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Q. Hopper
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HAYDEN SMELTERS
EMISSION SURVEY

FINAL REPORT - EMI PROJECT NO. 102

EPA PURCHASE ORDER NO. PP5090462B

Prepared for:

U.S. Environmental Protection Agency
Region IX, Air Programs Branch
San Francisco, California
Charlotte Hopper, Project Director

Prepared by:

Environmental Measurements, Inc.
San Francisco, California
Roger B Sperling, Project Manager

17 July 1975

EPA
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75-010

SO_2 MASS FLUX

Emission rates for the smelters have been estimated from the moving remote sensor data. The SO_2 burden results and information derived from the pibal measurements were combined with traverse route geography to calculate SO_2 mass flux. A total of 23 Events were processed by computer; the results are tabulated in Table IV. The mass flux values--estimates for the amount of SO_2 in the overhead plumes--are listed in both kilograms per hour (kg/hr) and pounds per hour (lb/hr); averages for each day are included.

The average SO_2 mass flux for all five days (23 calculations) is 23,330 kg/hr (51,450 lb/hr) SO_2; the standard deviation (as a percent of the mean) is 77%; this statistic indicates a wide spread in the calculated flux values. Some of this spread in the results is the expected error of the remote sensor measurements (See Section 3). However, the smelters cannot be assumed to be constant emission sources; thus, some of the spread is due to the true variation in the combined SO_2 emissions.

The calculations in Table IV are the result of individual passes of the AQML-mounted COSPEC under the dispersing plumes. The remote sensor makes a near-instantaneous measurement--a "snapshot" of the SO_2 in the overhead plume. Because the plume shape is usually not constant with time, each measurement produces a different result. As described in Section 3

TABLE IV

SO_2 MASS FLUX
Hayden Smelters Emission Survey

DATE	TIME (MST)	EVENT	WIND (M/S)	SO_2 MASS FLUX* (KG/HR)	AVG	(LB/HR)	AVG
14 Apr 75	1036-1055	8	5.9,3.9	28,750		63,350	
	1451-1500	18	7.1	47,500	38,150	104,700	84,100
15 Apr 75	0900-0910	3	2.5	12,600		27,750	
	0910-0925	4	2.5	10,050		22,150	
	0925-0940	5-6	2.9	16,700		36,800	
	1122-1136	10	3.0	17,750	18,500	39,100	40,750
	1136-1150	11	2.8	6,000		13,200	
	1630-1638	26	6.0	15,000		33,050	
	1645-1652	28	6.0	51,328		113,150	
16 Apr 75	0859-0927	4	3.1	14,200		31,300	
	0927-0952	5	4.0	35,200		77,600	
	1609-1616	23	6.8	34,250	20,600	75,500	45,400
	1616-1623	24	6.6	11,183		24,650	
	1623-1631	25	6.3	12,416		27,350	
	1631-1643	26	6.1	16,500		36,350	
17 Apr 75	1203-1211	14	6.0	31,000		68,300	
	1534-1539	26	5.5	21,100	45,500	46,500	100,300
	1555-1603	29	11.0	84,250		185,700	
18 Apr 75	0951-0959	7	2.4	10,800		23,800	
	1223-1228	17	2.9	15,250		33,600	
	1228-1232	18	2.9	10,400	14,200	22,900	31,300
	1232-1235	19	2.9	9,700		21,400	
	1235-1238	20	2.9	24,750		54,550	

* Combined SO_2 emission rates for the entire two-smelter complex.

a set of measurements (typically six) is required to obtain a reliable flux figure. This is illustrated by the averages for 15 and 16 April which are derived from six and seven separate calculations. The averages for the two days (18,500 kg/hr and 20,600 kg/hr) agree within 12%. The standard deviations are 81% (15th) and 54% (16th). The daily averages are a better measure of smelter SO_2 emissions than any one individual calculation.

These emission rates are for the entire smelter complex. All SO_2 plumes measured by the remote sensor--whether emanating from stacks or as fugitive emissions--are included in the calculations. For most measurements it was not practical to attempt to separate stack plumes from fugitive plumes; nor was it usually possible to identify plume anomalies in the data records as originating from the KCC or ASARCO stacks. In general, there were too little detailed wind data (even with the 35 pibals) to be able to define precise plume trajectories for a significant number of measurements. The rugged terrain had a pronounced effect on the plume paths, as well. Source separation would require additional field studies with, hopefully, more favorable wind directions than were experienced during this program.

The combined mass flux values can be expected to be larger than other SO_2 emission rates for the two smelters because essentially all of the SO_2 source points were being

tested simultaneously. There are other reasons why some of the fluxes may be high. Traverse routes that are sharply curved and terrain that is rough can cause positive errors in the calculation of remotely measured mass flux.

Higher emission rates were calculated along the Globe Highway (in the Gila River Canyon) than in the Montgomery Ranch area. The average of the sixteen Globe Highway SO_2 mass flux calculations is 26,900 kg/hr (59,300 lb/hr); this is significantly higher (78%) than the average for the COSPEC measurements west of the smelters, 15,150 kg/hr (33,400 lb/hr). There are two reasons for this difference. First, the only available traverse route northeast of Hayden is a curved canyon road (the Globe Highway). The plumes being measured were generally above the canyon. But the canyon walls may have channelled portions of the plumes along an irregular trajectory--unrelated to the straight-line plume path assumed for analysis. The effect is to distort the wind/road angle and plume width. The errors which enter the flux calculations tend to be positive; they increase the computed flux value. By comparison, the Montgomery Ranch traverses would be less influenced by this type of error because the topography is less rugged.

The second reason relates to the non-stack (fugitive) emissions. A single wind speed and direction was selected

from the pibal results to be representative of the wind conditions that existed within the elevated plume. In the case of the Globe Highway these wind data were applied to total burdens measured overhead in the plume--but also to any SO_2 gas which may have originated at low elevation points in the smelter complex. It is presumed that much of the remote sensor data were a combination of elevated plume and lower level fugitive emissions; this is supported by the high ground level SO_2 concentrations measured on this road. Because these low elevation emissions were probably being influenced by different "canyon winds" (both in speed and direction) the winds aloft data were incorrectly applied, causing an increase in the calculated mass flux. Again, by comparison, data collected in the Montgomery Ranch area would not suffer the same degree of error because of the less severe topography and micrometeorological effects.

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TABLES

Section 1
INTRODUCTION

PURPOSE

Environmental Measurements, Inc. was contracted by the U.S. Environmental Protection Agency Region IX, Office of Air Programs to conduct a moving measurements survey of smelter emissions in Hayden, Arizona (Purchase Order #PP5090462B). The field survey was conducted 14-18 April 1975; five data-days were completed under the field direction of the EPA Project Officer.

The purpose of this study was to monitor sulfur dioxide (SO_2) smelter emissions overhead and at ground level in the vicinity of the two copper smelters in Hayden. One smelter is operated by Kennecott Copper Corporation (KCC) and the other by American Smelting and Refinery Company (ASARCO). Their main stacks are 800 meters apart. The KCC stack is 182 meters (600 feet) above ground level; the ASARCO stack is 305 meters (1000 feet) high. An Air Quality Moving Laboratory (AQML) was used to study ambient SO_2 at this complex source.

SUMMARY

This report presents a description of field measurements, data processing procedures and results and discussion for the five data-day survey of smelter emissions. The survey was conducted with a Barringer Correlation Spectrometer (COSPEC II) to measure overhead burdens and a Bendix total sulfur monitor

to measure ground-level concentrations. The speed and direction of winds aloft were monitored by the periodic release of pilot balloons.

Measurement activity consisted of moving measurements-- traversing the plumes downwind of the sources-- and plume rise measurements-- measuring plume height and vertical plume geometry downwind of the sources.

Results are presented in map form indicating ground-level concentrations, SO_2 dispersion and plume rise profiles. SO_2 emission rates were calculated from the remote sensing data.

CONCLUSIONS

The AQML traced smelter emissions to the west and northeast of Hayden. The remote sensor located overhead plumes as far away as 40 km (25 miles) downwind; the point monitor measured plume touchdown there, also. The variability of plume behavior from one measurement to the next was documented by both overhead and ground level SO_2 data.

Plume rise measurements revealed a complex plume structure reflecting the irregular terrain and meteorological conditions in the vicinity of the smelters. The centerline height of the combined plume 0.5 - 2.0 kilometers downwind was 300 - 600 meters above ground level.

Mass flux calculations for the combined emissions from the two stacks as well as fugitive emissions were made for twenty-three

sets of remote sensor data. The combined average emission rate for the entire two-smelter complex over the five day period was 23,330 kg/hr (51,450 lb/hr) SO_2.

Section 2

FIELD MEASUREMENTS

ACTIVITIES

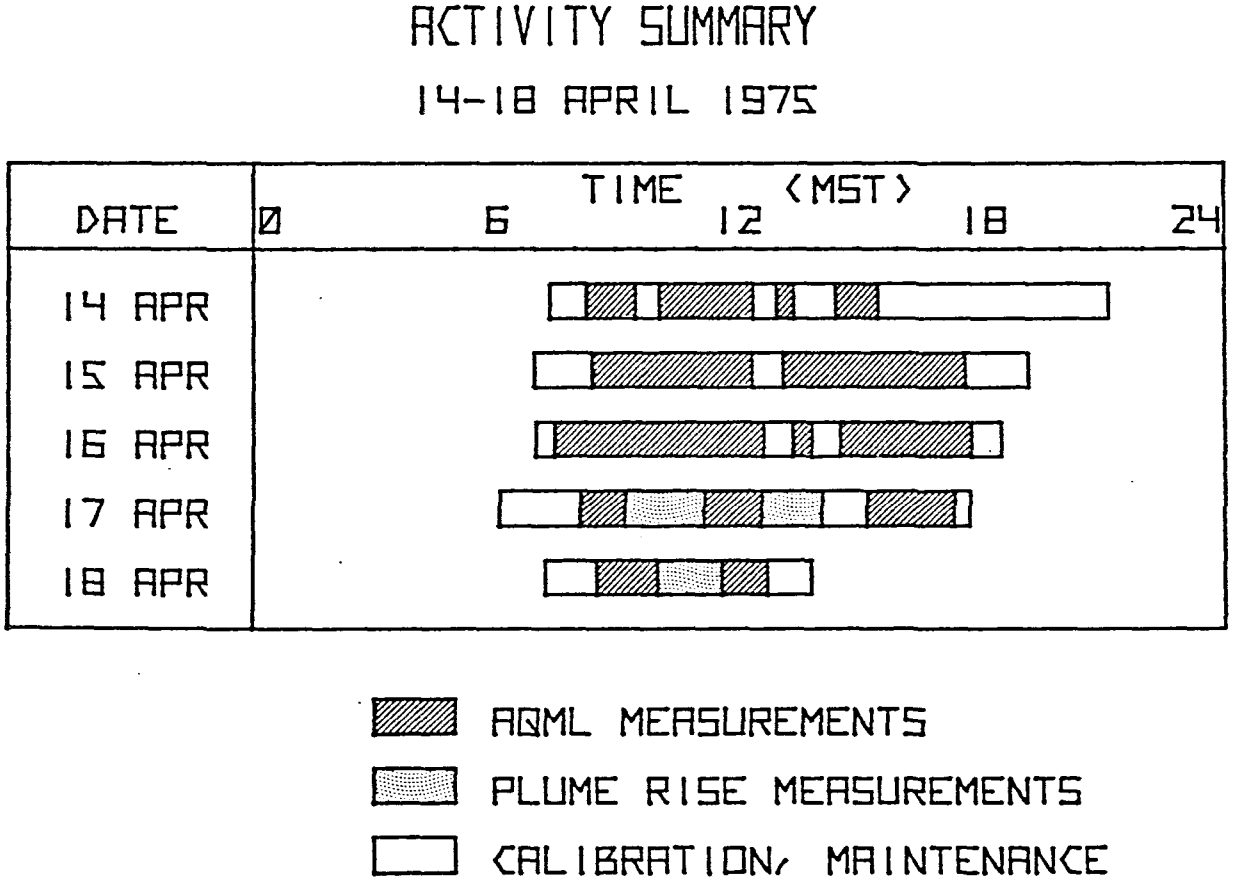
EMI brought an Air Quality Moving Laboratory (AQML) to Hayden, Arizona for the smelter emissions study. A crew of three persons operated it during the daylight hours on 14-18 April 1975. A remote sensor and total sulfur analyzer were used in a moving measurement mode near the smelters and far downwind--to 40 kilometers--to measure overhead and ground-level concentrations of SO_2. Meteorological forecasts were used to select the most suitable days for moving measurements; plume rise measurements were scheduled on other days. Pilot balloon (pibal) measurements were made periodically to determine wind speeds within the plumes. The field measurements were conducted under the direct supervision of the EPA Project Officer.

A total of 57 activity hours were logged during the course of this study. Figure 1 is a graphic summary of the activities for the five days in the field. A total of 1210 km (755 mi) were traveled in the moving laboratory; on the typical measurement day 240 km (150 mi) were traversed.

A summary of activities for each data-day follows:

14 April 75: An initial survey was performed along highway AZ-177 from Kearny to Hayden. Measurements were made in the Montgomery

Figure 1


ACTIVITY SUMMARY
14-18 APRIL 1975
DATE
TIME (MST)
0
6
12
18
24
14 APR
15 APR
16 APR
17 APR
18 APR
AQML MEASUREMENTS
PLUME RISE MEASUREMENTS
CALIBRATION/ MAINTENANCE

Ranch area west of the smelters in the morning. In the afternoon the plumes shifted to the northeast; they were monitored on the Globe Highway (AZ-77).

15 April 75: Early morning measurements were made west of Hayden by traversing on mine roads to the west and north of the Montgomery monitoring station. At noon the plumes shifted again; an extensive three-hour survey was performed on the Globe Highway.

16 April 75: The wind rotation occurred earlier in the day and the wind speed increased; a long distance survey on AZ-77 and US-70 successfully located the plumes 40 km (25 mi) downwind. On return to Hayden a Globe Highway survey was conducted.

17 April 75: Plume rise measurements were made from two sites, alternating with moving measurements of SO_2 on AZ-77.

18 April 75: Plume rise was measured from one site; a moving survey was performed before and after on the Globe Highway.

EQUIPMENT

Air Sensors. Environmental Measurements, Inc. provided an Air Quality Moving Laboratory (Figure 2) equipped to measure overhead SO_2 and ground-level SO_2. The principal instrument was the Correlation Spectrometer (COSPEC II) remote sensor used to measure overhead burdens. The COSPEC viewed the sky through a side window in the van, using a right angle mirror to reflect overhead light. The natural radiation of the solar electromagnetic spectrum is influenced by the absorption spectrum of the target gas, sulfur dioxide. The Correlation Spectrometer, an electro-optical instrument, detects portions of the molecular absorption bands specific for this molecule. The optical unit includes a Cassegrain telescope, an Ebert-Fastie quarter-meter dispersive element, a correlation disc assembly, and a photomultiplier to detect light energy levels. The electronics of the COSPEC contain signal processing circuits to provide an analog output suitable for strip chart recorders.

A Bendix Model 8300 flame photometric total sulfur monitor measured ground-level concentrations. A teflon sampling manifold (4 cm ID) gathered air into the van by means of a squirrel cage fan; a 20 mm diameter teflon inlet tube, in turn, sampled this air stream for analysis by the point monitor. The analog signals were recorded on a Rikadenki strip chart recorder. A rear-mounted propane-powered generator supplied electrical power for all instrumentation.

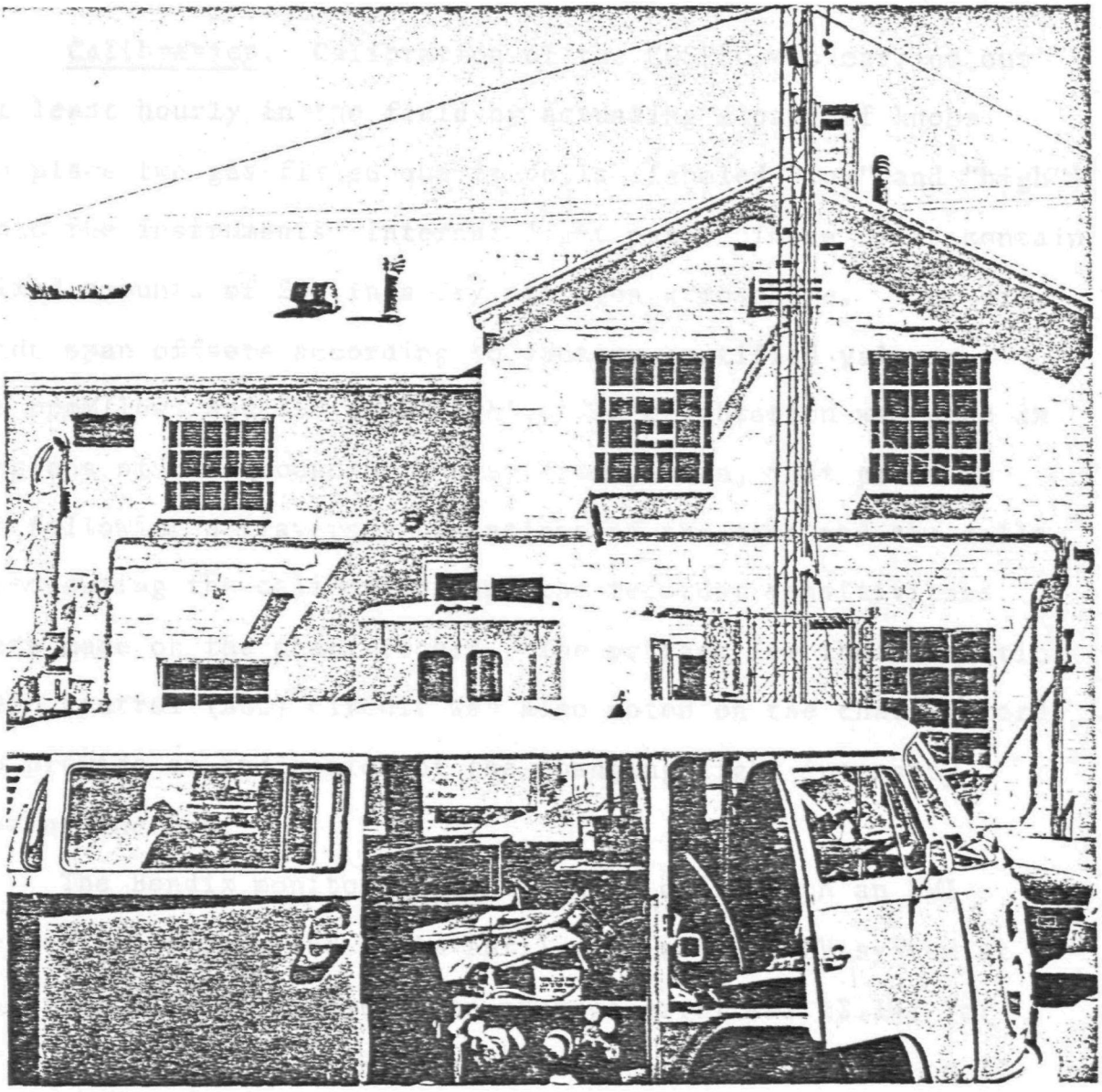


Figure 2. EMI's Air Quality Moving Laboratory, a completely self-contained monitoring system, is shown at the Joint Control Station in Hayden, Arizona.

Calibration. Calibration of the COSPEC was carried out at least hourly in the field by actuating a pair of knobs to place two gas-filled quartz cells (labeled "low" and "high") into the instruments' internal light path. These cells contain fixed amounts of SO_2 in a dry nitrogen atmosphere. They provide span offsets according to factory certified values: 65 ppmM(low) and 350 ppmM(high). The calibration was done in regions of background SO_2, away from plumes, just prior to or following a traverse. Notations of the time and the cells used during the calibration and the recorder sensitivities were made on the chart record. The voltage for the automatic gain control (AGC) circuit was also noted on the chart record to provide an indication of the changing light intensity during the day.

The Bendix monitor was calibrated daily with an EMI permeation system, and on 14 April with a NERC-LV system at Williams Air Force Base. The average error was ±2.14% for eleven calibration points (excluding two calibrations on 17 April 75 when there was a leak in the test system). The range of errors was from +6.5% to -4.8%. Therefore, the SO_2 data in this report are within ±10% accuracy. To verify the calibrations the Metronics Dynacal Permeation Tube (No. 90-125) was recertified following the field study. It was within 0.8% of the previously certified value.

The electronic circuitry of the Bendix instrument establishes an upper limit on the concentration of ambient SO_2 that it can

measure. The peak concentrations of SO_2 at Hayden frequently exceeded this limit. Therefore, the maximum ground-level concentration reported, 1390ppb (1.4ppm) SO_2, is a function of instrument design; it was exceeded on many occasions, but the true peak values are unknown.

The point monitor was calibrated for SO_2, the target gas of this study. The Bendix instrument measured *total sulfur* in actual application. No filter was used on the incoming airstream to discriminate between SO_2 and other gases. For sources such as copper smelters it is assumed that the gas detected by this unit is SO_2 and the data are reported as "ground-level SO_2". This is a reasonable assumption; the remote sensor data--which are specific for SO_2--corroborate the presence of SO_2 in the measured plumes.

Pibals. Single-theodolite pilot balloon measurements were made to measure winds aloft. The measurements were used in the field to understand the changes in wind movement occurring while the survey was in progress; also the data were used in the calculation of SO_2 Mass Flux. The theodolite, balloons and helium, were transported in the moving laboratory. Pibals were released at different locations as the need for wind information occurred (Figure 3). The locations of the pibal measurements are given in Table I; they also are shown on the Route Index Maps (Figures 6A and 6B).

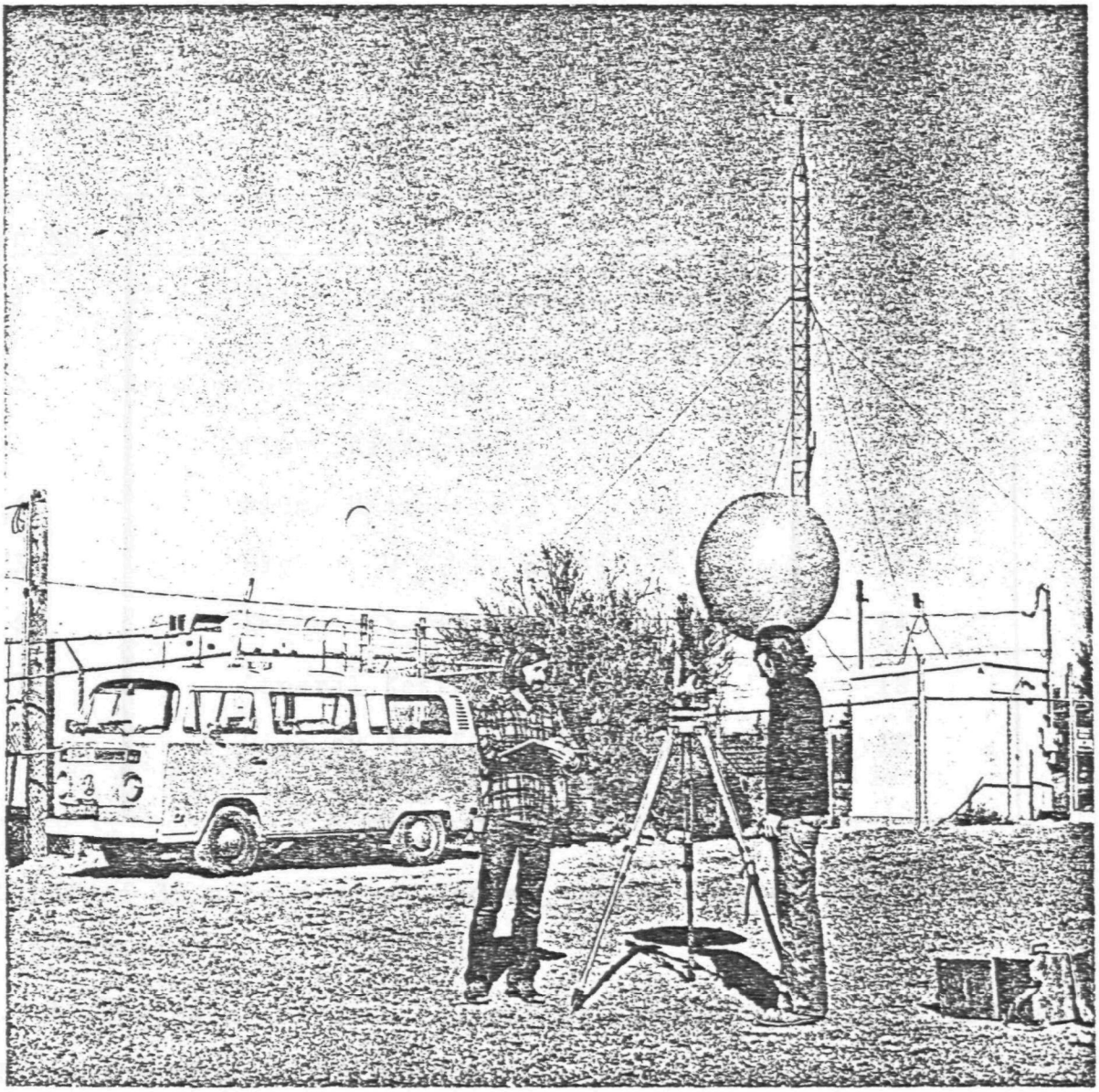


Figure 3. Pilot baloon measurement at Montgomery Ranch air monitoring station while stationary AQML monitors ambient and overhead SO_2.

Table I

Pibal Sites

Site No.	Location	Dates Used April 1975
1	Joint Control Station	14, 15 16,17,18
2	Montgomery Ranch Station	14
3	Plume Rise Site 1	17
4	Plume Rise Site 2	17, 18
5	Highway U.S. 70 at AZ 170	16
6	Kennecott Office	14
7	General Kearny Inn	18
8	Highway AZ 77 at Christmas Mine Road	16

A total of 35 pibals were tracked; the processed results appear in Appendix B.

A supplementary data collection technique was provided by EMI for the study. A time-lapse motion picture camera was located on the roof of the Montgomery Ranch monitoring station, approximately four kilometers west of the smelters, to record plume and cloud activity during the day. An edited film for the five days has been provided to the EPA as a separate data record for this study.

METHODOLOGY

Moving Measurements. EMI employed unique methods to make moving measurements of smelter plumes. To interpret the results required that the moving laboratory data be related to the geography of the study site. Prior to the actual field work a set of U.S. Geological Survey Topographic Maps (7.5 minute) was annotated with numerical identifications of key road intersections. By labeling the routes a systematic identification system was used. During a traverse, the identification numbers from these maps were recorded on the chart record to locate where the total burdens and ground-level concentrations of the target gases were recorded.

The AQML was driven downwind of the Hayden smelters, usually within a five kilometer radius, but as far away as 40 kilometers. The objective was to cross the plumes at as many different downwind distances as possible, to map the dispersing SO_2. Two problems at Hayden made this difficult to achieve. The rough terrain limited the available traverse routes; and the juxtaposition of the two smelters with their differing stack heights presented a complex source to study. The limited traversing road problem was overcome by 1) using the mine roads west of the smelters and 2) making repetitive surveys on available highways, such as the Globe Highway. The complex source problem required wider ranging traverses because the stack emissions originated from widely differing

elevations. Furthermore, fugitive emissions created a third, broad source of SO_2. To cross all of these "plumes" necessitated long traverses, even close to the smelters.

Traversing speed varied with the distance from the source. Close to the smelters the speed was kept low (below 30 km/hr) to allow the instruments to respond fully and to provide clear definition of narrow plumes. As the AQML moved further downwind from the plant it moved faster through the plume. The speed of the vehicle increased to a maximum of 90 km/hr at the farthest radius. Because the plume is broader at the greater distances, changes in overhead burdens and ground-level concentrations were less abrupt, and the instruments responded to them easily.

Decisions were made in the field based on the real-time data: whether to repeat the plume-tracking measurement at the present radius or to move to a second radius of measurement; whether to turn right or left to recross the dispersing plume at a different radius.

Plume Rise. To measure plume geometry in the vertical plane the COSPEC remote sensor was placed on a stationary tripod. The AQML was parked nearby to provide necessary power and connection to the chart recorder (Figure 4). Two plume rise sites were used: Site 1 was 1.4 kilometers northwest of the smelters and Site 2 was 2.0 kilometers to the southeast. On the days when fixed COSPEC measurements were

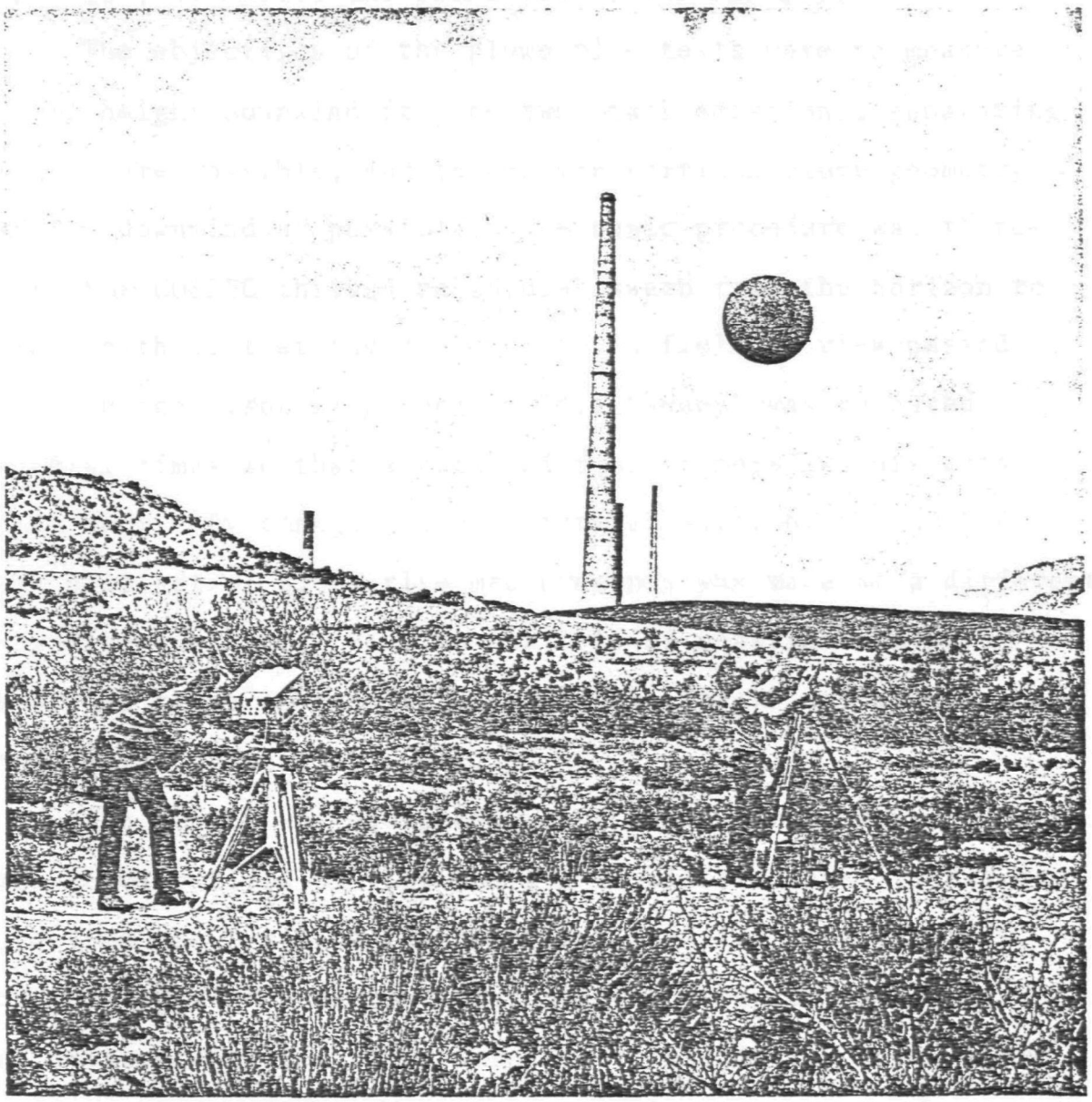


Figure 4. Tripod-mounted COSPEC measures plume rise as pibal is released to determine wind direction.

made (17, 18 April) the plume vector was easterly.

The objectives of the plume rise tests were to measure plume height downwind for the two-stack emissions, separating them where possible, and to measure vertical plume geometry as far downwind as possible. The basic procedure was to rotate the COSPEC through an angular sweep from the horizon to the zenith so that the spectrometer's field of view passed through the dispersing plume. This "sweep" was repeated several times so that a total of four or more measurements were made. By changing the horizontal angle of the COSPEC the next set of plume rise measurements was made at a different downwind distance. Four to six sets of measurements were made, as close as two degrees from the stacks and as far away as 65 degrees.

The COSPEC was equipped with a narrow-angle telescope; its angular field of view was 1 x 10 milleradians. (This compares to the 1 x 1 degree telescope used for vertical-view traversing). The narrow telescope was used for plume rise to measure detailed plume structure close to the stack where the diameter of the plumes were relatively small. It was used farther downwind also, even though the dispersing plume presented a larger "target."

To relate the angular positions of the COSPEC to the geometry of the stacks it was necessary to collect concurrent data on the plume vector. This was done by tracking pibals

at the plume rise sites to measure the wind direction (and speed) at the time remote sensor measurements were made. Also, the AQML was used in the moving mode; the COSPEC was put back in the moving laboratory so that horizontal plume geometry measurements could be made immediately after the vertical data were collected. The moving data were used to convert the plume rise vertical angles to downwind distances.

Section 3

DATA PROCESSING

MOVING MEASUREMENTS

The AQML data collected in Hayden were taken to the EMI office in San Francisco for processing.

Events. The chart records were first annotated to define Events. The continuous recordings were separated into individual measurements, whether single plume crossings or regional surveys, to establish an orderly, chronological list. This Event list formed the basis for selecting data to be processed. Key Events were identified and evaluated for relevance to the project goals and priorities were established. A summary of Events is presented in Table II. Events are grouped by major measurement activities; time periods are identified.

Digitizing. The raw moving laboratory data were the analog traces for SO_2 total burdens and ground-level concentrations. These records also included hand-written annotations of time and positions made by the data-logger, as well as instrument calibrations and weather conditions. Figure 5 is a sample chart record of moving measurements. The data were recorded on 15 April in the early morning. Event 5 began (at the bottom of the record) at the gate on the mine road behind the KCC smelter. The AQML moved to the northwest until it reached the Chilito Mine Road and proceeded south toward highway 177; from there it turned left and returned to the Joint Control Center at 0940 MST. The far right

Table II

EVENT SUMMARY

DATE	TIME (MST)	EVENTS	DESCRIPTION
14 April 75	1036-1055	8	Plume tracking west of Hayden
	1309-1514	15-19	Globe highway survey
15 April 75	0900-1223	3-13	Plume tracking west of Hayden
	1352-1713	16-33	Globe highway surveys
16 April 75	0857-0952	4-5	Plume tracking west of Hayden and on Globe highway
	1042-1323	7-11	Long distance (40 km) plume tracking
	1331-1351	13-16	Miami smelter survey
	1550-1643	21-26	Globe highway survey
17 April 75	0910-1111	4-10	Plume Rise - Site 1
	1150-1217	12-15	Globe highway survey
	1237-1405	17-22	Plume Rise - Site 2
	1513-1645	24-32	Globe highway survey
18 April 75	0933-1000	4-7	Globe highway survey
	1002-1138	9-15	Plume Rise - Site 2
	1223-1242	17-20	Globe highway survey

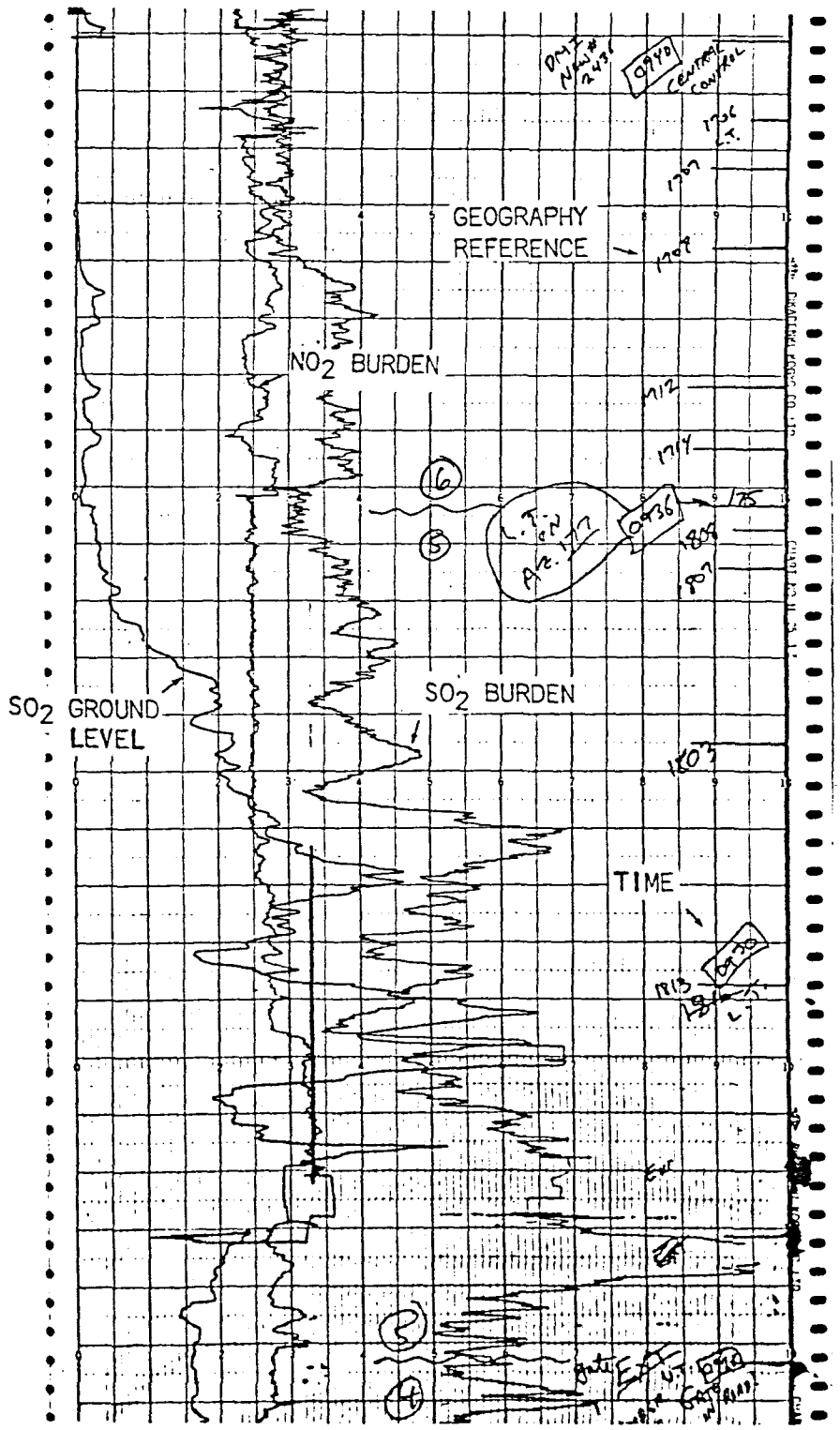
Figure 5

SAMPLE CHART RECORD

MOVING MEASUREMENTS

15 April 1975 0936-0940 MST

Events 5,6



trace is from the remote sensor and records the overhead burdens of SO_2 monitored along this traverse route. The left hand trace is the ground-level SO_2 monitored by the flame photometric analyzer. (A third trace located at approximately 25% fullscale is the NO_2 COSPEC signal.) Note that the SO_2 overhead and SO_2 ground-level traces tracked one another as the moving laboratory traced a near-axial path through the plume (Event 5) then moved away from the plume (Event 6).

Reference baselines were first drawn for the SO_2 burden records. The background was defined as the instrument output on either side of well defined plume anomalies. Using hand digitization methods each analog trace was sampled at inflection points and at geographic reference points. Major assumptions of this procedure are a constant velocity of the vehicle between indicated landmarks, and straight line interpolation between geographic points and inflection points. Therefore, assuming straight line variations between each of the digitized points, they may be joined by straight lines to recreate the original record.

All of the geographic location points were digitized from U.S. Geological Survey 7.5 minute topographic maps into X and Y coordinates. The Universal Transverse Mercator (UTM) system (in kilometers) provided a convenient reference grid. Each of these coordinates was assigned an ID number. These ID numbers were subsequently used to refer to the geographic

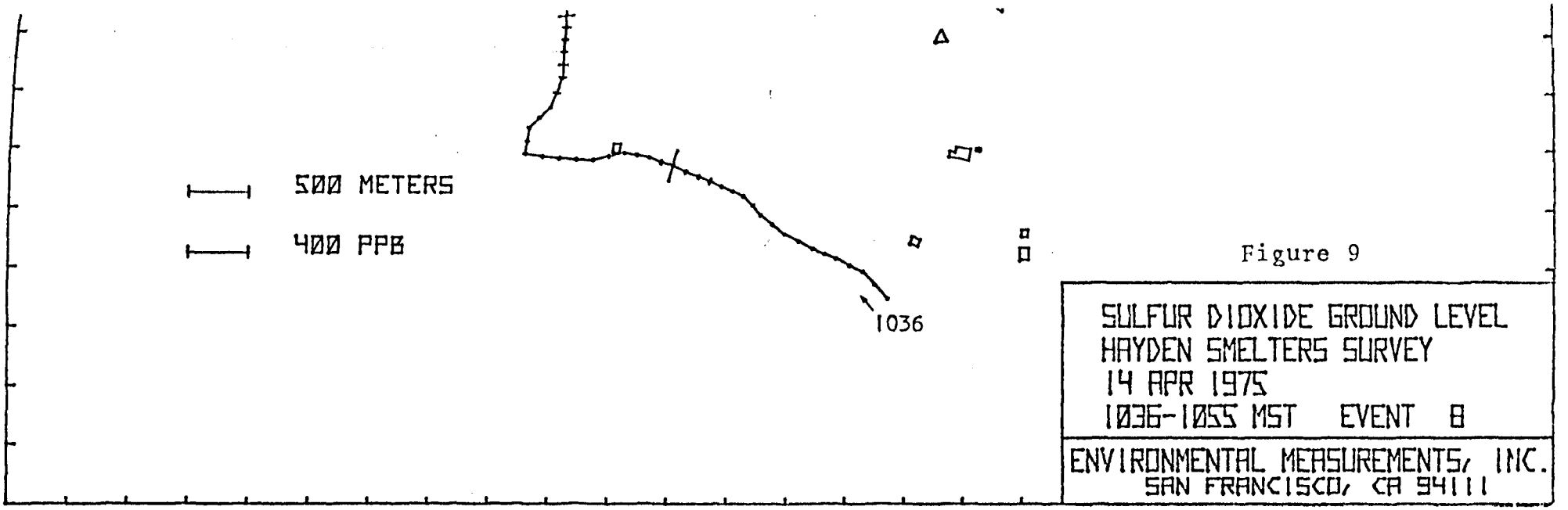


Figure 9

SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
14 APR 1975
1036-1055 MST EVENT 8

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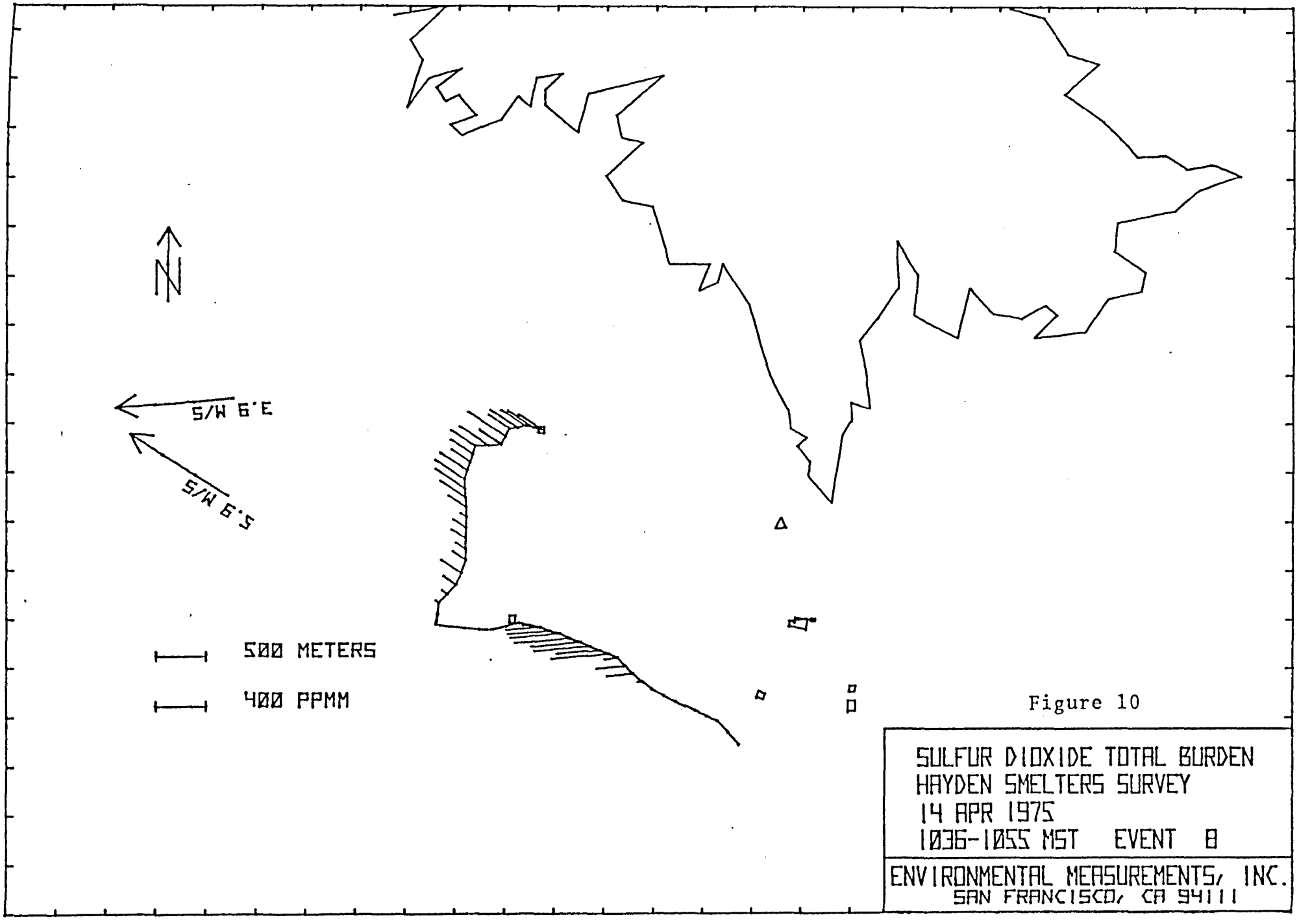

Figure 10

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
14 APR 1975
1036-1055 MST EVENT 8

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SAN FRANCISCO, CA 94111

points for map making. Route Index Maps, Figures 6-A and 6-B, display all the routes (shown dotted) used during the survey and the geographic references (monitoring stations, pibal sites, smelter buildings and stacks, and the 3200-foot contour) used on the computer drawn maps.

Data Listings. The two sets of data--pollutant and geographic--were stored on a computer and merged into listings of five parameters in engineering units (see Appendix A):

- X Coordinate (km)
- Y Coordinate (km)
- Geography point
- SO_2 Total Burden (ppmM)
- SO_2 Ground Level (ppb)

The data listings in Appendix A are for 28 selected Events covering the five-day span of the study.

The density of the listed numbers varies between geographic points. Where the instrument readings were very low and near background levels, only a few numbers were required to describe the spatial variations that occurred; however, where fluctuations occurred within the boundaries of the plume, the density of numbers was increased to properly describe the changes in the measured results. Where data were inserted a zero was added between the geography points. In most cases one additional point was added; in some instances two were added.

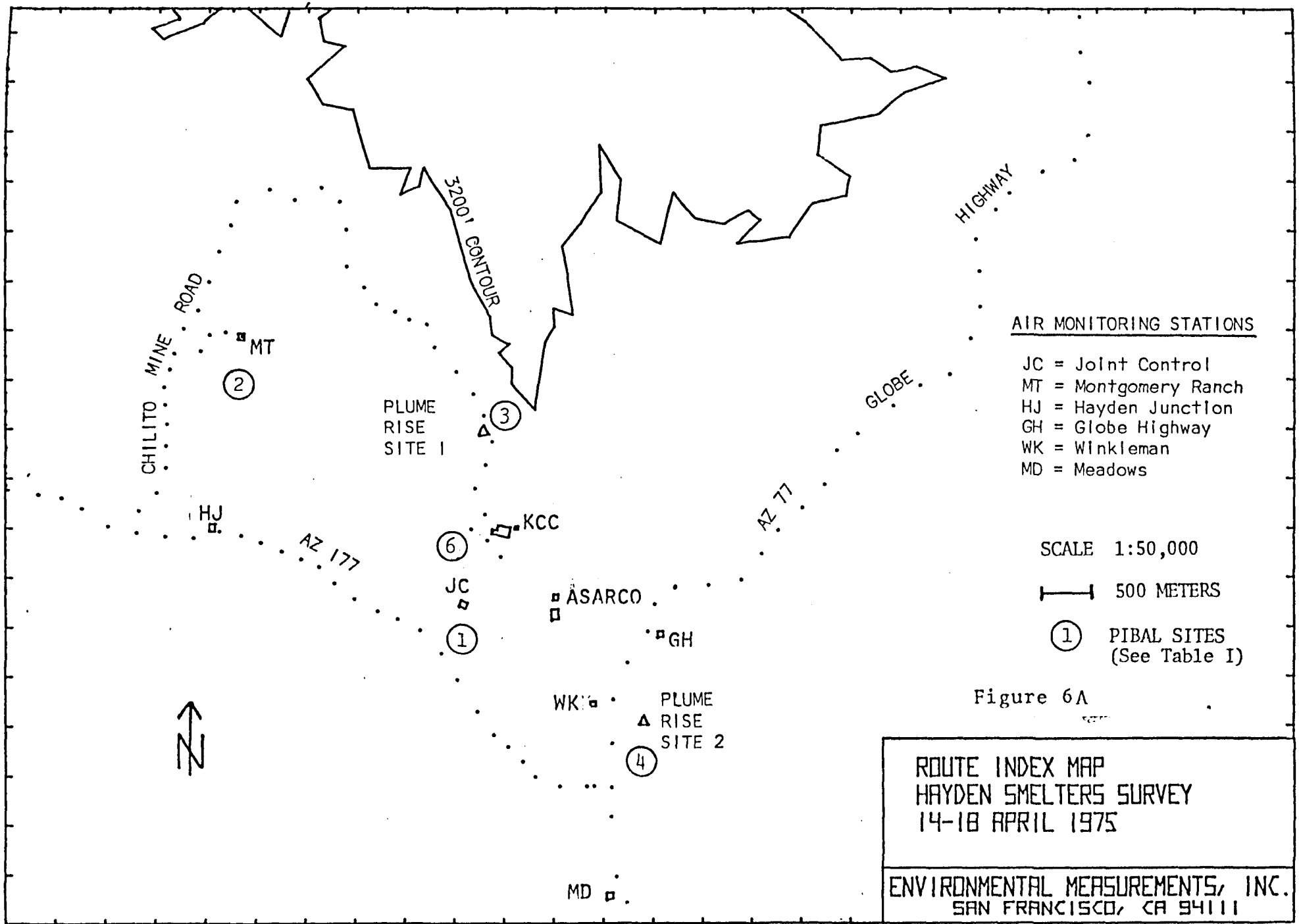

Figure 6A

ROUTE INDEX MAP
HAYDEN SMELTERS SURVEY
14-18 APRIL 1975

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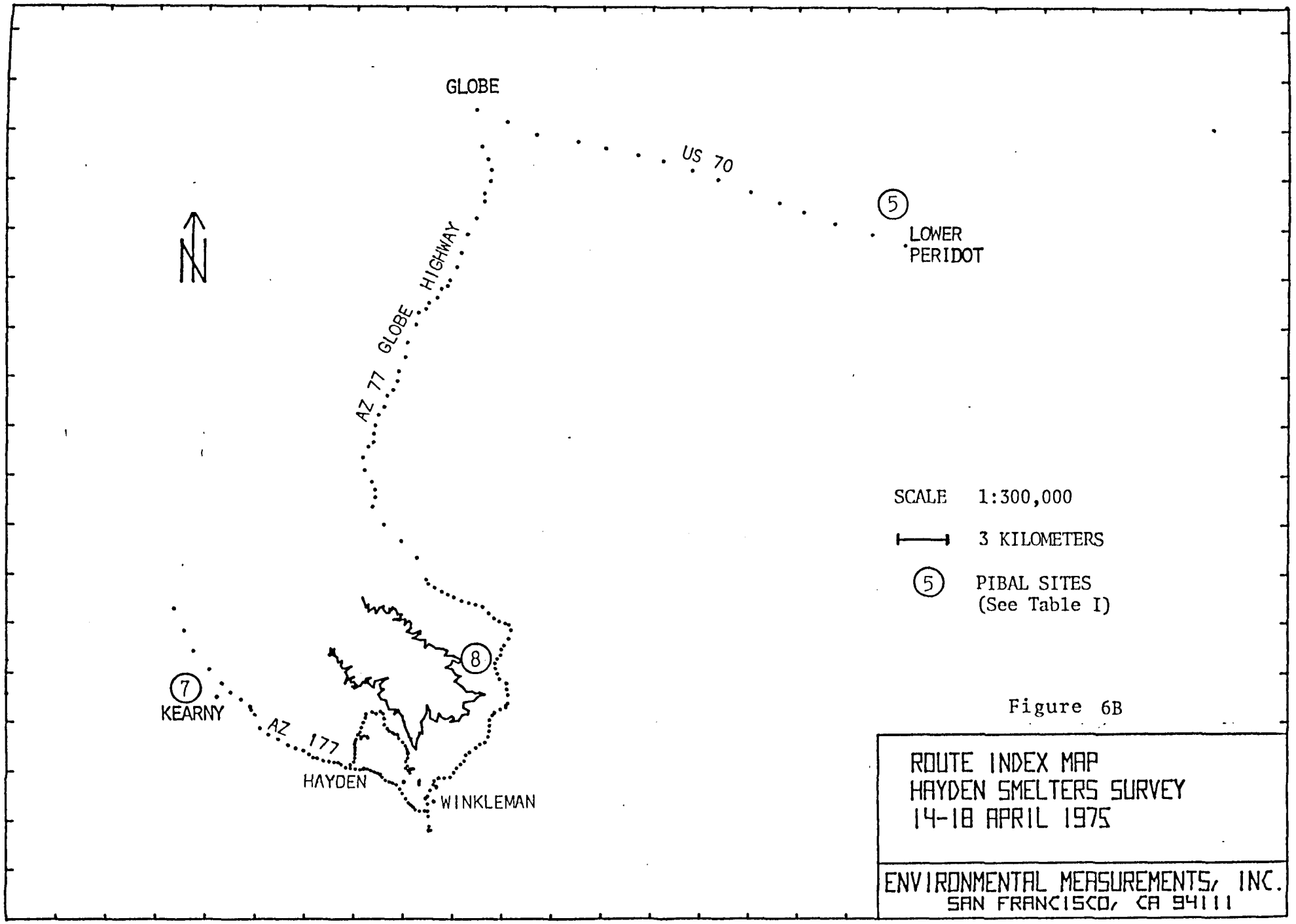


Figure 6B

ROUTE INDEX MAP
HAYDEN SMELTERS SURVEY
14-18 APRIL 1975

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Total Burden Maps. The COSPEC data have been plotted in map form to display the spatial distribution of the results. Figure 7-A is a typical SO_2 total burden map. The total burden map shows the remotely measured overhead SO_2 using "total burden lines". The lines extend from the roadway in the direction of wind flow; the length of the lines is proportional to the COSPEC readings, calibrated in parts per million-meters (ppmM) SO_2. A plume anomaly recorded on the original data appears on the map as a set of lines showing the "shape" of the overhead gas.

The 15 total burden maps in this report (Figures 10, 12, etc., Section 4) are drawn to a geographic scale of 1:50,000 (1 cm = 500 meters), with two exceptions. One map required a scale of 1:100,000 (1 cm = 1 km), and another 1:300,000 (1 cm = 3 km), to display broader regional measurements. The scale of the total burden is 400 ppmM per centimeter, the same on all maps. The selected wind speed (from the pibal results) labels the wind arrow.

On two maps there is a pair of wind arrows. In the first case (Figure 10) there were two separate, distinct plumes. The pibal results indicated a wind shear; different wind speeds and directions were assigned to each plume, therefore. In the second case (Figure 22), the survey extended over a half-hour period when the wind was rotating from easterly to southerly; the pibal results confirm the SO_2 measurements showing two plume crossings.

Figure 7-A

TYPICAL SO_2 TOTAL BURDEN MAP

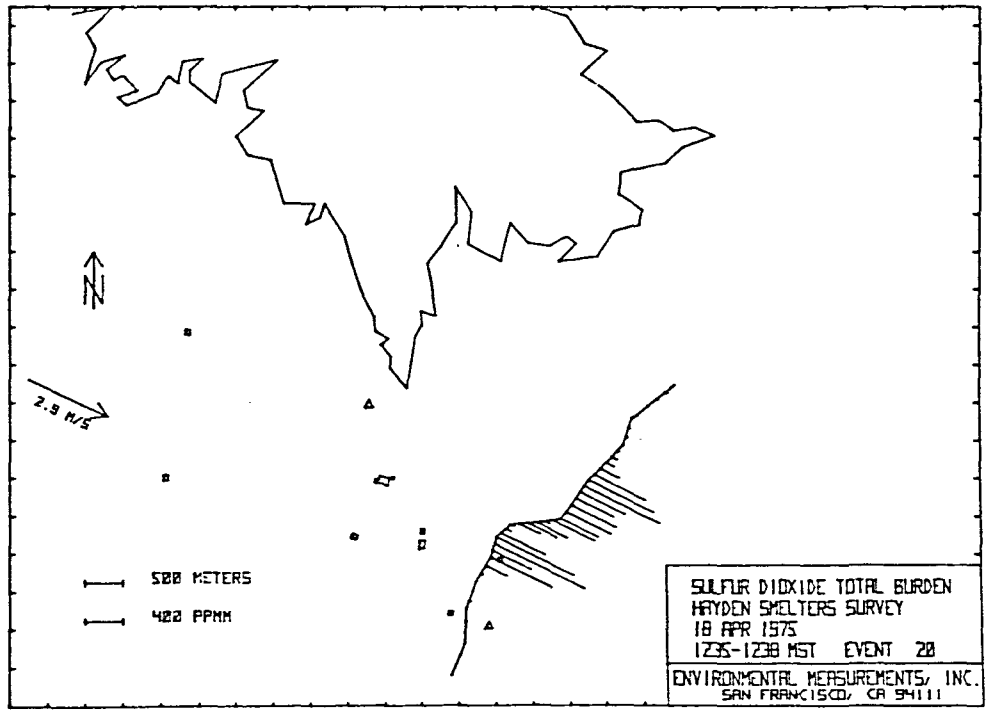
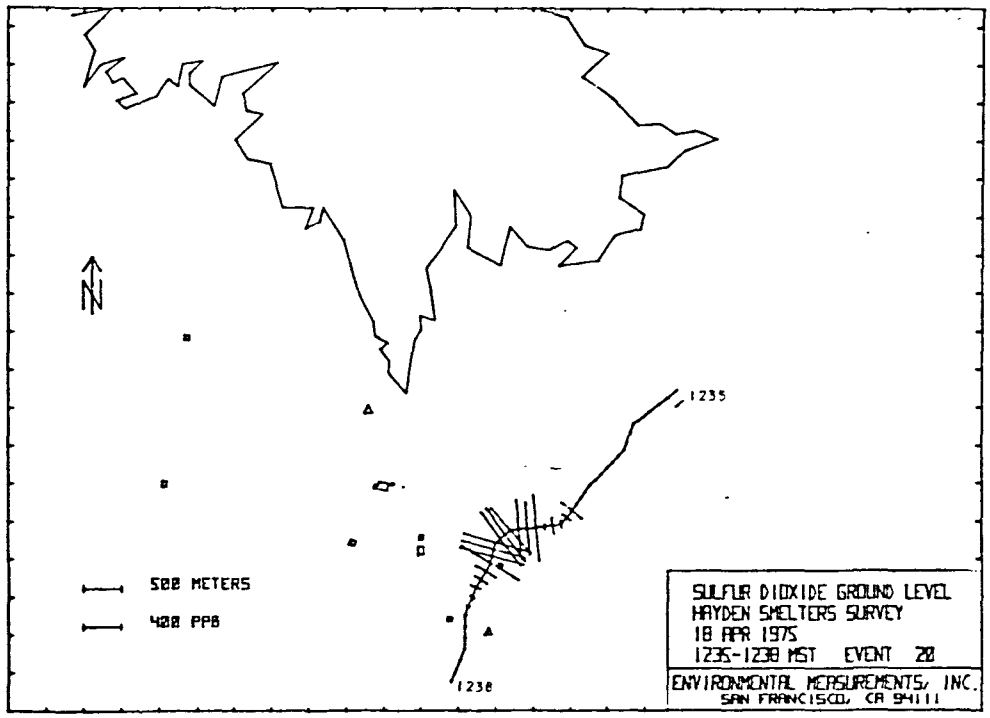


Figure 7-B

TYPICAL SO_2 GROUND-LEVEL MAP



Ground-Level Maps. A complementary set of 15 maps showing ground-level SO_2 concentrations measured concurrently with the overhead SO_2 is presented in Section 4 (Figures 9, 11, etc.). The ground-level data are plotted as ladder rungs (See Figure 7-B), lines normal to the traverse route; they are calibrated in parts per billion (ppb) SO_2 (400 ppb per cm). No wind arrows are shown. The ground-level maps are printed on vellum to permit simultaneous viewing with each total burden map.

SO_2 Dispersion Maps. A third type of map has been prepared for this study to document the dispersion of SO_2 over traverse routes used repeatedly during the survey. These SO_2 dispersion maps (Figures 39-53) are smaller than the computer-drawn total burden and ground-level maps and have hand written annotations. They are drawn to a scale of 1:200,000; 1 centimeter = 2 kilometers.

These sketch maps summarize the time/topography variations in SO_2 burdens and concentrations along the Globe Highway (47 maps) and in the Montgomery Ranch area (12 maps). The extent of the overhead (narrow line) and ground level (wide line) SO_2 plumes are marked; the peak readings (in ppmM and ppb SO_2) are located. Each individual map is identified by date and time; the time is the approximate central time of the moving measurements, as near the time of the peak readings as practical.

Figure 7-A

TYPICAL SO_2 TOTAL BURDEN MAP

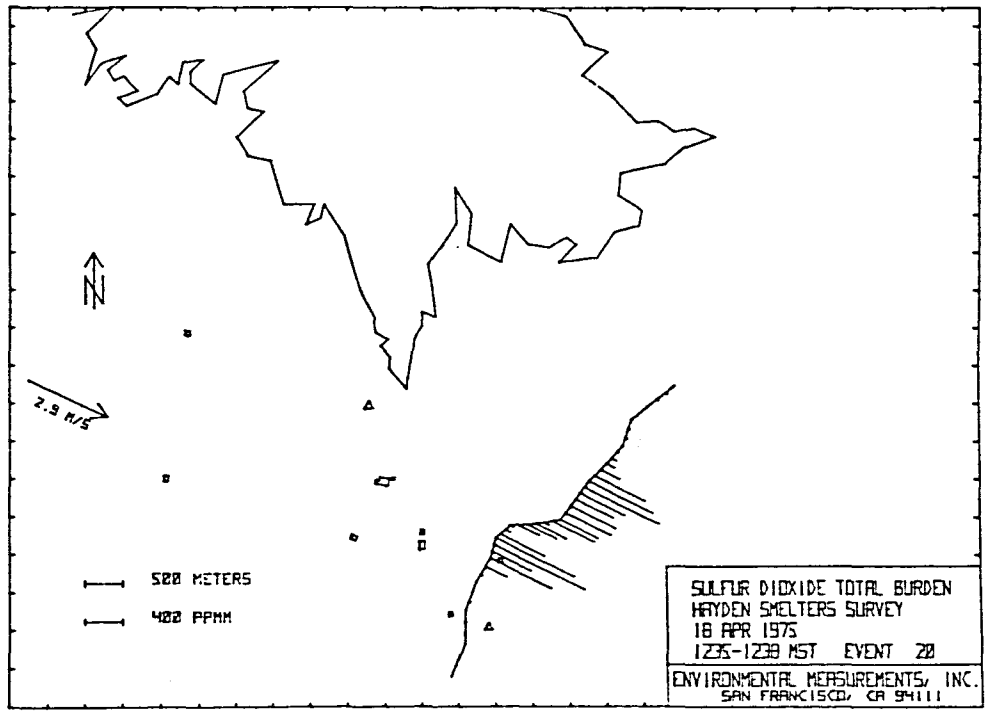
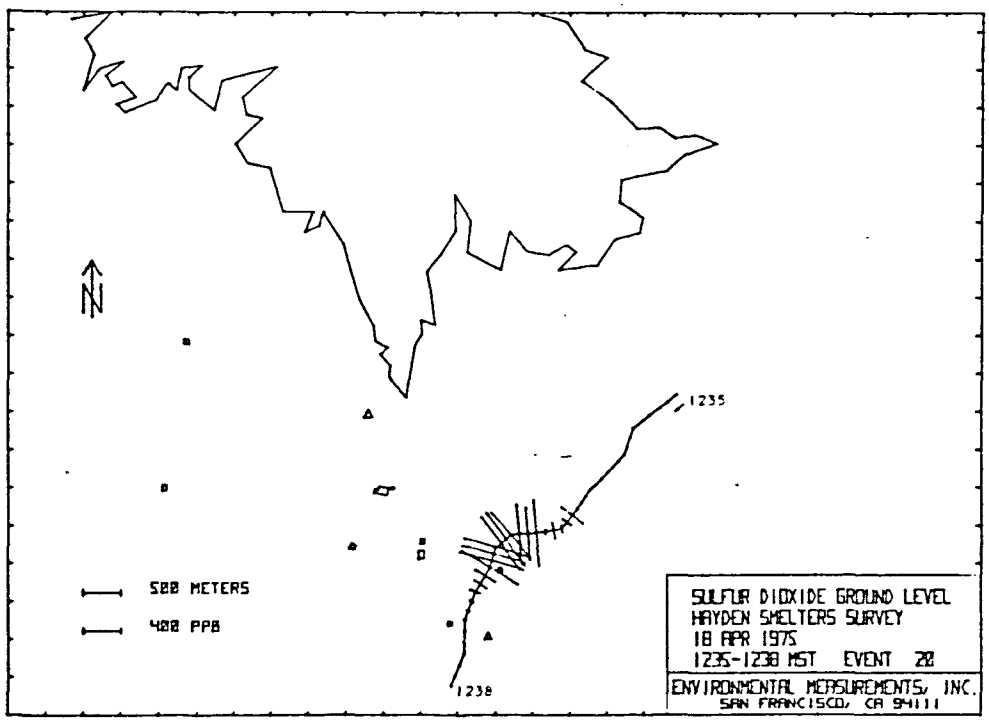


Figure 7-B

TYPICAL SO_2 GROUND-LEVEL MAP



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PLUME RISE

The stationary COSPEC data--measurement of plume rise--required a separate data processing procedure. The same type of chart record was used as for moving measurements, but the results had to be related to the geometry of the measurement site relative to the stack heights and local topography.

A sample chart record of plume rise measurements is shown in Figure 8. Two individual measurements are recorded; the instrument field of view was rotated from 6° above the horizon to 25°. The trace labeled E-1 is the SO_2 analog signal for the instrument moving upward to the highest angle; in E-2 the instrument returns to the lowest angle. Number notations are given for each angle of the plume rise measurements. Note that the two traces are dissimilar even though the measurements cover a time-span of only four minutes.

The records were digitized by taking chart readings for each degree of angular movement. The readings were multiplied by appropriate calibration factors and stored in a computer memory. The results were plotted in sets. These plots (Figures 55, 56, etc., Section 4) indicate the horizon line to show the lower limit of the remote sensor measurements. The vertical scale is in degrees inclination and elevation (meters).

