TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
TTI-2-8-75-218-1		

4. Title and Subtitle	5. Report Date
Analytical and Experimental Assessment of Highway Impact on Air Quality	August 18, 1976
	6. Performing Organization Code
7. Author(s) J. A. Bullin, J. C. Polasek	8. Performing Organization Report No. 218-1
9. Performing Organization Name and Address Chemical Engineering Department and Texas Transportation Institute Texas A&M University College Station, Texas 77843	10. Work Unit No. 11. Contract or Grant No. 2-8-75-218
12. Sponsoring Agency Name and Address Texas State Department of Highways and Public Transportation; Transportation Planning Division P. O. Box 5051 Austin, Texas 78763	13. Type of Report and Period Covered Interim - September, 1974 August, 1975 14. Sponsoring Agency Code

15. Supplementary Notes

Work done in cooperation with FHWA, DOT

16. Abstract

Air quality measurements along Houston freeways have been made at an "at-grade" site and are to be started shortly at a "cut" site. These measurements are used to characterize carbon monoxide concentrations downwind from highway line sources. Measurements at each site consist of carbon monoxide concentrations at 10 locations, vehicle length, speed and count by lane, and detailed meteorological data from four stations between five and 101.5 feet. All of the instruments are interfaced to a Data General Nova 1200 computer which allows the data to be taken simultaneously and on a rapid time basis. The data from the experimental program will be used to verify line source dispersion models for Texas.

Experimental data from essentially all previous experimental programs have been assembled and used in developing and verifying an improved roadway dispersion model. The improved model along with the well known models of CALINE-2, AIRPOL-4 and HIWAY were compared to the data from the previous programs. Significantly improved results were obtained with the modified model. All of the models and all of the previous data are based on one hour average concepts. The data from the current experimental program have not been compared to the models at this time.

17. Key Words	18. Distribution Statement
Computer controlled sampling, CO data base	No Restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	95	

Form DOT F 1700.7 (8-69)

Interim Report

on

ANALYTICAL AND EXPERIMENTAL ASSESSMENT OF HIGHWAY IMPACT ON AIR QUALITY

by

J. A. Bullin
J. C. Polasek

Submitted to

File D-8 P
State Department of Highways
and Public Transportation

Research Report 218-1

Research Study No. 2-8-75-218

Sponsored by

State Department of Highways and Public Transportation
in cooperation with the
U. S. Department of Transportation
Federal Highway Administration

CHEMICAL ENGINEERING DEPARTMENT
and
TEXAS TRANSPORTATION INSTITUTE
College Station, Texas 77843

August 18, 1976

Implementation

A study of dispersion of pollutants from roadways is underway. Progress in the model development portion of the work indicates that existing models should be used with caution. An improved model based on data from previous experimental programs is presented. Extensive experimental data from the current project will soon be available for continued model improvement.

Disclaimer

Summary

Air quality measurements along Houston freeways have been made at an "at-grade" site and are to be started shortly at a "cut" site. These measurements are used to characterize carbon monoxide concentrations downwind from highway line sources. Measurements at each site consist of carbon monoxide concentrations at 10 locations, vehicle length, speed and count by lane, and detailed meteorological data from four stations between five and 101.5 feet. All of the instruments are interfaced to a Data General Nova 1200 computer which allows the data to be taken simultaneously and on a rapid time basis. The data from the experimental program will be used to verify line source dispersion models for Texas.

Experimental data from essentially all previous experimental programs have been assembled and used in developing and verifying an improved roadway dispersion model. The improved model along with the well known models of CALINE-2, AIRPOL-4 and HIWAY were compared to the data from the previous programs. Significantly improved results were obtained with the modified model. All of the models and all of the previous data are based on one hour average concepts. The data from the current experimental program have not been compared to the models at this time.

TABLE OF CONTENTS

CHAPTER		PAGE
1.	Introduction	1
2.	Description of Field Monitoring Sites in Houston	3
	Introduction	3
	North Loop Site	3
	Katy Freeway Site	7
3.	Experimental Methods	10
	Introduction	10
	Data Collection System	10
	Traffic Measurements	11
	Meteorological Measurements	13
	Atmospheric Temperature and Humidity	14
	Solar Radiation	14
	Carbon Monoxide Measurements	14
	Hydrocarbons and Nitrogen Oxide Measurements	16
4.	Data Handling	17
	Introduction	17
	Data Reduction Program	17
	Format of Computed Averages	20
5.	Diffusion Model Analysis and Development	23
	Introduction	23
	Discussion of Previous Experimental Data Collection Programs	23
	Tennessee Data	23
	North Carolina Data	25
	Virginia Data	26
	Illinois Data	27
	California Data	27
	Analysis of Instrument Error	28
	Effect of Bag Sampler Material on the Accuracy of Measurement	30
	Discussion of Previous Model Developement Programs	30
	Caline-2	30
	Hiway	32
	Airpol-4	36
	Emp-1	39
	Model Validation	40
	Development of Improved Model	41

TABLE OF CONTENTS continued

CHAPTER		PAGE
6.	Discussion of Results	47
	Discussion of Experimental Data Collection Program	47
	Discussion of Dispersion Model Analysis and Development	47
	Summary	
	Literature Cited	
	Appendix A	79
	Appendix B	90
	Appendix C	97

ACKNOWLEDGEMENTS

The authors wish to thank all those individuals who contributed to this report by utilizing their energies and talents to facilitate gathering data and type the manuscript. Special appreciation is extended to Mr. Rod Moe, Mr. Gerry Biggs, and Mr. Larry Galloway, all of the State Department of Highways and Public Transportation. The success of this project has been largely a result of their contributions.

This work was sponsored by the Texas State Department of Highways and Public Transportation in cooperation with the United States Department of Transporation, Federal Highway Administration.

LIST OF TABLES

No.	Title	Page
1	Data Sampling Rate	4
2	Record Formats	18
3	Accuracy of Instruments Used in Data Acquisition	29
4	Summary of Regression Analysis of Roadside CO Concentrations	45
5	Data Locations	55
6	Five-minute Averages for Data Taken from 14:55 to 16:00 4 May 76	56
7	Fifteen-minute Averages for Data Taken from 14:45 to 16:00 4 May 76	63
8	Hourly Averages for Data Taken from 15:00 to 16:00 4 May 76	66
9	Five-minute averages for Data Taken from 16:00 to 17:00 4 May 76	67
10	Fifteen-minute Averages for Data Taken from 16:00 to 17:00 4 May 76	73
11	Hourly Averages for Data Taken from 16:00 to 17:00 4 May 76	75

LIST OF FIGURES

No.	Title	Page
1	Aerial View of Instrument Configuration, Loop 610 Site	5
2	Cross-Sectional View of Instrument Configuration, Loop 610 Site	6
3	Aerial View of Instrument Configuration, Katy Freeway Site	8
4	Cross-Sectional View of Instrument Configuration, Katy Freeway Site	9
5	Virtual Origin Concept	43
6	Overhead View of At-grade Site as Seen by Hiway Model	34
7	Coordinate System Used by Hiway Model	35
8	Coordinate System Used by Airpol-4	37
9	Regression Lines of Models for Tennessee Data	50
10	Regression Lines of Models for North Carolina Data	51
11	Regression Lines of Models for Virginia Data	52
12	Regression Lines of Models for Illinois Data	53
13	Regression Lines of Models for California Data	54

Chapter I

Introduction

Project 2218, "Analytical and Experimental Assessment of Highway Impact on Air Quality", is being used to validate existing mathematical models for dispersion of air pollutants along a highway. This project will also improve on the accuracy of these models where feasible. Mathematical models are currently used to predict future levels of carbon monoxide along highways for various meteorology, topography, and highway conditions.

Currently, the Federal Highway Administration requires an estimate of the carbon monoxide concentrations along proposed new highways or where major improvements are proposed to existing highways. The carbon monoxide levels are predicted for the time when the highway is built and at intervals until 20 years afterward. These predictions are included in the Air Quality Reports which are reviewed by many governmental agencies including the Texas Air Control Board, the Federal Highway Administration, the Environmental Protection Agency and others.

Highways which would seriously degrade the air quality would probably not receive federal financing. The National Ambient Air Quality Standards are used as a basis of judging the air quality. The current work is particularly important since it will establish the validity of applying mathematical models, which were developed outside of Texas, to Texas.

There have been many models proposed to predict pollutant concentrations from roadways. However, there have been only a few experimental validation programs undertaken and these have met with varying degrees of success. The current validation program for Texas is designed for thorough data collection.

The measurements required for model validation work are vehicle numbers, speed and classification (car or truck), wind speed and direction, atmospheric stability and carbon monoxide concentrations at various distances from the roadway. The current validation project is set up to take all of the required measurements simultaneously by using a minicomputer to read the instruments and record the data on cassette magnetic tapes.

Two sites for data collection in Houston have been selected. The "at grade" site is at North Loop and Link Road in Houston while the "cut" or below grade site is at Katy Freeway and Reinermann Road. The current plans call for data collection in Houston this year and in Dallas, San Antonio, and El Paso next year.

Chapter II

Description of Field Monitoring Sites in Houston

Introduction

Field investigations were undertaken at two locations in Houston, Texas. These included an at grade site and a cut site. The locations were at 843 Link Road at Loop 610 and Katy Freeway at Reinermann Road. Due to the requirements of the site, very few locations in Houston are suitable.

North Loop Site

Measurements have been made at the North Loop Site during the period from May 1, 1976 to June 30, 1976. This site was chosen due to the large right of way width and suitability for erection of equipment. At this point the Freeway runs east-west and results in a good location since the prevailing wind is from the south.

The site is somewhat typical of the urban city in that trees and one story houses are located to the south as well as to the north. A diagram of the site is shown in Figure 1. (The symbols used in Figure 1 are defined in Table 1.) At this location the ground is essentially flat and the roughness is due to the trees and houses. The instrumentation at the Link Road Site include 12 Ecolyzers, 10 radars and 5 sets of meteorological instruments. Solar radiation is monitored by a global pyranometer. Ecolyzers are used to measure the carbon monoxide and are mounted in pairs in metal boxes. Each pair is located at a specific distance from the roadway as shown in Figure 2. This figure also shows the heights at which the various instruments are located as well. There are essentially four stations located on the down wind side of the freeway and one on the up wind side in order to obtain a background level. The lower Ecolyzers sample the ambient air at "breathing height" (1.5 meters), while the upper Ecolyzers analyze the air at 10 meter heights. In addition, two

TABLE 1

INSTRUMENT LIST

NAME	CHANNEL	INSTRUMENT	SAMPLE INTERVAL	REASON CHOSEN
RAD0	1	Radar	.01 sec	Special
RAD1	2	"	"	handling
RAD2	3	"	"	"
RAD3	4	"	"	"
RAD4	5	"	"	"
RAD5	6	"	"	"
RAD6	7	"	"	"
RAD7	8	"	"	"
RAD10	9	"	"	"
RAD11	10	"	"	"
VA1.5m	11	1.5 meter vertical anemometer	2 sec	4* highest frequency
VA10m	12	8 " " "	4 sec	"
VA20m	13	16 " " "	5 sec	"
VA40m	14	30 " " "	5 sec	"
HA1.5m	15	1.5 meter horizontal anemometer	15 sec	1 recovery time
HA10m	16	8 " " "	15 "	"
HA20m	17	16 " " "	15 "	"
HA40m	18	30 " " "	15 "	"
WV1.5m	19	1.5 meter wind vane	5 sec	4* highest frequency
WV1.0m	20	8 " " "	5 "	"
WV20m	21	16 " " "	5 "	"
WV40m	22	30 " " "	5 "	"
TM1.5m	23	1.5 meter thermometer	60 sec	"
TMP10m	24	9 " "	60 "	"
TMP20m	25	13 " "	60 "	"
TMP30m	26	25 " "	60 "	"
RH1.5m	27	1.5 meter psychrometer	60 sec	"
RH30m	28	25 " "	60 "	"
PYRAN	29	Heliopyranometer	60 sec	"
CO1H	30	Ecolyzers	30 sec	1 recovery time
CO1L	31	"	"	"
CO2H	32	"	"	"
CO2L	33	"	"	"
CO3H	34	"	"	"
CO3L	35	"	"	"
CO4H	36	"	"	"
CO4L	37	"	"	"
CO5H	38	"	"	"
CO5L	39	"	"	"
CO6H	40	"	"	"
CO6L	41	"	"	"

FIGURE 1

OVERHEAD VIEW AT GRADE SITE

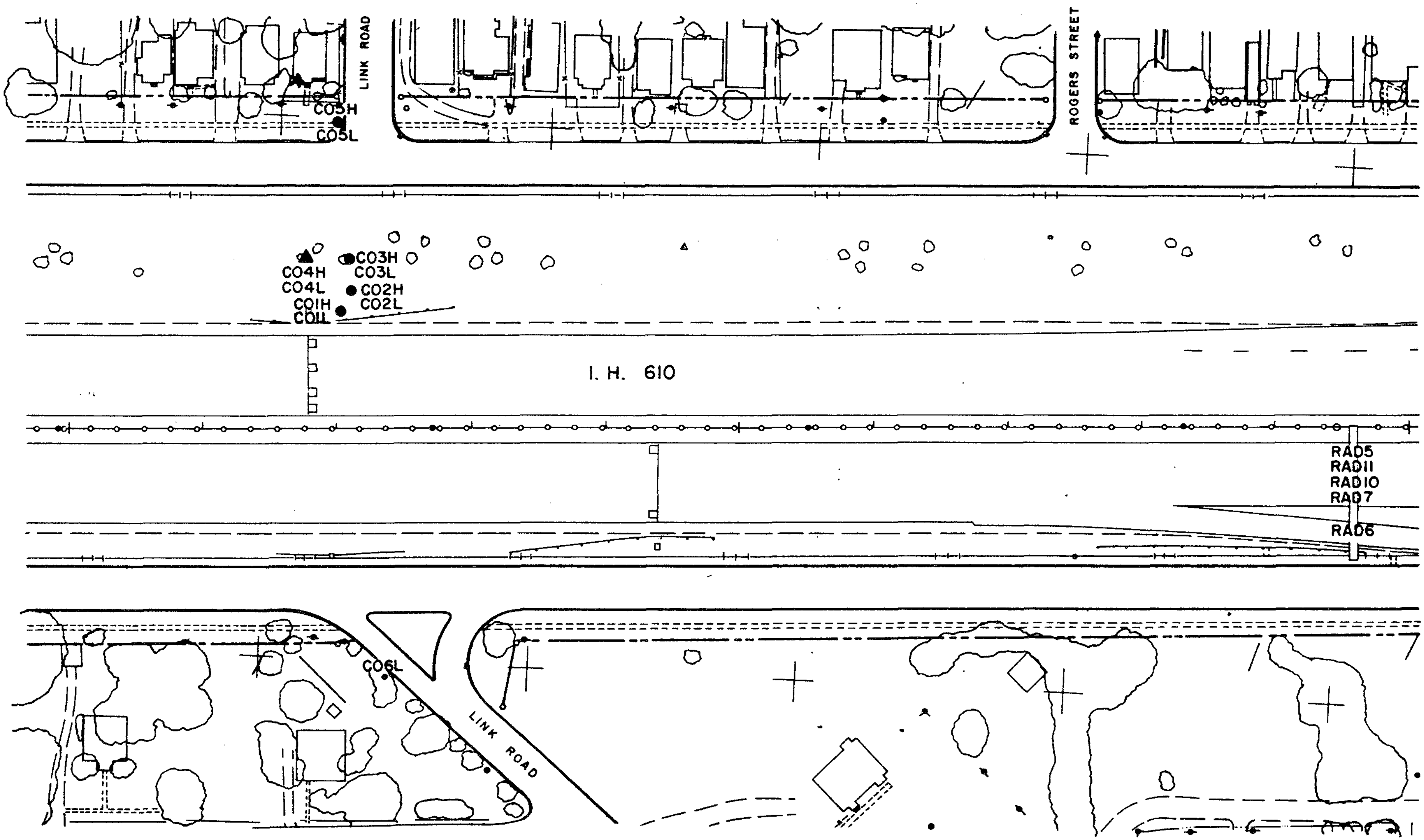
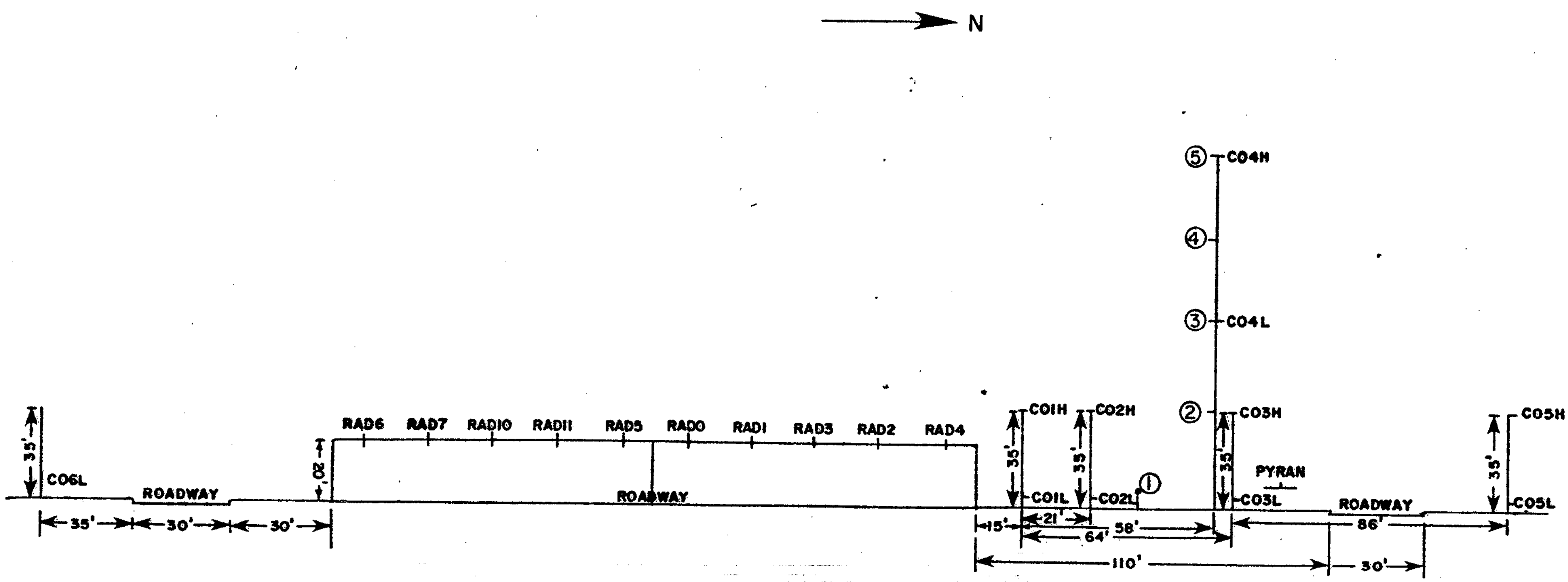


FIGURE 2

INSTRUMENT LOCATIONS

LOOP 610 HOUSTON

① = VA 1.5M, HA 1.5M, TM 1.5M, WV 1.5M, RH 1.5M
② = VA 10M, HA 10M, TMP 10M, WV 10M
③ = VA 20M, HA 20M, TMP 20M, WV 20 M
④ = TMP 30 M, RH 30 M
⑤ = VA 40M, HA 40 M, WV 40 M



Ecolyzers analyze air samples at 20 meters and 40 meters up the tall tower.

The meteorological instruments are located on the tall tower at the locations shown on Figure 2. This tower was located 64 ft. from the roadway. The traffic monitoring radars were mounted on two sign bridges which were 500 ft. to the west and 1100 ft. to the east.

Katy Freeway Site

It was desired in the program to measure the carbon monoxide level from a section of roadway that was below grade which is also known as a cut site. The instrumentation and configuration are somewhat different at the cut site from the at grade site. The presence of a pedestrian overpass with a concrete pipe rack at the cut site greatly simplifies the installation of the equipment. It also provides easy access to service the equipment and for calibration. The site is located at 5200 Katy Freeway and Reinermann Road. At this point the freeway is about 22 ft. below grade. A diagram of the roadway is shown in Figure 3. Katy Freeway runs in an east-west direction and has very light traffic on the service roads. The surface roughness of the area is again trees and one story buildings. This combined with the wide right of way and the pedestrian walkway makes this site a very desirable one. At this location the shoulders of the road way are cut at approximately a 30 degree angle leading down to the pavement.

The instrumentation is deployed as shown in Figure 4. The availability of the pedestrian walkway allows a sample to be taken at the center median between the two directions of traffic. The meteorological equipment is mounted on the tall tower located on the north side of the freeway.

The equipment has been erected at this site and data collection is ready to begin.

FIGURE 3

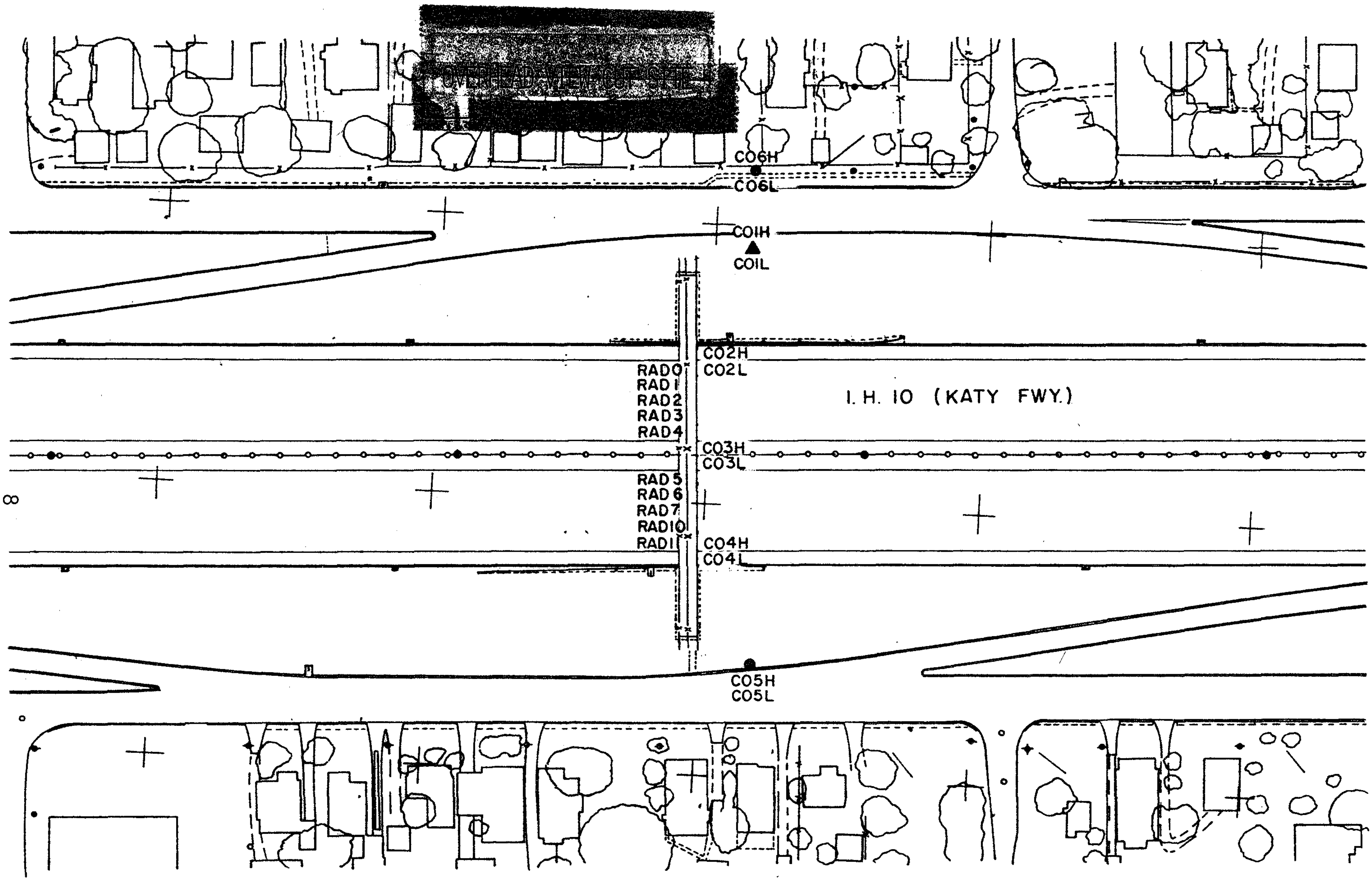
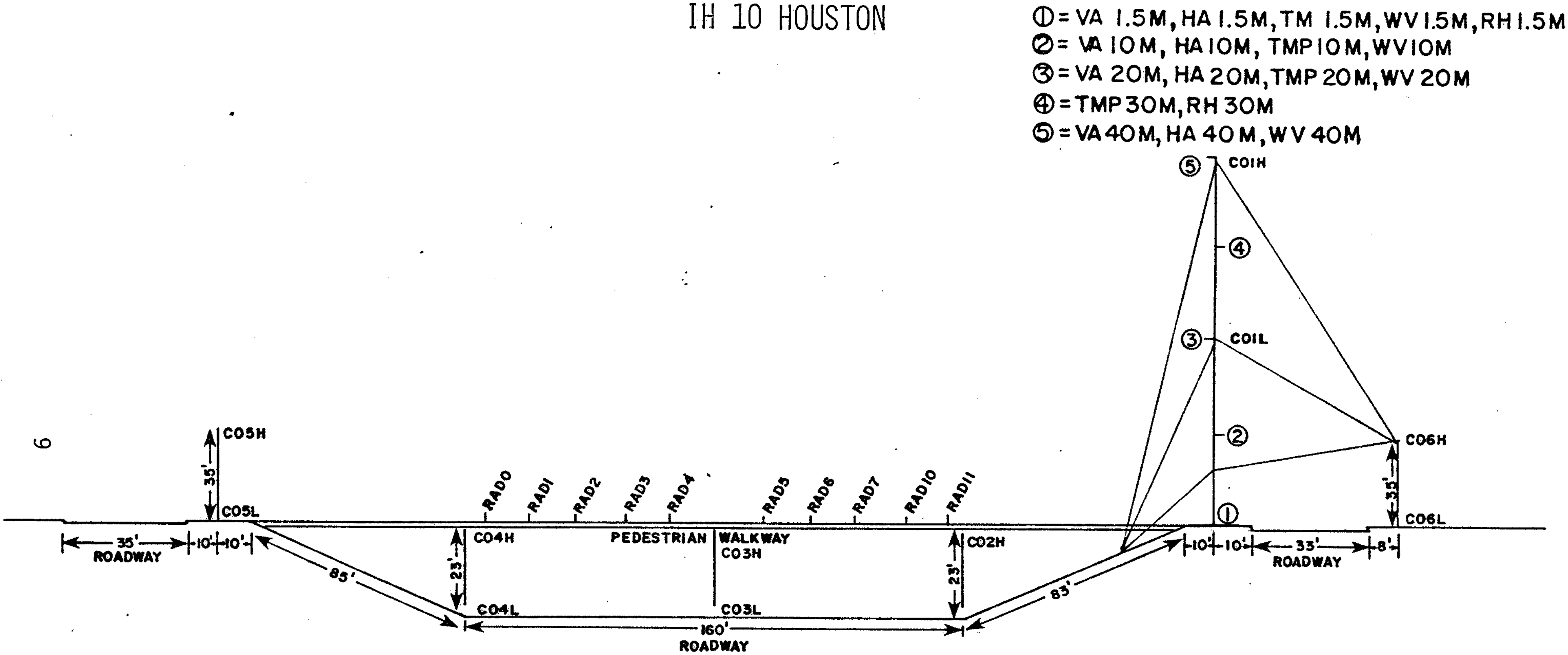

CO6H
CO6L
CO1H
CO1L
CO2H
CO2L
RAD0
RAD1
RAD2
RAD3
RAD4
I. H. 10 (KATY FWY.)
CO3H
CO3L
RAD5
RAD6
RAD7
RAD10
RAD11
CO4H
CO4L
CO5H
CO5L

FIGURE 4

INSTRUMENT LOCATIONS

IH 10 HOUSTON



Chapter III

Experimental Methods

Introduction

An extensive program of experimental measurements is underway for this study. The measurements required for model validation work are traffic measurements, meteorological conditions and air pollution levels. The current program is set up to take all of the required measurements simultaneously by using a minicomputer to read the instruments and record the information on magnetic tapes. All of the instruments are tied to a Data General NOVA 1200 computer through an analog to digital interface. The details of the data handling procedure will be discussed in the next chapter. The systems used to make the experimental measurements will be discussed here.

Data Collection System

For this study, a NOVA 1200 mini-computer with 3 cassette tape drives, a teletype console and a Radian A-D converter is used. The computer is used to read and record onto magnetic tape each instrument at a rate commensurate with the instrument response time and the rate of data fluctuation. Table 1 in page 4 gives each instrument's sampling rate, as well as its six-letter code which the computer uses to name each instrument. The required software program is quite sophisticated and was written by File D-19 of the State Department of Highways and Public Transportation in Austin. This software has been modified in minor ways by the project personnel.

The computer is a very valuable tool in data collection. It can read all instruments effectively simultaneously and can check each instrument reading against a maximum and minimum expected value. This expected value can be set by the operator and varies from instrument to instrument. If a value falls outside the expected range, the operator is so informed by the teletype and a special record is entered on the cassette tape. The rate at which the data are collected for each individual instrument will be discussed in the following sections. (See Table 1, page 4.)

Traffic Measurements

Four traffic parameters must be determined for the purpose of this study. They are the vehicle age mix, heavy duty vehicle fraction, the vehicle count and the vehicle speed. The vehicle age mix must be approximated by using figures obtained from vehicle registrations in the area. The other three parameters were obtained by using a Stevenson Mark 5 Radar Unit mounted over each lane.

These units were obtained from the Department of Public Safety and had to be modified for use on the project. The units were originally designed for use inside of a vehicle and thus were modified by mounting them on 10 inch "C" clamps and providing a weather proof shelter for them.

These devices can give a very fast and accurate measurement of a vehicle speed while the vehicle is within the unit's field of view. The size of the field of view can be varied both in length and diameter by use of the range control adjustment on the unit. To obtain the traffic parameters needed, the units must be used in a special way. Each unit is located directly above a single traffic lane looking down at a 45° angle. The range control is turned down until the indicator needle on the unit just barely detects compact cars. This restricts the units field of view to an elliptical path approximately 15 ft. long and 10 ft. wide at the pavement. This procedure has worked well but an analog integrator has been built which hopefully will give a more accurate reading of the observed length. Because of the angle at which the unit is mounted, the observed vehicle speed is only 71% of the actual value. However, this can be easily corrected by the computer.

