Final Report

MODEL INPUTS AND AREA SOURCE EMISSION ESTIMATES FOR PHOENIX AND TUCSON

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Pacific Environmental Services, INC.

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MODEL INPUTS AND AREA SOURCE EMISSION ESTIMATES FOR PHOENIX AND TUCSON

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ABSTRACT

Transportation data were collected from various Federal, state and local transportation areas relating to the metropolitan areas of Phoenix and Tucson, Arizona. These data were utilized to project motor vehicle traffic levels for future time periods, and for generating inputs for the APRAC-1A model and the Climatological Dispersion Model (CDM).

The projections were performed by analyzing over 3,000 primary traffic links containing vehicle miles traveled (VMT) for numerous roadways and by developing traffic modification factors for each year between the base period (1970) and fiscal year 1975. This task was further complicated by the necessity to account for the effects of the energy crisis.

The technique utilized included forming an automated data base of the 3,000 traffic links and coding computer programs to heuristically test sample growth factors by comparing projected traffic counts with recent actual data.

APRAC-1A inputs were also prepared with the aid of computer programs. Input data consisting principally of primary traffic link data were converted directly into the required APRAC-1A format. In addition, another routine was developed to automatically allocate secondary traffic to the study area in the proper format. Among the factors considered as other model inputs were the following:

- Vehicle age distribution
- Diurnal traffic distribution
- Monthly traffic distribution
- Gasoline consumption
- Vehicle speeds

The CDM inputs were produced with the aid of data processing techniques. Programs were coded to accumulate transportation, other area source and point source data by grid zone and output this information in CDM format. This technique proved to be efficient and cost-effective.

The final task in this project required the preparation of an area source emission inventory for carbon monoxide and hydrocarbons in each region.

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CHAPTER 1
INTRODUCTION

Air quality models are computational programs by which expected concentrations of contaminants in the atmosphere can be calculated. In order to utilize these models for any selected region, sufficient information regarding pollution emissions and weather conditions must be available. Often the appropriate classes of information are sufficient to operate models effectively, rather than exact pollutant and meteorological readings. Naturally, the better the quality of available data for input, the more useful generated results are likely to be. The reliable data processing adage of "garbage in, garbage out," is certainly relevant to modeling applications.

I. SCOPE OF THE PROJECT

The prinicpal objective of this project was to develop area source emission estimates for Metropolitan Phoenix and Tucson, Arizona, with regard to carbon monoxide and hydrocarbons. The emission estimates were derived from both stationary and mobile source information, with the latter being based primarily upon motor vehicle traffic data.

The emission estimates were needed for two principal reasons; firstly, to obtain an area source emissions inventory in the National Emissions Data Systems (NEDS) format, and secondly, to provide inputs for two air quality simulation models in order to predict future levels of carbon monoxide and hydrocarbons. The models utilized were the APRAC-1A Urban Diffusion Model and the Climatological Dispersion Model (CDM).

The emission inventory was conducted in accordance with the basic procedures outlined in EPA publication APTD-1135, Guide for Compiling a Comprehensive Emission Inventory. Emission factors were obtained from AP-42, Compilation of Air Pollutant Emission Factors.

Fiscal year 1975 emission estimates were developed for one square mile grid zones covering both metropolitan regions. This information was generated from transportation data collected from State and local agencies.

All model inputs were coded in the appropriate format, keypunched, manipulated as necessary to create monthly data sets, and stored on a magnetic computer tape. This tape was delivered to the project officer in lieu of computer cards because of the volume of data involved.

II. TECHNICAL APPROACH

In carrying out the scope of work for this project, PES selected an approach that was cost-effective, flexible and produced a reusable by-product. The approach centered on employing data processing techniques to the greatest extent possible, given that large amounts of data were involved, and that PES was supplied with a magnetic tape containing primary traffic link data by the Maricopa Association of Governments Transportation Planning Program (MAGTPP).

This approach using data processing techniques was cost-effective and flexible in that it generated feedback quickly and encouraged changes to be made to traffic growth factors. The reusable by-product is the system of computer programs that was utilized to develop traffic levels for a future time period and produce model inputs in the desirable formats. These routines can be employed at any time in the future to generate model inputs from a completely new set of traffic data. These results could be accomplished at a fraction of the cost that would normally be expected without using the existing routines.

The use of these computer programs is not limited to the Phoenix and Tuscon areas. These routines can be employed to convert data from virtually any region into APRAC-1A and CDM inputs, provided that the raw data is converted into a compatible format or new data input programs are coded.

CHAPTER 2

SOURCES OF DATA

Data necessary for successful execution of this project was principally obtained from State and County agencies in Arizona, EPA, the Federal Aviation Agency (FAA) and a private firm, R.L. Polk and Co. Listed below are the sources and type of all information utilized in this project.

Data Source	Data Description
Maricopa Association of Governments, Transportation and Planning Office	1) Computer tape of traffic link for a 1970 based network. 2) Monthly factors for traffic distribution. 3) Daily factors for traffic distribution. 4) Traffic volume map for 1972. 5) Records of continuous traffic stations in the Phoenix area. 6) Estimates of total daily area traffic for 1972 and 1973.
City of Phoenix, Traffic Planning Department	1) Traffic volume map for 1972. 2) Other traffic distribution data.
State of Arizona, Highway Department	Traffic count data for State and Federal assisted roads.
City of Phoenix, Planning Department	Planning and population data for Phoenix
Pima Association of Governments Transportation Planning Program	1) Traffic volume map for 1972. 2) Traffic distribution data 3) Population and other planning information.

Data Source	Data Description
City of Tuscon, Department of Transportation	1) Traffic volume map for 1972-73.
	2) Traffic count data.
Federal Aviation Agency	Aircraft landing and take-off data.
Environmental Protection Agency	Point Source Data for plants in the Metropolitan Phoenix and Tuscon areas.
R.L. Polk and Co.	Yearly vehicle registration data.
State of Arizona, Division of Motor Vehicles	Gasoline consumption data for 1972 and 1973.
Pima County Air Pollution Control District	Aircraft landing and take-off data.

CHAPTER 3
DATA PREPARATION

In order to produce a complete set of model inputs for the APRAC-1A and CDM models, it was necessary to reformat and update much of the information gathered in the data collection phase of the project.

Prior to the use of computer programs for generation of model inputs, certain information had to be determined. For example, traffic data had to be analyzed to compute growth factors to be used in updating traffic counts to FY '75. Since a slightly different technique was used to analyze the Phoenix traffic data from that used for Tucson, the analyses will be treated separately in this report.

I. PHOENIX DATA ANALYSIS

The computer tape received from MAGTPP contained a set of approximately 2400 traffic link records. The contents of a typical record are shown in Figure 3.1. After considering the alternatives, it was concluded that it would be cost-effective to code the data sets for the models based on the coordinate system which was developed and utilized by MAGTPP rather than develop a new coordinate system. This choice facilitated the use of the magnetic tape data and eliminated the need for preparing coordinate conversion algorithms. Figure 3.2 illustrates the location of the coordinate system in the Maricopa County area.

When the traffic data tape was transmitted to PES, it was noted that the data on the tape represented CY 1970 information. In order to project this data to FY '75, a yearly growth factor had to be developed to simulate traffic increases over this period.

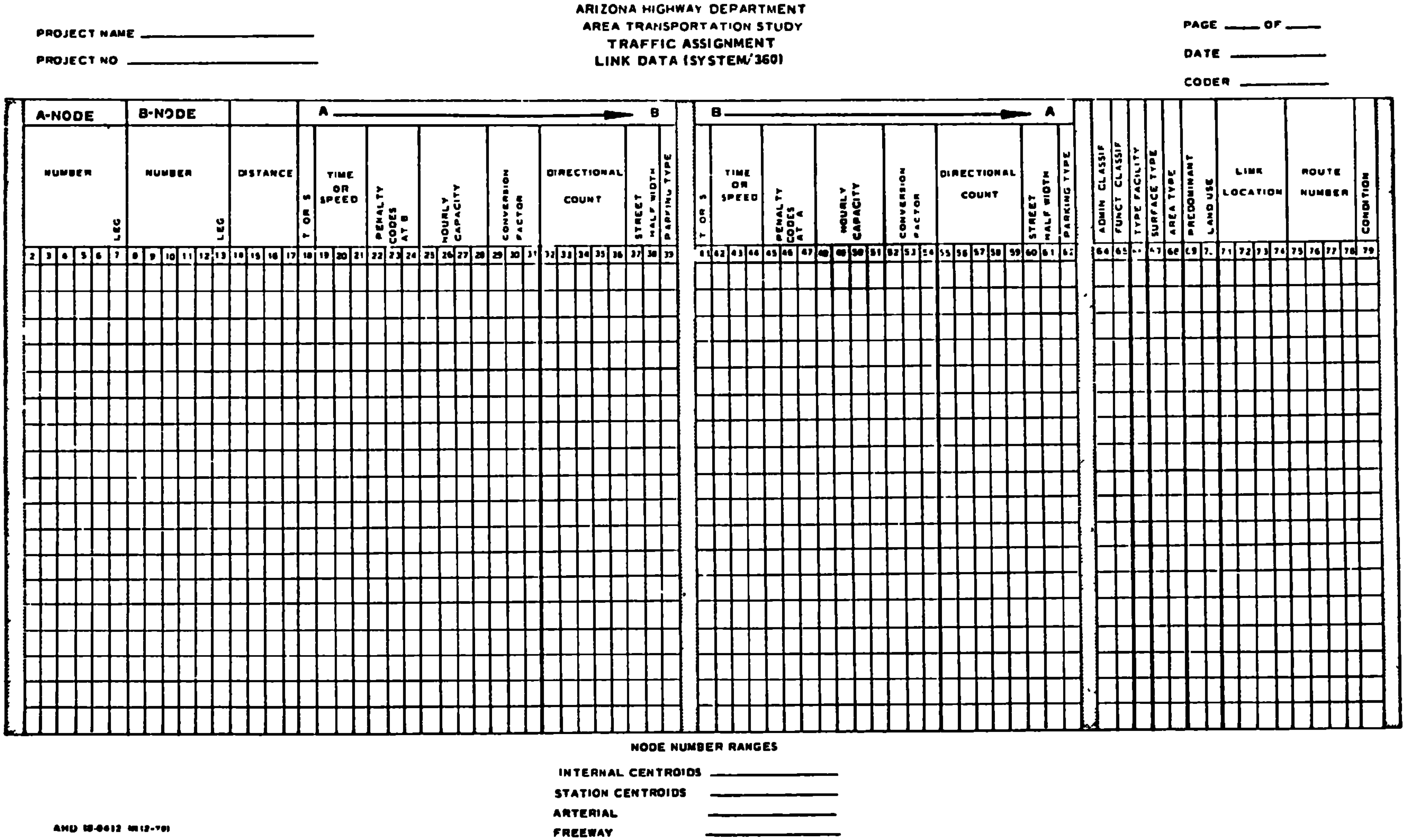

Figure 3.1: SAMPLE CODING SHEET FOR MAGTPP TRAFFIC DATA

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AVAILABLE

DIGITALLY

A. Growth Factor Development

The goal of this task was to develop one or more factors that would accurately reflect traffic growth during the four and one-half year period from calendar year 1970 to fiscal year 1975. It was desired to represent the traffic increase during this period by a simple factor as opposed to a compound factor. The former refers to a percentage increase value that could be applied to the 1970 data. The latter can be applied to data for consecutive years. The distinction is similar to the one drawn between simple and compound interest.

PES assumed that a normal growth pattern existed for the period 1970-1973 and that a sharp reduction in the increase in traffic occurred during the next year and one-half due to the energy crisis. By analyzing the traffic data on hand and comparing year to year levels in the normal period, it appeared quite reasonable to assume a growth rate of between 8% and 10% per year. Although only minimal information was available for the post energy crisis period, this growth rate was hypothesized at one-quarter to one-half the normal rate.

The procedure used to determine the simple factor for the entire period began with calculating compound factors, multiplying them, and converting the result to a simple factor. The compound factors were calculated with the aid of the compound interest formula $A = P\ (1 + i)^n$, where

A = amount or fiscal 1975 traffic
P = principal or 1970 data
i = interest rate or growth factor
n = number of years (4.5)

The formula was actually applied in stages. For the 1970-1973 period, i was given the value 9%. Applying the compound interest formula to this case yields $(1.09)^3$ or 1.295, which shows a total growth on a simple basis of 29.5%.

For second period of 1.5 years, a growth rate of 3% per year was selected. Once again, applying the formula yields $(1.03)^{1.5}$ or 1.045, which yields a total growth on a simple basis of 4.5%. Multiplying these two values together gives a 35.3% traffic increase for the four and one-half year period. This value converts to approximately 8% per year on a simple basis and 7% per year on a compound basis.

To test and justify this simple growth factor of 8% per year a set of traffic counts for calendar year 1972 was generated by multiplying the 1970 values by 16%. The projected 1972 data was then compared to reported 1972 traffic values shown in Figure 3.2. It was anticipated that on an overall basis the projected results would be slightly low to account for the higher growth rate in this period.

From a detailed inspection of the projected vs. actual data it was noticed that traffic growth in the downtown Phoenix area was progressing at a slower rate than that exhibited in the surrounding areas. Accordingly, it was decided to develop separate growth rates for the downtown and circumjacent areas in order to more accurately reflect the actual situation. Graphs such as the one shown in Figure 3.3 were used to study differences between projected and reported traffic counts on individual links. Inspections of sets of these graphs resulted in the project staff fixing a boundary around the "slow growth" downtown region. This boundary is illustrated in Figure 3.4.