The elevation scale is nonlinear because the height of the plume varies with the tangent of the angle by the formula:

$H = L \tan \alpha + (\Delta h)$ where H is the height of the plume,

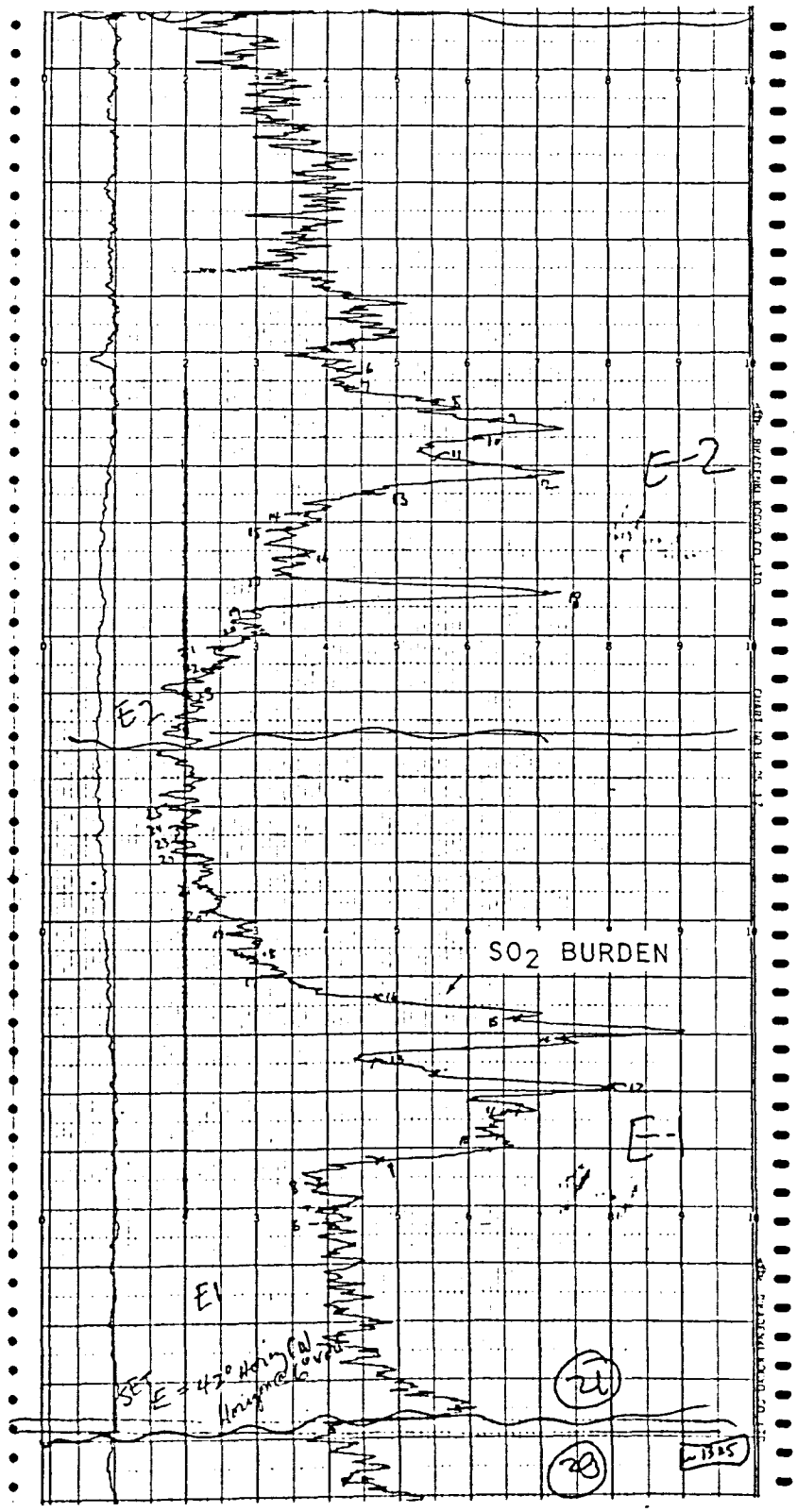
Figure 8

SAMPLE CHART RECORD

PLUME RISE MEASUREMENTS

17 April 1975 1325-1330 MST

Event 21



above the bottom of the stacks, L is the horizontal distance from the COSPEC to the plume centerline, α is the angle of inclination, and Δh is the difference in elevation between the plume rise site and the base of the stacks.

To calculate the distance L the plume vectors first had to be determined. A review of the plume rise and AQML data revealed that the plumes from the two main stacks almost always were co-mingled (beyond 200 meters downwind). Therefore, it was not possible to perform separate vector analyses on the two plumes. Rather, a combined analysis was done.

The results of the plume vector analysis are shown on Plume Rise Geometry Maps (Figures 54, 62, and 70). They display the COSPEC site and the horizontal angles used to measure plume rise. The "effective plume centerline" is drawn as the best estimate of the vector of the combined plumes during the measurement period. These vectors are drawn as if originating from a single "equivalent stack", between the two actual stacks. The constructed plume vectors and the angles of measurement were used to determine the distance L, and hence the elevation of the plume, in meters.

PIBALS

All of the Pibal Results have been reduced into a graphic format and are presented in Appendix B. The plotted results show a "birds-eye" map view on the left and a vertical view on the right. In the map view the plotted line shows the direction and the distance the balloon traveled, beginning at the center--the balloon's release point. The arrows in the vertical view are plotted with the base of the arrow at the coordinates of the wind speed and the altitude of each 30-second pibal observation. The arrow is plotted in the direction of wind flow (straight up is North); they are aligned with the balloon trajectory shown in the map view.

Some of the pibal measurements were abbreviated by uncontrollable conditions at the site. Data were lost when the balloon travelled toward the sun or when the balloon was lost behind a nearby hill. All computable balloon observations have been plotted to provide the complete set of wind observations.

Selecting wind speeds and wind directions for analysis of the remote sensor results required a detailed study of the pibal results. First it was necessary to determine which readings represented the wind speed at the top of the stacks so that proper winds would be chosen for flux calculations. Each hourly pibal was averaged for both direction and speed.

Each route and the burden data were reviewed to determine which of the pibals were appropriate and whether more

than one wind direction or speed was necessary (because of wind changes during the traverse). A final adjustment in wind directions was made by checking the burden data to determine the compass angle of the line from the source(s) to the measured plume peak(s). This figure usually was within five degrees of the averaged pibal direction. On occasions there were differences caused by topographic influences on wind flow. In such cases, the direction determined from the burden data was used for map plotting.

SO_2 MASS FLUX

Calculations. The computation of SO_2 mass flux--emission rate of a source--were derived from the COSPEC total burdens, the geography, and the wind speed according to the following formula:

$$SO_2 \text{ Mass Flux} = \text{Cospec Read.} \times \text{Cospec Calib.} \times \text{Trav. Dist.} \times \text{Wind Speed} \times \text{Wind/Road Angle} \times \text{Gas/Weight/Time Conversions}$$

$$\text{kg/hr } SO_2 = \text{Div. Defl.} \times \frac{\text{ppmM}}{\text{Div.}} \times \text{Meters} \times \text{M/S} \times \sin a \times 9.576 \times 10^{-3}$$

The *COSPEC reading, COSPEC calibration* and the *traverse distance* were taken from the chart records and maps. The *wind/road angle* was derived from the pibal results and by relating the peak of the measured plume to the traverse route and the assumed center of emissions for a given source. The *conversions* bring the computations to a result in kilograms per hour (kg/hr) SO_2; equivalent pounds per hour (lb/hr) values are reported, as well.

Error Estimate. The accuracy of the flux computations can be estimated from the errors of individual parameters. There are six identifiable sources for error in the data collection and processing procedures: spectrometer precision, spectrometer calibration, spectrometer record interpretation, wind speed, wind direction and burden location. Each of these errors is a random quantity which takes on different (and unpredictable) values from traverse to traverse. The first three error sources are related to the operation of

the spectrometer; the next two pertain to wind data used in the flux calculations; the last occurs in transferring original data records onto digitized maps.

COSPEC II non-linearity (above 500 ppmM) was treated as part of the spectrometer calibration error. The calculated instrument sensitivity was used to convert the digitized spectrometer outputs from millivolts to parts-per-million-meters. Corrections for occasional readings greater than 500 ppmM were made prior to the calculation of flux.

The RMS Error for the SO_2 mass flux results can be calculated by assigning individual values to each of the six component errors (V_i) and making a root-mean-square calculation. The equation is:

$$\text{RMS Error} = \sqrt{V_1^2 + V_2^2 + \cdots + V_n^2} \Big/ \sqrt{N}$$

Where V_i is the RMS error of one of the contributing sources of error, and N is the number of remote sensor measurements.

The values of each error for SO_2 data gathered in this study are:

Spectrometer precision	± 7%	(average noise as a percent of signal within one kilometer of source)
Spectrometer calibration	± 5%	(actual daily variation in field calibrations)
Spectrometer interpretation	± 5%	(typical error in determining reference baselines on chart records)

Wind speed	± 15%	(expected variation in extrapolating fixed-site wind data to plume location)
Wind direction	± 3%	(average error in determining wind direction (α) when converted to sine α)
Burden location	± 8%	(combined field notation and data handling errors of geographic locations)

The computed RMS Error for a SO_2 Mass Flux calculation is:

$$\text{RMS Error} = \sqrt{(7)^2+(5)^2+(5)^2+(15)^2+(3)^2+(8)^2} \Big/ \sqrt{N}$$

$$= \pm 20\% \Big/ \sqrt{N}$$

For N=1 the RMS Error is ±20%; where N=6 the RMS Error is reduced to ±8.2%.

This RMS Error incorporates the principal sources of error in making remote sensor measurements and converting the results to emission rates. If one of the component errors is reduced, the RMS Error is reduced. For example, if the actual wind speed error is ±5% (rather than ±15%) the RMS Error is reduced to ±14% (where N=1).

Conversely, for plume crossings 10 km from the source the spectrometer precision can increase from ±7% to ±20%; the resulting RMS Error is ±26% (with N=1). To accurately determine a flux value, therefore, a number of separate measurements (usually six but at least three) are made and the results averaged; this averaging procedure cancels out random errors

and reduces the probable error by the factor $1/\sqrt{N}$. Therefore, while the RMS Error of a remote sensor flux value may be as high as ±26% for one particular measurement, it is significantly less (e.g. ±8.2% for an average of six measurements).

Section 4

RESULTS AND DISCUSSION

The results of the Hayden Smelters Emission Survey are presented in three sections:

- MOVING MEASUREMENTS - Total burden and ground-level maps and SO_2 dispersion sketch maps
- PLUME RISE - Individual profiles and plume height to two kilometers downwind
- SO_2 MASS FLUX - Estimates of smelter emissions from remote sensor and pibal data

MOVING MEASUREMENTS

The moving measurements were successful in locating overhead and ground-level SO_2 in the near vicinity of the smelters and as far as 40 kilometers downwind. Significant events and typical moving measurements results have been plotted in map form.

Total Burden/Ground-Level Maps. Thirty computer drawn maps are presented in chronological order. Each day's results are summarized and interpreted on the page preceeding the daily map set. This discussion and the maps are both presented in a horizontal format.

14 APRIL 75/EVENTS 8, 18

The first pair of maps (Figures 9 and 10) shows a moving survey from Hayden west to the Montgomery Ranch air monitoring station. Two distinct plumes were measured: one was crossing highway AZ-177, and the second was above the Chilito Mine Road. The second plume had the most significant SO_2 touchdown (550 ppb peak). Two wind speeds and directions were observed; the slower winds were at lower elevations.

Figures 11 and 12 show ground-level and total burden SO_2 data gathered on AZ-77 later the same day, after wind shifted direction. The northeasterly plume trajectory was documented by both the remote and point monitors. The ground-level concentrations were greatest (to 540 ppb) at the southern edge of the plume activity; the total burden peak (405 ppmM) was five kilometers to the north.

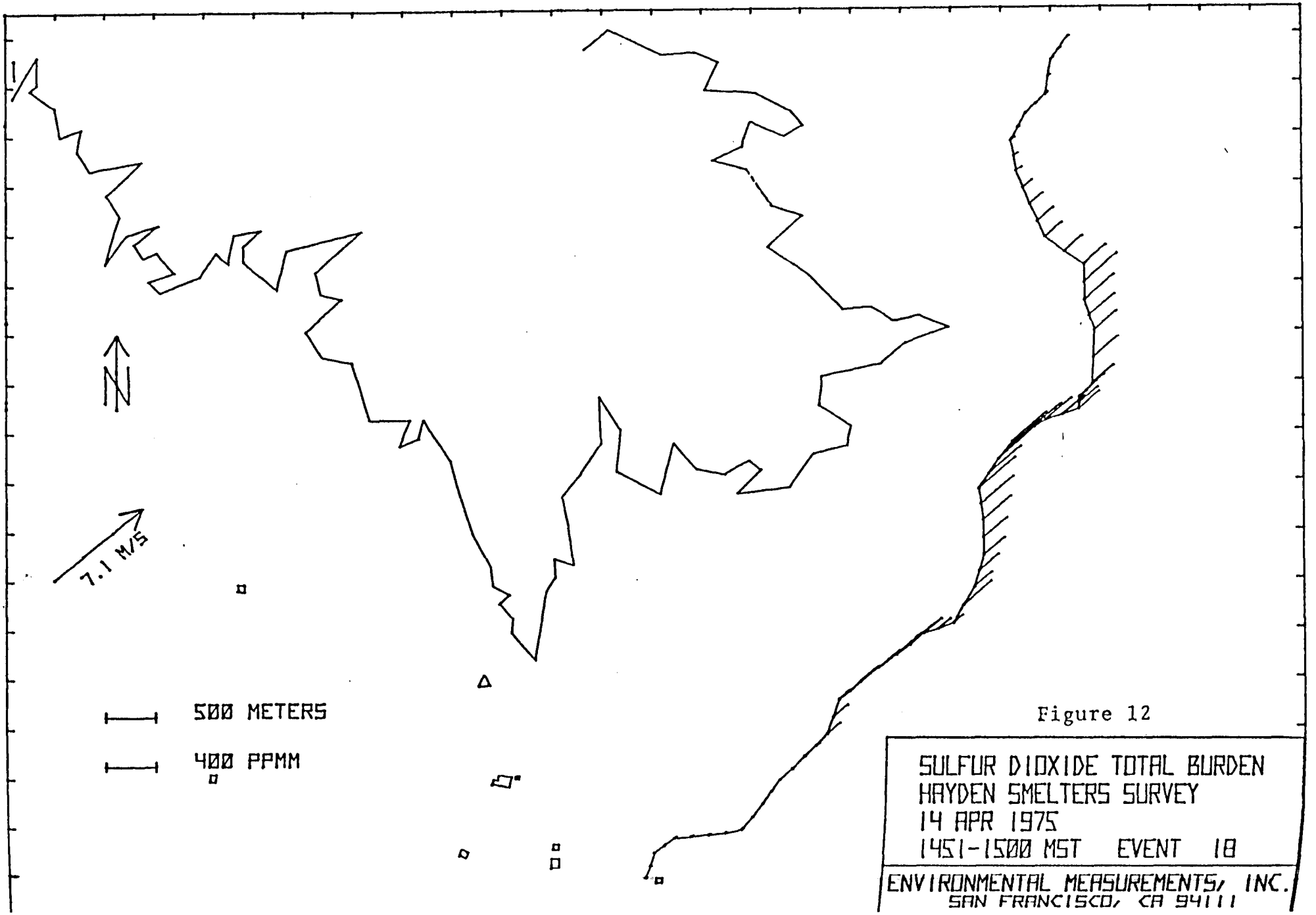


Figure 12

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
14 APR 1975
1451-1500 MST EVENT 18

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15 APRIL 75/EVENTS 4,5-6, 10, 28

Events 4, 5-6 and 10 are representative of a morning survey conducted west of the smelters on 15 April. The first two total burden maps (Figures 14 and 16) are similar; high SO_2 burdens (to 3400 ppmM) were measured on the mine road northwest of Hayden. The corresponding ground-level maps (Figures 13 and 15) illustrate the wide variations in plume touchdown. The maximum recorded SO_2 concentrations were 440 ppb for Event 4 and > 1390 ppb for Events 5-6 (1390 ppb was the limit of detectability for the SO_2 monitor; see Section 2). Two hours later (Event 10) plume activity was again measured, but at a different location (Figures 17 and 18); the peak SO_2 readings were 790 ppmM total burden and 1370ppb ground-level concentrations.

One set of afternoon measurements on AZ-77, the Globe Highway (Event 28), is plotted in Figure 19 and 20. The peak burden (1820 ppmM) and peak concentration (760 ppb) nearly coincide at a point two kilometers from the Globe Highway monitoring station.

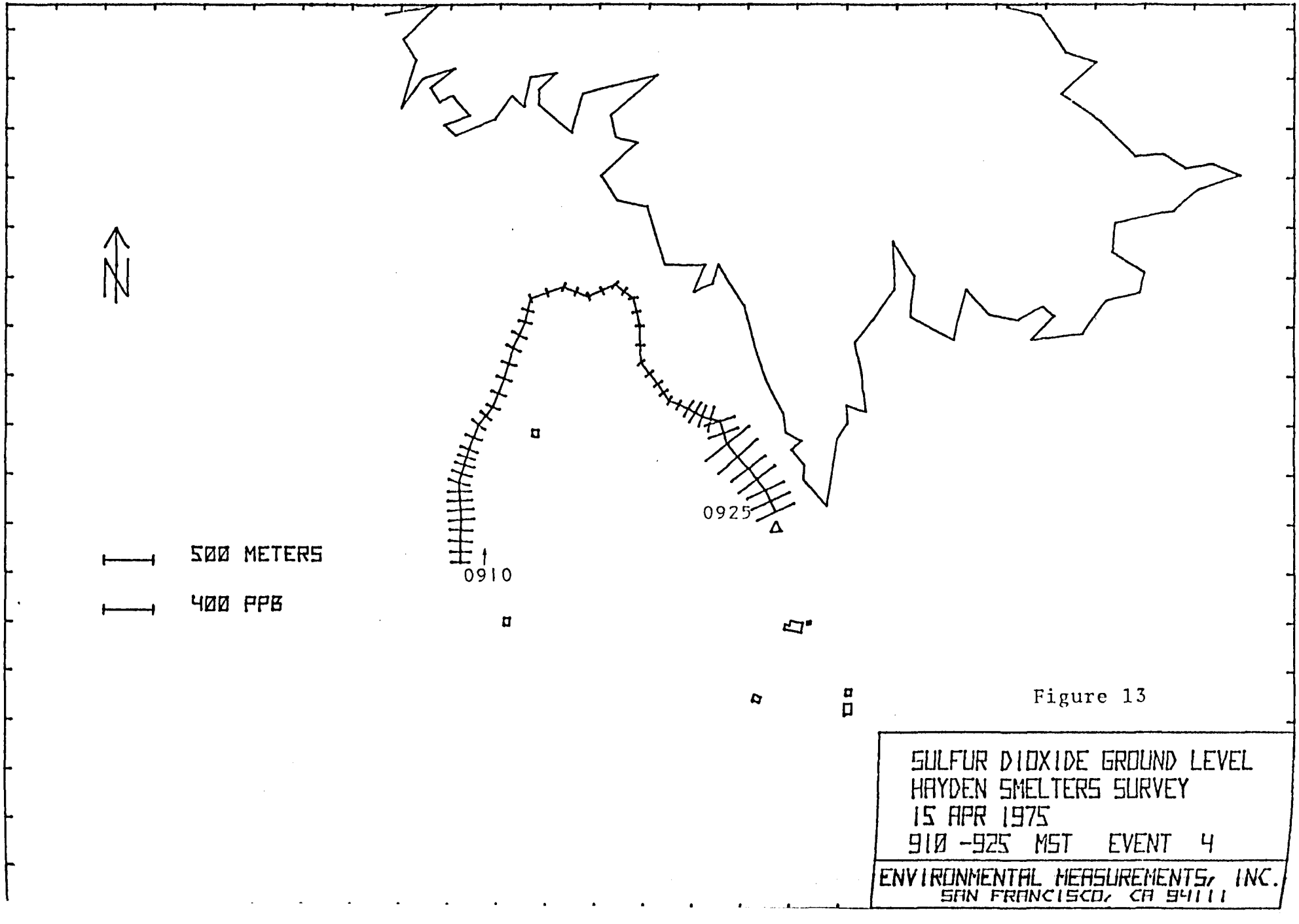

Figure 13

SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
15 APR 1975
910 -925 MST EVENT 4

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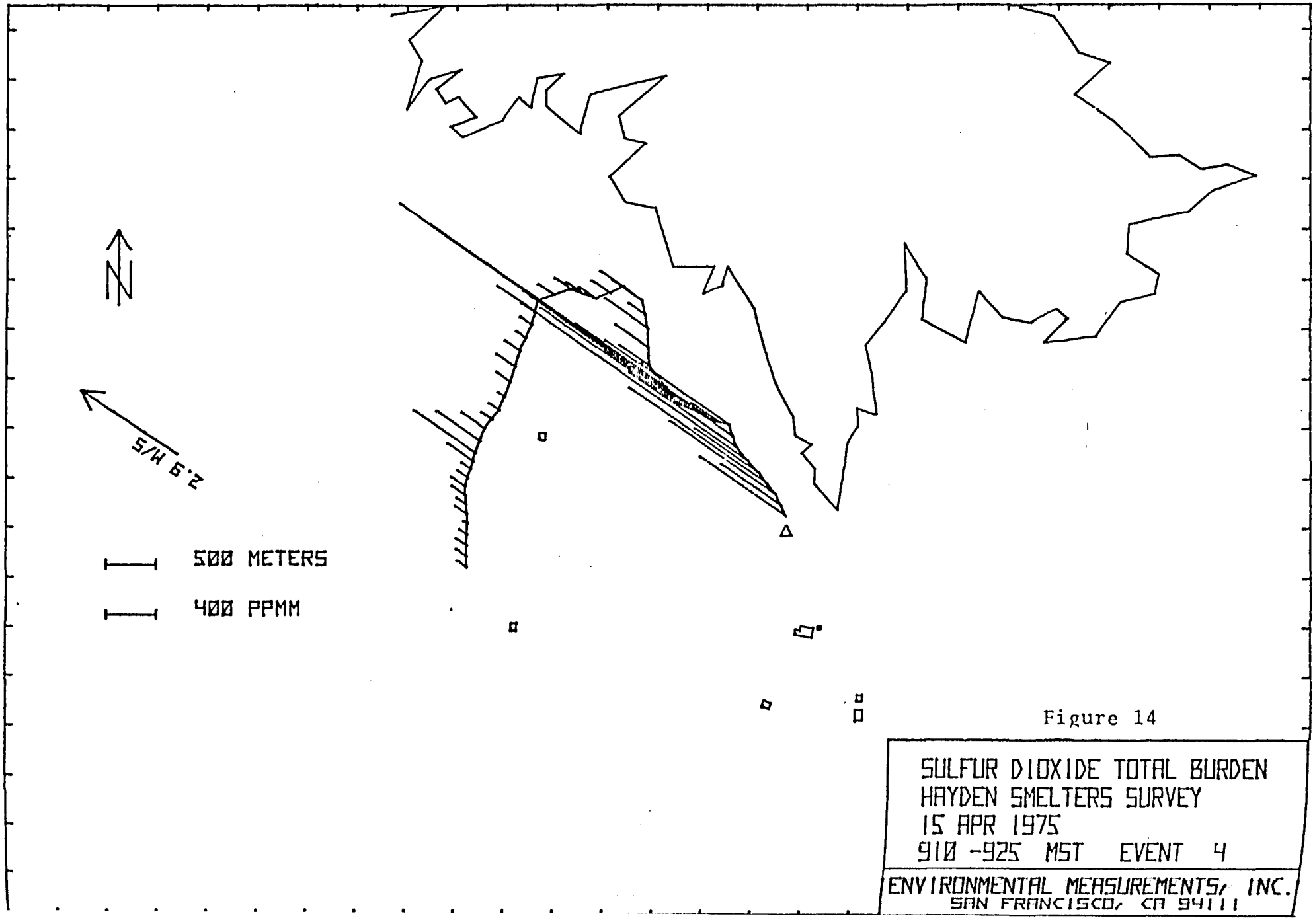

Figure 14

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
15 APR 1975
910 -925 MST EVENT 4

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

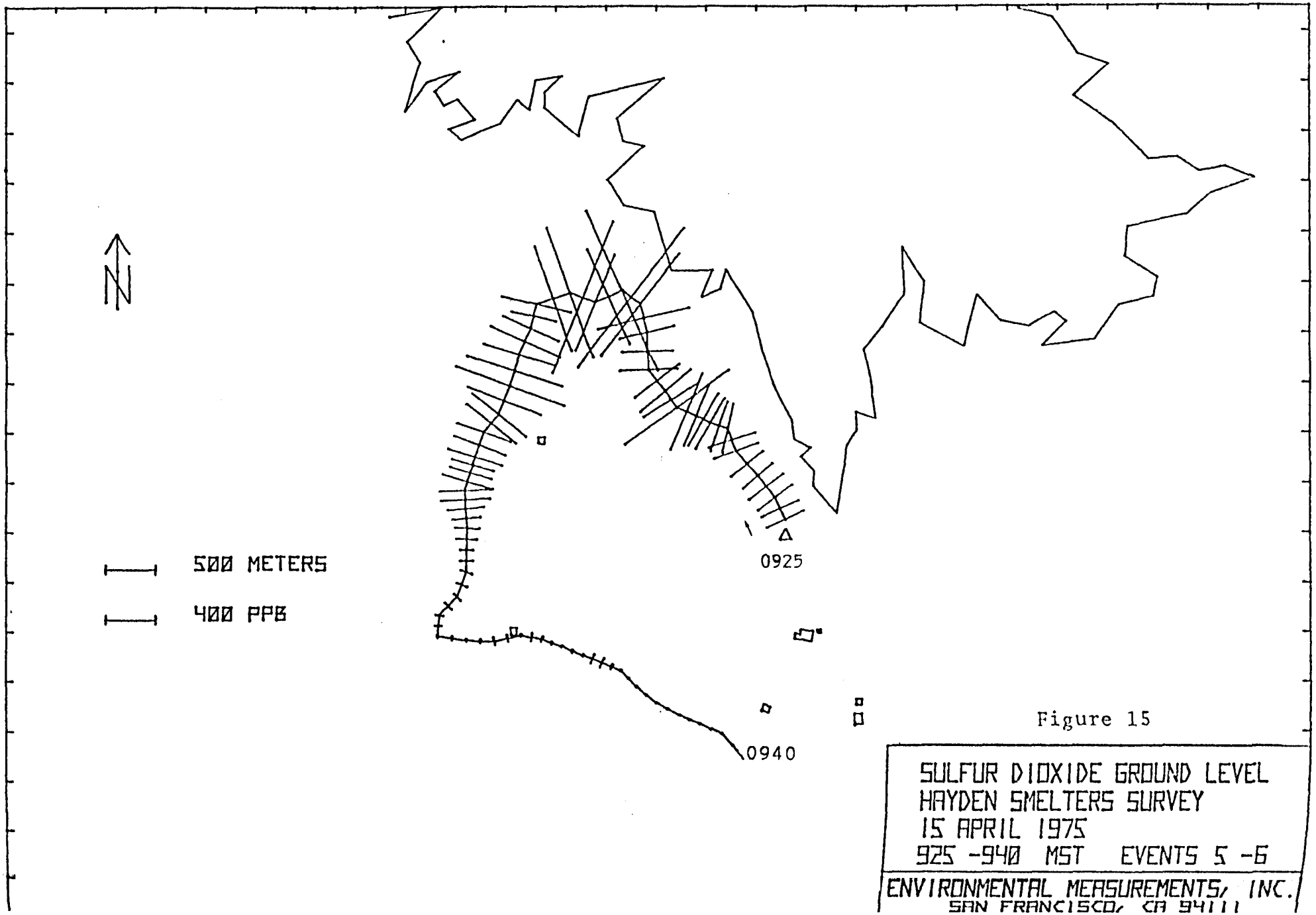

Figure 15

SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
15 APRIL 1975
925 -940 MST EVENTS 5 -6

ENVIRONMENTAL MEASUREMENTS, INC.
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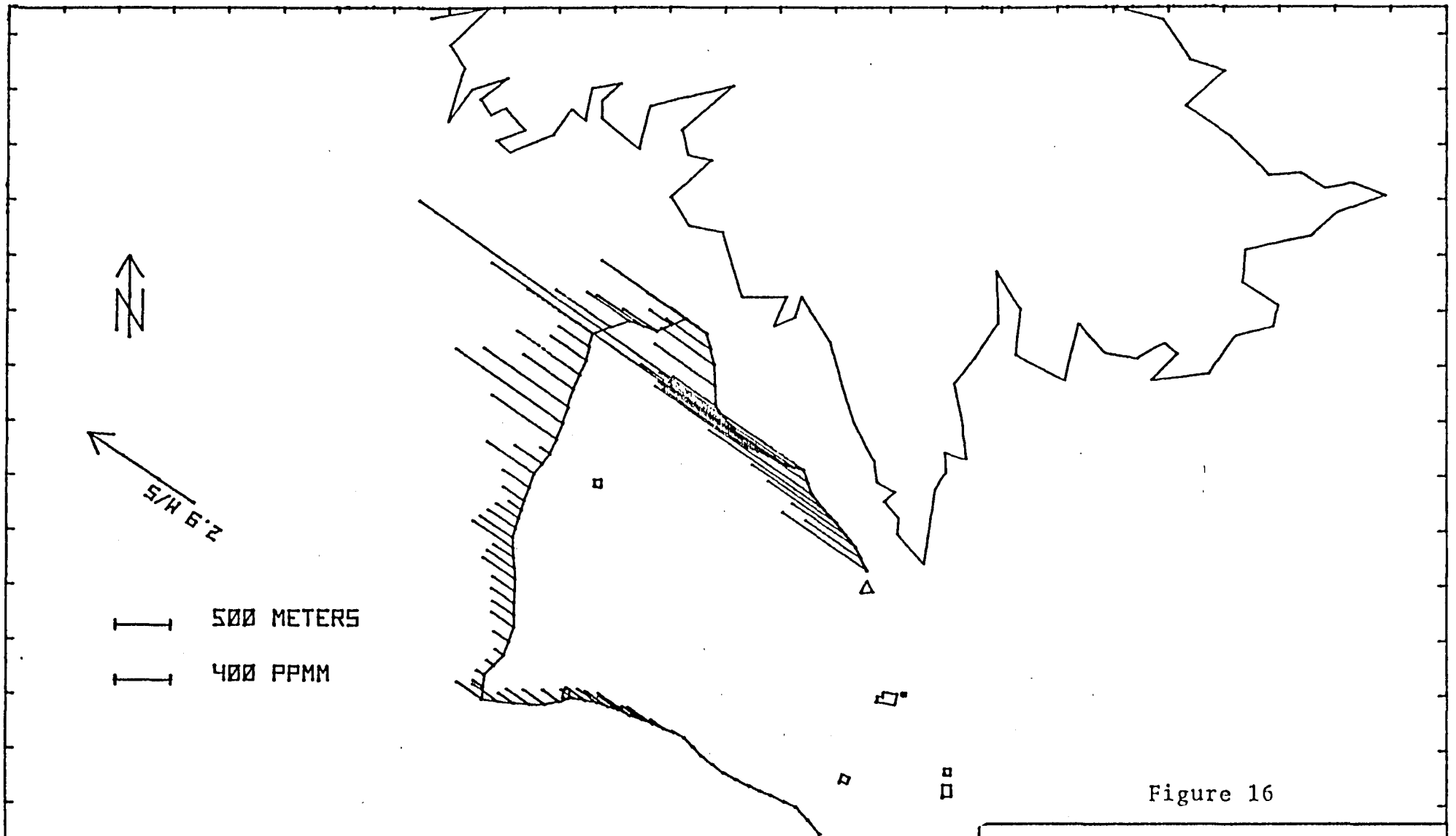

Figure 16

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
15 APRIL 1975
925 -940 MST EVENTS 5 -6

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

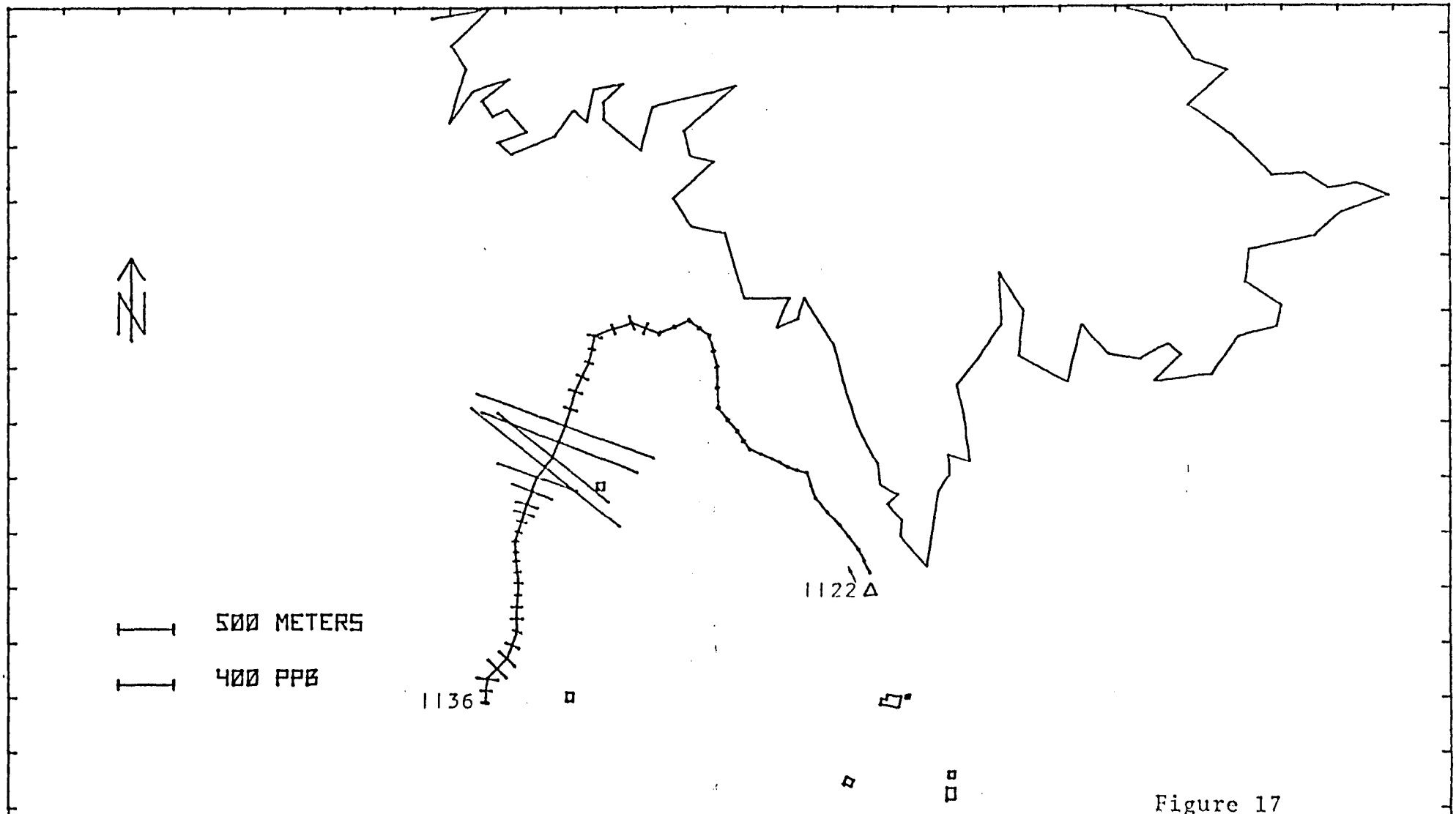

Figure 17

SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
15 APR 1975
1122-1136 MST EVENT 10

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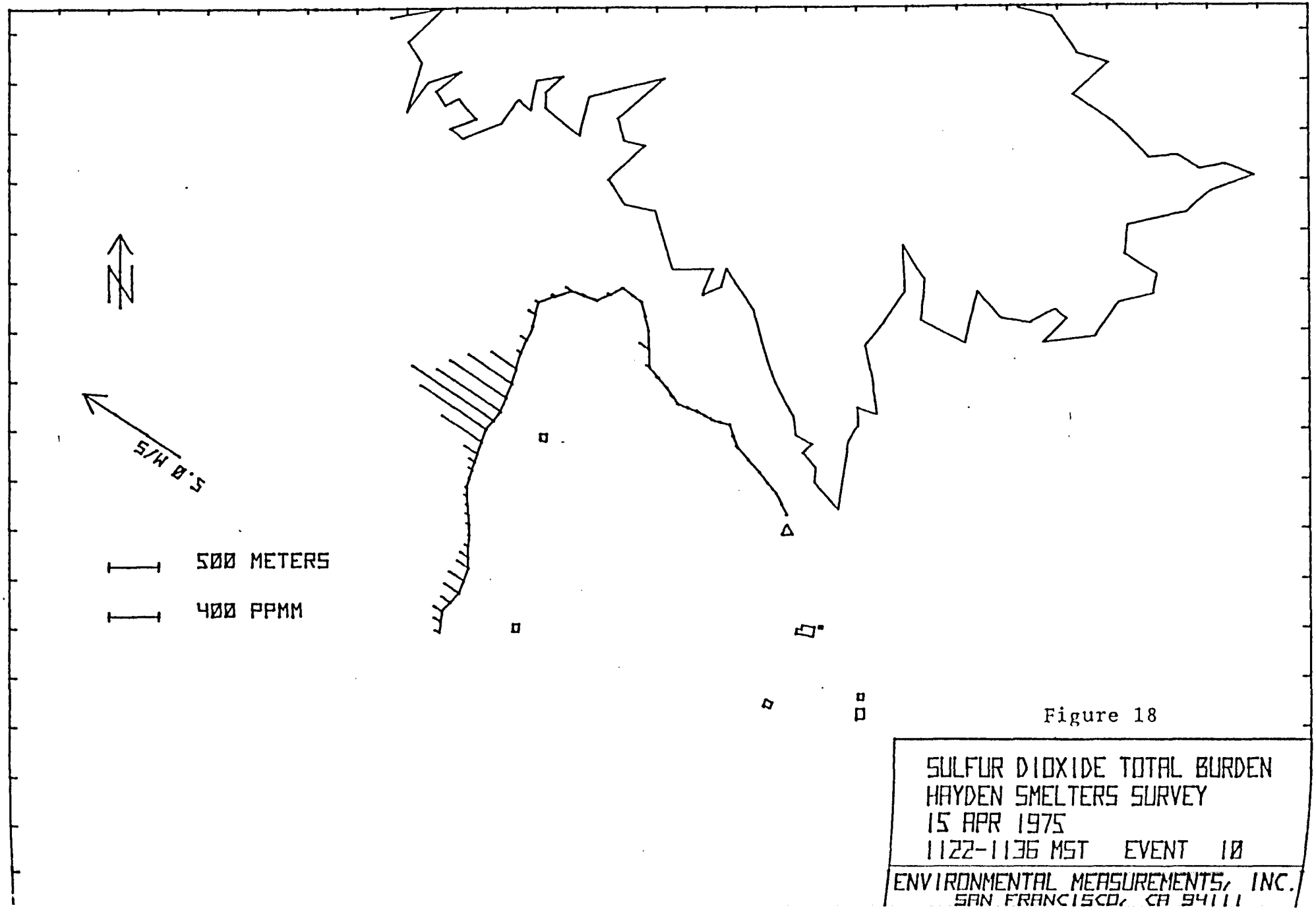
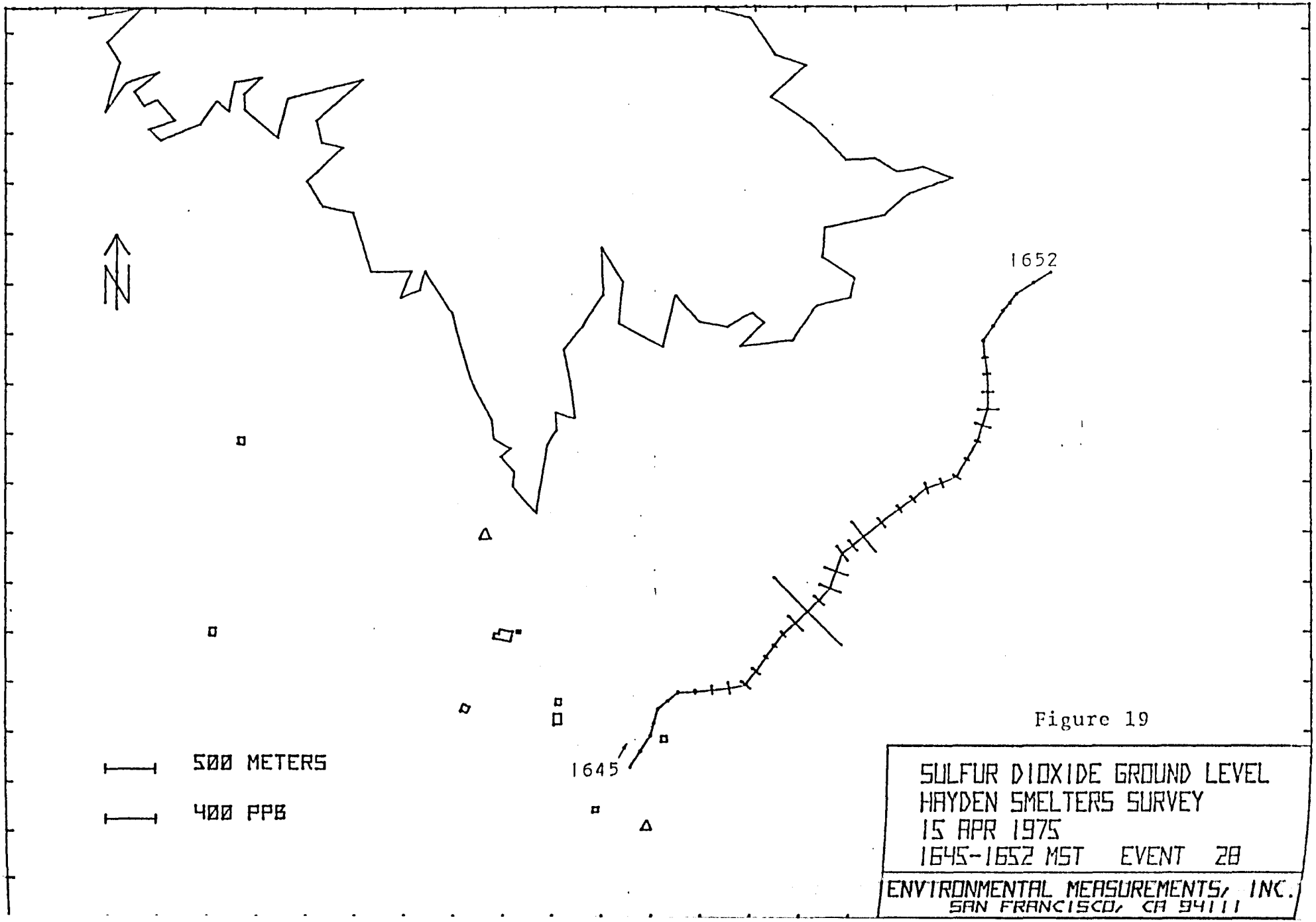


Figure 18

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
15 APR 1975
1122-1136 MST EVENT 10

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111


N
1652
1645
500 METERS
400 PPB
SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
15 APR 1975
1645-1652 MST EVENT 28
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SAN FRANCISCO, CA 94111

Figure 19

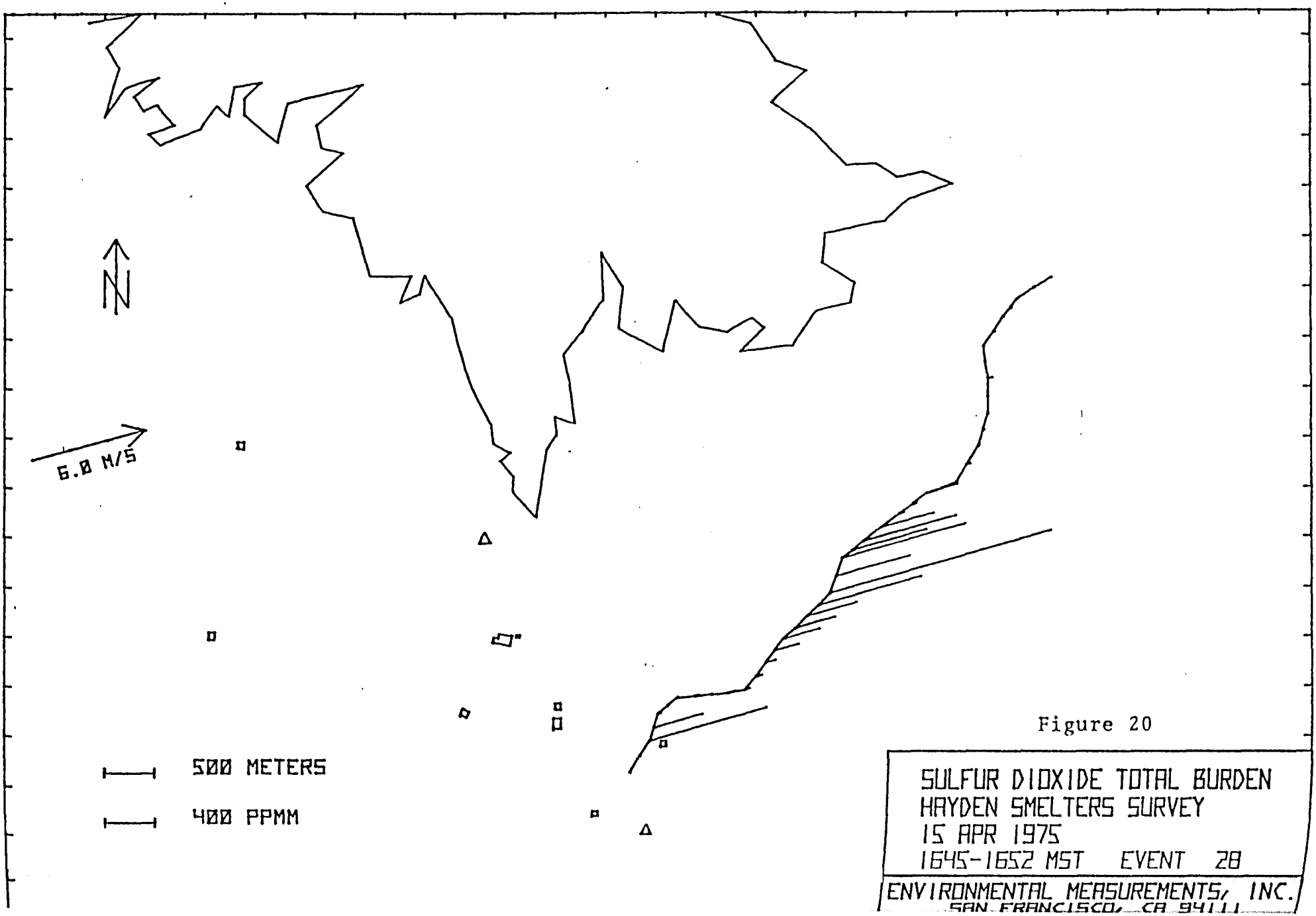
N
6.0 M/S
500 METERS
400 PPMM
SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
15 APR 1975
1645-1652 MST EVENT 28
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Figure 20

16 APRIL 75/EVENTS 4, 7-8, 21,26

On the morning of 16 April the smelter plumes were detected to the west of Hayden (Event 4). By the end of the 28-minute traverse the wind had shifted; SO_2 was again detected 11 kilometers almost due north of the smelters. Figure 22 shows the two plume crossings; Figure 21 shows that the plumes touched down to the west (4 kilometers downwind) but not to the north.

Figures 23 and 24 are plots of a long distance traverse (Events 7-8) north on AZ-77 (to Globe) and east on US 70. The SO_2 plume from the smelters was crossed 10 kilometers to the northeast--and again 40 kilometers downwind. The burden plume (140 ppmM peak) was about 15 kilometers wide at this second crossing; the peak SO_2 concentration at ground level was 65 ppb.

Two Globe Highway traverses (Events 21 and 26) are shown in Figures 25-28. The magnitude and location of peak burdens and concentrations varied widely, as shown on the maps. The peak SO_2 concentration near the Globe Highway station for Event 26 was 940 ppb.

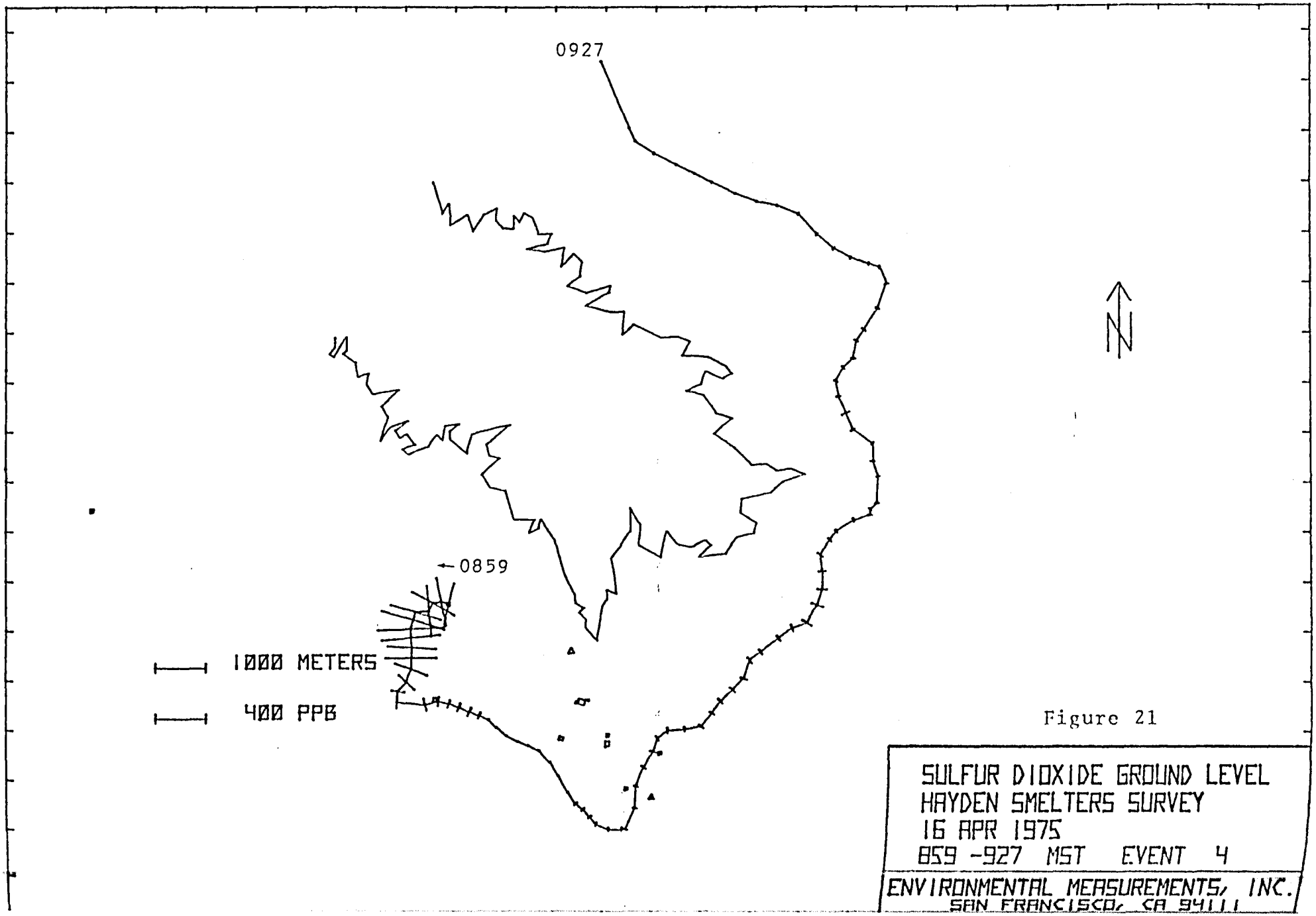
0927
0859
1000 METERS
400 PPB
N
SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
16 APR 1975
859 -927 MST EVENT 4
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 21

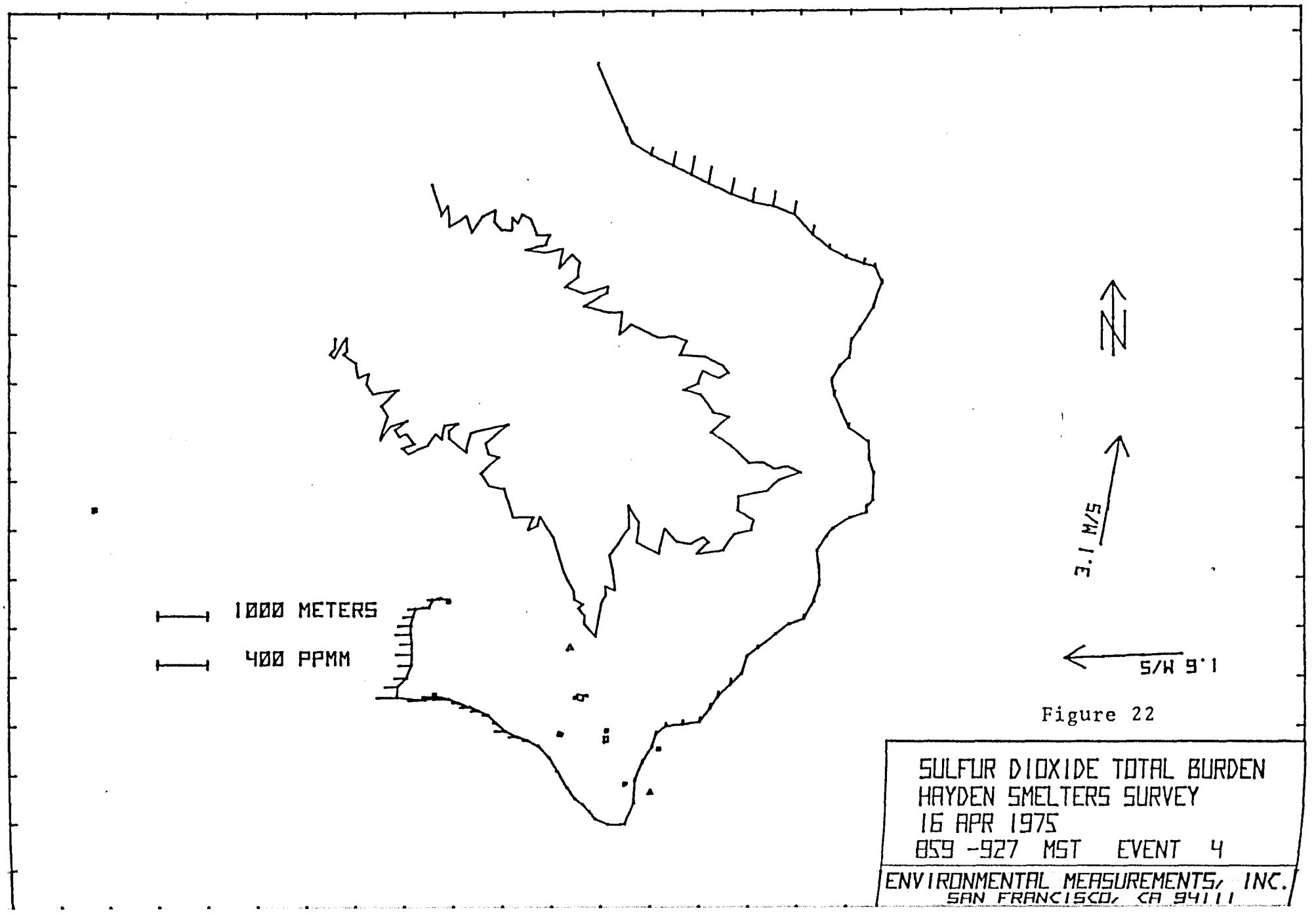
1000 METERS
400 PPMM
3.1 M/S
1.6 M/S
SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
16 APR 1975
859 -927 MST EVENT 4
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 22

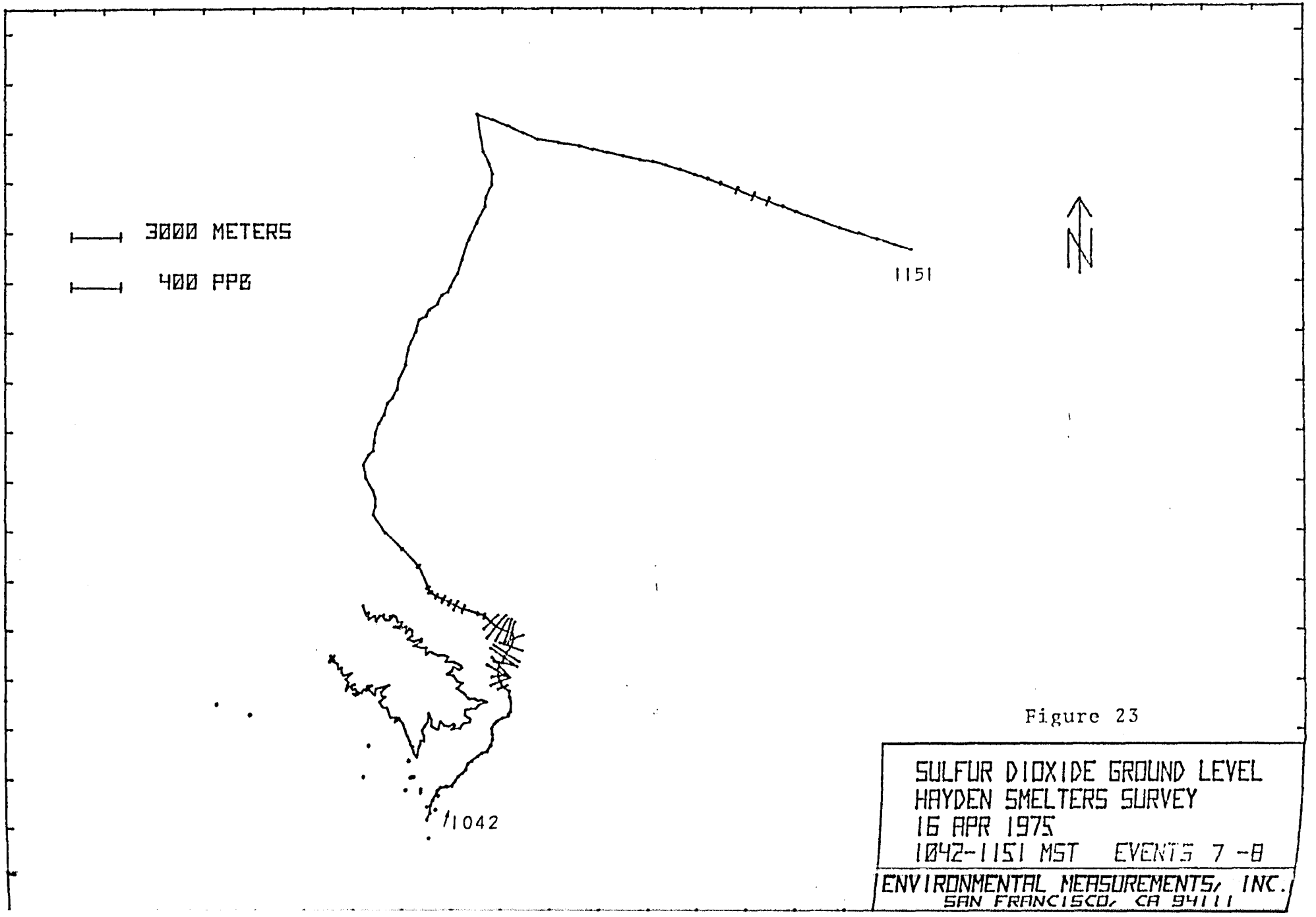

Figure 23

SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
16 APR 1975
1042-1151 MST EVENTS 7 -8

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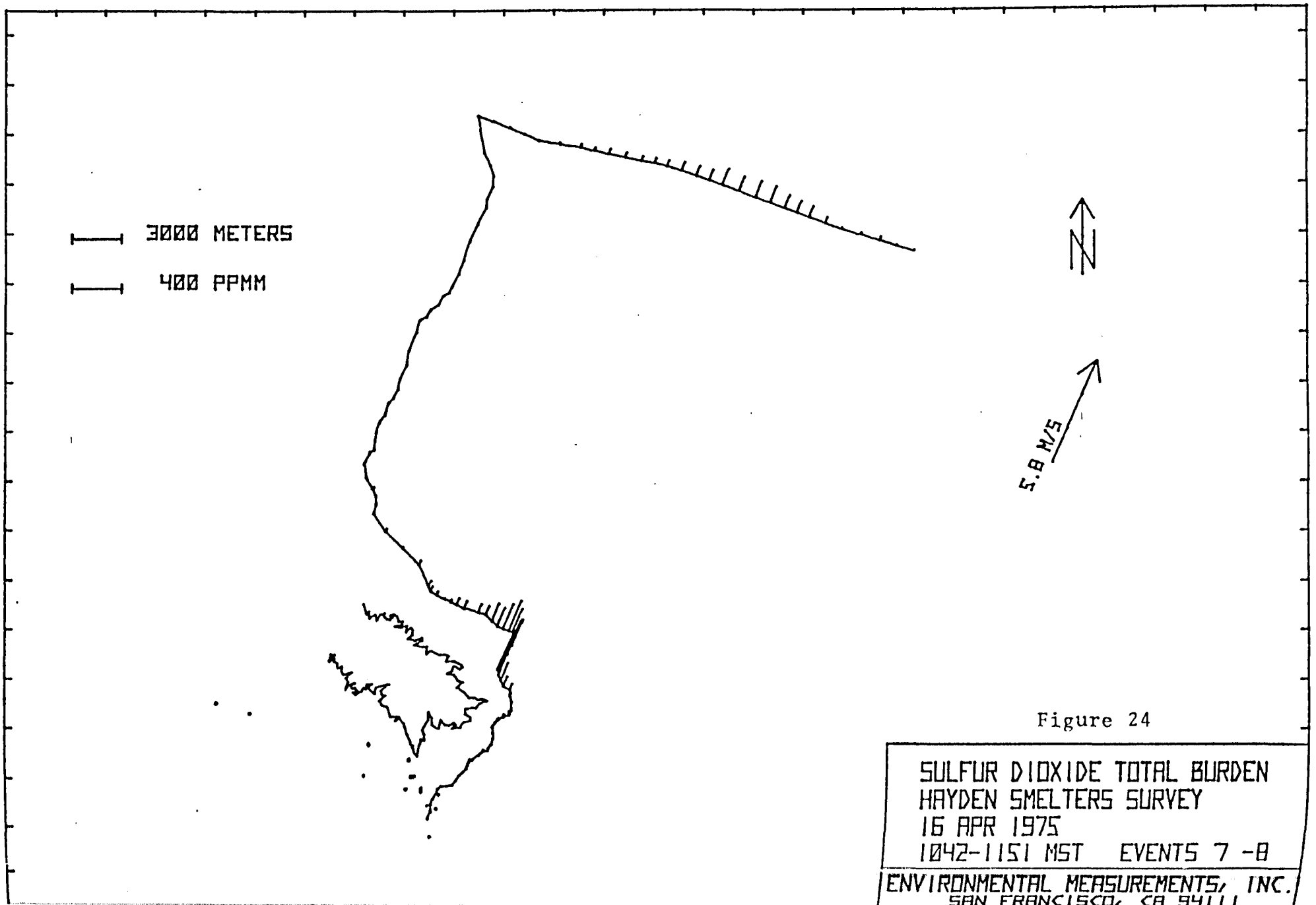

Figure 24

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
16 APR 1975
1042-1151 MST EVENTS 7 -8

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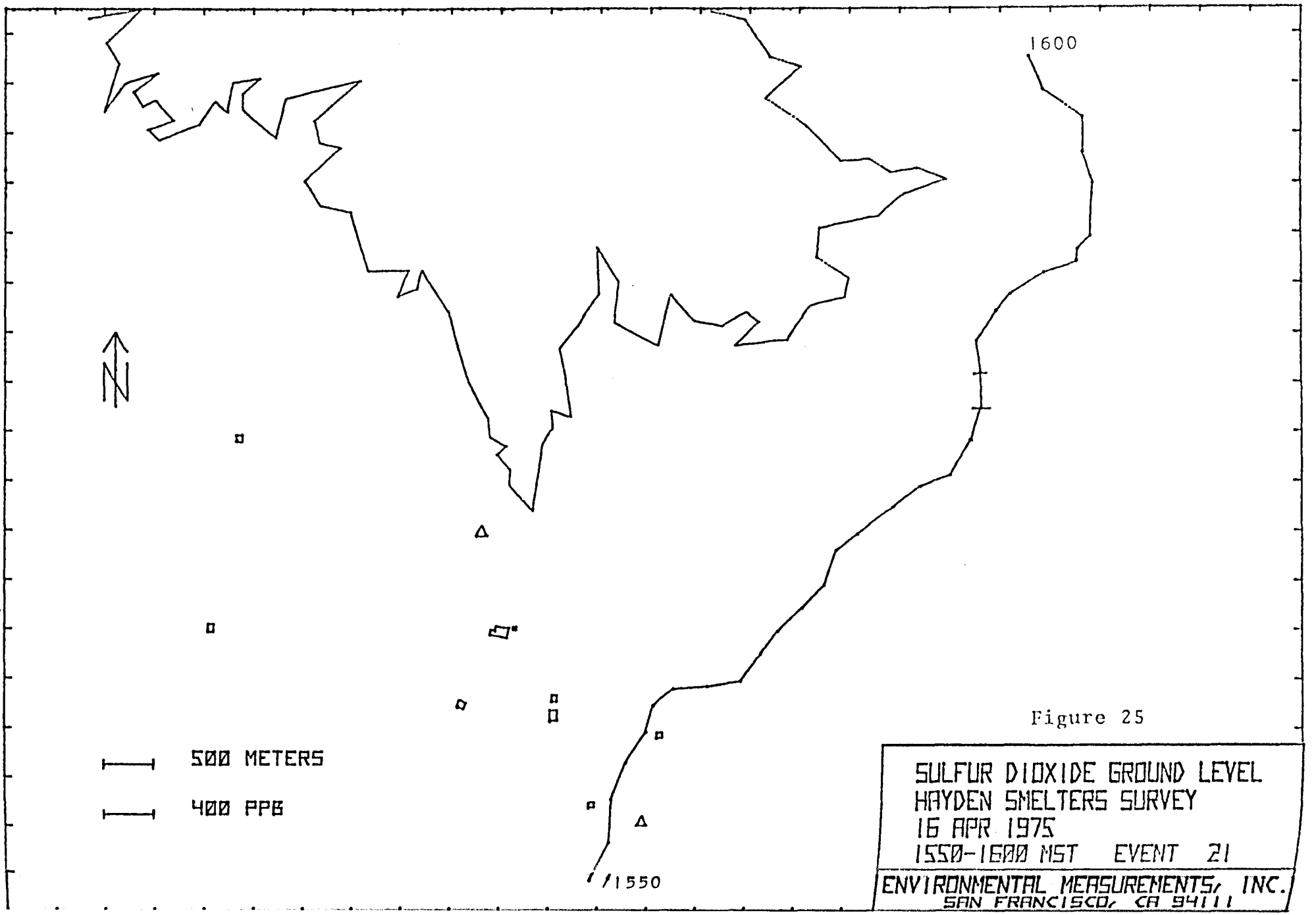

Figure 25

SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
16 APR 1975
1550-1600 MST EVENT 21

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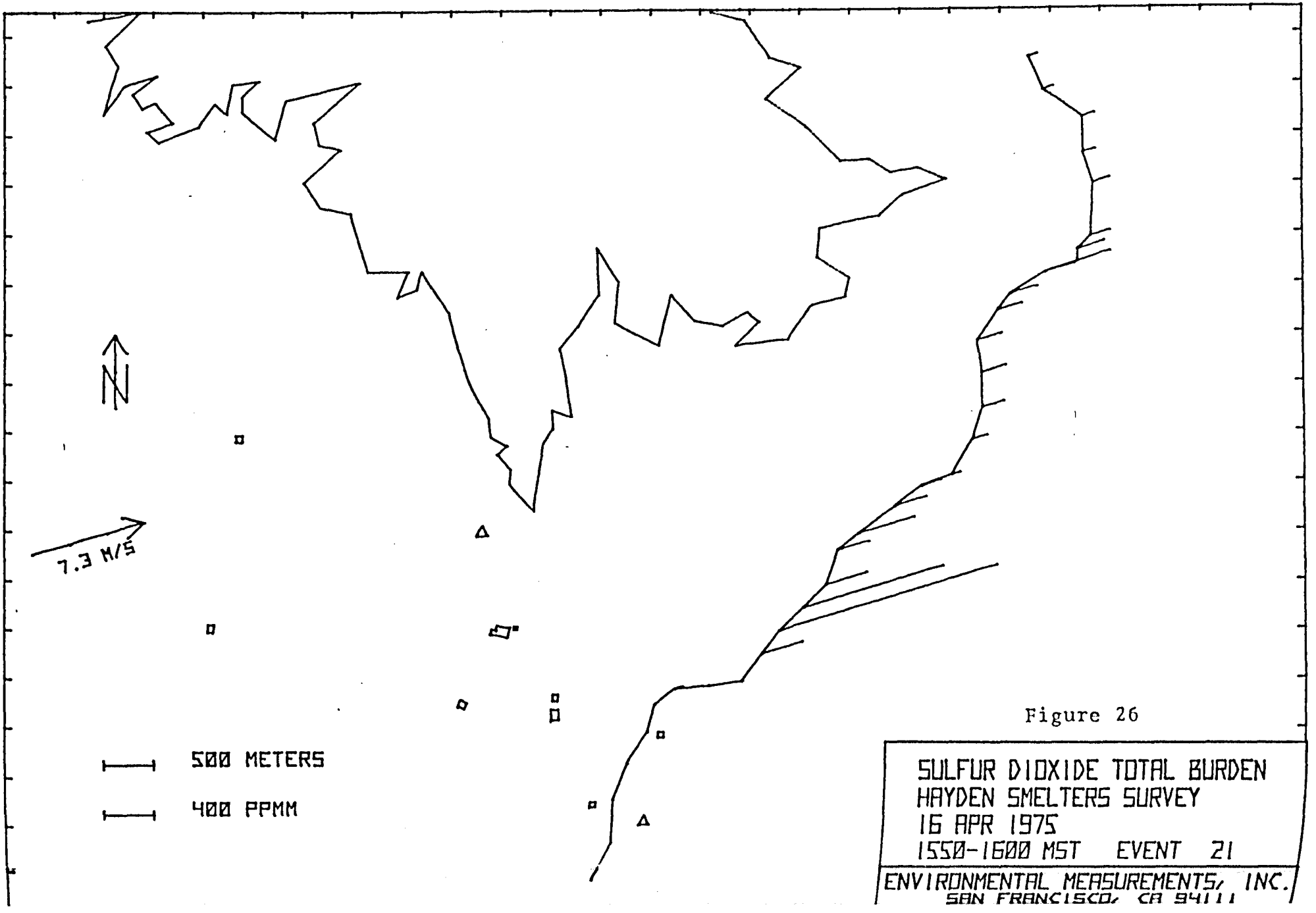
N
7.3 M/S
500 METERS
400 PPMM
SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
16 APR 1975
1550-1600 MST EVENT 21
ENVIRONMENTAL MEASUREMENTS, INC.
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Figure 26

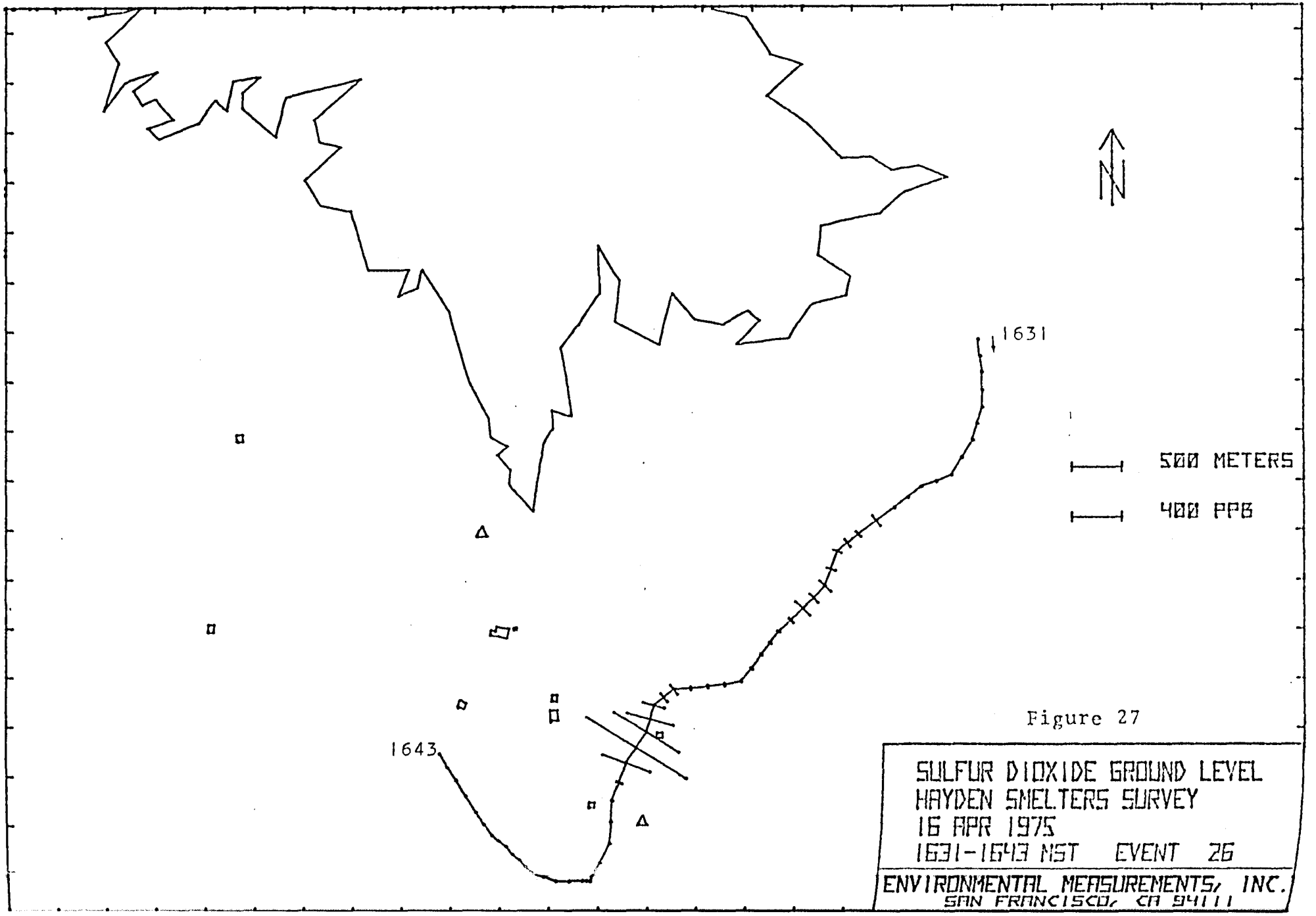

1631
1643
N
500 METERS
400 PPB
SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
16 APR 1975
1631-1643 MST EVENT 26
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 27

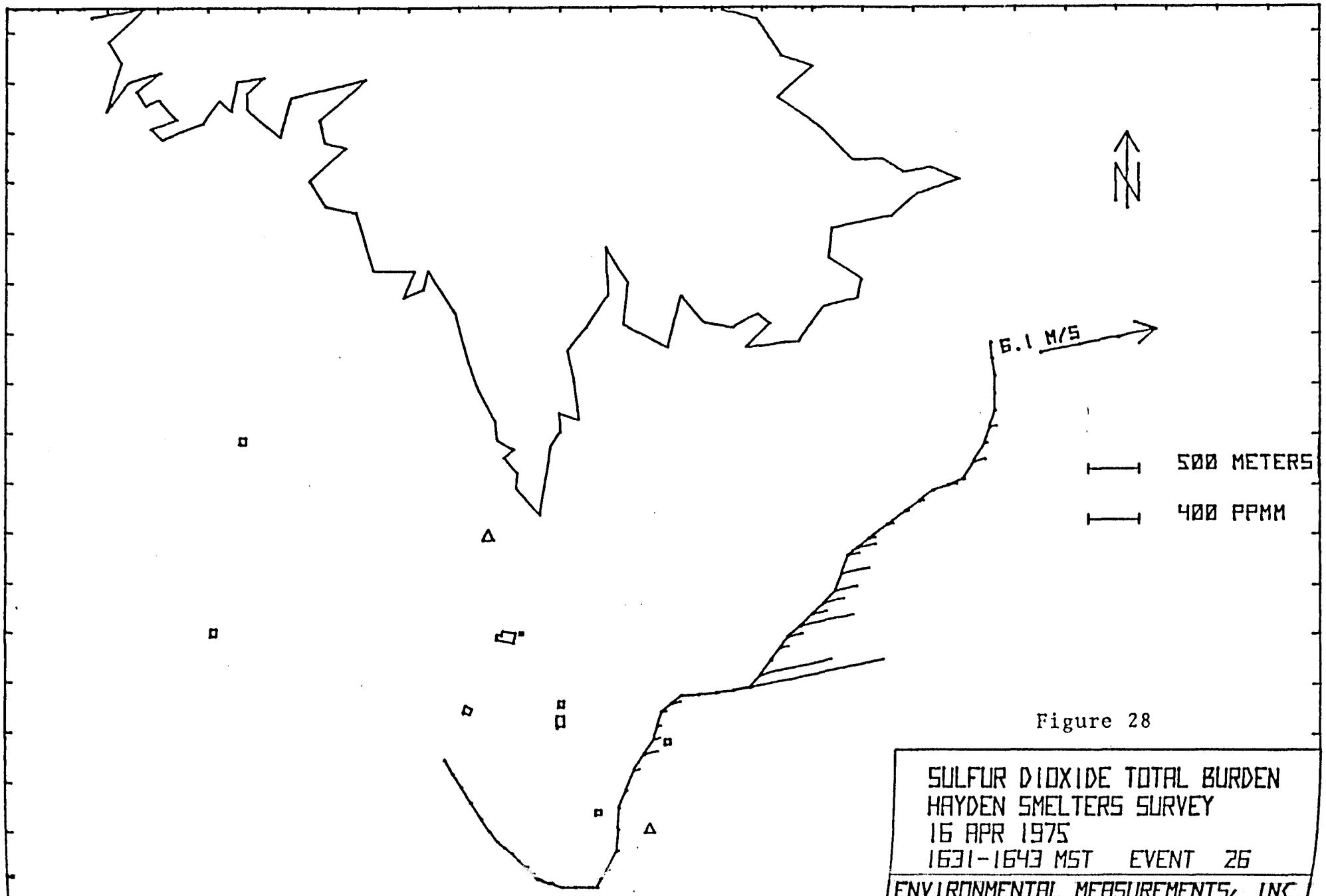


Figure 28

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
16 APR 1975
1631-1643 MST EVENT 26

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

17 APRIL 75/EVENTS 14, 29

The two Globe Highway surveys, plotted in Figures 29-32, were made between and following plume rise measurements. Good correlation of overhead and ground-level SO_2 occurred during Event 14; both peak values (1050 ppmM and 1000 ppb) were recorded 4 kilometers from the smelters. In contrast, the correlation was poor for Event 29. The peak SO_2 concentration (930 ppb) was located 5 kilometers to the northeast but there was relatively little SO_2 burden associated with it (190 ppmM peak). However, near the Globe Highway station there was a total burden peak of 2340 ppmM SO_2; there was also a high ground-level reading (>1390 ppb) but it was located 500 meters to the south of the overhead plume.