The radar units have both an indicator needle and a 0 to 10 volts recorder output. Since a car moving at 60 miles per hour spends only 1/2 of a second in the unit's field of view, the indicator needle does not have time to respond before the car is out of the field. However, due to its speed the computer can obtain the full response from the unit. The radar unit sends a voltage pulse to the computer for each vehicle passage. The height of the pulse is proportional to the vehicle's speed and the number of pulses is equal to the number of vehicles resulting in an accurate vehicle count. These pulses can yield yet another item of useful information. The area under the pulse is proportional to the length of the vehicle. This allows the cars to be separated from trucks, giving an accurate breakdown of the heavy duty vehicle fraction. To obtain the area under the pulse the computer is required to do a numerical integration. Since most pulses coming from the radars are less than 1/2 second long, the radars are monitored at a very high rate of speed. A sampling rate of 100 samples per second was selected as the highest practical rate. At this rate, the NOVA computer is idle only 5% of the time. 94% of the time the computer is processing the radar units. 1% of the time is sufficient to handle all other samples, compute averages, and to run the cassette units and teletype. The numerical integration method used is the fastest in terms of computer time available. The readings are simply summed for the duration of the pulse and then divided by a calibration factor after the pulse is over. The result is then compared to the five length catagories selected by the programmer and the appropriate counter is incremented by one. The speed is also summed with the appropriate vehicle speed accumulator. At the end of each one minute interval the vehicle speed count and length information are averaged and written to the cassette tape.

The five vehicle categories were chosen as category 1-cars, category 2-pick-ups and vans, category 3-light trucks, category 4-heavy trucks, and category 5-calibration. The radar units have an internal calibrate capability and thus can be calibrated periodically.

Several problems arose in the application of the radar units to the project. At the North Loop Site it was discovered that there was a large amount of 60 cycle noise in the lines. Low pass filters were added as a temporary measure and shielded cable was later added to correct the problem. At the North Loop Site the shielded cable completely corrected the problem on the west sign bridge but had no effect on the noise from the east sign bridge. This is currently being investigated and the low pass filter will continue to be used until it is corrected. A second difficulty arose in the range control on the radar units. The 3/4 turn potentiometers used to adjust the range control in the original units was a very course adjustment. The potentiometers were replaced with 10 turn pots which have worked very well.

Meteorological Measurements

Horizontal Windspeed and Direction:

Horizontal windspeed and direction were measured continuously with 6 cup anemometers and windvanes manufactured by Texas Electronics. The starting threshold for the anemometers is 0.75 MPH and 1.0 MPH for the windvanes. The accuracy of the wind speed is ± 1% of full scale and ± 0.5% for the wind direction. The anemometers use the light chopper technique while the wind direction vanes consist of potentiometers in a one volt curcuit.

A Gill propeller anemometer (Model No. 27100) is used to determine the vertical wind speeds. This instrument has a starting threshold of less than .5 MPH and an accuracy of ± 1% of full scale.

In order to obtain a good description of the wind profile, stations containing horizontal windspeed and direction and vertical windspeed are located at heights of 5, 26, 52, and 102 ft. This equipment has been very trouble free. The only problem has been the replacement of the light emitting diode at the top location on the tall tower. Lightning is believed to be the culprit here.

Atmospheric Temperature and Humidity

To obtain information on atmospheric stability, temperature is recorded at 4 different heights. Temperature measurements are made with a Texas Electronics Model No. 2015 Thermistor. These units have an accuracy of ± 0.5% of full scale. One sensor is located at each of the heights 5, 29, 42 and 82 ft. as shown in Figure 1. With such detailed wind speeds and temperature, it is hoped that Richardson numbers may be reasonably accurately calculated.

The relative humidity is measured at two heights of 5 and 82 ft. and with a Texas Electronics Model No. 2013 relative humidity system. The accuracy of the instrument is better than ± 3% relative humidity. The psychrometer measures relative humidity by utilizing the fact that a fiber, such as a hair, will change length in proportion to the amount of water vapor present. As the fiber length changes it causes an inductance change in a coil.

Solar Radiation

The incoming solar radiation is measured with an Eppley pyranometer Model No. 8-48. Due to the low voltage output from this instrument an amplifier had to be constructed for the signal to feed the analog to digital interface. This instrument has worked very trouble free.

Carbon Monoxide Measurements

The concentration of the carbon monoxide levels from the road is measured by model 2600 Ecolyzers. The analyzer uses an acid electrochemical sensor to determine the quantity of carbon monoxide in parts per million, with an accuracy of ± 0.5 ppm. These analyzers are easy to operate, but span and zero drift require very frequent calibrations of the instrument. The accuracy of the instrument is affected by the pH value of the acid in the cell. Thus as the cell ages the accuracy tends to decrease. In addition, under the current operating conditions the instruments exhibit some fluctuations due to internally generated noise. With careful attention and frequent calibration these instruments have provided carbon monoxide levels with a error of no greater than 1 part per million of carbon monoxide.

As shown in Figure 2, carbon monoxide levels are measured at heights of 5 and 35 ft. above the ground and at distances from the road way of 15, 36, 79, and 165 ft. An upwind station at 130 ft. from the road way was also used. The carbon monoxide levels at 47 and 101.5 ft. above ground are also measured at the station located at 56 ft. from the road. The measurements at the elevated sites are made by pulling a sample of air from the elevation down to ground level with a small vacuum cleaner. The Ecolyzers are connected upstream of the vacuum cleaner.

The Ecolyzers are calibrated by attaching bags of calibration gas to the instrument. The normal calibration interval is 2 hours. When the Ecolyzers analyzing samples from the elevated height are calibrated, a manometer is used to insure the flow to the instrument remains the same during calibration as when in actual operation. The samples are drawn from the elevated point through black 1 inch polyethylene thin wall tubing. In all cases the tubing was allowed to sit on the pole for several days before actual use.

All Ecolyzers are read by the computer at the rate of once every 30 seconds. The measured response time of the instrument was about 25 seconds.

A second sampling system consisting of sequential bag samplers is also used. Each bag sampler is composed of a container that holds 24 PVC bags, a pump for each bag, 6 volt dry cell batteries for power and the necessary circuitry for control. During the period of operation, a bag sampler energizes each pump sequentially allowing each one 15 minutes of running time for a total of 6 hours of operation. Thus each bag will yield a carbon monoxide concentration that will be very close to the 15-minute average calculated by the computer for the Ecolyzers. The pumps were set to deliver 60 milliliters per minute, which yields a sample volume of about 900 milliliters. When the bag sampler has cycled through all the pumps, the timer shuts it down. The bags can then be analyzed by an Ecolyzer, non-dispersive infrared instrument or other device.

The bag samplers have proven to be quite troublesome from an operational point of view. The timer sometimes skips over several bags; often the check valves remained open and the sample is lost; and the output of the pumps is rather unstable. In addition there are up to 240 bags to be analyzed which can require 2-1/2 to 3 hours. Finally, once all the bags have been analyzed they must be emptied by hand to remove any residual samples to prepare them for the next sequence.

Hydrocarbons and Nitrogen Oxide Measurements

The instruments to analyze for hydrocarbons and nitrogen oxides are currently being delivered. After a short check out time these instruments will also be used.

Chapter IV

Data Handling

Introduction

As a result of the desire to obtain a dynamic response, data collection in the project occurs at a prodigious rate. Over 15,000 numbers per hour are recorded on cassette tape. A printout of the original data for an eight-hour day would be over an inch thick with twenty numbers per line, thirty lines per page. In its original form, the data are thus nearly worthless. The sheer volume prevents any trends from being noticed. For preliminary data reduction and analysis, the researcher must turn to the computer.

The computer cannot reach conclusions by itself. However, it can manipulate the data in such a way that it becomes useful.

Data Reduction Program

The objective of the data reduction program is to reduce the amount of data from one hundred thousand numbers per day to possibly as few as one thousand. Regrettably, some of the fine detail of the original data is lost, but it suddenly becomes possible to see the whole picture and some pattern to the data.

The data originally resides on a one track cassette in sixteen bit word variable length record blocks. This means each number contains sixteen bits, the collections of numbers (records) are not all the same length, and that a large number of records are output to tape at once in a block. All data are in binary form. Integers are represented directly and character data are represented in ASCII code, two letters per sixteen bit number (word). Record formats can be found in Table 2. The length of type 0,5,11,...17 records is determined by the amount of computer memory available after the program is set up. Sizes of up to 120 numbers/record have been used, but with the addition of more instruments, the size will have to

TABLE 2

Record Formats

Type Ø, 5	Type 1	Type 2,3,6,7	Type 4	Type 10	Type 11, ..., 17
Length	Length	Length	Length	Length	Length
Type	Type	Type	Type	Type	Type
Time high	Time high	Time high	Time high	Time high	Time high
Time low	Time low	Time low	Time low	Time low	Time low
ASCII code	Channel	Channel	Channel	Channel	Channel
	Sample Interval		bad time high	sample interval	Interval
•	data type		bad time low	min expected value	Lost data count
	max expected value		bad value	max expected value	min expected value
•	min expected value			begin time high	max expected value
	calibration factor			begin time low	sample value
•	zero adjustment factor			end time high	sample value
	ASCII code			end time low	
ASCII code	ASCII code			veh 1 count	•
	ASCII code			veh 1 spd high	•
				veh 2 count	
				veh 2 spd high	•
				veh 2 spd low	sample value
				•	
				•	
				•	
				Veh 5 count	
				veh 5 spd high	
				veh 5 spd low	

be dropped to 40 numbers/record until an additional 8K of memory arrives.

Data in this form are easily handled by NOVA computers. However, the AMDAHL 470 V6 used at Texas A&M cannot read cassette tape. For this computer to reduce the data it is first necessary to have them transferred from cassette onto nine track computer tape which the AMDAHL can access.

This transfer is done by a direct copy method. No changes or checks are made by the transferring program. Thus, the nine track tape obtained still contains the data in its original recorded form. This form is incompatible with IBM (and AMDAHL) standard conventions, and as a result, the standard software for unpacking the blocks into individual records and for breaking the records into individual numbers cannot be used. The records must be broken down by programmer written software and then repacked in the standard conventions. The program to do this has been labeled Set A and a copy can be found in Appendix A.

This makes it very easy for the Set B program to get to the individual records. Set B has two functions to perform. It converts all the integers to more useful forms and it sorts the data, getting together all records dealing with a particular channel. The conversion comes in two parts. First all character data must be converted from ASCII to EBCDIC, which is used by the AMDAHL to store characters. Secondly, all instrument readings are more useful in floating point numbers than as raw integers: 2.5 ppm is easier to comprehend than 100 A/D counts. The data is thus restructured and then temporarily stored on a scratch disk.

The sorting is then handled by a standard IBM OS Sort/Merge Utility. This packaged program can very rapidly sort as much data as there is external scratch space. It pulls the stored data from disk and sorts them first by date, by channel, by record type and by time in that order. It then outputs the result to standard nine track tape.

In this form, the data are ready for the third part of the data reduction called Set C. An example of Set C can be found in Appendix C. In the same appendix is a sample of the results of this program. This is the real data reduction program. It takes the modified and sorted data and uses them to calculate total traffic counts and speeds and instrument means and standard deviations for every instrument for a given time period. Five-, fifteen-, and sixty-minute intervals were chosen as representative, but those can be changed as desired.

Format of Computed Averages

The data printout as shown in Table 5 (page 56) contains a somewhat graphic picture of where the instruments are located. Titles were omitted in order to achieve two averages per page of printout and cut down on the high cost of computer printing. The center of the average contains the traffic counts of the ten radars and the observed average speeds. The eleventh column on the right contains the total vehicle count for each type of vehicle along with the average speed for each type. The rows represent the vehicle types aforementioned. The sixth row is the total by lane count of all vehicles with their average speed. The three numbers below the table are the count and speed in each direction and the grand total count and average speed. It can be noted in passing that the 55 mph speed limit was being observed only in the exit lanes and during traffic jams. The upper right hand corner contains all meterological data. The columns are from left to right: Vertical windspeed in tenths of a mile per hour, horizontal windspeed in miles per hour, wind direction in degrees, temperature in degrees Fahrenheit, and radiation in watts per square meter and relative humidity in per cent in the last column. The vertical arrangement of the numbers represents the arrangement of the instruments except that the higher relative humidity readings should be level with the top thermometer reading.

The third section of the average is the lower right and the lower left. These readings represent the carbon monoxide levels in parts per million. The background instruments are separated from the rest of the instruments by the traffic table, and the arrangement of the entries on the right hand side is identical to the arrangement of the instruments at the site.

It should be noted that each entry for the meteorological instruments and carbon monoxide monitors is double. The upper number of each pair is the mean instrument value for the time interval, and the lower number is the standard deviation of all the values. It should be noted that the Ecolyzers require some special handling in this program. Since their zero and span tend to drift, they were calibrated at approximate two-hour intervals. The procedure followed was to issue a Begin Calibrate record (Type 2), ground the A/D input for the channel, rezero the instrument, attach a bag of gas of known CO concentration, reattach the instrument to the A/D, wait 30 seconds, reground the A/D input, wait one minute, reattach the instrument to the A/D and issue an End Calibrate record (Type 3) for the channel. An attempt was made to also read the zero drift before rezeroing the instrument, but study showed that zero drifts were sudden and drastic, although small enough to be completely masked by the minute-to-minute fluctuations in the CO level. However, at very low CO levels, the zero drift can approach 30% of the instrument reading. Thus, no correction could be applied and the obtained value was worthless. Span drift, however is smooth and gradual as far as is known. Thus, a linear correction factor was applied. These corrections were fairly small ($\approx$ 10%). If during any averaging period, more than one fourth of the data is missing for an instrument, the average is dropped and is replaced in the output with stars.

Due to the averaging of the results, much of the fine detail is lost. However, by using the results of the averaging program, better methods can be found for analyzing the data at a later date. At present, the averaging program is sufficient for the project needs and provides an adequate data base for preliminary conclusions.

Chapter V

Diffusion Model Analysis and Development

Introduction

In attempting to comply with the laws requiring environmental statements for construction and modification of roadways, several research programs have been undertaken. These programs have met with varying degrees of success. Many people have attempted to develop models to predict pollutant concentrations from roadways with no experimental verification whatsoever. Essentially all of the experimental data collection programs which have been undertaken are discussed here. All of the major dispersion models are also reviewed. All work to date excluding the present experimental work is based on the concept of one-hour samples and averages. This is the largest data base on dispersion from roadways ever assembled and the first extensive comparison of previous models.

Discussion of Previous Experimental Data Collection Programs

Tennessee Data

The data obtained by Noll, Miller, Rainey, and May (1975) were taken at Gallatin Road in north Nashville, Tennessee. The road used was a five-lane at-grade highway with a total width, including shoulders, of 80 feet. The area around the highway is essentially a flat, open field.

Traffic counts were taken continuously with pneumatic counters. This device counts each vehicle axle crossing the detector. In order to assure good data, no more than two lanes of traffic were monitored with one pneumatic counter. Fifteen-minute averages of double axles were recorded and used to obtain values for the traffic flow in vehicles per hour. Vehicle speed was monitored with radar units and with a clocking method. This clocking method consisted of timing vehicles over a known distance and calculating the speed from the time obtained. The radar unit was not considered to give good representative route speeds; therefore, the clocking method was preferred. A course length greater than 500 feet and a stop watch were used in providing the route speed. The heavy duty vehicle mix was obtained by manual counts.

The wind speed and direction were continuously monitored with mechanical wind instruments at a height of 10 meters. The data were recorded onto strip chart paper. The wind instruments were checked for calibration twice daily.

Three different methods were used in obtaining CO samples.

1) on-line continuous sampling
2) intermittent sequential sampling (ISS)
3) fifteen-minute integrated sample

The on-line sampling was used to obtain data at a single point with the results being recorded on to strip chart paper. The ISS method involved several sampling points connected to a common manifold. This allowed all the sampling to be done with one analyzer. The integrated samples were obtained with bag samplers. The samples were later collected and analyzed.

The type of bag used was an aluminized polyester (Scotchpak) bag. As discussed in a succeeding section, this type of bag was found to be the best suited to hold carbon monoxide.

In analyzing for carbon monoxide, two instruments were used, a Beckman Model 315-BL non-dispersive infrared (NDIR) absorption instrument, and an Energetics Science Ecolyzer coulometric titration instrument. The error of the NDIR can be considered to be 1 percent of full scale, which translates to $\pm$ 1 ppm. The span drift of an Ecolyzer is $\pm$ 1.0 percent of full scale, which translates to an error of $\pm$ 1 ppm. The zero drift of the Ecolyzer is $\pm$ 0.5 percent of full scale which translates to $\pm$ 0.5 ppm. In addition, the instrument accuracy is $\pm$ 1 ppm. It should be noted that the above figures are for an Ecolyzer which has a new electrochemical sensor and is calibrated frequently (approximately every two hours).

The instruments used were calibrated after each peak traffic hour's sampling runs with a certified 38 ppm carbon monoxide span gas. From the above discussion, an estimated accuracy of $\pm$ 1.5 ppm for instrument readings was obtained.

North Carolina Data

The data presented by Noll (1973) were taken at the First Street - Hawthorne exit of Interstate 40 in Winston-Salem, North Carolina. This is a four-lane, at-grade highway with a total width of 56 feet.

Traffic volume data were taken with two electrical traffic counters, one in each directional lane group. Fifteen minute averages of the double axles were recorded and used in obtaining an hourly traffic volume. The average route speed was determined using the "floating car" technique, and the heavy duty vehicle mix was determined by manual count.

The wind speed and direction were continuously monitored with mechanical wind instruments at a height of 12 feet (3.66 meters) and recorded onto strip chart paper.

Similar to the previous data set, three different procedures were used in obtaining carbon monoxide samples. These were

1) Continuous on-line sampling
2) Short period cycle sampling
3) Fifteen minute integrated sample

Here again, on-line sampling was performed to obtain data at a single point. The short period sampling involved several sampling points connected to a common manifold, which allowed the sampling to be done with one instrument. Bag samples were taken every 15 minutes and later analyzed. As in the previous data set, aluminized polyester (Scotchpak) bags were used. The same type of instruments were used here as were used in the previous data set. Calibration of the instruments was performed at least three times a day with a two point certified zero span gas and upscale span gas. The accuracy of these data sets was estimated to be ± 1.5 ppm.

Virginia Data.

The data given by Carpenter, Clemena, and Lunglhofer (1975) were taken at several sites in Virginia. The locations of interest are

1) Interstate 495 near Telegraph Road in Fairfax County Virginia
2) Interstate 64 near Hampton Boulevard in Norfolk, Virginia
3) Interstate 64 near Norview Avenue in Norfolk, Virginia

The first is an at-grade, six-lane, dual-divided highway with a 37-foot median. One side of the highway is open while the other side contains scattered single family housing. The second site is an at-grade, six-lane, dual-divided highway with a 60-foot median. The land use in this area is primarily agricultural. The third site is an at-grade, six-lane, dual-divided highway with a 60-foot median. Both sides of the roadway contain single story houses.

Traffic counts were taken manually for each test period. A radar unit was used in determining vehicle speed, and the resulting data were recorded onto strip charts. Calibration of the radar units was done every two hours of continuous use.

Wind speed and direction were continuously monitored at a height of 10 meters during each test period. This was done with mechanical wind instruments.

Bag samplers equipped with aluminized polyester (Scotchpak) bags, were used in obtaining samples for carbon monoxide analysis. The one hour integrated samples were simultaneously collected at the sampling points of a roadway site. The samples were collected and analyzed at the end of each day with a gas chromatograph. Calibration of the chromatograph was done daily using a certified span gas. Since the zero and span drift of a gas chromatograph are negligible, the instrument was considered to be very accurate. The estimated accuracy of the gas chromatograph was estimated at 1 percent of scale, which translates to ± 0.1 ppm.

Illinois Data:

The data given by Habbeger, et al. (1974) were taken on Interstate 55 near Cicero Avenue in Chicago, Illinois. This is an at-grade, six-lane highway with a 61-foot median. One side of the roadway is an open field and the other had some residential and commercial buildings.

Traffic counts were performed manually for two 5-minute intervals, evenly spaced, every hour. These values were then used in determining the hourly traffic flow. The route speed was determined by clocking vehicles over a predetermined distance. Heavy duty vehicle counts were done manually.

Wind speed and direction data were obtained with a mechanical weather station at a height of about nine feet.

Carbon monoxide samples were obtained with a bag sampler equipped with aluminized polyester bags. The 60-minute integrated samples were analyzed with an Ecolyzer. The instrument was calibrated daily with a span gas and also tested for calibration against a gas chromatograph. Since the Ecolyzer was calibrated only once daily, the accuracy associated with this instrument may range from ± 1 ppm to as much as ± 3 ppm. As previously noted, an Ecolyzer needs frequent calibration in order for its accuracy to remain in the range of ± 1 ppm. Hence the accuracy of this data set was estimated to be ± 2.5 ppm.

California Data

The data given by Ranzieri, Bemis, and Shirley (1975) were for the San Diego Freeway at Weigh Station in Los Angeles, California. This is an at-grade, 8-lane highway with a total width of 138 feet. The highway is surrounded by an open grassy field on one side and a golf course on the other.

The traffic data for this site were obtained from yearly traffic census pads located approximately one-quarter of a mile from the site. The route speed was determined by the "floating car" technique. This was done during peak and off-peak traffic hours.

The wind speed and direction data were monitored with a mechanical weather station at a height of 10 meters and recorded onto strip chart paper.

Carbon monoxide samples were obtained with bag samplers equipped with aluminized polyester (Scotchpak) bags and analyzed with a Beckman model 315BL nondispersive infrared (NDIR) analyzer. The analyzer was calibrated once daily with a zero and 90 ppm span gas. Because of the tendency of an NDIR to remain within its design zero and span drift limits, the lack of frequent calibration did not present a serious problem. The accuracy obtained by this instrument was estimated to be 1 percent of full scale which translates to $\pm$ 1 ppm.

Analysis of Instrument Error:

In arriving at a valid estimation for the error of measurement, the accuracy of the above instruments was considered.

The design specifications of the instruments used are listed in Table 3. From the accuracies given in this table, an error of $\pm$ 1 ppm seems appropriate for all the readings.

It should be noted that the zero and span drift on the Ecolyzer are a function of the age of the electrochemical sensor used in the instrument. The sensors used have a shelf life of 120 days and must be replaced at the end of this period to ensure accurate results. Using 10-month old sensors and a certified span gas, it was found that the zero drift was 1.5 ppm and the span drift was 2 - 3 ppm in an eight-hour period. Hence, the accuracy indicated in Table 8 may be overestimated for the case of old sensors.

TABLE 3. Accuracy of Instruments Used in Data Acquisition

Instrument	Zero Drift per 24 hours	Span Drift per 24 hours	Accuracy	Scale Used
Beckman Model 315BL NDIR	1 percent full scale	1 percent full scale	± 1 percent full scale	0 - 100 ppm
Energetics Science Ecolyzer Model 2400	0.5 percent full scale	1 percent full scale	± 1 percent full scale	0 - 50 ppm
Gas Chromatograph	1 percent full scale	1 percent full scale	± 1 percent full scale	0 - 10 ppm

Effect of Bag Sampler Materials on the Accuracy of Measurement:

The bag materials used in the bag samplers may greatly affect the validity of the data obtained. In a special study, Ranzieri, Beamis, and Shirley (1975) tested several bag materials. The materials tested were aluminized polyester (Scotchpak), clear Mylar, and opaque Mylar. Tests showed the Mylar bags yielded consistently higher carbon monoxide (sometimes more than double) readings than the Scotchpak bags when collecting the same ambient sample. Thus, the aluminized polyester bags were found to be made suitable for carbon monoxide sampling. It was also found that there is no decay in CO concentration when the sample is held (for up to 92.5 hours) in a bag made of Scotchpak. The aluminized polyester bags have also been tested and accepted by the California Air and Industrial Hygiene Laboratory in Berkeley, California. Since all the bags used in obtaining the data presented were made of Scotchpak, it is assumed that the carbon monoxide concentrations were not altered by the bags.

Discussion of Previous Model Development Programs

CALINE-2

This model is based on the work of Turner (1970), and Ranzieri, et al. (1975). CALINE-2 employs a fixed box model together with a Gaussian dispersion model. The box model is used to simulate the initial dispersion of pollutants caused by the mechanical turbulence from the moving vehicles. The box model assumes the emissions are uniformly distributed over the roadway and up to a fixed height termed a "mixing lid". The height of this lid was empirically derived from an experimental program known as "Project Smoke" performed by the California Division of Highways (1972). The mixing height was determined to be about 12 feet. The width of the box is determined by adding the width of all the traffic lanes, plus the median and an extra distance equal to about 10 feet on each side of the highway.

The concentrations at a downwind distance from the roadway are predicted through the use of both the continuous line source equation and the continuous point source equation. The assumption made in obtaining the solutions to these equations are

1.) Gaussian distribution in both horizontal and vertical planes
2.) Dispersion coefficients are a function of downwind distance
3.) The wind speed is constant with height.
4.) Dispersion is independent of site topography.

The equations used in the model are for crosswind line sources:

$$\Psi_c = \frac{Q_1 F_1}{\sqrt{2\pi}\ \sigma_z u} \left\{ \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)\right] \right\} \qquad (1)$$

where

Q_1 = VPH x EF
VPH = vehicles per hour,
EF = emission factor
H = height of pavement above ground surface
F = conversion factor

For parallel wind line sources:

$$\Psi_p = \sum_{i=1}^{\infty} \frac{Q_2\ F_2}{2\pi\sigma_{y_i}\ \sigma_{z_i}\ u} \left\{ \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_{y_i}}\right)^2\right] \right\} * \left\{ \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_{z_i}}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_{z_i}}\right)^2\right] \right\} \qquad (2)$$

where

$Q_2 = Q_1$ x W
W = highway width

The assumption is made that a highway with a parallel wind can be approximated by the summation of a series of square area sources, each having the same source strength but at a different distance from the recepter. The area sources are, in turn, approximated by virtual point sources.

For oblique winds (0 deg < angle < 90 deg), the downwind concentration is calculated through the use of the trignometric identity, $\cos^2\theta + \sin^2\theta = 1$. The concentration is assumed equal to

$$\Psi_o = \Psi_c \sin^2\theta + \Psi_p \cos^2\theta \qquad (3)$$

A preliminary verification study reportedly supports this assumption.

Hiway:

This model developed by Zimmerman and Thompson (1974) and based on Turner's (1970) work is the Environmental Protection Agency's model. The calculational procedure is centered around a numerical integration of the Gaussian plume point source equation for a finite length.

The predictive equation used by Zimmerman and Thompson for stable conditions is expressed in the form

$$\Psi_H = u\Psi_p \qquad (4)$$

For the unstable or neutral cases, if σ is greater than 1.6 times the mixing height, L, the concentration below the mixing height is independent of height and is given by

$$\Psi_H = \frac{1}{(2\pi)^{1/2}\sigma_y L} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \qquad (5)$$

For other unstable or neutral conditions, Hiway uses a form suggested by Bierly and Hewson (1962) which accounts for plume trapping

$$\Psi_H = \frac{1}{2\,\sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y^{\;2}}\right)^2\right] \left(\exp\left[-\frac{1}{2}\left(\frac{z-h}{\sigma_z}\right)^2\right.\right.$$

$$+ \exp\left[-\frac{1}{2}\left(\frac{z+h}{\sigma_z}\right)^2\right] + \sum_{n=1}^{j} \left(\exp\left[-\frac{1}{2}\left(\frac{z-h-2n^L}{\sigma_z}\right)^2\right]\right.$$

$$+ \exp\left[-\frac{1}{2}\left(\frac{z+h+2n^L}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z-h+2n^L}{\sigma_z}\right)^2\right]$$

$$\left.\left.+ \exp\left[-\frac{1}{2}\left(\frac{z+h+2n^L}{\sigma_z}\right)\right]\right)\right) \qquad j = 1,4 \tag{6}$$

Figure 6 shows an overhead view of the geometry of an at-grade section of roadway as seen by the model. The line sources are shown as dashed lines in each lane with the source length specified by (R_1,S_1) and (R_2,S_2) and a receptor location designated by (R_K,S_K). As can be concluded by Figure 7, for a given receptor at (R_K,S_K) and a point (R,S), x downwind distance, and y croswind distance are given by

$$x = (S - S_K)\cos\theta + (R - R_K)\sin\theta \tag{7}$$

$$y = (S - S_K)\sin\theta + (R - R_K)\cos\theta \tag{8}$$

respectively.

