ALASKA LEGISLATURE COMMITTEE FILES 1985-1986 8672

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Eight-Hour Means and Medians -

Measures of central tendency such as means (arithmetic averages) and medians (the mid-point value of data ranked by magnitude) were examined to evaluate aspects of the chronic nature of concentrations reported at each site. As there is little significant difference between the mean and median for each site, only the mean will be referenced here. For each site, all eight-hour averages reported during the study were averaged to produce the mean eight-hour concentration. Figures 6, 7, and 8 exhibit eight-hour means and medians for each sampling site.

Group 1 Sites

(General Discussion)

A. Means for the Group 1 sites ranged from 2.0 ppm (site 20) to 14.5 ppm (site 24).

B. Means for sites 11/7th&C and 25/Spenard were 4.1 and 8.1 respectively.

(Study/Permanent Site Comparison)

C. Means for 16 Group 1 sites were 2% to 254% greater than that for site 11/7th&C (10 of which were more than 50% higher).

D. Means for 5 Group 1 sites were 6% to 79% greater than that for site 25/Spenard (3 of which were 27% to 79% higher).

E. Means for 4 Group 1 sites were greater than the standard while none of the permanent sites exhibited one.

F. Means for 8 Group 1 sites were within ± 30% of that for site 25/Spenard.

Frequency of Eight-Hour NAAQS Exceedances -

There was wide variability in the number of eight-hour NAAQS exceedances reported from sites in the study network. The statistic chosen for evaluation here is the simple frequency of exceedance values to all values for each site. Figures 6, 7, and 8 exhibit exceedance characteristics.

Group 1 Sites

(General Discussion)

A. The frequency of exceedances for the 14 Group 1 sites exhibiting exceedances ranged from 2% (site 5) to 84% (site 24).

B. The frequency of exceedances for site 11/7th&C and site 25/Spenard were 0% and 37% respectively.

(Study/Permanent Site Comparison)

C. The frequency of exceedances for 5 Group 1 sites were 30% to 111% higher than that for site 25/Spenard (3 of which were 30% to 228% higher).

D. The frequency of exceedances at 12 Group 1 sites were 70% or lower than that for site 25/Spenard (5 of which measured one or no exceedances).

Minimum Eight-Hour Averages -

Minimum values are of interest insofar as they assist in characterizing "background" types of concentrations. Figures 6, 7, and 8 exhibit the minimum eight-hour averages for each site.

Group 1 Sites

(General Discussion)

A. Minimum eight-hour averages for Group 1 sites ranged from 0.2 ppm (site 20) to 3.7 ppm (site 7).

B. Minimum eight-hour averages for site 11/7th&C and site 25/Spenard were 1.5 ppm and 2.3 ppm respectively.

C. Minimum eight-hour averages for 2 Group 1 sites in the CBD (sites 6 & 7) were at least 1.0 to 2.0 ppm higher than than any other Group 1 sites.

Ratios of Study to Permanent Sites

An intuitively appealing way of expressing the relationship between a pair of sites is computing a simple ratio of the sites' values for the same day. The relationship between each of the microscale sites and site 11/7th&C and site 25/Spenard are exhibited in Figures 9 and 10 respectively.

Group 1 Sites

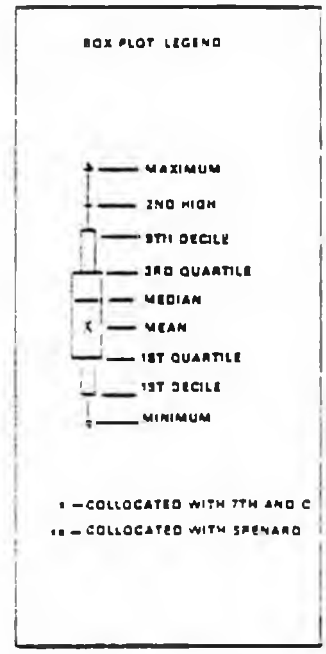
A. All but one Group 1 sites (site 20, the CBD "background" site had a mean ratio with site 11/7th&C greater than 1.0.

B. Seven of the 18 Group 1 sites had mean ratios with site 25/Spenard greater than or equal to 1.0.

FIGURE 9

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE OF DAILY 8-HOUR (11:00 A.M. TO 7:00 P.M.) RATIOS OF EACH STUDY SITE TO THE 7TH & C STUDY SITE



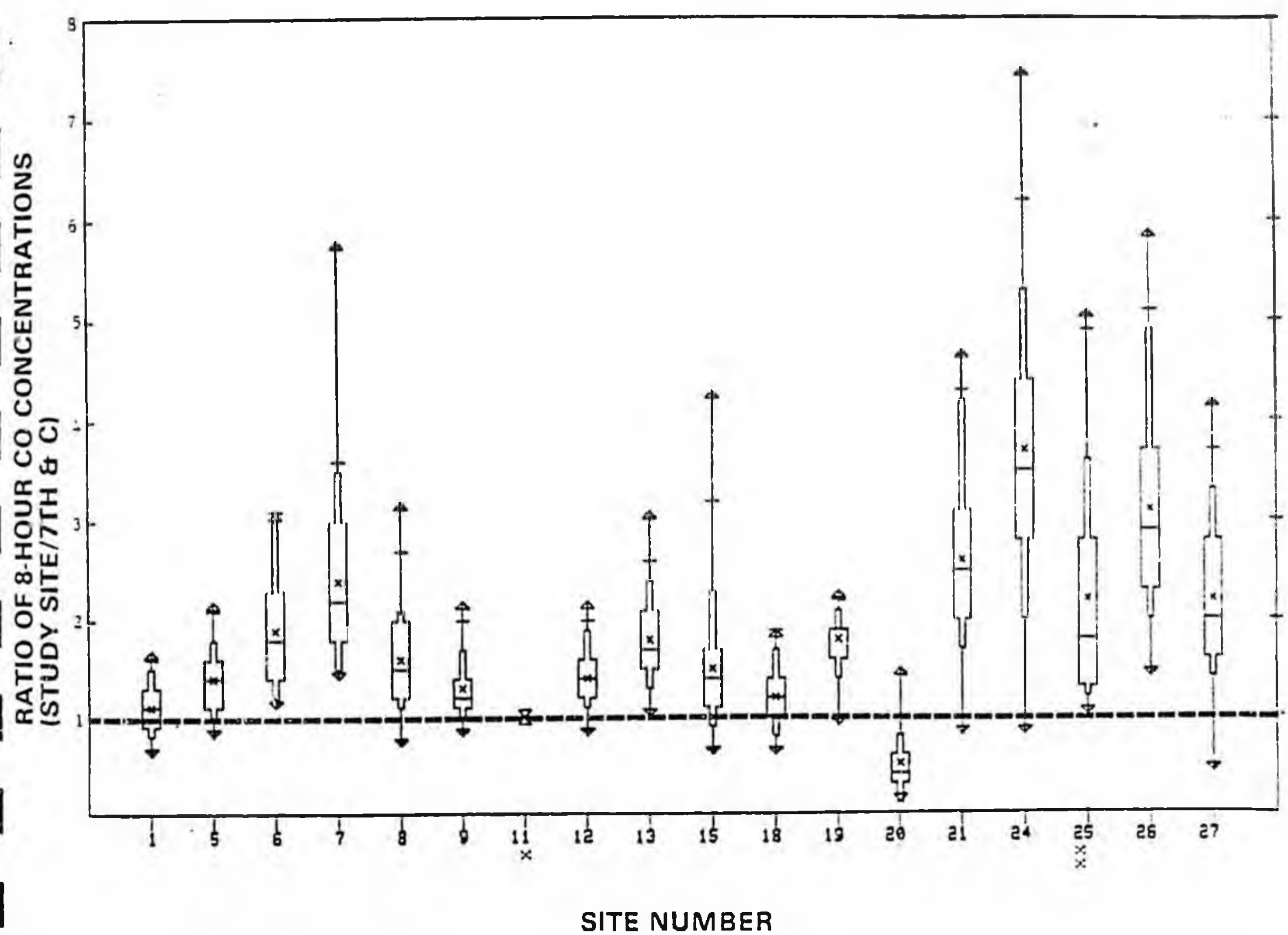
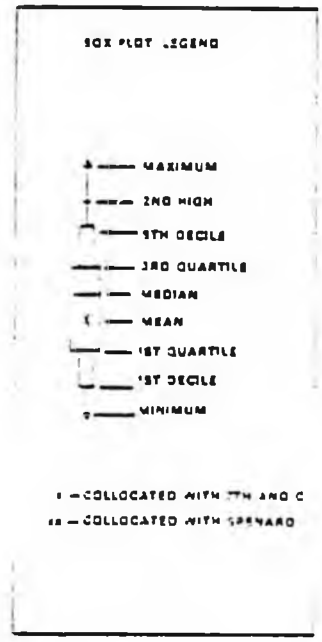
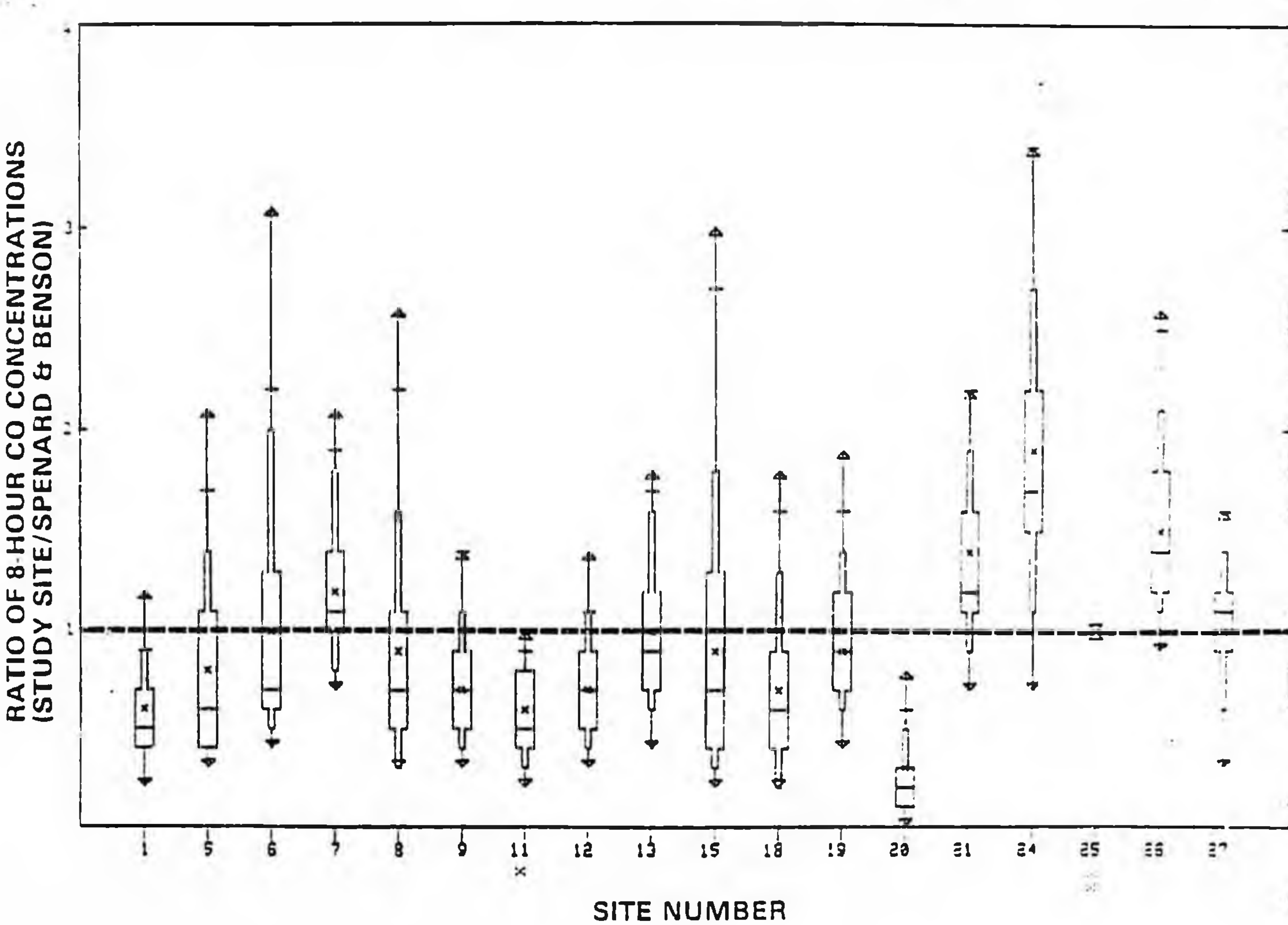


FIGURE 10

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE OF DAILY 8-HOUR (11:00 A.M. TO 7:00 P.M.) RATIOS OF EACH STUDY SITE TO THE SPENARD & BENSON STUDY SITE





Daily Network Characteristics

Another facet of the data analysis examined the day-to-day characteristics of the study data. This kind of analysis not only provides a profile of "simultaneous" impacts throughout the study area, but facilitates examining patterns of CO concentrations measured at the permanent sites and elsewhere in the study area. Figures 11 and 12 exhibit the daily composite of 8-hour concentrations reported from Group 1 study sites.

Daily Maximum Eight-Hour Averages -

The daily maximum value reported from among all sites in the study network illustrate the variable and chronic aspects of inter-site relationships on a day-specific basis. Table 9 exhibits the relationship of the daily study network maximum to corresponding site 11/7th&C and site 25/Spenard daily values.

Group 1 Sites

(General Discussion)

A. Daily maximum eight-hour averages for Group 1 sites ranged from 6.1 ppm (12/27) to 27.4 ppm (12/3), both measured at site 24.

B. The daily maximum eight-hour average was most frequently recorded at sites 24 and 26. Site 24 was the site of the daily maximum on 69% of the sample days (with 5 "ties"*), while site 26 recorded the daily maximum on 24% of the sample days (with 9 "ties").

C. The daily maximum eight-hour average was recorded at only four other Group 1 sites at an individual frequency of less than 7% of all sample days.

D. Site 11/7th&C and site 25/Spenard reported the daily maximum on 0% and 2% ("tied" with 3 other sites) respectively over all sample days.

* - Tied values are those within approximately ± 0.5 ppm of each other.

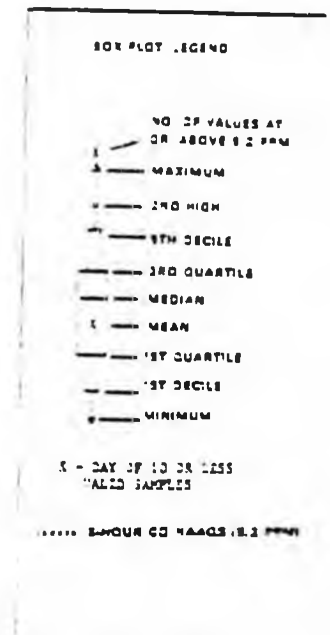
FIGURE 11

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE RANGE OF CO CONCENTRATIONS FOR ALL SITES DURING THE 8-HOUR PERIOD (11:00 A.M. TO 7:00 P.M.)

NOVEMBER & DECEMBER 1982

(GROUP 1 SITES ONLY)



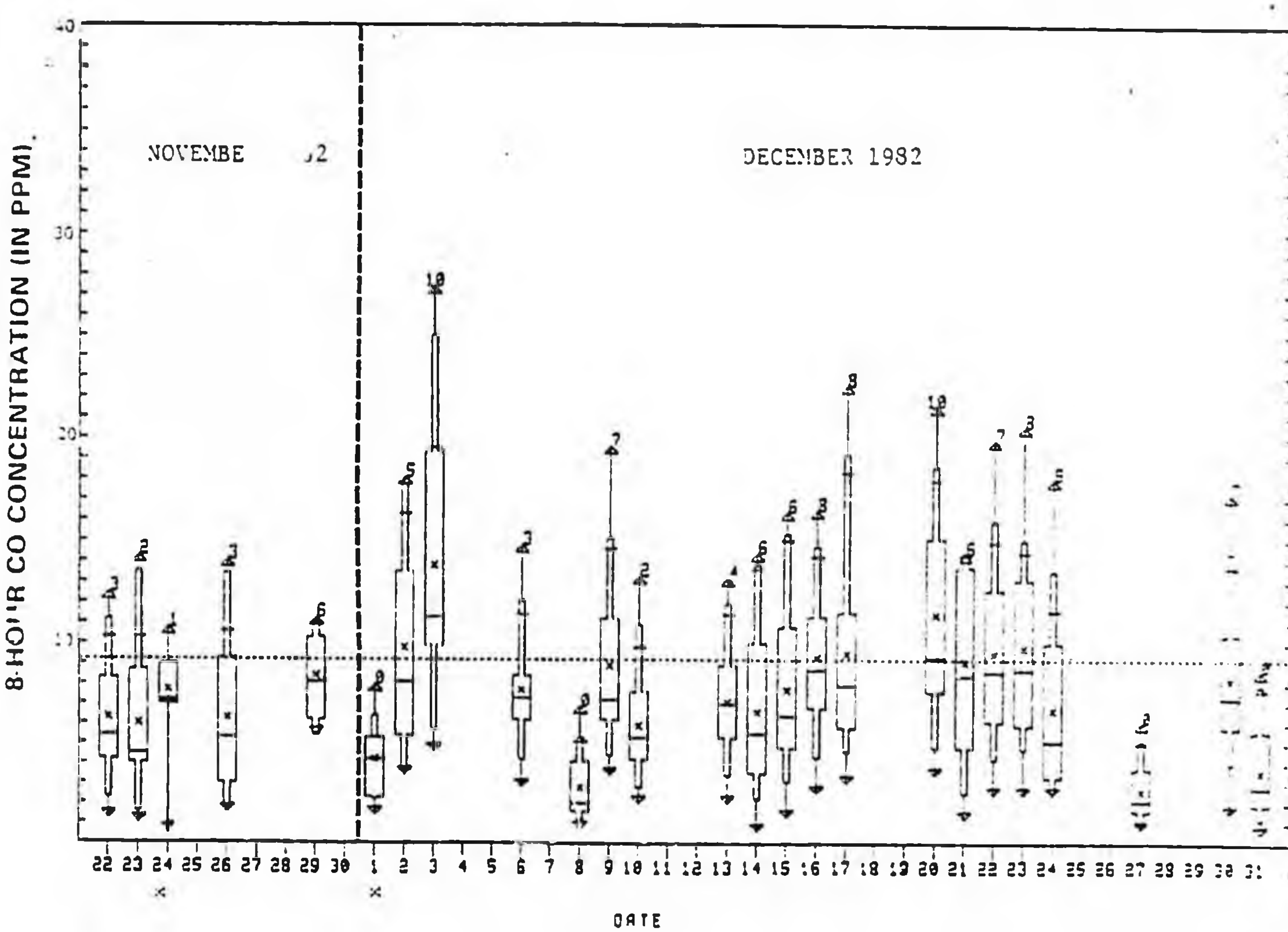


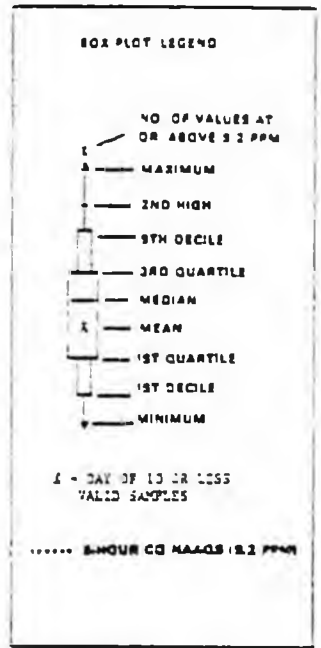
FIGURE 12

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
COMPOSITE RANGE OF CO CONCENTRATIONS FOR ALL SITES DURING THE 8-HOUR PERIOD
(11:00 A.M. TO 7:00 P.M.)

JANUARY & FEBRUARY 1983

(GROUP 1 SITES ONLY)



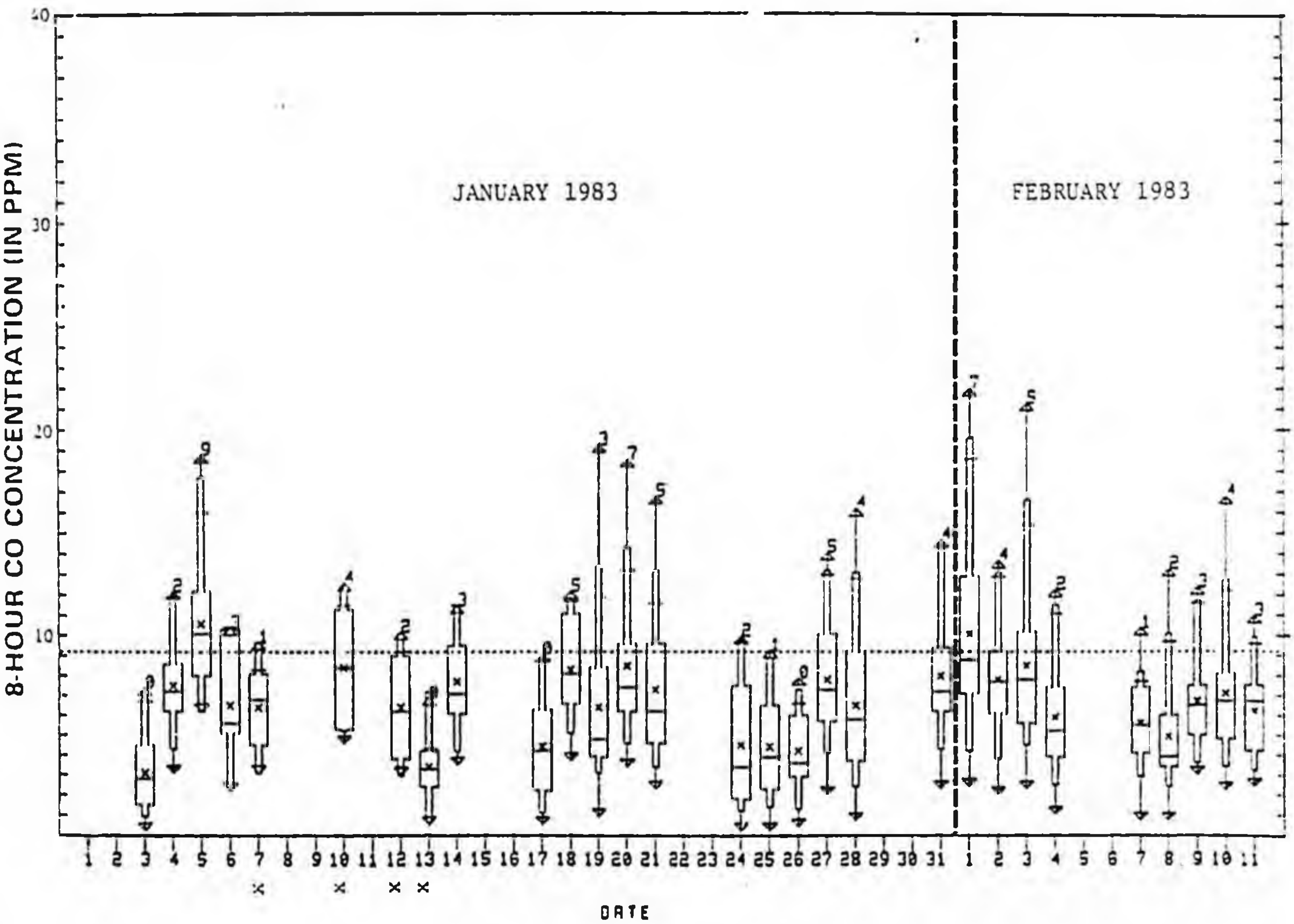


Table [illegible]

Daily Comparison of Study Network Maximum 8-Hour CO Concentration to Permanent Site Values

Site w/ Daily Max(*)	Date	Daily Maximum 8-HR CO Conc. (PPM)	Site 11/7th&[illegible] Corresponding 8-HR CO Conc. (PPM)	Ratio of Daily Maximum Site To Site 11/7th & [illegible]	Site 25/Spenard Corresponding 8-HR CO Conc. (PPM)	Ratio of Daily Max. Site To Site 25th/Spenard
24	11/22/82	12.5	3.1	4.0	6.8	1.9
24	11/23/82	14.3	-	-	7.5	[illegible]
7	11/24/82	10.5	-	-	-	-
24	11/26/82	14.1	2.7	5.2	7.5	1.9
24(26)	11/29/82	11.3	5.4	2.1	6.0	1.9
24	12/01/82	8.0	2.3	3.5	3.3	2.4
24	12/02/82	18.1	5.1	3.6	10.5	1.7
24	12/03/82	27.4	8.1	3.4	14.8	1.9
24	12/06/82	14.5	5.3	2.8	6.5	2.2
15	12/08/82	6.8	1.5	4.5	2.3	3.0
24	12/09/82	19.6	5.9	3.3	10.7	1.8
24	12/10/82	13.3	3.2	4.2	8.3	1.6
24	12/13/82	13.2	4.7	2.8	6.0	2.2
24	12/14/82	14.4	-	-	9.7	1.5
24	12/15/82	16.4	3.5	4.7	10.4	[illegible]
24	12/16/82	13.5	5.2	2.7	5.2	[illegible]
24	12/17/82	22.5	5.0	4.5	9.9	[illegible]
24	12/20/82	21.5	6.2	3.5	15.1	[illegible]
26(27)	12/21/82	14.4	3.9	3.7	12.4	[illegible]
24	12/22/82	19.9	4.6	4.3	11.8	[illegible]
24	12/23/82	20.5	5.0	4.1	12.3	[illegible]
24	12/24/82	18.0	2.4	7.5	10.4	1.7
15	12/27/82	6.1	1.9	3.2	2.3	2.7
24	12/30/82	17.3	5.1	2.8	7.3	2.4
7	12/31/82	8.7	1.5	5.8	7.7	[illegible]
26	1/03/83	7.4	1.7	4.4	4.9	1.5
26(21)	1/04/83	12.2	5.1	2.4	6.2	[illegible]
24	1/05/83	18.6	6.2	3.0	-	-
26(7)	1/06/83	10.4	-	-	[illegible]	[illegible]
24	1/07/83	9.7	3.3	[illegible]	[illegible]	[illegible]
24	1/10/83	12.5	-	-	[illegible]	[illegible]
26	1/12/83	10.2	-	-	5.4	[illegible]
25(34)	1/13/83	5.9	2.3	3.0	[illegible]	[illegible]
21(26)	1/14/83	11.5	-	-	8.3	[illegible]
21(24)	1/17/83	9.1	2.1	4.3	5.8	[illegible]
26(21)	1/18/83	12.2	5.4	2.3	6.8	[illegible]
24	1/19/83	19.3	3.7	5.2	9.9	[illegible]
24	1/20/83	18.6	5.8	3.2	9.5	[illegible]
24	1/21/83	16.8	3.9	4.3	10.9	[illegible]
24(26)	1/24/83	10.0	1.7	5.9	5.3	[illegible]
26(26)	1/25/83	9.8	1.9	5.2	[illegible]	[illegible]
39	1/26/83	9.3	-	-	[illegible]	[illegible]
26	1/27/83	14.1	4.8	2.9	13.0	[illegible]
24	1/28/83	13.2	2.6	5.2	9.6	[illegible]
24(26,39)	1/31/83	14.7	5.5	2.7	5.9	[illegible]
24	2/01/83	22.0	7.2	3.1	[illegible]	[illegible]
24	2/02/83	13.7	5.2	2.6	5.3	[illegible]
26	2/03/83	15.4	5.0	3.1	5.9	[illegible]
24	2/04/83	12.5	4.3	2.8	5.8	[illegible]
39	2/07/83	14.6	5.0	2.9	[illegible]	[illegible]
24	2/08/83	13.5	3.1	4.3	3.9	[illegible]
24	2/09/83	12.4	3.7	3.4	[illegible]	[illegible]
24	2/10/83	16.6	3.5	4.6	4.9	[illegible]
26(39)	2/11/83	11.3	3.4	3.2	4.3	2.5

* Tied ± 0.5 ppm

(Study/Permanent Site Comparison)

E. The daily maximum from one (or more) of the Group 1 sites exceeded the corresponding value from site 11/7th&C and site 25/Spenard on all but one sample day (1/13 when site 25/Spenard "tied" three other study sites at a value of 6.9 ppm).