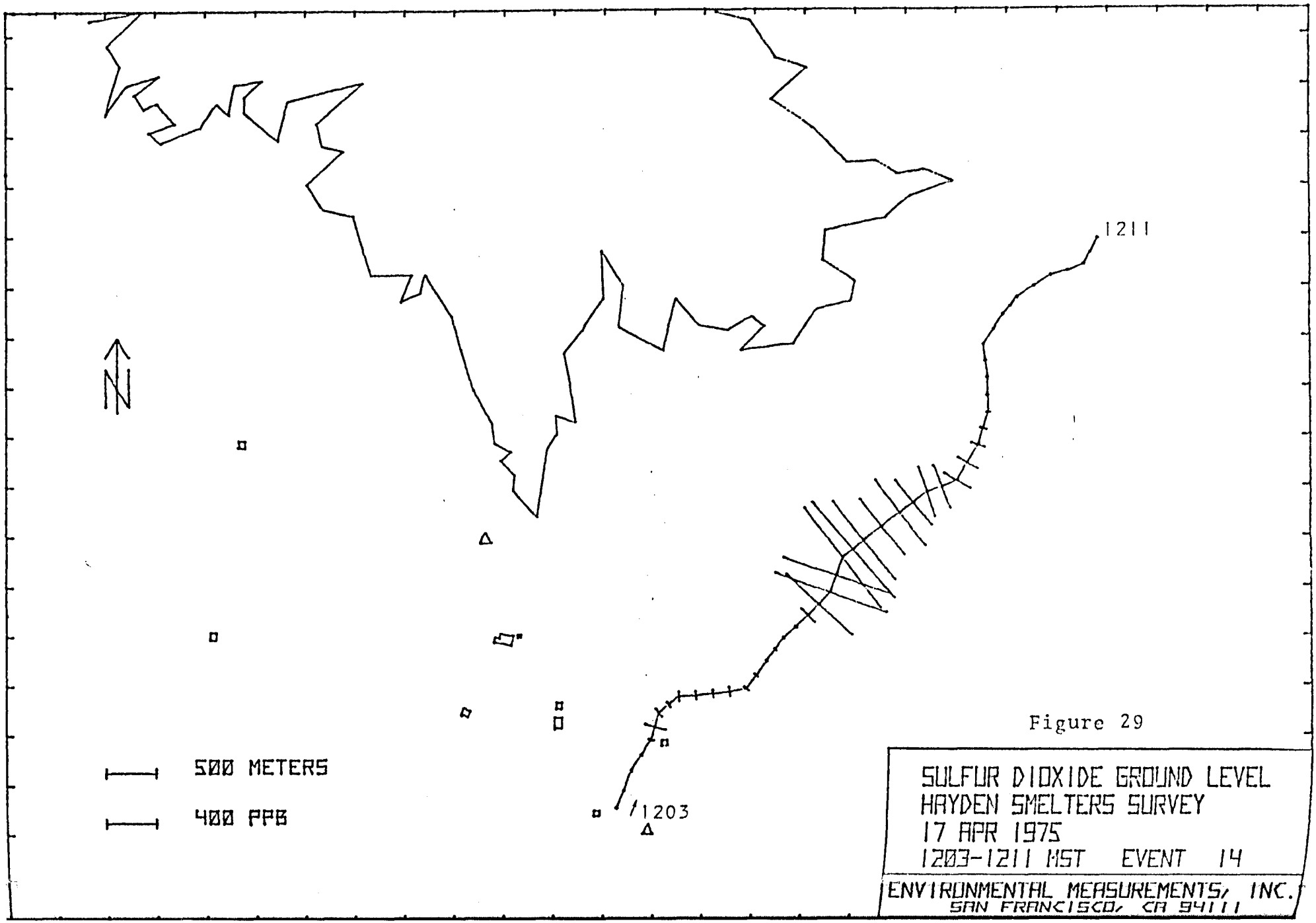

1211
1203
500 METERS
400 PPB
SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
17 APR 1975
1203-1211 MST EVENT 14
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 29

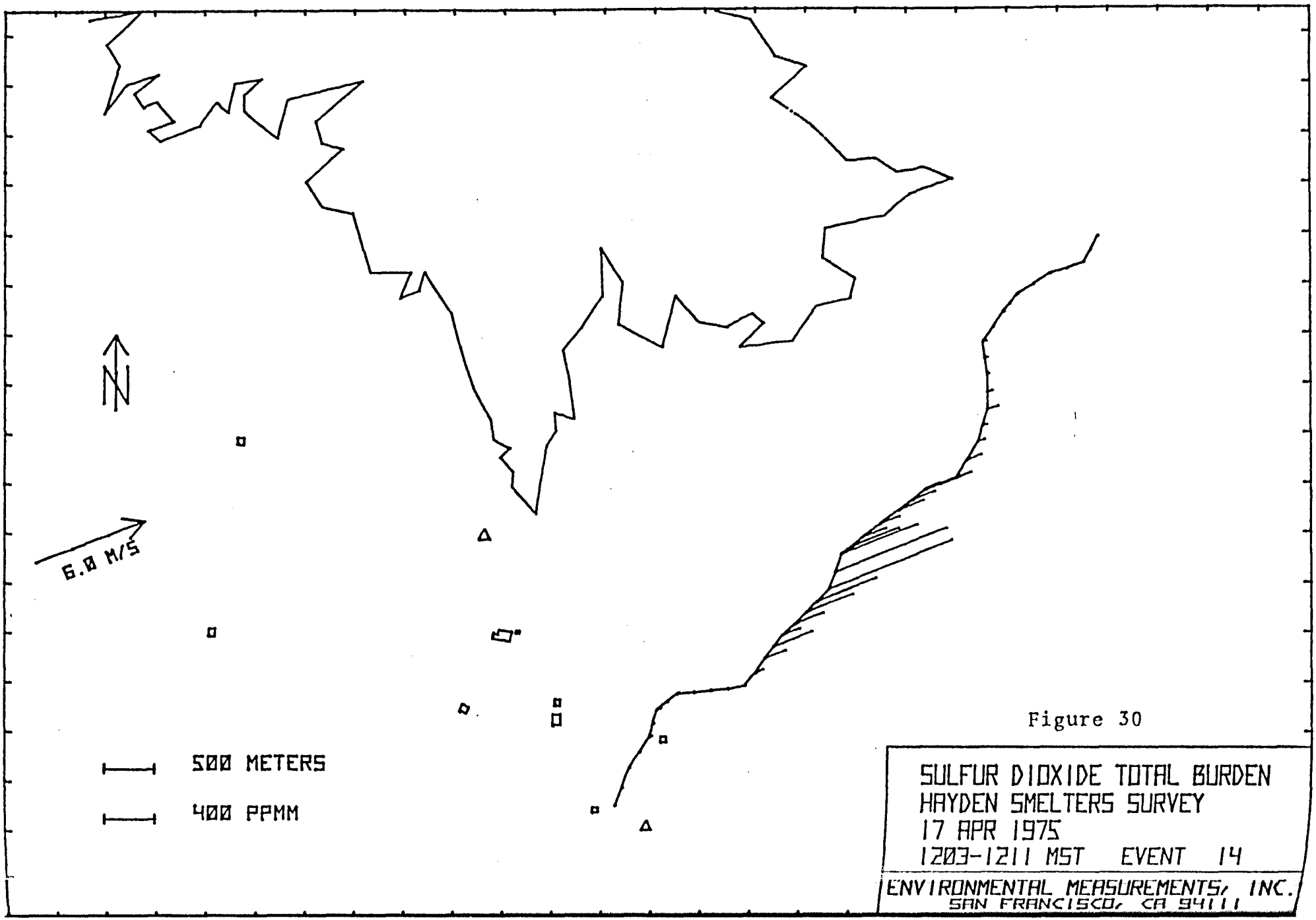

N
6.0 M/S
500 METERS
400 PPMM
SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
17 APR 1975
1203-1211 MST EVENT 14
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 30

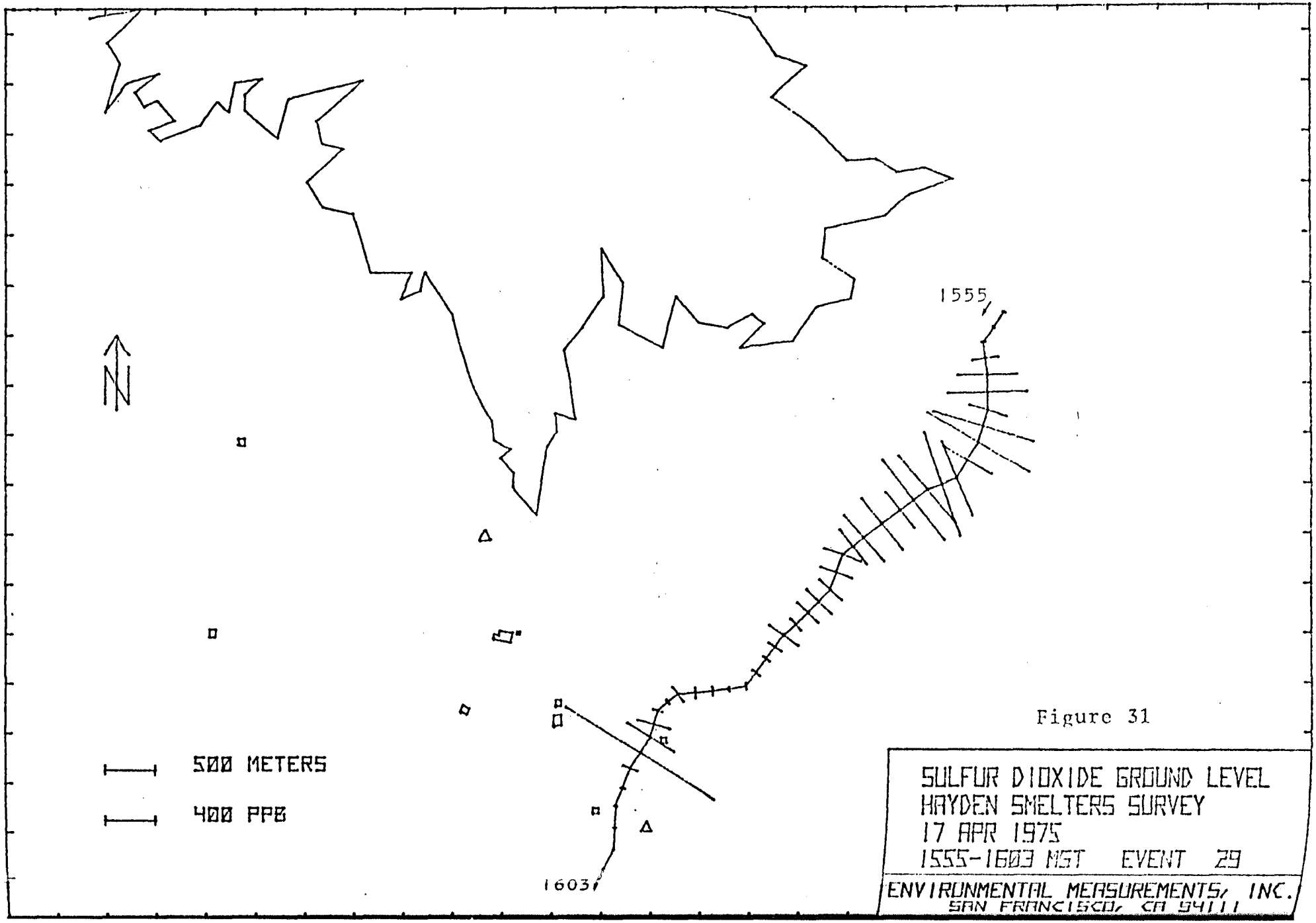

1555
1603
N
500 METERS
400 PPB
SULFUR DIOXIDE GROUND LEVEL
HAYDEN SMELTERS SURVEY
17 APR 1975
1555-1603 MST EVENT 29
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 31

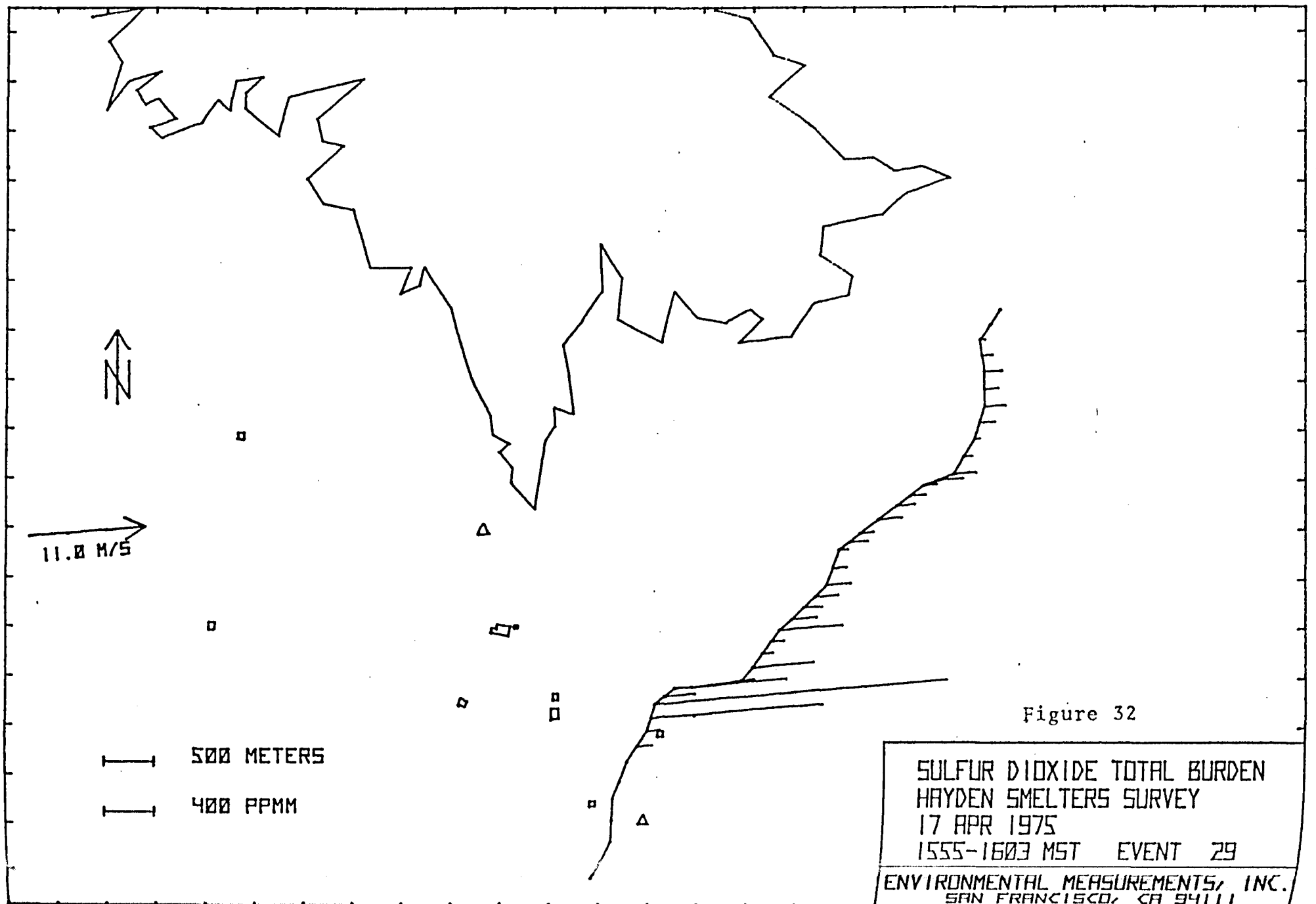

N
11.0 M/S
500 METERS
400 PPMM
SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
17 APR 1975
1555-1603 MST EVENT 29
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 32

18 APRIL 75/EVENTS 7, 17, 20

These three Events were Globe Highway traverses before and after plume rise measurements. The variability in both the burden and concentration data are apparent from these six maps (Figures 33-38). Only the first pair of maps (Event 7) show good correlation between the two sets of results. Events 17 and 20, which occurred after the wind had rotated and became somewhat stronger, show lack of agreement between the locations for the integrated and point measurements. The wind shift separated the overhead plumes, especially for Event 20 (Figure 38). Two plumes are more evident on this map because they were crossing the road at approximately a right angle, in contrast to most Globe Highway maps which show burden data along portions of the road nearly parallel with the plume centerlines.

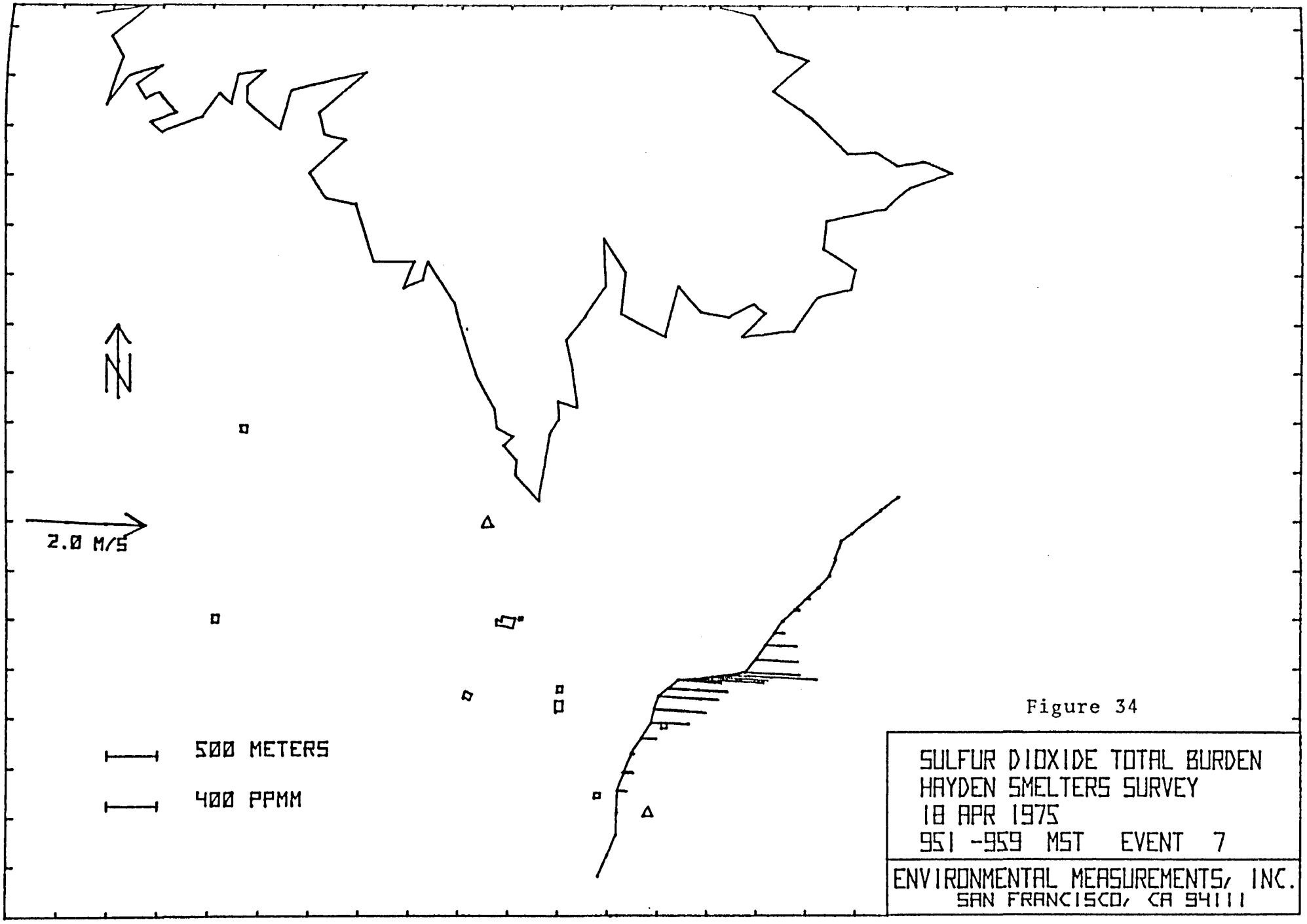

N
2.0 M/S
500 METERS
400 PPMM
SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
18 APR 1975
951 -959 MST EVENT 7
ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

Figure 34

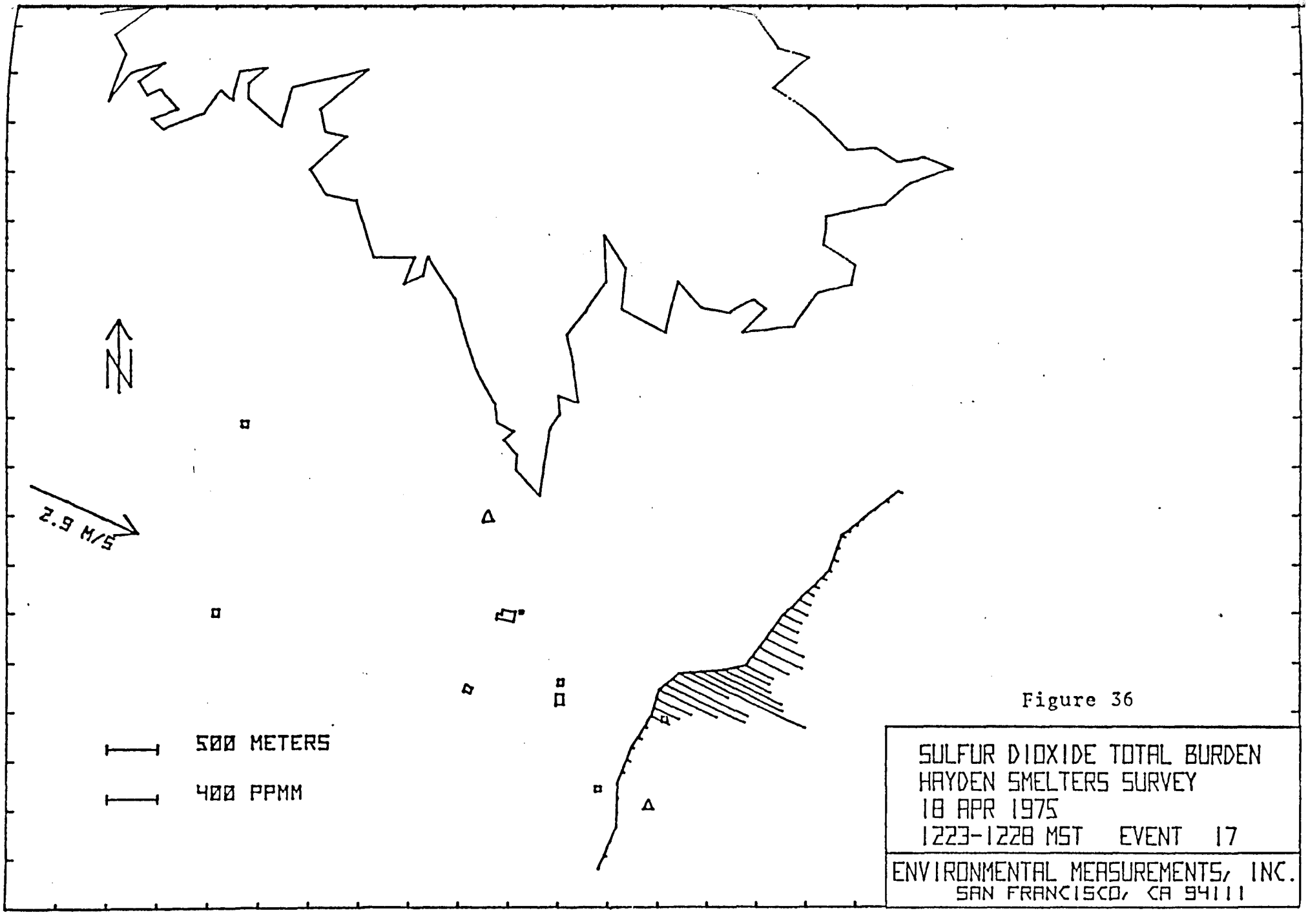


Figure 36

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
18 APR 1975
1223-1228 MST EVENT 17

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

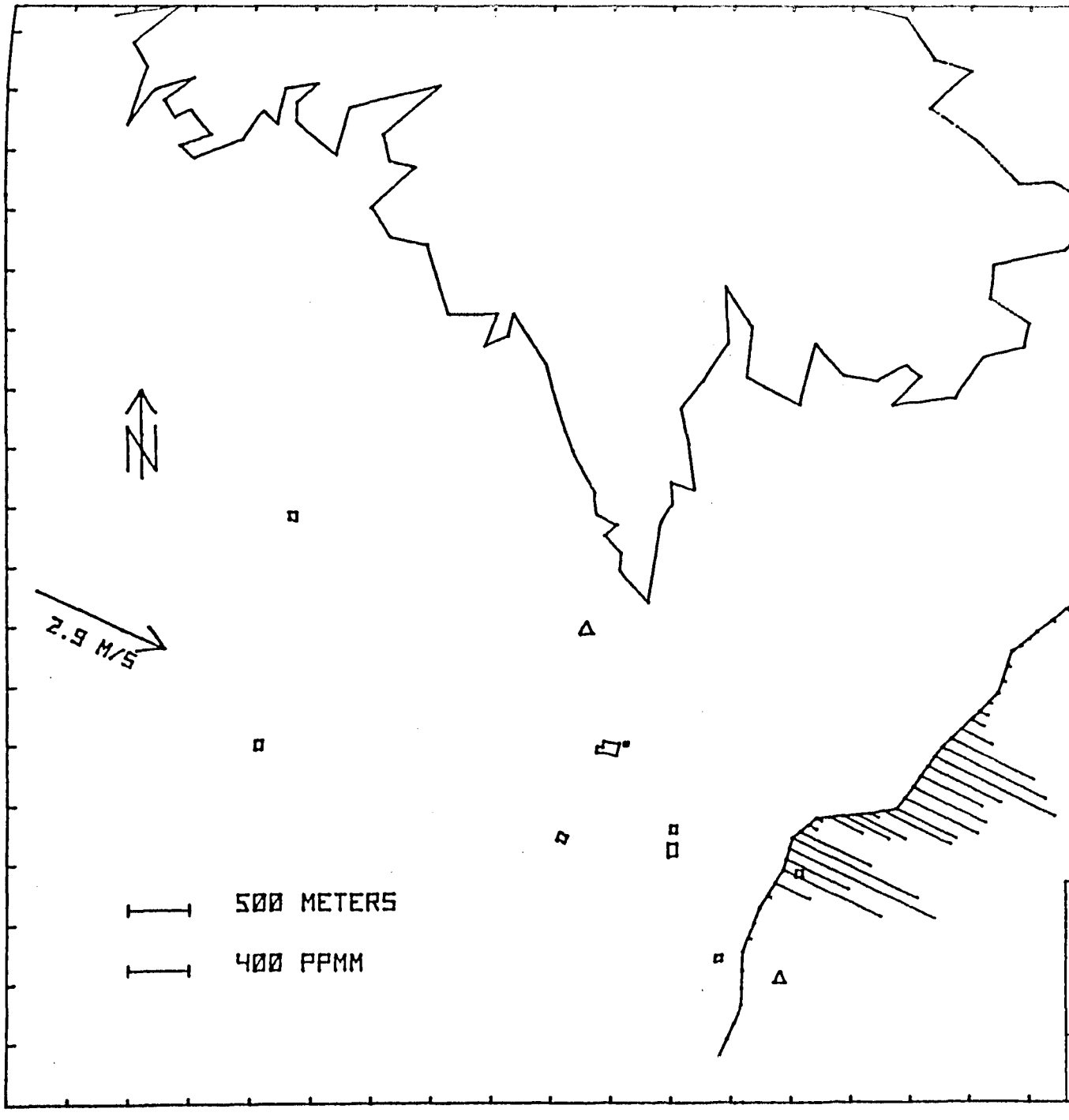


Figure 38

SULFUR DIOXIDE TOTAL BURDEN
HAYDEN SMELTERS SURVEY
18 APR 1975
1235-1238 MST EVENT 20

ENVIRONMENTAL MEASUREMENTS, INC
SAN FRANCISCO, CA 94111

SO_2 Dispersion. The influence of the rough terrain north of the smelters was evident in the moving measurement results. This was especially true for the Globe Highway where extreme fluctuations occurred from one traverse to the next in both SO_2 burden and concentration data. Measurements in the Montgomery Ranch area also exhibited variability. To illustrate these variations two sets of sketch maps are presented: Figures 39-50 for Globe Highway and Figures 51-53 for Montgomery Ranch. There are maps for all five days of the study for Globe Highway; Montgomery Ranch maps are for 14 and 15 April 75. The maps are 16 km x 16 km squares.

These maps show the extent of overhead and ground level SO_2 as measured by the AQML. They also give peak values for both burdens (ppmM) and concentrations (ppb). The peaks are the maximum SO_2 burdens and concentrations recorded on each traverse; where multiple peaks were recorded only the highest value is shown. While these hand drawn maps are not precise plots they do show the geographic locations (within 500 meters) of data gathered in these two critical areas.

The SO_2 dispersion maps depict the location of smelter plumes and the correlation between the two sets of data. Figure 39, for example, shows displacement of the ground-level SO_2 along the Globe Highway relative to the SO_2 burden; in contrast Figure 40 shows good correlation for four traverses spanning a fifteen minute period.

Figure 39

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

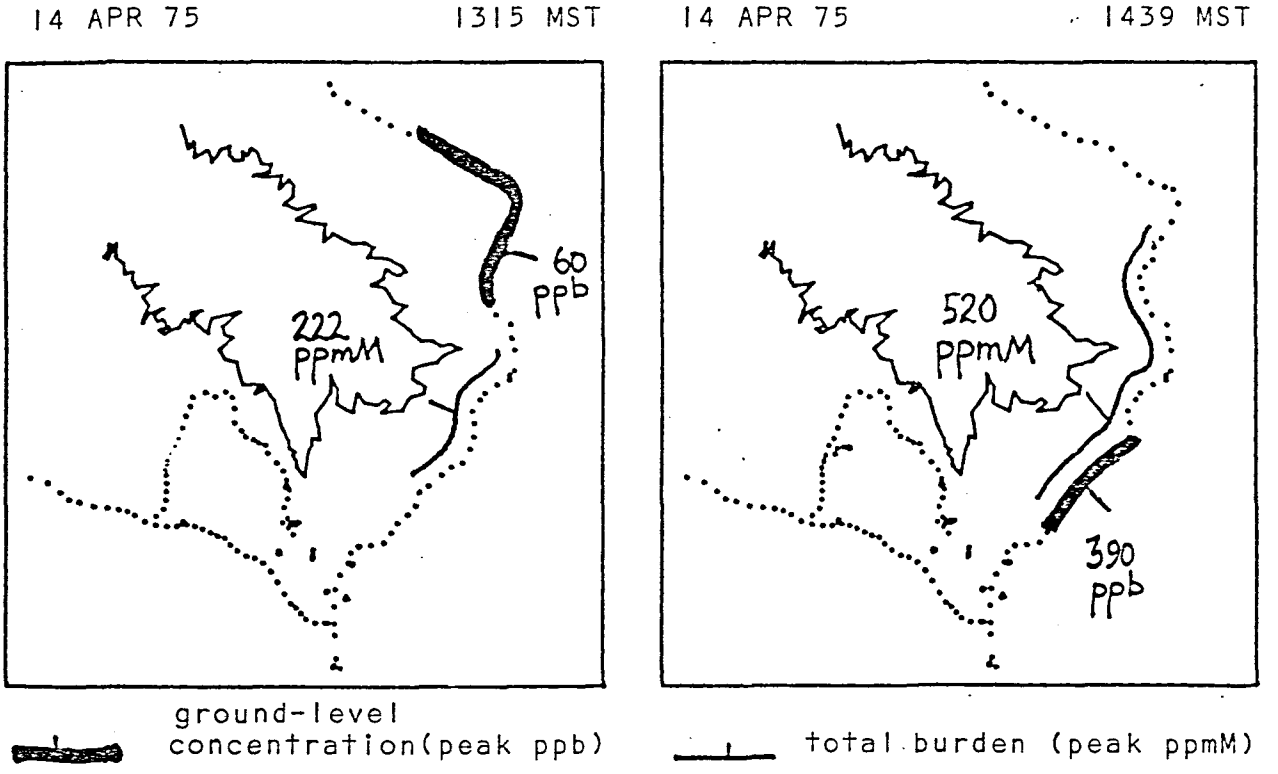


Figure 40

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

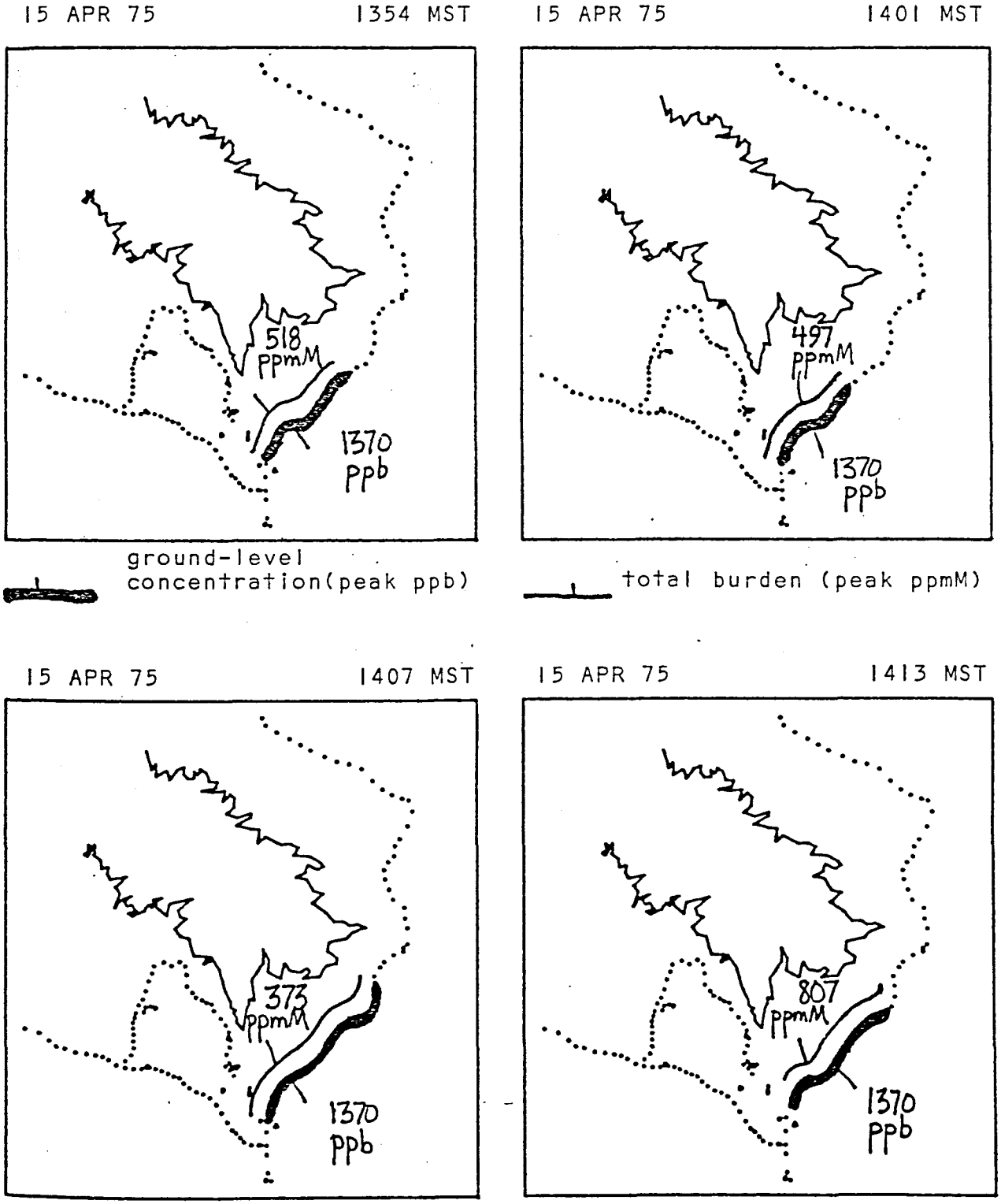


Figure 41

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

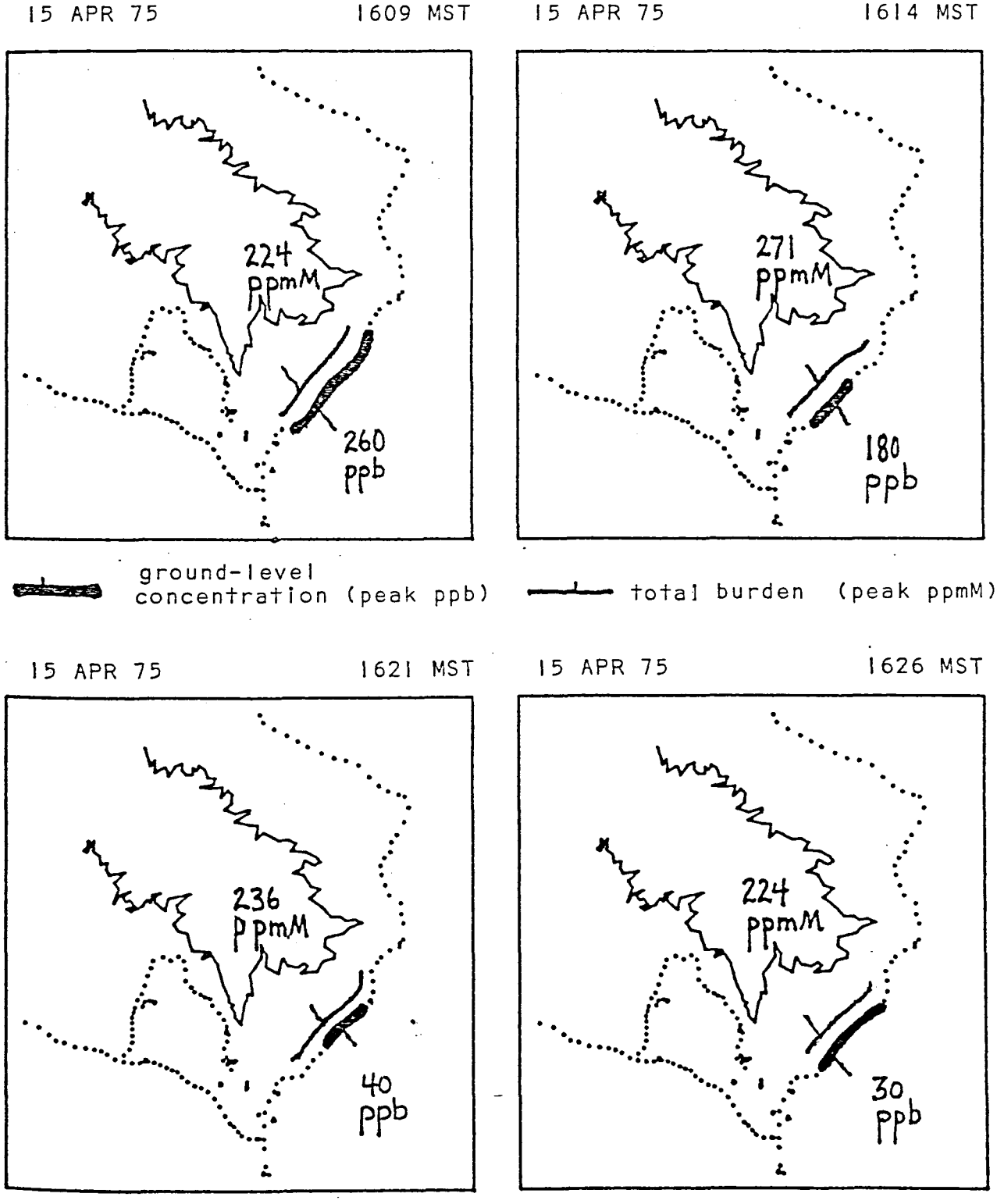


Figure 42

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

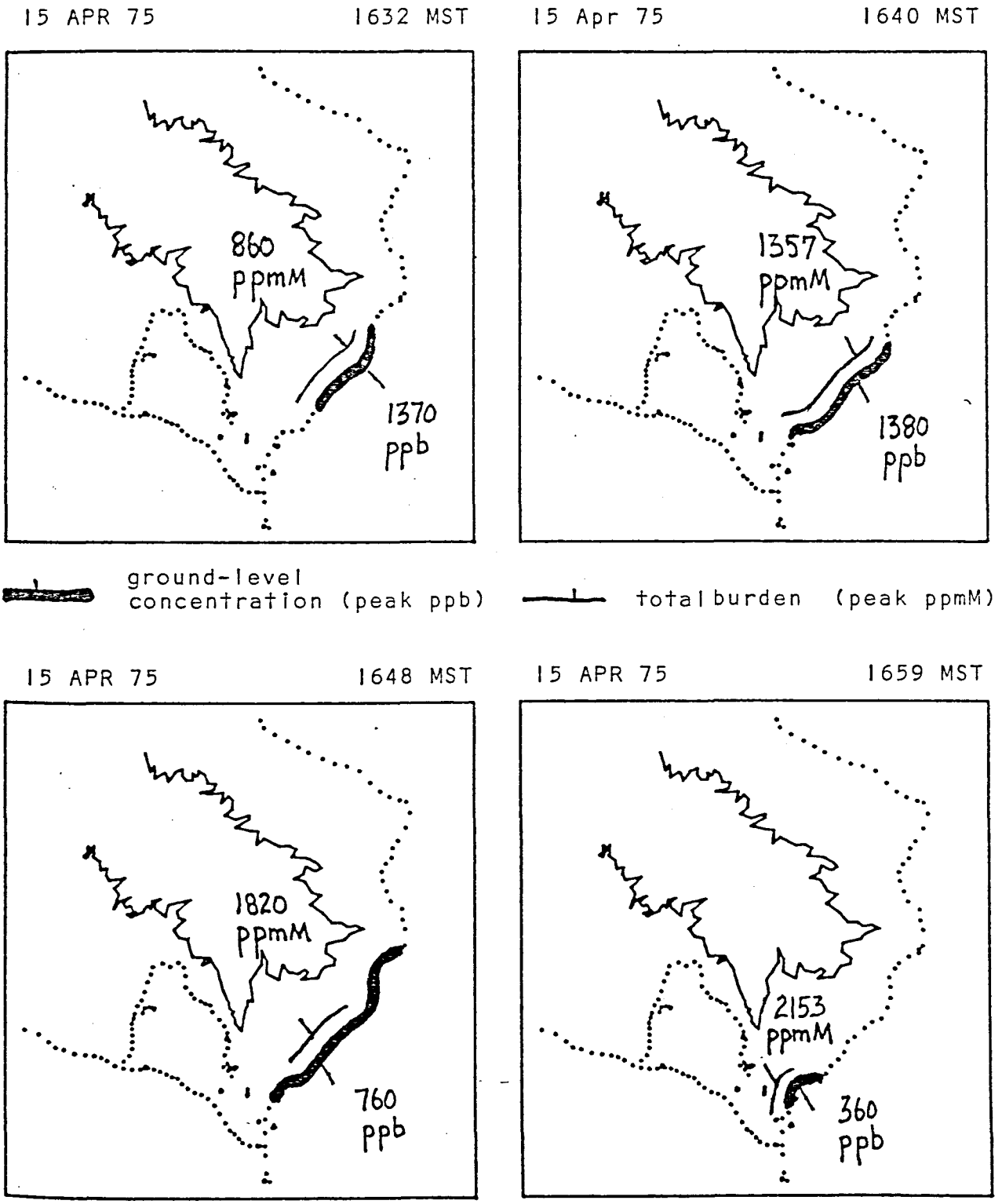


Figure 43

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

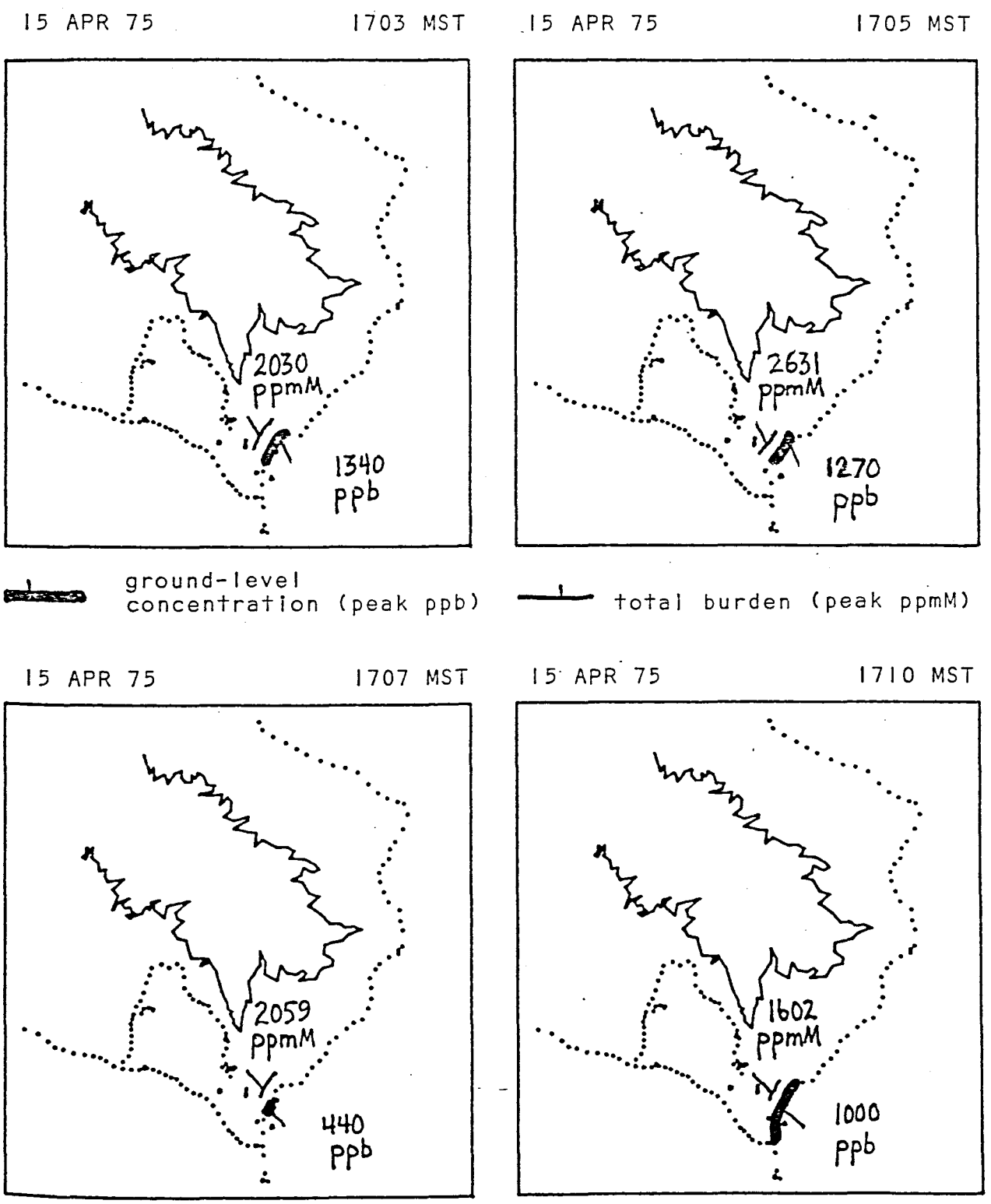


Figure 44

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

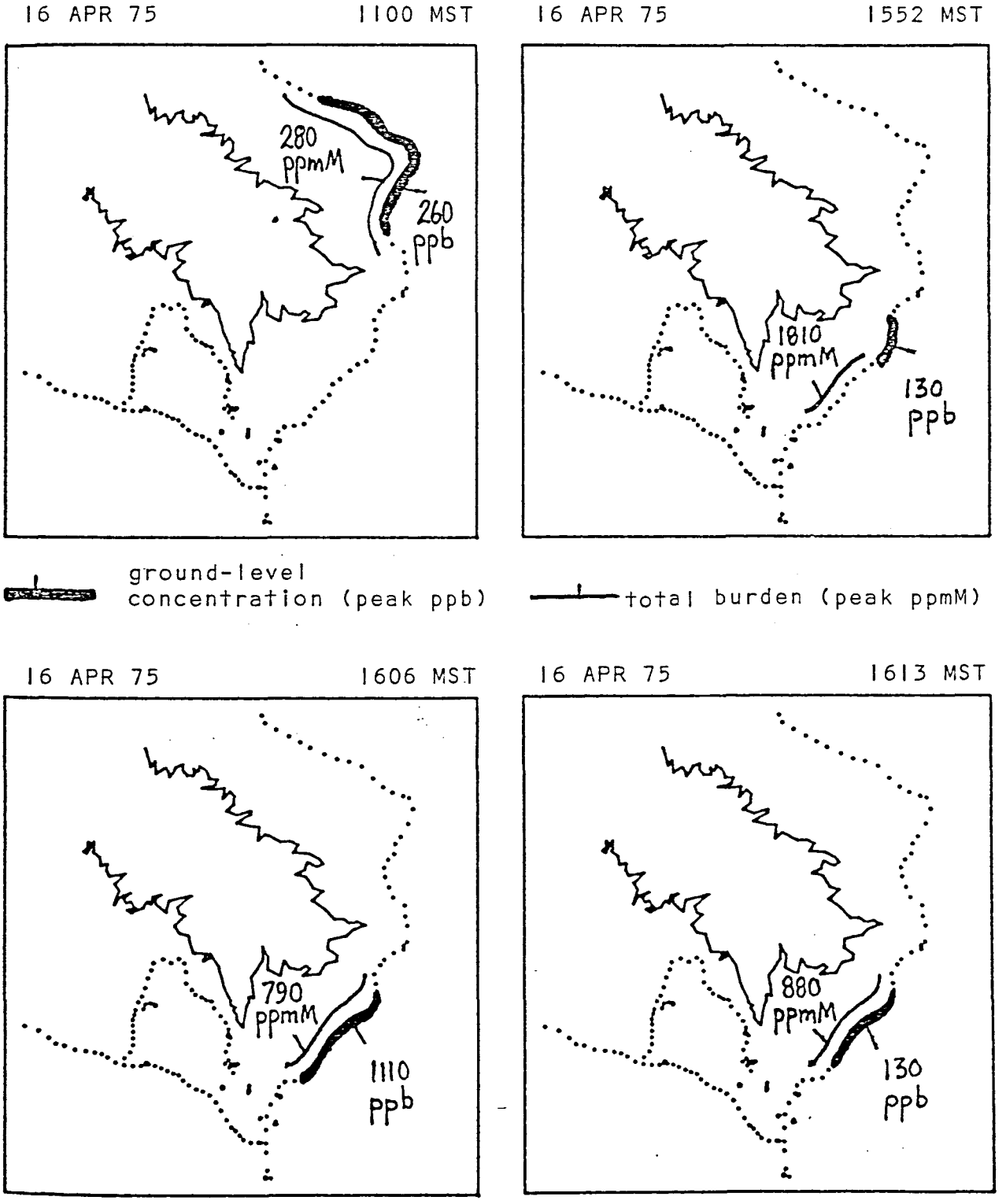


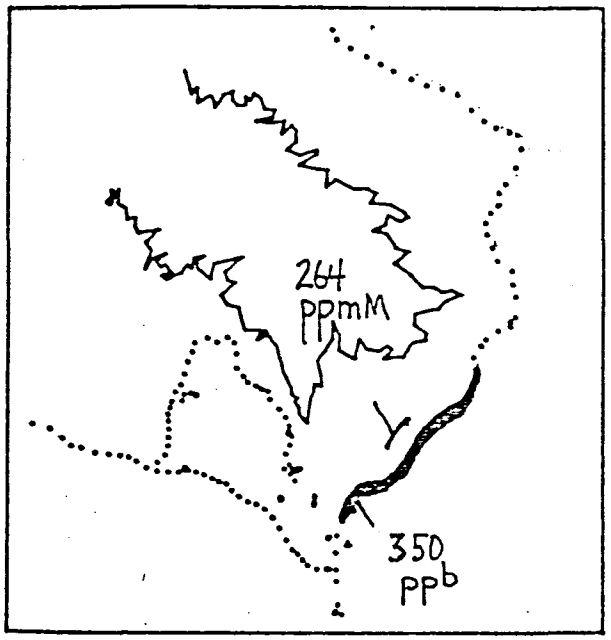
Figure 45

SO_2 DISPERSION

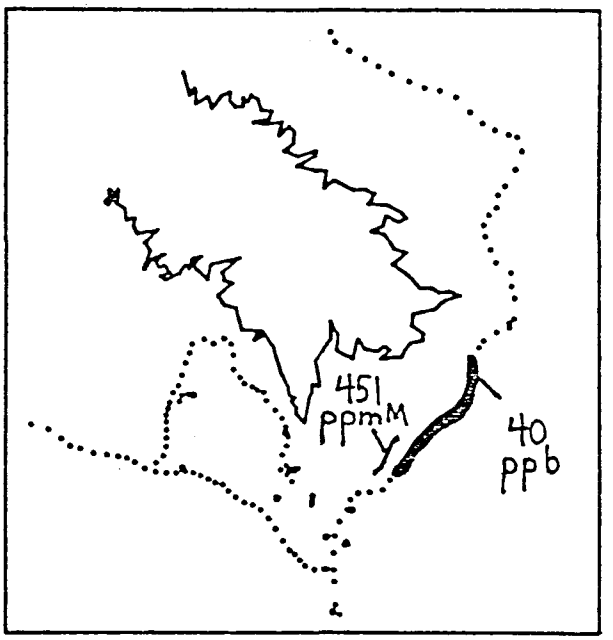
HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

16 APR 75 1618 MST



16 APR 75 1627 MST



ground-level concentration (peak ppb)

total burden (peak ppmM)

