AMBIENT AIR ANALYSIS OF BUNKER
HILL LEAD EMISSIONS

Prepared for:

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1.0 EXECUTIVE SUMMARY

This study utilizes computer-assisted cartographic modeling to empirically relate ambient lead and cadmium particulate observations to known emission estimates in the Silver Valley of northern Idaho. Through this technique, the many factors influencing ambient lead concentrations were simultaneously considered and quantified. Particular attention was paid to the multiplicity and inconstancy of particlate sources, the confounding effects of complex terrain on local meteorology, and the impact of windblown dusts.

All of the known particulate sources in the valley were included in one of the following five categories, chemical consituency and magnitude estimates were developed from existing reports or direct or inferred measurements: (1.) Industrial Point Sources, (2.) Industrial Process Fugitive Sources, (3.) Industrially-related Active Fugitive Sources, (4.) Transportation-related Active Fugitive Sources, and (5.) Passive (windblown) Fugitive Sources. The first three categories represent emissions from current industrial activities. The latter two categories' emissions are residual in character and result from cumulative effects over the years.

In the first portion of the analysis, cadmium measurements were used as a tracer to quantify the important atmospheric dispersion characteristics through the use of a Gaussian plume analogy. The results indicate that mountain-valley drainage phenomema and associated nocturnal inversions dominate dispersal activity on the majority of days. Under this situation,

the standard Gifford-Pasquill dispersion parameter estimates hold for unstable conditions. As neutral and stable conditions are encountered, dispersion becomes more and more inhibited and Gifford-Pasquill parameter esimates are grossly inadequate. This situation is often observed in complex terrain.

Stability is the critical variable in estimating pollutant dispersion in the Silver Valley. However, there are several meteorological and operational situations that require special treatment. They have to do with special synoptic conditions, stable layers aloft, or smelter operations. Stagnant high pressure areas, limited mixing depths, low wind speeds, and synoptic drainage winds result in severe pollution episodes on about thirty to fifty days per year. Inefficient smelter operations and frequent upsets and malfunctions create severe episodes twenty to thirty days per year.

In the second portion of this study, the dispersion model was applied to all lead sources and model estimates were related to observed ambient levels. Two years of data were used. The result was a self-calibrated empirical expression of lead impacts at monitored locations. Four source groups were found to significantly impact ambient lead concentrations. They were: Low-level smelter sources, or those that emanate from below forty feet, and exhibit their greatest impact within one-half mile of the smelter. Most are associated with the sintering operation or the ore preperation area. These sources constitute over seventy-five percent of the lead impact in this zone and absolute model estimates are as high as 6.5 ug/m3 on a quarterly basis. Mid-level smelter sources or those that emanate from forty to one hundred forty feet and exhibit their greatest impact at about two miles from the smelter. Blast furnace upsets and pellet dryer emissions constitute the bulk of this category. Their maximum modeled estimate was 3.5 ug/m3 at two miles.

Active fugitive sources, generally road dust and sinter storage, and Passive fugitive sources (windblown dusts) exert small but significant lead impact at several stations. The former accounts for less than five percent of total impact and the latter as much as twelve percent in summer months at non-attainment locations.

Current smelter emissions from the low and mid-level sources account for at least eighty-five percent of total lead impact within eight miles of the smelter. Tall stack emissions are insignificant in comparison. The highest ambient concentrations occur in winter months and are associated with prolonged periods of atmospheric stability. It is most important to remember that the different sources' impacts vary with location and season and that their combined effect determines the limiting situation for standard attainment. Control of upsets and malfunctions is also critical to the development of any implementation strategy. These items are discussed in detail in the final section of the report.

2.0 CONCLUSIONS

1. Meeting the NAAQS in the Silver Valley may be extremely difficult for the following reasons:

   a. The standard is small (less than 10%) when compared to current and historical lead levels.

   b. There are several types of sources capable of significantly impacting the NAAQS concentration.

   c. The maximum effects of these different sources occur at different locations and during different seasons, consequently all must be treated.

   d. Ambient concentrations are very sensitive to severe events, both meteorological and operational; any control strategy must be capable of accomodating serious upsets or prolonged stagnations.

   e. There are numerous residual pollutant effects that are not well understood.

2. Source reductions will have to be accomplished in several source categories and all to high degrees.

   a. 80% to 90% reductions in all low and mid-level smelter point and process fugitive sources.

   b. A comprehensive program of controlling and/or eliminating upset conditions, especially at the smelter blast furnace.

   c. A program of reducing transportation related and sinter storage related active fugitive emissions in and around the smelter.

   d. A program of surface stabilization of contaminated soils in the airport area, fairgrounds-lumberyard industrial corridor, and Bunker Hill tailings pond embankment.

3. Evidence suggests that configuration changes, both in emissions and real property, may be viable alternatives to emission reductions in some locations.

   a. As tall stack emissions do not have a significant impact in comparison to low and mid-level sources, venting these sources through the main baghouse would significantly reduce impacts. This would be especially pertinent to blast furnace and pellet dryer emissions.

b. As low-level emissions reductions are almost wholly dependent on their impact at Silver King and Smelterville, this requirement could be significantly reduced were the company to purchase these properties.

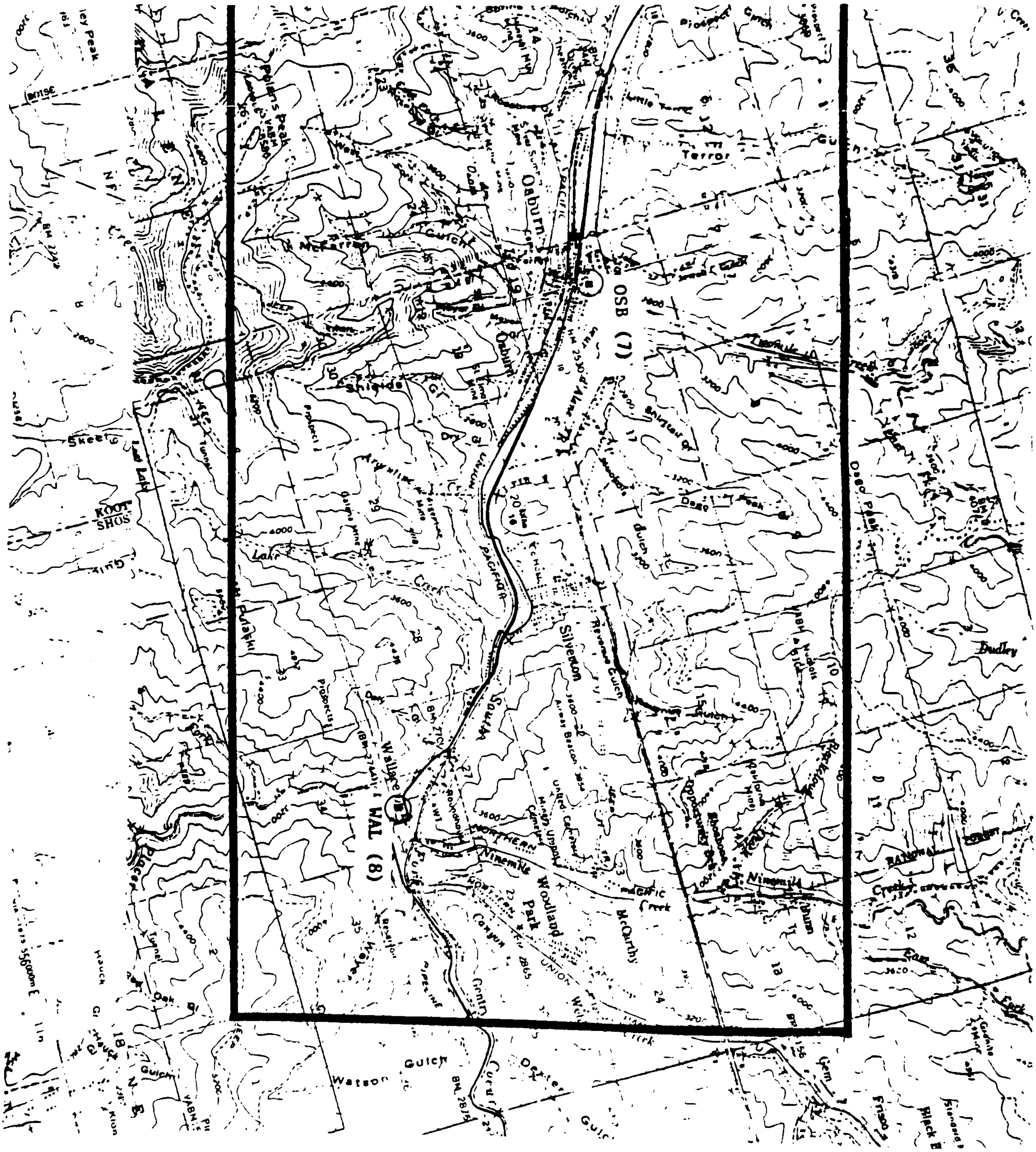
4. An updated emissions inventory and a detailed analysis of OSHA compliance activities are needed.

3.0 LEAD CONTAMINATION IN SHOSHONE COUNTY, IDAHO

Attainment of the National Ambient Air Quality Standard (NAAQS) for lead will requre substancial control and capture of current lead emissions in the Silver Valley. There are numerous sources of lead to the ambient air in this area and their impact varies considerably with location and season. In depth analyses of the complex source-receptor relationships are necessary. Such studies usually involve diffusion model applications. This area, however, is particularly ill-suited for diffusion modeling.

The study area is an enlogated, narrow, deep valley encompassing the South Fork of the Coeur d' Alene River. Figure 3.1 is a map of the area. Appendix A contains computerized representations of the Valley's industrial and topogapghic features. The valley is subject to adverse meteorological conditions and the regular formation of surface-based inversions and diabatic winds. There are large denuded areas where deposition of water and windborne contaminants have combined with industrial wastes to create large area sources associated with transportation activities and inconstant industrial processes combine with large point sources to effect a complex source spectrum with considerable spatial and temporal variation. The smelting complex is the hub of the industrial community. There are five principal processes within the industrial area: (1.) a galean (Pbs) ore mine, (2.) a lead/zinc milling and concentrating operation, (3.) a lead smelter, (4.) an electrolytic zinc plant, and (5.) a phosphate fertilizer production plant. Vegetation levels and soil characteristics are important to this study. Denuded areas subject to deposition of heavy metals could contribute to lead exposures through

Monitor	Symbol	Number
Cataldo	CAT	1
Kingston	KIN	10
Pinehurst	PNH	2
Smelterville	SMV	3
Silver King School	SKS	4
Kellogg Medical Center	KMC	5
Kellogg City Hall	KCH	6
Osburn	OSB	7
Wallace	WAL	8



reentrainment of the exposed soils. A variety of vegetation is found in the area. A considerable change in the natural vegetation has resulted from prevalent industrial activities. Much of the original coniferous forest was harvested for timber and fuel. Sulfur dioxide gas from the smelter has damaged or destroyed much of the native vegetation near Kellogg, and has increased soil acidity to levels intolerable for many species. Following a 1910 fire and installation of the present smelter in World War I, natural plant invasion did not occur and young trees did not survive. Most of the burned area outside the smelter influence has been retimbered by second growth lodgepole pine. Bushy plants and grasses cover the hillsides in uneven distribution dependent on moisture availability (University of Idaho, 1974).

Soils in the area vary with their location. On the mountain slopes parent materials consist of decomposed rocks and a thin layer of forest litter. In scattered areas at lower elevations, small amounts of volcanic ash and loess are found (University of Idaho, 1974). In an area of high rainfall and steep slopes devoid of protective vegetation, these materials erode rapidly. Accelerated erosion destroyed many of the acid-resistant plants in the smelter zone. The loss of surface soil and decreased water-holding capacity increased runoff. The result is the bare, severely eroded hills surrounding the smelter. Little or no vegetation is found there. The soils are surface hardened remnants of the native materials.

The valley floor is partially filled with alluvial deposits varying in thickness from a few inches to several feet. The alluvium is principally unconsolidated sand and gravel. Mine and mill tailings have formed a metal-laden veneer of silt over large areas of the valley. The use of mine wastes for fill and construction activities have also resulted in redistribution of soil metals throughout the area (State of Idaho, 1974a, 1975a, 1978b). In Appendix B are representations of vegetation cover and soil metal distributions in the valley.

The climatic conditions show a mean annual temperature of 47.4°F, a mean number of days (138) above 32°F, with average frost dates of May 12 and September 27. Mean annual precipitation is 31 inches ranging from 9.4 inches in January to <0.1 inch in August. Most precipitation is in the form of snow with snow cover prevalent from December to late February. Thunder showers persist from mid-June through July with short rainy seasons in early spring and late September (NOAA, 1976).

4.0 SOURCE IDENTIFICATION AND EMISSIONS EVALUATION

4.1 GENERAL

There are several sources of lead to the atmosphere in the Silver Valley. These sources vary in magnitude, frequency, chemical constituency, and configuration. Some categorization scheme is necessary for purposes of discussion and analysis. Developing reasonable source categories requires certain knowledge of the different sources' behavior and the responsible environmental and industrial processes. Lead/zinc ores have been mined in several locations in the Silver Valley for nearly one hundred years. All currently active mines are east of the smelting complex. Galena (PbS) is the predominant lead ore. The ore is concentrated by wet-chemical milling processes near the mines. Both lead and zinc concentrates are produced. Concentrates are typically 60% metal in the sulfide form and are the consistency of coffee grounds. They are transported to their respective smelters by rail in a wet form.

Direct air pollution from these activities is insignificant. The milling operations are wet and the material is transported before it dries. Concentrates spilled on the roadways constitute an active source of heavy metal particulate after drying. Other residual aspects of the milling operations can have significant air quality effects. Large quantities of tailings containing significant amounts of heavy metals are produced by the milling operations. Currently these tailings are stored in large ponds. The dikes of these ponds are usually made of dried tailings. These metal-laden, low pH, fine sandy materials are not conducive to vegetation, and the dikes and abandoned ponds can be significant sources of reentrained fugitive dusts.

In the first eighty years of mining, tailings were discharged directly into the river or dumped at convenient locations. Periodically, the river would flood and deposit the waste material on the valley flood plain. These silts are also a source of particulate reentrainment. Tailing sands are typically 1 to 4% lead by weight.

After arriving at the smelters, the concentrates are dried and mixed with other concentrates and residual materials in preparation for pyrometallurgical treatment. Zinc concentrates are roasted at the zinc plant to produce a powdered oxide of zinc. Lead concentrates are "sintered" to produce a lead oxide compound, similar to furnace clinkers, called sinter product. Both of these processes burn the sulfur from the sulfide concentrations as a fuel. This roasting of the ores produces the tremendous quantities of sulfur dioxide associated with non-ferrous smelters. There are several process-fugitive sources associated with the materials handling aspects of these processes. Those before roasting are in association with the ore-preparation and crushing plants in the lead smelter. Drying of the concentrate compounds is a significant point source of particulates. These are all fine particulate emissions, about 30% lead by weight in the sulfide form. Materials handling of zinc concentrates seems to be an insignificant particulate source. Roasting of the ores is a significant particulate source in both smelters. Over two-thirds of the total zinc plant emissions result from ore-roasting. In the smelter, over a quarter of the total lead emissions are associated with the "Lurgi" sinter operations. Most of these are point source emissions from scrubbers attached to the process. Others are fugitive emissions associated with materials handling of the highly abrasive sinter product. Point source emissions are generally fine particulate. The fugitive source emissions vary from very fine to very large settleable particulate. Lead concentrations are 10% or less in the zinc smelter and 45 to 60% lead in the sinter operations emissions. Both are in the oxide form.

After roasting, base metals are recovered from the metallic oxides. In the zinc plant, the powdered zinc oxide is dissolved in sulfuric acid and zinc is recovered electrolytically. In the lead smelter, the sinter product is combined with coke and smelted in a blast furnace. Oxygen-enriched air is "blasted" into the furnace and the coke is burned as a fuel. The coke also supplies carbon as a reducing agent in an oxidation-reduction reaction that results in molten metallic lead. This is a violent operation that produces over one-half of the total lead emissions in the entire complex. Much of it is emitted from the facility's main stack after the particulates are removed in the smelter's primary particulate control facility, the main baghouse. A significant amount is also discharged directly to the atmosphere as a result of upsets in blast furnace operation. Emissions from this stage of the process are fine particulates and metal fume of about 60% lead content in the oxide and pure metallic form.

