APTD-1448

TRANSPORTATION CONTROLS TO REDUCE MOTOR VEHICLE EMISSIONS IN SPOKANE, WASHINGTON

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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Prepared by

GCA Corporation
GCA Technology Division
Bedford, Massachusetts

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I. INTRODUCTION AND SUMMARY

A. BACKGROUND

States were required to submit implementation plans by January 30, 1972, that contained control strategies demonstrating how the national ambient air quality standards would be achieved by 1975. Many urban areas could not achieve the carbon monoxide and oxidant air quality standards by 1975 or even 1977 through the expected emission reductions from the 1975 exhaust systems control. Major difficulty was encountered by many states in the formulation of implementation plans that included transportation control strategies (including, for example, retrofit and inspection, gaseous fuel conversions, traffic flow improvements, increased mass transit usage, car pools, motor vehicle restraints, and work schedule changes). Because of the complex implementation problems associated with transportation controls, states were granted until February 15, 1973 to study and select a combination of transportation controls that demonstrated how the national air quality standards would be achieved and maintained by 1977.

B. PURPOSE, SCOPE AND LIMITATIONS OF STUDY

The purpose of the study reported on herein was to identify and develop transportation control strategies that will achieve the carbon monoxide and oxidant air quality standards required to be met by the State of Washington in the Spokane urban area by the year 1977. The re- results of the study were to help determine the initial direction that the State of Washington should take in selecting feasible and effective transportation controls. It was anticipated that the control strategies outlined in this study would be periodically revised in the coming years. The State's Implementation Plan was analyzed to verify and assess the severity of the carbon monoxide and oxidant pollutant problems, and the most promising transportation controls and their likely air quality impact were determined. Major implementation obstacles were noted after discussions with those agencies responsible for implementing the controls, and finally, a surveillance review process (January, 1973 - December, 1976, inclusive) was developed for EPA to use in monitoring implementation progress and air quality impact of transportation control strategies.

It should be noted that the study was carried out relying on the best data and techniques available during the period of the study and further, that a large number of assumptions were made as to the nature of future events. The 1977 air quality predictions were based on extant air quality data and on predicted stationary source emissions and predicted traffic patterns, and these predicted parameters themselves were based on anticipated emission control techniques, anticipated growth patterns, and the assumed outcome of unresolved legal and political decisions. Further, the development, ranking and selection of transportation controls were based on extant and predicted economic, sociological, institutional and legal considerations. Finally, the surveillance process presented in this report, although showing key checkpoints towards implementation of the recommended controls, is in itself dependent upon the same assumed pattern of future events.

It should be emphasized therefore, that to the extent that the time-scale of the recommended program permits, the conclusions and recommendations of this report should not be construed as a program which must be rigidly followed until 1977, but rather it should be regarded first, as a delineation as to what appears at the present time to be a feasible course of action to attain air quality goals, and secondly, as a framework upon which an optimum on-going program can be built as new data and techniques become available, as legal and political decisions are made, and as the assumptions as to future events are, or are not, validated.

C. CONTENT OF REPORT

Section II of this report describes how the pollutant concentration levels which could be expected to occur in 1977 in the Spokane area were predicted. These levels were determined by an adaptation of the proportional model using motor vehicle emissions from traffic patterns predicted for 1977 together with predicted non-vehicular emissions for 1977 obtained from state agencies. Comparison of these predicted 1977 air pollutant concentrations with the national air quality standards enabled the computation of the motor vehicle emissions which would result in the air quality standards being met, and therefore, to what extent, if any, reductions in the predicted 1977 motor vehicle emissions would be required. In order to determine the pollutant concentration(s) which was to serve as the basis for the proportional model, an intensive evaluation of all existing meteorological and air quality data was performed.

The final determination as to the concentration value used was made in close cooperation with representatives of local and state agencies and of EPA.

Section III describes how candidate control strategies were developed, evaluated and ranked having regard to technical, legal, institutional, sociological and economic criteria. An important feature of this task was the continuing interaction between, on one hand, the GCA study team, and on the other hand, representatives of local and state environmental planning and transportation agencies, concerned citizen's groups, and EPA representatives.

Section IV presents the rationale for selecting the optimum package of controls necessary to achieve the required reduction in motor vehicle emissions and also presents the confirmed effect on air quality.

Section V deals in detail with the obstacles to the implementation of the selected strategies. Since the obstacles to implementation were important criteria in the evaluation of the feasibility of candidate transportation controls, there is considerable discussion on such obstacles in earlier sections.

Section VI presents the surveillance review process which will enable EPA to monitor the implementation progress and air quality impact of the recommended strategies. Curves showing predicted air quality levels for the years 1973 to 1977 and beyond are presented, based on the Federal Motor Vehicle Control Program alone, and on the federal program in conjunction with three recommended transportation control strategies. These curves indicate the rate at which air quality should improve as time passes and as controls are implemented. In addition, important checkpoints are provided delineating the salient actions which must be taken in order to implement the strategies.

It should be noted, however, that the surveillance process thus provided is of necessity based on the problem, and the concomitant transportation controls as they are presently perceived. An equally important part of any surveillance process is the continuing reassessment of both the problem itself and the appropriateness of the required controls. As was discussed earlier in this Introduction, the present study employed a whole range of both of extant data and techniques, and also of assumptions about the course of future events. This data base should be continuously reviewed as new information becomes available. Thus, although the key background parameters are called out in the Surveillance Process, a thorough and continuing review of all the data, techniques and assumptions contained in this report will be required to properly update the problem definition and appropriate control measures.

D. SUMMARY OF PROBLEM AND REQUIRED TRANSPORTATION CONTROLS

The analysis described in the body of this report indicates a need for transportation control strategies to reduce CO emissions within Spokane's central business district if the national 8-hour average standard for CO concentration is to be met by 1977. On the other hand, the available data indicates that the oxidant standard and the 1-hour average

CO standard will be met throughout the urban area by means of the Federal Motor Vehicle Control Program alone.

After evaluating a large number of possible controls, three strategies are recommended for implementation. They are:

(1) A computer controlled signal system in downtown Spokane

(2) Transit improvement

(3) Pedestrian separations (second level sidewalks)

These three strategies together provide about half the reduction in emissions required to meet the national 8-hour standard. The remaining reduction can be achieved through strategies which directly limit emissions from operating vehicles, such as retrofit, gaseous conversion of fleet vehicles and inspection, or by strategies which eliminate older vehicles from the CBD. A table of 1977 emissions by model year and vehicle type is included in Section IV to facilitate selection of a workable combination of these strategies. The single strategy of excluding all pre-controlled vehicles from the CBD, in conjunction with Strategies 1, 2, and 3 above is judged to be more than sufficient to bring about the necessary reduction in emissions. The necessary additional reduction can also be attained by the use of the "air bleed to intake manifold" retrofit device on pre-1968 vehicles.

Table I-1 summarizes the CO problem and the cumulative effects of Strategies 1, 2, and 3 plus the exclusion of pre-controlled light duty vehicles. It is emphasized again that the air quality estimates are "best estimates" based on available data and the proportional model. Also, experience shows that

TABLE I-1

SUMMARY EMISSION AND CO AIR QUALITY DATA FOR SPOKANE CBD

	Without Strategies				With Strategies (1977)			
	1971	1977	1978	1979	Sig. Sys.	+ Trans. Imp.	+ Ped. Sep.	+ Vehicle Exclusion
a) Emission Densities (kg/8 hr/mi^2)								
Vehicular	7932	4751	4066	3482	4454	4352	4351	3,543
Non-vehicular	162	162	162	162	162	162	162	162
Total	8094	4913	4228	3644	4616	4514	4513	3,705
b) Air Quality (8-hr average in ppm)								
Observed (2nd highest)	18							
Estimated		10.9	9.4	8.1	10.3	10.0	10.0	8.2

c) Maximum Allowable Emission Level (kg/8 hr/mi^2)

Total	Non-Vehicular	Vehicular
4047	162	3885

d) Reduction in Vehicular Emissions from 1971 levels

	Percent
From Federal Motor Vehicle Control Program	40
Additional Required by Transportation Control Strategies	11

d) Reduction in Vehicular Emissions from 1977 "no strategy" level

	Percent
Required by Transportation Control Strategies	18

considerable variation in the maximum (or second highest) 8-hour concentration will be experienced at a given sampling location from year to year even under relatively constant emission rates. Finally, in addition to the temporal variation in air quality at a given station, substantial spatial variations are to be expected within the CBD. The predicted concentrations are presented in tenths of a part per million simply to indicate the anticipated overall trend in air quality.

II. VERIFICATION AND ASSESSMENT OF AIR POLLUTION PROBLEM

A. OUTLINE OF METHODOLOGY

1. General

The basic procedure employed was to develop, for the urban area of Spokane, pollutant concentration levels which could be expected in 1977 without the application of transportation controls (the potential 1977 levels). Pollutant levels were determined by the proportional model using non-vehicular emissions supplied by state agencies and using vehicular emissions based on traffic data developed during the course of this study. More sophisticated techniques could not be employed due to the lack of suitable extant calibrated diffusion models, and the short time period of the contract which precluded the development of a suitable model and the required inputs. Comparison of potential 1977 air quality levels with the appropriate standard gave the allowable motor vehicle emissions in 1977, which in turn formed the basis for the development of transportation control strategies.

Emissions from non-vehicular sources were obtained from the State Implementation Plan. Emissions from vehicular sources were computed following the recommendations given in EPA draft publication An Interim Report on Motor Vehicle Emission Estimation by David S. Kircher and Donald P. Armstrong, dated October 1972. Air quality data for each sensor within the city area were reviewed and evaluated in close cooperation with state and local agencies. The instrumental method and sensor location was studied and records of instrument maintenance and calibration examined so as to identify questionable readings. Meteorological records were then examined and compared with seasonal and diurnal variations in air quality levels. Finally the pollutant concentration which would form the basis for the proportional rollback calculations was decided upon in concert with state and local agencies and EPA representatives. The year in which this concentration level occurred defined the base year for the proportional rollback calculations.

The detailed methodologies for carbon monoxide and oxidants are presented separately below.

2. Methodology for Carbon Monoxide

Because ambient concentrations of carbon monoxide at any given location appear to be highly dependent on carbon monoxide emissions in the near vicinity, it was felt that some justification existed for a modification of the proportional model. It was felt that in order to reduce ambient CO levels in, for example, a central business district (CBD), it would be more appropriate to roll back CO emissions in the CBD itself, rather than the entire air quality region. Accordingly, the Spokane urban area was divided into six one-mile-square traffic zones (one of these zones being identified as the CBD) and the assumption was made that pollutant concentration in each zone was directly proportional to the emission rate of the pollutant within that zone.

The application of the proportional model, generalized for an urban area with multiple monitoring stations, comprises the following steps:

- Calculation of the total CO emission density (vehicular plus non-vehicular) for each zone in which CO concentrations are available for the baseline year. (In practice, baseline emission densities were calculated for all zones).
- Selection of the observed CO concentration for rollback computations at each monitoring station.
- Calculation of an emission density/concentration (e/c) ratio at each monitoring station.
- Calculation of the allowable emission density in each zone from the appropriate e/c ratio. (When measured e/c ratios differ from zone to zone, or within a single zone, the selection of an e/c ratio for general application is largely a matter of judgment.)
- Calculation of the total CO emission density for each zone for 1977 on the assumption that no transportation controls are imposed.
- Calculation, where required, of the reduction in emissions needed to meet the national air quality standard.

Although the principal contributing sources of CO to the urban area are motor vehicles, an attempt was made to apportion total CO emissions to vehicular and non-vehicular sources. Non-vehicular emissions for the years of interest were estimated from the State Implementation Plan which took into account predicted growth and predicted control strategies. The predicted control strategies were generally those that state agencies considered to be the maximum feasible, and therefore the predicted non-vehicular emissions were assumed to be irreducible for the purposes of this study. On the assumption that the predicted emission densities from non-vehicular sources were to be taken as irreducible, the allowable emissions from motor vehicles in each zone for the year of interest were then determined. For the purposes of evaluating the effects of candidate transportation controls, the maximum allowable emission density for the year 1977 was expressed as a percentage reduction from the 1977 "no strategy" emission density. However, as will be seen in following sections of this report, as each traffic control was developed, emissions were recomputed, using the revised VMT's and speeds resulting from the application of the control measures.

3. Discussion of Methodology for Carbon Monoxide

a. Modified Proportional Model

The applications and the limitations of the conventional proportional rollback method have been well documented and reviewed* and need not be discussed further here. The technique used in the present study was an extension of the conventional rollback technique to the extent that it was assumed first that the constant of proportionality between emissions and concentration may be derived from emissions emanating from the relatively small area around the sensor (the traffic zone), and second, that this constant of proportionality (the emission/concentration

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*Noel de Nevers. Rollback Modeling, Basic and Modified. Draft Document, EPA, Durham, N.C. (August 1972).

ratio) could be applied to determine pollutant concentrations in other zones of comparable area on the basis of the pollutant emissions in those zones. Some justification of the first assumption can be found, for example, in recent work of Hanna* and Gifford** who demonstrate the dominance of urban pollution patterns by the distribution of the local area sources. The success of their urban diffusion model, in which concentration is simply directly proportional to the area source strength and inversely proportional to wind speed, is attributed largely to the relatively uniform distribution of emission within an urban area and the rate at which the effect of an area source upon a given receptor decreases with distance. In the proportional model, meteorological effects, such as wind speed, are assumed to be duplicated over one-year periods. The validity of the second assumption depends, in large part, upon the extent to which diffusion and transport parameters are uniform from zone to zone - a factor which could not be investigated because of the constraints of the program. Thus, it was felt that, in the absence of a more sophisticated technique, the use of this extension to the proportional model was justified first, to obtain some assessment as to whether the existing sensors were located in the "hot-spots," and second, to obtain some assurance that transportation strategies intended to reduce emission densities in one zone (to the level required to meet ambient standards) did not increase emission densities to unacceptable levels in adjacent zones. In many cities it was found that

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*Hanna, S.R., "A Simple Method of Calculating Dispersion from Urban Area Sources," J. APCA 21, 774-777 (December 1971).

**Gifford, F.A., "Applications of a Simple Urban Pollution Model," (paper presented at the Conference on Urban Environment and Second Conference on Biometeorology of the Amer. Meteor. Soc., October 31 - November 2, 1972, Philadelphia, Pa.).

the sensors were, in fact, in the "hot spot" zones and also that the recommended transportation controls did not increase emissions in adjacent areas to unacceptable levels. Thus the final rollbacks were confined to the zones with a sensor within their boundaries and the extensions of the techniques to other non-sensor zones did not, therefore, play a primary role in the final computations.

Experience in urban areas that had several sensors showed that the emission concentration ratio differed substantially from zone to zone and served to underline the fundamental limitations of the technique employed. An implicit assumption in the technique employed was that the air quality in a traffic zone could be fairly represented by one concentration level and that this level depended only upon the average emission density within that zone. The two major factors mitigating against this assumption are:

(a) Emission densities are not uniform across even a small traffic zone.

(b) Concentration levels are not uniform across the traffic zone partly because of the lack of uniformity of emission density and partly because the point surface concentrations are affected by micrometeorology and microtopography as well as emission density.

Considerable judgment had to be used, therefore, both in the derivation of e/c ratios and in their subsequent use. In heavily trafficked downtown areas the variation was judged not to be too great, so that the single recorded concentration might reasonably be expected to be representative of the zone's air quality and emission density. However, in suburban zones having overall low traffic densities, sensors were often found to be placed at very localized hot spots, such as a traffic circle, so that the recorded concentration levels were neither representative of the overall air quality nor of the overall emission density in the zone.

Accordingly, e/c ratios were generally derived from sensors in the central areas of the cities and applied to suburban areas for the prediction of 1977 concentration levels. This procedure gave air quality levels which were generally representative of the suburban zone. However it must be realized that control strategies based on this procedure, while they may ensure that the overall air quality in a suburban zone will not exceed ambient standards, do not preclude the occurrence of higher concentrations in very localized hot spots such as might occur in the immediate vicinity of a major traffic intersection.

The analysis in Spokane, based on two monitors, indicated that the monitor at City Hall was at a representative location within the zone of maximum emissions and that rollback would not be required in other zones. Thus the final rollback calculations were confined to a single zone (the CBD) with a sensor within its boundaries.

b. Seasonal and Diurnal Variations

The CO observations at City Hall showed that the 1-hour average concentration was much closer to the standard than the 8-hour average, so that controls required to meet the 8-hour standard would also result in the 1-hour standard being met. A comparison of the diurnal variation of concentration at City Hall during the seasons of maximum concentration (fall and winter) showed close correspondence to the daily traffic flow. Thus, strategies which reduce emissions over the extended daytime heavy traffic period should prove effective. Traffic data were not available on a seasonal basis, so vehicle emissions were based on annual average workday traffic data. Emission densities were calculated for the 8-hour period during the day with maximum traffic.

c. Background Concentration

Background concentration levels of CO were not taken into account. The only large point source judged to be a possible external contributor of CO to the CBD in Spokane was an aluminum reduction plant outside of the city limits. "Worst case" diffusion calculations indicated that the contribution of the plant could be safely neglected in the roll-back calculations.

4. Methodology and Discussion for Oxidants

Oxidant levels are currently below the standards, and the evaluation of the oxidant problem was therefore restricted to showing a substantial decrease in total hydrocarbon emissions throughout the urban area by 1977.