Given this concept of two distinct traffic regions, traffic growth factors had to be determined for each of these two areas. Again employing the 1970 data as a basis, detailed analysis was conducted for the two distinct areas producing simple factors of 3.6% and 9% per year for the downtown and suburban areas, respectively. The combination of these two

NOTE: A + VALUE INDICATES PROJECTED TRAFFIC GREATER THAN 1972 REPORTED

A - VALUE INDICATES PROJECTED TRAFFIC LESS THAN 1972 REPORTED

Y-COORDS \ X-COORDS	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
35	+60	+908	-504	-1232	-420	-1028		+1144	+964	-1480									
34		-692	-2528	-5212	-5544	-2932	-728	-2108	-3408										
33		+5240	-2892	-5072	-3128	-2940	+3440	-3548	-2280	-3072	-5152								
32		+632	-1588	-1860	-5692	-4052	+2328	+6960	+3940	-804	+1800								
31		-6860	-3272	+780	-3340	-11324	+1900	+6656	+3148	+3236	+3192	+3700	+7788						
30		+3340	-6820	-2972	+4944	+3988	+9440	+3916		+7296	+7440	+4772	+6016	+5748					
29																			
28		-636	-1064	-2388	-3004	+3968	+6148	+3592	+3484	+5064	+4592	-72	+5204				+4768	+5500	-1752
27		-2652	-1692	+1568	-4588	-484	+2676	+2600	+2728	+6904		+4956	+1700	-1432	+1404				
26		+1064	+1648	+1572	+580	-2348	+3404	+8444	+2484	-876	+3404								
25		-40	-260	-1224	-1192	+44								+1088		-3020			

Figure 3.3: GRAPH USED IN DEVELOPMENT OF SLOW DOWNTOWN GROWTH REGION

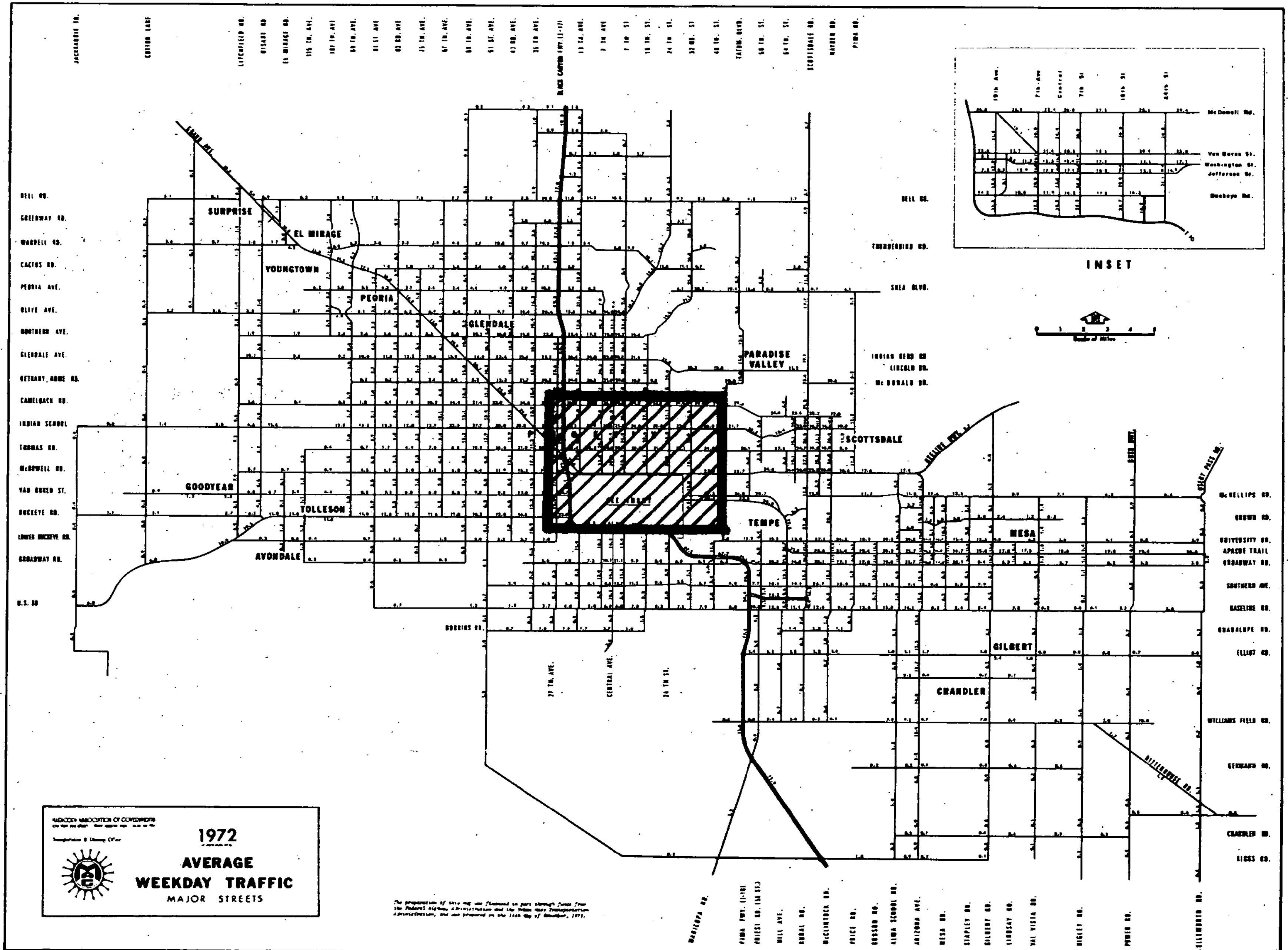


Figure 3.4: BOUNDARIES OF SLOW DOWNTOWN GROWTH AREA

values still resulted in the 8% per year figure for the entire region.

B. APRAC-1A Data Set

Once the growth rates had been determined, it was possible to employ data processing techniques to produce APRAC-1A primary traffic inputs for FY '75 from the available data. A computer program entitled PHX75 was coded to accomplish this task. Documentation for this program can be found in Appendix A. Basically, this program accepts a set of traffic link records as input and produces an APRAC-1A primary link record set in Card N format as output. Necessary information which must be provided on the input records includes:

1) Node number or (x,y) coordinates of starting point
2) Node number or (x,y) coordinates of end point
3) Distance between nodes or end points of links
4) Vehicle count for some known time period
5) Average speed or road type

In this particular application of the program, records from the 1970 data base were examined and processed individually. First, the node numbers of the end points of each link were located in a computer file and the (x,y) coordinates of the end points were extracted from this file. Since these coordinates were listed in miles, they were multiplied by a factor of 100 to change their units to hundredths of miles as required by APRAC-1A. Based on these coordinates, it was determined whether the link lay in the "slow-growth" downtown area, or in the suburban area of the region. The two fields containing one-way directional count figures were added together and multiplied by a growth factor according to the area in which the link resided.

Next, the field containing the speed category code was examined. The program assigned an APRAC-1A traffic code number according to the scheme shown in Table 3.1.

Table 3.1: SPEED CATEGORY CODES UNSED IN PHOENIX STUDY AREA

Phoenix Speed Category Code	Type of Road	Average Speed on Link (mi/hr.)	APRAC-1A Traffic Code Number
A	Freeway	45	1
B	Urban Expressway	37	2
C	Urban Major Street	27	3
D	Urban Minor Street	22	4
E	Grand Avenue	22	5
F	Rural Major Street	27	3
G	Urban Connector	20	6
H	Rural Connector	20	6
J	CBD* Major Street	22	7
K	Rural Minor Street	27	8

*Central Business District

Finally, the length of the link was extracted from the "distance" field. This figure also had to be multiplied by 100 to give units of hundredths of miles as required by APRAC-1A format. Using this newly generated information, a series of properly formatted APRAC-1A primary links was created and output.

The only problem left to be resolved was that approximately 2400 links were generated from the 1970 data, and only 1200 could be utilized for the APRAC-1A input data set. It was determined that a central area of the study region would be defined, as illustrated in Figure 3.5, which contained about 1200 links. Other links outside of this central area would be allocated to secondary traffic grids. The main advantage of this plan was that traffic emissions could be concentrated in a central area, rather than scattered throughout the area.

A number of alternatives were considered for the generation of secondary traffic data. Since in normal usage of the APRAC-1A program, secondary traffic accounts for only 5-10% of the total traffic occurring in a region, the method of allocation need not be extremely precise. Methods of allocation based on population, estimated gasoline consumption, or eyeballing of street density from local maps may be used. In the Phoenix/Tucson study regions, however, it was found that secondary traffic occurred in higher percentages. One reason for this situation was the 1200 extra primary links which were added to the secondary traffic grids. Consequently, a more precise allocation method was desired.

The method employed was based on the assumption that dense secondary traffic occurs in given areas in the same percentages that dense primary traffic occurs. Secondary traffic densities were computed by a program entitled GRID.

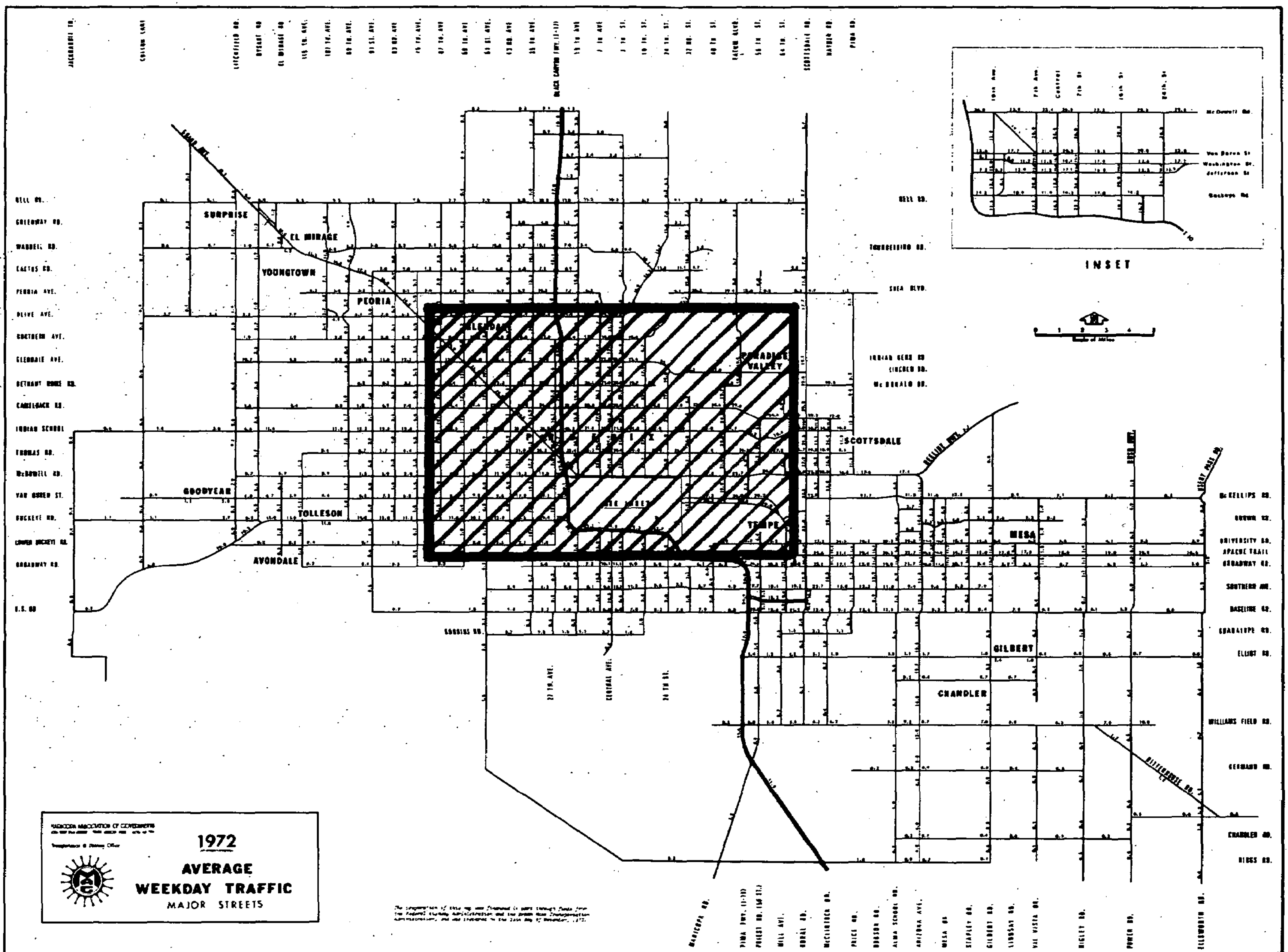


Figure 3.5: BOUNDARIES OF 1200 PRIMARY LINK AREA

1. <u>General Description of Program GRID</u>

This program takes the primary link data prepared in APRAC-1A format, and allocates the daily vehicle miles travelled (VMT) on these links to a grid system overlaying the region of interest. The method used by the program to allocate link traffic begins by determining the end point of each primary traffic link that has a location furthest to the west. This point is designated as occupying position "A". This process reduces the number of possible link orientations which must be considered by the program. Next, the grid zone in which this "A" end point lies is determined and the coordinates of the center point of this grid are retained. The mathematical slope of the link is then calculated and examined. If the link is vertically oriented (i.e., has a north-south direction), its slope is infinite, and program control is passed to a separate routine for processing.

Basically, the processing of all links consists of moving along the link path until a grid line is encountered. At this point, the link is divided into two segments - one inside the original grid and the remainder of the link outside. VMT are then allocated to the first grid area by multiplying the vehicle count for the link by the length of the segment inside the grid. A new "A" end point is then taken to be the intersection of the link with the grid line, and once again, the link path is traced from the new "A" end point until a grid line is intersected, or the other end point of the link is reached. This process continues, with new "A" end points being created as necessary, until the entire length of the link has been apportioned.

In addition, the program has the capability of determining if a link coincides with a grid line, and allocating half of the VMT to each grid immediately on either side of the link.

When all the links in the APRAC-1A primary traffic data set have been allocated in the described manner, the total primary traffic is calculated by accumulating the VMT by grid zone. The percentage of secondary traffic occurring in each grid is then computed by dividing the individual zone VMT value by the total traffic link VMT for the region. In order to represent that some amount of secondary traffic occurs throughout the area, a minimum value of total secondary traffic volume is allocated to each grid. The percentages are integerized and multiplied by a factor of 100 to ensure that the lowest percentage shown is greater than zero. The output of this part of the program consists of the (x,y) coordinates of the center point of each grid zone and the associated percentage of the total secondary traffic. For further documentation of GRID, see Appendix A.