Noting that x and y are implicit functions of ℓ, where ℓ is the source path, the concentration can be found by integration

$$\Psi = \frac{Q'}{u}\int_0^{\overline{AB}} \Psi_H \, d\ell \tag{9}$$

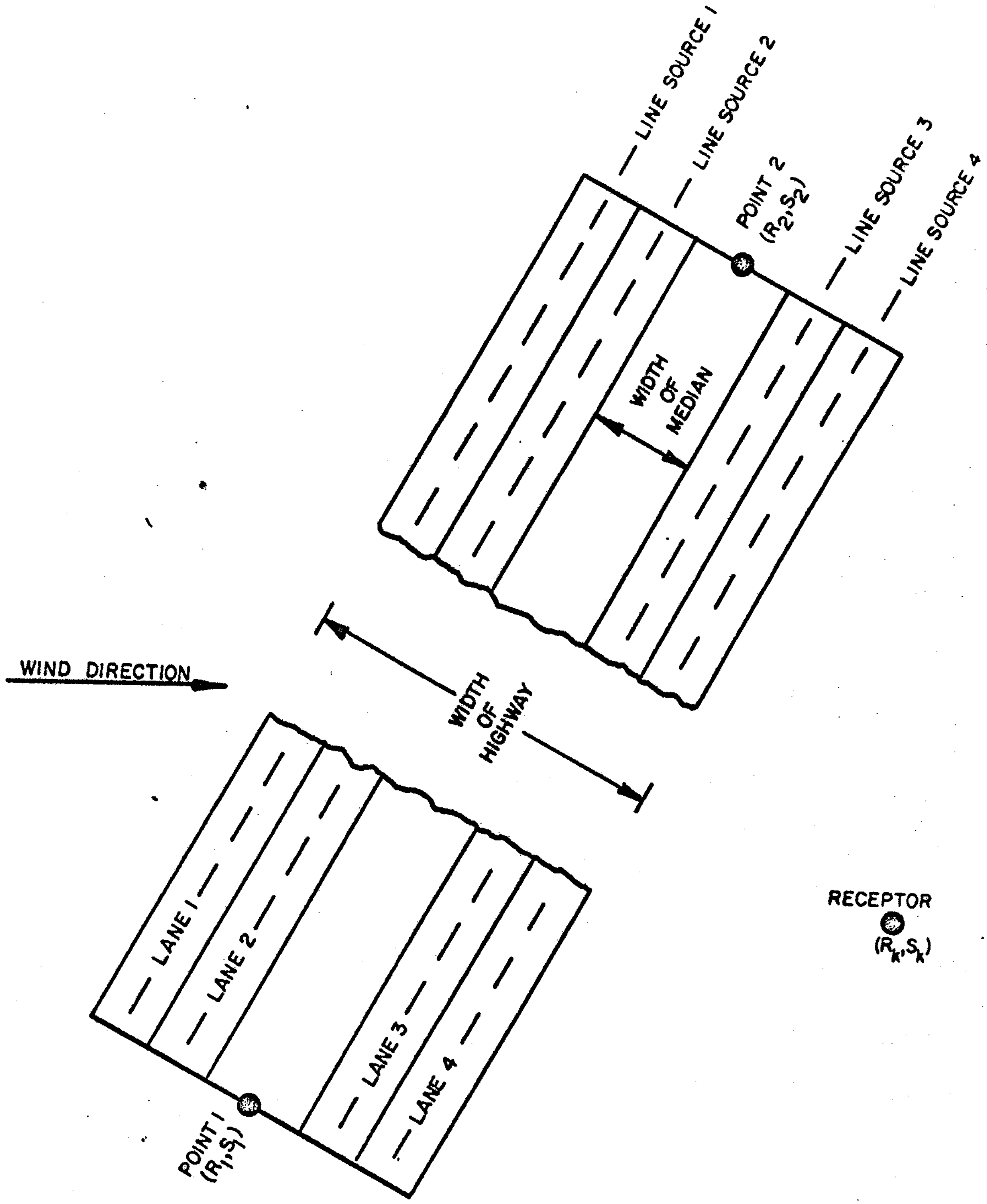


FIGURE 6. OVERHEAD VIEW OF AT-GRADE SITE AS SEEN BY HIWAY MODEL (from Zimmerman and Thompson (1974)).

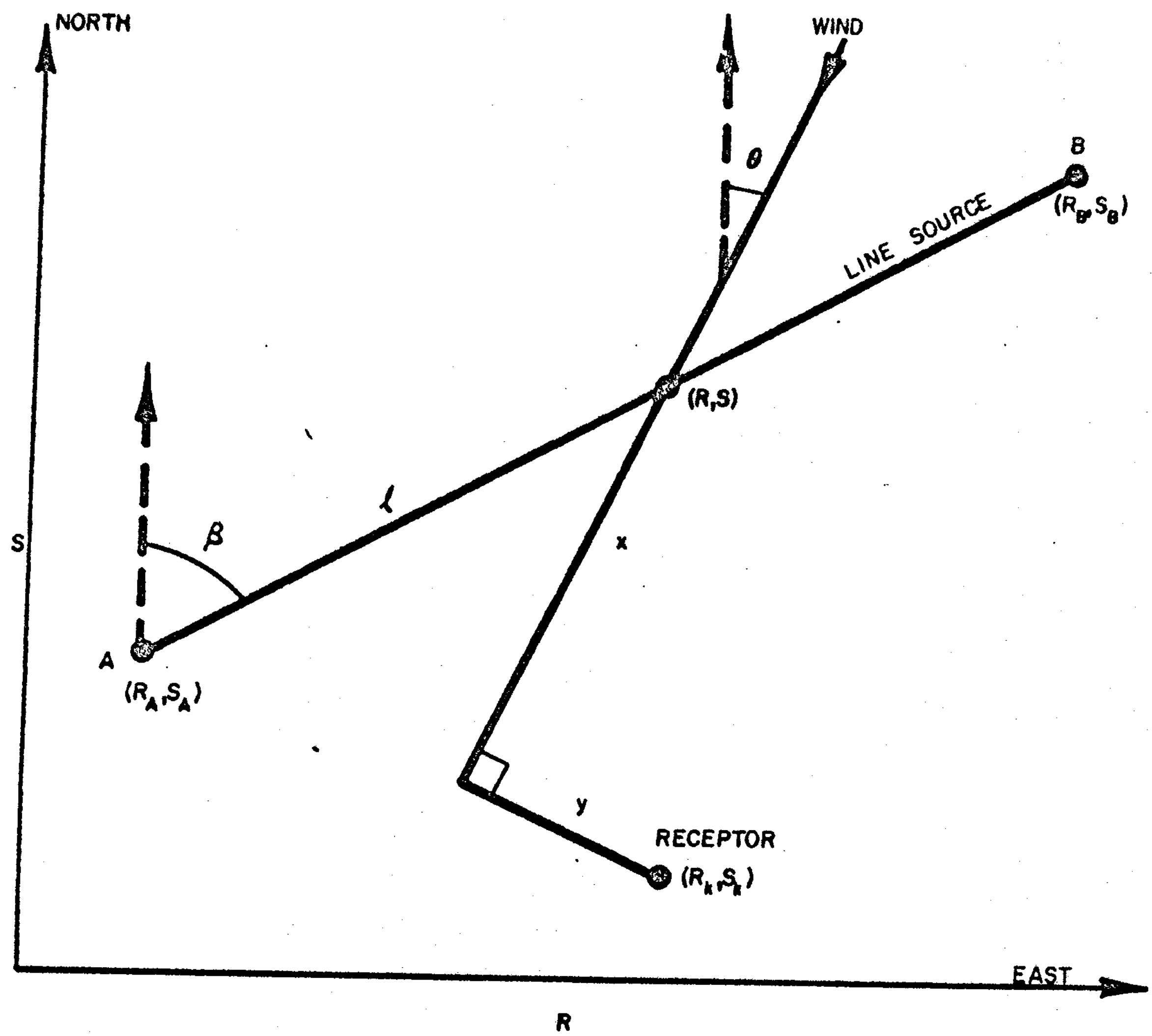


FIGURE 7. COORDINATE SYSTEM USED BY HIWAY MODEL (from Zimmerman and Thompson (1974)).

where the upper limit of integration is the source length (see Figure 7). This model employs a trapezoidal approximation for the numerical integration.

The dispersion coefficients used in this model are obtained from Pasquill-Gifford curves. To obtain estimates for the dispersion coefficients where a downward distance is less than 0.1 kilometers, an extrapolation of the existing curves is used.

Airpol-4:

This model, developed by Carpenter and Clemena (1975), also uses a Gaussian type of formulation. Although this model predicts both upwind and downwind concentrations, only the latter will be considered here.

Airpol-4 is unique in that it uses two Euclidean coordinate systems, the receptor and roadway coordinate systems. These are illustrated in Figure 8. The method employed calls for the mapping of the roadway coordinate system onto the receptor coordinate system. The transformation

$$T:(o,r,h) \xrightarrow[\text{roadway}]{} (p,dist,z) \tag{10}$$

is performed by the use of

$$\begin{aligned} p &= -d(\cos\theta) + r(\cos\theta) \\ dist &= d(\sin\theta) + r(\cos\theta) \\ z &= h \end{aligned} \tag{11}$$

The authors of this model point out that this transformation is advantageous since it allows the equation to be integrated over all roadway points contributing to the pollution at a particular point.

$$\Psi(x,y,z,h) = \frac{Q}{2\pi\sigma_y\sigma_z u} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \left(\exp\left[-\frac{1}{2}\left(\frac{z-h}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+h}{\sigma_z}\right)^2\right]\right) \tag{12}$$

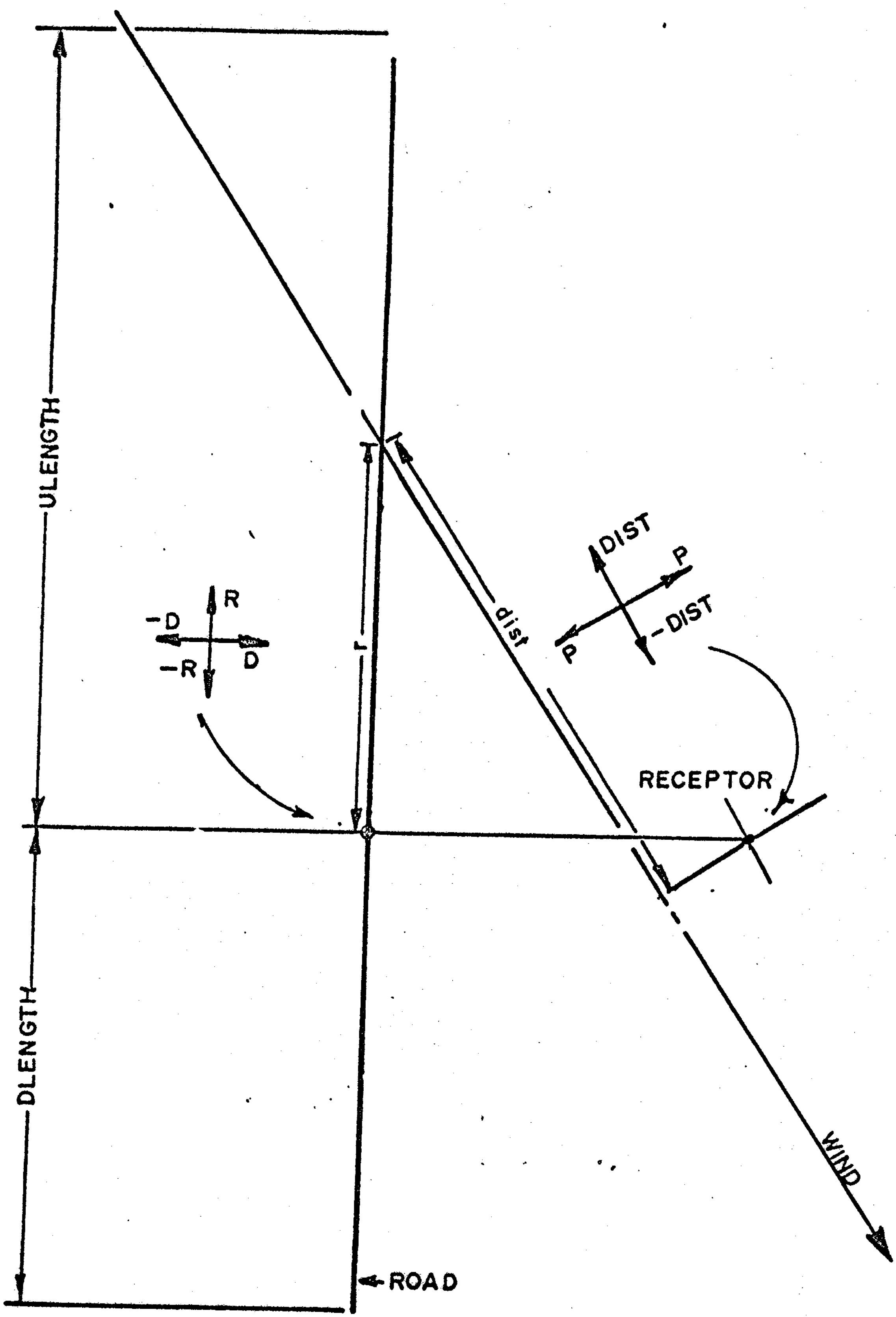


FIGURE 8. COORDINATE SYSTEM USED BY AIRPOL-4 (from Carpenter and Clemena (1975)).

Since the Pasquill-Gifford σ_y are based on sampling times of 3 to 10 minutes, the effect of horizontal micro-wind variations are ignored. Following Turner's (1970) suggestions, the authors of Airpol-4 developed a method to adjust the Pasquill-Gifford σ_y values. This was done through the use of a power law relationship

$$\frac{(\sigma_y)_{t2}}{(\sigma_y)_{t1}} = \left(\frac{t_2}{t_1}\right)^p \tag{13}$$

t = time

where the exponent p is a function of stability.

Carpenter and Clemena (1975) also solve the mathematical difficulty presented when a dispersion function is expressed as

$$\Psi \propto 1/u \tag{14}$$

It is clear that as the wind speed approaches 0, Ψ approaches infinity. Airpol-4 uses

$$\Psi \propto 1/(u + 1.29 \cdot \exp(-0.22 \cdot u)) \tag{15}$$

which is bound by finite limits and therefore is not subject to the difficulty presented above.

Now, using the above information, the problem of predicting the concentration is reduced to evaluating

$$\Psi = \frac{Q'}{2\pi u}\int_{M}^{UL}\left\{\frac{\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]}{\sigma_y} \cdot \frac{\exp\left[-\frac{1}{2}\left(\frac{z-h}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+h}{\sigma_z}\right)^2\right]}{\sigma_z}\right\} dr \tag{16}$$

where (note: see Figure 8)

UL = the distance roadway extends in a straight line upwind from the point $(0,0,h)_{roadway}$

DL = the distance the roadway extends, in a nearly straight line, downwind from the point $(0,0,h)_{roadway}$

M' = distance between intersections of R and P axes and $(0,0,h)_{roadway}$

M = max (M', -DL)

Since numerical integration of the above equation with a digital computer is costly, a mathematical technique is used in evaluating the integrand. The authors of Airpol-4 found that, in the neighborhood of $\theta \simeq 90^{o}$, the integrand behaves much like

$$g(r) = a\ e^{-(ar)^2} \tag{17}$$

where r is defined in Figure 8,

and

$$a \simeq (\sigma_y + \sigma_z) \tag{18}$$

In the neighborhood of $\theta \simeq 0$; the integrand behaves much like

$$h(r) = \frac{e^{-(\frac{a}{r})^2}}{r} \tag{19}$$

By using the above reproductive models of the integrand, the computation time is greatly reduced.

EMP-1:

This is an empirical model developed by Noll, Miller, Raney, and May (1975). This model was derived through a dimensional analysis of the form

$$\Psi \propto \frac{kQ}{u'(x/\sin\theta)^{a}} \tag{20}$$

where

x = downwind distance

k & a = empirical coefficients

u' = component of mean wind velocity normal to road

By performing a regression analysis on $\ell n(\Psi u'/Q)$ versus $\ell n(x/\sin\theta)$ Noll obtained values for the constants in the above equation. The calibrated equation is

$$\Psi = \frac{8.18\, Q'}{u'(x/\sin\theta)^{1.106}} \tag{21}$$

Model Validation:

The above models were all initially calibrated by their developers, with limited data. This calibration was performed through the use of a calibration coefficient in the predictive equation or by calibrating the dispersion coefficients. With the calibration performed, these models were tested for accuracy against the same data that were used in the calibration. In doing this, one may expect good results because the same data were used to "fit" the model as were used to validate it. A test of these models with independent data sets is needed before the validity of each model may be determined.

Upon reviewing the above models, it is apparent that many assumptions concerning micrometeorological parameters have been made. Furthermore, it seems that the validation of these models is inconclusive. In view of this, a model which takes into account meteorological phenomena and is also validated with several independent sets of data is presented.

Development of Improved Model

As can be seen from a review of the attempts to model pollutant dispersion from roadways discussed in the previous section, the major assumptions in the models are:

1.) Gaussion distribution of pollutants in both horizontal and vertical planes.

2.) Both horizontal and vertical dispersions are functions of stability and downwind distance traveled from the source and not a function of height.

3). Diffusion is independent of site topography.

4). Wind speed is constant with height.

The main difference in the models discussed in the previous section is in the methods used to obtain values for the dispersion coefficients. These assumptions result in diffusion equations which are easily solved and require simple input information. Table 4 summarizes the dispersion coefficants used by each model.

To remove the last three of the above restrictions which are known to be in error, a more general solution to the diffusion equation was found, i.e.

$$\Psi\ (X_o, Z) = \frac{Q'r}{u_1\Gamma(s)} \left(\frac{u_1}{r^2K_1x_D}\right)^2 \exp\left[\frac{-u_2Z^r}{r^2K_1K_o}\right] \qquad (22)$$

where

$r = \alpha - \beta + 2 > 0$

$s = (\alpha + 1)/r$

α = function of wind profile

β = function of stability

$\Gamma(s)$ = Gamma function of s

$x_o = x + x_1$

K_1 = eddy diffusivity at reference height of 1m

u_1 = reference wind velocity at 1m

x_o = downwind distance from virtual origin

Z_1 = reference height = 1m

This equation as used here is valid only for the reference height $Z_1 = 1$ m. The virtual origin concept is used when an initial dispersion of pollutants is assumed and is shown in Figure 5. The virtual origin is a hypothetical source that would produce a plume having a width equal to that of the source at its location.

Thus equation 22 allows for 1) the variation of the mean wind speed in the vertical direction, and 2) variations in surface roughness and variations in atmospheric stability. However, sensitivity analysis run on the model showed that variation in atmospheric stability had negligible effect on the predicted concentrations. Therefore, the stability variation was dropped from the model.

The well known logarithmic velocity profile

$$u(z) = \frac{u_*}{k} \ln (z/z_o) \tag{23}$$

where

u_* = friction velocity

z_o = surface roughness parameter

k = von Karmons constant

was used to describe the velocity in the model. The surface roughness parameter can be calculated from

$$z_o = 0.15\ h_c \tag{24}$$

where

h_c = mean height of actual surface roughness elements

The friction velocity may be calculated from a measurement of the actual wind velocity at a one meter height for a particular site

$$u_* = \frac{0.4\ u_1}{\ln (z_1/z_o)} \tag{25}$$

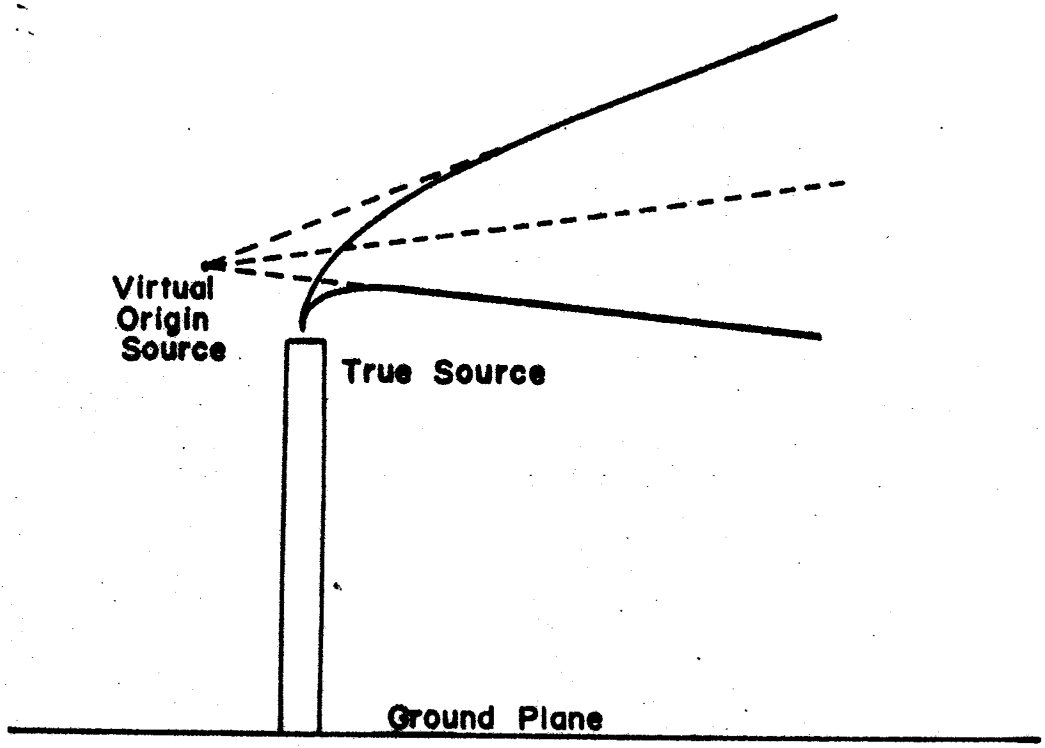


Figure 5. Virtual Origin Concept

where u_1 is the measured velocity at height z_1. In the calculational procedure for the model, the virtual origin distance is found by minimizing the function

$$G(x') = \sum_{i=1}^{4} (\Psi_i - \chi_i)^2 \qquad (26)$$

where

Ψ = concentration calculated by equation 24

χ = concentration at downwind edge of roadway

x' = distance of virtual origin from downwind roadway edge.

The summation is performed over the profile at the edge of the road (at heights of 5,10,15, and 20 feet). Since the 5-foot concentration is of more interest, the minimization at the 5-foot level is weighted more heavily than the others.

A predictive equation for the concentrations at the downwind edge of the roadway was found in much the same manner as Noll, Miller, Rainey, and May (1975) found EMP-1. By performing a dimensional analysis on the independent variables involved, the following equation was obtained,

$$\chi = \frac{\Lambda Q'}{u \cdot \sin\theta \cdot 0.5w} \qquad (27)$$

where

Λ = empirical calibration coefficient

w = width of roadway

Calder (1973) has shown that the pollutant concentrations at any given point perpendicular to the roadway are virtually independent of the wind angle. Hence equation (27) reduces to

$$\chi = \frac{\Lambda Q'}{u \cdot 0.5w} \qquad (28)$$

which agrees with the form presented by Pasquill (1974) for the algebraic integration for an area source.

Using carbon monoxide data provided by Miller (Dr. Terry Miller, Enviromeasure Inc., Knoxville, Tennessee), regression analyses were performed. This was done with SAS, a computerized library of statistical subroutines designed by Barr and Goodnight (1972). The analysis was performed on both

$$\chi \text{ versus } \frac{2Q'}{u \cdot \sin\theta \cdot w} \quad (29)$$

and

$$\chi \text{ versus } \frac{2Q'}{u \cdot w} \quad (30)$$

where

χ = roadside concentration at 5-foot height

TABLE 4. Summary of Regression Analysis of Roadside CO Concentrations

Regression Performed	Wind Speed	Coefficient of Determination	Constants
χ vs. $\frac{2Q'}{u \cdot \sin\theta \cdot w}$	> .54 m/s	0.13	0.44
χ vs $\frac{2Q'}{u \cdot w}$	> .54 m/s	0.85	6.87

Through a preliminary graphical analysis of the concentration profiles at the edge of the roadway, the profile was found to be an exponential function of height, namely

$$\chi(z) = \chi_* \exp(a_o + a_1 z) \tag{31}$$

where

χ_* = concentration at 5-foot level calculated with equation (28)

a_o, a_1 = empirical constants

Performing a regression analysis on $\ln(\frac{\chi(z)}{\chi})$ versus z yielded values of 0.1478 and -0.1211 for a_o and a_1, respectively. For this regression a coefficient of determination of 0.17 was obtained. This low value was obtained because of the large scatter in the data. It should also be noted that this regression was performed with limited data. The minimization of equation (26) is now readily performed and a value for x' obtained.

The lowest wind velocity in the data used to calibrate the model was 0.54 meters per second. Thus, the minimum wind speed the model will accept is 0.54 meters per second. By setting this limit the model will not be applied beyond the range for which it is known to be valid. This limit also eliminates the problem of the asymptotic infinite behavior of equation (28) at very small wind speeds.

Once the virtual orgin has been located, the profiles downwind of the roadway are calculated from equation (22).

The current model was called "TRAPS" for Texas Roadway Air Pollution Simulator.

Chapter 6

Discussion of Results

The results presented here are of an interim nature and are not complete. They primarily represent the work progress as of August 1, 1976. The discussion will be divided into two sections consisting of the experimental data collection program and the model analysis and development.

Discussion of Experimental Data Collection Program

Experimental data have been collected for eight days at the North Loop Site in Houston. The data in their original are stored on nine track magnetic tape which is compatible with most computers. The data are collected on an almost continuous basis. A computer program has been developed which will assemble the data into averages of any desired length. A sample of the results are shown in Tables 6, 7, 8, 9, 10 and 11. These represent 5-minute, 15-minute and one hour averages for two one hour intervals.

The first one hour interval shown in Tables 6, 7, and 8 is typical of the usually good dispersion of the pollutants from the roadway. However, the second one hour interval shown in Tables 9, 10, and 11 is representative of an unusual condition. At approximately 16:15 hours on May 4, 1976, the wind profile "inverted". As can be seen in the tables, the highest windspeed was at ground level. This wind inversion lasted less than ten minutes, but during this period the carbon monoxide levels increased by 50 percent. The carbon monoxide concentration was still increasing when the inversion "broke".

This inverted wind condition has not been considered in any dispersion model to date. Furthermore, this condition also exemplifies the problem involved in using models that work on one hour averaged data. In ten minutes, a condition occurred from start to finish and the carbon monoxide response was not proportional to the condition change. The averaging models are all based on the assumption that the change in carbon monoxide concentration is proportional to the change in any parameter, assuming that the others hold constant. These data unfortunately show that this assumption is not always true and that dispersion from roadways is a very complex process.

The data collection equipment is currently set up at the Katy Freeway site and is ready to begin data collection. Present plans are to move back to the North Loop site by the first part of September, 1976 and then to Dallas and San Antonio. The original proposal called for data collection in Austin. However, no suitable site to set up the equipment could be found. It is also planned to move the equipment to El Paso in the spring or summer of 1977.

Discussion of Dispersion Model Analysis and Development

In determining the validity of any dispersion model, the accuracy of the data being used must be considered. Five sets of data were used in the analysis. These data sets were Noll, Miller, Rainey, and May (1975), Noll (1973), Carpenter, Clemena, and Lunglhofer (1975), Habegger et al. (1974) and Ranzieri (1975). These sets were discussed in Chapter 5. The current model along with CALINE -2, HIWAY and AIRPOL -4 which were discussed in Chapter 5, were compared to the data. As mentioned previously, both these models and the data are based on one hour averages.

The overall results of the comparison of these models to each data set are shown in Figures 9 through 13. These comparisons are for all of the data from a particular site and are summary comparisons. These results show that with the modifications used in the present model greatly improved results are obtained. Detailed comparisons of the results can be found in Maldonado's (1976) work and will be included in the final project report.

Model improvement work is continuing. The data from the current research program can be used for development of models based on other than one hour averages. Comparison of the various models with the experimental data from the current program is underway and has not been sufficiently completed to include in this report.

Summary

The experimental data collection program is well underway and several days data has been collected at the North Loop site in Houston. The equipment is also ready to begin data collection at the Katy Freeway Site in Houston. In addition, dispersion model analysis and development is well underway and greatly improved results have already been obtained.

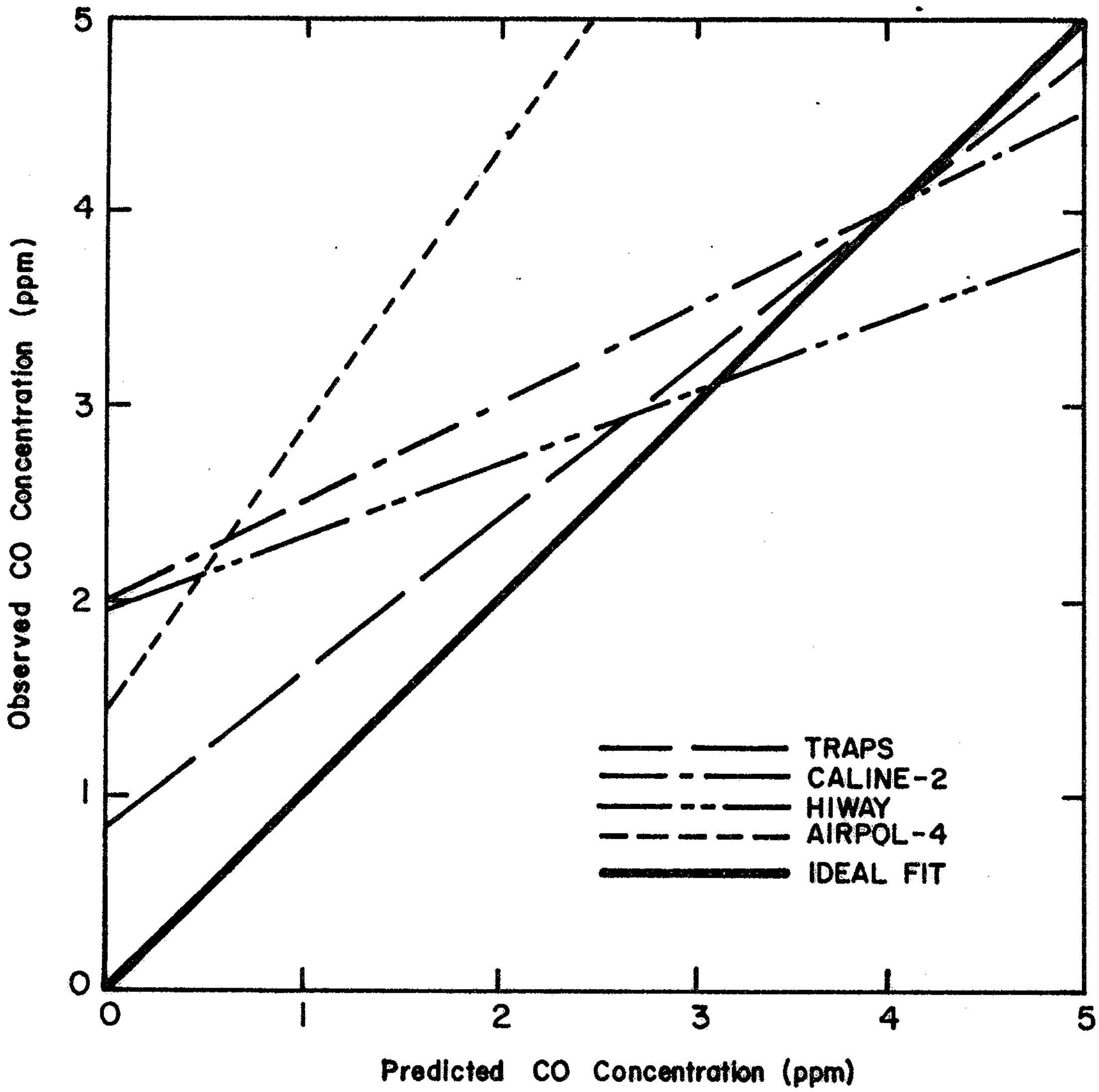


FIGURE 9. REGRESSION LINES OF MODELS FOR TENNESSEE DATA.