B. DISCUSSION OF 1970-1972 AIR QUALITY LEVELS

1. Natural Features Affecting Pollution Potential

Spokane, a city with a population of 170,516, is located in eastern Washington on the Spokane River northeast of the Columbia Basin. It is protected from Pacific storms by the Cascade mountain range to the west, and from severe weather from Canada by the Rocky Mountains to the east. As a result, the climate is quite dry. The Columbia Basin is comprised of broad rolling plateaus. The area to the west of Spokane is characterized by steep cliffs, old cascades, meadows, mesas and potholes. The rolling Palouse Hills lie to the southeast, and the Blue Mountains to the south.

The topographical and climatological features of central and eastern Washington favor the formation of stable, stagnating air masses which may result in the significant accumulation of air pollutants. Prevailing winds are southerly, but northeasterly winds are also common in all seasons of the year. Table II-1 gives the average mixing heights and mean wind speeds averaged through the mixing layer by season and time of day. These data are taken from Table B-1 of Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, by George C. Holzworth (Office of Air Programs Publication No. AP-101, EPA). The continental nature of Spokane's climate is apparent from the low morning mixing depths experienced at all seasons of the year, and from

TABLE II-1

AVERAGE MIXING DEPTHS AND WIND SPEEDS AT SPOKANE

a) Average Mixing Depths (m)

	WINTER	SPRING	SUMMER	FALL	ANNUAL
Morning	336	341	234	218	282
Afternoon	430	1861	2533	1261	1521

b) Average Mixing Layer Wind Speeds (m sec^{-1})

	WINTER	SPRING	SUMMER	FALL	ANNUAL
Morning	4.7	5.2	4.1	3.8	4.4
Afternoon	4.8	6.1	5.2	5.0	5.3

the high summertime afternoon mixing depths. The annual average morning mixing depth of 282 meters is approximately one half that measured in the coastal climate of Seattle, whereas the average summertime mixing depth at Spokane is approximately 1100 meters greater than that at Seattle.

2. Monitoring Network

a. General

Monitoring for oxidants and CO in Spokane is carried out by the Washington State Department of Ecology (DOE). The concepts used in designing the monitoring network, and details of network operation and data handling are covered in the Implementation Plan and will not be repeated here.

b. Type of Instrumentation

CO Analyzer - CO measurements are made by the EPA reference method (non-dispersive infrared spectrometry). The MSA units in use are operated continuously. They are calibrated by zero and span gas references every working day. Water discrimination is accomplished by silica gel drying columns changed three times each week.

Oxidant Analyzer - Oxidant measurements are made with Mast Ozone Meters. This instrument depends upon the oxidation of iodide to iodine and a subsequent coulometric reduction back to iodide for its operation. It detects all oxidants reducible by the iodide ion unlike the ozone-specific EPA reference method (chemiluminescence). The analyzers are equiped with SO_2 scrubbers to minimize interferences. Major maintenance and dynamic calibration are performed every six months.

c. Monitor Locations

Concentration measurements were available for analysis from two sites in Spokane. Table II-2 gives the locations and specifies the period over which the pollutants were measured at each location. The City Hall is located south of the Spokane River on the northern edge of the CBD. Gonzaga University is located just north of the river in an area classed as commercial.

3. Review of Air Quality Data

a. General

The CO and total oxidant concentrations observed during the periods listed in Table II-2 were reviewed in detail. The inclusion of data collected since submission of the Implementation Plan nearly doubles the total amount of data available for analysis and substantially increases the reliability of the baseline concentrates used in projecting air quality and estimating rollback requirements.

b. CO Air Quality Data

Table II-3 gives the highest 1-hour average concentration observed at each site during each month of the sampling period. The national standard of 35 ppm was reached or exceeded three times during the two year period at City Hall. The maximum 1-hour value observed during the 16-month observation period at Gonzaga University was 21 ppm.

TABLE II-2

SUMMARY OF CO AND OXIDANT MONITORING IN SPOKANE

SITE NAME	SITE ADDRESS	POLLUTANT	HEIGHT ABOVE GROUND (FEET)	LOCATION	PERIOD OF OBSERVATIONS	DURATION OF SAMPLING PERIOD (MONTHS)
City Hall	N221 Wall	CO	12	Side of Bldg.	July 1970-July 1972	25
		Oxidants	45	Out Window	July 1970-Nov. 1970	5
Gonzaga University	E. 302 Boone	CO	30	Above Trailer	Apr. 1971-July 1972	16
		Oxidants	30	Above Trailer	Apr. 1971-Aug. 1971	5

TABLE II-3

SUMMARY OF MAXIMUM 1-HOUR CO CONCENTRATIONS (IN PPM)
AT TWO LOCATIONS IN SPOKANE

		MONITOR LOCATION	
YEAR	MONTH	CITY HALL	GONZAGA UNIVERSITY
1970	July	13	
	Aug	18	
	Sept	35	
	Oct	35	
	Nov	27	
	Dec	21	
1971	Jan	27	
	Feb	32	
	Mar	20	
	Apr	25	13
	May	15	13
	June	15	9
	July	13	12
	Aug	15	11
	Sept	17	10
	Oct	30	21
	Nov	24	10
	Dec	40	11
1972	Jan	30	8
	Feb	22	14
	Mar	24	13
	Apr	16	6
	May	13	8
	June	13	7
	July	13	7

Figures II-1 through II-4 show the diurnal variation of CO concentration observed at the two monitoring stations in each of the four seasons. The curves for City Hall show a pronounced seasonal variation with maximum values occurring in the fall and winter. The diurnal variation at this downtown location tends to follow the daily traffic flow in the Spokane area (see Figure II-5), whereas concentrations are low during the middle of the day at Gonzaga University. At City Hall, the highest average concentrations occur during the late afternoon. Additional details of the diurnal and seasonal variations in concentration observed at the two sites during the period from August 1971 to July 1972 can be obtained from Table II-4 and Table II-5 which list, by month, the highest one-hour concentration observed during each hour of the day.

Table II-6 gives the highest 8-hour concentration observed each month at the two sites. The national 8-hour standard is exceeded significantly during all but the summer months at City Hall. During the 16-month period of observations at Gonzaga University, the standard was exceeded in April, May, and October of 1971, but was not exceeded during the period from November 1971 to July 1972. The number of times that the standard was exceeded per month given in the table is based on a running mean of 8 one-hour averages. This number does not, therefore, represent independent 8-hour periods.

Table II-7 lists the highest and second highest 1-hour and 8-hour average concentrations used in the Implementation Plan for estimating the required reduction in CO emissions and values obtained from the period from July 1971 to July 1972.

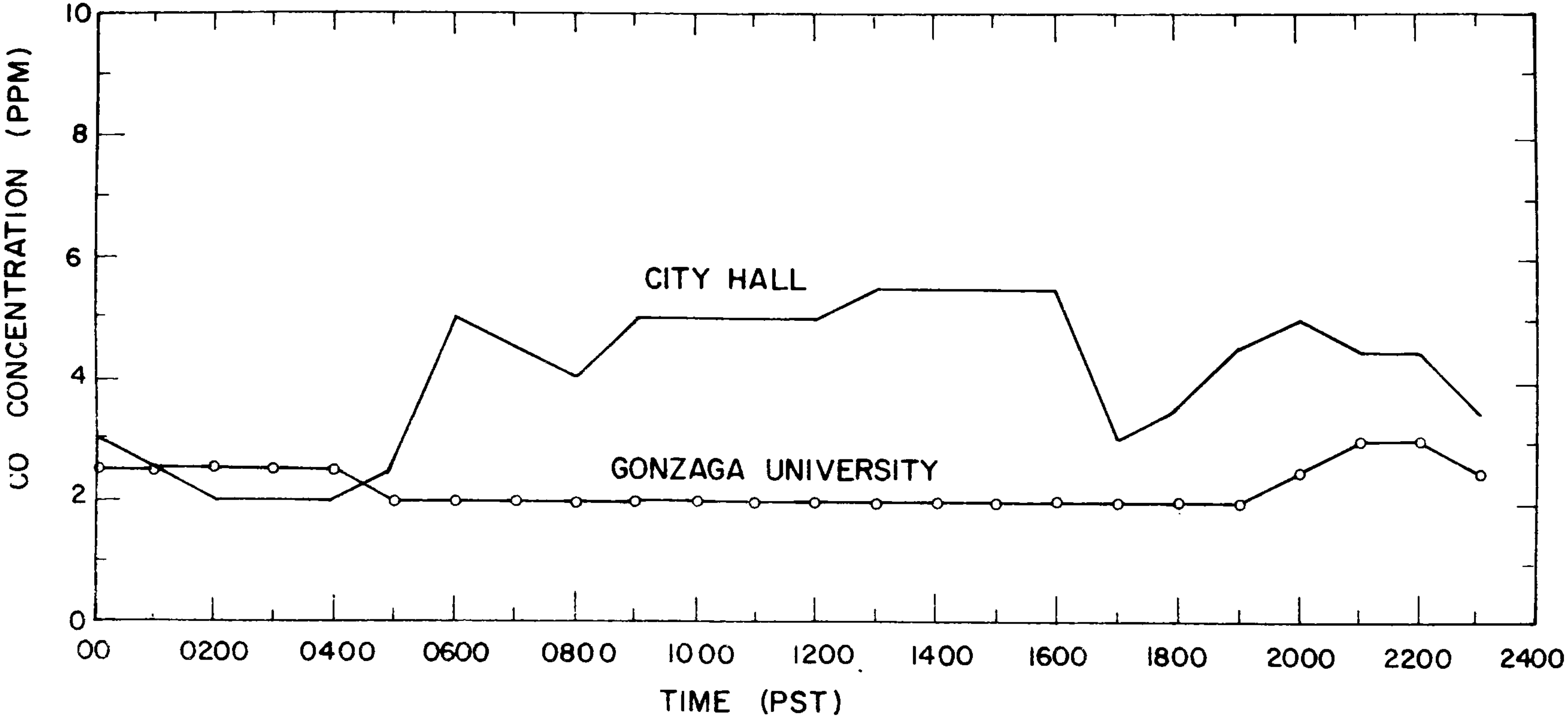

Figure II-1. Diurnal Variation in Carbon Monoxide Concentration at Spokane-Summer 1971

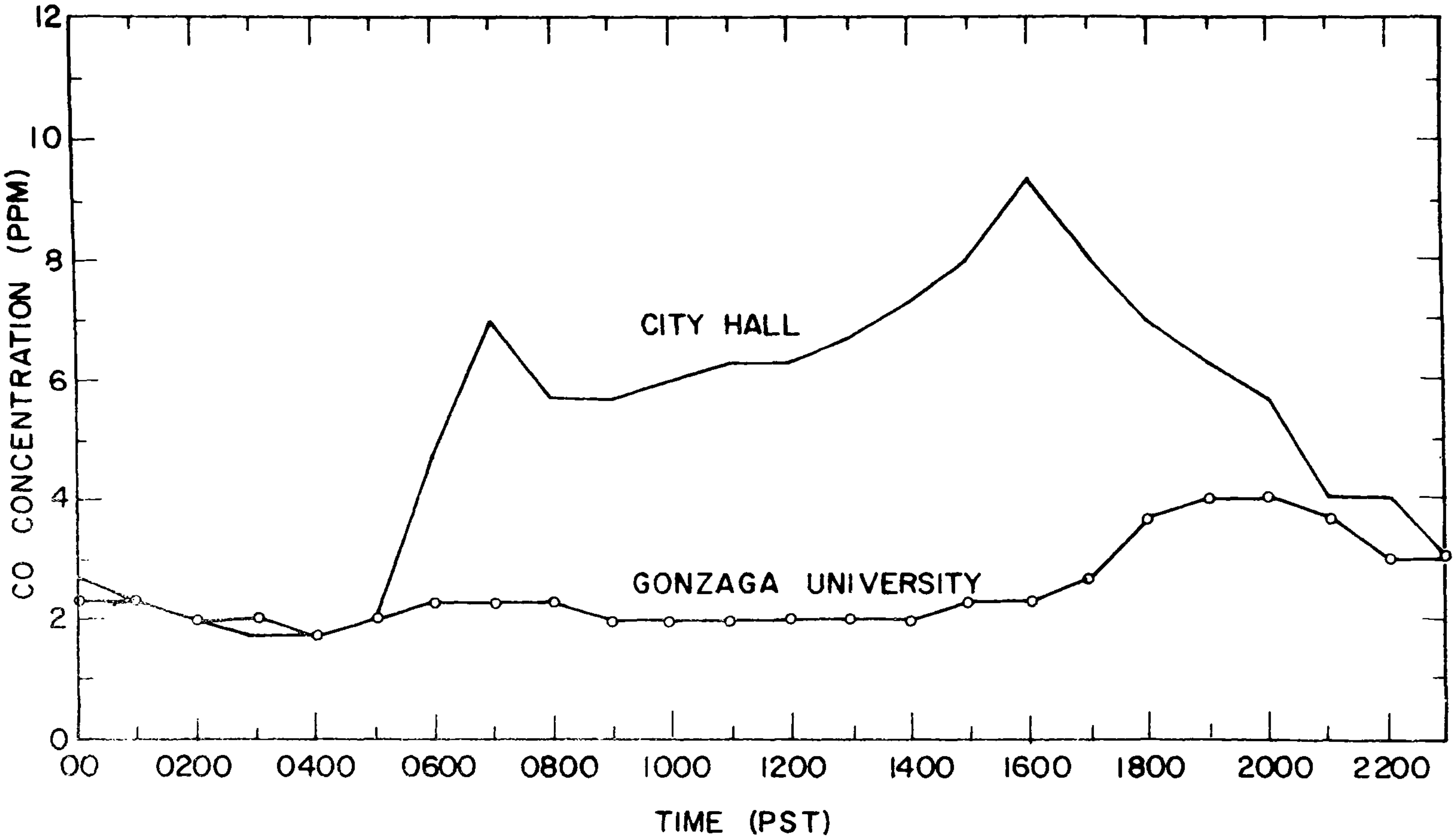

Figure II-2. Diurnal Variation in Carbon Monoxide Concentration at Spokane-Fall 1971.

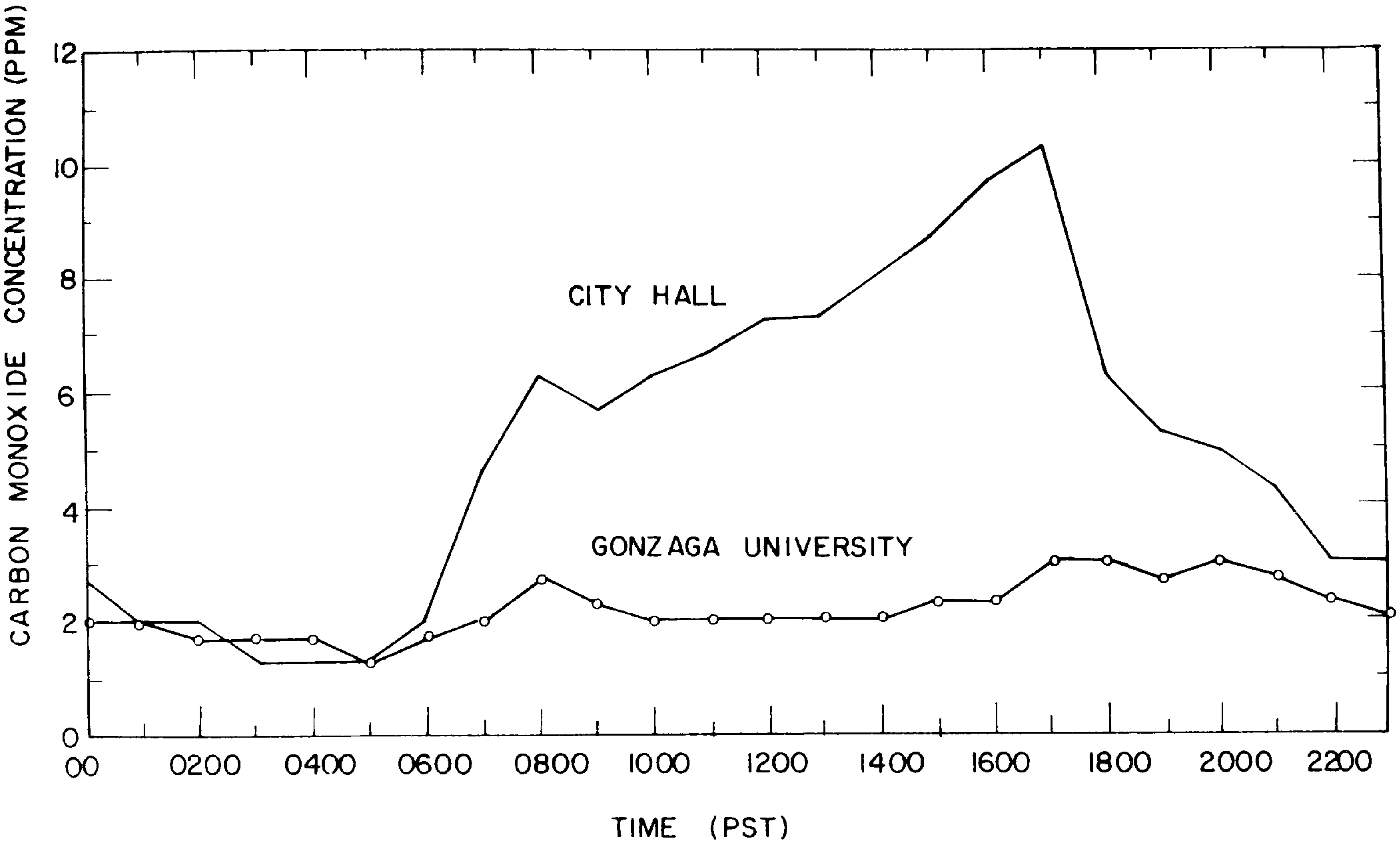

Figure II-3. Diurnal Variation in Carbon Monoxide Concentration at Spokane-Winter 1971-72