2. <u>Completion of APRAC-1A Input Cards C Through M</u>

To complete the APRAC-1A data set, the basic input information to be shown on cards C-M had to be determined. Each of these input cards is discussed individually below.

a. <u>Card C</u>

SLAT - City latitude = 33.0 degrees North Latitude from Arizona map

POP - City population = 1.174 million

1970 Census figure for Phoenix Urban Area = 863,357

Growth figure to July, 1974 = 1 + (.08 x 4.5) = x 1.36

1975 projected figure = 1,174,000

(XXT,YYT) = City Center location = (33.80, 30.20)

(See Figure 3.6)

DATA

CITY OF PHOENIX, ARIZONA, PLANNING DEPARTMENT – 251 WEST WASHINGTON

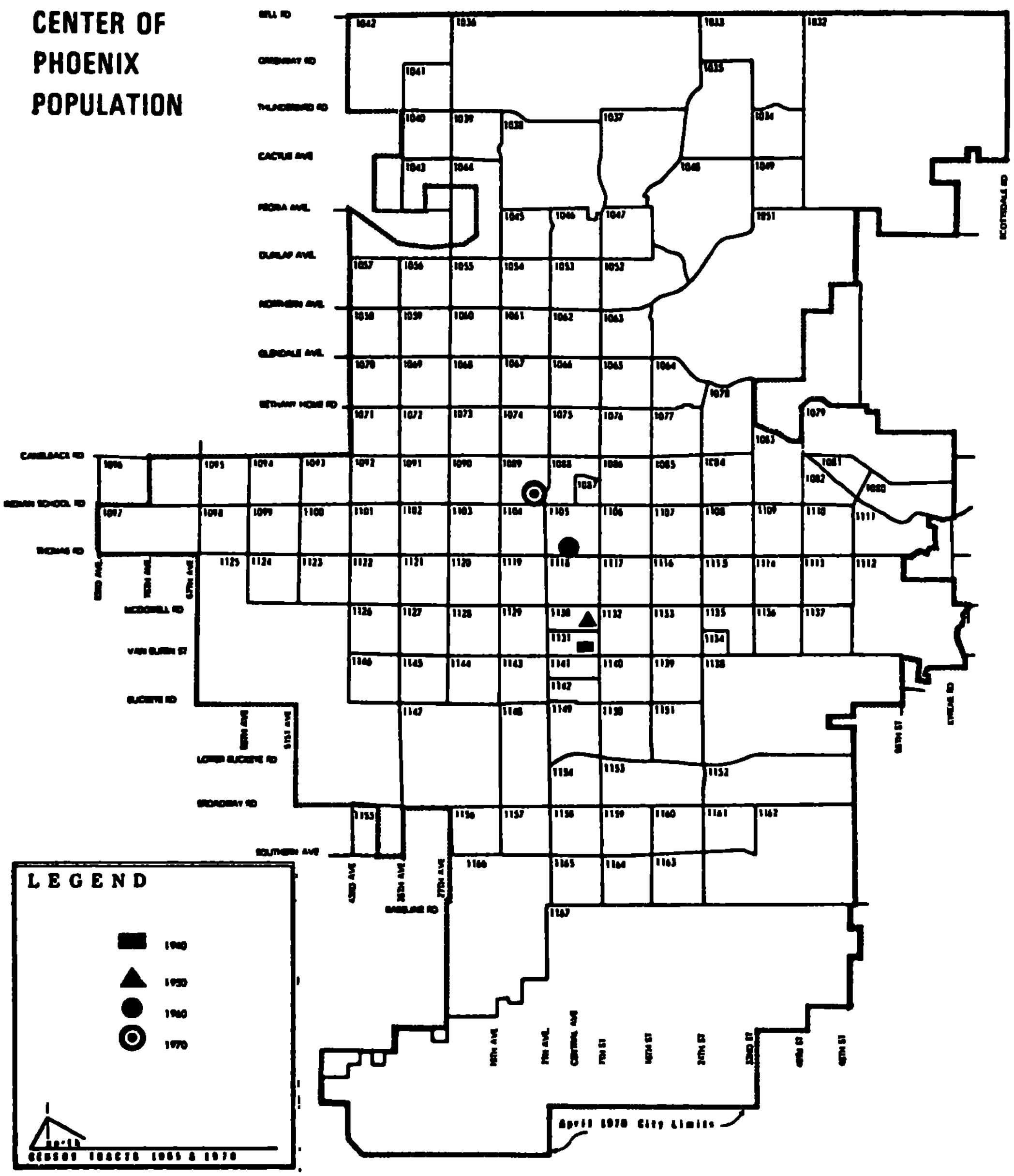


Figure 3.6: LOCATION OF PHOENIX CITY CENTER

CLE = City's total amount of secondary traffic equal to CLE percent of primary = 89.06

total secondary VMT = 8,018,304

total primary VMT = 9,004,488

$$CLE = \frac{8,018,304}{9,004,488} \times 100 = 89.06$$

PF1 = value for α = 667.0 (See Figures 3.7 and 3.8)

PF2 = value for β = -0.85

b. Calculation of α and β

The APRAC-1A program calculates carbon monoxide emissions from mobile traffic sources using the formula,

$$E = \alpha S^{\beta} \tag{1}$$

where S is the average speed on the roadway in miles per hour, E is the emission factor in grams of CO per mile, and α and β are constants determined from the vehicle mix of the study area. In order to calculate a value for β, a correction factor, ν is defined, such that

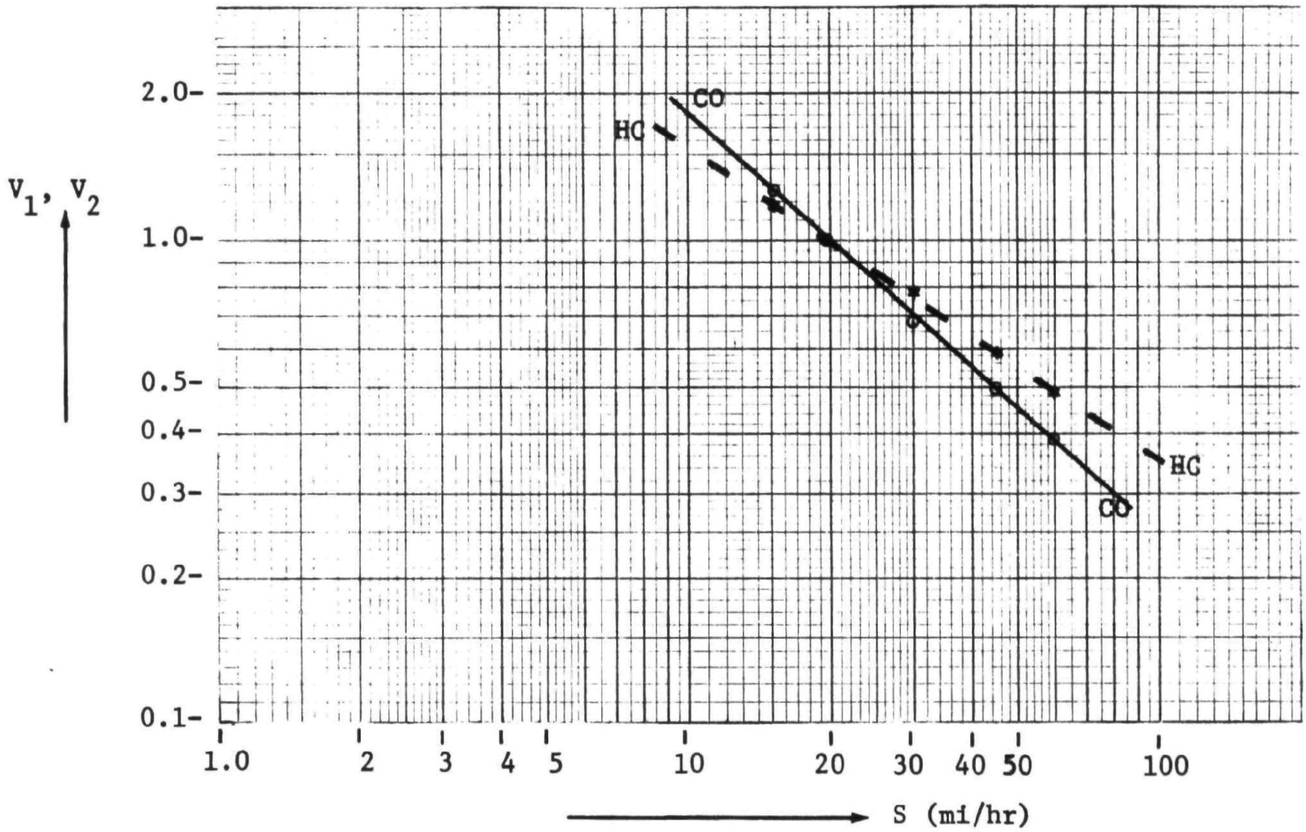
$$\nu = S^{\beta} \tag{2}$$

Values for ν are plotted in EPA documents AP-42, "Compilation of Air Pollutant Emission Factors." This plot is shown in Figure 3.9. From the note in Figure 3.9, it is assumed that these values for ν are valid for a current vehicle mix. Equation (2) can be manipulated to the form

$$\ln \nu = \beta(\ln S) \tag{2a}$$

A plot of ln ν versus ln S yields a straight line of the form

$$y = mx + b \tag{2b}$$



	Correction Factors CO	HC			
S (mi/hr)	V_1	V_2	ln S	ln V_1	ln V_2
59.9	0.39	0.48	4.09268	-0.94161	-0.73397
45.1	0.50	0.59	3.80888	-0.69315	-0.52763
30.0	0.68	0.78	3.40120	-0.38566	-0.24846
19.6	1.00	1.00	2.97553	0.0	0.0
15.1	1.26	1.19	2.71469	0.2311	0.17395

Calculation of α and β for CO

$$M_1 = \frac{-.94161 - .23111}{4.09268-2.71469} = -0.85 = \beta$$

$$\alpha \times (19.6)^{-0.85} = E$$

$$-0.85 \ (\ln 19.6) = \ln (E/\alpha)$$

$$0.080 = E/\alpha$$

$$\alpha = \frac{E}{0.080}$$

Calculation of γ and Δ for HC

$$M_2 = \frac{-.73397 - .17395}{4.09268-2.71469} = -0.66 = \Delta$$

$$\gamma \times (19.6)^{-0.66} = E$$

$$-0.66 \ (\ln 19.6) = \ln (E/\gamma)$$

$$0.141 = E/$$

$$\gamma = \frac{E}{0.141}$$

Figure 3.7: DETERMINATION OF α AND β FOR CO AND γ AND Δ FOR HYDROCARBONS

Light-Duty Vehicles	Cars	Trucks	Total	%	EF	Emission
pre 1968	238,680	64,367	303,047	35.62693	87	30.995429
1968	44,662	7,650	52,312	6.14992	46	2.8289632
1969	51,023	10,243	61,266	7.20257	39	2.8090023
1970	48,041	10,589	58,630	6.89268	36	2.4813648
1971	46,368	10,455	56,823	6.68024	34	2.2712816
1972	56,277	15,634	71,911	8.45403	19	1.6062657
1973-74	102,943	26,730	129,673	15.24467	19	2.8964873
1975	50,338	12,056	62,394	7.33518	12.5	.9168975

Heavy Duty Gas	Vehicles	% of Total	EF	Emission
pre 1970	19,830	2.33126	140	3.263764
1970-75	19,368	2.27694	130	2.960022

Heavy Duty Diesel	Vehicles	% of Total	EF	Emission
All	15,358	1.80552	20.4	.370366

Total Emission = 53.39984

From Figure 3.7,

$$\alpha = \frac{E}{0.08} = \frac{53.39984}{0.08}$$

$$\alpha = 667$$

Figure 3.8: CALCULATION OF α FOR PHOENIX STUDY AREA

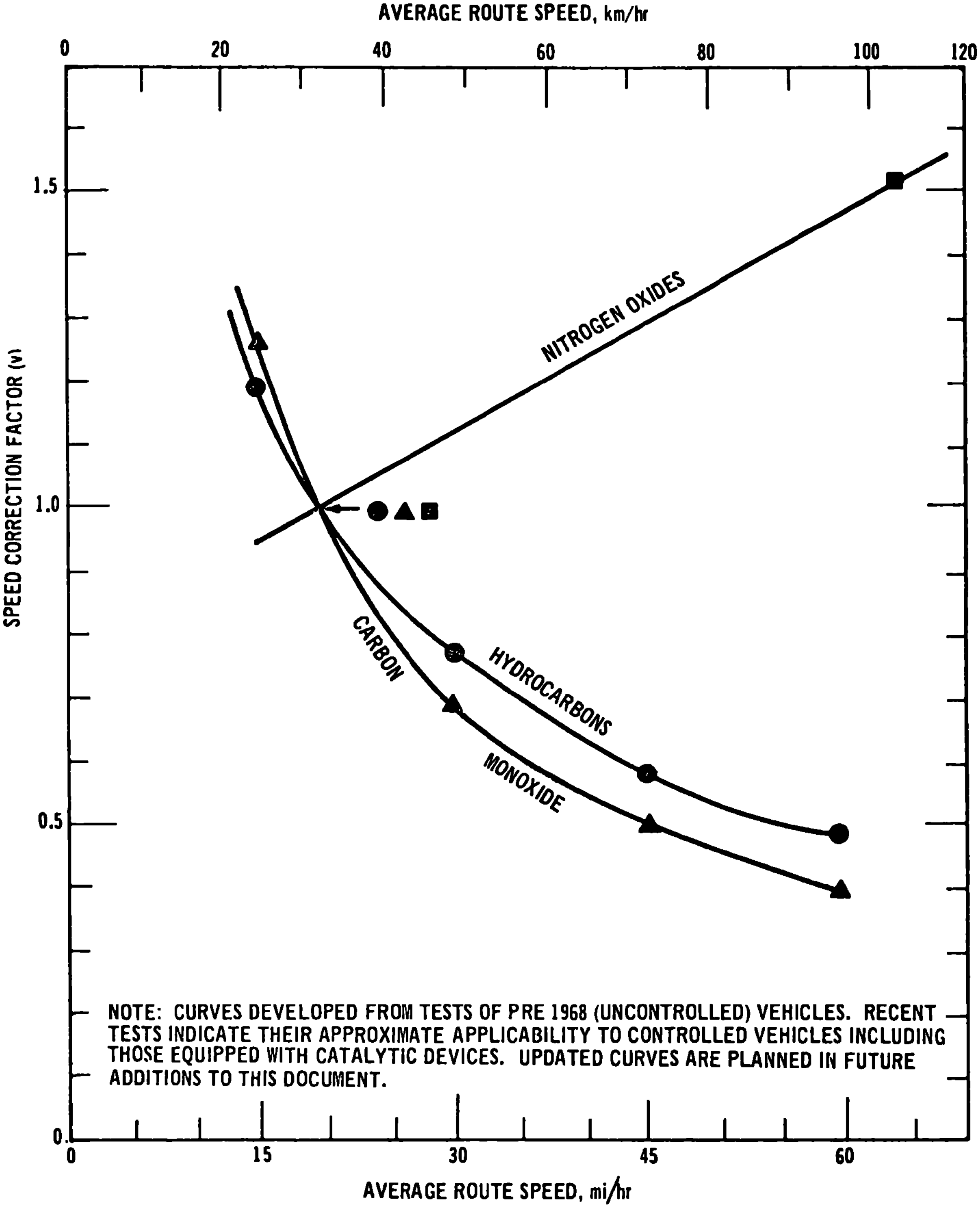


Figure 3.9: SPEED CORRECTION FACTORS FROM AP-42

where $y = \ln \nu$

$x = \ln S$

$b = o$

$m = \beta$

The slope of this line as plotted in Figure 3.7 can be taken as the value of β.

