6. Tracer Results

6.1 Introduction

A detailed discussion of each tracer test is given in the following sections. The significant features of this discussion are the trajectories of the tracer clouds and their associated dispersion.

Trajectories were constructed for each of the tracer releases from the observed wind observations in the area. Although most of the calculated trajectories exhibited the characteristics of the observed tracer concentrations, many of the details of these concentration patterns were not reproduced. This results from the complex wind field structure in the region downwind from Montezuma Hills. As a consequence, the trajectories shown on the accompanying test maps were drawn subjectively from a best-estimate consideration of the observed wind field and the observed tracer concentrations. In many cases, the apparent trajectory changed considerably during the test and attempts have been made to indicate these changes on the maps.

Dispersion characteristics are presented primarily in terms of the peak concentrations observed on each of the auto traverses when the tracer cloud was encountered. These peak concentrations have been plotted on a standard diffusion graph (e.g., Yanskey et al., 1966) as a function of downwind distance so that they can be compared with previous diffusion experience. The downwind distances have been obtained by measurement along the trajectories as indicated on the trajectory maps. To the extent that the trajectories may be somewhat inaccurate due to lack of wind field definition, the downwind distances may also be somewhat in error.

Peak concentrations are given in terms of $\chi u/Q$ where χ is the observed concentration at the site, Q is the release rate and u is the mean wind speed at the release site. An average wind speed over the period of the release was used to determine u.

6.2 Test 1 - August 31, 1976

The SF_6 tracer material was released from the Montezuma Hills site from 1200 to 1700 PDT. The test was conducted under clear skies near the end of a weather sequence which had produced relatively high surface temperatures in the Central Valley.

The wind flow at the Montezuma Hills site during the release period was typical of the afternoon onshore flow which characterizes the area during most of the summer. Table 6-1 shows the hourly wind values at

Table 6-1

TEST 1 - AUGUST 31, 1976

a. Meteorological Parameters

Time (PDT)	Dow Tower Wind at 10 m (°)	Dow Tower Wind at 10 m (m/s)	Dow Tower Temp. (°C)	B & W Resort Wind at 211 m (°)	B & W Resort Wind at 211 m (m/s)	B & W Resort Mixing Layer Depth (m)
1200	290	4.5	27	293	3.3	500
1300	270	4.9	29	293	2.1	500
1400	250	5.8	33	289	2.9	600
1500	260	5.4	32	305	2.2	1400
1600	260	5.4	35	220	0.7	1200
1700	270	6.3	36	218	4.8	1200
1800	290	7.6	35	239	7.8	900
1900	270	9.8	34	-	-	-
2000	280	9.8	31	-	-	-

b. Peak Tracer Concentrations ($\overline{u}$ = 5.3 m/s)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
2	1420-1433	7.3	1.81×10^{-6} m^{-2}
3	1430-1445	8.1	3.00×10^{-6}
4	1515-1527	6.6	2.24×10^{-6}
6	1630-1641	6.5	3.62×10^{-6}
7	1701-1753	57.0	1.89×10^{-7}

c. Peak Hourly Tracer Concentrations

Station No.	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
8	1800-1900	41	3.05×10^{-7} m^{-2}

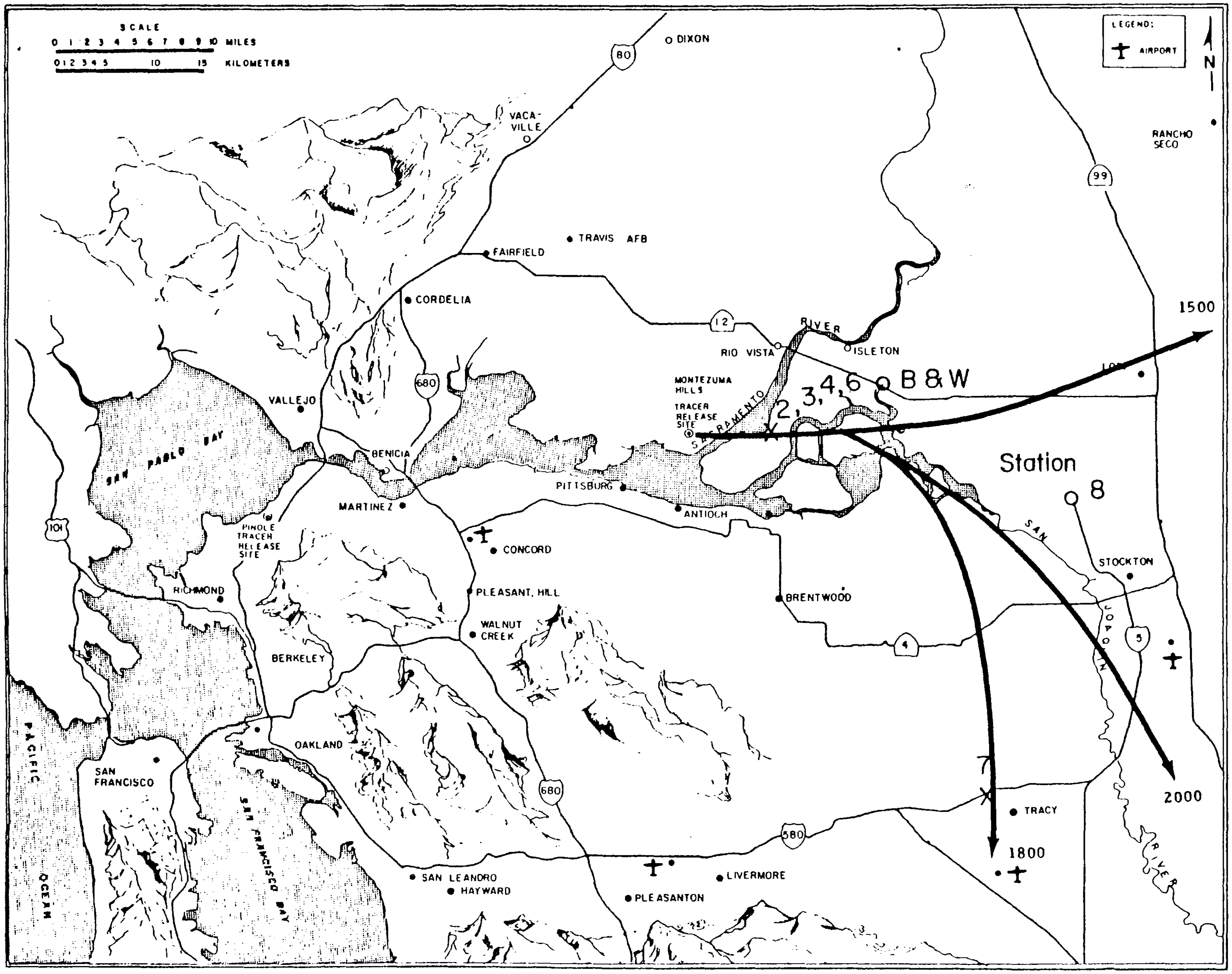
the Dow Tower (10 m) and the pibal wind at 211 m as measured at the B & W Resort during and immediately after the tracer release. Winds at the Tower varied between 250° and 290° throughout the period, increasing in velocity somewhat after the release had been terminated. Winds at the B & W site, on the other hand, were from the northwest changing to southwesterly after 1500 PDT. As shown in the table, the mixing layer depth measured at the B & W site increased sharply during the mid-afternoon as a result of strong surface heating.

Trajectory estimates for the tracer cloud are shown in Figure 6-1. Locations of the maximum concentrations observed on each auto traverse are shown in the figure. Values of the maximum concentrations are given in terms of the normalized concentration ($\chi u/Q$). The location and value of the largest hourly concentration observed during the test are also given.

Initially the cloud moved primarily to the east, passing over Highway 99 near Lodi about 1500 PDT. Subsequently, the trajectory shifted toward the south and, between 1800 and 2000 PDT, the path of the tracer lay between Stockton and Tracy. No significant tracer amounts were observed after 2000 PDT, indicating that the last tracer material released (1700 PDT) took about three hours to clear the observational area and move to the southeast.

The surface streamline pattern at 1500 PDT is shown in Figure 6-2. The westerly flow characteristics to the east of the Montezuma Hills site correspond well to the observed tracer trajectory at 1500 PDT. Thereafter, the tracer material apparently entered the northwesterly branch of the flow pattern and moved to the southeast toward Stockton and Tracy. The surface wind observations (e.g., Venice Ferry) did not indicate this change in trajectory as a significant shift in the wind flow pattern to the east of the site. As shown in Table 6-1, however, the 211 m wind at B & W Resort indicated a change from the west-northwest flow to southwesterly direction beginning about 1600 PDT. There is evidence, therefore, that some change in the flow pattern did occur although the details of the change are not well defined.

Figure 6-3 shows the observed maximum values of $\chi u/Q$ plotted on a diffusion graph adapted from a similar graph given by Yanskey et al. (1966). The sloping lines are labeled in terms of categories A through G corresponding to stability conditions described by Turner (1964). A refers to the most unstable conditions, G to the most stable. Data shown on the graph are labeled with the traverse identifiers given in Table 6-1 and in Figure 6-1.



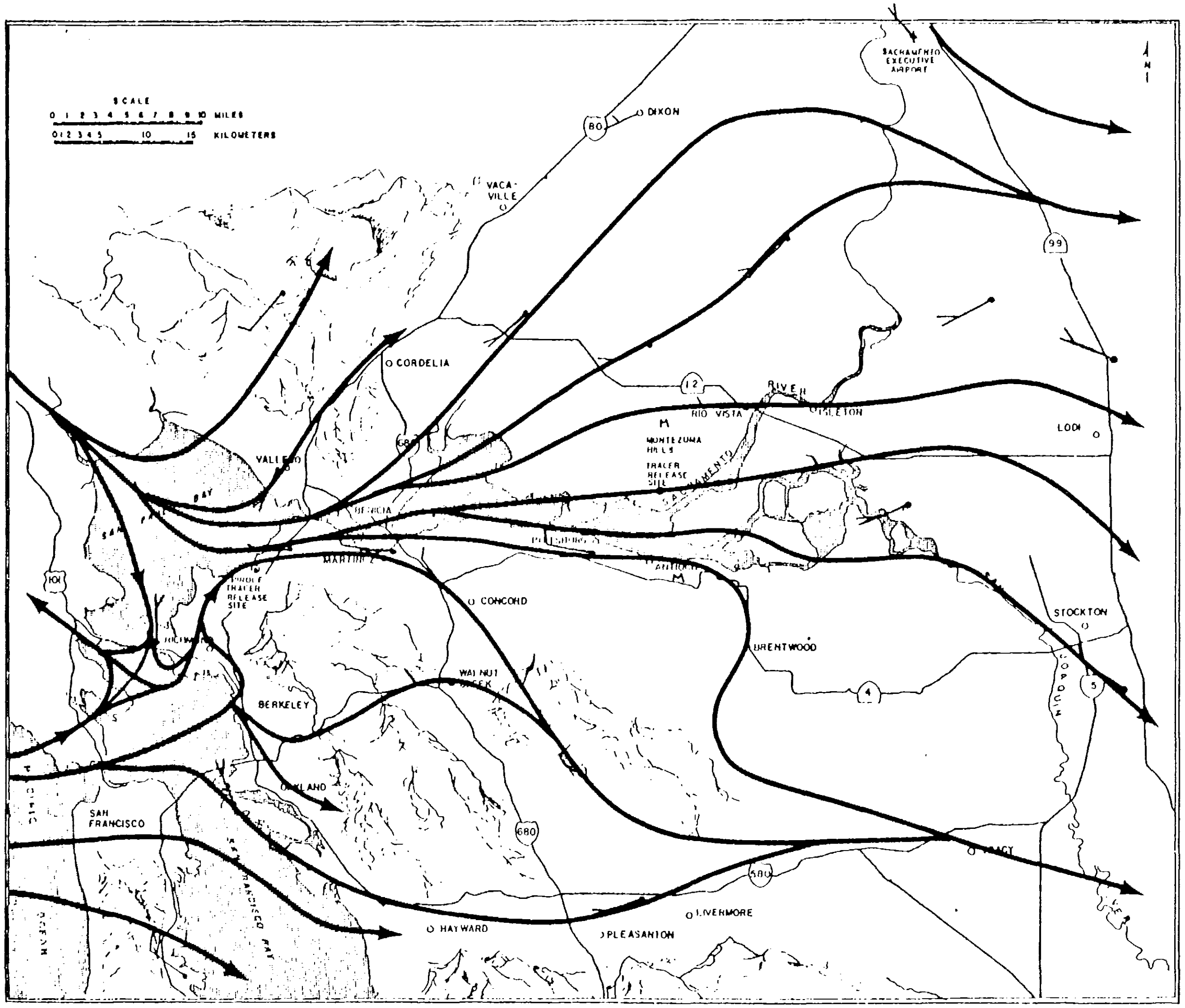
X Traverse Maximum Concentrations

O Station (hourly) Maximum Concentration

77-570

Figure 6-1

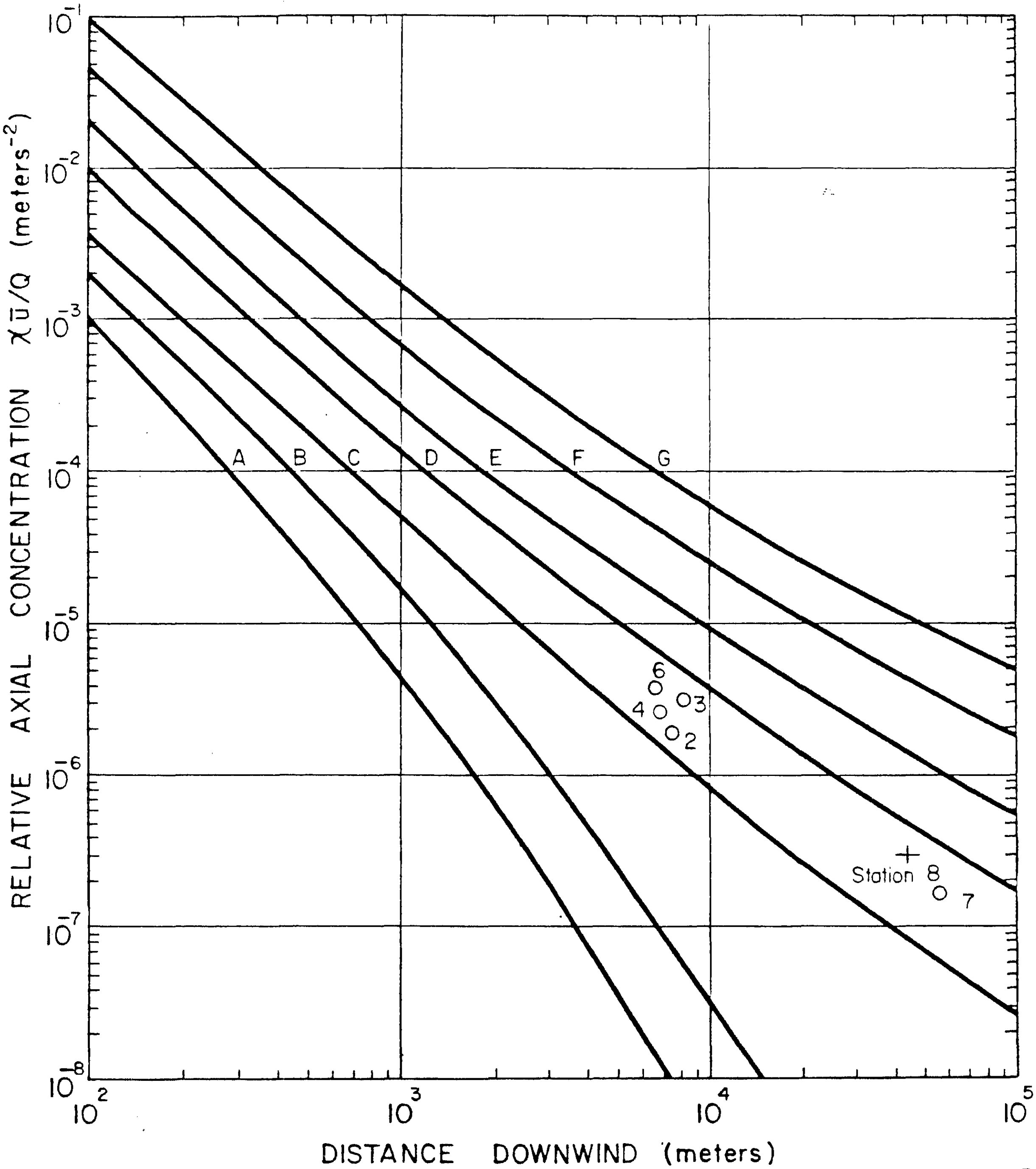
Surface Tracer Trajectories - Test #1
(31 August 1976, 1200 PDT Release)



77-561

Figure 6-2

Surface Streamline Pattern
(August 31, 1976, 1500 PDT)



77-585

Figure 6-3

Diffusion Graph - Test 1
(August 31, 1976)

All of the $\chi u/Q$ data for Test 1 fall in the stability range between C and D, regardless of distance from the source. The C-D stability range corresponds to a slightly unstable regime which would be typical of afternoon heating conditions. The data therefore indicate a straightforward afternoon diffusion test to a downwind distance of 57 km.

6.3 Test 2 - September 2, 1976

The second test was carried out from 1100 to 1600 PDT with an SF_6 release from Martinez and a 1300-1500 PDT CB_rF_3 release from the Dow site. Skies were clear but maximum temperatures were considerably below those encountered during Test 1.

Table 6-2 gives the meteorological parameters observed during and slightly after the releases. The 10 m wind at the Dow Tower was westerly at 8-10 m/s throughout the period. At the B & W site the winds at the lowest pibal level (211 m) were also westerly increasing to 8-10 m/s after 1400 PDT. The mixing layer depth again showed a typical rapid increase during the mid-afternoon due to surface heating.

Figure 6-4 shows the estimated surface trajectories for the tracer cloud in Test 2. There is clear evidence that the material released from Martinez divided into a southerly and a northerly branch. During the early portion of the release, the southerly branch passed slightly to the west of Concord and then moved southeasterly, subsequently influencing the region east of Tracy. Later in the release period the southern branch moved slightly northward (see Traverse 7 in Figure 6-4) in response to a wind change toward a more westerly direction.

The balance of the tracer material from Martinez moved eastward toward Montezuma Hills. Three traverses (4, 5, 6) showed SF_6 peaks at about the same location as the larger CB_rF_3 peaks resulting from the Montezuma Hills site. This provided evidence that a portion of the emissions from the Martinez area can directly influence the background levels in the immediate vicinity of the Montezuma Hills site.

Farther downwind, peak concentrations of both SF_6 and CB_rF_3 were observed between Lodi and Stockton in the late afternoon, having arrived by the northerly route. At the same time, Traverses 9 and 10 showed SF_6 peaks slightly east of Tracy without significant evidence of CB_rF_3 concentrations. It is therefore suggested that this material arrived by the southerly route as indicated in Figure 6-4. Virtually all of the tracer cloud had passed through the observational area by 0000 PDT (September 3) although a few small concentrations were observed during the remainder of the night.

Table 6-2

TEST 2 - SEPTEMBER 2, 1976

a. Meteorological Parameters

Time (PDT)	Dow Tower Wind at 10 m (°)	(m/s)	Temp. (°C)	B & W Resort Wind at 211 m (°)	(m/s)	Mixing Layer Depth (m)
1100	280	8.5	18	289	3.0	500
1200	280	8.0	23	300	2.9	500
1300	280	8.0	26	268	4.2	600
1400	270	8.7	27	266	3.6	700
1500	270	9.8	27	264	7.9	900
1600	270	9.8	27	273	7.9	1300
1700	270	9.8	29	269	7.8	800
1800	270	10.7	30	261	10.5	600

b. Peak Tracer Concentrations ($\overline{u}$ = 4.0 m/s at Martinez, 9.2 m/s at Dow Tower)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	1130-1143	1.3	6.24×10^{-5} m^{-2}
2	1215-1228	0.8	6.24×10^{-5}
3	1240-1328	22.5	8.52×10^{-8}
4	1400-1415	38.0	6.84×10^{-8}
4 C*	1400-1415	8.0	1.56×10^{-5}
5	1445-1503	38.0	3.93×10^{-8}
5 C	1445-1503	8.0	6.06×10^{-6}
6	1515-1530	35.0	5.84×10^{-8}
7	1545-1635	22.0	6.32×10^{-7}
9	1630-1715	80.0	6.04×10^{-8}
9 C	1630-1715	48.0	1.03×10^{-6}
10	1630-1737	71.0	1.89×10^{-7}

Table 6-2 (Continued)

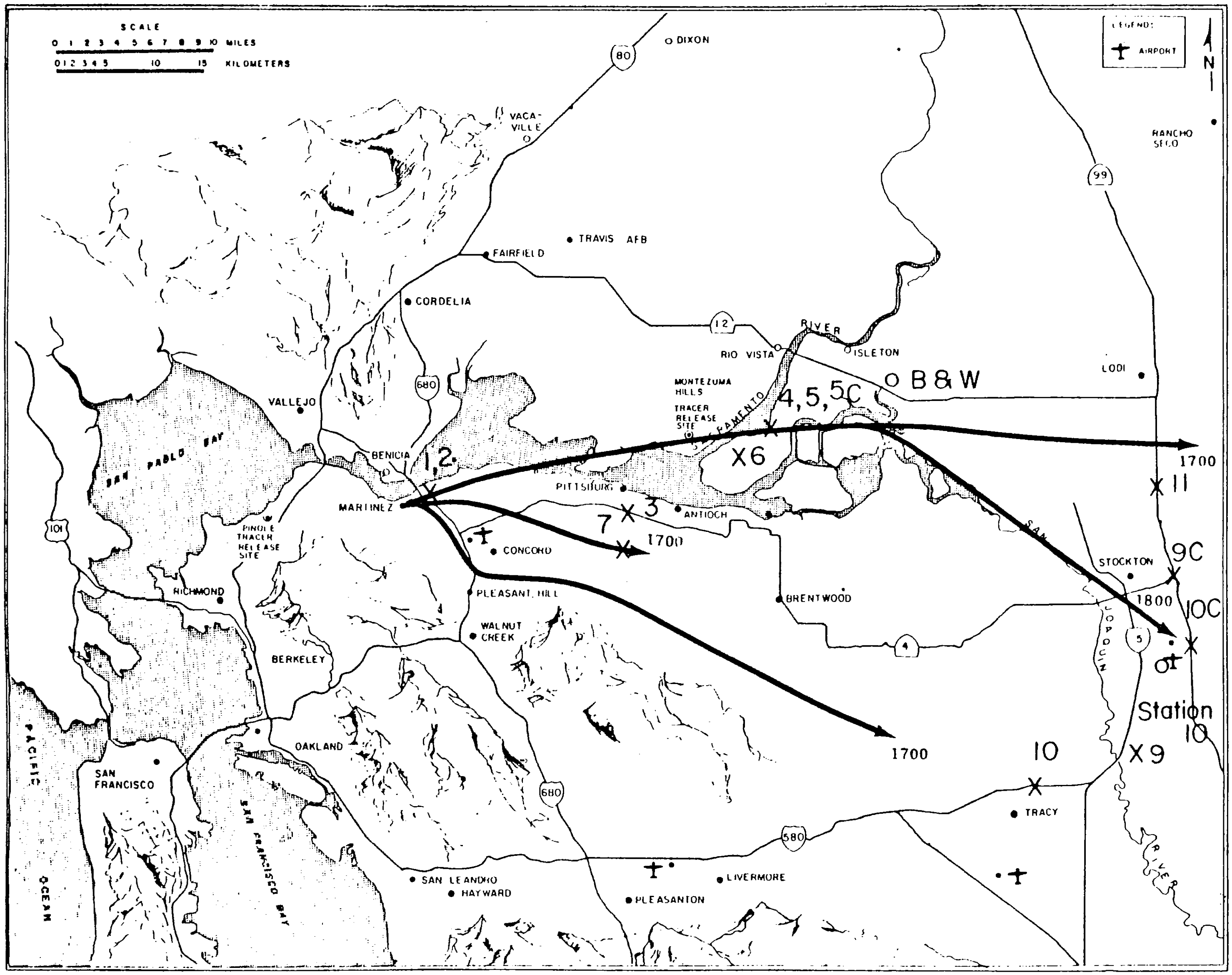
TEST 2 - SEPTEMBER 2, 1976

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
10 C	1630-1737	57.0	2.16×10^{-6} m^{-2}
11	1731-1815	9.5	6.64×10^{-8}

* C refers to CB_rF_3 concentration

c. Peak Hourly Tracer Concentrations

Station No.	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
10	1800-1900	77.0	4.35×10^{-8} m^{-2}



77-571

Figure 6-4

Surface Tracer Trajectories - Test #2
(2 September 1976, 1100 PDT Release)

An anomalous group of hourly concentrations was observed in Fairfield between 1900 and 2200 PDT on September 2. Peak hourly concentration was 7.4×10^{-8} m^{-2} in the hour from 1900-2000 PDT. In general, the winds at Martinez and Benicia continued westerly throughout the period of these observations. Vallejo and Travis AFB showed west-southwest winds throughout the period of interest. The only indications of any change in the flow pattern occurred at Concord (1900 PDT) and Voice of America (1700 PDT) which showed a shift to a south-southwest wind at these times. The observed winds, therefore, do not provide strong support for the tracer material to be carried into Fairfield at 1900 PDT but the lack of detailed definition in the wind field does not permit any more definitive statement regarding the reality of the Fairfield observations.

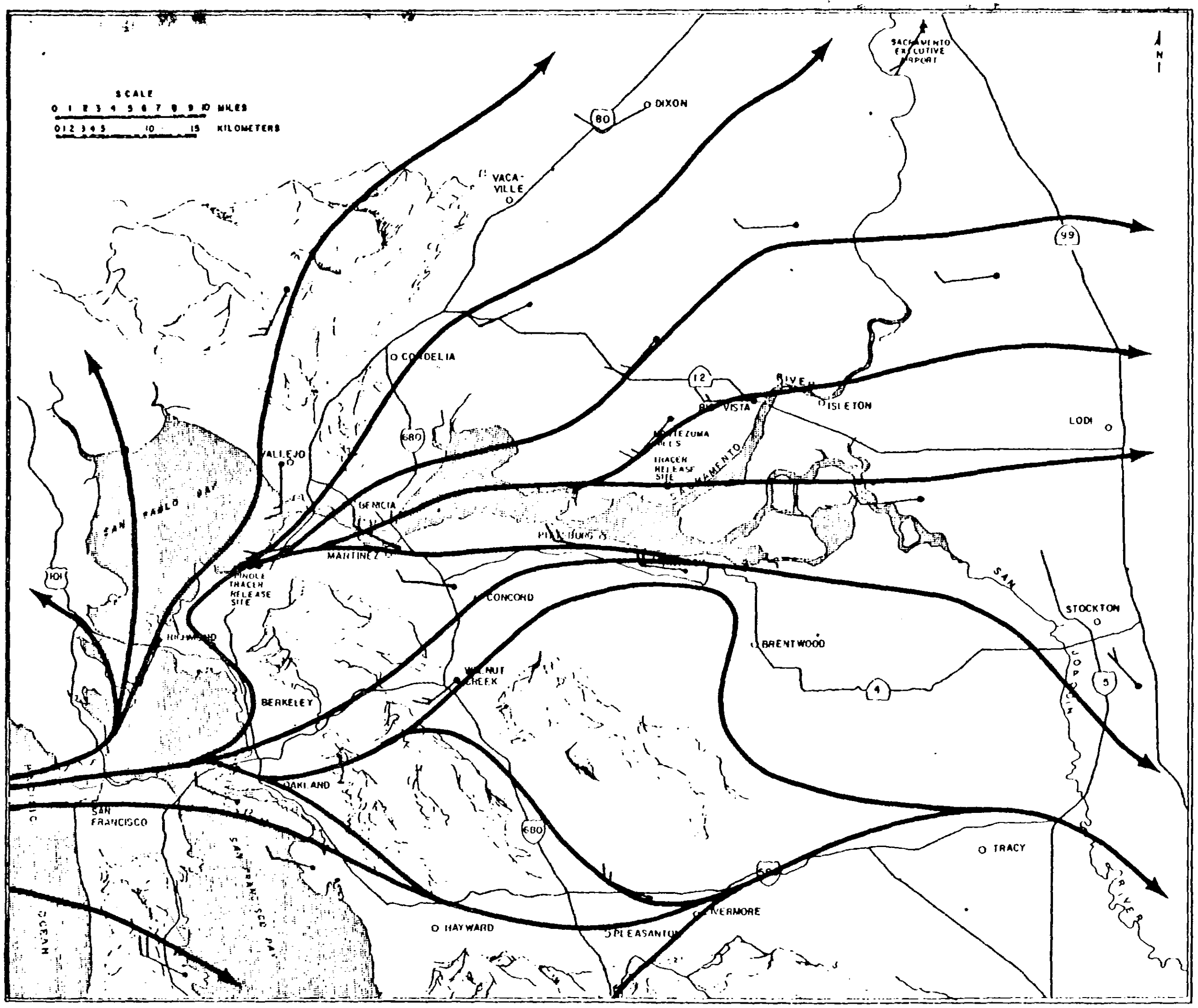
Figure 6-5 shows the streamline flow pattern for 1500 PDT on September 2. The wind at Martinez and Concord show some evidence of the southerly trajectory branch but the predominant flow was westerly through the Delta region shifting to northwest in the Brentwood-Stockton region. The trajectories of the tracer material are well borne out by the streamline pattern in the eastern sections of the area but there is inadequate documentation of the flow details in the Martinez-Concord area.