F. The daily maximums, from one (or more) of the study sites was on average, 285% higher than the corresponding values at site 11/7th&C, ranging from 110% to 650% higher.

G. The daily maximum from one (or more) of the study sites was on average 195% higher than corresponding values at site 25/Spenard, ranging from 0% to 240% higher.

Frequency of Daily Eight-Hour Exceedances From the Network -

The number of eight-hour exceedances reported by the study network on a daily basis provides a measure of the spatial severity of the CO situation during identical periods.

Group 1 Sites

(General Discussion)

A. An exceedance of the standard was recorded at one or more Group 1 sites on 85% of all sample days.

B. An exceedance of the standard was reported at four or more Group 1 sites on 57% of all days sampled.

(Study/Permanent Site Comparison)

C. Site 11/7th&C did not report an exceedance on any day when one or more Group 1 sites did.

D. Site 25/Spenard did not report an exceedance on 56% of the days when one or more Group 1 sites did and on 36% of the days when four or more Group 1 sites did.

Distribution of Daily Eight-Hour Averages

Quartiles and deciles were derived to describe the distribution of values reported from the study network during a sample day.

Group 1 Sites

(Study/Permanent Site Comparison)

A. On a daily basis, site 25/Spenard was at or below the median (2nd quartile) of Group 1 sites on 28% of the days and at or below the 3rd quartile on 74% of the days for which corresponding data are available.

B. On a daily basis, site 11/7th&C was at or below the 1st quartile of all Group 1 sites on 87% of the days for which corresponding data are available.

Range of Daily Eight-Hour Averages

The range of values reported from the study network during a particular day can provide a valuable index of intra-network variability. In addition, it can grossly imply that portion of the daily maximum which may be attributable to "background" levels of CO. This information can be important insofar as the calculation of the design value incorporates a "background" component. For instance, a high "background" level might establish that less site-specific control is required to bring levels at an 'offending' site into compliance. The reverse is also the case for low "background" levels.

Group 1 Sites

A. The daily range of eight-hour averages ranged from 4.0 ppm(11/24) to 22.8 ppm (12/3).

B. The daily range of eight-hour averages averaged 11.9 ppm.

C. The daily range of eight-hour averages exceeded 18.0 ppm on seven or 13% of the sample days, and 20.0 ppm on one day.

D. On the 22 days when the daily range of eight-hour averages was less than 10.0 ppm, the daily maximum did not exceed 12.5 ppm.

Correlation and Regression Analysis

One way of mathematically expressing the relationship between data from two sites is by fitting a line that best minimizes the distance of all data points to that line. One such line is the linear regression line. Straight by definition, a simple equation describes the origin and rate of change or slope of this line. So, by knowing the value of what is called the "independent" variable, one can predict what could be described as the "average" value of the "dependant" variable.

This "average" value is typically subject to some error due to the fact that not all actual data points are situated precisely on the regression line. Therefore, statistics are needed to describe the variability associated with this prediction. One such statistic is the coefficient of correlation. When squared, it becomes the coefficient of determination which is the proportion of variation in the dependant variable explained by variation in the independent variable. The higher the value of this coefficient, the more variation is explained and the stronger the relationship is between two data sets.

A particularly nettlesome problem with the traditional regression line is that it assigns all the variability due to sampling error to the dependant variable ignoring similar errors introduced by the independent variable. Since this would not accurately reflect the realities of errors in study sampling, a variation of this approach called two-way regression has been devised by statisticians to distribute this error term symmetrically to both variables. The regression parameters for Group 1 sites, including both one-way and two-way regression lines are presented in Table 10 (it should be noted that one cannot actually "solve" for 'x' in the one-way line). It should be noted that all references to regression parameters such as slope and intercept reflect the two-way line.

Typically, the greater the number of cases one can inspect relative to a particular phenomenon, the greater the confidence one has in 'understanding' it. This is exhibited in regression/correlation statistics where the confidence interval about some statistic (correlation coefficient for instance) shrinks, or confidence increases as more cases are considered. For reference in conjunction with the regression/coefficient tables, Table 11 has been prepared to illustrate the effect the number of cases has on confidence limits about various 'r' values.

Two basic kinds of correlation/regression analyses were performed on the data. The first type of analysis compared data for a particular interval that were paired by date to examine relative levels of CO experienced concurrently at a pair of sites. The second analytical approach used data sets ranked by magnitude and paired by rank. This second approach recognizes the effects of especially meteorology on the temporal variability of CO levels between sites, in particular microscale sites, by not 'requiring' any pair of sites to 'perform' in some characteristic fashion simultaneously (as the first approach does). This typically lends itself to examining larger (seasonal) patterns and frequencies of CO levels throughout some study area.

Date-Paired Correlation/Regression

Group 1 Sites

A. All eighteen sites had coefficients of correlation greater than or equal to 0.80 with at least one other site, ranging from one site (site 25) to twelve sites (site 12).

B. Sixteen sites had coefficients of correlation greater than or equal to 0.85 with at least one other site, ranging from one site (sites 15 and 25) to six sites (sites 12 and 27).

C. Nine sites had coefficients of correlation greater than or equal to 0.90 with at least one other site, ranging from one site (sites 1,8,9, and 18) to three sites (sites 12 and 19).

Rank-Paired Correlation/Regression

Each Group 1 site correlated with all other Group 1 sites at 0.93 or better.

TABLE 13 CORRELATION/REGRESSION RESULTS FOR GROUP 1 SITES

INDEX SITE	REF. SITE	STD DEVIATION	CORRELATION	NO. OF PAIRS	1-WAY REGRESSION EQ.	2-WAY REGRESSION EQ.
1	6	0.850	0.738	34.0	Y = 1.471X + -2.277	Y = 1.344X + -0.611
1	9	0.977	0.159	38.0	Y = 2.209X + -1.359	Y = 1.104X + 2.401
1	7	0.755	0.579	33.0	Y = 2.089X + -1.924	Y = 1.594X + 2.271
1	4	0.744	0.620	38.0	Y = 2.007X + -4.555	Y = 1.214X + -0.841
1	4	0.815	0.584	40.0	Y = 1.545X + -1.347	Y = 1.168X + 2.234
1	11	0.792	0.612	40.0	Y = 1.293X + -1.149	Y = 0.957X + [illegible]
1	12	0.889	0.409	40.0	Y = 1.775X + -1.901	Y = 1.513X + -0.818
1	13	0.826	0.683	42.0	Y = 2.266X + -2.425	Y = 1.658X + 3.150
1	15	0.605	[illegible]	34.0	Y = 1.430X + -4.133	Y = 1.409X + 0.176
1	18	0.803	[illegible]	41.0	Y = 2.083X + -3.570	Y = 1.470X + -1.009
1	19	0.835	0.697	35.0	Y = 2.490X + -3.317	Y = 1.432X + -0.591
1	20	0.793	0.629	43.0	Y = 1.019X + -2.325	Y = 3.419X + -1.500
1	21	1.417	0.807	41.0	Y = 3.103X + -1.082	Y = 2.164X + 0.712
1	24	1.149	0.632	35.0	Y = 5.315X + -7.977	Y = 3.426X + 0.029
1	25	0.810	0.372	41.0	Y = 3.838X + -7.993	Y = 1.570X + 1.383
1	26	0.750	0.562	40.0	Y = 3.837X + -4.338	Y = 2.259X + 2.217
1	27	0.817	0.668	39.0	Y = 3.460X + -5.709	Y = 2.398X + -1.553
5	3	0.794	0.630	39.0	Y = 0.931X + 1.851	Y = 0.750X + 2.811
5	7	0.888	0.471	36.0	Y = 1.421X + 1.418	Y = 0.875X + 4.367
5	4	0.932	0.888	39.0	Y = 1.361X + -1.257	Y = 1.242X + -0.591
5	9	1.002	0.841	39.0	Y = 0.818X + 0.582	Y = 0.662X + 1.328
5	11	0.792	0.628	38.0	Y = 0.687X + 0.300	Y = 0.547X + 0.851
5	12	0.818	0.702	40.0	Y = 0.472X + 0.148	Y = 0.818X + 3.481
5	13	0.783	0.613	43.0	Y = 1.165X + 0.551	Y = 0.841X + 2.111
5	15	0.802	0.644	38.0	Y = 1.372X + -1.822	Y = 1.018X + 0.012
5	16	0.935	0.875	42.0	Y = 1.113X + -1.080	Y = 1.015X + -0.827
5	18	0.755	0.588	34.0	Y = 1.495X + -1.083	Y = 1.049X + 1.395
5	20	0.832	0.893	42.0	Y = 0.571X + -1.134	Y = 0.514X + -0.450
5	21	0.725	0.525	41.0	Y = 1.720X + 0.376	Y = 1.381X + 3.888
5	24	0.814	0.379	37.0	Y = 3.769X + -6.152	Y = 1.544X + 5.883
5	25	0.340	0.115	38.0	Y = 3.044X + -4.494	Y = 0.530X + 4.442
5	26	1.576	0.332	41.0	Y = 2.463X + -1.754	Y = 1.012X + 5.830
5	27	0.880	0.463	38.0	Y = 2.111X + -3.074	Y = 1.154X + 1.491
6	3	0.378	0.143	38.0	Y = 1.835X + -3.421	Y = 0.181X + 5.314
6	4	0.818	0.792	37.0	Y = 1.367X + -3.103	Y = 1.091X + -1.113
6	9	0.796	0.634	39.0	Y = 0.817X + -0.091	Y = 0.614X + 3.279
6	11	0.714	0.554	40.0	Y = 0.718X + -0.951	Y = 0.540X + 1.912
6	12	0.833	0.401	41.0	Y = 1.148X + -2.381	Y = 0.691X + 1.785
6	13	0.591	0.351	41.0	Y = 1.502X + -3.508	Y = 0.758X + 1.824
6	15	0.782	0.611	35.0	Y = 1.343X + -3.628	Y = 0.896X + -1.110
6	18	0.777	0.604	40.0	Y = 1.253X + -1.620	Y = 0.475X + -1.123
6	19	1.504	0.341	34.0	Y = 1.611X + -5.364	Y = 0.518X + 1.318
6	20	0.815	0.403	43.0	Y = 0.515X + -1.508	Y = 0.604X + -0.280
6	21	0.508	0.254	11.0	Y = 2.701X + -4.010	Y = 1.693X + [illegible]
6	23	0.185	0.131	38.0	Y = 7.077X + -34.187	Y = 1.310X + 7.381
6	25	1.002	0.004	41.0	Y = 175.730X + ********	Y = [illegible] + [illegible]
6	26	0.154	0.129	42.0	Y = 3.588X + -11.388	Y = 0.828X + 1.221
6	27	0.188	0.119	39.0	Y = 3.460X + -14.590	Y = 0.711X + 1.765
[illegible]	4	0.897	0.247	39.0	Y = 0.824X + -1.313	Y = 0.451X + 2.147
[illegible]	9	0.513	0.269	34.0	Y = 0.481X + 0.547	Y = 0.347X + 1.783
[illegible]	11	0.653	0.333	38.0	Y = 0.527X + -0.882	Y = 0.125X + 0.281
[illegible]	12	0.270	0.756	35.0	Y = 0.763X + -1.380	Y = 0.847X + -0.676
[illegible]	13	0.815	0.715	38.0	Y = 1.018X + -2.207	Y = 0.457X + -0.115
[illegible]	15	0.330	0.152	33.0	Y = 1.075X + -1.319	Y = 0.401X + 2.151
[illegible]	16	0.650	0.473	37.0	Y = 0.939X + -1.388	Y = 0.521X + -0.888
[illegible]	18	0.797	0.835	29.0	Y = 1.225X + -3.767	Y = 0.917X + -1.113
[illegible]	20	0.149	0.239	39.0	Y = 0.253X + -0.387	Y = 0.219X + [illegible]
[illegible]	21	0.833	0.694	38.0	Y = 1.484X + -3.145	Y = 1.147X + -0.242
[illegible]	23	1.814	0.862	35.0	Y = 2.579X + -4.741	Y = 1.318X + -1.811
[illegible]	25	0.747	0.620	35.0	Y = 1.122X + -3.763	Y = 0.982X + -0.881
[illegible]	26	0.751	0.567	39.0	Y = 1.889X + -1.771	Y = 1.128X + 1.851
[illegible]	27	0.881	0.776	37.0	Y = 1.558X + -5.615	Y = 1.301X + -1.279
[illegible]	4	0.715	0.554	38.0	Y = 0.580X + 1.118	Y = [illegible] + [illegible]
[illegible]	11	0.745	0.526	38.0	Y = 0.508X + 0.438	Y = 0.415X + 2.244
[illegible]	12	0.707	0.400	40.0	Y = 0.597X + 1.219	Y = 0.548X + 2.148
[illegible]	13	0.881	0.363	41.0	Y = 0.917X + 1.417	Y = 0.611X + 3.131
[illegible]	15	0.881	0.774	38.0	Y = 1.320X + -0.403	Y = 0.494X + 1.581
[illegible]	16	0.885	0.749	40.0	Y = 0.799X + 0.123	Y = 0.713X + 0.588
[illegible]	18	0.652	0.126	34.0	Y = 1.113X + 0.283	Y = 0.760X + 2.294
[illegible]	20	0.929	0.845	42.0	Y = 0.821X + -0.885	Y = 0.795X + -0.814
[illegible]	21	0.820	0.385	40.0	Y = 1.417X + 1.882	Y = 1.772X + 5.883
[illegible]	23	0.351	0.205	38.0	Y = 4.051X + -10.388	Y = 0.388X + 4.815
[illegible]	25	0.259	0.085	38.0	Y = 2.280X + -5.588	Y = 0.318X + [illegible]
[illegible]	26	0.129	0.184	39.0	Y = 2.218X + -1.888	Y = [illegible] + [illegible]
[illegible]	27	0.371	0.223	38.0	Y = 1.840X + -1.011	Y = 0.518X + 4.882
[illegible]	11	0.417	0.891	40.0	Y = 0.882X + -0.330	Y = 0.401X + -0.118
[illegible]	12	0.827	0.881	41.0	Y = 1.276X + -0.850	Y = 1.711X + [illegible]
[illegible]	13	0.719	0.511	42.0	Y = 1.684X + -1.341	Y = 1.119X + 1.888
[illegible]	15	1.577	0.333	35.0	Y = 1.924X + -3.732	Y = 0.867X + 1.853
[illegible]	16	0.441	0.708	42.0	Y = 1.385X + -1.379	Y = 1.109X + -0.588
[illegible]	18	0.471	0.759	35.0	Y = 1.750X + -1.892	Y = 0.127X + -0.588
[illegible]	20	0.880	0.802	43.0	Y = 0.841X + -1.872	Y = 1.500X + [illegible]
[illegible]	21	0.700	0.590	40.0	Y = 2.374X + -2.379	Y = 1.127X + [illegible]
[illegible]	24	0.588	0.387	37.0	Y = 4.870X + -10.178	Y = 0.410X + 5.176
[illegible]	25	0.809	0.167	42.0	Y = 3.517X + -4.491	Y = 0.754X + 1.788
[illegible]	26	0.981	0.437	42.0	Y = 3.053X + -1.411	Y = 0.548X + 1.435
[illegible]	27	0.518	0.303	39.0	Y = 3.357X + -4.102	Y = [illegible] + [illegible]

(TABLE 10 CONT.)

IND. SITE	DEP. SITE	CORRELATION	CORRELATION	NO. OF PAIRS	2-WAY REGRESSION EQ.			1-WAY REGRESSION EQ.		
11	12	[illegible]	0.743	40.0	Y =	1.472X +	-1.141	Y =	1.211X +	[illegible]
11	13	0.306	0.449	44.0	Y =	1.770X +	[illegible]	Y =	1.254X +	2.307
11	15	0.609	0.416	37.0	Y =	1.953X +	-2.111	Y =	1.051X +	1.612
11	16	0.449	0.719	42.0	Y =	1.557X +	-1.272	Y =	1.217X +	0.055
11	19	0.920	0.847	35.0	Y =	1.349X +	-0.294	Y =	1.712X +	0.186
11	20	0.702	0.493	43.0	Y =	0.705X +	-0.419	Y =	2.543X +	-0.251
11	21	0.738	0.545	43.0	Y =	2.869X +	-1.973	Y =	1.542X +	1.614
11	23	0.701	0.192	38.0	Y =	4.587X +	-4.848	Y =	2.151X +	4.883
11	25	0.457	0.200	41.0	Y =	1.545X +	-6.436	Y =	0.881X +	4.441
11	26	0.749	0.561	42.0	Y =	2.961X +	-0.278	Y =	1.751X +	4.445
11	27	0.721	0.523	42.0	Y =	2.910X +	-1.265	Y =	1.656X +	1.953
12	13	0.911	0.829	44.0	Y =	1.227X +	0.203	Y =	1.097X +	0.919
12	15	0.597	0.356	37.0	Y =	1.654X +	-1.207	Y =	0.412X +	1.112
12	16	0.835	0.697	43.0	Y =	1.228X +	-1.623	Y =	0.901X +	-0.322
12	19	0.935	0.875	35.0	Y =	1.324X +	-0.131	Y =	1.216X +	0.444
12	20	0.708	0.501	44.0	Y =	0.522X +	-0.950	Y =	0.440X +	-0.436
12	21	0.860	0.740	42.0	Y =	1.763X +	0.233	Y =	1.410X +	2.226
12	23	0.802	0.644	37.0	Y =	3.101X +	-2.915	Y =	2.095X +	2.766
12	25	0.627	0.393	41.0	Y =	1.990X +	-2.590	Y =	0.970X +	2.673
12	26	0.823	0.677	42.0	Y =	1.961X +	0.626	Y =	1.449X +	3.475
12	27	0.835	0.697	40.0	Y =	2.049X +	-2.616	Y =	1.541X +	-0.026
13	15	0.630	0.396	39.0	Y =	1.142X +	-2.231	Y =	0.645X +	1.065
13	16	0.777	0.604	47.0	Y =	1.080X +	-2.339	Y =	0.825X +	-0.558
13	19	0.809	0.626	36.0	Y =	1.165X +	-1.103	Y =	1.044X +	-0.232
13	20	0.615	0.379	45.0	Y =	0.378X +	-0.747	Y =	0.320X +	-0.335
13	21	0.807	0.652	45.0	Y =	1.534X +	-0.911	Y =	1.114X +	1.949
13	23	0.831	0.695	41.0	Y =	2.595X +	-1.119	Y =	1.992X +	3.874
13	25	0.649	0.120	47.0	Y =	1.436X +	-2.354	Y =	0.422X +	2.393
13	26	0.803	0.645	46.0	Y =	1.666X +	-0.433	Y =	1.210X +	2.424
13	27	0.850	0.723	44.0	Y =	1.609X +	-2.993	Y =	1.290X +	-0.637
15	16	0.765	0.585	38.0	Y =	0.846X +	0.200	Y =	0.673X +	1.211
15	19	0.511	0.261	30.0	Y =	1.307X +	-0.651	Y =	0.587X +	1.559
15	20	0.743	0.552	38.0	Y =	0.346X +	-0.141	Y =	0.320X +	3.011
15	21	0.551	0.304	38.0	Y =	1.565X +	0.613	Y =	0.710X +	5.344
15	23	0.380	0.145	32.0	Y =	4.669X +	-14.074	Y =	0.645X +	9.627
15	25	0.088	0.008	36.0	Y =	4.187X +	-16.794	Y =	0.104X +	7.447
15	26	0.401	0.161	37.0	Y =	2.279X +	-1.502	Y =	0.575X +	8.444
15	27	0.491	0.241	36.0	Y =	1.980X +	-2.992	Y =	0.703X +	4.474
16	19	0.777	0.603	36.0	Y =	1.271X +	0.206	Y =	0.936X +	2.341
16	20	0.475	0.941	45.0	Y =	0.594X +	-0.549	Y =	0.467X +	-0.376
16	21	0.671	0.458	43.0	Y =	1.612X +	1.680	Y =	0.736X +	5.215
16	23	0.613	0.401	41.0	Y =	3.262X +	-1.309	Y =	1.158X +	7.206
16	25	0.262	0.068	42.0	Y =	2.807X +	-5.108	Y =	0.359X +	5.080
16	26	0.612	0.374	45.0	Y =	2.152X +	1.236	Y =	0.972X +	6.611
16	27	0.637	0.419	43.0	Y =	2.023X +	-1.443	Y =	1.042X +	3.272
19	20	0.650	0.436	38.0	Y =	0.339X +	-0.394	Y =	0.302X +	-0.133
19	21	0.827	0.687	37.0	Y =	1.232X +	1.304	Y =	0.988X +	3.033
19	23	0.821	0.674	30.0	Y =	2.087X +	-0.292	Y =	1.526X +	1.429
19	25	0.671	0.451	37.0	Y =	1.224X +	-0.647	Y =	0.769X +	2.530
19	26	0.842	0.709	34.0	Y =	1.397X +	1.363	Y =	1.114X +	1.968
19	27	0.809	0.655	35.0	Y =	1.303X +	-1.038	Y =	1.003X +	1.195
20	21	0.676	0.458	44.0	Y =	1.667X +	2.488	Y =	1.407X +	6.898
20	23	0.600	0.360	40.0	Y =	6.814X +	1.080	Y =	2.519X +	9.259
20	25	0.353	0.132	44.0	Y =	6.063X +	-4.557	Y =	0.991X +	6.152
20	26	0.524	0.274	45.0	Y =	5.588X +	0.964	Y =	1.651X +	4.629
20	27	0.606	0.367	43.0	Y =	5.093X +	-1.366	Y =	1.942X +	4.688
21	23	0.822	0.675	38.0	Y =	1.649X +	-1.991	Y =	1.216X +	2.162
21	25	0.766	0.587	42.0	Y =	0.974X +	-1.410	Y =	0.751X +	1.425
21	26	0.865	0.738	43.0	Y =	1.160X +	0.543	Y =	1.114X +	2.233
21	27	0.881	0.776	43.0	Y =	1.104X +	-2.623	Y =	0.961X +	-1.131
23	25	0.773	0.597	37.0	Y =	0.513X +	0.612	Y =	0.455X +	1.511
23	26	0.891	0.795	41.0	Y =	0.678X +	1.822	Y =	0.624X +	4.525
23	27	0.890	0.793	39.0	Y =	0.548X +	-0.800	Y =	0.604X +	-1.146
25	26	0.765	0.614	43.0	Y =	1.177X +	2.209	Y =	0.893X +	4.523
25	27	0.853	0.728	42.0	Y =	1.109X +	-0.602	Y =	0.332X +	[illegible]
26	27	0.852	0.726	44.0	Y =	0.971X +	-2.761	Y =	0.411X +	-1.127