Equation (1) can now be rewritten in the form

$$E = \alpha \nu \qquad (3)$$

It is now desirable to determine a value for α such that the value for E obtained from equation (3) is reflective of the vehicle mix of the study area.

Vehicle registration counts by year for passenger cars and trucks were obtained for Maricopa County from the Motor Statistical Division of R.L. Polk & Co. These counts contained registration statistics up to July 1, 1973, so that the first problem encountered was to project these figures to reflect an FY '75 vehicle mix. This projection was based upon two assumptions:

1) The number of vehicles added to the mix by the latest model year is equal to about 10% of the total number of vehicles in the mix for the previous year.

2) Each model year except the current year loses about 1% of its previous year's figure.

For example:

73	5,000	74	1,940
72	4,900	73	4,950
71	4,800	72	4,851
70	4,700	71	4,752
		70	4,653
	19,400		21,146
	Given '73 vehicle mix		Projected '74 vehicle mix

When these assumptions were used on the available data in Phoenix and Tucson, an approximate growth of about 9% per year was observed in the total number of vehicles in the mix. One other assumption was made when dealing with truck registration statistics. It was assumed that the truck population could be divided into three categories as follows:

Light-duty gas powered (pickup trucks)	74%
Heavy-duty gas powered	19%
Heavy-duty diesel powered	7%

These figures are based on nationwide statistics found in 1973 American Trucking Trends. Employing these three assumptions, PES was able to project a complete vehicle mix for FY '75. Then utilizing emission factors found in the EPA emission factors document AP-42, (See Table 3.2), an average emission factor, E, was calculated for the particular mix. Substituting this value in equation (3) yields a value for α. This process is illustrated in Figure 3.8.

c. Card D

The question of the determination of gasoline consumption rates by sectors was discussed in a telephone conversation with Dr. F.L. Ludwig of the Stanford Research Institute. Dr. Ludwig indicated that this sector data was necessary to calculate the extra-urban contribution to the CO concentrations in the study region. However, he related that this contribution is on the order of a tenth of a part per million, and that this does not justify the effort required to obtain the necessary gasoline consumption data. Therefore, he recommended that values of 0.0 be assigned to these variables.

Table 3.2: **AVERAGE EMISSION FACTORS FOR HIGHWAY VEHICLES BASED ON NATIONWIDE STATISTICS**[a]

Year	Carbon monoxide		Hydrocarbons				Nitrogen oxides (NO_x as NO_2)		Particulates				Sulfur oxides (SO_2)	
			Exhaust		Crankcase and evaporation				Exhaust		Tire wear			
	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km	g/mi	g/km
1965	89	55	9.2	5 7	5.8	3.6	4.8	3.0	0.38	0.24	0.20	0.12	0 20	0.12
1970	78	48	7.8	4.8	3.9	2.4	5.3	3 3	0.38	0.24	0 20	0.12	0.20	0.12
1971	74	46	7.2	4.5	3.5	2.2	5.4	3 4	0.38	0.24	0.20	0.12	0.20	0.12
1972	68	42	6.6	4.1	2.9	1.8	5.4	3.4	0.38	0.24	0 20	0.12	0.20	0.12
1973	62	39	6.1	3.8	2.4	1.5	5.4	3.4	0.38	0.24	0.20	0.12	0.20	0.12
1974	56	35	5.5	3.4	2.0	1.2	5.2	3.2	0.38	0.24	0.20	0.12	0.20	0.12
1975	50	31	4.9	3.0	1.5	0.93	4.9	3.0	0.38	0.24	0.20	0.12	0.20	0.12
1976	42	26	4.2	2.6	1.3	0.81	4.7	2.9	0.38	0.24	0.20	0.12	0.20	0.12
1977	36	22	3:6	2.2	1 0	0.62	4.2	2.6	0.38	0.24	0.20	0.12	0.20	0.12
1978	31	19	3.1	1.9	0 83	0.52	3.7	2.3	0.38	0.24	0.20	0.12	0.20	0.12
1979	26	16	2.7	1.7	0.67	0.42	3.4	2.1	0.38	0.24	0.20	0.12	0.20	0.12
1980	22	14	2.4	1.5	0.53	0.33	3.1	1.9	0.38	0.24	0.20	0.12	0.20	0.12
1990	14	8.7	1.6	0.99	0.38	0.24	2.2	1.4	0.38	0.24	0.20	0.12	0.20	0.12

[a]Motor Vehicle Emission Factors From AP-42

NOTE: This table does not reflect interim standards promulgated by the EPA Administrator on April 11, 1973. These standards will be incorporated in the next revision to this section.

d. Card E

S(I) = Car speeds for up to eight road types derived from the Maricopa County Traffic Network Coding Manual:

= 45.0	Freeway
= 37.0	Urban expressway
= 27.0	Urban, rural major street
= 22.0	Urban minor street
= 22.0	Grand Avenue
= 20.0	Urban, rural connector
= 22.0	CBD major street
= 27.0	Rural minor street

e. Cards F-K - Description of hourly traffic characteristics

Card F KT(I) = Whether hour of day is peak (=1) or off-peak (=2)

Card G PT12(I) = Fraction of daily traffic in each hour for weekdays, and for Road Types 1 and 2

Card H PT34(I)= Fraction of daily traffic in each hour for weekdays, and for Road Types 3, 4, and 5

Card I PT6(I) = Fraction of daily traffic in each hour for weekdays, and for the street model

Card J PTSAT(I) = Fraction of daily traffic in each hour for Saturdays, and for all Road Types

Card K PTSUN(I) = Fraction of daily traffic in each hour for Sundays, and for all Road Types.

The derivation of these factors was based on data provided by the City of Phoenix Traffic Engineering Department and MAGTPP. Table 3.3 shows a typical hourly traffic breakdown for an average weekday. Data was not available which differentiated daily traffic by road type, so the same hourly factors were used for PT12(I) and PT34(I). In conversations with Dr. F.L. Ludwig of Stanford Research Institute, it was indicated that about four hours during the day should be designated as "peak" hours. He also related that 7% would be a reasonable cut-off point between "peak" and "off-peak" hours. These criteria were followed in the assignment of values to KT(I).

Daily factors and hourly factors were developed from statistical analyses of county station count data. The hourly factors assigned to PTSAT(I) and PTSUN(I) reflect a drop in traffic for Saturdays and Sundays based on the developed daily factors. (See Table 3.4)

f. Cards L, M

Preparation of these cards is straight forward. The following holidays were coded for FY '75.

July 4, 1974
September 2, 1974 (Labor Day)
November 28, 1974 (Thanksgiving)
December 25, 1974 (Christmas)
January 1, 1975
February 12, 1975 (Lincoln's Birthday)
February 17, 1975 (Washington's Birthday)
March 30, 1975 (Easter)
May 26, 1975 (Memorial Day)

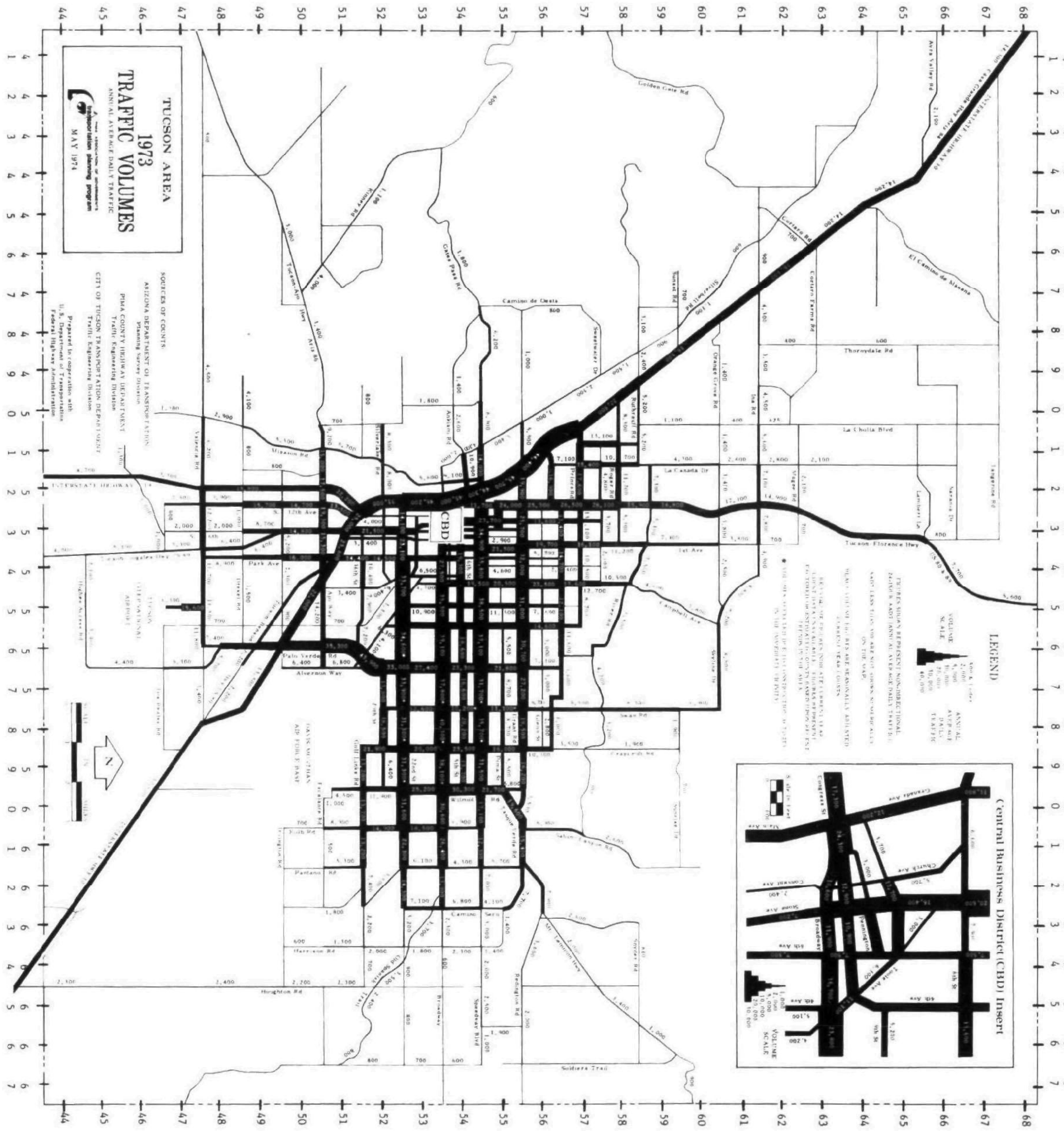


Figure 3.12: COORDINATE SYSTEM AND 1973 TRAFFIC COUNTS FOR TUCSON AREA

Table 3.3: HOURLY TRAFFIC BREAKDOWN FOR PHEONIX AREA

December 14, 1973
PHOENIX TRAFFIC ENGINEERING DEPARTMENT
HOURLY PER CENT OF TWENTY-FOUR-HOUR VOLUME

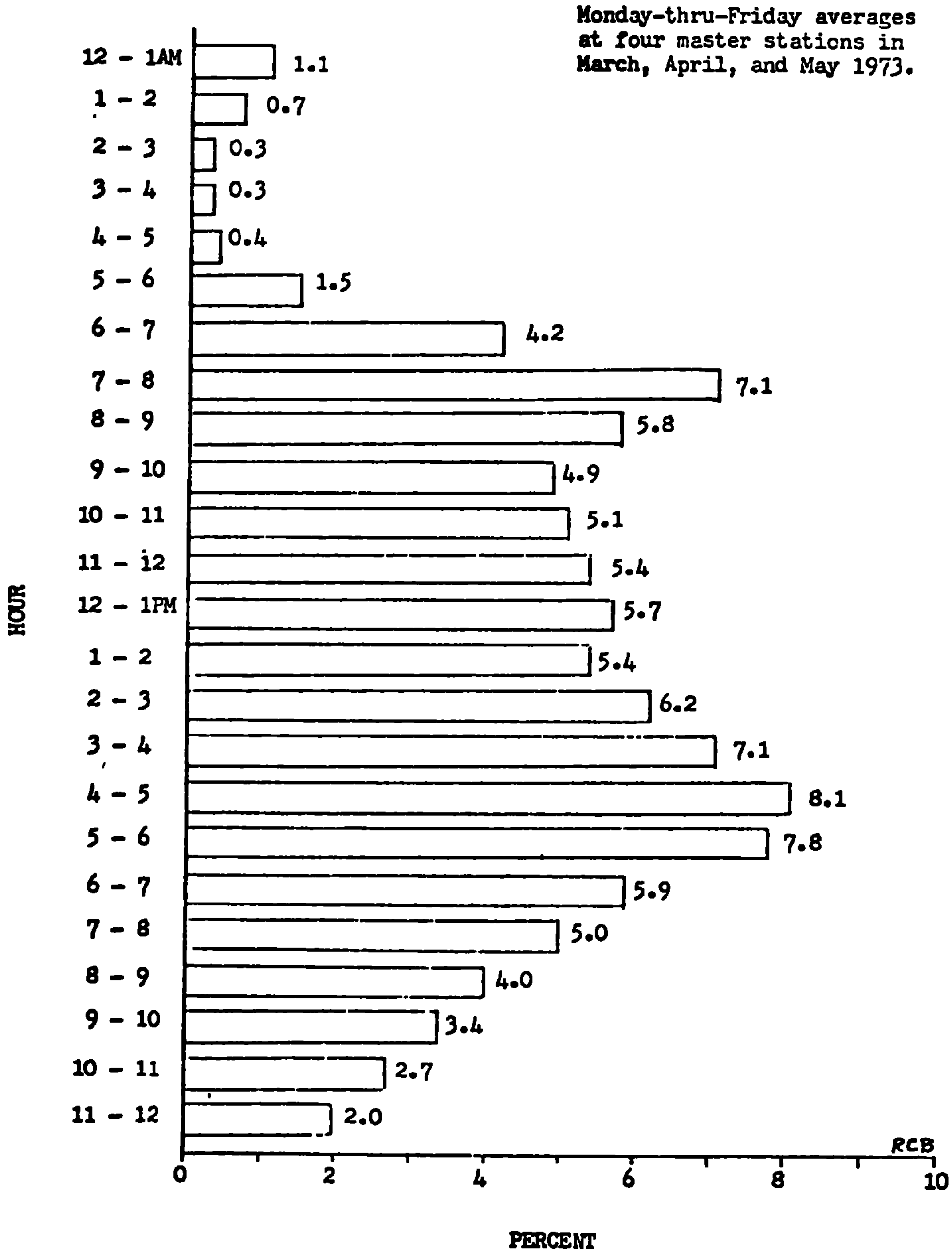


Table 3.4: VALUES FOR APRAC-1A INPUT CARDS F-K

I	1	2	3	4	5	6	7	8
IT(I)	2	2	2	2	2	2	2	1
PT12(I)	.011	.007	.003	.003	.004	.015	.042	.071
PT34(I)	.011	.007	.003	.003	.004	.015	.042	.071
PT6(I)	.011	.007	.003	.003	.004	.015	.042	.071
PTSAT(I)	.0219	.0152	.0080	.0047	.0038	.0087	.0185	.0298
PTSUN(I)	.0215	.0169	.0080	.0048	.0033	.0048	.0090	.0131

