.75	4.09	4.09	4.09	4.10	4.10	4.10	4.10
Gasoline Storage and Handling	3.57	1.58	1.58	1.56	2.14	2.06	1.90	1.79
Motor Vehicles	50.33	11.85	12.60	11.93	7.40	6.98	6.9	6.65
Other	3.82							
Transportation	0.25	3.05	3.05	3.05	4.33	4.33	4.33	4.33
Total, Tons/3 Hrs.	65.01	22.11	22.86	22.17	19.77	19.27	19.08	18.67
Percent Contributed by Automotive, 6-9 a.m.	77.4	53.6	55.1	53.8	37.4	36.2	36.4	35.6
Percent Reduction in HC Emissions, 6-9 a.m. from 1970	---	66.0	64.8	65.9	69.6	70.4	70.7	71.3

6 - 9 AM Hydrocarbon

	1972 Region	1972 BMATS	1970 BMATS	1980 BMATS	1998 BMATS
Power Plants(1)	0.62	0.62	0.60	0.65	0.71
Ind. Process Heating(2)	0.72	0.72	0.69	0.78	0.95
Solvent Usage(3)	5.72	5.72	5.75	4.09	4.10
Gasoline Storage & Handling(4)	3.90	3.90	3.57	1.58	2.14
Motor Vehicles(5)	66.40	44.30	50.90	----	----
Refuse(6)	.15	.15	.25	0.11	0.14
Other Transportation(7)					
Trains	1.11	1.10	1.08	1.19	1.35
Aircraft	0.92	0.92	2.41	1.43	2.40
Misc.	0.35	0.35	0.33	0.43	0.58
Sub-total	79.89	57.78	65.58	10.26	12.37

(1) 1% per year increase due to increased fuel usage. Calvert Cliffs and Brandon Shores in operation by 1980.

(2) 1% per year increase due to increased fuel usage. Conservative increase factor.

(3) No increase from growth, '72 and '73 HC regulations will reduce the base year figures.

(4) All sources controlled by May '77 at 90% or better, growth at 3% per year with increased consumption factored into total.

(5) From June 15, 1973 Implementation Plan.

(6) Increases at population increase, no new incinerators, municipal incinerators controlled at best available technology.

(7) Trains, ships, etc. increase at 1% per year, Aircraft increase at 7% per year (very conservative estimate) after full control due to better combustion in 1972, miscellaneous increases at 3% uncontrolled.

AMV

MEMORANDUM

TO: Distribution DATE: May 29, 1974

FROM: Ken Axetell K.A. JOB: 357

SUBJECT: Revised Projections for Nitrogen Dioxide Emissions and Air Quality

---

On May 24, we received updated NO_2 emission projections from Anne Marie DeBiase of the Maryland Bureau of Air Quality Control for all source categories except motor vehicles. These values are shown in Table 1 attached. The primary change was in the power plant category, as a result of revised future fuel usage estimates by Baltimore Gas and Electric. The other large revision was an increase in emissions from the diesel and shipping category from the values originally reported in the 1972 inventory used in BREIS. Other changes reflect relatively small differences in growth factors used by BAQC from those used in BREIS.

The resulting overall reduction in projected regional emissions also affects the estimated ambient concentrations of NO_2 reported in Technical Memorandum No. 3 for future years. Using the same proportional modeling (rollback) technique and base year NO_2 emissions of 139,226 tons, the projected maximum annual average concentrations of NO_2 in the BMATS area (slightly smaller than the AQCR) for each of the alternatives were estimated as shown in Table 2.

These revised emission projections indicate that the region will be able to achieve and maintain the ambient air quality standard of 0.05 ppm for all alternatives. However, the calculations still do not include the effects of relaxing the Federal emission standards for NO_2 on 1976 model cars or the transportation control plan. Since motor vehicle emissions account for a small percentage of total required NO_2 emissions, we feel that either of these changes will probably not significantly alter the results of the rollback calculations.

Distribution: S. Bellomo
S. Liff
W. Bonta
A.M. BeBiase
W. Ockert
I. Shafran

TABLE 1

PROJECTED EMISSIONS OF OXIDES OF NITROGEN, TONS/YEAR
BALTIMORE AIR QUALITY CONTROL REGION
(BREIS Study Area)

Source Category	Projected Annual Emissions 1980	1995
Power plants	22,140	25,000 (approx.)
Refuse	255	330
Heating	15,520	19,300
Industrial	23,360	29,500
Stationary Sources Subtotal	(61,275)	(74,130)
Diesel and shopping	15,420	19,200
Aircraft	2,148	3,450
Miscellaneous gasoline use	1,700	2,535
Mobile Sources Except Motor Vehicles Subtotal	(19,268)	(25,185)
All Sources Except Motor Vehicles	80,543	99,315

Source: Maryland Bureau of Air Quality Control, May 24, 1974.

TABLE 2

ESTIMATED MAXIMUM NO_2 CONCENTRATIONS BY PROPORTIONAL MODELING
BMATS STUDY AREA

Source Category	1972 Alt. 1 Existing	1980 Alt. 3 Complete 3-A	1980 Alt. 4 3-A less Ft. McHenry Cross.	1980 Alt. 5 No. 3-A	1995 Alt. 6 Complete 3-A & GDP Impr.	1995 Alt. 7 No. 3-A, All Other GDP	1995 Alt. 8 Complete 3-A No other GDP	1995 Alt. 9 No 3-A or other GDP
Mobile								
Motor Vehicles	38,179	20,600	20,580	20,030	11,710	11,300	10,570	10,000
Other Transportation	5,984*	19,013	19,013	19,013	24,805	24,805	24,805	24,805
Stationary								
Point	89,062	52,435	52,435	52,435	63,820	63,820	63,820	63,820
Area	6,001	7,800	7,800	7,730	9,640	9,370	9,500	9,100
Total	139,226	99,848	99,828	99,208	109,975	109,295	108,695	107,725
Projected Maximum NO_2 Concentration, ppm	(0.06)	0.04	0.04	0.04	0.05	0.05	0.05	0.05

*This value is from the base year BREIS emission inventory, and has not been changed to reflect revision of the BAQC emission estimates for the diesel and shipping category. Such a change would have the effect of reducing projected NO_2 concentrations for Alternatives 3 through 9.