Figure 6-6 gives the values of $\chi u/Q$ plotted on the diffusion graph. All of the SF_6 concentrations follow the general range indicated by a C-D stability category. The $CBrF_3$ concentrations are slightly higher for all values and correspond to a D category. It is of interest that Traverses 3, 4, 5, 6, and 11 (northerly trajectory) all show lower concentrations than Traverses 7, 9, and 10 (southerly trajectory). This suggests that a larger portion of the tracer material may have entered the southerly branch.

6.4 Test 3 - September 5, 1976

Test 3 was the first of the nighttime releases. SF_6 was released from the Montezuma Hills site from 0000 to 0500 PDT. The 10 m wind at the Dow Tower (Table 6-3) was from a westerly direction with speeds decreasing from 10 m/s to 6-7 m/s shortly after the release had been completed. The B & W wind was from a west-southwesterly direction and slightly lower in velocity than the Dow Tower wind. The mixing layer depths remained low throughout the entire test, reflecting the stable nocturnal conditions which are typical of the area.

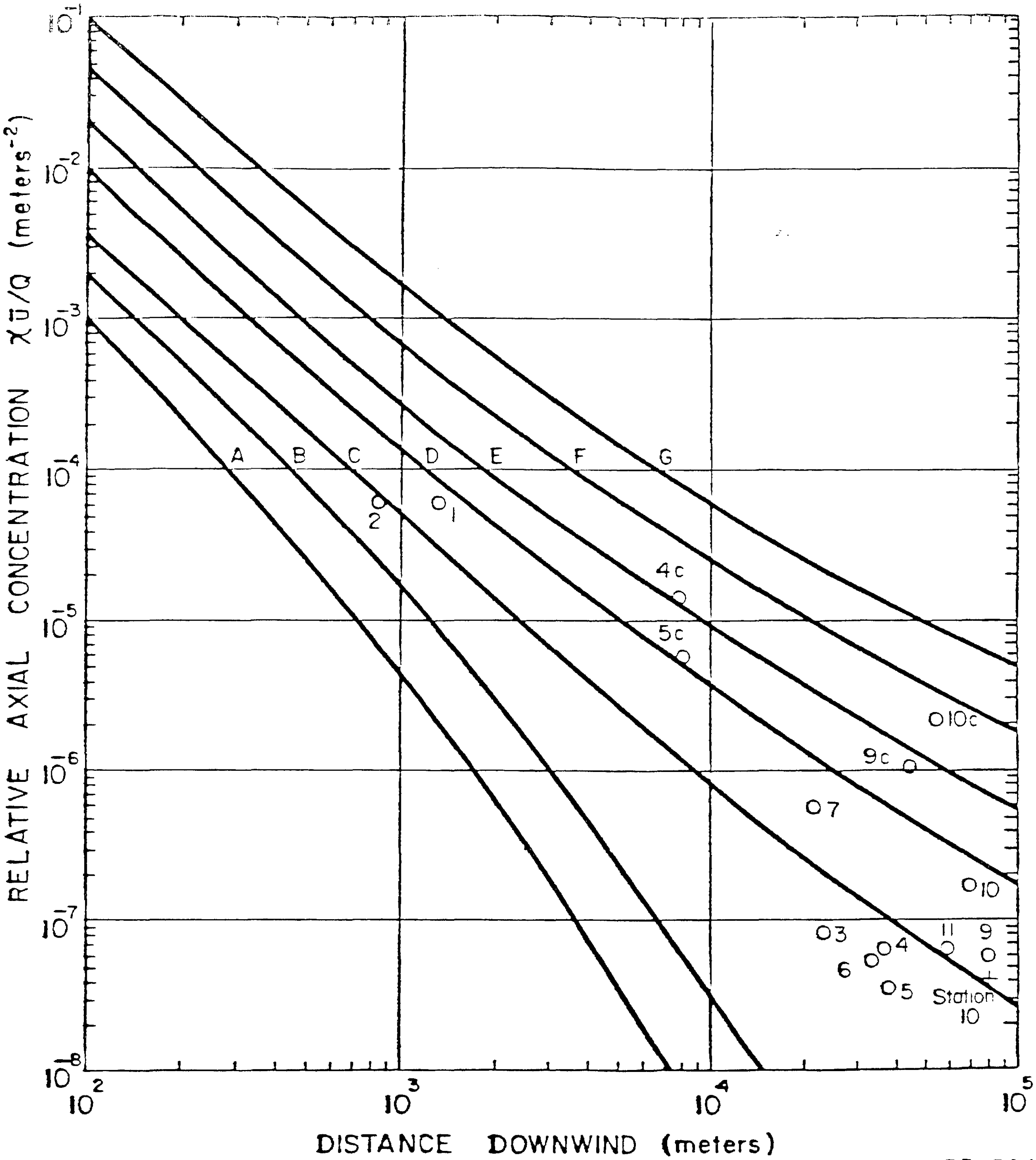
Two trajectory maps have been prepared (Figures 6-7 and 6-8) to indicate the estimated trajectories corresponding to the beginning of the release (0000 PDT) and the end of the release (0500 PDT). In



77-564

Figure 6-5

Surface Streamline Pattern
(September 2, 1976, 1500 PDT)



77-586

Figure 6-6

Diffusion Graph - Test 2
(September 2, 1976)

Table 6-3

TEST 3 - SEPTEMBER 5, 1976

a. Meteorological Parameters

Time	Dow Tower			B & W Resort		
	Wind at 10 m		Temp.	Wind at 211 m		Mixing Layer Depth
(PDT)	(°)	(m/s)	(°C)	(°)	(m/s)	(m)
0000	280	10.7	20	267	6.2	300
0100	270	10.7	18	255	5.3	300
0200	280	11.2	15	246	5.7	300
0300	280	8.9	17	-	-	300
0400	280	8.0	16	237	4.4	300
0500	280	7.6	16	227	7.7	300
0600	310	5.4	15	236	4.4	300
0700	290	8.0	15	-	-	-

b. Peak Tracer Concentrations ($\overline{u}$ = 9.3 m/s)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	0100-0112	7.3	4.71×10^{-5} m^{-2}
3	0213-0259	52.0	3.12×10^{-6}
4	0240-0300	7.3	1.08×10^{-5}
6	0259-0306	7.3	4.92×10^{-5}
8	0414-0545	46.0	2.14×10^{-6}
9	0430-0445	7.3	3.58×10^{-5}
10	0432-0517	38.0	3.52×10^{-6}
11	0441-0450	7.3	1.65×10^{-5}
12	0502-0511	7.3	1.31×10^{-5}
14	0637-0647	38.0	9.95×10^{-7}

c. Peak Hourly Tracer Concentrations

Station No.	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
8	0600-0700	41	5.33×10^{-6} m^{-2}

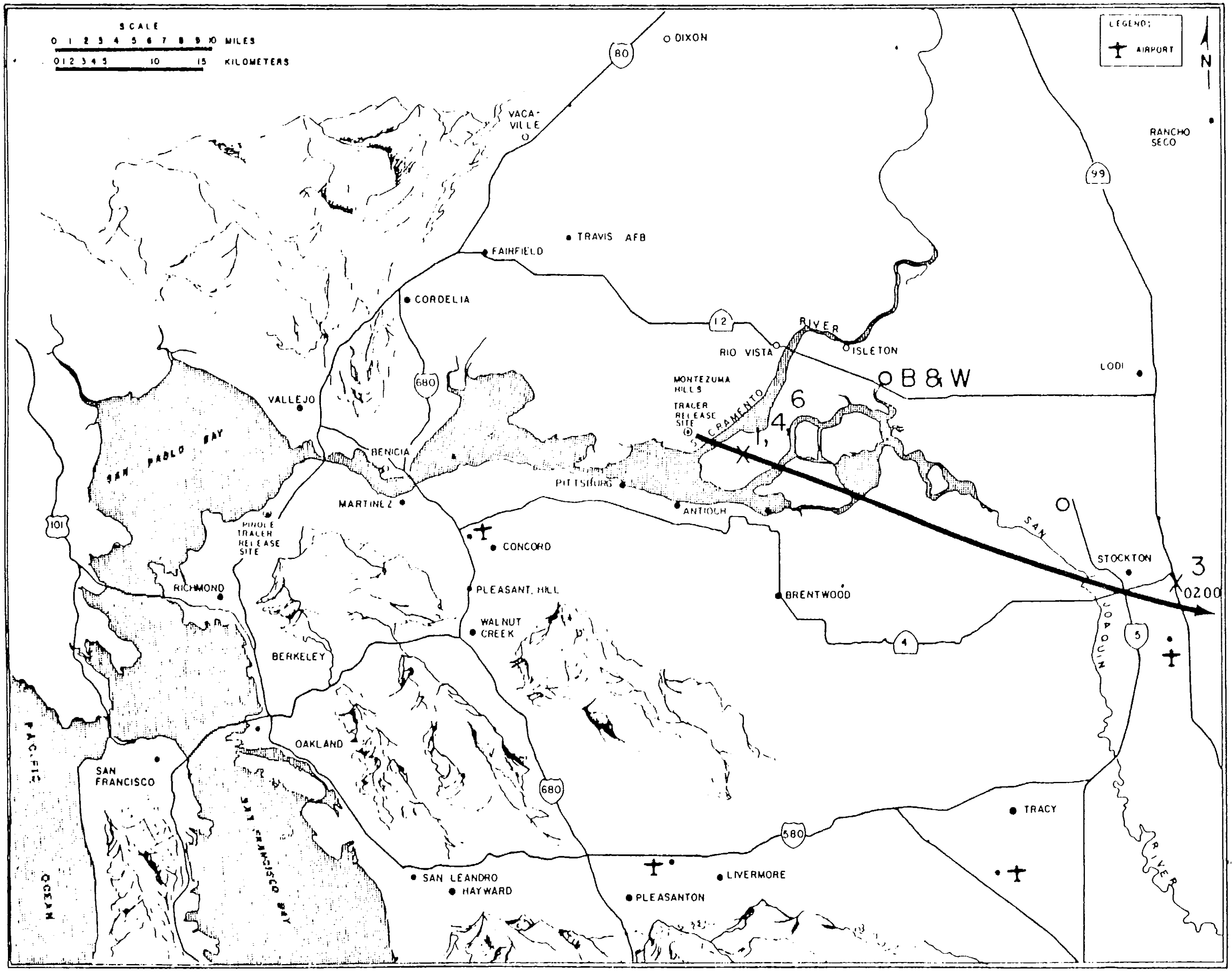
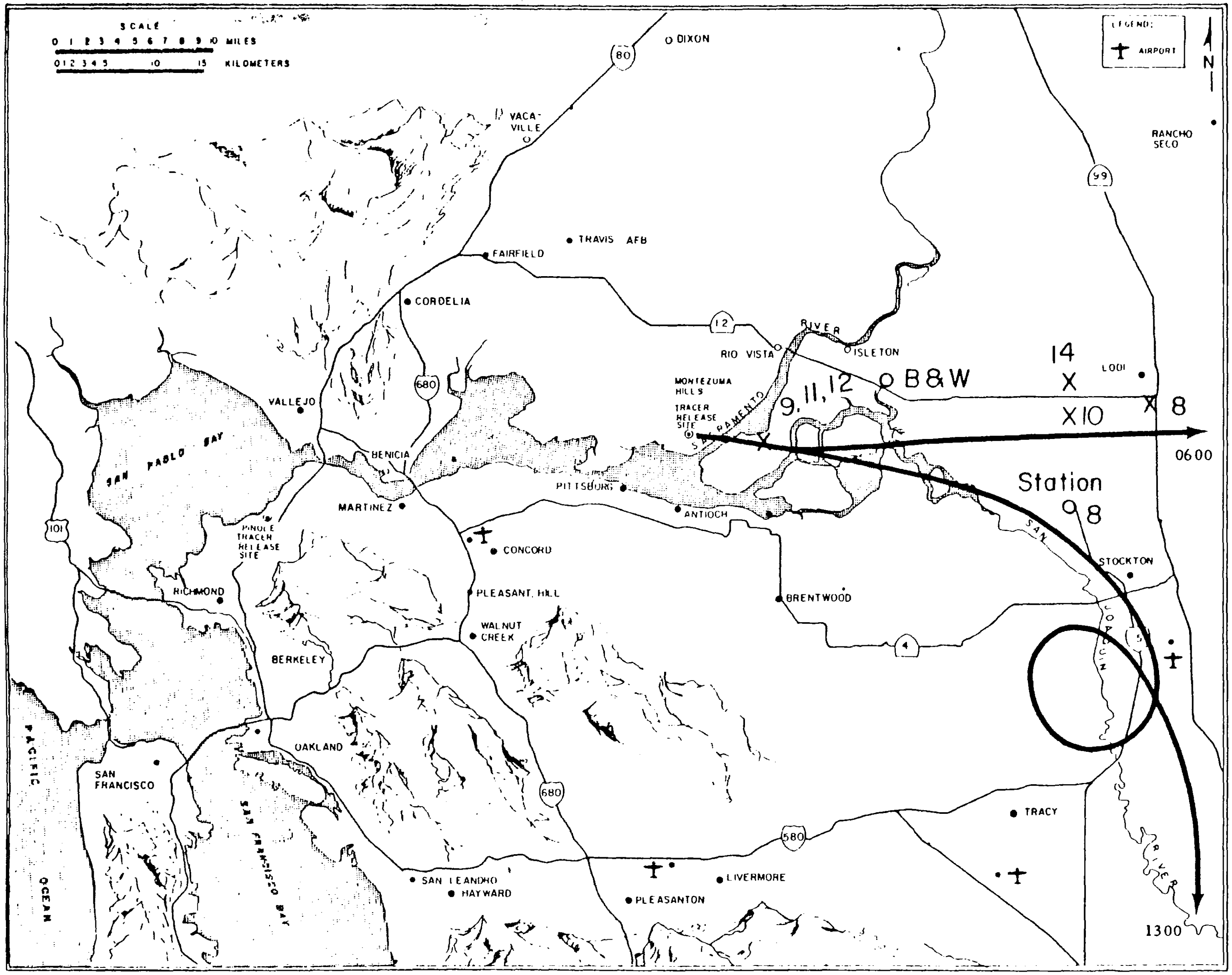


Figure 6-7

77-572

Surface Tracer Trajectories - Test #3
(5 September 1976, 0000 PDT Release)



77-573

Figure 6-8

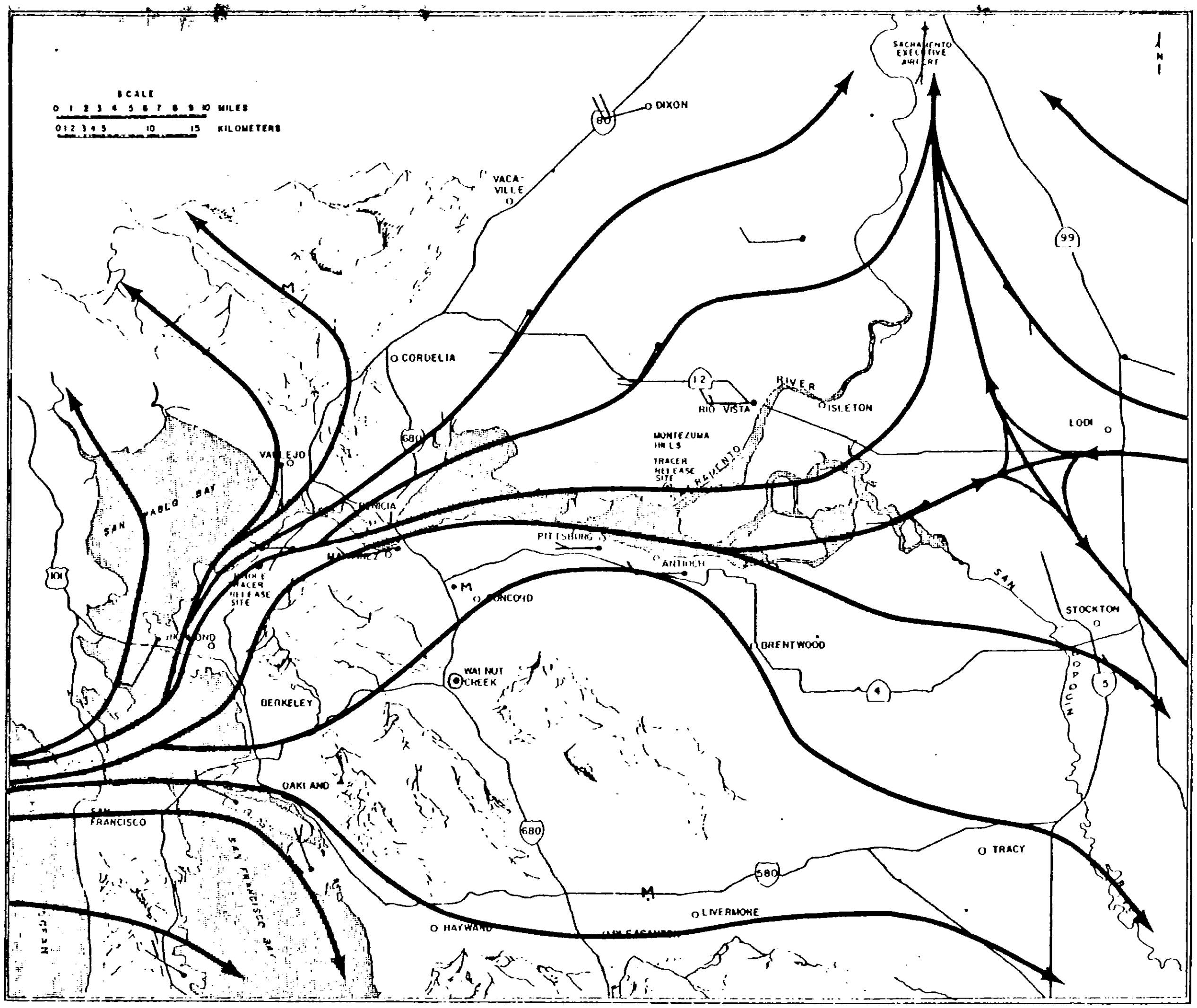
Surface Tracer Trajectories - Test #3
(5 September 1976, 0500 PDT Release)

Figure 6-7, the tracer trajectory appeared to be toward the east-southeast, passing over Highway 99 about 0200 PDT or about two hours after the beginning of the release.

By the early morning hours (Figure 6-8) the trajectory was almost directly eastward. Thereafter, the data suggest that the trajectory shifted again toward the southeast. Station 8 received its largest hourly concentration between 0600 and 0700 PDT. The hourly stations to the south (Stations 9, 10, and 11) indicated residual tracer concentrations as late as 1200-1300 PDT. The trajectory shown in Figure 6-8 represents an effort to suggest a stagnation of the tracer cloud in the Stockton-Tracy area for several hours prior to moving southeastward out of the observational area by 1300 PDT. The loop shown in the trajectory was drawn for conceptual purposes only to show a general meandering and unorganized motion in the area.

Figure 6-9 shows the surface streamline pattern for 0300 PDT. The flow was generally westerly through the Montezuma Hills area, turning to the north and south in a divergent manner to the east of the area. There is evidence of drainage flow influencing the eastern part of the observational area including a portion of Highway 99. The data suggest that this drainage flow may have been a principal factor in deflecting the flow from the Montezuma Hills area to the southeast in the early morning hours.

Figure 6-10 gives the values of $\chi u/Q$ for Test 3 plotted on the standard diffusion graph. The $\chi u/Q$ values immediately downwind of the Montezuma Hills site range from a F-G stability condition to an E condition. In general (except for Traverse 4), they show a trend toward increasing dilution (decrease in stability) from midnight to the early morning hours. Accompanying this trend is a general decrease in wind speed at the release site (Table 6-3). The $\chi u/Q$ values at 40-50 km downwind follow a similar pattern. The earliest traverse (Traverse 3) showed the highest concentrations while Traverse 14 (0637-0647 PDT) showed the lowest values. There is also a slight trend indicated in Figure 6-10 toward more rapid dilution as a function of distance than indicated by the standard diffusion graph. This trend was not indicated in the previous graphs for Tests 1 and 2 (Figures 6-3 and 6-6). Whereas there might be some concern about increased downwind concentrations under nocturnal conditions due to restricted vertical mixing, the data appear to indicate a slightly more rapid dilution than expected.



77-563

Figure 6-9

Surface Streamline Pattern
(September 5, 1976, 0300 PDT)

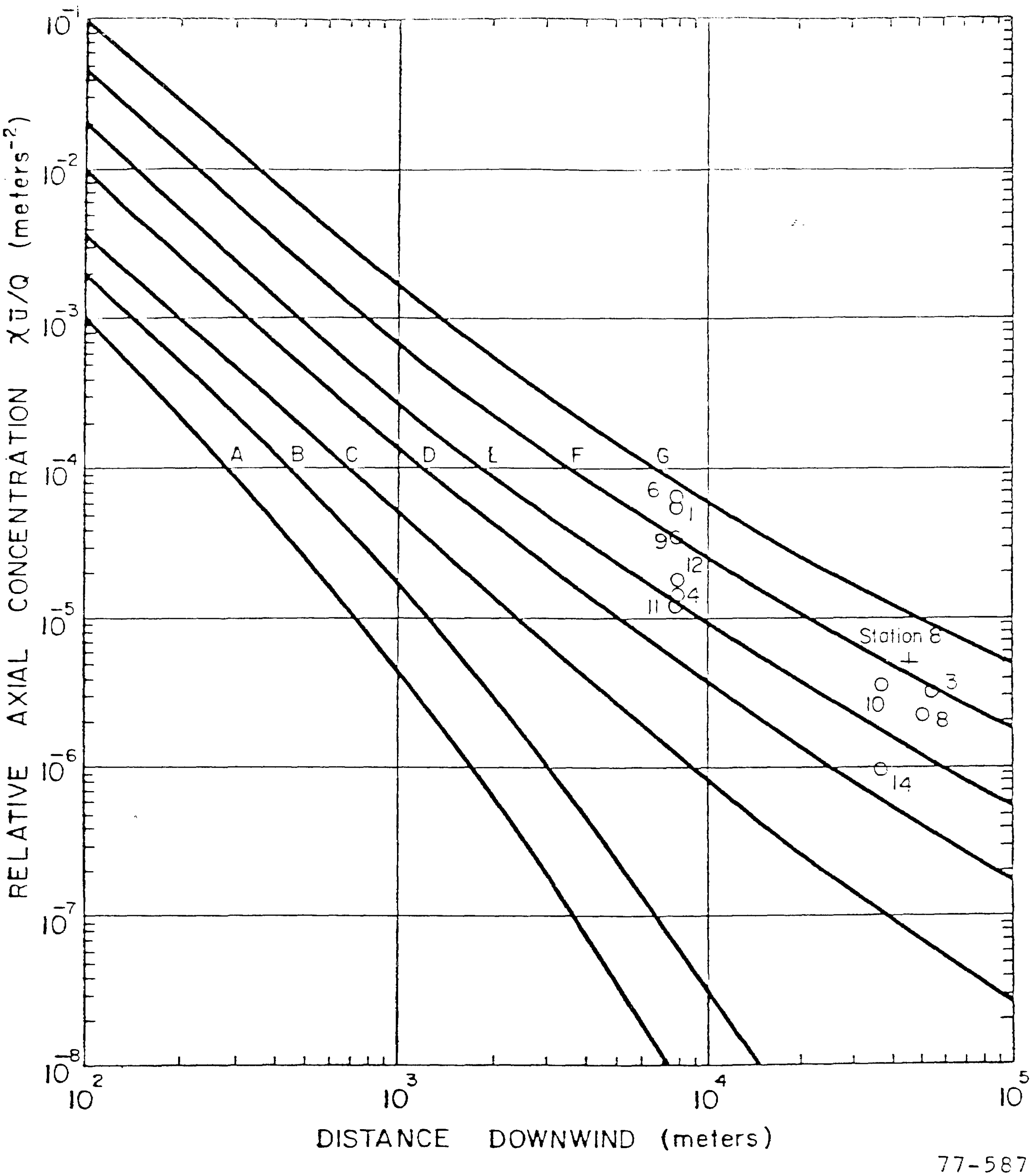


Figure 6-10

Diffusion Graph - Test 3
(September 5, 1976)

6.5 Test 4 - September 6, 1976

SF_6 tracer material was released from the Montezuma Hills site from 1800-2300 PDT to examine the diffusion characteristics of the late evening regime. Winds at the Dow Tower site were westerly at 6-8 m/s as indicated in Table 6-4. Low-level winds at the B & W site were similar in magnitude and direction. Mixing layer depths were somewhat higher than indicated for Test 3 but were steady throughout the test period.

Figures 6-11 and 6-12 show the estimated trajectories for two different portions of the release period (1800 and 2300 PDT). The tracer material released early in the period (Figure 6-11) appeared to move to the east-southeast passing over Highway 99 slightly north of Stockton by 2000 PDT or about two hours after release. During the remainder of the evening the trajectory of the tracer cloud shifted toward the south to lie between Stockton and Tracy. The last significant hourly concentration observed in the sampling area was between 0700 and 0800 PDT.

Surface streamlines for 2400 PDT on September 6 (Figure 6-13) show a moderate westerly flow in the vicinity of the release site with the trajectories indicating northwesterly flow to the southeast of the site. The streamline pattern corresponds, in general, with the indicated trajectories from the sampling data although the slight shift in the wind flow which results in rather substantial changes in tracer trajectory (2000 vs. 0200 PDT in Figures 6-11 and 6-12) are not well defined. There is again an indication that a drainage flow from the east was influencing the northern portion of Highway 99 and may have contributed to a deflection of the tracer cloud to the southeast.

Figure 6-14 gives the $\chi u/Q$ values for Test 4 plotted as a function of downwind distance on the diffusion graph. With the exception of Traverse 1 both of the short downwind distance traverses (3 and 5) show an F stability category similar to the Test 3 data. Farther downwind, all of the concentration data are grouped very closely between an E and F category. The same trend as in Test 3 toward more rapid dilution with distance downwind is in evidence compared with the standard diffusion graph.

Traverse 1 represents an anomaly in the sampling data. As indicated in Figure 6-14 the actual measured concentration was approximately the same as those measured at distances of 50-60 km downwind. It appears probable, therefore, that the true maximum was not sampled during that traverse.