16 APR 75 1635 MST

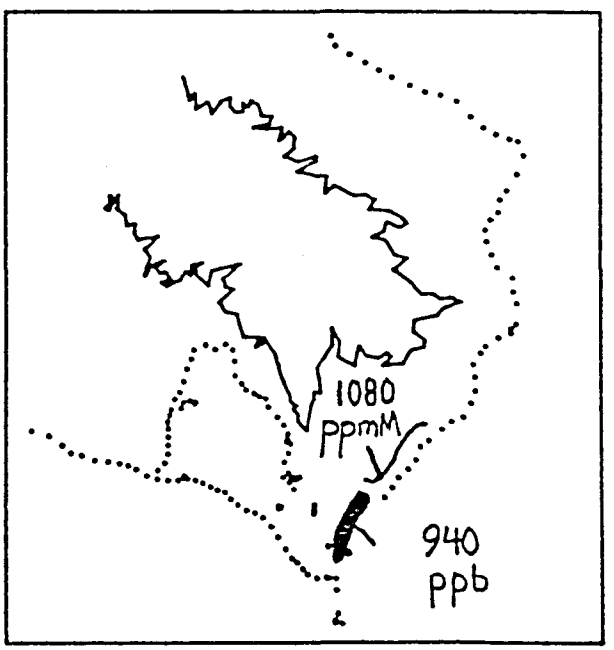


Figure 46

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

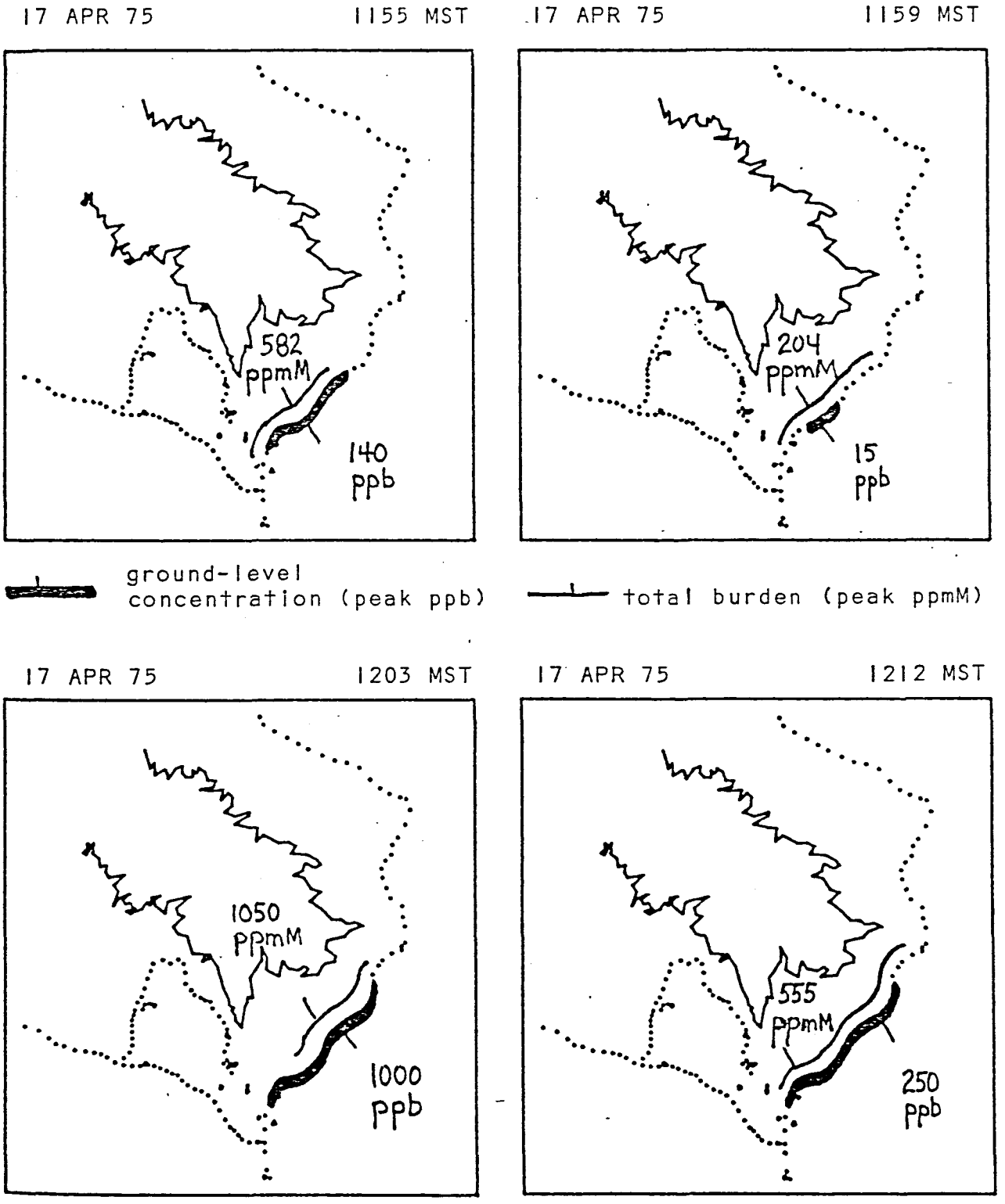


Figure 47

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

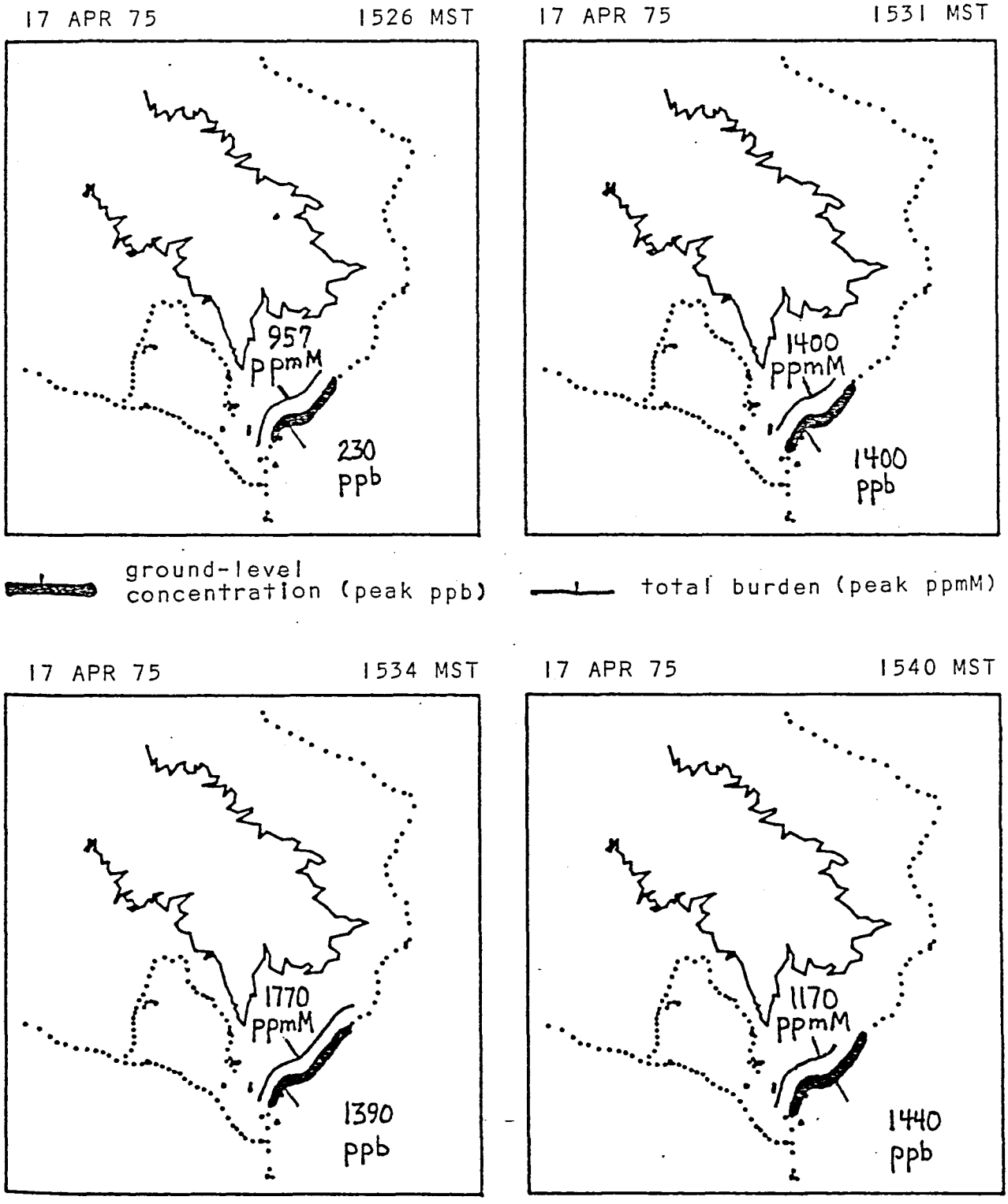


Figure 48

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

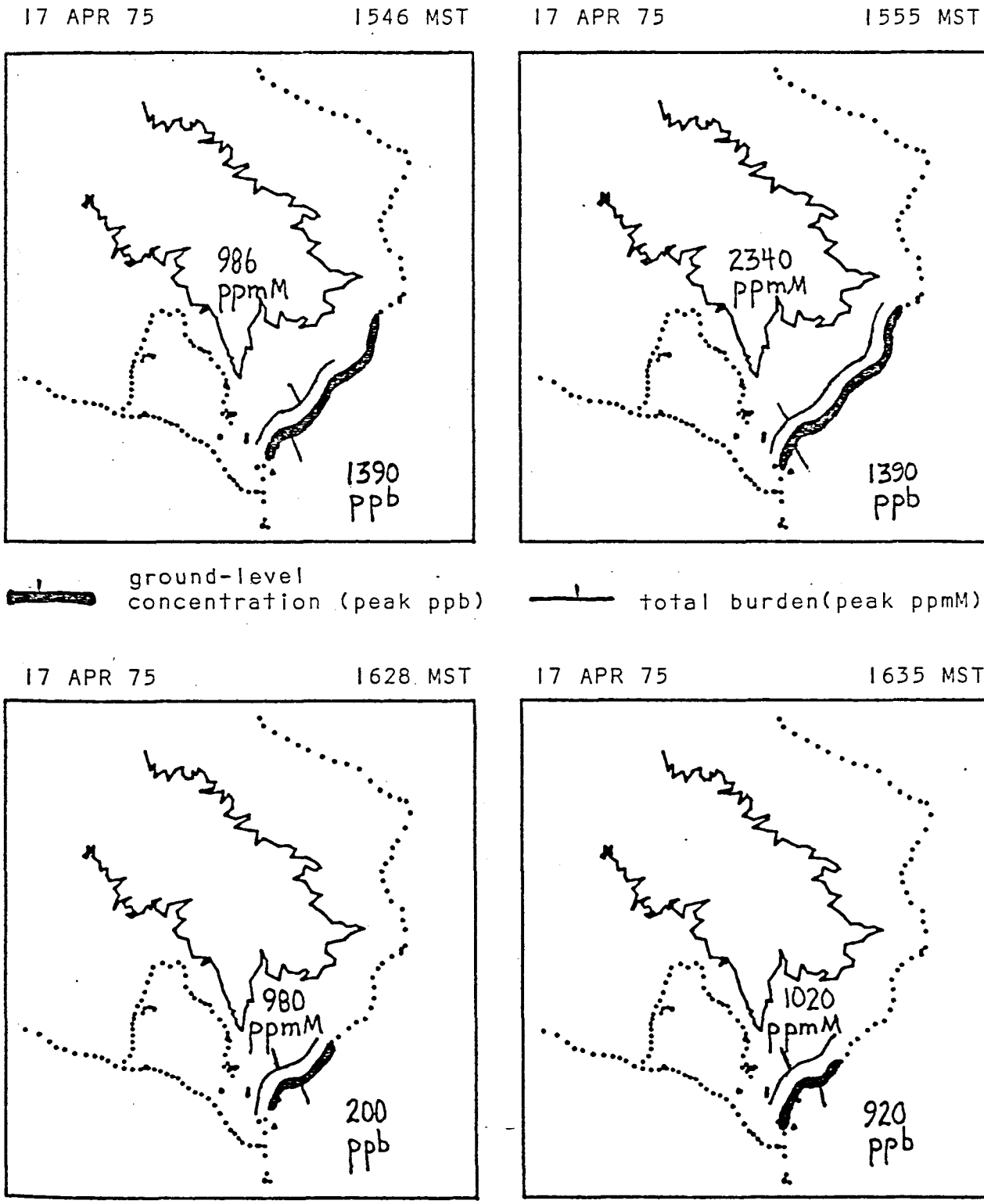


Figure 50

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway

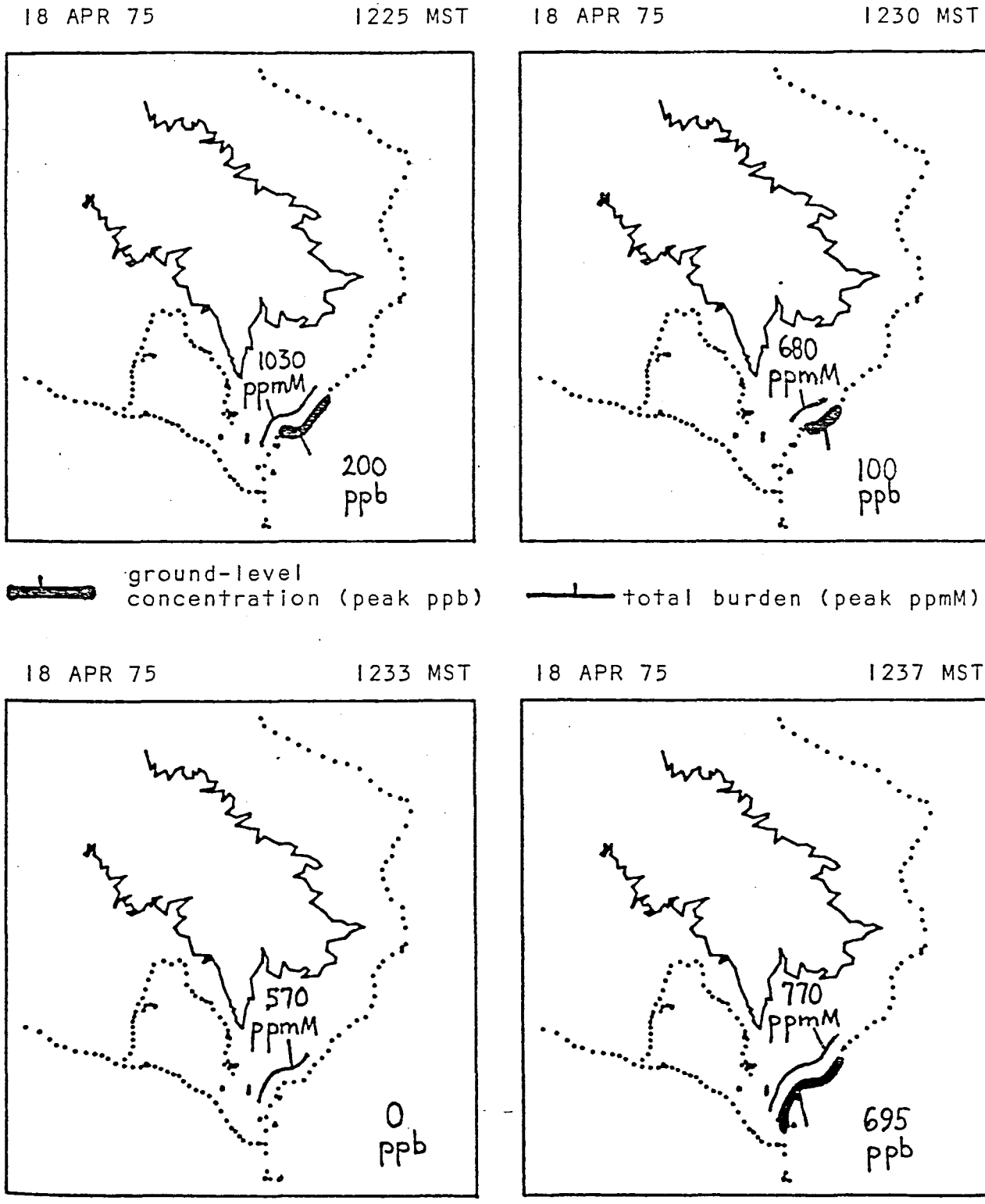
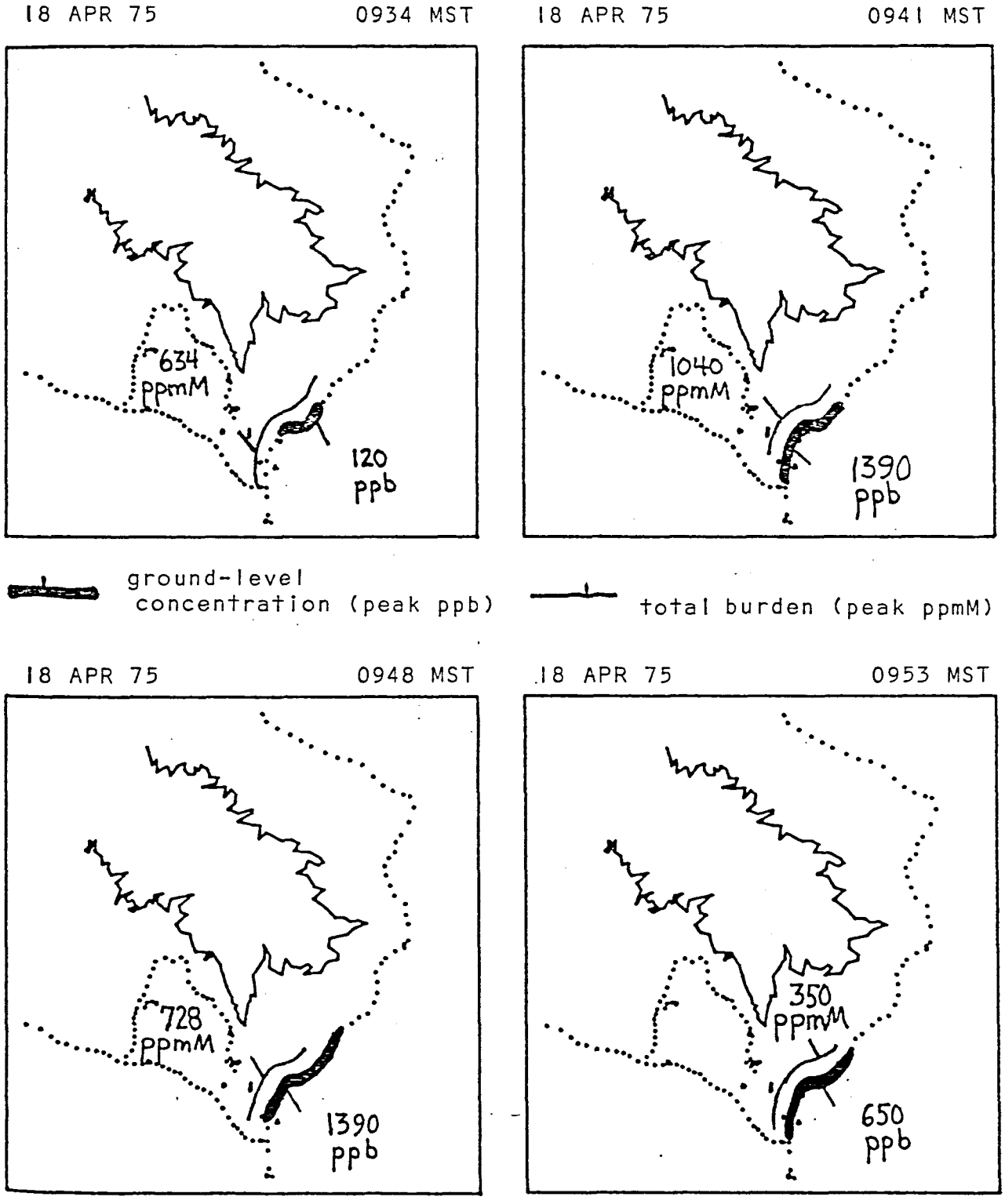


Figure 49

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Globe Highway



The Montgomery Ranch SO_2 dispersion maps show similar patterns. The plume touchdown points (concentrations) have relatively poor correlation with the overhead plumes (burdens). For four of the twelve traverses the ground level exceeded the detection limit of the SO_2 monitor (1390 ppb).

Figure 51

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Montgomery Ranch

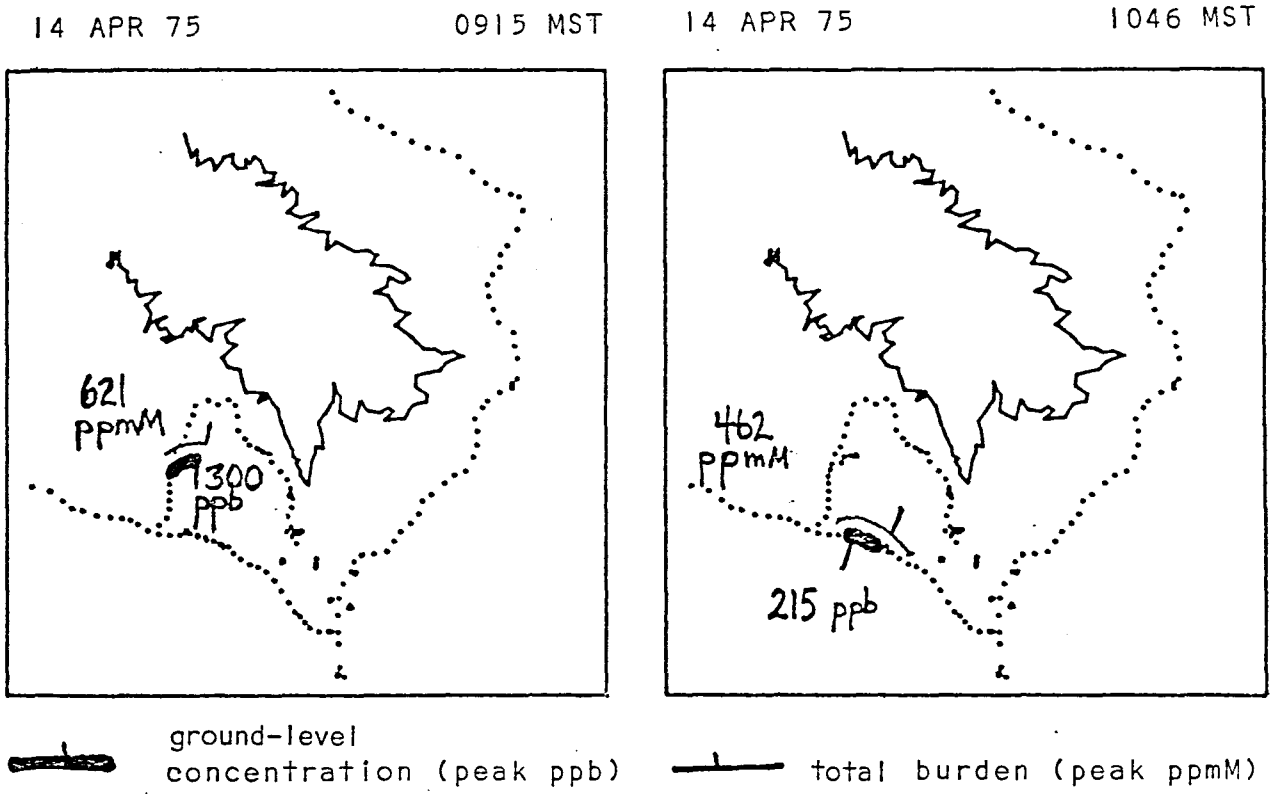


Figure 52

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Montgomery Ranch

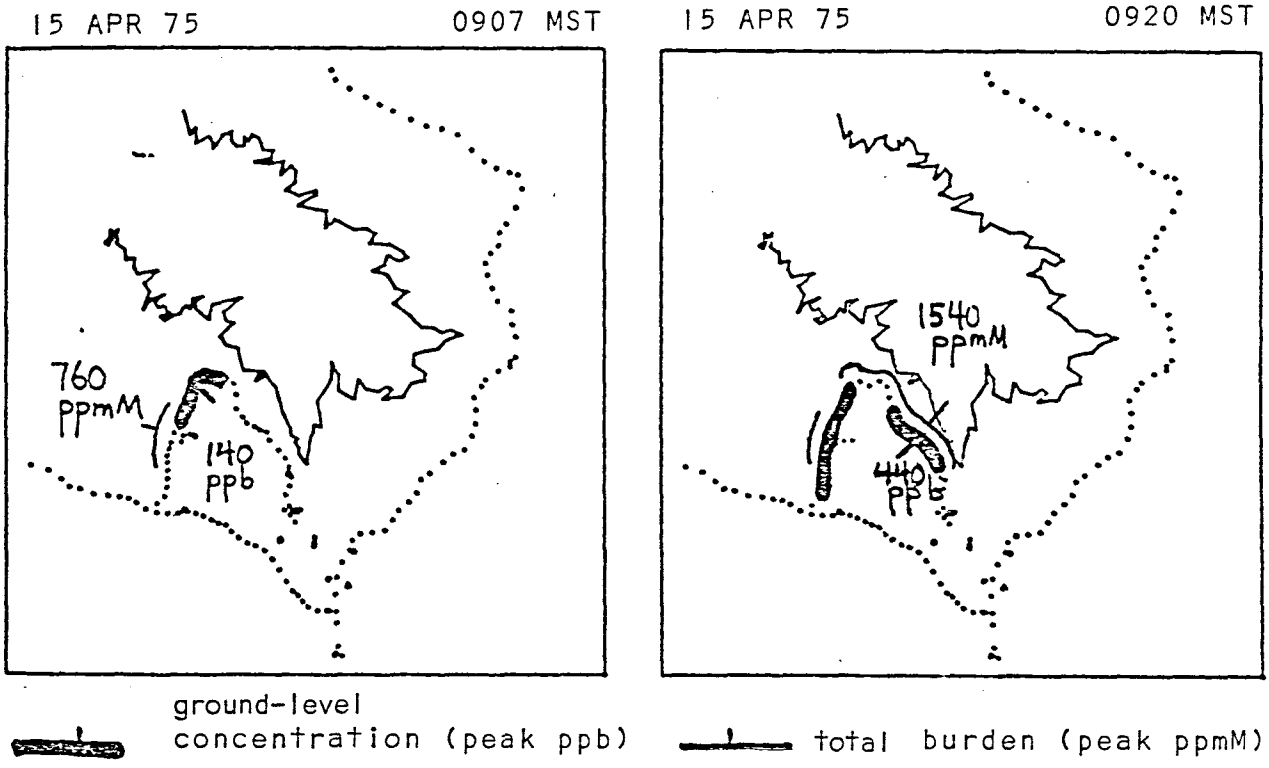
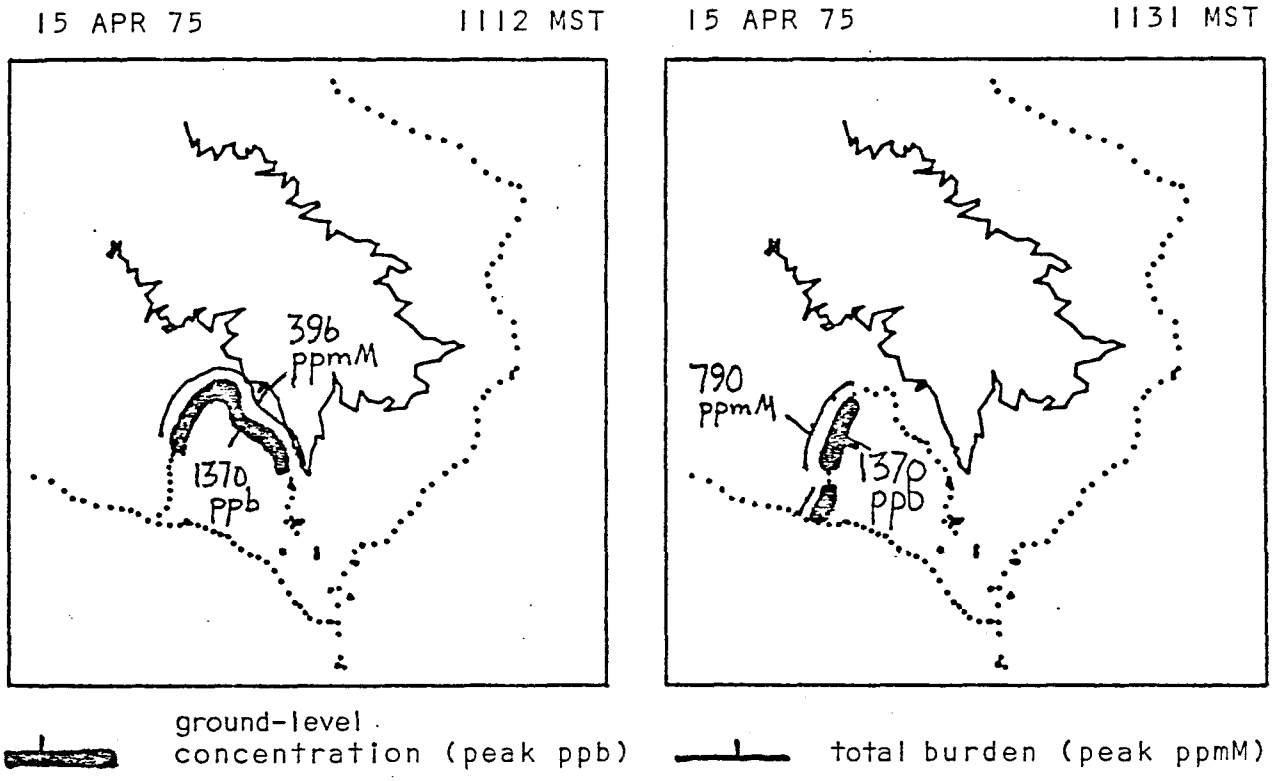


Figure 53

SO_2 DISPERSION

HAYDEN SMELTERS EMISSION SURVEY

Montgomery Ranch



PLUME RISE

The Plume Rise measurements were made at two sites on two days. A summary of the twenty sets of measurements is given in Table III.

Individual Profiles. The eighty-five individual profiles, single vertical sweeps through the plumes, are plotted in sets. Each set contains two to eight profiles. The sets are grouped by site and day; each group is presented separately with a discussion and a Plume Rise Geometry Map. All pages are in the horizontal page format.

TABLE III

EPA/HAYDEN

Plume Rise Summary

Date	Site	Time(MST)	Set	Location
17 APR 75	1	0924	1	Between Stacks
	1	0947	2	10° Left KCC Stack
	1	0959	3	25° Left KCC Stack
	1	1033	4	25° Left KCC Stack
	1	1046	5	Between Stacks
	1	1055	6	10° Left KCC Stack
	1	1103	7	25° Left KCC Stack
17 APR 75	2	1254	1	Between Stacks
	2	1303	2	2° Right ASARCO Stack
	2	1314	3	15° Right ASARCO Stack
	2	1325	4	42° Right ASARCO Stack
	2	1337	5	42° Right ASARCO Stack
	2	1355	6	65° Right ASARCO Stack
	2	1401	7	65° Right ASARCO Stack
18 APR 75	2	1017	1	Between Stacks
	2	1027	2	Between Stacks
	2	1036	3	5° Right ASARCO Stack
	2	1049	4	20° Right ASARCO Stack
	2	1104	5	45° Right ASARCO Stack
	2	1120	6	65° Right ASARCO Stack

17 APRIL 75/SITE 1 PLUME RISE

Site 1 was above and behind the smelters; it was selected because it had the advantage of being elevated with good line-of-sight to the distant horizon. However, it had the disadvantage of presenting a view of the two stack tops at nearly the same angle of inclination. Thus it was difficult to separate the KCC and ASARCO plumes from Site 1. The KCC stack was used as a zero degree reference. The 4°, 10°, and 25° horizontal angles used to measure plume rise are shown on Figure 54. The plume vectors were almost due east, as represented by the "effective plume centerline" on the map.

A total of 42 plume profiles are plotted for Site 1 (Figures 55 - 61). The profiles between the stacks show only SO_2 emissions from the KCC stack (Figures 55 and 59). Set 1 shows eight profiles with good repeatability; Set 5 illustrates some low level emissions near the horizon. The other Sets are downwind of both the ASARCO and KCC stacks; some profiles have two distinct plumes but most do not. Low level emissions (below 200 meters) were measured frequently.

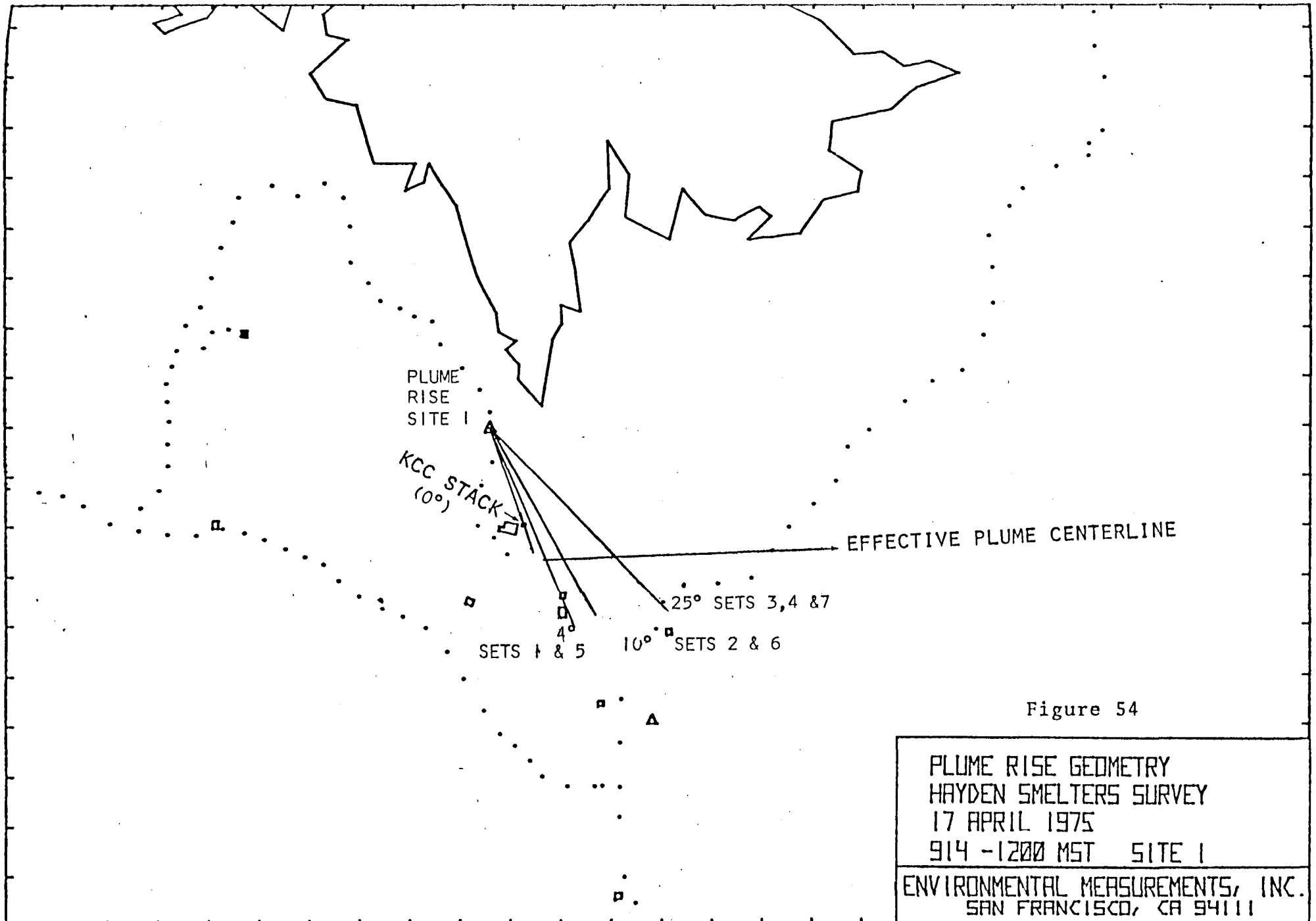


Figure 54

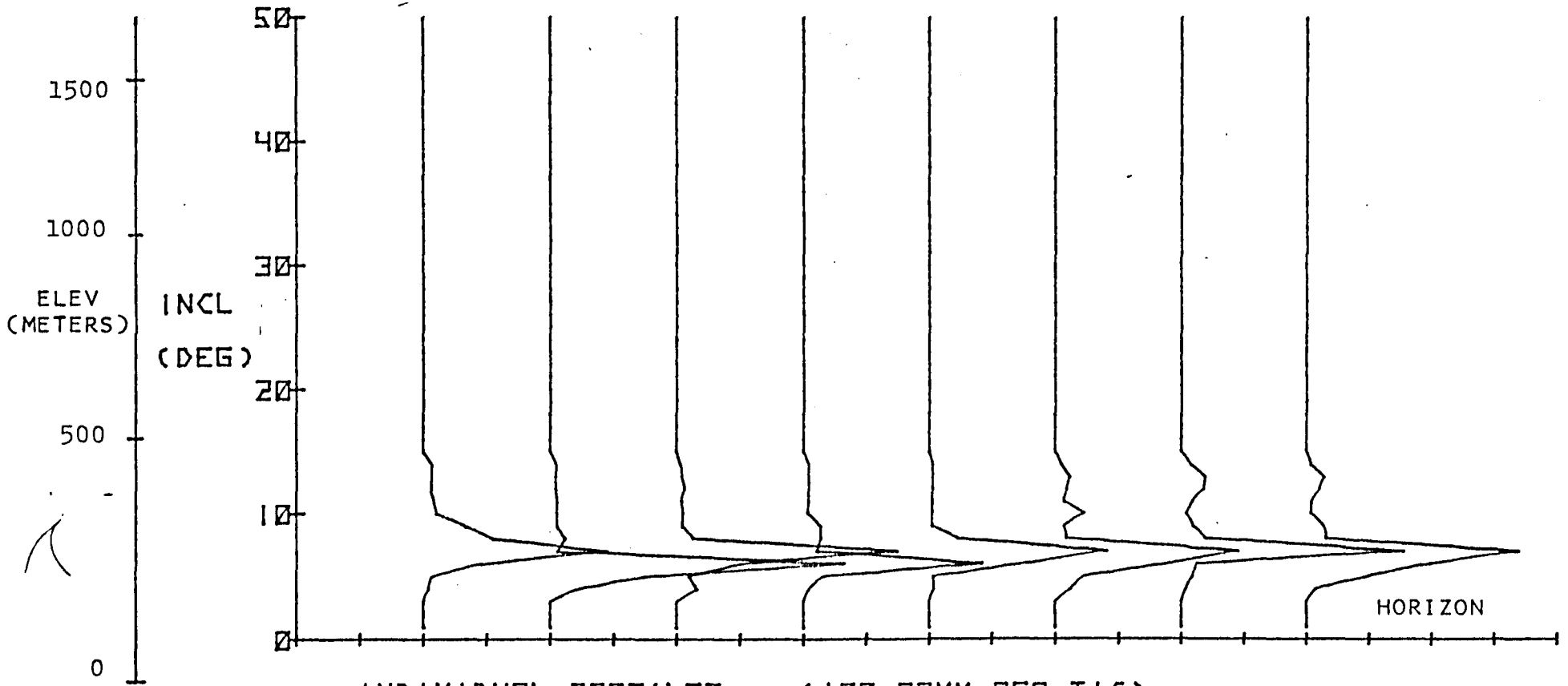
PLUME RISE GEOMETRY
HAYDEN SMELTERS SURVEY
17 APRIL 1975
914 -1200 MST SITE 1

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

FIGURE 55

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

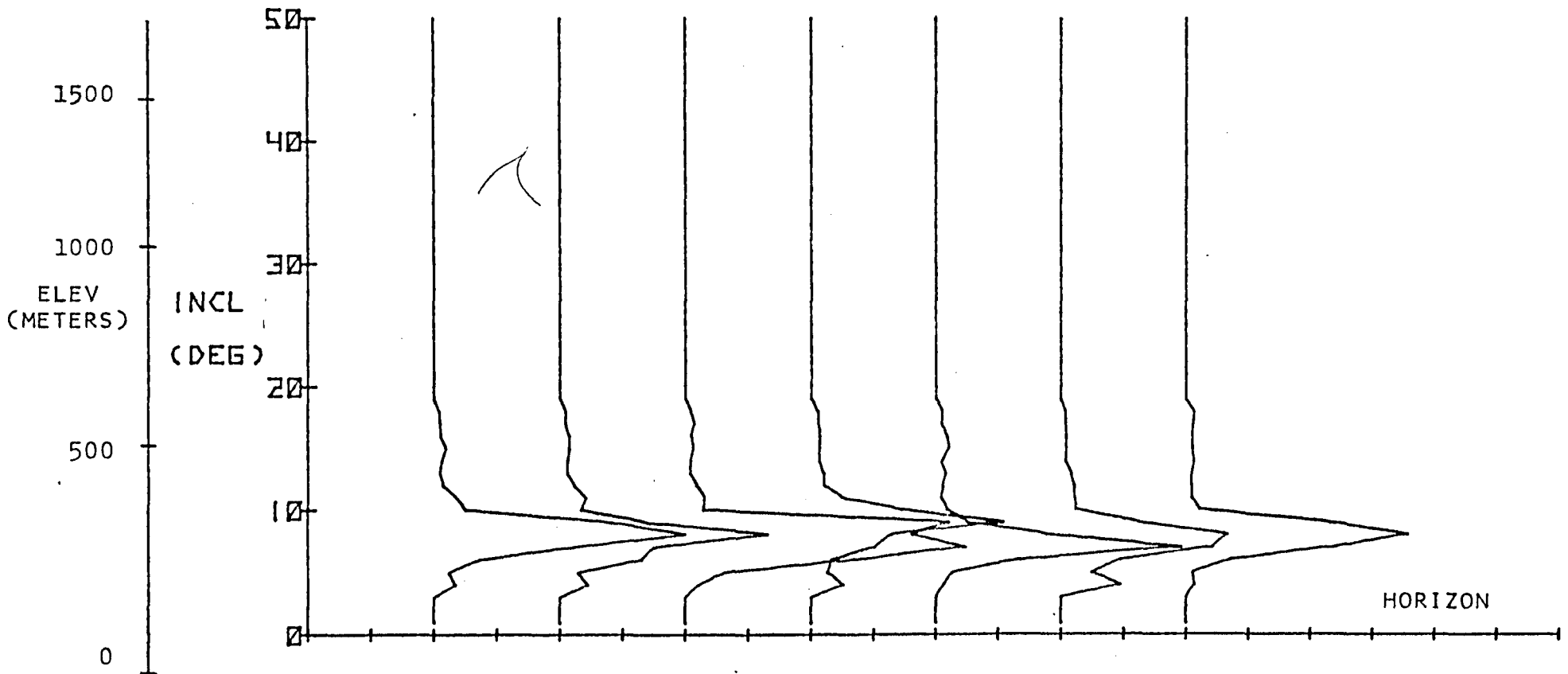
DATE: 170475
TIME: 924

SITE: 1
SET: 1 BETWEEN STACKS

FIGURE 56

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

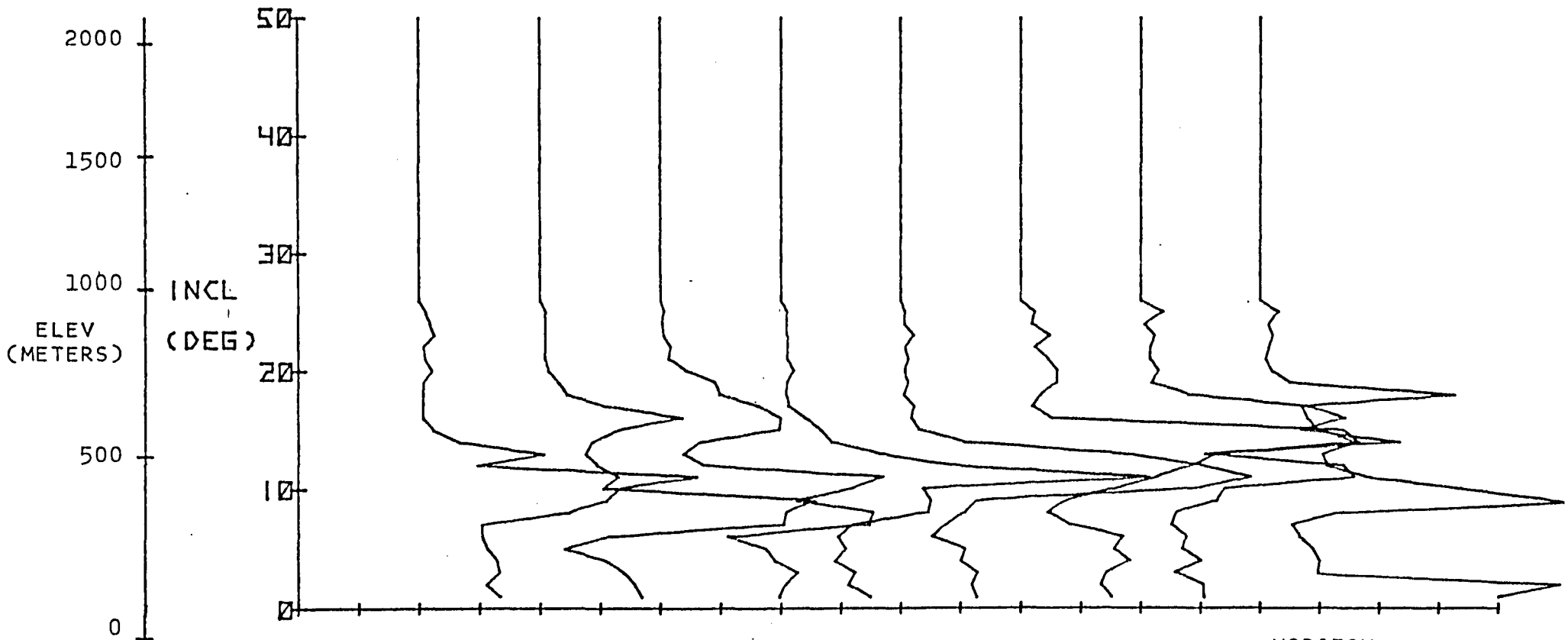
DATE: 170475
TIME: 947

SITE: 1
SET: 2 185 METERS EAST

FIGURE 57

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



DATE: 170475
TIME: 959

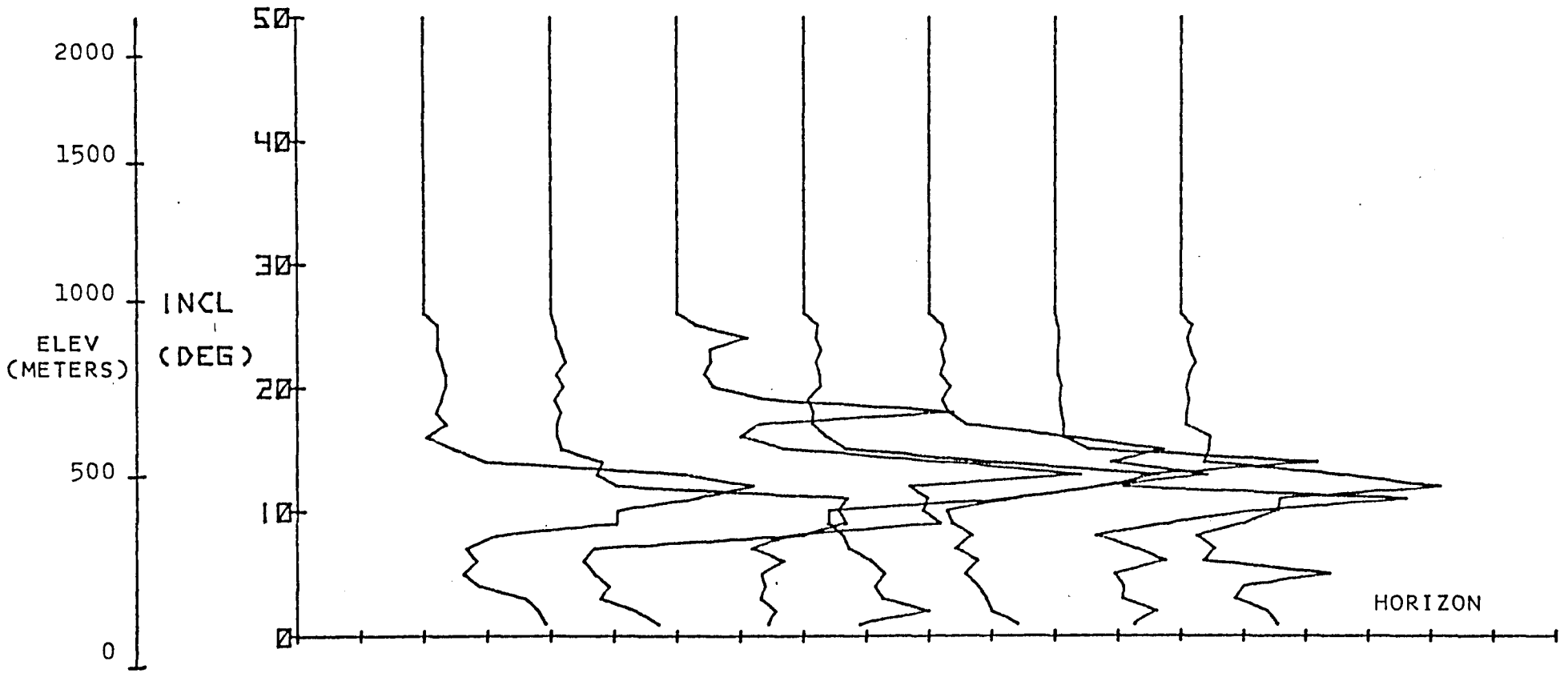
SITE: 1
SET: 3

700 METERS EAST

FIGURE 58

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1003

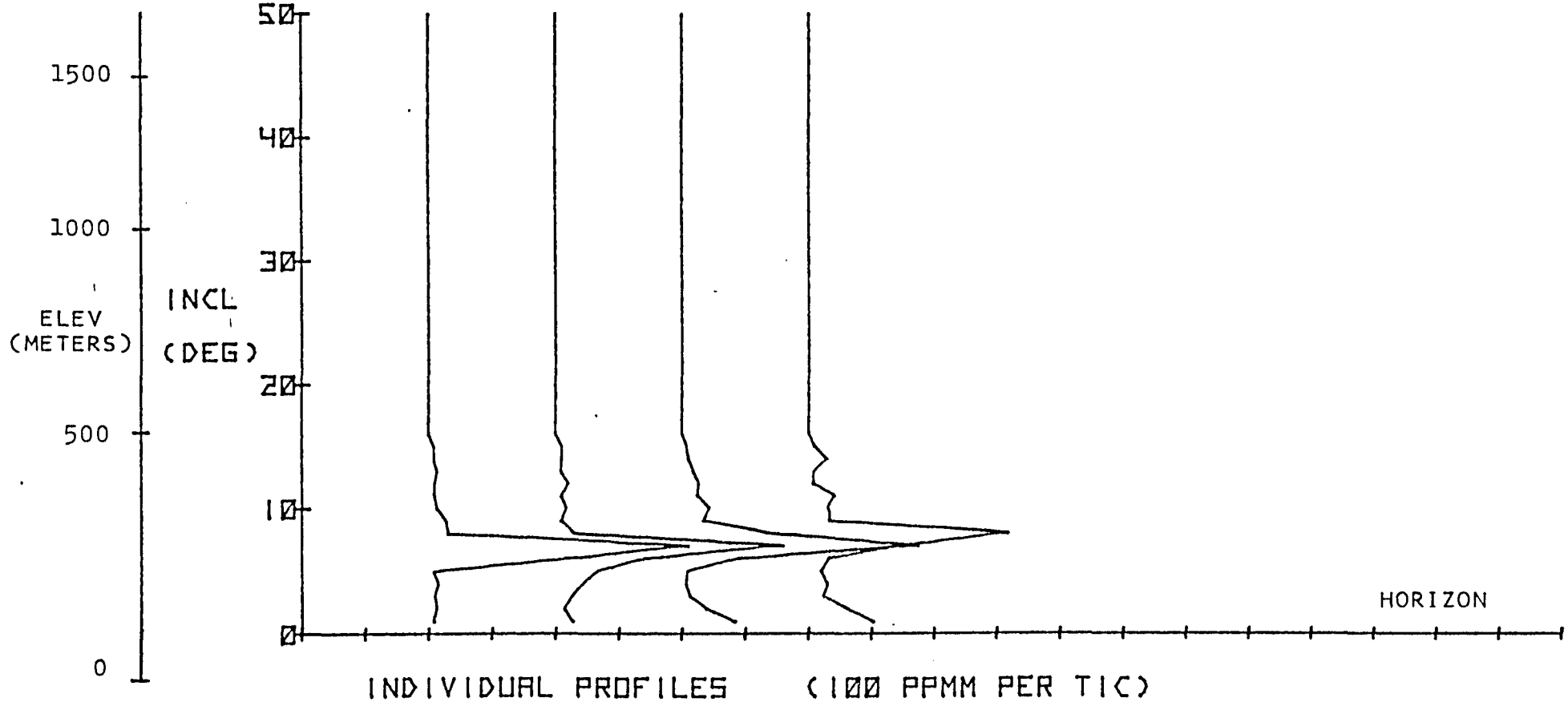
SITE: 1
SET: 4

700 METERS EAST

FIGURE 59

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

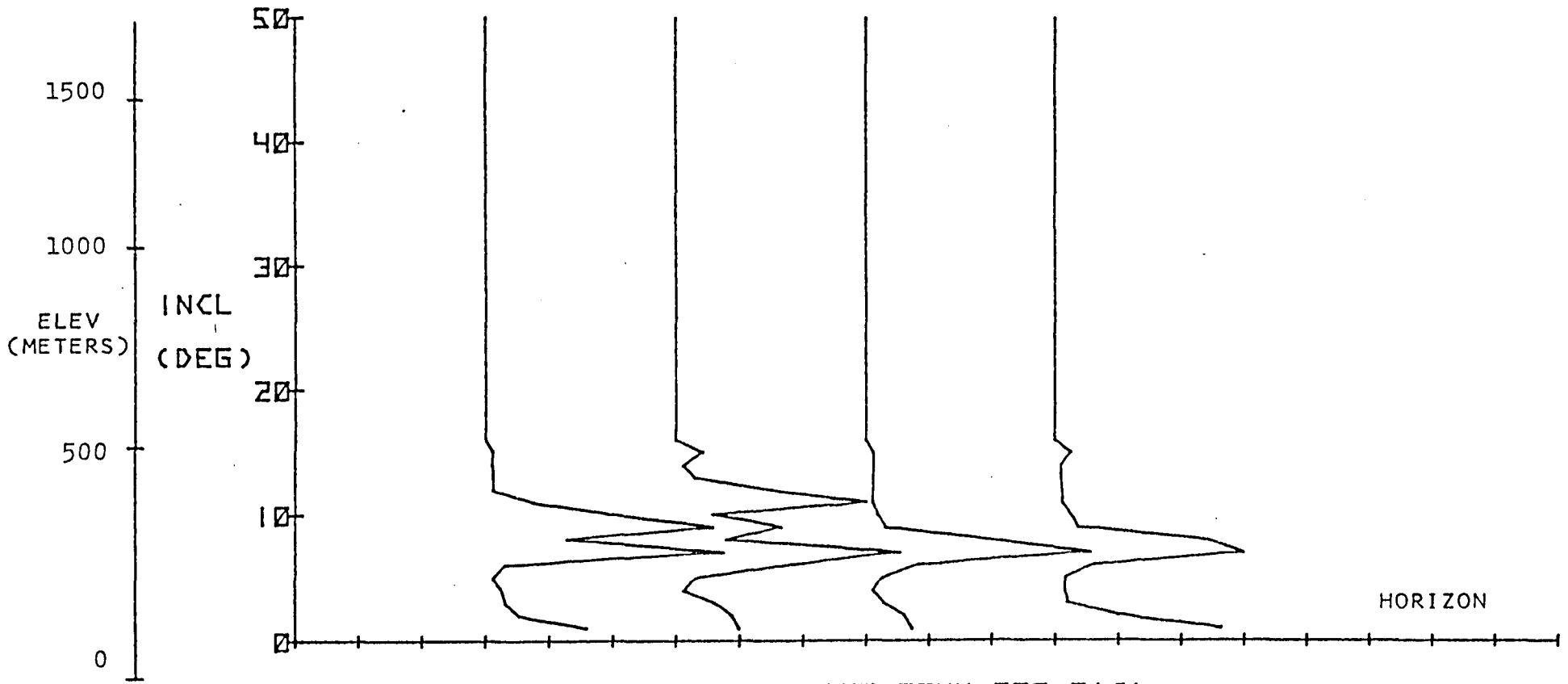
DATE: 170475
TIME: 1046

SITE: 1
SET: 5 BETWEEN STACKS

FIGURE 60

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1055

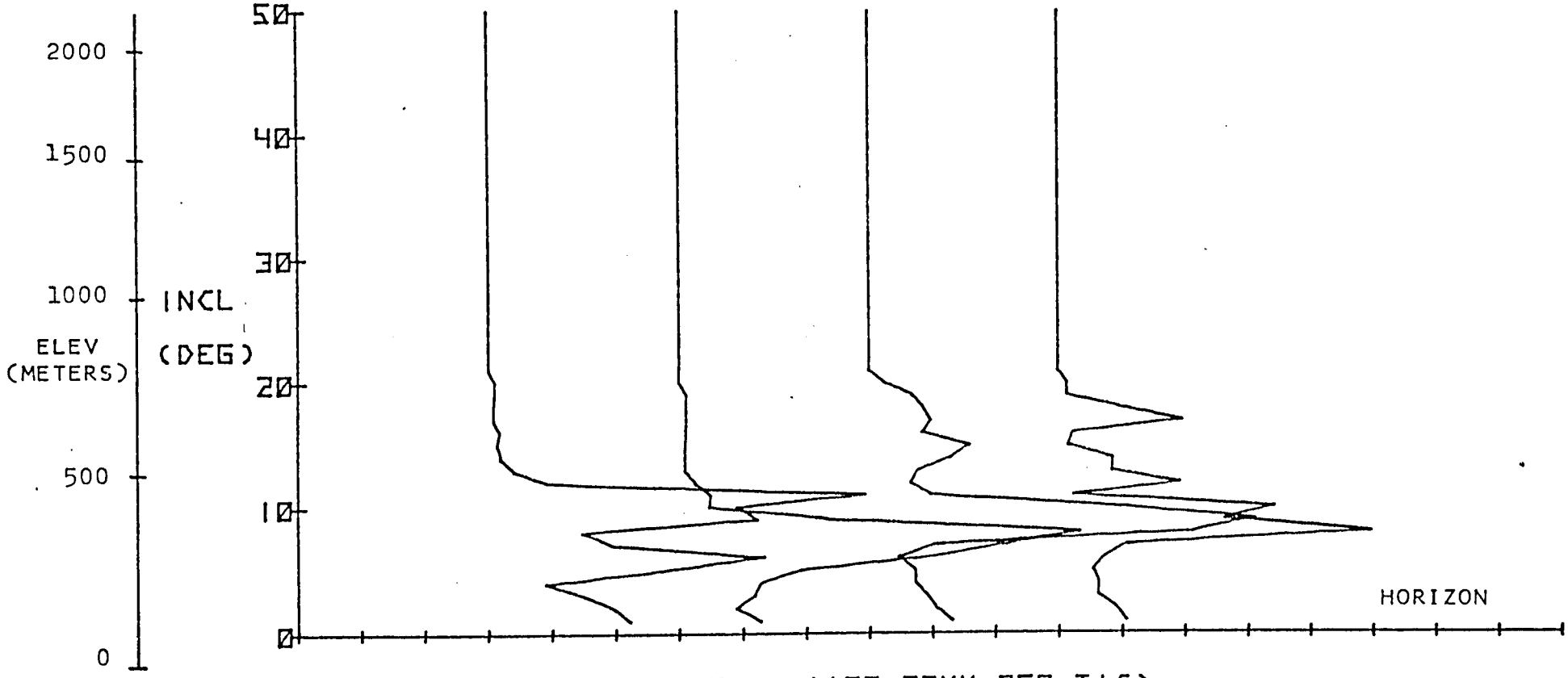
SITE: 1
SET: 6

185 METERS EAST

FIGURE 61

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1103

SITE: 1
SET: 7

700 METERS EAST

17 APRIL 75/SITE 2 PLUME RISE

Site 2 was located in Winkleman southeast of the stacks; it was superior to Site 1 because the two stack tops were separated vertically. It had the disadvantage of having mountainous terrain at the horizon; therefore, measurements of plume rise were limited to a minimum angle of about 5 degrees. The ASARCO stack was used as the zero degree reference. The 15°, 42°, and 65° measurement angles are shown on Figure 62. The plume vector was east-southeast to easterly.

For 17 April, 21 plume profiles are plotted (Figures 63 - 69). Because of the lower elevation of Site 2 the horizon line appears above zero degrees (as noted on each plot). The Set 1 measurements (between Stacks, Figure 63) shows ASARCO stack emissions (at 400 meters) and fugitive emissions at the horizon. Downwind profiles are more complex; multiple peaks occur frequently as do low elevation emissions. Except for Set 5 (Figure 67) the SO_2 plumes remained below 20 degrees (600 meters) to nearly two kilometers downwind.

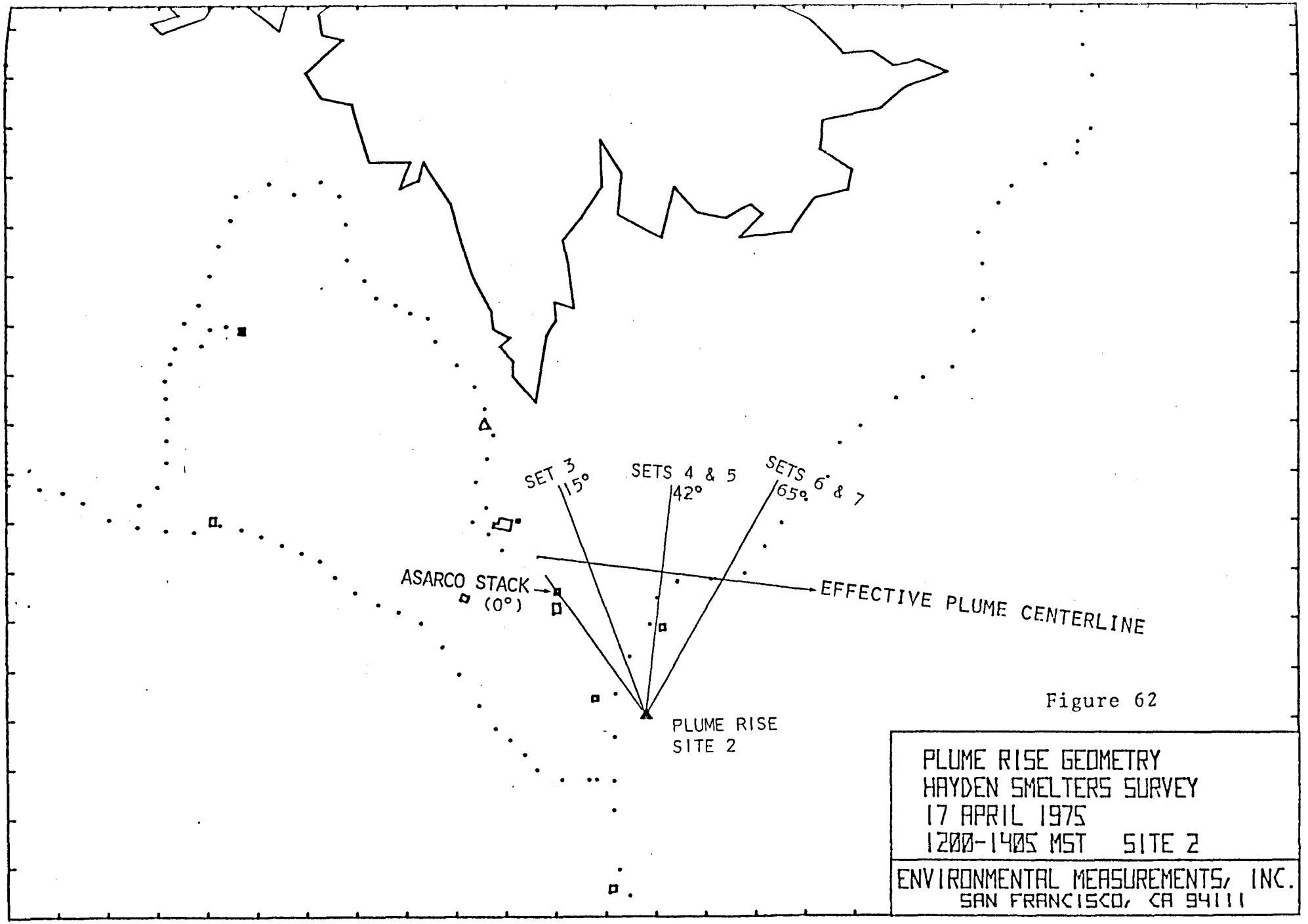


Figure 62

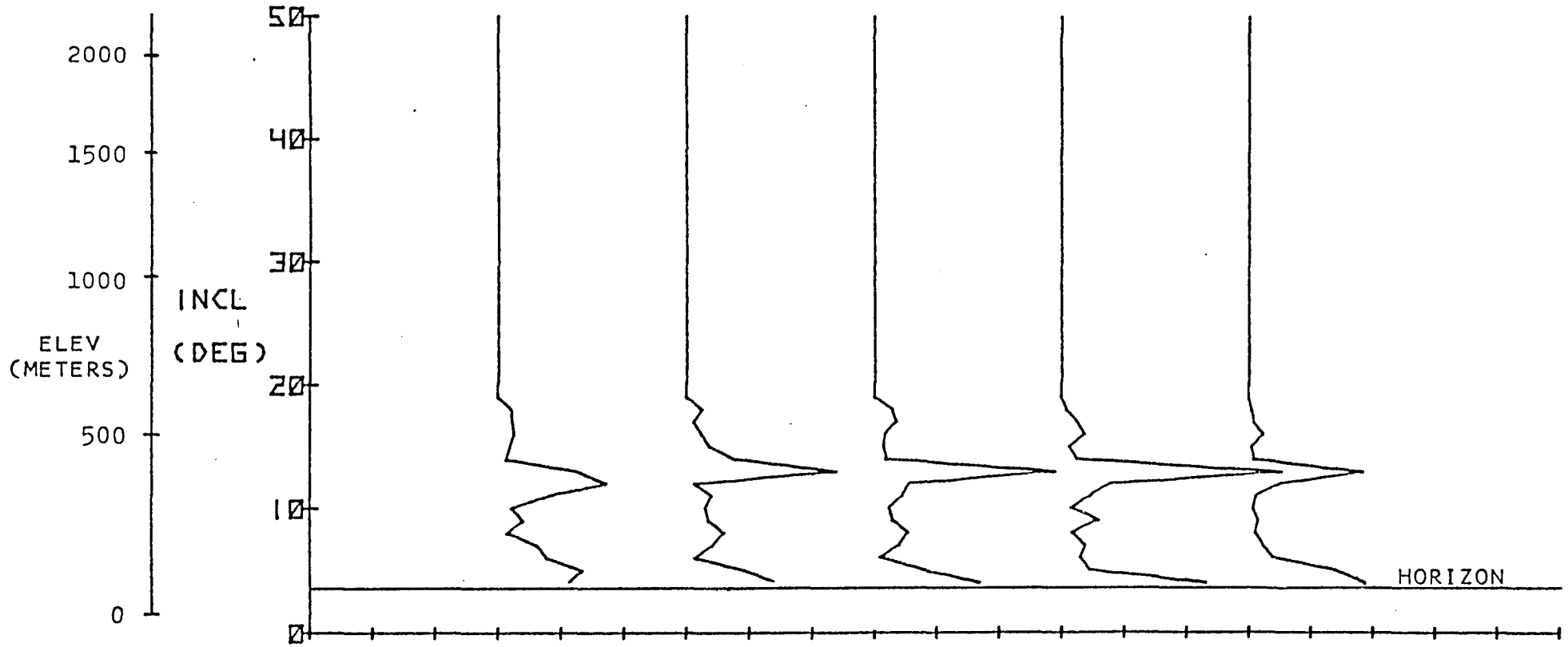
PLUME RISE GEOMETRY
HAYDEN SMELTERS SURVEY
17 APRIL 1975
1200-1405 MST SITE 2

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

FIGURE 63

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1254

SITE: 2
SET: 1 BETWEEN STACKS

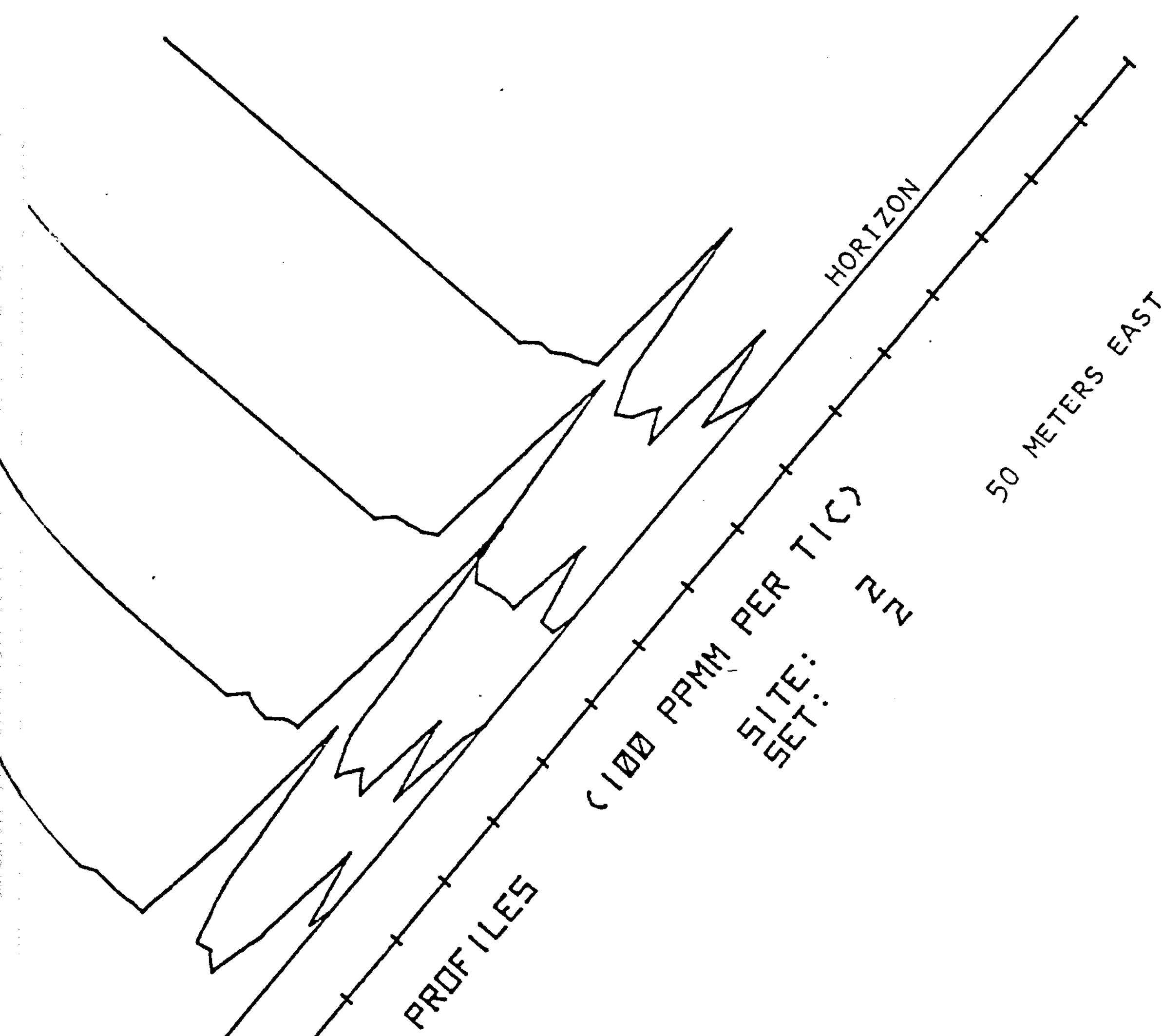
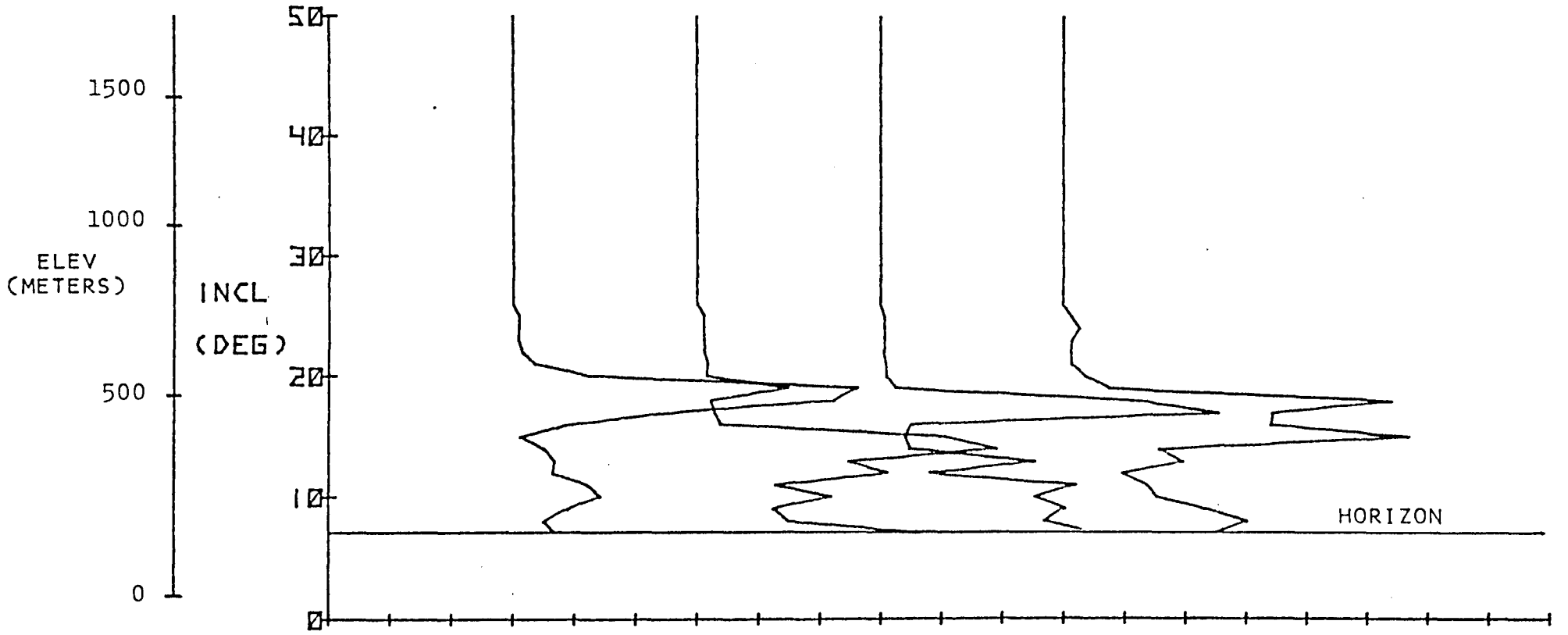

HORIZON
PROFILES (100 PPMM PER TIC)
SITE: 2
SET: 2
50 METERS EAST

FIGURE 65

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1314

SITE: 2
SET: 3 600 METERS EAST

18 APRIL 75/SITE 2 PLUME RISE

Site 2 was used again on 18 April. The wind had a more southerly component so the plume vector was east-southeast. The 5°, 20°, 45°, and 65° horizontal measurement angles are shown on Figure 70.

A total of 23 plume rise profiles are plotted (Figures 71-76). Compared to the previous day these profiles show SO_2 dispersing more vertically, up to 40 degrees (1000 meters) or more. This was due partly to the more southerly plume trajectory. But the combination of meteorology and topography caused higher burdens at the horizon; both stack and fugitive emissions could have contributed to the near-ground SO_2. Even though the stack tops were visually separated (see Figure 4) the profiles do not show individual plumes that can be attributed to either stack.