I	9	10	11	12	13	14	15	16
KT(I)	2	2	2	2	2	2	2	1
PT12(I)	.058	.049	.051	.054	.057	.054	.062	.071
PT34(I)	.058	.049	.051	.054	.057	.054	.062	.071
PT6(I)	.058	.049	.051	.054	.057	.054	.062	.071
PTSAT(I)	.0381	.0468	.0527	.0563	.0607	.0572	.0561	.0562
PTSUN(I)	.0190	.0331	.0385	.0438	.0575	.0495	.0482	.0493

I	17	18	19	20	21	22	23	24
KT(I)	1	1	2	2	2	2	2	2
PT12(I)	.081	.078	.059	.050	.040	.034	.027	.020
PT34(I)	.081	.078	.059	.050	.040	.034	.027	.020
PT6(I)	.081	.078	.059	.050	.040	.034	.027	.020
PTSAT(I)	.0588	.0551	.0529	.0476	.0381	.0313	.0298	.0274
PTSUN(I)	.0494	.0472	.0447	.0405	.0347	.0292	.0230	.0170

C. CDM Data Set

The presentation of the CDM set differed from the APRAC-1A in that point source emissions were included as well as area source emissions. In addition, this data was prepared for reactive hydrocarbons as well as carbon monoxide.

1. Gathering of Point Source Data

The required data for the development of the point source input cards for the CDM was obtained from the EPA Regional Office in San Francisco. The EPA files containing National Emissions Data System (NEDS) data forms for Maricopa and Pima Counties were searched for information prepared for each point source. From the NEDS forms, data pertaining to CO and hydrocarbon emission estimates, stack data, and UTM coordinates of point locations were obtained. Data was extracted for all point sources emitting one ton per year or more of CO or hydrocarbons. For the most part, the major sources consisted of petroleum product storage tanks, power plants, and users of organic solvents for the manufacture of electronic components.

2. Processing of Point Source Data

In order to prepare acceptable input data for the CDM, the NEDS information had to be manipulated into the specified set of units and formats. To accomplish this task a computer program called POINT was coded to read in the data extracted from EPA files, convert each item to metric units and print a record in CDM input format. Documentation for this program can be found in Appendix A. For a larger scale project, this program could be modified to examine any NEDS data base, extract sources which emit the pollutants being studied, and produce a set of point source inputs in correct CDM format.

The preparation of the area source data for CDM included the allocation of mobile source emissions to the same grid system that was used for APRAC-1A secondary traffic. The program GRID was set up to produce this area source data. Grid uses the same procedure to allocate traffic emissions as was used to allocate secondary traffic. The CDM input data, however, is given in terms of actual emissions instead of vehicle miles traveled (VMT). Therefore, as each link is allocated to a grid the emission rate is calculated according to the following formula:

$$E_1 = \frac{(\alpha S^{\beta}) \times VMT}{86400}$$

where

E_1 = emission rate in grams CO/second

α = emission constant for CO based on vehicle mix

β = emission constant for CO based on vehicle mix

S = speed in miles per hour

VMT = vehicle miles traveled as calculated by program

A set of emission factor constants is also input for hydrocarbon emissions and another emission rate is calculated according to

$$E_2 = \frac{(\gamma S^{\nabla}) \times VMT}{86400}$$

where

E_2 = emission rate in grams HC/second

γ = emission constant for HC based on vehicle mix

∇ = emission constant for HC based on vehicle mix

This process is followed for each primary link in the area to give an emission rate for each grid based on primary traffic. The data generated for percent of total secondary traffic is used to calculate secondary traffic contributions to emissions in each grid. For this calculation an average speed of 19.6 miles per hour is used.

These two emissions are added together to give total emissions due to traffic for each grid.

In addition, the program is set up to accept input data for airport emissions. At the present time, data can be input for two airports in the study region. The program can be easily modified to accept more airport data if necessary. It is assumed that up to ten grids for each airport can be designated for an equal portion of the total emissions from the airport. To calculate the airport emissions which should be added to the appropriate grids, data for landing and take-off cycles (LTOs) was obtained from Federal Aviation Administration(FAA) tower information. An example of this type of information is shown in Figure 3.10. After contacting FAA personnel and other supplementory data sources, it was possible to categorize these LTOs into the 12 classes shown in Figure 3.11 from EPA publication AP-42. Using EPA emission factors and FAA overall growth projections, total emissions due to aircraft LTOs were calculated for each airport. These total emissions were then allocated equally to the selected grids and added to the previously calculated automobile traffic emissions. The program's final function was to output a source record in CDM card 100 format for each grid in the study area.

II. TUCSON DATA ANALYSIS

For the most part, the same procedures used for Phoenix to prepare the APRAC-1A and CDM data sets were utilized in Tucson. The purpose of this section, then, is to point out and discuss any changes in the methodology employed in Tucson from that summarized in the Phoenix discussion above.

PHOENIX TOWER, ARIZONA NON-APPROACH CONTROL TOWER FISCAL YEAR 1974 ACTIVITY REPORT

ACTIVITY PERIOD	AIRCRAFT OPERATIONS: ITINERANT OPERATIONS: AIR CARRIER	AIR TAXI	GENERAL AVN	MIL	TOTAL ITINERANT	LOCAL OPERATIONS: GENERAL AVN	MIL	TOTAL LOCAL	TOTAL AIRCRAFT OPERATIONS	INSTRUMENT OPERATIONS: PRIMARY AIRPORT TOTAL	SECONDARY AIRPORT TOTAL	OVER FLIGHTS TOTAL	TOTAL INSTRUMENT OPERATIONS	TOTAL AIRCRAFT SERVICES
JUL 1973	7694	762	16922	280	25648	6848	148	6996	32644	9393	0	0	9393	70216
AUG 1973	7718	783	16699	393	25598	6926	450	7376	32974	9391	0	0	9391	70538
SEP 1973	7383	728	18132	304	26547	7224	303	7527	34074	8875	0	0	8875	69574
OCT 1973	7698	733	19721	332	28474	7148	452	7600	36074	9546	0	0	9546	74258
NOV 1973	6138	684	18851	269	25942	5813	344	6157	32099	8255	0	0	8255	65119
DEC 1973	6515	636	17898	208	25257	6668	250	6918	32175	8224	0	0	8224	65071
JAN 1974	7018	682	16548	283	24531	5695	511	6206	30737	9535	0	0	9535	68877
FEB 1974	6139	622	19275	297	26333	5428	710	6138	32471	8410	0	0	8410	66111
MAR 1974	6948	659	20155	361	28123	5502	854	6356	34479	9753	0	0	9753	73471
APR 1974	6955	736	20915	258	28864	6494	554	7048	35912	9544	0	0	9544	74088
MAY 1974	7206	685	21570	298	29759	6482	438	6920	36679	9731	0	0	9731	75603
JUN 1974	7094	691	19832	350	27967	6367	216	6583	34550	9180	0	0	9180	71270
FY 1965	55164	0	145910	6676	207750	74836	5568	80404	288154	0	0	0	0	288154
FY 1966	55663	0	163509	7108	226280	84533	4633	89166	315446	0	0	0	0	315446
FY 1967	58812	0	189256	5837	253905	100589	4578	105166	359071	0	0	0	0	359071
FY 1968	74506	0	202474	5553	282533	90013	3308	93321	375854	73534	0	0	73534	669956
FY 1969	79364	0	185311	5729	270404	74157	2928	77085	347489	83296	0	0	83296	680673
FY 1970	86608	0	185025	5044	276677	65936	3636	69572	346249	89150	0	0	89150	702849
FY 1971	78057	0	193168	5542	282767	70498	3761	74259	357026	93497	0	0	93497	731314
FY 1972	75765	5217	199977	5819	286778	72036	4318	76354	363132	90934	0	0	90934	726668
FY 1973	85255	6754	184759	4568	281336	51492	3800	55292	336628	104743	0	0	104743	755600
FY 1974	84486	8401	226518	3638	323043	76595	5230	81825	404868	109837	0	0	109837	844216
CURRENT YEAR ACTIVITY GAIN/LOSS PERCENTAGE AND CURRENT YEAR PERCENTAGE OF REGIONAL ACTIVITY														
FY 74 +/-	- 00.90	24.38	22.60	- 20.35	14.82	48.75	37.63	47.99	20.27	04.86	00.00	00.00	04.86	11.72
% OF REG.	10.99	01.93	05.17	04.46	05.93	01.66	03.65	01.72	03.97	07.29	00.00	00.00	07.25	05.19

ACTIVITY VOLUME AND TRENDS

ACTIVITY	ACTUAL COUNT FOR FY/74	BASE PERIOD	FY/75	CUM CHANGE	FY/76	CUM CHANGE	FY/77	CUM CHANGE	FY/78	CUM CHANGE	FY/81	CUM CHANGE	FY/84	CUM CHANGE
ITINERANT OPERATONS	323043		328657	+ 01.7	334776	+ 03.6	340801	+ 05.4	346935	+ 07.3	372595	+ 15.3	379301	+ 17.4
LOCAL OPERATIONS	81825	4	85670	+ 04.6	89696	+ 09.6	93911	+ 14.7	98324	+ 20.1	116151	+ 44.3	123704	+ 51.1
AIRCRAFT OPERATIONS	404868	YEARS	414584	+ 02.3	424534	+ 04.8	434722	+ 07.3	445155	+ 09.9	489451	+ 20.8	501197	+ 23.7
INSTRUMENT OPERS	109837		115109	+ 04.7	120634	+ 09.8	126424	+ 15.1	132492	+ 20.6	159816	+ 45.5	167489	+ 52.4
AIRCRAFT SERVICES	844216		877140	+ 03.9	911158	+ 07.9	946890	+ 12.1	983819	+ 16.5	1146505	+ 35.8	1191218	+ 41.1
ITINERANT OPERATONS	323043		331765	+ 02.6	340722	+ 05.4	349921	+ 08.3	359368	+ 11.2	399777	+ 23.7	410570	+ 27.0
LOCAL OPERATIONS	81825	7	76425	- 06.5	71381	- 12.7	66670	- 18.5	62270	- 23.8	47390	- 42.0	44263	- 45.9
AIRCRAFT OPERATIONS	404868	YEARS	402844	- 00.4	400830	- 00.9	398826	- 01.4	396832	- 01.9	388956	- 03.9	387012	- 04.4
INSTRUMENT OPERS	109837		117964	+ 07.3	126693	+ 15.3	136069	+ 23.8	146137	+ 33.0	194434	+ 77.0	208822	+ 90.1
AIRCRAFT SERVICES	844216		884736	+ 04.7	927205	+ 09.8	971710	+ 15.1	1018352	+ 20.6	1228407	+ 45.5	1287370	+ 52.4
ITINERANT OPERATONS	323043		333380	+ 03.1	344048	+ 06.5	355057	+ 09.9	366418	+ 13.4	415617	+ 28.6	428916	+ 32.7
LOCAL OPERATIONS	81825	10	79284	- 03.0	76832	- 06.1	74451	- 09.0	72144	- 11.8	63608	- 22.2	61637	- 24.6
AIRCRAFT OPERATIONS	404868	YEARS	408106	+ 00.7	411370	+ 01.6	414660	+ 02.4	417977	+ 03.2	431511	+ 06.5	434963	+ 07.4
INSTRUMENT OPERS	109837		INSUFFICIENT DATA TO ESTABLISH TREND											
AIRCRAFT SERVICES	844216		893180	+ 05.7	944984	+ 11.9	999793	+ 18.4	1057780	+ 25.2	1325371	+ 56.9	1402242	+ 66.0

Figure 3.10: FAA LTO DATA FOR PHOENIX AIRPORT

(lb/engine and kg/engine)
EMISSION FACTOR RATING: B

Aircraft	Solid particulates[a]		Sulfur oxides[d]		Carbon monoxide[e]		Hydrocarbons[e]		Nitrogen oxides[d] (NO_x as NO_2)	
	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg
1. Jumbo jet	1.30	0 59	1.82	0 83	46.8	21.2	12.2	5.5	31.4	14.2
2. Long range jet	1.21	0.55	1.56	0.71	47.4	21.5	41.2	18.7	7 9	3.6
3. Medium range jet	0.41	0.19	1.01	0.46	17.0	7.71	4.9	2.2	10.2	4.6
4. Air carrier turboprop	1.1	0.49	0.40	0.18	6.6	3.0	2.9	1.3	2.5	1.1
5. Business jet	0.11	0.05	0.37	0.17	15.8	7.17	3.6	1.6	1 6	0.73
6. General aviation turboprop	0.20	0.09	0.18	0.08	3.1	1.4	1.1	0.5	1.2	0.54
7. General aviation piston	0.02	0.01	0.014	0.006	12.2	5.5	0.40	0.18	0 047	0 021
8. Piston transport	0.56	0.25	0.28	0.13	304.0	138.0	40.7	18.5	0.40	0.18
9. Helicopter	0.25	0.11	0.18	0.08	5.7	2.6	0.52	0.24	0 57	0.26
10. Military transport	1.1	0.49	0.41	0.19	5.7	2.6	2.7	1.2	2 2	1.0
11. Military jet	0.31	0 14	0.76	0.35	15.1	6.85	9.93	4.5	3.29	1.49
12. Military piston[f]	0 28	0.13	0.14	0.04	152.0	69.0	20.4	9.3	0.20	0.09

Figure 3.11: EMISSION FACTORS FOR AIRCRAFT FROM AP-42

A. APRAC - 1A Data Set

Unlike the Phoenix data, no traffic counts for Tucson were available in machine readable format. Therefore, the method for preparing the APRAC-1A primary link data for Phoenix was not applicable in Tucson. A map was provided by the City of Tucson Traffic Department which contained link count data for the major traffic arteries in the Tucson area. A date was given for each link showing when that particular count had been taken. After examining the data available for Tucson, it appeared to be reasonable to use the same simple growth factor of 8% per year that had been derived previously for Phoenix. All of the counts were updated to give projected figures for FY '75. A coordinate system was devised which was similar to that used for Phoenix as shown in Figure 3.12. At this point, it was possible to code by hand all of the primary links in the study area in APRAC-1A format. With additional link information obtained from the Pima Association of Governments Transportation Planning Program (PAGTPP) a total of 455 primary links were coded for the study area.