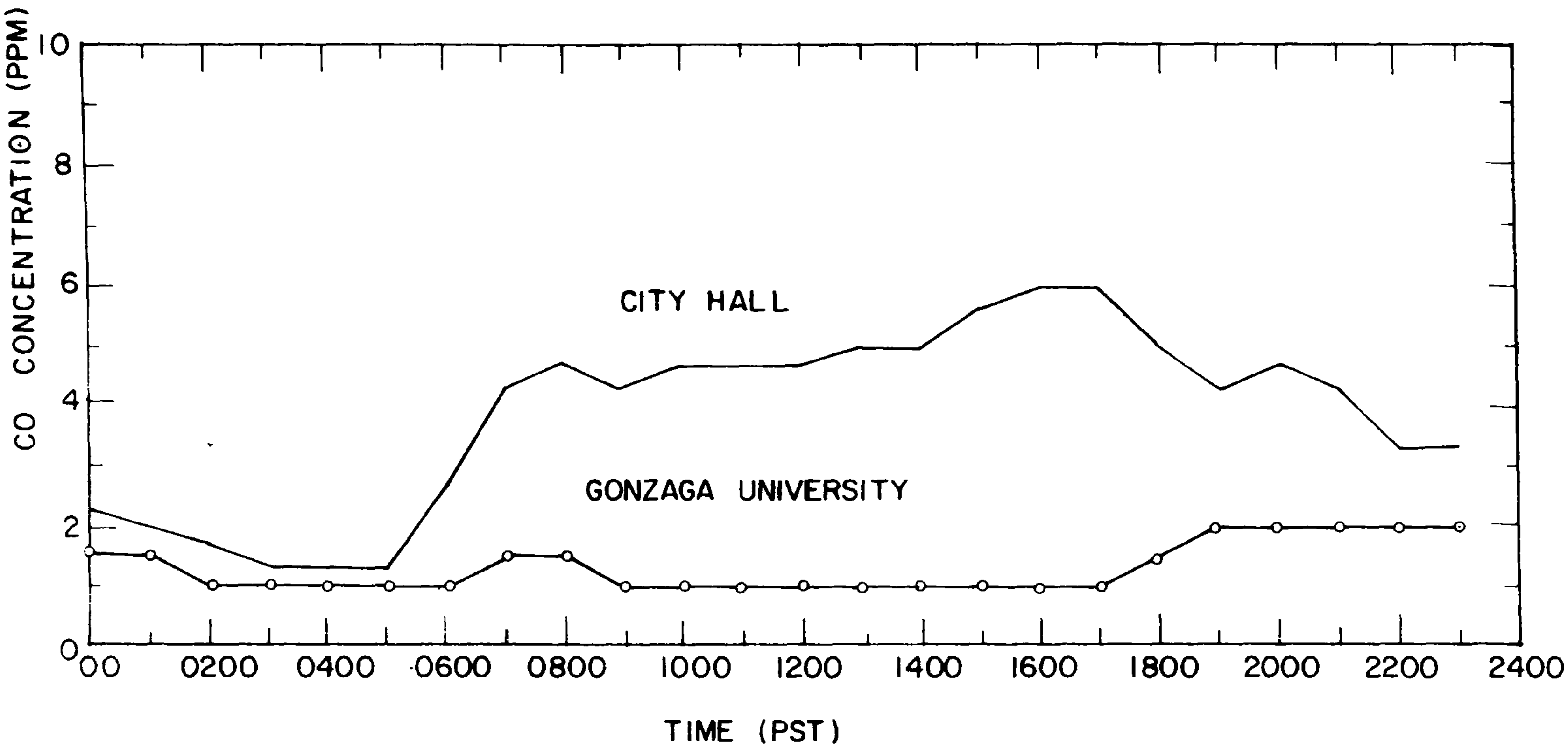

Figure II-4. Diurnal Variation in Carbon Monoxide Concentration at Spokane-Spring 1972

TABLE II-4

MAXIMUM 1-HOUR CO CONCENTRATIONS (IN PPM) OBSERVED AT CITY HALL, SPOKANE.
AN ASTERISK INDICATES A VALUE GREATER THAN THE STANDARD (35 PPM).

HOUR	1971 AUG	SEPT	OCT	NOV	DEC	1972 JAN	FEB	MAR	APR	MAY	JUNE	JULY	MAXIMUM
00	5	5	6	5	8	9	5	7	4	5	5	4	9
01	4	4	6	5	7	6	5	5	3	4	4	3	7
02	3	4	5	4	3	4	4	4	3	3	4	3	5
03	3	3	9	3	3	3	2	5	2	3	4	2	9
04	3	3	3	2	3	3	2	2	2	3	4	2	4
05	4	3	14	3	4	3	3	2	3	4	4	3	4
06	10	13	15	12	4	10	5	4	3	8	9	11	15
07	15	13	20	14	11	8	9	11	7	9	12	8	20
08	10	9	13	15	13	15	14	12	7	8	8	8	15
09	8	10	11	16	12	15	12	10	7	10	7	11	16
10	8	10	11	15	15	7	12	10	10	8	11	9	15
11	10	8	11	16	17	4	10	9	8	11	9	10	17
12	11	12	14	15	15	16	11	10	9	13	9	9	16
13	9	10	13	15	15	18	11	10	13	12	10	8	18
14	11	9	15	22	16	18	16	10	8	13	13	8	22
15	8	12	14	19	22	18	16	10	9	13	12	12	22
16	11	17	16	22	40*	22	15	12	8	13	11	8	40*
17	6	10	24	24	22	30	22	24	16	6	7	6	30
18	7	10	30	16	15	13	13	15	7	7	8	7	30
19	12	10	18	16	13	13	12	15	13	9	8	10	18
20	10	11	19	12	13	9	10	15	10	10	10	13	19
21	8	8	10	9	11	9	8	11	9	-	7	10	
22	8	9	10	11	8	8	7	11	5	-	7	7	
23	7	5	7	12	6		10	8	5	6	5	5	12
MAXIMUM	15	17	30	24	40	30	22	24	16	13	13	13	40*
OBS.	96	45	99	99	96	91	94	84	91	98	99	98	

TABLE II-5

MAXIMUM 1-HOUR CO CONCENTRATIONS (IN PPM) OBSERVED AT GONZAGA UNIVERSITY, SPOKANE

HOUR	1971 AUG	SEPT	OCT	NOV	DEC	1972 JAN	FEB	MAR	APR	MAY	JUNE	JULY	MAXIMUM
00	5	5	11	7	6	6	6	5	4	4	4	4	11
01	4	4	12	6	6	5	5	4	3	4	4	4	12
02	4	3	10	5	4	4	4	3	3	3	4	3	10
03	4	3	8	3	3	4	3	3	3	3	4	2	8
04	4	3	5	3	4	4	3	3	3	3	4	2	5
05	4	4	5	3	4	4	3	3	3	3	4	2	5
06	4	5	9	4	4	4	4	4	3	3	5	2	9
07	4	6	9	5	5	6	6	5	3	3	5	2	9
08	4	5	6	7	7	6	8	5	3	3	5	1	8
09	3	3	4	6	6	5	9	4	3	3	5	1	9
10	3	3	3	7	6	5	6	3	2	3	5	2	7
11	3	3	3	4	6	5	4	3	2	3	5	2	6
12	3	3	3	5	4	5	3	3	2	3	5	1	5
13	3	2	3	6	5	4	3	3	2	3	5	1	6
14	3	2	3	8	6	4	3	3	2	3	5	1	8
15	3	3	3	5	8	4	3	3	3	3	5		8
16	3	3	4	6	8	6	4	3	3	3	4	1	8
17	3	4	8	6	7	8	9	4	4	3	4	1	9
18	4	10	17	8	8	7	14	5	2	3	4		14
19	8	10	21	10	7	7	12	9	4	3	5	4	21
20	11	10	17	7	11	8	8	8	5	4	7	6	17
21	8	10	13	7	8	6	7	13	5	6	7	7	13
22	9	9	11	9	6	8	7	7	6	8	-	6	11
23	7	7	9	8	5	6	6	10	4	6	6	6	10
MAXIMUM	11	10	21	10		8	14	13	6	8	-	7	21
OBS.	88	97	98	95	99	97	85	98	97	86	71	88	

TABLE II-6

SUMMARY OF MAXIMUM 8-HOUR CO CONCENTRATIONS IN SPOKANE

Year	Month	City Hall Max Conc. (PPM)	City Hall No. Cases >9 PPM	Gonzaga Univ. Max. Conc. (PPM)	Gonzaga Univ. No. Cases >9 PPM
1970	July	9	0		
	Aug	9	0		
	Sept.	16	51		
	Oct.	20	166		
	Nov.	16	50		
	Dec.	17	M*		
1971	Jan	16	99		
	Feb	13	56		
	Mar	13	13		
	Apr	19	69	12	46
	May	6	0	12	35
	June	10	12	4	0
	July	8	0	7	0
	Aug	9	0	6	0
	Sept	10	5	6	0
	Oct	17	55	14	9
	Nov	18	97	7	0
	Dec	18	147	7	0
1972	Jan	17	53	5	0
	Feb	13	45	7	0
	Mar	14	10	6	0
	Apr	9	0	4	0
	May	10	3	4	0
	June	9	0	6	0
	July	9	0	4	0

* M = Missing

TABLE II-7

SUMMARY DATA FOR ESTIMATING REQUIRED REDUCTIONS IN CO EMISSIONS

STATION	SAMPLING PERIOD	AVERAGING TIME	CONCENTRATION (PPM)			REDUCTION REQUIRED (PERCENT) BASED ON	
			HIGHEST	2ND HIGHEST	STANDARD**	HIGHEST	2ND HIGHEST
City Hall*	Jul 1970-	1-Hour	35	35	35	0	0
	Jun 1971	8-Hour	20	20	9	55	55
City Hall	Jul 1971-	1-Hour	40	30	35	12	0
	Jul 1972	8-Hour	18	18	9	50	50
Gonzago University	Jul 1971-	1-Hour	21	17	35	0	0
	Jul 1972	8-Hour	14	9	9	36	0

*Used in Implementation Plan.

**Not to be exceeded more than once a year.

c. Oxidant Air Quality Data

Table II-8 and Table II-9 give the highest 1-hour concentrations of total oxidants at each site during each month of the observation period. The highest 1-hour average measured at City Hall was 0.05 ppm, well below the national standard of 0.08 ppm. The highest value observed at Gonzaga University was 0.02 ppm.

4. Impact of Stationary Sources

a. Major CO Sources

The only major point source of CO in Spokane County is the Kaiser aluminum reduction plant located in Mead, approximately 9 miles from the CBD. The emission rate of this plant has been estimated to be 14,400 tons per year. Turner's Workbook of Atmospheric Dispersion Estimates gives a maximum ground-level concentration (10-min average) from a source of this magnitude at a distance of 9 miles as approximately 0.73 ppm under Class E stability conditions and a wind speed of 3 meters per second. Under these conditions, the average 8-hour concentration will be roughly one-half this amount, or about 4 percent of the standard. Accordingly, special consideration is not given to individual point sources in the proportional modeling carried out in Section II-D.

b. Major Hydrocarbon Sources

The largest single point source for hydrocarbons in the area is the Spokane Airport. Since oxidant levels are currently well below the standard, hydrocarbon emissions need not be treated in detail.

TABLE II-8

MAXIMUM 1-HOUR CONCENTRATIONS OF TOTAL OXIDANTS (IN PPM) AT CITY HALL, SPOKANE

	1970					
HOUR	JULY	AUG	SEPT	OCT	NOV	MAXIMUM
00	.03	.02	.01	0	.02	.03
01	.03	.02	.01	0	.02	.03
02	.03	.02	.01	0	.02	.03
03	.03	.03	.01	.01	.02	.03
04	.03	.03	.01	0	.02	.03
05	.03	.03	.01	0	.02	.03
06	.02	.02	.01	.01	.01	.02
07	.03	.03	.01	.01	.01	.03
08	.03	.03	.01	.01	.01	.03
09	.05	.04	.01	.01	.01	.05
10	.03	.03	.01	.01	.01	.03
11	.03	.03	.01	.01	.02	.03
12	.04	.04	.01	.01	.02	.04
13	.04	.04	.01	.01	.02	.04
14	.04	.04	.01	.01	.02	.04
15	.05	.04	.01	.01	.01	.05
16	.04	.04	.01	.01	.01	.04
17	.04	.05	.01	.01	.01	.05
18	.04	.04	.01	.01	.01	.04
19	.03	.03	.01	.01	.01	.03
20	.02	.03	.01	.01	.01	.03
21	.03	.03	.01	.01	.01	.03
22	.03	.03	.01	.01	.01	.03
23	.03	.02	.01	.01	.02	.03
MAXIMUM	.05	.05	.01	.01	.02	.05
% OBS.	92	25	99	100	23	

TABLE II-9

MAXIMUM 1-HOUR CONCENTRATIONS OF TOTAL OXIDANTS
(IN PPM) AT GONZAGA UNIVERSITY, SPOKANE

	1971					
HOUR	APR	MAY	JUNE	JULY	AUG	MAXIMUM
00	.02	.01	.01	.01	.01	.02
01	.01	.01	.01	.01	.01	.01
02	.01	.01	.01	0	.01	.01
03	.01	.01	.01	0	0	.01
04	.01	.01	.01	0	.01	.01
05	.01	0	.01	0	.01	.01
06	.01	0	.01	0	.01	.01
07	.01	0	.01	0	0	.01
08	0	0	0	0	0	0
09	.01	.01	.01	0	0	.01
10	.01	.01	.01	0	.01	.01
11	.01	.01	.01	0	.01	.01
12	0	0	.01	0	0	.01
13	0	0	.01	0	0	.01
14	0	0	.01	0	0	.01
15	0	0	.01	0	0	.01
16	0	0	.01	0	0	.01
17	0	0	.01	0	0	.01
18	0	0	.01	0	.01	.01
19	.01	.01	.01	0	.01	.01
20	.01	.01	.01	0	.01	.01
21	.01	.01	.01	.01	.01	.01
22	.01	.02	.01	.01	.01	.02
23	.02	.01	.01	.01	.01	.02
MAXIMUM	.02	.02	.01	.01	.01	.02
% OBS.	97	74	84	13	85	

C. DISCUSSION OF 1971 AND 1977 VEHICLE MILES OF TRAVEL

1. General

The objective of the tasks described in the following paragraphs is to provide information on vehicle miles of travel within high traffic density areas of the Eastern Washington-Northern Idaho Interstate Area to be used for the calculation of vehicle emissions and subsequent evaluation of air quality. These data are then used as a basis for developing transportation control strategies that will achieve air quality standards for carbon monoxide and oxidants by the 1977 deadline.

The general procedure followed was to select critical areas by inspection of traffic counts, calculate vehicle miles of travel for 1971, and then project vehicle miles of travel to 1977 and beyond based on recent growth trends.

Since high traffic densities and high emission levels were found only in the Spokane, Washington area, efforts were concentrated there and geographical reference in the following paragraphs is to the "Spokane" area.

2. Overall Research Methodology

Vehicle mile data for the Spokane region were developed by the Washington State Highway Department and the Spokane Metropolitan Area Transportation Study. These data, however, were either for the region as a whole or were for specific facilities within the region. Therefore, methodology had to be developed to provide data on vehicle miles of travel for small areas within the region where emissions were high and air quality poor.

One-square-mile grids were laid out (along range and township lines for possible coordination with other data collection efforts) on USGS 1:24,000 maps. Using twenty-four hour average daily traffic flow maps produced in 1969-1970 by the City of Spokane Traffic Engineering Department and by the Office of the Spokane County Engineer, areas of greatest traffic concentration were selected for coverage with these mile-square grids.

3. 1971 Vehicle Miles of Travel

The 1971 daily vehicle miles of travel were calculated for each square-mile studied by measuring the length of each street or highway facility within each grid, and multiplying that length by the daily traffic volume obtained from the most current traffic flow maps plus data from the Annual Traffic Report series produced by the Washington State Highway Commission.

This calculation was carried out separately for each roadway appearing on the flow map. In cases where a length of roadway within a grid had substantially different traffic volumes in various locations, the roadway was split into two or more sections for the vehicle-mile calculation.