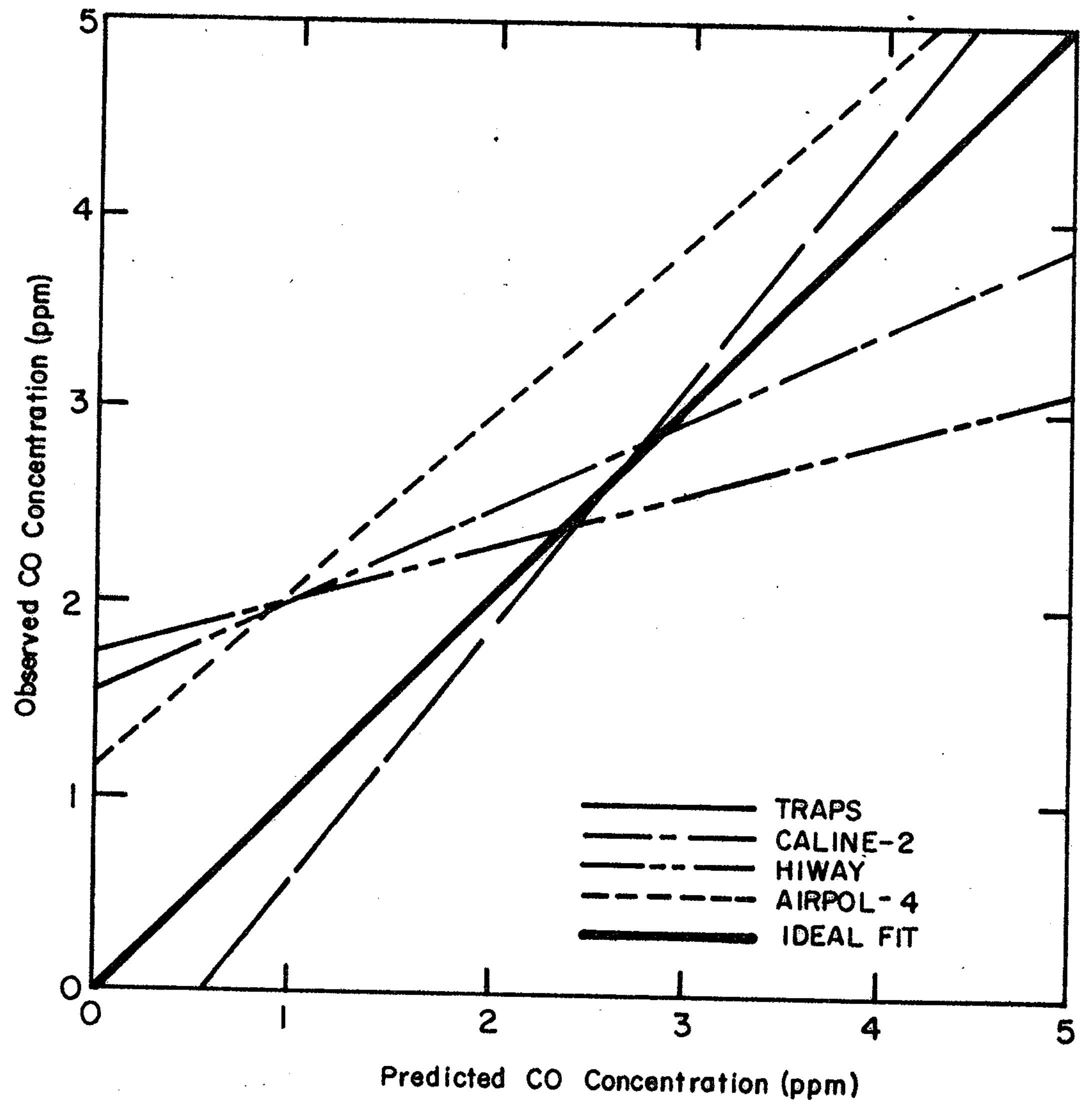


FIGURE 10. REGRESSION LINES OF MODELS FOR NORTH CAROLINA DATA.

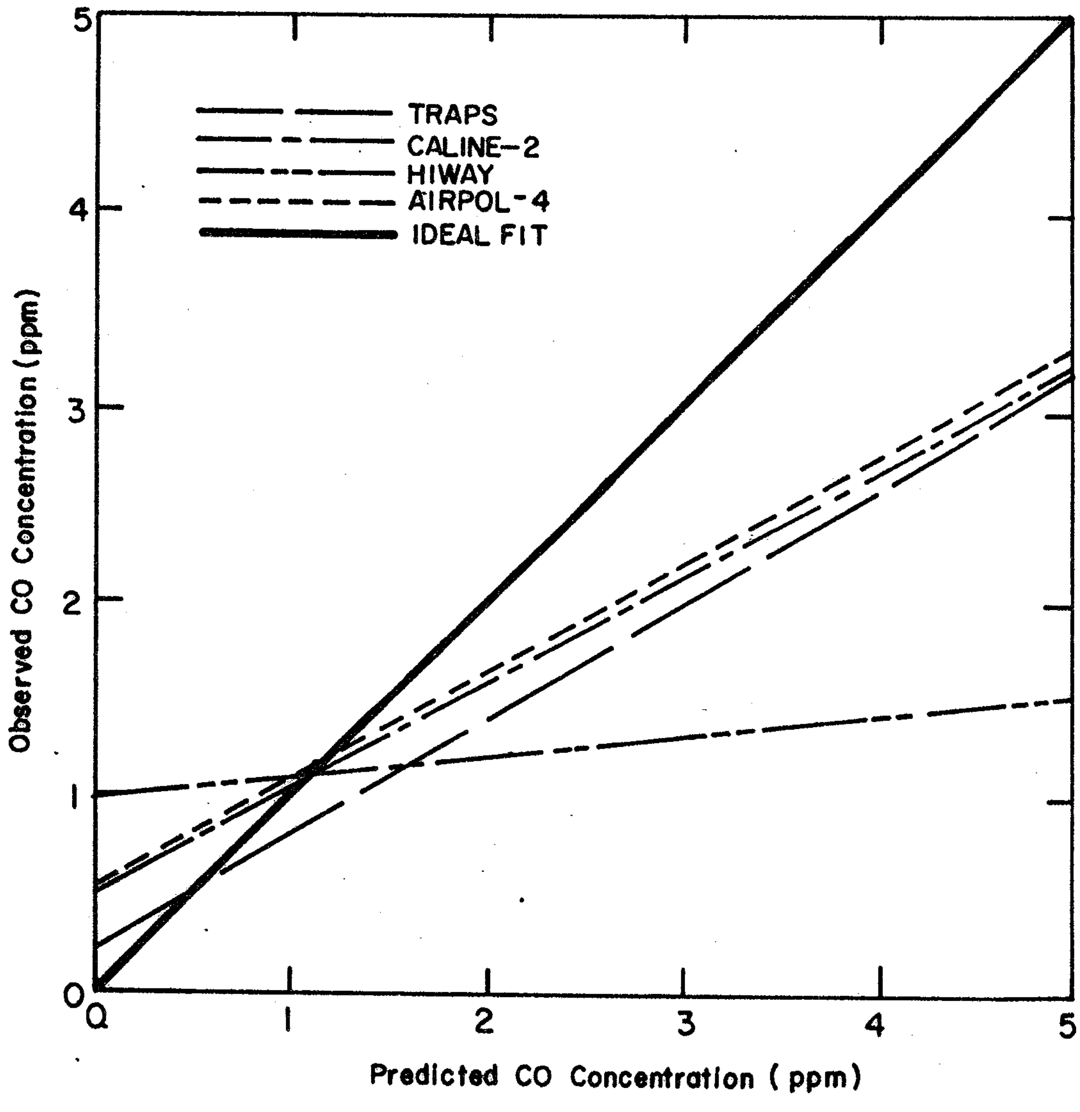


FIGURE 11. REGRESSION LINES OF MODELS FOR VIRGINIA DATA.

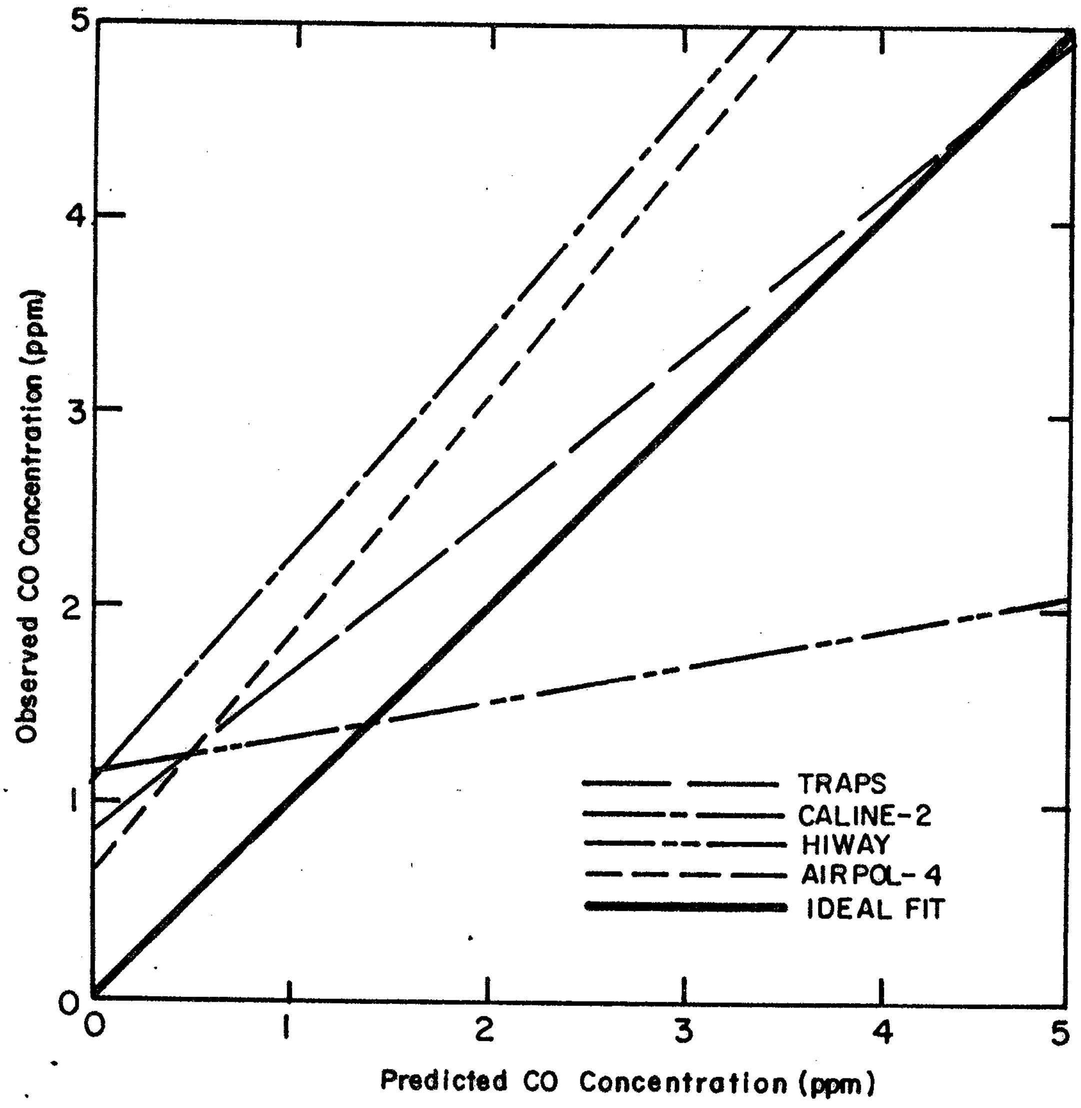


FIGURE 12. REGRESSION LINES OF MODELS FOR ILLINOIS DATA.

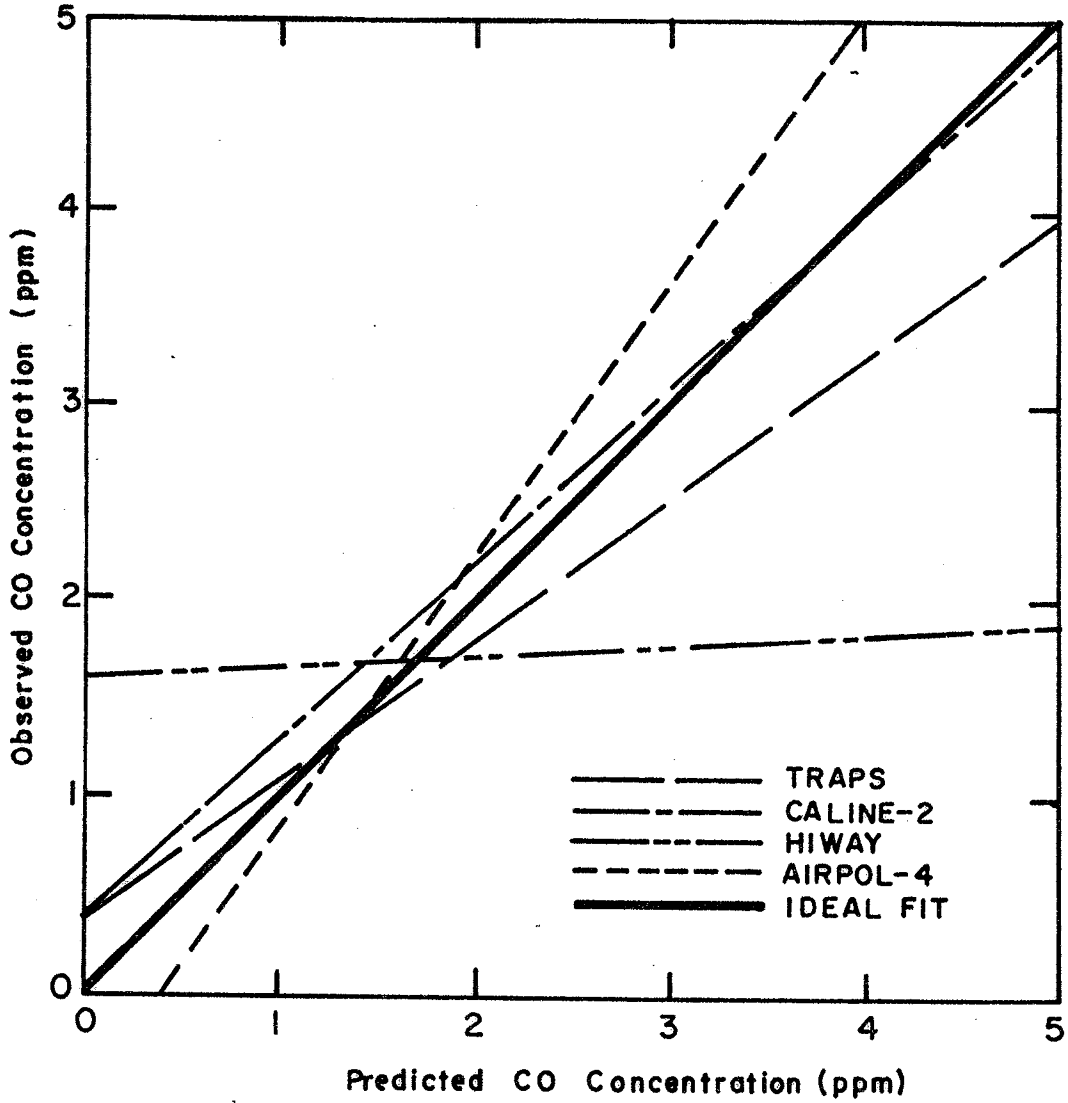


FIGURE 13 REGRESSION LINES OF MODELS FOR CALIFORNIA DATA

TABLE 5

Data Locations

	(RAD0)	(RAD1)	(RAD2)	(RAD3)	(RAD4)	(RAD5)	(RAD6)	(RAD7)	(RAD10)	(RAD11)	(TOTAL)	
	CARS	CARS	CARS	CARS	CARS	CARS	CARS	CARS	CARS	CARS	CARS	VA40m HA40m WV40m TMP30m PYRAN
	VANS	VANS	VANS	VANS	VANS	VANS	VANS	VANS	VANS	VANS	VANS	VA20m HA20m WV20m TMP20m
	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	MED TRCKS	VA10m HA10m WV10m TMP10m RH30m
	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	HVY TRCKS	VA1.5m HA1.5m WV1.5m TMP1.5m RH1.5m
	CAL	CAL	CAL	CAL	CAL	CAL	CAL	CAL	CAL	CAL	CAL	C04H
	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL	TOTAL		C04L
C06H		TOTAL EASTBOUND						TOTAL WESTBOUND				C01H C02H C03H C05H
C06L					GRAND TOTAL							C01L C02L C03L C05L

TABLE 6

5 MINUTE AVERAGE AT 14:55 FILE: MAY 4,1976 ATGRADE

	21	61	0	46	16	13	66	8	45	0	276	1.68	*******	216.30	75.21	734.2
	70.4	60.4	0.0	53.4	28.2	45.1	53.0	54.9	53.1	0.0	54.3	13.943	*******	18.028	0.843	54.9340
	17	14	0	3	3	2	12	6	8	0	65	0.37	10.60	166.33	76.38	
	72.7	64.1	0.0	58.7	36.3	56.1	60.5	55.4	53.6	0.0	61.8	12.889	4.449	29.211	0.909	
	5	5	0	4	0	0	1	0	4	0	19	1.73	9.93	133.88	76.69	39.89
	71.2	63.2	0.0	59.6	0.0	0.0	59.5	0.0	57.0	0.0	63.1	11.079	3.527	19.651	0.579	0.364
	3	2	0	2	1	3	9	0	2	1	23	-1.16	9.27	284.91	80.06	37.77
	66.5	62.2	0.0	73.4	42.3	60.0	58.8	0.0	58.3	76.9	61.5	5.643	2.018	26.221	0.362	0.441
	0	0	0	0	0	1	0	0	0	0	1			2.34		
	0.0	0.0	0.0	0.0	0.0	55.9	0.0	0.0	0.0	0.0	55.9			0.5358		
	46	82	0	55	20	18	88	14	59	1				2.25		
	71.1	61.2	0.0	54.9	30.1	48.8	54.7	55.1	53.6	76.9				0.3680		
*******			203					180				1.54	0.84	0.90	0.50	
*******			58.7					53.9				0.9724	0.6695	0.3668	0.2560	
-0.04					383							3.38	2.48	2.06	1.81	
0.3000					56.4							1.6791	1.3062	0.5915	0.6298	

5 MINUTE AVERAGE AT 15: 0 FILE: MAY 4,1976 ATGRADE

	21	43	0	39	19	6	45	10	33	0	216	-3.24	*******	220.25	74.92	736.4
	68.6	61.3	0.0	53.3	29.0	44.9	53.2	53.2	52.7	0.0	53.9	14.087	*******	9.870	0.731	34.6554
	14	11	0	3	0	1	8	2	5	0	44	-7.56	14.25	171.45	76.26	
	74.0	61.4	0.0	57.7	0.0	51.5	61.9	53.3	54.6	0.0	63.9	14.842	2.990	24.915	0.754	
	3	3	0	0	0	1	2	1	0	0	10	0.82	12.97	139.12	76.50	39.19
	69.8	58.3	0.0	0.0	0.0	52.9	55.8	58.4	0.0	0.0	60.7	12.641	3.715	16.963	0.834	0.397
	2	4	0	2	0	1	10	0	1	0	20	-0.98	9.78	291.01	79.72	37.36
	70.1	60.1	0.0	59.8	0.0	55.4	62.7	0.0	54.6	0.0	61.8	6.595	3.063	31.027	0.829	0.313
	0	0	0	0	0	0	0	0	0	0	0			1.84		
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.4211		
	40	61	0	44	19	9	65	13	39	0				1.82		
	70.7	61.1	0.0	53.9	29.0	47.7	55.8	53.6	53.0	0.0				0.3109		
*******			164					126				0.85	0.44	0.48	0.43	
*******			57.8					54.1				0.3306	0.5463	0.3939	0.2447	
0.06					290							2.49	2.01	2.10	1.60	
0.2551					56.2							0.6614	0.9915	0.8475	0.5982	

TABLE 6 (continued)

5 MINUTE AVERAGE AT 15: 5   FILE: MAY 4,1976 ATGRADE

	34	64	0	72	21	3	48	9	33	0	284	0.52	*******	211.85	74.14	773.4
	71.3	60.9	0.0	54.8	26.7	51.7	54.2	52.4	52.4	0.0	55.6	14.908	*******	17.355	0.736	25.6125
	21	15	0	11	0	5	7	6	5	0	70	-3.13	13.32	159.71	75.34	
	72.0	60.6	0.0	60.1	0.0	57.8	61.2	54.2	53.9	0.0	62.8	17.330	1.994	28.844	0.634	
	6	6	0	1	1	2	10	1	2	0	29	2.26	12.31	129.44	75.91	38.55
	70.4	59.8	0.0	58.2	38.6	58.4	63.5	57.0	47.7	0.0	61.5	13.072	2.519	23.673	0.265	0.348
	3	9	0	1	3	6	6	0	5	0	33	0.49	10.01	278.16	79.39	36.62
	78.4	62.0	0.0	47.6	47.2	61.3	66.9	0.0	59.2	0.0	62.0	6.346	3.558	32.660	0.743	0.375
	0	0	0	0	0	1	0	0	0	0	1			1.83		
	0.0	0.0	0.0	0.0	0.0	61.7	0.0	0.0	0.0	0.0	61.7			0.4705		
	64	94	0	85	25	16	71	16	45	0				1.98		
	71.8	60.9	0.0	55.4	29.6	58.0	57.3	53.4	53.1	0.0				0.5058		
*******			268					148				0.89	0.79	0.88	0.48	
*******			58.8					55.7				0.3253	0.7752	0.5440	0.3696	
0.16					416							3.21	2.77	2.50	2.23	
0.5019					57.7							1.2203	1.6120	1.1080	1.0334	

5 MINUTE AVERAGE AT 15:10   FILE: MAY 4,1976 ATGRADE

	25	61	1	47	18	14	51	9	34	1	261	0.29	*******	226.88	73.95	748.6
	70.7	60.2	46.5	54.1	28.0	45.6	52.4	53.3	50.9	56.7	54.1	17.881	*******	17.234	0.574	31.5832
	8	8	0	3	2	0	16	4	7	0	48	-5.10	12.31	183.33	75.21	
	69.0	64.7	0.0	55.2	37.9	0.0	60.4	49.9	49.4	0.0	58.8	15.175	4.209	25.382	0.367	
	0	1	0	0	0	2	2	1	4	0	10	-2.51	10.85	150.11	75.68	39.23
	0.0	58.9	0.0	0.0	0.0	60.0	54.2	43.4	49.5	0.0	52.9	12.045	3.460	21.717	0.349	0.718
	2	3	0	1	1	1	10	1	7	1	27	-1.18	8.89	302.39	78.83	37.02
	72.7	63.6	0.0	57.1	50.5	55.0	66.8	42.6	53.3	58.7	60.8	5.752	3.541	33.486	0.852	0.691
	0	0	0	0	0	0	0	0	0	0	0			1.83		
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.3037		
	35	73	1	51	21	17	79	15	52	2				1.94		
	70.5	60.8	46.5	54.2	30.0	47.9	55.9	51.0	50.9	57.7				0.4714		
*******			181					165				0.74	0.34	0.40	0.54	
*******			57.2					53.1				0.2828	0.5125	0.5001	0.3433	
0.26					346							2.23	1.86	1.74	1.73	
0.4741					55.2							0.4935	1.0054	0.5603	0.6120	

TABLE 6 (continued)

5 MINUTE AVERAGE AT 15:15 FILE: MAY 4,1976 ATGRADE

	31	55	0	61	25	13	63	9	38	0	295	0.42	*******	223.44	74.05	717.6
	68.5	59.3	0.0	55.1	28.4	44.4	53.3	52.7	50.5	0.0	53.5	16.921	*******	17.121	0.882	12.7083
	15	7	0	1	5	1	10	10	13	0	62	1.92	10.77	181.77	76.00	
	70.3	63.9	0.0	52.5	42.1	47.3	63.3	59.0	53.6	0.0	60.2	15.829	3.847	24.971	0.818	
	4	2	0	1	3	0	4	1	1	0	16	-0.57	8.60	149.87	76.26	39.40
	72.9	64.6	0.0	64.1	44.4	0.0	57.5	58.0	58.7	0.0	60.3	11.467	3.316	30.304	0.474	0.054
	2	6	0	0	1	4	12	2	7	0	34	0.49	6.46	313.10	79.49	37.23
	69.7	61.3	0.0	0.0	43.4	61.9	64.9	50.3	57.6	0.0	61.2	6.994	2.133	43.189	0.347	0.246
	0	0	0	0	0	1	0	0	1	0	2			1.99		
	0.0	0.0	0.0	0.0	0.0	61.6	0.0	0.0	48.4	0.0	55.0			0.6776		
	52	70	0	63	34	18	89	22	59	0				1.74		
	69.4	60.1	0.0	55.2	32.2	48.5	56.2	55.6	52.2	0.0				0.6133.		
*******			219					188				*******	0.90	0.65	0.33	
*******			56.6					54.1				*******	0.4876	0.6077	0.2970	
0.05					407							*******	2.22	2.15	1.81	
0.2792					55.4							*******	0.8717	0.5682	0.4643	

58

5 MINUTE AVERAGE AT 15:20 FILE: MAY 4,1976 ATGRADE

	30	68	0	44	26	12	60	7	41	0	288	-1.04	*******	208.57	74.35	699.6
	69.2	59.4	0.0	54.3	27.3	44.9	53.1	56.2	50.5	0.0	53.5	14.536	*******	12.646	0.715	22.0964
	12	9	0	6	0	2	14	4	9	0	56	-5.26	10.70	154.63	75.57	
	70.0	61.8	0.0	60.3	0.0	54.1	58.2	56.6	52.6	0.0	60.4	11.892	2.605	29.354	0.913	
	2	6	0	2	0	1	4	3	1	0	19	-0.36	10.53	124.18	76.18	39.43
	71.7	61.1	0.0	63.4	0.0	53.9	56.8	51.5	51.4	0.0	59.1	11.384	3.311	17.323	0.643	0.703
	3	3	0	0	2	6	9	0	8	0	31	0.41	9.73	276.18	80.18	37.09
	74.3	55.7	0.0	0.0	47.3	55.3	62.4	0.0	54.9	0.0	58.6	5.551	2.877	16.431	1.304	0.446
	0	0	0	0	0	1	1	0	0	0	2			2.49		
	0.0	0.0	0.0	0.0	0.0	63.4	69.4	0.0	0.0	0.0	66.4			0.6056		
	47	86	0	52	28	21	87	14	59	0				1.85		
	69.9	59.6	0.0	55.4	28.8	49.2	55.0	55.3	51.4	0.0				0.4403		
*******			213					181				**************		1.16	0.43	
*******			56.8					53.2				**************		0.7483	0.2519	
0.27					394							**************		3.03	2.36	
0.2557					55.1							**************		0.9332	0.6394	

TABLE 6 (continued)

5 MINUTE AVERAGE AT 15:25 FILE: MAY 4,1976 ATGRADE

	31	75	0	46	29	7	58	11	34	0	291	-1.62	*******	198.57	****************
	69.4	60.6	0.0	52.7	28.0	51.9	54.0	55.0	52.3	0.0	54.3	14.898	*******	14.342	****************
	13	11	0	2	5	2	11	4	8	0	56	-1.84	11.33	147.08	*******
	70.1	62.0	0.0	60.3	40.0	57.1	59.6	58.2	50.5	0.0	59.3	12.589	2.846	31.977	*******
	4	3	0	1	0	2	8	1	3	0	22	-0.29	11.04	117.17	**************
	70.9	55.0	0.0	62.6	0.0	56.6	60.2	58.9	50.6	0.0	59.8	10.820	2.525	16.068	**************
	4	2	0	0	3	5	8	2	8	0	32	0.59	10.31	271.02	**************
	81.4	67.5	0.0	0.0	43.0	55.9	65.0	53.8	54.3	0.0	60.4	4.428	2.075	18.892	**************
	0	0	0	0	0	0	1	0	0	0	1			2.21	
	0.0	0.0	0.0	0.0	0.0	0.0	60.8	0.0	0.0	0.0	60.8			0.3329	
	52	91	0	49	37	16	85	18	53	0				1.67	
	70.6	60.7	0.0	53.2	30.8	54.4	56.4	55.8	52.3	0.0				0.4913	
*******			229					172				1.27	*******	0.86	0.25
*******			56.5					54.8				0.7825	*******	0.5622	0.2318
0.08					401							3.19	*******	2.24	1.89
0.2867					55.8							1.3603	*******	1.1068	0.7284

5 MINUTE AVERAGE AT 15:30 FILE: MAY 4,1976 ATGRADE

	36	71	0	69	15	11	59	16	52	0	329	-0.73	*******	215.37	****************
	70.0	59.6	0.0	54.3	26.6	45.6	54.3	53.2	49.9	0.0	54.9	14.364	*******	18.461	****************
	21	13	0	0	3	3	10	10	5	0	65	-4.24	11.37	162.06	*******
	69.2	60.2	0.0	0.0	38.9	61.3	59.6	53.0	50.2	0.0	60.2	12.658	1.867	28.776	*******
	3	6	0	1	3	1	4	2	2	0	22	0.06	11.10	129.50	**************
	74.0	63.8	0.0	60.2	45.9	62.7	61.2	58.4	47.4	0.0	60.1	10.277	2.537	21.531	**************
	5	10	0	4	2	6	10	2	5	0	44	0.49	9.86	278.19	79.02*******
	73.4	64.5	0.0	58.9	44.7	60.2	64.6	51.1	52.1	0.0	61.5	5.741	2.366	23.633	0.242*******
	1	0	0	0	0	2	1	0	0	0	4			2.23	
	83.7	0.0	0.0	0.0	0.0	63.6	64.1	0.0	0.0	0.0	68.7			0.6975	
	65	100	0	74	23	21	83	30	64	0				1.45	
	70.2	60.4	0.0	54.6	32.3	52.8	56.5	53.4	50.0	0.0				0.4379	
*******			262					198				1.15	*******	*******	0.36
*******			58.7					53.5				0.6202	*******	*******	0.3213
0.11					460							3.28	2.73	*******	1.95
0.3339					56.5							1.3136	1.1952	*******	0.3910

TABLE 6 (continued)