Table 11 95% Confidence Limits About 'r' as a Function of 'n'

r \ n	10	20	30	40	50	60	70	80	90	100
0.10	0.10 .69/-.57	0.10 .52/-.36	0.10 .44/-.27	0.10 .40/-.22	0.10 .37/-.18	0.10 .35/-.16	0.10 .33/-.14	0.10 .31/-.12	0.10 .30/-.11	0.10 .29/-.10
0.20	0.20 .74/-.49	0.20 .59/-.27	0.20 .52/-.17	0.20 .48/-.12	0.20 .45/-.08	0.20 .43/-.06	0.20 .42/-.04	0.20 .40/-.02	0.20 .39/-.01	0.20 .38/0.00
0.30	0.30 .75/-.41	0.30 .66/-.16	0.30 .60/-.07	0.30 .56/-.01	0.30 .53/0.02	0.30 .51/0.05	0.30 .50/0.07	0.30 .49/0.09	0.30 .48/0.10	0.30 .47/0.11
0.40	0.40 .82/-.31	0.40 .72/-.05	0.40 .66/0.05	0.40 .63/0.10	0.40 .61/0.14	0.40 .59/0.16	0.40 .59/0.19	0.40 .57/0.20	0.40 .56/0.21	0.40 .56/0.22
0.50	0.50 .86/-.19	0.50 .77/0.07	0.50 .73/0.17	0.50 .70/0.22	0.50 .68/0.26	0.50 .67/0.28	0.50 .66/0.30	0.50 .65/0.31	0.50 .64/0.33	0.50 .63/0.34
0.60	0.60 .89/-.09	0.60 .82/0.21	0.60 .79/0.31	0.60 .77/0.35	0.60 .75/0.39	0.60 .74/0.41	0.60 .73/0.42	0.60 .72/0.44	0.60 .72/0.45	0.60 .71/0.46
0.70	0.70 .92/0.13	0.70 .87/0.37	0.70 .85/0.45	0.70 .83/0.50	0.70 .82/0.52	0.70 .81/0.54	0.70 .80/0.56	0.70 .80/0.57	0.70 .79/0.58	0.70 .79/0.59
0.80	0.80 .95/0.34	0.80 .92/0.55	0.80 .90/0.62	0.80 .89/0.65	0.80 .88/0.67	0.80 .88/0.69	0.80 .87/0.70	0.80 .87/0.70	0.80 .86/0.71	0.80 .86/0.72
0.90	0.90 .98/0.62	0.90 .96/0.76	0.90 .95/0.80	0.90 .95/0.82	0.90 .94/0.83	0.90 .94/0.84	0.90 .94/0.84	0.90 .93/0.85	0.90 .93/0.85	0.90 .93/0.85

Comparison of CBD and Corridor Sites

Both the magnitude of CO levels and the frequency of NAAQS exceedances recorded at most Corridor sites were consistently and markedly higher than those recorded at most of the CBD sites.

Group 1 Sites

A. Maximum eight-hour averages for CBD sites ranged from 6.2 ppm (sites 1 and 20) to 15.1 ppm (site 7), while those for the Corridor sites ranged from 15.1 ppm (site 25/Spenard) to 27.4 (site 24).

B. The second highest eight-hour averages for CBD sites ranged from 4.6 ppm (site 20) to 13.7 ppm (site 7), while those for the Corridor sites ranged from 13.1 ppm (site 25/Spenard) to 22.6 ppm (site 24).

C. The frequency of NAAQS exceedances for CBD sites ranged from 0% (sites 1, 9, 11, and 20) to 51% (site 7), while those for Corridor sites ranged from 37% (site 25) to 84% (site 24).

D. The means and ranges (minimum to maximum) of values at all Corridor sites were markedly greater than those for all CBD sites, except that CBD site 7's mean was greater than two of the five Corridor sites (sites 25 and 27).

E. Site 1 had a coefficient of correlation greater than or equal to 0.75 with fourteen of the seventeen other Group 1 sites (and 0.80 for nine) in both CBD and Corridor locations.

F. While ten sites in the CBD (sites 1,5,6,8,9,11,12,13,18, and 19) had coefficients of correlation greater than approximately 0.75 with between five (site 6) to eleven (site 5) other CBD sites, they did not correlate with any Corridor sites at 0.75 or better.

G. Three CBD sites (sites 7,15, and 20) had coefficients of correlation greater than approximately 0.75 with between four (site 7) and ten (site 1) other CBD sites and with between two (site 11) and four (sites 1,7,12,13, and 19) of the five Corridor sites.

H. All five corridor sites had coefficients of correlation greater than 0.77 with each other.

I. Site 25/Spenard did not correlate with any CBD sites at 0.80 or better. However, when the continuous record is used in lieu of the integrated data, the Spenard & Benson permanent site correlated at 0.74, 0.77, and 0.81 with sites 7,12, and 13 respectively.

Relationship of "AM" to "PM" Four-Hour Averages

The analysis of both intra-site and inter-site relationships of "AM" (11:00 A.M. to 3:00 P.M.) and "PM" (3:00 P.M. to 7:00 P.M.) four-hour values can provide a characterization of the temporal variability of CO levels at individual sites and over the entire study area. Figures 13 and 14 present the composite statistics from each site for the "AM" and "PM" periods respectively. Due to time constraints, this analysis received a relatively limited treatment in this report.

Group 1 Sites Only

A. For parameters such as range, maximums, 2nd highs, minimums, means, and medians, each site's "PM" values were consistently greater than or equal to the "AM" values when all sample days are considered. The notable exceptions to this were sites 13 and 20 where the maximum and 2nd highest "AM" values exceeded those "PM" measures, with site 13's "AM" mean also exceeding its' "PM" mean.

B. The maximum "AM" averages ranged from 6.4 ppm (site 1) to 25.1 (site 24). The maximum "PM" averages ranged from 5.8 ppm (site 20) to 30.' ppm (site 24).

C. The minimum values for both "AM" and "PM" periods were essentially equal (within ± 1.0 ppm) at 15 of the 18 Group 1 sites.

D. The median of each site's daily "AM"/"PM" ratio ranged from 0.8 (sites 1,5,7,9,11,18, and 20) to 1.2 (site 13).

E. Some 16 of the Group 1 sites exhibited median "AM"/"PM" ratios less than or equal to 1.0, demonstrating general dominance of "PM" over "AM" values when considered on a daily basis.

F. The minimum "AM"/"PM" ratios ranged from 0.0* (sites 20) to 0.5 (sites 13,15, and 24), with an average minimum ratio over all sites of 0.3.

G. The maximum "AM"/"PM" ratios ranged from 1.5 (sites 1 and 13) to 17.8 (site 26) with an average maximum ratio over all Group 1 sites of 3.0.

Groups 1 and 2 Combined

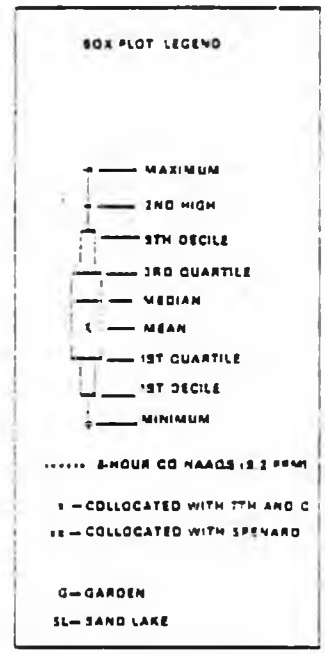
H. Considering all sites (Groups 1 and 2), the daily "PM" maximum was greater than the "AM" maximum on 59% of all sample days (not including 10 days that were within ± 0.5 ppm) by an average of 4.6 ppm, and ranging from 0.6 ppm (12/1) to 16.3 ppm (2/1) greater. Conversely, the daily "AM" maximum was greater than the "PM" maximum on 22% of all sample days, not including those days within 0.5 ppm, by an average of 3.2 ppm, and ranging from 0.7 ppm (1/3) to 10.7 ppm (12/10) greater.

* - Reflects rounding of a ratio value less than 0.05.

FIGURE 13

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE AVERAGE CONCENTRATIONS FOR THE "AM" 4-HOUR PERIOD (11:00 A.M. TO 3:00 P.M.) AT EACH SITE



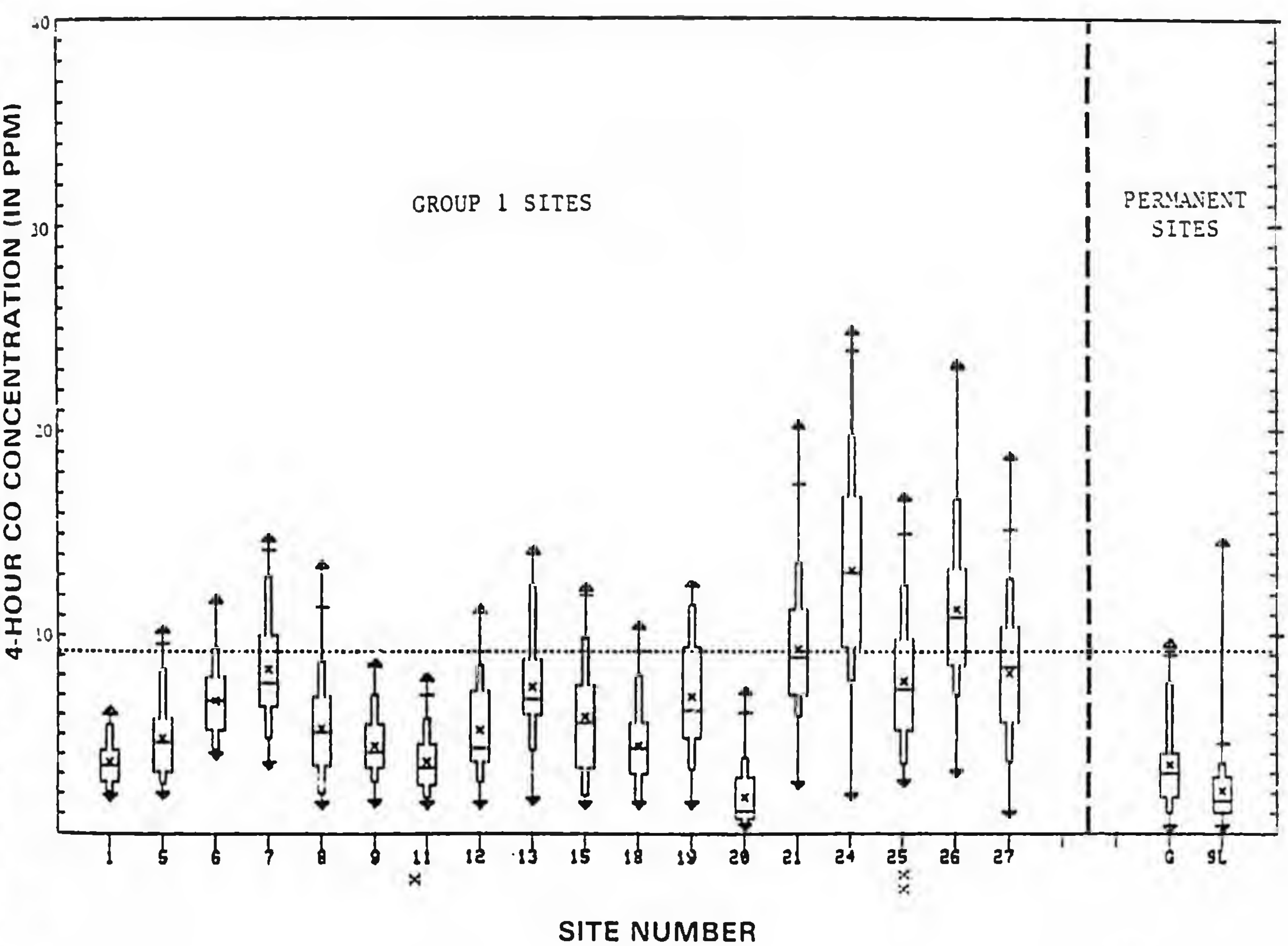
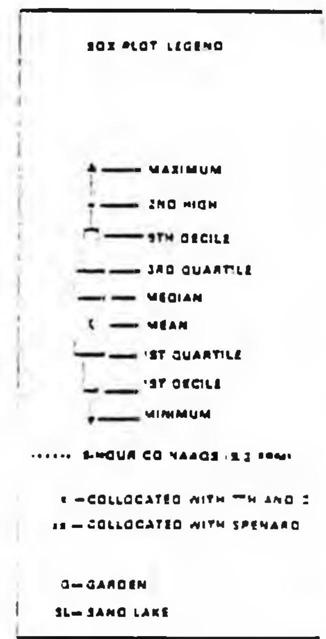
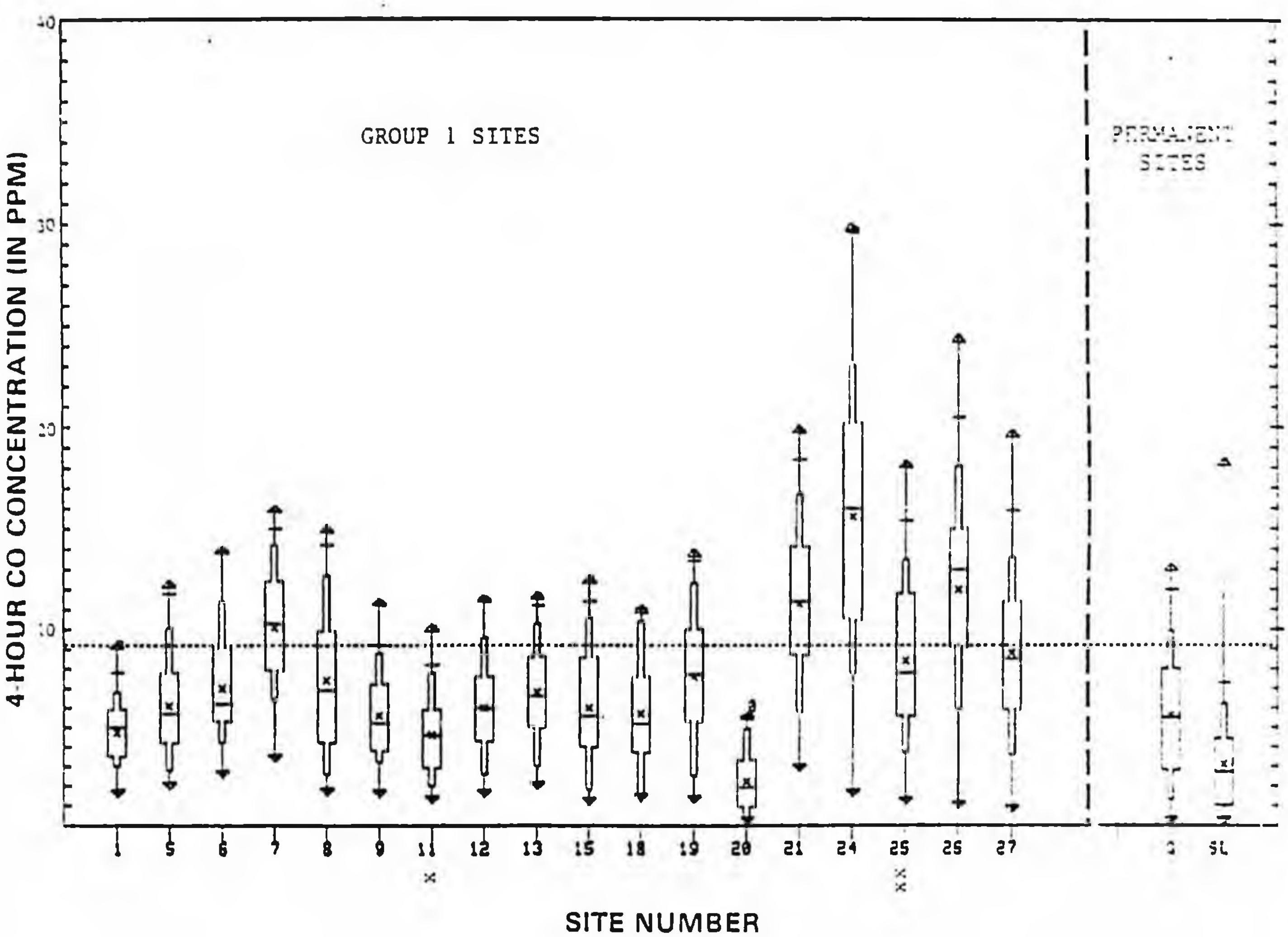


FIGURE 14

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE AVERAGE CONCENTRATIONS FOR THE "PM" 4-HOUR PERIOD (3:00 A.M. TO 7:00 P.M.) AT EACH SITE





I. On 67% of all sample days, the daily composite median of all sites'(again Groups 1 and 2) "AM"/"PM" ratios was less than 1.0.

J. The average number of daily exceedances reported from the study network (Groups 1 and 2) was essentially identical regardless of whether the "AM"/"PM" ratio was greater or less than 1.0. However, on the day when the highest proportion of sites exceeded the standard (78% on 12/3), "AM" averages were clearly greater than "PM" at over 55% of the study sites. Conversely, on the day when the second highest proportion of exceedances were recorded (68% on 1/5), "PM" averages were clearly greater than "AM" averages at about 63% of the study sites.

GRID NETWORKS

The primary emphasis of the grid monitoring networks was to establish the representativeness of the Spenard & Benson, Garden, and Sand Lake permanent sites over middle and neighborhood spatial scales. The results and discussion that follow are given on a network-specific basis.

Garden Network

The objective for the Garden study network was to examine and establish, if possible, the homogenous representativeness of the permanent Garden site. A total of five sequential samplers were dedicated to this study network. The locations of these samplers are plotted in Figure 4. Note that site 105 was collocated with the permanent probe for purposes of method comparison and quality assurance. Inspection of the data reveals that a systematic difference between the sequential and continuous sampling methods may be indicated (refer to Quality Assurance section). Therefore, site 105 was considered the surrogate of the permanent site for the purpose of maintaining congruity among the data bases considered during the regression portion of the analysis.

Even though the samplers employed in this network collected hourly data, four-hour block data were used in these inter-site comparisons to overcome potential biases due to autocorrelation and to dampen potential temporal shifts or offsets associated with impacts at one sampler (or samplers) not simultaneously, but eventually experienced at the other grid sites. If these temporal variations were profound (on the order of two or more hours) and/or intermittent, then the determination of homogeneity would be made immensely more difficult. This is not thought to have occurred here to any appreciable extent.

Data arising from the Garden network are displayed in Table 12 and Figure 15.

A. The Garden permanent site had a coefficient of correlation between 0.94 (site 101) and 0.96 (sites 102 and 103) with each of the five sites in the Garden study network (0.95 with collocated site 105).

B. The regression lines for each of the Garden site/study site pairings had slopes of between 0.83 and 0.87 with intercepts at or below 0.6 ppm.