Table 6-4

TEST 4 - SEPTEMBER 6, 1976

a. Meteorological Parameters

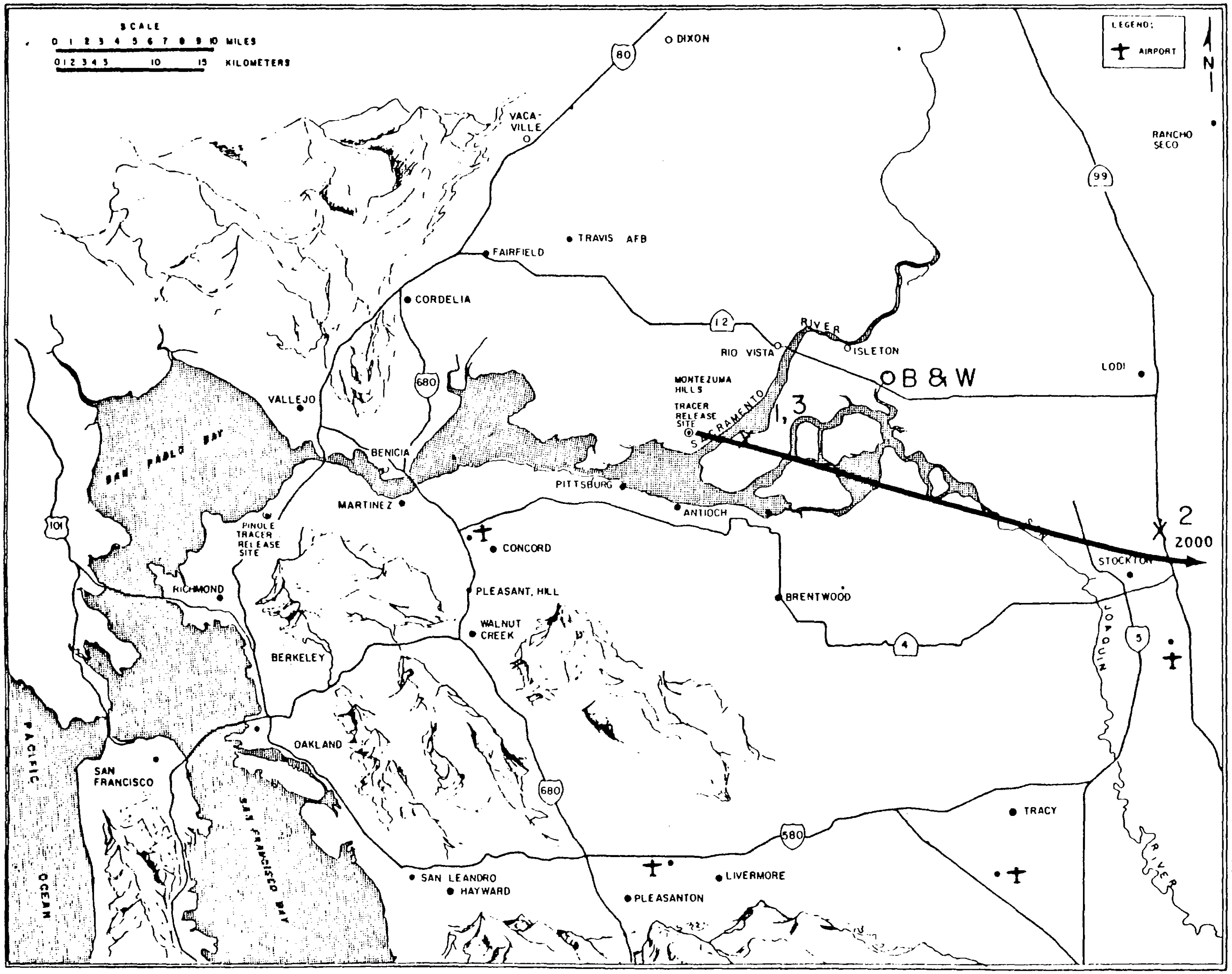
Time (PDT)	Dow Tower: Wind at 10 m (°)	Dow Tower: Wind at 10 m (m/s)	Dow Tower: Temp. (°C)	B & W Resort: Wind at 211 m (°)	B & W Resort: Wind at 211 m (m/s)	B & W Resort: Mixing Layer Depth (m)
1800	280	6.7	27	275	5.0	500
1900	270	7.2	26	277	7.3	500
2000	280	5.8	22	254	6.0	400
2100	290	7.6	19	253	7.4	400
2200	280	7.6	19	261	6.8	400
2300	290	8.0	17	269	7.9	400
2400	-	-	16	283	6.6	400

b. Peak Tracer Concentrations ($\bar{u}$ = 7.1 m/s)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	1928-1946	7.3	3.40×10^{-6} m^{-2}
2	2130-2217	47.0	2.90×10^{-6}
3	2132-2140	7.3	4.12×10^{-5}
4	2200-2246	47.0	2.44×10^{-6}
5	2214-2222	7.3	4.76×10^{-5}
6	2232-2320	54.0	2.15×10^{-6}
7	2315-2400	61.0	2.15×10^{-6}

c. Peak Hourly Tracer Concentrations

Station No.	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
9	2200-2300	51.0	2.20×10^{-6} m^{-2}



77-575

Figure 6-11

Surface Tracer Trajectories - Test #4
(6 September 1976, 1800 PDT Release)

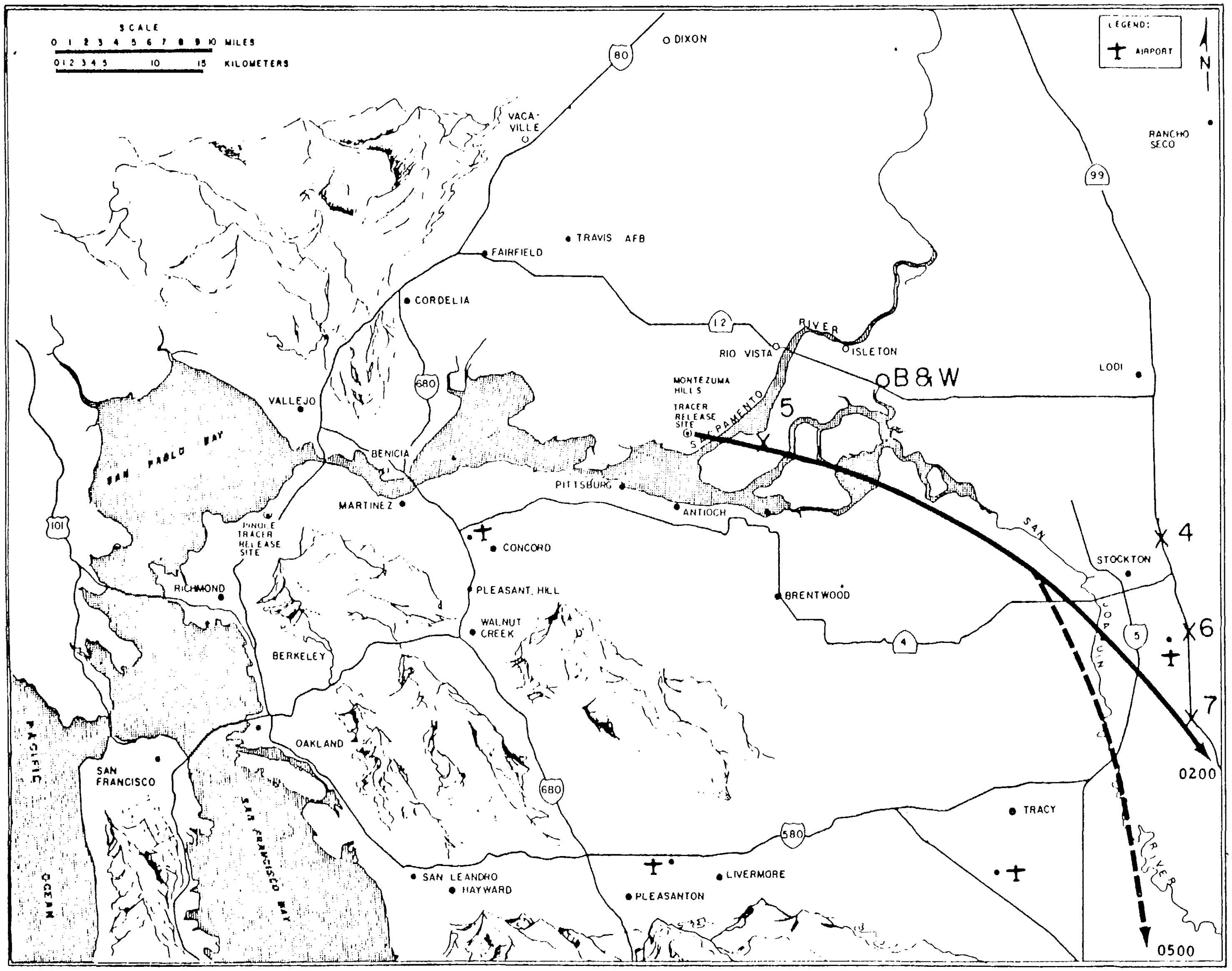
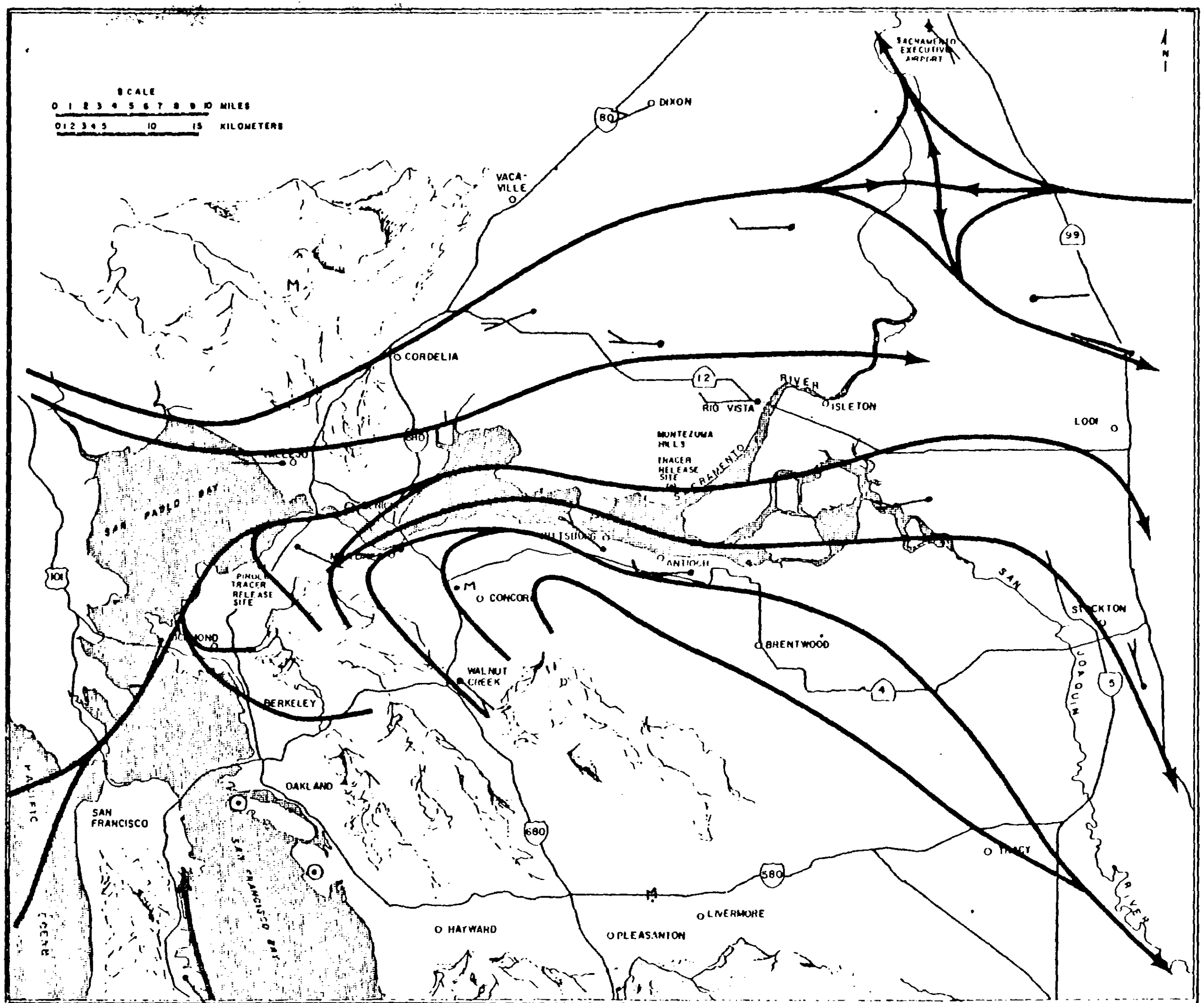


Figure 6-12

77-574

Surface Tracer Trajectories - Test #4
(6 September 1976, 2300 PDT Release)



77-559

Figure 6-13

Surface Streamline Pattern
(September 6, 1976, 2400 PDT)

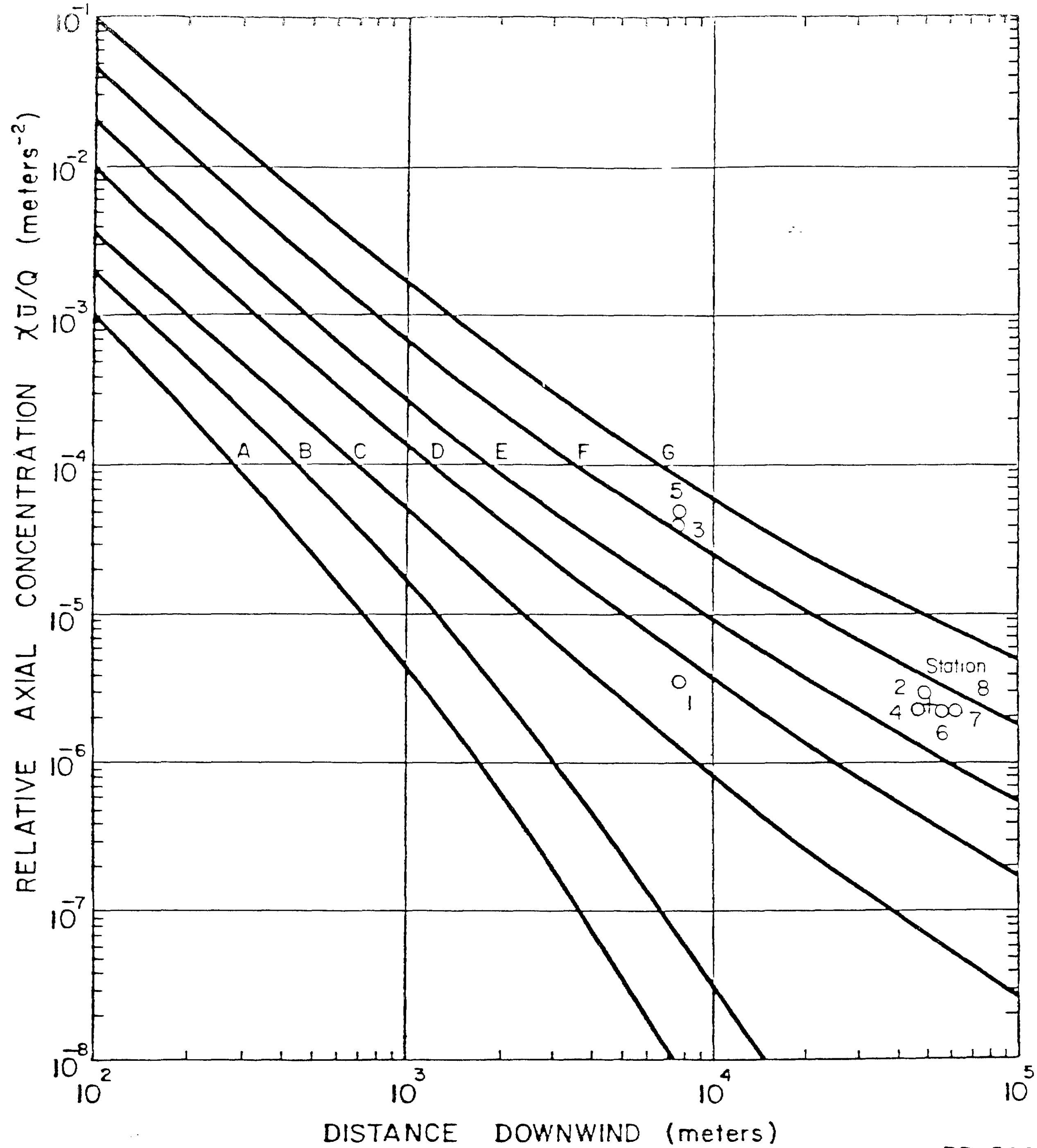


Figure 6-14

Diffusion Graph - Test 4
(September 6, 1976)

6.6 Test 5 - September 9, 1976

Test 5 was carried out from the Montezuma Hills site between 1130 and 1330 PDT. The 10 m wind direction at the Dow Tower indicated a north to northeast wind until 1300 PDT when the direction shifted to a more normal west to southwest wind. The release was terminated shortly after the shift to a westerly direction so that most of the release was made under the northerly flow regime. Table 6-5 gives the wind data at the Tower site and the B & W Resort for the period of release and immediately thereafter.

Figure 6-15 shows the estimated trajectories from the site together with locations of observed peak concentrations. The northerly flow produced a trajectory which was well documented by a number of auto traverses. Subsequently, it appears that this trajectory continued east and southeastward resulting in light concentrations to the east of Tracy as late as 2200 PDT.

The largest hourly concentration observed was at Station 8 between 1700 and 1800 PDT. Surface wind trajectories associated with the northerly flow do not readily permit this branch of the trajectory to have influenced Station 8. It appears more probable that material released about 1300 PDT (near the end of the release period) took a more normal route to the east-southeast and resulted in the peak hourly concentration at Station 8. This trajectory is indicated in Figure 6-15.

Figure 6-16 shows the surface streamline pattern for 1200 PDT and clearly indicates the northerly flow regime existing during most of the release. The flow pattern changed abruptly in the next few hours into a more westerly condition.

Figure 6-17 shows the observed peak concentrations plotted on a diffusion graph for Test 5. All of the test data group consistently along the line corresponding to C stability. In view of the light winds and relatively warm temperatures (Table 6-5) a C stability condition appears to be appropriate from a meteorological standpoint.

6.7 Test 6 - September 10, 1976

Test 6 was conducted from the Montezuma Hills site from 0600 to 1100 PDT in order to examine the morning trajectory and diffusion regime. Table 6-6 gives the winds at the Dow Tower site and the low-level pibal winds observed at B & W Resort. Westerly winds occurred with velocities generally between 3 and 8 m/s at both sites. The

Table 6-5

TEST 5 - SEPTEMBER 9, 1976

a. Meteorological Parameters

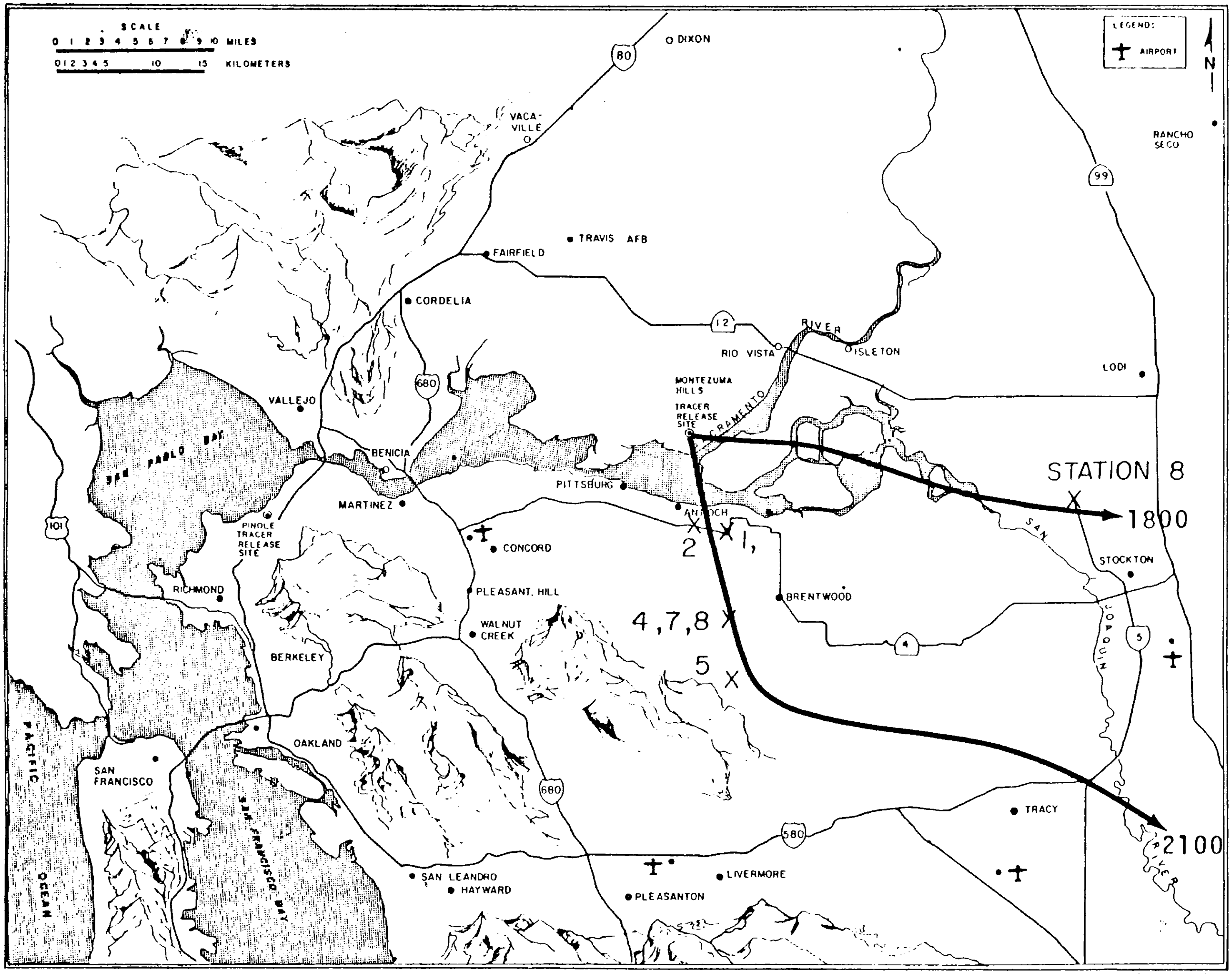
Time	Dow Tower			B & W Resort		
	Wind at 10 m		Temp.	Wind at 211 m		Mixing Layer Depth
(PDT)	(°)	(m/s)	(°C)	(°)	(m/s)	(m)
1100	030	4.0	27	-	-	-
1200	040	2.2	29	348	3.1	-
1300	270	1.8	31	329	5.1	1000
1400	210	2.7	34	328	4.3	1400
1500	230	4.0	33	-	-	-
1600	250	5.8	37	-	-	-

b. Peak Tracer Concentrations ($\bar{u}$ = 1.8 m/s)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	1255-1315	10.5	7.97×10^{-7} m^{-2}
2	1314-1330	9.5	5.27×10^{-7}
4	1351-1405	18.0	1.37×10^{-7}
5	1356-1428	24.0	1.07×10^{-7}
6	1358-1416	10.0	4.43×10^{-7}
7	1413-1426	18.0	1.40×10^{-7}
8	1436-1450	18.0	1.82×10^{-7}

c. Peak Hourly Tracer Concentration

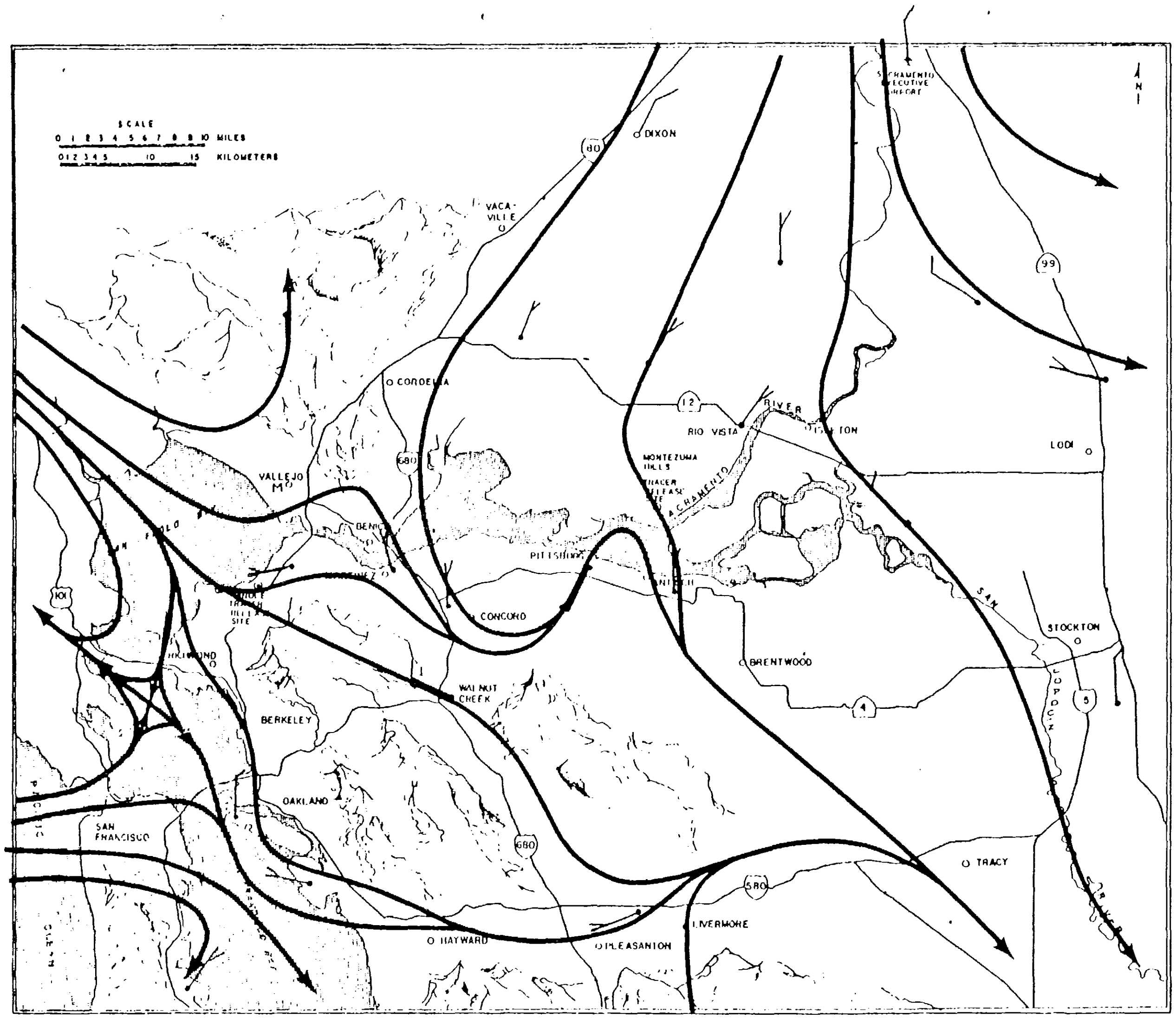
Station No.	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
8	1700-1800	41.0	4.65×10^{-8} m^{-2}



77-593

Figure 6-15

Surface Tracer Trajectories - Test #5
(9 September 1976, 1130 PDT Release)



77-560

Figure 6-16

Surface Streamline Pattern
(September 9, 1976, 1200 PDT)