The input information needed for cards C-M is discussed below.

1. Card C

SLAT - City latitude = 32.0 degrees

POP - City population = 396,000

1970 census figure for the Tucson urban area = 290,661

Growth figure to July, 1974 = 1 + (.08 x 4.5) = 1.36

1975 projected figure = 396,000

(XXT,YYT) = City center location = (53.20, 52.65)

CLE = City's total amount of secondary traffic equal to CLE per cent of primary = 51.80

total secondary VMT = 2,670,095

total primary VMT = 5,154,486

$$CLE = \frac{2670095}{5154486} \times 100 = 51.80$$

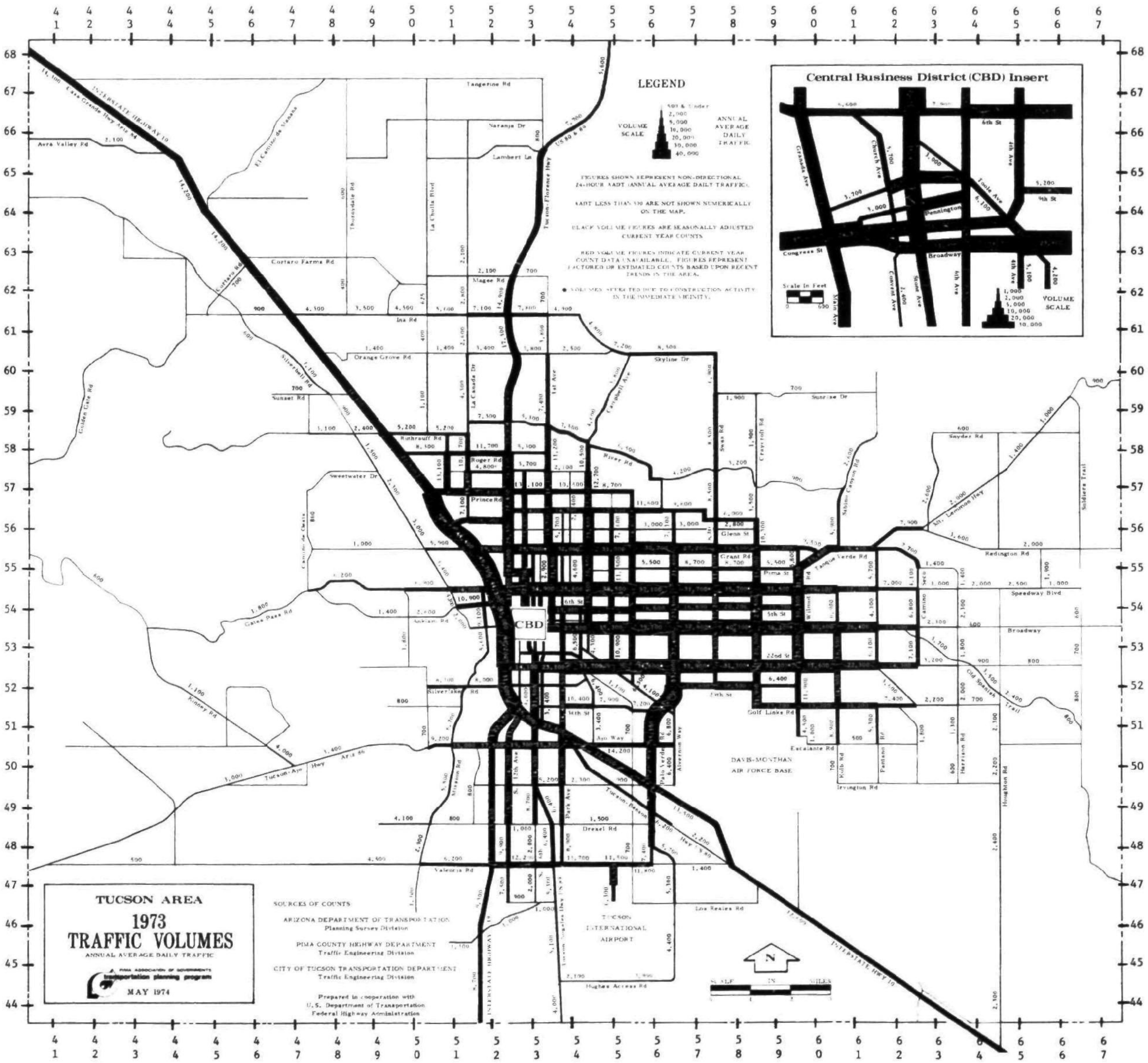


Figure 3.12: COORDINATE SYSTEM AND 1973 TRAFFIC COUNTS FOR TUCSON AREA

PF1 = value for α = 670.0 } (See Figures 3.7 and 3.13)
PF2 = value for β = -0.85 }

2. Card E

S(I) = Car speeds for up to eight road types

= 15.0	Urban minor street
= 30.0	Urban major street
= 40.0	Rural major street
= 55.0	Freeway

3. Card L-M

The following holidays were coded for FY '75

July 4, 1974
September 2, 1974(Labor Day)
November 11, 1974 (Rodeo Day)
November 28, 1974 (Thanksgiving)
December 25, 1974 (Christmas)
January 1, 1975
February 14, 1975 (Valentine's Day)
February 17, 1975 (Washington's Birthday)
March 30, 1975 (Easter)
May 26, 1975 (Memorial Day)

Light Duty Vehicles		Cars	Trucks	Total	%	EF	Emission
pre	1968	90,874	21,203	112,077	37.00046	87	32.1904
	1968	15,515	2,425	17,940	5.9226	46	2.724396
	1969	17,718	3,449	21,230	7.00875	39	2.7334125
	1970	16,376	3,475	19,851	6,55349	36	2.3592564
	1971	15,879	3,495	18,374	6.39602	34	2.1746468
	1972	18,974	5,450	24,424	8.0632	19	1.532008
	1973-74	38,655	8,389	47,044	15.53083	19	2.9508577
	1975	18,313	4,102	22,415	7.39996	12.5	.924995

Heavy Duty Gas		Vehicles	% of Total	EF	Emission
pre	1970	6,929	2.2875	140	3.2025
	1970-75	6,394	2.11085	130	2.7441

Heavy Duty Diesel		Vehicles	% of Total	EF	Emission
	All	5,229	1.72627	20.4	.0352144

Total Emission = 53.571784

From Figure 3.7

$$\alpha = \frac{E}{0.08} = \frac{53.571784}{0.08}$$

$$\alpha = 670$$

Figure 3.13: CALCULATION OF α FOR TUCSON STUDY AREA

B. <u>CDM Data Set</u>

Preparation of the CDM data set for Tucson was very similar to that for the Phoenix area. Point source data was obtained from the Pima County NEDS file at the EPA regional offices and was processed by the POINT computer routine. Point source records in CDM format were combined with area source records produced by the GRID computer routine. The area source emissions were given for one square mile zones and included contributions from primary traffic links, secondary traffic, Tucson International Airport and Davis-Monthan Air Force Base. Emission factor constants α, β, ∇ and γ were developed from project vehicle mix information in an identical manner as the development for Phoenix.

CHAPTER 4

PREPARATION OF NEDS AREA SOURCE FORMS

County Numbers

Pima -0620

Maricopa - 0440

Gasoline Fuel Usage and VMT

Maricopa County -

Total Gas and Diesel Consumed in Gallons (Ariz. Tax Dept., Motor Vehicle Division, Monthly Reports

January 73	50,704,568
February 73	51,579,841
March 73	54,171,386
April 73	51,605,642
May 73	49,043,520
June 73	51,011,797
July 73	50,416,697
August 73	50,810,139
September 73	48,391,382
October 73	51,013,109
November 73	53,468,065
December 73	49,537,450
	611,753,450 gallons (gas and diesel) consumed in 1973

From US DOT publication 1972 Highway Statistics, 10.2% of this is diesel. 62,398,851 gallons diesel consumed in 1973.

This leaves 549,354,600 gallons of gas consumed in '73.
From APTD-1135, "Guide for Compiling an Emission Inventory", we find that an average factor of 12.2 mpg can be used to determine gas VMT.

This gives 6,702,126,100 VMT due to gas vehicles

From APTD-1135

11% of this or 737,233,870 VMT is due to heavy duty gas vehicles and 89% or 5,964,892,200 VMT is due to light duty gas vehicles

Also using APTD-1135 factors, we obtain

$$737{,}233{,}870 \text{ miles/year} \div 8.4 \frac{\text{miles}}{\text{gallon}} = 87{,}765{,}936 \text{ gallons gas consumed by heavy duty vehicles}$$

$$5{,}964{,}892{,}200 \text{ miles/year} \div 13.6 \frac{\text{miles}}{\text{gallon}} = 461{,}588{,}660 \text{ gallons gas consumed by light duty vehicles}$$

$$\begin{aligned} \text{Total VMT} &= 6{,}702{,}126{,}100 + \text{diesel VMT} \\ &= 6{,}702{,}126{,}100 + 62{,}398{,}851 \frac{\text{gallons}}{\text{year}} \times 5.1 \frac{\text{miles}}{\text{gallon}} \\ &= 7{,}020{,}360{,}230 \text{ VMT} \end{aligned}$$

This can be divided into urban and rural VMT

$$\text{Urban VMT} = 15{,}521{,}882 \text{ VMT/day} \times 365 \text{ day/year} = 5{,}665{,}486{,}900 \frac{\text{VMT}}{\text{year}}$$

$$\text{Rural VMT} = 7{,}020{,}360{,}230 - 5{,}665{,}486{,}900 = 1{,}354{,}873{,}300 \frac{\text{VMT}}{\text{year}}$$

Pima County

Using same factors and procedure as before we have,

Total gas and diesel fuel consumed in 1973 in gallons

January 73	17,235,306
February 73	20,222,716
March 73	19,433,835
April 73	18,222,534
May 73	17,803,397
June 73	18,682,090
July 73	17,304,510
August 73	18,667,729
September 73	16,551,274
October 73	19,112,466
November 73	18,692,095
December 73	17,178,068
	219,106,040 gallons (gas and diesel) consumed in '73.

Diesel gallons consumed = 219,106,040 x 10.2 = 22,348,816 gallons

This leaves 196,757,220 gallons gas consumed in '73

This gives 196,757,220 gal/yr x 12.2 mile/gal = 2,400,437,800 VMT due to gas vehicles

of which

11% or 264,048,150 is heavy duty VMT

and 89% or 2,136,389,600 is light duty VMT

This then gives,

$264{,}048{,}150\ \frac{\text{miles}}{\text{year}} \div 8.4\ \frac{\text{miles}}{\text{gallon}} = 31{,}434{,}303$ gallons gas consumed by heavy duty vehicles

and $2{,}136{,}389{,}600\ \frac{\text{miles}}{\text{year}} \div 13.6\ \frac{\text{miles}}{\text{gallon}} = 165{,}322{,}920$ gallons gas consumed by light duty vehicles

$$\text{Total VMT} = 2{,}400{,}437{,}800 + \text{Diesel VMT}$$
$$= 2{,}400{,}437{,}800 + 22{,}348{,}816\ \frac{\text{gallons}}{\text{year}} \times 5.1\ \frac{\text{miles}}{\text{gallon}}$$
$$= 2{,}514{,}418{,}800\ \text{VMT/year}$$

This can be divided into Urban and Rural VMT

$$\text{Urban VMT} = 6{,}709{,}839\ \frac{\text{VMT}}{\text{day}} \times 365\ \frac{\text{day}}{\text{year}} = 2{,}449{,}091{,}400\ \text{VMT/year}$$

$$\text{Rural VMT} = 2{,}514{,}418{,}800 - 2{,}449{,}091{,}400 = 65{,}327{,}400\ \text{VMT/year}$$

Population

Maricopa	- Pop = 967,552	Density Code = 9	(From 1970 Census data).
Pima	- Pop = 351,667	Density Code = 8	

Aircraft

Maricopa Operations

Military	Civil	Commercial	
4075	200,603	93457	Phoenix Itinerant
3847	66,373	0	Phoenix Local
63	43,568	7	PHX-Litch Itinerant
76	119,118	0	PHX-Litch Local
8061	429,662	93,464	Total Operations
4031	214,831	46,732	Total LTOs

Pima Operations

Military	Civil	Commercial	
			Tucson Itinerant
			Tucson Local
			Davis-Monthan
18,348	66,507	16,486	Total LTOs

CHAPTER 5
SUMMARY AND RECOMMENDATIONS

Performance of this project was facilitated by excellent data availability from numerous agencies, especially within the State of Arizona. These organizations generously provided large amounts of data to PES relating to motor vehicle transportation sources and other modes of travel. These data pertained to the Phoenix and Tuscon metropolitan areas in the vast majority.

PES staff was presented with a two-fold problem. In the first place, these data had to be closely examined and organized before they could be set up for model input. This function was complicated by the fact that much of the data were found to overlap. Care had to be taken to prevent extraneous or repeated information from being coded.

The second problem was unsolvable in the course of this contract since it was beyond the scope of this effort. It concerns identifying the sensitivity of various model input parameters. For example, grid size is a case in point. For any given region in which APRAC-1A is to be utilized, what is the optimum grid zone size? As grid size decreases, does the model tend to be more accurate? Additionally, one might ask, how should traffic data be divided among primary and secondary traffic? Which category has a greater effect upon model predictability?

The main purpose behind raising these questions is to promote an effort to determine the procedures that should be applied to achieve the most effective model results on a cost-benefit basis. Accordingly, it would be helpful to know which parameters affect output most significantly so that those charged with the responsibility to prepare model inputs be aware as to how to best apply their efforts. If such information is not currently available, PES recommends that such a study be undertaken.