Table 12 Correlation/Regression Results* for Permanent and Study Sites

IND. SITE	DEP. SITE	CORRELATION	COEF.DETER.	NO.OF PAIRS	2-WAY REGRESSION EQ.	1-WAY REGRESSION EQ.
7AC	SPBE	0.702	0.492	211.0	Y = 2.118X + -0.971	Y = 1.215X + 2.150
7AC	GARO	0.734	0.538	218.0	Y = 1.752X + -1.548	Y = 1.116X + 0.665
7AC	SOLK	0.652	0.425	207.0	Y = 1.224X + -1.748	Y = 0.744X + -0.293
7AC	1019	0.640	0.410	107.0	Y = 1.565X + -1.563	Y = 0.658X + 0.947
7AC	1029	0.589	0.347	51.0	Y = 1.872X + -2.552	Y = 0.866X + 1.317
7AC	1039	0.563	0.317	44.0	Y = 1.5[illegible]X + -1.558	Y = 0.730X + 1.550
7AC	1049	0.596	0.355	48.0	Y = 1.602X + -1.539	Y = 0.794X + 1.414
7AC	1059	0.627	0.393	46.0	Y = 1.509X + -1.462	Y = 0.815X + 1.243
7AC	2019	0.785	0.616	97.0	Y = 0.956X + 3.292	Y = 0.758X + 3.978
7AC	2029	0.751	0.564	90.0	Y = 1.334X + -0.197	Y = 0.770X + 0.746
7AC	4019	0.788	0.621	58.0	Y = 1.101X + -0.901	Y = 0.450X + 0.359
7AC	3019	0.690	0.477	75.0	Y = 2.056X + 0.417	Y = 1.160X + 3.523
SPBE	GARO	0.694	0.482	213.0	Y = 0.831X + -0.761	Y = 0.510X + 0.542
SPBE	SOLA	0.783	0.613	202.0	Y = 0.595X + -1.252	Y = 0.518X + -0.750
SPBE	1019	0.586	0.344	107.0	Y = 0.640X + 0.388	Y = 0.449X + 1.301
SPBE	1029	0.632	0.400	54.0	Y = 0.680X + -0.635	Y = 0.494X + 0.678
SPBE	1039	0.647	0.419	46.0	Y = 0.572X + 0.199	Y = 0.448X + 1.127
SPBE	1049	0.546	0.298	39.0	Y = 1.038X + 0.246	Y = 0.424X + 1.608
SPBE	1059	0.590	0.348	86.0	Y = 0.588X + 0.500	Y = 0.428X + 1.594
SPBE	2019	0.687	0.471	48.0	Y = 0.498X + 0.746	Y = 0.417X + 1.215
SPBE	2029	0.860	0.740	91.0	Y = 0.592X + 0.375	Y = 0.546X + 0.354
SPBE	2039	0.804	0.646	57.0	Y = 0.716X + -0.766	Y = 0.613X + -0.135
SPBE	3019	0.749	0.561	76.0	Y = 0.797X + 2.384	Y = 0.631X + 3.467
GARO	SOLK	0.685	0.469	209.0	Y = 0.685X + -0.540	Y = 0.527X + 0.180
GARO	1019	0.943	0.890	108.0	Y = 0.83[illegible]X + 0.234	Y = 0.792X + 0.416
GARO	1029	0.958	0.918	54.0	Y = 0.875X + 0.133	Y = 0.843X + 0.27[illegible]
GARO	1039	0.958	0.917	47.0	Y = 0.835X + 0.560	Y = 0.805X + 0.712
GARO	1049	0.945	0.893	100.0	Y = 0.844X + 0.317	Y = 0.805X + 0.591
GARO	1059	0.953	0.909	38.0	Y = 0.847X + 0.356	Y = 0.814X + 0.516
GARO	2019	0.723	0.523	100.0	Y = 0.544X + 1.308	Y = 0.400X + 1.669
GARO	2029	0.754	0.569	93.0	Y = 0.591X + 0.815	Y = 0.503X + 1.225
GARO	2039	0.606	0.367	58.0	Y = 0.653X + 0.174	Y = 0.466X + 1.373
GARO	3019	0.470	0.221	76.0	Y = 1.078X + 1.089	Y = 0.447X + 5.548
SOLK	1019	0.586	0.343	103.0	Y = 1.514X + 0.418	Y = 0.751X + 2.254
SOLK	1029	0.725	0.526	48.0	Y = 1.621X + -0.135	Y = 1.017X + 1.316
SOLK	1039	0.670	0.449	47.0	Y = 1.548X + 0.171	Y = 0.944X + 1.363
SOLK	1049	0.565	0.320	44.0	Y = 2.190X + -0.581	Y = 0.907X + 2.250
SOLK	1059	0.557	0.310	88.0	Y = 1.465X + 0.536	Y = 0.691X + 2.634
SOLA	2019	0.588	0.345	96.0	Y = 1.[illegible]18X + 1.178	Y = 0.594X + 2.308
SOLA	2029	0.701	0.492	93.0	Y = 1.[illegible]35X + 1.192	Y = 0.719X + 1.423
SOLK	2039	0.667	0.445	58.0	Y = 1.089X + 0.751	Y = 0.706X + 1.657
SOLA	3019	0.569	0.324	71.0	Y = 2.528X + 1.827	Y = 1.011X + 5.338
1019	1029	0.875	0.766	44.0	Y = 1.179X + -0.456	Y = 1.012X + 0.271
1019	1039	0.918	0.843	37.0	Y = 1.081X + 0.063	Y = 0.988X + 0.419
1019	1049	0.920	0.846	40.0	Y = 1.023X + 0.349	Y = 0.940X + 0.452
1019	1059	0.907	0.823	46.0	Y = 1.036X + 0.058	Y = 0.937X + 0.487
1019	2019	0.712	0.507	94.0	Y = 0.617X + 1.198	Y = 0.501X + 1.562
1019	2029	0.710	0.505	39.0	Y = 0.670X + 0.724	Y = 0.533X + 1.291
1019	2039	0.630	0.396	58.0	Y = 0.419X + -0.195	Y = 0.555X + 0.914
1019	3019	0.459	0.210	63.0	Y = 1.432X + 3.647	Y = 0.611X + 5.121
1029	1039	0.895	0.801	45.0	Y = 1.028X + 0.163	Y = 0.917X + 0.522
1029	1049	0.924	0.853	46.0	Y = 0.937X + 0.437	Y = 0.870X + 0.726
1029	1059	0.940	0.883	28.0	Y = 1.080X + -0.174	Y = 1.010X + 0.143
1029	2019	0.650	0.423	40.0	Y = 0.433X + 1.791	Y = 0.365X + 2.253
1029	2029	0.749	0.561	15.0	Y = 0.577X + 0.569	Y = 0.559X + 1.224
1029	3019	0.410	0.168	52.0	Y = 1.254X + 2.664	Y = 0.450X + 5.257
1039	1049	0.890	0.792	37.0	Y = 0.955X + 0.368	Y = 0.894X + 0.51[illegible]
1039	1059	0.963	0.927	27.0	Y = 1.340X + -0.105	Y = 1.300X + [illegible]
1039	2019	0.779	0.607	10.0	Y = 0.784X + 0.600	Y = 0.644X + 1.137
1039	2029	0.838	0.702	34.0	Y = 0.767X + 0.354	Y = 0.670X + 0.192
1039	3019	0.503	0.253	43.0	Y = 1.629X + 1.373	Y = 0.644X + 5.349
1049	1059	0.887	0.787	51.0	Y = 1.047X + -0.376	Y = 0.924X + 0.490
1049	2019	0.712	0.507	33.0	Y = 0.648X + 1.604	Y = 0.521X + 1.535
1049	2029	0.729	0.531	71.0	Y = 0.735X + 0.376	Y = 0.581X + 1.293
1049	2039	0.600	0.360	52.0	Y = 0.601X + -0.169	Y = 0.525X + 0.391
1049	3019	0.419	0.176	58.0	Y = 1.669X + 3.987	Y = 0.534X + 5.730
1059	2019	0.686	0.471	75.0	Y = 0.661X + 0.931	Y = 0.515X + 1.559
1059	2029	0.704	0.496	77.0	Y = 0.651X + 0.869	Y = 0.514X + 1.331
1059	2019	0.619	0.383	54.0	Y = 0.787X + 0.022	Y = 0.533X + 1.142
1059	3019	0.459	0.211	42.0	Y = 1.565X + 0.726	Y = 0.571X + 5.141
2019	2029	0.891	0.793	53.0	Y = 1.001X + -0.245	Y = 0.891X + 0.157
2019	2039	0.832	0.692	53.0	Y = 1.191X + -0.907	Y = 0.901X + -0.124
2019	3019	0.602	0.362	57.0	Y = 2.392X + -1.177	Y = 1.358X + 1.355
2029	2039	0.862	0.743	51.0	Y = 1.123X + -0.698	Y = 0.951X + -0.142
2029	3019	0.651	0.424	47.0	Y = 2.031X + 0.562	Y = 1.355X + 3.816
2039	3019	0.328	0.085	13.[illegible]	Y = 1.968X + -1.318	Y = 1.466X + [illegible]

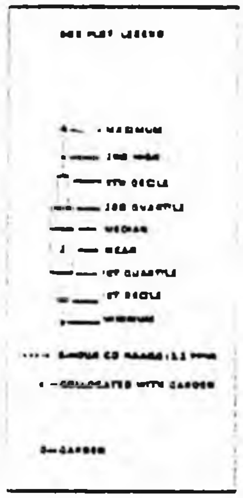
* - Reflects Data for Three 4-Hour Blocks per Day: 11:00 a.m. - 3:00 p.m.
3:00 p.m. - 7:00 p.m.
7:00 p.m. - 11:00 p.m.

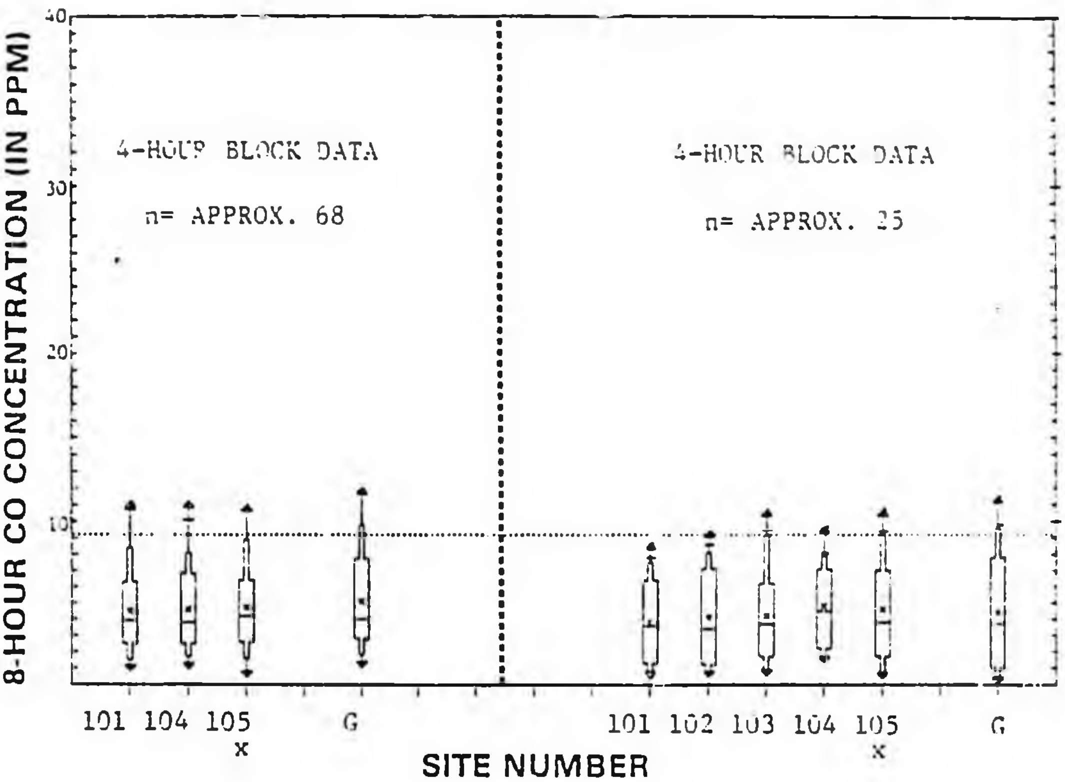
FIGURE 15

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE

GARDEN NETWORK





C. While the correlation coefficients for the pairings of site 105 and the other Garden network study sites were somewhat lower than those for the Garden permanent site pairings, ranging from 0.89 (site 104) to .96 (site 103), the slopes were closer to unity (1.0) ranging from 0.93 (site 102) to 0.97 (site 101), with intercepts less than 0.6ppm.

Sand Lake Network

The objective for the Sand Lake study network was to examine and establish, if possible, the homogenous and analogous representativeness of the Sand Lake permanent site. Three study sites were deployed about the permanent site. Their locations are plotted on Figure 5. Study site 29 was sited to examine the homogenous representativeness of the Sand Lake site. Because sites 28 and 30 were located across one or more well-traveled arterials from the Sand Lake site, they yielded data relative to analogous representativeness.

As a result of the use of 8-hour integrated samplers in this network, daily eight-hour block data were used in these inter-site comparisons. In addition, sampling was not conducted during the period of most frequent maximum daily concentrations for logistical reasons. Therefore, the relationships described by Figure 16 and the correlation/regression results appearing in Table 12 may not adequately characterize the circumstances of other periods within a day.

A. The Sand Lake permanent site had a coefficient of correlation of 0.88 with site 28, 0.97 with site 29, and 0.92 with site 30, with slopes indicating that study sites 29 and 30 were 2% and 19% higher on average than the Sand Lake site, while site 28 was 6% lower on average.

B. Site 30, across Jewell Lake Road from the other sites, correlated at 0.79 and 0.73 with sites 28 and 29 respectively, with slopes indicating that it is 26% lower than site 28 and [illegible] higher than site 29 on average.

Spenard & Benson Network

The objective for the Spenard & Benson network was to examine and establish the homogenous and analogous representativeness of the Spenard permanent site. A total of four sites were eventually deployed in the Spenard network, consisting of three sequential and one integrated samplers. The location of these sites are plotted on Figure 3. Sites 201 and 203 were located across one or more major traffic facilities and therefore retrieved data relative to analogous representativeness. Sites 202 and 204 were located in the neighborhood contiguous with the Spenard permanent site and examined homogenous representativeness.

Again, though hourly data were available from three of these study sites, four- hour block data were utilized in the correlation/regression analysis. As site 204 retrieved 8-hour block data, comparisons with that site were made on that basis.

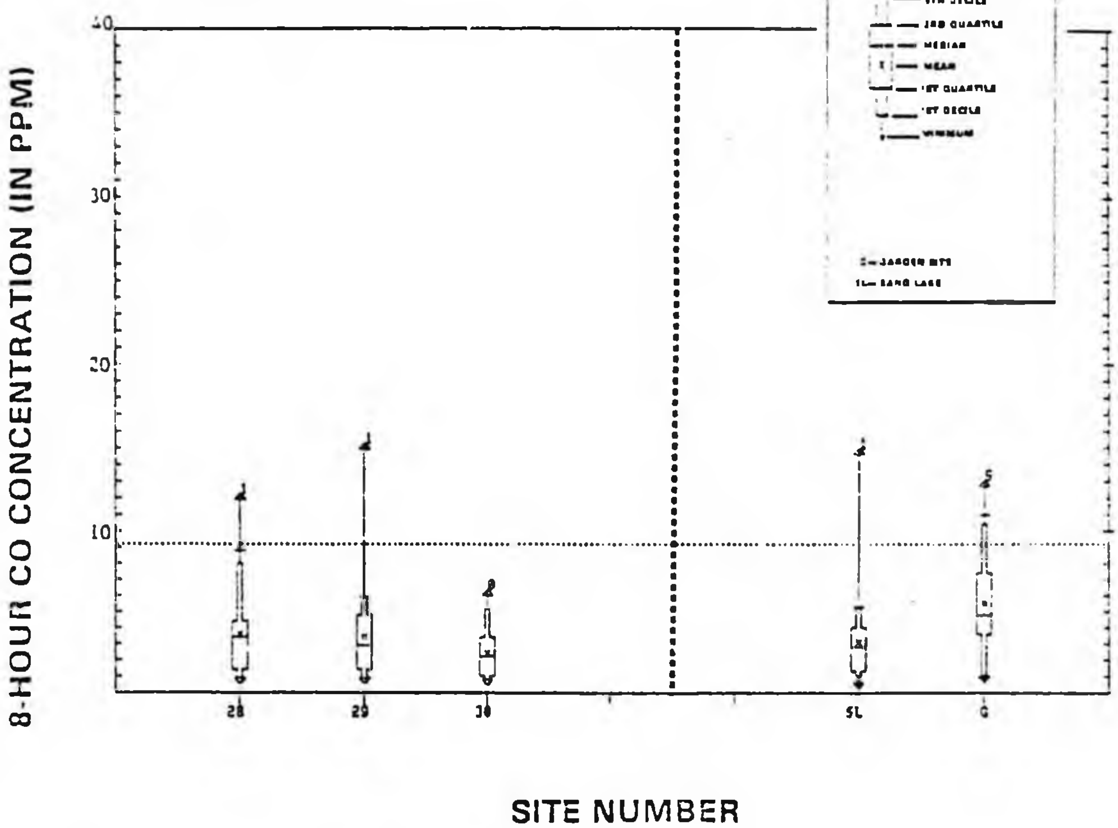
In addition to the Spenard grid sites, site 38, located in the neighborhood of the intersection of Spenard and Minnesota was included for comparison with the Spenard grid network.

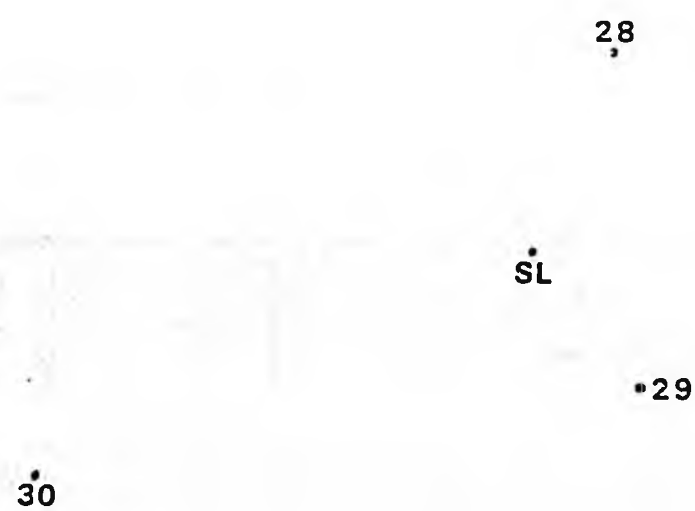
ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

FIGURE 16

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE
AVERAGE CONCENTRATIONS FOR AN 8-HOUR PERIOD (8:00 A.M. to 4:00 P.M.)
AT EACH SITE

SAND LAKE NETWORK





Data arising from this network are displayed in Figure 17 and Table 12.

A. The Spenard permanent site had coefficients of correlation of 0.69, 0.86, and 0.80 with sites 201, 202, and 203 respectively, at slopes of 0.50, 0.59, and 0.72.

B. On an 8-hour block basis, the Spenard permanent site correlated at 0.72 with study site 204.

C. Site 202 correlated at 0.89 and 0.86 with sites 201 and 203 respectively, and with slopes of 1.00 and 1.12.

D. Site 201 correlated with site 203 at 0.83 with a slope of 1.10.

E. On an 8-hour block basis, site 204 correlated with sites 201, 202, and 203 at 0.80 or better with slopes indicating that it is on average between 15% to 28% higher.

F. On an 8-hour block basis, site 204 correlated at 0.35 with site 38, running 4% higher on average.

INTER-NETWORK COMPARISONS

Relationships of CO levels measured in areas spatially removed from each other were examined in order to characterize their distribution throughout the city. This kind of analysis can be difficult in that impacts may not be simultaneous over the entire breadth of the study area (city). A more exhaustive analysis towards accounting for any of these potential temporal shifts will be attempted when time allows.

Four-hour block data was used throughout the bulk of this analysis. Correlation/regression results are displayed in Table 12. Instances where it was necessary to use 8-hour block data (as with the Sand Lake samplers) are identified.

Because there was no integrated sampler collocated with the Garden permanent site, Garden data were used for comparisons with the integrated sites. However, it should be noted when reviewing these comparisons that there may be a small systematic difference in the sampling methodologies between the integrated and continuous sites with the latter perhaps 3% to 5% higher than the former on average (refer to Quality Assurance section).

Finally, all available data (including weekends) from the permanent sites were used in comparisons with each other.

Inter-Permanent Site Comparisons

A. Between the permanent sites, correlations ranged from 0.59 to 0.80.

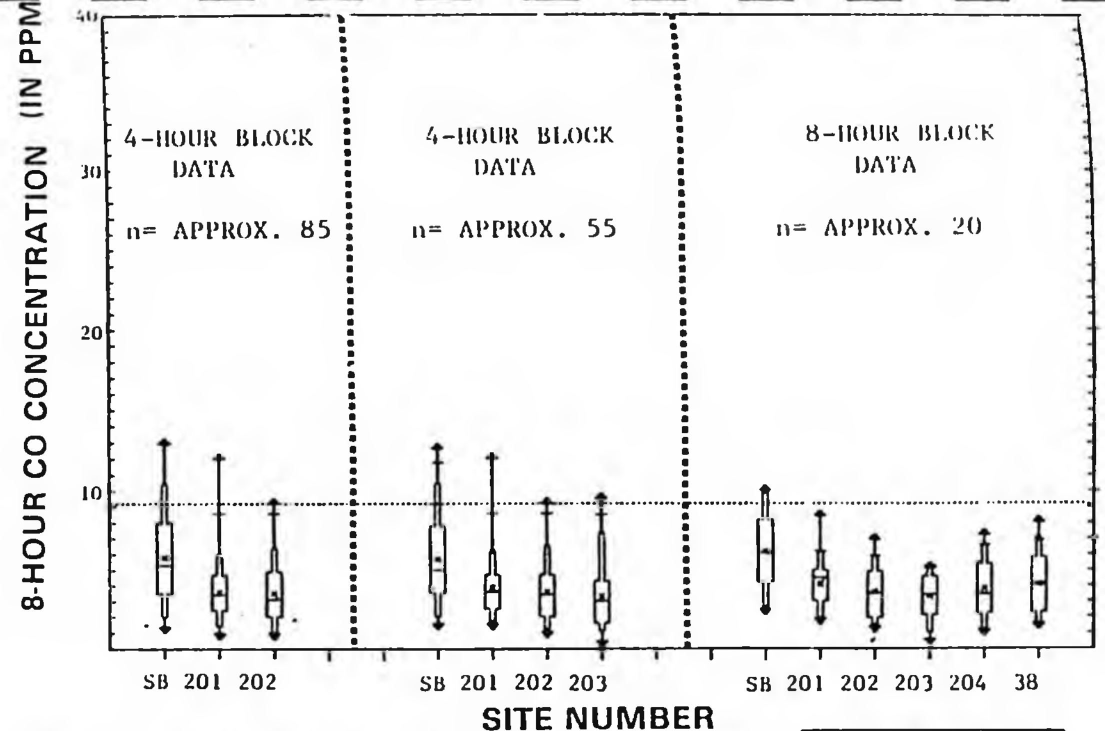
B. As indicated by the slope of the regression line, Spenard & Benson was 98% and 31% higher on average than the 7th & [illegible] and Sand Lake sites respectively, with intercepts of -0.6[illegible] and [illegible].

C. Spenard & Benson was 11% higher on average than the Garden site.

ANCHORAGE CARBON MONOXIDE STUDY
11/22/82 TO 2/11/83

CHARACTERISTICS OF WEEKDAY CARBON MONOXIDE

SPENARD & BENSON NETWORK



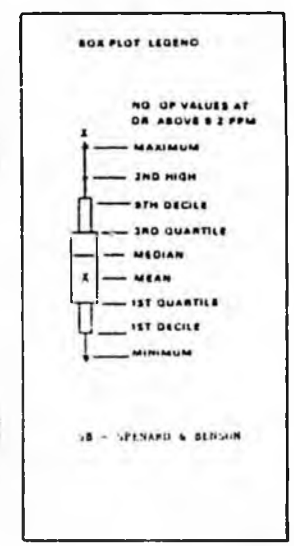


FIGURE 17

D. Garden was 87% and 73% higher on average than the 7th & C and Sand Lake sites respectively, with intercepts of -1.15 and 0.11.

E. Sand Lake was 9% higher on average than the 7th & C site, with an intercept of -1.00.

Permanent/Group 1 Site Comparisons (8-Hour Block Data)

F. The 7th & C and Spenard & Benson sites have been compared to Group 1 sites in a previous section.

G. The Garden site correlated at 0.80 or better with four other Group 1 sites (sites 19,21,24, and 26).

H. The Sand Lake site did not correlate at 0.80 or better with any Group 1 sites.

Permanent/Garden Network Comparison

I. The 7th & C, Spenard & Benson and Sand Lake permanent sites did not correlate at 0.75 or better with any Garden study site

Permanent/Sand Lake Network Comparison (8-Hour Block Data)

J. The 7th & C, Spenard & Benson, and Garden sites correlated at 0.74 to 0.80 with site 29 in the Sand Lake network. In addition, Spenard & Benson correlated at 0.87 with site 23 in the Sand Lake Network.

Permanent/Spenard & Benson Network Comparison

K. The 7th & C and Garden permanent sites correlated at 0.75 or better with five (sites 201,202, and 203 on a 4-hour block basis, and sites 204 and 38 on an 8-hour block basis), and one (site 202) sites respectively in the Spenard & Benson network. The Sand Lake site did not correlate with any Spenard network site at 0.75 or better.

Other Network to Network Comparisons

L. Sites 201 and 202 of the Spenard grid network correlated at 0.75 or better with one (site 103) and two (sites 102 and 103) sites respectively in the Garden network.

M. Twelve of eighteen Group 1 sites and no Group 2 sites correlated at 0.75 or better with site 38 (in the neighborhood adjoining Spenard and Minnesota).

Table 13 Correlation/Regression Results* for Permanent Sites

IND. SITE	DEP. SITE	CORRELATION	CORR.DETER.	NO.OF PAIRS	2-WAY REGRESSION EQ.			1-WAY REGRESSION EQ.		
7AC	SPBE	0.780	0.609	417.0	Y =	1.9031 X +	-0.516	X =	[illegible]	[illegible]
7AC	GARD	0.751	0.565	434.0	Y =	[illegible]	-1.449	X =	1.2151 Y +	[illegible]
7AC	SOLA	0.692	0.479	410.0	Y =	1.3951 X +	-1.302	X =	[illegible]	[illegible]
SPBE	GARD	0.737	0.543	422.0	Y =	0.9048 X +	-0.577	X =	0.5444 Y +	[illegible]
SPBE	SOLA	[illegible]	0.611	398.0	Y =	0.5511 X +	-0.504	X =	[illegible]	-0.242
GARD	SOLA	0.703	0.494	416.0	Y =	0.5781 X +	-0.463	X =	[illegible]	[illegible]

* - Reflects Data for Six 4-Hour Blocks per Day

QUALITY ASSURANCE

The number and diversity of study sampling regimes necessitated a comprehensive and highly coordinated approach to yield data of appropriate precision, accuracy, and completeness. As referenced previously, a rigorous quality assurance (QA) program was developed and applied to the study. An enormous body of quality assurance documentation was amassed during the study in support of data quality. This QA program was composed of three basic elements: sampling QA, analytical QA, and data handling QA to preserve both the integrity and completeness of the data.

Sampling QA

Explicit and routine field QA protocols were designed and implemented to ensure that samples being collected were both representative of ambient CO concentrations at the individual sampling sites and comparable in terms of quality to samples collected elsewhere in the study network. Measures of sampling performance are described below.

Sampling Precision

A pair of integrated samplers was collocated (within 2 meters) to quantify the extent of variability associated with the sampling method. The results in terms of 8-hour averages are described below:

A. Collocated samplers 9 and 10 correlated at 0.97 with a slope of nearly 1.0.

B. The mean difference between sites 9 and 10 was 0.0, with individual differences ranging from -0.9 to 1.6 ppm.

C. Eighty percent of the differences between sites 9 and 10 were within ± 0.6 ppm (leaving only two differences greater than ± 0.6 ppm: -0.9 ppm and 1.6 ppm).

Sampling Accuracy

Pairs of integrated samplers/permanent monitors and sequential sampler/permanent monitor were deployed in the study network. While in the traditional sense this was not a true audit of sampler accuracy since an absolute standard was not directly employed, it was assumed that data retrieved from the permanent monitors were of sufficiently higher or at least less variable quality that they were considered a "quasi" audit source. This also provided a measure of method comparability. The results are described below:

A. Collocated sites 11 and 7th & C correlated at 0.95 with the permanent site running about 3% higher on average than site 11.