5 MINUTE AVERAGE AT 15:35 FILE: MAY 4,1976 ATGRADE

	28	74	0	60	29	16	58	8	37	0	310	0.51	*******	225.89	74.45	716.8
	69.6	59.5	0.0	53.4	27.4	44.9	52.8	54.8	52.6	0.0	53.3	14.351	*******	15.370	0.843	29.9792
	26	18	0	4	5	7	7	10	7	0	84	-1.14	11.61	177.03	75.94	
	70.9	58.5	0.0	57.6	37.4	52.1	61.2	51.8	54.4	0.0	59.6	14.725	4.185	16.973	0.836	
	1	5	0	1	1	1	4	4	6	0	23	-0.70	9.53	143.78	76.12	40.50
	67.1	60.9	0.0	55.3	41.3	55.6	61.7	54.4	51.6	0.0	56.4	12.633	2.911	23.276	0.553	0.165
	8	11	0	3	3	6	15	1	10	0	57	0.33	7.62	284.30	79.55	37.93
	70.7	61.6	0.0	49.4	41.9	57.9	62.7	58.7	54.5	0.0	59.8	5.497	2.993	31.464	0.329	0.244
	0	0	0	0	0	1	1	0	0	0	2			2.68		
	0.0	0.0	0.0	0.0	0.0	59.9	60.3	0.0	0.0	0.0	60.1			1.6154		
	63	103	0	68	38	30	84	23	60	0				1.50		
	70.3	59.6	0.0	53.5	30.2	49.5	55.7	53.6	53.0	0.0				0.5367		
*******			277					197				1.46	-0.92	6.48	*******	
*******			56.5					53.7				1.7117	1.7308	10.5992	*******	
0.00					474							2.37	3.95	6.08	*******	
0.1903					55.3							2.6746	2.1948	8.7138	*******	

5 MINUTE AVERAGE AT 15:40 FILE: MAY 4,1976 ATGRADE

	33	75	0	76	36	15	59	10	34	0	338	0.81	*******	221.67	74.89	672.4
	69.2	59.6	0.0	54.8	27.6	43.1	53.3	50.6	52.9	0.0	53.3	17.479	*******	11.681	0.922	15.1822
	19	21	0	4	1	4	12	12	11	0	84	-3.12	11.35	175.58	76.28	
	69.2	60.7	0.0	60.5	37.9	53.7	58.2	54.5	53.6	0.0	59.8	16.146	3.404	19.309	0.648	
	6	7	0	0	0	3	1	6	4	0	27	2.12	10.75	142.03	76.54	40.59
	64.4	63.6	0.0	0.0	0.0	51.8	60.3	52.1	51.3	0.0	58.0	13.599	2.511	16.543	0.624	0.426
	15	8	0	0	1	6	13	0	9	0	52	0.65	8.64	280.30	80.11	37.91
	71.1	60.9	0.0	0.0	49.8	55.1	62.0	0.0	58.6	0.0	62.8	5.456	2.728	31.054	0.521	0.379
	0	0	0	0	0	1	0	0	0	0	1			*******		
	0.0	0.0	0.0	0.0	0.0	60.5	0.0	0.0	0.0	0.0	60.5			*******		
	73	111	0	80	38	28	85	28	58	0				*******		
	69.2	60.2	0.0	55.0	28.4	48.1	55.4	52.6	53.8	0.0				*******		
*******			302					199				1.02	-1.20	0.74	*******	
*******			57.0					53.5				0.3487	0.7674	0.4515	*******	
0.02					501							3.50	3.33	2.55	*******	
0.2189					55.6							1.1283	1.4758	0.8073	*******	

TABLE 6 (continued)

5 MINUTE AVERAGE AT 15:45 FILE: MAY 4,1976 ATGRADE

	47	74	0	66	31	19	65	17	47	0	366	2.10	*******	220.59	74.15	687.0
	68.8	60.6	0.0	52.8	28.8	45.9	52.5	53.4	50.9	0.0	53.8	13.016	*******	12.392	0.566	30.7571
	24	21	0	6	3	2	12	21	8	0	97	-0.35	10.92	175.76	75.62	
	69.0	59.7	0.0	57.0	38.8	48.2	61.3	54.8	49.7	0.0	59.3	17.223	2.055	27.282	0.497	
	4	2	0	4	2	1	4	6	2	0	25	1.14	9.99	139.72	76.20	40.52
	71.3	61.0	0.0	55.0	38.2	57.8	61.7	57.3	63.0	0.0	59.1	13.537	2.326	21.259	0.339	0.271
	9	12	0	4	7	5	3	1	8	0	49	0.47	8.05	283.09	80.38	37.48
	74.1	64.0	0.0	58.0	41.6	54.0	64.2	58.5	57.8	0.0	60.1	6.153	1.871	27.775	0.368	0.325
	1	0	0	0	0	0	0	0	0	0	1			*******		
	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.0			*******		
	84	109	0	80	43	27	84	45	65	0				*******		
	69.6	60.8	0.0	53.5	32.0	48.0	54.6	54.7	52.0	0.0				*******		
*******			316					221				1.24	-0.71	0.99	0.33	
*******			57.4					53.0				0.4501	0.5199	0.6004	0.2369	
0.19					537							4.42	4.26	3.25	2.15	
0.4005					55.6							1.9174	2.1508	0.8720	0.4581	

5 MINUTE AVERAGE AT 15:50 FILE: MAY 4,1976 ATGRADE

	44	83	0	77	21	11	49	17	41	0	343	-0.96	*******	218.54	75.37	661.0
	69.5	59.5	0.0	53.4	28.3	43.8	53.8	55.9	51.3	0.0	55.0	12.535	*******	15.482	0.931	25.2587
	24	21	0	5	0	2	12	14	13	0	91	-1.03	10.09	167.94	76.25	
	70.4	61.4	0.0	62.5	0.0	60.1	60.2	58.8	50.4	0.0	61.7	16.148	2.819	23.717	0.890	
	2	4	0	1	0	0	5	2	3	0	17	-0.43	9.85	131.32	76.34	41.35
	76.0	60.5	0.0	57.8	0.0	0.0	64.9	59.1	52.2	0.0	61.8	14.117	2.606	19.232	0.510	0.283
	10	6	0	3	4	9	19	2	8	0	61	0.46	9.02	275.10	79.66	38.46
	74.8	63.9	0.0	58.2	46.7	61.1	64.3	59.2	55.7	0.0	62.8	5.847	2.677	24.753	0.385	0.428
	0	0	0	0	0	2	0	0	0	0	2			*******		
	0.0	0.0	0.0	0.0	0.0	63.8	0.0	0.0	0.0	0.0	63.8			*******		
	80	114	0	86	25	22	85	35	65	0				2.38		
	70.6	60.1	0.0	54.2	31.2	52.4	57.7	57.4	51.7	0.0				0.3064		
*******			305					207				1.75	-0.81	0.71	0.42	
*******			58.8					55.2				0.6933	0.5825	0.6980	0.2541	
-0.11					512							4.16	3.74	2.54	1.78	
0.3667					57.4							1.1246	1.3198	1.3404	0.7290	

TABLE 6 (continued)

5 MINUTE AVERAGE AT 15:55 FILE: MAY 4,1976 ATGRADE

	44	75	0	66	21	10	48	19	38	0	321	-2.95	*******	208.00	75.55	535.6
	70.0	59.3	0.0	53.9	30.6	47.9	52.3	52.1	51.1	0.0	55.0	12.396	*******	13.964	0.657	58.4294
	25	15	0	2	3	2	5	21	11	0	84	-4.32	9.75	159.23	76.52	
	71.3	60.8	0.0	56.8	42.0	52.2	62.8	55.0	52.0	0.C	60.5	11.209	3.123	31.793	0.203	
	5	5	0	1	1	1	6	7	4	0	30	-0.83	9.60	129.57	77.00	40.53
	71.0	63.5	0.0	59.5	46.9	52.5	60.5	52.0	57.0	0.0	59.6	13.531	3.058	20.563	0.349	0.652
	10	12	0	2	2	9	14	3	7	0	59	-0.20	8.03	270.60	79.85	37.98
	72.2	65.8	0.0	65.0	44.2	57.5	63.6	50.0	53.5	0.0	62.1	5.634	1.837	21.340	0.697	0.631
	0	0	0	0	0	1	0	0	0	0	1			1.82		
	0.0	0.0	0.0	0.0	0.0	59.1	0.0	0.0	0.0	0.0	59.1			0.7993		
	84	107	0	71	27	22	73	50	60	0				1.94		
	70.7	60.5	0.0	54.3	33.5	52.4	55.9	53.2	51.9	0.0				0.4630		
*******			289					205				1.57	-0.65	1.08	0.33	
*******			59.4					53.7				0.8879	1.0261	0.8095	0.1859	
*******					494							4.21	3.60	2.73	2.73	
*******					57.0							1.5785	1.4984	0.7189	0.7801	

5 MINUTE AVERAGE AT 16: 0 FILE: MAY 4,1976 ATGRADE

	43	83	0	71	35	13	49	16	41	0	351	-1.72	*******	214.34	74.25	712.8
	69.3	59.7	0.0	54.3	29.2	45.4	53.0	53.0	50.8	0.0	53.9	12.420	*******	13.187	0.748	31.6346
	17	11	0	5	1	3	12	24	4	0	77	-6.61	10.53	156.39	75.45	
	69.1	62.0	0.0	60.6	38.5	47.6	52.9	55.8	45.8	0.0	58.4	10.432	2.428	28.002	1.012	
	3	3	0	0	1	2	3	5	7	0	24	0.10	10.30	129.61	75.86	39.67
	66.9	61.6	0.0	0.0	45.5	49.7	61.3	52.9	54.9	0.0	56.8	10.391	2.378	18.411	0.753	0.358
	5	10	0	1	2	4	13	1	9	0	45	0.20	8.52	277.37	79.55	37.14
	67.5	64.5	0.0	56.3	49.6	55.7	55.1	55.0	54.3	0.0	58.3	5.523	2.330	20.203	0.505	0.180
	0	0	0	0	0	2	1	0	0	0	3			0.98		
	0.0	0.0	0.0	0.0	0.0	51.5	67.6	0.0	0.0	0.0	56.9			0.3632		
	68	107	0	77	39	22	77	46	61	0				1.51		
	69.0	60.4	0.0	54.7	30.9	47.9	53.7	54.5	51.5	0.0				0.3632		
*******			291					206				1.17	*******	0.56	0.34	
*******			57.0					52.6				0.6290	*******	0.4579	0.3068	
0.19					497							3.76	3.33	2.24	1.89	
0.2414					55.1							1.0640	1.1492	0.5636	0.4699	

TABLE 7

15 MINUTE AVERAGE AT 14:45 FILE: MAY 4,1976 ATGRADE

	98	176	0	139	79	44	178	26	93	0	833	1.14*******		223.97	74.57	739.0
	70.1	60.5	0.0	54.4	28.1	45.1	55.2	52.9	48.7	0.0	54.0	15.993*******		13.080	0.782	233.8044
	43	36	0	15	12	14	16	14	21	0	171	-1.23	12.84	176.01	75.92	
	68.9	61.7	0.0	57.5	38.6	55.9	62.3	58.4	55.8	0.0	60.1	14.615	4.147	24.155	0.637	
	15	11	0	6	0	8	13	1	6	0	60	-0.08	10.76	144.49	76.32	40.68
	68.7	61.6	0.0	58.4	0.0	59.5	62.5	52.6	54.1	0.0	62.1	13.588	3.733	23.342	0.500	0.744
	13	24	0	10	7	21	24	2	21	0	122	0.56	8.40	289.49	79.49	38.70
	76.5	60.0	0.0	57.9	45.3	58.7	64.5	53.7	56.8	0.0	60.8	6.550	2.386	30.204	0.691	0.747
	0	0	0	0	0	1	1	0	0	0	2			1.80		
	0.0	0.0	0.0	0.0	0.0	66.4	68.7	0.0	0.0	0.0	67.5			0.4309		
	169	247	0	170	98	87	231	43	141	0				2.33		
	70.2	60.7	0.0	55.0	30.6	51.5	57.1	54.7	51.2	0.0				0.4473		
*******			684					502				1.18	0.61	0.71	0.35	
*******			57.3					54.2				0.5839	0.5049	0.3870	0.2019	
0.10					1186							2.82	2.40	2.09	1.75	
0.3159					56.0							0.8386	0.9412	0.7238	0.4401	

15 MINUTE AVERAGE AT 15: 0 FILE: MAY 4,1976 ATGRADE

	71	169	0	135	59	33	157	34	124	1	783	0.00*******		220.73	75.02	766.1
	69.2	60.5	0.0	53.8	28.6	45.0	53.2	53.0	52.5	55.6	54.0	13.711*******		16.351	0.713	57.8174
	43	39	0	10	4	6	28	14	17	0	161	-3.86	12.29	171.96	76.41	
	72.6	62.1	0.0	58.1	35.6	53.3	61.0	53.1	53.6	0.0	61.8	1[illegible].055	4.056	26.905	0.747	
	13	15	0	5	2	1	8	2	5	1	52	0.46	11.11	138.99	76.65	39.56
	68.7	60.5	0.0	58.6	39.9	52.9	60.4	53.6	56.2	78.5	61.1	11.909	3.710	20.754	0.658	0.419
	8	13	0	5	2	10	26	2	7	1	74	-0.49	9.04	291.14	80.06	37.57
	70.7	61.9	0.0	66.1	41.4	60.2	62.1	60.3	59.3	76.9	62.3	6.013	2.593	30.952	0.579	0.345
	0	0	0	0	0	1	0	0	0	0	1			2.01		
	0.0	0.0	0.0	0.0	0.0	55.9	0.0	0.0	0.0	0.0	55.9			0.5540		
	135	236	0	155	67	50	219	52	153	3				1.96		
	70.3	60.8	0.0	54.6	29.8	49.2	55.5	53.3	53.1	70.3				0.4032		
*******			593					477				1.09	0.66	0.69	0.36	
*******			57.9					53.9				0.7368	0.5618	0.4062	0.2901	
0.01					1070							2.99	2.30	2.06	1.64	
0.2353					56.1							1.2482	1.0950	0.7003	0.6283	

TABLE 7 (continued)

15 MINUTE AVERAGE AT 15:15 FILE: MAY 4,1976 ATGRADE

	90	180	1	180	64	30	162	27	105	1	840	0.41	*******	220.73	74.05	746.5
	70.2	60.1	46.5	54.7	27.7	45.7	53.3	52.8	51.2	56.7	54.4	16.505	*******	18.199	0.688	32.8133
	44	30	0	15	7	6	33	20	25	0	180	-2.10	12.13	175.17	75.52	
	70.9	62.5	0.0	58.7	40.9	56.1	61.5	55.8	52.4	0.0	60.8	16.300	3.588	27.970	0.691	
	10	9	0	2	4	4	15	3	7	0	55	-0.27	10.59	143.06	75.95	39.06
	71.4	60.8	0.0	61.2	42.9	59.2	60.9	52.8	50.3	0.0	59.6	12.315	3.435	26.863	0.417	0.576
	7	18	0	2	5	11	28	3	19	1	94	-0.07	8.46	296.85	79.24	36.96
	74.3	62.0	0.0	52.4	47.1	61.0	66.0	47.7	56.5	58.7	61.4	6.418	3.437	38.414	0.701	0.517
	0	0	0	0	0	2	0	0	1	0	3			1.88		
	0.0	0.0	0.0	0.0	0.0	61.7	0.0	0.0	43.4	0.0	57.3			0.4957		
	151	237	1	199	80	51	239	53	156	2				1.89		
	70.7	60.6	46.5	55.0	30.8	51.3	56.4	53.6	52.0	57.7				0.5259		
*******			668					501				*******	0.68	0.65	0.45	
*******			57.6					54.2				*******	0.6347	0.5688	0.3380	
0.16					1169							*******	2.28	2.13	1.92	
0.4241					56.2							*******	1.2244	0.8226	0.7517	

64

15 MINUTE AVERAGE AT 15:30 FILE: MAY 4,1976 ATGRADE

	97	214	0	159	70	30	177	34	127	0	908	-1.13	*******	207.45	*******	*******
	69.6	59.9	0.0	53.9	27.5	46.8	53.8	54.4	50.7	0.0	54.3	14.508	*******	16.646	*******	*******
	46	33	0	8	8	7	35	18	22	0	177	-3.78	11.13	154.69	*******	
	69.7	61.2	0.0	60.3	39.6	58.0	59.0	55.0	51.3	0.0	60.0	12.385	2.445	30.359	*******	
	9	15	0	4	3	4	16	6	6	0	63	-0.20	10.89	123.55	*******	*******
	72.1	60.9	0.0	62.4	45.9	57.4	59.6	55.0	49.7	0.0	59.7	10.790	2.779	18.980	*******	*******
	12	15	0	4	7	17	27	4	21	0	107	0.50	9.96	275.10	79.58	*******
	76.3	63.1	0.0	58.9	44.7	57.2	64.0	52.5	54.0	0.0	60.3	5.261	2.438	19.998	0.977	*******
	1	0	0	0	0	3	3	0	0	0	7			2.31		
	83.7	0.0	0.0	0.0	0.0	63.5	64.8	0.0	0.0	0.0	66.9			0.5692		
	164	277	0	175	88	58	255	62	176	0				1.65		
	70.2	60.3	0.0	54.5	30.6	51.9	56.0	54.5	51.2	0.0				0.4697		
*******			704					551				1.05	*******	*******	0.35	
*******			57.4					53.8				0.7546	*******	*******	0.2730	
0.15					1255							2.95	*******	*******	2.08	
0.2966					55.9							1.8110	*******	*******	0.6209	

TABLE 7 (continued)

15 MINUTE AVERAGE AT 15:45 FILE: MAY 4,1976 ATGRADE

	108	223	0	202	96	50	182	35	118	0	1014	1.14	*******	222.70	74.50	592.1
	69.1	59.9	0.0	53.7	27.9	44.7	52.9	52.9	52.0	0.0	53.5	14.980	*******	13.362	0.802	30.9631
	69	60	0	14	9	13	31	43	26	0	265	-1.53	11.30	176.14	75.95	
	69.8	59.7	0.0	58.2	37.9	52.0	60.1	54.0	52.6	0.0	59.5	15.998	3.289	21.611	0.685	
	11	14	0	5	3	5	9	16	12	0	75	0.85	10.09	141.83	76.29	40.54
	67.1	62.3	0.0	55.1	39.2	53.8	61.5	54.6	53.4	0.0	57.9	13.256	2.600	20.522	0.518	0.293
	32	31	0	7	11	17	31	2	27	0	158	0.48	8.11	282.57	80.01	37.77
	71.8	62.3	0.0	54.3	42.4	55.8	62.6	58.6	56.9	0.0	60.9	5.700	2.567	30.023	0.522	0.372
	1	0	0	0	0	2	1	0	0	0	4			*******		
	70.0	0.0	0.0	0.0	0.0	60.2	60.3	0.0	0.0	0.0	62.7			*******		
	220	328	0	228	119	85	253	96	183	0				*******		
	69.6	60.2	0.0	54.0	30.3	48.6	55.2	53.8	52.9	0.0				*******		
*******			895					617				1.24	-0.94	2.73	*******	
*******			57.0					53.4				1.0213	1.1128	6.5032	*******	
0.07					1512							3.43	3.84	3.88	*******	
0.2909					55.5							2.1176	1.9392	4.9469	*******	

15 MINUTE AVERAGE AT 16: 0 FILE: MAY 4,1976 ATGRADE

	131	241	0	214	77	34	146	52	120	0	1015	-1.88	*******	213.62	75.06	669.8
	69.6	59.5	0.0	53.8	29.3	45.6	53.1	53.6	51.1	0.0	54.6	12.394	*******	14.772	0.947	50.4911
	66	47	0	12	4	7	29	59	28	0	252	-3.99	10.12	161.31	76.07	
	70.4	61.3	0.0	60.8	41.1	52.5	57.6	56.2	50.3	0.0	60.3	12.967	2.776	28.269	0.871	
	10	12	0	2	2	3	14	14	14	0	71	-0.39	9.92	130.17	76.40	40.52
	70.8	62.0	0.0	58.7	46.2	50.6	62.3	53.3	55.0	0.0	59.2	12.734	2.665	19.331	0.710	0.830
	25	28	0	6	8	22	46	6	24	0	165	0.15	8.52	274.36	79.69	37.86
	72.3	64.9	0.0	60.2	46.8	58.7	61.5	53.9	54.5	0.0	61.3	5.664	2.304	22.228	0.518	0.707
	0	0	0	0	0	5	1	0	0	0	6			1.48		
	0.0	0.0	0.0	0.0	0.0	58.0	67.6	0.0	0.0	0.0	59.6			0.7323		
	232	328	0	234	91	66	235	131	186	0				1.92		
	70.2	60.3	0.0	54.4	31.7	50.9	55.8	54.8	51.7	0.0				0.5135		
*******			885					618				1.50	*******	0.78	0.36	
*******			58.4					53.8				0.7590	*******	0.6838	0.2483	
*******					1503							4.04	3.56	2.50	2.13	
*******					56.5							1.2490	1.2948	0.9264	0.7808	

TABLE 8

60 MINUTE AVERAGE AT 15: 0 FILE: MAY 4,1976 ATGRADE

	313	681	0	532	260	155	657	118	336	9	3061	0.18	*******	216.46	74.52	678.2
	69.6	60.5	0.0	53.9	28.4	45.7	54.3	53.5	50.7	52.5	54.1	15.156	*******	15.868	0.790	196.0097
	160	138	0	49	32	30	109	54	137	0	709	-2.08	12.06	157.41	75.67	
	70.8	61.4	0.0	58.1	38.0	54.1	61.8	54.7	56.0	0.0	60.4	14.139	3.856	29.923	0.921	
	44	54	0	22	9	17	50	8	53	1	258	0.70	10.77	134.44	76.12	41.19
	68.8	61.4	0.0	58.5	42.0	57.9	60.4	54.4	56.0	78.5	60.0	12.401	3.561	22.692	0.717	1.271
	42	73	0	30	17	59	106	5	96	2	430	0.44	9.22	281.63	79.08	38.93
	73.4	61.7	0.0	60.3	43.6	57.9	63.0	56.4	58.5	88.2	61.2	5.921	2.833	28.786	1.034	1.039
	0	0	0	0	0	6	4	0	7	0	17			2.17		
	0.0	0.0	0.0	0.0	0.0	59.5	68.5	0.0	56.2	0.0	60.2			0.8026		
	559	946	0	633	318	261	922	185	622	12				2.54		
	70.2	60.8	0.0	54.7	30.5	50.2	56.5	54.0	53.5	60.6				3.5546		
*******			2456					2002				1.02	0.74	0.94	0.39	
*******			57.4					54.5				1.5598	0.6203	0.6535	0.2717	
0.05						4458						2.98	2.51	2.05	1.60	
0.2868						56.1						1.1295	1.1714	1.2173	2.2796	

60 MINUTE AVERAGE AT 16: 0 FILE: MAY 4,1976 ATGRADE

	426	858	1	755	307	144	667	148	470	1	3777	-0.37	*******	216.14	74.54	702.1
	69.6	59.8	46.5	54.0	28.1	45.6	53.3	53.5	51.3	56.7	54.2	14.682	*******	15.858	0.857	46.4295
	225	170	0	49	28	33	126	140	101	0	874	-2.85	11.17	167.07	75.78	
	70.2	60.9	0.0	59.3	39.6	54.1	59.6	55.3	51.7	0.0	60.1	14.520	3.123	28.384	0.781	
	40	50	0	13	12	16	55	39	39	0	264	-0.00	10.37	134.50	76.20	40.00
	70.2	61.5	0.0	58.8	43.3	55.5	61.0	54.1	52.8	0.0	59.0	12.297	2.897	22.927	0.573	0.882
	76	92	0	19	31	67	132	15	91	1	524	0.27	8.76	281.39	79.63	37.51
	72.9	63.2	0.0	56.9	44.8	57.9	63.2	52.9	55.5	58.7	61.0	5.776	2.798	29.823	0.730	0.645
	2	0	0	0	0	12	5	0	1	0	20			2.01		
	76.9	0.0	0.0	0.0	0.0	60.3	64.5	0.0	48.4	0.0	62.4			0.8394		
	767	1170	1	836	378	260	982	342	701	2				1.79		
	70.1	60.3	46.5	54.5	30.8	50.5	55.9	54.3	51.9	57.7				0.5353		
*******			3152					2287				1.19	*******	1.33	0.38	
*******			57.6					53.8				0.8139	*******	3.5399	0.2751	
0.11						5439						3.37	3.21	2.80	2.02	
0.3413						56.0						1.7050	1.6380	2.7462	0.6783	

TABLE 9

5 MINUTE AVERAGE AT 16: 5 FILE: MAY 4,1976 ATGRADE

	33	74	0	75	31	16	37	19	31	4	320	7.77	*******	231.03	75.46	626.6
	69.5	59.8	0.0	51.8	28.3	37.1	48.8	51.1	47.4	55.4	51.7	18.991	*******	20.105	0.712	73.9459
	27	18	0	5	7	2	13	21	19	1	113	6.53	8.64	183.58	76.86	
	71.0	59.5	0.0	59.5	38.1	27.5	48.5	51.8	43.9	43.5	54.9	14.285	2.685	21.436	0.688	
	5	9	0	0	1	1	4	8	7	0	35	1.99	7.63	144.13	77.38	39.85
	70.2	59.5	0.0	0.0	39.8	25.6	40.7	53.7	41.3	0.0	52.4	10.538	1.662	27.924	0.548	0.451
	8	9	0	0	1	5	9	4	9	0	45	1.21	6.84	270.55	80.75	37.53
	70.4	63.1	0.0	0.0	47.6	49.7	49.7	55.7	44.4	0.0	55.5	6.650	2.209	35.852	0.569	0.441
	0	0	0	0	0	3	0	0	0	0	3			2.30		
	0.0	0.0	0.0	0.0	0.0	36.4	0.0	0.0	0.0	0.0	36.4			0.8400		
	73	110	0	80	40	24	63	52	66	5				2.35		
	70.2	60.0	0.0	52.3	30.8	38.5	48.3	52.1	45.3	53.1				0.7737		
*******			303					210				2.29	*******	1.60	0.22	
*******			56.6					47.3				1.2927	*******	0.4398	0.1846	
-0.01						513						4.71	4.59	3.12	2.29	
0.2265						52.8						1.4020	1.4870	0.7256	0.6139	

5 MINUTE AVERAGE AT 16:10 FILE: MAY 4,1976 ATGRADE

	46	79	0	85	29	13	18	31	14	0	315	-0.23	*******	220.48	74.89	605.0
	68.5	59.3	0.0	53.6	28.2	17.5	12.5	41.1	15.1	0.0	48.1	14.830	*******	15.734	0.347	18.2620
	21	19	0	5	3	11	7	51	28	0	145	-2.29	10.41	168.55	76.49	
	68.6	58.7	0.0	57.1	34.7	21.9	16.8	41.1	16.9	0.0	40.5	11.452	2.922	25.759	0.535	
	8	7	0	1	5	7	2	13	14	0	57	0.24	9.51	134.95	76.91	39.74
	68.9	59.7	0.0	53.5	40.2	23.4	13.9	39.1	20.6	0.0	38.8	11.711	3.004	20.648	0.351	0.174
	10	5	0	1	4	8	1	2	9	0	40	-0.03	9.34	282.71	80.12	37.29
	71.6	63.8	0.0	60.6	42.8	24.1	11.2	38.4	17.7	0.0	42.7	6.546	3.379	30.289	0.599	0.083
	0	0	0	0	0	1	0	0	1	0	2			1.66		
	0.0	0.0	0.0	0.0	0.0	27.9	0.0	0.0	15.8	0.0	21.8			0.8178		
	85	110	0	92	41	39	28	97	65	0				1.75		
	68.9	59.4	0.0	53.9	31.6	21.2	13.6	40.8	17.4	0.0				0.4152		
*******			328					229				1.57	*******	0.96	0.26	
*******			56.8					27.5				1.1453	*******	0.7076	0.1951	
0.09						557						5.13	4.85	3.97	2.47	
0.3988						44.8						1.8402	2.1286	2.0032	0.9912	

TABLE 9 (continued)

5 MINUTE AVERAGE AT 16:15 FILE: MAY 4,1976 ATGRADE

	45	61	0	55	31	10	8	25	8	0	243	2.29	*******	205.82	75.07	602.4
	68.3	58.9	0.0	52.6	29.4	17.7	12.6	37.9	14.3	0.0	48.6	13.703	*******	17.136	0.794	8.0312
	11	22	0	2	3	10	16	27	17	0	108	-2.42	9.64	146.43	76.11	
	72.6	61.7	0.0	57.3	36.6	21.3	17.6	35.1	15.1	0.0	37.8	13.052	3.427	32.418	0.748	
	6	6	0	3	4	1	5	17	11	0	53	-0.91	9.68	114.82	76.76	39.38
	68.2	60.7	0.0	56.8	40.4	23.8	16.7	36.0	17.0	0.0	38.0	12.498	2.899	19.533	0.162	0.397
	5	8	0	4	2	13	10	10	12	1	65	1.81	10.11	261.93	79.42	37.27
	77.8	59.2	0.0	56.4	40.9	25.4	18.1	33.9	17.6	101.8	35.9	4.548	2.606	20.570	0.407	0.503
	0	0	0	0	0	0	1	0	2	0	3			3.42		
	0.0	0.0	0.0	0.0	0.0	0.0	24.5	0.0	23.7	0.0	23.9			1.7020		
	67	97	0	64	40	34	39	79	48	1				2.22		
	69.7	59.7	0.0	53.1	31.6	21.9	16.6	36.0	16.0	101.8				0.5872		
*******			268					201				2.76	*******	2.14	0.24	
*******			56.4					25.4				1.4297	*******	0.9716	0.2194	
0.02					469							7.71	7.08	5.39	3.72	
0.3424					43.1							2.5577	1.7721	1.3851	1.3464	

5 MINUTE AVERAGE AT 16:20 FILE: MAY 4,1976 ATGRADE

	39	59	0	54	39	9	16	28	6	0	250	0.64	*******	201.89	74.57	577.6
	68.9	59.9	0.0	55.6	28.6	26.7	15.5	38.3	15.1	0.0	48.0	9.880	*******	9.947	1.295	31.1689
	18	13	0	8	1	11	21	37	21	0	130	-3.76	12.32	140.96	75.52	
	72.2	60.5	0.0	58.9	48.2	25.8	18.9	40.3	21.0	0.0	40.2	11.343	3.118	34.301	1.546	
	7	10	0	1	2	4	3	12	8	0	47	-0.93	11.69	115.29	76.25	39.46
	66.8	59.2	0.0	55.7	45.2	22.2	20.5	39.4	23.3	0.0	42.9	8.925	3.331	15.340	0.913	0.661
	3	12	0	2	6	25	22	6	29	0	105	1.92	10.66	264.20	79.40	37.08
	71.6	59.8	0.0	58.4	43.0	25.2	22.2	34.0	21.3	0.0	30.9	4.683	2.496	14.178	0.815	0.608
	1	0	0	0	0	5	2	0	0	0	8			2.23		
	77.8	0.0	0.0	0.0	0.0	26.7	25.5	0.0	0.0	0.0	32.8			0.9532		
	67	94	0	65	48	49	62	83	64	0				2.18		
	69.7	59.9	0.0	56.1	31.5	25.3	19.3	39.0	20.9	0.0				0.6894		
*******			274					258				2.26	*******	1.69	0.40	
*******			56.4					27.2				1.3444	*******	0.7146	0.3225	
0.13					532							5.32	5.13	4.39	2.52	
0.3860					42.2							1.7951	1.8313	1.2920	0.6428	