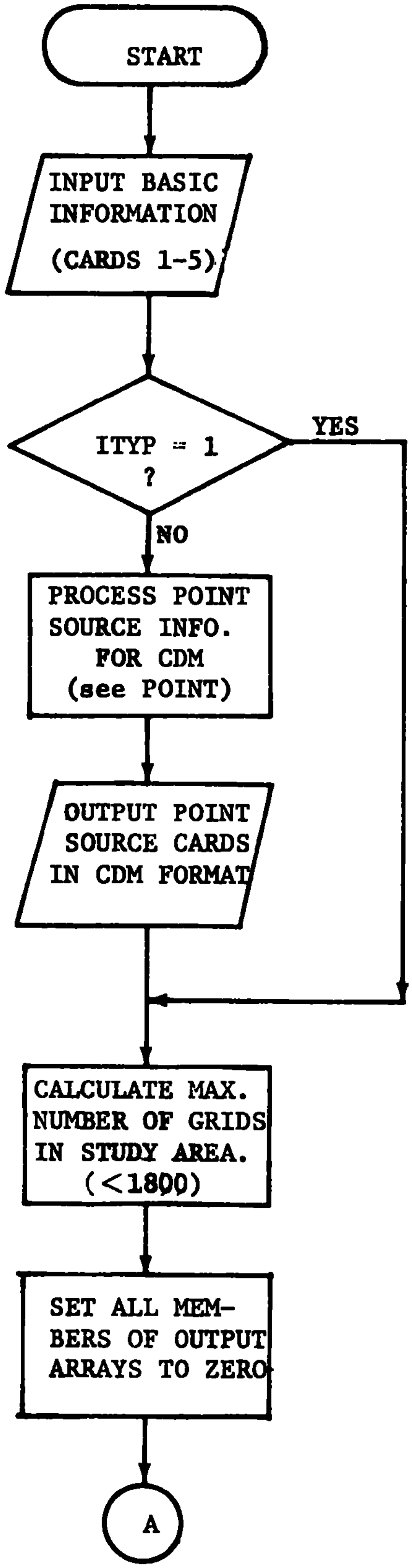
APPENDIX A

FLOWCHARTS AND INPUT VARIABLE DESCRIPTIONS FOR:

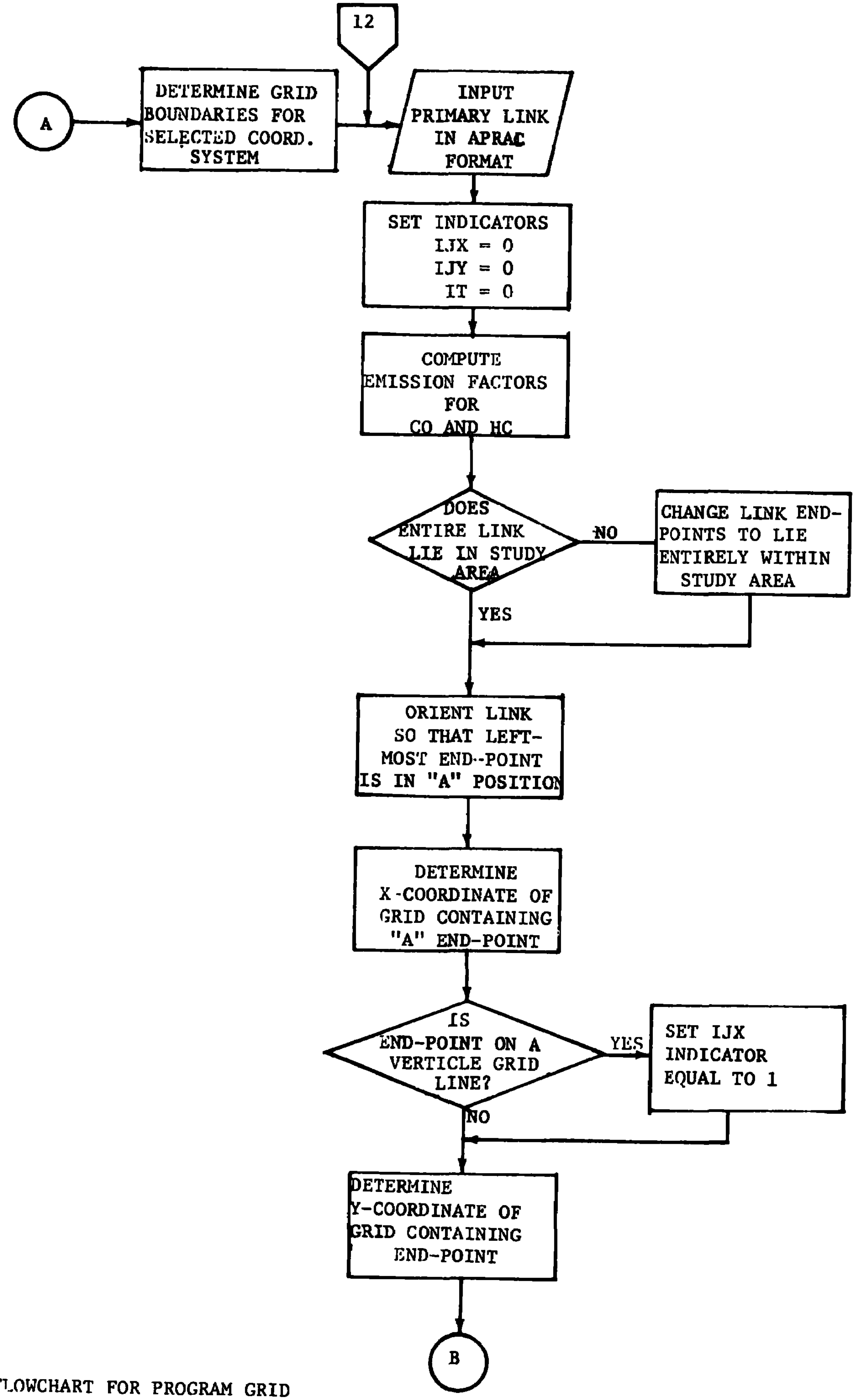
GRID

POINT

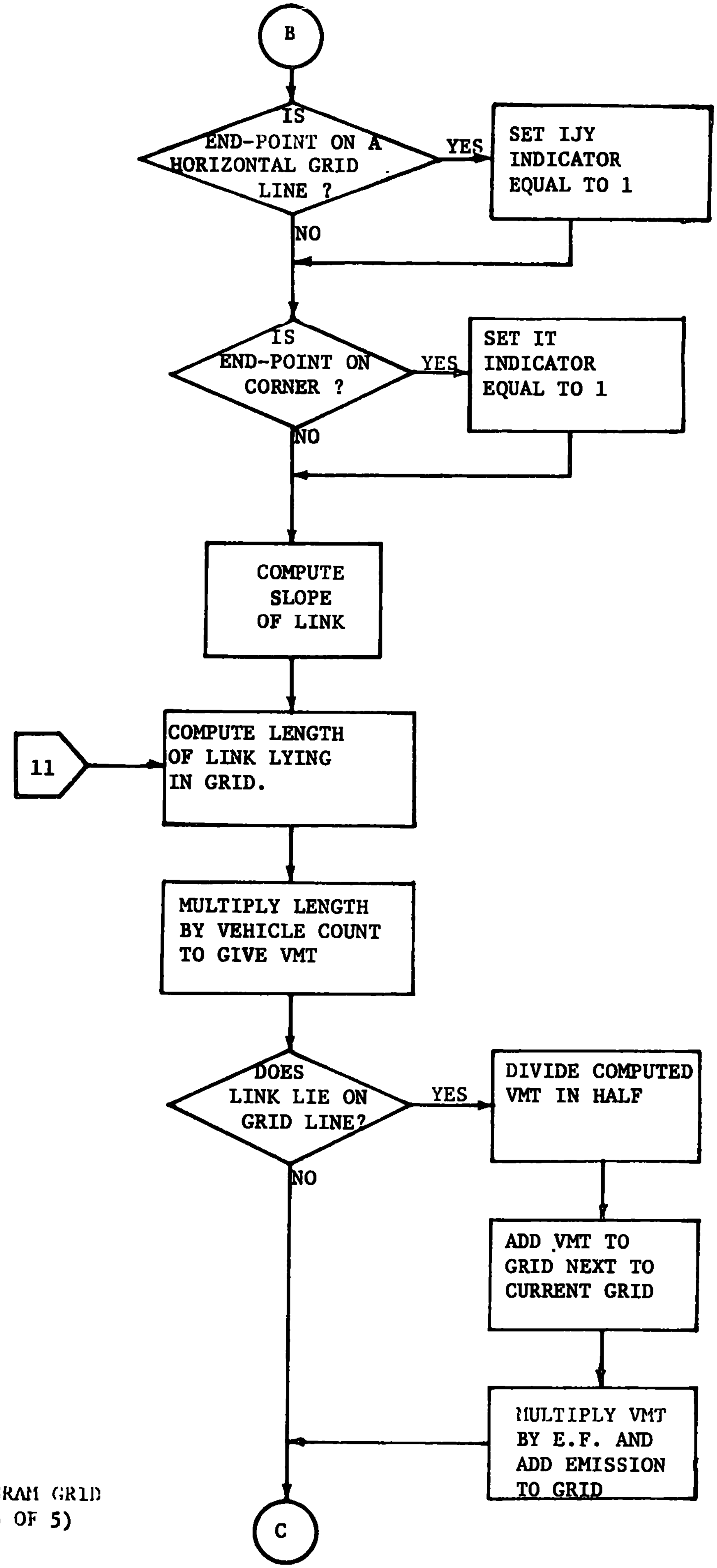
PHX 75



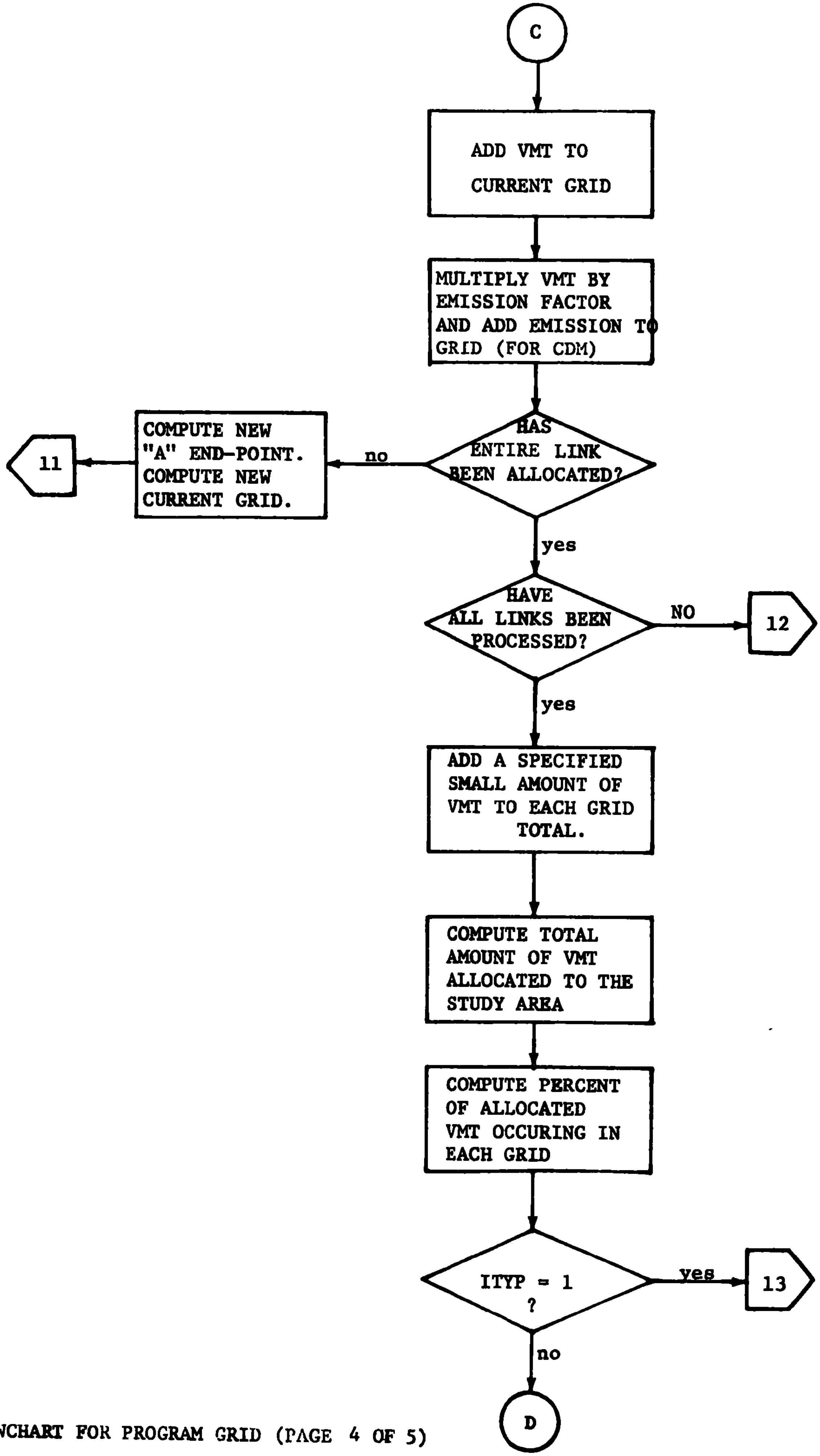
FLOWCHART FOR PROGRAM GRID (PAGE 1 OF 5)