B. Absolute differences between site 11 and 7th & C ranged from -1.1 ppm to 1.1 ppm.

C. Collocated sites 25 and Spenard correlated at 0.90 with the Spenard & Benson permanent site running about 5% higher on average (at an intercept of -1.52) than site 25.

D. Of the 43 total pairs of data resulting from the comparison of site 25 and the Spenard & Benson permanent site, differences ranged from -1.8 ppm to 4.8 ppm. Of these, 22 were within ± 1.3 ppm and 38 were within ± 2.6 ppm. Seventeen of the 21 differences greater than ± 1.3 ppm occurred when one or both members of the pair were less than 9.0 ppm.

(Because the variability exhibited by this particular pair of sites was greater than that of other collocated pairs, it became the object of further investigation towards accounting for the source of the variability. It is now thought that both sampling devices were operating within their normal respective limits and that the source of most of the few but large differences is attributable to site-specific peculiarities.)

E. Using 4-hour block data, collocated sites 105 and Garden correlated at 0.95 with the permanent site running 18% higher on average than 105 (a systematic dilution problem associated with the sequential method is suspected as the source of this offset).

Study Sampling Method Comparison

An integrated sampler and a sequential sampler were collocated to provide an index of the comparability of these two methods. Collocated sites 7 and 301 correlated at 0.90 with the integrated sampler (site 7) running about 12% higher on average than the sequential sampler (the same sequential dilution problem referenced in "C" above is suspected as the source of this difference).

Analytical QA

Analytical performance was continually monitored to ensure the integrity of the study data. Two measures of this analytical performance are described below.

Analytical Precision

The Beckman Model 866 CO analyzer used for analysis of bag samples was challenged 5 to 10 times daily with a precision atmosphere traceable to the National Bureau of Standards (NBS). Due to the limited availability of precision materials, the level of these precision checks varied from [illegible] to 36% of analyzer range. It should be noted that the precision confidence limits were computed using the percent difference of analyzer response to the known concentration of the precision atmosphere. As the proportional difference of a fixed absolute difference is greater for lower than higher concentrations, results from each precision level were considered individually. The results of these checks are described below.

A. For the 24 precision checks performed at the nominal 6 ppm level, the absolute differences ranged from -0.7 ppm to [illegible] ppm, with percent differences yielding an upper 95% confidence limit (CI) of 5.62 and a lower 95% CI of -5.48.

B. For the 84 precision checks performed at the nominal 9 ppm level, the absolute differences ranged from -0.7 ppm to 0.3 ppm, with percent differences yielding an upper 95% CI of 6.42 and a lower 95% CI of -2.20.

C. For the 102 precision checks performed at the 17 ppm level, the absolute differences ranged from -0.7 ppm to 0.3 ppm, with percent differences yielding an upper 95% CI of 2.31 and a lower 95% CI of -2.01.

Another routine measure of analytical precision was the re-analysis of a number of samples to ascertain the cumulative variability associated with the analytical protocol. The results of these checks are not presented here.

Analytical Accuracy

The CO analyzer was audited two times with test atmospheres traceable to NBS to evaluate its response to known and absolute concentrations of CO. The number of audits do not merit a statistical treatment of the resulting data. The results of these audits are summarized below:

A. The first audit (performed on January 5, 1983) indicated that the analyzer was reading between 2.0% and 4.4% high.

B. The second audit (performed on February 18, 1983) indicated that the analyzer was reading between 0.4% and 2.6% high.

Data Handling QA

The abundant amount of data arising from the study and the numerous manipulations it underwent created the potential for errors in transcription, processing, and computation. A rigorous program of routine checks was instituted towards identifying and correcting these errors. The results of this program will not be presented here. However, this program was extremely effective in minimizing and eliminating these errors.

Data Completeness

Data completeness is a function of two somewhat competing objectives: 1) maximizing the proportion of successfully collected samples relative to all sampling attempts while 2) preserving the fundamental and desired integrity of the data base. The stated objective of this study was to successfully capture valid data for 85% of the total attempts (validity criteria was defined in the study QA plan). Data recovery rates for each of the subject study sites are shown in Table 13.

Table 14 Valid Data Recovery Rates By Site

Group 1 Sites	"AM"* Data Recovery Rate (in percent)	"PM"** Data Recovery Rate (in percent)	8-Hour Data Recovery Rate (in percent)
1	85.2	96.3	81.5
5	95.3	85.2	83.3
6	92.6	88.9	83.3
7	81.5	94.4	75.9
8	90.7	79.6	77.8
9	98.1	87.0	85.2
11	92.6	92.6	85.2
12	95.3	88.9	85.2
13	96.3	94.4	92.6
15	81.5	88.9	74.1
18	90.7	96.3	90.7
19	92.6	75.9	70.4
20	96.3	90.7	90.7
21	94.4	88.9	85.2
24	90.7	90.7	81.5
25	95.3	87.0	85.2
26	95.3	92.6	90.7
27	90.7	94.4	85.2
Sand Lake Sites* **			
28			85.7
29			85.7
30			82.1

* - 11:00 a.m. to 3:00 p.m.

** - 3:00 p.m. to 7:00 p.m.

*** - Reflects eight-hour interval of 8:00 a.m. to 4:00 p.m.

02-001B Rev. 10/76

STATE of ALASKA

MEMORANDUM

TO: Stanley W. Hungerford, Environmental Engineer IV

DATE: April 2, 1980

FILE NO:

TELEPHONE NO:

FROM: T.C. Trible T.C.T
Chief, EQM&LO

SUBJECT: Tesoro-Alaska Kenai Refinery; Suggestions for Monitoring

I have reviewed Mr. Frates' letter regarding the Tesoro-Alaska Kenai refinery. The following are my suggestions and comments.

Generally speaking, the many concerns expressed by Mr. Frates represent hypothetical situations rather than actual or anticipated conditions. There is no point in my trying to address Mr. Frates' concerns individually since I presume that you will be doing that in your letter.

However, there are some actions that we can take in order to provide you with factual information regarding environmental conditions.

We can develop an ambient air monitoring strategy for the area of concern considering siting requirements, instrument selection and performance testing, calibration, maintenance and data reduction. District office personnel must operate the equipment, however. We might want to establish SO2, O3, Oxides of Nitrogen and TSP sites at one or two locations.

We can develop a program for monitoring water quality of nearby lakes and streams evaluating parameters such as TKN, NO3-NO2, sulfate, pH, carbonate alkalinity and perhaps even hydrocarbons. Again district office support would be required to collect samples and measure pH as well as carbonate alkalinity. EQM&LO can provide the required laboratory support.

In order for you to decide how far you wish to go with this problem, I have included in the following an estimate of new equipment costs.

I AMBIENT AIR MONITORING

A Sulfur Dioxide

1.	TECO Model 43 SO2 analyzer	8,500
2.	METRONICS Dynacalibrator	5,350
3.	SUPERSCRIBE strip chart recorder	1,600
4.	MONITOR LABS signal averager	1,100
5.	Miscellaneous commodities	250
		16,800 per site

B Ozone

1.	DASIBI Model 1003-RS Ozone analyzer	5,750
2.	SUPERSCRIBE strip chart recorder	1,600
3.	MONITOR LABS signal averager	1,100
4.	Miscellaneous commodities	250
		8,700 per site

C Oxides of Nitrogen

1.	MONITOR LABS Model 844-E NO(X) analyzer	10,000
2.	CSI Gas phase titration calibrator	9,000
3.	SUPERSCRIBE strip chart recorder	1,600
4.	MONITOR LABS signal averager	1,100
5.	Miscellaneous commodities	250
		21,950 per site

Total equipment costs per site for ambient air monitoring are $47,450. I recommend a back-up strip chart recorder and signal averager for an additional $2,700 and a total of $50,150.

II WATER QUALITY MONITORING

A Non-conservative Parameters

1. ORION pH meter, probe and buffer solutions, alkalinity gear 950

B Conservative Parameters

1. All required water chemistry can be incorporated into the existing program.

I have included one of these sites in our request for additional ambient air monitoring equipment. Please advise me how you want to go with this problem.

I A 5C

Tom Trible
Chief, EQM & LO

April 9, 1980

Stanley W. Hungerford
Environmental Engineer IV

Kenai Air/Water
Monitoring Program

Tom, your suggestions for a multi-parameter monitoring program for obtaining "background" air and water quality data in the Kenai area looks good to me. Please obtain the equipment (via Tom Hanna's grant funds) and arrange to set up a monitoring station somewhere in the vicinity of the Collier-Phillips-Tesoro industrial complex about 10 miles north of Kenai. Enclosed is a map from Tesoro's PSD application which indicates calculated pollutant concentrations in the area, and another map showing locations of major facilities.

I hope you can get the program started while I am on leave, but if not, we should get together as soon as I return. Here are the names of company officials who might be able to help you site the instruments and obtain power:

Union Chemicals --

Mr. George Ford, Plant Manager (776-8121)
Mr. Bill -witzer, Environment Engineer

Phillips Petroleum --

Mr. J. F. Settle (776-8166)

Tesoro Alaska Refining --

Mr. Mark Necessary (776-8191)
Mr. Ray Measles, Laboratory Supervisor

Chevron USA (refinery) --

Mr. George E. Day, Manager (776-8161)

Chugach Electric Ass'n --

Mr. L. J. Schultz, General Manager (276-3500)
Mr. Larry Marley, Manager, Environmental

APP F - ok

DATE: AUG. 02, 1984

STATE AND LOCAL AIR MONITORING REPORT
CREATED FROM NATIONAL AEROMETRIC DATA BANK

SUSPENDED PARTICULATE UG/M3 ALASKA 1983

METHOD: GRAVIMETRIC, 24-HOUR HI-VOLUME FILTER SAMPLE-91

State Standard

SITE CODE AND ADDRESS	METH	REP ORG	NUMBER 24-HR OBS.	ANNUAL GEOMETRIC MEAN	24-HR VALUES > 260	24-HR VALUES > 150	24-HR VALUES 1ST MAX DATE	24-HR VALUES 2ND MAX DATE
ANCHORAGE BOROUGH								
020040003I01 STATE W.I.N. PROGRAM BLDG 527 E. 4TH AVE. ANCHORAGE	91	020	59	55		5	223 05/12	195 06/[illegible]
020040005I01 CITY FIRE STATION 7TH & C STREET ANCHORAGE	91	020	58	64		10	224 04/06	223 06/23
020040009I01 TUDOR #1 - 3500 EAST TUDOR ROAD ANCHORAGE	91	020	59	65		10	215 09/27	188 05/12
020040019I01 1/4 MILE S OILWELL RD & 3/4 MILE MULDOON ANCHORAGE	91	020	57	21			100 01/30	100 02/11
020040020I01 1045 WEST 8TH STREET ANCHORAGE	91	020	59	49		3	170 06/23	160 05/12
020040021I01 SAND LAKE DISTRICT 3426 RASPBERRY ROAD ANCHORAGE	91	020	19	44?		2	208 03/25	156 03/07
020040029I01 TUDOR #2 - 3500 EAST TUDOR ROAD ANCHORAGE	91	020	59	63		8	232 09/27	181 06/23
FAIRBANKS NORTH STAR BOROUGH								
020160010F01 675 7TH AVE, FAIRBANKS FAIRBANKS	91		38	105?	1	11	265 12/08	245 04/06
020160015G01 NEW BOROUGH BLDG SITE #1 - 4TH & LACEY FAIRBANKS	91	020	30	93?		3	238 06/11	157 04/18

DATE: AUG. 02, 1984

STATE AND LOCAL AIR MONITORING REPORT
CREATED FROM NATIONAL AEROMETRIC DATA BANK

SUSPENDED PARTICULATE UG/M3 ALASKA 1983

METHOD: GRAVIMETRIC, 24-HOUR HI-VOLUME FILTER SAMPLE-91

SITE CODE AND ADDRESS	METH	REP ORG	NUMBER 24-HR OBS.	ANNUAL GEOMETRIC MEAN	24-HR VALUES > 260	24-HR VALUES > 150	24-HR VALUES 1ST MAX DATE	24-HR VALUES 2ND MAX DATE
FAIRBANKS NORTH STAR BOROUGH								
020160016G01 NEW BOROUGH BLDG SITE #2 4TH & LACEY FAIRBANKS	91	020	59	76		4	233 06/11	174 12/08
020160017G01 NORDALE ELEMENTARY SCHOOL HAMILTON-EUREKA FAIRBANKS	91	020	54	66		2	175 10/15	152 09/27
020160019G01 NOEL WIEN LIBRARY - COWLES & AIRPORT RDS FAIRBANKS	91	020	59	67		2	201 10/15	159 11/08
020160022G01 NOEL WIEN LIBRARY #2,COWLES & AIRPORT RDS FAIRBANKS	91		11	76?		2	207 10/15	158 11/08
JUNEAU BOROUGH								
020200002F01 JUNEAU FIRE DEPARTMENT JUNEAU	91	020	57	35		1	162 05/06	120 10/15

DATE: AUG. 02, 1984

STATE AND LOCAL AIR MONITORING REPORT
CREATED FROM NATIONAL AEROMETRIC DATA BANK

SUSPENDED PARTICULATE UG/M3 ALASKA 1983

METHOD: GRAVIMETRIC, 24-HOUR HI-VOLUME FILTER SAMPLE-91

SITE CODE AND ADDRESS	METH	REP ORG	** * *	NUMBER OF 24-HOUR CONCENTRATIONS IN RANGES: 0 TO 65	66 TO 130	131 TO 195	196 TO 260	261 TO 325	326 TO 390	391 TO 455	** OVER * 455 *
ANCHORAGE BOROUGH											
020040003I01 STATE W.I.N. PROGRAM BLDG 527 E. 4TH AVE. ANCHORAGE	91	020		35	16	7	1				
020040005I01 CITY FIRE STATION 7TH & C STREET ANCHORAGE	91	020		28	18	8	4				
020040009I01 TUDOR #1 - 3500 EAST TUDOR ROAD ANCHORAGE	91	020		31	17	10	1				
020040019I01 1/4 MILE S OILWELL RD & 3/4 MILE MULDOON ANCHORAGE	91	020		53	4						
020040020I01 1045 WEST 8TH STREET ANCHORAGE	91	020		40	14	5					
020040021I01 SAND LAKE DISTRICT 3426 RASPBERRY ROAD ANCHORAGE	91	020		11	6	1	1				
020040029I01 TUDOR #2 - 3500 EAST TUDOR ROAD ANCHORAGE	91	020		31	18	9	1				
FAIRBANKS NORTH STAR BOROUGH											
020160010F01 675 7TH AVE, FAIRBANKS FAIRBANKS	91			9	15	8	5	1			
020160015G01 NEW BOROUGH BLDG SITE #1 - 4TH & LACEY FAIRBANKS	91	020		6	18	5	1				

DATE: AUG. 02, 1984

STATE AND LOCAL AIR MONITORING REPORT
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SUSPENDED PARTICULATE UG/M3 ALASKA 1983

METHOD: GRAVIMETRIC, 24-HOUR HI-VOLUME FILTER SAMPLE-91

SITE CODE AND ADDRESS	METH	REP ORG	** * *	NUMBER OF 24-HOUR CONCENTRATIONS IN RANGES: 0 TO 65	66 TO 130	131 TO 195	196 TO 260	261 TO 325	326 TO 390	391 TO 455	** OVER * 455 *
FAIRBANKS NORTH STAR BOROUGH											
020160016G01 NEW BORDUGH BLDG SITE #2 4TH & LACEY FAIRBANKS	91	020		21	30	7	1				
020160017G01 NORDALE ELEMENTARY SCHOOL HAMILTON-EUREKA FAIRBANKS	91	020		22	29	3					
020160019G01 NOEL WIEN LIBRARY - COWLES & AIRPORT RDS FAIRBANKS	91	020		26	30	2	1				
020160022G01 NOEL WIEN LIBRARY #2,COWLES & AIRPORT RDS FAIRBANKS	91			4	5	1	1				
JUNEAU BOROUGH											
020200002F01 JUNEAU FIRE DEPARTMENT JUNEAU	91	020		39	17	1					

DATE: AUG. 02, 1984

STATE AND LOCAL AIR MONITORING REPORT
CREATED FROM NATIONAL AEROMETRIC DATA BANK

LEAD UG/M3 ALASKA 1983

METHODS: JARRELL-ASH EMISSION SPECTRA ICAP-90, EMISSION SPECT MUFFLE FURNACE-91, ATOMIC ABSORPTION-92, DITHIOZONE METHOD-93
EMISSION SPECT (LOW TEMP ASH)-95, X-RAY FLUORESCENCE-96

SITE CODE AND ADDRESS	METH	REP ORG	QUARTER	NUMBER OF 24-HOUR SAMPLES	QUARTERLY ARITHMETIC AVERAGE
ANCHORAGE BOROUGH					
020040005I01	92	020	JANUARY-MARCH	15	0.51
CITY FIRE STATION 7TH & C STREET			APRIL-JUNE	15	0.36
ANCHORAGE			JULY-SEPTEMBER	10	0.29
			OCTOBER-DECEMBER		
FAIRBANKS NORTH STAR BOROUGH					
020160016G01	92	020	JANUARY-MARCH	13	0.64
NEW BOROUGH BLDG SITE #2 4TH & LACEY			APRIL-JUNE	15	0.19
FAIRBANKS			JULY-SEPTEMBER	14	0.19
			OCTOBER-DECEMBER	14	0.74

Lead Standard is 1.5 micrograms per cubic meter of air averaged over a calendar quarter

CARBON MONOXIDE PPM ALASKA 1983

METHOD: NONDISPERSIVE INFRARED (NDIR) CONTINUOUS, HOURLY VALUES-11, FLAME IONIZATION-21

SITE CODE AND ADDRESS	METH	REP ORG	NUMBER HOURLY OBS.	1-HOUR OBSERVATIONS 1ST MAX DATE-TIME	2ND MAX DATE-TIME	TIMES > 35	8-HOUR OBSERVATIONS 1ST MAX DATE TIME END HR	2ND MAX DATE TIME END HR	TIMES > 9
ANCHORAGE BOROUGH									
020040013101 625 C STREET ANCHORAGE	11		5122	15.0 02/24 1800	14.0 02/02 1600		8.5 01/05 1900	8.5 01/23 2200	
020040017101 2932 SPENARD ROAD ANCHORAGE 99503 ANCHORAGE	11	020	8595	34.0 12/02 1700	26.0 11/04 0800		20.2 12/02 2100	16.0 12/26 1900	72
020040018101 TRINITY CHRISTIAN CHURCH 3000 E. 16TH AVE ANCHORAGE	11	020	8401	23.0 01/28 0800	23.0 12/02 1700		19.6 12/27 1500	18.0 12/26 1900	43
020040021101 SAND LAKE DISTRICT 3426 RASPBERRY ROAD ANCHORAGE	11	020	8621	19.0 12/27 0800	18.0 12/02 1800		11.4 12/02 2100	11.3 12/26 2300	9
FAIRBANKS NORTH STAR BOROUGH									
020160013F01 675 7TH AVE, FAIRBANKS FAIRBANKS	11	020	5277	36.0 02/22 1800	33.0 02/22 1700	1	19.0 02/22 1900	15.9 02/23 2200	34
020160014G01 4TH AVE. AND LACEY ST., FAIRBANKS FAIRBANKS	11		6315	32.0 02/23 1700	31.5 02/23 1600		18.3 02/23 2100	17.6 02/04 1700	40
020160020G01 HUNTER ELEMENTARY SCHOOL 17TH & GILLIAM FAIRBANKS	11	020	5763	26.0 01/25 1800	22.0 02/22 1900		15.1 01/21 2300	14.0 01/25 1900	26

— number of standard violations

State Standard is 9 parts per million averaged over a ~~#~~ 8 hour period

STATE AND LOCAL AIR MONITORING REPORT
CREATED FROM NATIONAL AEROMETRIC DATA BANK

CARBON MONOXIDE PPM ALASKA 1983

METHOD: NONDISPERSIVE INFRARED (NDIR) CONTINUOUS, HOURLY VALUES-11, FLAME IONIZATION-21

SITE CODE AND ADDRESS	METH	REP ORG	** NUMBER OF 8-HOUR AVERAGE CONCENTRATIONS IN RANGES: * 0 TO 4	5 TO 8	9 TO 12	13 TO 16	17 TO 20	21 TO 24	25 TO 28	** OVER 28 *
ANCHORAGE BOROUGH										
020040013I01 625 C STREET ANCHORAGE	11		4795	315	5					
020040017I01 2902 SPENARD ROAD ANCHORAGE 99503 ANCHORAGE	11	020	6421	1636	440	67	8			
020040018I01 TRINITY CHRISTIAN CHURCH 3000 E. 16TH AVE ANCHORAGE	11	020	7148	944	216	55	16			
020040021I01 SAND LAKE DISTRICT 3426 RASPBERRY ROAD ANCHORAGE	11	020	8177	362	51					
FAIRBANKS NORTH STAR BOROUGH										
020160013F01 675 7TH AVE, FAIRBANKS FAIRBANKS	11	020	4150	864	171	33	4			
020160014G01 4TH AVE. AND LACEY ST., FAIRBANKS FAIRBANKS	11		5101	931	211	38	6			
020160020G01 HUNTER ELEMENTARY SCHOOL 17TH & GILLIAM FAIRBANKS	11	020	4819	732	169	15				

ALASKA
DEPT. OF ENVIRONMENTAL CONSERVATION
AUTOMATED ANALYZERS

NATIONAL AEROMETRIC DATA BANK
ENVIRONMENTAL PROTECTION AGENCY
SAROAD/PRECISION-ACCURACY REPORT

AUG 2, 1984
NA283/NAP000

PRECISION-ACCURACY DATA KEY RG	ST	RO	TYP	POLL	YR-Q	PRECISION DATA # OF ANLYZRS	PRECIS CHECKS	PROB LIM LO	PROB LIM UP	ACCURACY DATA SOURCE AUD GAS	TRACE ABLTY	# AUDITS L1-3	# AUDITS L4	PROB LIM LO-L1	PROB LIM L1-UP	PROB LIM LO-L2	PROB LIM L2-UP	PROB LIM LO-L3	PROB LIM L3-UP	PROB LIM LO-L4	PROB LIM L4-UP
10	02	020	C	42101	83-5	005	0106	-03	+04			0013	0000	-10	+06	-02	+04	-04	+03		
** CARBON MONOXIDE **																					

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CHARACTERIZATION OF AIR QUALITY IMPACTS FROM RESIDENTIAL WOOD COMBUSTION IN JUNEAU AND FAIRBANKS, ALASKA

FINAL REPORT

VOLUME II
FAIRBANKS

Prepared For:
State of Alaska
Dept. of Environmental Conservation
Pouch O
Juneau, Alaska 99811

By:
NEA, INC.
10950 S.W. 5th Street, Suite 380
Beaverton, Oregon 97005

June 20, 1984

CHARACTERIZATION OF AIR QUALITY IMPACTS FROM RESIDENTIAL WOOD COMBUSTION IN JUNEAU AND FAIRBANKS, ALASKA

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Clifton A. Frazier,
and
Lyle C. Pritchett

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June 20, 1984

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-Continued-

EXECUTIVE SUMMARY

The impact of wood smoke on ambient particulate levels in Fairbanks, Alaska, was studied during January and February of 1984. Aerosol samples were collected at the Nordale and Wood River schools using Sierra virtual impactor dichotomous samplers which sorted aerosol particles into a fine particles fraction (< 2.5 µm) and a coarse particle fraction (> 2.5 µm but less than 10 µm diameter). Twenty-four hour samples were collected on an every third day frequency. Samples were selected for analysis on the basis of high TSP loadings and fine particle loadings greater than 20 µg/m³.

Fine and coarse teflon filters were analyzed for their elemental content by X-ray fluorescence. Selected glass fiber TSP filters were analyzed for their organic and elemental carbon content by a pyrolysis-flame ionization procedure. Source contributions were quantified using a chemical mass balance receptor modeling procedure.

Eighty-five percent of the particulate mass collected by the dichotomous sampler was fine particles, most of which was carbon. Sulfur was the most abundant inorganic fine particle species accounting for 3.9% of the fine particle mass, almost twice the next most abundant species, which was Pb. Silicon was the most abundant coarse particle species (14.2%) followed by Ca (7.8%). The fine particle S concentration of 1.03 µg/m³ was substantially greater than the 0.68 µg/m³ concentration of coarse particle Si. Calcium and Si were more abundant in the coarse particle fraction while S, K, Br, and Pb were enriched in the fine particle fraction.