Following the smelting processes, the base metals move to their respective refineries where they are concentrated to 99.99% pure form. Some fine particulate emissions are associated with refinery processes.

In this analysis the sources are first separated into the gross regulatory categories, point sources, and fugitive sources. Point sources are defined here as controlled sources that emanate from stacks or equivalent devices. Fugitive sources are all those sources that are not classified as point sources. Four sub-categories of fugitive sources, based on the source's suspension energy, have been developed for these analyses. They are (1) process fugitive sources that are attendant to and derive their suspension energy from industrial processes, (2) active fugitive sources associated with gross materials handling in industrial areas, (3) active emissions arising from transportation activities, and (4) passive fugitive emissions that are reentrained by the wind. All of the sources in the valley were located on computerized maps prepared especially for these analyses. These maps are presented and discussed in Appendix A. References to the appropriate maps are made here.

4.2 POINT SOURCES

All point sources in the valley are inventoried by the NEDS classification system designation number. Table 4.1 shows the source characteristic information available for the 32 point sources identified. The variables in that table are as follows:

NEDS--the National Emission Data System identification number

UNIT--identifies the associated industrial process unit (i.e., 1 crushing plant, 5 sinter or Lurgi operation)

PBFR, CDFR--percent lead and cadmium, respectively, in the particulate emission

EXITVEL--exit velocity of the stack emission (m/s)

STHGHT--physical stack height above ground (m)

STDIAM--physical stack diameter (m)

EXITTEMP--stack gas exit temperature (°K)

VOLFLOW--stack gas volumetric flow rate (m^3/s)

YROPPCT--percent of annual operation time.

Table 4.1 Point Source Inventory Information

OBS	UNIT	NEDS	PBFR	CDFR	EXITVEL	STHGHT	STDIAM	EXITTEMP	VOLFLOW	YROPPCT	NAME	PSNUM
1	1	2	31	0							Crushpl Dryer	1
2	1	3	31	1						50	Crushpl Collect	1
3	1	4	31	1						50	Crushpl Rodmill	1
4	1	5	31	1		3.1		289	6.62	50	Crushpl Baghouse	1
5	2	6	31	1		9.8		291	3.70	80	Oreprep Baghouse	2
6	3	7	31	1		24.8		310	9.93	75	Pellet Dryer	3
7	5	8	45	1	5.20	6.1	1.07	294	4.72	75	Lurgi D Scrubber	4
8	5	9	45	1		3.0		297	1.66	100	Lurgi N Rotoclon	4
9	5	10	45	1	10.50	6.1	1.07	294	9.45	75	Lurgi B Scrubber	4
10	5	12	45	1	10.90	6.1	3.14	312	84.46	85	Lurgi A Scrubber	4
11	5	11	45	1	10.50	6.1	1.07	294	9.45	75	Lurgi C Scrubber	4
12	7	16	5	1	10.90	53.4	3.14	312	84.46	85	ZN Fume Main St.	5
13	7	17	5	1	10.90	24.4	0.91	344	7.08	85	ZN Fuming Gran	6
14	8	32								85	Pbreein Scrubber	7
15	8	1				9.1		292	4.32	75	Reverb Baghouse	7
16	9	15				19.8		323	1926.00	11	EF Gran Scrubber	7
17	11	1	55	7	14.30	217.9	4.15	327	193.10	100	Smelter Main St.	8
18	20	18	10	1	9.00	186.0	1.83	311	23.62	50	Zinc Main Stack	9
19	21	33	10	1							Concent Dryer	10
20	21	19	10	1							Concent Silo	10
21	22	22	20	1							Rosconv Scrubber	11
22	23	25	10	1							Meltdrs Scrubber	11
23	23	23	10	1							Rodross Baghouse	11
24	23	20	20	1	2.07	18.3	0.76	472	0.94		#1Wedge Scrubber	11
25	24	21	10	1							Residue Dryer	12
26	25	28	5	1							Scrap Furnace	12
27	25	26	5	1	17.90	6.1	0.46	30	1.32	0	#3Melt Scrubber	12
28	25	27	5	1							#2Melt Scrubber	12
29	26	24	5	1							ZN Pure Baghouse	12
30	31	30	0	0	20.60	13.4	0.91	347	14.17		AMP Reactor	13
31	32	29	0	0							AMP Dryer	13
32	33	31	0	0							Doyle Reactor	13

* variables defined on page 26

NAME--emission point name

PSNUM--point source identification number

With the exception of the last variable, these data were gathered from previous reports of PEDCo (1975), Valentine and Fisher (1975), PES (1978), and EPA (1975a,c). The last variable, PSNUM, is a categorization variable developed for the purposes of this study. It is explained in a later section of the report. Point sources are located on the Map PTSOURCE in Appendix A.

4.3 PROCESS FUGITIVE SOURCES

These emissions are associated with the metals industry. These are pollutants that escape to the atmosphere from industrial processes. They may be leaks, vents, and overflows from production and pollution control equipment or buildings. They may escape from uncontrolled portions of processes exposed to the atmosphere, such as conveyor belts or by-product dumps. Many of these fugitive sources are attendant to the processes and exhibit regularity in their location and strength (e.g., building fans). Others, particularly leaks and overflows associated with process upset conditions and malfunctions, are erratic in both frequency and magnitude.

Process fugitive particulate sources were identified and mean emission rates were estimated in previous studies (PEDCo, 1975c; Valentine and Fisher, 1975; PES, 1978; PEDCo, 1979). Those sources have been identified in Table 4.2, together with percentage lead and cadmium components measured in the same surveys.

All industrial process-related lead sources were combined in categories for later analyses. Those sources and mean emission rate estimates and rankings can be found in Table 4.3. This table represents the best

Table 4.2 Process Fugitive Sources Ordered by Lead Source Strength

Name	EMR	PBFR	CDFR	PBEMR	CDEMR
Blast furnace	30.00	61	9	18.3000	2.7000
CPP exhaust fams	34.00	31	1	10.5400	0.3400
CRE con exhaust fans	25.00	34	1	8.5000	0.2500
Cast roof fans	12.40	31	1	3.8440	0.1240
PB ref roof vent	6.70	37	1	2.4790	0.0670
Elec fur roof	4.30	10	0	0.4300	0.0000
Sinter prod dump	0.54	31	1	0.1674	0.0054

EMR--total particulate emission rate, lb/hr; PBFR--percentage lead in emission; CDFR--percentage cadmium in emission; PBEMR--lead emission rate, lb/hr; CDEMR--cadmium emission rate, lb/hr.

estimates for comparing industrial sources that could be developed with the available data. It was developed from information collected between late 1974 and early 1979 and some updating may be required.

4.4 ACTIVE FUGITIVE SOURCES

These sources are varying and intermittent pollutant sources whose suspension energy is provided by agents other than steady state industrial processes. They may be industrial sources related to activities such as stockpiling, truck and train loading and unloading, or materials handling. They may be related to land use such as ground working, construction, or surface mining. Or they may be related to transportation sources such as reentrainment by vehicular traffic, from open carriers, or mobile source

Table 4.3 Point Source Category Components and Lead Emission Rates (EMR)

I. Smelter Low-Level Sources

NEDS	Name	Mean Lead EMR lb./hr.	% of Category	EMR Rank
2	Crushing Plant Dryer	3.4	6	6
3	Crushing Plant Collector	.4	1	12
4	Crushing Plant Rodmill	.4	1	13
5	Crushing Plant Baghouse	.4	1	14
6	Oreprep Baghouse	.3	1	16
8	Lurgi D Scrubber	1.4	2	10
9	Lurgi N Rotoclon	16.0	28	1
10	Lurgi B Scrubber	4.1	7	4
11	Lurgi A Scrubber	3.4	6	5
12	Lurgi C Scrubber	2.7	5	7
17	Zinc Fume Granulator	1.8	3	9
32	PB Refinery Scrubber	---	0	--
15	Electric Furnace Scrubber	---	0	--
FUG	Oreprep Exhaust Fans	10.5	18	2
FUG	Ore Conc Exhaust Fans	8.5	15	3
FUG	PB Refinery Roof Vent	2.5	4	8
FUG	BF Roof Vents	.9	2	11
FUG	Electric Furnace Roof	.4	1	15
FUG	Sinter Product Dump	.2	1	17
	Total Low Smelter PB EMR	57.3		

II. Smelter Mid-Level Sources

NEDS	Name	Mean Lead EMR lb./hr.	% of Category	EMR Rank
7	Pellet Dryer	8.0	24	2
16	Zinc Fume Main Stack	2.3	7	4
FUG	Blast Furnace	18.3	54	1
FUG	Casting Roof Fans	3.8	11	3
FUG	Fuming Furnace Roof	1.3	4	5
	Total Mid Smelter PB EMR	33.7		

Table 4.3 Continued

III. Smelter High Level Sources

NEDS	Name	Mean Lead EMR lb./hr.	% of Category	EMR Rank
1	Smelter Main Stack	43.0	100	1

IV. Zinc Plant Low-Level Sources

NEDS	Name	Mean Lead EMR lb./hr.	% of Category	EMR Rank
33	Concentrate Dryer	.02	1	5
19	Concentrate Silo	0	0	--
22	Rosconv Scrubber	0	0	--
25	Melt DRS Scrubber	.07	3	4
23	Rodross Baghouse	.02	1	6
20	#1 Wedge Scrubber	1.36	67	1
21	Residue Dryer	0	1	7
28	Scrap Furnace	.07	3	4
26	#3 Melt.	.37	18	2
27	#2 Melt.	.11	5	3
24	ZN Pure. Baghouse	0	0	--
	Total ZN Plant Low Level	2.02		

V. Zinc Plant High Level Sources

NEDS	Name	Mean Lead EMR lb./hr.	% of Category	EMR Rank
18	Zinc Plant Main Stack	2.28	100	1

VI. Ammonium-Phosphate Plant Sources

NEDS	Name	Mean Lead EMR lb./hr.	% of Category	EMR Rank
31	AMP Reactor	0	---	--
32	AMP Dryer	0	---	--
33	Doyle Reactor	0	---	--

combustion emissions. They are distinguished from the previous category in that their frequency and magnitude are not attendant to industrial processes in the steady state time frame, and from the following category in that their suspension energy is independent of kinetic meteorological factors.

Active Sources (Industrial)--Particulate fugitive sources were identified in the same surveys cited in the process fugitive discussion. Similarly, mean emission rates and chemical constituencies were estimated in those studies. These sources are identified in Table 4.4. They can be located on Map ACTIVES in Appendix A.

Table 4.4 Active Fugitive Source Characteristics

Name	MapID	EMR	PBFR	CDFR	PBEMR	CDEMR
Silica slag pile	73	17.8	5	0	0.890	0.000
Sinter storage	45	1.6	42	1	0.672	0.016
Slag storage	33	20.2	2	0	0.404	0.000
State highway piles	74	30.3	1	0	0.303	0.000
Sinter storage	49	0.4	42	1	0.168	0.004
Coke storage	45	0.6	0	0	0.000	0.000

EMR--total particulate emission rate, lb/hr; PBFR--percentage lead in emission; CDFR--percentage cadmium in emission; PBEMR--lead emission rate, lb/hr; CDEMR--cadmium emission rate, lb/hr.

Active Sources (Transportation)--Several researchers have investigated those factors most contributory to road dust impacts. The condition of the road surface seems most important. Unpaved roads result in orders of magnitude greater particle suspension than paved roads. In fact, some studies have ignored the effect of particle resuspension from paved roads altogether (PES, 1978). However, others have found considerable resuspension of tracer materials from paved roads (Sehmel, 1973). The PEDCo (1975a) study recognized three categories of roads: unpaved, paved, and dusty paved. In general, it seems that in comparison to unpaved roads, paved road contributions to total suspended particulate may be negligible. However, with respect to hazardous materials or trace elements deposited on roadways, traffic induced resuspension may be significant (Sehmel, 1973). Suspension from unpaved roads has been related to particle size in the roadbed (Becker and Takle, 1979). PEDCo (1975a) has developed formulas for total particulate suspension from unpaved roadways based on traffic characteristics and the silt content of the roadbed.

Various studies identify differing ambient impacts associated with vehicle weight and speed and the number of vehicle passes (Becker and Takle, 1979; PEDCo, 1976; Sehmel, 1973; Smith, 1976). Vehicle characteristics affect both suspension rates and initial dilution through mechanically induced turbulence. The latter results in a shallower dilution gradient away from highways and a lesser dependence on atmospheric stability and source height (Becker and Takle, 1979; Sistla et al., 1979).

Other factors found to be important in road dust impacts are the angle between the wind and road (Calder, 1973; Sistla et al., 1979) and the surface roughness of the roadside environment. Little and Wiffen (1979), Smith (1971), and Heichel and Hankin (1976) found the characteristics of roadside flora significantly affected ambient lead concentrations. Becker and Takle (1979) suggest that sampling height is an important consideration due to the differing particle sizes and settling rates of the suspended material.

Each of the roads identified in this study was characterized as paved, unpaved, or dusty paved. Annual vehicle miles traveled (VMT) for each road were obtained from previous reports and traffic studies (PEDCo, 1975c; PES, 1978; State of Idaho, 1974a). Emission Rate Factors developed by the EPA as described by PEDCo (1975c) were then applied to get per unit distance emission rates for these roads. Both road dust and gasoline combustion factors were included.

Active Sources (Urban)--Urban active fugitive source strengths were considered to be proportional to the traffic volume on city streets. The total VMT estimates for each city were obtained and proportionately allocated over the area of the community. No absolute estimates of emission rates were determined for the last two sub-categories as they were treated proportionately in later regression analysis correlating these estimates to observed concentrations. The details may be found in the parent document. However, these sources are located on the Maps TOWNS and ROADS in Appendix A. Specific emissions estimates could be developed for these sources by using the final regression coefficients in a calibration procedure. However, this would require additional work.

4.5 PASSIVE FUGITIVE SOURCES

These sources are reentrained by the wind. They include open areas of bare soil and exposed industrial areas. Their magnitude depends on wind speed and direction and surface conditions. The air quality aspects of these sources have attracted significant attention in recent years due to the need for predicting urban air pollution levels, and in the nuclear industry where resuspension of spilled nuclear materials is a possible health hazard. Like roadway sources, passive source strengths are greatly dependent on surface conditions. Soil particle size distribution, surface roughness, orientation, cover, and moisture conditions are the principal surface variables. Those factors that contribute most to wind suspension have been investigated for many years in relation to soil erosion. Those studies have been modified to develop air pollution impact estimates (PEDCo, 1973; Wilson, 1975).

The basic technique utilized in assessing passive source impacts was developed in a series of publications by Chepil and associates and was reviewed by Woodruff and Siddoway (1965). In that publication, they modified the techniques to develop "A Wind Erosion Equation." Those definitions and techniques have been extended for use as air quality predictors commonly termed the "Modified Wind Erosion Equation Method." The Modified Wind Erosion Equation is as follows:

$$E = I \cdot K' \cdot C' \cdot L' \cdot V'$$

where

E = total mass soil movement, tons/acre/yr

I = soil erodibility (or the potential to erode), tons/yr

K' = soil ridge roughness factor

C' = climatic factor (soil moisture and wind velocity)

L' = field length factor

V' = vegetation cover factor

The strategy of this equation is that the erodibility, I, is defined as the potential loss of soil in tons/acre per annum from a wide, unsheltered, isolated field with a bare, smooth surface. It is based on both wind tunnel and field observations (Woodruff and Siddoway, 1965). The others are mitigative variables varying in value from 0 to 1.0 that reduce the final erosion estimate.

This equation has been used to estimate emission rates from area sources by multiplying E by the area of the source in acres times a conversion factor. That conversion factor represents that fraction of the total soil movement (E) that is observed as ambient particulate. Literature values for the conversion factor are found from 0.3 to 10% (Wilson, 1975).

The physics of erosion involves three transport processes: saltation, surface creep, and suspension. Saltation is the movement of soil by a short series of bounces usually rising no more than a foot above the ground. Surface creep is the rolling or sliding of the larger particles along the surface. Suspension is the entrainment of fine particles up away from the surface (Buckman and Brady, 1972). A significant gradient of particle size with height results from these processes. Only the suspension process produces long range air pollutants.