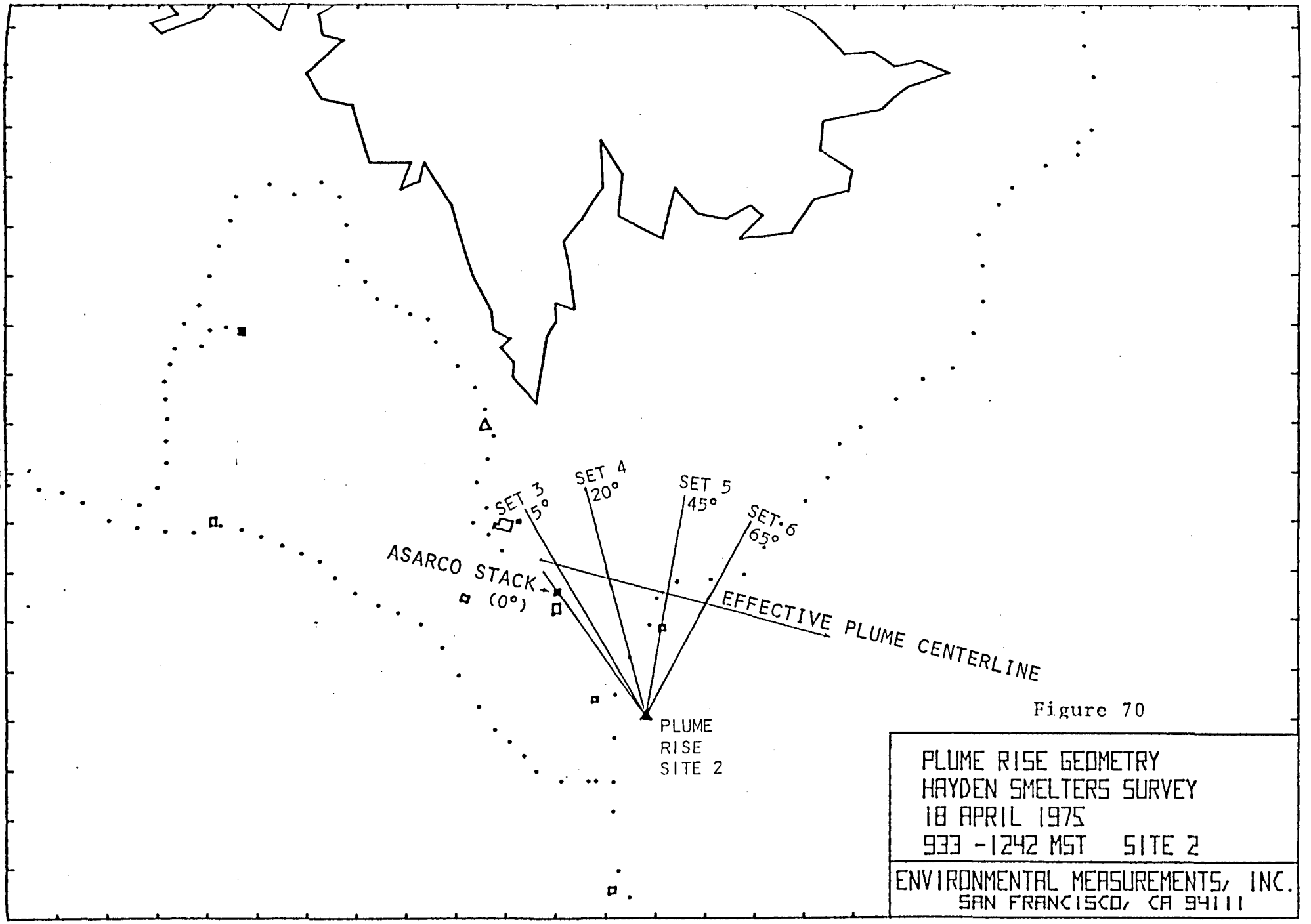


Figure 70

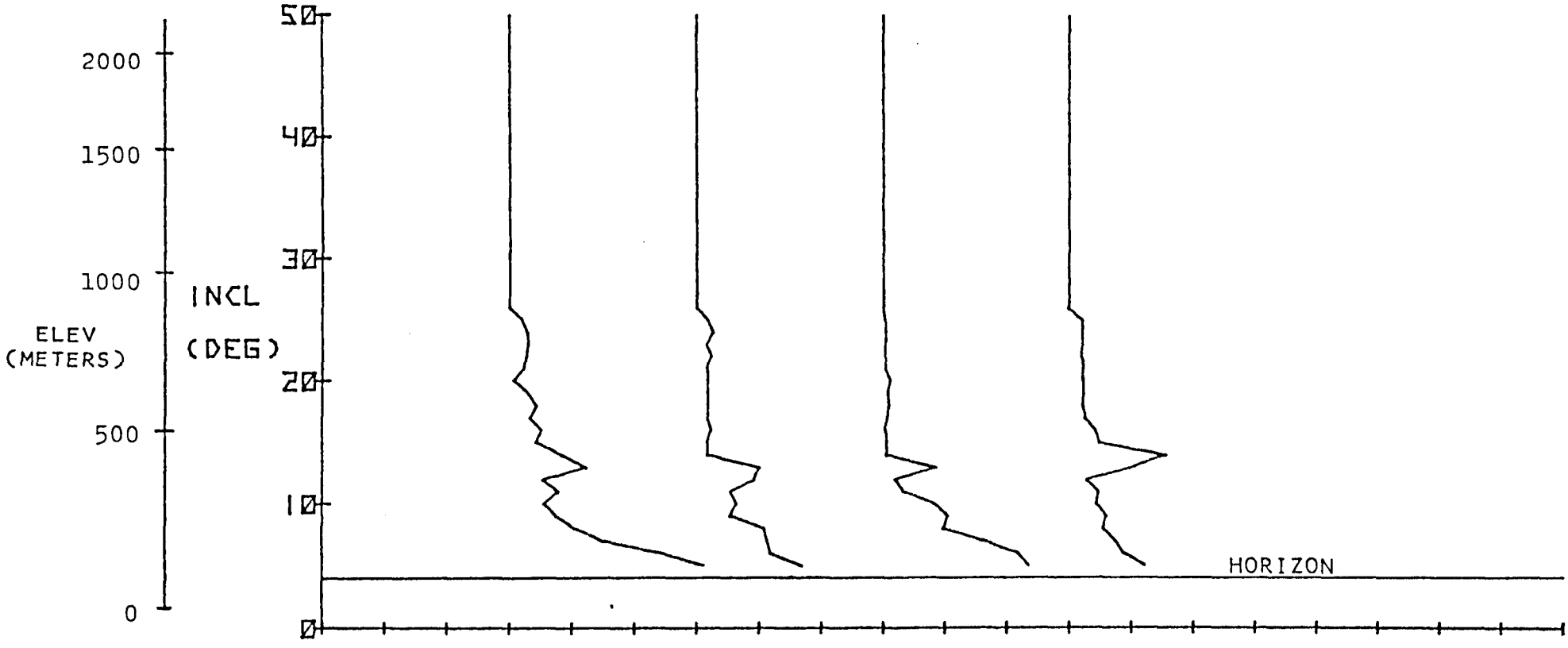
PLUME RISE GEOMETRY
HAYDEN SMELTERS SURVEY
18 APRIL 1975
933 -1242 MST SITE 2

ENVIRONMENTAL MEASUREMENTS, INC.
SAN FRANCISCO, CA 94111

FIGURE 71

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 180475
TIME: 1017

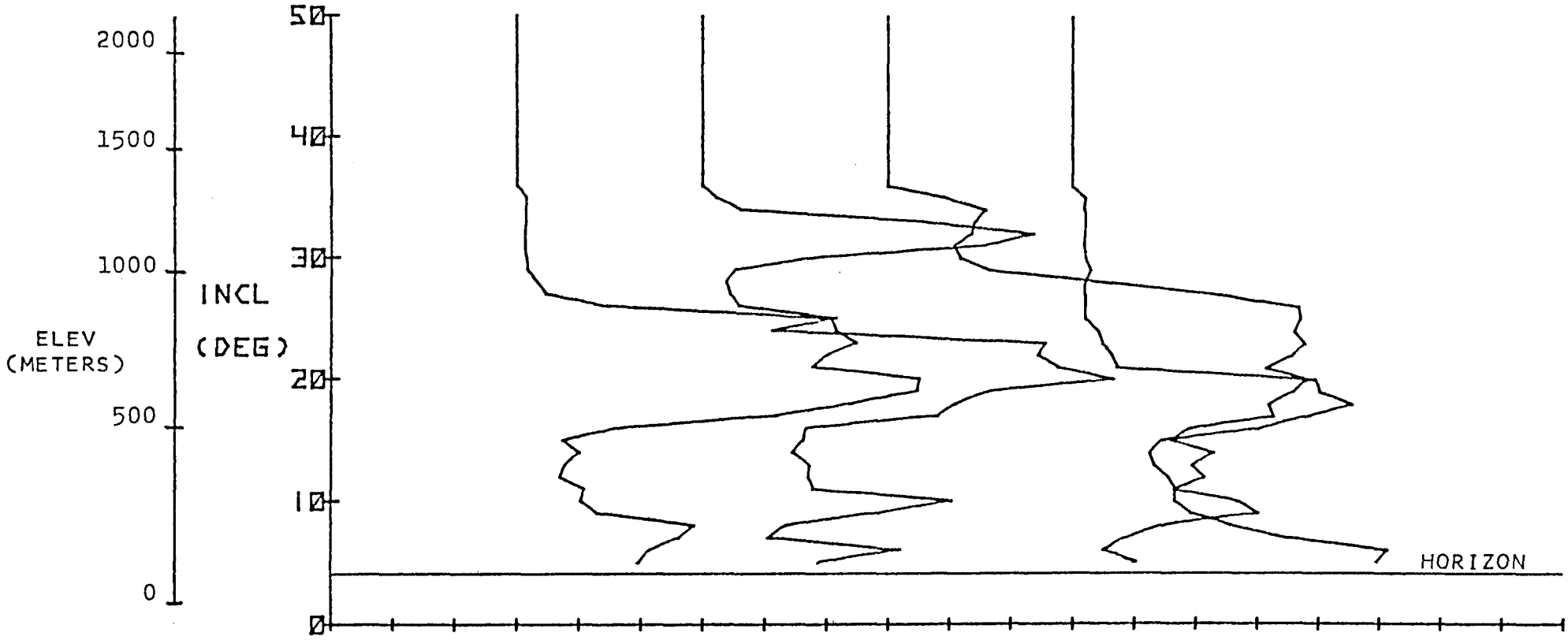
SITE: 2
SET: 1

BETWEEN STACKS

FIGURE 72

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

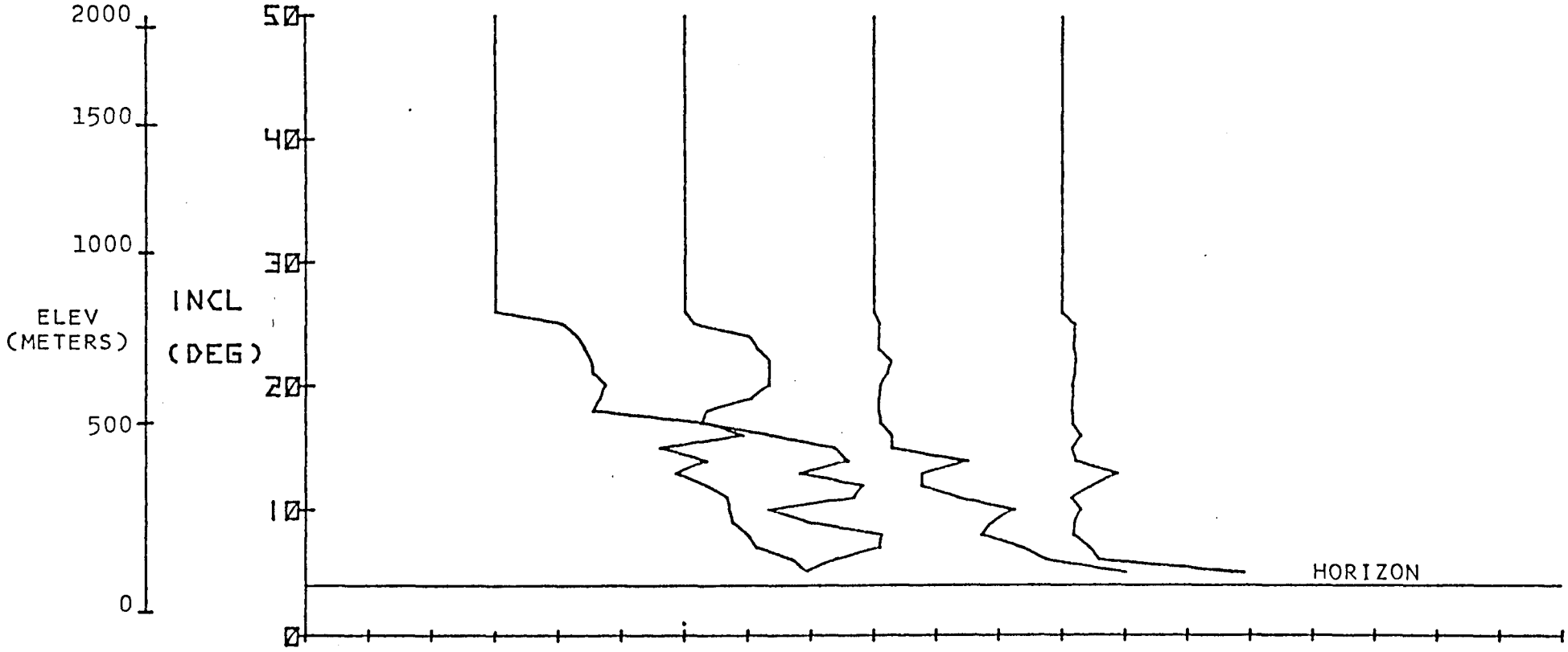
DATE: 180475
TIME: 1027

SITE: 2
SET: 2 BETWEEN STACKS

FIGURE 73

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 180475
TIME: 1036

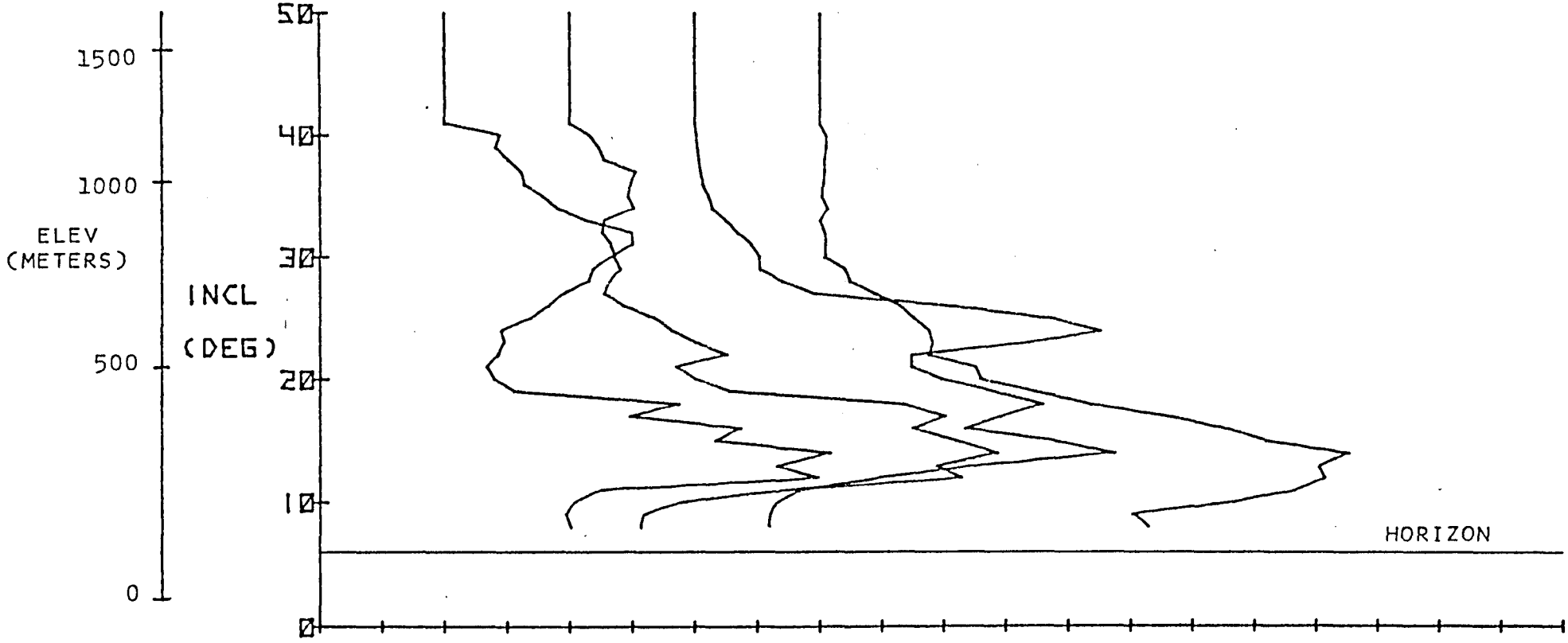
SITE: 2
SET: 3

160 METERS EAST

FIGURE 74

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 180475
TIME: 1049

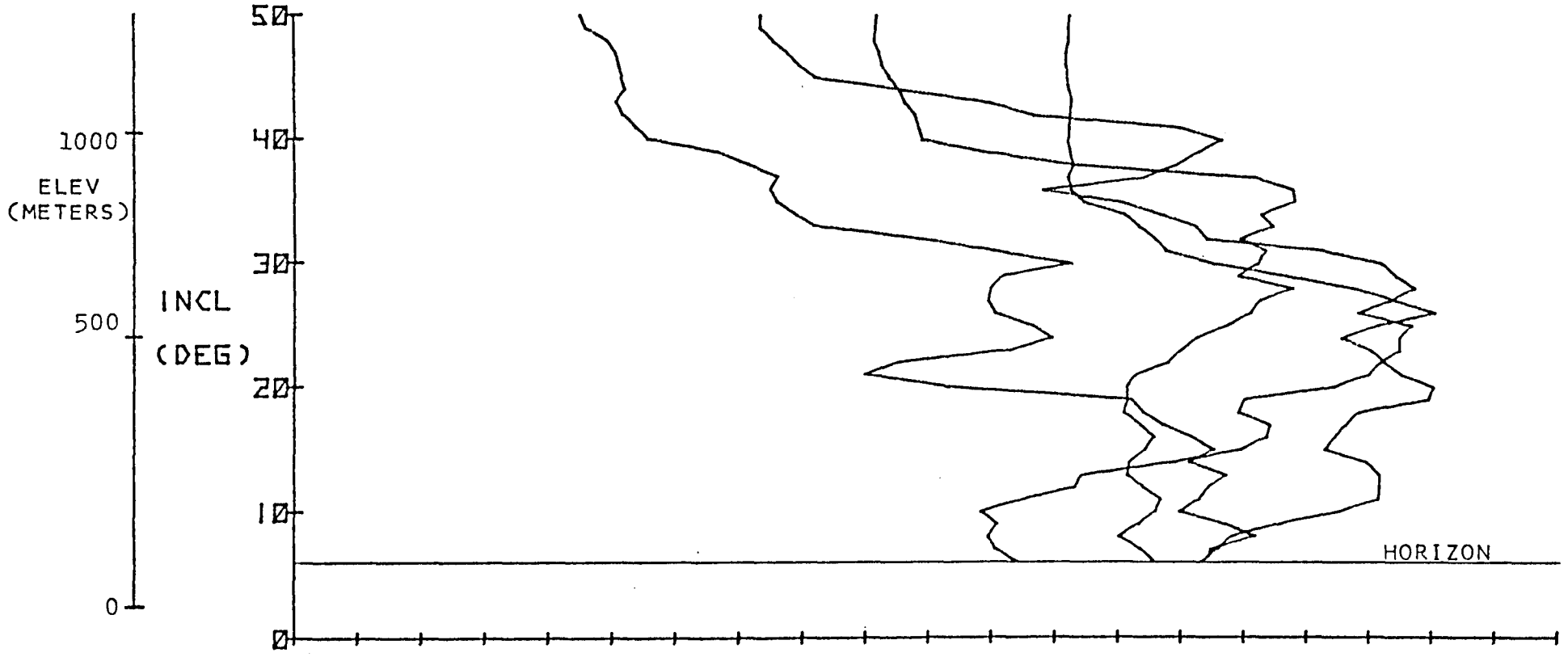
SITE: 2
SET: 4

700 METERS EAST

FIGURE 75

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 180475
TIME: 1104

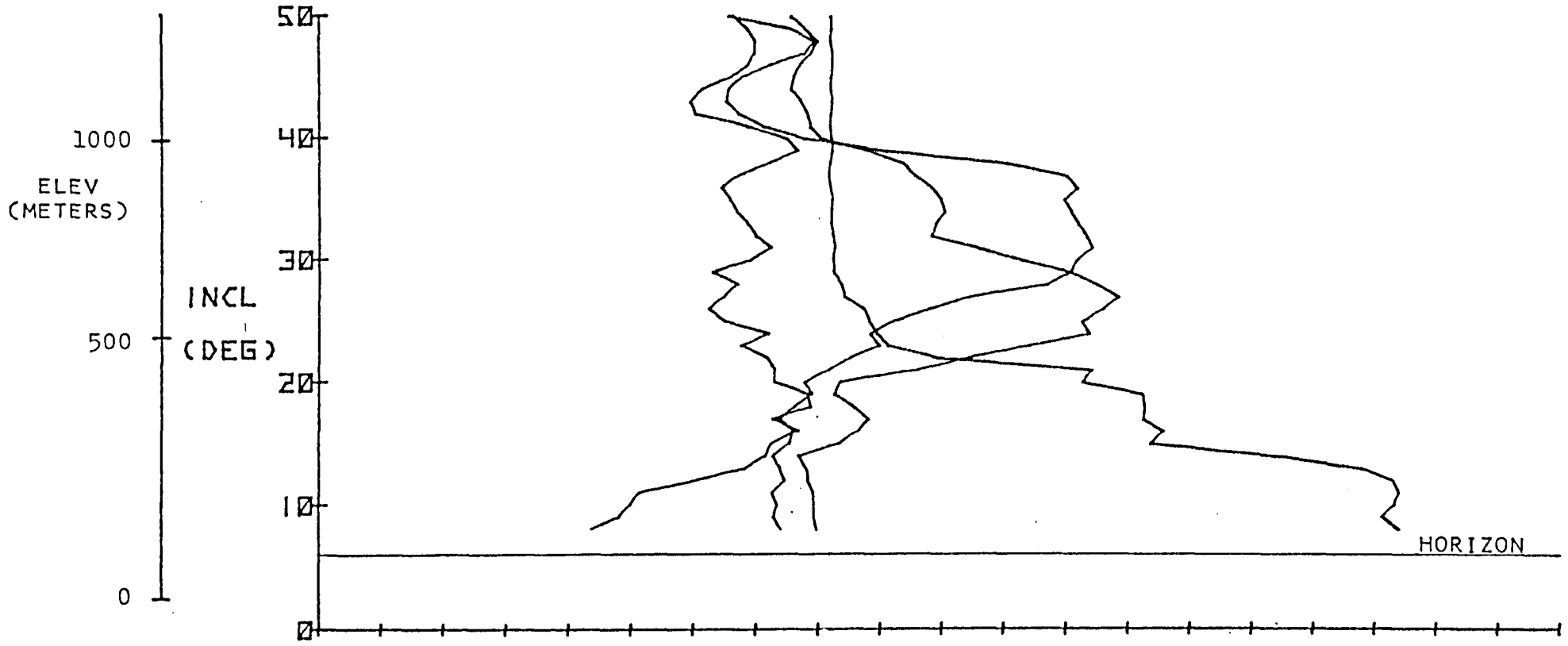
SITE: 2
SET: 5

1300 METERS EAST

FIGURE 76

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 180475
TIME: 1120

SITE: 2
SET: 6

1700 METERS EAST

Plume Height. The individual plume rise profiles for 17 and 18 April illustrate a lack of uniformity in vertical plume geometry for the meteorological conditions that existed in Hayden. More measurements and extended study would be required to better understand the plume behavior for this tall stack/complex terrain situation. No detailed analyses of the KCC and ASARCO plumes--individually and as a combined plume--were made. However, the plume height for each set of profiles was analyzed.

The plume height was determined from the remote sensor data and the site and stack geometry. Using the effective plume centerlines the height of the plume (in meters) was calculated for each downwind distance (in meters, converted from angles); the height was measured from the ground, midway between the two stacks.

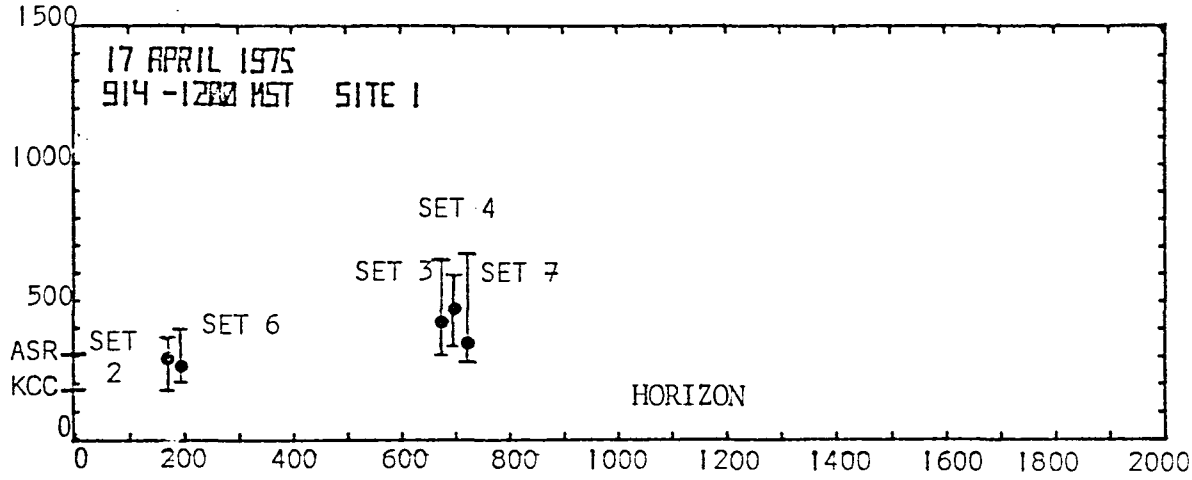
Three plots of plume height are shown in Figure 77. They show the vertical location of averaged sets of plume rise measurements. The plume center (the peak ppmM value) of each set is a "dot" located at an elevation; the vertical width of the average plume is drawn as a scale line. The tops of the stacks are labeled KCC and ASR.

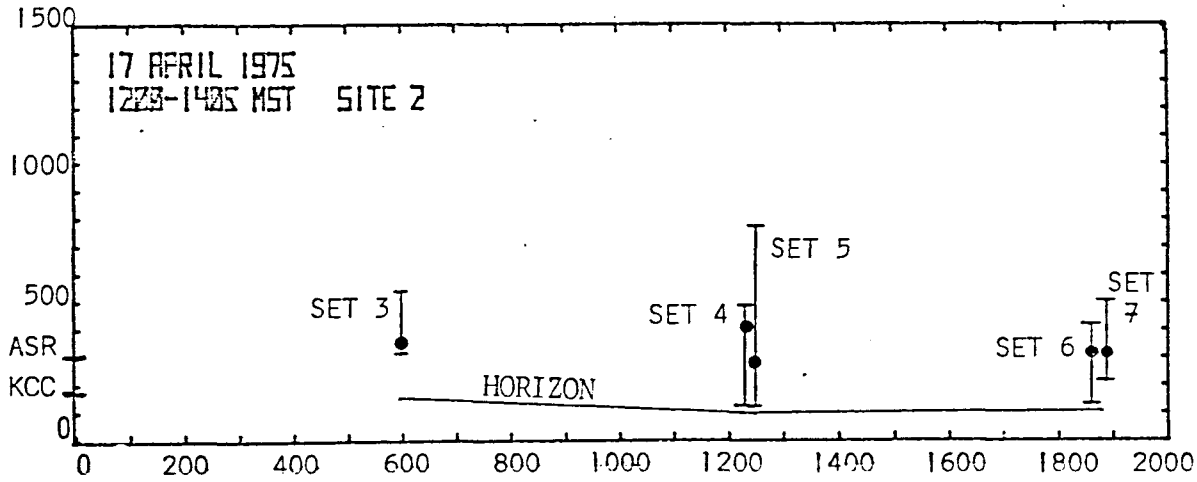
The two plots for 17 April show a rising plume centerline in the morning (to 500 meters) and a flatter trajectory (to 400 meters) later in the day. The plume (or plumes)

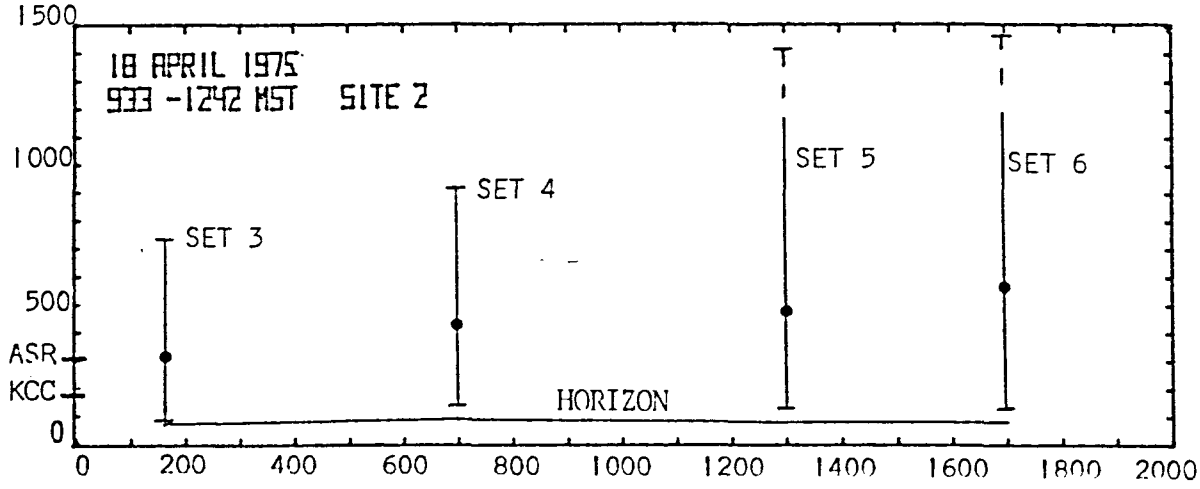
Figure 77

PLUME HEIGHT

HAYDEN SMELTERS EMISSION SURVEY







were well defined (except for Set 5) with a vertical dimension of 400 meters or less.

The 18 April plume centerline reached nearly 600 meters elevation, 1700 meters downwind. The vertical plume dimension was 750 meters or more; the top edge of the plume was less well defined for Sets 5 and 6, as indicated by the dashed lines.

SO_2 MASS FLUX

Emission rates for the smelters have been estimated from the moving remote sensor data. The SO_2 burden results and information derived from the pibal measurements were combined with traverse route geography to calculate SO_2 mass flux. A total of 23 Events were processed by computer; the results are tabulated in Table IV. The mass flux values--estimates for the amount of SO_2 in the overhead plumes--are listed in both kilograms per hour (kg/hr) and pounds per hour (lb/hr); averages for each day are included.

The average SO_2 mass flux for all five days (23 calculations) is 23,330 kg/hr (51,450 lb/hr) SO_2; the standard deviation (as a percent of the mean) is 77%; this statistic indicates a wide spread in the calculated flux values. Some of this spread in the results is the expected error of the remote sensor measurements (See Section 3). However, the smelters cannot be assumed to be constant emission sources; thus, some of the spread is due to the true variation in the combined SO_2 emissions.

The calculations in Table IV are the result of individual passes of the AQML-mounted COSPEC under the dispersing plumes. The remote sensor makes a near-instantaneous measurement--a "snapshot" of the SO_2 in the overhead plume. Because the plume shape is usually not constant with time, each measurement produces a different result. As described in Section 3

TABLE IV

SO_2 MASS FLUX
Hayden Smelters Emission Survey

DATE	TIME (MST)	EVENT	WIND (M/S)	SO_2 MASS FLUX* (KG/HR)	AVG	(LB/HR)	AVG
14 Apr 75	1036-1055	8	5.9,3.9	28,750		63,350	
	1451-1500	18	7.1	47,500	38,150	104,700	84,100
15 Apr 75	0900-0910	3	2.5	12,600		27,750	
	0910-0925	4	2.5	10,050		22,150	
	0925-0940	5-6	2.9	16,700		36,800	
	1122-1136	10	3.0	17,750	18,500	39,100	40,750
	1136-1150	11	2.8	6,000		13,200	
	1630-1638	26	6.0	15,000		33,050	
	1645-1652	28	6.0	51,328		113,150	
16 Apr 75	0859-0927	4	3.1	14,200		31,300	
	0927-0952	5	4.0	35,200		77,600	
	1609-1616	23	6.8	34,250	20,600	75,500	45,400
	1616-1623	24	6.6	11,183		24,650	
	1623-1631	25	6.3	12,416		27,350	
	1631-1643	26	6.1	16,500		36,350	
17 Apr 75	1203-1211	14	6.0	31,000		68,300	
	1534-1539	26	5.5	21,100	45,500	46,500	100,300
	1555-1603	29	11.0	84,250		185,700	
18 Apr 75	0951-0959	7	2.4	10,800		23,800	
	1223-1228	17	2.9	15,250		33,600	
	1228-1232	18	2.9	10,400	14,200	22,900	31,300
	1232-1235	19	2.9	9,700		21,400	
	1235-1238	20	2.9	24,750		54,550	

* Combined SO_2 emission rates for the entire two-smelter complex.

a set of measurements (typically six) is required to obtain a reliable flux figure. This is illustrated by the averages for 15 and 16 April which are derived from six and seven separate calculations. The averages for the two days (18,500 kg/hr and 20,600 kg/hr) agree within 12%. The standard deviations are 81% (15th) and 54% (16th). The daily averages are a better measure of smelter SO_2 emissions than any one individual calculation.

These emission rates are for the entire smelter complex. All SO_2 plumes measured by the remote sensor--whether emanating from stacks or as fugitive emissions--are included in the calculations. For most measurements it was not practical to attempt to separate stack plumes from fugitive plumes; nor was it usually possible to identify plume anomalies in the data records as originating from the KCC or ASARCO stacks. In general, there were too little detailed wind data (even with the 35 pibals) to be able to define precise plume trajectories for a significant number of measurements. The rugged terrain had a pronounced effect on the plume paths, as well. Source separation would require additional field studies with, hopefully, more favorable wind directions than were experienced during this program.

The combined mass flux values can be expected to be larger than other SO_2 emission rates for the two smelters because essentially all of the SO_2 source points were being

tested simultaneously. There are other reasons why some of the fluxes may be high. Traverse routes that are sharply curved and terrain that is rough can cause positive errors in the calculation of remotely measured mass flux.

Higher emission rates were calculated along the Globe Highway (in the Gila River Canyon) than in the Montgomery Ranch area. The average of the sixteen Globe Highway SO_2 mass flux calculations is 26,900 kg/hr (59,300 lb/hr); this is significantly higher (78%) than the average for the COSPEC measurements west of the smelters, 15,150 kg/hr (33,400 lb/hr). There are two reasons for this difference. First, the only available traverse route northeast of Hayden is a curved canyon road (the Globe Highway). The plumes being measured were generally above the canyon. But the canyon walls may have channelled portions of the plumes along an irregular trajectory--unrelated to the straight-line plume path assumed for analysis. The effect is to distort the wind/road angle and plume width. The errors which enter the flux calculations tend to be positive; they increase the computed flux value. By comparison, the Montgomery Ranch traverses would be less influenced by this type of error because the topography is less rugged.

The second reason relates to the non-stack (fugitive) emissions. A single wind speed and direction was selected

from the pibal results to be representative of the wind conditions that existed within the elevated plume. In the case of the Globe Highway these wind data were applied to total burdens measured overhead in the plume--but also to any SO_2 gas which may have originated at low elevation points in the smelter complex. It is presumed that much of the remote sensor data were a combination of elevated plume and lower level fugitive emissions; this is supported by the high ground level SO_2 concentrations measured on this road. Because these low elevation emissions were probably being influenced by different "canyon winds" (both in speed and direction) the winds aloft data were incorrectly applied, causing an increase in the calculated mass flux. Again, by comparison, data collected in the Montgomery Ranch area would not suffer the same degree of error because of the less severe topography and micrometeorological effects.

SO_2 MASS FLUX

Emission rates for the smelters have been estimated from the moving remote sensor data. The SO_2 burden results and information derived from the pibal measurements were combined with traverse route geography to calculate SO_2 mass flux. A total of 23 Events were processed by computer; the results are tabulated in Table IV. The mass flux values--estimates for the amount of SO_2 in the overhead plumes--are listed in both kilograms per hour (kg/hr) and pounds per hour (lb/hr); averages for each day are included.

The average SO_2 mass flux for all five days (23 calculations) is 21,150 kg/hr (44,960 lb/hr) SO_2; the standard deviation (as a percent of the mean) is 50%; this statistic indicates a wide spread in the calculated flux values. Some of this spread in the results is the expected error of the remote sensor measurements (See Section 3). However, the smelters cannot be assumed to be constant emission sources; thus, some of the spread is due to the true variation in the combined SO_2 emissions.

The calculations in Table IV are the result of individual passes of the AQML-mounted COSPEC under the dispersing plumes. The remote sensor makes a near-instantaneous measurement--a "snapshot" of the SO_2 in the overhead plume. Because the plume shape is usually not constant with time, each measurement produces a different result. As described in Section 3

TABLE IV

SO_2 MASS FLUX
Hayden Smelters Emission Survey

DATE	TIME (MST)	EVENT	WIND (M/S)	SO_2 MASS FLUX* (KG/HR)	AVG	(LB/HR)	AVG
14 Apr 75	1036-1055	8	5.9,3.9	34,000		75,000	
	1451-1500	18	7.1	34,600	34,300	76,200	75,600
15 Apr 75	0900-0910	3	2.5	9,900		21,700	
	0910-0925	4	2.5	16,600		36,600	
	0925-0940	5-6	2.9	33,800		74,600	
	1122-1136	10	3.0	16,100	18,800	35,400	41,500
	1136-1150	11	2.8	3,500		7,700	
	1630-1638	26	6.0	20,000		44,100	
	1645-1652	28	6.0	31,800		70,100	
16 Apr 75	0859-0927	4	3.1	10,200		22,400	
	0927-0952	5	4.0	33,000		72,800	
	1609-1616	23	6.8	33,200	18,800	73,200	41,500
	1616-1623	24	6.6	8,100		17,800	
	1623-1631	25	6.3	8,500		18,500	
	1631-1643	26	6.1	20,100		44,100	
17 Apr 75	1203-1211	14	6.0	11,200		25,900	
	1534-1539	26	5.5	23,500	23,300	51,800	51,900
	1555-1603	29	11.0	35,300		77,900	
18 Apr 75	0951-0959	7	2.4	32,500		32,500	
	1223-1228	17	2.9	21,300		47,000	
	1228-1232	18	2.9	13,300	20,600	29,400	37,600
	1232-1235	19	2.9	12,800		28,200	
	1235-1238	20	2.9	23,200		51,100	

* Combined SO_2 emission rates for the entire two-smelter complex.

a set of measurements (typically six) is required to obtain a reliable flux figure. This is illustrated by the averages for 15 and 16 April which are derived from six and seven separate calculations. The average is the same for both days, 18,800 kg/hr (41,500 lb/hr). The standard deviations are 58% (15th) and 63% (16th). The daily averages are a better measure of smelter SO_2 emissions than any one individual calculation.

These emission rates are for the entire smelter complex. All SO_2 plumes measured by the remote sensor--whether emanating from stacks or as fugitive emissions--are included in the calculations. For most measurements it was not practical to attempt to separate stack plumes from fugitive plumes; nor was it usually possible to identify plume anomalies in the data records as originating from the KCC or ASARCO stacks. In general, there were too little detailed wind data (even with the 35 pibals) to be able to define precise plume trajectories for a significant number of measurements. The rugged terrain had a pronounced effect on the plume paths, as well. Source separation would require additional field studies with, hopefully, more favorable wind directions than were experienced during this program.

The combined mass flux values can be expected to be larger than other SO_2 emission rates for the two smelters because essentially all of the SO_2 source points were being

tested simultaneously. There are other reasons why some of the fluxes may be high. Traverse routes that are sharply curved and terrain that is rough can cause positive errors in the calculation of remotely measured mass flux.

Higher emission rates were calculated along the Globe Highway (in the Gila River Canyon) than in the Montgomery Ranch area. The average of the sixteen Globe Highway SO_2 mass flux calculations is 22,600 kg/hr (49,700 lb/hr); this is significantly higher (28%) than the average for the COSPEC measurements west of the smelters, 17,700 kg/hr (38,900 lb/hr). There are two reasons for this difference. First, the only available traverse route northeast of Hayden is a curved canyon road (the Globe Highway). The plumes being measured were generally above the canyon. But the canyon walls may have channelled portions of the plumes along an irregular trajectory--unrelated to the straight-line plume path assumed for analysis. The effect is to distort the wind/road angle and plume width. The errors which enter the flux calculations tend to be positive; they increase the computed flux value. By comparison, the Montgomery Ranch traverses would be less influenced by this type of error because the topography is less rugged.

The second reason relates to the non-stack (fugitive) emissions. A single wind speed and direction was selected

from the pibal results to be representative of the wind conditions that existed within the elevated plume. In the case of the Globe Highway these wind data were applied to total burdens measured overhead in the plume--but also to any SO_2 gas which may have originated at low elevation points in the smelter complex. It is presumed that much of the remote sensor data were a combination of elevated plume and lower level fugitive emissions; this is supported by the high ground level SO_2 concentrations measured on this road. Because these low elevation emissions were probably being influenced by different "canyon winds" (both in speed and direction) the winds aloft data were incorrectly applied, causing an increase in the calculated mass flux. Again, by comparison, data collected in the Montgomery Ranch area would not suffer the same degree of error because of the less severe topography and micrometeorological effects.

Accounting for the influence of the Gila River Canyon on flux calculations the five-day average SO_2 mass flux for the smelter complex should be reduced approximately 20%, to 16,920 kg/hr (35,970 lb/hr) SO_2.

APPENDIX A

Data Listings

Appendix A

Data Listings Index

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

AVIDON SMELTERS EMISSION SURVEY
PROJECT 102 14 APRIL 1975
EVENT NO. 8 1036 - 1055 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
1	519.87	3651.11	1706	0	10
2	519.76	3651.23	0	0	10
3	519.65	3651.35	1707	0	10
4	519.54	3651.41	0	0	10
5	519.43	3651.46	1761	0	10
6	519.33	3651.50	0	0	10
7	519.23	3651.54	1708	0	10
8	519.11	3651.60	0	0	10
9	518.94	3651.66	1760	11	10
10	518.80	3651.74	0	42	10
11	518.74	3651.82	1709	210	10
12	518.72	3651.90	0	231	10
13	518.64	3651.98	1710	105	10
14	518.53	3652.02	0	462	10
15	518.40	3652.06	1759	347	15
16	518.36	3652.10	0	452	30
17	518.26	3652.14	1711	399	25
18	518.16	3652.19	0	441	20
19	518.09	3652.23	1758	399	215
20	517.99	3652.27	0	336	25
21	517.86	3652.30	1712	273	15
22	517.75	3652.32	0	53	15
23	517.64	3652.34	1713	21	15
24	517.51	3652.31	0	0	15
25	517.30	3652.28	1714	0	15
26	517.24	3652.29	0	0	15
27	517.10	3652.29	1757	11	15
28	516.95	3652.31	0	11	15
29	516.81	3652.33	1715	11	15
30	516.72	3652.44	0	11	15
31	516.64	3652.56	1804	32	15
32	516.52	3652.64	0	53	15
33	517.41	3652.73	1807	126	15
34	517.06	3652.86	0	189	35
35	517.14	3652.98	1806	126	35
36	517.19	3653.09	0	95	60
37	517.18	3653.20	1850	137	30
38	517.11	3653.31	0	126	30
39	517.12	3653.42	1805	63	45
40	517.11	3653.52	0	168	90
41	517.14	3653.62	1851	242	40
42	517.09	3653.71	0	284	30
43	517.09	3653.80	1804	284	15
44	517.12	3653.80	0	263	310
45	517.15	3653.98	1852	179	420
46	517.17	3654.06	0	210	260
47	517.20	3654.14	1803	231	190
48	517.33	3654.15	0	273	440
49	517.46	3654.16	1853	210	210

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 14 APRIL 1975
EVENT NO. 8 1036 - 1055 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
50	517.50	3654.24	0	357	280
51	517.54	3654.32	1802	209	210
52	517.62	3654.34	0	263	190
53	517.70	3654.35	1854	231	210
54	517.78	3654.33	0	242	320
55	517.87	3654.31	1801	221	550

END OF EVENT 8

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 14 APRIL 1975
EVENT NO. 18 1451 - 1500 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
56	521.94	3651.33	762	9	10
57	521.97	3651.47	0	14	10
58	522.01	3651.60	763	14	10
59	522.11	3651.68	0	14	10
60	522.21	3651.76	747	18	10
61	522.30	3651.78	0	18	10
62	522.55	3651.79	764	18	10
63	522.72	3651.82	0	9	10
64	522.89	3651.84	746	18	10
65	523.09	3651.98	0	9	10
66	523.10	3652.11	765	9	10
67	523.18	3652.23	0	9	10
68	523.27	3652.35	745	5	5
69	523.39	3652.47	0	0	10
70	523.51	3652.58	766	5	20
71	523.62	3652.70	0	36	200
72	523.74	3652.81	767	135	400
73	523.86	3652.99	0	153	475
74	523.96	3653.16	768	108	400
75	524.06	3653.25	0	261	540
76	524.17	3653.33	744	189	380
77	524.25	3653.47	0	225	250
78	524.43	3653.61	743	261	200
79	524.57	3653.72	0	270	170
80	524.70	3653.82	769	189	160
81	524.85	3653.88	0	126	205
82	525.00	3653.93	743	99	230
83	525.18	3654.11	0	288	290
84	525.21	3654.29	741	180	55
85	525.26	3654.45	0	207	70
86	525.31	3654.61	770	216	45
87	525.31	3654.79	0	243	170
88	525.30	3654.97	771	297	180
89	525.28	3655.13	0	342	170
90	525.27	3655.29	740	378	220
91	525.37	3655.44	0	333	270
92	525.47	3655.59	772	378	320
93	525.53	3655.68	0	405	260
94	525.60	3655.76	739	360	100
95	525.77	3655.87	0	333	65
96	525.94	3655.98	773	270	50
97	526.10	3656.04	0	234	50
98	526.27	3656.09	738	216	50
99	526.27	3656.15	0	194	40
100	526.27	3656.21	774	185	40
101	526.34	3656.28	0	198	40
102	525.41	3656.34	737	221	50
103	526.42	3656.61	0	257	70
104	526.47	3656.87	736	234	60

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 14 APRIL 1975
EVENT NO. 18 1451 - 1500 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
105	526.38	3657.00	0	270	90
106	526.33	3657.18	775	315	60
107	526.32	3657.36	0	351	45
108	526.32	3657.54	735	234	30
109	526.13	3657.68	0	189	40
110	525.93	3657.81	734	180	45
111	525.86	3657.98	0	167	35
112	525.70	3658.14	733	135	30
113	525.72	3658.31	0	90	30
114	525.60	3658.48	776	54	25
115	525.69	3658.64	0	41	20
116	525.60	3658.79	732	41	20
117	525.67	3658.93	0	18	20
118	525.75	3659.06	777	9	20
119	525.85	3659.16	0	14	20
120	525.95	3659.25	731	27	20
121	525.90	3659.42	0	27	20
122	526.00	3659.59	778	27	20
123	526.00	3659.71	0	27	20
124	526.16	3659.82	730	27	20

END OF EVENT 18

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 3 900 - 910 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
125	517.01	3655.67	1813	22	120
126	517.78	3655.55	0	66	120
127	517.76	3655.43	1812	66	120
128	517.70	3655.30	0	55	110
129	517.64	3655.17	1811	33	100
130	517.59	3655.02	0	44	80
131	517.54	3654.86	1855	110	60
132	517.44	3654.72	0	242	50
133	517.43	3654.57	1810	638	50
134	517.36	3654.48	0	484	60
135	517.29	3654.39	1809	760	60
136	517.24	3654.27	0	528	60
137	517.20	3654.14	1808	154	60
138	517.17	3654.06	0	88	60
139	517.15	3653.98	1852	55	60
140	517.12	3653.89	0	44	60
141	517.09	3653.80	1804	99	60
142	517.09	3653.71	0	110	60
143	517.10	3653.62	1851	132	80
144	517.11	3653.52	0	154	90
145	517.12	3653.42	1805	143	90
146	517.11	3653.31	0	176	100
147	517.10	3653.20	1850	132	120
148	517.10	3653.09	0	132	120
149	517.10	3652.98	1806	88	140

END OF EVENT 3

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 4 910 - 925 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
150	517.10	3652.98	1806	88	140
151	517.10	3653.09	0	99	160
152	517.10	3653.20	1850	99	180
153	517.11	3653.31	0	77	180
154	517.12	3653.42	1805	44	200
155	517.11	3653.52	0	110	200
156	517.10	3653.62	1851	88	190
157	517.09	3653.71	0	132	180
158	517.90	3653.80	1804	132	170
159	517.12	3653.99	0	99	160
160	517.15	3653.98	1852	88	150
161	517.17	3654.06	0	242	140
162	517.20	3654.14	1803	594	140
163	517.24	3654.27	0	418	140
164	517.29	3654.39	1809	220	130
165	517.36	3654.48	0	99	110
166	517.43	3654.57	1810	99	110
167	517.49	3654.72	0	66	120
168	517.54	3654.86	1855	132	120
169	517.59	3655.02	0	176	120
170	517.64	3655.17	1811	143	120
171	517.70	3655.30	0	88	120
172	517.76	3655.43	1812	110	100
173	517.78	3655.55	0	132	90
174	517.81	3655.67	1813	143	60
175	517.98	3655.73	0	154	60
176	518.15	3655.79	1922	154	60
177	518.27	3655.74	0	165	60
178	518.40	3655.69	1921	165	60
179	518.53	3655.75	0	176	60
180	518.66	3655.81	1923	220	50
181	518.76	3655.74	0	66	60
182	518.87	3655.67	1919	286	60
183	518.98	3655.53	0	154	60
184	519.91	3655.39	1918	418	60
185	519.02	3655.21	0	319	60
186	519.93	3655.02	1917	286	60
187	519.01	3654.92	0	506	70
188	519.10	3654.81	1916	880	70
189	519.15	3654.73	0	1380	70
190	519.21	3654.64	1915	1340	70
191	519.31	3654.00	0	800	80
192	519.41	3654.56	1914	594	140
193	519.48	3654.52	0	2680	180
194	519.55	3654.48	1913	1020	170
195	519.64	3654.46	0	275	200
196	519.73	3654.43	1912	860	240
197	519.76	3654.32	0	3250	240
198	519.80	3654.20	1911	1950	440

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 4 910 - 925 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
199	519.91	3654.08	0	2440	420
200	520.02	3653.95	1910	616	340
201	520.10	3653.84	0	1340	360
202	520.19	3653.73	1909	1020	320
203	520.24	3653.62	0	572	330
204	520.29	3653.51	1908	830	320

END OF EVENT 4

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 5-6 925 - 940 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
205	520.29	3653.51	1908	740	320
206	520.24	3653.62	0	484	320
207	520.19	3653.73	1909	550	340
208	520.10	3653.84	0	680	340
209	520.03	3653.95	1910	740	310
210	519.91	3654.08	0	1020	330
211	519.80	3654.20	1911	1390	370
212	519.76	3654.32	0	2800	380
213	519.74	3654.43	1912	3400	400
214	519.64	3654.46	0	1100	420
215	519.55	3654.48	1913	880	460
216	519.48	3654.52	0	940	480
217	519.41	3654.56	1914	940	520
218	519.31	3654.60	0	850	660
219	519.21	3654.64	1915	740	1020
220	519.16	3654.73	0	720	520
221	519.14	3654.81	1916	820	520
222	519.01	3654.92	0	840	440
223	518.93	3655.02	1917	374	450
224	518.92	3655.21	0	528	400
225	518.91	3655.39	1918	462	440
226	518.88	3655.53	0	385	740
227	518.85	3655.67	1919	528	1020
228	518.76	3655.74	0	840	1390
229	518.66	3655.81	1920	132	1390
230	518.53	3655.75	0	198	830
231	518.40	3655.69	1921	297	820
232	518.27	3655.74	0	407	1290
233	518.15	3655.79	1922	374	1090
234	517.98	3655.73	0	484	880
235	517.81	3655.67	1813	572	560
236	517.73	3655.55	0	264	360
237	517.76	3655.43	1812	308	480
238	517.70	3655.30	0	550	600
239	517.64	3655.17	1911	572	590
240	517.59	3655.02	0	440	790
241	517.54	3654.86	1855	740	920
242	517.49	3654.72	0	940	620
243	517.43	3654.57	1810	572	550
244	517.36	3654.48	0	88	500
245	517.29	3654.39	1809	242	450
246	517.24	3654.27	0	418	430
247	517.20	3654.14	1808	231	440
248	517.17	3654.06	0	187	340
249	517.15	3653.98	1852	110	340
250	517.12	3653.89	0	198	410
251	517.09	3653.80	1804	242	400
252	517.00	3653.71	0	286	390
253	517.10	3653.62	1851	352	280

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 5-6 925 - 940 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
254	517.11	3653.52	0	176	220
255	517.12	3653.42	1805	242	190
256	517.11	3653.31	0	286	160
257	517.10	3653.20	1850	198	100
258	517.10	3653.09	0	198	100
259	517.10	3652.98	1806	187	90
260	517.06	3652.86	0	198	80
261	517.01	3652.73	1807	132	70
262	516.92	3652.64	0	77	70
263	516.84	3652.55	1808	66	60
264	516.02	3652.44	0	66	50
265	516.01	3652.33	1715	88	20
266	516.95	3652.31	0	220	30
267	517.10	3652.29	1757	220	20
268	517.24	3652.29	0	132	30
269	517.38	3652.28	1714	198	60
270	517.51	3652.31	0	187	50
271	517.64	3652.34	1713	143	20
272	517.75	3652.32	0	110	60
273	517.85	3652.30	1712	165	40
274	517.95	3652.27	0	176	20
275	518.05	3652.23	1758	198	20
276	518.16	3652.19	0	176	20
277	518.26	3652.14	1711	286	20
278	518.36	3652.10	0	176	70
279	518.46	3652.06	1759	220	80
280	518.55	3652.02	0	110	40
281	518.64	3651.98	1710	22	10
282	518.72	3651.90	0	0	10
283	518.79	3651.82	1709	0	10
284	518.80	3651.74	0	0	0
285	518.99	3651.66	1760	0	0
286	519.11	3651.60	0	0	0
287	519.23	3651.54	1708	0	0
288	519.33	3651.50	0	0	0
289	519.43	3651.46	1761	0	0
290	519.54	3651.41	0	0	0
291	519.65	3651.35	1707	0	0
292	519.76	3651.23	0	0	0
293	519.87	3651.11	1706	-0	0

END OF EVENT 5-6

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

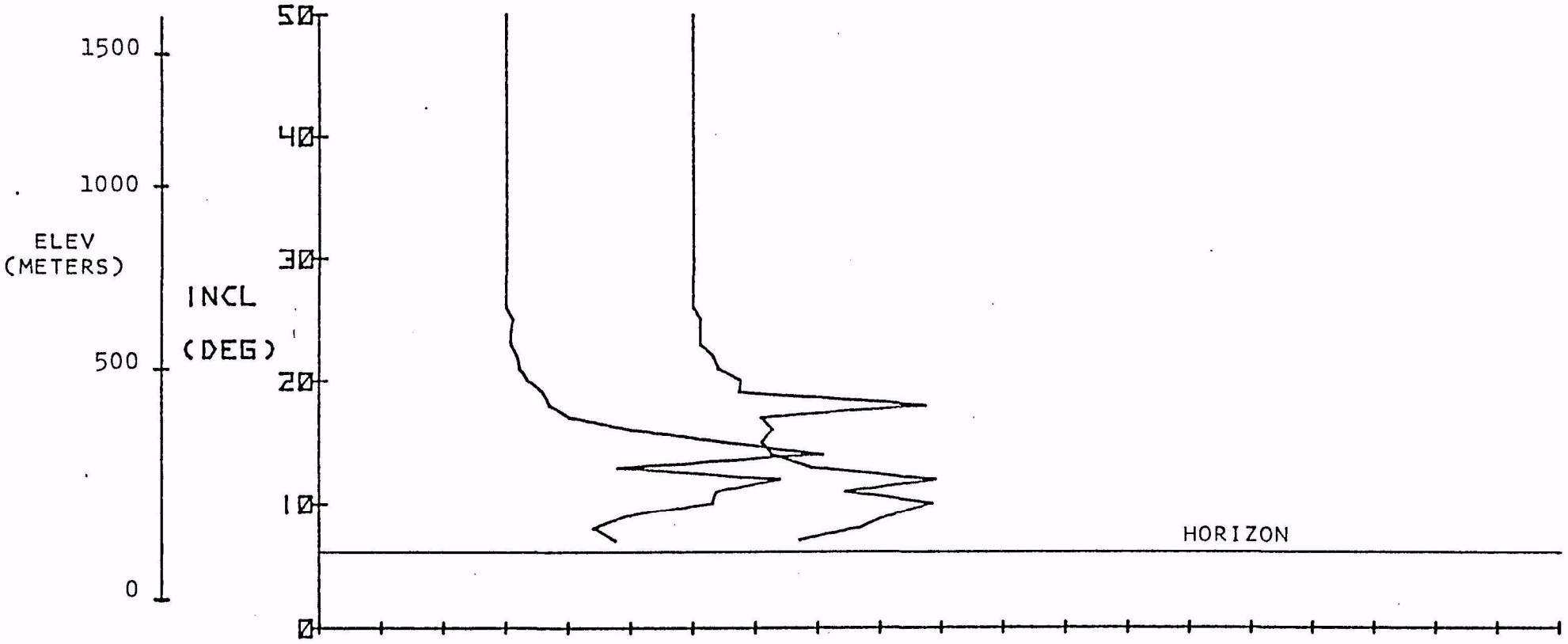
HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 10 1122 - 1136 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
1	520.20	3653.51	1908	0	0
2	520.24	3653.62	0	0	0
3	520.19	3653.73	1909	0	0
4	520.10	3653.84	0	0	0
5	520.02	3653.95	1910	0	0
6	519.91	3654.08	0	0	0
7	519.80	3654.20	1911	17	0
8	519.76	3654.32	0	17	0
9	519.73	3654.43	1912	6	0
10	519.64	3654.46	0	17	0
11	519.55	3654.48	1913	17	0
12	519.48	3654.52	0	11	0
13	519.41	3654.56	1914	17	0
14	519.31	3654.60	0	11	0
15	519.21	3654.64	1915	17	10
16	519.16	3654.73	0	22	20
17	519.10	3654.81	1916	17	20
18	519.01	3654.92	0	22	20
19	518.93	3655.02	1917	33	20
20	518.92	3655.21	0	88	20
21	518.91	3655.39	1918	6	20
22	518.88	3655.53	0	0	20
23	518.85	3655.67	1919	11	20
24	518.76	3655.74	0	17	20
25	518.66	3655.81	1920	11	20
26	518.53	3655.75	0	22	20
27	518.40	3655.69	1921	22	20
28	518.27	3655.74	0	22	80
29	518.15	3655.79	1922	50	100
30	517.90	3655.73	0	28	70
31	517.81	3655.67	1813	28	100
32	517.78	3655.55	0	66	40
33	517.76	3655.43	1812	11	50
34	517.70	3655.30	0	55	80
35	517.64	3655.17	1811	33	90
36	517.59	3655.02	0	237	90
37	517.54	3654.86	1855	413	1350
38	517.49	3654.72	0	539	1200
39	517.43	3654.57	1810	616	1020
40	517.36	3654.48	0	790	1370
41	517.29	3654.39	1809	638	600
42	517.24	3654.27	0	385	300
43	517.20	3654.14	1808	121	160
44	517.17	3654.06	0	55	140
45	517.15	3653.98	1852	33	60
46	517.12	3653.89	0	11	40
47	517.09	3653.80	1804	17	40
48	517.09	3653.71	0	33	30
49	517.10	3653.62	1851	22	40

FIGURE 66

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

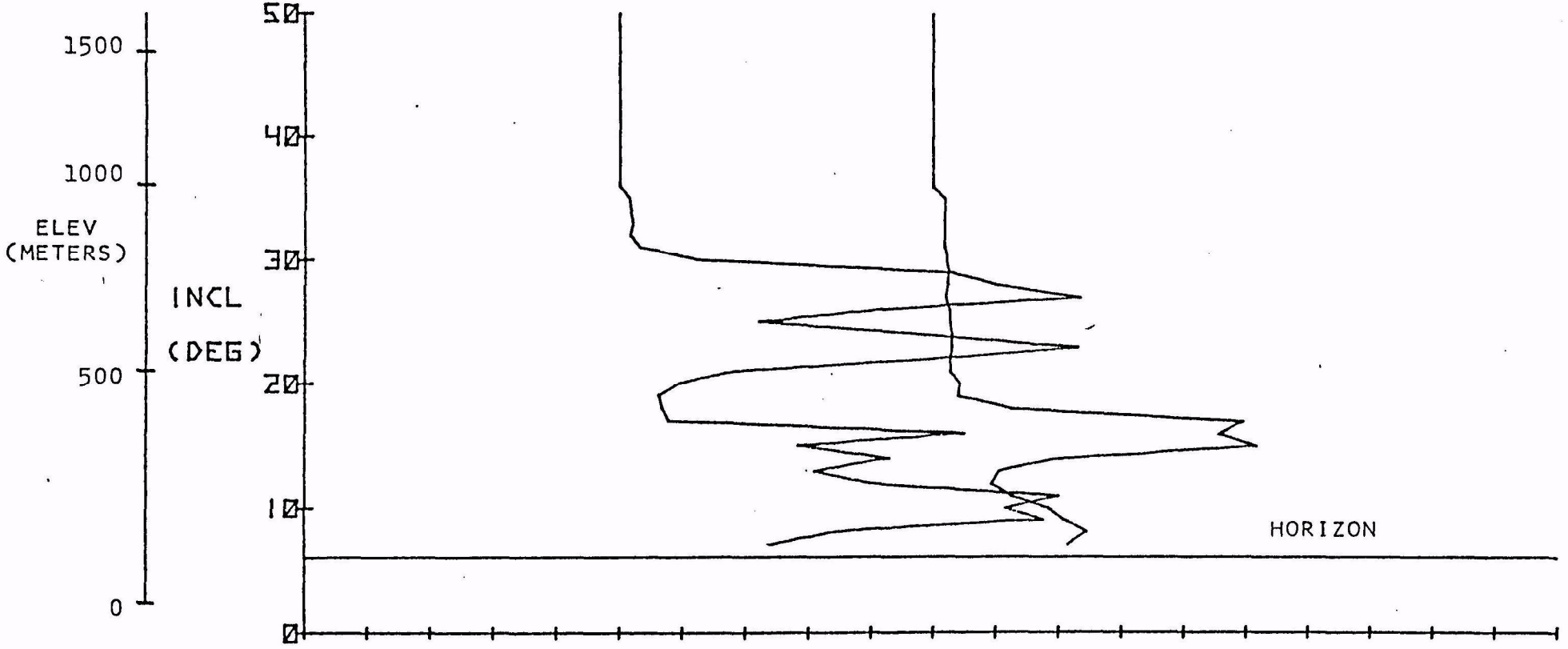
DATE: 170475
TIME: 1325

SITE: 2
SET: 4 1250 METERS EAST

FIGURE 67

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1337

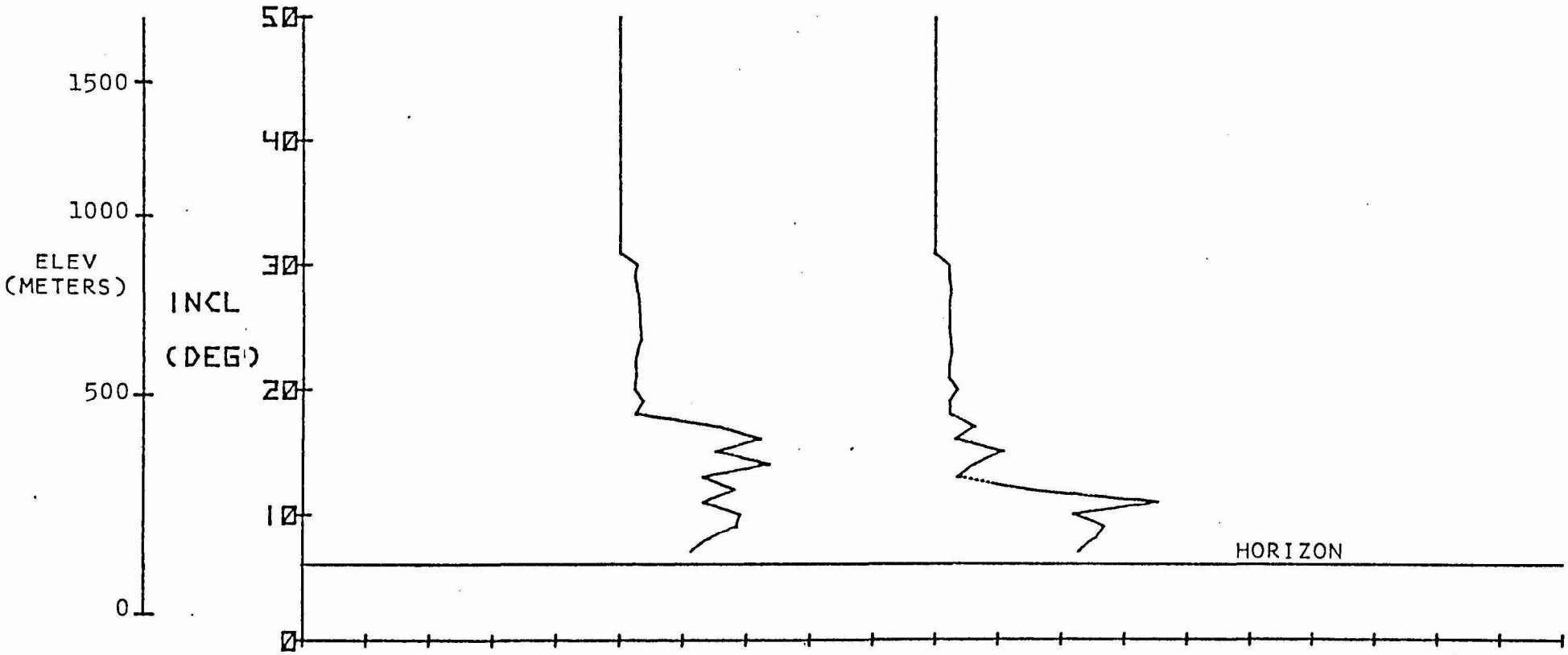
SITE: 2
SET: 5

1250 METERS EAST

FIGURE 68

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1355

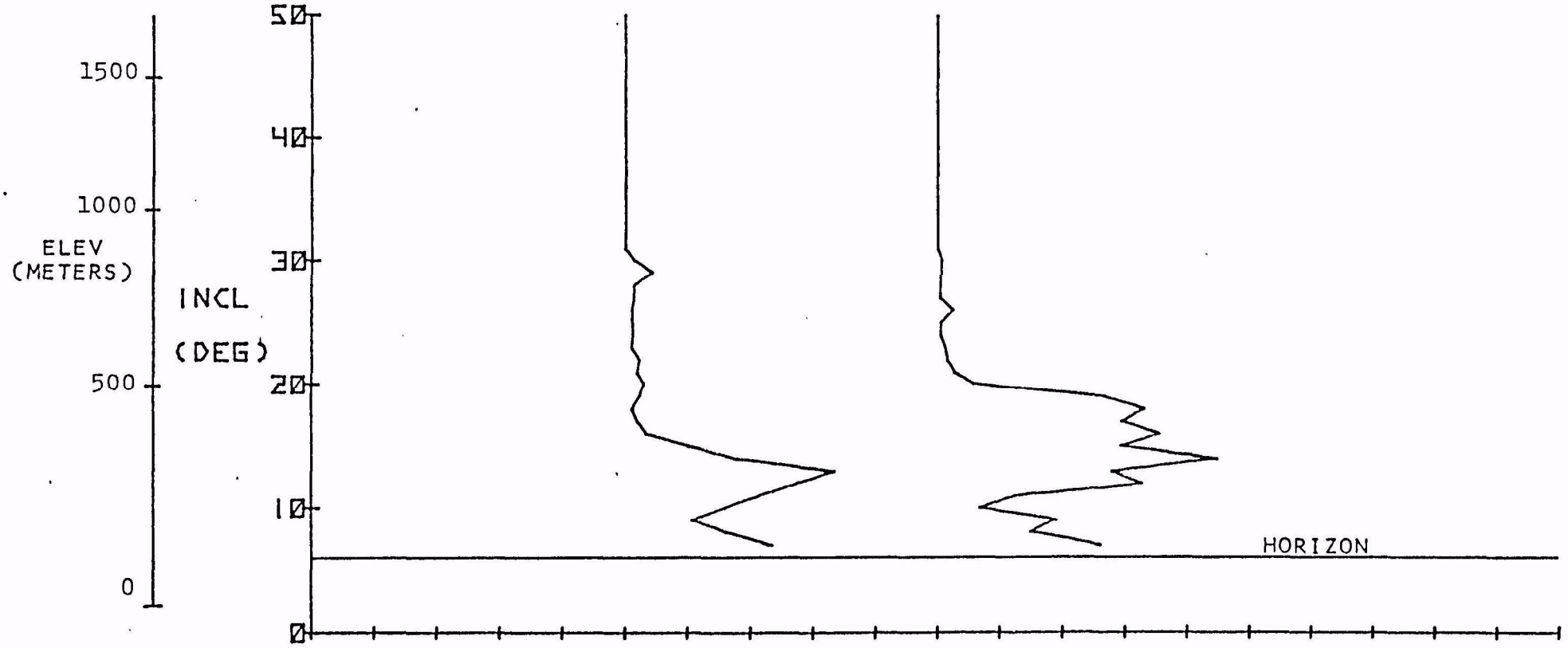
SITE: 2
SET: 6

1875 METERS EAST

FIGURE 69

ENVIRONMENTAL MEASUREMENTS INC.