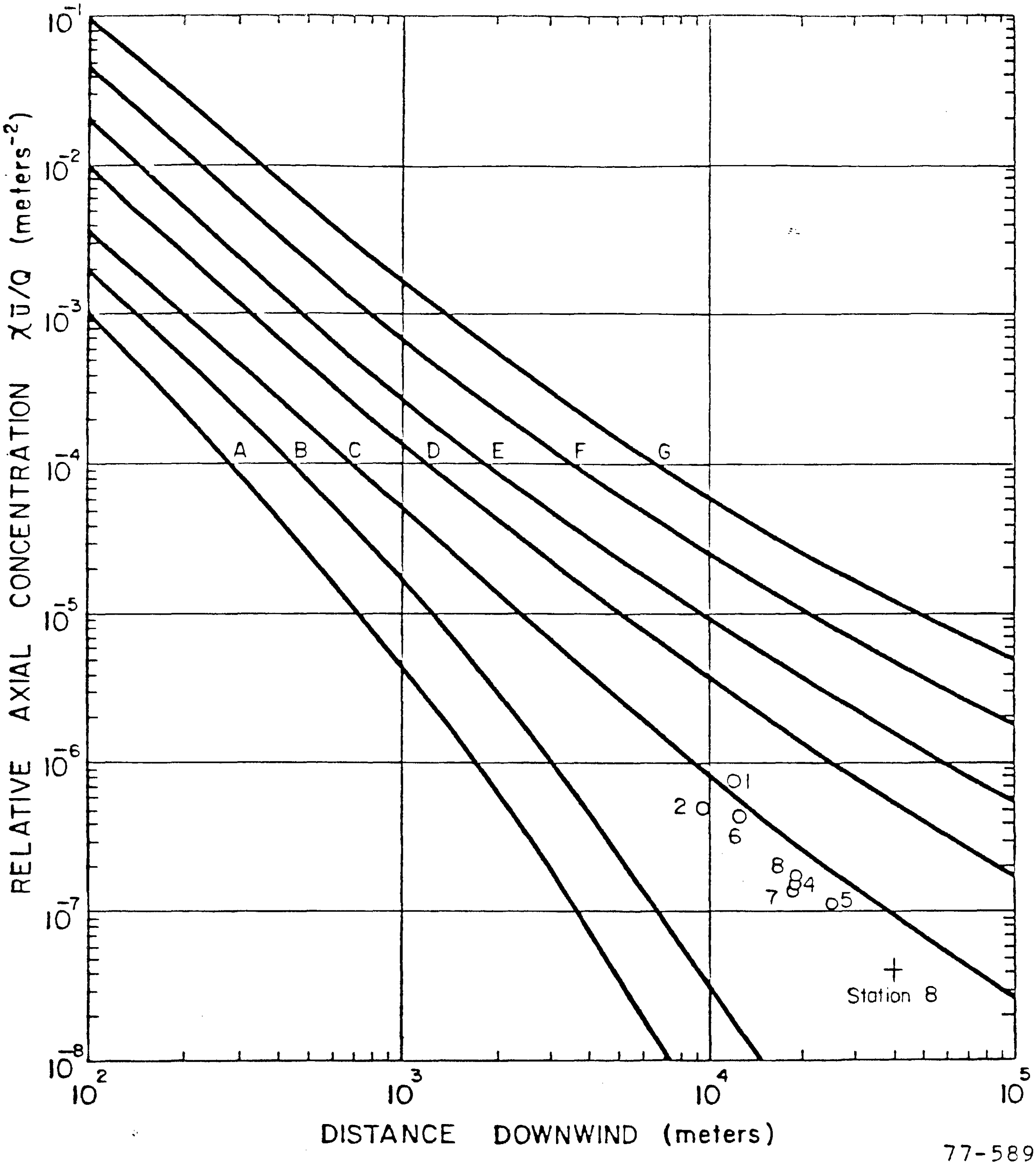


Figure 6-17

Diffusion Graph - Test 5
(September 9, 1976)

Table 6-6

TEST 6 - SEPTEMBER 10, 1976

a. Meteorological Parameters

Time (PDT)	Dow Tower: Wind at 10 m (°)	Dow Tower: Wind at 10 m (m/s)	Dow Tower: Temp. (°C)	B & W Resort: Wind at 211 m (°)	B & W Resort: Wind at 211 m (m/s)	B & W Resort: Mixing Layer Depth (m)
0800	-	-	-	261	5.2	500
0900	-	-	-	263	7.9	500
1000	-	-	-	275	9.4	400
1100	280	6.3	22	264	4.8	500
1200	290	4.5	21	275	3.4	800
1300	260	2.7	26	264	4.5	500
1400	250	3.0	25	225	1.5	200
1500	280	4.0	24	259	3.0	400
1600	280	5.8	25	271	5.7	800
1700	270	7.6	26	261	7.8	600
1800	260	5.8	25	266	9.4	600
1900	280	5.8	23	264	8.2	600

b. Peak Tracer Concentrations ($\overline{u}$ = 6.3 m/s)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	0800-0815	4.8	3.38×10^{-5} m^{-2}
2	0740-0753	7.3	2.83×10^{-5}
3	1001-1051	55.0	7.06×10^{-8}
4	1023-1033	11.0	1.32×10^{-5}
5	1030-1115	55.0	3.91×10^{-8}
6	1022-1033	7.3	1.51×10^{-5}
7	1103-1112	7.3	2.54×10^{-5}
8	1105-1203	49.0	4.26×10^{-8}

Table 6-6 (Continued)

TEST 6 - SEPTEMBER 10, 1976

c. Peak Hourly Tracer Concentration

Station No.	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
7	1500-1600	46	2.92×10^{-7} m^{-2}

d. Peak Airborne Tracer Concentrations

Traverse	Time (PDT)	Altitude [Above Sea Level] (m)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
5	1054-1107	183	17	4.93×10^{-6} m^{-2}
7	1140-1153	427	18	1.17×10^{-7}
8	1229-1235	305	49	7.06×10^{-9}
9	1238-1251	305	50	1.54×10^{-8}
12	1200-1239	183	26	7.43×10^{-8}

e. Aircraft Spiral Tracer Concentrations (1203-1208 PDT)

Downwind Distance = 18 km

Altitude (m MSL)	$\chi u/Q$	Altitude (m MSL)	$\chi u/Q$
472	3.55×10^{-9} m^{-2}	320	3.58×10^{-7} m^{-2}
457	3.55×10^{-9}	305	7.10×10^{-9}
442	1.06×10^{-8}	290	2.48×10^{-8}
427	7.10×10^{-9}	274	2.84×10^{-8}
411	7.10×10^{-9}	259	3.90×10^{-8}
396	1.06×10^{-8}	244	4.61×10^{-8}
381	7.10×10^{-9}	229	1.14×10^{-7}
366	1.42×10^{-8}	213	3.76×10^{-7}
351	1.77×10^{-8}	198	2.41×10^{-7}
335	1.06×10^{-8}	183	7.24×10^{-7}

Table 6-6 (Continued)

Altitude (m MSL)	$\chi u/Q$	Altitude (m MSL)	$\chi u/Q$
168	8.27×10^{-7} m^{-2}	76	1.31×10^{-6} m^{-2}
152	1.25×10^{-6}	61	1.99×10^{-7}
137	2.90×10^{-6}	46	3.19×10^{-8}
122	3.22×10^{-6}	30	1.06×10^{-8}
107	2.50×10^{-6}	15	1.77×10^{-8}
91	1.97×10^{-6}		

f. Tracer Cross Sections from Airborne Traverses

Downwind Distance = 18 km

Traverse	Time (PDT)	Altitude (m MSL)	Peak Concentration ($\chi u/Q$)
2	0950-1005	305	7.10×10^{-9} m^{-2}
5	1054-1107	183	4.93×10^{-6}
7	1140-1153	427	1.17×10^{-7}

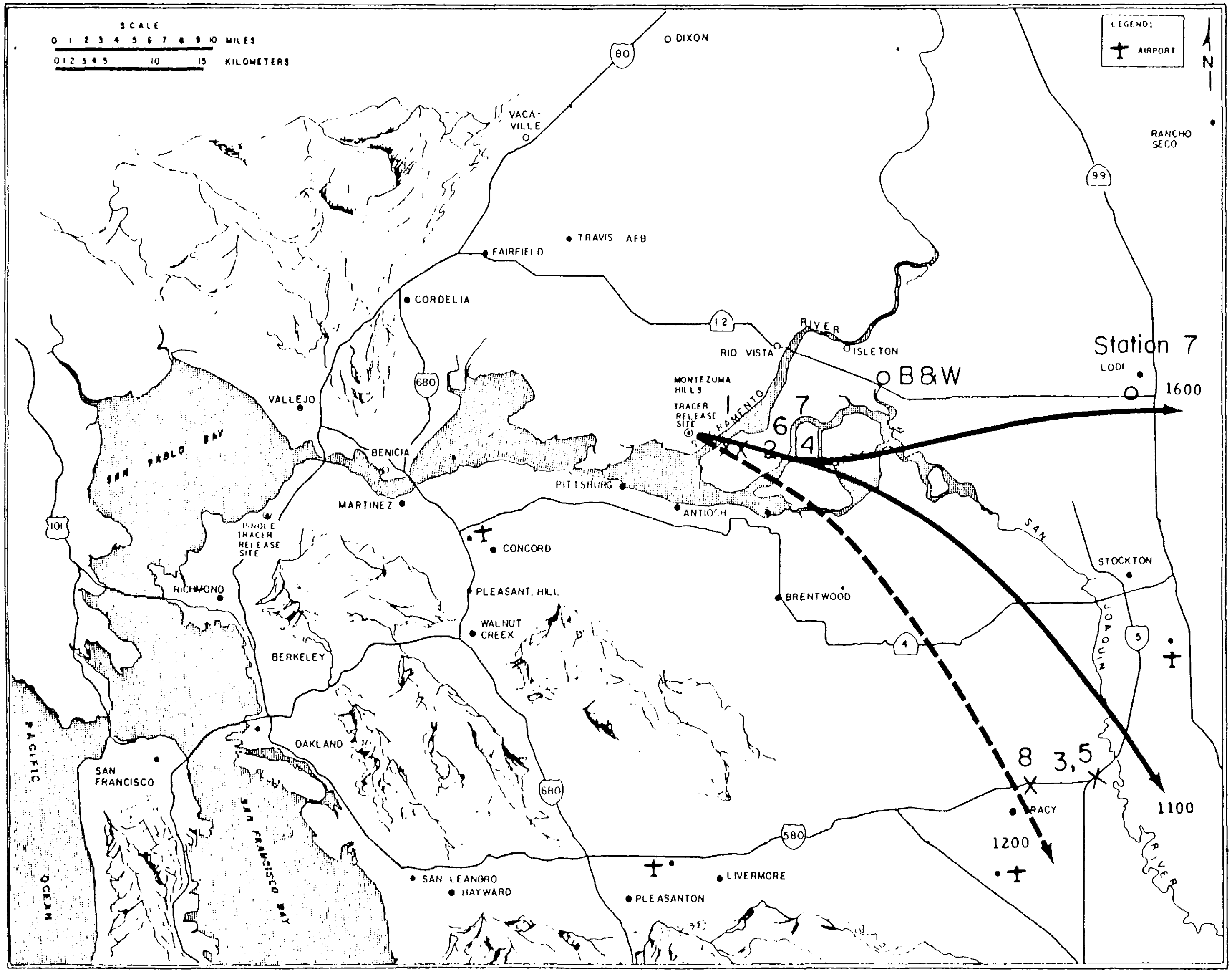
mixing layer depth at B & W Resort showed a minimum about 1400 PDT which is assumed to be associated with an undercutting marine air mass moving in from the west.

Figure 6-18 shows the estimated trajectories of the tracer cloud for several periods of time following the release. During the morning the trajectory indicates a path to the southeast, passing slightly to the east of Tracy. By mid to late afternoon the trajectory was more directly toward the east. Station 7 showed the peak hourly concentration in the area between 1500 and 1600 PDT.

Figure 6-19 gives the locations of maximum tracer concentrations observed during aircraft traverses. Concentration values and altitudes of the traverses are shown in Table 6-6(d). Table 6-6(e) shows the concentration data observed during a vertical spiral made with the aircraft at a distance of about 18 km east of the release site. Individual syringe samples were obtained at intervals during the spiral as shown in the table. Also shown in Table 6-6(f) is a summary of traverses made at different altitudes in cross section form at a distance of 18 km downwind. Peak concentrations found on each traverse are shown together with the corresponding altitudes.

Table 6-6(e) shows that the vertical depth of the tracer cloud at 18 km downwind was about 270-290 m, depending on how the cloud-top is defined. Table 6-6(f) gives a similar indication of the depth with a large concentration observed at 183 m with negligible concentrations at 305 m. The peak concentration shown in the spiral data was at 122 m with a rapid decrease in observed concentrations below 76 m. Although it is tempting to suggest that the centerline of the cloud had been lifted off the ground at this stage, it is more probable that the lower portion of the spiral was made in an area where the low-level concentrations were not at a maximum. The large surface concentrations found immediately downwind of the site (Table 6-6(b)) do not fit with the concept of an elevated plume centerline at the spiral location some 10-11 km farther downwind.

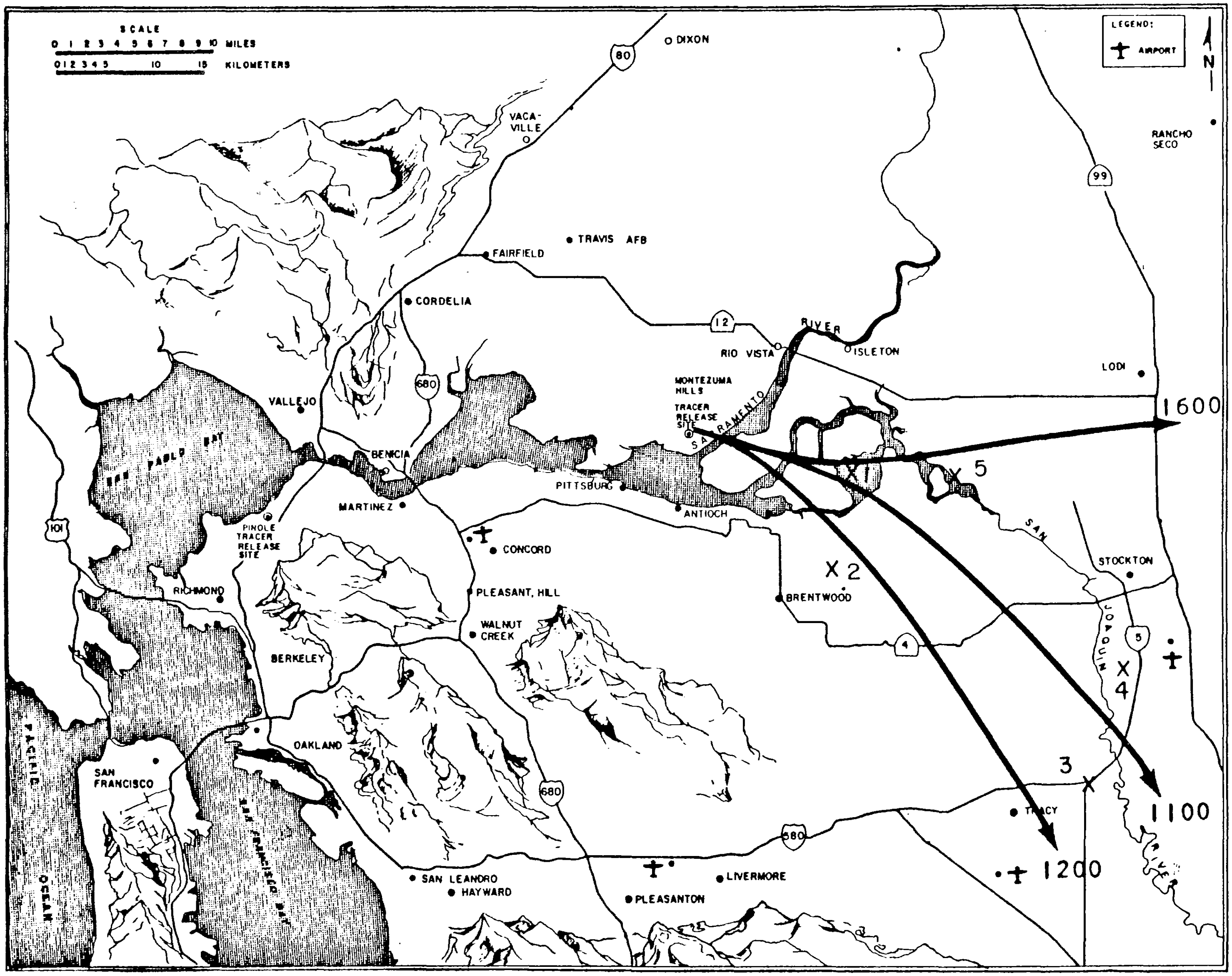
The surface streamline pattern for 0600 PDT is shown in Figure 6-20. The pattern indicates a split in the flow toward the north and south in the area to the east of Montezuma Hills. By 1500 PDT this pattern downwind of the site had shifted to a more westerly regime. These patterns correspond well with the observed trajectories in Figure 6-18.



77-577

Figure 6-18

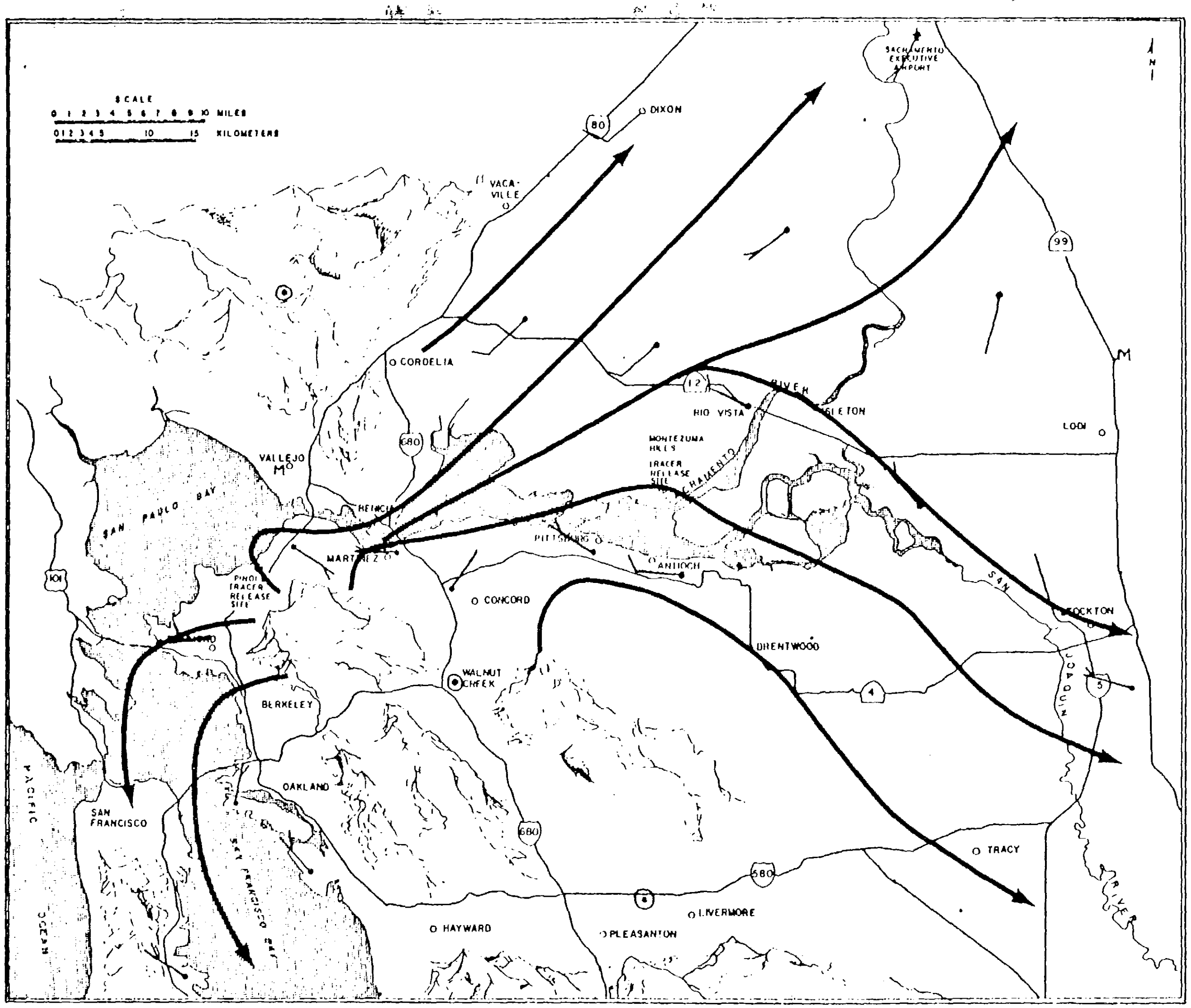
Surface Tracer Trajectories - Test #6
(10 September 1976, 0600 PDT Release)



77-567

Figure 6-19

Location of Airborne Maximum Concentrations - Test 6
(10 September 1976, 0600 PDT Release)



77-566

Figure 6-20

Surface Streamline Pattern
(September 10, 1976, 0600 PDT)

Figure 6-21 gives the $\chi u/Q$ data for Test 6 plotted on a diffusion graph. The peak concentration observed during the spiral is also shown for comparison with the surface concentrations.

The near-downwind concentrations shown in Figure 6-21 (Auto Traverses 1, 2, 4, 6, 7) all group in the E-F stability range. This diffusion category is in reasonable agreement with the previous test data for the early morning observations. It might be expected, however, that the Traverses 6 and 7 (1022-1033 and 1103-1112 PDT) might show the effects of increased dilution due to surface heating (e.g., Test 2). The lack of such an effect in Test 6 may well have been the result of an overcast cloud condition (ceiling 10,000 to 15,000 ft) which prevailed most of the day. Under these conditions the surface heating was restricted as evidenced by the maximum surface temperature at the Dow Tower of only 26°C.

Further downwind, (Figure 6-21) there is a decided trend toward more dilute concentrations than can be associated with the E-F category. At Stockton, the maximum surface temperatures reached 29° in spite of the persistent high clouds. The data in Figure 6-21 indicate clearly that the rate of dilution increased with downwind distance during Test 6, perhaps as a combined result of increased surface heating and the existence of divergent flow.

6.8 Test 7 - September 13, 1976

Test 7 consisted of an SF_6 release from 0600-1500 PDT from Pinole and a CB_rF_3 release from Montezuma Hills from 0900-1100 and again from 1310 to 1400 PDT. As shown in Table 6-7 winds at the Dow Tower site ranged between west-northwest and west-southwest at 4-6 m/s. In the lowest pibal layer the winds at the Tower site generally veered toward the northwest. Mixing layer depths were relatively low at the Dow Tower site, partly reflecting the cool surface temperatures which prevailed.

Figure 6-22 shows the estimated tracer cloud trajectories for Test 7. The sampling data clearly indicate that a split in the trajectory occurred in the vicinity of Martinez with one branch of the trajectory continuing eastward through the Montezuma Hills area before turning to the southeast. This trajectory apparently led to the arrival of tracer material in the Tracy area about 1500 PDT. The southern branch of the trajectory moved southeast from Martinez past Concord, Walnut Creek, and Livermore. It is suggested that this branch contributed material to the Tracy area about 2000 PDT. The afternoon intrusion of marine air can be seen in the southern trajectory as a change in direction from a northwesterly

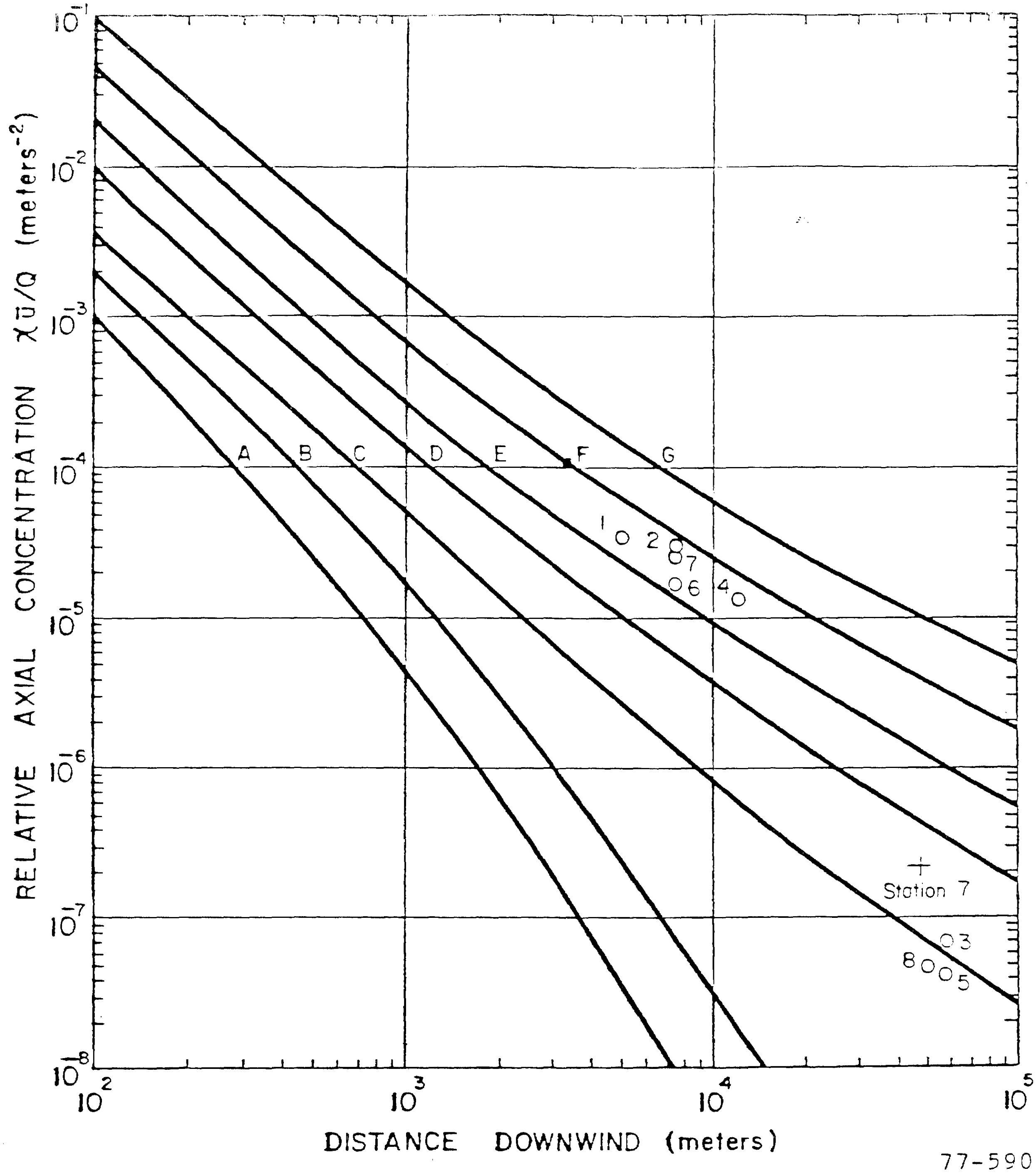


Figure 6-21

Diffusion Graph - Test 6
(September 10, 1976)

Table 6-7

TEST 7 - SEPTEMBER 13, 1976

a. Meteorological Parameters Dow Tower

Time (PDT)	Wind at 10 m (°)	Wind at 10 m (m/s)	Temp. (°C)	Wind at 211 m (°)	Wind at 211 m (m/s)	Mixing Layer Depth (m)
0600	270	5.8	16	-	-	-
0700	290	5.4	15	271	7.4	300
0800	280	5.8	14	295	4.8	300
0900	270	6.3	15	296	4.8	300
1000	280	4.9	18	334	1.9	200
1100	280	4.5	18	300	4.1	400
1200	260	4.5	21	299	1.4	200
1300	230	3.6	22	292	3.2	400
1400	240	4.9	24	279	2.8	600
1500	230	4.9	24	262	5.2	500
1600	250	5.4	26	-	-	-
1700	260	5.8	26	276	6.0	1000

b. Peak Tracer Concentrations ($\overline{u}$ = 2.6 m/s at Pinole, 4.6 m/s at Dow)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	0924-0956	15.0	8.22×10^{-7} m^{-2}
2 C*	0940-1100	4.6	2.12×10^{-5}
3	1113-1217	51.0	1.26×10^{-7}
4	1130-1146	2.7	2.42×10^{-7}
6	1340-1414	2.8	1.75×10^{-7}
7	1429-1451	57.0	1.87×10^{-8}
8	1450-1706	5.6	2.68×10^{-6}
8	1450-1706	53.0	4.03×10^{-8}

Table 6-7 (Continued)

TEST 7 - SEPTEMBER 13, 1976

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
9	1458-1532	57.0	1.60×10^{-8} m^{-2}
10	1537-1611	28.0	2.14×10^{-8}
11	1654-1820	75.0	1.60×10^{-8}
12	1835-1901	53.0	1.73×10^{-8}

* C refers to CB_rF_3 concentration

c. Peak Hourly Tracer Concentration

Station No.	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
13	2100-2200	65	1.20×10^{-8} m^{-2}

d. Peak Airborne Tracer Concentrations

Traverse	Time (PDT)	Altitude [Above Sea Level] (m)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	0916-0918	427	17	0
2	0925-0938	305	17	1.34×10^{-9} m^{-2}
3	0945-0958	183	17	2.68×10^{-7}
4	1327-1343	183	68	2.53×10^{-8}
5	1348-1408	305	68	3.22×10^{-8}
6	1428-1456	427	76	2.01×10^{-9}
7	1759-1812	457	78	3.90×10^{-8}
8	1815-1822	457	96	6.68×10^{-9}
9	1850-1912	457	90	5.36×10^{-9}

Table 6-7 (Continued)

e. Aircraft Spiral Tracer Concentration

(1) Spiral No. 2 (0849-0854 PDT) Downwind Distance = 18 km

Altitude (m MSL)	$\chi u/Q$	Altitude (m MSL)	$\chi u/Q$
472	0 m^{-2}	229	4.14×10^{-8} m^{-2}
457	0	213	8.15×10^{-8}
442	0	198	7.08×10^{-8}
427	0	183	1.07×10^{-7}
411	0	168	6.68×10^{-8}
396	0	152	4.81×10^{-8}
381	0	137	9.35×10^{-8}
366	0	122	1.03×10^{-7}
351	0	107	1.11×10^{-7}
335	0	91	9.22×10^{-8}
320	0	76	1.40×10^{-7}
305	0	61	1.46×10^{-7}
290	0	46	1.08×10^{-7}
274	0	30	1.22×10^{-7}
259	0	15	9.35×10^{-8}
244	6.68×10^{-9}		

Table 6-7 (Continued)

e.

