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Technical Report

Status Report on the CO "Hot Spot" Project

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by

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Abstract

This report outlines the preliminary information from an EPA study known as the "CO Hot Spot Project." For this purpose, a "hot spot" is an area with high ambient concentrations of pollutants which are almost entirely due to the sources in the immediate area. This investigation centers on carbon monoxide (CO), a pollutant which in urban areas, has been found to be due almost entirely to motor vehicles. The effort is designed to gather information on meteorological conditions, vehicle characteristics and ambient CO levels in portions of four metropolitan areas which have been found to experience exceptionally high levels. The overall objective of this project is a complete reassessment of the current FTP as a measurement tool for evaluating light-duty vehicle CO emissions.

The results contained in this report include only early data from the first city (Phoenix) and are unclear in the determination that ambient CO levels are strictly a "hot spot" phenomenon. There are indications that a "regional" aspect to the problem may exist. More conclusive information will be available by November, 1978 after the remaining results are processed and the final report is drafted.

Status Report on the CO "Hot Spot" Project

Background

It is important that a good test procedure accurately predict the on-the-road percent reduction in emissions that would be expected to occur with different mobile source emission standards. It is not as important that it accurately predict the exact level of the emissions. This is because ambient concentration levels are assumed to be reduced in the same proportion as are the emissions from the various sources. Thus, a test procedure could be non-representative of regional or local driving conditions and still accurately quantify percent reductions if vehicle emission control systems uniformly reduce emissions over a wide portion of the engine map. If, on the other hand, the emission control systems are optimized to obtain the greatest reduction over the specific test procedures (as presently occurs with the Federal Test Procedure), emission reductions can be termed "cycle dependent" and the ambient concentration reductions estimated would be in error.

The 1975 Federal Test Procedure (FTP) for light duty vehicles is currently used to measure exhaust emission level hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) from passenger cars and light-duty trucks. This procedure was developed to approximate the emission burden which can be attributed to a single vehicle during typical daily operation. The 1975 FTP includes both cold-start and hot-start testing and the measured results are weighted in proportion to the number of each type of start per average vehicle day. Such a procedure should adequately estimate mobile source emissions which are area dependent. It ought to therefore accurately predict changes in ambient air quality (on a concentration basis) as a result of more stringent standards for emissions from mobile sources. The chemical processes leading to oxidant formation are known to take place over time. Therefore, both HC and NOx can be considered to be area pollutants, i.e. all pollutants of these types emitted in an urban environment will, in time, contribute to the urban oxidant problem.

Carbon monoxide (CO) is not a reactive pollutant but does pose an additional analytical problem. Some very high ambient levels are known to occur at times of low traffic, indicating that under certain meteorological conditions, CO can act as an area-wide pollutant. A recent analysis by the Office of Air Quality Planning and Standards (OAQPS) addressed the time of day that the 8-hour CO standard is exceeded at 30 CO sites throughout the nation. They found that about 50% of CO violations occur between 6 p.m. and 1 a.m. One cannot be sure of the geographic spread of the problem from these data, but they do seem to indicate that the evening peak-hour emissions are more than proportionally influencing the number of 8-hour CO violations because of a reduced dispersal rate.

High ambient concentrations of CO are, however, also known to occur as a result of traffic in the immediate vicinity of a receptor site. On this basis, CO appears to have both local and regional characteristics. At the present time, CO emissions for vehicles are measured concurrently with HC and NOx emissions and the same regional hot/cold weighting factors are applied. At any given receptor site, the fraction of hot and cold operation may be significantly different from the respective fractions which occur over the "average vehicle-day" defined for the FTP. Furthermore, driving cycles in locales experiencing excessive ambient CO levels may differ markedly from the speed-time listing specified in the 1975 FTP.

CO Hot Spot Program Design

The situation as described above suggested that an evaluation program was necessary to determine what vehicle mix and operating characteristics occur at locations with these high CO concentrations so that CO emissions can be controlled in a way that will allow the National Ambient Air Quality Standard (NAAQS) for CO to be met. Research on the CO Hot Spot problem was initiated in 1974 to address these concerns. The current CO test procedure can be evaluated with respect to the findings of the program. If the current FTP does not represent vehicle operating conditions under which CO is a serious problem, the improvements in air quality which have resulted and will continue to result from the imposition of CO emission standards may be far less or far more than the intended percent reduction. Moreover, the control technology currently applied to mobile sources to meet exhaust emission standards is highly dependent on the present test procedure. If it becomes necessary to revise the FTP to reflect the findings of the program, new control technologies, possibly more cost effective than the present ones, might be available. Thus, the CO Hot Spot Project will help to ensure EPA that the reductions in CO emissions necessary to meet the CO NAAQS can be achieved by an equivalent reduction in CO emissions as measured by EPA test procedures. This also helps to ensure that the most effective and economical control technologies are being employed to control CO emitted by motor vehicles.