Erosion rates are also sensitive to meteorological variables. Total soil movement varies with the wind speed cubed and inversely with soil moisture (Woodruff and Siddoway, 1965). Rain and snow cover eliminate wind erosion when in sufficient quantity. In this area, diffusion of suspended materials by wind erosion is practically independent of atmospheric stability. Significant wind speeds are required to initiate suspension. In the Silver Valley such wind speeds are observed only in near neutral conditions and only in the up or down valley direction (PES, 1978). It seems that significant reentrainment from these sources occurs in the Silver Valley under meteorologically limited circumstances.

All of the available data for passive sources have been accumulated from three studies conducted in the Silver Valley (PEDCo, 1973, PES, 1978; State of Idaho, 1978). The sources can be found in Table 4.5 and located on Maps found in Appendix A, by using the value VAL as described in Part E of that Appendix. No absolute emission rate estimates were prepared for these sources because of the nature of the later analyses as detailed in the parent document. However, they are listed in their relative order of lead source strength in Appendix C. Estimates could be accomplished by a calibration procedure utilizing the final regression coefficients. Such an analysis would be interesting but is beyond the resources of the report.

Table 4.5 Passive Fugitive Source Characteristics

ID -- are the code numbers from the original studies referenced in the text.

VAL -- is a number used to key the map input information.

ERODE, ROUGH, LENGTH, VEG -- are the source development factors for the Windblown Dust Equation as defined by Chepin.

PBPPM, CDPPM -- are the lead and cadmium ppm soil levels

PBFRAC, CDFRAC -- are the ppm lead and cadmium levels in the fines fraction of the soils samples where available.

CHARNOTE, PBNOTE, CDNOTE -- The note denotes the source of the data for the variables above. The value E refers to the PES report, P to the Pedco reports, V to estimates by author, H to Health and Welfare Department reports, S & Z to estimates from similar samples.

ID	VAL	ERODE	ROUGH	LENGTH	VEG	PBPPM	CDPPM	PBFRAC	CDFRAC	CHARNOTE	PBNOTE	CDNOTE	DESCRIPT
C1A	247	47	1.00	3.53	1.00	14631	84.3	18796	106.0	E	H	H	C1A SOUTH ROAD
C1B	[illegible]	47	1.00	3.53	1.00	[illegible]	38.4	15673	76.0	E	H	H	C1A SOUTH DIKE
C1C	51	47	1.00	3.93	1.00	16000	133.0	.	.	E	V	V	SOUTH C1A GYPSUM
C0[illegible]	52	47	1.00	3.88	1.00	10000	103.0	.	.	E	V	V	GYPSUM DIKE
C03	53	47	1.00	3.05	1.00	[illegible]	133.0	.	.	E	V	V	GYPSUM POND
C07	57	86	0.83	0.89	0.70	30700	143.0	24000	190.0	E	V	V	OLD HUMESITES
C0[illegible]	[illegible]	86	1.00	0.87	1.00	25000	233.0	.	.	E	V	V	PARK LOT S CONC
C08	58	86	1.00	3.91	1.00	[illegible]	[illegible]	.	.	E	V	V	CONE PILE
C09	[illegible]	86	1.00	3.96	1.00	20000	230.0	.	.	E	V	V	ZINC RESIDUE
C10	63	156	0.83	3.45	0.90	25000	233.0	.	.	E	V	V	W OF ORE GRIND
C11	61	86	1.00	3.85	1.00	23000	233.0	.	.	E	V	V	WHSE E ORE GRIND
C12	62	86	1.00	3.93	1.00	[illegible]	52.9	36063	80.8	E	H	H	NEAR SHOSH APTS
C13	[illegible]	86	1.00	3.93	1.00	[illegible]	157.0	[illegible]	312.0	E	E	V	ROSS OIL AREA
C14	66	86	0.83	3.71	0.70	15000	151.0	17897	319.0	E	V	V	HILLSIDE A ROSS
C15	65	47	1.00	3.90	0.90	30000	.	.	.	E	V	.	C1A NW END A
C3A	253	86	1.00	3.93	0.90	30000	.	.	.	V	V	.	C1A NW END B
C3B	252	86	1.00	3.93	0.90	11734	89.4	17957	147.0	V	H	H	OLD TOWN SITE
C7A	255	86	1.00	3.90	0.90	44912	147.0	31[illegible]	243.0	V	H	H	OLD TOWN SITE
C7B	256	86	1.00	3.55	1.00	105	0.5	1[illegible]	0.5	E	H	H	SUNSHINE POND
D23	262	156	1.00	3.57	1.00	[illegible]	.	.	.	E	V	.	W OF TRAIL PARK
G15	215	86	1.00	3.83	0.95	7500	.	.	.	E	V	.	OLD RIV CH MOUN
G17	217	47	0.55	[illegible]	1.00	10000	.	.	.	V	Z	2	HIWAY GRAVEL ST
G19	219	47	0.93	[illegible]	1.00	10000	.	.	.	E	S	.	WEST OF ASPH PLT
G20	361	86	0.83	0.79	1.00	1500	9.2	.	.	E	Z	2	TERRACED HILLSID
G23	240	47	0.55	0.70	1.00	[illegible]	30.0	.	.	E	V	.	S OF FREEWAY 823
G24	223	86	0.55	3.67	0.95	13000	48.8	17062	61.5	E	H	H	MOVIE THEATRE
G25	224	86	1.00	3.91	1.30	12000	.	.	.	E	V	.	RIV CH N ZANNETT
G32	225	86	1.00	3.71	0.95	12000	.	.	.	E	V	.	PINE CR CUT
F06	169	86	1.00	3.90	1.00	1000	.	.	.	E	P	.	ROCK & GRAV PRN
P09	108	47	3.00	3.93	1.00	6000	.	.	.	P	P	.	SMV PLAYGROUND
P10	109	86	1.00	3.93	1.00	16000	.	.	.	P	P	.	TAILINGS AREA
P13	110	86	1.00	1.00	1.00	3000	.	.	.	P	P	.	SEDIMENT BASIN
P14	113	86	1.00	0.57	1.00	1000	.	.	.	P	P	.	ORE STORAGE AREA
P16	114	86	0.93	3.93	1.00	19400	.	.	.	P	P	.	HIWAY FILL
P18	116	86	1.00	3.85	1.00	11000	.	.	.	P	P	.	ATLETIC FIELD
P19	118	86	1.00	3.00	1.00	5000	.	.	.	P	P	.	GRAVEL AREA
P20	119	86	0.83	3.50	1.00	5000	.	.	.	P	P	.	GRAVEL STORAGE
P21	120	47	1.00	3.50	1.00	4000	.	.	.	P	P	.	GRADED AREA
P22	121	47	1.00	3.76	1.00	9000	.	.	.	P	P	.	REGRAD STR BED
P23	122	86	1.00	3.55	1.00	11000	.	.	.	P	P	.	TAILING POND OSB
P24	123	134	1.00	3.87	0.75	15000	.	.	.	P	P	.	STREAM BEG
P26	124	86	1.00	3.55	1.00	12000	.	.	.	P	P	.	GRAVEL PIT
P28	126	47	1.00	3.72	1.00	8000	.	.	.	P	P	.	STREAM BED
P33	128	86	1.00	3.55	1.00	8000	.	.	.	P	P	.	EQUIP STOR AREA
P34	133	86	1.00	3.66	1.00	8000	.	.	.	P	P	.	MINE SPOILS
P35	134	86	1.00	3.59	1.00	13000	.	.	.	P	P	.	HILLCUT AT SMELT
P36	135	86	1.00	3.67	0.90	29000	.	.	.	P	P	.	SMELTER STORAGE
P37	136	86	1.00	3.80	1.00	70000	.	.	.	P	P	.	SMELTER STORAGE
P38	137	56	1.00	3.80	1.00	14000	.	.	.	P	P	.	SMELTER STORAGE
P39	138	86	1.00	3.86	1.00	6000	.	.	.	P	P	.	RUBBLE & FILL
P42	139	86	1.00	3.55	1.00	13000	.	.	.	P	P	.	RUBBLE & FILL
P43	140	86	1.00	3.55	1.00	13000	.	.	.	P	P	.	LUMBER YARD STOR
P44	143	86	1.00	3.60	1.00	10000	.	.	.	P	P	.	W END OF STP
P46	144	134	1.00	3.98	1.00	5000	.	.	.	S	P	.	LUMBER YARD STOR
[illegible]	145	86	3.55	3.90	1.00	13000	.	.	.	[illegible]	[illegible]	.	[illegible]

Table 4.5 continued

ID	VAL	ERODE	ROUGH	LENGTH	VEG	PBPPM	CDPPM	PBFRAC	CDFRAC	CHARNOTE	PBNOTE	CDNOTE	DESCRIPT
R01	1	86	1.00	0.86	1.00	20961	63.9	35500	93.0	E	H	H	AREA NEAR J& HI
R02	2	47	[illegible]	0.81	0.95	10020	.	.	.	E	V		ACROSS FRM BH
R03	3	86	1.03	0.91	1.00	6000	.	.	.	E	V		OUTDOOR THEATRE
R04	4	86	1.00	0.99	0.90	10422	39.8	14087	43.1	E	H	H	AIRPORT AREA
R05	5	38	0.55	0.95	0.75	11020	.	.	.	E	V		BY CH N AIRPORT
R06	6	47	0.55	0.79	0.40	11050	.	.	.	E	V		SF PINE CR CONFL
R07	7	38	[illegible]	0.80	1.00	11020	.	.	.	E	V		RIV ACCESS PINCR
R08	8	86	[illegible]	0.77	1.00	6000	.	.	.	E	V		SHV GRAVEL PIT
R09	9	86	[illegible]	0.95	1.00	21449	57.4	22443	62.3	E	H	H	SHV SWAMP
R10	10	86	[illegible]	0.87	0.80	20020	35.0	.	.	E	V	V	E OF SIP PAGE PD
R11	11	86	1.00	0.85	1.00	12020	35.0	.	.	E	V	V	PACIFIC CROWN
R12	12	86	1.00	0.93	1.00	12000	35.0	.	.	E	V	V	LOG STORAGE
R13	13	86	1.00	0.94	1.00	12000	35.0	.	.	E	V	V	FAIRGROUNDS
R15	15	86	1.00	0.90	1.00	10741	49.2	14985	84.3	E	H	H	LINFOR LUMBER
S02	32	56	0.55	0.85	0.95	15000	150.0	.	.	E	V	V	NO SIDE MCKINLEY
S04	34	47	1.03	0.52	1.00	1000	10.0	.	.	E	V	V	SLAG REMOVAL AR
S05	35	56	1.00	0.66	1.00	10000	100.0	.	.	E	V	V	H2SO4 TANK CAR
S06	36	38	1.00	0.79	1.00	10000	100.0	.	.	E	V	V	MAIN GYP POND
S07	37	56	1.00	0.85	1.00	10000	100.0	.	.	E	V	V	WSIDE GYP DIKE
S09	39	47	1.00	0.83	1.00	10000	100.0	.	.	E	V	V	S OF CIA DIKE
S10	40	56	0.55	0.82	0.90	30000	300.0	.	.	E	V	V	RR AREA S OF CIA
S16	46	56	0.55	0.50	1.00	30000	300.0	.	.	E	V	V	SWEENY POND AREA
[illegible]	91	86	0.95	0.60	0.95	10000	43.0	.	.	E	V	V	AREA NEAR ZP
[illegible]	92	86	[illegible]	0.65	0.90	10000	43.0	.	.	E	V	V	AREA NEAR AMP
[illegible]	211	47	1.00	0.81	1.00	22908	243.0	25111	249.0	E	H	H	OLD GYP POND
[illegible]	212	47	1.00	0.66	1.00	29F20	241.0	52425	506.0	E	H	H	SMELT PARK LOT
[illegible]	213	86	1.00	0.94	1.00	5510	23.2	9426	43.7	E	H	H	FAIR GROUNDS
[illegible]	251	86	1.00	0.79	1.00	5544	19.1	6430	29.8	E	H	H	E TRAILER PARK
[illegible]	259	56	0.83	0.80	1.00	300000	300.0	.	.	E	V	V	SINTER STORAGE
[illegible]	216	38	0.8[illegible]	.	0.80	2020	.	.	.	E	V		ZP HILLSIDE
[illegible]	219	86	1.00	0.90	0.90	20493	82.9	36993	88.8	E	H	H	SHOSHONE APTS
[illegible]	220	86	1.00	0.86	1.00	20961	63.9	35500	110.0	E	H	H	[illegible] HI AREA
[illegible]	221	86	0.8[illegible]	0.95	1.00	21449	57.4	22443	62.3	E	H	H	SHV SWAMP
[illegible]	222	47	0.83	0.56	0.95	11133	32.3	13559	36.1	E	H	H	S OF FREEWAY #22
[illegible]	224	47	0.85	0.72	1.00	1097	7.0	2980	15.1	E	H	H	ZANNETTI AREA
[illegible]	226	27	0.8[illegible]	0.81	0.85	7500	.	.	.	E	V		E OF CIA RV/INT
[illegible]	227	86	1.03	0.90	0.90	18669	62.5	26635	73.0	E	H	H	S OF FREEWAY #27
[illegible]	230	86	1.00	0.93	1.00	10741	49.2	14985	84.0	E	H	H	LINFOR LUMBER
[illegible]	231	47	0.93	0.79	0.40	6000	.	.	.	E	V		SF & PINECR CONF
[illegible]	232	38	0.23	0.80	1.00	7500	.	.	.	E	V		N OF BH POND
[illegible]	233	86	0.83	0.77	1.00	6000	.	.	.	E	V		SHV GRAVEL PIT
[illegible]	234	86	0.83	0.95	1.00	17896	65.3	22045	71.1	E	H	H	MOTOCROSS
[illegible]	235	38	0.93	0.95	0.75	12000	35.0	.	.	E	V	V	N OF AIRPORT
[illegible]	236	86	1.00	0.99	0.90	10422	30.8	14087	43.1	E	H	H	AIRPORT AREA
[illegible]	237	47	0.85	0.72	0.90	10000	30.0	.	.	E	V		S OF FREEWAY #37
[illegible]	225		.	.		.	.	.	.				
[illegible]	207	56	0.62	0.79	0.90	11444	41.0	17685	81.1	E	V	V	N GYP POND
[illegible]	208	56	0.62	0.79	0.90	11444	41.0	17685	81.1	E	H	H	N GYP POND SLAG

5.0 AMBIENT ANALYSIS

5.1 GENERAL

The heavy-metal contamination problem in the Silver Valley is extremely complex. The air pollution component is especially difficult. Considerable care must be exercised in any analysis of the support data and the particulars of the analytical procedures. In any type of modeling study where mathematical expressions are used to represent physical phenomena, certain assumptions have to be made to accommodate the analysis. The adequacy of those assumptions most often determines the quality of the results and conclusions. The types of assumptions that are inherent to simulation diffusion models (at the practiced state-of-art) could possibly make such analyses unreliable for the Silver Valley situation. However, given the wealth of data available, an empirical application in this situation could result in a more reliable analysis. Literature citations and a support argument for this position can be found in von Lindern (1980b).

This is not to say, however, that there are no problems in an empirical analysis. Analyses where observed pollutant concentrations are related to atmospheric and emissions indices, in the ignorance of the physical phenomena involved, are particularly prone to erroneous conclusions. Great care must be exercised in the design of the model and the interpretation of results. In any modeling analysis, it is important to understand the physical and anthropogenic factors involved. This background information is necessary to select and to evaluate the assumptions discussed above. Most of this background material has been summarized in earlier sections. However, there are three areas of specific difficulty that should be discussed. The problems are presented in detail in von Lindern (1980b). However, they are important enough to repeat briefly in this presentation. They are:

1. Meteorological factors associated with complex terrain.
2. Spatial and temporal valuation in source strength and multiple source configurations.
3. Interdependency of source strength and configuration with meteorological variables.