(2) Spiral No. 4 (1011-1017 PDT) Downwind Distance = 18 km

Altitude (m MSL)	$\chi u/Q$	Altitude (m MSL)	$\chi u/Q$
457	0 m^{-2}	213	4.84×10^{-7} m^{-2}
442	0	198	4.42×10^{-7}
427	0	183	4.41×10^{-7}
411	0	168	4.50×10^{-7}
396	0	152	5.21×10^{-7}
381	0	137	3.17×10^{-7}
366	0	122	5.92×10^{-7}
351	0	107	4.90×10^{-7}
335	0	91	5.10×10^{-7}
320	3.07×10^{-8}	76	3.77×10^{-7}
305	1.17×10^{-7}	61	4.97×10^{-7}
290	5.08×10^{-8}	46	5.20×10^{-7}
274	2.78×10^{-7}	30	4.26×10^{-7}
259	1.71×10^{-7}	15	3.39×10^{-7}
244	3.33×10^{-7}	0	3.26×10^{-7}
229	3.39×10^{-7}		

Table 6-7 (Continued)

e.

(3) Spiral No. 8 (1559-1603 PDT) Downwind Distance = 53 km

Altitude (m MSL)	$\chi u/Q$	Altitude (m MSL)	$\chi u/Q$
1829	0 m^{-2}	701	0 m^{-2}
1768	0	671	5.34×10^{-9}
1707	0	640	8.01×10^{-9}
1646	0	610	0
1585	0	579	9.35×10^{-9}
1524	0	549	5.34×10^{-9}
1463	0	518	6.68×10^{-9}
1402	0	488	9.35×10^{-9}
1341	0	457	6.68×10^{-9}
1280	0	427	6.68×10^{-9}
1219	0	396	8.01×10^{-9}
1158	0	366	6.68×10^{-9}
1097	6.68×10^{-9}	335	0
1036	9.35×10^{-9}	305	5.34×10^{-9}
975	8.01×10^{-9}	274	5.34×10^{-9}
914	2.67×10^{-9}	244	5.34×10^{-9}
884	8.01×10^{-9}	213	0
853	4.01×10^{-9}	183	0
823	5.34×10^{-9}	152	6.68×10^{-9}
792	0	122	6.68×10^{-9}
762	2.67×10^{-9}	91	6.68×10^{-9}
732	0		

Table 6-7 (Continued)

e.

(4) Spiral No. 9 (1832-1838) PDT) Downwind Distance = 90 km

Altitude (m MSL)	$\chi u/Q$	Altitude (m MSL)	$\chi u/Q$
1524	0 m^{-2}	1158	4.01×10^{-8} m^{-2}
1463	0	1097	6.01×10^{-8}
1402	0	1036	1.27×10^{-6}
1341	0	975	9.35×10^{-9}
1280	0	914	5.34×10^{-9}
1219	3.07×10^{-8}	853	1.33×10^{-9}
		792 to 30	0

f. Tracer Cross Sections from Airborne Traverses

Downwind Distance = 17 km

Traverse	Time (PDT)	Altitude (m MSL)	Peak Concentration ($\chi u/Q$)
4	0906-0918	427	0 m^{-2}
5	0925-0938	305	1.34×10^{-9}
6	0945-0958	183	2.68×10^{-7}
		Downwind Distance = 68 km	
8	1327-1343	183	2.53×10^{-8}
9	1348-1408	305	3.22×10^{-8}
11	1428-1456	427	2.01×10^{-8}

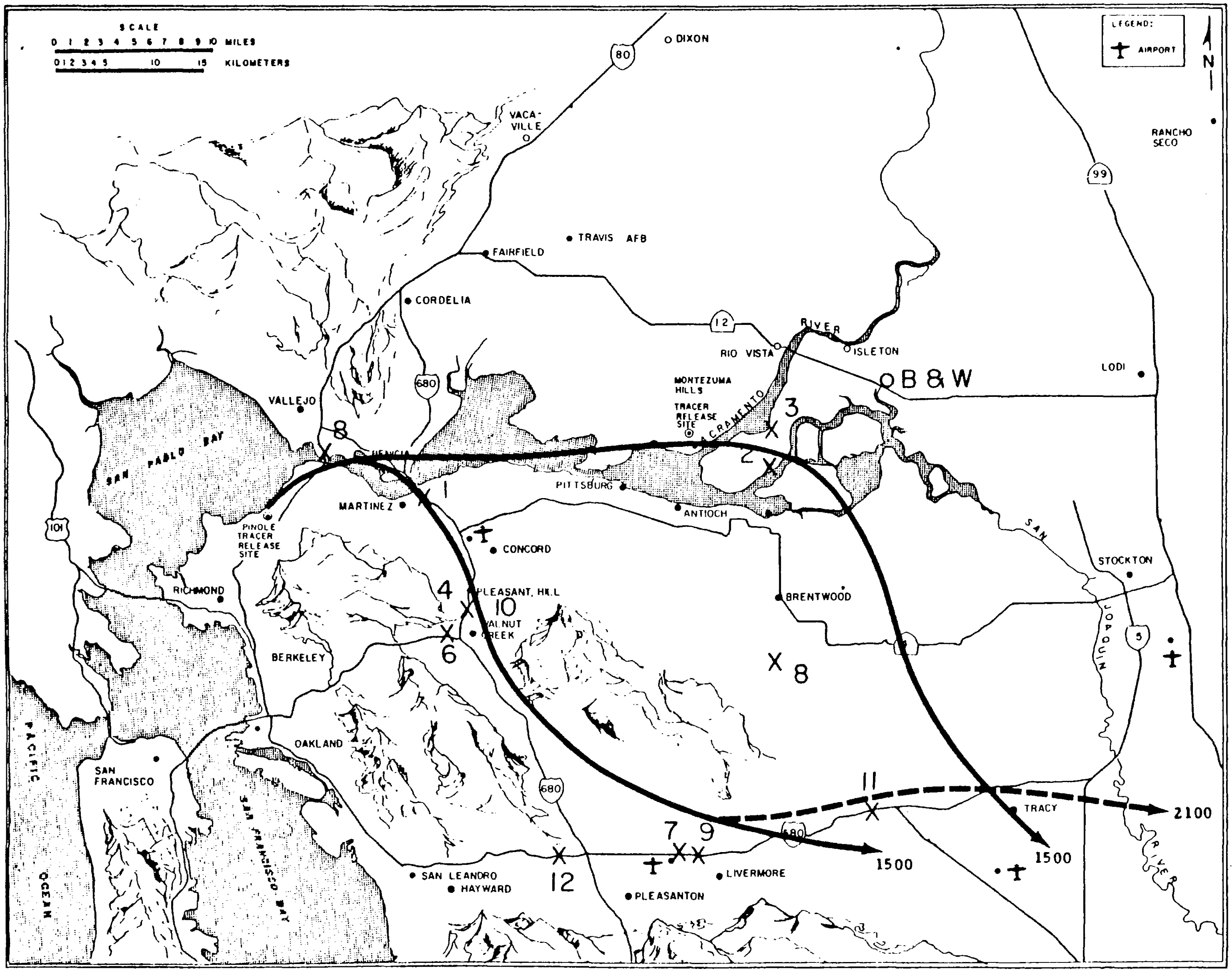


Figure 6-22

77-578

Surface Tracer Trajectories - Test #7
(13 September 1976, 0600 PDT Release)

wind to a westerly flow. This marine air apparently displaced the air in the Tracy area which had originally passed the Montezuma Hills site.

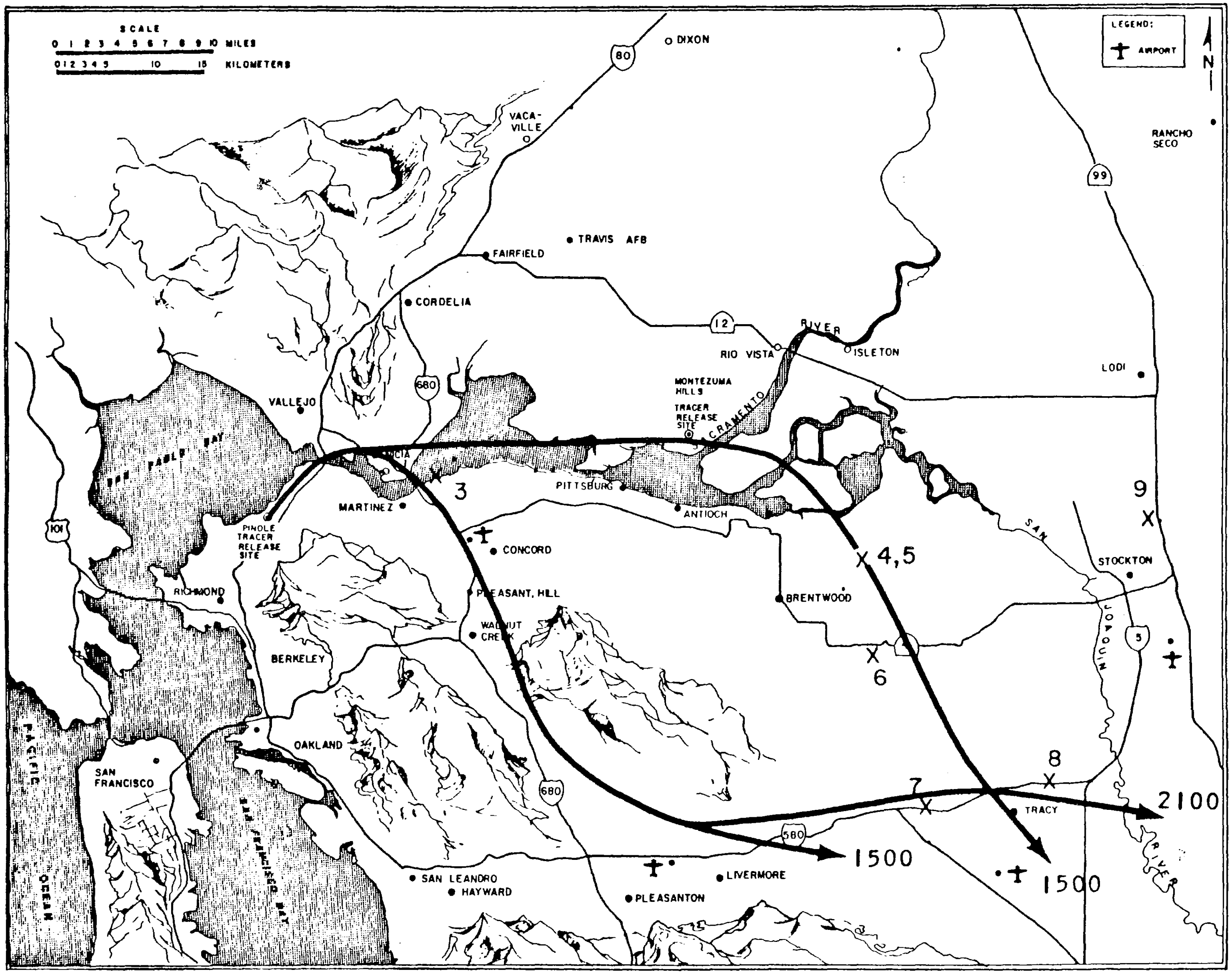
Locations of the airborne maximum concentrations are given in Figure 6-23. Also shown are the locations of the four vertical sampling spirals whose data are given in Table 6-7(e). Table 6-7(f) provides data on the two groups of aircraft traverses which can be considered to represent a vertical section through the tracer cloud. It can be seen from Figure 6-23 that the airborne traverses provided strong support to the surface trajectory flow patterns and auto traverse data shown in Figure 6-22.

Spiral sampling data (Spiral No. 2, 0849-0854 PDT) in Table 6-7(e) show the depth of the tracer cloud at about 240 m. Subsequently, at 1011-1017 PDT in the same area, the depth of the cloud had increased to a little over 300 m, apparently reflecting some effect of surface heating. A vertical section (Table (6-8(d) through the cloud between 0906 and 0958 PDT in the same area further verifies the depth of the tracer cloud at near 300 m.

Spiral No. 8 was made near Tracy between 1559 and 1603 PDT at a distance estimated at 96 km downwind of the release site. All observed SF_6 concentrations were small but were rather uniformly distributed to an elevation of 1100 m MSL.

Spiral No. 9 was carried out near Stockton between 1832 and 1838 PDT. There are indications in the spiral data of an elevated tracer cloud with a base of 850 m and a top of 1220 m MSL. Below 850 m there was no evidence of any tracer material. This layer is believed to result again from the intrusion of marine air into the eastern sections of the region. It is suggested that the original mixing layer extended to about 1200 m prior to the arrival of the marine intrusion whose depth at that location was approximately 850 m. The lower layers of the original mixed tracer cloud were displaced by the intrusion air resulting in a layered structure as indicated.

A peak tracer concentration of 1.27×10^{-6} m^{-2} was reported at 1036 m during this spiral. Comparison with diffusion graphs indicates that this value is unacceptably large for a downwind distance of about 90 km. Further, the large value occurred at only one level. Sixty meters above or below this level the reported concentrations were much lower. Since the elevated concentrations undoubtedly resulted from mixing throughout a considerable depth (1200 m) it is unlikely that such a marked vertical gradient in tracer material could occur naturally. It is considered, therefore, that the value at 1036 m is anomalous but that the balance of the concentrations in the elevated layer are valid.



77-569

Figure 6-23

Location of Airborne Maximum Concentrations - Test 7
(13 September 1976 - 0600 PDT Release)

Finally, Table 6-8(d) shows a vertical section made through the tracer cloud just east of Brentwood between 1327 and 1456 PDT. The data indicate a vertical section made through the tracer cloud just east of Brentwood between 1327 and 1456 PDT. The data indicate a well-mixed tracer cloud layer throughout the lowest 430 m with no significant evidence of a layer top.

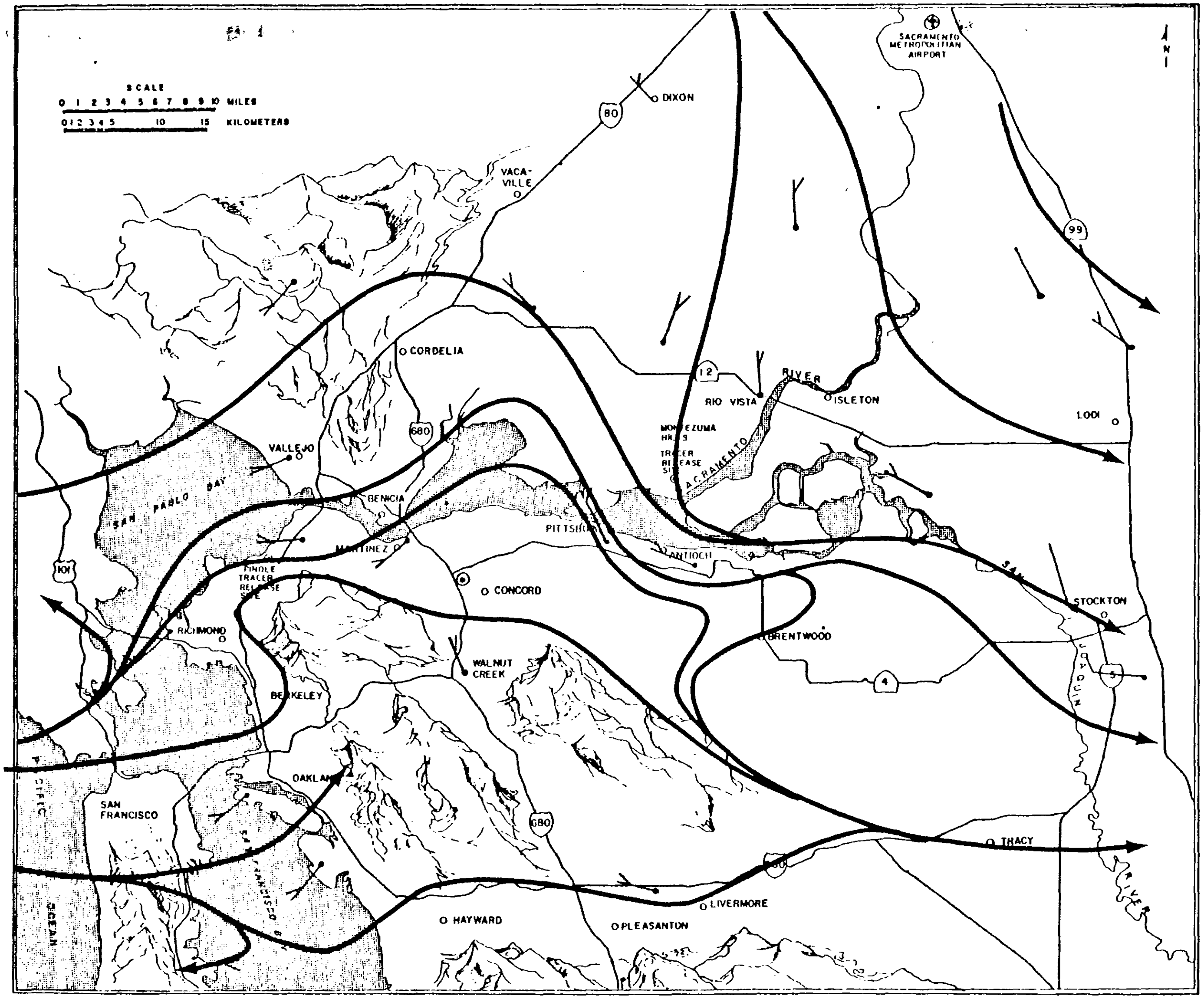
The surface streamline flow for 0900 PDT is shown in Figure 6-24. There is streamline evidence of a flow from Concord southeastward toward Tracy together with a northerly flow pattern extending into Montezuma Hills area from the north. By 1200 PDT the afternoon heating had become more dominant and the flow past Montezuma Hills had changed to a more normal westerly pattern.

All peak concentration data for Test 7 have been plotted on a diffusion graph in Figure 6-25. The SF_6 data cluster around the C stability condition with the one CB_rF_3 data point (2c) again indicating a comparatively higher value. An examination of the data in Figure 6-25 suggest two general groupings. These are Auto Traverses 1, 3, 4, 6, and 8 and Auto Traverses 7, 8, 9, 10, 11, 12 with the latter data corresponding to stability category B-C. In general, the second group of traverse data were obtained after 1400 PDT. It is suggested, therefore, that the principal variation between the two groups of data is the diluting effect of afternoon surface heating. In spite of this possible variation within the test period, the data from Test 7 correspond well with results obtained for other comparable daytime releases (e.g., Test 2).

6.9 Test 8 - September 14, 1976

SF_6 was released from Pinole between 0730 and 1300 PDT during Test 8. As indicated in Table 6-8, winds at the Dow Tower site were westerly from 8-9 m/s and somewhat higher in the lowest pibal layer. Mixing layer depth was relatively low in the early morning increasing to 600 m by noon. Surface temperatures were unusually cool for mid-September.

Figure 6-26 shows the estimated tracer trajectories for Test 8. Material leaving Pinole took a path toward the northeast to the vicinity of Martinez. At that point in the trajectory there was again evidence of a division of the trajectory into a northerly component through the Montezuma Hills area and a southerly branch directed toward Concord. From Auto Traverse 3 at 1047-1151 the center of the SF_6 cloud appeared to pass in close vicinity to the Montezuma Hills site. Under these conditions, potential emissions from the Montezuma Hills area



77-562

Figure 6-24

Surface Streamline Pattern
(September 13, 1976, 0900 PDT)

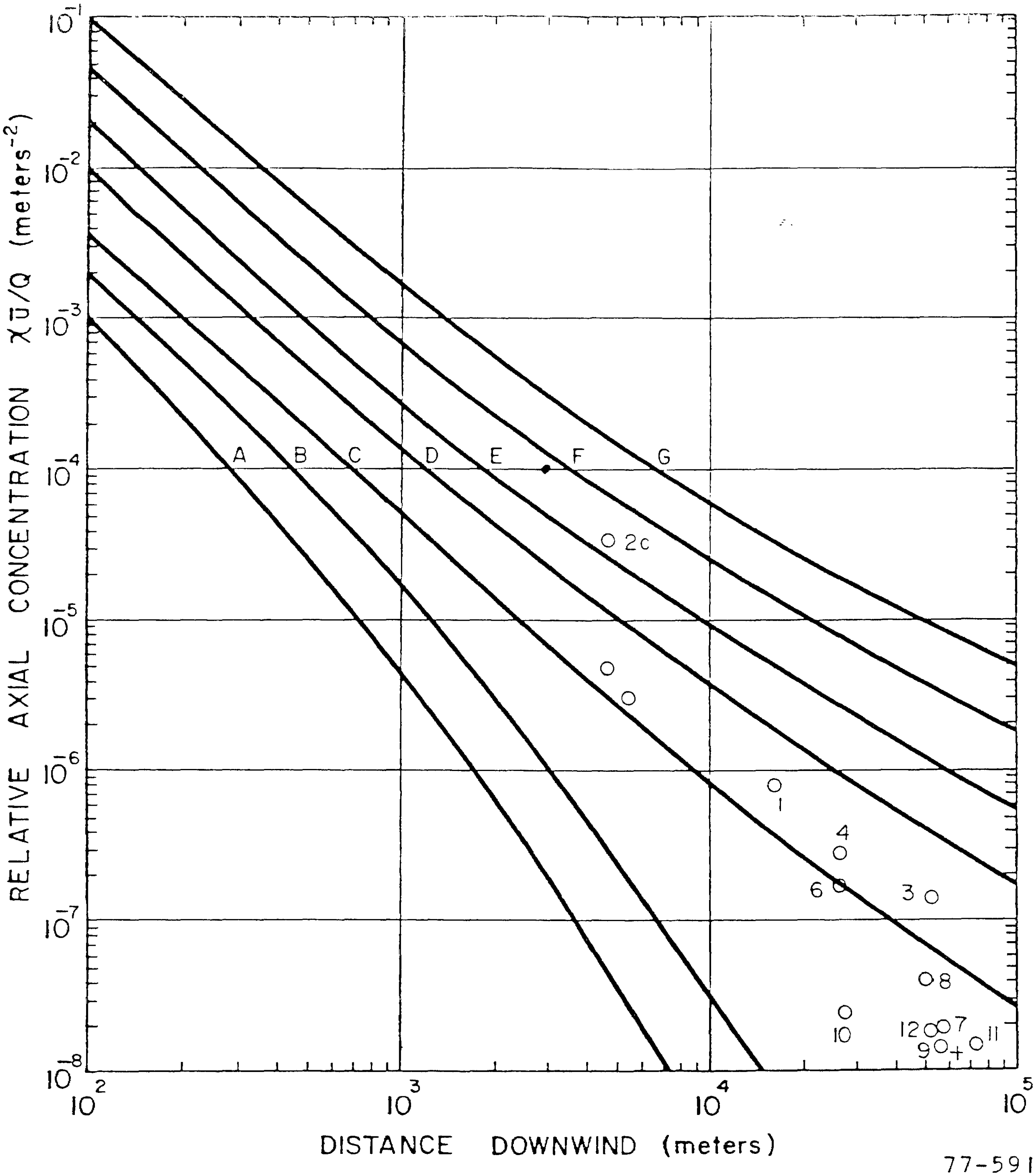


Figure 6-25

Diffusion Graph - Test 7
(September 13, 1976)

Table 6-8

TEST 8 - September 14, 1976

a. Meteorological Parameters   Dow Tower

Time (PDT)	Wind at 10 m (°)	Wind at 10 m (m/s)	Temp. (°C)	Wind at 211 m (°)	Wind at 211 m (m/s)	Mixing Layer Depth (m)
0700	260	8.5	18			
0800	260	8.9	16	254	9.8	300
0900	260	8.0	16	263	11.3	-
1000	260	8.0	19	265	8.8	400
1100	270	8.0	18	271	8.8	600
1200	280	8.9	19	264	13.2	600

b. Peak Tracer Concentrations ($\overline{u}$ = 3.7 m/s)

Traverse	Time (PDT)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	0906-0931	14	3.05×10^{-6} m^{-2}
2	0941-1007	16	7.84×10^{-7}
3	1047-1151	48	1.49×10^{-7}
4	1154-1218	19	2.46×10^{-7}

c. Peak Airborne Tracer Concentrations

Traverse	Time (PDT)	Altitude [Above Sea Level] (m)	Downwind Distance (km)	Normalized Concentration ($\chi u/Q$)
1	0942-0958	427	15	4.18×10^{-8} m^{-2}
2	0959-1012	305	16	2.55×10^{-7}
3	1016-1028	183	16	5.77×10^{-7}

Table 6-8 (Continued)

d. Aircraft Spiral Tracer Concentrations

(0921-0930 PDT) Downwind Distance - 18 km

Altitude (m MSL)	$\chi u/Q$	Altitude (m MSL)	$\chi u/Q$
1067	0 m^{-2}	305	3.42×10^{-7} m^{-2}
1006	0	290	3.84×10^{-7}
945	0	274	3.08×10^{-7}
884	0	259	2.76×10^{-7}
823	0	244	2.91×10^{-7}
762	1.90×10^{-8}	229	4.01×10^{-7}
701	0	213	8.01×10^{-7}
640	0	198	5.27×10^{-7}
579	0	183	5.42×10^{-7}
518	1.81×10^{-7}	168	4.79×10^{-7}
457	1.10×10^{-6}	152	1.07×10^{-6}
442	0	137	1.63×10^{-6}
427	7.04×10^{-8}	122	7.84×10^{-7}
411	1.98×10^{-7}	107	1.28×10^{-6}
396	1.01×10^{-7}	91	8.60×10^{-7}
381	2.82×10^{-7}	76	6.15×10^{-7}
366	7.80×10^{-8}	61	8.35×10^{-7}
351	2.78×10^{-7}	46	8.41×10^{-7}
335	2.15×10^{-7}	30	8.33×10^{-7}
320	4.70×10^{-7}	15	2.40×10^{-7}

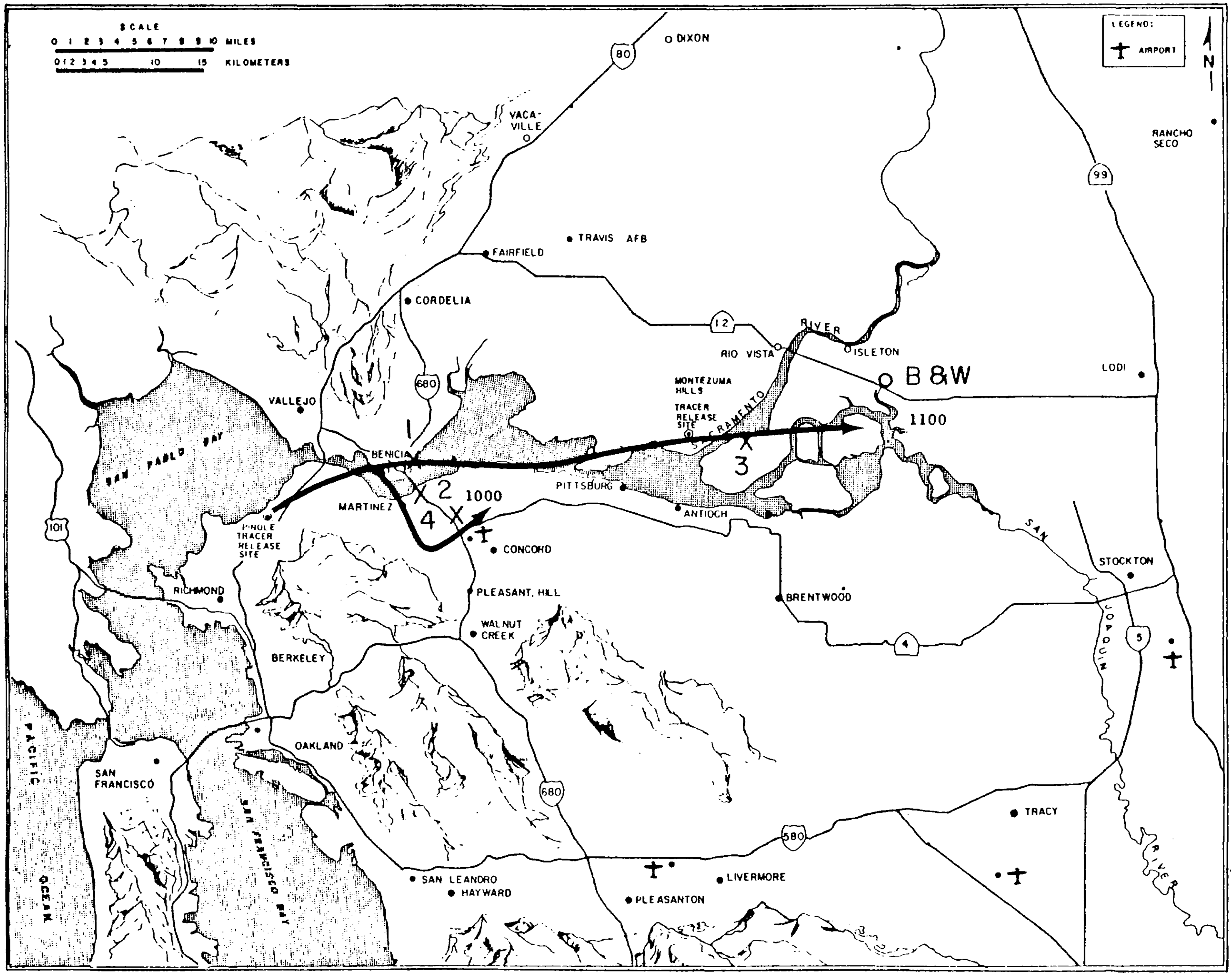


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Figure 6-26

Surface Tracer Trajectories - Test #8
(14 September 1976, 0730 PDT Release)

would be superimposed on the background pollutants transported into the area from the Pinole-Martinez region.