TABLE 9 (continued)

5 MINUTE AVERAGE AT 16:25 FILE: MAY 4,1976 ATGRADE

	46	70	0	64	32	19	31	16	18	1	297	0.82	*******	220.32	75.02	544.6
	69.6	59.8	0.0	54.7	28.9	33.9	47.9	48.4	43.2	38.9	52.3	14.859	*******	15.872	0.716	18.7617
	17	21	0	5	2	12	14	23	24	0	118	-0.98	9.49	170.82	75.72	
	70.9	61.7	0.0	59.4	37.6	41.5	45.8	48.9	26.6	0.0	49.0	16.354	3.025	32.750	0.519	
	5	4	0	0	0	3	7	11	8	0	38	0.99	8.96	143.20	75.92	40.59
	73.0	60.5	0.0	0.0	0.0	32.8	43.3	44.9	27.1	0.0	45.2	10.036	2.772	28.128	0.174	0.409
	3	7	0	0	3	12	17	2	15	0	59	-0.11	8.33	283.30	78.65	38.24
	68.3	68.4	0.0	0.0	42.5	43.2	44.3	52.7	28.7	0.0	44.4	6.218	2.290	31.764	0.269	0.493
	0	0	0	0	0	3	1	0	3	0	7			2.12		
	0.0	0.0	0.0	0.0	0.0	35.0	50.0	0.0	39.6	0.0	39.1			0.7733		
	71	102	0	69	37	46	59	52	65	1				2.52		
	70.1	60.8	0.0	55.0	30.5	38.2	46.1	48.0	31.7	38.9				0.8124		
*******			279					233				2.31	*******	1.59	0.46	
*******			57.7					40.9				1.2691	*******	0.7255	0.2000	
0.03						512						4.60	4.13	3.16	2.22	
0.3200						50.1						1.5658	1.7148	1.3105	0.7996	

5 MINUTE AVERAGE AT 16:30 FILE: MAY 4,1976 ATGRADE

	47	76	0	76	31	9	51	15	44	0	349	-3.31	*******	*******	73.80	587.4
	70.7	60.8	0.0	53.6	28.9	46.3	52.2	56.2	51.2	0.0	54.7	12.525	*******	*******	0.697	19.9499
	17	22	0	1	2	0	9	21	9	0	81	-0.25	10.46	*******	75.49	
	70.9	61.2	0.0	63.0	37.9	0.0	62.7	55.3	47.9	0.0	59.8	12.812	4.490	*******	0.582	
	5	3	0	0	4	4	4	4	2	0	26	1.78	8.87	*******	75.94	41.07
	69.4	63.6	0.0	0.0	42.8	53.7	60.9	53.7	47.2	0.0	56.8	11.977	3.261	*******	0.320	0.341
	0	7	0	1	2	3	3	1	6	0	23	1.08	8.02	*******	79.74	38.16
	0.0	67.1	0.0	65.5	45.8	58.7	60.1	65.2	53.6	0.0	59.6	4.534	2.300	*******	0.240	0.449
	0	0	0	0	0	0	0	0	1	0	1			1.29		
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.6	0.0	47.6			0.4377		
	69	108	0	78	39	16	67	41	61	0				1.78		
	70.6	61.3	0.0	53.9	31.7	50.5	54.5	55.7	50.8	0.0				0.3728		
*******			294					185				1.55	*******	0.72	0.47	
*******			57.6					53.2				0.8024	*******	0.7917	0.2965	
0.18						479						3.05	2.71	2.61	2.06	
0.3864						55.9						0.9071	0.9262	0.9027	0.5268	

TABLE 9 (continued)

5 MINUTE AVERAGE AT 16:35 FILE: MAY 4,1976 ATGRADE

	42	67	0	61	26	7	51	19	45	0	318	7.54	*******	219.70	74.49	597.4
	70.0	60.0	0.0	52.9	29.4	45.3	53.5	57.1	50.9	0.0	54.6	17.023	*******	21.148	0.639	17.8045
	19	19	0	1	4	2	6	13	6	0	70	-0.62	9.62	164.03	75.57	
	71.2	61.6	0.0	51.9	36.7	57.0	60.1	54.4	51.0	0.0	60.1	14.901	2.492	25.691	0.514	
	4	7	0	0	1	3	3	4	3	0	25	-0.17	9.50	127.94	75.89	41.41
	74.6	61.9	0.0	0.0	37.7	58.4	64.3	57.3	49.0	0.0	60.5	10.490	2.066	17.272	0.507	0.372
	3	3	0	0	3	4	5	3	9	0	30	1.53	8.53	272.56	79.06	38.65
	70.6	63.3	0.0	0.0	39.1	62.5	62.9	49.1	55.5	0.0	57.7	4.337	2.148	22.959	0.300	0.389
	0	0	0	0	1	0	0	0	0	0	1			1.47		
	0.0	0.0	0.0	0.0	34.0	0.0	0.0	0.0	0.0	0.0	34.0			0.5032		
	68	96	0	62	34	16	65	39	63	0				2.13		
	70.7	60.5	0.0	52.8	31.4	53.5	55.3	55.6	51.4	0.0				0.4070		
*******			260					183				1.32	*******	0.82	0.38	
*******			57.5					53.9				0.9103	*******	0.7308	0.2138	
-0.01					443							3.94	3.50	3.18	2.06	
0.2357					56.0							1.1268	1.2018	1.0959	0.5031	

5 MINUTE AVERAGE AT 16:40 FILE: MAY 4,1976 ATGRADE

	53	81	0	56	32	9	42	19	54	0	346	2.79	*******	212.64	74.62	540.6
	69.6	60.6	0.0	53.0	27.4	52.4	51.1	53.8	50.7	0.0	54.4	12.905	*******	18.087	0.193	19.0788
	12	17	0	1	2	0	15	28	9	0	84	-2.01	8.43	160.87	75.63	
	72.4	61.7	0.0	60.6	39.8	0.0	59.4	53.9	49.6	0.0	58.4	11.921	2.730	25.049	0.242	
	3	5	0	0	0	0	2	4	1	0	15	-1.77	8.06	125.87	76.28	40.74
	72.0	65.5	0.0	0.0	0.0	0.0	64.7	53.9	50.1	0.0	62.6	9.322	2.583	17.945	0.462	0.381
	6	4	0	2	3	5	5	2	11	0	38	1.03	7.77	270.94	79.36	38.26
	75.1	60.7	0.0	53.3	46.1	60.9	61.2	52.4	54.2	0.0	59.2	4.410	2.197	18.475	0.483	0.193
	1	0	0	0	0	0	0	0	0	0	1			1.77		
	74.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.8			0.7978		
	74	107	0	59	37	14	64	53	75	0				2.33		
	70.6	61.0	0.0	53.2	29.6	55.4	54.2	53.8	51.1	0.0				0.4679		
*******			277					206				1.78	*******	0.95	0.33	
*******			57.7					53.1				0.6828	*******	0.7463	0.1766	
0.08					483							4.96	4.54	3.43	2.58	
0.2442					55.7							1.0284	1.4435	0.8890	0.5344	

TABLE 9 (continued)

5 MINUTE AVERAGE AT 16:45 FILE: MAY 4,1976 ATGRADE

	50	68	0	50	23	9	39	31	36	2	308	-0.74	*******	212.80	74.29	561.0
	69.5	59.5	0.0	55.2	26.6	43.3	52.2	49.8	50.9	51.4	54.5	14.077	*******	13.221	0.963	19.3778
	18	24	0	6	3	1	10	18	6	1	87	-1.41	12.88	152.52	75.12	
	70.1	63.1	0.0	58.0	34.3	48.2	61.2	49.1	51.5	62.3	59.1	13.408	4.589	39.418	1.321	
	5	11	0	1	2	0	4	7	6	0	36	0.13	12.94	119.76	75.31	40.48
	71.6	62.4	0.0	57.5	39.1	0.0	61.7	49.5	56.2	0.0	58.6	12.604	2.822	14.172	0.908	0.345
	5	5	0	2	3	3	7	2	11	0	38	1.09	12.48	271.63	78.16	38.11
	74.8	63.4	0.0	65.0	46.9	53.4	64.1	43.8	53.8	0.0	59.2	5.564	3.316	18.037	0.960	0.443
	0	0	0	0	0	2	0	0	0	0	2			1.56		
	0.0	0.0	0.0	0.0	0.0	59.3	0.0	0.0	0.0	0.0	59.3			0.4437		
	78	108	0	59	31	13	60	58	59	3				1.78		
	70.1	60.8	0.0	55.9	30.1	46.0	55.7	49.3	52.1	55.0				0.3635		
*******			276					193				1.14	*******	0.58	0.25	
*******			58.9					52.0				0.3936	*******	0.4335	0.2995	
-0.08					469							3.53	3.40	2.87	1.82	
0.2975					56.1							0.9079	1.0379	1.1511	0.6595	

5 MINUTE AVERAGE AT 16:50 FILE: MAY 4,1976 ATGRADE

	40	76	0	63	30	9	40	16	35	0	309	2.62	*******	207.21	73.69	531.2
	69.7	60.4	0.0	54.9	26.4	44.0	54.0	51.7	50.9	0.0	54.4	15.252	*******	13.756	0.663	13.7386
	19	21	0	2	5	0	5	11	9	0	72	-2.38	11.16	154.69	74.31	
	71.8	62.0	0.0	57.6	38.1	0.0	62.7	51.5	51.5	0.0	59.9	14.816	3.805	37.398	0.971	
	3	2	0	1	1	3	1	7	4	0	22	1.73	10.32	128.23	75.29	40.42
	71.3	56.2	0.0	61.3	40.2	53.0	56.8	52.4	52.3	0.0	55.4	10.472	2.584	14.210	0.403	0.314
	5	8	0	0	3	2	5	3	8	0	34	1.25	10.21	272.52	78.00	38.04
	73.9	64.7	0.0	0.0	43.1	56.4	65.7	51.9	54.2	0.0	60.2	4.914	2.293	16.565	0.507	0.183
	0	0	0	0	0	0	0	0	2	0	2			1.92		
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.0	0.0	53.0			0.9754		
	67	107	0	66	39	14	51	37	56	0				2.06		
	70.7	61.0	0.0	55.1	29.6	47.7	56.1	51.8	51.5	0.0				0.3342		
*******			279					158				1.47	*******	0.71	0.51	
*******			57.5					52.7				0.6837	*******	0.8102	0.2360	
0.13					437							4.50	3.88	3.27	2.15	
0.2976					55.8							0.8884	0.9598	0.8709	0.4054	

TABLE 9 (continued)

5 MINUTE AVERAGE AT 16:55 FILE: MAY 4,1976 ATGRADE

	41	79	0	55	25	6	37	23	43	0	309	-3.57	*******	211.40	73.51	481.0
	69.4	59.8	0.0	54.8	28.5	40.2	53.9	51.7	49.6	0.0	54.5	12.001	*******	13.030	0.520	13.4164
	14	16	0	2	1	0	4	23	5	0	65	-6.35	11.94	161.95	74.08	
	70.8	61.8	0.0	63.6	37.1	0.0	61.2	53.6	54.0	0.0	59.9	11.977	2.120	28.140	0.878	
	2	4	0	1	1	2	4	7	1	0	22	-1.76	11.09	130.27	75.07	40.90
	72.3	61.2	0.0	57.1	42.0	59.5	55.2	49.3	58.1	0.0	57.8	12.718	2.215	21.198	0.311	0.188
	2	2	0	0	0	3	3	0	10	2	22	-0.92	9.43	284.21	77.89	38.42
	71.5	63.3	0.0	0.0	0.0	56.7	66.3	0.0	54.7	65.5	59.8	6.741	2.858	26.636	0.411	0.125
	0	0	0	0	0	0	0	0	0	0	0			1.31		
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.4534		
	59	101	0	58	27	11	48	53	59	2				1.91		
	69.9	60.2	0.0	55.1	29.3	48.2	56.2	52.2	50.9	65.5				0.4793		
*******			245					173				1.00	*******	0.56	0.42	
*******			57.9					52.8				0.4852	*******	0.7451	0.3342	
0.18					418							3.37	3.17	2.71	1.97	
0.2947					55.8							1.3602	1.2623	1.2756	0.6824	

5 MINUTE AVERAGE AT 17: 0 FILE: MAY 4,1976 ATGRADE

	42	68	0	49	30	4	40	16	42	5	296	0.60	*******	220.08	73.69	477.0
	70.2	60.9	0.0	51.3	28.0	47.0	54.1	54.6	53.0	58.2	54.7	11.976	*******	18.329	0.422	9.3274
	14	14	0	4	3	0	2	13	5	0	55	-2.22	9.32	170.54	74.61	
	70.0	62.8	0.0	58.0	38.2	0.0	56.1	52.9	53.1	0.0	59.5	17.612	2.935	32.721	0.794	
	3	9	0	1	2	1	3	4	1	0	24	0.54	8.48	137.94	74.98	41.44
	67.2	62.3	0.0	61.9	41.4	55.9	62.1	52.0	56.4	0.0	59.0	9.268	3.200	28.570	0.687	0.398
	3	3	0	0	3	3	6	3	8	1	30	0.22	7.95	277.10	77.91	38.75
	68.4	60.5	0.0	0.0	42.7	61.7	63.1	52.7	58.2	102.2	60.1	4.811	3.008	25.423	0.699	0.198
	0	0	0	0	0	1	0	0	0	1	2			1.49		
	0.0	0.0	0.0	0.0	0.0	64.4	0.0	0.0	0.0	113.7	89.0			0.6130		
	62	94	0	54	38	8	51	36	56	6				2.05		
	69.9	61.3	0.0	52.0	30.7	53.6	55.7	53.6	53.8	65.5				0.6109		
*******			248					157				1.48	*******	0.64	0.44	
*******			56.7					54.8				0.5347	*******	0.3737	0.3098	
-0.01					405							3.20	2.87	2.80	2.22	
0.3809					56.0							1.1578	1.2238	0.8029	0.8181	

TABLE 10

15 MINUTE AVERAGE AT 16:15 FILE: MAY 4,1976 ATGRADE

	124	214	0	215	91	39	63	75	53	4	878	3.28	*******	219.05	75.14	611.3
	68.7	59.4	0.0	52.7	28.6	25.6	33.8	42.6	33.8	55.4	49.5	16.245	*******	20.175	0.648	42.4500
	59	59	0	12	13	23	36	99	64	1	366	0.61	9.56	166.97	76.49	
	70.4	60.1	0.0	58.1	37.0	22.1	28.6	41.7	24.4	43.5	44.1	13.562	3.064	29.942	0.691	
	19	22	0	4	10	9	11	38	32	0	145	0.44	8.94	131.02	77.02	39.66
	69.0	59.9	0.0	56.0	40.2	23.7	24.9	40.8	23.9	0.0	41.8	11.620	2.716	25.490	0.458	0.402
	23	22	0	5	7	26	20	16	30	1	150	0.99	8.77	271.44	80.10	37.36
	72.5	61.9	0.0	57.2	42.9	29.7	32.0	39.9	25.7	101.8	43.6	6.029	3.069	30.540	0.750	0.387
	0	0	0	0	0	4	1	0	3	0	8			2.46		
	0.0	0.0	0.0	0.0	0.0	34.3	24.5	0.0	21.0	0.0	28.1			1.3686		
	225	317	0	236	121	97	130	228	179	6				2.11		
	69.6	59.7	0.0	53.1	31.3	25.7	31.3	41.7	27.3	61.2				0.6439		
*******			899					640				2.21	*******	1.57	0.24	
*******			56.6					33.3				1.3445	*******	0.8633	0.1941	
0.03					1539							5.85	5.51	4.16	2.83	
0.3214					46.9							2.3478	2.0889	1.7072	1.1840	

15 MINUTE AVERAGE AT 16:30 FILE: MAY 4,1976 ATGRADE

	132	205	0	194	102	37	98	59	68	1	896	-0.56	*******	212.41	74.46	569.9
	69.8	60.2	0.0	54.5	28.8	35.2	44.9	45.6	45.9	38.9	52.0	12.645	*******	15.861	1.020	29.1694
	52	56	0	14	5	23	44	81	54	0	329	-1.68	10.76	159.54	75.58	
	71.3	61.2	0.0	59.[illegible]	39.8	34.0	36.4	46.7	28.0	0.0	48.2	13.669	3.737	34.472	0.931	
	17	17	0	1	6	11	14	27	18	0	111	0.59	9.84	130.79	76.04	40.41
	69.4	60.2	0.0	55.7	43.6	36.5	43.4	43.7	27.6	0.0	46.9	10.374	3.349	26.113	0.547	0.846
	6	26	0	3	11	40	42	9	50	0	187	0.96	9.00	274.68	79.26	37.83
	69.9	64.1	0.0	60.8	43.4	33.1	33.9	41.6	27.4	0.0	38.7	5.267	2.611	25.263	0.671	0.733
	1	0	0	0	0	8	3	0	4	0	16			1.87		
	77.8	0.0	0.0	0.0	0.0	29.8	33.6	0.0	41.6	0.0	36.5			0.8343		
	207	304	0	212	124	111	198	176	190	1				2.15		
	70.2	60.7	0.0	54.9	31.3	34.3	40.6	45.6	34.2	38.9				0.6931		
*******			847					676				2.03	*******	1.32	0.45	
*******			57.3					39.0				1.1700	*******	0.8464	0.2724	
0.11					1523							4.29	3.95	3.35	2.27	
0.3583					49.2							1.6998	1.7865	1.3598	0.6661	

TABLE 10 (continued)

15 MINUTE AVERAGE AT 16:45 FILE: MAY 4,1976 ATGRADE

	145	216	0	167	81	25	132	69	135	2	972	3.20	*******	214.99	74.47	566.3
	69.7	60.1	0.0	53.6	27.8	47.1	52.3	52.9	50.8	51.4	54.5	15.060	*******	17.988	0.644	29.8855
	49	60	0	8	9	3	31	59	21	1	241	-1.35	10.31	159.58	75.44	
	71.1	62.2	0.0	57.6	36.6	54.0	60.1	52.6	50.5	62.3	59.2	13.387	3.845	31.190	0.807	
	12	23	0	1	3	3	9	15	10	0	76	-0.60	10.17	124.50	75.82	40.88
	72.7	62.9	0.0	57.5	38.6	58.4	63.2	52.7	53.4	0.0	60.0	10.874	3.218	16.793	0.732	0.533
	14	12	0	4	9	12	17	7	31	0	106	1.22	9.60	271.70	78.86	38.34
	74.0	62.5	0.0	59.2	44.0	59.6	62.9	48.5	54.4	0.0	58.8	4.798	3.303	19.864	0.796	0.412
	1	0	0	0	1	2	0	0	0	0	4			1.60		
	74.8	0.0	0.0	0.0	34.0	59.3	0.0	0.0	0.0	0.0	56.8			0.5946		
	220	311	0	180	102	43	189	150	197	3				2.08		
	70.4	60.8	0.0	53.9	30.4	51.9	55.1	52.5	51.5	55.0				0.4637		
*******			813					582				1.42	*******	0.78	0.32	
*******			58.1					53.0				0.7240	*******	0.6491	0.2338	
-0.00					1395							4.14	3.82	3.16	2.15	
0.2610					55.9							1.1615	1.3060	1.0409	0.6376	

15 MINUTE AVERAGE AT 17: 0 FILE: MAY 4,1976 ATGRADE

	123	223	0	167	85	19	117	55	120	5	914	-0.12	*******	212.83	73.63	496.4
	69.8	60.3	0.0	53.8	27.6	43.4	54.0	52.5	51.1	58.2	54.5	13.331	*******	15.998	0.522	27.9617
	47	51	0	8	9	0	11	47	19	0	192	-3.65	10.81	162.58	74.33	
	71.0	62.1	0.0	59.3	38.0	0.0	61.0	52.9	52.6	0.0	59.8	15.002	3.179	33.301	0.853	
	8	15	0	3	4	6	8	18	6	0	68	0.17	9.97	131.96	75.12	40.92
	70.0	61.2	0.0	60.1	41.3	55.6	63.0	51.2	54.0	0.0	57.4	10.961	2.871	22.446	0.482	0.524
	10	13	0	0	6	8	14	6	26	3	86	0.18	9.20	277.80	77.93	38.40
	71.8	63.5	0.0	0.0	42.9	58.5	64.7	52.3	55.6	77.7	60.1	5.618	2.852	23.661	0.509	0.344
	0	0	0	0	0	1	0	0	2	1	4			1.57		
	0.0	0.0	0.0	0.0	0.0	64.4	0.0	0.0	53.0	113.7	71.0			0.7373		
	188	302	0	178	104	33	150	126	171	8				2.01		
	70.2	60.8	0.0	54.2	29.9	49.3	56.0	52.5	52.1	65.5				0.4763		
*******			772					488				1.32	*******	0.63	0.45	
*******			57.4					53.4				0.5990	*******	0.6504	0.2885	
0.10					1260							3.69	3.31	2.93	2.11	
0.3258					55.9							1.2576	1.1958	1.0005	0.6442	

TABLE 11

60 MINUTE AVERAGE AT 17: 0 FILE: MAY 4,1976 ATGRADE

	524	858	0	743	359	120	410	258	376	12	3660	1.46	*******	214.88	74.43	561.0
	69.5	60.0	0.0	53.6	28.3	35.9	48.2	48.1	47.6	54.5	52.7	14.474	*******	17.808	0.900	52.5267
	207	226	0	42	36	49	122	286	158	2	1128	-1.52	10.36	162.30	75.46	
	70.9	61.4	0.0	58.7	37.5	29.6	42.4	47.2	32.5	52.9	51.2	13.967	3.487	32.249	1.118	
	56	77	0	9	23	29	42	98	66	0	400	0.15	9.73	129.45	76.00	40.46
	70.0	61.1	0.0	57.5	41.1	38.8	46.5	45.3	32.1	0.0	49.3	10.960	3.067	23.060	0.888	0.773
	53	73	0	12	33	86	93	38	137	4	529	0.84	9.14	273.90	79.04	37.98
	72.5	63.0	0.0	58.8	43.4	38.1	43.4	43.8	38.5	83.8	47.6	5.457	2.967	25.256	1.046	0.639
	2	0	0	0	1	15	4	0	9	1	32			1.88		
	76.3	0.0	0.0	0.0	34.0	37.2	31.4	0.0	37.3	113.7	41.2			0.9875		
	840	1234	0	806	451	284	667	680	737	18				2.09		
	70.1	60.5	0.0	54.0	30.8	35.8	46.3	47.1	41.3	60.8				0.5719		
*******			3331					2386				1.74	*******	1.07	0.37	
*******			57.3					43.9				1.0653	*******	0.8411	0.2621	
0.06					5717							4.49	4.15	3.40	2.34	
0.3187					51.7							1.8542	1.8135	1.3737	0.8576	

60 MINUTE AVERAGE AT 18: 0 FILE: MAY 4,1976 ATGRADE

	509	975	0	721	327	33	482	238	454	27	3766	0.64	*******	221.30	72.99	312.6
	68.9	60.0	0.0	53.5	27.9	47.7	53.6	53.8	51.2	53.4	54.7	15.247	*******	14.409	0.698	148.2116
	214	175	0	31	26	10	55	226	65	3	805	-2.40	11.28	174.60	74.03	
	69.5	61.0	0.0	60.0	38.3	58.0	61.6	55.5	52.7	60.7	60.3	15.400	3.350	23.400	0.742	
	42	60	0	14	8	7	28	48	28	4	239	0.83	9.86	139.82	74.54	42.57
	69.5	61.9	0.0	59.9	40.9	59.5	60.0	55.7	53.4	81.	60.2	12.000	3.313	21.955	0.668	0.513
	58	78	0	9	35	23	43	21	77	15	359	0.29	8.10	283.81	77.35	39.70
	73.6	63.2	0.0	62.3	43.0	61.6	62.6	54.3	56.1	93.2	61.9	5.914	2.951	30.453	0.740	0.493
	1	2	0	0	1	1	0	0	0	1	6			1.14		
	72.8	58.0	0.0	0.0	37.1	67.6	0.0	0.0	0.0	143.2	72.8			0.6608		
	823	1288	0	775	396	73	608	533	624	49				1.79		
	69.5	60.4	0.0	53.9	30.2	54.6	55.3	54.7	52.1	68.3				0.6564		
*******			3282					1887				1.36	*******	*******	0.44	
*******			57.5					54.4				0.6011	*******	*******	0.2062	
0.07					5169							3.38	3.30	2.42	1.80	
0.2618					56.4							2.2166	1.2827	0.9588	0.5991	

LITERATURE CITED

Barr, Anthony and James Goodnight, "SAS (Statistical Analysis System) Computer Library Subroutines," Department of Statistics, North Carolina State University, Student Supply Stores, NCSU, Raleigh, N.C. (1972).

Beaton, John L., Andrew J. Ranzieri, and John B. Skog, "Air Quality Manual: Vol. I. Meteorology and its Highway Line Sources." California Division of Highways Report No. CA-HWY-MR6570825(1)-72-11, Sacramento, California (1972).

Beaton, James L., Andrew J. Ranzieri and John B. Skog, "Air Quality Manual: Vol. IV. Mathematical Approach to estimating Highway Impace on Air Quality." California Division of Highways Report No. CA-HWY-MR6570825(4)-72-08, Scramento, California (1972).

Calder, K. L., "Eddy Diffusion and Evaporation in Flow over Aerodynamically Smooth and Rough Suraces: A Treatment Based on Laboratory Laws of Turbulent Flow with Special Reference to Conditions in the Lower Atmosphere," Quart. Journal Mech. and Applied Math., II, 153 (1949).

Calder, Kenneth L., "On Estimating Air Pollution Concentration From a Highway in an Oblique Wind," Atmospheric Environment, 7, 863 (1973).

California Division of Highways, Material and Research Department, "Project Smoke", an unpublished study on atmospheric diffusion, Scramento, California (1972).

Carpenter, William A., and Gerardo G. Clemena, "The Theory and Mathematical Development of Airpol-4," Virginia Highway and Transportation Research Council, Report No. VHTRC75-R49, Charlottesville, Virginia (1975).

Carpenter, William A., Gerardo G. Clemena, and W. Richard Lunglhofer, "Supportive Data and Methods for the Evaluation of Airpol-4," Virginia Highway and Transportation Research Council, Report No. UHTRC75-R57, Charlottesville, Virginia (1975).

Habegger, L. J., et al., "Dispersion Simulation Techniques for Assessing the Air Pollution Impacts of Ground Transportation Systems," Report for Argonne National Laboratory, Argonne, Illinois (1974).

Noll, K. E., "Air Quality Report: Interstate 40 Modification Between Stratford Road and Peters's Creek Parkway in Forsyth County, North Carolina," Report for Harland Bartholomew and Associates, Raleigh, N.C. (1973).

Noll, K. E., T. L. Miller, R. H. Raniney, and R. C. May, "Final Report on the Air Monitoring Program to Determine the Impact of Highways on Ambient Air Quality," Department of Civil Engineering, University of Tennessee, Knoxville, Tennessee (1975).

Pasquil, F., Atmosperic Diffusion, D. Van Nostrand Company, Ltd., London (1962).

Passquil, F., Atmospheric Diffusion, 2nd Edition, Ellis Horwood Ltd., Sussex (1974).

Ranzieri, Andrew J., et al., "Advanced Air Quality Analysis," California Division of Transportation Training Manual, Sacramento, California (1975).

Ranzieri, Andrew J., Gerald R. Bemis and Earl C. Shirley, "Air Pollution and Roadway Location, Design, and Operation," California Division of Transportation Report No. A-DOT-TL-7080-75-15, Sacramento, California (1975).

Turner, D. Bruce, "Workbook of Atmospheric Dispersion Estimates," U.S. Department of health, Education and Welfare, Washington, D. C. (1970).

U.S. Environmental Protection Agency, AP-42, "Compilation of Air Pollutant Emission Factors, Supplement No. 5," Office of Air Programs, Research Triangle Park, North Carolina (1975).

Zimmerman, John L., and Roger S. Thompson, "Hiway: A Highway Air Pollution Model," National Environmental Research Center, Research Triangle Park, North Carolina (1974).