PLUME RISE STUDY: EPA/HAYDEN



INDIVIDUAL PROFILES (100 PPMM PER TIC)

DATE: 170475
TIME: 1401

SITE: 2
SET: 7

1875 METERS EAST

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 10 1122 - 1136 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
50	517.11	3653.52	0	28	40
51	517.12	3653.42	1805	28	50
52	517.11	3653.31	0	11	40
53	517.10	3653.20	1850	33	70
54	517.10	3653.09	0	77	80
55	517.10	3652.98	1805	110	60
56	517.06	3652.86	0	143	100
57	517.01	3652.73	1807	143	150
58	516.92	3652.64	0	88	180
59	516.84	3652.55	1808	77	150
60	516.82	3652.44	0	66	70
61	516.81	3652.38	1715	44	40

END OF EVENT 10

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 11 1136 - 1150 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
62	516.01	3652.33	1715	44	30
63	516.04	3652.55	1808	11	20
64	517.01	3652.73	1807	11	20
65	517.10	3652.98	1806	22	15
66	517.10	3653.20	1850	55	40
67	517.12	3653.42	1805	72	70
68	517.10	3653.62	1851	55	50
69	517.09	3653.80	1804	44	50
70	517.15	3653.98	1852	11	40
71	517.20	3654.14	1803	66	50
72	517.29	3654.39	1809	66	70
73	517.43	3654.57	1810	132	40
74	517.54	3654.86	1855	116	35
75	517.64	3655.17	1811	77	60
76	517.76	3655.43	1812	66	35
77	517.81	3655.67	1813	33	30
78	518.15	3655.79	1922	17	15
79	518.44	3655.69	1921	17	30
80	518.60	3655.81	1920	33	20
81	518.85	3655.67	1919	33	15
82	518.91	3655.39	1918	11	15
83	518.90	3655.02	1917	11	45
84	519.10	3654.81	1916	6	20
85	519.21	3654.64	1915	0	15
86	519.41	3654.56	1914	44	10
87	519.55	3654.48	1913	264	10
88	519.73	3654.43	1912	99	10
89	519.88	3654.20	1911	187	10
90	520.02	3653.95	1910	198	10
91	520.19	3653.73	1909	66	10
92	520.29	3653.51	1908	77	10

END OF EVENT 11

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 26 1630 - 1638 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
120	521.94	3651.33	762	0	0
121	521.97	3651.47	0	0	0
122	522.01	3651.60	763	0	0
123	522.11	3651.68	0	0	0
124	522.21	3651.76	747	0	0
125	522.38	3651.78	0	0	0
126	522.55	3651.79	764	0	0
127	522.72	3651.82	0	0	0
128	522.89	3651.84	746	0	0
129	522.99	3651.98	0	0	0
130	523.10	3652.11	765	0	0
131	523.10	3652.23	0	0	0
132	523.27	3652.35	745	0	0
133	523.39	3652.47	0	0	0
134	523.51	3652.58	766	0	0
135	523.62	3652.70	0	0	0
136	523.74	3652.81	767	0	0
137	523.88	3652.99	0	24	0
138	523.96	3653.16	768	360	20
139	523.96	3653.25	0	180	60
140	524.07	3653.33	744	408	20
141	524.25	3653.47	0	192	140
142	524.43	3653.61	743	288	270
143	524.57	3653.72	0	648	1370
144	524.70	3653.82	769	588	1370
145	524.85	3653.88	0	690	1370
146	525.00	3653.93	742	860	560
147	525.10	3654.11	0	408	260
148	525.21	3654.29	741	132	90
149	525.26	3654.45	0	72	90
150	525.31	3654.61	770	60	80
151	525.31	3654.79	0	48	60
152	525.30	3654.97	771	36	100
153	525.20	3655.13	0	24	50
154	525.27	3655.29	740	24	50
155	525.37	3655.44	0	48	30
156	525.47	3655.59	772	48	20
157	525.53	3655.68	0	36	20
158	525.60	3655.76	739	30	10
159	525.77	3655.87	0	24	10
160	525.94	3655.98	773	24	10
161	526.14	3656.04	0	36	0
162	526.27	3656.09	738	36	0

END OF EVENT 26

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 15 APRIL 1975
EVENT NO. 28 1645 - 1652 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
163	521.74	3651.01	761	0	0
164	521.80	3651.17	0	0	10
165	521.84	3651.33	762	960	10
166	521.97	3651.47	0	400	10
167	522.01	3651.60	763	25	10
168	522.11	3651.68	0	0	10
169	522.21	3651.76	747	0	20
170	522.38	3651.78	0	38	30
171	522.50	3651.79	764	0	60
172	522.72	3651.82	0	50	90
173	522.89	3651.84	746	38	90
174	522.99	3651.98	0	50	70
175	523.10	3652.11	765	75	30
176	523.13	3652.23	0	200	30
177	523.27	3652.35	745	300	50
178	523.39	3652.47	0	325	160
179	523.51	3652.58	766	400	760
180	523.62	3652.70	0	840	100
181	523.74	3652.81	767	1820	170
182	523.80	3652.99	0	600	190
183	523.86	3653.16	768	1010	140
184	523.96	3653.25	0	600	100
185	524.07	3653.33	744	760	300
186	524.25	3653.47	0	425	90
187	524.43	3653.61	743	38	60
188	524.57	3653.72	0	25	60
189	524.70	3653.82	769	75	80
190	524.85	3653.88	0	125	70
191	525.00	3653.93	742	0	60
192	525.10	3654.11	0	25	40
193	525.21	3654.29	741	13	40
194	525.26	3654.45	0	13	120
195	525.31	3654.61	770	0	150
196	525.31	3654.79	0	0	80
197	525.30	3654.97	771	38	50
198	525.28	3655.13	0	0	40
199	525.27	3655.29	740	0	20
200	525.37	3655.44	0	13	20
201	525.47	3655.59	772	0	10
202	525.53	3655.68	0	13	10
203	525.60	3655.76	739	13	10
204	525.77	3655.87	0	0	10
205	525.94	3655.98	773	0	10

END OF EVENT -28

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 4 859 - 927 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
206	517.87	3654.31	1801	10	340
207	517.70	3654.35	1854	20	390
208	517.54	3654.32	1802	40	380
209	517.46	3654.16	1853	50	405
210	517.20	3654.14	1803	60	410
211	517.15	3653.98	1852	80	510
212	517.09	3653.80	1804	95	520
213	517.10	3653.62	1851	120	460
214	517.12	3653.42	1805	90	380
215	517.10	3653.20	1850	120	400
216	517.10	3652.98	1806	100	270
217	517.01	3652.73	1807	100	165
218	516.94	3652.55	1808	100	100
219	516.81	3652.33	1715	160	90
220	517.38	3652.28	1714	130	90
221	517.44	3652.34	1713	120	70
222	517.85	3652.30	1712	120	60
223	518.05	3652.23	1758	50	60
224	518.26	3652.14	1711	70	70
225	518.46	3652.06	1759	60	50
226	518.64	3651.98	1710	40	10
227	518.79	3651.82	1709	20	5
228	519.49	3651.66	1760	80	0
229	519.13	3651.54	1708	60	0
230	519.44	3651.46	1761	30	0
231	519.65	3651.35	1707	0	0
232	519.87	3651.11	1706	0	0
233	520.08	3650.84	1705	10	0
234	520.23	3650.52	1762	0	0
235	520.40	3650.29	1704	0	30
236	520.54	3650.17	1703	0	30
237	520.69	3650.02	1763	0	30
238	520.01	3649.87	1702	0	30
239	521.06	3649.77	1701	0	30
240	521.33	3649.77	1764	5	30
241	521.41	3649.77	750	10	30
242	521.50	3650.20	760	20	30
243	521.60	3650.64	740	20	30
244	521.74	3651.01	761	20	40
245	521.94	3651.33	762	20	50
246	522.01	3651.60	763	20	40
247	522.21	3651.76	747	20	40
248	522.55	3651.79	764	30	35
249	522.89	3651.84	746	40	40
250	523.10	3652.11	765	40	40
251	523.27	3652.35	745	40	50
252	523.51	3652.58	766	50	50
253	523.74	3652.81	767	0	50
254	523.96	3653.16	768	10	55

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 4 859 - 927 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
255	524.07	3653.33	744	20	45
256	524.43	3653.61	743	10	50
257	524.79	3653.82	769	10	55
258	525.00	3653.93	742	30	80
259	525.21	3654.29	741	40	90
260	525.51	3654.61	770	40	70
261	525.30	3654.97	771	20	50
262	525.27	3655.29	740	10	45
263	525.47	3655.59	772	0	35
264	525.60	3655.76	739	0	30
265	525.94	3655.98	773	10	30
266	526.27	3656.09	738	15	30
267	526.27	3656.21	774	20	30
268	526.41	3656.34	737	20	30
269	526.42	3656.87	736	20	25
270	526.33	3657.18	775	10	30
271	526.32	3657.54	735	10	30
272	525.93	3657.81	734	40	30
273	525.73	3658.14	733	10	60
274	525.65	3658.48	776	40	30
275	525.00	3658.79	732	20	30
276	525.75	3659.06	777	20	30
277	525.95	3659.25	731	10	30
278	526.00	3659.59	778	20	30
279	526.16	3659.82	730	20	30
280	526.44	3660.24	729	30	30
281	526.61	3660.74	728	30	30
282	526.47	3661.09	727	20	25
283	526.25	3661.16	726	35	20
284	525.90	3661.27	779	20	20
285	525.57	3661.46	725	30	20
286	525.23	3661.74	780	70	20
287	524.85	3662.14	724	100	20
288	524.43	3662.30	781	120	15
289	524.01	3662.39	723	110	10
290	523.59	3662.55	782	120	10
291	523.13	3662.76	722	140	10
292	522.77	3662.94	783	150	10
293	522.40	3663.13	721	110	10
294	521.96	3663.35	784	60	10
295	521.58	3663.53	720	10	10
296	521.46	3663.85	719	20	10
297	520.90	3665.16	718	20	10

END OF EVENT 4

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 5 927 - 952 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
315	520.90	3665.16	718	20	0
316	521.46	3663.85	719	20	0
317	521.58	3663.59	720	20	0
318	521.96	3663.35	784	80	10
319	522.40	3663.13	721	160	20
320	522.77	3662.94	783	200	50
321	523.13	3662.76	722	160	45
322	523.59	3662.55	782	220	30
323	524.01	3662.39	723	160	30
324	524.43	3662.30	781	100	30
325	524.65	3662.14	724	70	25
326	525.23	3661.74	780	50	20
327	525.57	3661.46	725	60	25
328	525.90	3661.27	779	70	35
329	526.25	3661.16	726	45	40
330	526.47	3661.09	727	50	60
331	526.61	3660.74	728	60	60
332	526.44	3660.24	729	40	60
333	526.16	3659.82	730	50	50
334	526.00	3659.59	778	50	60
335	525.95	3659.25	731	50	80
336	525.75	3659.06	777	50	110
337	525.60	3658.79	732	50	155
338	525.65	3658.48	776	55	130
339	525.78	3658.14	733	50	70
340	525.93	3657.81	734	50	50
341	526.32	3657.54	735	60	50
342	526.33	3657.18	775	60	40
343	526.42	3656.87	736	60	40
344	526.41	3656.34	737	60	40
345	526.27	3656.21	774	60	40
346	526.07	3656.09	738	60	40
347	525.94	3655.98	773	60	40
348	525.80	3655.76	739	60	40
349	525.47	3655.59	772	70	40
350	525.27	3655.29	740	70	40
1	525.30	3654.97	771	60	40
2	525.31	3654.61	770	50	45
3	525.21	3654.29	741	60	50
4	525.00	3653.93	742	80	50
5	524.70	3653.82	769	75	50
6	524.43	3653.61	743	70	60
7	524.07	3653.33	744	70	60
8	523.86	3653.16	768	75	65
9	523.74	3652.81	767	70	70
10	523.51	3652.58	766	70	70
11	523.27	3652.35	745	70	70
12	523.10	3652.11	765	70	75
13	522.89	3651.84	746	60	80

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 5 927 - 952 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
14	522.55	3651.79	764	60	85
15	522.21	3651.76	747	70	90
16	522.01	3651.60	763	70	145
17	521.94	3651.33	762	65	100
18	521.74	3651.01	761	60	75
19	521.60	3650.64	748	60	70
20	521.58	3650.20	760	50	55
21	521.41	3649.77	750	50	50
22	521.06	3649.77	1701	55	50
23	521.33	3649.77	1764	50	50
24	520.81	3649.87	1702	50	50
25	520.68	3650.02	1763	50	50
26	520.54	3650.17	1703	55	50
27	520.40	3650.29	1704	60	50
28	520.33	3650.52	1762	65	80
29	520.43	3650.84	1705	80	200
30	519.87	3651.11	1706	110	330

END OF EVENT 5

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 7 1042 - 1131 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
44	521.41	3649.77	750	0	0
45	521.58	3650.20	760	0	0
46	521.60	3650.64	748	0	0
47	521.74	3651.01	761	0	0
48	521.94	3651.33	762	0	0
49	522.01	3651.60	763	0	0
50	522.21	3651.76	747	0	0
51	522.55	3651.79	764	0	0
52	522.39	3651.84	746	0	0
53	523.10	3652.11	765	0	0
54	523.27	3652.35	745	0	0
55	523.51	3652.58	766	0	0
56	523.74	3652.81	767	30	0
57	523.86	3653.16	769	30	0
58	524.07	3653.33	744	10	0
59	524.43	3653.61	743	0	5
60	524.70	3653.82	769	20	5
61	525.00	3653.93	742	20	5
62	525.21	3654.29	741	0	10
63	525.31	3654.61	770	0	10
64	525.30	3654.97	771	5	5
65	525.27	3655.29	740	15	5
66	525.47	3655.59	772	15	5
67	525.69	3655.76	739	20	5
68	525.94	3655.98	773	20	5
69	526.27	3656.09	738	15	5
70	526.27	3656.21	774	10	5
71	526.41	3656.34	737	0	5
72	526.42	3656.87	736	0	5
73	526.33	3657.18	775	30	10
74	526.32	3657.54	735	60	10
75	525.98	3657.81	734	80	80
76	525.78	3658.14	733	155	165
77	526.65	3658.48	776	175	100
78	525.60	3658.79	732	240	185
79	525.75	3659.06	777	260	190
80	525.95	3659.25	731	220	150
81	526.00	3659.59	778	230	260
82	526.16	3659.82	730	280	245
83	526.44	3660.24	729	210	190
84	526.61	3660.74	728	160	160
85	526.47	3661.09	727	200	190
86	526.25	3661.16	726	260	215
87	525.90	3661.27	779	220	210
88	525.57	3661.46	725	160	240
89	525.26	3661.74	780	160	160
90	524.85	3662.14	724	75	40
91	524.43	3662.30	781	70	15

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 7 1042 - 1131 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
92	523.50	3662.55	782	60	60
93	523.13	3662.76	722	60	75
94	522.77	3662.94	783	20	40
95	522.40	3663.13	721	10	60
96	521.96	3663.35	784	30	40
97	521.58	3663.59	720	40	35
98	521.46	3663.85	719	50	30
99	520.90	3665.16	718	40	30
100	519.92	3666.18	717	15	20
101	518.69	3667.18	716	25	0
102	518.18	3668.24	715	0	0
103	518.31	3668.82	785	20	0
104	518.31	3669.28	714	20	0
105	518.13	3669.77	786	20	0
106	517.71	3670.48	713	10	0
107	517.62	3671.26	787	20	0
108	517.91	3671.93	712	20	0
109	518.20	3672.20	788	10	0
110	518.24	3672.69	789	15	0
111	518.38	3673.20	711	10	0
112	518.54	3673.82	790	20	0
113	519.83	3674.31	710	30	0
114	519.06	3675.01	791	10	0
115	519.39	3675.36	709	20	0
116	519.60	3675.90	792	10	0
117	519.77	3676.49	708	0	0
118	520.18	3677.06	793	0	0
119	520.32	3678.25	707	0	0
120	520.80	3679.36	794	0	0
121	520.97	3680.07	706	0	0
122	521.41	3680.30	795	0	0
123	521.62	3680.66	796	0	0
124	522.03	3680.99	705	0	0
125	522.37	3681.55	797	0	0
126	522.72	3681.75	798	0	0
127	522.88	3682.06	704	0	0
128	523.30	3682.87	799	0	0
129	523.61	3683.73	703	0	0
130	523.96	3684.86	800	0	0
131	524.47	3685.87	801	0	0
132	524.97	3686.85	702	0	0
133	525.00	3687.33	802	0	0
134	525.35	3688.07	803	0	0
135	525.39	3688.75	701	0	0
136	525.19	3689.42	804	0	0
137	524.83	3690.19	700	0	0

END OF EVENT 7

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 8 1131 - 1151 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
138	524.46	3692.41	850	0	0
139	525.40	3692.06	0	0	0
140	526.30	3691.70	851	0	0
141	527.23	3691.30	0	0	0
142	528.13	3690.89	852	0	0
143	529.08	3690.70	0	10	0
144	530.03	3690.51	853	30	0
145	531.46	3690.31	0	30	0
146	532.30	3690.11	854	45	0
147	533.23	3689.90	0	40	0
148	534.26	3689.69	805	40	0
149	535.04	3689.53	0	45	5
150	535.82	3689.36	855	50	5
151	536.70	3689.06	0	75	10
152	537.58	3688.76	856	85	10
153	538.36	3688.48	0	90	15
154	539.15	3688.20	857	140	25
155	540.15	3687.83	0	125	50
156	541.10	3687.46	858	140	60
157	542.03	3687.14	0	140	65
158	542.91	3686.81	806	110	15
159	543.65	3686.54	0	100	5
160	544.40	3686.26	859	90	0
161	545.06	3685.91	0	50	0
162	546.31	3685.56	807	15	0
163	547.45	3685.22	0	20	0
164	548.60	3684.87	808	30	0
165	549.60	3684.56	0	10	0
166	550.61	3684.25	860	10	0

END OF EVENT 8

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 21 1550 - 1600 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
167	521.41	3649.77	750	0	10
168	521.58	3650.20	760	0	5
169	521.60	3650.64	748	10	5
170	521.74	3651.01	761	0	5
171	521.94	3651.33	762	0	5
172	522.01	3651.60	763	5	5
173	522.21	3651.76	747	70	5
174	522.55	3651.79	764	10	5
175	522.89	3651.84	746	10	5
176	523.10	3652.11	765	330	5
177	523.27	3652.35	745	1810	5
178	523.51	3652.58	766	1160	5
179	523.74	3652.81	767	340	5
180	523.85	3653.16	768	260	5
181	524.07	3653.33	744	460	5
182	524.43	3653.61	743	260	5
183	524.70	3653.82	769	160	5
184	525.00	3653.93	742	70	5
185	525.21	3654.29	741	120	20
186	525.21	3654.61	770	180	130
187	525.34	3654.97	771	200	95
188	525.27	3655.29	740	200	10
189	525.47	3655.59	772	200	10
190	525.60	3655.76	739	220	5
191	525.64	3655.98	773	250	5
192	526.17	3656.09	738	280	5
193	526.27	3656.21	774	220	5
194	526.41	3656.34	737	160	5
195	526.42	3656.87	736	140	5
196	526.33	3657.18	775	100	5
197	526.32	3657.54	735	100	5
198	525.93	3657.81	734	80	5
199	525.78	3650.14	733	70	5

END OF EVENT 21

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 22 1600 - 1609 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
200	525.78	3658.14	733	84	10
201	525.86	3657.98	0	105	10
202	525.93	3657.81	734	84	10
203	526.13	3657.68	0	105	10
204	526.32	3657.54	735	63	10
205	526.32	3657.36	0	63	10
206	526.33	3657.18	775	105	10
207	526.38	3657.03	0	95	10
208	526.42	3656.87	736	84	10
209	526.42	3656.61	0	84	10
210	526.41	3656.34	737	126	10
211	526.34	3656.28	0	126	10
212	526.27	3656.21	774	95	10
213	526.27	3656.15	0	84	10
214	526.27	3656.09	738	105	10
215	526.10	3656.04	0	84	10
216	525.94	3655.98	773	84	10
217	525.77	3655.87	0	84	10
218	525.60	3655.76	739	126	10
219	525.53	3655.68	0	126	10
220	525.47	3655.59	772	126	10
221	525.37	3655.44	0	63	10
222	525.27	3655.29	740	105	10
223	525.20	3655.13	0	105	10
224	525.30	3654.97	771	105	10
225	525.31	3654.79	0	105	10
226	525.31	3654.61	770	126	10
227	525.26	3654.45	0	189	10
228	525.21	3654.29	741	147	10
229	525.10	3654.11	0	168	100
230	525.00	3653.93	742	378	400
231	524.85	3653.88	0	567	540
232	524.70	3653.82	769	441	600
233	524.57	3653.72	0	504	1060
234	524.43	3653.61	743	399	1110
235	524.25	3653.47	0	252	800
236	524.07	3653.33	744	189	770
237	523.96	3653.25	0	126	700
238	523.86	3653.16	768	231	640
239	523.80	3652.99	0	389	450
240	523.74	3652.81	767	273	430
241	523.62	3652.70	0	231	420
242	523.51	3652.58	766	189	270
243	523.39	3652.47	0	790	90
244	523.27	3652.35	745	483	140
245	523.18	3652.23	0	420	50
246	523.10	3652.11	765	630	45
247	522.99	3651.98	0	441	40
248	522.89	3651.84	746	168	60

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 22 1600 - 1609 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
249	522.72	3651.82	0	126	90
250	522.55	3651.79	764	126	55
251	522.38	3651.78	0	105	100
252	522.21	3651.76	747	116	100
253	522.11	3651.68	0	168	270
254	522.01	3651.60	763	63	150
255	521.97	3651.47	0	84	75
256	521.94	3651.33	762	84	130
257	521.84	3651.17	0	63	20
258	521.74	3651.01	761	84	10

END OF EVENT 22

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 23 1609 - 1616 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
259	521.74	3651.01	761	88	10
260	521.94	3651.33	762	132	10
261	522.61	3651.60	763	209	40
262	522.21	3651.76	747	132	95
263	523.55	3651.79	764	132	50
264	522.09	3651.84	740	110	20
265	523.10	3652.11	765	220	15
266	523.27	3652.35	745	638	20
267	523.51	3652.58	766	880	40
268	523.74	3652.81	767	220	60
269	523.96	3653.16	768	286	90
270	524.07	3653.33	744	330	45
271	524.43	3653.61	743	418	130
272	524.70	3653.82	769	286	50
273	525.00	3653.98	742	242	100
274	525.11	3654.29	741	220	70
275	525.31	3654.61	770	121	20
276	525.30	3654.97	771	66	15
277	525.27	3655.29	740	66	10
278	525.47	3655.59	772	55	10

END OF EVENT 23

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 24 1616 - 1623 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
279	525.47	3655.59	772	24	10
280	525.27	3655.29	740	0	10
281	525.00	3654.97	771	0	10
282	525.01	3654.61	770	0	10
283	525.21	3654.29	741	48	20
284	525.00	3653.93	742	48	60
285	524.70	3653.82	769	72	340
286	524.49	3653.61	743	72	40
287	524.07	3653.33	744	120	90
288	523.86	3653.16	768	72	90
289	523.74	3652.81	767	264	70
290	523.51	3652.58	766	144	170
291	523.17	3652.35	745	72	60
292	523.10	3652.11	765	72	30
293	522.89	3651.84	746	0	40
294	522.55	3651.79	764	0	50
295	522.21	3651.76	747	24	70
296	522.01	3651.60	763	24	350
297	521.94	3651.39	762	24	100
298	521.74	3651.01	761	0	10
299	521.60	3650.64	748	48	10

END OF EVENT 24

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 25 1623 - 1631 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
300	521.60	3650.64	748	0	10
301	521.74	3651.01	761	22	10
302	521.94	3651.33	762	44	10
303	522.01	3651.60	763	0	10
304	522.21	3651.76	747	44	10
305	522.55	3651.79	764	22	10
306	522.84	3651.84	746	44	10
307	523.10	3652.11	765	187	10
308	523.27	3652.35	745	374	10
309	523.51	3652.58	766	451	10
310	523.74	3652.81	767	55	20
311	523.86	3653.16	768	99	35
312	524.07	3653.38	744	66	20
313	524.43	3653.61	743	77	15
314	524.70	3653.82	769	88	30
315	525.00	3653.93	742	110	30
316	525.11	3654.29	741	198	30
317	525.31	3654.61	770	110	40
318	525.40	3654.97	771	66	35
319	525.27	3655.29	740	0	10

END OF EVENT 25

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 26 1631 - 1643 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
1	525.27	3655.29	740	0	10
2	525.28	3655.13	0	0	10
3	525.30	3654.97	771	0	10
4	525.31	3654.79	0	0	10
5	525.31	3654.61	770	0	5
6	525.26	3654.45	0	58	10
7	525.21	3654.29	741	23	15
8	525.10	3654.11	0	92	10
9	525.00	3653.93	742	0	10
10	524.85	3653.88	0	69	10
11	524.70	3653.82	769	0	10
12	524.57	3653.72	0	35	10
13	524.43	3653.61	743	23	10
14	524.25	3653.47	0	46	100
15	524.07	3653.33	744	46	60
16	523.96	3653.25	0	138	70
17	523.86	3653.16	768	92	60
18	523.80	3652.99	0	219	70
19	523.74	3652.81	767	173	120
20	523.62	3652.70	0	161	90
21	523.51	3652.58	766	115	160
22	523.39	3652.47	0	426	50
23	523.27	3652.35	745	115	25
24	523.18	3652.23	0	69	20
25	523.10	3652.11	765	0	20
26	522.99	3651.98	0	575	20
27	522.89	3651.84	746	1080	15
28	522.72	3651.82	0	138	25
29	522.55	3651.79	764	23	25
30	522.38	3651.78	0	23	25
31	522.21	3651.76	747	0	90
32	522.11	3651.68	0	69	80
33	522.01	3651.60	763	35	175
34	521.97	3651.47	0	23	370
35	521.94	3651.33	762	46	610
36	521.84	3651.17	0	115	940
37	521.74	3651.01	761	46	400
38	521.67	3650.83	0	0	40
39	521.60	3650.64	748	0	15
40	521.59	3650.42	0	12	10
41	521.58	3650.20	760	23	10
42	521.50	3649.99	0	23	10
43	521.41	3649.77	750	12	10
44	521.37	3649.77	0	0	10
45	521.33	3649.77	1764	12	10
46	521.19	3649.77	0	0	10
47	521.06	3649.77	1701	0	10
48	520.94	3649.82	0	23	10
49	520.81	3649.87	1702	0	5

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 16 APRIL 1975
EVENT NO. 26 1631 - 1643 MST

	MAP COORDS (KM) X	Y	CEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
50	520.75	3649.95	0	23	5
51	520.08	3650.02	1763	23	5
52	520.61	3650.10	0	0	5
53	520.54	3650.17	1703	0	5
54	520.47	3650.23	0	0	5
55	520.40	3650.29	1704	0	5
56	520.31	3650.41	0	0	0
57	520.23	3650.52	1762	0	0
58	520.13	3650.68	0	0	0
59	520.03	3650.84	1705	0	0
60	519.95	3650.98	0	0	0
61	519.87	3651.11	1706	0	5

END OF EVENT 26

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 17 APRIL 1975
EVENT NO. 14 1203 - 1211 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
1	521.60	3650.64	748	0	15
2	521.67	3650.83	0	0	10
3	521.74	3651.01	761	11	15
4	521.84	3651.17	0	14	15
5	521.94	3651.33	762	25	40
6	521.97	3651.47	0	14	165
7	522.01	3651.60	763	39	75
8	522.11	3651.69	0	18	50
9	522.21	3651.76	747	21	70
10	522.38	3651.78	0	0	65
11	522.55	3651.79	764	0	55
12	522.72	3651.82	0	4	70
13	522.89	3651.84	745	7	50
14	522.99	3651.98	0	70	30
15	523.10	3652.11	765	170	20
16	523.18	3652.23	0	329	20
17	523.27	3652.35	741	147	20
18	523.34	3652.47	0	245	20
19	523.51	3652.58	766	399	180
20	523.62	3652.70	0	497	715
21	523.74	3652.81	767	1050	935
22	523.89	3652.99	0	950	645
23	523.86	3653.16	768	650	1000
24	523.96	3653.25	0	400	1000
25	524.01	3653.33	744	200	790
26	524.25	3653.47	0	161	500
27	524.43	3653.61	743	207	550
28	524.54	3653.72	0	189	450
29	524.79	3653.82	769	133	410
30	524.87	3653.88	0	161	300
31	524.98	3653.93	742	130	240
32	525.10	3654.11	0	126	175
33	525.21	3654.29	741	63	115
34	525.30	3654.45	0	39	50
35	525.31	3654.61	776	91	30
36	525.31	3654.79	0	42	20
37	525.30	3654.97	771	21	15
38	525.28	3655.13	0	21	10
39	525.27	3655.29	748	28	10
40	525.27	3655.44	0	7	10
41	525.47	3655.59	772	14	10
42	525.53	3655.60	0	0	10
43	525.60	3655.76	739	18	10
44	525.77	3655.97	0	0	10
45	525.94	3655.98	773	7	10
46	526.10	3656.04	0	7	10
47	526.27	3656.09	739	0	10
48	526.44	3656.22	0	4	10
49	526.41	3656.34	737	7	10

END OF EVENT 14

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 17 APRIL 1975
EVENT NO. 26 1534 - 1539 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
53	521.60	3650.64	749	0	10
54	521.67	3650.83	0	0	10
55	521.74	3651.01	761	20	10
56	521.84	3651.17	0	60	250
57	521.94	3651.33	762	60	840
58	521.97	3651.47	0	140	1390
59	522.01	3651.60	763	60	1390
60	522.11	3651.68	0	110	1300
61	522.21	3651.76	747	60	940
62	522.38	3651.78	0	80	600
63	522.55	3651.79	764	40	220
64	522.72	3651.82	0	120	760
65	522.89	3651.84	746	1150	560
66	522.99	3651.98	0	1770	480
67	523.10	3652.11	765	560	340
68	523.18	3652.23	0	810	360
69	523.27	3652.35	745	80	240
70	523.33	3652.47	0	0	220
71	523.51	3652.58	766	20	200
72	523.62	3652.70	0	20	140
73	523.74	3652.81	767	0	80
74	523.80	3652.99	0	20	70
75	523.86	3653.16	760	20	40
76	523.96	3653.25	0	140	40
77	524.07	3653.33	744	260	40
78	524.23	3653.47	0	80	30
79	524.43	3653.61	743	0	30

END OF EVENT 26

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 17 APRIL 1975
EVENT NO. 29 1555 - 1603 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
80	525.47	3655.59	772	0	20
81	525.37	3655.44	0	10	20
82	525.27	3655.29	740	40	30
83	525.18	3655.13	0	80	200
84	525.09	3654.97	771	140	460
85	525.01	3654.79	0	110	620
86	525.01	3654.61	770	160	300
87	525.26	3654.45	0	120	820
88	525.21	3654.29	741	40	930
89	525.10	3654.11	0	60	430
90	525.00	3653.93	742	180	640
91	524.85	3653.88	0	190	880
92	524.70	3653.82	769	100	700
93	524.57	3653.72	0	120	800
94	524.43	3653.61	743	140	360
95	524.26	3653.47	0	180	520
96	524.07	3653.33	744	100	480
97	523.96	3653.25	0	140	340
98	523.86	3653.16	768	70	300
99	523.80	3652.99	0	110	260
100	523.74	3652.81	767	130	240
101	523.62	3652.70	0	180	280
102	523.51	3652.58	766	140	230
103	523.39	3652.47	0	200	120
104	523.27	3652.35	745	500	280
105	523.18	3652.23	0	100	120
106	523.10	3652.11	765	80	60
107	522.99	3651.98	0	490	70
108	522.89	3651.84	746	90	50
109	522.72	3651.82	0	100	30
110	522.56	3651.79	764	620	60
111	522.48	3651.78	0	10	80
112	522.21	3651.76	747	20	140
113	522.11	3651.68	0	240	40
114	522.01	3651.60	763	2340	70
115	521.97	3651.47	0	1380	260
116	521.94	3651.33	762	100	430
117	521.84	3651.17	0	120	1390
118	521.74	3651.01	761	0	120
119	521.67	3650.83	0	-0	30
120	521.60	3650.64	748	0	20
121	521.59	3650.42	0	0	20
122	521.58	3650.20	760	0	10
123	521.58	3649.99	0	0	10
124	521.41	3649.77	750	0	10

END OF EVENT 29

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 18 APRIL 1975
EVENT NO. 7 951 - 959 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
125	524.43	3653.61	743	0	10
126	524.25	3653.47	0	0	10
127	524.07	3653.33	744	10	10
128	523.96	3653.25	0	0	10
129	523.76	3653.16	768	0	10
130	523.80	3652.99	0	10	10
131	523.74	3652.81	767	20	10
132	523.62	3652.70	0	30	10
133	523.51	3652.58	769	30	10
134	523.39	3652.47	0	40	20
135	523.27	3652.35	745	20	20
136	523.10	3652.23	0	80	40
137	523.10	3652.11	769	250	50
138	522.99	3651.98	0	340	80
139	522.89	3651.84	746	450	280
140	522.71	3651.82	0	700	540
141	522.55	3651.79	764	470	380
142	522.38	3651.78	0	560	265
143	522.21	3651.76	747	320	370
144	522.11	3651.68	0	490	430
145	522.01	3651.60	763	480	650
146	521.97	3651.47	0	420	380
147	521.94	3651.33	762	300	595
148	521.84	3651.17	0	120	180
149	521.74	3651.01	761	20	55
150	521.67	3650.89	0	60	40
151	521.64	3650.64	740	80	40
152	521.59	3650.42	0	20	30
153	521.54	3650.20	760	0	20
154	521.50	3649.99	0	0	20
155	521.41	3649.77	750	0	15

END OF EVENT 7

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 18 APRIL 1975
EVENT NO. 17 1223 -1228 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
156	521.41	3649.77	750	0	5
157	521.47	3649.91	0	20	5
158	521.53	3650.06	0	0	5
159	521.53	3650.20	760	0	5
160	521.59	3650.35	0	0	5
161	521.59	3650.49	0	0	5
162	521.60	3650.64	748	0	5
163	521.64	3650.76	0	20	5
164	521.69	3650.89	0	30	5
165	521.74	3651.01	761	20	5
166	521.80	3651.12	0	30	5
167	521.87	3651.22	0	20	5
168	521.94	3651.33	762	150	10
169	521.96	3651.42	0	220	10
170	521.99	3651.51	0	310	10
171	522.01	3651.60	763	520	10
172	522.08	3651.65	0	710	10
173	522.15	3651.71	0	680	15
174	522.21	3651.76	747	440	10
175	522.38	3651.77	0	1030	10
176	522.44	3651.78	0	730	10
177	522.50	3651.79	764	620	20
178	522.67	3651.81	0	420	50
179	522.79	3651.82	0	310	80
180	522.90	3651.84	746	240	210
181	522.96	3651.93	0	320	230
182	523.03	3652.02	0	380	200
183	523.10	3652.11	765	330	170
184	523.15	3652.19	0	220	110
185	523.21	3652.27	0	100	80
186	523.27	3652.35	745	160	60
187	523.35	3652.43	0	140	60
188	523.43	3652.50	0	100	40
189	523.51	3652.58	766	60	30
190	523.59	3652.66	0	40	30
191	523.66	3652.73	0	40	80
192	523.74	3652.81	767	20	40
193	523.78	3652.93	0	40	25
194	523.82	3653.04	0	20	20
195	523.86	3653.16	768	30	15
196	523.93	3653.22	0	20	15
197	524.00	3653.27	0	20	10
198	524.07	3653.33	744	0	10
199	524.19	3653.42	0	0	10
200	524.31	3653.52	0	20	10
201	524.43	3653.61	743	30	10

END OF EVENT 17

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 18 APRIL 1975
EVENT NO. 18 1228 - 1232 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
202	524.43	3653.61	743	30	10
203	524.31	3653.52	0	40	10
204	524.19	3653.42	0	20	10
205	524.07	3653.33	744	0	10
206	524.00	3653.27	0	0	10
207	523.93	3653.22	0	20	10
208	523.86	3653.16	768	30	10
209	523.82	3653.04	0	20	10
210	523.78	3652.93	0	20	10
211	523.74	3652.81	767	40	10
212	523.66	3652.73	0	40	10
213	523.59	3652.66	0	60	10
214	523.51	3652.58	766	70	10
215	523.43	3652.50	0	50	10
216	523.35	3652.43	0	60	10
217	523.27	3652.35	745	50	75
218	523.21	3652.27	0	60	90
219	523.15	3652.19	0	140	50
220	523.10	3652.11	765	110	100
221	523.03	3652.02	0	170	95
222	522.96	3651.93	0	230	90
223	522.89	3651.84	746	350	40
224	522.78	3651.82	0	510	30
225	522.67	3651.81	0	680	20
226	522.55	3651.79	764	540	15
227	522.44	3651.78	0	300	10
228	522.33	3651.77	0	120	10
229	522.21	3651.76	747	40	10
230	522.15	3651.71	0	40	10
231	522.08	3651.65	0	110	10
232	522.01	3651.60	763	80	10
233	521.99	3651.51	0	80	10
234	521.96	3651.42	0	120	10
235	521.94	3651.33	762	240	10
236	521.97	3651.22	0	280	10
237	521.80	3651.12	0	120	10
238	521.74	3651.01	761	20	10
239	521.69	3650.89	0	0	10
240	521.64	3650.76	0	0	10
241	521.60	3650.64	748	0	10

END OF EVENT 18

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 18 APRIL 1975
EVENT NO. 19 1232 - 1235 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
242	521.60	3650.64	748	0	10
243	521.64	3650.76	0	10	10
244	521.69	3650.89	0	40	10
245	521.74	3651.01	761	30	10
246	521.80	3651.12	0	70	10
247	521.87	3651.22	0	100	10
248	521.94	3651.33	762	50	10
249	521.96	3651.42	0	360	10
250	521.99	3651.51	0	210	10
251	522.01	3651.60	763	300	10
252	522.08	3651.65	0	330	10
253	522.15	3651.71	0	230	10
254	522.21	3651.76	747	310	10
255	522.33	3651.77	0	360	10
256	522.44	3651.78	0	440	10
257	522.55	3651.79	764	210	10
258	522.67	3651.81	0	220	10
259	522.79	3651.82	0	410	10
260	522.84	3651.84	746	570	10
261	522.90	3651.93	0	340	10
262	523.00	3652.02	0	150	5
263	523.10	3652.11	765	150	5
264	523.15	3652.19	0	50	5
265	523.21	3652.27	0	50	5
266	523.27	3652.35	745	60	5
267	523.34	3652.43	0	50	5
268	523.43	3652.50	0	40	5
269	523.51	3652.58	766	40	5
270	523.59	3652.66	0	20	5
271	523.65	3652.73	0	20	5
272	523.74	3652.81	767	40	5
273	523.78	3652.93	0	20	5
274	523.82	3653.04	0	0	5
275	523.86	3653.16	768	40	5
276	523.93	3653.22	0	40	5
277	524.00	3653.27	0	10	5
278	524.07	3653.33	744	10	5
279	524.19	3653.42	0	0	5
280	524.31	3653.52	0	0	5
281	524.43	3653.61	743	0	5

END OF EVENT 19

ENVIRONMENTAL MEASUREMENTS INC
SAN FRANCISCO, CALIFORNIA

HAYDEN SMELTERS EMISSION SURVEY
PROJECT 102 18 APRIL 1975
EVENT NO. 20 1235 - 1238 MST

	MAP COORDS (KM) X	Y	GEOG PT	SO2 BURDEN PPMM	SO2 GROUND PPB
282	524.43	3652.61	743	0	5
283	524.31	3653.52	0	20	5
284	524.19	3653.42	0	20	5
285	524.07	3653.33	744	0	5
286	524.00	3653.27	0	0	5
287	523.93	3653.22	0	10	5
288	523.86	3653.16	768	10	5
289	523.82	3653.04	0	20	5
290	523.70	3652.93	0	20	5
291	523.74	3652.81	767	10	5
292	523.66	3652.73	0	20	5
293	523.59	3652.66	0	60	5
294	523.51	3653.58	766	100	5
295	523.43	3652.50	0	230	5
296	523.35	3652.43	0	610	5
297	523.27	3652.35	745	770	5
298	523.21	3652.27	0	890	5
299	522.13	3652.19	0	540	5
300	523.14	3652.11	765	450	10
301	523.08	3652.02	0	540	200
302	522.96	3651.93	0	540	110
303	522.89	3651.94	746	440	75
304	522.71	3651.82	0	500	170
305	522.67	3651.81	0	60	55
306	522.59	3651.79	764	360	695
307	522.41	3651.78	0	340	560
308	522.38	3651.77	0	240	630
309	522.21	3651.76	747	40	630
310	522.15	3651.71	0	60	695
311	522.08	3651.65	0	520	695
312	522.01	3651.60	763	930	695
313	521.93	3651.51	0	1080	695
314	521.96	3651.42	0	460	695
315	521.94	3651.33	762	720	695
316	531.87	3651.22	0	250	240
317	521.80	3651.12	0	20	150
318	521.74	3651.01	761	0	110
319	521.69	3650.89	0	0	45
320	521.64	3650.76	0	20	30
321	521.60	3650.64	748	0	25
322	521.59	3650.49	0	10	20
323	521.59	3650.35	0	0	15
324	521.58	3650.20	760	0	15
325	521.53	3650.06	0	0	10
326	521.47	3649.91	0	0	10
327	521.41	3649.77	750	0	10

END OF EVENT 20

APPENDIX B

PIBAL RESULTS

Appendix B

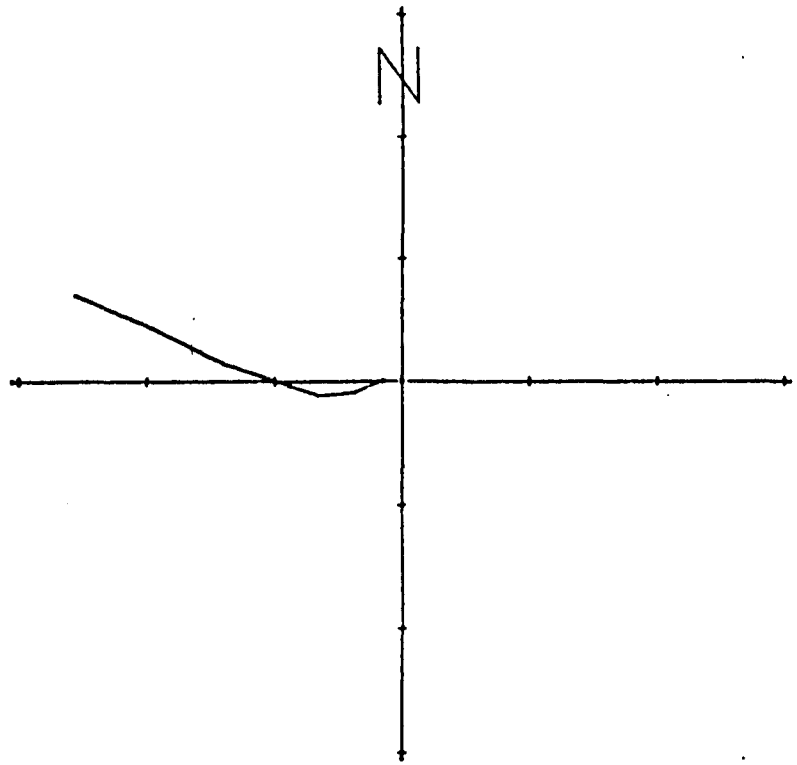
Pibal Results
Index

PIBAL RESULTS

945 MST 14 APR 75

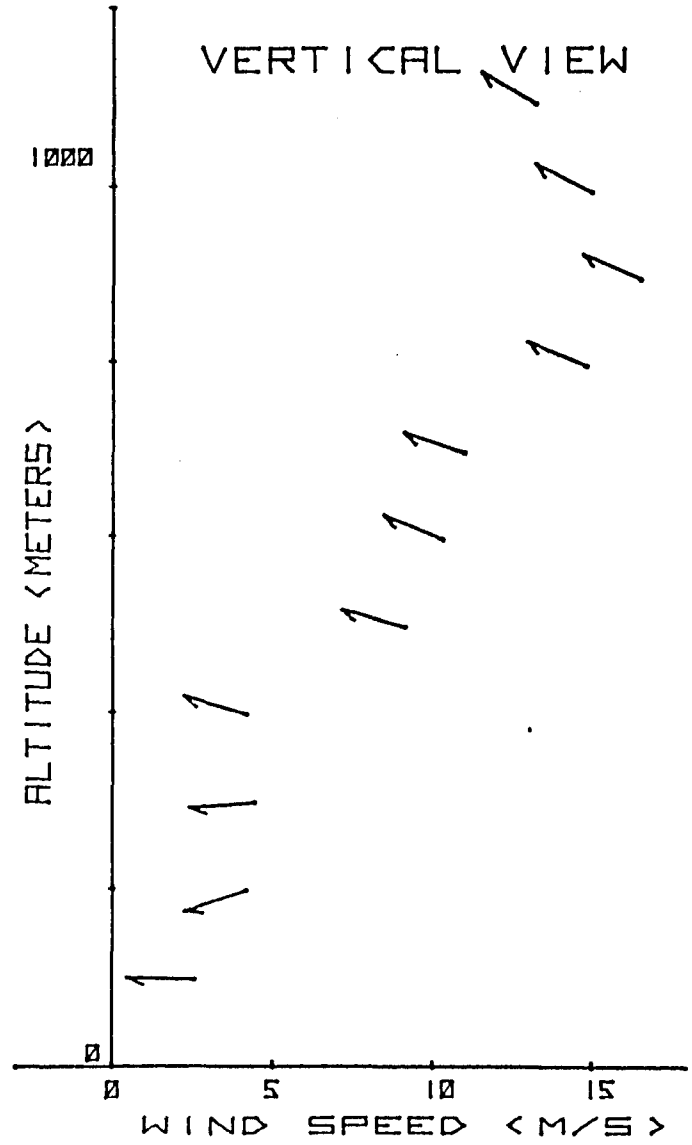
MAP VIEW

SITE 6



SCALE DIV <0.5 KM>

VERTICAL VIEW

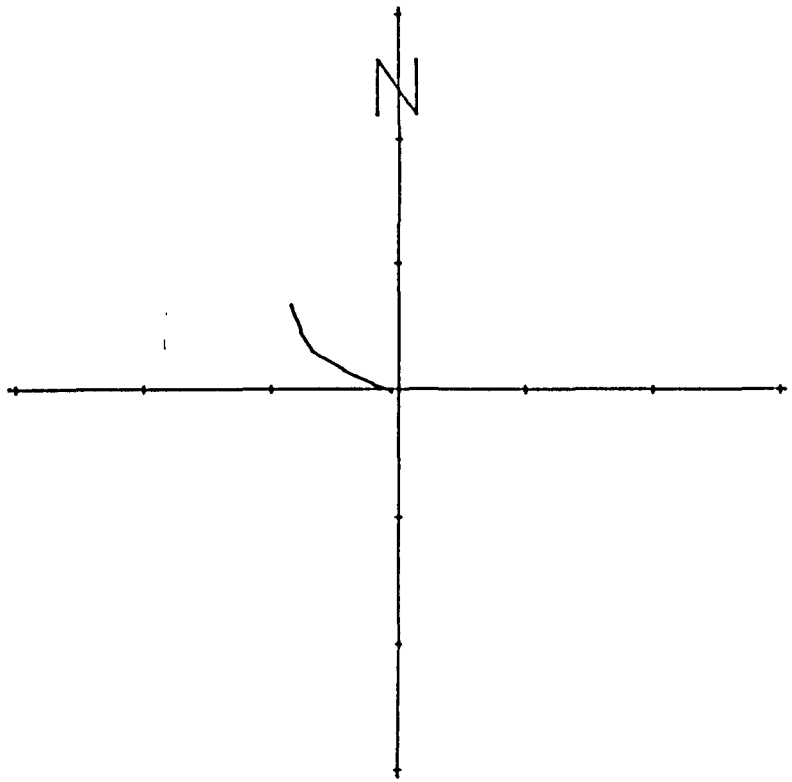


PIBAL RESULTS

1202 MST 14 APR 75

MAP VIEW

SITE 1



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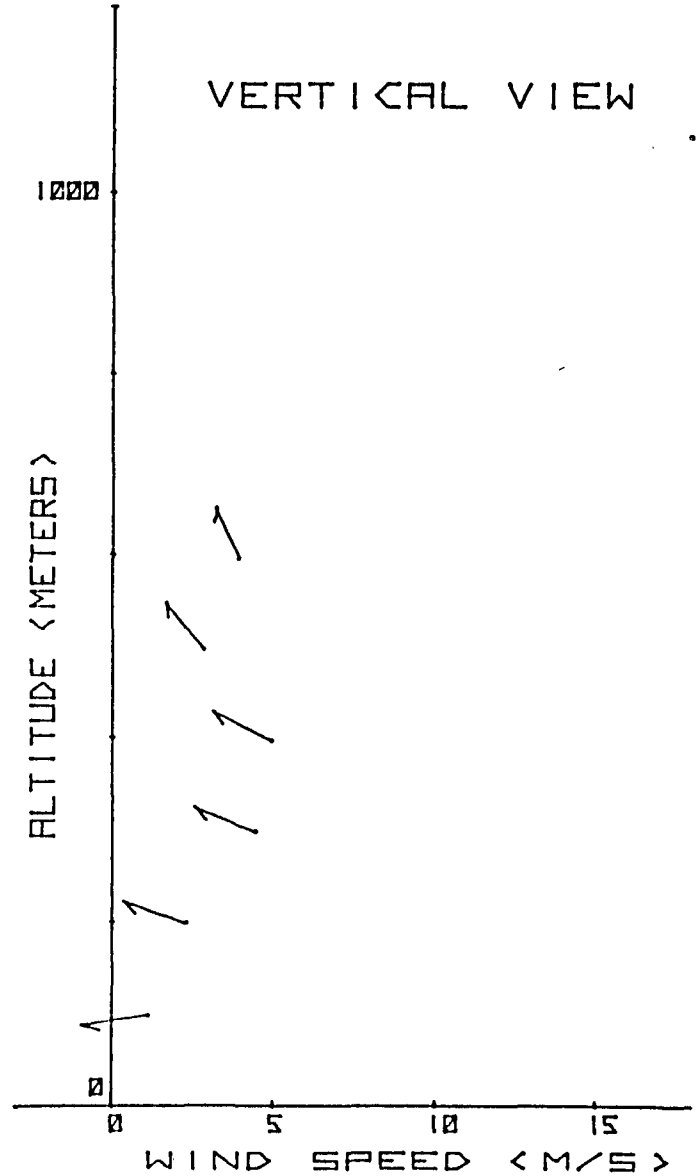
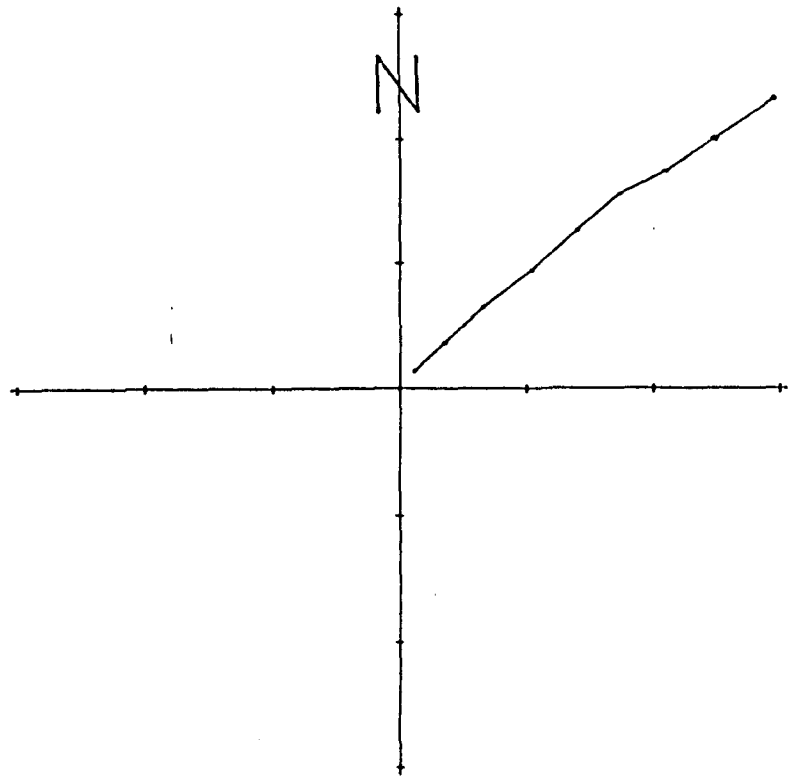
VERTICAL VIEW



PIBAL RESULTS

1354 MST 14 APR 75

MAP VIEW SITE 1



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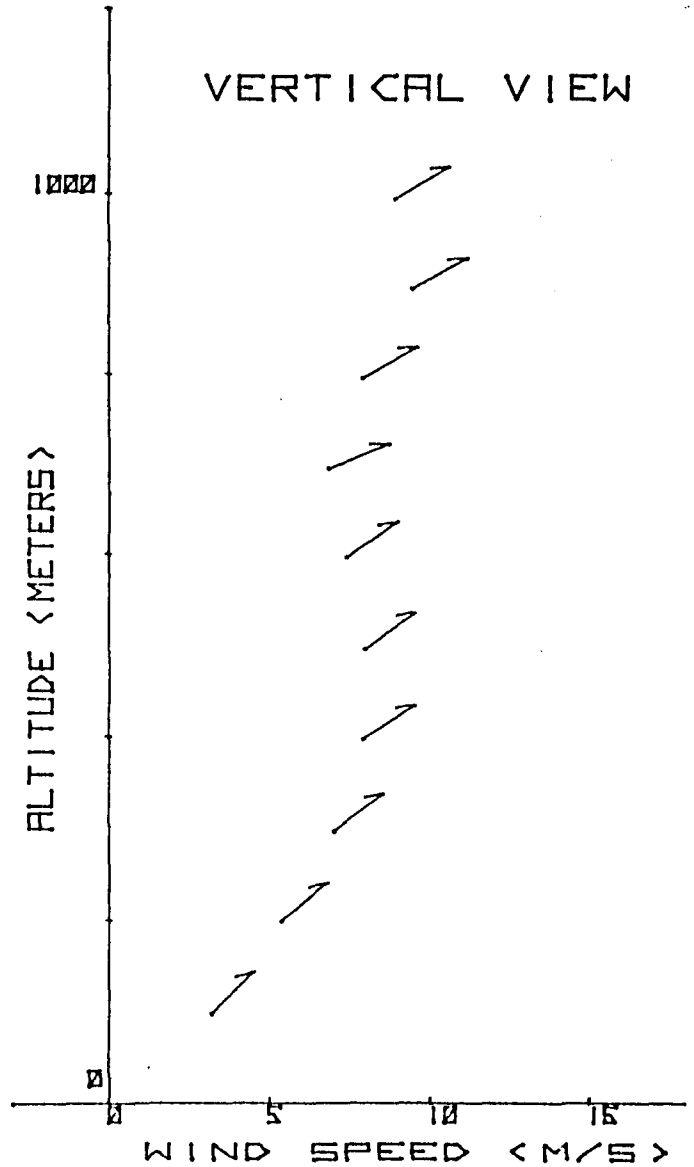
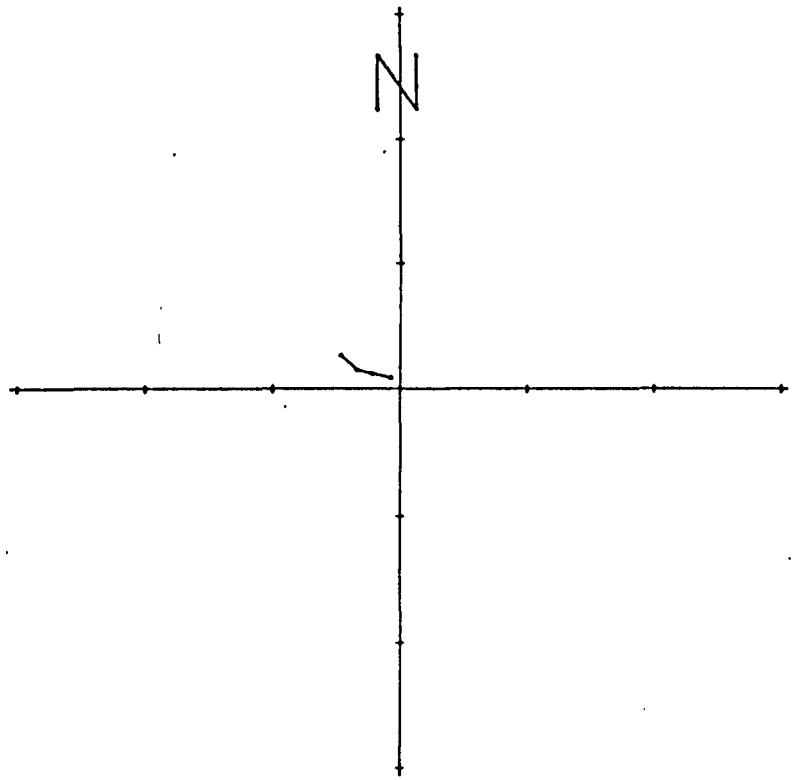
VERTICAL VIEW



PIBAL RESULTS

955 MST 15 APR 75

MAP VIEW SITE 1



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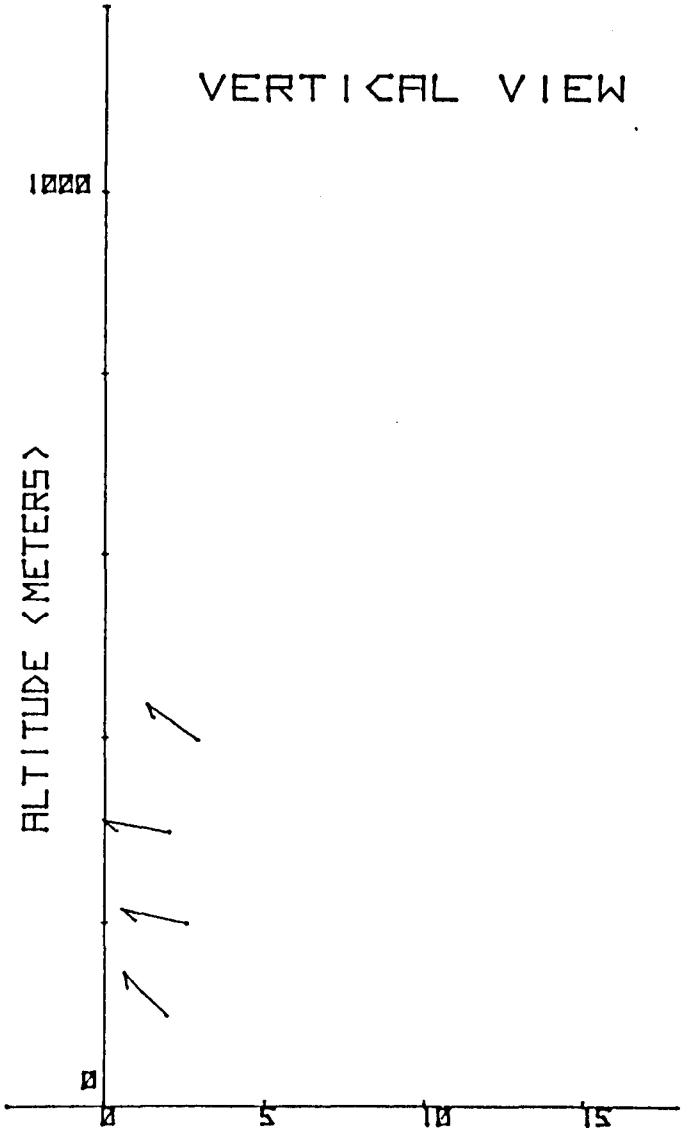
VERTICAL VIEW



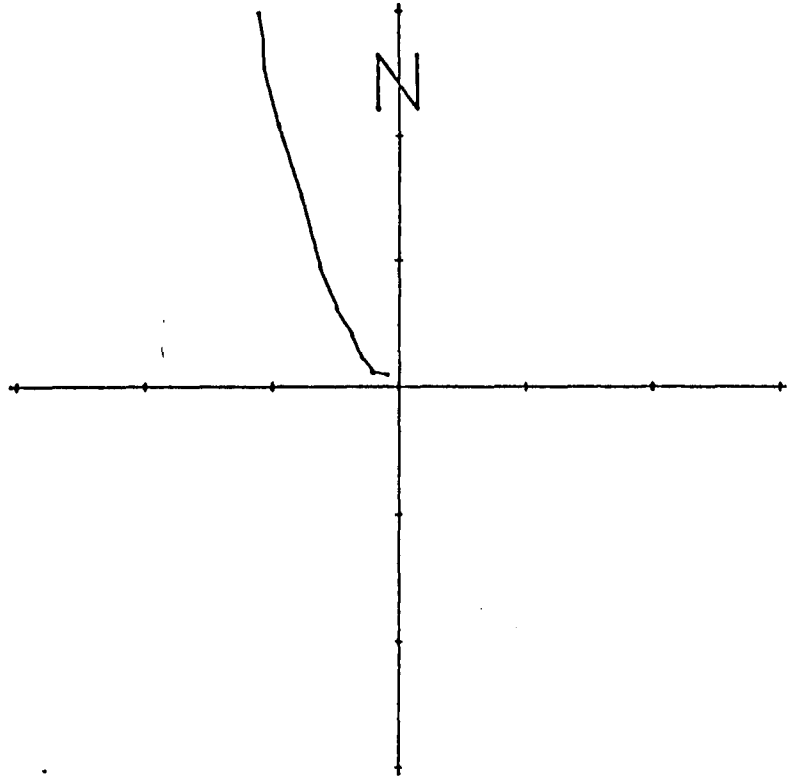
WIND SPEED <M/S>

PIBAL RESULTS

1000 MST 15 APR 75

MAP VIEW

SITE 1



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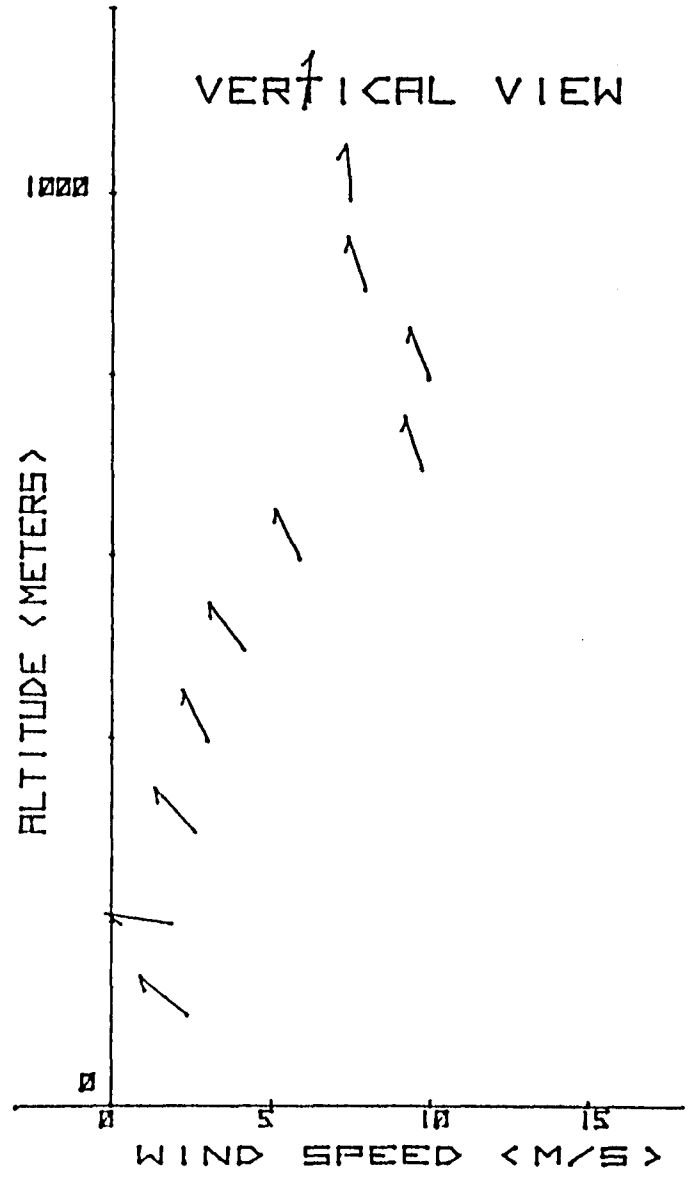
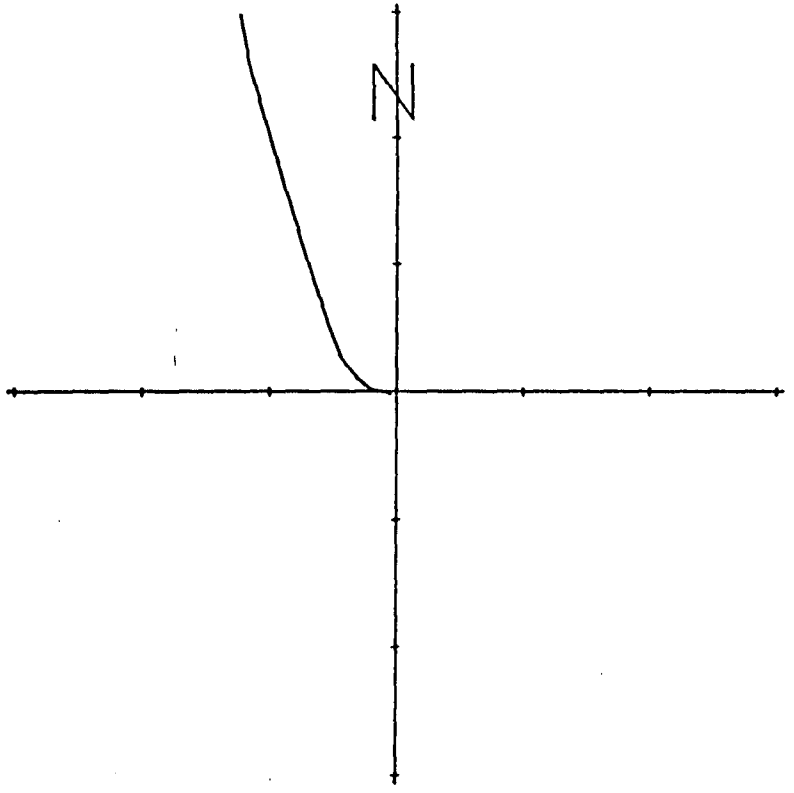
VERTICAL VIEW