In July, 1977, a contract for the CO Hot Spot Program was awarded to Stanford Research Institute (SRI). The intent of this contract was to assess the extent of the CO problem in "hot spot" areas and to determine vehicle operating characteristics (driving cycle and thermal state) in CO violation areas. For this purpose, a "hot spot" is an area with high ambient concentrations of pollutants which are almost entirely due to the sources in the immediate area. The "hot spot" definition was interpreted to mean that we should concentrate on determining vehicle operating characteristics within several hundred feet of the emissions monitors and not further than 1/2 mile away.

Data were collected in San Jose, Seattle, Chicago and Phoenix during the months of December, 1977 through March, 1978. All four sites were chosen because they were established CO hot spots according to OAQPS analysis. Meteorological conditions, vehicle characteristics and ambient concentration levels were recorded.

Meteorological conditions included ambient temperature, wind speed and direction, barometric pressure, humidity and general climatic observations. Vehicle characteristics included vehicle age and type mix, hot/cold engine temperature mix, traffic speed and modal behavior, and traffic volume. Ambient concentration levels of CO, as well as levels of HC and NOx, were measured and recorded.

Locations for the monitors were chosen after local and state agencies were contacted to obtain their recommendations as to which areas of the test city were CO problem areas. Of the areas recommended, the one chosen contained an intersection at which driver interview and vehicle temperature measurements could be most easily obtained. This process was conducted on the first vehicle in line as it stopped at the traffic signal. During the interview, the driver was asked the car's make and model year, how long he had been driving and how long had the car been parked with the engine off before the present trip began. At the same time, a second member of the contractor's staff used an infrared gun to measure the temperature of the car's hood, trunk and tailpipe. Monitor sites were grouped into those along the roadway in the vicinity of the intersection and those either off or above that roadway. The former group was intended to capture local "hot spot" CO, while the second group was intended to establish "background CO", as used in the hot-spot model developed by OAQPS. An investigation of background versus local CO levels may be used in an evaluation regarding the appropriateness of the FTP as the CO test procedure.

The data were collected on seven-day, 24-hours per day basis in the four test cities. In each city, daily collection periods were nine hours over 15 minute intervals; for the remaining 15 hours each day, the data were collected over one hour intervals.

Preliminary Results

Although data reduction and analysis are not expected to be complete until mid-November, 1978, some very preliminary CO data from the Phoenix test site are available now. Figure 1 is an aerial photograph showing the pace car route and equipment locations for Phoenix. (The pace car is used to model the traffic in the vicinity of the receptor sites by mirroring a typical vehicle's accelerations, decelerations, average speed and stops). The Phoenix receptor sites can be grouped into those in the immediate vicinity of a roadway (1-5, 8 and 11) and those either off or above a roadway (6, 7, 9 and 10). Receptor sites 1, 2, 4 and 5 are immediately next to the same roadway. Site 3 is in the middle of a parking lot near another roadway and site 11 is next to a third roadway. Site 6 is in the middle of a field approximately 30 meters from a roadway. Site 7 is next to the State of Arizona monitor approximately 33 meters from a roadway. Site 8 is on top of the SRI mobile laboratory (6 meters elevation) approximately 20 meters from a roadway. Sites 9 and 10 are atop different five- story buildings.

Figures 2 and 3 show CO concentrations in parts per million (ppm) measured during January 29, 1978. Figures 4 and 5 show CO concentrations measured during February 2nd. For both days, until the wind picks up, concentrations are high in the early morning hours, a time when there is relatively little traffic. On the 2nd, a Thursday, concentrations are higher during the morning rush hours than they are during the same period on the 29th, a Sunday. However, by noon on both days, CO has, for the most part, dispersed. Then, during the evening rush hours, CO concentrations begin to increase. However, those monitors in the immediate vicinity of a roadway ("local" monitors) measured a higher rate of CO increase during the evening rush hour than did those monitors either off or above a roadway ("background" monitors). Figures 3 and 4 also show that on February 2, CO began to disperse after the evening rush hours but increased again approaching its maximum at 11 p.m. This lack of CO dispersal could be due to an inversion layer and seems to indicate that CO has both local hot spot and regional characteristics.