Appendix A

```
//STEP1 EXEC ASMFC
//ASM.SYSIN DD *
QSIO     TITLE '     QSAM VARIABLE LENGTH INPUT/OUTPUT ROUTINE'
***********************************************************************
*                                                                     *
*        QSAM VARIABLE LENGTH INPUT/OUTPUT ROUTINE  -  FORTRAN        *
*        ROCKETDYNE DIVISION   N. A. R.                2/12/68        *
*                                                                     *
***********************************************************************
*                                                                     *
*        ENTRY POINTS                                                 *
*                                                                     *
*                          GETR      INPUT   (OPEN DCB IF NECESSARY)  *
*                                                                     *
*                          PUTR      OUTPUT  (OPEN DCB IF NECESSARY)  *
*                                                                     *
*                          ENDQ      CLOSE DATA CONTROL BLOCK         *
*                                                                     *
***********************************************************************
*                                                                     *
*        THIS ROUTINE MAY BE USED TO READ/WRITE SEQUENTIAL DATA       *
*        SETS.  THE DATA MANAGEMENT USED IS QSAM.  ONLY ONE DATA      *
*        SET EACH CAN BE INPUT AND OUTPUT AT A TIME.  THAT IS,        *
*        ONE DATA SET FOR INPUT AND ONE DATA SET FOR OUTPUT CAN       *
*        BE OPEN AT THE SAME TIME.  IN ORDER TO INPUT/OUTPUT MORE     *
*        THAN ONE DATA SET, THE 'OLD' DATA SET MUST BE CLOSED         *
*        PRIOR TO INPUT/OUTPUT OF THE 'NEW' DATA SET.                 *
*                                                                     *
*        DATA SETS ARE AUTOMATICALLY OPENED WHEN GETR OR PUTR IS      *
*        CALLED AND THE DCB FOR GETR OR PUTR IS CLOSED.  DATA SETS    *
*        ARE CLOSED VIA CALLING ENDQ.  TWO OPTIONS ARE PROVIDED FOR   *
*        CLOSING DATA SETS, NAMELY                                    *
*                                                                     *
*        CLOSE AND POSITION AT BEGINNING OF THE DATA SET              *
*        CLOSE AND POSITION AT THE END OF THE DATA SET                *
*                                                                     *
*        FOR CALLING SEQUENCES, SEE SPECIFIC ENTRY POINT              *
*                                                                     *
***********************************************************************
         EJECT
QSIO     START 0
*
*        GENERAL REGISTER DEFINITIONS AND USAGE
*
R0       EQU   0         SCRATCH
R1       EQU   1         PARM 1 POINTER  AND  SCRATCH
R2       EQU   2         PARM 2 POINTER
R3       EQU   3         PARM 3 POINTER
R4       EQU   4         PARM 4 POINTER
```

```
R5       EQU   5          DCB BASE REGISTER                                QSI00470
R6       EQU   6          SCRATCH                                          QSI00480
R7       EQU   7                                                           QSI00490
R8       EQU   8                                                           QSI00500
R9       EQU   9                                                           QSI00510
R10      EQU   10                                                          QSI00520
R11      EQU   11         POINTER TO CALLER'S SAVE AREA                    QSI00530
R12      EQU   12         PROGRAM BASE REGISTER                            QSI00540
R13      EQU   13         SAVE AREA POINTER                                QSI00550
R14      EQU   14         EXTERNAL RETURN                                  QSI00560
R15      EQU   15         EXTERNAL LINKAGE                                 QSI00570
*                                                                          QSI00590
*        ENTRY POINTS                                                      QSI00600
*                                                                          QSI00610
         ENTRY GETR                                                        QSI00620
*                                                                          QSI00630
         ENTRY PUTR                                                        QSI00640
*                                                                          QSI00650
         ENTRY ENDQ                                                        QSI00660
         EJECT                                                             QSI00670
*        G E T R   C A L L I N G   S E Q U E N C E                       * QSI00680
*                                                                        * QSI00690
************************************************************************** QSI00700
*                                                                        * QSI00710
*        CALL GETR(DDNAME,IND,ARRAY,NCHAR)                               * QSI00720
*                                                                        * QSI00730
*        DDNAME    8 CHARACTER LITERAL OR VARIABLE WHICH IS THE          * QSI00740
*                  DDNAME FROM THE DD CARD OF THE DATA SET               * QSI00750
*                                                                        * QSI00760
*         ARRAY    ARRAY INTO WHICH THE RECORD IS MOVED.  ARRAY          * QSI00770
*                  MUST BE DIMENSIONED SUCH THAT IT CAN RECEIVE          * QSI00780
*                  THE LARGEST RECORD EXPECTED.  SIZE OF ARRAY           * QSI00790
*                  SHOULD CORRESPOND TO BLKSIZE FROM DCB PARM.           * QSI00800
*                                                                        * QSI00810
*         NCHAR    INTEGER*4 VARIABLE.  THE VALUE PASSED BACK TO         * QSI00820
*                  THE CALLER IS THE NUMBER OF CHARACTERS MOVED          * QSI00830
*                  INTO ARRAY.  IF AN ERROR OR END FILE CONDITION        * QSI00840
*                  IS DETECTED, NCHAR IS UNDEFINED                       * QSI00850
*                                                                        * QSI00860
*           IND    INTEGER*4 VARIABLE.  THE VALUE PASSED BACK TO         * QSI00870
*                  THE CALLER INDICATES THE FOLLOWING                    * QSI00880
*                                                                        Q QSI00890
*            -3    NOT MORE THAN ONE DATA SET CAN BE OPENED AT           * QSI00900
*                  THE SAME TIME BY GETR                                 * QSI00910
*                                                                        * QSI00920
*            -2    DATA SET COULD NOT BE OPENED SUCCESSFULLY.            * QSI00930
*                  PROBABLY MEANS THAT DDNAME DID NOT CORRESPOND         * QSI00940
*                  TO DDNAME FROM DD CARD                                * QSI00950
*                                                                        * QSI00960
```

```
*              -1    END FILE DETECTED                                 *
*                                                                      *
*               0    NO ERRORS WERE DETECTED                           *
*                                                                      *
*              >0    AN ERROR HAS OCCURRED.  THE VALUE PASSED BACK     *
*                    TO THE CALLER IS STATUS BYTES 0 AND 1 AND         *
*                    SENSE BYTES 0 AND 1, LEFT TO RIGHT IN IND         *
*                                                                      *
************************************************************************
         EJECT
         USING GETR,R15
GETR     B     G#1
         DC    X'4',CL5'GETR'
G#1      STM   R14,R12,12(R13)
         L     R12,LDPNT
         DROP  R15
         USING QSIO,R12
         BAL   R6,INIT                 INITIALIZE - SAVE AREA CHAIN ETC.
         LA    R5,GETDCB               POINT TO DCB
         USING IHADCB,R5
         TM    DCBOFLGS,X'10'          IS DCB OPEN?
         BC    1,G#2                   YES. BRANCH
         MVC   DCBDDNAM,0(R1)          NO.. MOVE DDNAME TO DCB
         MVC   GDDNAME,0(R1)           SAVE DDNAME
         XC    DCBLRECL,DCBLRECL       0 TO LRECL.  OPEN GETS IT FROM DD
         OPEN  (GETDCB,(INPUT))        OPEN DCB FOR INPUT
         TM    DCBOFLGS,X'10'          WAS OPEN SUCCESSFUL?
         BC    1,G#4                   YES. BRANCH
         B     ER#2                    NO.. TAKE ERROR EXIT
G#2      CLC   GDDNAME,0(R1)           DID CALLER CHANGE DDNAME?
         BNE   ER#3                    YES. TAKE ERROR EXIT
G#4      GET   GETDCB,(R3)             GET A RECORD
         LH    R0,DCBLRECL             PICK UP RECORD LENGTH
         ST    R0,0(R4)                AND PASS IT TO CALLER
         B     EXIT                    GO EXIT TO CALLER
         EJECT
*        P U T R    C A L L I N G   S E Q U E N C E                    *
*                                                                      *
************************************************************************
*                                                                      *
*        CALL PUTR(DDNAME,IND,ARRAY,NCHAR)                             *
*                                                                      *
*        DDNAME    8 CHARACTER LITERAL OR VARIABLE WHICH IS THE        *
*                  DDNAME FROM THE DD CARD OF THE DATA SET             *
*                                                                      *
*         ARRAY    ARRAY FROM WHICH THE RECORD IS WRITTEN              *
*                                                                      *
*         NCHAR    INTEGER*4 VARIABLE OR CONSTANT WHICH IS THE         *
*                  NUMBER OF CHARACTERS TO BE WRITTEN                  *
```

```
*                                                                           *
*            IND    INTEGER*4 VARIABLE.  THE VALUE PASSED BACK TO          *
*                   THE CALLER INDICATES THE FOLLOWING                     *
*                                                                           *
*             -3    NOT MORE THAN ONE DATA SET CAN BE OPENED AT            *
*                   THE SAME TIME BY PUTR                                  *
*                                                                           *
*             -2    DATA SET COULD NOT BE OPENED SUCCESSFULLY.             *
*                   PROBABLY MEANS THAT DDNAME DID NOT CORRESPOND          *
*                   TO DDNAME FROM DD CARD                                 *
*                                                                           *
*             -1    NOT USED                                               *
*                                                                           *
*              0    NO ERRORS WERE DETECTED                                *
*                                                                           *
*             >0    AN ERROR HAS OCCURRED.  THE VALUE PASSED BACK          *
*                   TO THE CALLER IS STATUS BYTES 0 AND 1 AND              *
*                   SENSE BYTES 0 AND 1, LEFT TO RIGHT IN IND              *
*                                                                           *
         EJECT
         USING PUTR,R15
PUTR     B     P#1
         DC    X'4',CL5'PUTR'
P#1      STM   R14,R12,12(R13)
         L     R12,LDPNT
         DROP  R15
         USING QSIO,R12
         BAL   R6,INIT                  INITIALIZE - SAVE AREA CHAIN ETC.
         LA    R5,PUTDCB                POINT TO DCB
         USING IHADCB,R5
         TM    DCBOFLGS,X'10'           IS DCB OPEN?
         BC    1,P#2                    YES. BRANCH
         MVC   DCBDDNAM,0(R1)           NO.. MOVE DDNAME TO DCB
         MVC   PDDNAME,0(R1)            SAVE DDNAME
         OPEN  (PUTDCB,(OUTPUT))        OPEN DCB FOR OUTPUT
         TM    DCBOFLGS,X'10'           WAS OPEN SUCCESSFUL?
         BC    1,P#4                    YES. BRANCH
         B     ER#2                     NO.. TAKE ERROR EXIT
P#2      CLC   PDDNAME,0(R1)            DID CALLER CHANGE DDNAME?
         BNE   ER#3                     YES. TAKE ERROR EXIT
P#4      L     R0,0(R4)                 PICK UP RECORD LENGTH
         STH   R0,DCBLRECL              AND STORE IT IN DCB
         PUT   PUTDCB,(R3)              PUT A RECORD
         B     EXIT                     GO EXIT TO CALLER
         EJECT
*        E N D Q   C A L L I N G   S E Q U E N C E                          *
*                                                                           *
*****************************************************************************
*                                                                           *
```

```
*          CALL ENDQ(DDNAME,IND,OPTION)                                  * QSI01896
*                                                                        * QSI01897
*          DDNAME    8 CHARACTER LITERAL OR VARIABLE WHICH IS THE        * QSI01898
*                    DDNAME FROM THE DD CARD OF THE DATA SET             * QSI01899
*                                                                        * QSI01900
*             IND    INTEGER*4 VARIABLE.  THE VALUE PASSED BACK TO       * QSI01901
*                    THE CALLER INDICATES THE FOLLOWING                  * QSI01902
*                                                                        * QSI01903
*              -2    DDNAME DOES NOT CORRESPOND TO A DATA SET THAT       * QSI01904
*                    WAS PREVIOUSLY OPENED                               * QSI01905
*                                                                        * QSI01906
*               0    DATA SET HAS BEEN CLOSED                            * QSI01907
*                                                                        * QSI01908
*          OPTION    THE LITERAL 'REWIND' OR 'LEAVE' OR A VARIABLE       * QSI01909
*                    CONTAINING THE CHARACTERS REWIND OR LEAVE           * QSI01910
*                                                                        * QSI01911
*                    REWIND - POSITION DATA SET AT BEGINNING             * QSI01912
*                     LEAVE - POSITION DATA SET AT END                   * QSI01913
*                                                                        * QSI01914
* NOTE ***           IF THE DATA SET IS ALREADY CLOSED THEN OPTION       * QSI01915
*                    HAS NO EFFECT.  E.G. IF A DATA SET IS CLOSED        * QSI01916
*                    WITH LEAVE AND LATER A CALL TO ENDQ IS MADE         * QSI01917
*                    WITH REWIND - THE DATA SET WILL NOT BE POSITIONED   * QSI01918
*                    AT THE BEGINNING                                    * QSI01919
*                                                                        * QSI01920
************************************************************************** QSI01921
         EJECT                                                           QSI01922
         USING ENDQ,R15                                                  QSI01923
ENDQ     B     E#1                                                       QSI01924
         DC    X'4',CL5'ENDQ'                                            QSI01930
E#1      STM   R14,R12,12(R13)                                           QSI01940
         L     R12,LOPNT                                                 QSI01950
         DROP  R15                                                       QSI01960
         USING QSIO,R12                                                  QSI01970
         BAL   R6,INIT               INITIALIZE - SAVE AREA CHAIN ETC.   QSI01980
         USING IHADCB,R5                                                 QSI01990
         LA    R5,PUTDCB             POINT TO DCB                        QSI02000
         CLC   PDDNAME,0(R1)         CLOSE THIS ONE?                     QSI02010
         BE    E#2                   YES. BRANCH                         QSI02020
         LA    R5,GETDCB             NO.. POINT TO OTHER DCB             QSI02030
         CLC   GDDNAME,0(R1)         CLOSE THIS ONE?                     QSI02040
         BNE   ER#2                  NO.. TAKE ERROR EXIT                QSI02050
E#2      TM    DCBOFLGS,X'10'        IS DCB OPEN?                        QSI02060
         BC    8,EXIT                NO.. BRANCH                         QSI02070
         CLC   0(6,R3),=C'REWIND'    YES. DOES HE WANT TO REWIND?        QSI02080
         BE    E#4                   YES. BRANCH                         QSI02090
         CLOSE ((R5),LEAVE)          NO.. CLOSE WITH LEAVE OPTION        QSI02100
         B     EXIT                  GO EXIT TO CALLER                   QSI02110
E#4      CLOSE ((R5),REREAD)         CLOSE WITH REREAD                   QSI02120
```

```
         B     EXIT                     GO EXIT TO CALLER
         EJECT
         USING QSIO,R12
INIT     LR    R11,R13                  SAVE CALLER'S SA POINTER
         LA    R13,SA                   INITTIALIZE NEW SA POINTER
         ST    R13,8(R11)               CHAIN
         ST    R11,4(R13)               SAVEAREAS
         LM    R1,R4,0(R1)              LOAD PARAMETER POINTERS
         SR    R0,R0                    ZERO
         ST    R0,0(R2)                 TO CALLER'S ERROR INDICATOR
         BR    R6                       LOCAL RETURN
*
*        ERROR EXIT #2                  DCB FAILED TO OPEN SUCCESSFULLY
*
ER#2     LA    R0,2                     SET ERROR INDICATOR = 2
         B     ER#4                     GO MAKE IT NEGATIVE
*
*        ERROR EXIT #3                  DDNAME CHANGE WHILE DCB WAS OPEN
*
ER#3     LA    R0,3                     SET ERROR INDICATOR = 3
ER#4     LNR   R0,R0                    MAKE ERROR INDICATOR NEGATIVE
         ST    R0,0(R2)                 AND PASS TO CALLER
*
*        EXIT TO CALLER
*
EXIT     LR    R13,R11                  RESTORE CALLER'S SA POINTER
         LM    R14,R12,12(R13)          RESTORE REGISTERS
         MVI   12(R13),X'FF'            INDICATE RETURN
         BR    R14                      EXIT TO CALLER
         EJECT
*
*        EODAD ROUTINE
*
EOFX     LA    R0,1                     SET ERROR INDICATOR = 1
         B     ER#4                     GO MAKE IT NEGATIVE AND EXIT
*
*        SYNAD ROUTINE
*
ERRX     LR    R1,R0                    POINT TO STATUS INDICATOR AREA
         MVC   0(2,R2),12(R1)           MOVE STATUS 0 & 1 TO CALLERS IND
         MVC   2(2,R2),2(R1)            MOVE SENSE  0 & 1 TO CALLERS IND
         BR    R14                      EXIT TO IOS
*
         EJECT
LDPNT    DC    A(QSIO)                  ADDRESS OF LOAD POINT
SA       DC    18F'0'
GDDNAME  DC    CL8' '
PDDNAME  DC    CL8' '
GETDCB   DCB   DSORG=PS,DEVD=DA,SYNAD=ERRX,MACRF=(GM),EODAD=EOFX,      X
```

```
                 EROPT=ACC
PUTDCB    DCB    DSORG=PS,DEVD=DA,SYNAD=ERRX,MACRF=(PM)
          EJECT
          DCBD   DSORG=(QS),DEVD=(DA)
          END
/*
//STEP2 EXEC FORTGCLG
//FORT.SYSIN DD *
      DOUBLE PRECISION DDNM(50)
      INTEGER*2 DATA(2000)
      I=1
      IBD=0
      IBLK=0
      READ(5,500) NFILE
      READ(5,501) (DDNM(J),J=1,NFILE)
    1 CONTINUE
      IBLK=IBLK+1
      CALL GETR(DDNM(I),ITST,DATA,ILNG)
      IF (ITST) 2,4,3
    2 IF (ITST .EQ.-1) GO TO 6
      WRITE (6,600) ITST,DDNM(I)
      STOP
    3 IF (IBD .GT.2) GO TO 1
      IBD=IBD+1
      IBLK=IBLK-1
      BACKSPACE 1
      WRITE (6,601) IBD, DDNM(I)
      GO TO 1
    4 IL=ILNG/2
      IBD=0
      JS=2
    5 JL=DATA(JS)
      JDM=DATA(JS+1)
      JE=JS+JL-1
      IF (JE .GT.IL) GO TO 1
      IF (JDM .EQ.0 .OR.JDM .EQ.5) CALL LIST(DATA,JS+4,JE)
      IF (JL .GT. 120) GO TO 7
      IF (DATA(JS+1) .LT.0 .OR. DATA(JS+1) .GT.20) GO TO 7
C     WRITE (2,200) (DATA(N),N=JS,JE)
      IF (JE .EQ.IL) GO TO 1
      JS=JE+1
      GO TO 5
    6 CALL ENDQ(DDNM(I),ITST,'LEAVE')
      IBLK=0
      I=I+1
      IF (I .GT. NFILE) STOP
      GO TO 1
    7 WRITE (6,602) IBLK,NFILE
      GO TO 1
```

```
500 FORMAT (I5)
501 FORMAT (8(A8,2X))
600 FORMAT (' RETRY:',I2,'  FILE:',A8)
601 FORMAT (' READ ERROR:',I5,'     FILE:',A8)
602 FORMAT (' ********BAD BLOCK',I3,' FILE:',2X,A8,'  ********')
    END
    SUBROUTINE LIST(I,JU,KU)
    INTEGER*2L(128)/0,1,2,3,55,45,46,47,22,5,37,11,12,13,14,15,16,17,
   >18,18,60,61,50,38,24,25,63,39,34,34,53,53,64,90,127,123,91,108,
   >80,125,77,93,92,78,107,96,75,97,240,241,242,243,244,245,246,247,
   >248,249,122,94,76,126,110,111,124,193,194,195,195,197,198,199,
   >200,201,209,210,211,212,213,214,215,216,217,226,227,228,229,230,
   >231,232,233,192,0,208,0,0,121,27*0,250,0,204,7/
    INTEGER*2 I(2000),C(2),IB(55)
    CALL CNVRT(ITM,I(JU-2),I(JU-1))
    IB(2)=I(JU-3)
    J=4
    IA=KU-JU+5
    IH=ITM/360000
    IM=ITM/6000-IH*60
    DO 18 I1=JU,KU
    J=J+1
    CALL DEPAK(I(I1),C)
    IF ( C(1) .GE. 128 .OR.C(2).GE. 128) GO TO 4
    IB(J)=256*L(C(1)+1)+L(C(2)+1)
    IF (C(1).NE.13) GO TO 16
    IB(J)=0
    GO TO 19
 16 IF(C(2).NE.13) GO TO 17
    IB(J)=L(C(1)+1)*256
    GO TO 19
 17 CONTINUE
 18 CONTINUE
 19 IF (J.GT.IA) J=IA
    IF (J .GT.50) J=50
    JD=J-4
    IF (ITM .EQ. 0) RETURN
    WRITE (6,600) IB(2),IH,IM,(IB(K),K=5,J)
600 FORMAT (10X,'TYPE: ',I2,' AT ',I2,':',I2,' HOURS.',50A2)
  4 RETURN
    END
    SUBROUTINE CNVRT (I,IH,IL)
    INTEGER*2 IH,IL
    I=IL
    IF (I .LT.0) I=I+65536
    I=I+65536*IH
    RETURN
    END
    SUBROUTINE DEPAK(I,J)
```

```
      INTEGER*2 I, J(2), K(2)
      LOGICAL*1 A(4)
      EQUIVALENCE (K,A)
      K(1)=I
      K(2)=0
      A(4)=A(1)
      A(1)=A(3)
      J(1)=K(1)
      J(2)=K(2)
      RETURN
      END
//GO.DUMMY DD DUMMY
//FT01F001 DD UNIT=TAPE9,VOL=SER=ZZ3893,DISP=(OLD,KEEP),
//         LABEL=(1,NL,,IN),DCB=(LRECL=3200,BLKSIZE=3200,DEN=2,RECFM=U)
//FT01F002 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(2,NL,,IN),DCB=(*.FT01F001)
//FT01F003 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(3,NL,,IN),DCB=(*.FT01F001)
//FT01F004 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(4,NL,,IN),DCB=(*.FT01F001)
//FT01F005 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(5,NL,,IN),DCB=(*.FT01F001)
//FT01F006 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(6,NL,,IN),DCB=(*.FT01F001)
//FT01F007 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(7,NL,,IN),DCB=(*.FT01F001)
//FT01F008 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(8,NL,,IN),DCB=(*.FT01F001)
//FT01F009 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(9,NL,,IN),DCB=(*.FT01F001)
//FT01F010 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(10,NL,,IN),DCB=(*.FT01F001)
//FT01F011 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(11,NL,,IN),DCB=(*.FT01F001)
//FT01F012 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(12,NL,,IN),DCB=(*.FT01F001)
//FT01F013 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(13,NL,,IN),DCB=(*.FT01F001)
//FT01F014 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(14,NL,,IN),DCB=(*.FT01F001)
//FT01F015 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(15,NL,,IN),DCB=(*.FT01F001)
//FT01F016 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(16,NL,,IN),DCB=(*.FT01F001)
//FT01F017 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(17,NL,,IN),DCB=(*.FT01F001)
//FT01F018 DD UNIT=TAPE9,VOL=SER=ZZ3893,
//         DISP=(OLD,KEEP),LABEL=(18,NL,,IN),DCB=(*.FT01F001)
//GO.SYSIN DD *
```

```
   18
FT01F001  FT01F002  FT01F003  FT01F004  FT01F005  FT01F006  FT01F007  FT01F008
FT01F009  FT01F010  FT01F011  FT01F012  FT01F013  FT01F014  FT01F015  FT01F016
FT01F017  FT01F018  FT01F019  FT01F020  FT01F021  FT01F022  FT01F023  FT01F024
/*
/*END
```

Appendix B

```
//STEP1 EXEC WATFIV,REGION=256K
//FT01F001 DD UNIT=TAPE9,VOL=SER=000123,DSN=RAWDATA1,
//         DISP=(OLD,KEEP),LABEL=(1,SL,,IN)
//FT01F002 DD UNIT=TAPE9,VOL=SER=000123,DSN=RAWDATA2,
//         DISP=(OLD,KEEP),LABEL=(2,SL,,IN)
//FT01F003 DD UNIT=TAPE9,VOL=SER=000123,DSN=RAWDATA3,
//         DISP=(OLD,KEEP),LABEL=(3,SL,,IN)
//FT02F001 DD UNIT=SYSDA,VOL=SER=WORK33,DISP=(NEW,PASS),
//         SPACE=(CYL,(30,6)),DSN=SEMISORT,
//         DCB=(RECFM=VB,LRECL=3700,BLKSIZE=13000)
//SYSIN DD DATA
//$OPTIONS
      INTEGER*2L(128)/0,1,2,3,55,45,46,47,22,5,37,11,12,13,14,15,16,17,
     >18,18,60,61,50,38,24,25,63,39,34,34,53,53,64,90,127,123,91,108,
     >80,125,77,93,92,78,107,96,75,97,240,241,242,243,244,245,246,247,
     >248,249,122,94,76,126,110,111,124,193,194,195,196,197,198,199,
     >200,201,209,210,211,212,213,214,215,216,217,226,227,228,229,230,
     >231,232,233,192,0,208,0,0,121,27*0,250,0,204,7/
      INTEGER    IN(64),IT(64),MN(64),MX(64),UN(64),OF(64),
     > IE(11,64,28)/19712*0/,IC(5)
      INTEGER*2 SP0,SP1,SP2/0/,C(2),NM(3,64),IB(150)
      INTEGER*2 NTO(50)
      REAL O(150)
      IP0=1
      READ (5,502) (NTO(I),I=1,50)
      IF=1
      SP0=0
      SP1=1
      READ (5,500) N
    1 READ (5,501,END=3) I,IN(I),IT(I),MN(I),MX(I),UN(I),OF(I),
     >(NM(J,I),J=1,3)
      DO 2 J=1,3
      CALL DEPAK(NM(J,I),C)
    2 NM(J,I)= 256*L(C(1)+1)+L(C(2)+1)
      GO TO 1
    3 DO 21 I=1,N
    4 READ (1,100,END=20) IA,(IB(J),J=2,IA)
      CALL CNVRT(ITM,IB(3),IB(4))
      IF (IB(2)-1)  15,12,5
    5 IF (IB(2)-10) 10,8,6
    6 IF (IA .LT.10) GO TO 4
      IB(5)=IB(5)+1
      IN(IB(5))=IB(6)
      DO 7 J=10,IA
      K=J-9
      IF (UN(IB(5)).EQ.0) UN(IB(5))=32000
    7 O(K)=FLOAT(IB(J)+OF(IB(5)))/FLOAT(UN(IB(5)))
      IE(11,IB(5),IF)=IE(11,IB(5),IF)+1
      WRITE (2,200) SP1,IB(2),IB(5),ITM,K,(O(J),J=1,K)
```

```
      GO TO 4
    8 CALL CNVRT(ITM,IB(10),IB(11))
      IB(5)=IB(5)+1
      DO 9 J=1,5
      ID=11+3*J
      IC(J)=IB(ID)
      CALL CNVRT(IPD,IB(ID+1),IB(ID+2))
      O(J)=0.
      IF (IC(J).GT.0) O(J)=FLOAT(IPD)/FLOAT(IC(J)*UN(IB(5)))
    9 CONTINUE
      WRITE (2,201) SP1,IB(2),IB(5),ITM,(IC(J),O(J),J=1,5)
      IE(10,IB(5),IF)=IE(10,IB(5),IF)+1
      GO TO 4
   10 IF (IB(2)-5)11,15,11
   11 IB(5)=IB(5)+1
      WRITE (2,200) SP1,IB(2),IB(5),ITM
      IE(IB(2),IB(5),IF)=IE(IB(2),IB(5),IF)+1
      GO TO 4
   12 ID=5
   13 IF (ID.GE.IA) GO TO 4
      IB(ID)=IB(ID)+1
      IN(IB(ID))=IB(ID+1)
      IT(IB(ID))=IB(ID+2)
      MN(IB(ID))=IB(ID+3)
      MX(IB(ID))=IB(ID+4)
      UN(IB(ID))=IB(ID+5)
      OF(IB(ID))=IB(ID+6)
      DO 14 J=1,3
      CALL DEPAK(IB(ID+J+6),C)
   14 NM(J,IB(ID))=256*L(C(1)+1)+L(C(2)+1)
      J=IB(ID)
      ID=ID+10
      GO TO 13
   15 DO 18 J=5,IA
      CALL DEPAK(IB(J),C)
      IF ( C(1) .GE. 128 .OR.C(2).GE. 128) GO TO 4
      IB(J)=256*L(C(1)+1)+L(C(2)+1)
      IF (C(1).NE.13) GO TO 16
      IB(J)=0
      GO TO 19
   16 IF(C(2).NE.13) GO TO 17
      IB(J)=L(C(1)+1)*256
      GO TO 19
   17 CONTINUE
   18 CONTINUE
   19 IF (J.GT.IA) J=IA
      IF (J .GT.50) J=50
      JD=J-4
      IF (ITM .EQ. 0) GO TO 4
```

```
      IF (IB(2).EQ.0) CALL DMRTN(IB(2),NT0,IP0)
      IF (IB(2).NE.0) GO TO 197
      DO 195 M=1,64
      IE(1,M,IF)=IE(1,M,IF)+1
      WRITE (2,204) SP1,SP2,M,SP1,IN(M),IT(M),MN(M),MX(M),JN(M),OF(M),
     >(NM(K,M),K=1,3)
  195 CONTINUE
  197 CONTINUE
      IF (IB(2).EQ.0) SP0=SP0+2
      SP1=SP0+1
      IF (IB(2).EQ.0) IF=IF+1
      IF (IB(2) .EQ. 0) WRITE (6,601)
      WRITE (6,600) IB(2),ITM,(IB(K),K=5,J)
      WRITE (2,202) SP0,IB(2),SP2,ITM,JD,(IB(K),K=5,J)
      IE(5,1,IF)=IE(5,1,IF)+1
      GO TO 4
   20 CONTINUE
   21 CONTINUE
      I1=SP0+1
      M=SP0/2+1
      DO 22 J=1,64
      IE(1,J,M)=IE(1,J,M)+1
      WRITE (2,204)I1,SP2,J,SP1,IN(J),IT(J),MN(J),MX(J),UN(J),OF(J),
     >(NM(K,J),K=1,3)
   22 CONTINUE
      WRITE (2,203) SP2,SP2,SP2,SP2,((IE(J,K,1),J=1,11),K=1,64)
      DO 23 I=2,SP0,2
      I1=I+1
      M=I/2+1
      WRITE (2,203) I,SP2,SP2,SP2,((IE(J,K,M),J=1,11),K=1,64)
      WRITE (6,602)((IE(J,K,M),J=1,11),K=1,64)
   23 CONTINUE
  100 FORMAT (200(10I6))
  200 FORMAT (3I5,I15,I5,2(250F10.2))
  201 FORMAT (3I5,I15,7(I5,F5.1))
  202 FORMAT (3I5,I15,I5,100A2)
  203 FORMAT (3I5,I15, 65(11I5))
  204 FORMAT (3I5,I15,6I10,3A2)
  500 FORMAT (I5)
  501 FORMAT (10I8)
  502 FORMAT (50I1)
  600 FORMAT ('    TYPE:   ',I1,'   AT ',I10,5X,200A2)
  601 FORMAT (///)
  602 FORMAT (///,64(20X,11I5,/))
      STOP
      END
      SUBROUTINE CNVRT (I,IH,IL)
      INTEGER*2 IH,IL
      I=IL
```

```
      IF (I .LT.0) I=I+65536
      I=I+65536*IH
      RETURN
      END
      SUBROUTINE DMRTN(I,J,K)
      INTEGER*2 J(50),I
      I=J(K)
      K=K+1
      RETURN
      END
      SUBROUTINE DEPAK(I,J)
      INTEGER*2 I, J(2), K(2)
      LOGICAL*1 A(4)
      EQUIVALENCE (K,A)
      K(1)=I
      K(2)=0
      A(4)=A(1)
      A(1)=A(3)
      J(1)=K(1)
      J(2)=K(2)
      RETURN
      END
//$DATA
005050550005055
    3
```