Sulfur and K are highly correlated with fine particle mass but not with each other. Lead is correlated with fine particle mass but less than S and K. Lead is also highly correlated with fine particle Br but was not correlated with S.

The average source contributions are summarized in Table I and illustrated with the pie charts shown in Figures I-IV.

There are three primary sources of fine particles: transportation, wood smoke, and distillate oil. This is consistent with the above noted correlations. Wood smoke was responsible for 47% (20 $\mu g/m^3$) of the fine particle mass sampled at Nordale school, while distillate oil contributed 18% (7.7 $\mu g/m^3$) and transportation contributed 16% (6.8 $\mu g/m^3$).

Soil and road dust accounted for 41% (1.7 $\mu g/m^3$) of the coarse particle mass at the Nordale school; coal fly ash accounted for 38% (1.6 $\mu g/m^3$) and transportation was responsible for 20% (0.84 $\mu g/m^3$).

A large portion of the TSP was not sampled by the dichotomous sampler and as a result was not apportioned to specific sources. This unapportioned TSP mass, however, more than likely originates from the same sources responsible for the dichotomous coarse particle mass. Since almost all of the wood smoke particles are less than 2.5 μm, the fine particle mass impacts for this source are an accurate representation of this source's contribution to TSP within its listed uncertainty.

Table I

SUMMARY OF AVERAGE JANUARY AND FEBRUARY SOURCE CONTRIBUTIONS*

City	Site No.	Site Name	Part. Size	SOURCE CONTRIBUTION*							
				TRANSP	WBURN	DUST	SULFATE	MARINE	DSTOIL	RESIDU.	COAL.
Juneau	1	F.D. School	F	2.1	30	0.13	1.7	0.17	1.3	-	-
				5.8	82	0.36	4.7	0.47	3.6	-	-
			C	0.13	-	1.8	0.11	0.20	-	-	-
				5.7	-	80	4.8	8.7	-	-	-
	2	S. Bear	F	3.9	27	0.29	2.1	0.19	0.41	-	-
				11.1	77	0.83	6.0	0.54	1.17	-	-
			C	0.59	-	4.2	0.04	0.056	-	-	-
				13.1	-	93	0.89	1.2	-	-	-
	3	L. Creek	F	0.66	9.1	0.26	0.26	-	2.2	-	-
				3.1	43	1.2	1.2	-	10.4	-	-
			C	0.15	-	1.9	0.08	0.03	0.66	-	-
				6.0	-	76	3.3	1.2	26	-	-
Fairbanks	4	N. School	F	7.4	22	0.05	1.6	-	7.5	-	-
				17	49	0.1	3.6	-	17	-	-
			C	0.84	-	1.7	-	-	-	0.002	1.6
				20	-	41	-	-	-	0.05	38
	5	W.R. School	F	3.0	12.3	1.2	1.1	-	1.1	-	-
				14	57	5.6	5.1	-	5.1	-	-
			C	0.20	-	1.26	-	-	-	0.004	0.57
				10.5	-	66	-	-	-	0.19	30

* The top number listed is the source contribution in $\mu g/m^3$, while the bottom number listed in the source contribution in percent of measured mass. TRANSP: Transportation, WBURN: Wood Smoke, DUST: Road and soil dust, SULFATE: $SO_4^=$, DSTOIL: Distillate oil smoke, RESIDU: Residual Oil smoke, COAL: Coal Fly Ash

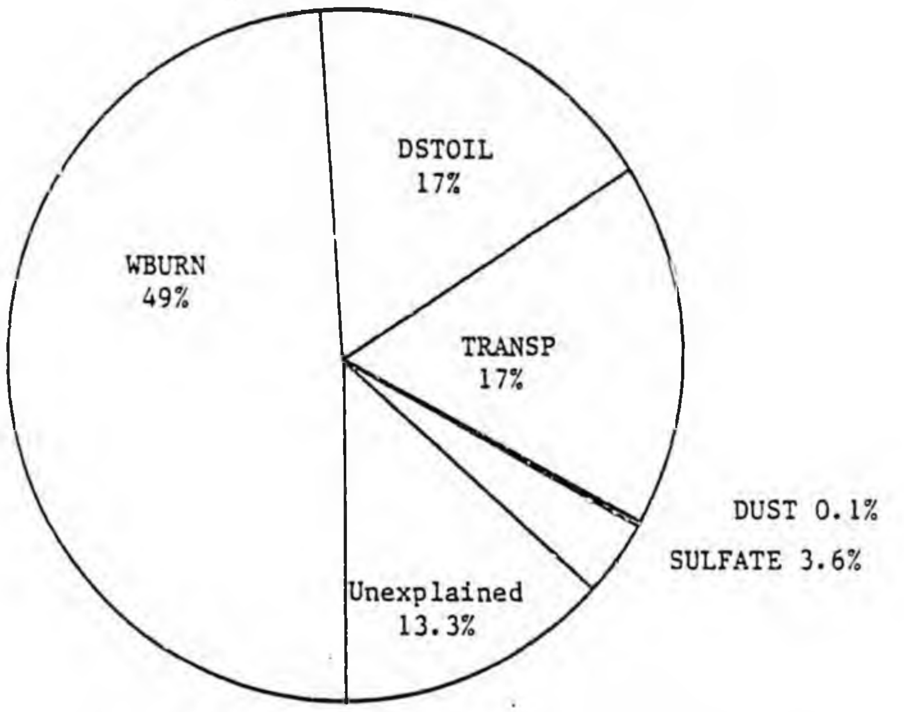

Figure I. Pie chart of percent source contributions to fine particle mass measured at the Nordale School monitoring site.

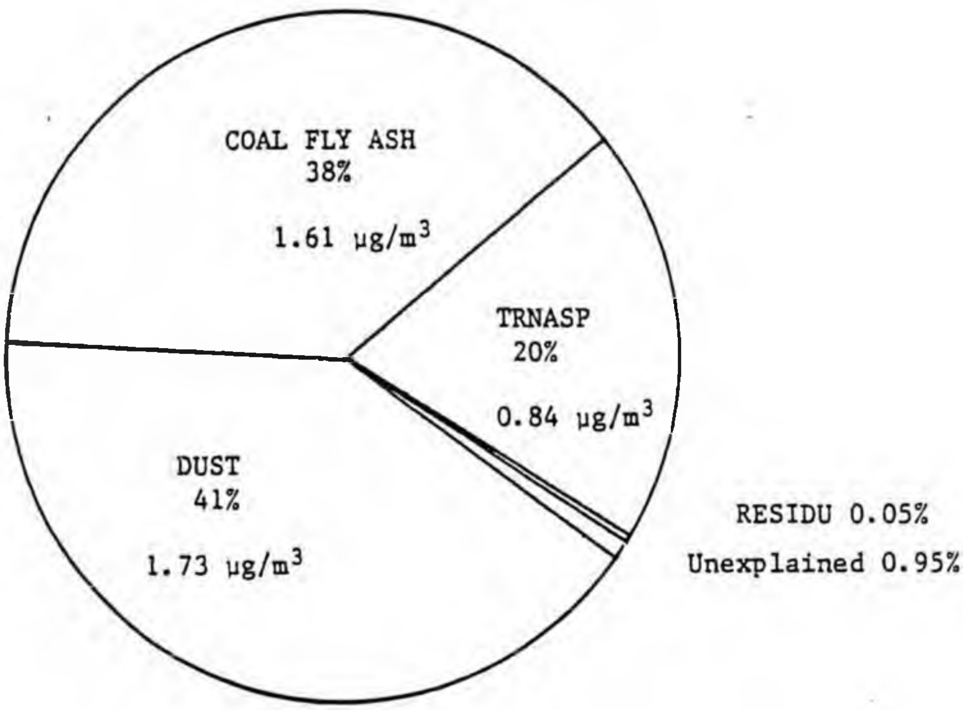

Figure II. Pie chart of percent source contributions to coarse particle mass measured at the Nordale School monitoring site.

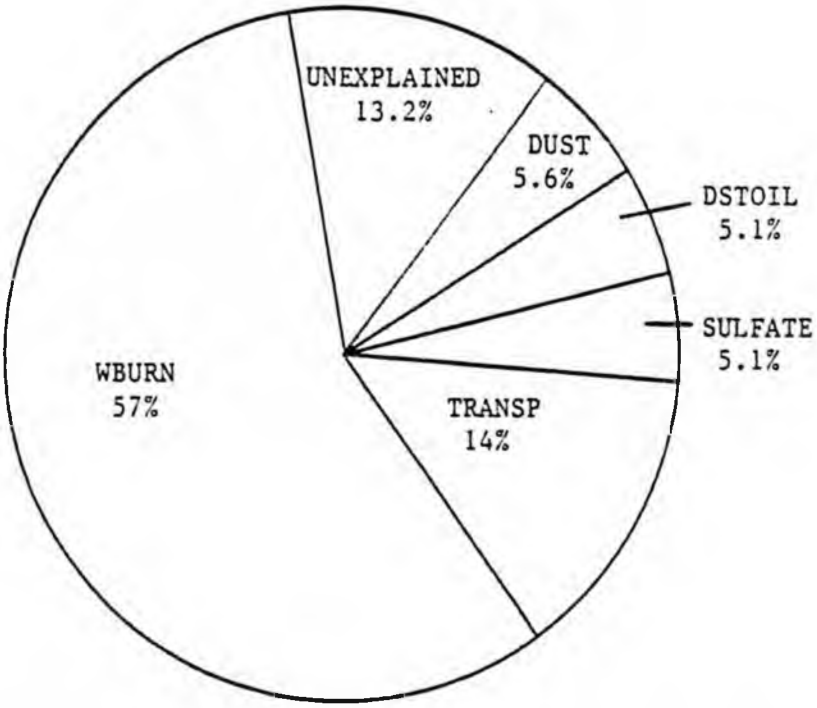

Figure III. Pie chart of percent source contributions to fine particle mass measured at the Wood River School monitoring site.

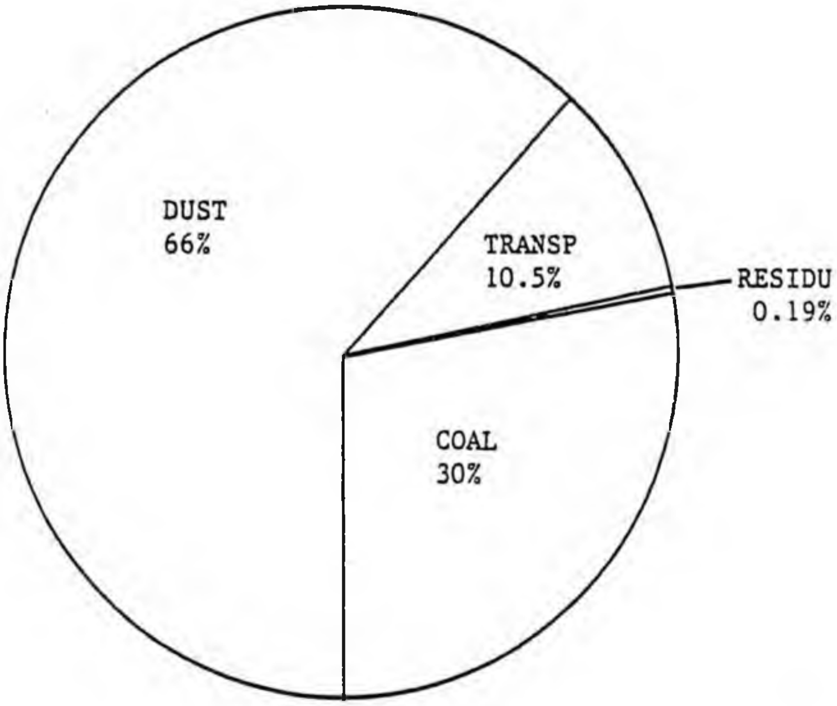

Figure IV. Pie chart of percent source contributions to coarse particle mass measured at the Wood River School monitoring site.

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CHARACTERIZATION OF AIR QUALITY IMPACTS FROM RESIDENTIAL WOOD COMBUSTION IN JUNEAU AND FAIRBANKS, ALASKA

FINAL REPORT

VOLUME I
JUNEAU

Prepared For:
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Beaverton, Oregon 97005

June 20, 1984

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EXECUTIVE SUMMARY

The impact of wood smoke on ambient particulate levels in Juneau, Alaska, was studied during January and February of 1984. Aerosol samples were collected at Floyd Dryden school, Super Bear shopping center, and at a Lemon Creek residential site using Sierra virtual impactor dichotomous samplers which sort aerosol particles into a fine particle fraction (< 2.5 μm) and a coarse particle fraction (> 2.5 μm but less than 10 μm). Twenty-four hour samples were collected on an every third day frequency. Samples were selected for analysis on the basis of high TSP loadings and fine particle mass loadings greater than 20 μg/m^3.

Fine and coarse teflon filters were analyzed for their elemental content by X-ray fluorescence. Selected glass fiber TSP filters were analyzed for their organic and elemental carbon content by a pyrolysis-flame ionization procedure. Source contributions were quantified using chemical mass balance receptor modeling procedures.

Eighty-one percent of the particulate mass collected by the dichotomous sampler was fine particles, most of which was carbon. Sulfur was the most abundant inorganic fine particle species accounting for 2.6% of the fine particle mass. Chlorine, Si, and Pb were also relatively abundant fine particle species. Silicon was the most abundant coarse particle species (12.5%) followed by Cl which accounted for 8.5% and Fe (3.2%). Silicon, Cl, Ca, and Fe were more abundant in the coarse fraction, while S, K, Zn, Br, and Pb were enriched in the fine particle fraction.

Sulfur and K are highly correlated with the fine particle mass and with each other. Lead is correlated with the fine particle mass but less than S and K. Lead is also highly correlated with Br.

The average source contributions are summarized in Table I and illustrated with pie charts shown in Figures I-VI.

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-Continued-

Wood smoke was responsible for about 80% (30 $\mu g/m^3$) of the fine particle mass. Transportation, secondary sulfate, and distillate oil are the only other fine particle sources.

Soil and road dust accounts for 80% of the coarse particle fraction.

High TSP episodes are usually the result of either high wood smoke, high soil and road dust, or combinations of these two sources.

Table I

SUMMARY OF AVERAGE JANUARY AND FEBRUARY SOURCE CONTRIBUTIONS*

City	Site No.	Site Name	Part. Size	SOURCE CONTRIBUTION*							
				TRANSP	WBURN	DUST	SULFATE	MARINE	DSTOIL	RESIDU.	COAL
Juneau	1	F.D. School	F	2.1	30	0.13	1.7	0.17	1.3	-	-
				5.8	82	0.36	4.7	0.47	3.6	-	-
			C	0.13	-	1.8	0.11	0.20	-	-	-
				5.7	-	80	4.8	8.7	-	-	-
	2	S. Bear	F	3.9	27	0.29	2.1	0.19	0.41	-	-
				11.1	77	0.83	6.0	0.54	1.17	-	-
			C	0.59	-	4.2	0.04	0.056	-	-	-
				13.1	-	93	0.89	1.2	-	-	-
	3	L. Creek	F	0.66	9.1	0.26	0.26	-	2.2	-	-
				3.1	43	1.2	1.2	-	10.4	-	-
			C	0.15	-	1.9	0.08	0.03	0.66	-	-
				6.0	-	76	3.3	1.2	26	-	-
Fairbanks	4	N. School	F	7.4	22	0.05	1.6	-	7.5	-	-
				17	49	0.1	3.6	-	17	-	-
			C	0.84	-	1.7	-	-	-	0.002	1.6
				20	-	41	-	-	-	0.05	38
	5	W.R. School	F	3.0	12.3	1.2	1.1	-	1.1	-	-
				14	57	5.6	5.1	-	5.1	-	-
			C	0.20	-	1.26	-	-	-	0.004	0.57
				10.5	-	66	-	-	-	0.19	30

* The top number listed is the source contribution in $\mu g/m^3$, while the bottom number listed in the source contribution in percent of measured mass. TRANSP: Transportation, WBURN: Wood Smoke, DUST: Road and soil dust, SULFATE: $SO_4^{=}$, DSTOIL: Distillate oil smoke, RESIDU: Residual Oil smoke, COAL: Coal Fly Ash

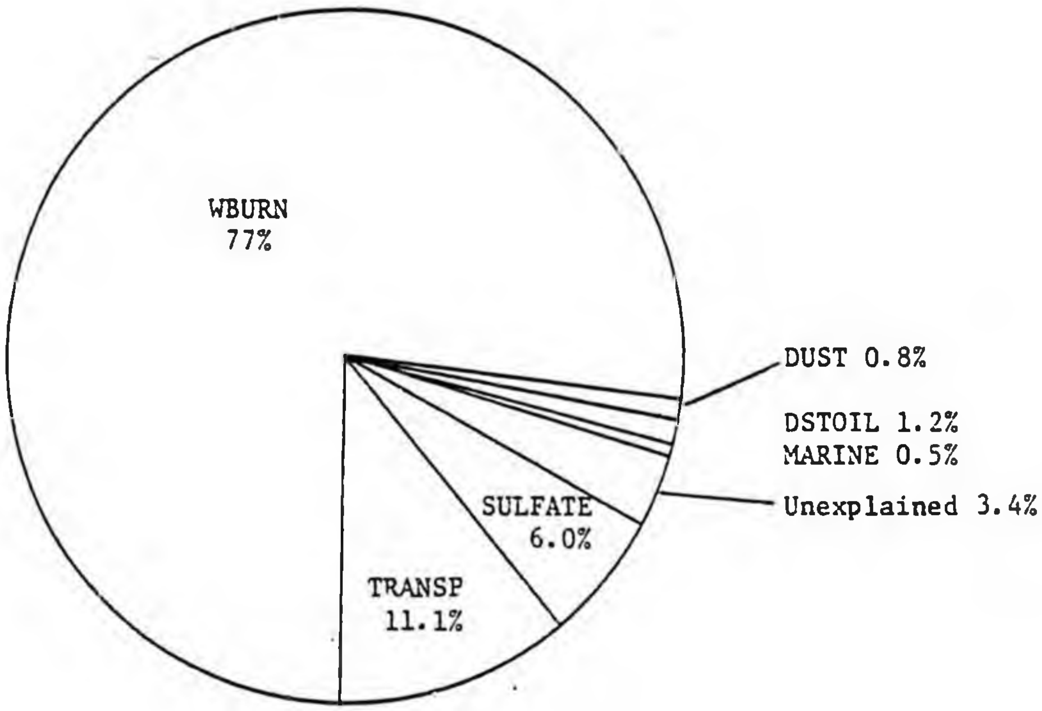

Figure III. Pie chart of percent source contributions to fine particle mass measured at the Super Bear monitoring site.

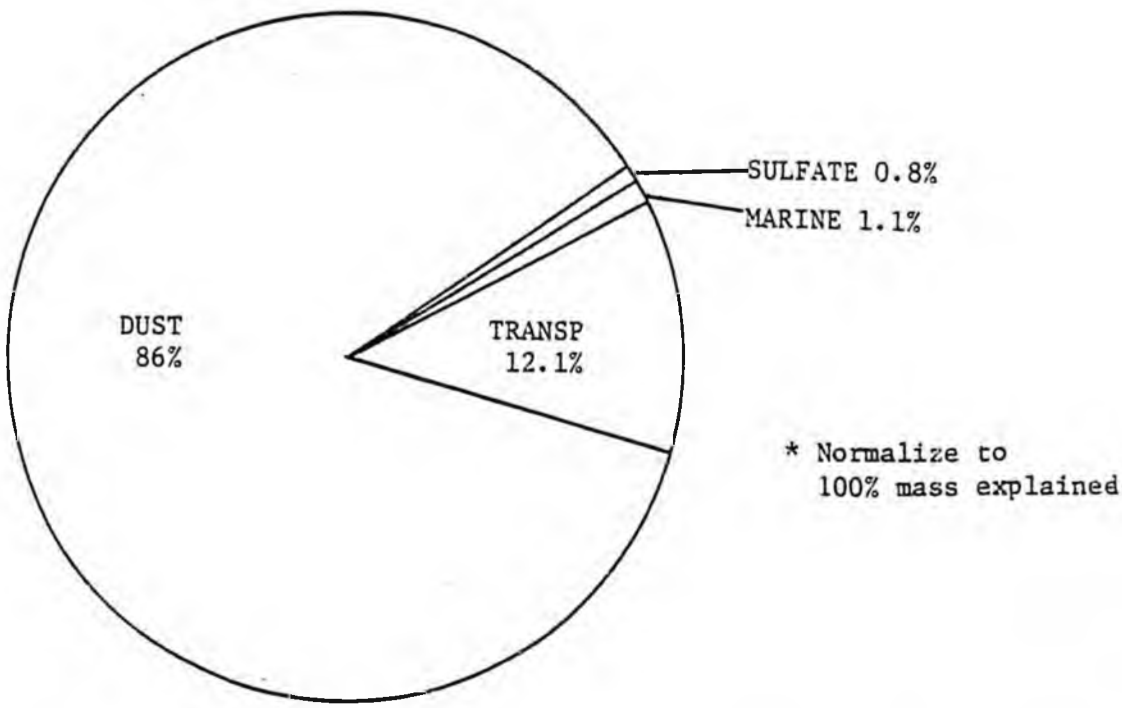

Figure IV. Pie chart of percent source contributions to coarse particle mass measured at the Super Bear monitoring site.

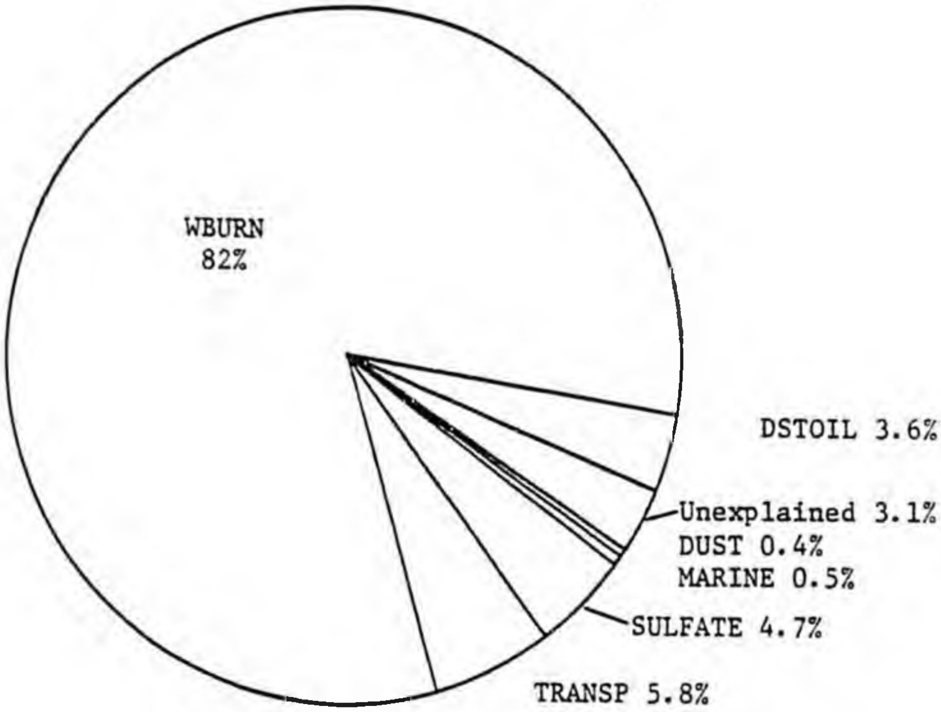

Figure I. Pie chart of percent source contributions to fine particle mass measured at the Floyd Dryden school monitoring site.