PIBAL RESULTS

1012 MST 15 APR 75

MAP VIEW SITE 1



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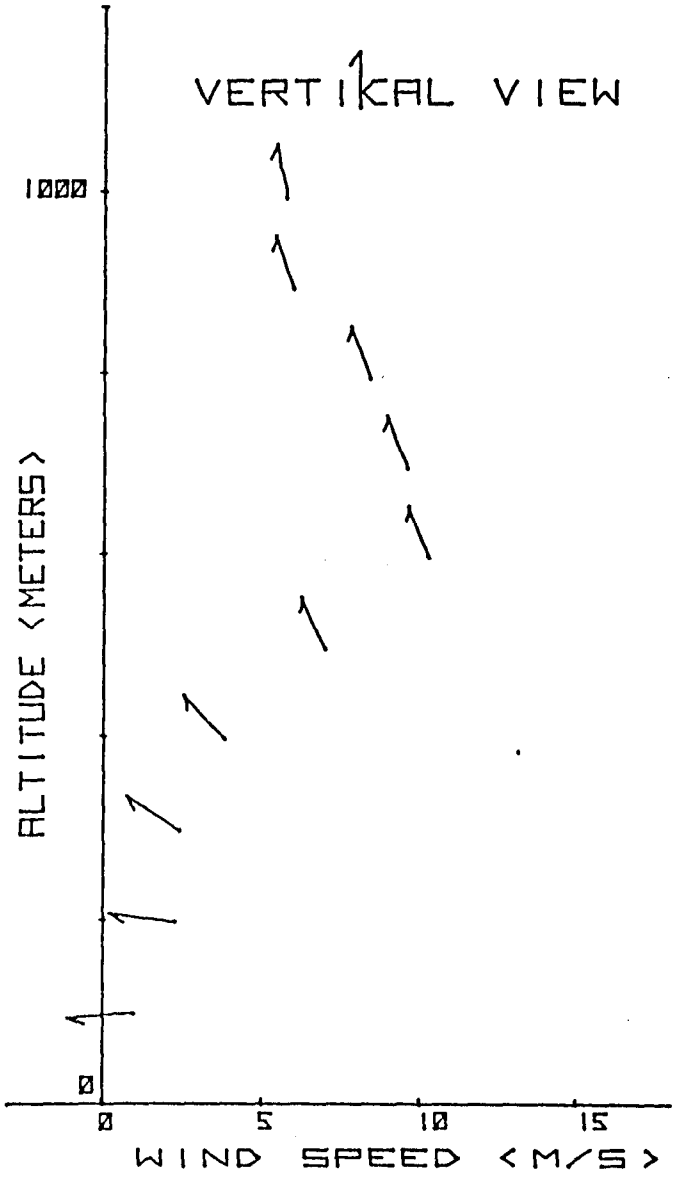
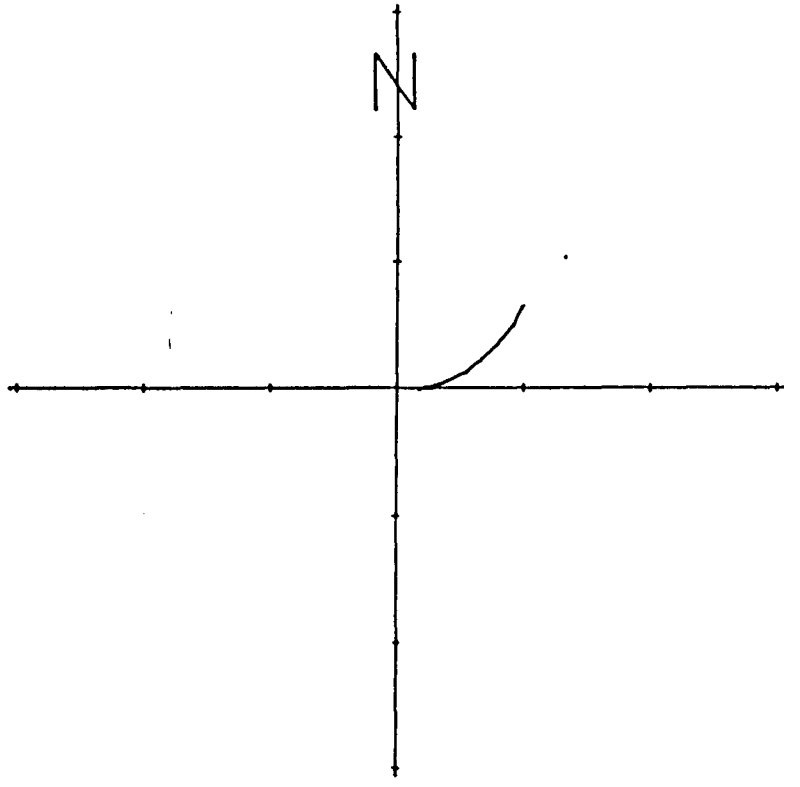
VERTICAL VIEW



PIBAL RESULTS

1328 MST 15 APR 75

MAP VIEW SITE 1



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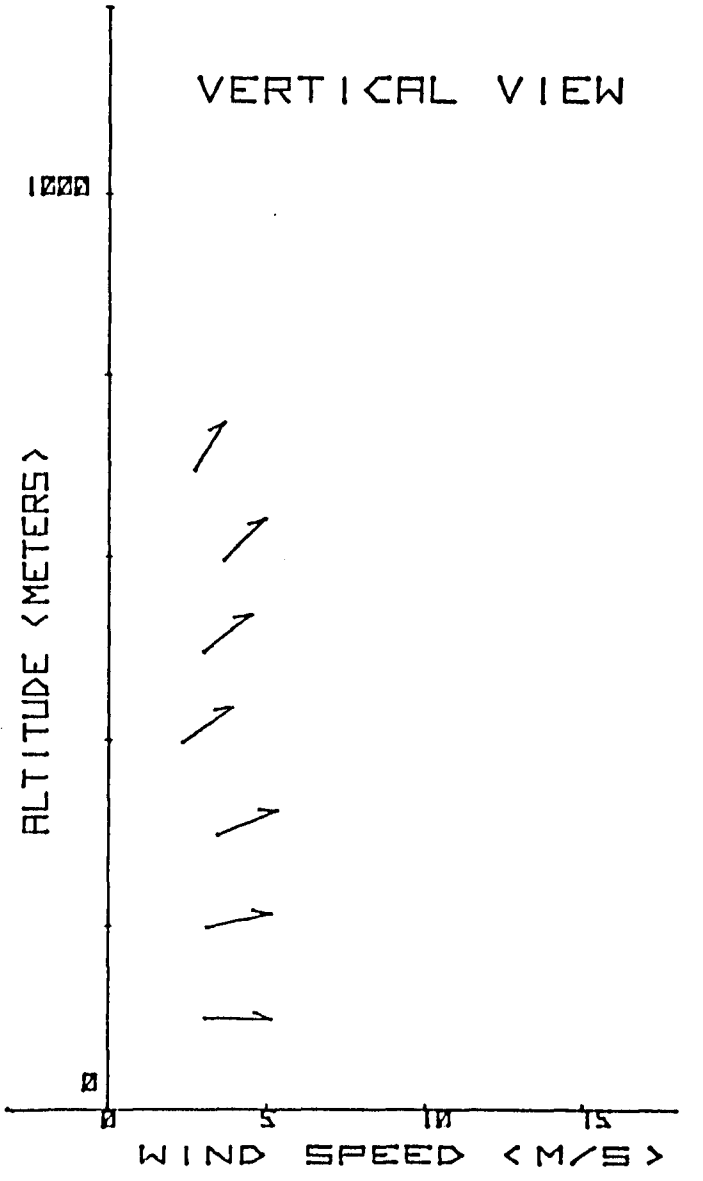
VERTICAL VIEW

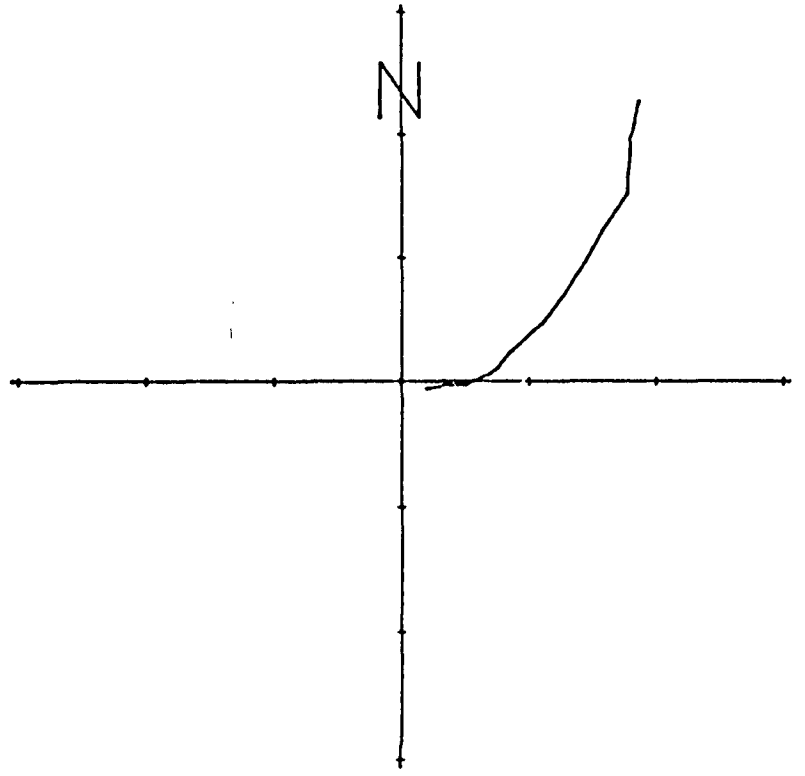


PIBAL RESULTS

1337 MST 15 APR 75

MAP VIEW

SITE 1



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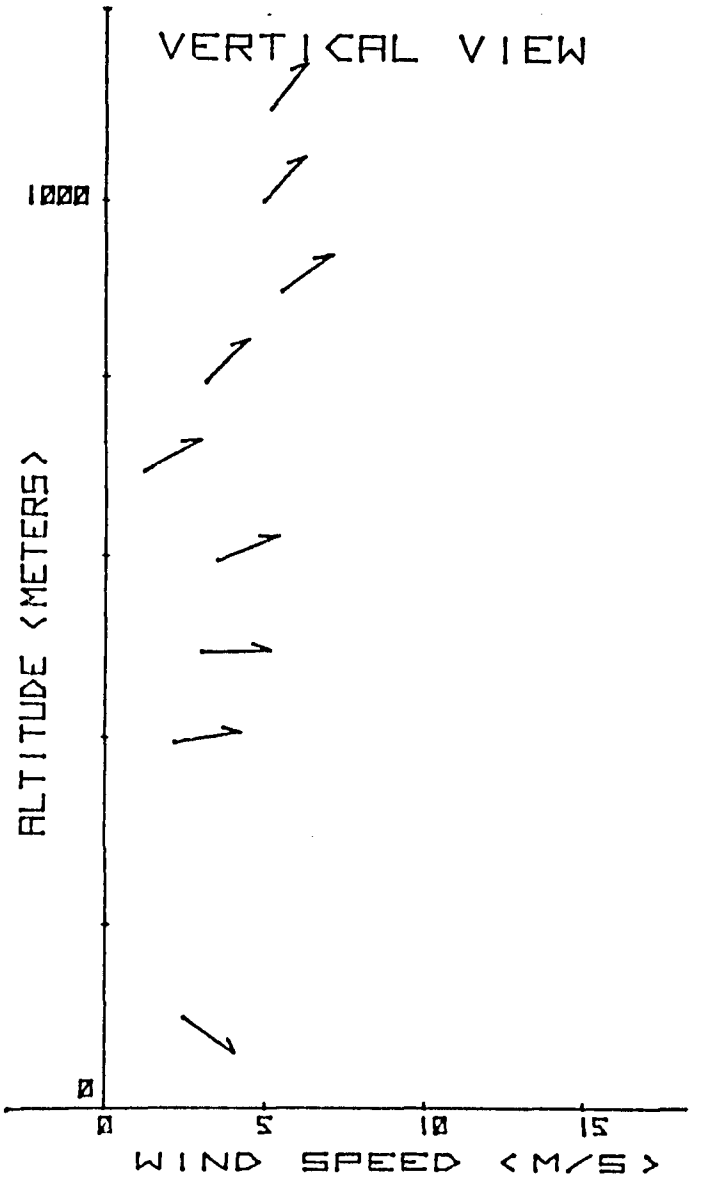
VERTICAL VIEW

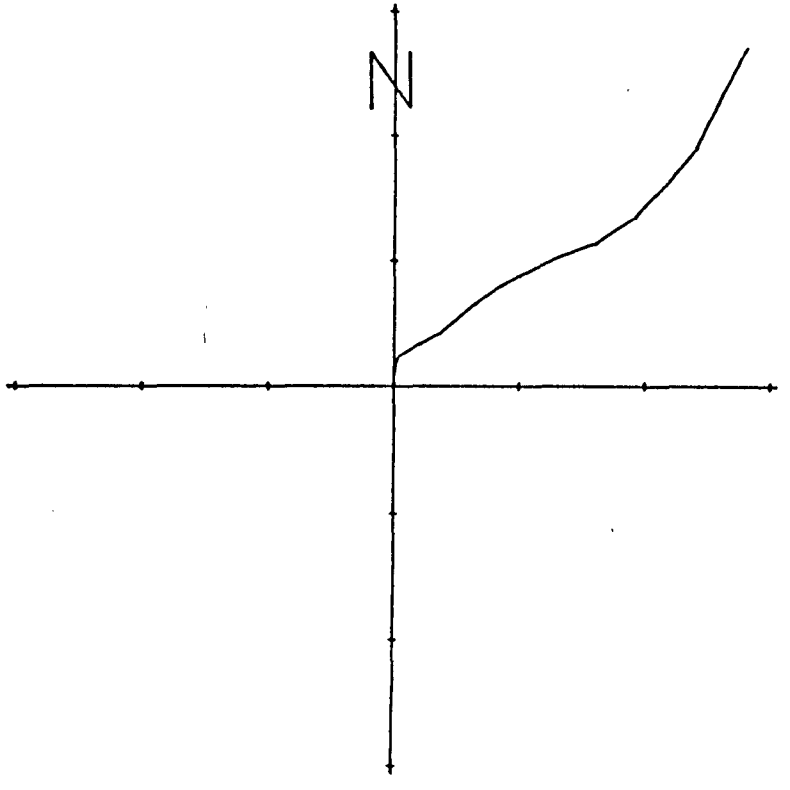


PIBAL RESULTS

1425 MST 15 APR 75

MAP VIEW

SITE 1



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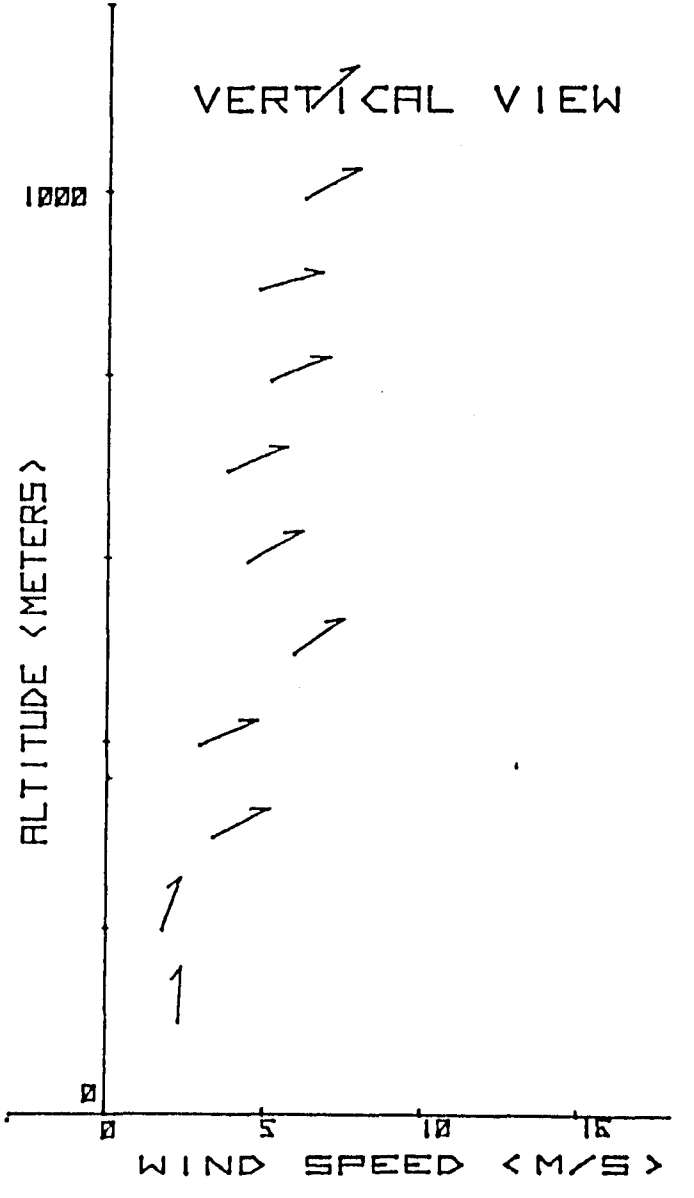
VERTICAL VIEW

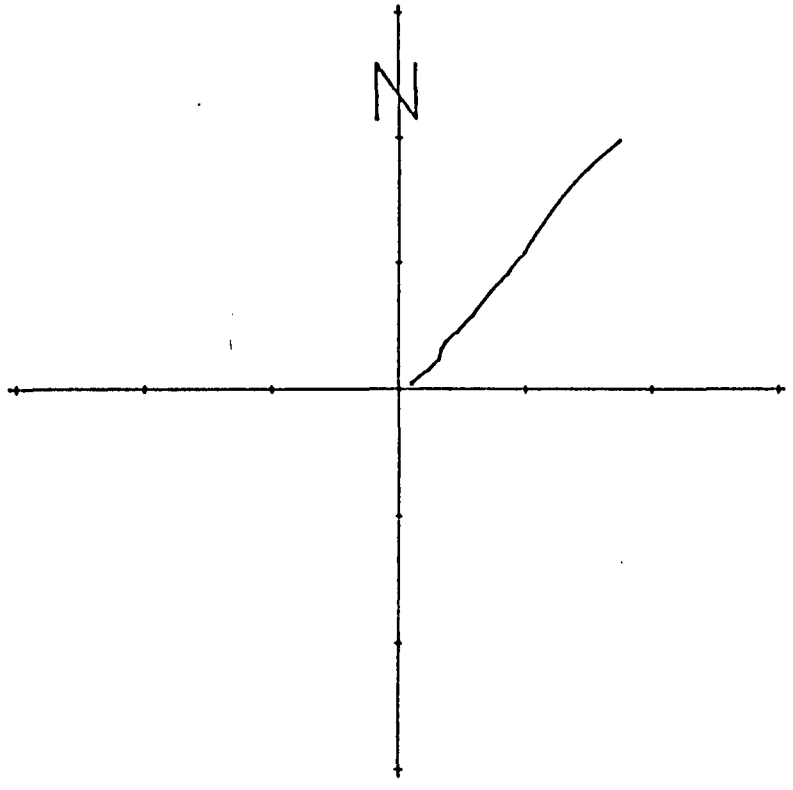


PIBAL RESULTS

1533 MST 15 APR 75

MAP VIEW

SITE 1



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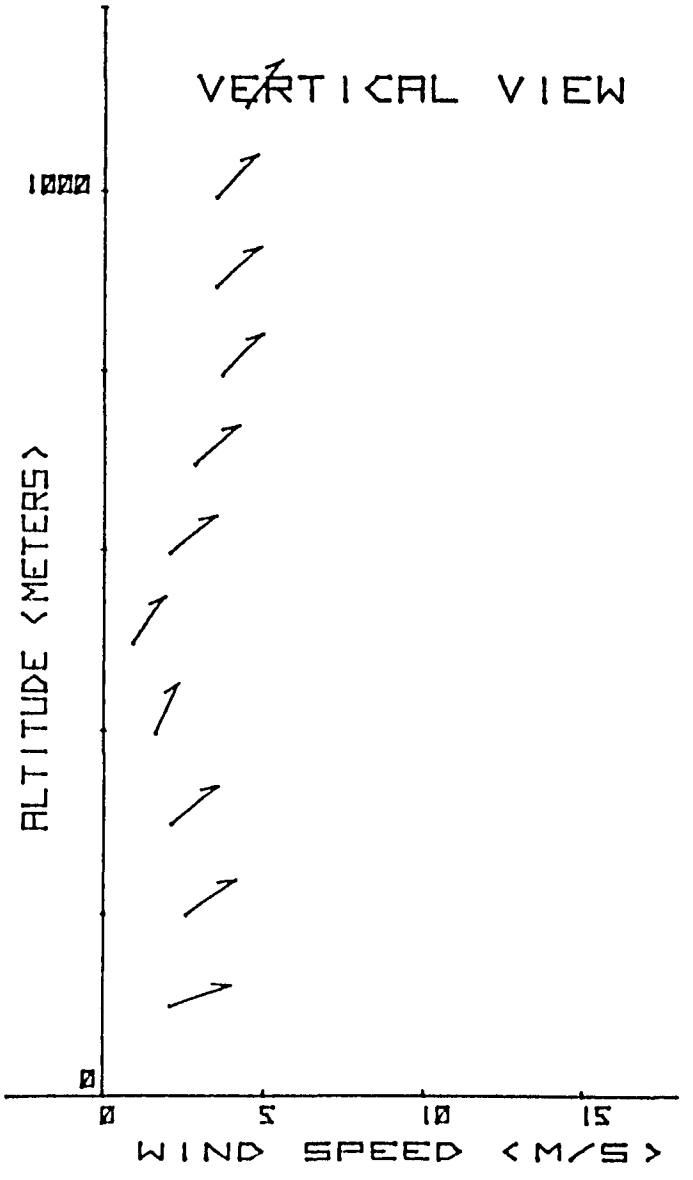
VERTICAL VIEW

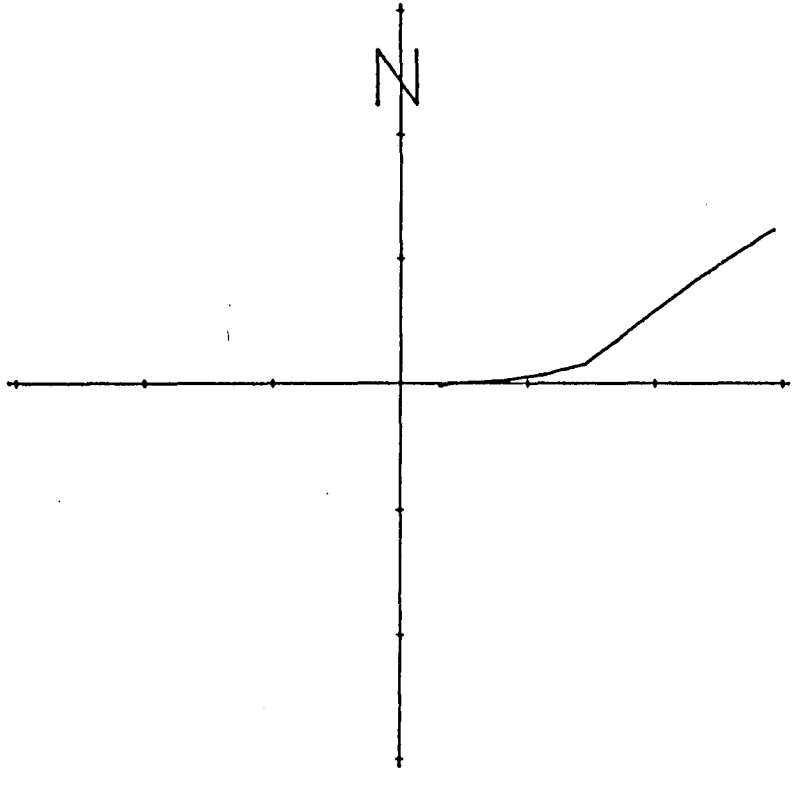


PIBAL RESULTS

1545 MST 15 APR 75

MAP VIEW

SITE 1



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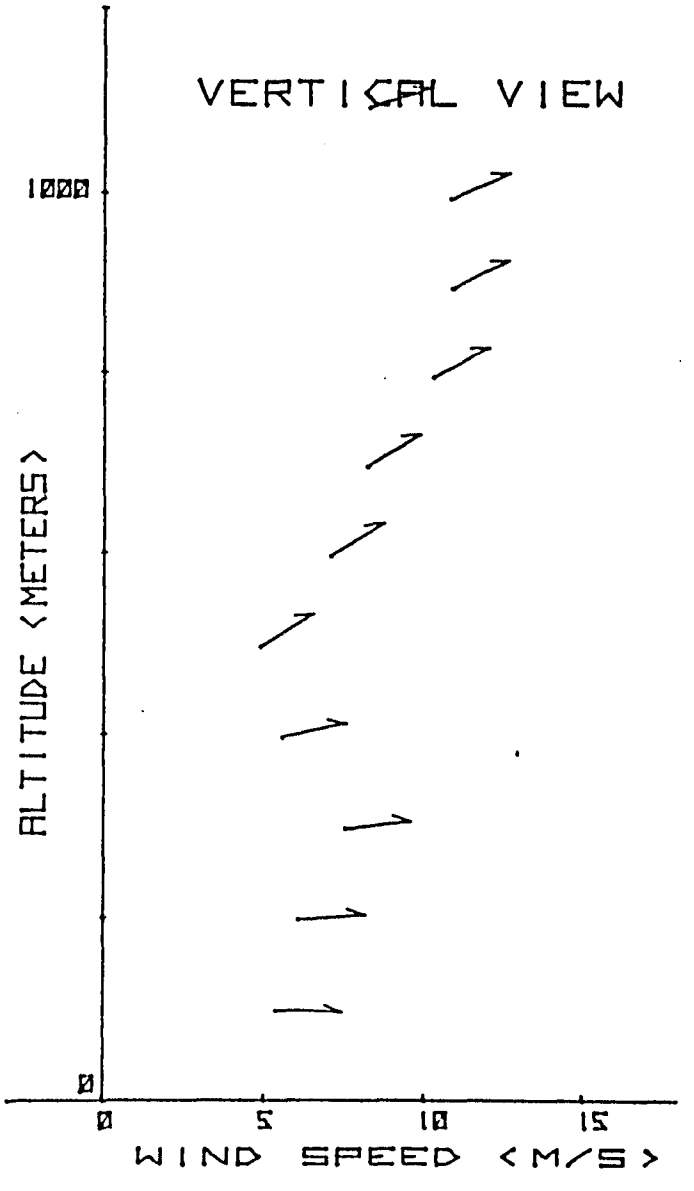
VERTICAL VIEW

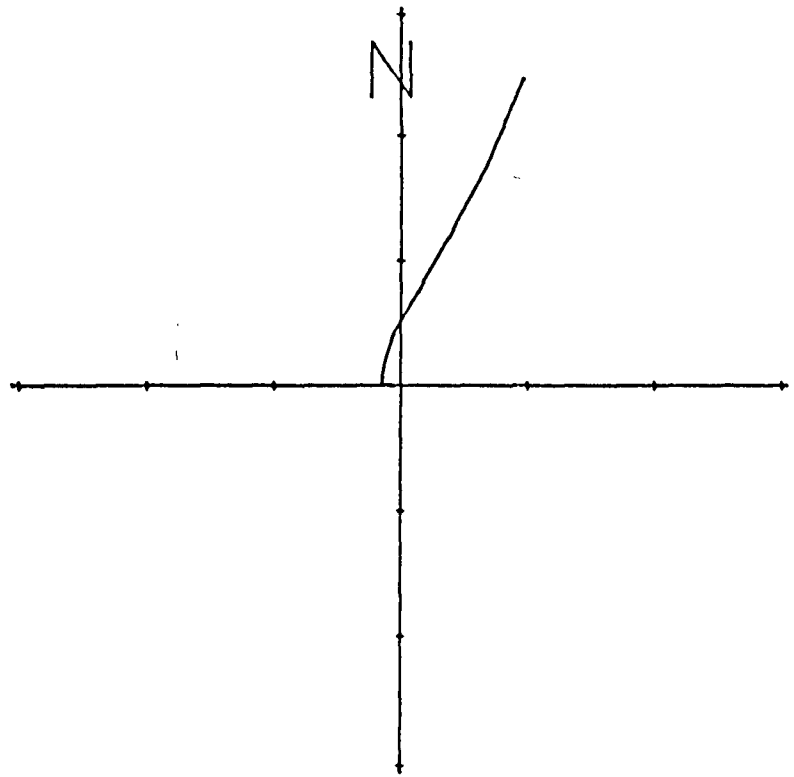


PIBAL RESULTS

800 MST 16 APR 75

MAP VIEW

SITE 1



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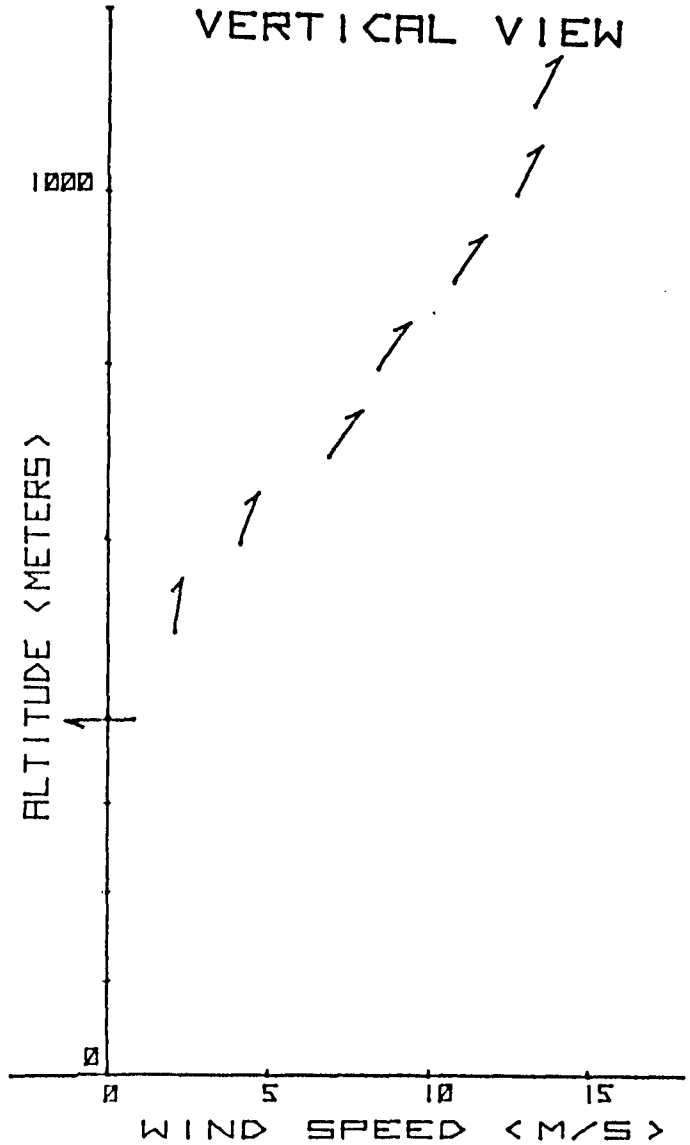
VERTICAL VIEW

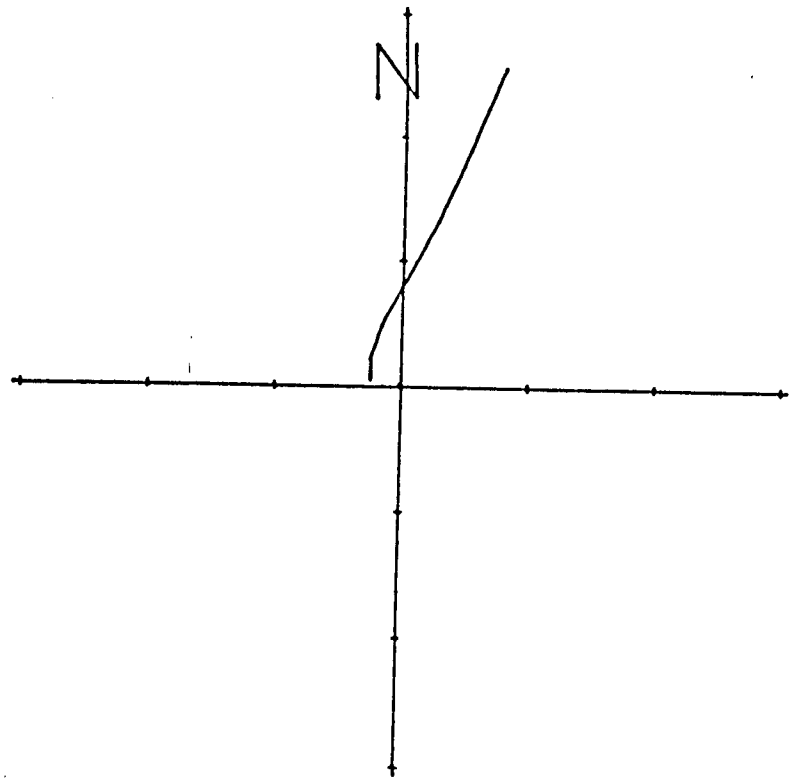


PIBAL RESULTS

807 MST 16 APR 75

MAP VIEW

SITE 1



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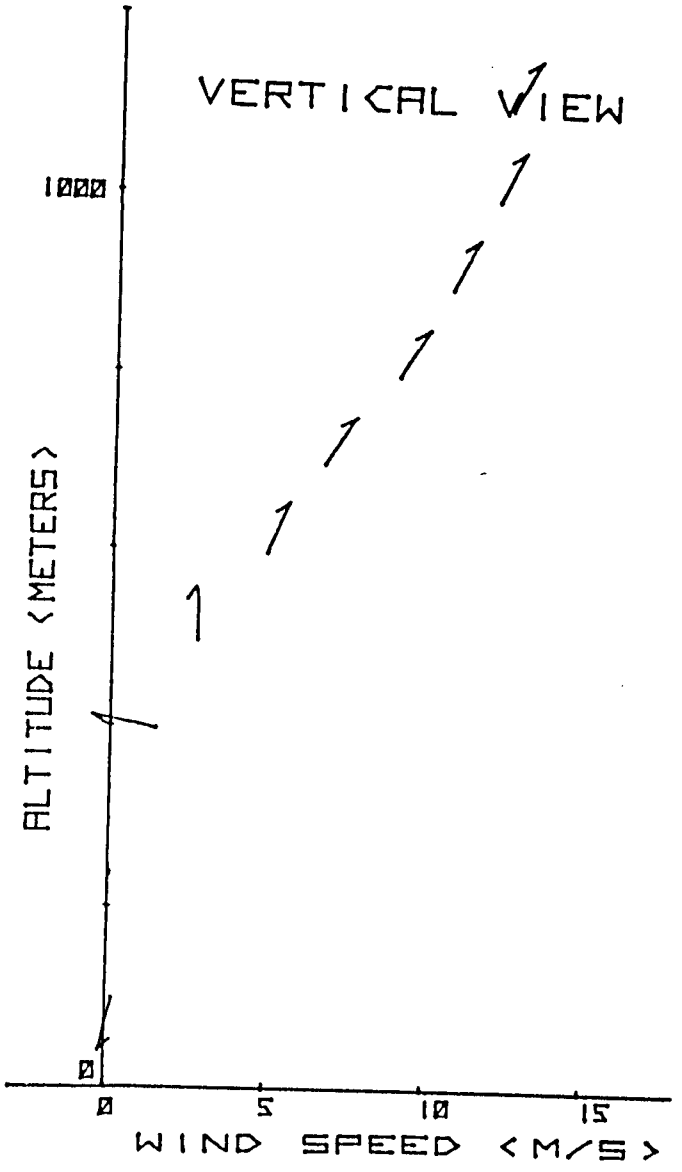
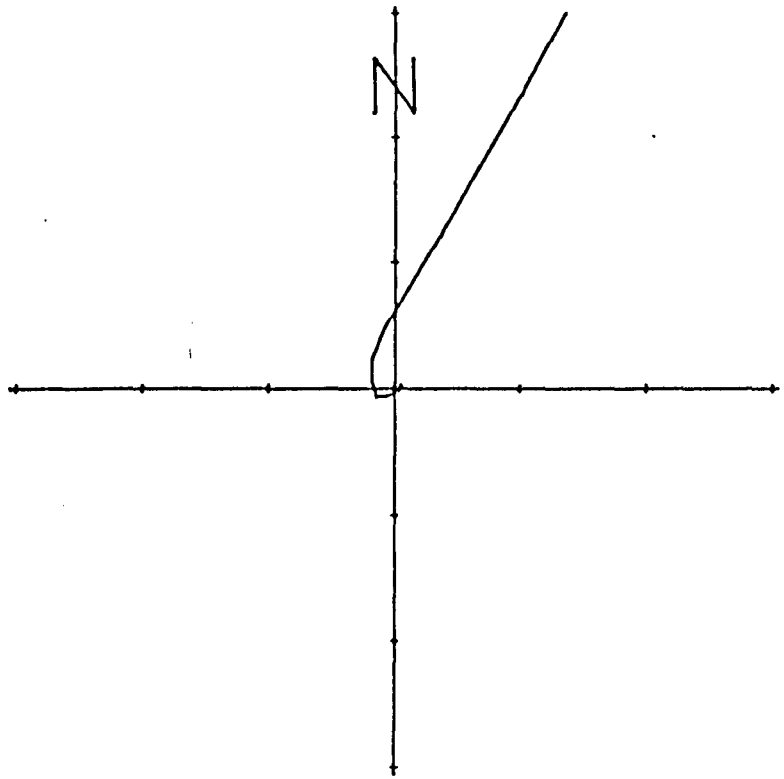


PIBAL RESULTS

828 MST 16 APR 75

MAP VIEW SITE 1



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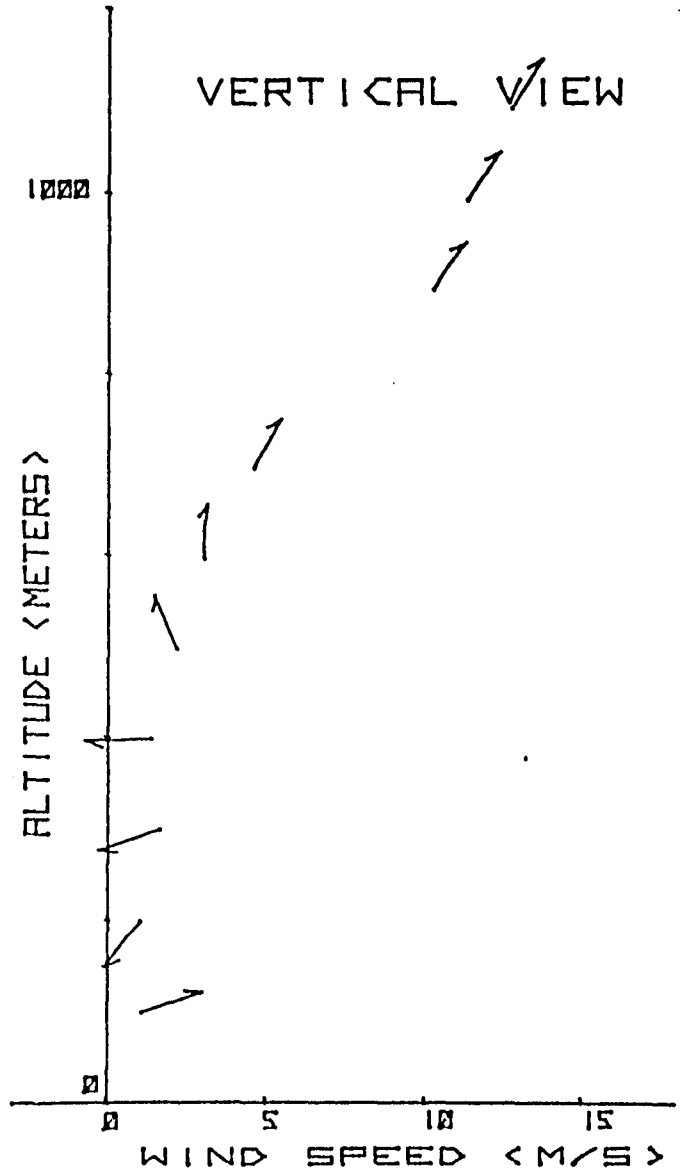
VERTICAL VIEW

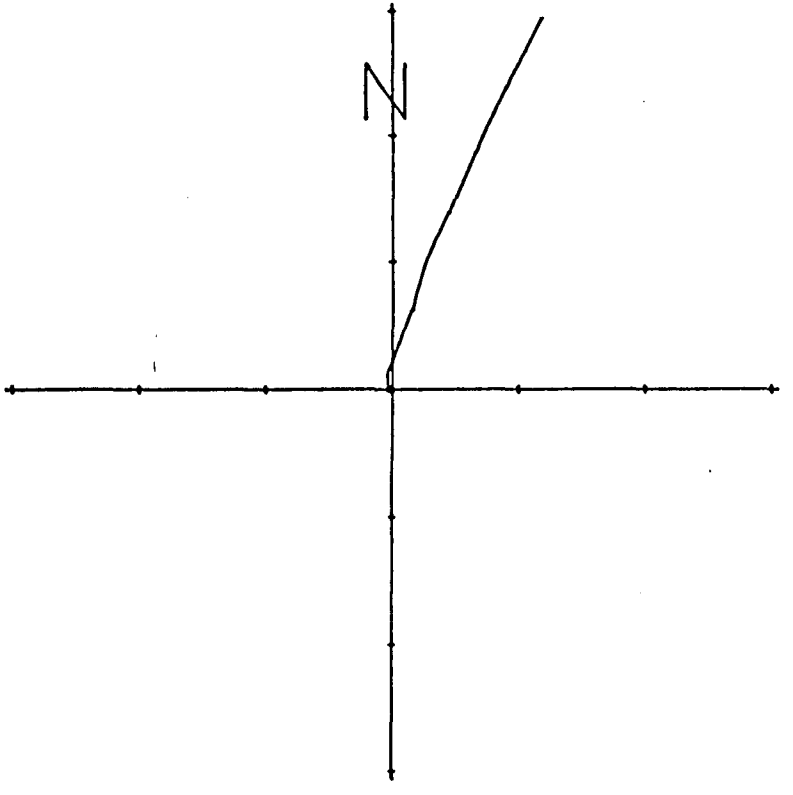


PIBAL RESULTS

958 MST 16 APR 75

MAP VIEW

SITE 1



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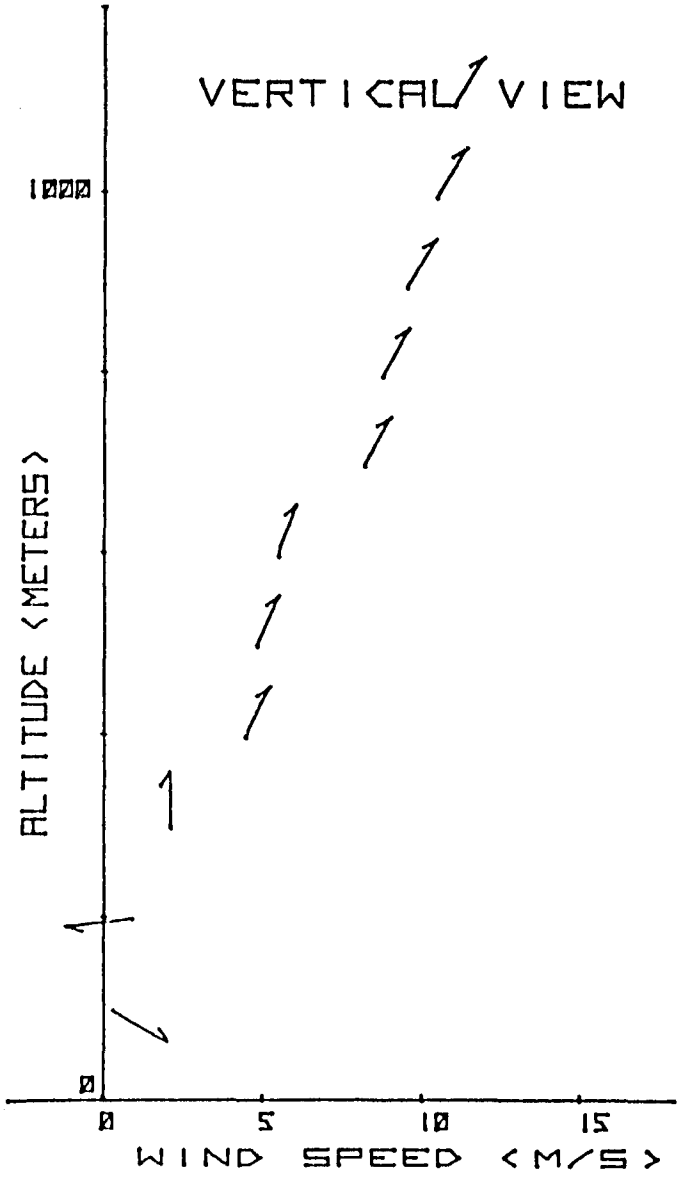
VERTICAL VIEW

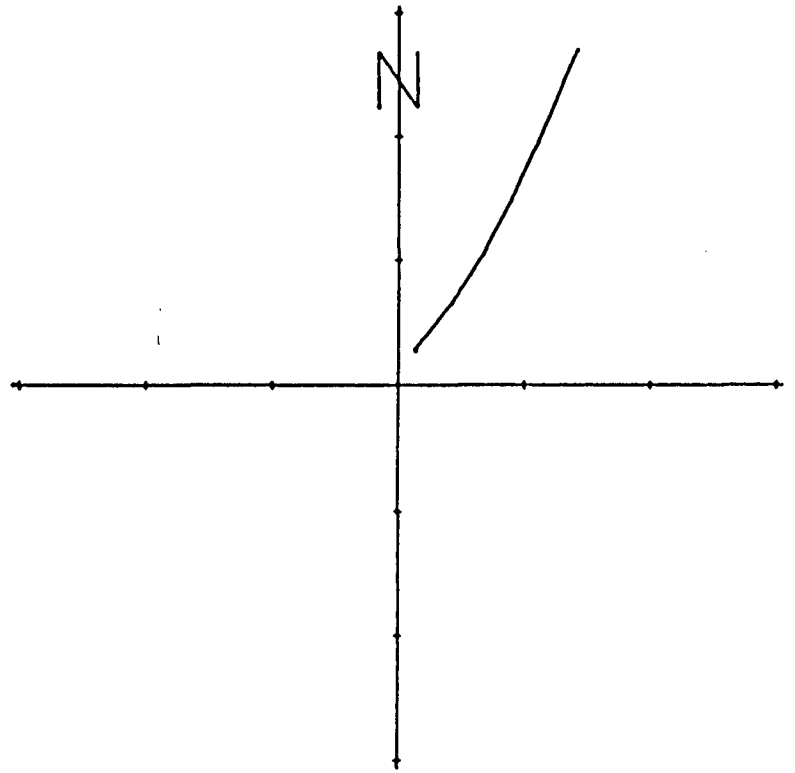


PIBAL RESULTS

1200 MST 16 APR 75

MAP VIEW

SITE 5



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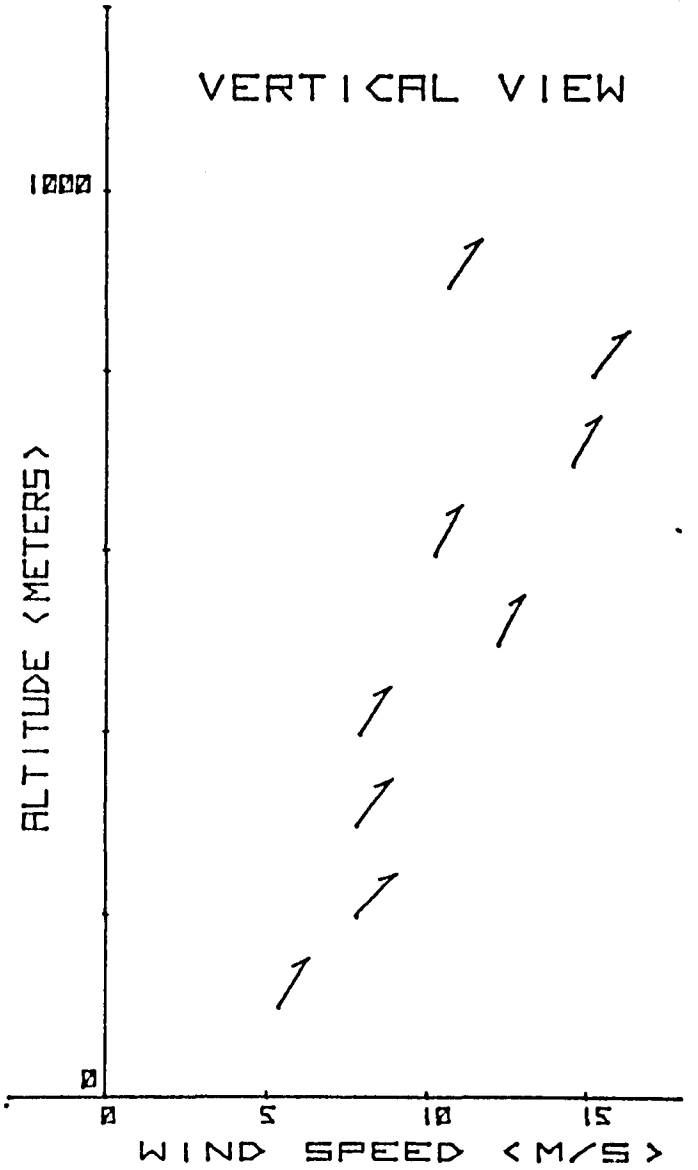
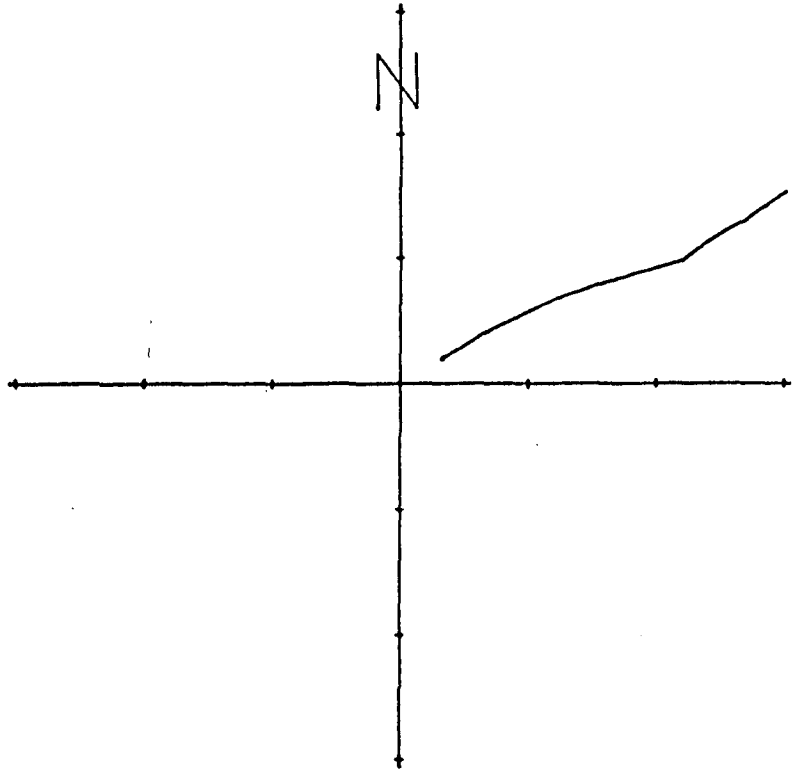
VERTICAL VIEW



PIBAL RESULTS

1517 MST 16 APR 75

MAP VIEW SITE B



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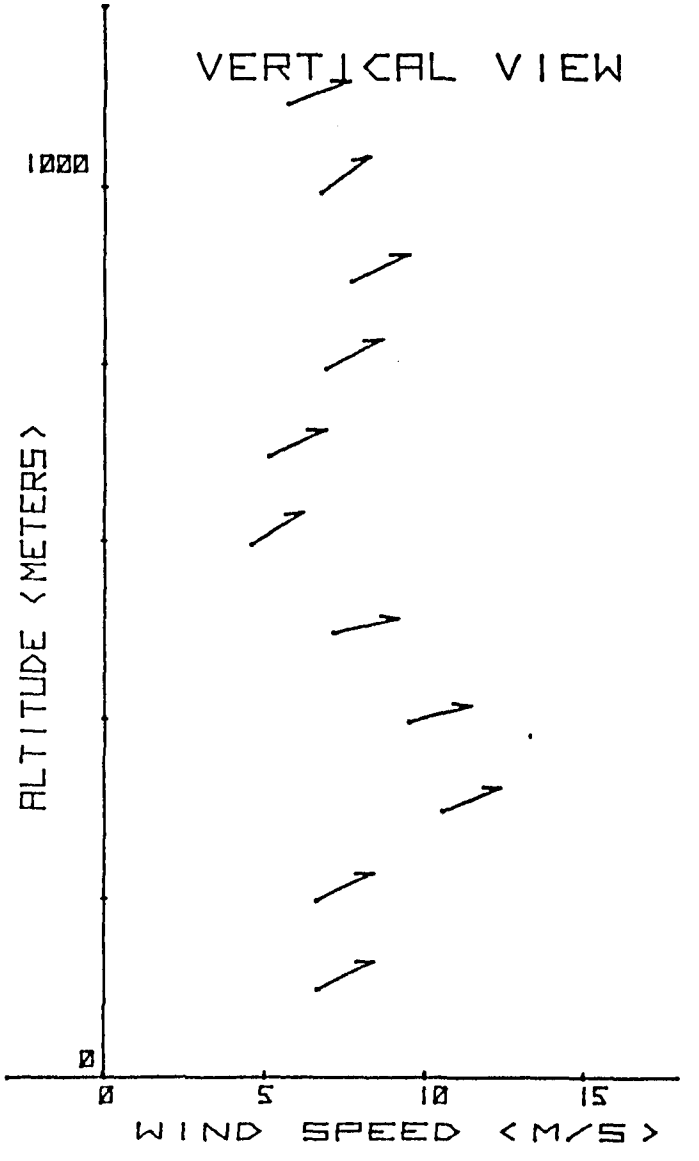
VERTICAL VIEW

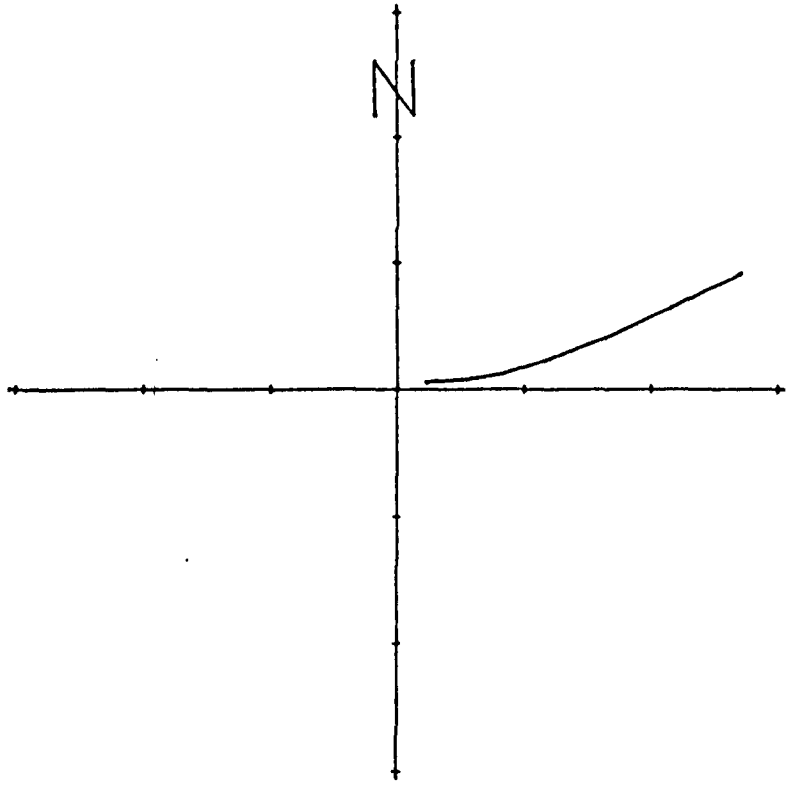


PIBAL RESULTS

1650 MST 16 APR 75

MAP VIEW

SITE 1



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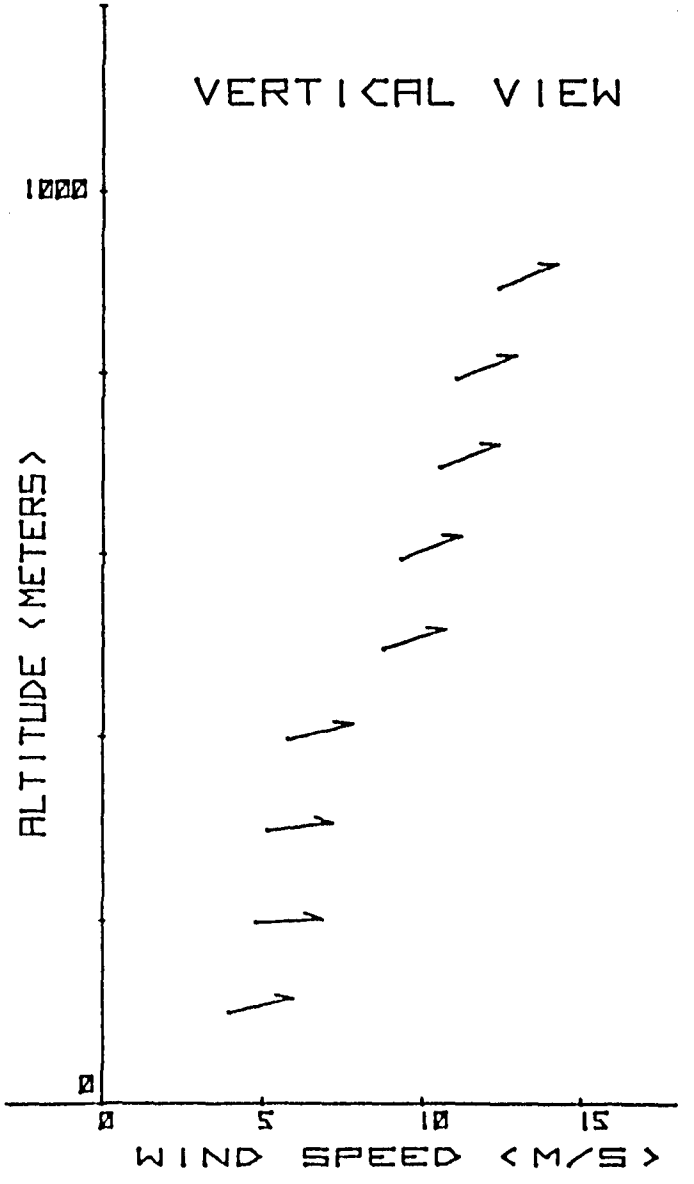
VERTICAL VIEW

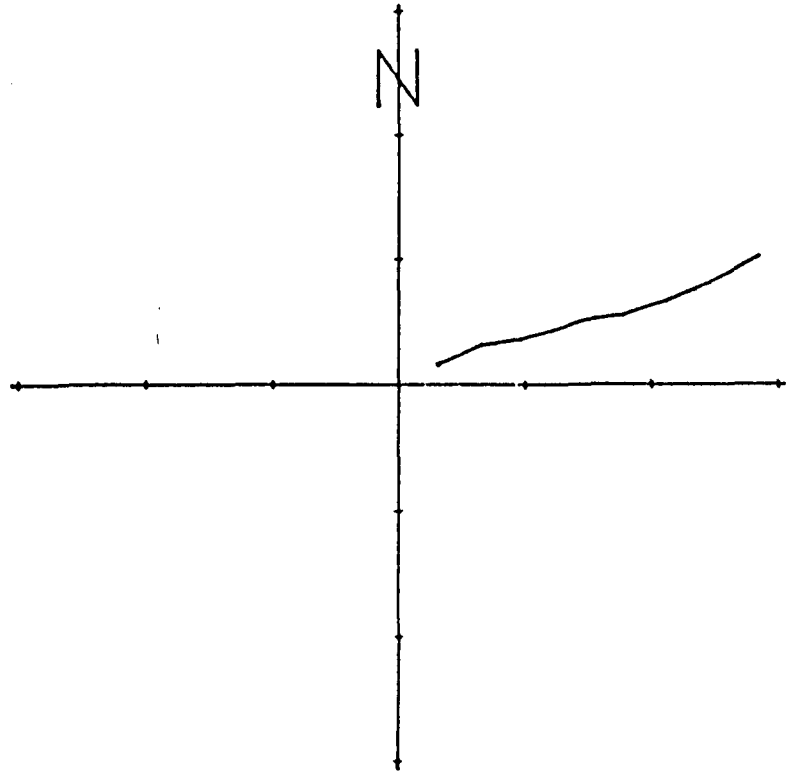


PIBAL RESULTS

823 MST 17 APR 75

MAP VIEW

SITE 1



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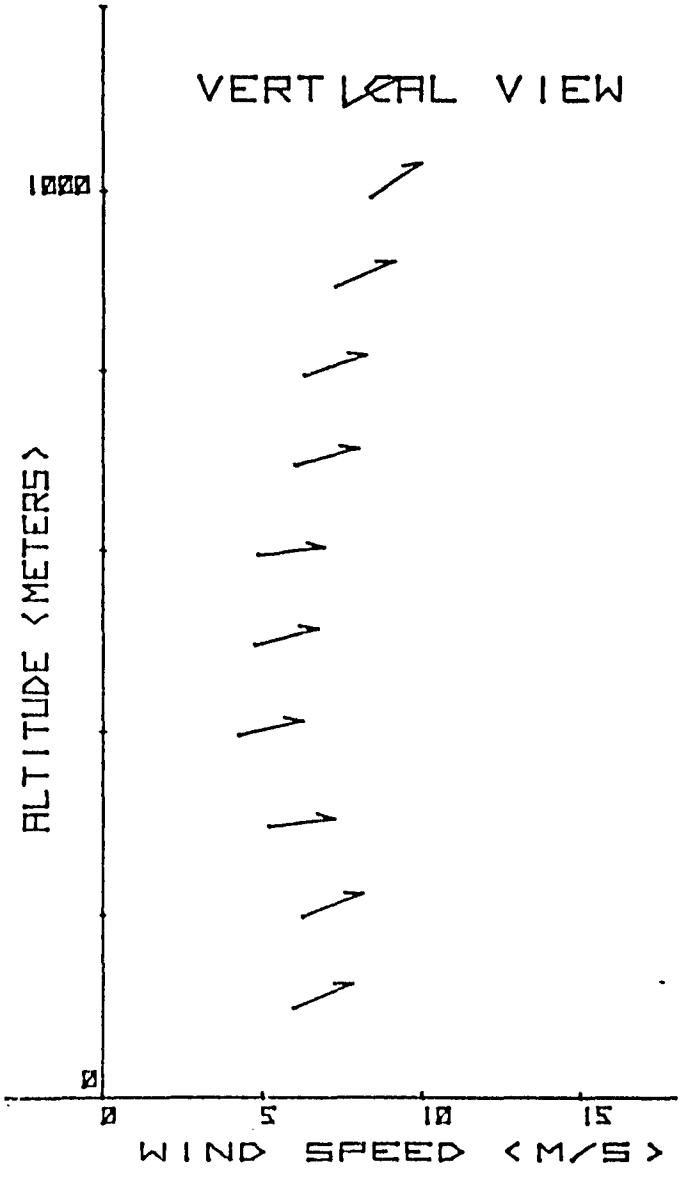
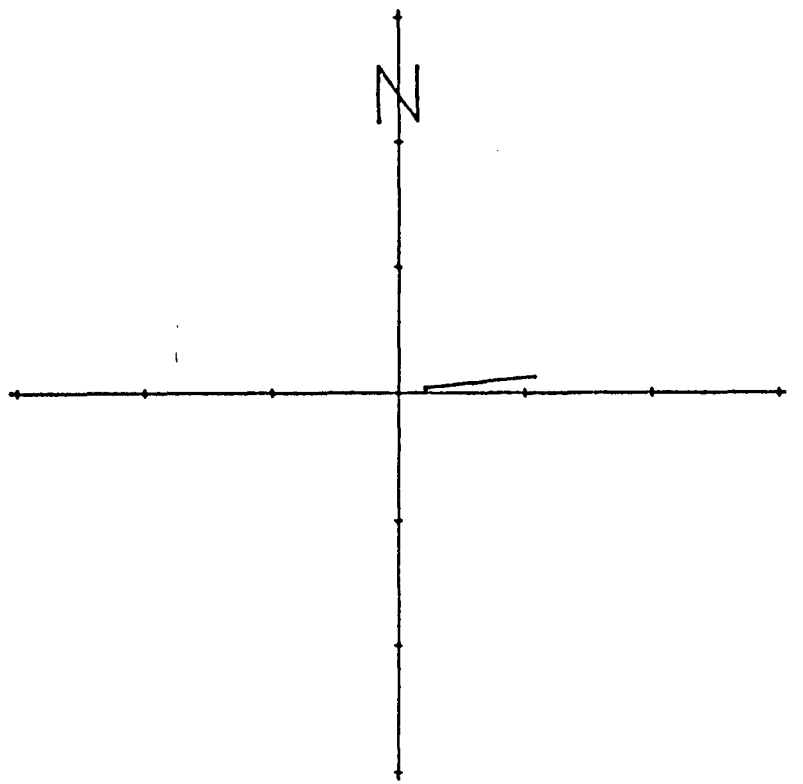
VERTICAL VIEW



PIBAL RESULTS

920 MST 17 APR 75

MAP VIEW SITE 3



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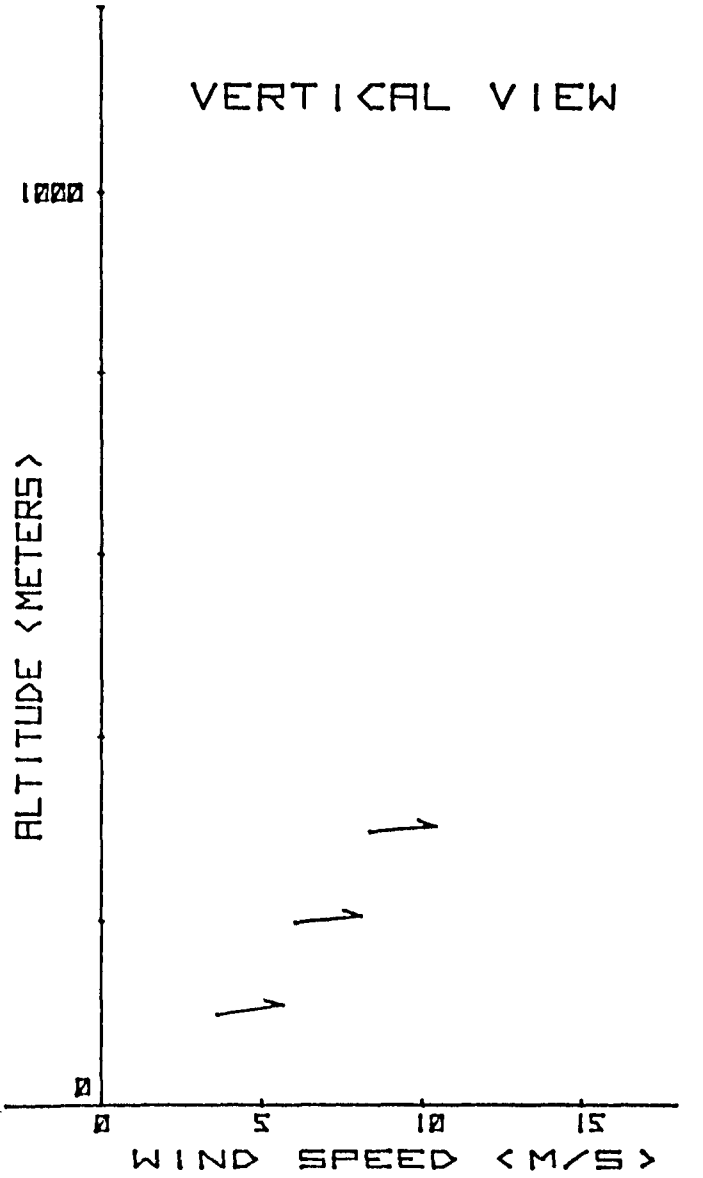
VERTICAL VIEW

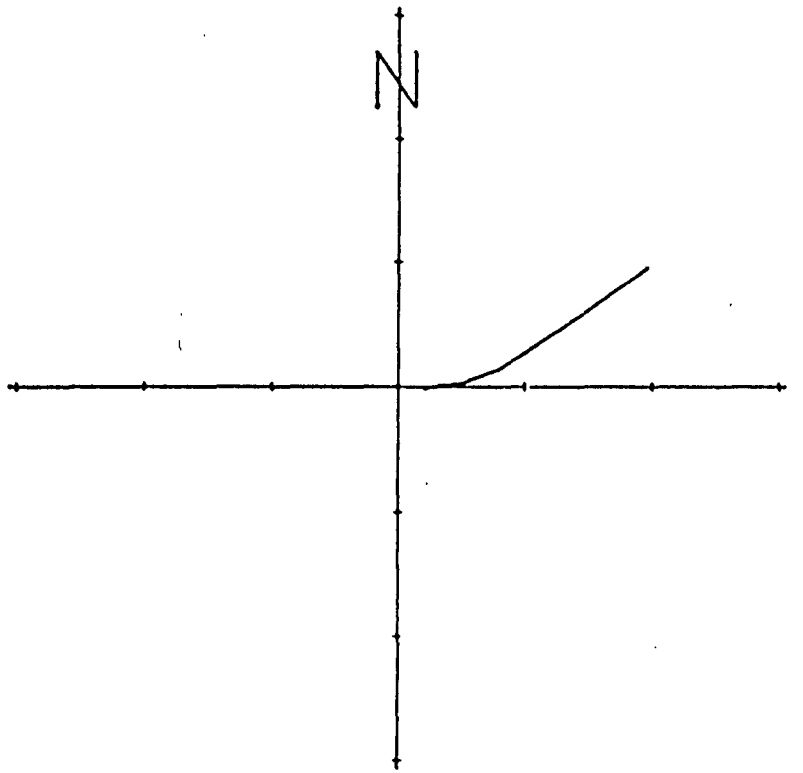


PIBAL RESULTS

951 MST 17 APR 75

MAP VIEW

SITE 3



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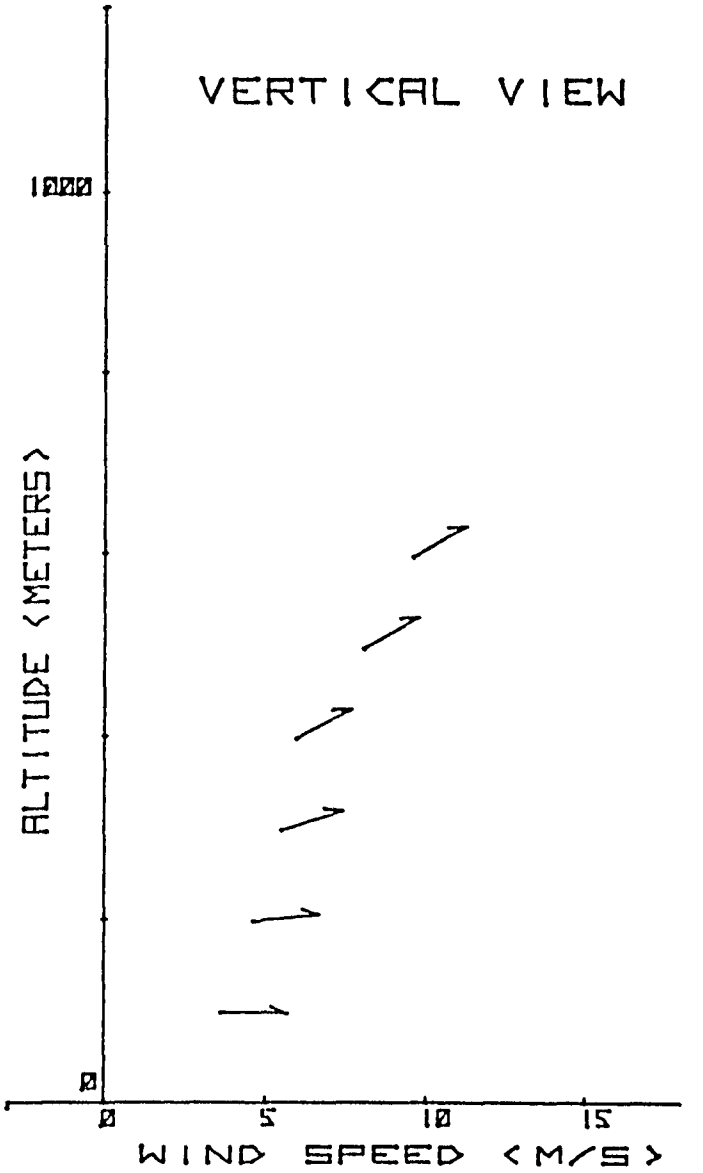
VERTICAL VIEW