Two other information sources also indicate that there is a regional aspect to the CO problem. OAQPS used their Storage and Retrieval of Aerometric Data (SAROAD) base to determine maximum CO values in areas with a high number of CO violations and found that those violations often occur late at night when traffic flow is very low. Furthermore, the state environmental agency in Arizona does not view the Phoenix CO level as a hot spot problem. Special monitoring conducted by that agency has demonstrated that elevated CO levels occur through the early a.m. hours on a broad front extending in excess of 10 miles.

At this time, testing has been completed in all four cities and the data are being analyzed by the contractor. The focus of the analysis will be to answer the following questions:

1. What time of day are high CO readings or CO violations occurring?

2. To what extent is CO a local problem rather than a regional problem?

3. Can the vehicle operational characteristics for those vehicles that contribute to the local CO problem be defined?

4. Can the ambient conditions be characterized for peak CO periods?

5. Was the one week monitoring period in each site representative of typical operation at that site during CO violation periods?

This work is currently scheduled to be completed by November, 1978 with the final report due in January, 1979. Additional status reports will be prepared as data from the CO Hot Spot project becomes available.

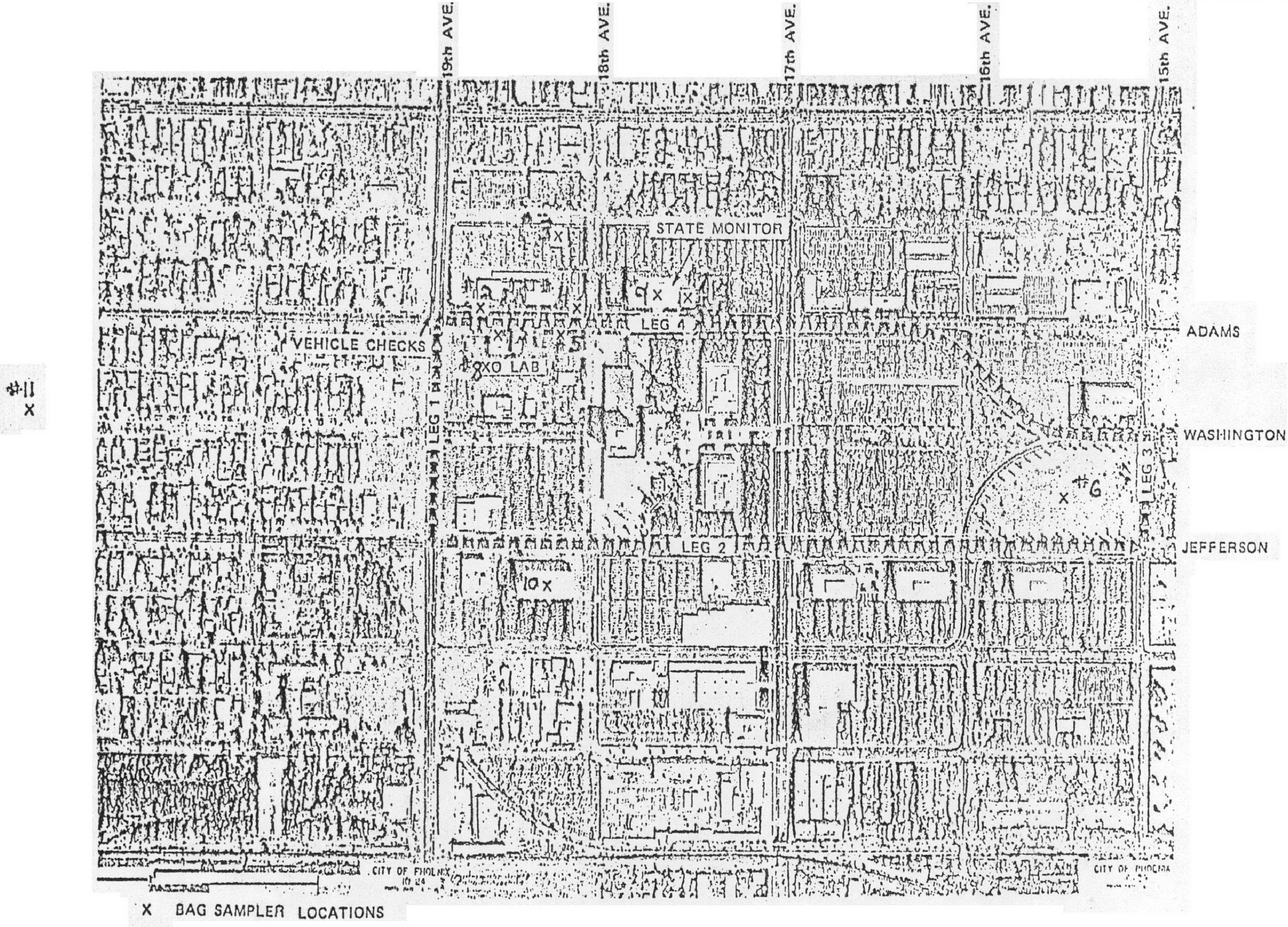


FIGURE 1 PACE CAR ROUTE AND EQUIPMENT LOCATIONS FOR THE PHOENIX TEST

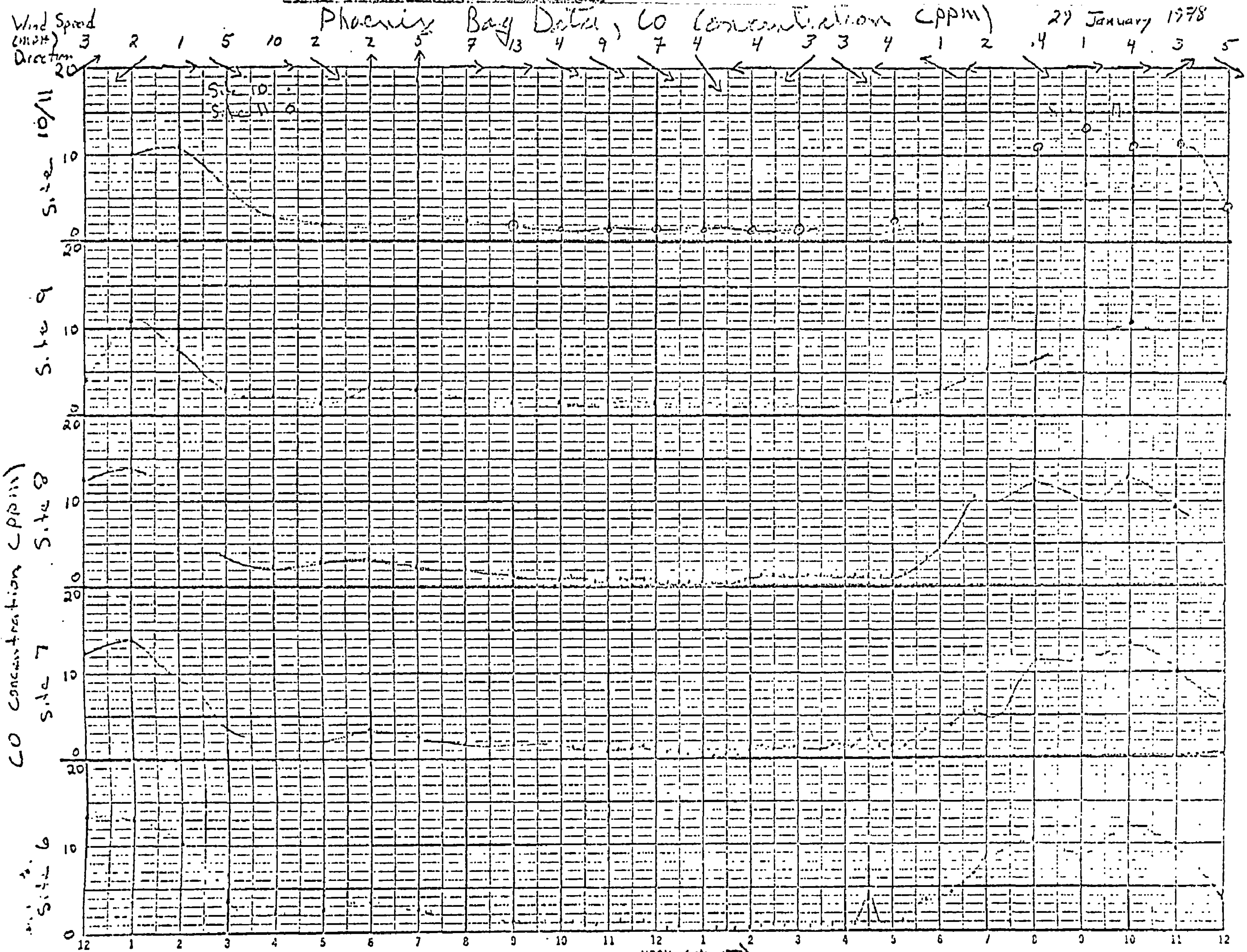

Phoenix Bay Data, CO Concentration (ppm)
27 January 1978
Wind Speed (mph)
Direction
3 2 1 5 10 2 2 5 7 13 4 9 7 4 4 3 3 4 1 2 .4 1 4 3 5
Site 10 •
Site 11 o
Site 10/11
Site 9
Site 8
Site 7
Site 6
CO Concentration (ppm)
0
10
20
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON (MST)