Information was gathered from the records of the City Traffic Engineer on surveys of peak and off-peak roadway speeds. Table II-10 summarizes these data. Table II-10 was used as a guideline for selecting

TABLE II-10

GUIDELINE AVERAGE SPEEDS (MPH)

Roadway Classification	CBD		CBD Fringe		Other Urban	
	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
Freeway	40-45	45-50			50	55-60
Expressway					35	35
Arterial and Collector	18	18	20	20	20	25

and assigning average speeds for each roadway in absence of specific data for that facility. Data were collected from screenline and arterial traffic counts so that the hourly traffic profile could be evaluated. Figure II-5 shows this profile as used for Spokane, and Table II-11 lists the hourly percentages.

From the diurnal traffic profile data, the percentages of daily traffic that would occur in various critical time periods were developed These time periods were:

(1) The peak hour (usually in the afternoon).

(2) 6:00 AM to 9:00 AM in the morning.

(3) The highest 8 hours of the day.

The appropriate portion of the daily vehicle miles of travel occurring in each time period was in calculated using these percentages, and the average speed for each facility was assigned for that particular time period.

In the Spokane area, the peak hour had 8.3 percent of the daily VMT. The morning three hours equaled 14.6 percent, and the highest 8 hours equaled 50.5 percent.

Streets that were not included on the traffic flow maps were assumed to be in the "local street" category. The mileage of these streets was measured in each grid and a speed of 15 miles per hour and a daily volume of 500 vehicles was assumed. The vehicle miles of travel generated were

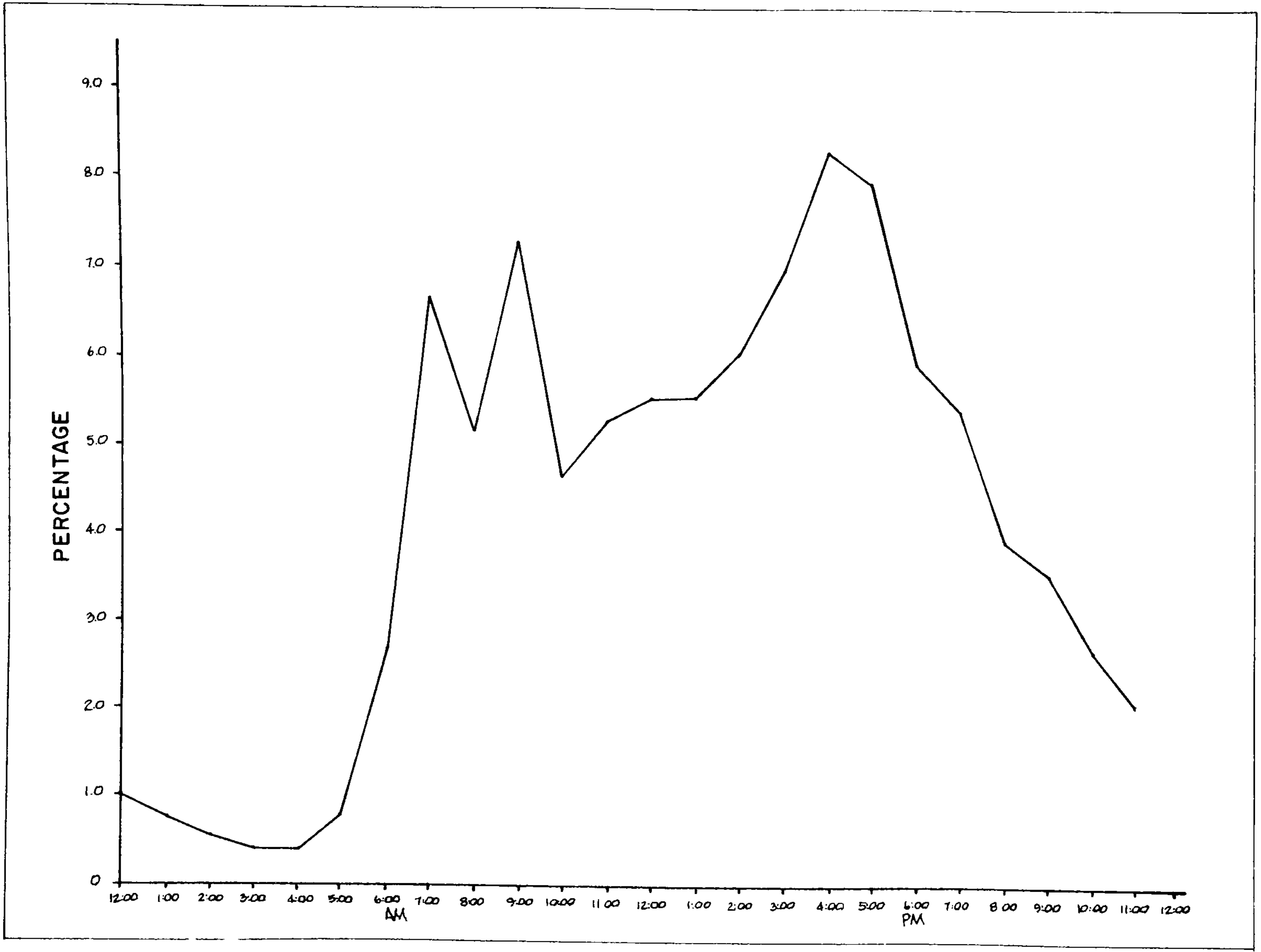

Figure II-5. Percent of Daily Traffic by Hour - Spokane Area.

TABLE II-11

PERCENT OF DAILY TRAFFIC BY HOUR

Hour	Spokane
12:00 - 1:00 a.m.	1.0%
1:00 - 2:00 a.m.	0.8
2:00 - 3:00 a.m.	0.6
3:00 - 4:00 a.m.	0.4
4:00 - 5:00 a.m.	0.4
5:00 - 6:00 a.m.	0.8
6:00 7:00 a.m.	2.7
7:00 - 8:00 a.m.	6.7
8:00 - 9:00 a.m.	5.2
9:00 - 10:00 a.m.	7.3
10:00 - 11:00 a.m.	4.7
11:00 12:00 a.m.	5.3
12:00 - 1:00 p.m.	5.6
1:00 - 2:00 p.m.	5.6
2:00 - 3:00 p.m.	6.1
3:00 - 4:00 p.m.	7.0
4:00 5:00 p.m.	8.3
5:00 6:00 p.m.	7.9
6:00 - 7:00 p.m.	5.9
7:00 - 8:00 p.m.	5.4
8:00 - 9:00 p.m.	3.9
9:00 - 10:00 p.m.	3.6
10:00 - 11:00 p.m.	2.7
11:00 - 12:00 p.m.	2.1
	100.0%

added to that estimated for the freeways, arterials and collector roadways appearing on traffic flow maps.

In order to insure that calculations of vehicle miles of travel were available for all potential "hot spots" of poor air quality, grids were added to the system until it appeared that coverage was achieved such that grids with high emission levels were surrounded by grids with emissions below the critical level, roughly estimated at about 90,000 vehicle miles of travel. This procedure resulted in a total of 6 grids, and the resulting pattern is shown in Figure II-6.

4. Vehicle Mix

Table II-12 shows vehicle mix and classification data for the Spokane region. The 1971 registration data by vehicle type was abstracted from State registration data. The daily vehicle trip information is from origin and destination surveys conducted by the transportation study groups in each area.

The breakdown on daily vehicle miles of travel was developed from similar information, but has been subdivided into the three vehicle types using information of trip lengths for automobiles and commercial vehicles, and for internal trips and through trips.

Vehicle age mix is obtained from two sources. Statewide data was obtained from the Washington Department of Motor Vehicles by the Department of Ecology. A breakdown by county was obtained from R.L. Polk and Company. These data are summarized in Table II-13.

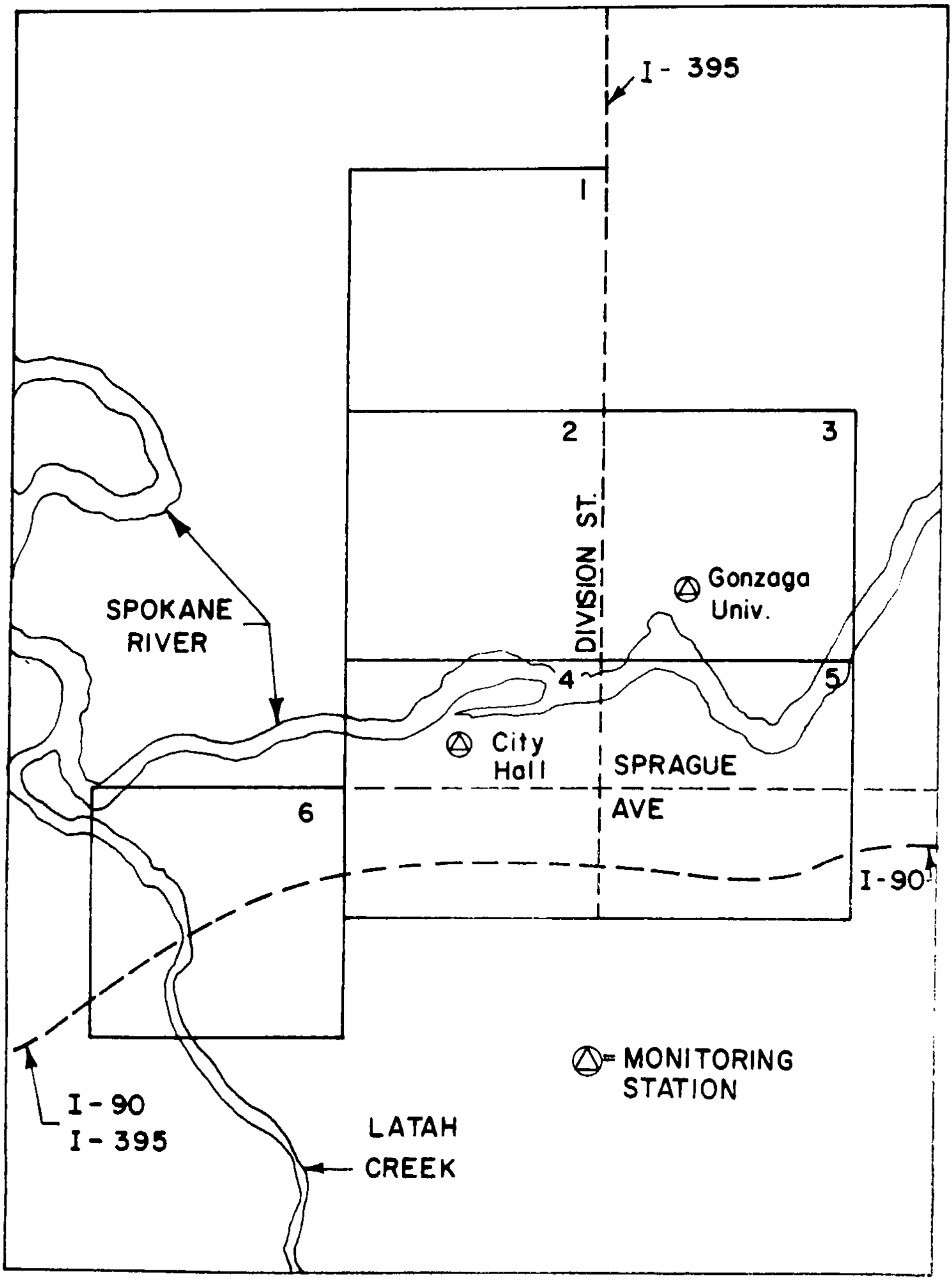

Figure II-6. Locations of One Mile-Square Grids Spokane Area.

TABLE II-12

VEHICLE MIX AND CLASSIFICATION

	Spokane	Statewide
1971 Registration:		
Gasoline light duty	79.2%	79.1%
Gasoline heavy duty	20.5	20.5
Non-gasoline	0.3	0.4
	100.0%	100.0%
Study Year:	1965	
Daily Vehicle Trip:		
Auto	90.5%	
Truck	9.5	
	100.0%	
Daily VMT:		
Gasoline light duty	91.0%	
Gasoline heavy duty	7.3	
Non-gasoline	1.7	
	100.0%	

Not including motorcycles

TABLE II-13

VEHICLE AGE MIX

Model Year	Statewide as of July 1, 1971	Spokane County 1972
72	-	3,712
71	58,644	6,698
70	108,632	7,713
69	132,956	9,295
68	132,599	9,529
67	129,889	8,950
66	136,964	9,668
65	136,427	10,121
64	116,486	8,313
63	107,192	7,286
62 & Prior	403,260	25,066
Total	1,463,049	106,351

5. <u>1977 Vehicle Miles of Travel</u>

For 1977 it is assumed that:

(1) The division of vehicle miles of travel into vehicle types will be the same as for 1971.

(2) The diurnal traffic profile will be the same.

The overall technique used in estimating 1977 vehicle miles of travel was a trend projection and growth factor method. Since the time period from 1971 to 1977 is relatively short-term, a trend projection method was judged to be at least as accurate as currently available travel forecasts based on travel model and traffic assignment techniques. Moreover, short-range assignments to current streets were not available. However, trip generation totals from longer-range travel forecasts did provide the trend lines for Central Business District travel.

For Spokane, trends of growth on selected arterials were evaluated. Trends of daily traffic since 1959 on arterials such as Market Street, Frances Avenue, Mission Avenue and Grand Blvd. were plotted and inspected. Similarly, trends on Interstate 90 and State Routes 2 and 395 were assessed. The ratio of the 1971 volumes to 1977 varied from 1.01 to 1.25, with the central business district at 1.18.

6. <u>Transportation System Improvements</u>

Vehicle miles of travel in each grid, and the average speeds, could be significantly affected by improvements in the system of streets and highways. For example, Interstate 90 was only partially completed through downtown Spokane in 1971. Most trips passing through the grid east-west on the freeway, plus many downtown-bound trips using the freeway, were detoured to arterials operating at a lower average speed than the freeway. This freeway is now completed and will serve 1977 travel at higher speeds. The diversion of trips to the freeway was estimated by analysis of freeway counts and manual assignment of volumes at the 1971 level. The 1971 volumes on the completed freeway and those remaining on arterials were then projected to 1977.

The principal new project in the Spokane area is "Expo'74". This world exposition, scheduled for May through October 1974, will involve substantial rebuilding and rehabilitation of the northerly fringes of Spokane's Central Business District and the adjacent banks and islands of the Spokane River.

Even though the facilities of Expo'74 will remain for other uses after the exposition closes, the traffic generating impact of Expo'74 is assumed to be completely over by 1977.

Preliminary plans indicate that two large fringe parking lots totaling some 7,000 spaces will be constructed with some sort of mass transportation access of the exposition site. At the present time it is unknown whether these fringe parking lots will remain until 1977, and whether or not there will be an adequate method of connecting these lots with the Spokane Central Business District. Therefore, for purposes of initial estimates of the 1977 conditions in Spokane, it was assumed that Expo'74 would have no impact.

Other projects include a revised signal system in downtown Spokane, and a substantial transit improvement program. These and others were ignored in the initial 1977 estimates, and became candidate strategies for solving any 1977 air quality problem.

The total daily vehicle miles of travel resulting from the calculations and assumptions described above for grids in Spokane are shown in Figure II-7.

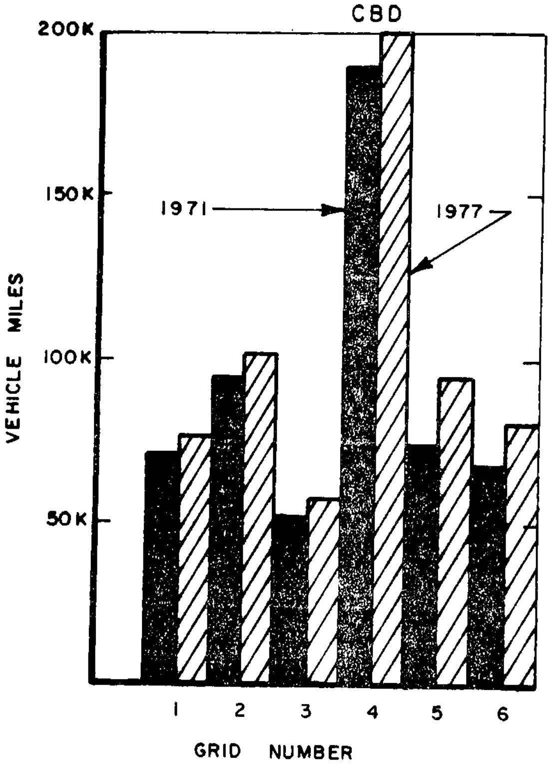

Figure II-7. Daily Vehicle Miles per Square Mile in Spokane.

D. DERIVATION OF 1977 AIR QUALITY LEVELS

1. General

The methodology presented in Section II-A, which assumes that ambient concentrations are directly proportional to the total emissions of the pollutant over an area of appropriate size, was used to estimate the maximum allowable emission density and the level of air quality expected in 1977 as a result of the Federal Motor Vehicle Control Program. The 1977 estimates were made using baseline VMT and air quality data for 1971. The percent reduction in vehicular emissions required by means of strategies was estimated by comparing calculated 1977 emission densities with the maximum allowable emission density. In the calculations, allowance was made for non-vehicular sources.

Hydrocarbon emission densities were calculated for the 3-hour period from 0600 to 0900 local time in agreement with the time period specified by the national standard for hydrocarbons. Carbon monoxide emission densities were calculated for the 8-hour period of maximum traffic.