The location of the peak airborne concentrations indicated in Table 6-8 and measured during Air Traverses 4, 5, and 6 is shown in Figure 6-27. These traverses form a vertical section through the tracer cloud at about 16 km downwind. Data given in Table 6-8(c) indicate that the tracer cloud was about 400 m deep at the time of the sampling.

Location of an aircraft spiral at 0921-0930 PDT is also shown in Figure 6-27. Concentration data associated with the spiral are given in Table 6-8(d). These data also suggest a vertical depth of the cloud of slightly over 400 m at a location of 18 km downwind. The spiral data indicate a well-mixed cloud to a depth of about 350 m with increased concentration variations above that level.

Surface wind flow streamlines for 0900 PDT are shown in Figure 6-28. The flow pattern is typical of the morning hours with westerly winds through the Montezuma Hills area and a split in the flow toward the north and south in the easterly portion of the area. The observed flow characteristics near Martinez did not indicate the split in the flow which was evidenced in the tracer observations.

The peak concentration data for Test 8 were plotted on a diffusion graph and shown in Figure 6-29. The limited data obtained lie in the range of C-D stability category which corresponds to the results of other releases made at comparable times (e.g., Test 7).

6.10 Summary of Tracer Results

The tracer tests were designed to examine a full range of diurnal meteorological environments. The day was divided meteorologically into four six-hour periods; (1) an afternoon sea breeze flow, (2) an early morning nocturnal flow and two transition periods in the forenoon and late evening when nonsteady state conditions might be anticipated. According to this classification system, the various tests can be described as:

Classification of Test Environment Conditions

Test No.		Test No.	
1	Afternoon sea breeze	6	Forenoon
2	Afternoon sea breeze	7	Forenoon
3	Early morning	8	Forenoon
4	Late evening		

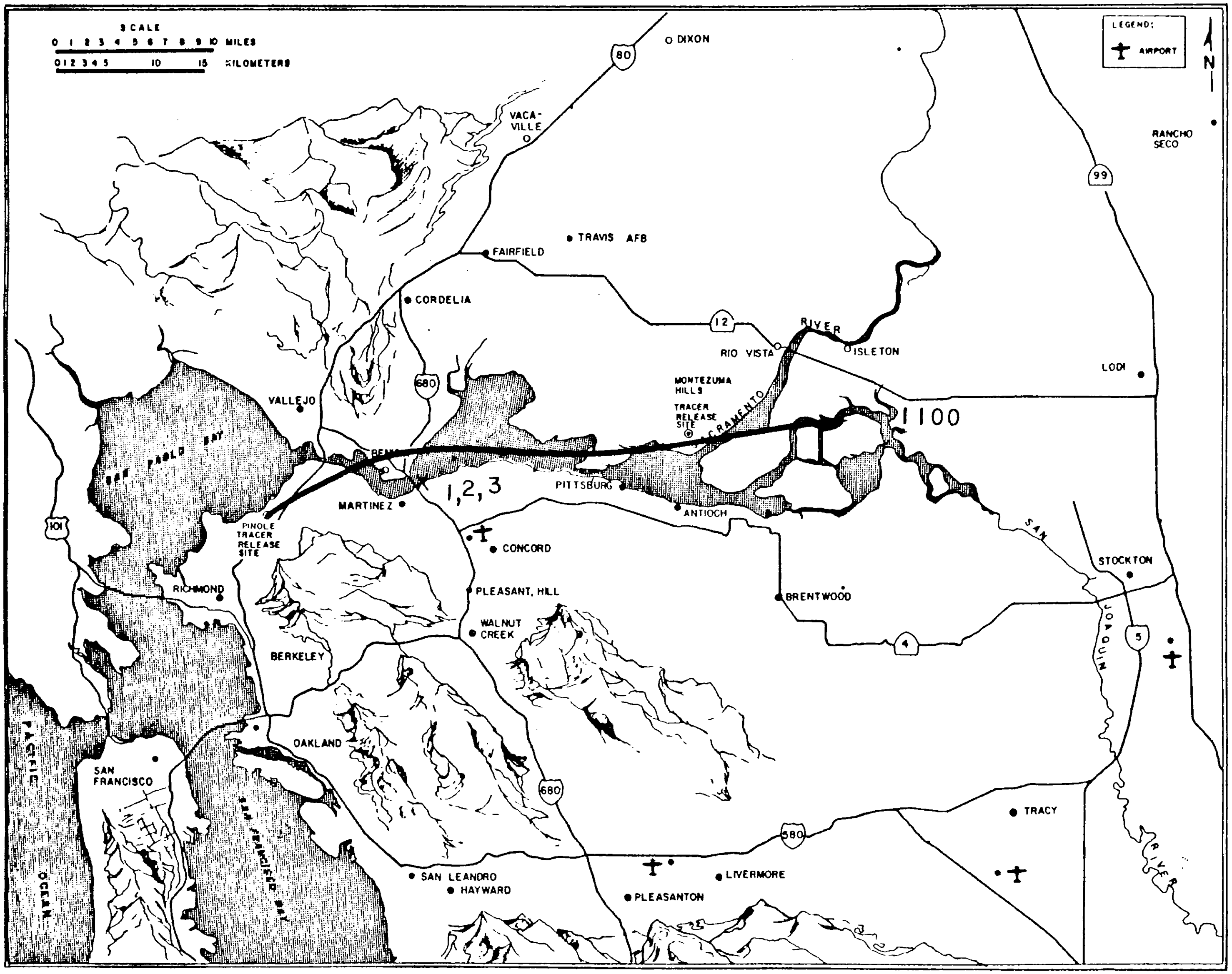

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Figure 6-27

Location of Airborne Maximum Concentrations - Test #8
(14 September 1976, 0730 PDT Release)

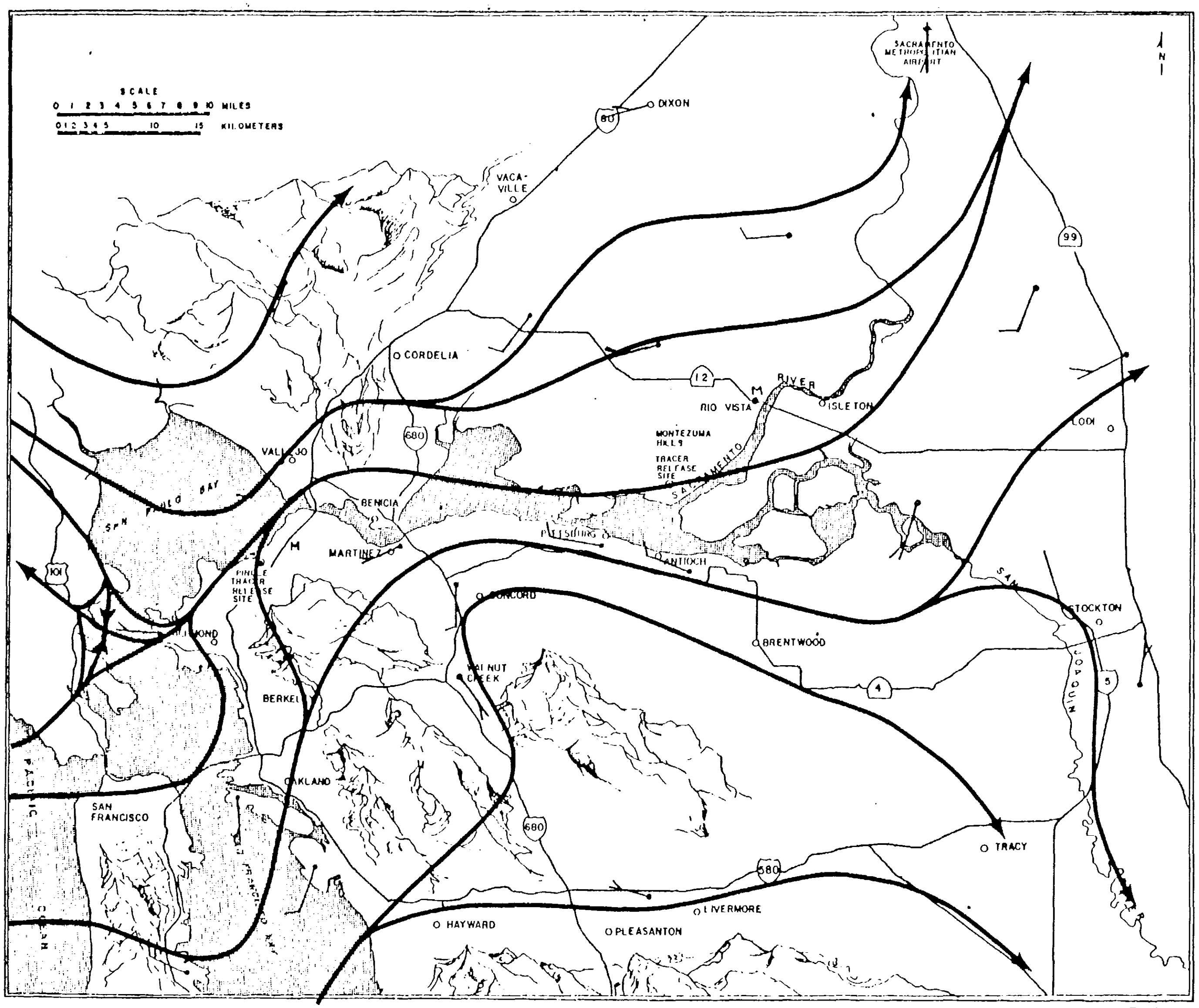

Figure 6-28

Surface Streamline Patterns
(September 14, 1976, 0900 PDT)

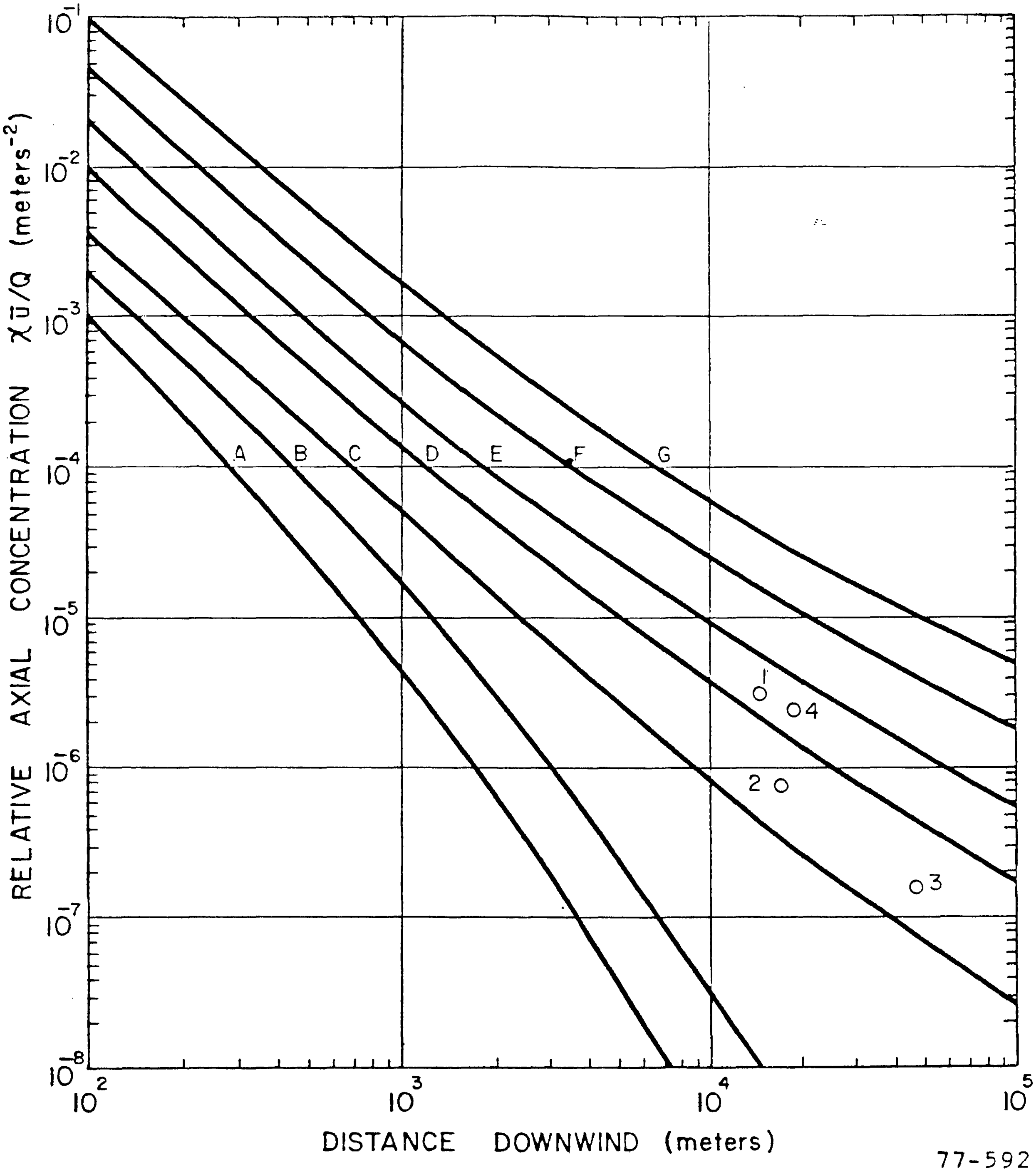

Figure 6-29

Diffusion Graph - Test 8
(September 14, 1976)

Although it was not possible to cover a variety of meteorological ranges within any given environment condition, the test results were sufficiently consistent to permit a few generalizations of the results.

The discussion of the test results can be readily separated into (1) trajectories and (2) dispersion.

6.10 Trajectory Comments

1. The westerly flow through the Montezuma Hills area dominates the tracer trajectory results, day and night. Only Test 5 was carried out in a nonwesterly wind condition. Aside from Test 5, the variations in trajectory immediately east of the site were very small.

2. To the east of the site the trajectories varied markedly ranging from near Lodi to Tracy. Tests 1 through 4 suggest a late afternoon or evening flow from a westerly direction which carried tracer material to the east of Highway 99. During the night or early morning the flow pattern shifted to the southeast, perhaps in response to the opposing flow of drainage air from the foothills to the east of Highway 99. Tests 5, 6, and 7 also show evidence of the westerly flow regime in the late afternoon or evening but the tests may have been terminated before the northwesterly flow could develop.

3. The wind pattern east of the Montezuma Hills area was not observed in sufficient detail to fully document these shifts in trajectory. The tracer results, in fact, suggest that slight shifts in wind flow in the area to the east of the site may lead to substantial changes in the ultimate trajectory of the potential emissions.

4. There was evidence in one test (Test 3) of early morning stagnation of the tracer cloud for several hours in the Stockton-Tracy area. Subsequently, during the forenoon, the air movement picked up again and the tracer material finally cleared through the observational area.

5. Trajectories from Pinole and Martinez (Tests 2, 7, and 8) all showed that a portion of the tracer cloud split off in the vicinity of Martinez and moved southeast through Concord. The wind flow pattern was not sufficiently well-detailed to define this feature adequately although a west-northwest wind is common at Martinez.

6. In Tests 2 and 7 when two types of tracers were released, the peak SF_6 tracer concentration was found to be at essentially the same location downwind of Montezuma Hills as the tracer released from

the site itself. In Test 8 only SF_6 was released (from Pinole). Again the location of the peak concentration was nearly identical to the location downwind of the Montezuma Hills site where peak tracer concentrations from site releases were observed. These data indicate that a frequent trajectory for emissions from Pinole and Martinez is directly over or very close to the Montezuma Hills site.

6.11 Dispersion Comments

Peak traverse concentrations plotted on the diffusion graphs are 10-second syringe samples. Also included on the graphs are maximum station hourly averages. In general, the 10-second peaks might be expected to be larger than the one-hour values due to the usual meandering nature of most trajectories. In the present cases, there is little apparent difference between the two types of sampling. Lamb and Shair (1977) have estimated that the observed ratio of peak concentrations is:

$$\frac{\text{Concentration (hour average)}}{\text{Concentration (10-second)}} = 0.70$$

for the Montezuma Hills data. Dispersion graphs in the preceding sections support the general view that the difference is smaller than suggested by Hino (1968). This discrepancy is attributed to the relatively steady-state nature of the trajectories in the present study. It should be noted, however, that the 10-second data shown in the dispersion graphs may represent slight overestimates of the true hourly values and consequently are conservative with respect to the impact estimation of potential Montezuma Hills emissions.

Specific comments on the diffusion data are:

1. The afternoon dispersion condition is characterized by C-D stability conditions at all distances downwind.

2. Highest concentrations downwind were observed during Tests 3 and 4 from releases made between 2100 and 0400 PDT. These concentrations were in the stability range between F and G.

3. Releases made about 0600 PDT tended to show intermediate stability conditions, i.e., in the range of E-F (Test 6).

4. Afternoon releases (Tests 1, 2, 5) followed a normal relationship of dispersion versus downwind distance as indicated on the standard diffusion graph.

5. Morning releases (Tests 6, 7, 8) showed indications of more rapid dilution with downwind distance than indicated by the standard diffusion graph. This characteristic is attributed to increasing instability as the tracer cloud moved downwind.

6. Late evening or nighttime releases (Tests 3, 4) also showed more rapid dilution as a function of downwind distance. In this case, it is suggested that divergence of the plume under low inversion conditions may have contributed to this dilution.

7. Three-Dimensional Pollutant Analysis

The MRI aircraft was used during the program to examine the three-dimensional structure of the pollutants in the Carquinez Strait area and, in particular, to estimate the flux moving into the Montezuma Hills region from anthropogenic sources upwind. Details of the airborne sampling system and the flight schedule are given in Section 4. Aircraft sampling routes are shown in Figure 7-1.

7.1 Cross Sections

Selected vertical cross-sectional diagrams showing the vertical structure of the various air quality parameters along the sampling aircraft flight paths are shown in Figures 7-2 through 7-6. Contours were drawn using aircraft data from both horizontal traverses and vertical soundings plotted at the applicable geographical locations in the cross section. Dashed contours are used in areas of limited data. Flight paths, both vertical (V) and horizontal (T) are shown as solid straight lines. The horizontal positions of data points used to produce the contours were determined by calculation of the time position of each data point in the aircraft pass assuming a constant aircraft speed relative to the ground.

Figure 7-2 gives the vertical cross sections for NO_x and O_3 on September 10 (1600 PDT) while the simultaneous cross sections for SO_2 and b_{scat} are given in Figure 7-3. To the north of Concord there is found to be a peak aloft (300-600 m) in NO_x, SO_2, and b_{scat} with a simultaneous deficit in O_3. The SO_2 peak is pronounced and rather narrow, suggesting a source not far upwind or a constricted flow eastward out of the San Pablo Bay area. An additional NO_x peak is found slightly north of Highway 580, showing the effects of air moving through the Hayward Gap. It is of interest that there was no apparent ozone deficit associated with this peak, indicating more aged pollutant than was present in the northern peak.

By way of comparison, the peak hourly O_3 value at the Dow Tower site on September 10 was 0.078 ppm between 1500 and 1600 PDT. Peak value of SO_2 observed was 0.036 ppm between 1300 and 1400 PDT. These peak values are relatively low by comparison with the remainder of the daily peak observations made at the Dow site during the program.

Figures 7-4 and 7-5 give similar data for 1000 PDT on September 13 when the SF_6 was released from Pinole. The location of the peak values in the cross sections are slightly north of Concord, similar to the

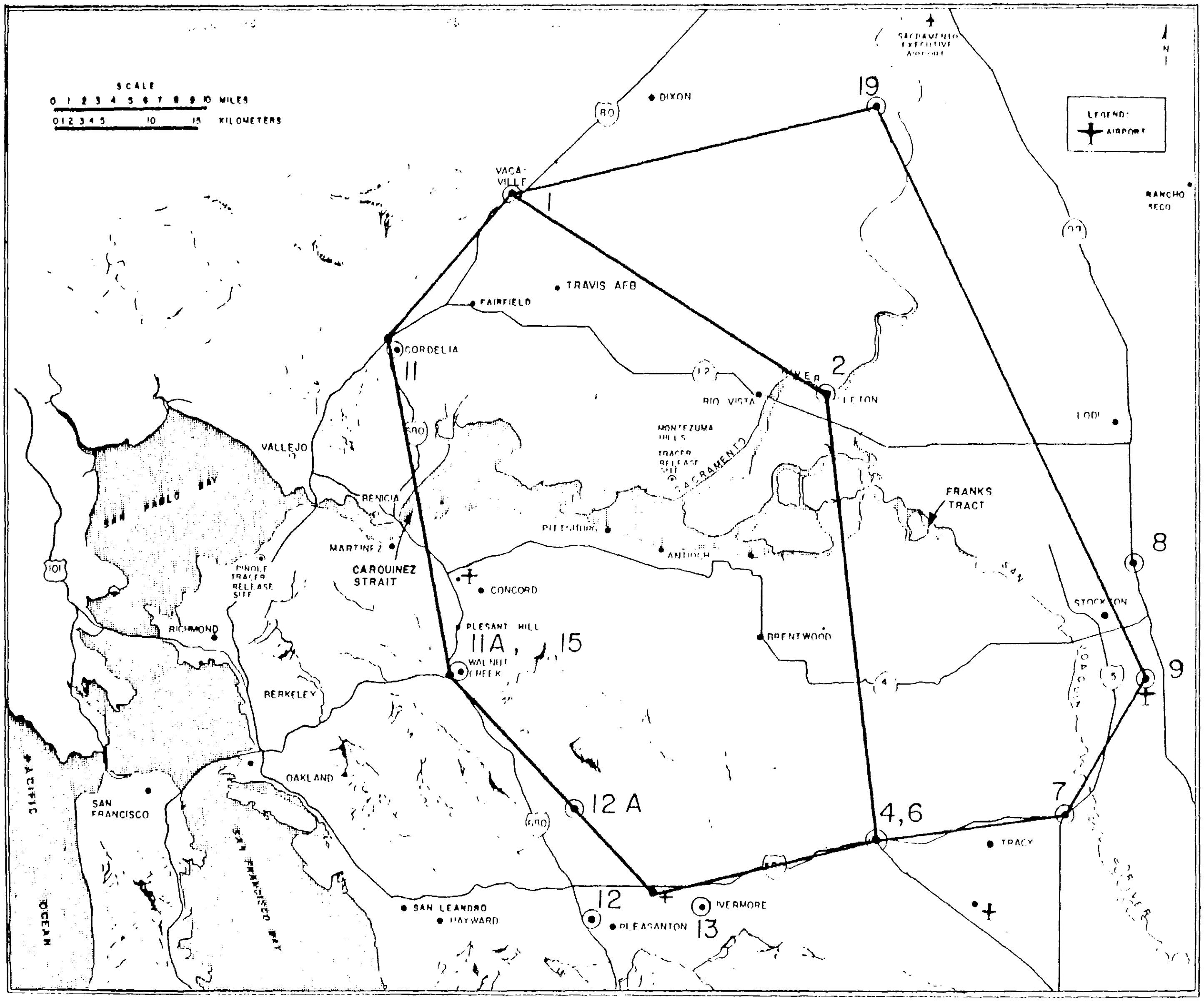

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Figure 7-1

Aircraft Sampling Routes

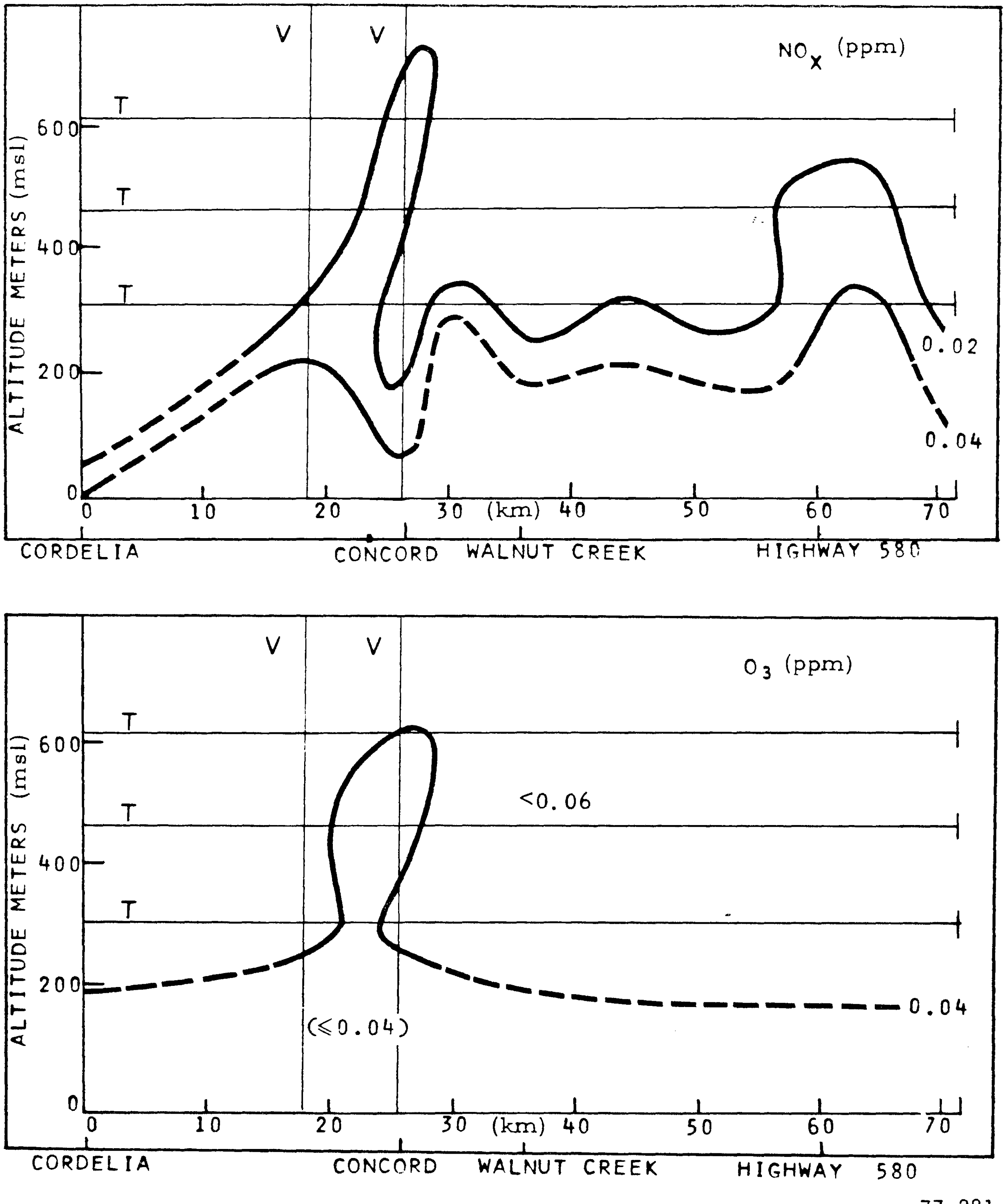

Figure 7-2

Pollutant Cross Sections
(September 10, 1976, 1558-1745 PDT)