Two atmospheric phenomena common to complex terrain literature are especially important in the Silver Valley: the frequent formation of surface based nocturnal inversions and the mountain-valley drainage wind. Radiative cooling of the slopes of the valley causes air temperature to decrease near the surface. As it cools, it becomes more dense and flows downslope to the valley floor and subsequently down valley. Extreme diurnal shear and low level isothermal structures can result from this drainage. This capping phenomena inhibits pollutant diffusion and enhances terrain channelling. After sunrise the slopes of the valley heat more rapidly than the floor. This results in the descent of the inversion layer as insolation proceeds and fumigation phenomena can return residual pollutants trapped aloft overnight to the ground. Following this period flow up the valley predominates. This flow is typically associated with the prevailing synoptic winds augmented by upslope winds resulting from differential heating. The valley narrows and deepens considerably in this direction. As a result, significant terrain channelling is expected with up-valley winds, even in the absence of stable layers aloft.

Conventional modeling analysis dealing with long-term effects requires some degree of uniformity and homogeneity in both atmospheric and source behavior. The second difficulty in analyzing the Silver Valley via modeling concerns the spatial and temporal irregularities in source behavior. Source descriptions were provided in the last section. Point sources are generally uniform in their behavior. Industrial processes are designed to operate at particular rates and capacities. Control equipment is correspondingly designed and emission rates are consistent. When dealing with process fugitive sources, emission rates become irregular, depending on process fluctuations and outside stimuli. These two categories are also subject to upsets and malfunctions that can result in orders of magnitude changes in emission rates for short periods of time. Active fugitive sources are sporadic and their emission rates depend on the frequency of their parent mechanical activity and local meteorological conditions. Passive fugitive source emission rates are wholly dependent on meteorological factors and vary not only in magnitude and frequency but in configuration as well. Wind speed, wind direction, and surface conditions dictate these sources' contribution to atmospheric levels.

This last factor, the interdependency of source strength and configuration with meteorological variables is, perhaps, the most confounding factor in applying modeling techniques to this problem. Ironically, it is this same dependence that allowed solution of this problem through the techniques employed. As an excellent meteorological data base was available through the Bunker Hill Company's Supplementary Control System (SCS) monitoring network, source behavior could be quantified through meteorological indices. However, doing so in an empirical format utilizing over thirty variables and two years of data from hundreds of sources was a tremendous computational demand. In this study, the problem was addressed by using the geographic information system described in von Lindern (1980b).

5.2 THE MODELING PROCEDURES AND ASSUMPTIONS

5.2.1 The Basic Source-Receptor Model. The objective of this modeling analysis is to quantify those factors most important in air lead contamination in the Silver Valley and to ascertain the relative contribution of different sources to excess atmospheric concentrations. Considering the wealth of data available and the particular difficulties of applying standard diffusion models, an empirical approach was selected. The first step in the solution strategy was to develop the basic source-receptor model describing the fundamental relationship between a receptor and any source of exposure. The design of that model should account for those particular topographical emissions, and meteorological phenomena suspected of confounding air pollution impact analysis in this area. The most important of these considerations have just been discussed. Cursory examination of the wind spectra in the Silver Valley suggests that the mountain-valley drainage/nocturnal inversion scenario dominates the local meteorology on the majority of days. The model developed sought to quantify the basic source-receptor relationship in a quasi-Gaussian fashion by accounting for the peculiar flows associated with this diurnal phenomenon. It is also known that certain meteorological conditions can void or considerably modify the basic relationship. The Bunker Hill Company SCS has identified those critical meteorological situations. Their data are used to modify the basic relationship where appropriate by dummy variable additions to the regression procedure.

5.2.2. Variable Construction. A derivation of the modeling equations and construction of the variables and regression analyses are not contained in this report but can be found in von Lindern (1980b). It is most important in this report to point out and discuss the assumptions inherent to the modeling strategy and how those assumptions affect the quality of the results and limit the conclusions that may be drawn from these techniques.

The basic modeling equation was the simple Gaussian plume model

$$x = Q \cdot \frac{1}{2\pi u} \cdot \frac{1}{\sigma y \sigma z} \cdot \exp\left(\frac{-y^2}{2\sigma y^2}\right) \cdot \exp\left(\frac{-H^2}{2\sigma z^2}\right)$$

where

x = the pollutant concentration at the receptor

Q = the initial pollutant source strength

u = the wind speed in the x direction

σy and σz = the standard deviations in pollutant concentration in the y and z directions

x,y,z = the Cartesian coordinates

H = the difference in elevation between source and receptor

No provision is made for differential plume rise or particulate settling. This model was derived in a surrogate form to accommodate those variables that were available from the emissions, meteorological, and geographic data bases. Three basic requirements were involved in the surrogate derivations: (1) the equation had to be derived using variables that were both available from the emissions and meteorological inventories and that were amenable to manipulation in the geographic information system, (2) the model had to be capable of empirical parameterization via linear regression, and (3) the model, to the maximum extent possible, should reflect the concepts of accepted air pollution meteorology. Simultaneously accommodating these constraints involved making several assumptions and adjustments to the solution strategy. Those basic assumptions are discussed below.

OBSERVATION TIME PERIOD BASIS. The dependent variable in the equation is the mean 24-hour pollutant concentration observed at the various stations. These data were obtained from the State's hi-vol network shown on page 20. These data are believed to be of excellent quality and were used as is. However, this daily periodicity defines the base time unit for the dependent variables.

ADEQUACY OF EMISSION DATA. This represents what could be called the weakest data base in the procedure. Only single observations were available for many of the sources. Quarterly, self-reported, emission rates were available for some smelter sources, but the reliability of these data is unknown. These estimates were reduced to 24-hour emission rates. It is suspected that many of these sources can vary more than an order of magnitude on a daily basis, especially when malfunctions and upsets are considered. Two elements of strategy were developed to deal with this deficiency. The first mitigative factor was to introduce on-off criteria as described in the parent document. Many sources were known to be inoperative on particular days for either operations or meteorological reasons. Zero emission rates were assigned to the appropriate sources for these days. The second mitigative element concerns the basic philosophy of the entire project. The source contributions and rollbacks eventually developed are discussed in relative rather than absolute terms. Pseudo-dummy variable analysis, as described by Draper and Smith, is utilized throughout. This technique is especially useful in determining the relative significance of different variables in regression analysis.

Source estimates were eventually grouped into eight categories for final analysis. The grouping was based on the spatial configuration of the sources. The basic assumption is that significant particulate lead sources emanate from eight predominant locations in the valley. By appropriately characterizing the emissions (by rate estimates and on-off criteria) and the atmosphere (by wind and stability indices), relative contributions could be ascertained by regression analysis.

THE VIEWFIELD ASSUMPTION. Downwind concentration dilution in the traditional Gaussian formula is inversely proportional to the wind speed. Doubling the wind speed doubles the space between particles and halves observed concentrations. However, this assumes a constant wind direction and speed. In the Silver Valley wind direction and speed change continuously and usually reverse themselves daily in association with the mountain-valley drainage phenomenon. In order to compensate for this difficulty in the daily time basis, two wind flow directions were assumed in conjunction with the mountain-valley drainage phenomenon. Up-valley and down-valley winds were defined. The mean daily wind speed, direction, duration, and standard deviation in wind direction were calculated for each flow. Each receptor's face was turned into the wind and its upstream "view" was considered. This is the

VIEWFIELD assumption. How many sources a receptor can see depends on its "viewfield" or a narrow upwind sector that contains those sources that could possibly impact that receptor. The depth of view depends on wind speed and duration of the wind flow from that direction. The width of the sector depends on the variation in wind direction. An expression was derived to express the number of hours per day that a receptor was exposed to a source and the assumption was made that the downwind component of dilution was proportional to that duration of exposure and inversely proportional to wind speed and the width of the view-sector. These terms are all calculable in the geographic information system and could be easily accomplished for each receptor location. In this way, both a proportioning factor and an additional on-off criteria were developed. If, because of wind speed or direction, a receptor is not exposed to a source during the day the exposure reduces to zero. If the wind blows consistently all day from source to receptor the downwind dilution becomes the 1/u term in the traditional equation. This variable is not meant to simulate wind flow in the valley. It is an index meant to represent downwind dilution from sources in the up- and down-valley directions and is designed for use in a regression equation.

THE STABILITY ASSUMPTION. The surrogate term for the $\frac{1}{\sigma_y \sigma_z}$ term in the Gaussian model equation was designed so that the Gifford-Pasquill form of these variables could be recovered from the eventual regression coefficients. First the traditional form of the Gifford-Pasquill plots were derived in a system of linear equations developed through logarithmic transformations. It was then assumed that the linear coefficients for this system were a function of atmospheric stability and would be specific for this situation.

Next the potential temperature gradient at Spokane International Airport was selected as the daily indicator of atmospheric stability. This has been found, through the Company's SCS, to be the most appropriate stability index available. It was then assumed that the linear coefficients were first degree functions of the potential temperature gradient. This assumption is consistent with the form of the Gifford-Pasquill charts and results in a convenient form of the expression for both parameterization and geographic manipulation.

THE PLUME MEANDER ASSUMPTION. The term $\exp(\frac{-y^2}{2\sigma y^2})$ in the Gaussian plume analogy represents the dilution effect of being remote from the mean wind vector. In the Gaussian formulation, a uniform wind direction is assumed and the degree of lateral dilution is a function of atmospheric stability. In the Silver Valley, wind direction fluctuates continuously and straight line flow is not expected. Thus, it was assumed that exposure reductions associated with being remote from the mean wind vector are more a function of variation in the mean wind vector than of the stability criteria per se. Two lines of reasoning justify this assumption. The variation in the mean wind vector (plume meander) is likely a function of stability itself. And the maintenance of a crosswind Gaussian distribution in the Silver Valley is unlikely. Plume meander, when considered on a daily basis, would predominate any such distribution. As a result the standard deviation in wind direction was selected as a measure of crosswind remoteness and dilution was assumed to be a function of the number of standard deviations a receptor was from the mean wind vector.

THE VERTICAL DISTRIBUTION ASSUMPTION. Differential plume rise, particulate settling, and plume depletion are all ignored in this model. A constant plume rise and constant plume elevation are assumed. The main reason for ignoring differential plume rise was the insufficiency of the data base for developing appropriate variables. In order to account for plume rise, an equation utilizing the atmospheric surface temperature and wind velocity would have to be included in the source height factor. These measurements are used in other independent variables in the modeling equation. Including them in another term would increase the possibility of undesirable effects associated with inter-variable correlation. Moreover, from a practical point of view, these are low temperature plumes and only a single morning surface temperature was available. The benefit of using that single observation in predicting an effective daily plume rise was considered not worth the confounding effects of adding a possibly redundant variable. Considering plume depletion, no data were available for developing settling estimates. Making unnecessary assumptions in the development of regression variables should be avoided. Practically, plume depletion must be significant with respect to certain sources. Fugitive sources in particular contain large particle emissions subject to considerable fallout. Point sources, on the other hand, are fine particle emissions that may approximate gaseous behavior. As explained later, cadmium emissions are used to parameterize the basic source receptor model. Cadmium emissions are predominantly fine particulate. Ignoring settling phenomena is, likely, permissible in defining parameters for the model. Later, when developing source estimates for lead and particulates, depletion from fugitive sources must be considered important. However, in the division of source categories, active and passive sources appear in separate independent variables. When linear regression analyses are applied to those variables it can be inherently assumed that some constant amount of plume depletion is accounted for in assigning the regression coefficients. In practical terms, the assumption is that a particular percentage of fugitive emissions fall out between the source and nearest receptor and that gaseous behavior is observed beyond. This assumption is adequate for the empirical format of the study.

THE EMPIRICAL MODIFIERS. The Bunker Hill Company meteorologists operating the Supplementary Control System (SCS) have long recognized those difficult meteorological factors discussed earlier in this section. They have, through years of experience, developed semi-quantitative indices to represent the onset of certain meteorological and operational conditions. For the most part, these variables identify the onset of non-routine conditions where "normal" assumptions do not apply. As such they are quite appropriate for use in regression analysis as dummy variables to account for the effects of special conditions where the base model may not apply. These variables were transformed to act as empirical modifiers in the regression analyses. Details of the variables and transformations can be found in the parent document.

5.2.3 Finding the Model Parameters. The model was assigned parameters through a stepwise regression procedure that forced inclusion of the variables developed as the initial surrogate model. The several empirical modifiers developed from the SCS were also offered for forward selection. There are several assumptions inherent to regression analysis that are not necessary to include. However, there are two assumptions made in solving the regression equation that are important to discuss here.

The first is the use of cadmium data to find the model parameters. The number of sources and the difficulties with defining configurations make it impossible to solve the modeling equation for lead or total particulates. Cadmuim emisions, however, seem to predominatly arise from within the lead smelter or, more to the point, from the same geographic location. This considerably reduces the complexity of the modeling equation for cadmuim. Because cadmuim emissions do emanate from three distinct source heights, one unknown function still precludes solution of the equation. An assumptive constraint has to be added to the regression matrix. That constraint was developed by assuming that the ratio between σ_y and σ_z at neutral stabilities at 0.1 miles from the source will be the same as the ratio found under there conditions in the traditional Gifford-Pasquill charts.

5.3 THE IMPORTANT SYSTEM VARIABLES

Using these two assumptions, the equation was solved and the selected model is shown below. An extensive discussion of the results is found in von Lindern(1980b).

The regression statistics for this model indicate that pollutant dispersion can be successfully quantified by this model form. Seventy-three percent of the variablity in observed concentrations is explained at strong significance levels. The initial model seems particularly strong ($R2$ = .71 at p .0001). This is especially encouraging considering the difficulties with cadmuim source estimates discussed earlier.

Table 5.1 Regression Statistics for Selected Stepwise Model

Initial Model: $DEPZ = \beta_0 + \beta_2 LNVWF + \beta_3 POTEMP + \beta_4 lnX + \beta_5 POTEMlnX + \beta_6 NSDSQ$

Model Statistics by Step

Step	Variable Added	Sum of Squares Model	F-Model (P>F)	F-Variable on Entry (P>F)	R^2 Model
0	(Initial Model)	7749.4	673.3(.0001)	(all .0001)	.712
1	MD50LNX	7836.9	583.3(.0001)	39.0(.0001)	.720
2	REGVAR	7870.1	507.3(.0001)	15.0(.0001)	.724
3	BFDOWN	7892.5	448.2(.0001)	10.2(.0015)	.726
4	MD36	7914.2	402.1(.0001)	10.0(.0016)	.728
5	W15	7930.8	364.4(.0001)	7.6(.0059)	.729

Total SS = 10877.5

Parameter Statistics on Final Step

Source	Parameter Estimate	Sum of Squares	F (P>4)
INTERCEPT	2.31	(SAS Type II)	
LNVWF	.17	31.0	14.2(.0002)
POTEMP	.65	1511.5	694.5(.0001)
LNX	1.51	1999.4	918.7(.0001)
POTEMP*LNX	.15	898.2	412.7(.0001)
NSDSQ	-.04	91.8	42.2(.0001)
MD50LNX	.16	33.0	15.2(.0001)
REGVAR	.20	33.2	15.3(.0001)
BFDOWN	.75	40.9	18.8(.0001)
MD36	2.06	25.4	11.7(.0006)
W15	.084	16.5	7.6(.006)
SS (Model)		7930.8	F-Model = 36.4
SS (Error)		2446.7	R^2 Model = .729
SS (Total)		10877.5	

* variable descriptions can be found in Table 5.3

Table 5.2 Regression Statistics for Final Logarithmic Model

$$DEPZ = \beta_0 + \beta_2 LNVWF + \beta_3 POTEMP + \beta_4 LNX + \beta_5 POTEMP{*}LNX + \beta_6 NSDSQ + \beta_7 BFDOWN + \beta_8 MD36 + \beta_9 MD50LNX + \beta_{10} W15 + \beta_{11} REGVAR$$

Source	DF	Sum of Squares (SAS Type IV)	F-Value (PR>F)
LNVWF	1	40.4	22.0(.0001)
POTEMP	1	1327.9	720.8(.0001)
LNX	1	2016.8	1094.6(.0001)
POTEMP*LNX	1	784.4	425.7(.0001)
NSDSQ	1	80.7	43.8(.0001)
BFDOWN	1	23.4	13.0(.0003)
MD36	1	18.4	10.0(.0016)
MD50LNX	1	22.2	12.0(.0005)
W15	1	17.4	9.4(.0022)
REGVAR	1	36.4	19.8(.0001)
Model	10	7499.4	407.0(.0001)
Error	1428	2631.0	
Total	1438	10130.4	R^2 = .740

Parameter	Estimate	T-Value (PR>T)	Std. Error
β_0	2.26	6.50(.0001)	.347
β_2	.192	4.69(.0001)	.040
β_3	-.612	-6.62(.0001)	.023
β_4	-1.48	-26.85(.0001)	.045
β_5	.138	-33.08(.0001)	.007
β_6	-.039	-6.62(.0001)	.006
β_7	-.569	-3.61(.0003)	.157
β_8	1.75	3.16(.0016)	.554
β_9	-.124	-3.47(.0005)	.036
β_{10}	.085	3.07(.0022)	.027
β_{11}	.205	4.45(.0001)	.046

* variable descriptions can be found in Table 5.3

As in von Lindern (1980b) the best way to discuss these model results is in terms of the regression coefficients. Parts of those discussions are included here.