2. Estimation of CO Levels

a. Emission Densities

Vehicular Emissions - Emission densities for 1971 and 1977 were calculated for the 6 one-mile square zones shown in Figure II-6 using the traffic data given in Appendix A, and the EPA emission factors referred to in Section II-A. Figure II-8 shows the results. The computer printout listing the results by vehicle type is reproduced in Appendix B.

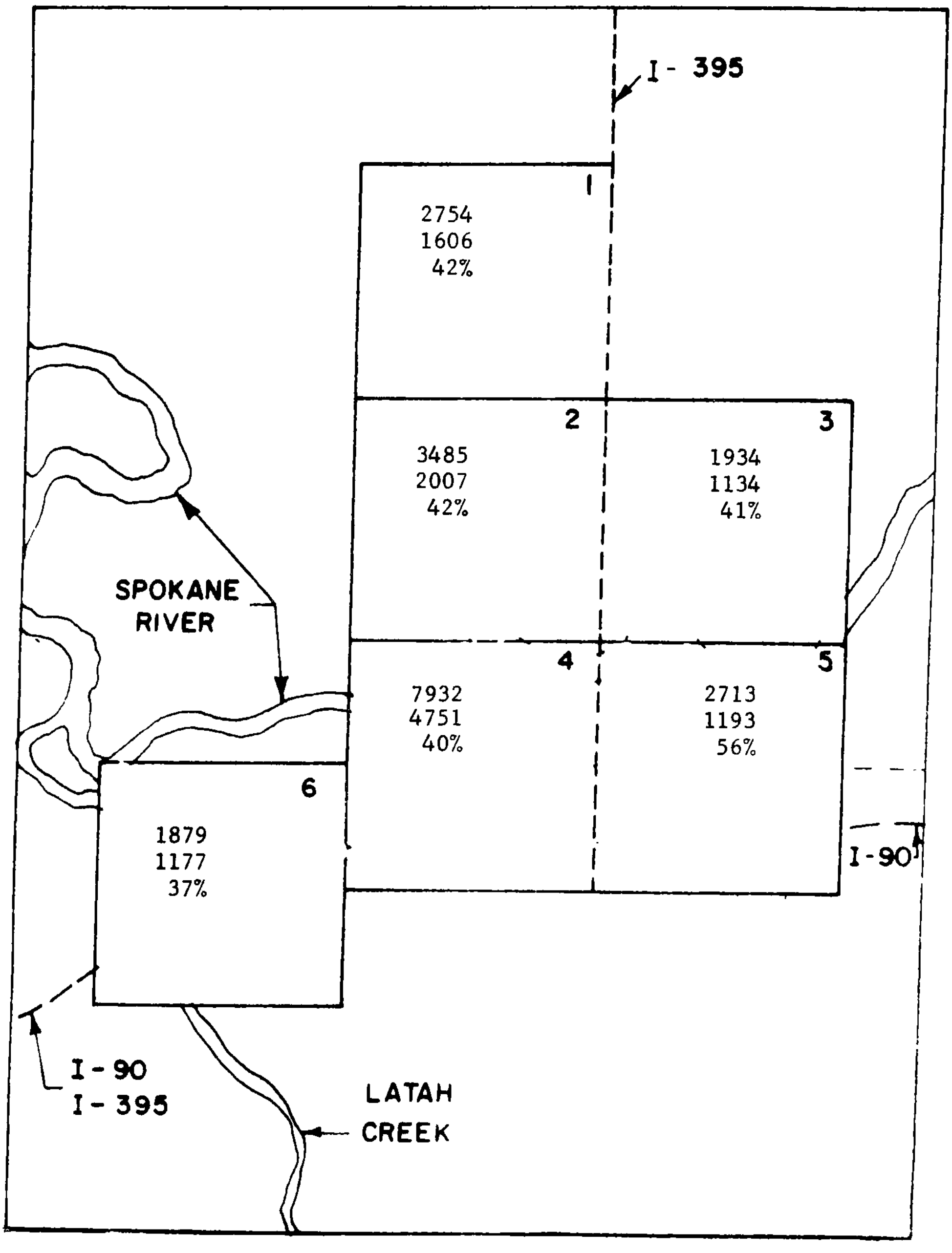

Figure II-8. Maximum 8-Hour CO emission densities (kg/mi^2) in Spokane. Upper values are for 1971, lower values are for 1977 and are based on Federal Motor Vehicle Control Program. Percent reduction is indicated on line three.

Non-Vehicular Emissions   Table II-14, compiled from data presented in Appendix C of the Implementation Plan, shows that 13 percent of the CO emissions within Spokane County are from non-vehicular sources. However, of these non-vehicular emissions, approximately 64 percent are from the Kaiser aluminum reduction plant, discussed under stationary sources, in Section II-B-4, and many of the remaining non-vehicular sources do not contribute significantly to concentrations in the CBD. Table II-15 gives the emission rates for various source categories for the Eastern Washington-Northern Idaho Interstate A.Q.C.R. in 1970 and 1975. For non-vehicular sources, these estimates show either no change or a decrease in emission rate between the two years. In the proportional modeling which follows, we attribute two percent of the CO emissions affecting the CBD to non-vehicular sources in 1971 and leave their emission rate unchanged throughout the 1970-1979 period.

b. Selection of Air Quality Baseline

The proportional modeling in the following section is based on the second-highest, 8-hour average concentration measured at City Hall since January 1971 (18 ppm), and the average 1971 emission density for the one-mile-square zone in which the monitor is located (Zone 4). Any reduction in emissions adequate to ensure meeting the 8-hour standard is believed to be more than adequate to ensure that the 1-hour standard will be met.

The location of the City Hall monitor with respect to traffic density within the CBD is shown in Figure II-9. The monitor appears to be suitably located to provide representative data for the CBD.

TABLE II-14

CO EMISSION ESTIMATES FOR SPOKANE COUNTY IN 1970

Source Category	Emissions (tons/yr)
Fuel Combustion	1,313
Process Losses	14,526*
Solid Waste Disposal	1,120*
Transportation	
Motor Vehicles	145,340
Other	577*
Misc. Area	5,050*
Subtotal (Non-vehicular)	22,583 (13%)
Total	167,926

*From sources not likely to significantly affect the CBD.

TABLE II-15

CARBON MONOXIDE EMISSION ESTIMATES FOR EASTERN WASHINGTON-NORTHERN IDAHO INTERSTATE A.Q.C.R.

Source Category	Emissions (tons/yr) 1970	1975
Process Losses	14,526	14,526
Fuel Combustion	1,474	1,474
Transportation*		
Motor Vehicles	193,601	146,101
Other	770	770
Solid Waste Disposal	7,985	4,634
Misc. Area Sources	10,299	5,149
Subtotal (Non-vehicular)	35,054	26,553
Totals	228,655	172,654

*1970 values have been distributed in accord with breakdown given in Spokane County 1970 estimates (Appendix C, Implementation Plan). "Other" transportation emissions are left unchanged for 1975.

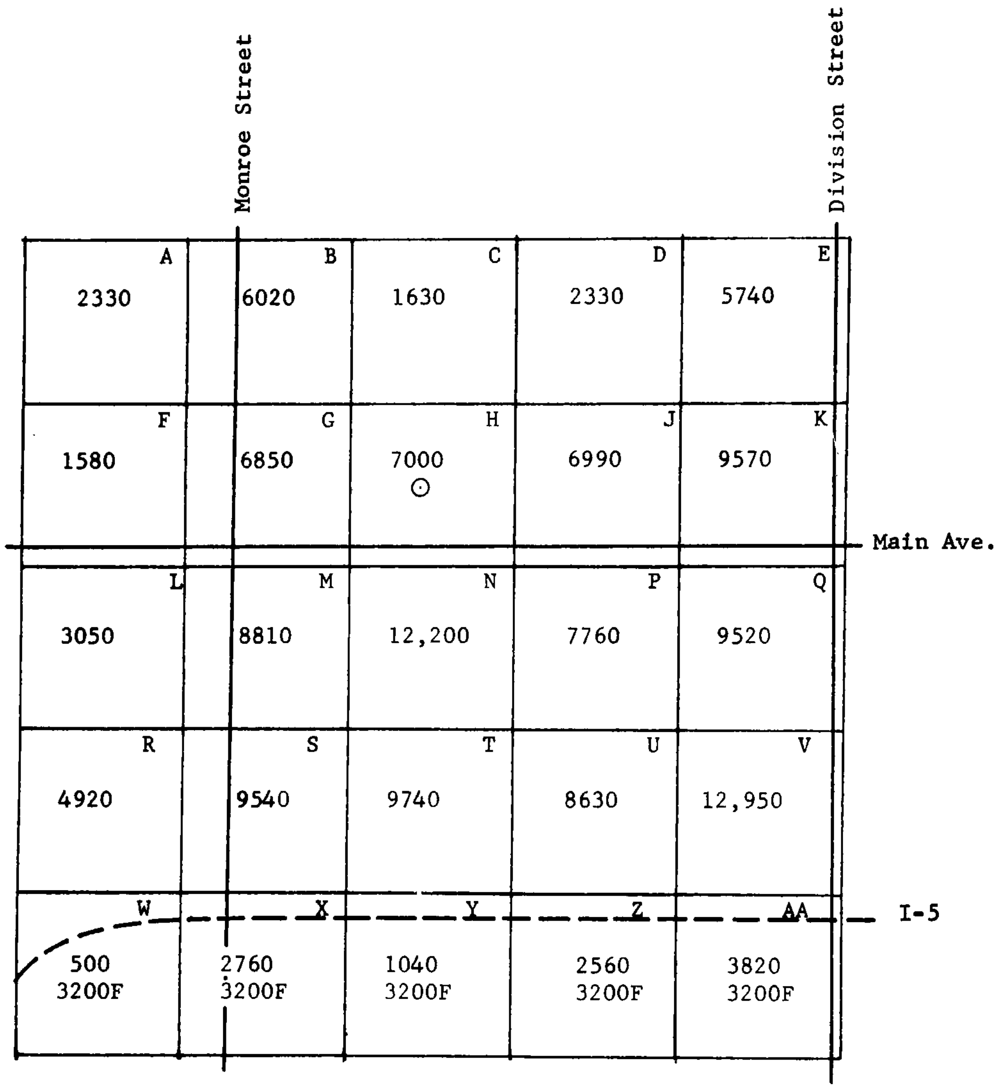

Figure II-9. 1971 daily vehicle miles traveled in Spokane CBD. VMT's are indicated by the letter F. Monitor location is shown by the symbol ⊙.

c. Results

Table II-16 summarizes the relevant emission density and air quality data for the CBD (Zone 4). According to these estimates, an 11 percent reduction in vehicular emissions from 1971 levels is required from transportation control strategies.

The maximum allowable vehicular emissions level is 3885 kg/8 hr/mi^2. Figure II-8 shows that the 1977 emission levels expected as a result of the Federal Motor Vehicle Control Program are well below this allowable level in all zones but the CBD.

d. Implementation Plan Estimates

The analysis presented in the Implementation Plan, reviewed in Section F of this report, indicated that a reduction of 22 percent between 1970 and 1977 would be required to meet the national standards, in addition to that expected through the Federal Motor Vehicle Control Program.

3. <u>Estimation of Oxidant Levels</u>

a. Emission Densities from Motor Vehicles

Figure II-10 shows 1971 and 1977 three-hour hydrocarbon emission densities calculated for the six zones using the traffic data in Appendix A and the appropriate emission factors. The computer printout listing the emission densities by vehicle type is reproduced in Appendix B. It can be seen from Figure II-10 that a reduction in hydrocarbon emissions from motor vehicles of about 50 percent is expected by 1977 as a result of the federal program.

TABLE II-16

SUMMARY DATA FOR ZONE 4 (CO)

(a) Emission Densities (kg/8 hr/mi^2)

Category	1971	1977
	Year	
Vehicular	7932	4751
Non-vehicular	162	162
Total	8094	4913

(b) Air Quality (8-hr average in ppm)

	1971	1977
	Year	
Observed (2nd highest)	18	
Estimated		10.9

(c) Maximum Allowable Emissions Level (kg/8 hr/mi^2)

Total	Non-vehicular	Vehicular
4047	162	3885

(d) Reduction in Vehicular Emissions from 1971 Levels

	Percent
From Federal Motor Vehicle Control Program by 1977	40
Additional Required by Transportation Control Strategies	11

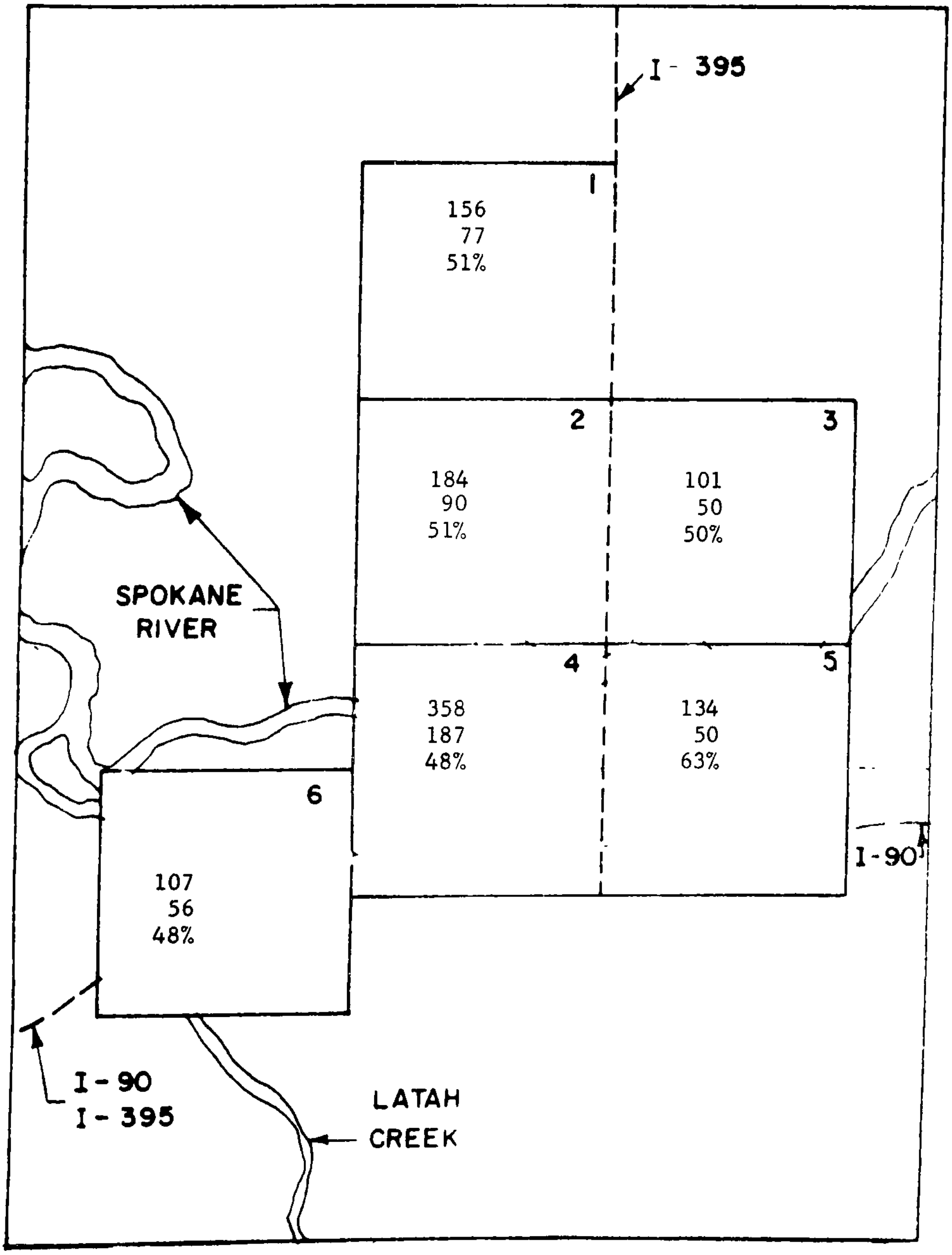

Figure II-10.
6 AM - 9 AM hydrocarbon emission densities (kg/mi^2) in Spokane. Upper values are for 1971, lower values are for 1977 and are based on Federal Motor Vehicle Control Program. Percent reduction in indicated on line three.

b. Non-Vehicular Hydrocarbon Emissions

Table II-17 gives estimated 1970 and 1975 hydrocarbon emission rates for the Eastern Washington-Northern Idaho Interstate A.Q.C.R. Over this period, the sum of emissions from non-vehicular sources shows a slight decrease.

c. Conclusion

Since oxidant levels are currently below the standard and a substantial decrease in total hydrocarbon emissions is expected by 1977, largely as a result of the Federal Motor Vehicle Control Program, oxidant levels will remain below the standard throughout the period under study.

d. Implementation Plan Estimate

The analysis presented in the Implementation Plan also showed that no reduction in hydrocarbon emissions was required from transportation control strategies.

TABLE II-17

HYDROCARBON EMISSION ESTIMATES FOR EASTERN WASHINGTON-NORTHERN IDAHO INTERSTATE A.Q.C.R.

Source Category	Emissions (Tons/yr) 1970	1975
Process Losses	6,276	6,276
Fuel Combustion	793	793
Transportation *		
Motor Vehicles	31,840	21,940
Other	3,259	3,259
Solid Waste Disposal	1,896	1,155
Misc. Area Sources	1,224	612
Subtotal (Non-vehicular)	13,448	12,095
Totals	45,288	34,035

*1970 values have been distributed in accord with breakdown given in Spokane County 1970 estimates (Appendix C, Implementation Plan). "Other" transportation emissions are left unchanged for 1975.