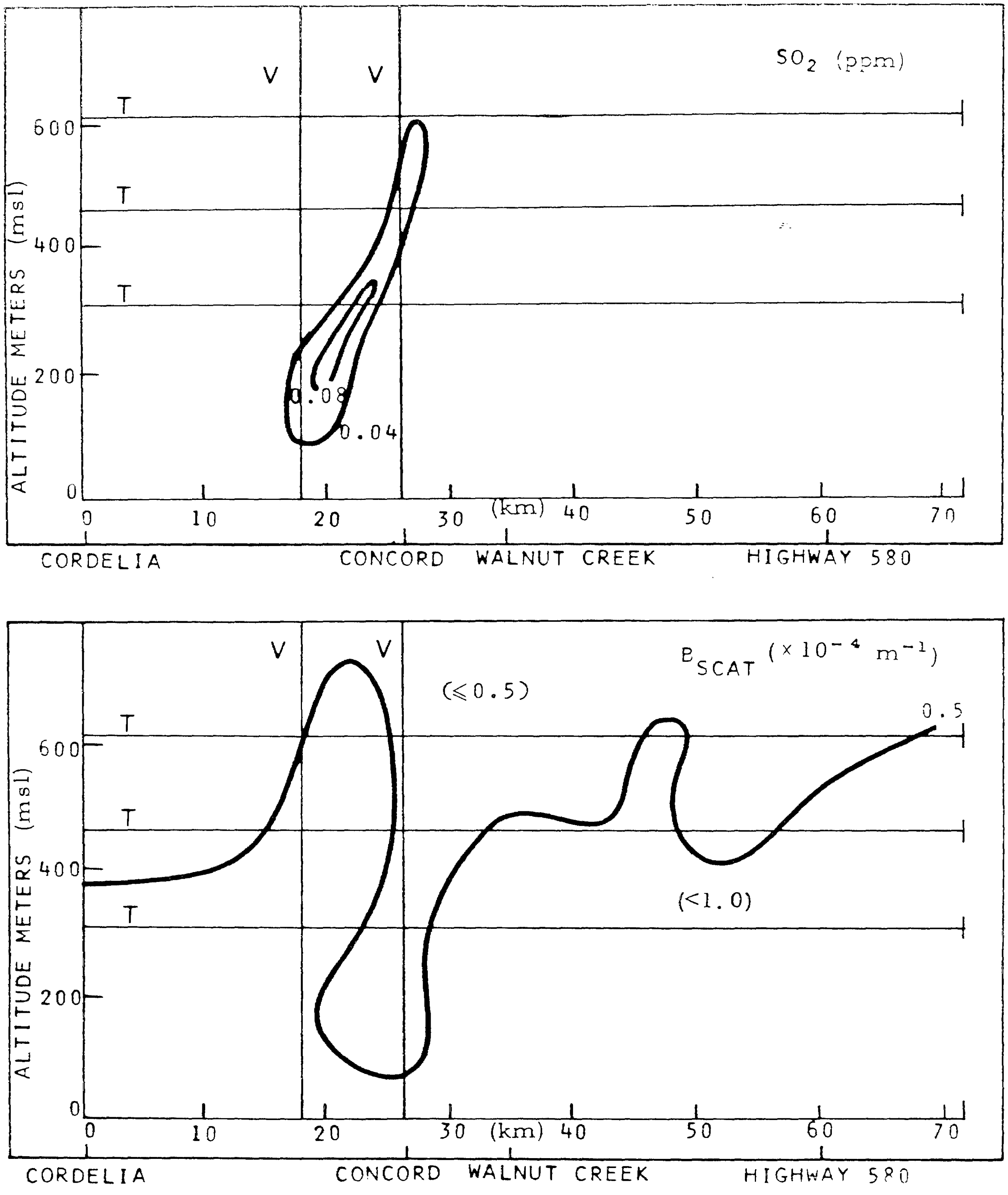

Figure 7-3

Pollutant Cross Sections
(September 10, 1976, 1558-1745 PDT)

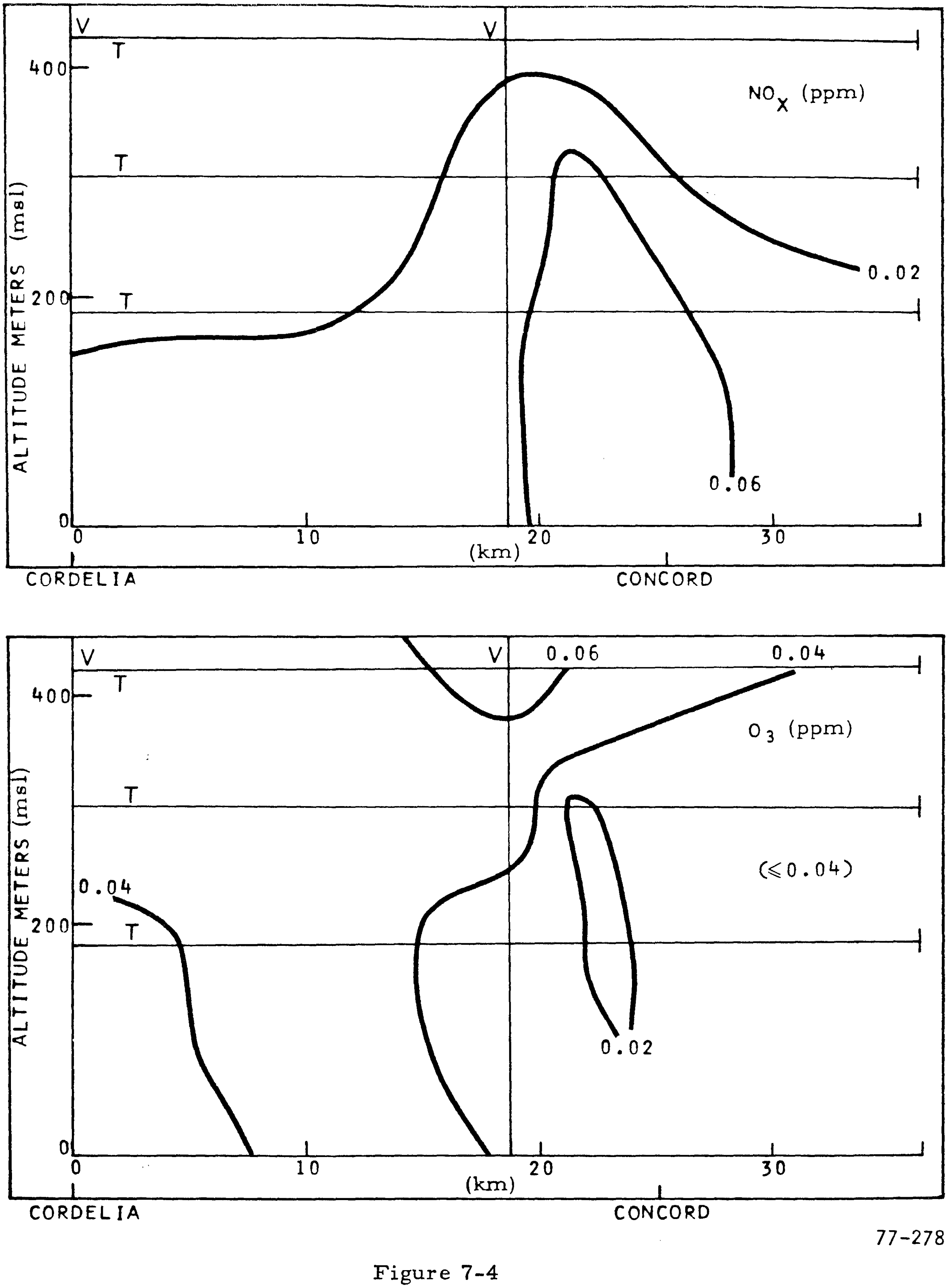

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Figure 7-4

Pollutant Cross Sections
(September 13, 1976, 0906-1009 PDT)

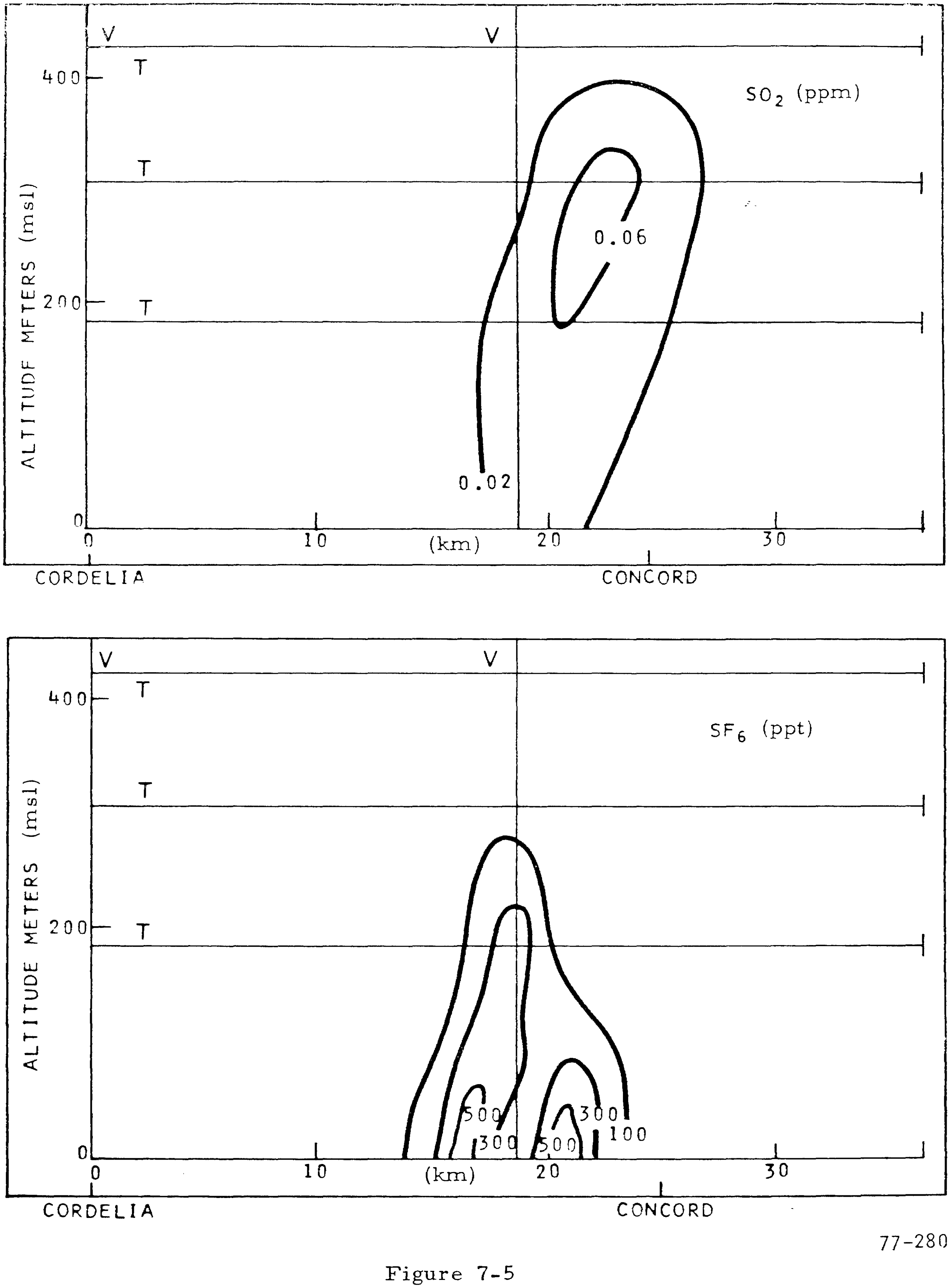
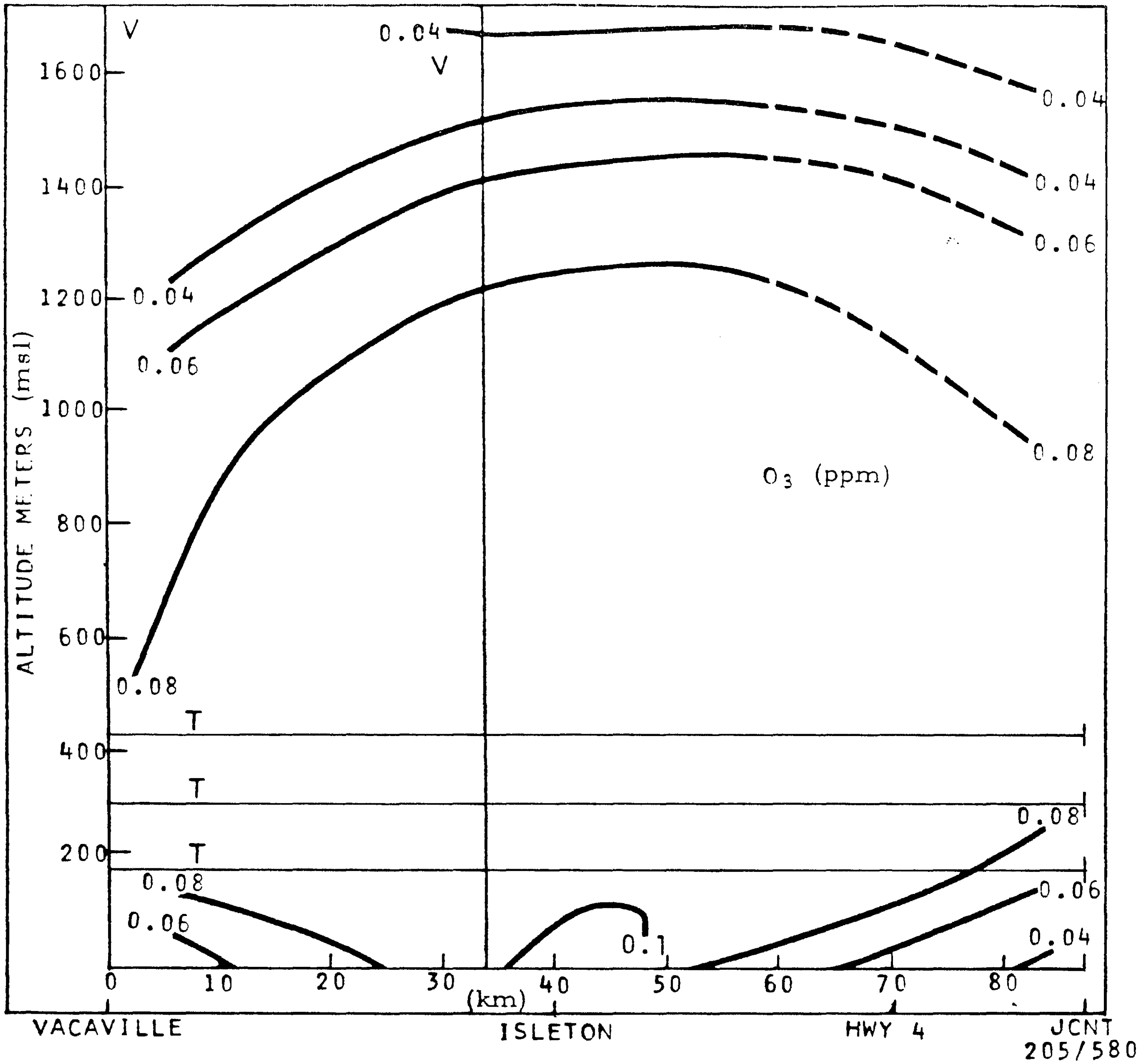


Figure 7-5

Pollutant Cross Sections
(September 13, 1976, 0906-1009 PDT)



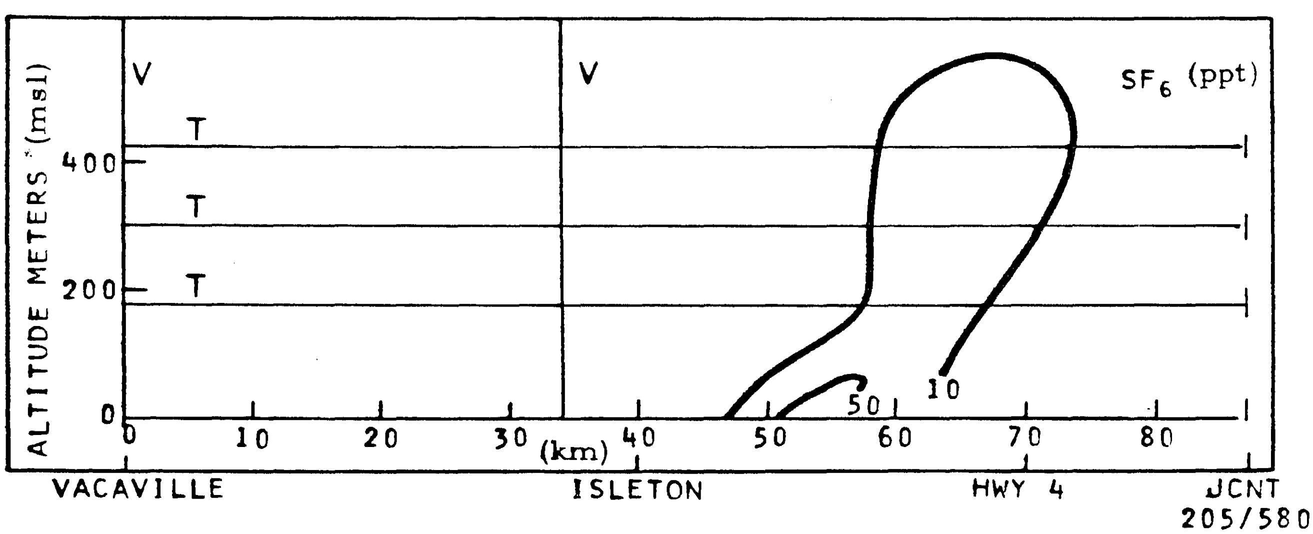


Figure 7-6

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Pollutant Cross Sections
(September 13, 1976, 1300-1518 PDT)

data shown in Figures 7-2 and 7-3. In this case, the SF_6 cross section is shown instead of the b_{scat} values. Again there was found an ozone deficit associated with the NO_x peak. The SO_2 peak appeared to be wider than shown in Figure 7-3, centered somewhat higher and with a somewhat lower peak concentration. The SF_6 peak was located close to the ground where the maximum should be for a ground release. It is of interest that the SF_6 peak nearly coincided with the SO_2 peak, indicating a similar trajectory for the two types of material.

Figure 7-6 gives cross sections of O_3 and SF_6 made along a flight path approximately 18 km downwind of the Montezuma Hills site (SF_6, during this test, was released from Pinole). The entire sampling flight covered a period of about three and one-half hours centered around 1400 PDT. The cross section shows an extensive, deep area of higher ozone concentrations with a peak value over 0.10 ppm near or south of Isleton. A peak O_3 value of 0.123 ppm was measured between 1300 and 1400 PDT at the Dow Tower site. This cross section represents a major change in the ozone levels from the upwind 1000 PDT cross section shown in Figure 7-4 and suggests a significant generation of ozone during transport through the general area of Montezuma Hills. The SF_6 peak in Figure 7-6 was located somewhat south of Isleton and reflects the SF_6 plume turning to the southeast as discussed previously.

7.2 Pollutant Flux Rates

Vertical cross sections of SO_2, NO_x, and O_3 (similar to Figures 7-1 through 7-5) together with pibal wind data were used to estimate the flux of these parameters across various traverse routes flown by the MRI aircraft. Fluxes were computed using ground air quality data, when available, as well as the aircraft sampling data. For each cross section, the flux was computed throughout the depth of the existing mixing layer and along the horizontal distance represented by the traverse. Tables 7-1 through 7-3 give the results of the flux calculations for September 10, 13, and 14, 1976 as well as traverse routes and mixing layer depths. Ozone fluxes were computed above a residual background of 0.04 ppm which represents the O_3 value observed well above the mixing layer and constitutes an average non-urban background level for the California area. SO_2 and NO_x fluxes were computed assuming a zero background level. Traverse routes are given in the tables in terms of the end points of the routes. These points are indicated in Figure 7-1.

Table 7-1 shows the pollutant flux values calculated for September 10. The earliest sampling period was carried out to the east of Montezuma Hills from Vacaville to Isleton to Highway 580. The northern half of the

Table 7-1

POLLUTANT FLUX VALUES

September 10, 1976

Time (PDT)	Traverse Route (Points)	Length of Traverse (km)	Top Mixing Layer (MSL) (m)	O_3 Flux (Kg/sec)	NO_x Flux (Kg/sec)	SO_2 Flux (Kg/sec)
0920-1221	1-2	38	325	-0.2	1.2	0
	2-4	47	325	-0.6	2.6	0.2
1229-1308	6-7	18	400	0	0.1	0
	7-8	28	400	0.03	1.5	0
1558-1621	11-11A	4	630	0.5	4.6	1.5
	11A-12A	21	630	0.6	1.3	0
	12A-12	16	630	0.5	1.6	0

Table 7-2

POLLUTANT FLUX VALUES

September 13, 1976

Time (PDT)	Traverse Route (Points)	Length of Traverse (km)	Top Mixing Layer (MSL) (m)	O_3 Flux (Kg/sec)	NO_x Flux (Kg/sec)	SO_2 Flux (Kg/sec)
0723-0854	11-15	37	430	-0.6	1.6	0.7
0906-1017	11-15	37	360	-0.3	2.1	0.5
1300-1533	1-2	38	220	0.6	0.06	0.5
	2-4	47	220	1.4	0.8	1.2
1553-1815	13-7	44	480	0.7	0.5	0.7
	7-9	16	480	1.1	0	1.3
1832-1912	9-19	67	460	2.1	1.0	3.4

Table 7-3

POLLUTANT FLUX VALUES

September 14, 1976

Time (PDT)	Traverse Route (Points)	Length of Traverse (km)	Top Mixing Layer (MSL) (m)	O_3 Flux (Kg/sec)	NO_x Flux (Kg/sec)	SO_2 Flux (Kg/sec)
0740-0930	11-15	37	460	-1.5	3.3	0.3
0942-1054	11-15	37	520	-3.0	5.1	0.3
1327-1551	1-2	38	460	1.2	0.4	0
	2-4	47	460	1.8	2.4	0
1605-1721	13-9	56	500	0.02	0.05	0
1732-1813	9-19	67	130	0.4	1.5	0

route showed little in the way of significant fluxes but the southern portion of the route indicated a moderate flux of NO_x. In both routes, the O_3 flux is shown as negative, indicating a normal morning deficit of O_3 as compared to the background level of 0.04 ppm. SO_2 flux values were relatively small.

The second cross section was carried out east along Highway 580 and north along Interstate 5. The ozone values were near background levels and small amounts of NO_x were observed.

The last cross section on September 10 was conducted from Cordelia south to Highway 580, passing over Carquinez Strait and Walnut Creek. Large fluxes of NO_x and SO_2 were observed between Cordelia and Walnut Creek with much lower amounts in the southern portion of the traverse. O_3 amounts were slightly above background levels along the entire route.

Table 7-2 shows the flux values for September 13. The first two sections were made between Cordelia and Walnut Creek (passing over Carquinez Strait) during early and mid-morning. O_3 deficits were observed together with moderate fluxes of NO_x and SO_2.

The third section was carried out from Vacaville to Isleton to Highway 580. The southern portion of the route, in particular, showed moderate fluxes of O_3 and SO_2. It is to be noted that the observed mixing layer depth of 220 m was less than previously observed upwind and suggests an undercutting of the principal pollutant mass by marine air.

The fourth and fifth sections were flown in the late afternoon or evening and indicate the strong flux of all pollutants across Interstate 5 in the late afternoon. O_3 flux values, in particular, were much higher than observed in any of the previous cross sections.

Table 7-3 gives the pollutant flux values calculated for September 14. The sampling routes followed the same pattern as used on September 13, i.e., morning sampling between Cordelia and Walnut Creek, ending with evening sampling along Interstate 5 north of Stockton. The flux values in Table 7-3 also show considerable similarity to those given in Table 7-2. There was a morning deficit of O_3 between Cordelia and Walnut Creek together with large fluxes of NO_x. In the middle of the sampling area (Vacaville-Isleton-Highway 580) the O_3 flux values had increased considerably while the NO_x values had decreased somewhat (see Traverse 2-4). By early evening the flux across Interstate 5 appeared to be somewhat reduced but the nocturnal mixing layer had formed (130 m depth) so that some of the pollutant material observed earlier undoubtedly existed aloft.

These flux data suggest a typical ozone generation pattern from the Carquinez Strait area eastward to Interstate 5. Ozone deficits together with sizeable amounts of NO_x pass through the Strait, moving eastward. No substantial NO_x sources appear to exist along the route and, in fact, NO_x fluxes appear to be somewhat reduced due to dilution. O_3 fluxes, however, increase substantially in the eastern portions of the area. SO_2 flux values appear to be somewhat erratic with a tendency for higher values to occur in the eastern areas.

7.3 NO/NO_x Ratios

Mean ratios of NO/NO_x have been calculated for each of the traverse routes described in the previous section. These data for all traverses up to 457 m msl are shown in Table 7-4

Several features are shown in the table:

1. There is an apparent increase in NO/NO_x ratio with sampling height in the Carquinez Strait area, particularly on September 14. Farther downwind (September 13 and 14 sampling along Traverse 2-4) the ratios are more uniform with height. It is suggested that this vertical distribution is another manifestation of the morning O_3 deficit in the Strait.

2. The morning NO/NO_x ratios average about 0.5 in the traverses made from Cordelia to Walnut Creek (September 13 and 14). By mid to late afternoon the ratios along Traverse 2-4 (Isleton to Highway 580) average less than 0.4. These two sections (morning and afternoon) represent one of the principal trajectories for pollutant material to follow into the Central Valley.

3. NO/NO_x ratios observed in the Tracy-Stockton area and northward show mixed values depending on time of day. During the mixed portion of the afternoon, low values may occur (September 13) but in the evening when the mixing is reduced the NO/NO_x ratios tend to be somewhat higher.

The NO/NO_x ratio data are consequently consistent in showing a decrease in relative amounts of NO as the pollutant mass moves eastward during the afternoon.

Table 7-4

NO/NO_x RATIOS

Time (PDT)	Traverse Route	Height [MSL] (m)	NO/NO_x Ratio
a. September 10, 1976			
0920-1221	2-4	183	0.36
	1-2	183	0.53
1229-1308	6-7	305	0.46
	7-8	305	0.37
1558-1621	11-12	305	0.33
	11-12	457	0.46
b. September 13, 1976			
0723-0854	15-11	305	0.50
	11-15	183	0.51
0906-1017	15-11	305	0.54
	11-15	183	0.49
1300-1533	1-2	183	0.51
	2-4	183	0.46
	2-1	305	0.48
	1-2	427	0.55
	2-4	427	0.47
1553-1815	13-7	457	0.33
	7-9	457	0.49
1832-1912	9-19	457	0.53
c. September 14, 1976			
0740-0930	15-11	366	0.65
	11-15	274	0.55
	15-11	183	0.50
0942-1054	11-15	427	0.55
	15-11	305	0.46
	11-15	183	0.41
1327-1551	2-4	305	0.36
	4-2	183	0.35
	2-4	427	0.37
1605-1721	13-9	457	0.67
1732-1813	9-19	457	0.55

7.4 Hydrocarbon Measurements

A number of grab samples of hydrocarbons were made during the aircraft sampling program. These samples were made using stainless steel, evacuated cylinders. Samples were later sent to Dr. Rei Rasmussen of Washington State University for hydrocarbon analysis. Light hydrocarbons (LHc), heavy hydrocarbons (HHc), total non-methane hydrocarbons (TNMHc) and methane concentrations were obtained in the analysis. A summary of the samples is shown in Table 7-5.