Ten variables were selected as important in predicting observed cadmium levels. The first five variables comprise the initial surrogate model. Five of the empirical modifiers offered were found to be significant. Briefly, they are:

BFDOWN--the on-off indicator of blast furnace operation.

MD36--an on-off indicator of the most severe limitation in mixing depth.

MD50LNX--the on-off variable for situation of uninhibited mixing depth times the logarithm of distance.

W15--an indicator of suppressed wind speeds in the middle atmospheric layers of the valley.

REGVAR--the severity code indicating adverse dispersal conditions associated with peculiar synoptic situations.

The model as taken from the parent document is as follows:

$$\ln(\chi_T) = \beta_0 + \beta_1 \ln QHF + \beta_2 \ln VWF + \beta_3 \, NSDSQ + \beta_4 \, POTEMP$$

$$+ \beta_5 \, LNX + \beta_6 \, POTEMP * LNX + \beta_7 \, BFDOWN + \beta_8 \, MD36$$

$$+ \beta_9 \, MD50LNX + \beta_{10} \, W15 + \beta_{11} \, REGVAR$$

The parameters, their associated independent variable, and the parameter values are shown in Table 5.3.

Table 5.3 Parameter Values for the Logarithmic Model

Parameter	Independent Variable	Factor Description	Parameter Value
β_0	Intercept	Initial dispersion	2.26
β_1	ln(QHF)	Source height function	1.00
β_2	ln(VWF)	Receptor View function	.192
β_3	NSDSQ	Lateral position factor	-.039
β_4	POTEMP	(Stability)	-.612
β_5	LNX	(and)	-1.48
β_6	POTEMP*LNX	(distance factors)	.138
β_7	BFDOWN	Operations factor	-.569
β_8	MD36	Limited mixing depth factor	1.75
β_9	MD50LNX	Uninhibited mixing depth factor	-.124
β_{10}	W15	Inhibited mid-level winds factor	.085
β_{11}	REGVAR	Severe synoptic factor	.204

* for a detailed description and derivation of these variables please see von Lindern 1980b

These parameters and associated variables can be grouped for discussion relative to their contribution to quantifying pollutant dispersion in this valley.

β_0, β_4, β_5, and β_6 are the dispersion parameters for the plume centerline dilution effect associated with the mean wind as derived from the traditional Gaussian form. These parameters were used to derive the familiar σ_y-σ_z plots of Gifford (1961) and direct comparisons of the dispersal conditions in this situation are made relative to the standard modeling assumptions.

β_1 is the unit coefficient for lnQHF or the source strength-source height term. This term reflects the initial source strength reduced by a factor dependent on the relative source-receptor height. The latter is developed from the same basic component parameters as β_0, β_4, β_5, and β_6 above.

β_2 and β_3 are associated with the terms ln(VWF)and NSDSQ. These two variables, as they were developed, serve to mitigate the standard model predictions with respect to the topographically induced wind conditions. VWF is an exposure factor that accounts for the reduced receptor "view" of the source associated with up- and down-valley wind shifts. NSDSQ is associated with the lateral variance in the mean wind and accommodates reduced exposures associated with the cross-valley wind shifts. In the form offered in the modeling analysis, they become empirical modifiers of the more traditional dispersion equation characterized by the above parameters and variables.

β_7 is the parameter for BFDOWN and is a direct empirical modifier associated with shutdown of the largest single cadmium source. The β estimate for this term is (-.569). When the blast furnace is down (BFDOWN = 1), the predicted effect is exp(-.569 * 1) = .57 times the model prediction. This suggests that when the blast furnace is nonoperative at least 16 hours per day, ambient cadmium levels are reduced 43%.

β_8 and β_9 are associated with extreme mixing depths. β_9 is the parameter for MD50LNX. This variable allows for greater dispersion under uninhibited vertical dispersion conditions. Because a limited mixing depth associated with nocturnal inversion is the "normal" situation in this valley, the standard diffusion parameters (β_0, β_4, β_5, β_6) are calculated under that circumstance. The value of β_9 is 0.125. The significance of this variable is as follows: when mixing depth is great (i.e., MD50 = 1, MD50LNX = ln(x)) the value of the coefficient of ln(x) or p + q = -(1.48 + .125) = -1.61. This is nearly the value supposed in the traditional Gifford-Pasquill form as discussed in von Lindern (1980b). This supports the idea that the "normal" situation in the Silver Valley has an associated limit to vertical dispersion probably related to the surface based nocturnal inversions. Uninhibited vertical dispersion is an "abnormal" situation. Similarly, when mixing depth is severely inhibited, an opposite "abnormal" effect is present. The variable MD36 has a value of 1 when mixing depth is most shallow and 0 at other times. The β value for this variable is 1.75. This suggests that when the lowest level inversion structure exists, the model predictions are increased by exp(1.75) = 5.75 times. This represents a severe condition treated here by a simple empirical modifier.

β_{10} and β_{11} are empirical modifiers associated with special synoptic situations. $\beta_{10}\cdot$W15 accounts for reduced wind speeds in the mid-level valley atmosphere. β_{11} is associated with REGVAR, an indicator of severe synoptic conditions. The W15 variable has greatest effect when the mean wind value is less than 1 mph. At that value the model estimate may be increased as much as exp(.08*5) = 1.5 times. This situation implies extreme calm or shear in the middle atmospheric levels. REGVAR is a severity code associated with some peculiar synoptic conditions. Two conditions are especially important. They are the valley drainage wind (=3) and stagnation (=5) that are both associated with high pressure areas in the mountain range vicinity. The former can increase model estimates by exp(3*.20) = 1.8 times and the latter by exp(5*.20) = 2.7 times.

The strength of the initial model indicates that the mountain valley drainage phenomena dominate pollutant dispersion in the Silver Valley. The two mixing depth variables selected in the stepwise process suggest that nocturnal inversions are also part of the "normal" dispersion picture for the valley. Four levels of mixing depth were offered in the stepwise procedure. The non-significance of the two middle levels indicates that they are accounted for in the remainder of the model. In practical terms this means that the basic source-receptor model reflects a diurnal capping inversion between 3600 and 4800 feet. Special modifiers to the basic model are required only when greater or lesser mixing depths are present.

It also means that the dispersion parameters derived from the regression coefficients for this situation reflect this diurnal phenomenon. Some important aspects of the montane air pollution meteorology for this area can be explained by comparing these derived dispersion coefficient estimates with the standard Gifford-Pasquill parameters.

Figures 5.1 a and b show the derived dispersion parameters for this situation plotted as solid lines. The dotted lines are the corresponding plots taken from the subroutine distributed by EPA (1976b) to estimate Gifford-Pasquill dispersion parameters. (The units have been converted as indicated in the axes labels.)

In discussing the differences in these two sets of curves, it is important to remember that the standard curves represent the expected standard deviations in the horizontal and vertical distributions of pollutants calculated for different stability criteria and downwind distances. Both sets assume a normal distribution around a plume centerline defined by the mean wind vector and have been developed from field observations over flat terrain for relatively short averaging periods (<30 min).

The curves offered in this study are derived in a totally different manner. The Gaussian form is present, but much modified in an effort to accommodate the majority of wind fluctuations in the NSDSQ and VWF terms. These two terms account for, respectively, the daily cross-valley variation in wind direction and the variation in wind speed and flow up and down the valley. In a sense they normalize the dispersion curves by accounting for the gross fluctuations related to the local wind phenomena.

The dependent variable in this model development was a twenty-four hour average. As a result, all independent variables were constructed on a

Figure 5.1a Comparison of Standard and Derived Horizontal Dispersion Parameter Estimates

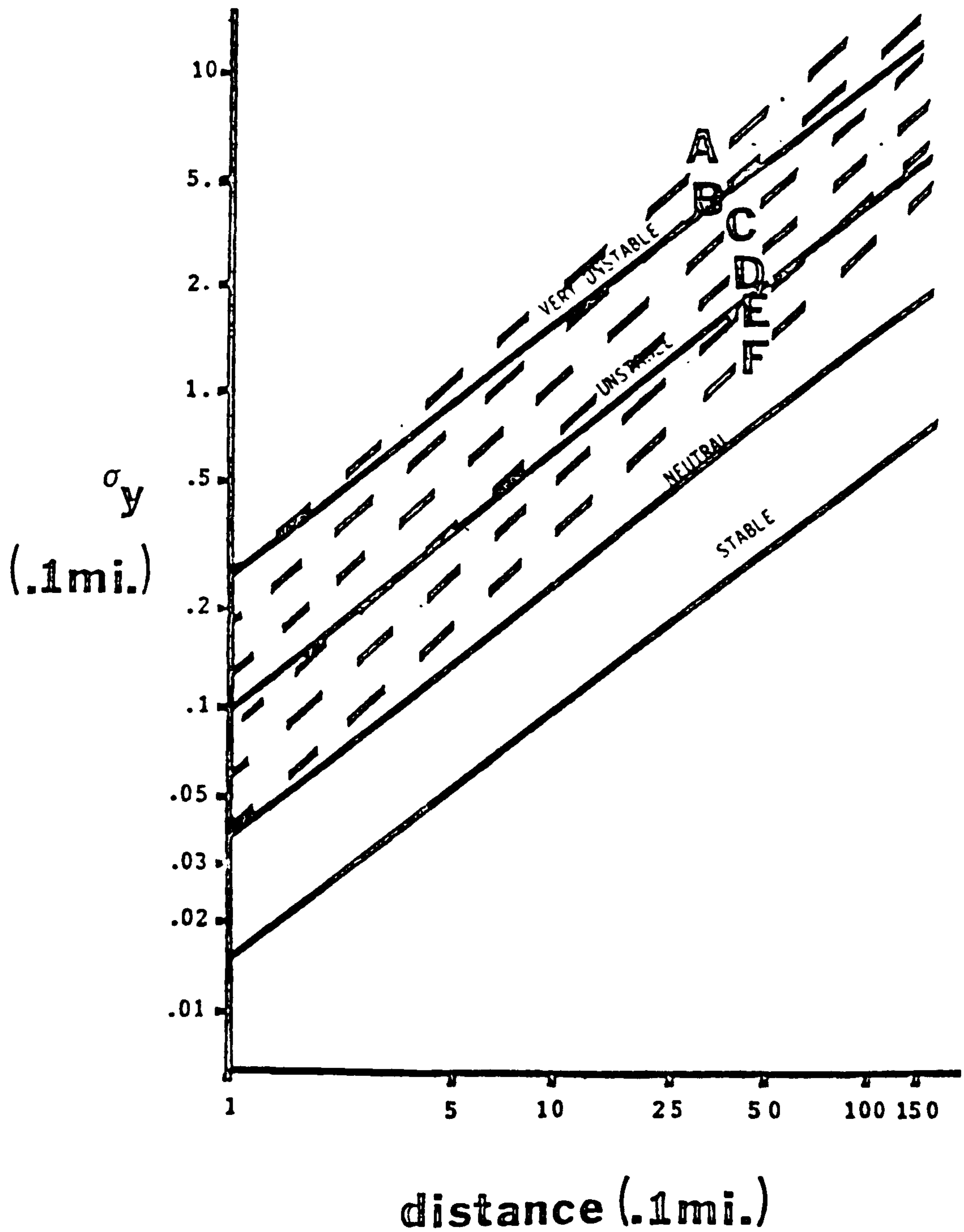
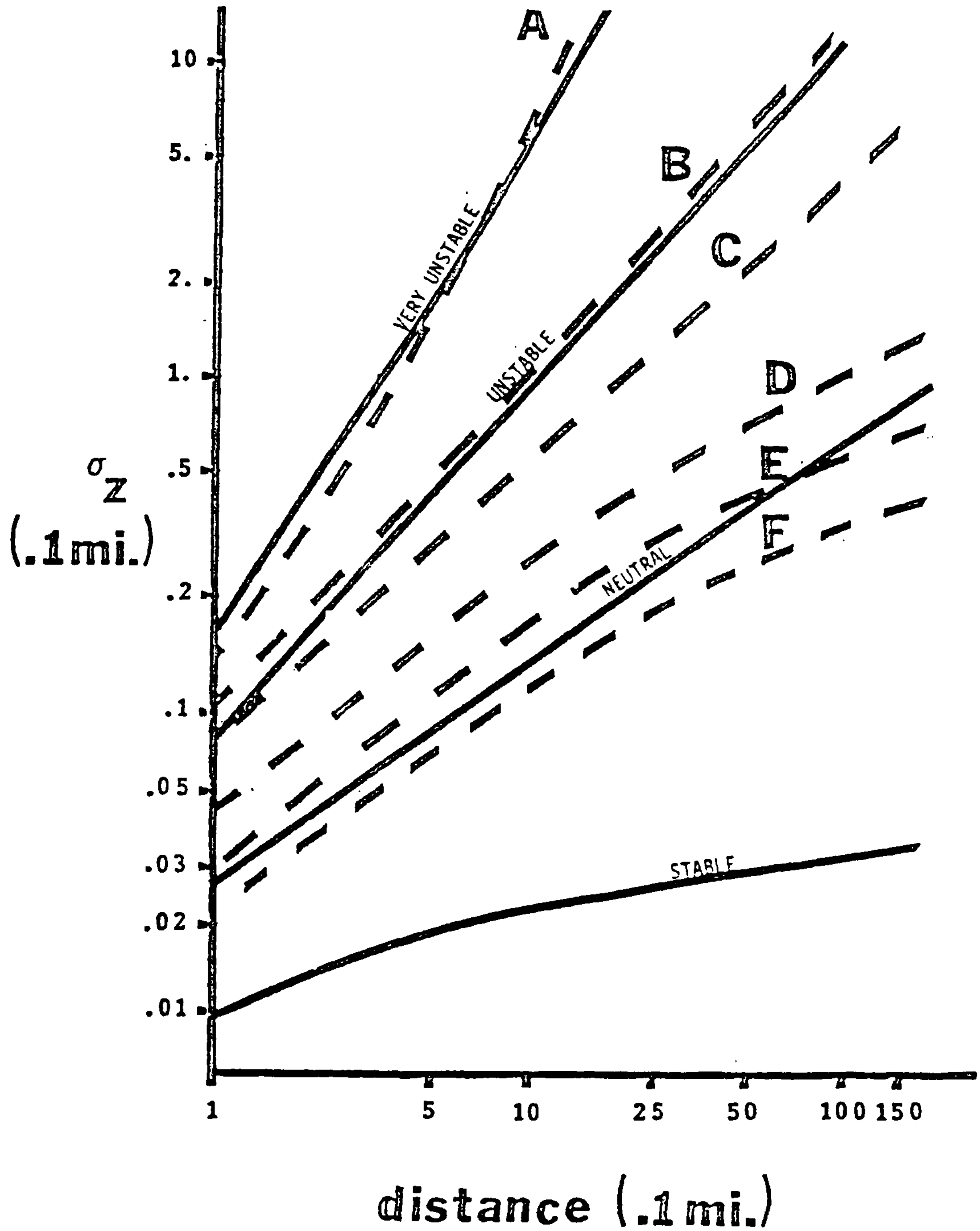


Figure 5.1b Comparison of Standard and Derived Vertical Dispersion Parameter Estimates



twenty-four hour basis. This represented no great inconvenience because the mountain-valley drainage wind is a diurnal phenomenon. However, it is not obvious what the σ_y and σ_z terms in the above derivations and charts represent. Examination of Table 5.2 shows that a certain amount of the variance in pollutant concentrations is explained by the gross wind variation terms, NSDSQ and VWF. Other empirical factors related to operations and "abnormal" meteorology explain a small percentage. However, the greatest portion of the sums of squares is explained in the three terms from which the σ_y and σ_z charts are derived. Those terms most likely represent the downwind pollutant distribution for the component wind period, averaged over twenty-four hours. The component averaging period is the one-hour mean wind. It is suspected that the σ_y and σ_z values derived are the expected standard deviations in downwind pollutant concentrations for one hour for a given stability category. However, that value necessarily reflects an average for all the hours of the day. This is a most important point to remember in discussing the differences in these and the standard curves.