E. PROJECTED CARBON MONOXIDE LEVELS IN 1978 AND 1979

Vehicular CO emission densities in 1978 and 1979 were calculated for the CBD, using projected VMT's and the appropriate emission factors, on the assumption of no transportation control strategies. The results are given in Table II-18. These estimates indicate that the national standards for CO will be met by 1979 by means of the Federal Motor Vehicle Control Program.

TABLE II-18

PROJECTED CO EMISSION LEVELS IN 1978 AND 1979, WITHOUT STRATEGIES

Source Category	Emission Density ($kg/8\ hr/mi^2$)		
	Allowable	1978	1979
Vehicular	3885	4066	3482
Non-vehicular	162	162	162
TOTAL	4047	4228	3644

F. SUMMARY OF PROBLEM AND CONCLUSIONS

1. Implementation Plan Assessment of CO and Oxidant Problems

The assessments of the CO and oxidant problems in Spokane made in the Implementation Plan were based on procedures specified in Appendix I of the Federal Register, Vol. 36, No. 153, pp. 15500-15501. The degree of improvement in air quality needed for attainment of the national air quality standards was made by the proportional model

$$\frac{(A - C)100}{A - B}$$

where A = the second highest concentration observed over the period of observation;

B = the air quality standard;

C = the background value, set equal to zero.

The formula for calculating the air quality level for some future year, as specified in Appendix I is

$$A.Q._1 = A.Q._0 \left[\frac{E_1}{E_0} F_0 + (1-F_0)(G F) \right]$$

where:

Subscripts 0 and 1 denote the base year and future year of interest, respectively.

A.Q. = Air Quality (measured or estimated) in region

E = Normalized emissions from Figures 1 and 2 in Appendix I

F = Ratio of motor vehicle emissions to total emissions of each pollutant in region

GF = Growth factor for emission increases from stationary sources.

The equation was applied directly for carbon monoxide. The percent reduction in hydrocarbon emissions expected from the Federal Motor Vehicle Control Program was estimated by the portion of the equation in the brackets and compared with the percent reduction required to meet the standard for photochemical oxidants obtained from Appendix J of the same Federal Register (p. 15502).

The rollback calculations for CO were based on observations made at the City Hall and indicated that a 22 percent reduction in CO emissions from 1970 levels would be required to meet the national standards, in addition to the reductions expected through the Federal Motor Vehicle Control Program. The limited amount of oxidant data available showed a maximum value of 0.05 ppm, well below the standard, and it was concluded that transportation controls would not be required to continue to meet the standards. Both of these conclusions are compatible with the results of the present study, summarized below.

2. Current Assessment of CO and Oxidant Problems

The results of the preceding analysis may be summarized as follows:

(1) Transportation control strategies are not required to maintain oxidant levels below the national standards in Spokane.

(2) The Federal Motor Vehicle Control Program will ensure that by 1977

- 1-hour CO concentrations will be below the national standard throughout Spokane
- 8-hour CO concentrations will be below the national standard except in the CBD

(3) An additional reduction in motor vehicle CO emissions of about 11 percent from 1971 levels will be required in the CBD to meet the 8-hour national standard by 1977. This is equivalent to a reduction of 18 percent from the 1977 "no strategy" level.

(4) The Federal Motor Vehicle Control Program will ensure that the national CO standards will be met in the CBD by 1979 without the use of transportation control strategies.

III. EVALUATION OF CANDIDATE TRANSPORTATION CONTROLS

A. GENERAL

It was concluded in Section II that an additional 11-percent reduction from 1971 CO emission levels will be needed, over and above the reduction provided by motor vehicle emission controls on new cars, if the national standards are to be met in the CBD by 1977. In selecting transportation control strategies, priority has been given to strategies that build upon presently planned programs and projects, rather than extensive new strategies that are intended for emission reduction only.

The emissions estimated for 1977 are based on the vehicle-mile data listed in Table III-1. The development of the requisite transportation control strategies is based first on an increase in average speed for arterials from 18 and 20 mph to a little over 22 mph, and second on a decrease in vehicle miles. Any additional improvement needed is to be accomplished by the reduction in emission rate from existing vehicles by such means as retrofit programs, gaseous conversion, or by programs to discourage the ownership or restrict the use of older vehicles.

B. ALTERNATIVE STRATEGIES

A very long list of potential strategies was developed for initial screening. This list is shown in Table III-2 arranged into groups by a feasibility rating. These groupings were the partial output of discussion with officials from the City of Spokane, Washington State Highway Department, and Washington State Department of Ecology.

TABLE III-1

8-HOUR VEHICLE-MILES OF TRAVEL IN
DOWNTOWN SPOKANE, 1977

Average Speed	Vehicle-Miles
60 MPH	15,434
20 MPH	39,210
18 MPH	56,911
15 MPH	1,948
Total	113,503

TABLE III-2

POTENTIAL STRATEGIES BY FEASIBILITY GROUPING - SPOKANE AREA

I. Strategies for Evaluation:

a. Implement a computer controlled traffic signal system in downtown with related street widenings, spot parking prohibitions, and other traffic controls.

b. Continue to implement a transit improvement program including satellite parking.

c. Develop State sponsored incentive programs for retrofit (and inspection) of heavy-duty fleet vehicles.

d. Encourage gaseous conversion for fleet vehicles.

e. Implement a system of second-level sidewalks in downtown.

f. Plan to take advantage of any residual fringe parking from Expo' 74.

g. Plan to take advantage of any residual driver advisory system from Expo'74.

h. Plan to exploit opportunities to encourage car pools and staggered days programs.

i. Plan to take advantage of opportunities to improve curb loading in downtown.

j. Support incentive programs to discourage ownership of older, uncontrolled vehicles.

II. Strategies of Doubtful Effectiveness in Downtown:

a. Reversible lanes or streets.

b. Ramp metering.

c. Air watch driver advisory.

d. Staggered hours.

Table III- 2 (II cont'd)

e. Regional area traffic bypass.

f. Fuel additives.

III. Strategies Outside Policies and Goals for Downtown:

a. Increase in parking fees.

b. Large-scale parking prohibitions.

c. Large-scale vehicle prohibitions.

d. Limitations in street capacity.

IV. Strategies for Long-range Consideration, but Effective Only Beyond 1977:

a. New-type vehicles.

b. Communications substitutes for travel.

c. Land use policies.

d. Planning of facilities to reduce emissions.

e. Bypass route for through traffic in downtown.

V. Strategies Outside Present Policy Framework:

a. Impose tolls.

b. Fuel rationing.

c. Increased uses taxes and fees.

d. Road use taxes.

e. Rationing of vehicle ownership.

f. Inspection and maintenance of all vehicles.

Simply stated, the strategies listed in Groups II through V do not have application because they are too long-range, not practical in downtown Spokane, or run counter to present local and Statewide policy.

Group I includes a fairly extensive list of activities that can become elements of one or more candidate strategies for Spokane.

C. STRATEGY EVALUATION

The strategies discussed in following paragraphs are recommended candidates for inclusion in any air quality implementation plan for Spokane either in total or in part. The estimated percentage reductions are from 1977 "no strategy" levels.

1. Computer-Controlled Downtown Signal System

A project is being implemented at the present time leading to full operation of a computer-controlled, fully-interconnected signal system in downtown Spokane by 1975. This system will include 37 intersections by 1974 and 79 by 1975. The signal system will be capable of traffic-responsive operation. Related to this overall improvement are Spokane River bridge widenings (part of improvements for Expo'74), traffic controls such as spot parking prohibition, and maintenance of the basic one-way street system.

It is estimated by the Spokane Traffic Engineer that a 2 mph increase in average speeds will result. This will not apply to the freeway, of course, and will apply only to a portion of the intersections within grid 4.

The 79 intersections are slightly over half of the total intersections, but comprise some 90 percent of the high volume intersections. Depending on the effectiveness of the signal system in terms of this coverage, the reduction in emissions expected could be from 3.7 percent to 6.2 percent.

2. Transit Improvements

Spokane's transit improvement program includes acquisition of private systems, new rolling stock, and service improvements. The report Transit Development Program for Spokane, Alan M. Voorhees and Associates, May 1970, conservatively projects no increase in patronage by 1980 while pointing out that service improvements and a vigorous public information program could achieve some gains.

The improvement program also includes six satellite parking locations of some 350 spaces each by 1977. Experience with the Blue Streak express park-ride in Seattle has shown that express park-ride service can succeed if transit speed is high and cost low in comparison to downtown parking.

Downtown cordon counts and transit counts indicate about a 14 percent mode split at present in the morning peak period. Full use of the proposed 2,100 satellite spaces by 1977 would increase mode split in the morning peak to 27 percent.

Using modal split curves developed in Seattle for Blue Streak it is indicated that a mode split of 21 percent might be achieved under the following conditions of express service:

(1) 15 mph average express bus speed

(2) 10-minute headways

(3) $0.25 fare.

If these (or closely similar) conditions occur, then it is also likely that the balance of the satellite parking will be used off-peak. If so, vehicle travel to downtown Spokane could be reduced 4.8 percent, with a total reduction in downtown vehicle miles (and emissions) of 2.3 percent.

3. Incentive Retrofit Programs

The retrofit program for heavy-duty fleet vehicles has been suggested by the Department of Ecology and was acceptable for City Officials hopefully as an incentive-type program.

A 58 percent reduction in carbon monoxide emissions from light duty vehicles is cited by EPA* for an "air bleed to intake manifold" device, available at a nominal $40 cost. Estimates place the portion of uncontrolled heavy-duty vehicles at between 45 and 55 percent of total heavy-duty by 1977. For Spokane, heavy-duty gasoline vehicles are estimated as 7.3 percent of vehicle miles, producing 16 percent of the carbon monoxide emissions. Assuming an identical effect on heavy duty vehicles, the potential impact could be:

*Control Strategies for In-Use Vehicles, Office of Air and Water Programs, Mobile Source Pollution Control Program, Washington, D.C., November 1972.

$$(0.16 \text{ emissions})(0.58 \text{ reduction})(0.50 \text{ uncontrolled}) = 0.047 \cong 5 \text{ percent}$$

If only fleet vehicles are regulated (about 9 percent of all trucks are in fleets) of 10 or more the potential reduction could be as low as 0.5 percent.

Advantages of such a program could be its ease of administration and enforcement as compared to retrofit of all older vehicles, and its relatively low cost. However, an evaluation of the effectiveness of such a device on heavy duty vehicles has not been made by EPA, and its acceptance as a strategy requires justification.

4. Gaseous Conversion

Present legislation in Washington provides a tax incentive for conversion of vehicles to LNG or LPG. Like retrofit, this program is best suited to fleet operation. Reductions in emissions for light-duty vehicles range from 65 to 90 percent*, and similar reductions are assumed for heavy duty. Considering the percent of emissions for each class, overall reductions could be:

(1) Heavy-duty, fleets of 10 or more: 1.1 percent
(2) Light-duty, fleets of 10 or more: 0.7 percent
(3) Light-duty, fleets of 10 or more plus all government: 2.2 percent

5. Second-Level Sidewalks

A plan for second floor sidewalks is now being implemented in the core of downtown Spokane along Main Avenue. These pedestrian separations could reduce pedestrian-vehicle conflict and further enhance

*Preliminary EPA estimates. Actual emission reductions have been found to vary widely. See Control Strategies for In-Use Vehicles, pp. 4-3 to 4-5.

traffic flow. Although it is difficult to gauge the impact of such a project, relatively few turning vehicles would be affected and relatively few of the downtown intersections would be involved. Nevertheless, an emissions reduction of 0.4 percent can be calculated under the assumption that a 20-second delay is eliminated from a quarter-mile trip.

6. Contingency Strategies

Several other strategies (or elements of strategies) are listed for evaluation in Table III-2. These are less sure than previously discussed items, since they depend on possibilities that may or may not occur in the future.

Fringe Parking 7,000 spaces are planned for Expo'74 in two sites north of the Spokane River and reasonably close to downtown. They are on railroad property, and cannot be counted for 1977 use. Nevertheless, 7,000 spaces with low parking cost (or, better yet, none) plus quick transit access to downtown could reduce 8-hour vehicle miles on the order of 14 percent if fully utilized by at least one vehicle per space daily.

Such utilization, however, could require that 40 percent of the travel to and from the north be captured by fringe parking — which appears to be unrealistic.

Assuming 10-minute headways for the downtown access link, and no parking cost, the mode split could probably range from 7 percent to 24 percent. Using the lower figure, overall reduction in downtown vehicle miles could be on the order of 2.7 percent.

Driver Advisories - Some sort of driver information system to guide visitors to Expo'74 parking may be developed. If so, there may be carry-over applicable to reducing the downtown "search for parking" circulation vehicle miles. In 1968 Los Angeles found 22 percent of downtown travel during peak periods to be of this type. Assuming 10 percent effectiveness of a changeable message sign system and a 20 percent share of downtown traffic affected, a reduction in total downtown 8-hour vehicle miles of 0.7 percent is estimated.

Car Pools - This technique is one that is frequently mentioned as a means to reduce vehicular travel demand, but is seldom found in actual practice except at large employment centers.

A practical maximum vehicle occupancy from a car pool program is 1.7 persons per car average. Based on 1965 survey trip purpose distribution to downtown, persent occupancy is about 1.6. Therefore, a realistic estimate of maximum effectiveness of a car pool program is a reduction of vehicle miles of 1.9 percent.

A car pool program could be approached from several standpoints. Incentives are important in terms of preferred parking location and access to any reserved lanes (such as exclusive bus lanes on streets, freeways, or ramps). The latter approach does not appear to be significant by 1977 in Spokane.

Publicity is another factor, along with a "matching" service to locate travellers with close-by origins and destinations.

Staggered Days - This program involves a four-day work week or similar approach. The effect could be removal of employee work trips from downtown on the fifth day - the "off" day.

The "4 - 40" plan has been implemented in some areas, usually on an experimental bases. Initial implementation on a large-scale could be with governmental employees. To be effective, the plan would have to spread the "off" day evenly throughout the week. Assuming 100 percent compliance (unlikely), the daily 20 percent employee reduction would produce a maximum reduction in vehicle miles of 3.7 percent.

Loading Control - Control of curb loading zones could have benefits by eliminating interferences with traffic flow and shifting truck vehicle miles to more favorable time periods. If loading zone use were allowed only outside of daytime traffic hours, truck emissions (16 percent of the 8-hour total) could be shifted away from the critical 8-hour period. This would achieve a maximum reduction in emissions of 7.5 percent.

Such a policy, with its impact on the operations of downtown establishments, would become attractive only in combination with needs from other standpoints such as capacity deficiencies.

Discourage Use of Older Vehicles - This strategy could be directed towards an incentive program to remove older,non-controlled vehicles from the traffic stream. By 1977, vehicles of 1966 vintage and older will probably have reached their minimum value. Therefore, a program to offer a "bounty" of $100.00 or so to scrap such vehicles might encourage owners to obtain and use newer model automobiles.

Such a program would undoubtedly have to be approached on a Statewide basis, or at least through State legislation. Financing such a program might be done by increasing user taxes on new vehicles. An additional benefit to this program would be improvement in visual pollution. The pay-off for such a program in terms of reduced pollution could be high, up to 20 percent.

7. Summary and Impact

The strategies discussed above are ranked in Table III-3 based on the combination of reduction in emissions provided and the potential for implementation. The impact of each strategy is listed under several categories.

Because of its high potential for reducing emissions, the exclusion of older model vehicles from the CBD has been included in Table III-3, even though such a strategy is viewed as discriminatory by the various state and local agencies. Its potential has been evaluated in the following section. Its use is suggested if an incentive program to discourage the use of older vehicles fails.

TABLE III-3

SUMMARY AND EVALUATION OF STRATEGIES FOR REDUCTION OF CO EMISSIONS

Rank	Strategy	Emission Reduction (from 1977)	Implementation Potential	IMPACT: Cost	Political	Economic	Institutional	Legal	Social	Technical
1	Implement computer-controlled signal system	3.7 to 6.2%	High	Funded		Favorable to				Emission reduction may be short term
2	Continue to implement transit improvements.	2.3%	High	Funded	Favorable Image	Usually a deficit activity	Public ownership accomplished.		Highly favorable to low income groups.	
3	Retrofit heavy duty fleet vehicles	0.5%	Moderate	Low unit cost	Should be an incentive program.		Small identified group for administration.	Legislation required, statewide or specific areas.		Air bleed to intake manifold device available.
4	Implement second level sidewalks in downtown.	0.4%	High	Private Construction.	Favorable Image	Improve downtown esthetics.	City plans, encourages development.			
5	Economic gaseous conversion fleet vehicles: Light duty Heavy duty	 0.7 to 2.2% 1.1%	Moderate	High unit cost.	Favorable image for government vehicle conv. should continue incentive program.		Small, identified group for administration.	Present legislation must be extended past 1975.		Fuel handling, some maintenance problems, Potential shortage of natural gas.
6	Exclusion of pre-controlled vehicles	Up to 20%	Low to moderate	Low	Unfavorable	May divert some business from downtown	Adds to administrative burden.	Legislation required.	Discriminatory	Requires enforcement.
7	Support program to discourage ownership of older pre-controlled vehicles.	0 to 20%	Low to moderate	High	Probably requires tax increases. Assist with beautification.		Adds to state administrative burden.	Legislation required, statewide or specific areas.	Should improve mobility for low income groups.	Requires towing, disposal means.
8	Contingencies: Fringe Parking	0 to 2.7%	Low	High	Considerable costs could be involved.	Favorable to downtown		Land ownership may be a problem.	Could also serve Expo facilities	Potential vehicle access problems. Transit link to downtown required.
	Driver Advisories.	0 to 0.7%	Low	Moderate to Low		Favorable to downtown.				Technology of advanced systems may require development.
	Car Pools	0 to 1.9%	Low	Low	Requires incentive	Favorable	Attitudes must be changed			Rider "matching" program required.
	Staggered Days	0 to 3.7%	Low	Low			May not be popular without long weekend potential. Requires attitude changes.	Labor laws may be obstacles.	Changes life styles.	
	Loading	0 to 7.5%	Low	Low	Probable business	May add to business cost.	Requires business operations changes	Local Legislation required.		