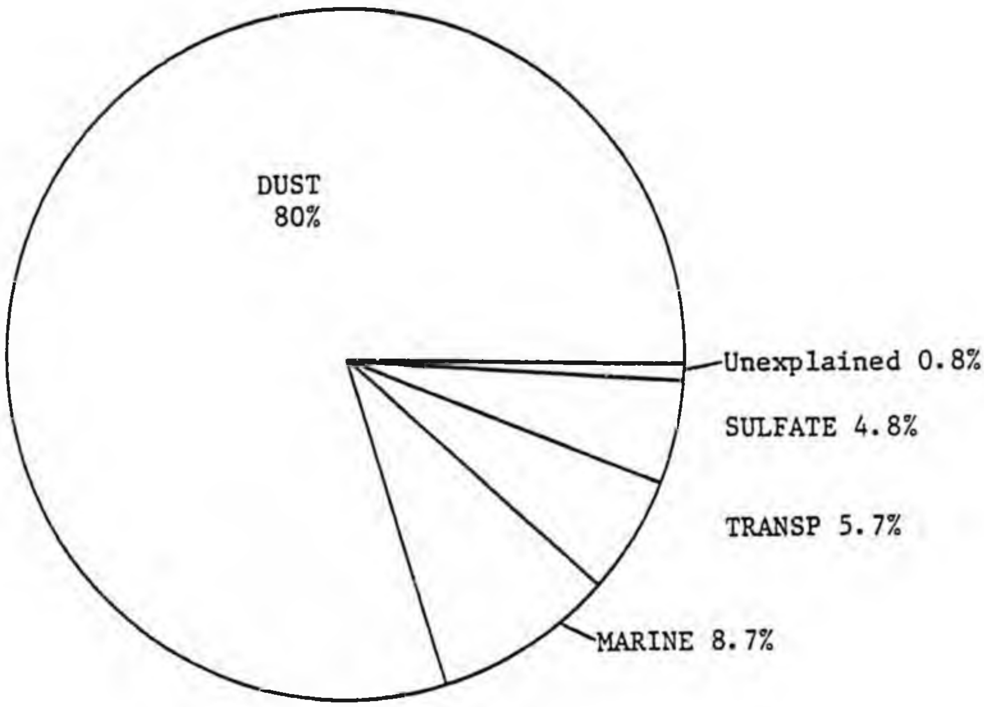

Figure II. Pie chart of percent source contributions to coarse particle mass measured at the Floyd Dryden school monitoring site.

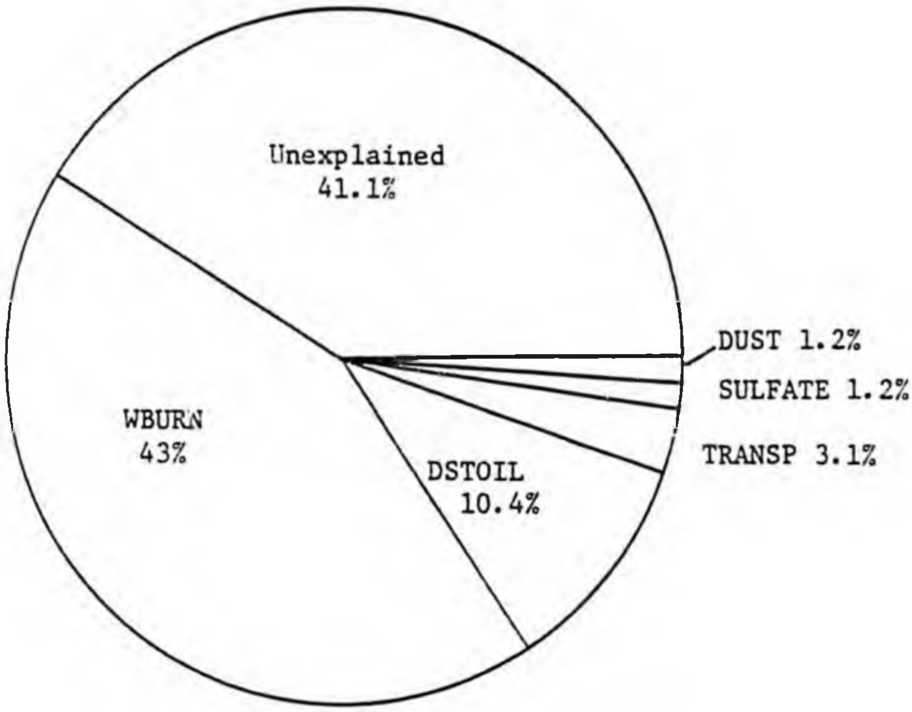

Figure V. Pie chart of percent source contributions to fine particle mass measured at the Lemon Creek monitoring site.

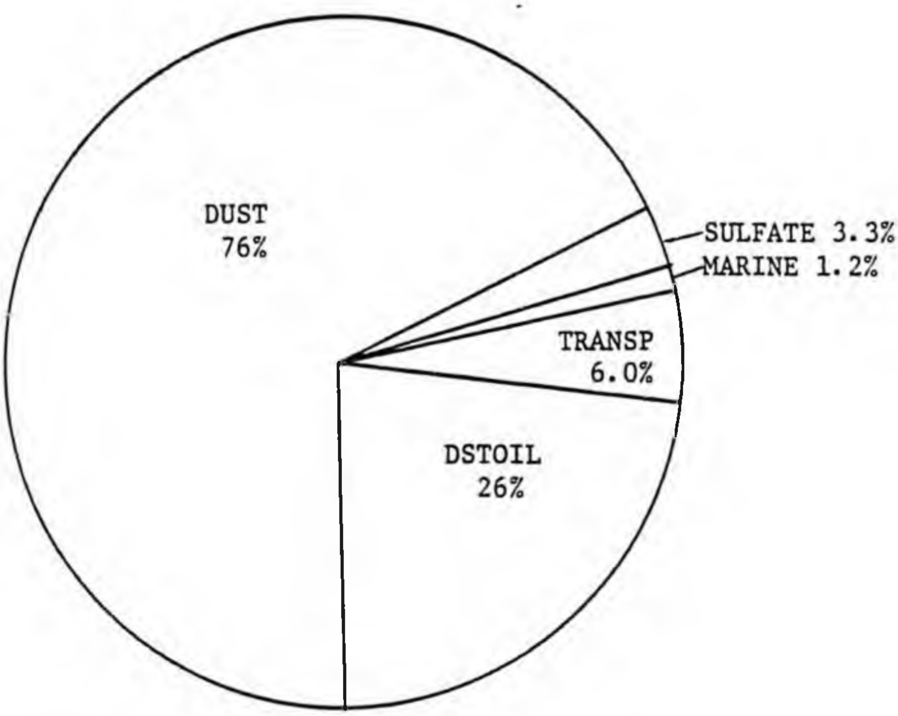

Figure VI. Pie chart of percent source contributions to coarse particle mass measured at the Lemon Creek monitoring site.

F10EZA
KENAI

A PRELIMINARY STUDY OF THE WATER QUALITY OF SELECTED KENAI LAKES WITH CONSIDERATIONS OF ACID RAINFALL

KENAI, ALASKA

SEPTEMBER 1980

A WORKING PAPER

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF ENVIRONMENTAL QUALITY OPERATIONS
ENVIRONMENTAL QUALITY MONITORING AND LABORATORY OPERATIONS

A working paper presents results of investigations which may be limited or incomplete. Therefore, conclusions expressed or implied are tentative. Mention of trade names or commercial products does not constitute endorsement or recommendation by the State of Alaska.

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PURPOSE

This investigation was conducted in order to evaluate the water quality of selected lakes located within the boundaries of the Kenai Peninsula. Of particular interest was the collection of parametric data that would determine the presence or absence of acid rainfall. The area under study was the Kenai industrial complex and surrounding public lands.

The planned expansion of the Kenai Tesoro refinery, together with the existing industrial complex, have raised questions regarding potential impacts upon the Kenai National Moose Range. Of concern are the levels of sulfur dioxide and oxides of nitrogen in ambient air and impacts, if any, caused by those pollutants on nearby aquatic and terrestrial environments.

INTRODUCTION

Through the combustion of fossil fuels, sulfur dioxide and oxides of nitrogen are emitted into the atmosphere. As these gases react with water vapor and rain, sulfuric and nitric acids are formed. Power plants, home oil furnaces, automobiles and refineries - in fact any process that oxidizes fossil fuels - can contribute to ambient levels of sulfur dioxide and nitrogen oxides.

Acid precipitation in the form of rain, snow, hail, sleet, fog or dew is considered to have a pH of less than 5.6(1). A pH of 7.0 is considered to be neutral. The international pH scale is logarithmic; each whole number is a factor of ten larger than its preceeding value. Precipitation in relatively clean air will have an approximate pH of 5.6. Rain is slightly acidic normally because atmospheric carbon dioxide is soluble in water and forms a dilute solution of carbonic acid. This in turn dissociates to form bicarbonate and carbonate ions via the following equilibrium:

$$CO_2 \text{ (gas)} \rightleftharpoons CO_2 \text{ (solution)}$$
$$CO_2 \text{ (solution)} + H_2O \rightleftharpoons H_2CO_3$$
$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$$
$$HCO_3^- \rightleftharpoons CO_3^{2-} + H^+$$

Acid deposition onto the earth's surface has a net cumulative effect. It results from a complex mixture of dissociated acidic and basic substances. The deposition of these substances may result from dissolution in the precipitation itself, and is referred to as "wet deposition". Or it may result from the "dry deposition" of particulate matter - smoke - through gravitational settling, impaction of particulate aeresols and/or absorbtion or adsorption of gases. In nature, both deposition processes are usually at work, to varying degrees.

The effects of atmospheric deposition upon freshwater aquatic ecosystems have been well documented in the Scandanavian countries and Canada (5). Although not as comprehensive, data is available that shows increasing acidity in lakes and streams predominately in the Northeast United States (6,8). This situation places stress upon the biota of an aquatic ecosystem, especially fish. Acid rainfall can mobilize heavy metal ions, decrease carbonate alkalinity and hence buffering capacity, and increase nitrate and sulfate concentrations (1,6).

Wind is the mechanism by which the source of acid rainfall is transported. Atmospheric deposition can occur a considerable distance from the emission source. It has been suggested that at least a portion of the acid rain found in Europe may originate from the large Northeast cities in the United States.

During the winter acid precipitation may accumulate in the form of snow. During spring thaw, acid melt water can surge into the aquatic ecosystem in a short time. Unless the natural buffering capacity of a lake or stream can neutralize the hydrogen ion activity of the melted snow, a significant decrease in pH can occur. This acidic condition stresses the aquatic biota. A substantial change in pH may prove toxic to emerging biota.

DESCRIPTION

The Kenai industrial complex is located on the west side of the Kenai Peninsula along Cook Inlet (See Figs. 1,2). It is approximately 8.5 miles north of Kenai, Alaska and situated along North Kenai Road. The complex includes the following industries:

1. Collier Ammonia and Urea Plant.
2. Phillips Marathon Liquification Facility.
3. Tesoro Refinery.
4. Standard Refinery.
5. Chugach Power Plant.

The Kenai National Moose Range lies east of the Tesoro Refinery with its closest boundary approximately 6.5 miles due east. Between the industrial complex and the Moose Range lies a strip of land utilized for residential, commercial and undeveloped state/municipal public lands.

Figure 3 shows the approximate wind directions during 1977 in per cent of month units for the Kenai area (10). Prevailing wind directions for Kenai based on a nineteen year record (pre-1970 data) depict a northerly direction during the fall, winter and spring months and a southerly direction in the summer. Apparently, this is related to a wind channeling effect of the inlet (7).

The maximum precipitation period in the Kenai area usually occurs between June through October with a maximum of 3.6 inches in September (7).

The surrounding terrestrial environment is typically flat and forested predominately with spruce, birch, and aspen. Forest and wetlands are the dominant ecotypes of the study environs. A network of glacially formed pothole lakes, bogs, interconnecting streams and the Kenai River provide aquatic diversity to the area.

METHODS

In order to determine the effects of industry upon lakes surrounding Kenai and within the Kenai National Moose Range, water samples were taken from several lakes and one stream drainage in the study area. Sampling locations were selected on the basis of accessibility, prevailing wind direction, distance both from the industrial complex and from Tesoro Alaska's model of ambient NO_2 concentrations (9).

For this study, Scout Lake was designated as an experimental control. This lake was selected in the same manner as the study lakes except that Scout was expected to be least impacted by the industrial development. Scout Lake is approximately 20 miles south - southwest from the Tesoro refinery and about one quarter mile south of the Sterling Highway. The lake is reasonably isolated from the highway be vegetation. There is no observable inlet or outlet stream and the western half of the lake is predominately muskeg. There are two residential sites at the southwestern tip of the lake and a public campground along the northwestern shore. Float plane facilities were also visible at the western tip of the lake.

Five lakes and one creek were selected as the study lakes:

1. <u>Bernice Lake</u> - located 0.5 miles north of the Tesoro refinery. Bernice has muskeg bog drainage into an outlet stream.

2. <u>Island Lake</u> - located 2 to 3 miles northeast of the Tesoro refinery. No apparent stream drainage.

3. <u>Daniels Lake</u> - located about 6 to 8 miles northeast of the refinery. This lake has both an inlet and an outlet stream.

4. <u>Lower Salamantof Lake</u> - This lake is located 4 miles south by southeast of the Tesoro refinery. Inlet and outlet drainages are visible.

5. <u>Rainbow Lake</u> - located about 20 miles ~~west~~ EAST of the refinery. This lake is situated within the Kenai National Moose Range along the Swanson River Road approximately 13 miles north. This lake has an outlet stream but no apparent inlet stream.

6. <u>Bishop Creek</u> - located 10 miles east by northeast of the Tesoro refinery. This stream was sampled where it intersects the North Kenai Road. A gauging station was in place about 150 yards downstream from the sampling site.

For additional information related to these sampling locations refer to the Appendix.

Transportation to and from the sampling locations was arranged through cooperation with the Alaska Department of Fish and Game, Sport Fish Division in Soldotna. Field assistance involving manpower and some equipment was arranged through cooperation with both the US Fish and Wildlife Service - Fishery Resource Center in Kenai and the Alaska Department of Environmental Conservation Field Office in Soldotna.

Water samples were acquired with the use of an 8 foot Zodiac inflatable boat and a 16 foot skiff and outboard motor, depending upon circumstances. However, the skiff had distinct advantages. Good access was available at all sampling locations.

The following parameters, sampling methods and analysis were employed:

PARAMETER	SAMPLING METHOD	ANALYTICAL METHOD
Water temperature	In Situ	YSI Model 57 D.O. Meter
Dissolved Oxygen	In Situ	YSI Model 57 D.O. Meter
pH	On Site	Orion Model 407 A Ionalyzer
Carbonate Alkalinity	On Site	EPA Method 310.0 titration to pH 4.5 end point
Color	Grab @ surface Van Dorn Bottle @ Depth	Laboratory - Standard Methods
Turbidity	Grab @ surface Van Dorn Bottle @ Depth	Laboratory - Standard Methods
Total Non Filterable	Grab @ surface Van Dorn Bottle @ Depth	Laboratory - Standard Methods
Residue dried @ 103-105C	Grab @ surface Van Dorn Bottle @ Depth Refridgerated	Laboratory - Standard Methods
Nitrate	Grab @ surface Van Dorn Bottle @ Depth Refridgerated Frozen at laboratory	Manual Cadmium Reduction; EPA Method
Sulfate	Grab @ surface Van Dorn Bottle Sample @ Depth Refridgerated	Barium sulfate turbidity method
Heavy Metals	Grab @ surface Van Dorn Bottle @ Depth Refridgerated	Graphite furnace AA. See See Table 3 which includes lower limits of detection and method for each parameter.

Sampling depths varied with the maximum depth of each lake. Sample stations were usually located at two sites for each lake, roughly in the center of each lake half. However, knowledge of bathymetry helped determine at least one sample site for each lake. Due to the extreme shallowness of lower Salamantof Lake, four stations were sampled at depths of zero and one meter with the lake quartered and each sampling station located roughly at the center of each quarter.

Bishop Creek was sampled at a cross section located approximately 150 yards above the gauging station. This station is located on the southern side of the North Kenai Road where it intersects Bishop Creek. Flow was estimated using the "floating object method". It is believed that the creek is representative of its drainage basin with respect to water quality.

All sampling was performed between September 4, 1980 through September 8, 1980.

RESULTS

The results of this study are tabulated on Tables 4 through 10. Analysis for antimony and berrilyium are pending receival of necessary standard materials. All other determinations are complete.

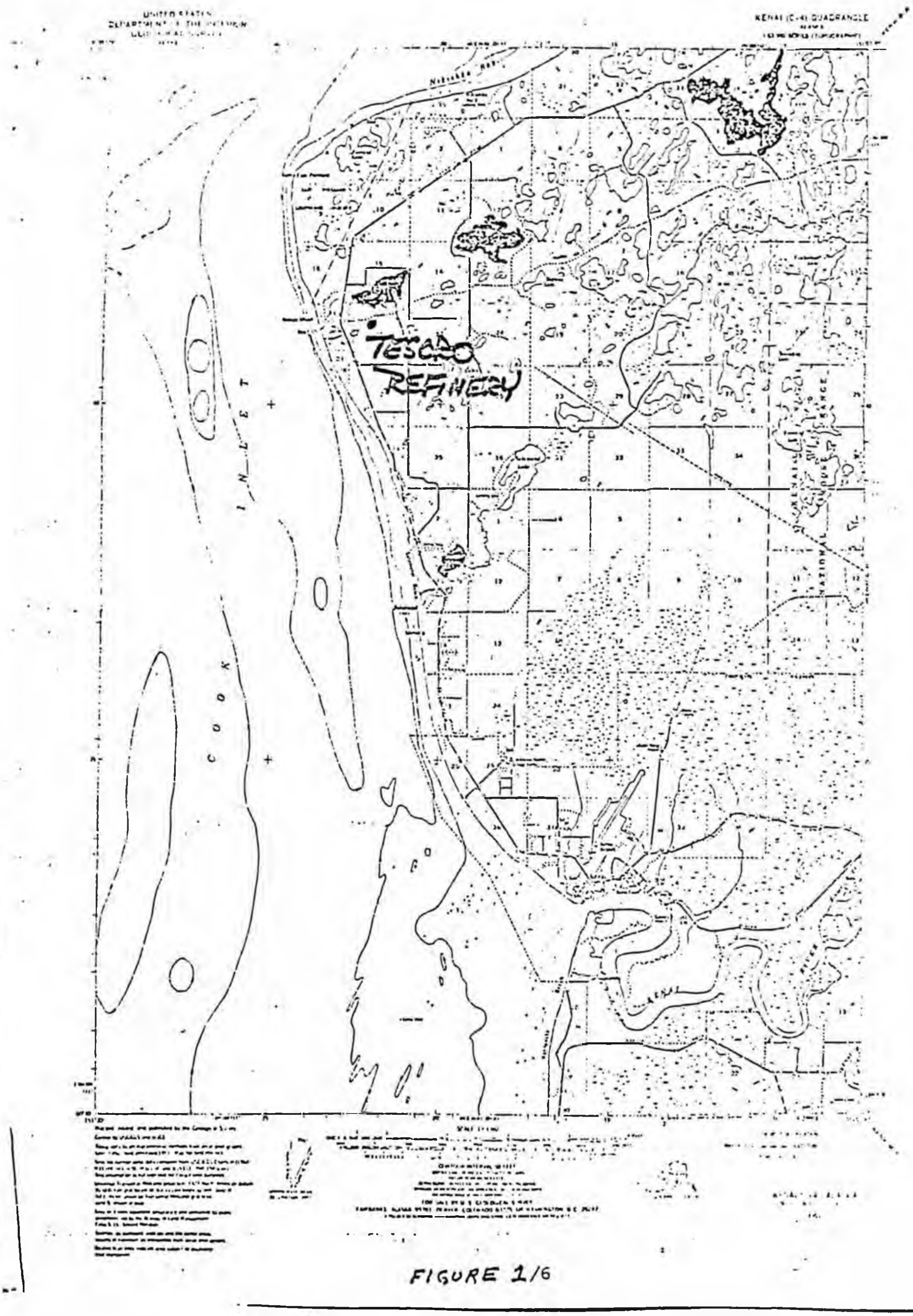

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
KENAI (C-4) QUADRANGLE
TESORO
REFINERY
COOK
INLET
KENAI

FIGURE 1/6

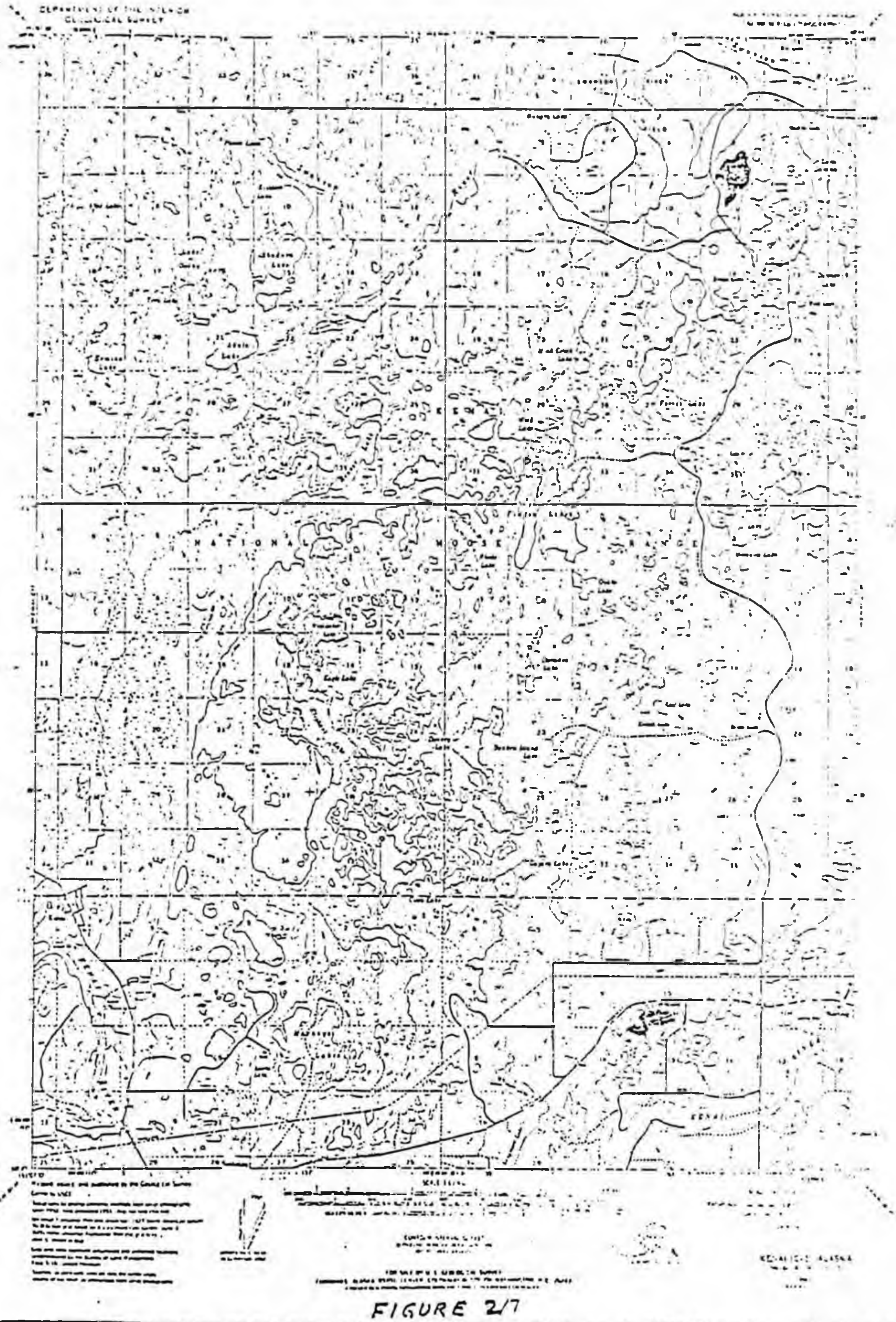
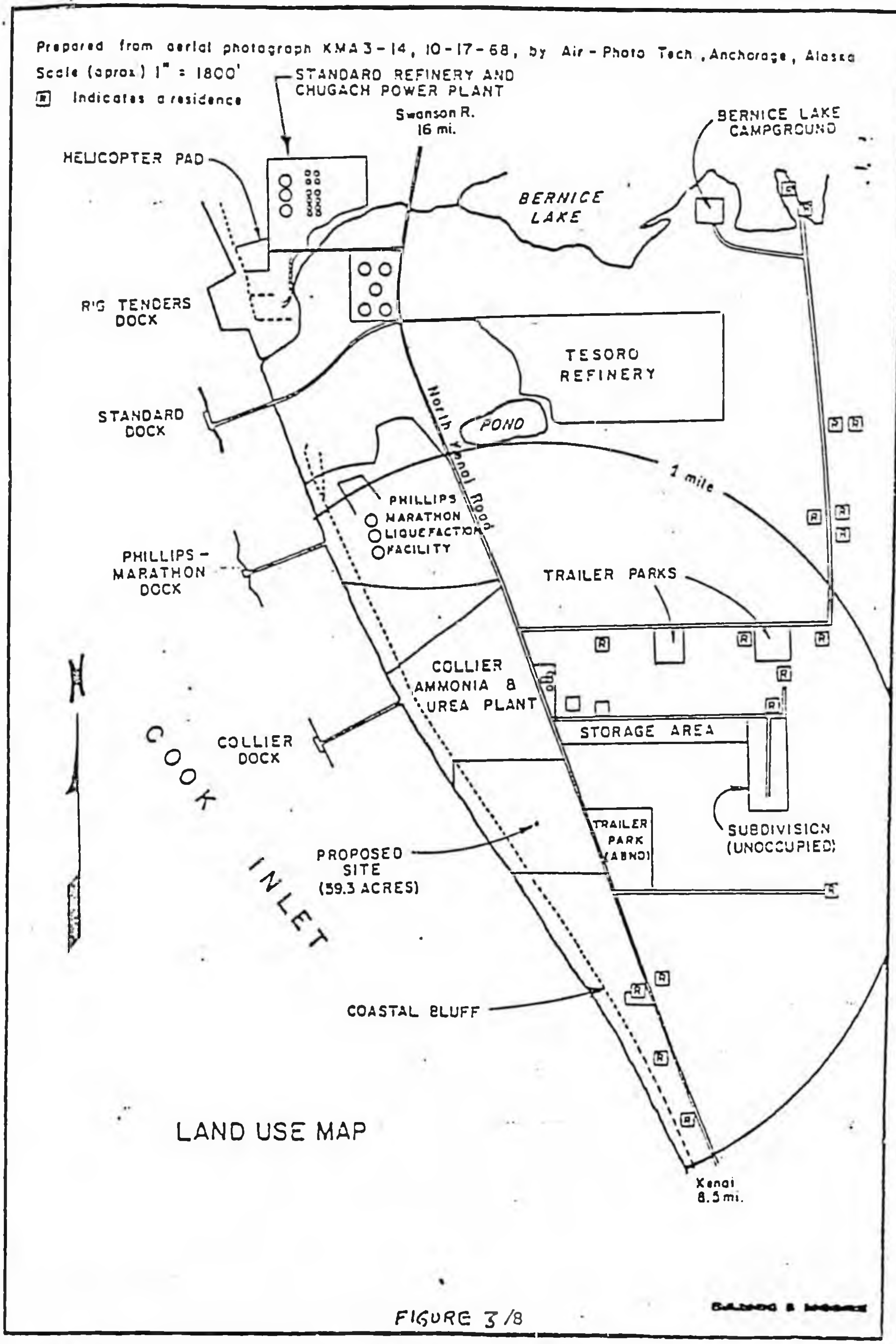