Turner (1979) pointed out that any modeling effort has to consider the pertinent averaging period with respect to both the prevalent meteorological phenomena and the ambient standard in question. The same logic prevails here. These charts and the other significant model variables can illustrate many of the difficulties encountered in applying Gaussian form models to complex terrain, provided the pertinent averaging time is considered.

There are three obvious differences in the form of these two sets of curves. The first difference is that the estimates are similar for unstable conditions but considerably less dilution occurs as neutral conditions are approached, and that effect is exacerbated toward stable conditions. The second inconsistency is that the slopes of the curves in the horizontal dispersion chart are notably less than their standard counterparts. The third difference is that under very stable conditions a nearly uniform distribution in the vertical with downwind distance is predicted in this study's σ_z chart.

The mitigation of terrain effects under unstable conditions has been noted by several researchers (Hinds, 1970; Fosberg et al., 1976; Reid, 1979). It is likely that when unstable conditions prevail, no capping phenomena are present and uninhibited vertical dispersion would persist. Similarly, the tendency to develop calm and stable layers aloft is reduced over the twenty-four hour period. As a result, the only inhibition to normal diffusion present would be terrain channeling. Under unstable conditions terrain channeling would likely exercise its influence in the horizontal, but not for some distance downwind. The effect of terrain channeling on the horizontal dispersion parameter may be seen in the reduced slopes noted above. Other complex terrain researchers have made similar findings as reviewed by Miller (1979). However, the result in these cases is usually curved σ_y lines starting out at or near standard slopes and decreasing in slope with distance. This is, perhaps, a more appropriate form than that presented in this study, as the effect of terrain channeling would become more pronounced with plume growth relative to the valley width. Unfortunately, this model form can only accommodate straight lines in the horizontal.

Essentially the mitigative effects of instability on complex terrain dispersion may be accounted for in the absence of those phenomena that produce the confounding situations. As neutral conditions are approached the nocturnal inversion and drainage wind phenomena become routine. Over a twenty-four hour period, a considerable period of time is spent under an inverted temperature structure, downslope winds develop, and at least two directional changes in valley flow occur. In addition, during inversion breakup a double dosage of pollutants can occur. As stable conditions develop these phenomena become more intense with increased duration. These hours or, more appropriately, the dispersion observed in these hours is included in the "average" that produces the above charts.

As very stable situations are encountered, calm conditions, intense inversions aloft, and severe limitations in mixing depth are likely. Most air quality models of the Gaussian form have recognized that, under limited mixing depths, uniform vertical distribution may develop some distance downwind. That observation may be seen in the σ_z curves at stable conditions.

Several researchers have noted that it is stable conditions that are difficult to simulate in complex terrain situations. In this case, the frequency and duration of particular phenomena (that become more frequent as stability increases) are ultimately responsible. It seems that with the inclusion of mitigating or normalizing variables that account for those phenomena, and with proper consideration of the averaging period, the complex terrain situation may be discussed in an empirical Gaussian format.

5.4 APPLYING THE BASIC SOURCE RECEPTOR RELATIONSHIP

5.4.1 Methodology. Thus far, the modeling procedure has concentrated on defining the basic relationship between a receptor and a source. Having developed a satisfactory model, the next step was to apply it to all the source-receptor combinations in the valley. In practice this was a mammoth task. However, it was greatly facilitated by employing the Geographic Information System. The details of this application are complex and can be found in von Lindern (1980b).

As the relationship was applied to each source, the impact estimates were accumulated by source category at each of the valley's nine monitoring locations. These categorical estimates were then regressed against observed ambient concentrations. This was accomplished for each day of the two-year study and done simultaneously for lead, cadmium, and TSP. The result is a calibrated model that reflects the most significant particulate sources and weights the relative impacts of the various categories. This, again, was an exhaustive and complex procedure that is detailed in von Lindern (1980b). Over 4300 observations were analyzed. The regression statistics are shown below.

The eight source categories are SMLOWEST (low-level smelter sources), SMMIDEST (mid-level smelter sources), SMHIEST (smelter tall stack), ZPLOWEST (zinc plant tall stack), AMP (ammonium phosphate plant), ACTEST (active fugitive sources), and PASEST (passive fugitive sources). They are described in detail in von Lindern (1980b) and the emissions inventory section of this report. Four of these source categories were found to be significant in predicting particulate concentrations in the Silvery Valley. They are low- and mid-level smelter sources, and both active and passive fugitive sources. The other source categories likely do contribute, but are insignificant in magnitude when combined with these sources. Final prediction statistics can be found in Tables 5.4a and b. BKGROUND refers to TSP background levels (BKGROUND = 0 for lead and cadmium).

Table 5.4a Regression Statistics for the Model:

$$TPOL = \beta_1 SMLOWEST + \beta_2 SMMIDEST + \beta_3 SMHIHEST + \beta_4 ZPLOWEST + \beta_5 ZPHIHEST + \beta_6 AMP + \beta_7 PASEST + \beta_8 ACTEST + \beta_9 BKGROUND$$

Source	DF	Sum of Squares (SAS Type IV)	F-Value (PR>F)
SMLOWEST	1	136963	379.9(.0001)
SMMIDEST	1	27801	77.1(.0001)
SMHIHEST	1	696	1.9(.1646)
ZPLOWEST	1	971	2.7(.1008)
ZPHIHEST	1	993	2.8(.0970)
AMP	1	1196	3.3(.0685)
PASEST	1	52130	144.6(.0001)
ACTEST	1	5246	14.6(.0001)
BKGROUND	1	576519	1598.9(.1646)
Model		3771996	1162.4(.0001)
Error		1527706	
Total		5299703	R^2 = .712

Parameter	Estimate	T-Value (PR>|T|)	Std. Error
β_1	.425	19.5(.0001)	.021
β_2	4.62	8.8(.0001)	.53
β_3	27.	-1.4(.1646)	5.14
β_4	27.8	-1.6(.1008)	17.0
β_5	-109.1	-1.7(.0970)	65.7
β_6	-7.16	-1.8(.0685)	3.93
β_7	19.9	12.0(.0001)	2.43
β_8	9.28	3.8(.0001)	1.65
β_9	35.5	40.0(.0001)	.887

TPOL	Total ambient particulate concentration
SMLOWEST	Low-level smelter sources estimated ambient impact
SMMIDEST	Mid-level smelter sources estimated ambient impact
SMHIHEST	Smelter tall stack estimated impact
ZPLOWEST	Low-level zinc plant sources estimated impact
ZPHIHEST	Zinc plant tall stack estimated impact
AMP	Ammonium phosphate plant estimated impact
PASEST	Passive fugitive sources estimated impact
ACTEST	Active fugitive sources estimated impact
BKGROUND	TSP estimated background concentration

Table 5.4b Regression Statistics for the Final Relative Source Impact Model:

$$TPOL = \beta_1 SMLOWEST + \beta_2 SMMIDEST + \beta_3 PASEST + \beta_4 ACTEST + \beta_5 BKGROUND$$

Source	DF	Sum of Squares (SAS Type IV)	F-Value (PR>F)
SMLOWEST	1	144129	402.(.0001)
SMMIDEST	1	33016	92.(.0001)
PASEST	1	45310	126.(.0001)
ACTEST	1	7458	21.(.0001)
BKGROUND	1	774061	2159.(.0001)
Model	5	3793243	2116.(.0001)
Error	4310	1545150	
Total	4315	5338393	R^2 = .711

Parameter	Estimate	T-Value (PR>|T|)	Std. Error
β_1	.423	20.1(.0001)	.021
β_2	4.20	9.6(.0001)	.437
β_3	17.9	11.2(.0001)	1.59
β_4	10.9	4.6(.0001)	2.39
β_5	35.2	46.5(.0001)	.757

This model in Table 5.4b was used to predict ambient concentrations for each quarter in the study period. Those predictions can be found in Appendix D and a quarterly summary is presented in Table 5.5. Those predictions are used to evaluate relative source contributions to ambient lead concentrations and to estimate required source reductions for achieving the NAAQS. The individual source results and a "residuals" analysis can be found in von Lindern (1980b). An observed/predicted concentrations summary follows.

Model predictions for quarterly lead means range from .26 to 7.2 $\mu g/m^3$ over the entire study area. Actual observed concentrations range from .25 to 12.5 $\mu g/m^3$. These results are summarized in Table 5.5 along with the ratio of predicted to observed values. This ratio on an annual basis consistently falls between .5 and 2.0 (a kind of unofficial measure of model quality). Moreover, on a quarterly basis the model does well in predicting means for most of the stations. This is especially true in consideration of the range of values and the fact that predictions are based on quarterly mean emissions averages.

However, the model does characteristically underpredict in certain situations. The most important are those where a few extremely high individual readings inflate the observed mean. Many of these outlying values do not seem to be meteorologically based, but do occur at different stations on the same day and always downwind from the smelter. It is most likely that these extreme values are the result of severe emissions excursions at the smelter. It is important to note that the model does not effectively predict the impact these days have on the quarterly means. This is important both in terms of utilizing the model output and developing an attainment

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Table 5.5 Summary of Mean Quarterly Ambient Air Lead Impact Estimates, Predicted Values, and Observed/predicted Ratios

KEY ≡ OBSERVED / PREDICTED (RATIO) μg PB/m^3

STATION	QUARTER 3-77	4-77	1-78	2-78	3-78	4-78	1-79	2-79
(1) CAT	.47 / .91 (.5)	.86 / .67 (1.3)	.57 / .76 (.8)	.37 / 1.22 (.3)	.20 / .89 (.2)	.54 / .56 (1.0)	.60 / 1.01 (.6)	.21 / 1.13 (.2)
(2) PNH	2.33 / 1.94 (1.2)	4.02 / 1.19 (3.4)	2.75 / 1.73 (1.6)	.99 / 1.50 (.7)	.85 / 1.62 (.5)	2.81 / 1.75 (1.6)	2.38 / 3.08 (.8)	.77 / 1.88 (.4)
(3) SHV	6.9 / 3.4 (2.0)	8.7 / 3.8 (2.2)	7.7 / 4.2 (1.8)	3.4 / 2.8 (1.2)	2.4 / 2.9 (.8)	6.1 / 3.3 (1.9)	4.8 / 4.2 (1.1)	2.6 / 3.1 (.8)
(4) SKS	12.5 / 4.4 (2.9)	12.3 / 7.2 (1.7)	11.6 / 3.0 (3.9)	6.2 / 3.0 (2.1)	3.6 / 3.6 (1.0)	6.0 / 5.5 (.9)	5.5 / 5.7 (1.0)	3.7 / 6.2 (.6)
(5) KMC	6.5 / 2.9 (2.2)	7.1 / 3.2 (2.2)	6.3 / 4.2 (1.5)	2.4 / 2.5 (1.0)	1.9 / 2.7 (.7)	5.2 / 3.7 (1.4)	4.5 / 6.3 (.7)	2.5 / 5.4 (.5)
(6) KCH	4.1 / 2.7 (1.5)	6.9 / 3.2 (2.1)	6.3 / 4.0 (1.6)	2.9 / 2.4 (1.2)	1.4 / 2.5 (.6)	5.6 / 3.6 (1.6)	4.6 / 6.0 (.8)	2.4 / 3.8 (.6)
(7) OSB	1.5 / .6 (2.5)	3.5 / .6 (6.4)	1.9 / .9 (2.2)	.7 / .5 (1.4)	.4 / .4 (1.0)	1.2 / .7 (1.8)	1.9 / .9 (2.1)	.4 / .5 (.8)
(8) WAL	.9 / .5 (1.9)	1.8 / .3 (.5)	.9 / .6 (1.6)	.5 / .5 (1.0)	.3 / .4 (.80)	.6 / .3 (2.1)	1.0 / .4 (2.7)	.3 / .3 (1.0)
(10) KIN	----	----	.65 / 1.33 (1.5)	.31 / .77 (.5)	.21 / .80 (.3)	1.12 / [illegible] (1.0)	.70 / 1.3 (.5)	.31 / .93 (.3)

strategy. The effect of these days is great enough that they deserve special treatment in attainment considerations; and they are separately discussed in the next section. What is important to remember, at this point, is that the model predictions are based on average emission rates. The resultant predictions are then "average predictions" and any attainment strategy based on the model applies reductions to average emission rates. These reductions will not guarantee compliance with the ambient standard in and of themselves. Simultaneous control of the severe excursions must be accomplished as well. Descriptions of the model results by station and source category follow.

5.4.2 Model Results by Station

CATALDO. Observed ambient lead concentrations range from .008 to 2.8 $\mu g/m^3$ on a twenty-four hour basis. Quarterly means vary from .20 to .86 $\mu g/m^3$ or from 13 to 57% of the quarterly standard. Model estimates range from .56 to 1.13 $\mu g/m^3$. In general the model overpredicts concentrations for this site. According to the model, passive sources are major contributors to lead levels at Cataldo. Percentage contributions from the passive source category run as high as 44% of the quarterly mean in the third quarter (July-September). Summer quarterly mean passive estimates of .6 to .7 $\mu g/m^3$ are predicted. These are among the highest passive predictions for any site. The predominant sources of this passive contribution seem to be alluvial deposits on the nearby Mission Flats and along the river's flood plain north and east of the townsite.

The remaining source contributions seem to be dominated by the mid-level smelter contribution, 60%; low-level smelter sources, 12%; active sources, 6%. Passive sources amount to 20% on an annual basis. It is suspected that, although not statistically significant, the tall stack emissions constitute an important portion of the mid-level impact at this distance.

KINGSTON. Quarterly means for lead are observed from .21 to 1.11 $\mu g/m^3$. Model predictions are from .77 to 1.33 $\mu g/m^3$. The model suggests lead levels observed here are 80% resultant of mid-level smelter emissions, 20% low-level. There are no significant passive or active sources of lead affecting the Kingston location according to this model.

WALLACE. Quarterly means for lead for Wallace range from .25 $\mu g/m^3$ to 1.8 $\mu g/m^3$ observed values. Model estimates vary from .26 to .47 $\mu g/m^3$. The maximum does exceed the proposed 1.5 $\mu g/m^3$ limit. However, that exceedance can be traced to an extraordinary single observation of 6.625 $\mu g/m^3$ that occurred on 12/21/77. Passive source estimates run as high as .21 $\mu g/m^3$ and can account for up to 32% of the total exposure on a quarterly basis. On an annual basis it is suspected that tall stack and mid-level emissions combine for 75% of the total exposure, low-level smelter sources contribute 14%, passive local sources (primarily north of the city) 11%, and there is no significant active lead source in Wallace.

OSBURN. Quarterly mean lead levels in Osburn range from .42 to 3.54 $\mu g/m^3$ while model estimates range from .49 to .94 $\mu g/m^3$. The 3.54 $\mu g/m^3$ quarterly average observed in the fourth quarter of 1977 can be traced in great part to a single daily observation of 20.4 $\mu g/m^3$ (the same day that an extraordinarily high value was observed in Wallace). Similarly, the proposed standard exceedances that were observed in three other quarters can be traced to single extraordinary days. If those extraordinary days are ignored, Osburn seems to be in compliance with the standard. Both passive and active source contributions seem minor, amounting to only 7% of the total impact in summer months. On an annual basis, high and mid-level sources account for 80% of the predicted impact, low-level 16%, passive 3%, and active sources 1%.