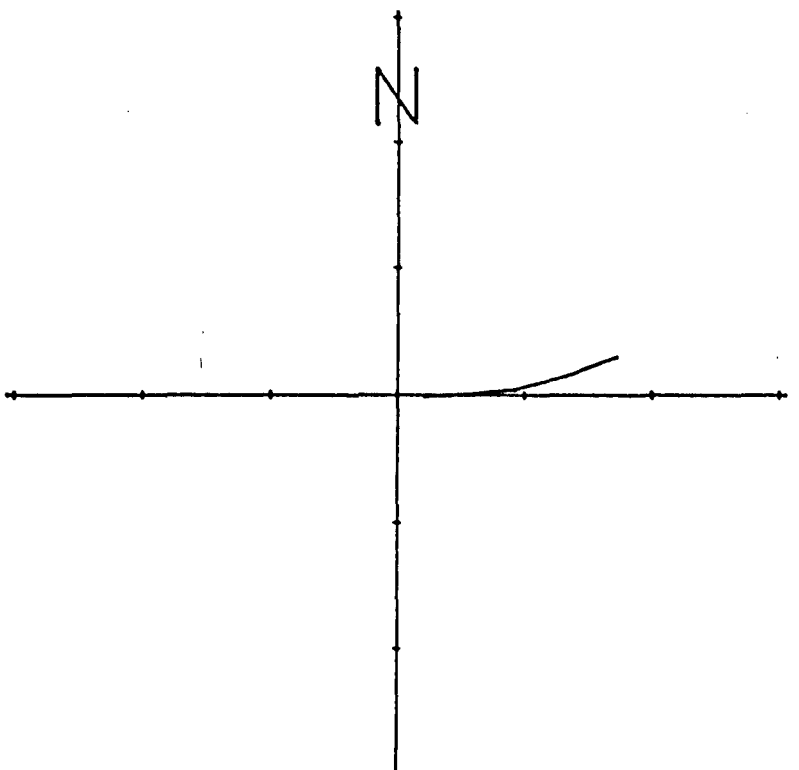


PIBAL RESULTS

1021 MST 17 APR 75

MAP VIEW

SITE 3



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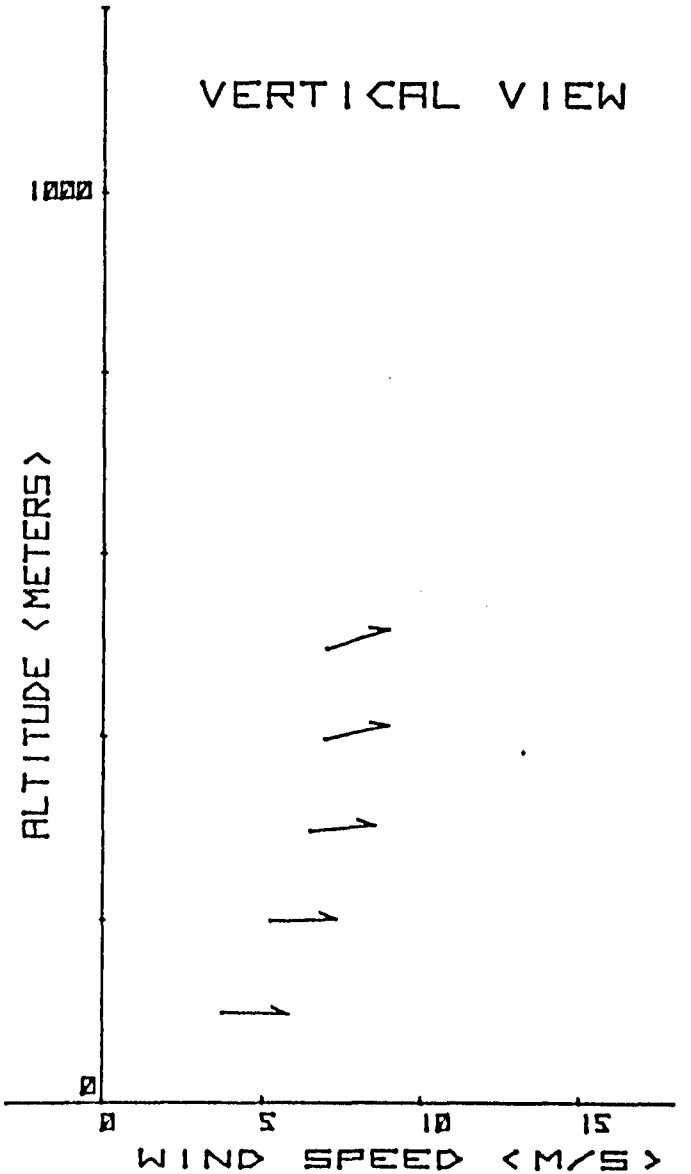

PIBAL RESULTS

1036 MST 17 APR 75

MAP VIEW

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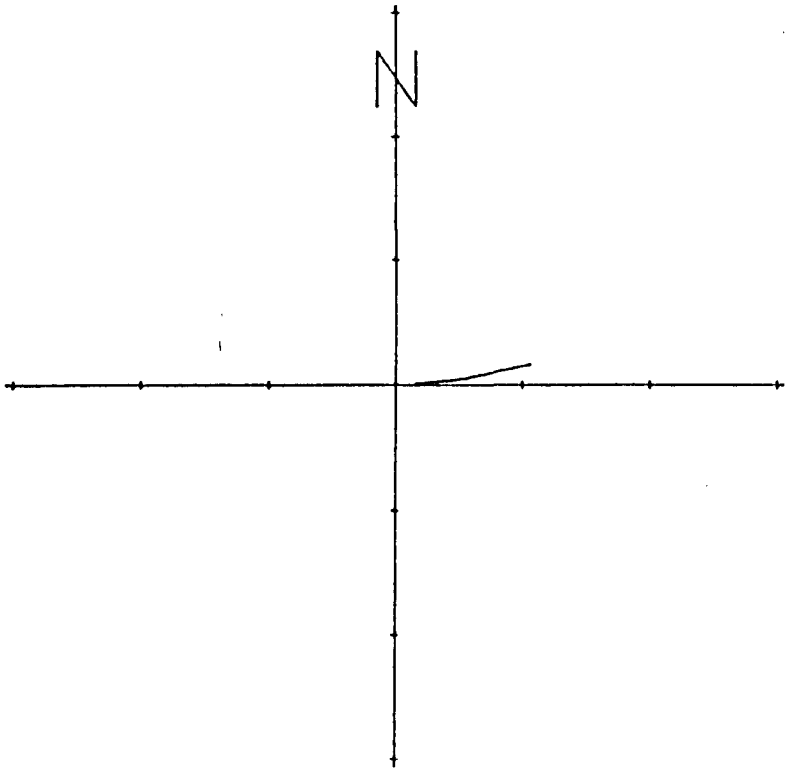

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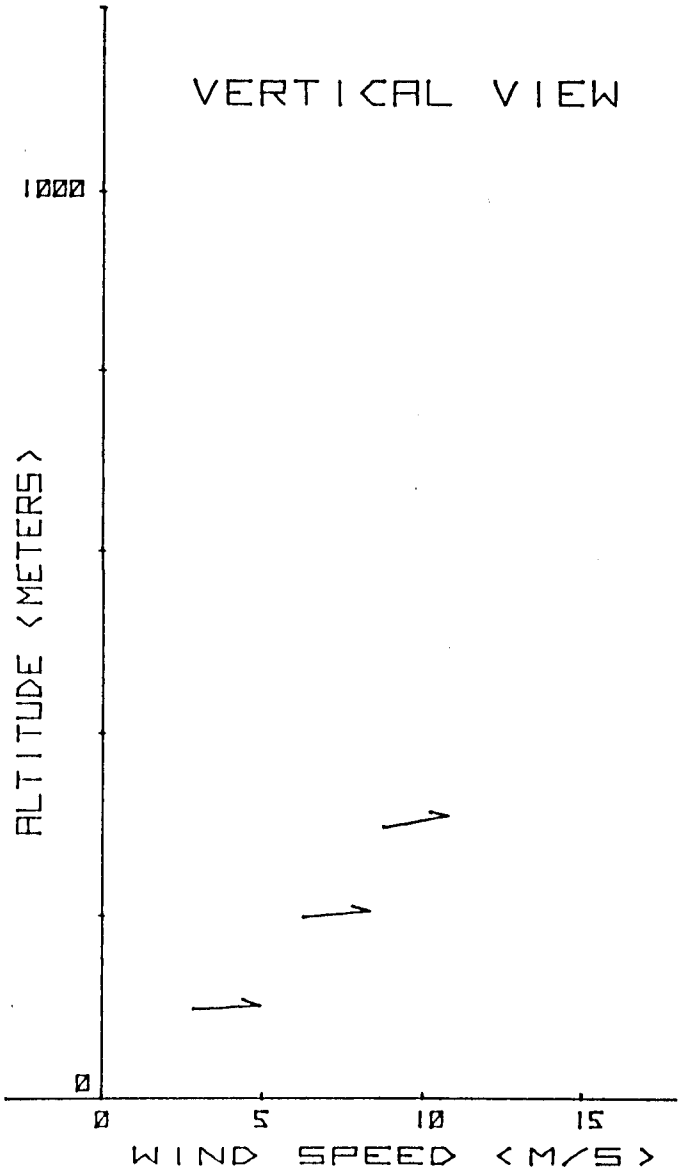

PIBAL RESULTS

1045 MST 17 APR 75

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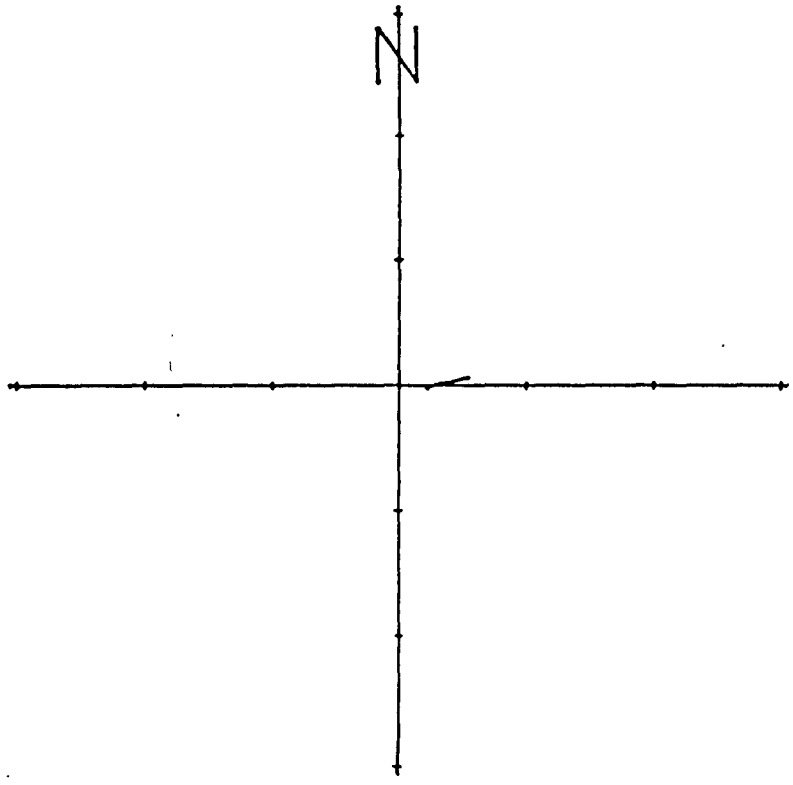

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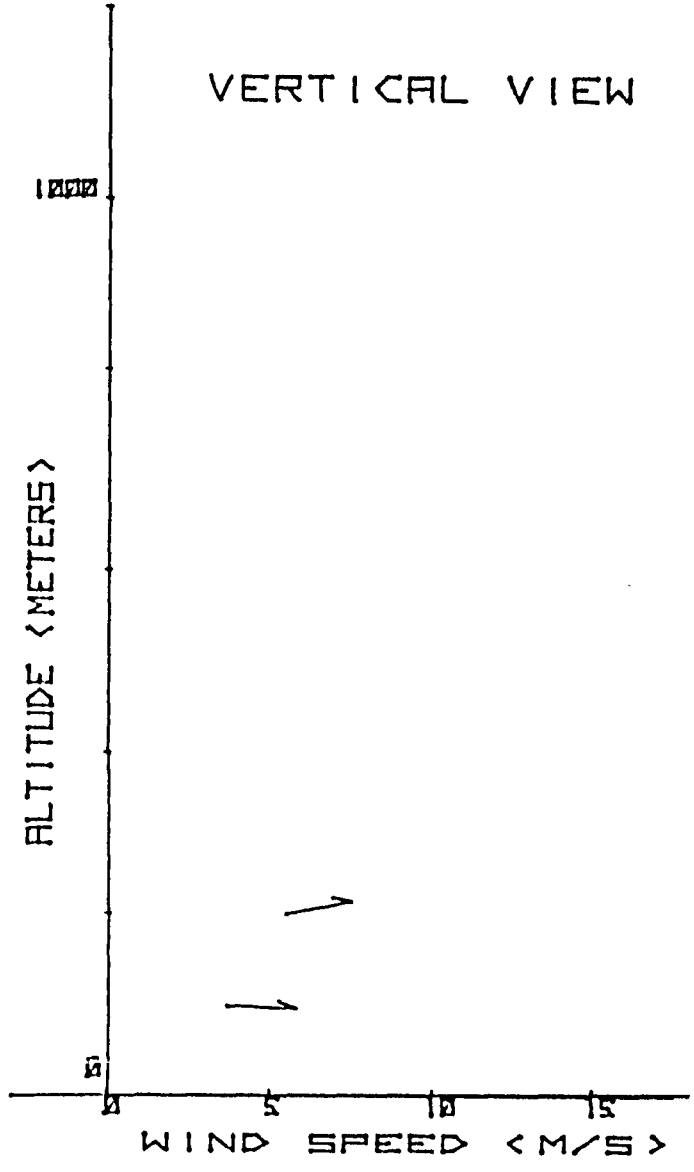
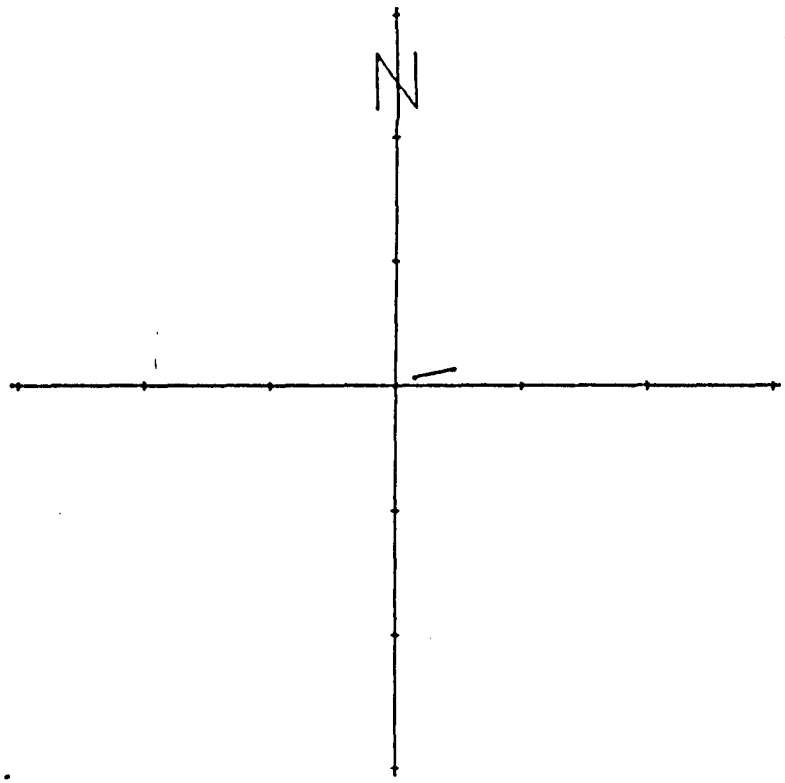


PIBAL RESULTS

1104MST 17 APR 75

MAP VIEW SITE 3



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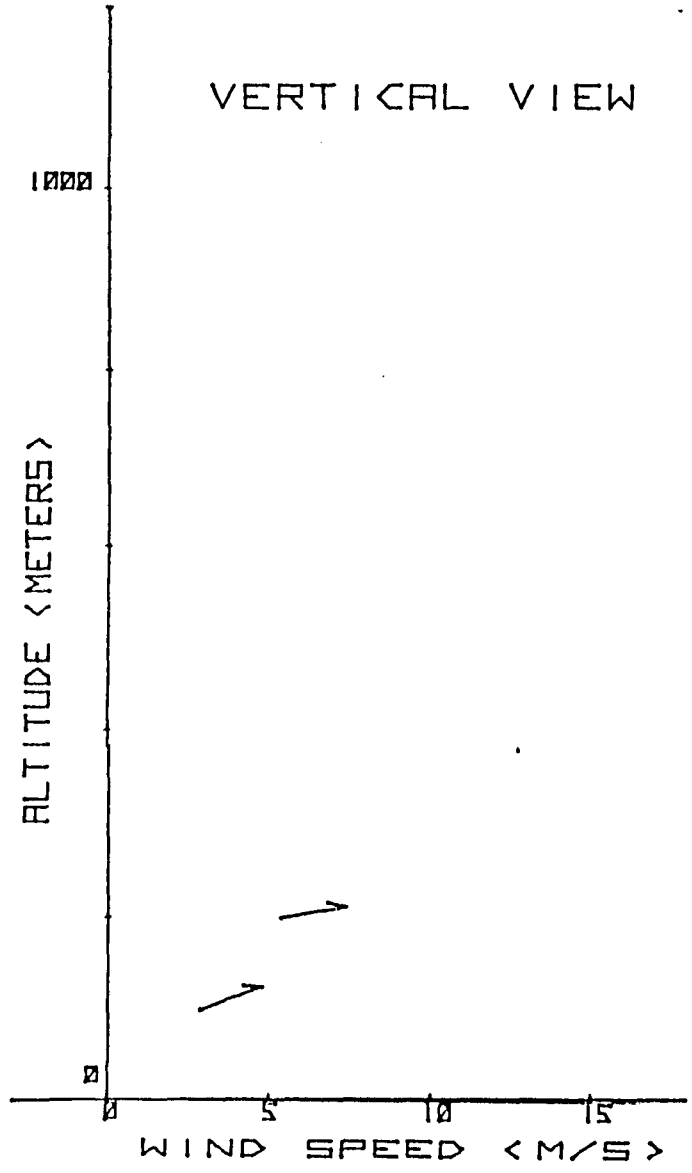
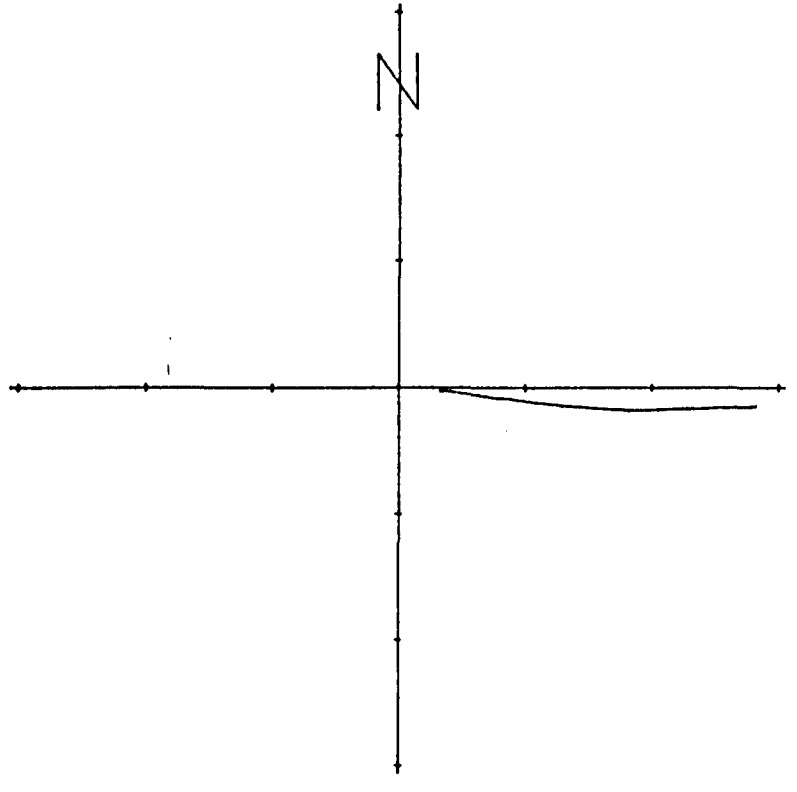


PIBAL RESULTS

1246 MST 17 APR 75

MAP VIEW

SITE 4



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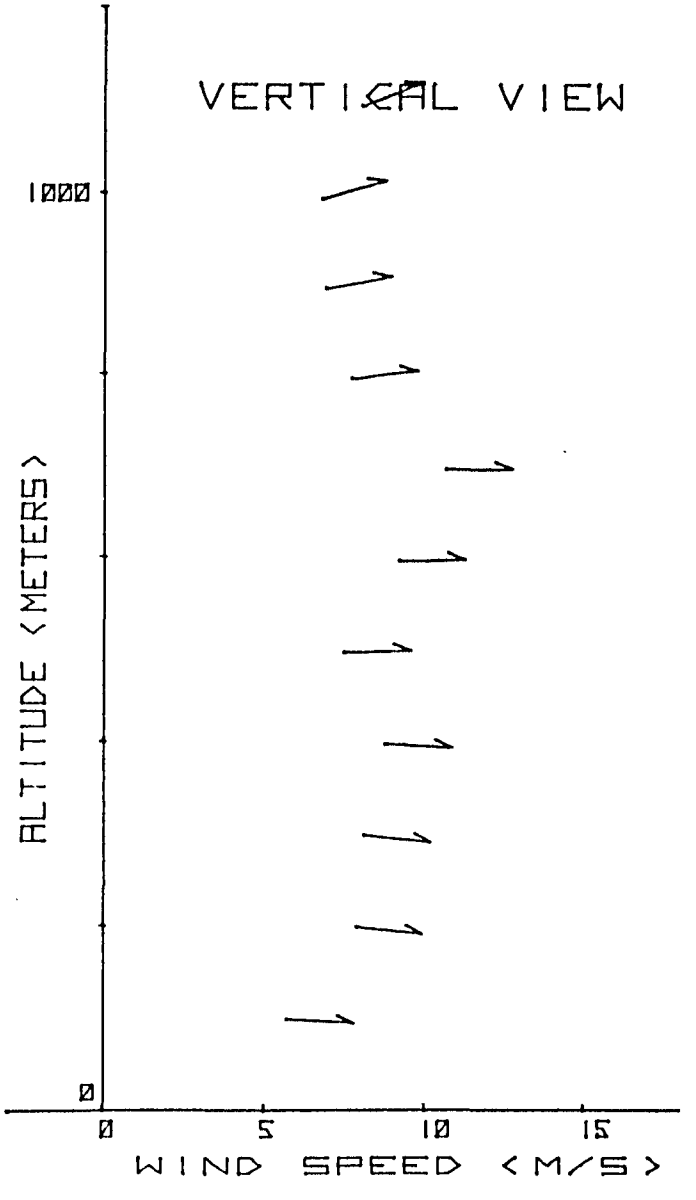
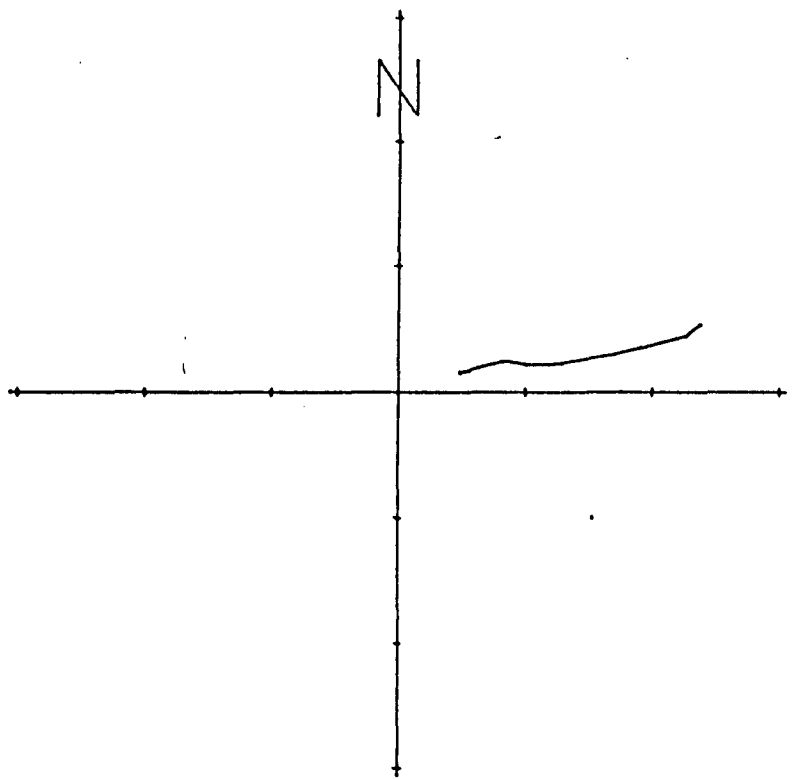


PIBAL RESULTS

1311 MST 17 APR 75

MAP VIEW SITE 4



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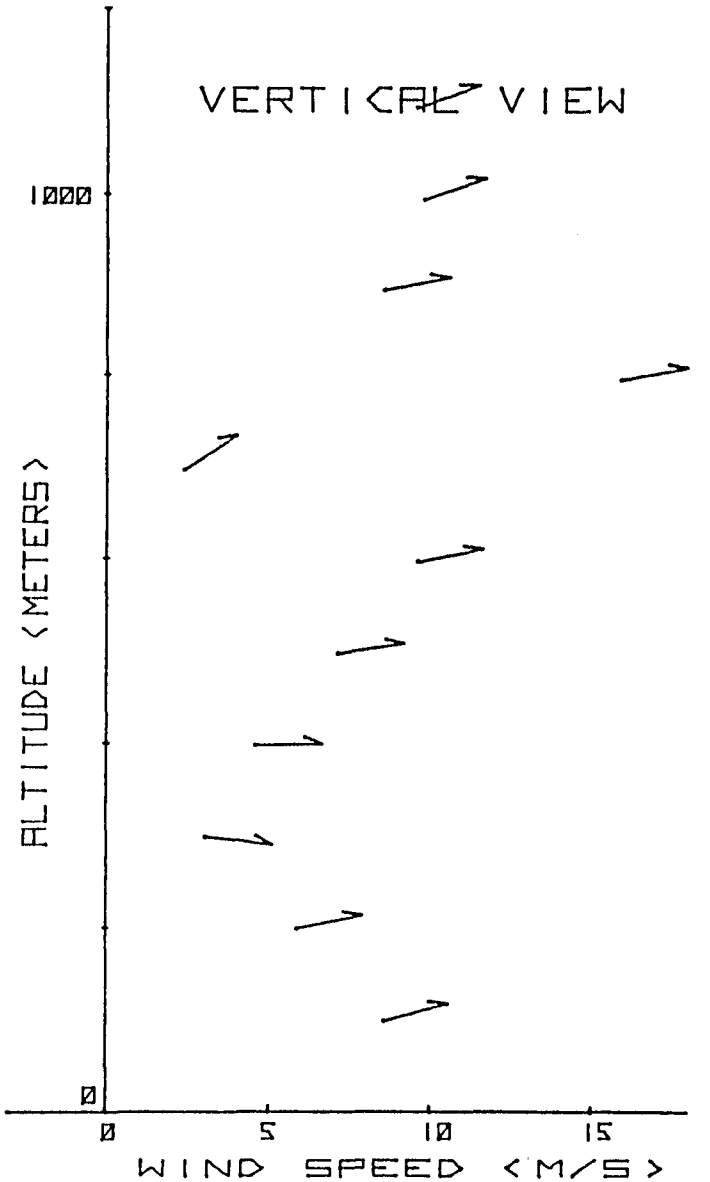

PIBAL RESULTS

1348 MST 17 APR 75

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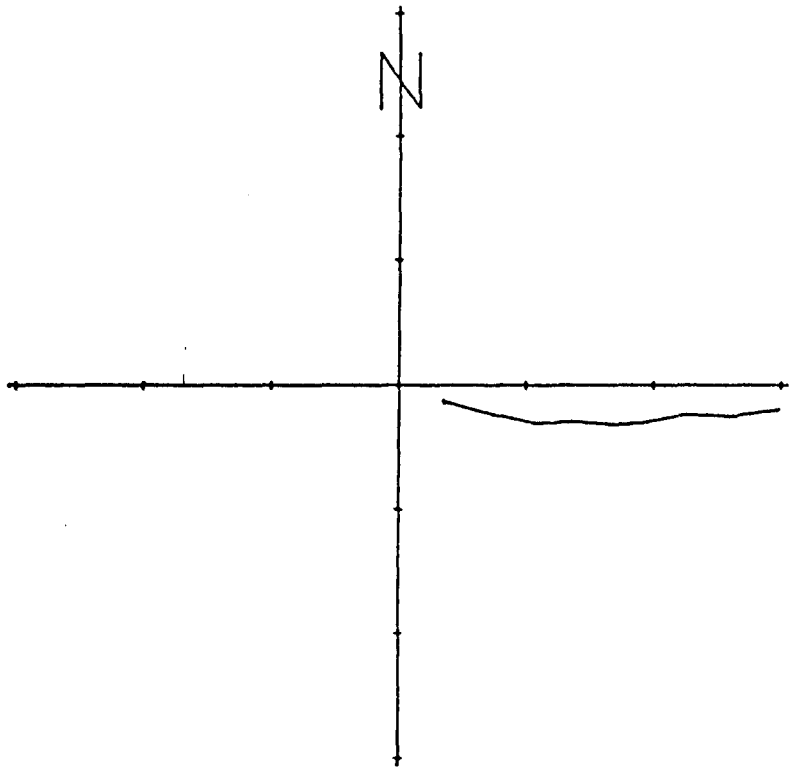

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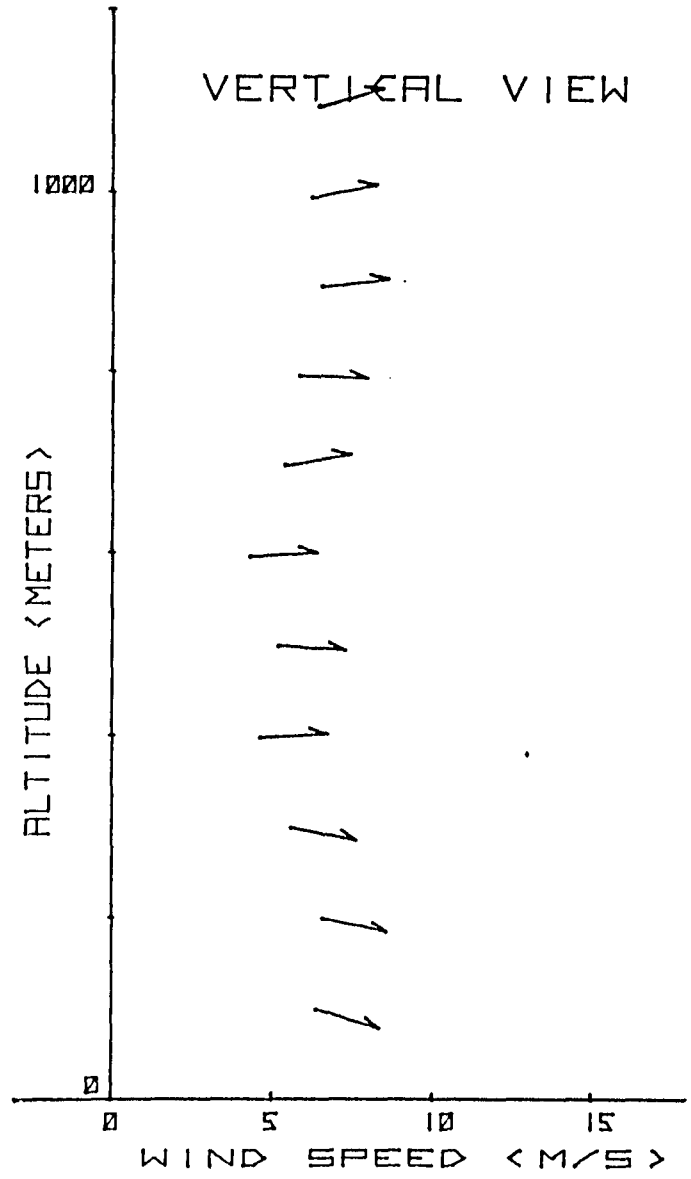
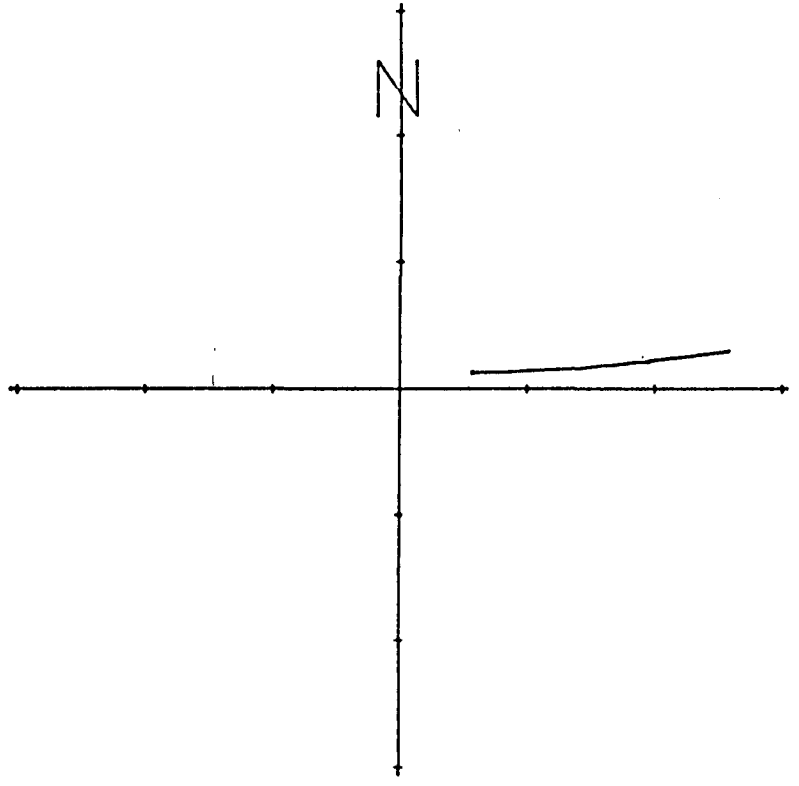


PIBAL RESULTS

1612 MST 17 APR 75

MAP VIEW

SITE 4



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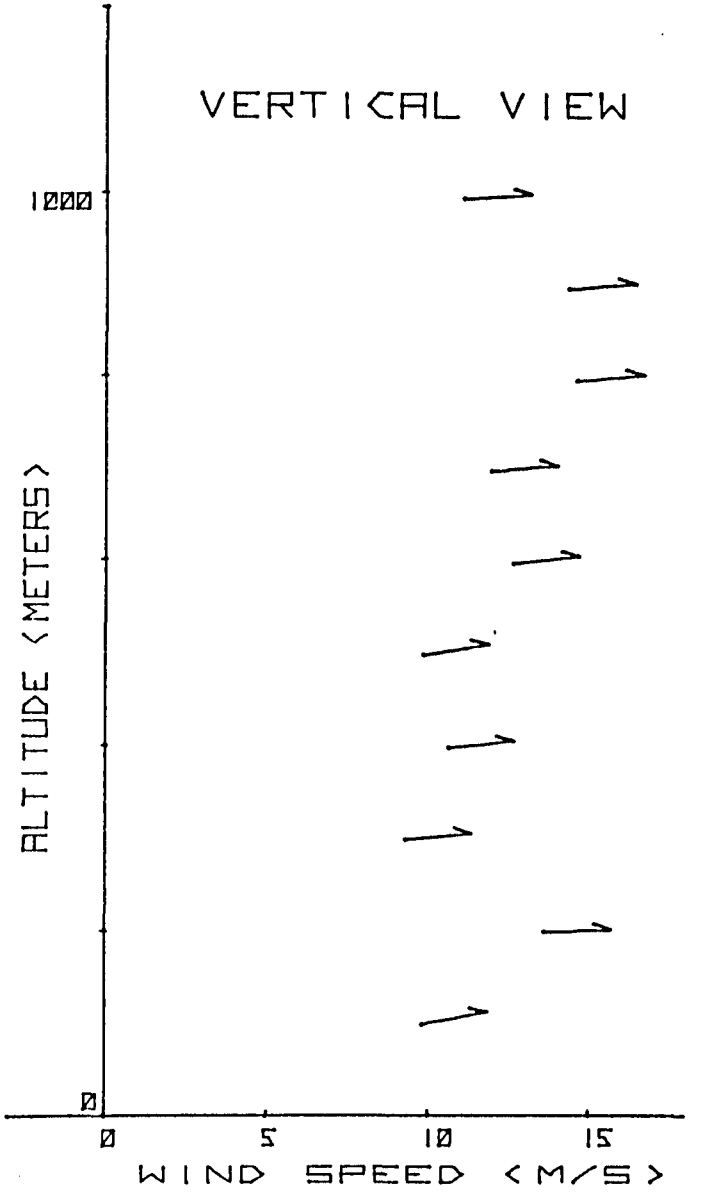
VERTICAL VIEW

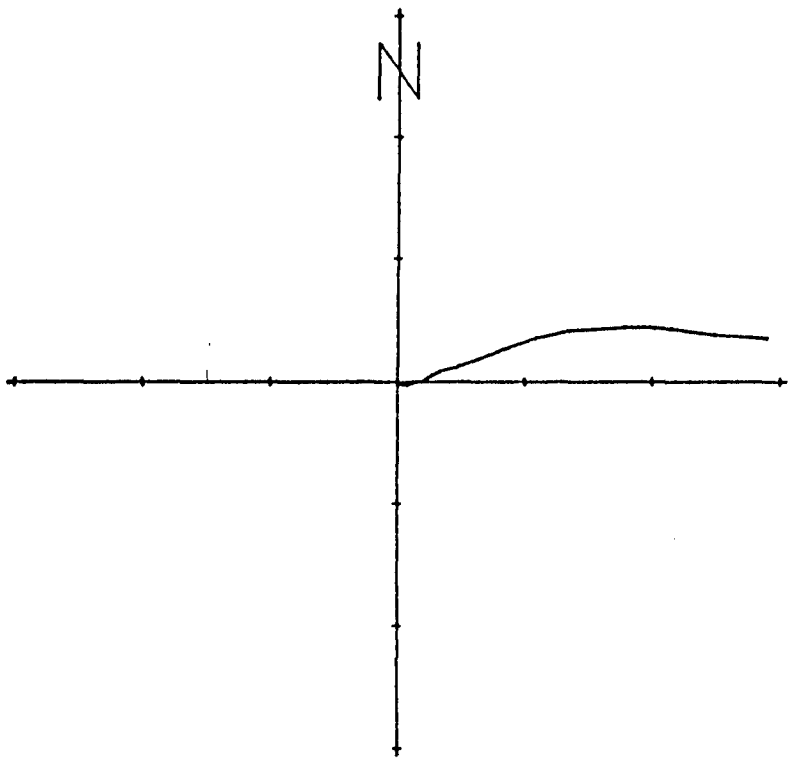


PIBAL RESULTS

755 MST 18 APR 75

MAP VIEW

SITE 7



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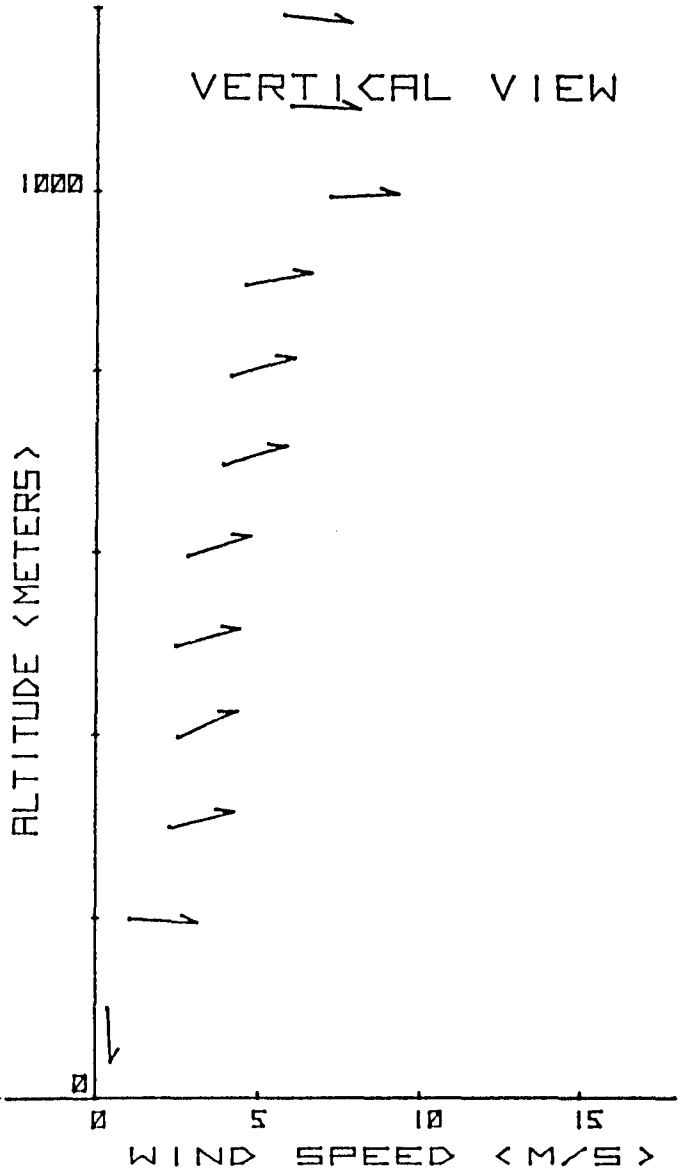
VERTICAL VIEW

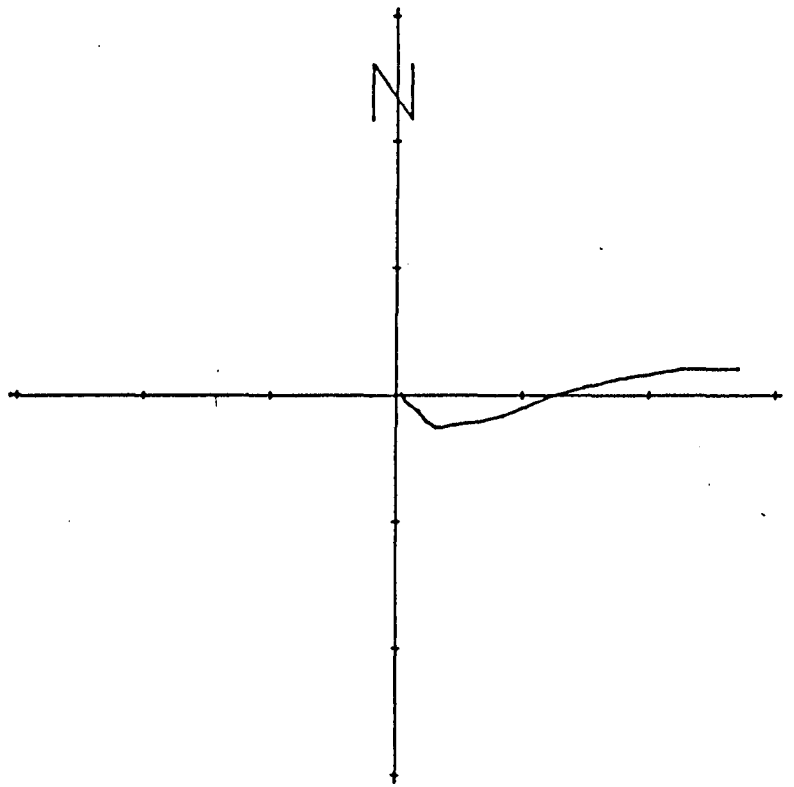


PIBAL RESULTS

900 MST 18 APR 75

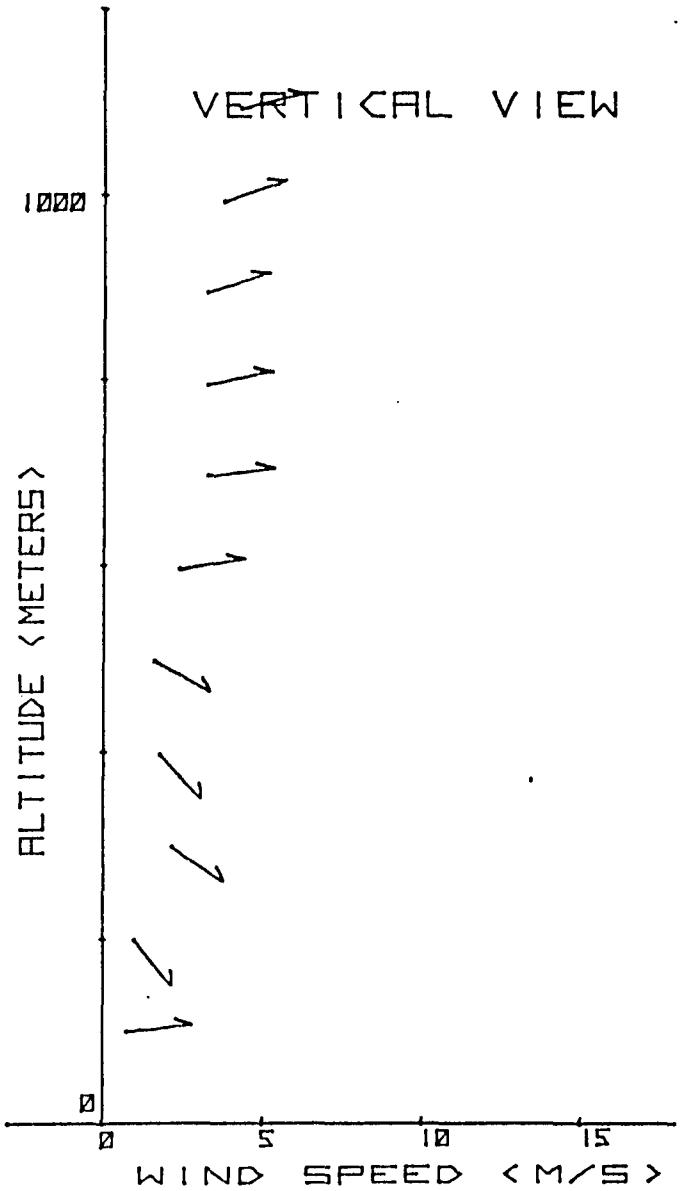
MAP VIEW

SITE 1



SCALE DIV <0.5 KM>

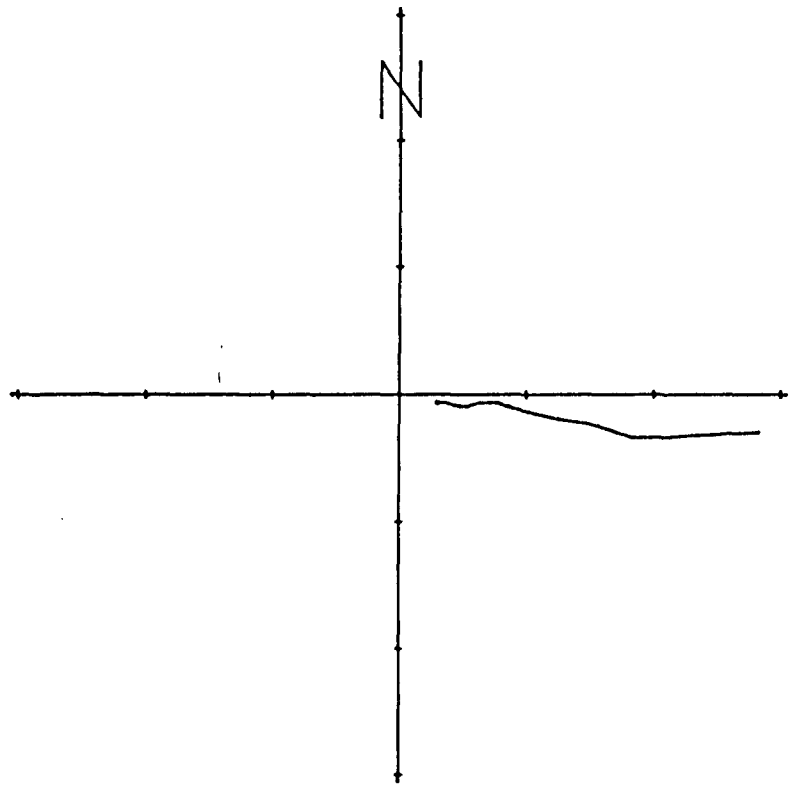
VERTICAL VIEW



PIBAL RESULTS

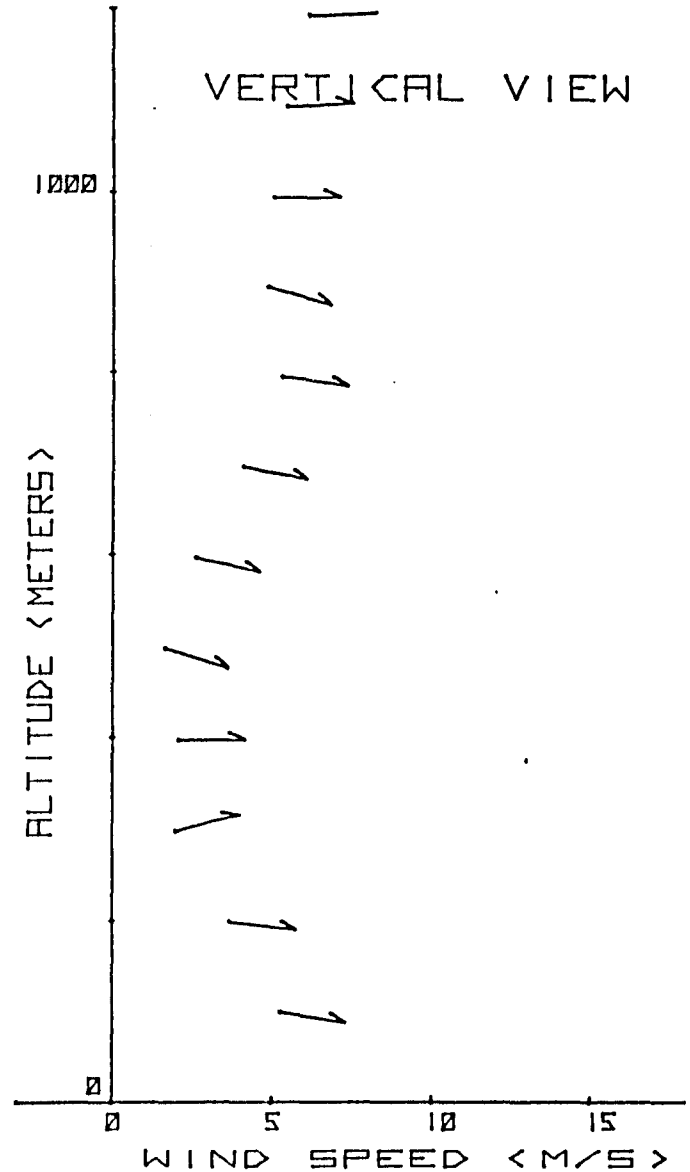
1020 MST 18 APR 75

MAP VIEW



SCALE DIV <0.5 KM>

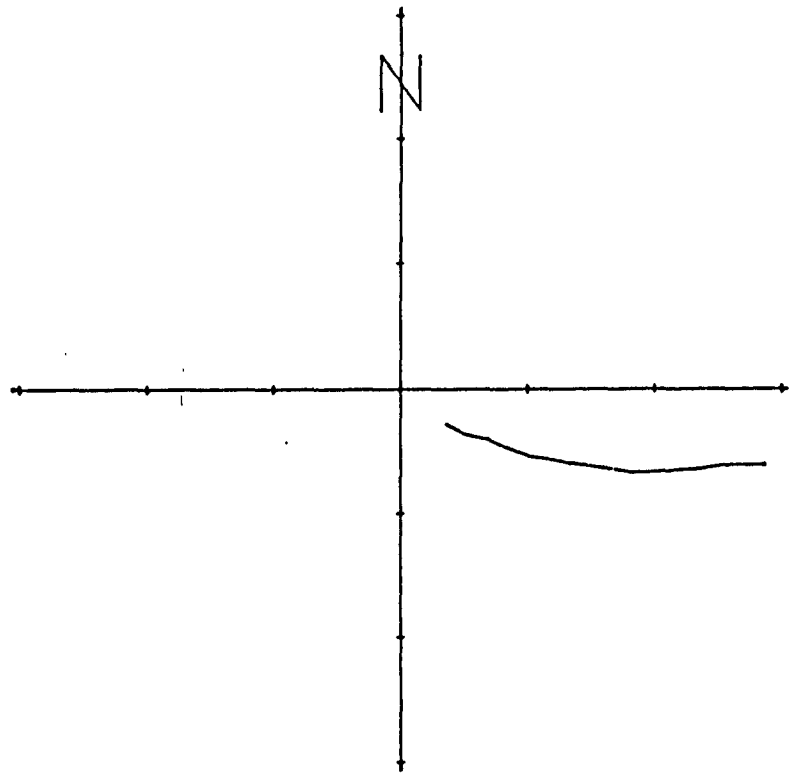
VERTICAL VIEW



PIBAL RESULTS

1046 MST 18 APR 75

MAP VIEW SITE 4



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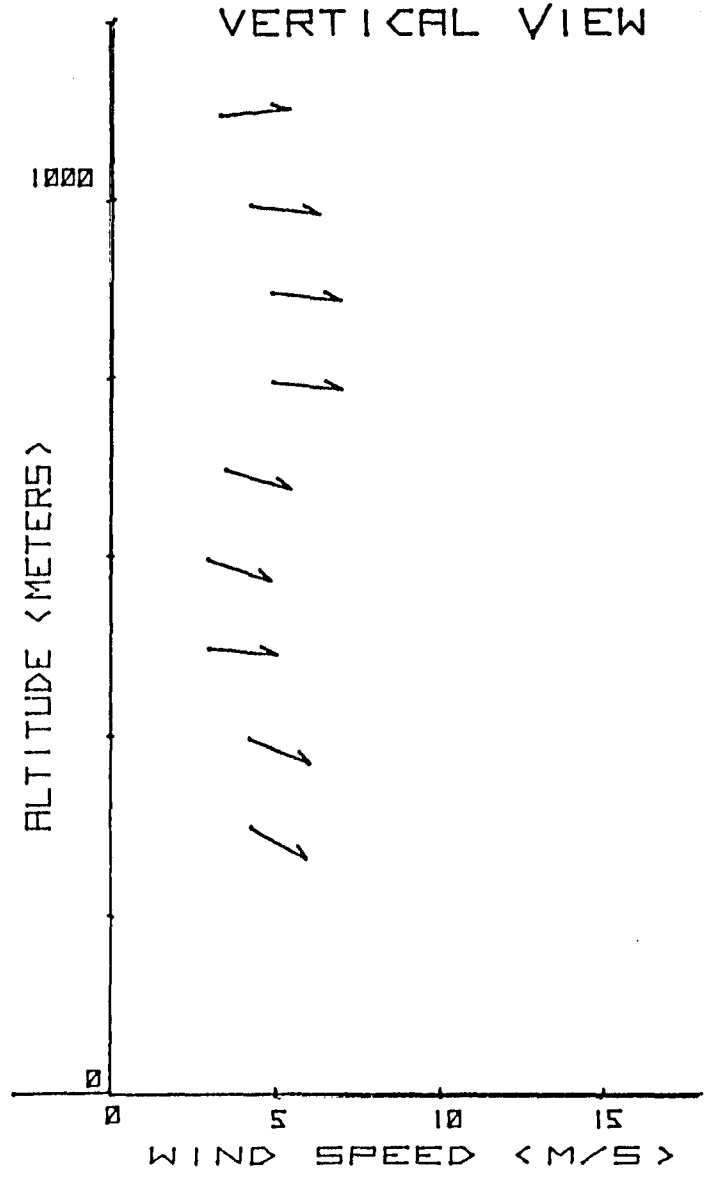
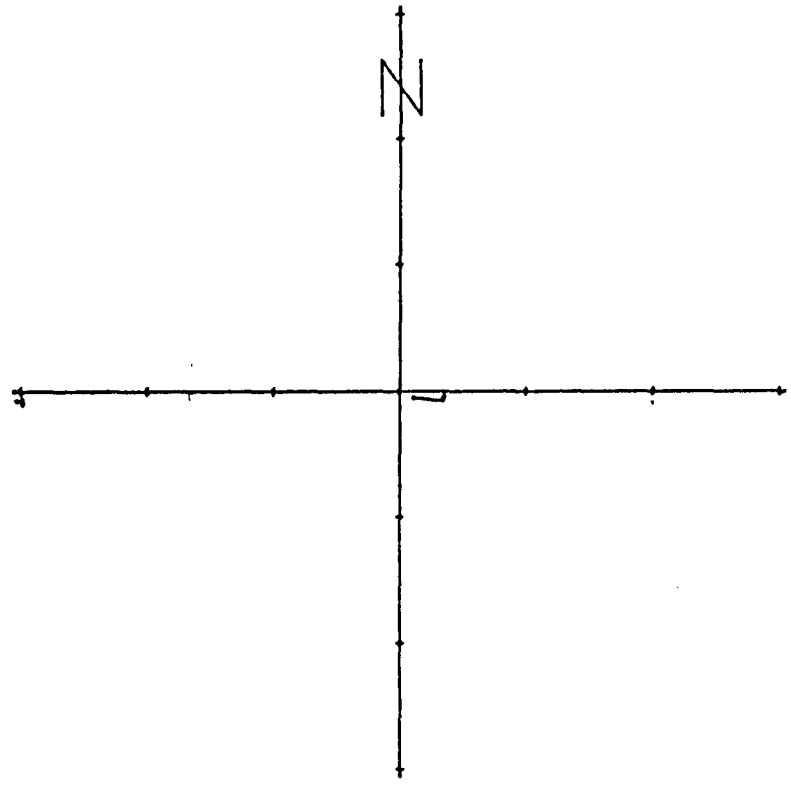


PIBAL RESULTS

1125 MST 18 APR 75

MAP VIEW

SITE 4



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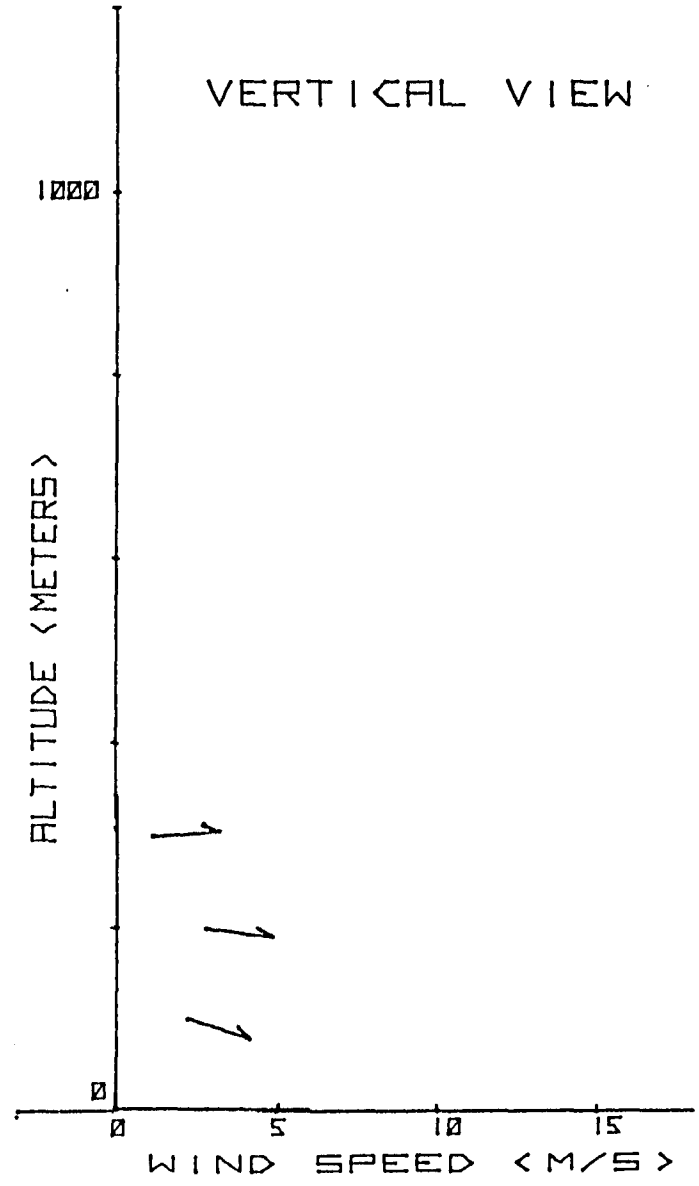
VERTICAL VIEW

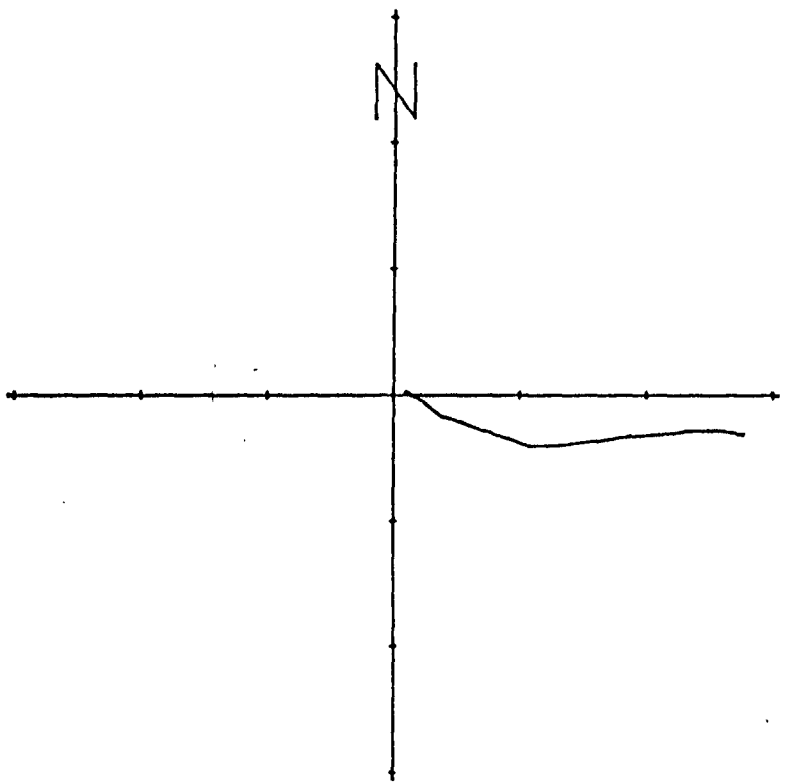


PIBAL RESULTS

1133 MST 18 APR 75

MAP VIEW

SITE 4



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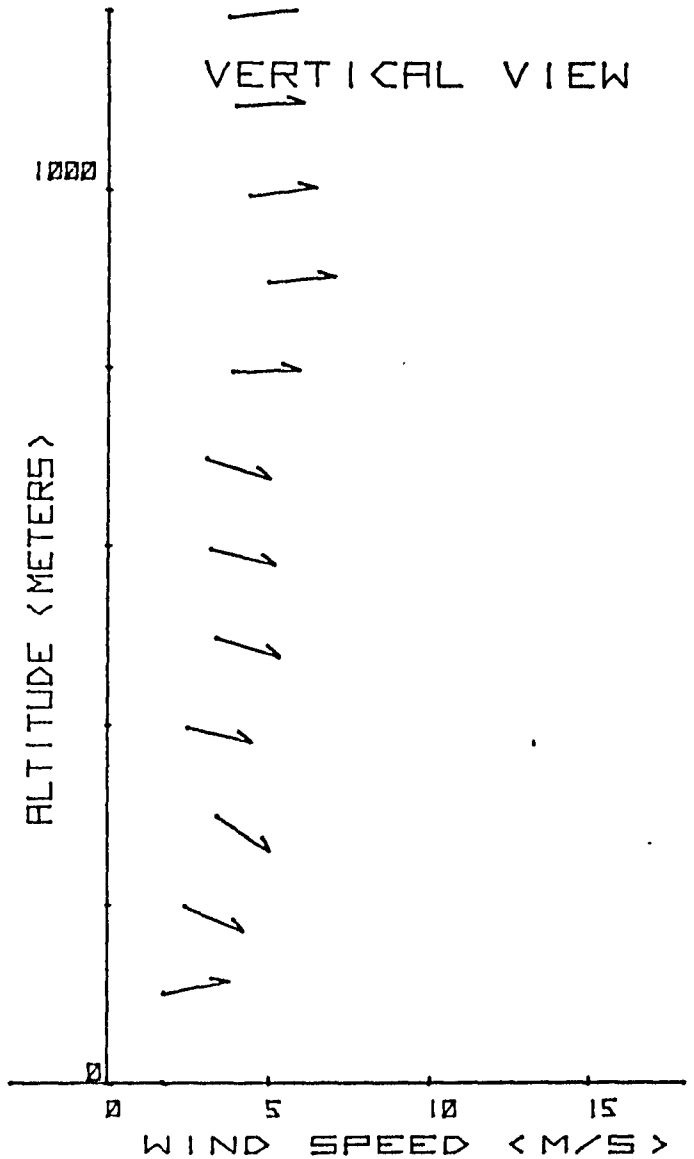
VERTICAL VIEW



GLOSSARY

AGC -	Automatic Gain Control, the light sensing circuit of the correlation spectrometer
AQML -	Air Quality Moving Laboratory, an array of instruments designed to monitor air pollutants in a truly mobile mode
Burden -	Vertically integrated concentration-path length measurements of pollutants as measured by the Correlation Spectrometer, (also overhead burden, total burden)
COSPEC -	Correlation Spectrometer, manufactured by Barringer Research Ltd., an electro-optical remote sensor which monitors pollutants along light paths originating from natural or artificial radiation
Data Day -	A measurement day when personnel and equipment are mobilized to survey air quality; actual hours of measurement may range from one to twenty-four depending on conditions at the site
Event -	A single measurement by the moving laboratory; a plume crossing or a regional survey; may vary in length from one minute to one hour
Flux -	See Mass Flux
Ground Level -	Ground-level concentrations of pollutants as measured by point monitors
Km -	Kilometers
MT/D -	Metric Tons per day, emission rate
ppb -	Parts per billion, concentration measurement
ppmM -	Parts per million-meters, concentration-path length measurement

GLOSSARY

Mass Flux -	Emission rate of pollutant across a traverse route calculated from remote sensing data (also mass flow rate)
Noise -	Spectrometer response due to spurious, unwanted electronic signals; usually a few ppmM depending on gas measured and available light
Overhead Burden -	See Burden
Pibal -	Pilot balloon, used to measure wind speed and wind direction at the elevation of the plume (stack emissions)
Plume -	Dispersing stack emissions
Total Burden -	See Burden
TB -	See Burden
Ground -	See Ground-level
GL	See Ground-level
RMS Error -	Root Mean Square Error
Traverse -	A moving measurement using a moving laboratory; a traverse route is a highway or road travelled during a survey
UTM -	Universal Transverse Mercator coordinates used on U,S, Geological Survey Topographic Maps

ACKNOWLEDGMENTS

The field measurements reported in this volume were made in Hayden, Arizona by Mr. Keith Kronmiller and Mr. Phil Shug under the supervision of Mr. Roger Sperling. The data analysis and report preparation were done in EMI's San Francisco office and they were organized by Mr. Roger Sperling and carried out by Mr. Micheal Peache, Ms. Kathleen Kronmiller, Ms. Leslie Connolly and Ms. Judi Kalinowski. The guidance provided by Ms. Charlotte Hopper, the EPA Project Officer, for both the design of the field experiments and the organization of the final report is gratefully acknowledged.