TNMHc observations at Carquinez Strait showed values of 52, 199, and 248 $\mu g/m^3$ with the small value occurring in the late afternoon while the two higher readings were made in the forenoon. Downwind of Montezuma Hills (Frank's Tract, Brentwood) lower values of TNMHc were observed (86 and 65 $\mu g/m^3$). At Stockton, TNMHc values of 122 and 124 $\mu g/m^3$ were found which may represent local increases due to sources in the vicinity. High values shown in the table for Vacaville and Rio Vista are not representative of the general area and are questionable. They may represent local sources or possible contamination.

Table 7-5

HYDROCARBON TOTALS - CALIFORNIA DELTA

(MEASURED BY AIRCRAFT)

Date/Time (PDT)	Sample No.	Location	Altitude (m MSL)	Methane (ppmC)	Total Hydrocarbons LHC ($\mu g/m^3$)	HHC ($\mu g/m^3$)	TNMHC ($\mu g/m^3$)
10 September							
≈ 1127	1	Vacaville	427	1.60	33.2	327.0	360.0
≈ 1202	2	Frank's Tract	≈400	1.52	15.5	37.6	53.0
≈ 1604	3	Carquinez Strait	305	1.54	13.1	39.6	52.0
13 September							
≈ 0825	1	Carquinez Strait	183	1.84	140.0	108.0	248.0
≈ 0945	2	Cordelia	183	MT	MT	MT	MT
≈ 1335	3	Near Brentwood	183	1.62	32.3	32.4	65.0
≈ 1528	4	Rio Vista	≈600	1.56	12.6	163.0	176.0
≈ 1838	5	Stockton Airport	≈760	1.52	14.3	108.0	122.0
14 September							
≈ 0905	1	Carquinez Strait	183	MT	MT	MT	MT
≈ 1050	2	Carquinez Strait	≈185	1.63	72.4	127.0	199.0
≈ 1430	3	Frank's Tract	183	1.59	28.9	57.0	86.0
≈ 1720	4	Livermore Airport	457	1.51	10.7	40.0	51.0
≈ 1740	5	Stockton Airport	457	1.54	15.9	108.0	124.0

LHC = Peaks one through four from the light hydrocarbon analysis (C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8)
HHC = Total from heavy hydrocarbon analysis ($\Sigma C_4 - C_{12}$)
TNMHC = LHC + HHC (total non-methane hydrocarbons)
MT Insufficient sample volume for analysis
ppmC Parts per million as methane = 0.0015 $\mu g/m^3$

8. Potential Impact of Emissions from Montezuma Hills Site

8.1 Introduction

The primary objective of the present study was to examine the impact of potential emissions from the Montezuma Hills site on ozone levels in the Central Valley. The tracer tests were conducted in late summer to simulate conditions when photolytic production of ozone might occur. Trajectories and diffusion conditions during the winter should be considerably different. In particular, easterly winds and low inversions might produce a significantly different concentration pattern in local areas than found during the test period. Since little detailed data were available from the site for the winter months, examination of potential impact of emissions from the site has been confined to the summer period where specific tracer data permitted a reasonable impact analysis.

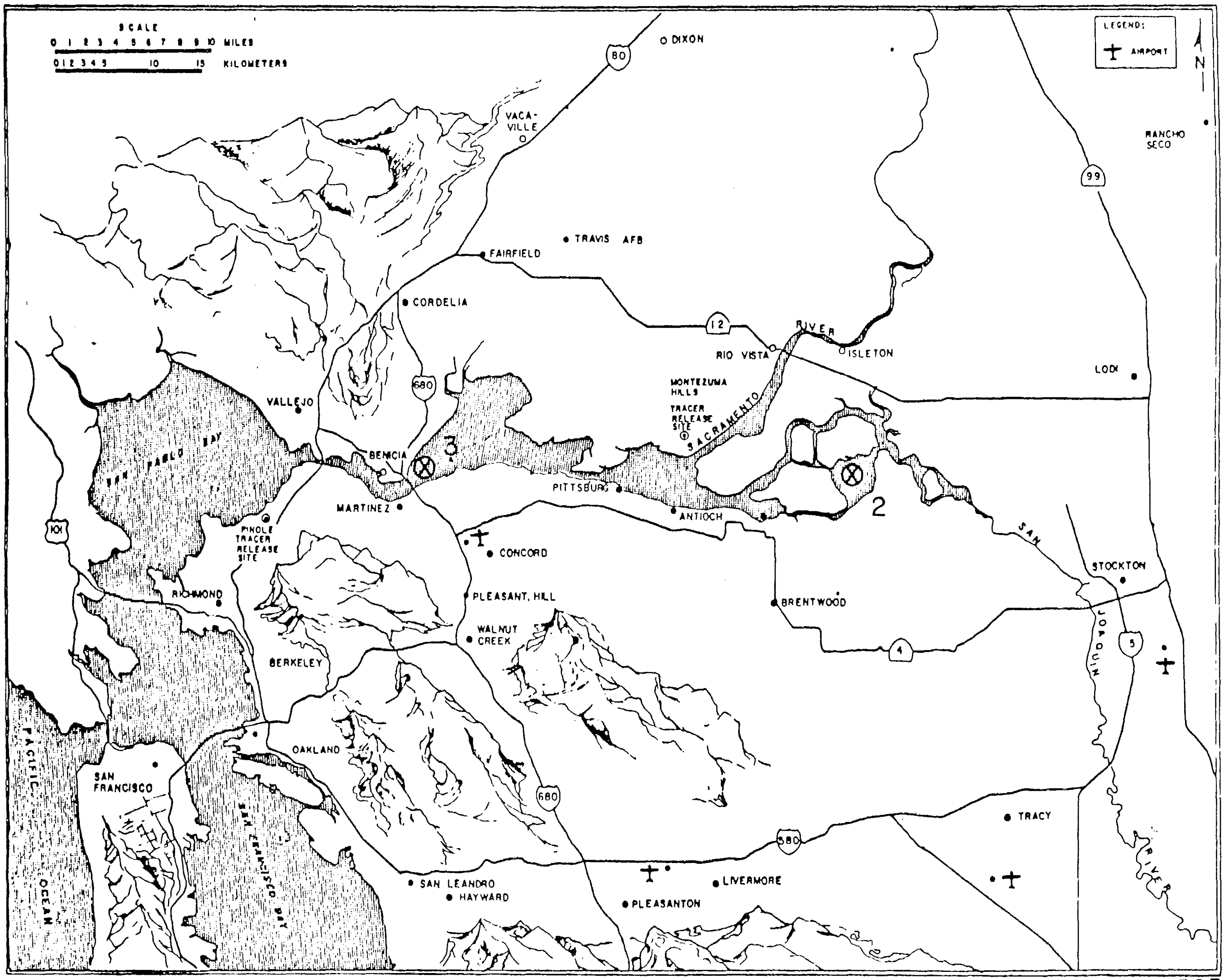
8.2 Ambient Pollutant Levels

Ambient pollutant levels of NO_x and NMHC measured by the aircraft on September 10, 13, and 14, 1976 are summarized in Table 8-1. Details of the aircraft data sampling and the NMHC concentrations are given in the Data Volume (1976)*. Locations of the samples given in Table 8-1 are shown in Figures 8-1 through 8-3.

Table 8-1a. shows the observed concentration data at the Carquinez Strait area. The limited data suggest a significant change in the NMHC concentrations between morning and afternoon. The morning values may be representative of the NMHC concentrations which develop over San Pablo Bay and thence move eastward. By the afternoon, the air containing these concentrations is replaced by much cleaner air representing the marine influence. Generally lower NMHC and NO_x concentrations are found in the Delta and Tracy-Stockton areas.

If the NMHC concentrations are considered to be in the form of olefins (C_4H_8), as suggested by Walker (1976), the morning concentrations in the Carquinez Strait amount to about 0.1 ppm while inland the NMHC concentrations are equivalent to 0.02 to 0.06 ppm.

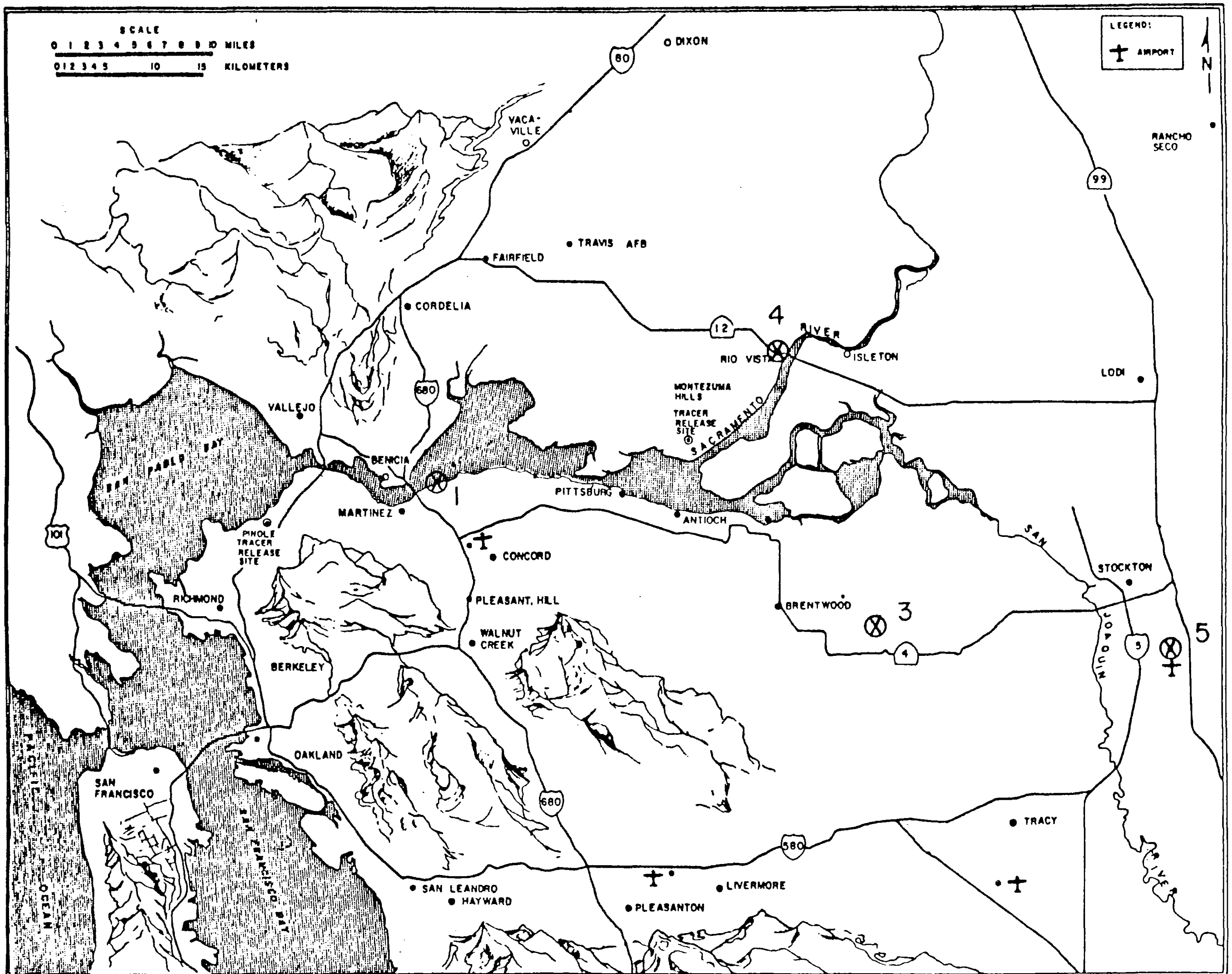
* Ogren, J. A., J. A. Anderson, J. A. Roebuck, and J. A. McDonald, 1976; Data Volume, Impact of Industrialization of the California Delta-Aircraft Sampling Program, MRI Rept. 76R-1461, ARB Contract No. A5-064-87.



77-597

Figure 8-1

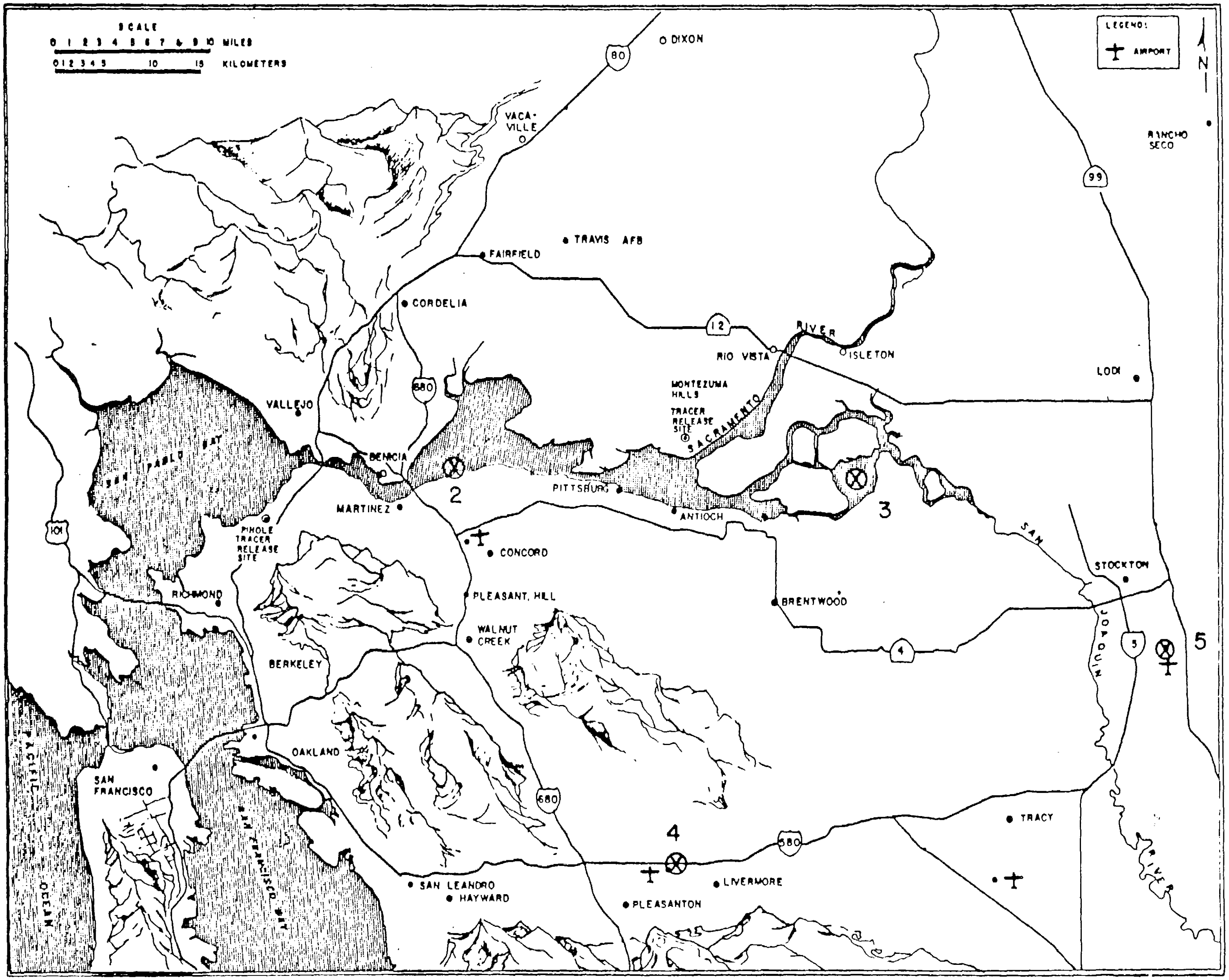
Locations of Hydrocarbon Samples (See Table 8-1)
September 10, 1976



77-598

Figure 8-2

Locations of Hydrocarbon Samples (See Table 8-1)
September 13, 1976



77-596

Figure 8-3

Locations of Hydrocarbon Samples (See Table 8-1)
September 14, 1976

Table 8-1

AMBIENT BACKGROUND LEVELS

a. Carquinez Strait Area

Date	Test No.	Sample No.	Time (PDT)	Altitude (m)	Total NMHC ($\mu g/m^3$)	Peak NO_x (ppm)	Altitude (m)
9/10/76	6	3	1604	305	52	0.03	305
9/13/76	7	1	0824	183	248	0.05	183
9/14/76	8	2	1045	190	199	0.03	240

b. Delta

Date	Test No.	Sample No.	Time (PDT)	Altitude (m)	Total NMHC ($\mu g/m^3$)	Peak NO_x (ppm)	Altitude (m)
9/10/76	6	2	1202	396	53	0.04	90
9/13/76	7	3	1334	183	65	0.01	183
	7	4	1527	594	176	0.01	layer
9/14/76	8	3	1430	183	86	0.02	183

c. Tracy-Stockton Area

Date	Test No.	Sample No.	Time (PDT)	Altitude (m)	Total NMHC ($\mu g/m^3$)	Peak NO_x (ppm)	Altitude (m)
9/13	7	5	1838	762	122	0.01	layer
9/14	8	4	1704	457	51	0.01	457
	8	5	1721	457	124	0.01	457

8.3 Potential Emissions from the Montezuma Hills Site

Potential emission values for the Montezuma Hills site have been given by Lamb and Shair (1977) for the proposed Dow site as:

Table 8-2

ESTIMATED MONTEZUMA HILLS SITE EMISSIONS

Pollutant	Emission Rate (Tons/Day)	Emission Rate (g/sec)
NO_x	9.41	98.8
SO_2	1.08	11.3
NMHC	1.52	16.0

* Considered as NO_2

Tests 1 and 3 appear to illustrate typical day and night releases from the site. From Figures 6-3 and 6-10 estimated maximum values of $\chi u/Q$ can be obtained as follows:

Table 8-3

TYPICAL DAY-NIGHT VALUES OF $\chi u/Q$

Test	$\chi u/Q$ at 7 km	$\chi u/Q$ at 45 km	Stability
1 (day)	4×10^{-6} m^{-2}	3×10^{-7} m^{-2}	C-D
3 (night)	5×10^{-5} m^{-2}	4×10^{-6} m^{-2}	F

Given the emission rates above and an average wind velocity, the estimated maximum values of the pollutants of 7 and 45 km downwind can be obtained.

Table 8-4

ESTIMATED CONCENTRATIONS AT 7 km

Test	$\overline{u}$ (m/s)	NO_x (NO_2) (ppm)	SO_2 (ppm)	NMHC (ppm)*
1 (day	5	0.042	0.003	0.005
3 (night)	9	0.292	0.024	0.040

* Calculated as C_4H_8

Table 8-5

ESTIMATED CONCENTRATIONS AT 45 km

Test	$\overline{u}$ (m/s)	NO_x (NO_2) (ppm)	SO_2 (ppm)	NMHC (ppm)*
1 (day	3	0.005	0.0004	0.0006
3 (night)	5	0.042	0.003	0.005

* Calculated as C_4H_8

8.4 Reactive Potential of Emissions

It is apparent in the previous section that the direct downwind impact of the potential emissions from the Dow site is minimal with the exception of the NO_2 exposure in the near downwind area, assuming rapid conversion of NO to NO_2. Comparison with the observed ambient background levels given in Table 8-1 indicates that significant contributions above the background levels would be primarily confined to the near-downwind portion of the nighttime case although the nighttime far-downwind concentrations of NO_2 were estimated to be about 0.04 ppm against a comparable background value. It is useful, therefore, to examine the potential reactive effect of these proposed emissions on the production of ozone.

Several authors (e.g., Pitts, 1977) have summarized the results of smog chamber studies by relating initial concentrations of NMHC (ppm C) and NO_x to the equilibrium chamber values of O_3 after a period of irradiation. Wenzel et al. (1976) plotted the results of morning NMHC concentrations (ppm C) versus subsequent oxidant readings for a number of locations and established an envelope curve which represented the maximum oxidant limit observed for a given initial value of NMHC.

Walker (1976) used the results of a measurement program carried out near St. Louis (White et al. 1977) and stoichiometric arguments to suggest that the maximum production of ozone would be two parts of ozone (by volume) per each part of NMHC (considered as C). These studies can be used to formulate various estimates of the contribution of the proposed Dow emissions to the downwind production of ozone.

If consideration is first given to background concentrations of NMHC, observed levels in the Carquinez Strait during the morning were about 0.1 ppm (measured as C_4H_8) or about 0.5 ppm (as C). Both Pitts (1977) and Wenzel et al. (1976) would lead to downwind estimates of 0.15 to 0.20 ppm ozone after several hours of irradiation, assuming no significant diffusion or removal effects. Walker (1976), on the other hand would predict a maximum possible ozone value of 0.5 to 1.0 ppm which would represent an inordinately large value.

Table 8-5 gives the peak hourly ozone concentrations at Montezuma Hills and Stockton during the various days of the test program. Peak values at Montezuma Hills on September 13 and 14 were 0.12 and 0.06 ppm, respectively, or slightly less than predicted by Pitts and Wenzel et al. but considerably less than the maximum value suggested by Walker. Observed concentrations at Montezuma Hills are, of course, partly influenced by dilution between the Carquinez Strait area and Montezuma Hills.

Ambient NMHC values in the Delta area (Table 8-1) show concentrations of 0.1 to 0.3 (referred to C). Again, peak values of ozone downwind at Stockton do not show concentrations as large as predicted by Walker (1976) but indicate values of 0.05 to 0.07 ppm which are in general agreement with the rate of ozone production between Carquinez Strait and the Montezuma Hills area. It is indicated from these comparisons, therefore, that Walker's estimates tend to give a maximum ozone value which, for various reasons, was not reached on September 10, 13, and 14. The estimates can be used, however, to give an upper bound on the impact of potential emissions as proposed for the Dow site.

Test 1 represents a typical daytime condition in which NMHC and NO_2 emitted near noon from the site might react, together with ambient concentrations, to generate ozone downwind in the late afternoon. Tables 8-4 and 8-5 indicate the maximum ozone impact due to Dow NMHC releases would be 0.01 ppm ozone at 7 km and 0.0012 ppm at 45 km, assuming Walker's stoichiometric estimates. The maximum ozone reaction could not, of course, be realized in as short a downwind distance as 7 km. These figures suggest that an increase in NMHC release rate of one order of magnitude (around 10 tons per day) would be required before a potential ozone increase of 0.01 ppm at Stockton could be expected.

Table 8-5

MAXIMUM HOURLY OZONE CONCENTRATIONS

Date		Montezuma Hills		Stockton	
		χ (ppm)	Time (PDT)	χ (ppm)	Time (PDT)
August	30	0.15	1400-1500	M	
	31	0.14	1400-1500	M	
September	1	0.12	1600-1700	M	
	2	0.10	1500-1700	0.13	1600-1700
	3	0.08	1500-1600	0.10	1400-1500, 1600-1700
	4	0.09	1400-1500	0.09	1600-1700
	5	0.08	1500-1600	0.10	1700-1800
	6	0.08	1500-1600	0.07	1600-1700, 1800-1900
	7	0.09	1500-1600	0.07	1400-1600
	8	0.09	2100-2200	0.07	1400-1700
	9	0.15	1600-1700	0.07	1400-1800
	10	0.08	1500-1600	0.05	1700-2100
	11	0.08	1600-1700	0.04	1800-2300
	12	0.12	1700-1900	0.08	2100-2200
	13	0.12	1300-1400	0.07	1800-2200
	14	0.06	1400-1500	0.06	1700-1800

M - Missing

Test 3 represents a typical nighttime condition in which NMHC and NO_2 would be released from the Montezuma Hills site during the early morning period and would reach the Stockton area in the early forenoon. Under these conditions emissions from the Dow site might be irradiated during the day and contribute to increased ozone levels near and downwind of the Stockton area. Peak NMHC concentrations near Stockton of 0.005 ppm could be expected in the early morning under these conditions. According to Walker, these NMHC concentrations form the potential of producing an additional 0.01 ppm ozone in the downwind area although the NMHC concentrations and the ozone levels would continue to dilute as the air parcels moved downwind. If further dilution over an irradiation period of 3-4 hours is included, a factor of 10 increase in NMHC emissions might also be required to produce a significant impact on ozone levels in the area near and downwind of Stockton.

The foregoing paragraphs have attempted to estimate the impact of NMHC emissions from the Montezuma Hills site on downwind ozone formation by incorporating upper limit bounds which are based on the relation between initial NMHC concentrations and subsequent ozone formation. On this basis, the impact of the proposed Dow emissions is considered to be minimal but a factor of 10 increase in emissions from the Montezuma Hills area might lead to the significant production of ozone in the Central Valley area.

9. Conclusions

1. During the summer months when the question of possible ozone formation downwind exists, winds at the Montezuma Hills site are predominantly (day and night) from a westerly direction with moderate velocities. These winds would consistently carry potential emissions from the site into the Central Valley area.

2. Trajectories of the tracer material (except Test 5) followed a nearly identical path for the first 10 km downwind. Thereafter, the trajectories varied with some paths continuing toward Lodi while others veered sharply southward toward Stockton and Tracy. Within - test variations in the far-downwind trajectories were observed in all tests.

3. There was evidence of early morning stagnation of the tracer cloud in the vicinity of Stockton during one of the tests (Test 3).

4. All releases from Pinole or Martinez showed that a portion of the tracer cloud moved southeasterly through Concord and into the Livermore Valley. The balance of the cloud continued eastward through the Montezuma Hills area.

5. When two tracers were released (Montezuma Hills and Pinole or Martinez) peak concentrations at about 7 km downwind of Montezuma Hills were in nearly the same location for the two tracers. This suggests that the release site at Montezuma Hills is nearly in the direct path of any material passing through the Carquinez Strait, traveling eastward.

6. Afternoon dispersion conditions were characterized by a C-D stability category at all downwind distances. Releases made between 2100 and 0400 PDT corresponded to a stability category between F and G with some indication of more rapid dilution far downwind. Releases made about 0600 PDT tended to show intermediate stability conditions. Several indications of more rapid dilution downwind than predicted by diffusion graphs were attributed to increased instability or to divergent flow.

7. Flux rates of ozone tend to increase substantially from the Carquinez Strait into the Delta area while NO_x fluxes appear to decrease somewhat due to dilution. The Carquinez Strait area was characterized by an ozone deficit during both cases of morning sampling. The generation of ozone in this air as it moves into and past the Montezuma Hills is clearly indicated.

8. NO/NO_x ratios tend to decrease as the pollutant mass moves eastward during the afternoon but significant amounts of NO were observed in the Delta area.

9. Hydrocarbon samples showed about 200 $\mu g/m^3$ of NMHC in the Carquinez Strait area during the morning hours. Values of less than 100 $\mu g/m^3$ were observed in the Delta area to the east and southeast of Montezuma Hills while slightly higher values were found near Stockton.

10. The primary impact of direct emissions from the Dow site would be in terms of NO_x (NO_2) at the near downwind distances. Nine tons per day of NO_x emissions would result in 0.29 ppm NO_2 at 7 km downwind if the NO was completely converted to NO_2 in that distance.

11. Two scenarios exist for production of ozone from potential emissions at the Montezuma Hills. The first of these is an early afternoon release of NMHC and NO_x with irradiation occurring along the 2-3 hour trip to the Stockton-Tracy vicinity. The second scenario would involve an early morning release with peak NMHC concentrations occurring about 0600-0800 PDT in the vicinity of Stockton-Tracy. These concentrations might then be irradiated as they traveled and diluted beyond Stockton into the Central Valley. By estimating upper bounds for the amounts of ozone which could be formed from given initial amounts of NMHC, it was estimated that around 10 tons per day of NMHC would have to be released from the Montezuma Hills site before a significant impact (≥ 0.01 ppm) on ozone in the Central Valley could be expected.

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