PINEHURST. Observed quarterly means range from .77 to 4.02 $\mu g/m^3$. Model estimates range from 1.19 to 3.08 $\mu g/m^3$. Although single maximum values constitute a large part of the quarterly average, Pinehurst does seem to be a bona fide noncompliance area even in ignorance of these values. Passive sources can account for up to 19% of the total lead levels observed here or a maximum of .37 $\mu g/m^3$. Active sources are absent. On an annual basis low-level smelter sources constitute 20% of the total, mid-level 70%, and passive 10%.

KELLOGG CITY HALL. Quarterly means ranging from 1.4 to 6.9 $\mu g/m^3$ are observed at Kellogg City Hall. Model predictions ranged from 2.5 to 6.0 $\mu g/m^3$. Passive and active sources combined constitute at the most a 7% contribution to these levels. On an annual basis mid-level sources contribute 66% of the impact, low-level sources 30%. The maximum quarterly mid-level impact is estimated at 3.41 $\mu g/m^3$, the maximum low-level impact is 2.52 $\mu g/m^3$.

KELLOGG MEDICAL CENTER. Observed levels at KMC range from 1.9 to 7.1 $\mu g/m^3$; model estimates range from 2.7 to 6.3 $\mu g/m^3$. Although these levels are similar to those at Kellogg City Hall, it seems that both passive and active sources make a greater contribution to total impact at this station. Passive source contributions are estimated as high as .74 $\mu g/m^3$, active sources as high as .36 $\mu g/m^3$. The principal passive sources seem to come from the airport and tailings pond bank areas. Principal active sources are roads and transportation facilities in the vicinity of the smelting and milling complex, and sinter-storage activities. Combined, passive and active contributions can constitute as much as 1.1 $\mu g/m^3$ quarterly mean or 14% of the total estimate in summer. On an annual basis passive and active sources constitute 7% of total impact, mid-level smelter sources 59%, low-level 35%. Maximum mid-level smelter contribution is 3.48 $\mu g/m^3$, maximum low-level 2.69 $\mu g/m^3$. These do not occur simultaneously with each other or the passive-active maxima.

SMELTERVILLE. Quarterly mean lead levels in Smelterville range from 2.41 to 8.56 $\mu g/m^3$. Model estimates range from 2.80 to 4.80 $\mu g/m^3$. Both this station and Silver King School suffer from a number of extraordinarily high individual readings that cause the actual resultant means to be higher than model predictions in most quarters. Passive sources can be significant amounting to 15% of the summer total or as high as .37 $\mu g/m^3$. Active source estimates go as high as .13 $\mu g/m^3$ but amount to less than 5% of the total impact in most quarters. Passive sources surround Smelterville and impact from all directions. However, the McKinley Avenue area and smelter active sources contribute the bulk of the active source contribution. Maximum quarterly mean mid-level estimate is 2.24 $\mu g/m^3$, maximum low-level is 2.92 $\mu g/m^3$. Mean annual relative contribution is 54% low-level sources, 37% mid-level, 2% active, and 7% passive.

SILVER KING SCHOOL. The highest concentrations of heavy metals occur at this station. Quarterly means range from 3.6 to 12.5 μg/m^3, while model estimates range from 3.0 to 7.2 μg/m^3. Larger means are underpredicted because of the effect of the extreme individual readings that occur in several quarters. Passive contributions are estimated as high as .6 μg/m^3, active contributions as high as .58 μg/m^3. They can amount to as much as 30% and 16%, respectively, of the total quarterly estimate. Their simultaneous maximum is 1.0 μg/m^3 amounting to 28% of that total quarterly estimate. Low smelter sources dominate the estimates at Silver King School, amounting to 77% of the total on an annual basis, mid-level smelter sources account for 6%, active 4%, and passive sources 13%. Quarterly mean estimates attributable to low smelter sources are as high as 6.53 μg/m^3, mid-level sources only as high as .2 μg/m^3.

5.4.3 Model Results by Source Category. There is little effect of stack height associated with low-level smelter emissions. As a result they exert their predominant effect close to the smelter and decrease rapidly with distance. Mid-level sources, on the other hand, have little effect within one-half mile of the smelter. As distance increases the relative impact of the mid-level sources increases markedly. Figure 5.2 shows the relative impact of low and mid-level sources, by station, on an annual basis. Figure 5.3 shows the actual estimate components at each station on an annual basis.

Active sources exert small effects on estimates at several stations. They seem to be important, in terms of attainment strategy, only during summer quarters at Silver King School, Kellogg Medical Center, and Smelterville. At these locations the active impacts can be traced to transportation activities around the smelter and McKinley Avenue area, and sinter product handling in areas peripheral to the smelter.

Figure 5.2 Percent Relative Impact Estimates for Ambient Lead by Source Category at each Monitoring Location

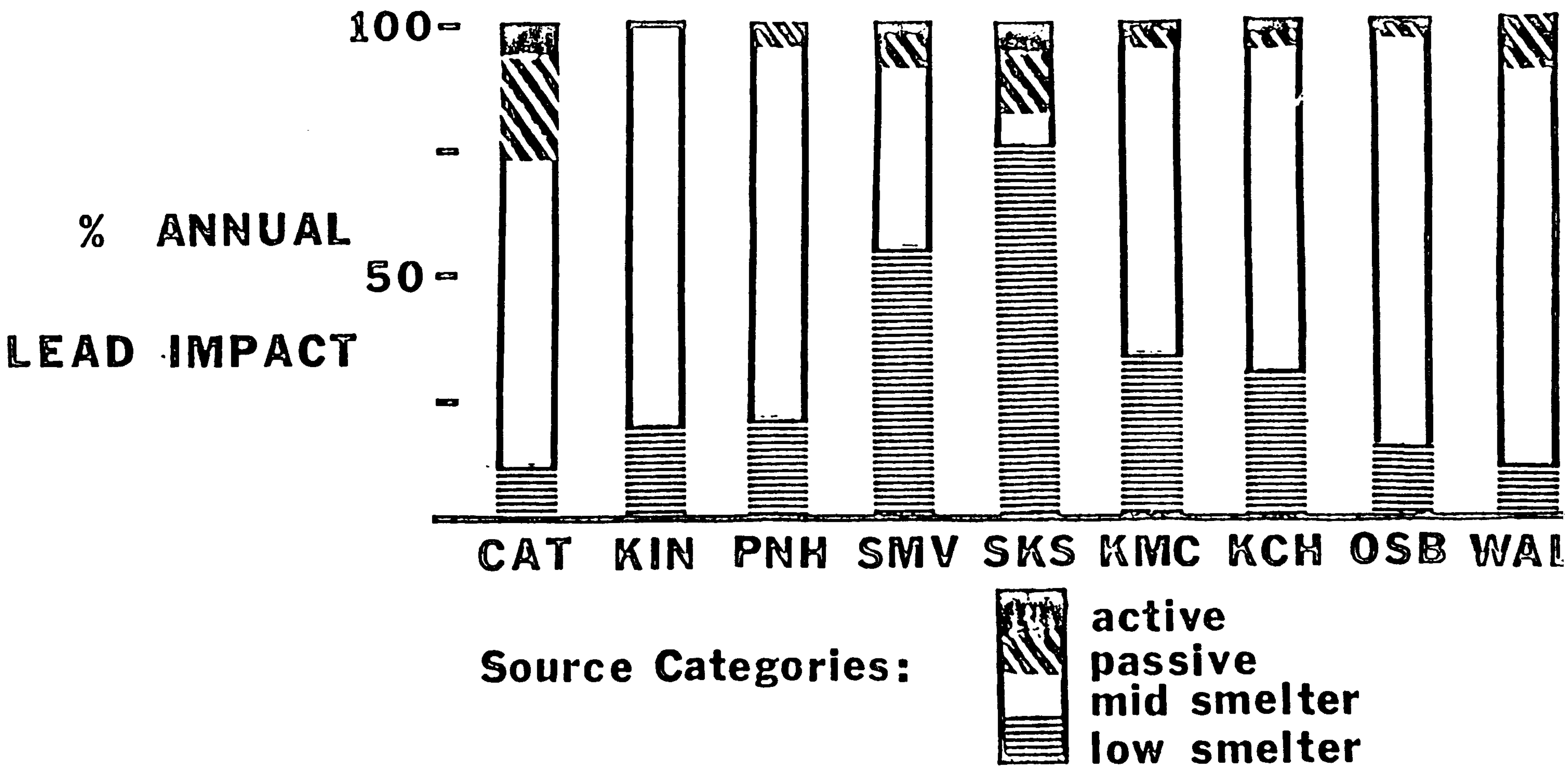
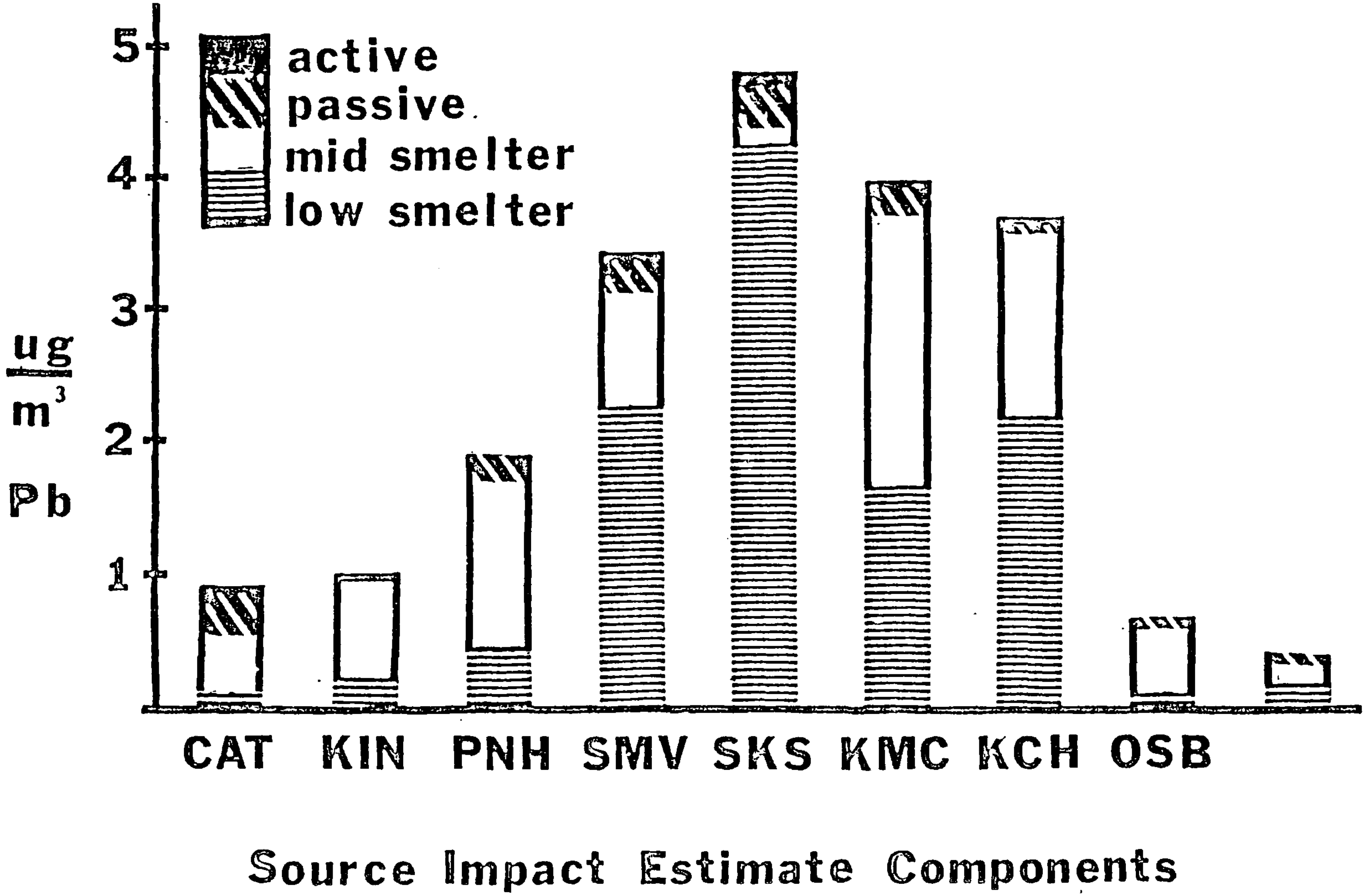


Figure 5.3 Predicted Ambient Lead Impact Estimates by Source Category at each Monitoring Location



Passive sources exert significant impact at several monitors. In terms of percentage impact, Cataldo is most affected as a result of high lead alluvium deposited across the flood plain and the Mission Flats. In concert with other sources, however, consideration of the passive sources is most important at Silver King School, Smelterville, and Kellogg Medical Center. Both Smelterville and Silver King are surrounded by numerous high lead passive sources, especially in the immediate vicinity of the smelter. Kellogg Medical Center is exposed in the predominant wind direction to the airport area and the massive tailings pond impoundment area and features.

5.5 DISCUSSION OF MODELING RESULTS

Perhaps the most important way to discuss the modeling results is in terms of seasonal impacts of the different source categories. In analyzing the basic source receptor relationship earlier, it was evident that certain meteorological conditions are critical in determining dispersal conditions and ambient concentrations in the Silver Valley. Because these conditions vary with season and because the NAAQS is a quarterly standard this becomes an extremely important consideration. Table 5.6 shows the major components, critical season, and impact area and ambient impact estimate for each significant source category. It is evident that the critical seasons for the several source categories do not coincide. Low- and mid-level smelter sources have their maximum impact under stable conditions exacerbated by light winds and high pressure synoptic patterns that inhibit dispersion. These conditions prevail in the late fall and winter. Active fugitive sources, on the other hand, have their maximum impact under unstable conditions with light winds in the absence of moisture. This type of weather

Table 5.6 Source Categories' Critical Seasons and Impact Areas

Source category	Largest component sources	Critical season (quarter)	Critical impact area	Maximum ambient estimate $\mu g\ Pb/m^3$ quarterly mean
Low-level smelter	Lurgi 50%	Fall, winter	< 1 mi.	$\simeq$ 7.0 $\mu g/m^3$
	OrePrep 35%	(4,1)	Silver King, Smelterville	$\simeq$ SKS
	Crushing 10%			$\simeq$
Mid-level smelter	Blast furnace 55%	Winter	2-4 mi.	$\simeq$ 3.5 $\mu g/m^3$
	Pellet dryer 25%	(1)	Kellogg,	$\simeq$ KMC, KCH
	Building vents 10%		Pinehurst	$\simeq$ 2.5 $\mu g/m^3$ PNH
Active futitive	Smelter roads	Spring, summer	< 1 mi.	$\simeq$ .6 $\mu g/m^3$ SKS
	McKinley Avenue	(2,3)	NW Kellogg	$\simeq$ .4 $\mu g/m^3$ KMC
	Sinter handling		Silver King	$\simeq$
Passive fugitive	Airport	Summer, fall	< 1 mi.	$\simeq$ .6 $\mu g/m^3$ SKS
	Smelter property	(3,4)	Smelterville, Silver King, NW Kellogg	$\simeq$ .4 $\mu g/m^3$ SMU
	Fairgrounds-lumberyard			$\simeq$ .75 $\mu g/m^3$ KMC

occurs in the spring and early summer. Finally, passive fugitive sources are active at neutral conditions with dry surface conditions and high winds. This weather occurs in the summer and early fall.

This situation has a tremendous impact on any strategy developed to meet the NAAQS. Table 5.7 examines the model estimates for the several non-attainment monitor locations. It can quickly be seen that the worst case situation for each of these locations occurs in the late fall and winter. Further, it is evident that the impacts during this period are nearly exclusively due to low- and mid-level smelter sources. Active and passive fugitive sources are, for all practical purposes, absent during this season.

There are some important conclusions that can be drawn at this point:

1. As the critical impact season for the non-attainment area occurs in the winter when active and passive sources are practically absent, the control strategy for this season must be aimed at the smelter sources.

2. As the primary impact areas for low- and mid-level smelter sources do not coincide, both must be reduced significantly in meeting the NAAQS.

3. A significant question remains as to the combined effect of smelter sources and passive and active fugitive sources in the summer months. Will the smelter source reductions required to meet the NAAQS in the winter be sufficient to guarantee the standard in the summer when combined with the active and passive source contributions?

The next section of this report deals with this most difficult question.