Figure 2

Phoenix Bag-Data, CO concentration (ppm)
29 JAN 1978

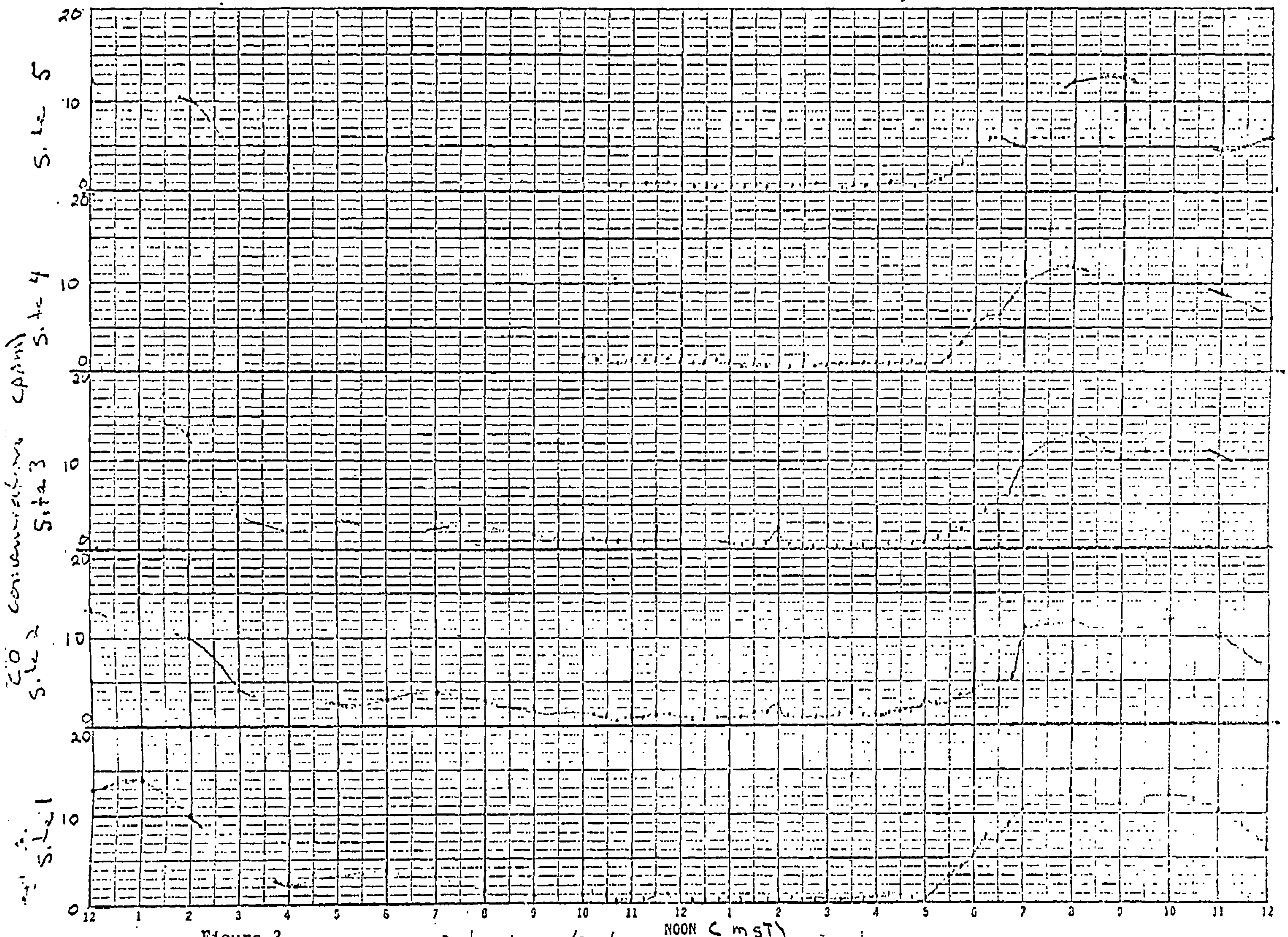


Figure 3

Date: 01/29/78 Sunday

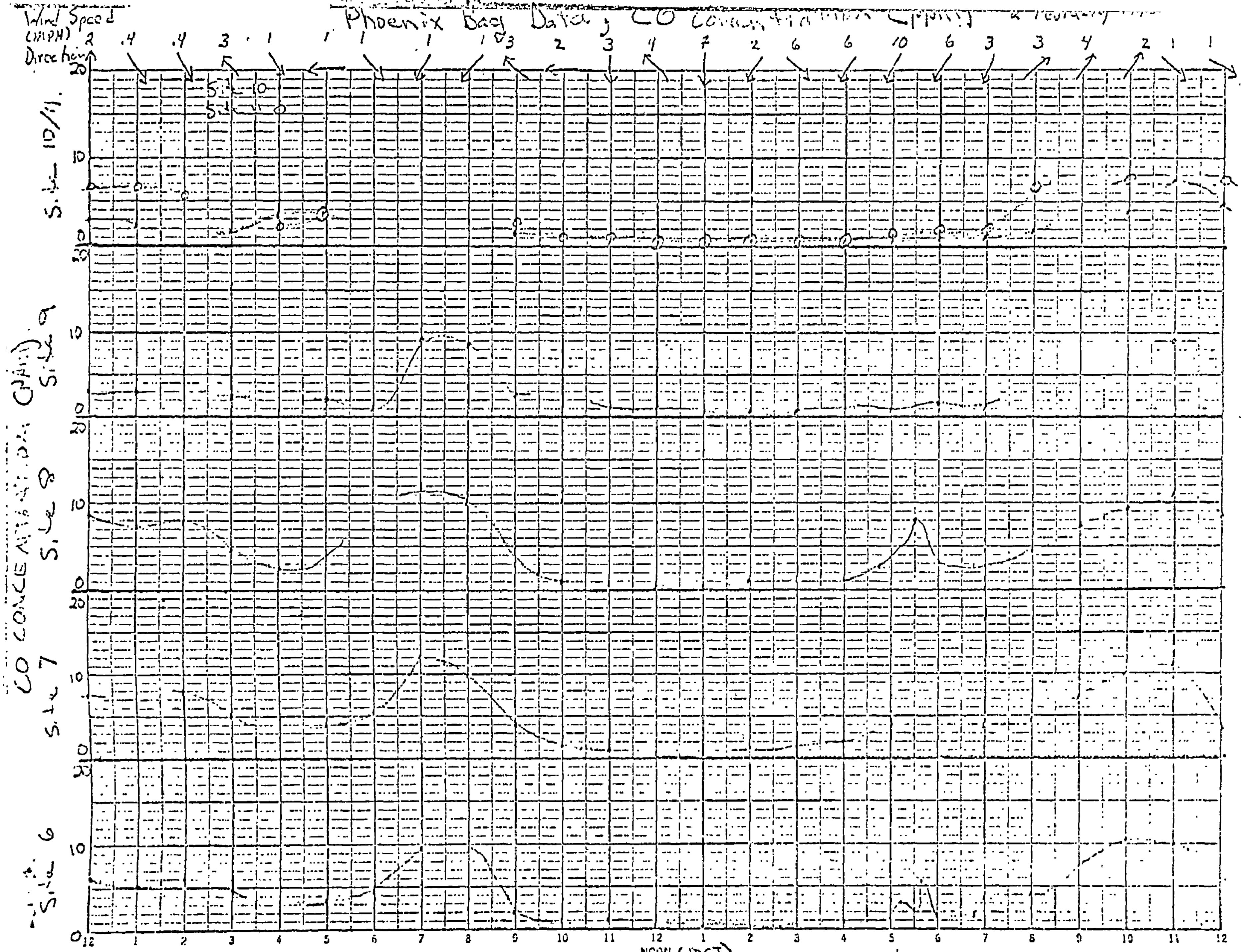