IV. SELECTION OF TRANSPORTATION CONTROLS AND ESTIMATE OF AIR QUALITY IMPACT

Strategies 1, 2, and 4 in Table III-3 produce changes either in the distribution of VMT's among the various speed categories, or in the total number of VMT's for certain speed categories. Estimates of VMT's by speed category after applying the three strategies in sequence are given in Table IV-1. These estimates were used to calculate 1977 emissions and the emissions were converted to CO concentrations by the proportional model discussed in Section II-D. The results are shown in Table IV-2.

These estimates indicate that a further reduction of 466 kg/8 hr/mi^2 will be required to meet the 8-hour standard. Judged by their potential for for implementation (see Table III-2), the next two strategies for selection are retrofit heavy duty fleet vehicles, with an estimated yield of 24 kg/ 8 hr/mi^2 (0.005 x 4751) and the gaseous conversion of fleet vehicles. The estimated yield for conversion of light duty fleets of 10 or more plus all government light duty vehicles is 105 kg/8 hr/mi^2 (0.022 x 4751). These two strategies together provide approximately 28 percent of the 466 kg/8 hr/mi^2 reduction required. Thus, further substantial reductions are needed.

Table IV-3 gives the expected 1977 emissions after the application of Strategies 1, 2, and 3, and provides a convenient means of evaluating strategies that affect selected years or vehicle types, such as the exclusion of pre-controlled vehicles from the CBD. For example, Table IV-3 shows that pre-controlled light duty vehicles (pre-1968 models) contribute 914 kg/8 hr/mi^2, and pre-controlled heavy duty vehicles (pre-1970 models) contribute 190 kg/8 hr/mi^2. Presumably, a policy of vehicular exclusion

TABLE IV-1

VEHICLE MILES TRAVELED IN 1977 FOR SELECTED STRATEGIES

Average Speed (mph)	8-hour VMT			
	Without Strategies	Strategies		
		1	1 + 2	1 + 2 + 3
60	15,434	15,434	15,079	15,079
22	0	35,150	34,342	34,422
20	39,210	55,060	53,794	53,794
18	56,911	5,911	5,775	5,695
15	1,948	1,948	1,903	1,903
Total	113,503	113,503	110,893	110,893

TABLE IV-2

IMPACT OF SELECTED STRATEGIES ON AIR QUALITY IN 1977

	Allowable	Without Strategies	WITH STRATEGIES				
			1	1 & 2	1 & 2 & 3	1 & 2 & 3 Exclu-sion	1 & 2 & 3 Retro-fit
Vehicular Emissions (kg/8 hr/mi^2	3885	4751	4454	4352	4351	<3543	3783*
8-Hr CO Conc. (ppm)	9.0	10.9	10.3	10.0	10.0	< 8.2	8.8

Key to Strategies

(1) Computer controlled signal system.
(2) Transit improvement.
(3) Pedestrian separations

* Example calculation based on an "air bleed to intake manifold" on pre-1968 models.

TABLE IV-3

1977 CO EMISSIONS IN THE SPOKANE CBD BY
MODEL YEAR AND VEHICLE TYPE

Model Year	Emissions (kg/8 hr/mi^2) Light Duty	Heavy Duty
1965 and earlier	355	97
1966	229	15
1967	330	17
1968	354	26
1969	583	35
1970	409	52
1971	522	60
1972	228	81
1973	259	87
1974	250	52
1975	42	60
1976	36	77
1977	15	41
1978	1	1
Total	3613	701

from the CBD would result, in part, in an increased use of public transportation systems, and, in part, in a shift in the age distribution of vehicles. For purposes of estimation, the following two assumptions have been made for pre-1968 light duty vehicle emissions:

1) Vehicle-trips contributing one-fourth of the emissions (228 kg/8 hr/mi^2) will be eliminated;

2) The remaining excluded vehicle trips will be replaced by trips made by more recent models: ½ by 1972-1974 models, and ½ by 1975 and later models.

The second assumption results in a drop in emissions of approximately 580 kg/8 hr/mi^2. Thus, the total decrease accomplished by the exclusion of light duty vehicles is 808 kg/8 hr/mi^2. If pre-1970 heavy duty vehicles are also excluded from the CBD, it is estimated that the total reduction of 866 kg/8 hr/mi^2 required from the "no strategy" level will be exceeded.

The effects of various retrofit programs can also be estimated from Table IV-3. For example, the 914 kg/8 hr/mi^2 contributed by pre-1968 light duty vehicles could be reduced by 568 kg/8 hr/mi^2 by the use of "air bleed to intake manifold" devices (assuming a 10 percent adjustment to a maintained baseline, and a 58 percent reduction* due to the retrofit device). Thus, the reduction that would be accomplished by the use of this strategy appears to be more than adequate to meet the requirements after the use of Strategies 1, 2, and 3. It has not be included in Table III-3 because the general use of retrofit systems and the establishment of the requisite inspection and maintenance facilities was not looked upon with favor by the various concerned agencies. Its effect on air quality, however, has been included in Table IV-2.

* See Control Strategies for In-Use Vehicles for percent reductions expected from retrofit devices.

It is significant to note that, with the principal exception of the downtown signal system, the proposed strategies will lead to reduced area-wide emissions, and that their favorable impact on air quality will not be limited to the CBD.

V. OBSTACLES TO IMPLEMENTATION OF SELECTED CONTROLS

For the Spokane area, the strategies ranked high are those that have the fewest obstacles to implementation. Because the air quality problem is relatively small by 1977, and is solved by 1979 by the Motor Vehicle Control Program, attention was directed first to strategies that are part of on-going programs already active to achieve other goals. However, the use of additional strategies has been found necessary.

A. INSTITUTIONAL OBSTACLES

No significant institutional obstacles are identified for the top five ranked strategies. The largest obstacles from an institutional standpoint affecting the lessor strategies are:

(1) Opposition of downtown business to any curb loading controls. A definite need from many standpoints in addition to air quality improvement must be shown.

(2) Possible opposition from downtown business to a staggered days program due to employee administrative problems and possible changes in business operations.

(3) Present traveller negative attitudes towards car-pools are a major impediment to this program.

(4) A staggered days program will require drastic modification of life styles that may be difficult or impossible to achieve.

B. LEGAL OBSTACLES

Strategies of retrofit, gaseous conversion, reduced ownership of older cars and the exclusion of uncontrolled vehicles from the CBD will require legislation at the City and State level. A tax incentive program for gaseous conversion presently exists but must be extended beyond 1975. Similar programs would be suitable for retrofit, but mandatory legislation would undoubtedly face severe opposition.

Programs to provide a "bounty" for discontinuing use of older, pre-controlled automobiles are likely to require equally unpopular tax increases to support the program.

C. ECONOMIC OBSTACLES

The cost of a downtown computer signal system are high compared to other traffic controls. Certainly the cost of transit rolling stock, land and equipment, and parking is high. However, fund resources are already available for the activities. Transit operation is usually a deficit activity, but is funded because of over-riding benefits from other than air quality improvement.

The high unit cost discourages gaseous conversion by vehicle owners. The contrary situation applies to a "bounty" program on older cars. The owner benefits, but the high cost of the program is an obstacle from the State point of view.

High costs may also be associated with fringe parking. However, Federal grant programs are available, and some portion of the development costs could be a part of Expo'74 expenses.

The cost of administering a program to exclude all pre-1968 vehicles from the CBD would be limited principally to enforcement costs. The administration of a partially restrictive program based on the installation of retrofit systems and periodic inspections would require the start-up and operation of inspection stations since the State of Washington does not currently have a vehicle inspection law. From a social-economic standpoint, such a program would be regressive, placing a burden on those least able to pay.

D. TECHNICAL OBSTACLES

Few, if any, technical obstacles exist to top-ranked strategies. The maintenance, fuel handling, and fuel supply problems of gaseous conversion are well-known. The "bounty" program for older vehicles presents administrative and financial problems, but also brings up obstacles in terms of disposal of surplus older vehicles. Technology is available, but perhaps not in the quantity needed.

Fringe parking, if implemented, could create problems of providing adequate street access capacity. Also, the transit link to downtown is a question:

What type of vehicle?

What routing?

Lastly, any driver advisory program that involves changeable message signing, possibly with some sort of master computer control, would require research and (possibly) development of hardware.

VI. SURVEILLANCE REVIEW PROCESS

The surveillance review process, by which the success of the Federal Motor Vehicle Control Program and any transportation control measures that may be implemented is to be judged, should be carried out on three levels. These are:

(1) Review progress in implementing the selected control measures.

(2) Monitor the impact of the control measures on traffic parameters.

(3) Monitor the air quality.

Each of these areas of surveillance is discussed briefly below.

A. CHECK IMPLEMENTATION PROGRESS

The three strategies selected for initial implementation are:

- A computer controlled signal system
- Transit improvement
- Second level sidewalks (pedestrian separation)

These are existing programs in the early phases of development, and their surveillance involves periodic checks on progress. The next three strategies for possible implementation are:

- Retrofit heavy duty fleet vehicles
- Gaseous conversion of fleet vehicles
- Discourage or prohibit the use of uncontrolled vehicles

To be effective, these strategies would need to be approached through state legislation.

Table VI-1 summarizes surveillance activities by year for the seven top-ranked strategies.

B. MONITOR TRAFFIC PARAMETERS

The two basic traffic parameters to be monitored to verify the success of the federal program and of any transportation control strategy are:

- Traffic volume
- Average operating speeds

A systematic method of calculating VMT by vehicle type and speed for the CBD should be employed throughout the critical period. The 1971 and 1977 VMT's presented earlier in this report for the CBD may be used as reference points in judging the success of the programs. For convenience, they are repeated here in Table VI-2.

C. MONITOR AIR QUALITY

Ultimately, the success of the program to reduce ambient CO concentrations to acceptable levels must be judged by air quality measurements. The three curves in Figure VI-1 show the decrease in CO concentration expected from 1970 through 1977 at the Municipal Building as a result of:

- No strategies
- Strategies 1, 2, and 3 (Signal system, Transit improvement, and pedestrian separation)
- Strategies 1, 2, and 3 plus the exclusion of pre-controlled vehicles from the CBD.

Because of year-to-year variations in meteorological and other controlling factors, actual observations are expected to show considerable scatter about the predicted curves. No attempt has been made to account for short-term effects of Expo '74.

TABLE VI-1

SURVEILLANCE REVIEW PROCESS

Rank	Strategy	1973	1974	1975	1976	1977
1	Implement computer controlled signal system	Check construction progress	Monitor status of first 37 intersections	Monitor status of complete 79 intersection system	Check progress of evaluation of results	
2	Continue to implement transit program		Monitor status of first four satellite parking lots	Monitor status of two additional satellite lots		
3	Retrofit heavy duty fleet vehicles	Check progress: a) Development of legislation b) Enactment c) Development of administrative regulations d) Development of implementation programs	Monitor implementation progress	Monitor implementation progress	Monitor implementation progress	Monitor implementation progress
4	Implement second level sidewalks in downtown	Check progress: a) Construction underway b) City planning for next phases c) Construction permits issued	Same as 1973	Same as 1973	Same as 1973	Same as 1973
5	Encourage gaseous conversion of fleets	Monitor success of conversion program. Check progress of promotion program.	Monitor success of conversion program Check progress of promotion program	Check progress: a) Development of legislation extending incentive program b) Enactment Monitor success of conversion program and promotional activities	Monitor program	Same as 1976
6	Exclusion of pre controlled vehicles	Check progress: a) Development of legislation b) Enactment c) Development of administrative regulations	Monitor enforcement procedures	Monitor enforcement procedures	Monitor enforcement procedures	Monitor enforcement procedures
7	Program to discourage ownership of older, pre-controlled vehicles.	Check progress: a) Development of legislation b) Enactment c) Development of administrative regulations. d) Development of implementation programs.	Monitor implementation progress	Monitor implementation progress	Monitor implementation progress	Monitor implementation progress

TABLE VI-2

1971 AND 1977 MAXIMUM 8-HOUR* VMT
(ZONE 4)

Roadway Type	Average Speed (mph)	VMT 1971	VMT 1977 Without Strategies	VMT 1977 Strategies 1, 2, and 3
Freeway	60	8,080	15,434	15,079
Arterial	22		0	34,422
"	20	37,770	39,210	53,794
"	18	48,230	56,911	5,695
Local	15	1,787	1,948	1,903
	Total	95,867	113,503	110,893

*The maximum 8-hour VMT is estimated to be 50.5 percent of the daily VMT.

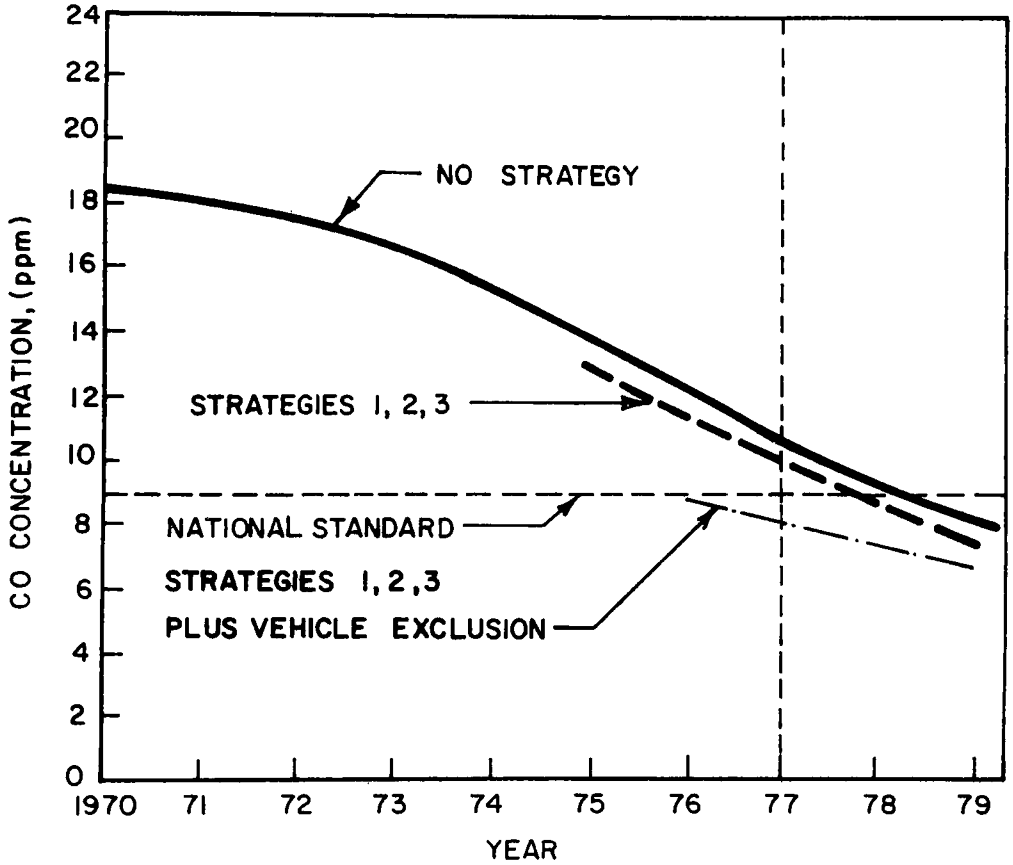

Figure VI-1. Projected 8-hour CO concentrations in Spokane CBD based on 1971 data.

APPENDIX A

1971 AND 1977 VEHICLE MILES OF TRAVEL

APPENDIX A

VEHICLE MILES OF TRAVEL (VMT)

The data contained in the following tables was provided as input to the emissions model. Total district VMT was estimated by facility type as described in Chapter II-C of the text. VMT by vehicle type was factored, as described in the text. It should be noted that the estimates for heavy duty vehicles (trucks) and diesel vehicles (non-gasoline) are based on regional and area factors, as real data for this level of detail is not available. These figures provide the best estimates of regional travel prorated to a district level for purposes of analysis.

In the tables which follow, roadway types have been classified in standard terminology as follows:

Freeway: A high-standard, grade-separated highway with complete control of access.

Arterial: A surface street or highway with limited or no access control and traffic signals at major intersections.

Collector: A surface street that feeds traffic to arterials.

Local: A surface street that provides access to adjacent land.