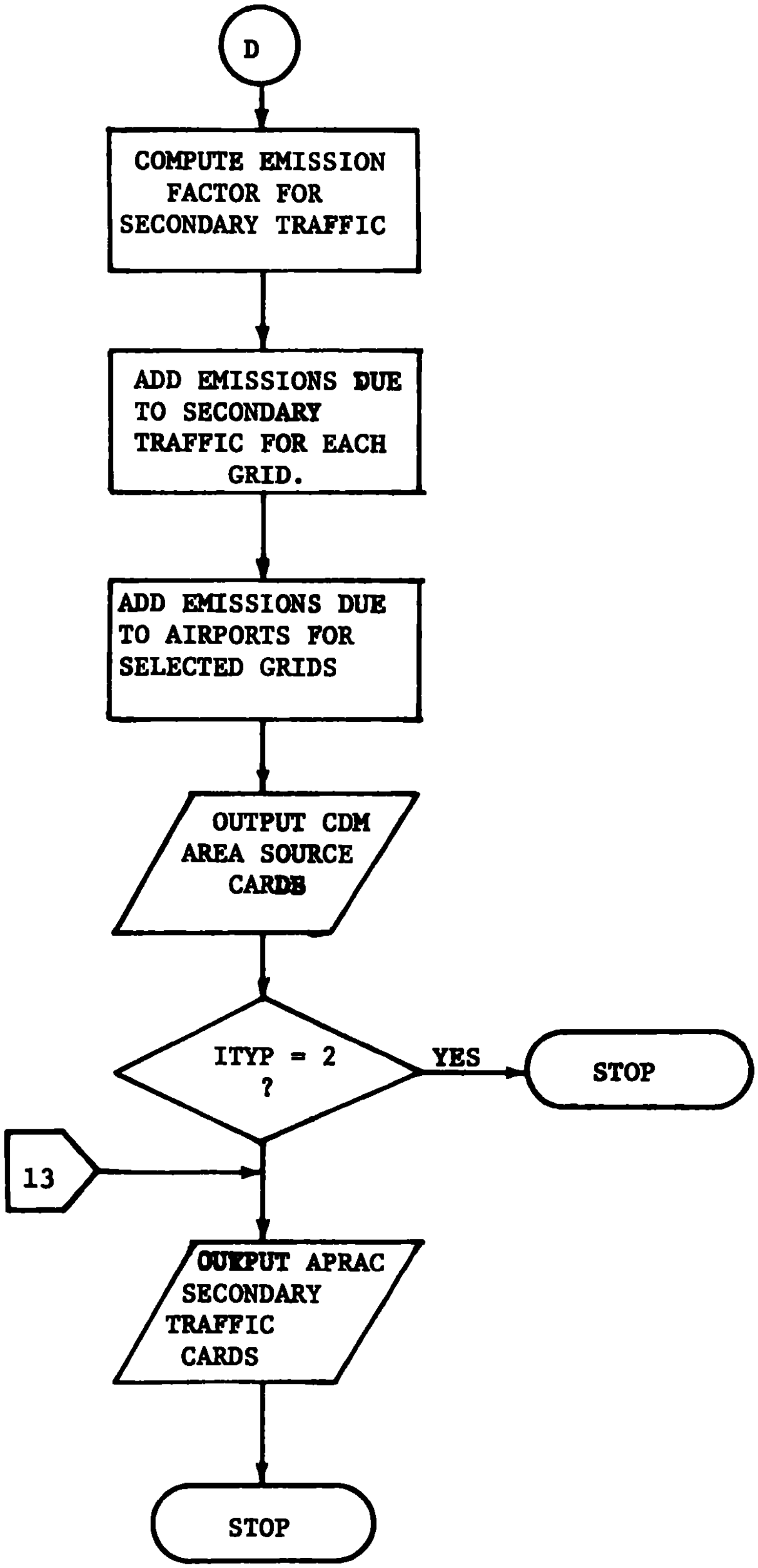
FLOWCHART FOR PROGRAM GRID
(PAGE 2 of 5)



FLOWCHART FOR PROGRAM GRID
(PAGE 3 OF 5)



FLOWCHART FOR PROGRAM GRID (PAGE 4 OF 5)



FLOWCHART FOR PROGRAM GRID (PAGE 5 OF 5)

NOTE: Units of variables and coordinates will vary from usage to usage. As long as all units are consistent, the program should accept any unit system with a few minor changes.

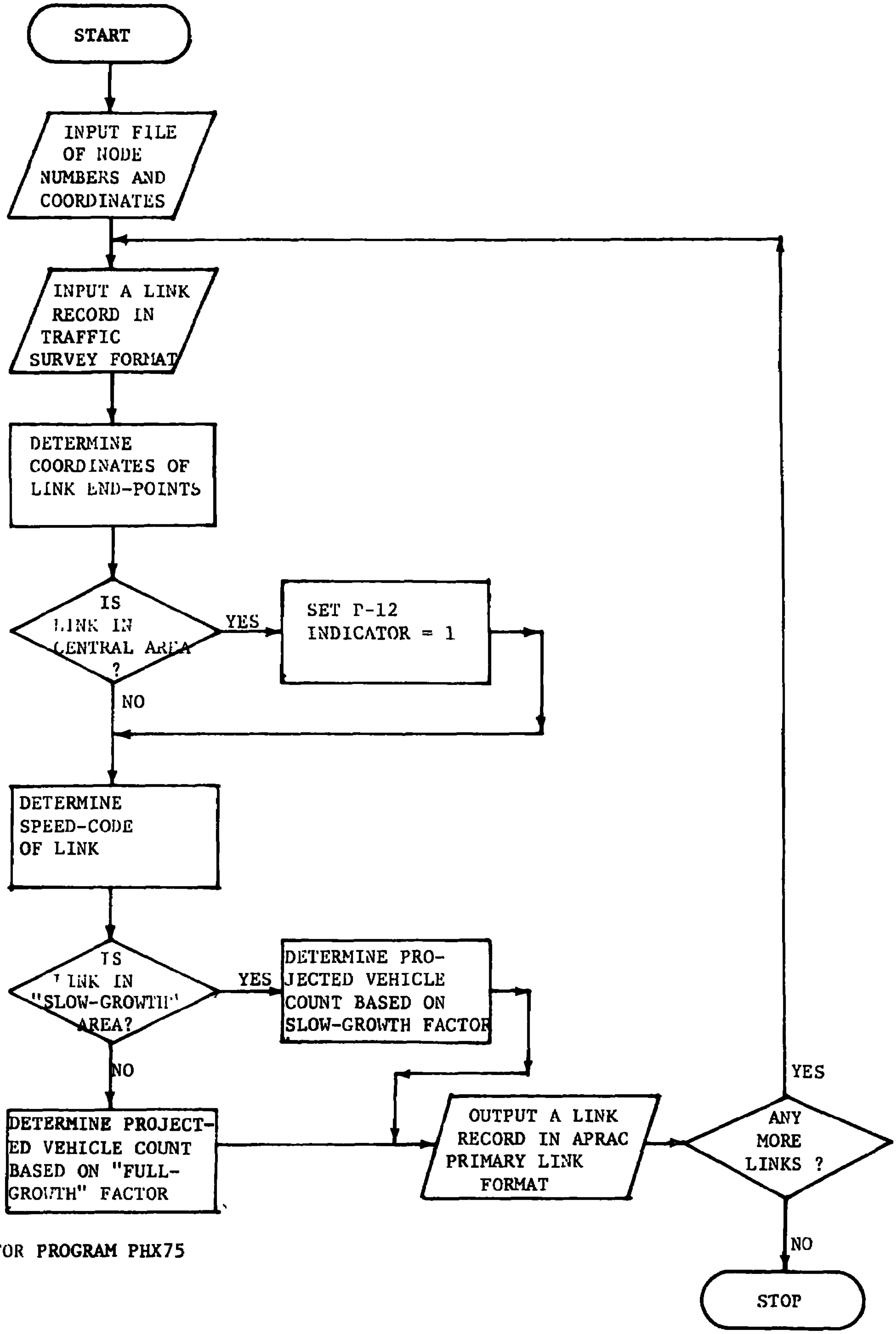
INPUT VARIABLE DESCRIPTIONS FOR GRID

Card	Column	Format	Name	Description
1.	1-10	I10	ITYP	Run type indicator: 1 = APRAC only 2 = CDM only 3 = Both
2.	1-10	F10.2	VTMXMN	Minimum X coordinate
	11-20	F10.2	VTMYMN	Minimum Y coordinate
	21-30	F10.2	GRDFAC	Length of a grid side
	31-40	I10	IXGRID	Number of grids in X direction
	41-50	I10	IYGRID	Number of grids in y direction
	51-60	F10.2	EXTRA	Extra Traffic to be addid for min. secondary
	61-70	F10.2	TOTAL	Total daily VMT
3.	1-10	F10.2	ALPHA	Emission constants for CO $E = \alpha S^{-\beta}$
	11-20	F10.2	BETA	
4.	1-10	F10.2	SPEED(1)	Up to 8 speeds (as shown in APRAC-1A card E)
	11-20	F10.2	SPEED(2)	
	21-30	F10.2	SPEED(3)	
5.	1-10	F10.2	GAMMA	Emission constants for HC $E = \gamma S^{-\Delta}$
	11-20	F10.2	DELTA	
	21-30	I10	NUMPT	Number of point sources

INPUT VARIABLE DESCRIPTIONS FOR GRID (continued)

Card	Column	Format	Name	Description
6(I)				Point Source Data Cards
I=1,NUMPT*	1-6	F6.1	PX	X coordinate in VTM's
	7-13	F7.1	PY	Y coordinate in VTM's
	21-28	F8.0	PCO	CO emission rate in TPY
	29-36	F8.0	PHC	HC emission rate in TPY
	37-43	F7.0	PH	Stack height in feet
	44-49	F6.1	PD	Stack diameter in feet
	50-56	F7.0	PS	Exit gas flow rate (cfm)
	57-63	F7.0	PT	Exit gas temperature in ^{o}F
7(I)				Primary Link Cards (APRAC-1A Format)
I=1,1200	11-15	F5.2	PAX	X and Y coordinates of one end of link
	16-20	F5.2	PAY	
	21-25	F5.2	PBX	X and Y coordinates of other end of link
	26-30	F5.2	PBY	
	31-36	I6	ICOUN	Number of vehicles per day on link
	37-41	I5	ISFAC	Traffic code number
	42-46	F5.2	PDIST	Length of link

*Point source data from NEDS forms. Necessary for CDM only.



FLOWCHART FOR PROGRAM PHX75

INPUT VARIABLE DESCRIPTIONS FOR PHX75

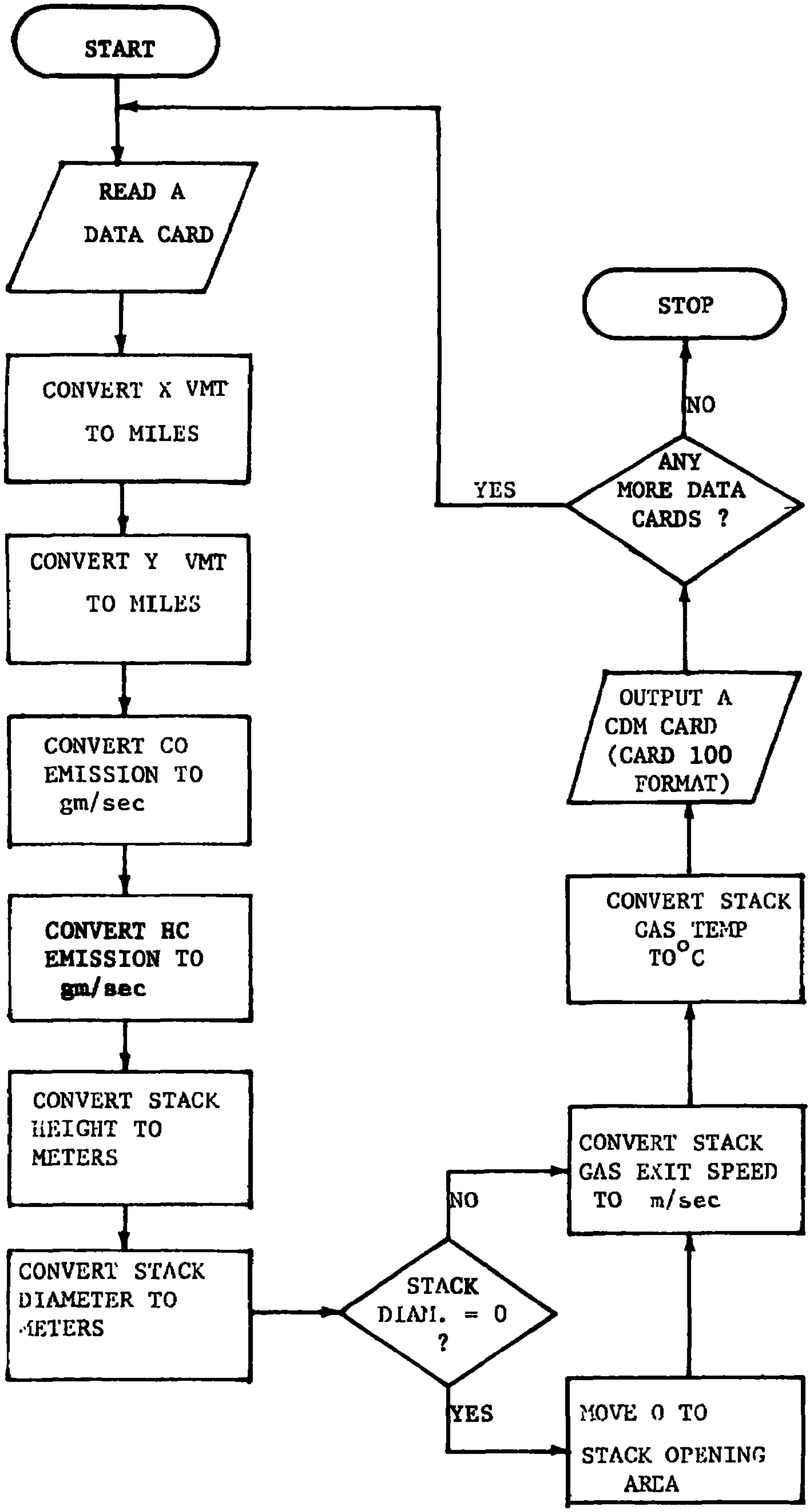
Card 1-Link cards

Column	Format	Name	Description
2-6	F5.0	A-COORD	Node number of "A" end-point.
8-12	F5.0	B-COORD	Node number of "B" end-point.
14-17	F4.2	DIST	Link length in miles.
32-36	F5.0	D-COUN1	One-way directional vehicle count.
55-59	F5.0	D-COUN2	Other-way directional vehicle count.
66	F1.0	S-CDE	Code for average speed on link.

Card 2-Node Cards

Column	Format	Name	Description
7-10	F4.0	CORD	Node number.
16-20	F5.3	X-CO	X-coordinate of node
26-30	F5.3	Y-CO	Y-coordinate of node

FLOWCHART FOR POINT:



INPUT VARIABLE DESCRIPTIONS FOR POINT

(all information available on NEDS form)

Column	Format	Name	Description
1-6	F6.1	X-COORD	X VMT coordinate in Kilometers
7-13	F7.1	Y-COORD	Y VMT coordinate in Kilometers
21-28	F8.0	CO	Carbon Monoxide emission in TPY
29-36	F8.0	HC	Hydrocarbon emission in TPY
37-43	F7.0	HEIGHT	Stack height in feet
44-49	F6.1	DIAM	Stack diameter in feet
50-56	F7.0	SPEED	Stack gas exit velocity in CFM
57-63	F7.0	TEMP	Stack gas exit temperature in ^{o}F

NOTE: In the flow chart, those operations that are not necessary can be by-passed.