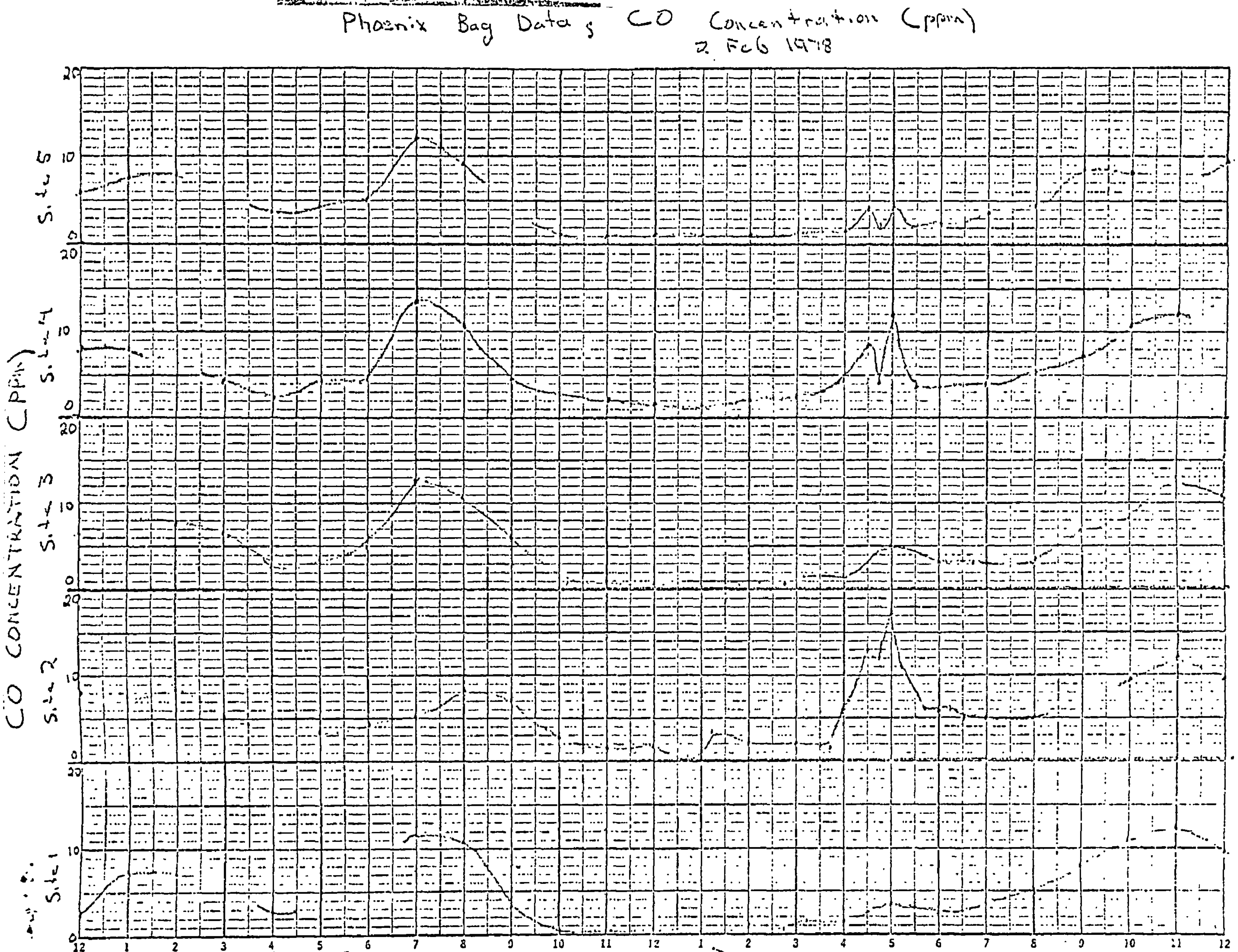

Phoenix Bag Data, CO Concentration (ppm)
Wind Speed (MPH) Direction
Site 10/11
Site 9
Site 8
Site 7
Site 6
CO CONCENTRATION (ppm)
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
NOON (MST)

Figure 4



Phoenix Bag Data; CO Concentration (ppm)
2 Feb 1978
CO CONCENTRATION (ppm)
Site 5
Site 4
Site 3
Site 2
Site 1
20
10
0
12
1
2
3
4
5
6
7
8
9
10
11
12
NOON (mst)

Figure 5