Vehicle Miles of Travel (VMT)

Metropolitan Area Spokane

Year 1971

Time Period Peak Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
1	Freeway		0	0	0	
	Arterial	20	4,914	394	92	
	Collector		--	--	--	
	Local	15	860	69	16	
	TOTAL		5,774	463	108	1
2	Freeway		0	0	0	
	Arterial	20	6,425	515	120	
	Collector		--	--	--	
	Local	15	737	59	14	
	TOTAL		7,162	574	134	1
3	Freeway		0	0	0	
	Arterial	20	3,331	267	62	
	Collector		--	--	--	
	Local	15	573	46	11	
	TOTAL		3,904	313	73	1
4	Freeway	50	1,210	97	23	
	Arterial	18-20	12,867	1,032	240	
	Collector		--	--	--	
	Local	15	282	23	5	
	TOTAL		14,359	1,152	268	1
5	Freeway		0	0	0	
	Arterial	20	5,305	426	99	
	Collector		--	--	--	
	Local	15	360	29	7	
	TOTAL		5,665	455	106	1
6	Freeway	50	2,321	186	43	
	Arterial	20-25	2,284	183	43	
	Collector		--	--	--	
	Local	15	593	48	11	
	TOTAL		5,198	417	97	1

Spokane - 1971 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
	Freeway Arterial Collector Local		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	TOTAL		42,062	3,374	786	46,222
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Spokane

Year 1971

Time Period 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway		0	0	0	
	Arterial	25	42,871	3,438	803	
	Collector		--	--	--	
	Local	15	7,503	602	140	
	TOTAL		50,374	4,040	943	1
2	Freeway		0	0	0	
	Arterial	25	56,053	4,493	1,047	
	Collector		--	--	--	
	Local	15	6,430	515	122	
	TOTAL		62,483	5,008	1,169	1
3	Freeway		0	0	0	
	Arterial	25	29,061	2,329	541	
	Collector		--	--	--	
	Local	15	4,999	401	96	
	TOTAL		34,060	2,730	637	1
4	Freeway	60	10,557	846	201	
	Arterial	18-20	112,254	9,004	2,094	
	Collector		--	--	--	
	Local	15	2,460	201	43	
	TOTAL		125,271	10,051	2,338	1
5	Freeway		0	0	0	
	Arterial	25	46,282	3,716	864	
	Collector		--	--	--	
	Local	15	3,141	253	61	
	TOTAL		49,423	3,969	925	1
6	Freeway	60	20,249	1,622	375	
	Arterial	25-30	19,926	1,596	375	
	Collector		--	--	--	
	Local	15	5,174	418	96	
	TOTAL		45,349	3,636	846	1

Spokane - 1971 - 12-Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
	Freeway Arterial Collector Local		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	TOTAL		366,960	29,434	6,858	403,252
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Spokane

Year 1971

Time Period 24-Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
1	Freeway		0	0	0	
	Arterial	25	59,214	4,748	1,109	
	Collector		--	--	--	
	Local	15	10,363	831	193	
	TOTAL		69,577	5,579	1,302	1
2	Freeway		0	0	0	
	Arterial	25	77,421	6,206	1,446	
	Collector		--	--	--	
	Local	15	8,881	711	169	
	TOTAL		86,302	6,917	1,615	1
3	Freeway		0	0	0	
	Arterial	25	40,139	3,217	747	
	Collector		--	--	--	
	Local	15	6,905	554	133	
	TOTAL		47,044	3,771	880	1
4	Freeway	60	14,581	1,169	277	
	Arterial	18-20	155,047	12,436	2,892	
	Collector		--	--	--	
	Local	15	3,398	277	60	
	TOTAL		173,026	13,882	3,229	1
5	Freeway		0	0	0	
	Arterial	25	63,925	5,133	1,193	
	Collector		--	--	--	
	Local	15	4,338	349	84	
	TOTAL		68,263	5,482	1,277	1
6	Freeway	60	27,968	2,241	518	
	Arterial	25-30	27,522	2,205	518	
	Collector		--	--	--	
	Local	15	7,146	578	133	
	TOTAL		62,636	5,024	1,169	1

Spokane - 1971 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway Arterial Collector Local		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicles Types
	TOTAL		506,848	40,655	9,472	556,975
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Spokane

Year 1977

Time Period Peak Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
1	Freeway		0	0	0	
	Arterial	20	5,546	445	104	
	Collector		--	--	--	
	Local	15	920	74	17	
	TOTAL		6,466	519	121	1
2	Freeway		0	0	0	
	Arterial	20	7,067	567	132	
	Collector		--	--	--	
	Local	15	782	63	15	
	TOTAL		7,849	630	147	1
3	Freeway		0	0	0	
	Arterial	20	3,746	301	70	
	Collector		--	--	--	
	Local	15	619	50	12	
	TOTAL		4,365	351	82	1
4	Freeway	50	2,309	185	43	
	Arterial	18-20	14,379	1,153	269	
	Collector		--	--	--	
	Local	15	308	25	6	
	TOTAL		16,996	1,363	318	1
5	Freeway		0	0	0	
	Arterial	20	4,301	345	80	
	Collector		--	--		
	Local	15	393	32	7	
	TOTAL		4,694	377	87	1
6	Freeway	50	2,898	233	54	
	Arterial	20-25	2,680	215	50	
	Collector		--	--	--	
	Local	15	647	52	12	
	TOTAL		6,225	500	116	1

Spokane - 1977 - Peak Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
	Freeway Arterial Collector Local		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	TOTAL		46,595	3,740	871	51,206
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Spokane

Year 1977

Time Period 12-Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
1	Freeway		0	0	0	
	Arterial	25	48,384	3,882	907	
	Collector		--	--	--	
	Local	15	8,026	646	148	
	TOTAL		56,410	4,528	1,055	1
2	Freeway		0	0	0	
	Arterial	25	61,654	4,947	1,152	
	Collector		--	--	--	
	Local	15	6,822	550	131	
	TOTAL		68,476	5,497	1,283	1
3	Freeway		0	0	0	
	Arterial	25	32,681	2,626	611	
	Collector		--	--	--	
	Local	15	5,400	436	105	
	TOTAL		38,081	3,062	716	1
4	Freeway	60	20,144	1,614	375	
	Arterial	18-20	125,445	10,059	2,347	
	Collector		--	--	--	
	Local	15	2,687	218	52	
	TOTAL		148,276	11,891	2,774	1
5	Freeway		0	0	0	
	Arterial	25	37,523	3,010	698	
	Collector		--	--	--	
	Local	15	3,429	279	61	
	TOTAL		40,952	3,289	759	1
6	Freeway	60	25,283	2,033	471	
	Arterial	25-30	23,381	1,876	436	
	Collector		--	--	--	
	Local	15	5,645	454	105	
	TOTAL		54,309	4,363	1,012	1

Spokane 1977 12-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
	Freeway		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	Arterial					
	Collector					
	Local					
	TOTAL		406,504	32,630	7,599	446,733
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					
	Freeway					
	Arterial					
	Collector					
	Local					
	TOTAL					

Vehicle Miles of Travel (VMT)

Metropolitan Area Spokane

Year 1977

Time Period 24-Hour

District	Facility Type	Avg Speed (mph)	VMT			Area (sq. mi.)
			LD	HD	Diesel	
1	Freeway		0	0	0	
	Arterial	25	66,829	5,362	1,253	
	Collector		--	--	--	
	Local	15	11,086	892	205	
	TOTAL		77,915	6,254	1,458	1
2	Freeway		0	0	0	
	Arterial	25	85,157	6,832	1,591	
	Collector		--	--	--	
	Local	15	9,423	759	181	
	TOTAL		94,580	7,591	1,772	1
3	Freeway		0	0	0	
	Arterial	25	45,139	3,627	844	
	Collector		--	--	--	
	Local	15	7,459	603	145	
	TOTAL		52,598	4,230	989	1
4	Freeway	60	27,823	2,229	518	
	Arterial	18-20	173,267	13,894	3,241	
	Collector		--	--	--	
	Local	15	3,711	301	72	
	TOTAL		204,801	16,424	3,831	1
5	Freeway		0	0	0	
	Arterial	25	51,827	4,157	964	
	Collector		--	--	--	
	Local	15	4,736	386	84	
	TOTAL		56,563	4,543	1,048	1
6	Freeway	60	34,921	2,808	651	
	Arterial	25-30	32,294	2,591	603	
	Collector		--	--	--	
	Local	15	7,796	627	144	
	TOTAL		75,011	6,026	1,398	1

Spokane - 1977 - 24-Hour

District	Facility Type	Avg Speed (mph)	VMT LD	VMT HD	VMT Diesel	Area (sq. mi.)
	Freeway Arterial Collector Local		TOTAL	TOTAL	TOTAL	VMT Total For All Vehicle Types
	TOTAL		561,468	45,068	10,496	617,032
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					
	Freeway Arterial Collector Local					
	TOTAL					

APPENDIX B

TABULATIONS OF VEHICULAR EMISSIONS

APPENDIX B

TABULATIONS OF VEHICULAR EMISSIONS

The computer printout contained in Appendix B provides a breakdown of emissions by vehicle type for the various zones as well as the total emissions for each zone which were presented in the body of the report. 1971 and 1977 CO emissions for the six zones are given on page B-2; corresponding hydrocarbon emission data are given on page B-3. CO emissions for Zone 4 (CBD) for years 1970, 1972, 1973, 1974, 1975, 1976, 1978, and 1979 are given on pages B-4 through B-6. 1977 CO emissions for Zone 4 under three strategy combinations are given on page B-7.

CITY OF SPOKANE CALENDAR YEAR IS 1971

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1959 TO 1972

LENGTH OF TIME PERIOD IS 8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.000	2443.63	2443.63	298.09	298.09	12.76	12.76	2754.47	2754.47
2	1.000	3091.64	3091.64	377.10	377.10	16.51	16.51	3485.25	3485.25
3	1.000	1715.99	1715.99	209.28	209.28	8.98	8.98	1934.25	1934.25
4	1.000	7040.79	7040.79	857.93	857.93	33.27	33.27	7931.98	7931.98
5	1.000	2406.81	2406.81	293.57	293.57	13.08	13.08	2713.46	2713.46
6	1.000	1663.85	1663.85	202.99	202.99	11.98	11.98	1878.82	1878.82

CITY OF SPOKANE CALENDAR YEAR IS 1977

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1965 TO 1978

LENGTH OF TIME PERIOD IS 8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.000	1333.51	1333.51	258.34	258.34	14.18	14.18	1606.04	1606.04
2	1.000	1664.98	1664.98	324.26	324.26	18.10	18.10	2007.35	2007.35
3	1.000	941.36	941.36	182.51	182.51	10.04	10.04	1133.90	1133.90
4	1.000	3956.72	3956.72	755.04	755.04	39.39	39.39	4751.15	4751.15
5	1.000	989.41	989.41	193.00	193.00	10.84	10.84	1193.25	1193.25
6	1.000	959.39	959.39	203.15	203.15	14.25	14.25	1176.79	1176.79

CITY OF SPOKANE CALENDAR YEAR IS 1971

REGION NO. 2 POLLUTANT SPECIES IS HYDROCARBONS

MODEL YEARS CONSIDERED IS FROM 1959 TO 1972

LENGTH OF TIME PERIOD IS 3 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.000	133.99	133.99	20.92	20.92	0.72	0.72	155.62	155.62
2	1.000	158.88	158.88	24.97	24.97	0.80	0.80	184.66	184.66
3	1.000	87.72	87.72	13.81	13.81	0.44	0.44	101.96	101.96
4	1.000	307.97	307.97	48.32	48.32	1.57	1.57	357.87	357.87
5	1.000	115.63	115.63	18.01	18.01	0.63	0.63	134.27	134.27
6	1.000	92.47	92.47	14.12	14.12	0.58	0.58	107.17	107.17

CITY OF SPOKANE CALENDAR YEAR IS 1977

REGION NO. 2 POLLUTANT SPECIES IS HYDROCARBONS

MODEL YEARS CONSIDERED IS FROM 1965 TO 1978

LENGTH OF TIME PERIOD IS 3 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.000	60.35	60.35	16.14	16.14	0.80	0.80	77.30	77.30
2	1.000	70.86	70.86	18.81	18.81	0.88	0.88	90.54	90.54
3	1.000	39.87	39.87	10.56	10.56	0.47	0.47	50.90	50.90
4	1.000	146.43	146.43	39.03	39.03	1.88	1.88	187.34	187.34
5	1.000	39.10	39.10	10.48	10.48	0.52	0.52	50.10	50.10
6	1.000	43.69	43.69	11.99	11.99	0.69	0.69	56.37	56.37

CITY OF SPOKANE CALENDAR YEAR IS 1970

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1958 TO 1971

LENGTH OF TIME PERIOD IS 8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	7222.29	7222.29	861.39	861.39	32.25	32.25	8115.92	8115.92

CITY OF SPOKANE CALENDAR YEAR IS 1972

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1960 TO 1973

LENGTH OF TIME PERIOD IS 8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	6721.48	6721.48	864.05	864.05	34.29	34.29	7619.82	7619.82

CITY OF SPOKANE CALENDAR YEAR IS 1973

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1961 TO 1974

LENGTH OF TIME PERIOD IS 8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	6299.39	6299.39	872.96	872.96	35.29	35.29	7207.63	7207.63

CITY OF SPOKANE   CALENDAR YEAR IS 1974

REGION NO. 2   POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1962 TO 1975

LENGTH OF TIME PERIOD IS   8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	5810.62	5810.62	855.62	855.62	36.33	36.33	6702.57	6702.57

CITY OF SPOKANE   CALENDAR YEAR IS 1975

REGION NO. 2   POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1963 TO 1976

LENGTH OF TIME PERIOD IS   8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)		EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	5288.94	5288.94	811.53	811.53	37.33	37.33	6137.79	6137.79

CITY OF SPOKANE   CALENDAR YEAR IS 1976

REGION NO. 2   POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1964 TO 1977

LENGTH OF TIME PERIOD IS   8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	4576.04	4576.04	783.12	783.12	38.37	38.37	5397.53	5397.53

CITY OF SPOKANE CALENDAR YEAR IS 1978

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1966 TO 1979

LENGTH OF TIME PERIOD IS 8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	3297.04	3297.04	728.91	728.91	40.09	40.09	4066.04	4066.04

CITY OF SPOKANE CALENDAR YEAR IS 1979

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1967 TO 1980

LENGTH OF TIME PERIOD IS 8 HOURS

VEHICLE CATEGORY -		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
ZONE NO.	AREA (SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
	1.000	2738.57	2738.57	703.05	703.05	40.84	40.84	3482.46	3482.46

CITY OF SPOKANE CALENDAR YEAR IS 1977

REGION NO. 2 POLLUTANT SPECIES IS CARBON MONOXIDE

MODEL YEARS CONSIDERED IS FROM 1965 TO 1978

LENGTH OF TIME PERIOD IS 8 HOURS ZONE 4

VEHICLE CATEGORY		LIGHT DUTY		HEAVY DUTY		OTHER		TOTAL	
STRATEGY	AREA SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)	EMISSIONS (KGM)	EMISSION DENSITY (KGM/SQ.MI)
1	1.000	3698.31	3698.31	716.73	716.73	39.39	39.39	4454.43	4454.43
1 + 2	1.000	3613.27	3613.27	700.21	700.21	38.47	38.47	4351.95	4351.95
1 + 2 + 3	1.000	3612.83	3612.83	700.14	700.14	38.47	38.47	4351.44	4351.44

BIBLIOGRAPHIC DATA SHEET	1. Report No. APTD-1448	2.	3. Recipient's Accession No.

4. Title and Subtitle Transportation Controls to Reduce Motor Vehicle Emissions in Spokane, Washington	5. Report Date December 1972
	6.
7. Author(s)	8. Performing Organization Rept. No.
9. Performing Organization Name and Address GCA Corporation GCA Technology Division Bedford, Massachusetts	10. Project/Task/Work Unit No. DU-72-B895
	11. Contract/Grant No. 68-02-0041
12. Sponsoring Organization Name and Address Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, N.C. 27711	13. Type of Report & Period Covered Final Report 8/14/72 to 12/15/72
	14.

15. Supplementary Notes Prepared to assist in the development of transportation control plans by those State Governments demonstrating that National Ambient Air Quality Standards cannot be attained by implementing emission standards for stationary sources only.

16. Abstracts

The document demonstrates the nature of the Air Quality problem attributed to motor vehicle operation, the magnitude of the problem and a strategy developed to neutralize these effects in order that National Ambient air quality standard may be attained and maintained.

17. Key Words and Document Analysis. 17a. Descriptors

Motor Vehicle emitted pollutants - air pollutants originating within a motor vehicle and released to the atmosphere.

National Ambient Air Quality Standards — Air Quality Standards promulgated by the Environmental Protection Agency and published as a Federal Regulation in the Federal Register.

17b. Identifiers/Open-Ended Terms

VMT - Vehicle Miles Traveled
Vehicle Mix - distribution of motor vehicle population by age group.
LDV light duty vehicle - less than 6500 lbs.
HDV - heavy duty vehicle greater than 6500 lbs.

17c. COSATI Field/Group Environmental Quality Control of Motor Vehicle Pollutants

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
For release to public	UNCLASSIFIED	all
	20. Security Class (This Page) UNCLASSIFIED	22. Price

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