FIGURE 2/7



LAND USE MAP

FIGURE 3/8

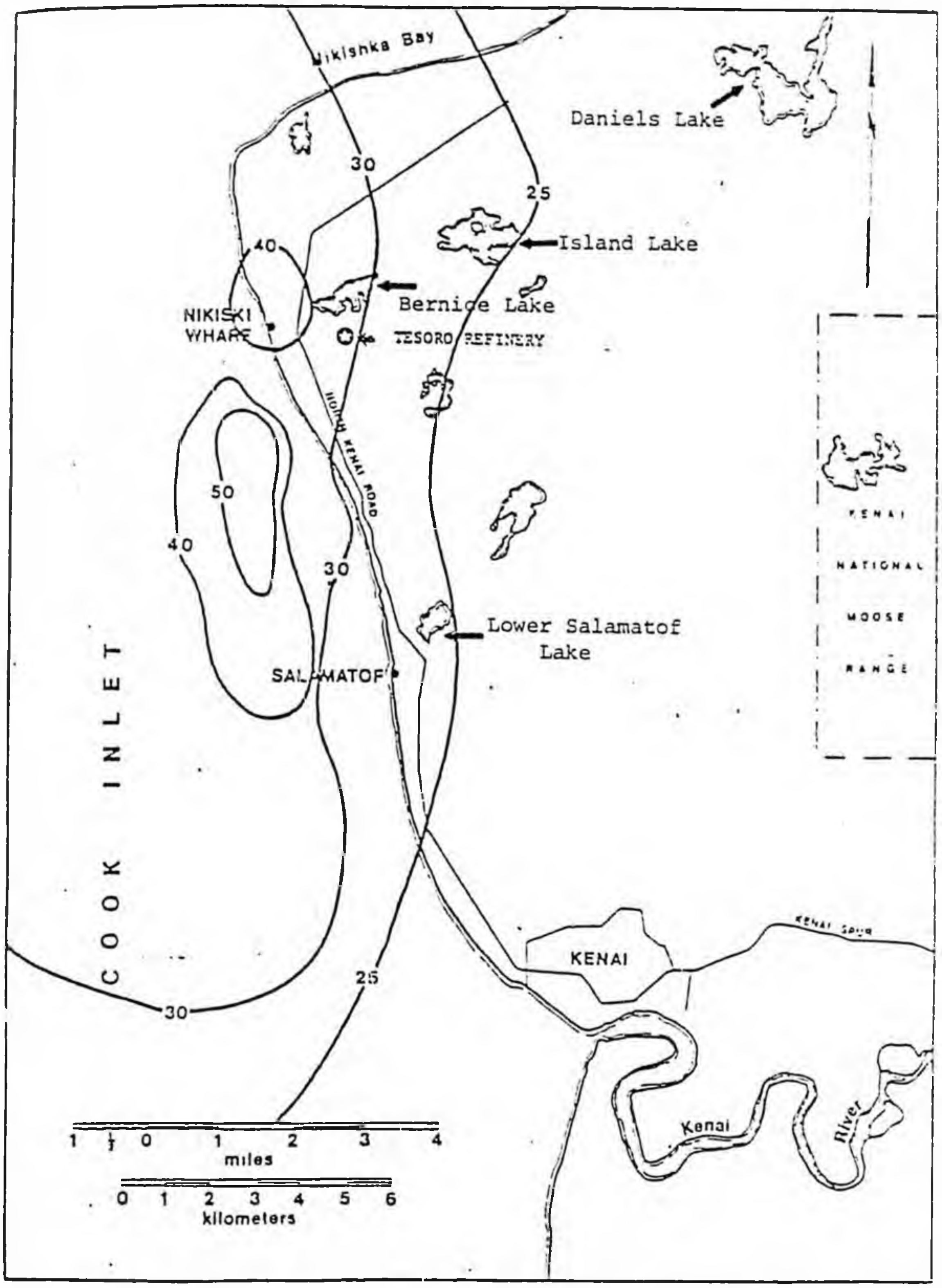


Figure 4. Existing NO_2 Concentrations in the Immediate Area of the Tesoro Refinery as Predicted by CDM (Background level included)

TABLE 1

Prevailing Wind Direction for Kenai by month, based on 19 year length of record (pre-1970 data). From: CLIMATOLOGICAL DATA SUMMARY; Dept. of Commerce, ESSA-Environmental Data Service.

Jan.	NNE	July	SSW
Feb.	N	August	S
March	N	Sept.	N
April	N	Oct.	N
May	N	Nov.	NNE
June	SSW	Dec.	NNE

June - October - Maximum precipitation period.

September mean for 19 year length of record = 3.6 inches.

Annual mean hourly wind speed based on 19 year length of record = 6.6 M.P.H.

TABLE 2

APPROXIMATE WIND DIRECTIONS

FOR KENAI - YEAR 1977

CLIMATIC ATLAS, VOLUME 1

GULF OF ALASKA - 1977

APPROXIMATE WIND DIRECTIONS - % OF MONTH

	N	NE	E	SE	S	SW	W	NW	CALM
Jan.	22	36	6	*	*	4	*	*	18
Feb.	37	30	*	*	5	*	*	*	14
March	38	22	*	*	6	*	*	7	11
April	29	17	6	5	9	9	*	8	13
May	17	13	7	7	15	18	5	6	10
June	9	8	*	7	24	29	5	*	9
July	8	5	*	8	28	29	5	*	11
August	13	11	5	8	22	18	*	*	15
Sept.	23	19	7	8	9	8	*	5	16
Oct.	30	25	8	8	6	*	*	*	15
Nov.	29	25	8	5	*	*	*	*	14
Dec.	30	33	7	*	*	*	*	*	19

*Denotes <5% of winds from specified direction.

TABLE [illegible]

Parameter of Interest	Lower Limit of detection (mg/l)	Lo[illegible] Limit of quantification (mg/l)	mg/l Reporting Interval	mg/l MCL	Method
Ag	<0.0003	0.003	ND<Trace<0.003	0.05	AA/HGA
As	<0.001	0.005	ND<Trace<0.005	0.05	AA/HGA
Ba	<0.002	0.05	ND<Trace<0.05	1.0	AA/HGA
Cd	<0.0002	0.001	ND<Trace<0.001	0.01	AA/HGA
Cr	<0.0007	0.005	ND<Trace<0.005	0.05	AA/HGA
F	<0.02	0.2	ND<Trace<0.2	2.4	Electrochem.
Fe	<0.01	0.1	ND<Trace<0.1	0.3	AA/HGA
Hg	<0.0002	0.001	ND<Trace<0.001	0.002	Flameless AA
Mn	<0.0004	0.005	ND<Trace<0.005	0.05	AA/HGA
Na	<0.1	0.03	ND<Trace<5.0	250	Flame AA
NO_3	<0.05	1.0	ND<Trace<1.0	10	Cd reduction
Pb	<0.003	0.005	ND<Trace<0.005	0.05	AA/HGA
Se	<0.001	0.003	ND<Trace<0.003	0.01	AA/HGA
Cu	<0.001	0.005	ND<Trace<0.005		AA/HGA
Ni	<0.003	0.010	ND<Trace<0.010		AA/HGA
Zn	<0.0005	0.010	ND<Trace<0.010		AA/HGA
Mo	<0.010	0.050	ND<Trace<0.050		AA/HGA
PO_4	<0.05	0.5	ND<Trace<0.5		Colorimetry
C.O.D.	<6.1	25	ND<Trace<25		Digestion
SO_4	<1	10	ND<Trace<10		Turbidity
NH_3	0.03	0.1	0.03<Tr.<0.1		Electrochem.
Cl	1	10	1<Tr.<10		Flame AA
K	0.05	1.0	0.05<1.0<1		Flame AA
CA	0.1	5.0	ND<Tr.<5		Flame AA
Mg	0.1	5.0	ND<Tr.<5		Flame AA

DISCUSSION OF RESULTS

SCOUT LAKE

Scout Lake was chosen as the control lake. Since it is located far from the industrial complex, it was expected to be less subjected to ambient levels of sulfur dioxide and oxides of nitrogen generated from the refineries.

Scout has no apparent inlet or outlet. It has a maximum depth of 7.3 meters and surface area of about 9.5 acres Scout Lake was found to be well oxygenated having DO concentrations ranging from 9 to 10 mg/l. It was also well thermally mixed at the time of sampling. The pH of this lake was relatively low compared to others in this study, ranging from 5.9 to 6.6. Similarly carbonate alkalinity was found to be low - only 5 to 8 mg/l expressed as $CaCO_3$.

Unexpectantly, levels of 'color' in Scout Lake were low ranging from 5 to 10 Platinum Cobalt Units (PCU). If this lake was receiving significant quantities of humic or fulvic acids from decaying vegetation as was assumed, it would be expected to have the color of weak tea - from 50 to 100 PCU.

Turbidity and total-non filterable residue (TNFR) were all quite low. Nitrate and sulfate were present in trace quantities or less.

Manganese found at 0.026-0.027 mg/l was the only measurable metal parameter. Trace quantities of arsenic, barium, cadmium, magnesium, sodium, calcium, nickel, zinc, and iron were also present.

BISHOP CREEK

At the point of sample collection, Bishop Creek was approximately 6 meters wide and about 1.3 meters deep. Flow was estimated to be 4 to 10 CFS. The drainage area for this creek is not known.

The sampling site for Bishop Creek lies close to the terminus of the drainage basin, just south of the North Kenai Road. This creek provides drainage for a number of lakes and streamlets, interspersed throughout the public and private lands west of the Kenai National Moose Range. Due to the large number of lakes and streams which ultimately discharge into Bishop Creek, one might assume that the creek would be representative of the overall drainage water quality. Naturally, the water quality of Bishop Creek should provide a generalized indicator of water quality within its drainage.

Dissolved oxygen was found to be 10.8 mg/l. pH at the Bishop Creek sampling station was 7.1 and carbonate alkalinity 25.6 mg/l. Color was quite high - 45 PCU - as compared to Scout Lake. Turbidity was 1.6 NTU and TNFR was found to be 10 mg/l. Nitrate was below detectable limits and sulfate levels existed in trace quantities.

DANIELS LAKE

This lake has both an observable inlet and outlet. It has an area of about 611 acres and a maximum depth of 24.5 meters.

Found to be well oxygenated in the upper levels, dissolved oxygen decreases with depth and ranges from 9.4 to 7.9 mg/l. A slight 1 C decrease in temperature was measured from the surface to a 10 meter depth. It is suspected that a depth of greater than 5 meters undergoes thermal stratification during the summer with associated low dissolved oxygen levels in the hypolimnion. Fall turnover was not complete at the time of sampling.

The pH of Daniels Lake was somewhat higher than the other lakes ranging from 7.7 to 8.1, with a correspondingly high carbonate alkalinity ranging from 19 to 22 mg/l. Color varied from 10 to 15 PCU. Turbidity was low - 0.7 to 1.1 NTU. Values for TNFR were found to be not detectable to 10 mg/l at station 1-10 meter depth. This may have resulted from bottom sediments being introduced during sampling. Nitrate was 0.05 mg/l and sulfate was not detectable, except in two instances where it was found in trace quantities.

Trace quantities of arsenic, barium, magnesium, sodium, nickel and zinc were detectable in Daniels Lake. Measurable quantities of manganese and calcium were found. One instance of zinc exceeding trace quantities was also determined.

RAINBOW LAKE

Rainbow Lake occupies 170 surface acres with a maximum depth of 7.6 meters. It is thermally homogenous with temperatures varying only from 12.0 to 12.5 C. Dissolved oxygen was found at levels of 10.4 to 10.6 mg/l. pH ranged from 6.6 to 6.9; carbonate alkalinity 7.4 to 8.0 mg/l.

The water of Rainbow Lake was moderately colored - 15 to 20 PCU; turbidity was 0.8 to 1.7 NTU and TNFR fround from not detectable to 10 mg/l.

Nitrates were below detectable limits 0.05 mg/l. Trace quantities to less than 10 mg/l of sulfate was measured at both the 2 meter depth sampling stations.

Trace quantities of magnesium, sodium, calcium and nickel were detected. Trace quantities of barium and iron were present at the 4 meter depth of station number one. Measurable quantities of manganese and zinc were intermittently detected.

ISLAND LAKE

Island Lake covers 268 surface acres and has a maximum depth of 9.5 meters. Lake temperatures found inferred that it is weakly thermally stratified during the summer months, at least at station 9-2. Temperatures were 14.0 C at the surface to 13.8 C at depth. Dissolved oxygen declined below 5 meters, ranging from 9.7 to 9.0 mg/l.

pH ranged from 6.6 to 7.8 and generally decreased with depth. Carbonate alkalinity declined similarly, ranging from 8 to 11 mg/l. Color was moderately low, ranging from 10 to 20 PCU. Turbidity ranged from 1.2 to 2.3 NTU and TNFR were either non-detectable or found at trace levels 10 mg/l. Nitrate was below detectable limits. Sulfate likewise was, for the most part, below detectable limits.

Measurable quantities of manganese were present with occasional measurable quantities of barium, cadmium, nickel and zinc present. Trace quantities of barium, magnesium, sodium, calcium, zinc and iron were also identified.

BERNICE LAKE

Bernice Lake has a surface area of 134 acres and a maximum depth of 3 meters. It is located approximately by occasional residential lots, a public campground and a highway at the southern end.

Results for the September sampling period indicate temperature homogeneity, with temperatures ranging from 11.5 to 12.0 C. Dissolved oxygen ranged from 7.6 to 8.7 mg/l. pH was somewhat low ranging from 6.1 to 6.8, carbonate alkalinity was likewise low ranging from 8-9 mg/l.

Color was high - 30-45 PCU - indicating the possible presence of humic and fulvic acids. Bernice Lake exemplified shallow, boggy like conditions with much littoral vegetation present. Somewhat more turbid than the other lakes studied, turbidity varied from 1.7 to 2.5 NTU. TNFR results were found from non-detectable to 10 mg/l. Windy conditions may have caused disturbance and mixing of bottom sediments from increased circulation, as well as wave action present along the shoreline areas, resulting in generally higher residue levels.

Nitrate was found in trace quantities (1 mg/l) and sulfate was either non-detectable or trace quantities.

Manganese, calcium and iron were present in measurable quantities. Other metals present in trace amounts were arsenic, barium, magnesium, sodium, copper zinc.

LOWER SALAMANTOF LAKE

Lower Salamantof Lake is an extremely shallow lake, with a maximum depth of 1.2 meters and a surface coverage of 100 acres. It has both an observable inlet and an outlet. Much of the lake is surrounded by boggy areas of littoral vegetation. Approximately one quarter of the lake was densely populated with aquatic vegetation. There are a few residential sites along its shoreline, and several floatplanes were moored along its banks.

Water temperature ranged from 10.0 to 10.5 C, no thermal stratification being evident. Quite well oxygenated due to its shallow depth, levels of DO ranged from 11.2 to 11.5 mg/l. pH ranged from 7.3 to 8.2 with carbonate alkalinity ranging from 12.0 to 15.6 mg/l.

Color varied widely from 5 to 120 PCU. The high color determination was only present at station 2-1 meter depth. This was probably a result of introducing bottom sediments into the sampler. Aquatic vegetation made sampling difficult. The arithmetic mean for color was approximately equal to 40 PCU, excluding the suspected sample. Again this tends to indicate the presence of organic acids.

Turbidity values ranged from 0.6 to 2.1 NTU. Again poor sampling techniques were responsible at station 2-1 meter depth yielding a result of 21 NTU, due to bottom sediment disturbance. Station 4-1 meter depth had a turbidity of 7.1 NTU which probably resulted from similar disturbance. TNFR data ranged from non-detectable to 30 mg/l. Excluding the station 2-1 datum, all TNFR levels were less than 10 mg/l.

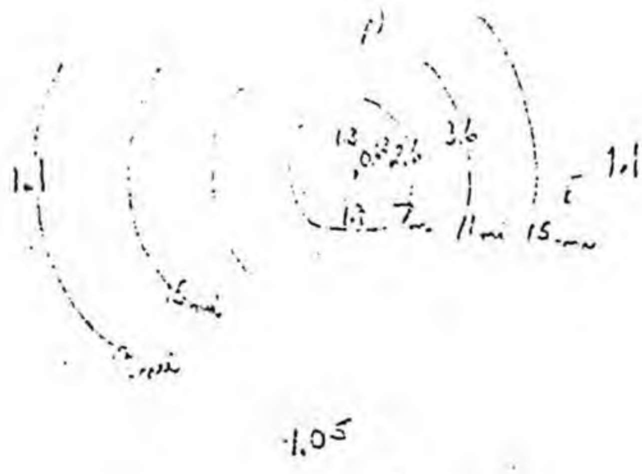
Nitrate was found to be below detectable levels. Sulfate analysis yielded trace quantities. However, station 2-1 meter yielded levels of 11 mg/l, probably due to bottom sediment disturbance.

Trace quantities of arsenic, barium, cadmium, magnesium, sodium, nickel and zinc were found. Measurable quantities of manganese, calcium and iron were also present.

ANALYSIS OF pH AND CARBONATE ALKALINITY DATA

The following table lists the average pH and carbonate of each lake investigated. Approximate distances and directions from the Kenai Tesoro Refinery are specified in the right hand column:

WATER BODY	pH	mg/l CARBONATE ALKALINITY	APPROXIMATE DISTANCE AND DIRECTION
Bishop Creek	7.1	25.6	11 mile N.E.
Daniels Lake	7.9	20.8	7 mile N.E.
Lower Salamantof Lake	7.7	14.1	4.5 mile S.
Island Lake	7.0	4.4	1.5 mile N.E.
Bernice Lake	6.3	8.4	0.5 mile N.
Rainbow Lake	6.7	7.6	19.5 mile W.
Scout Lake	6.2	6.5	21 mile S.



CONCLUSIONS

1. With the exception of Scout and Bernice Lakes, none of the lakes or streams exceeded AWQS for pH. In the case of Scout and Bernice, no hypothesis is proposed to explain why either lake is slightly low in pH and carbonate alkalinity. There is no evidence to determine that it is either a natural occurrence or a result of man's activity. The pH of these two lakes is not particularly low nor was any evidence found to indicate environmental degradation. Bernice Lake is high in color indicating the presence of humic or fulvic acids. Scout Lake was the farthest lake from the Kenai industrial complex. It gave the lowest pH of any lake measured and yet was low in color.

2. No general pattern was established that relates lake pH to distance from the industrial complex. We did not accumulate sufficient data to establish this relationship, if indeed, one exists.

3. If acid rainfall is occurring as a result of industrial activities on the Kenai Peninsula, it was not found with this study. It is possible that we may have selected lakes to close to the potential source. That is, plumes of NO_x and SO_2 - if they exist in concentrations to be of concern - may be windblown at high altitudes well outside the study area. Perhaps acid rainfall is occurring, but the natural buffering capacity of the ecosystem under examination is ameliorating its effects. Levels of nitrate and sulfate found in the water column were not unusual; however, this is hardly conclusive. These parameters are either part of the nutrient cycle or incorporated into lake sediments. Therefore, an excess source of either nitrate or sulfate from ambient air may not be measurable until the pathways incorporating them become upset or overloaded.

4. At the time of this study, the lakes were found to be well oxygenated and low in carbonate alkalinity. They were low in nitrate, sulfate, turbidity, and TNFR. Color was found to be moderate suggesting the presence of organic acids. Trace quantities of arsenic, barium, magnesium, sodium and zinc were encountered.

5. Scout Lake proved not to be an adequate control. The lake that is used for a basis of comparison with the study lakes must be located away from human activity, preferably in a remote location, with similar lithology or in the same watershed.

RECOMMENDATIONS FOR FUTURE WORK

1. Future studies will be made on rainfall and snowfall to determine levels of pH, nitrate and sulfate. More direct conclusions can then be reached concerning the input from ambient levels of NO_x and SO_2. Some of these sites will be selected for long term studies.

2. Long term seasonal studies should be undertaken including additional lakes, both in the immediate vicinity of refineries, as well as lakes at greater distances from them than this study.

3. The quantities and effects of organic acids should be investigated to determine their role in controlling lake pH in the Kenai Peninsula.

4. A fixed ambient air monitoring site will be established on the Kenai Peninsula to determine levels of No_x and SO_2. This site will assist in determining the magnitude of acid rainfall.

REFERENCES CITED

1. Acid Rain Coordination Committee; THE FEDERAL ACID RAIN ASSESSMENT PLAN - DRAFT; Co-edited by Hood, Kenneth, Dr. and Dochinger, Leon; Council of Environmental Quality, 722 Jackson Place, N.W. Washington, D.C.; 20006. 96 pp.

2. Alaska Department of Environmental Conservation, WATER QUALITY STANDARDS as revised February, 1979. Pouch O, Juneau, Alaska, 99811.

3. Alaska Department of Fish and Game, Division of Sport, FISH, LAKE SURVEY SUMMARY; Soldotna Field Office, Soldotna, Alaska. Various Years.

4. American Public Health Assoc., American Water Works Assoc., and Water Pollution Control Federation, STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, (14th ed.); Washington D.C. 1975.

5. Braekke, F.H., Ed. IMPACT OF ACID PRECIPITATION ON FOREST AND FRESH-WATER ECOSYSTEMS IN NORWAY (SNFS Project, 1432 AAS, Norwegian Forest Research Institute, Agricultural University of Norway, Norway, 1976.

6. Brezonik, Patrick L., Edgerton, Eric S. and Hendry, Charles D.; ACID PRECIPITATION AND SULFATE DEPOSITION IN FLORIDA; Science Vol. 208. No. 4447; May 30, 1980, pp - 1027 - 1029.

7. CLIMATOLOGICAL DATA SUMMARY; U.S. Dept. of Commerce, ESSA - Environmental Data Service.

8. Likens, Gene E. 1076 "ACID PRECIPITATION". CHEMICAL ENGINEERING NEWS. November 22, 1976. pp. 29 - 44.

9. PSD PERMIT APPLICATION FOR THE MODIFICATION OF TESORO - ALASKA KENAI REFINERY. Submitted to U.S. Environmental Protection Agency. September 5, 1979.

10. United States Environmental Protection Agency; METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES; Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, 45268, EPA-600/4-79-020. March, 1979.

11. U.S. Department of the Interior, Bureau of Land Management; CLIMATIC ATLAS OF THE OUTER CONTINENTAL SHELF WATERS AND COASTAL REGIONS OF ALASKA, Volume 1 - Gulf of Alaska. Arctic Environmental Information and Data Center, 707 A Street, Anchorage, Alaska, 99501, 1977.