1	1	10	-100	2047	20	0	16722	21060	12336
2	1	10	-100	2047	20	0	16722	21060	12592
3	1	10	-100	2047	20	0	16722	21060	12848
4	1	10	-100	2047	20	0	16722	21060	13104
5	1	10	-100	2047	20	0	16722	21060	13360
6	1	10	-100	2047	20	0	16722	21060	13616
7	1	10	-100	2047	20	0	16722	21060	13872
8	1	10	-100	2047	20	0	16722	21060	14128
9	1	10	-100	2047	20	0	16722	21060	12337
10	1	10	-100	2047	20	0	16722	21060	12593
11	200	11	-854	854	5	0	16726	11825	19765
12	400	11	-854	854	5	0	16726	12576	19760
13	600	11	-854	854	5	0	16726	12832	19760
14	600	11	-854	854	5	0	16726	13344	19760
15	1500	12	0	614	20	0	16712	11825	19765
16	1500	12	0	819	20	0	16712	12576	19760
17	1500	12	0	1228	20	0	16712	12832	19760
18	1500	12	0	1638	20	0	16712	13344	19760
19	500	13	0	2047	6	0	22103	11825	19765
20	500	13	0	2047	6	0	22103	11825	19765
21	500	13	0	2047	6	854	22103	12832	19760
22	500	13	0	2047	6	58	22103	13344	19760
23	6000	14	921	1791	13	-512	19796	11825	19765
24	6000	14	921	1791	13	-512	19796	12624	19760

25	6000	14	921	1791	13	-512	19796	12880	19760
26	6000	14	921	1791	13	-512	19796	13136	19760
27	6000	15	0	2047	20	0	18514	11825	19765
28	6000	15	0	2047	20	0	18514	13088	19760
29	6000	16	0	1500	1	0	22864	16722	8270
30	3000	17	0	2047	41	0	8224	20291	18481
31	3000	17	0	2047	41	0	8224	20291	19505
32	3000	17	0	2047	41	0	8224	20291	18482
33	3000	17	0	2047	41	0	8224	20291	19506
34	3000	17	0	2047	41	0	8224	20291	18483
35	3000	17	0	2047	41	0	8224	20291	19507
36	3000	17	0	2047	41	0	8224	20291	18484
37	3000	17	0	2047	41	0	8224	20291	19508
38	3000	17	0	2047	41	0	8224	20291	18485
39	3000	17	0	2047	41	0	8224	20291	19509
40	3000	17	0	2047	41	0	8224	20291	18486
41	3000	17	0	2047	41	0	8224	20291	19510
42	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0
47									
48									
49									
50									
51									
52									
53									
54									
55									
56									
57									
58									
59									
60									
61									
62									
63									
64									

```
/*
//STEP2 EXEC SORTD
//SORTIN DD UNIT=SYSDA,VOL=SER=WORK33,DSN=SEMISORT,DISP=(SHR,KEEP)
//SORTWK01 DD UNIT=SYSDA,VOL=SER=WORK33,DISP=(NEW,DELETE),
//         SPACE=(CYL,(30,3),,CONTIG)
//SORTWK02 DD UNIT=SYSDA,VOL=SER=WORK33,DISP=(NEW,DELETE),
//         SPACE=(CYL,(30,3),,CONTIG)
//SORTWK03 DD UNIT=SYSDA,VOL=SER=WORK33,DISP=(NEW,DELETE),
//         SPACE=(CYL,(30,3),,CONTIG)
```

```
//SORTOUT DD UNIT=TAPE9,VOL=SER=000102,DISP=(NEW,PASS),
//         LABEL=(1,SL),DSN=CHDATA1.F050476.L052676.LEV,
//         DCB=(LRECL=3700,BLKSIZE=22000,RECFM=VB)
//SYSIN DD *
 SORT FIELDS=(5,5,CH,A,15,5,CH,A,10,5,CH,A,20,15,CH,A),FILSZ=E35000
 RECORD TYPE=V,LENGTH=(3700,3700,3700,,110)
 END
/*
/*END
```

Appendix C

```
//SOPTIONS
C                                                                         00000100
C                                                                         00000200
C                                                                         00000300
C THIS PROGRAM  REDUCES THE SEMIRAW DATA TO AVERAGES AT WHATEVER          00000400
C THREE INTERVALS ARE CHOSEN.  AS PRESENTLY SET UP IT,WORKS ON TWO        00000500
C TAPEFILES, BUT THIS CAN BE CHANGED BY DELETION OF THE SECOND REWIND 1.00000600
C                                                                         00000700
C                                                                         00000800
C                                                                         00000900
C                                                                         00001000
C VARIABLE DEFINITIONS.  THESE OCCUPY A LARGE AREA OF CORE.  320K         00001100
C ARE NEEDED TO RUN WATFIVE.                                              00001200
      INTEGER *4  ICD(20),ICE(20),IBC(20),IEC(20),ITD(3000),IAC(20)       00001300
      REAL*4 SCT(11,6,150)/9900*0.0/
      REAL*4              SPD(6),D(200),COD(2000),AV(64,150),SG(64,150)00001500
     >,CF(20),FCTR(20),TSP(10,150)                                        00001600
      INTEGER*2 IB(11,64),IN(200),ITC(11,6,150)/9900*0/,ITF(20),ITTL(10,00001700
     >150)                                                                00001800
      CHARACTER*20 DATE                                                   00001900
      DO 590 MX=1,3                                                       00002000
C                                                                         00002100
C                                                                         00002200
C                                                                         00002300
C                                                                         00002400
C THIS TELLS HOW MANY DAYS OF DATA NEED BE TAKEN.  I5.                    00002500
      READ (5,5010) MA                                                    00002600
      DO 580 MB=1,MA                                                      00002700
C                                                                         00002800
C                                                                         00002900
C                                                                         00003000
C                                                                         00003100
C                                                                         00003200
C THERE ARE TWO CARDS FOR EACH DAY OF DATA.  THE FIRST IS THIS:A20.       00003300
C A 20 CHARACTER HEADER PRINTED ON EACH AVERAGE.                          00003400
      READ (5,5020) DATE                                                  00003500
C                                                                         00003600
C                                                                         00003700
C THE SECOND IS A CARD CARRYING THE TIME PARAMETERS.  BEGIN,INTERVAL,END00003800
C 3I10.  TIMES MUST BE SUPPLIED IN MINUTES.                               00003900
      READ(5,5000) IBT, IAT, IET                                          00004000
C                                                                         00004100
C                                                                         00004200
C                                                                         00004300
      IBT=IBT*6000                                                        00004500
      IAT=IAT*6000                                                        00004600
      IET=IET*6000                                                        00004700
    2 CONTINUE                                                            00004800
C                                                                         00004900
C                                                                         00005000
                                                                          00005100
```

```
C THIS READ READS THE A TABLE TELLING HOW MANY OF EACH TYPE RECORD
C ARE IN THIS DAYS DATA.
      READ (1,1000,END=580)(IA,I=1,4),((IB(I,J),I=1,11),J=1,64)
      CALL ITIM(IH,IX,IS,IAT)
      IF (IX .EQ. 0) IX=60
      IA=0
      DO 7 I=1,64
      DO 5 J=1,11
      SG(I,J)=10.**30.
      AV(I,J)=10.**30.
      IA=IB(J,I)+IA
      DO 5 K=1,6
      IF (I .LT. 12) SCT(I,K,J)=0.0
      IF (I .LT. 12) ITC(I,K,J)=0
    5 CONTINUE
      DO 7 J=12,120
      AV(I,J)=10.**30.
      SG(I,J)=1C.**30.
      DO 7 K=1,6
      IF (I .LT. 12) SCT(I,K,J)=0.0
      IF ( I .LT. 12) ITC(I,K,J)=0
    7 CONTINUE
      IF (IA .EQ.0) GO TO 2
      I2=IA
      IF ( IAT .EQ. 0) GO TO 578
      WRITE (6,6010)
      IF (IB(5,1) .EQ. 0) GO TO 20
      IA=IB(5,1)
C
C
C
C NOW THE LOG IS READ IN AND IMMEDIATLY PRINTED OUT.
      DO 10 I=1, IA
      READ(1,1010) (IC, J=1, 4), IL, (IN(J), J=1, IL)
      CALL ITIM(IH,IM,IS,IC)
      WRITE(6, 6000) IH, IM, (IN(J), J=1, IL)
   10 CONTINUE
   20 CONTINUE
      IB(5,1)=0
C
C
C
C THE FIRST TEN CHANNELS ARE RADAR CHANNELS AND AS A RESULT MUST BE
C HANDLED SEPERATLY.  THIS SECTION HANDLES THEM.
      DO 130 I=1, 10
      READ (1,1020) (IC,IKK=1,4),INC,ITY,MIN
      IA=IB(2,I)
      IBTT=IBT
      IETT=IBT+IAT
      K=1
      DO 30 J=3,9
      IA=IA+IB(J,I)
   30 CONTINUE
```

```
      CALL CMRD(IA)
      DO 40 J=1,5
      ITC(I,J,K)=0
      SCT(I,J,K)=0.
   40 CONTINUE
      IF (IB(10,I) .EQ. 0) GO TO 130
      IA=IB(10, I)
      ICTT=0
      DO 120 J=1, IA
      READ(1, 1040) (IC, L=1,4),(ITF(L), SPD(L), L=1, 5)
      IF (ICTT .EQ.IC) GO TO 120
      ICTT=IC
      IF (IC-IBTT) 110, 60, 60
   60 IF (IC-IETT) 70, 100, 100
   70  DO 80 L=1, 5
      ITC(I, L, K) = ITC(I, L, K)+ITF(L)
      SCT(I, L, K)=SCT(I, L, K)+ITF(L)*SPD(L)
   80 CONTINUE
      GO TO 120
   90 L=IA-J
      CALL CMRD(L)
      GO TO 130
  100 IF (IETT .GE. IET) GO TO 90
      IBTT=IETT
      IETT=IETT+IAT
      K=K+1
      DO 105 M=1, 5
      ITC(I,M,K)=0
      SCT(I,M,K)=0.
  105 CONTINUE
      GO TO 70
  110 CONTINUE
  120 CONTINUE
  130  CONTINUE
C
C
C
C THIS SECTION HANDLES ALL METEROLOGICAL INSTRUMENTS.  THE WIND VANES
C HAVE THEIR OWN SPECIAL CHARACTERISTICS AND ARE ROUTED DIFFERENTLY.
      DO 310 I=11, 29
      IZ=0
      SUM1=0.
      SUMSQ1=0.
      SUM=0.
      SUMSQ=0.
      IBTT=IBT
      IETT=IBT+IAT
      READ (1,1020) (IC,IKK=1,4),INC,ITY,MIN
```

```
      NMBR=IAT/INC
      IA=IB(2,I)+IB(3,I)+IB(4,I)+IB(5,I)
      CALL DMRD(IA)
      IF (IB(6,I) .EQ. 0) GO TO 160
      IA=IB(6,I)
      K=1
      ICD(1)=0
      DO 150 J=1, IA
      READ(1, 1030) (IC, L=1, 4)
      IF (ICD(K) .GE. IC) GO TO 140
      ICD(K)=IC
  140 CONTINUE
  150 CONTINUE
  160 CONTINUE
      ICE(1)=100000000
      IF (IB (7,I) .EQ. 0) GO TO 200
      IA=IB(7,I)
      K=K-1
      L=1
      DO 190 J=1, IA
      READ(1, 1030) (IC, M=1, 4)
      IF (IC .LE. ICD(L)) GO TO 190
      ICE(L)=IC
      L=L+1
      IF (ICD(L) .LT. ICE(L-1)) L=L+1
      IF (L .LE. K) GO TO 190
      L=IA-J
      CALL DMRD(L)
      GO TO 200
  190 CONTINUE
  200 CONTINUE
      NCD=K
      K=1
      M=1
      IF (IB(11, I) .EQ. 0) GO TO 310
      IA=IB(11, I)
      ITD(1)=0
      DO 280 J=1, IA
      READ(1, 1050) ID, ID, IC, IC, IL, (D(L), L=1, IL)
      IF (IC .LE. ITD(1)) GO TO 280
      ITD(1)=IC
      L=2
  205 CONTINUE
      ITD(L)=ITD(L-1)
  210 CONTINUE
      ITD(L)=ITD(L)+INC
      IF (M.GT. IB(6,I)) GO TO 215
      IF (ITD(L) .LT. ICE(M) .AND. ITD(L) .GT. ICD(M)) GO TO 210
      IF (ITD(L) .GT. ICE(M)) M=M+1
      IF (M .LT.2) GO TO 215
      IF (ICD(M) .LT. ICE(M-1)) M=M+1
```

```
  215 CONTINUE                                                          00020300
      L=L+1                                                             00020400
      IF (L .LE. IL) GO TO 205                                          00020500
      L=1                                                               00020600
  220 CONTINUE                                                          00020700
      IF (ITD(L) .LT. IBTT) GO TO 230                                   00020800
      IF (ITD(L) .GE. IETT) GO TO 250                                   00020900
      IZ=IZ+1                                                           00021000
      IF (ID .EQ. 13) GO TO 240                                         00021100
      SUM=SUM+D(L)                                                      00021200
      SUMSQ=SUMSQ+D(L)**2                                               00021300
  230 CONTINUE                                                          00021400
      L=L+1                                                             00021500
      IF (L .GT. IL) GO TO 280                                          00021600
      GO TO 220                                                         00021700
C                                                                       00021800
C                                                                       00021900
C                                                                       00022000
C HERE IS THE WIND VANE HANDLING SECTION.                               00022100
  240 CONTINUE                                                          00022200
      DD1=D(L)*3.1415926/180.                                           00022300
      DD=SIN(DD1)                                                       00022400
      DD1=COS(DD1)                                                      00022500
      SUM=SUM+DD                                                        00022600
      SUM1=SUM1+DD1                                                     00022700
      SUMSQ=SUMSQ+DD**2                                                 00022800
      SUMSQ1=SUMSQ1+DD1*DD1                                             00022900
      GO TO 230                                                         00023000
  250 CONTINUE                                                          00023100
      IF (IZ .LT. 2) GO TO 260                                          00023200
      AV(I,K)=SUM/IZ                                                    00023300
      SG(I,K)=SQRT ((SUMSQ-(SUM*SUM/IZ))/(IZ-1))                        00023400
      IF (ID .NE. 13) GO TO 260                                         00023500
      AV(I,K)=(180/3.1415926)*ATAN2(AV(I,K), SUM1/IZ)                   00023600
      IF (AV(I,K) .LT. 0.) AV(I,K)=AV(I,K)+360.                         00023700
      SG(I,K)=SQRT((SG(I,K)**2)+((SUMSQ1-(SUM1**2/IZ))/(IZ-1)))*57.14   00023800
  260 CONTINUE                                                          00023900
      IF (IZ .GT. 3*NMBR/4) GO TO 270                                   00024000
      AV(I,K)=10.**30.                                                  00024100
      SG(I,K)=10.**30.                                                  00024200
  270 CONTINUE                                                          00024300
      K=K+1                                                             00024400
      IBTT=IETT                                                         00024500
      IETT=IETT+IAT                                                     00024600
      IF (IETT .GT. IET) GO TO 290                                      00024700
      SUM=0.                                                            00024800
      SUM1=0.                                                           00024900
      SUMSQ=0.                                                          00025000
      SUMSQ1=0.                                                         00025100
      IZ=0                                                              00025200
      GO TO 220                                                         00025300
```

```
  280 CONTINUE                                                          00025400
      J=IA                                                              00025500
  290 CONTINUE                                                          00025600
      L=IA-J                                                            00025700
      CALL CMRD(L)                                                      00025800
  310 CONTINUE                                                          00025900
C                                                                       00026000
C                                                                       00026100
C                                                                       00026200
C THE ECOLYZERS ALSO REQUIRE A DIFFERENT APPROACH.  THEY ARE HANDLED IN 00026300
C SECTION.  THEY ARE THE ONLY INSTRUMENTS WHICH HAVE A CALIBRATION FACT00026400
C INTRODUCED.  THE METEROLOGICAL INSTRUMENTS DO NOT REQUIRE SUCH TREATME00026500
      DO 540 I=30, 41                                                   00026600
      READ (1,1020) (IC,IKK=1,4),INC,ITY,MIN                            00026700
      NCAL=0                                                            00026800
      ITF(1)=1000000000                                                 00026900
      IBC(1)=1000000000                                                 00027000
      IEC(1)=1000000000                                                 00027100
      FCTR(1)=0.0                                                       00027200
      IF (IB(2,I) .EQ. 0) GO TO 350                                     00027300
      IA=IB(2,I)                                                        00027400
      K=1                                                               00027500
      IBC(1)=0                                                          00027600
      DO 320 J=1, IA                                                    00027700
      READ (1, 1030) (IC, L=1, 4)                                       00027800
      IF (IC .LE. IBC(K)) GO TO 320                                     00027900
      IBC(K)=IC                                                         00028000
      IBC(K+1)=IC                                                       00028100
      IEC(K)=IC+60000                                                   00028200
      ITF(K)=IC                                                         00028300
      FCTR(K)=0.                                                        00028400
      K=K+1                                                             00028500
      ITF(K)=IC                                                         00028600
      FCTR(K)=0.                                                        00028700
  320 CONTINUE                                                          00028800
      NCAL=K-1                                                          00028900
      IF (NCAL .GT. IB(2,I)) NCAL=IB(2,I)                               00029000
      IB(2,I)=0                                                         00029100
      IF (IB(3,I) .EQ. 0) GO TO 350                                     00029200
      IA=IB(3,I)                                                        00029300
      IF (NCAL .EQ. 0) GO TO 350                                        00029400
      DO 340 J=1, IA                                                    00029600
      READ(1, 1030) (IC, L=1, 4)                                        00029700
      FCTR(J+1)=0.                                                      00029800
      DO 330 L=1, NCAL                                                  00029900
      IF (IC .GT. IBC(L) .AND. IC .LT. IEC(L)) IEC(L)=IC                00030000
```

```
      IF (IC .GT. IBC(L)) GO TO 340                                     00030100
  330 CONTINUE                                                          00030200
  340 CONTINUE                                                          00030300
      IB(3, I)=0                                                        00030400
  350 CONTINUE                                                          00030500
      K=1                                                               00029500
      IA=IB(2,I)+IB(3,I)+IB(4,I)+IB(5,I)                                00030600
      CALL CMRD(IA)                                                     00030700
      IF (IB(6,I) .EQ. 0) GO TO 420                                     00030800
      IA=IB(6,I)                                                        00030900
      ICD(1)=0                                                          00031000
      DO 380 J=1, IA                                                    00031100
      READ(1, 1030) (IC, L=1, 4)                                        00031200
      IF (ICD(K).GE. IC) GO TO 380                                      00031300
      ICD(K)=IC                                                         00031400
      ICD(K+1)=IC                                                       00031500
      K=K+1                                                             00031600
  380 CONTINUE                                                          00031700
      NCD=K-1                                                           00031800
      ICE(1)=8640000
      L=1                                                               00032000
      IA=IB(7,I)                                                        00032100
      IF (IA .EQ. 0) GO TO 420                                          00032200
      DO 410 J=1, IA                                                    00032300
      READ(1, 1030) (IC, K=1, 4)                                        00032400
      IF (L .GT. NCD) GO TO 410                                         00032500
      LD=L                                                              00032600
      DO 400 M=LD,NCD                                                   00032700
      IF (IC .LT. ICD(M)) GO TO 400                                     00032800
      ICE(M)=IC                                                         00032900
      L=M+1                                                             00033000
      IF (M .GE. NCD) GO TO 410                                         00033100
      IF (ICD(M+1) .LT.IC)L=L+1                                         00033200
      ICE(M+1)=IC                                                       00033300
      GO TO 410                                                         00033400
  400 CONTINUE                                                          00033500
  410 CONTINUE                                                          00033600
      IB(7,I)=0                                                         00033700
  420 CONTINUE                                                          00033800
      IA=IB(7, I)+ IB(8,I)+ IB(9,I)+ IB(10, I)                          00033900
      CALL CMRD(IA)                                                     00034000
      K=1                                                               00034100
      ITC(1)=0                                                          00034200
      M=1                                                               00034300
      IF (IB(11, I) .EQ. 0) GO TO 540                                   00034400
      IA=IB(11, I)                                                      00034500
      N=1                                                               00034600
      DO 460 J=1, IA                                                    00034700
```

```
      READ(1, 1050) (IC, L=1, 4), IL, (D(L), L=1, IL)
      IF (IC .LT. ITD(K)) GO TO 460
      ITD(K)=IC
      ID=K+IL
      COD(K)=D(1)
      ITD(K+1)=ITD(K)
      K=K+1
      DO 450 L=2, IL
      COD(K)=D(L)
  430 CONTINUE
      ITD(K)=ITD(K)+INC
      IF (ITD(K) .GT. 8640000) GO TO 435
      IF (M.GT.IB(6,I)) GO TO 435
      IF (ITD(K) .GT. ICE(M)) M=M+1
      IF (ITD(K) .GT. ICD(M)) GO TO 430
  435 CONTINUE
      ITD(K+1)=ITD(K)
      IF (ITD(K) .GT. IBC(N) .AND. D(L) .GT. FCTR(N)) FCTR(N)=D(L)
      IF (ITD(K) .GT. IBC(N) .AND. D(L) .GT. FCTR(N)) ITF(N)=ITD(K)
      IF (ITD(K) .GT. IBC(N))  COD(K)=-10000.
      IF ( N .GT. NCAL) GO TO 440
      IF (ITD(K) .GT. IEG(N)) N=N+1
      IF (N .LE. NCAL) GO TO 440
      IBC(N)=1000000000
      IEC(N)=1000000000
      FCTR(N)=0.
  440 CONTINUE
      K=K+1
  450 CONTINUE
      K=K-1
  460 CONTINUE
      SUM=0.
      SUMSQ=0.
      NDAT=K-1
      NMBR=IAT/INC
      CF(1)=1.
      IAC(1)=ITD(1)
      NCAL=NCAL+1
      IF (NCAL .LT.2) GO TO 500
      FCTR(NCAL)=FCTR(NCAL-1)
      DO 490 J=2, NCAL
      IAC(J)=ITF(J-1)
      CF(J)=FCTR(J-1)/29.
      IF (CF(J) .LT. .7) CF(J)=CF(J-1)
  490 CONTINUE
  500 CONTINUE
      CF(NCAL+1)=CF(NCAL)
      IAC(NCAL+2)=1000000000
      IAC(NCAL+1)=1000000000
```

```
      NCNT=0
      K=1
      L=1
      IBTT=IBT
      IETT=IBT+IAT
      DO 530 J=1, NDAT
      IF (ITD(J) .LT. IBTT) GO TO 530
      IF (ITD(J) .GT. IETT) GO TO 520
  510 CONTINUE
      IF (COD(J) .LT.-50.) GO TO 530
      CODD=COD(J)
      IF (IAC(L+1).EQ.IAC(L)) GO TO 515
      CODD=COD(J)*((FLOAT(ITD(J)-IAC(L))/FLOAT(IAC(L+1)-IAC(L)))*CF(L+1)
     >+(FLOAT(IAC(L+1)-ITD(J))/FLOAT(IAC(L+1)-IAC(L)))*CF(L))
  515 CONTINUE
      SUM=SUM+CODD
      SUMSQ=SUMSQ+CODD**2
      NCNT=NCNT+1
      IF (ITD(J) .GT. IAC(L+1)) L=L+1
      IF (ITD(J) .GT. IET) GO TO 540
      GO TO 530
  520 CONTINUE
      AV(I,K)=10.**30.
      SG(I,K)=10.**30.
      IF (NCNT .GT. (3*NMBR/4      ))AV(I,K)=SUM/NCNT
      IF (NCNT .GT. (3*NMBR/4      )) SG(I,K)=SQRT((SUMSQ-(SUM**2/NCNT))
     1/(NCNT-1))
      K=K+1
      IBTT=IETT
      IETT=IETT+IAT
      NCNT=0
      SUM=0.
      SUMSQ=0.
      GO TO 510
  530 CONTINUE
  540 CONTINUE
      IBTT=IBT-IAT
      NAVG=(IET-IBT)/IAT
      IPAG=1
C
C
C
C
C
C
C
C
C THIS IS THE REPORT WRITING SECTION
      DO 570 J=1, NAVG
      ITTL(3,J)=0
      ITTL(2,J)=0
      ITTL(1,J)=0
```

```
      TSP(1,J)=0.
      TSP(2,J)=0.
      DO 545 I=1, 6
      SCT(11,I,J)=0.
      ITC(11, I, J)=0
  545 CONTINUE
      DO 560 I=1, 11
      IF (I .EQ. 11) GO TO 546
      ITC(I, 6, J)=ITC(I, 1, J)+ITC(I, 2, J)+ITC(I, 3, J)+ITC(I, 4, J)
      SCT(I, 6, J)=SCT(I, 1, J)+SCT(I, 2, J)+SCT(I, 3, J)+SCT(I, 4, J)
  546 CONTINUE
      DO 550 K=1,6
      IF (I .EQ. 11) GO TO 548
      ITC(11, K, J)=ITC(11, K, J)+ITC(I, K, J)
      SCT(11, K, J)=SCT(11, K, J)+SCT(I, K, J)
  548 CONTINUE
      IF (ITC(I,K,J) .NE. 0)SCT(I,K,J)=(SCT(I,K,J)/ITC(I,K,J))*1.4
  550 CONTINUE
  560 CONTINUE
      ITTL(3, J)=ITC(11,6,J)
      TSP(3,J)=SCT(11,6,J)
      DO 565 I=1, 5
      IZ=I+5
      ITTL(1,J)=ITTL(1,J)+ITC(I,6,J)
      ITTL(2,J)=ITTL(2,J)+ITC(IZ,6,J)
      TSP(1,J)=TSP(1,J)+SCT(I,6,J)      *ITC(I,6,J)
      TSP(2,J)=TSP(2,J)+SCT(IZ,6,J) *ITC(IZ,6,J)
  565 CONTINUE
      IF (ITTL(1,J).NE.0) TSP(1,J)=TSP(1,J)/ITTL(1,J)
      IF (ITTL(2,J) .NE. 0) TSP(2,J)=TSP(2,J)/ITTL(2,J)
      IF (IPAG .EQ. 1) WRITE(6,6010)
      IF (IPAG .EQ. 2) IPAG=0
      IPAG=IPAG+1
      CALL ITIM(IH,IM,IS,(IBT+IAT*J))
      WRITE (6,6040)IX,IH,IM,DATE
      WRITE(6,6020) (ITC(I,1,J),I=1,11), AV(14,J), AV(18,J), AV(22,J),
     1AV(26,J), AV(29,J), (SCT(I,1,J), I=1,11), (SG(I,J), I=14, 26,4),
     2SG(29,J),(ITC(I,2,J),I=1,11), (AV(I,J),I=13,25,4), (SCT(I,2,J),
     3I=1,11),(SG(I,J),I=13,25,4),(ITC(I,3,J),I=1,11),(AV(I,J),I=12,28,4
     4),(SCT(I,3,J),I=1,11), (SG(I,J),I=12,28,4),(ITC(I,4,J),I=1,11),
     5(AV(I,J),I=11,27,4),(SCT(I,4,J),I=1,11),(SG(I,J),I=11,27,4)
      WRITE (6,6030) (ITC(I,5,J),I=1,11),AV(36,J),(SCT(I,5,J),I=1,11),
     1 SG(36,J),(ITC(I,6,J),I=1,10),AV(37,J),(SCT(I,6,J),I=1,10),
     5SG(37,J),AV(40,J),(ITTL(I,J),I=1,2),(AV(I,J),I=30,34,2
     6),AV(38,J),SG(40,J),(TSP(I,J),I=1,2),(SG(I,J),I=30,34,2),SG(38,J),
     7AV(41,J),ITTL(3,J),(AV(I,J),I=31,35,2),AV(39,J),SG(41,J),TSP(3,J),
     8(SG(I,J),I=31,35,2), SG(39,J)
  570 CONTINUE
      I2=0
```

```
      DO 575 I=1,11
      DO 575 J=42,64
      I2=I2+IB(I,J)
  575 CONTINUE
  578 CONTINUE
      CALL DMRD(I2)
  580 CONTINUE
      REWIND 1
  590 CONTINUE
      WRITE (6,6010)
C
C
C
C
C
C
C THESE ARE THE FORMATS RESPONSIBLE FOR THE READS A D WRITES.
 1000 FORMAT (3I5,I15,65(11I5))
 1010 FORMAT (3I5,I15,I5,100A2)
 1020 FORMAT (3I5,I15,3I10)
 1030 FORMAT (3I5,I15)
 1040 FORMAT (3I5,I15,7(I5,F5.1))
 1050 FORMAT (3I5,I15,I5,2(25OF10.2))
 5000 FORMAT (3I10)
 5010 FORMAT (I5)
 5020 FORMAT (A20)
 6000 FORMAT (' ',I2,':',I2,' NOTE:', 50A2)
 6010 FORMAT ('1')
 6020 FORMAT (24X,11I6,5X,4F7.2,F9.1,  /,  24X,11F6.1,5X,4F7.3,F9.4,//,
     124X,11I6,5X,4F7.2,  /,  24X,11F6.1,5X,4F7.3,  /,2(/  24X,11I6,5X,
     25F7.2,  /,  24X,11F6.1,5X,5F7.3,  /))
 6030 FORMAT (24X,11I6,19X,F7.2,/,24X,11F6.1,19X,F7.4,//,
     1        24X,10I6,25X,F7.2,  /,  24X,10F6.1,25X,F7.4,  //,8X,F7.2,
     2      20X,I7,23X,I7,23X,4F7.2,  /,  8X,F7.4,20X,F7.1,23X,F7.1,
     223X,4F7.4,  //,  3X,F7.2,35X,I7,38X,4F7.2,  /,  8X,F7.4,35X,
     3F7.1,38X,4F7.4)
 6040 FORMAT (////,40X,I3,' MINUTE AVERAGE AT ',I2,':',I2,10X,'FILE: ',
     >A20)
      STOP
      END

      SUBROUTINE DMRD(I)
      IF (I.EQ.0) RETURN
      DO 1 J=1,I
      READ (1,100) K
    1 CONTINUE
  100 FORMAT (I5)
      RETURN
      END
```

```
      SUBROUTINE ITIM(I,J,K,L)                                          00054500
      I=L/360000                                                        00054600
      J=L/6000-I*60                                                     00054700
      K=L/100-J*60-I*3600                                               00054800
      RETURN                                                            00054900
      END                                                               00055000
//$DATA
```