Table 5.7 Critical Quarters and Principal Sources for Non-Attainment Monitors

Location	Maximum ambient conc. μg Pb/m^3 quarterly mean	Critical season (quarter)	Component sources: Low-level	Component sources: Mid-level	Ambient impact (% max. impact): Active	Ambient impact (% max. impact): Passive
Pinehurst	3.1 $\mu g/m^3$	Winter	.9 $\mu g/m^3$	2.2 $\mu g/m^3$	0	0
		(1)	(18%)	(82%)	---	---
Smelterville	4.2 $\mu g/m^3$	Winter	2.9 $\mu g/m^3$	1.2 $\mu g/m^3$	<.1 $\mu g/m^3$	<.1 $\mu g/m^3$
		(1)	(69%)	(29%)	(1%)	(1%)
Silver King	7.2 $\mu g/m^3$	Fall	6.9 $\mu g/m^3$	.1 $\mu g/m^3$	.1 $\mu g/m^3$	.1 $\mu g/m^3$
		(4)	(94%)	(2%)	(2%)	(2%)
Kellogg Medical Center	6.3 $\mu g/m^3$	Winter	2.6 $\mu g/m^3$	3.5 $\mu g/m^3$	.1 $\mu g/m^3$	<.1 $\mu g/m^3$
		(1)	(23%)	(75%)	(1%)	(1%)
Kellogg City Hall	6.0 $\mu g/m^3$	Winter	2.1 $\mu g/m^3$	3.4 $\mu g/m^3$	0	0
		(1)	(24%)	(76%)	---	---

6.0 STRATEGIES FOR ATTAINING THE NAAQS

6.1 ATTAINMENT CURVES

In this modeled representation, the primary sources of lead impact have been grouped into four categories. Even with this considerable simplification, development of a sufficient attainment strategy will be difficult. Each of the four main source categories can make a significant contribution to ambient levels when applied to the 1.5 $\mu g/m^3$ proposed standard. Moreover, those meteorological situations that cause the greatest source impact for one category are not necessarily the most significant in other categories. As a result, great care must be exercised in selecting the proper conditions under which to evaluate an attainment strategy.

In order to determine those combinations of source reductions that will result in attainment of the 1.5 $\mu g/m^3$ standard, the concept of the "limiting situation" must be introduced. The "limiting situation" is that period (quarter) and location (monitor) that requires the greatest source reduction to meet the proposed standard. The "limiting situation" for any source category is determined not only by the absolute magnitude of that source estimate, but also the relative magnitudes of the other source categories in that same period.

Achieving the proposed standard under the modeled representation requires that the following constraints be true under the "limiting situation" for each source.

$$(1 - C_{LOW}) * (SMLOWEST) + (1 - C_{MID}) * (SMMIDEST)$$

$$+ (1 - C_{PAS}) * (PASEST) + (1 - C_{ACT}) * (ACTEST) \leq 15.$$

SMLOWEST = quarterly impact estimate of low smelter sources

SMMIDEST = quarterly impact estimate of mid smelter sources

PASEST = quarterly impact estimate of passive sources

ACTEST = quarterly impact estimate of active sources

C_{LOW} = fractional reduction of low smelter sources

C_{MID} = fractional reduction of mid smelter sources

C_{PAS} = fractional reduction of passive sources

C_{ACT} = fractional reduction of active sources

It follows that constraints for each source category can be developed as shown:

$$(1 - C_{LOW})(SMLOWEST) \leq 1.5 - (1 - C_{MID})(SMMIDEST)$$

$$- (1 - C_{PAS})(PASEST) - (1 - C_{ACT})(ACTEST) \text{ or}$$

$$C_{LOW} \geq 1 - \frac{(1.5)}{(SMLOWEST)} + (1 - C_{MID}) \frac{(SMMIDEST)}{(SMLOWEST)}$$

$$+ (1 - C_{PAS}) \frac{(PASEST)}{(SMLOWEST)} + (1 - C_{ACT}) \frac{(ACTEST)}{(SMLOWEST)} \text{ and,}$$

$$C_{MID} \geq 1 - \frac{(1.5)}{(SMIDEST)} + (1 - C_{LOW}) \frac{(SMLOWEST)}{(SMMIDEST)}$$

$$+ (1 - C_{PAS}) \frac{(PASEST)}{(SMMIDEST)} + (1 - C_{ACT}) \frac{(ACTEST)}{(SMMIDEST)}$$

$$C_{PAS} \geq 1 - \frac{(1.5)}{(PASEST)} + (1 - C_{LOW}) \frac{(SMLOWEST)}{(PASEST)}$$

$$+ (1 - C_{MID}) \frac{(SMMIDEST)}{(PASEST)} + (1 - C_{ACT} \frac{(ACTEST)}{(PASTEST)}$$

$$C_{ACT} \geq 1 - \frac{(1.5)}{(ACTEST)} + (1 - C_{LOW}) \frac{(SMLOWEST)}{(ACTEST)}$$

$$+ (1 - C_{MID}) \frac{(SMMIDEST)}{(ACTEST)} + (1 - C_{PAS}) \frac{(PASEST)}{(ACTEST)}$$

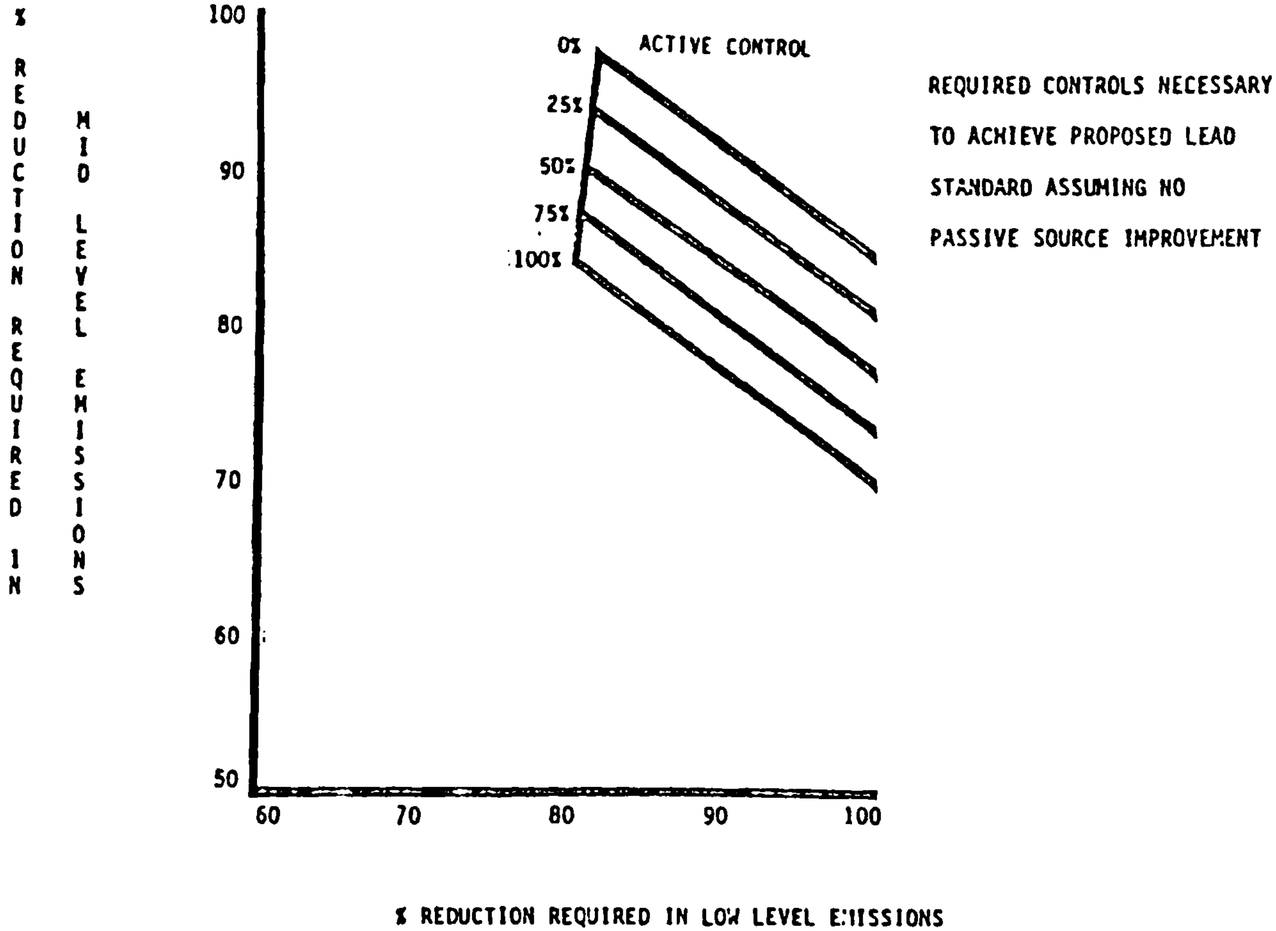
These equations can be used to determine the required control for any source category by defining a control regime for the other three categories. Given a proposed control regime for three of the sources, the appropriate equation is solved for each of the monitors for each quarter in the study. The maximum value of C for the fourth source as determined by this method then represents the "limiting situation" for that control strategy. If that maximum value exceeds 1.0, then attainment of the ambient standard is impossible, and further controls must be imposed on at least one of the other sources. By iterating this process for all interesting control strategies under all possible situations, attainment curves can be developed that illustrate those combinations of source reductions capable of achieving the proposed standard.

A primary concern of this study has been to evaluate the "background" contribution to ambient lead levels at various locations in the valley and how those "background" contributions can affect an attainment strategy for the area. First, a definition of background is in order. If "background" means lead levels in the absence of industrial activity, then they are probably best represented by passive source category. Active sources, although they are akin to industrial activity, are not easily addressed in an attainment strategy. The primary active source contributors to lead levels are materials handling of smelter by-products and intermediates in areas outside the smelter proper, and dusts raised by transportation activities in the vicinity of the smelter. The exact regulatory mechanism to be employed in reduction of these sources is unclear.

It is likely that the eventual definition of "background" will be the passive source contribution plus some fraction of the active source contribution. Figure 6.1 shows the results of solving the constraint equations for the limiting situations assuming no control in passive sources and 0, 25, 50, 75, and 100% control of active sources. The abscissal and ordinal values on this graph indicate the minimum combinations of low- and mid-level source reductions required. For example, given no passive control and 50% active control, possible minimal control requirements are found along the 50% line on the graph (e.g., LOW = 90, MID = 84; LOW = 82, MID = 90). Combinations of low- and mid-level control above and to the right of the solution line will achieve the standard; those to the left and below the line will not.

The vertical line in Figure 6.1 shows that no matter how much control is exercised in the active and mid-level source categories, at least 80% low-level control is necessary. This is figured assuming no passive control. However, even if 100% passive control is assumed, solving the C_{LOW} equation for the "limiting situation" yields a control requirement of 78%. The "limiting situation" in this case is the second quarter of 1978 at Silver King School. Knowing that at least 78% control of low-level sources will be required regardless of other source reductions, the constraint

Figure 6.1. Attainment Curve for No Improvement in the Passive Source Contribution



equations are solved assuming 80, 85, 90, 95, and 100% low-level control. One set of attainment curves was then developed for each of these low-level control strategies. That family of curves is shown in Figures 6.2a through 6.2e. In these figures mid-level control requirements are plotted against a supposed passive source reduction; the lines themselves represent a constant level of active source reduction. As with Figure 6.1, values above and to the right of a subject line will result in compliance; those to the left and below will not.

Any combination of source reductions in the four categories can be evaluated by these curves. For example, suppose no additional control on active or passive sources is contemplated, and 90% control of low-level sources is proposed. From Figure 6.2c, it is determined that 91% control of mid-level sources will be necessary. Or suppose 50% active and 25% passive control were feasible but only 80% low-level control were proposed. Under this proposal Figure 6.2a shows that 84% mid-level control would be required.

6.2 EXTREME EXCURSIONS

The inability of this model to predict extreme values at all stations has been discussed. Although that inability is not thought to affect the relative impact calculations for mean emissions, these particular days must be considered in an attainment strategy because of their effect on the quarterly arithmetic means. These days were identified and examined separately. The results of that examination can be found in Table 6.1. The data for each extreme day were qualitatively examined and each day was assigned to one of five categories. Those categories were determined by four factors found common to several of these excursions. The first

Figure 6.2a. Attainment Curve for 80% Improvement in Low-level Smelter Emissions

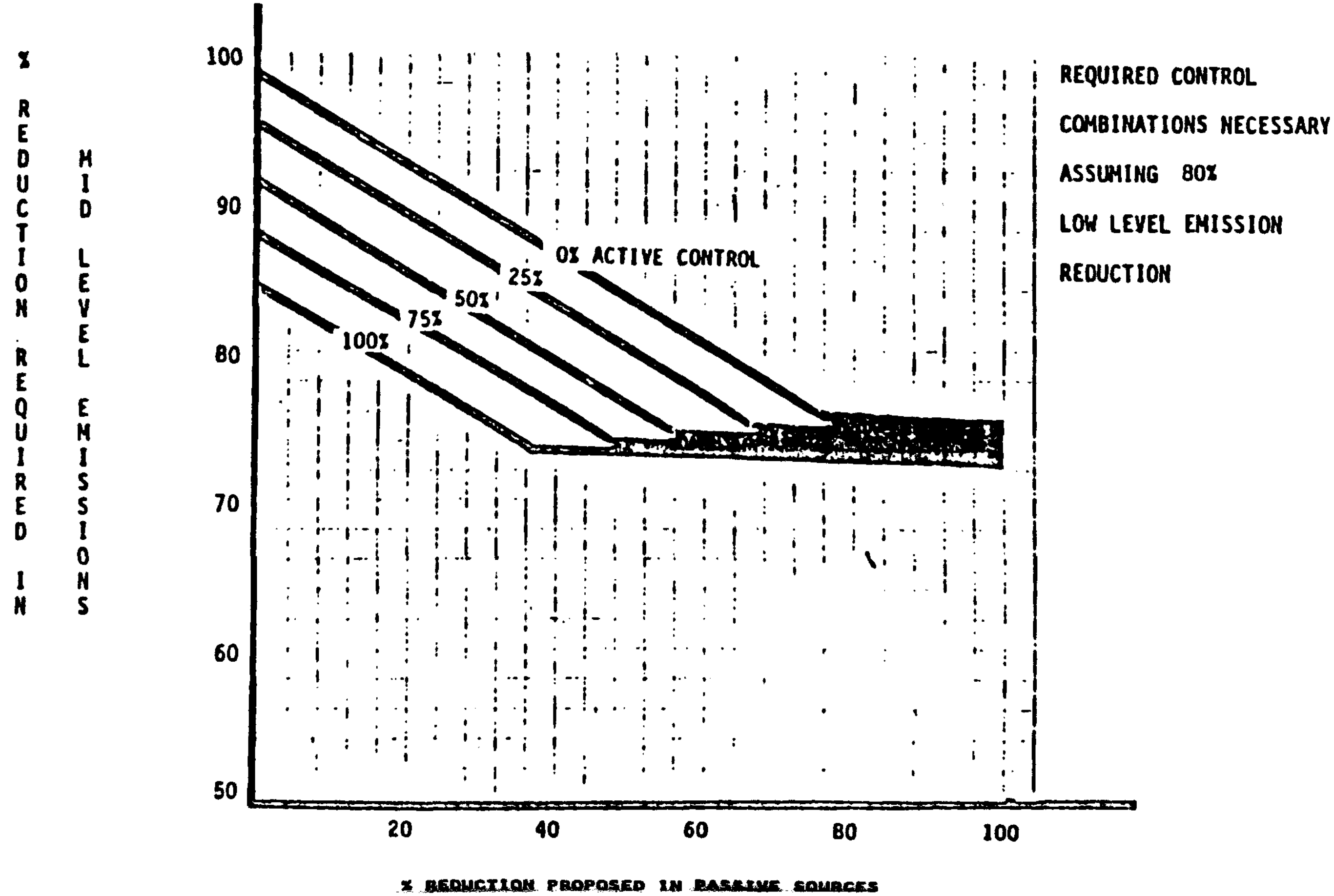


Figure 6.2b. Attainment Curve for 85% Improvement in Low-level Smelter Emissions

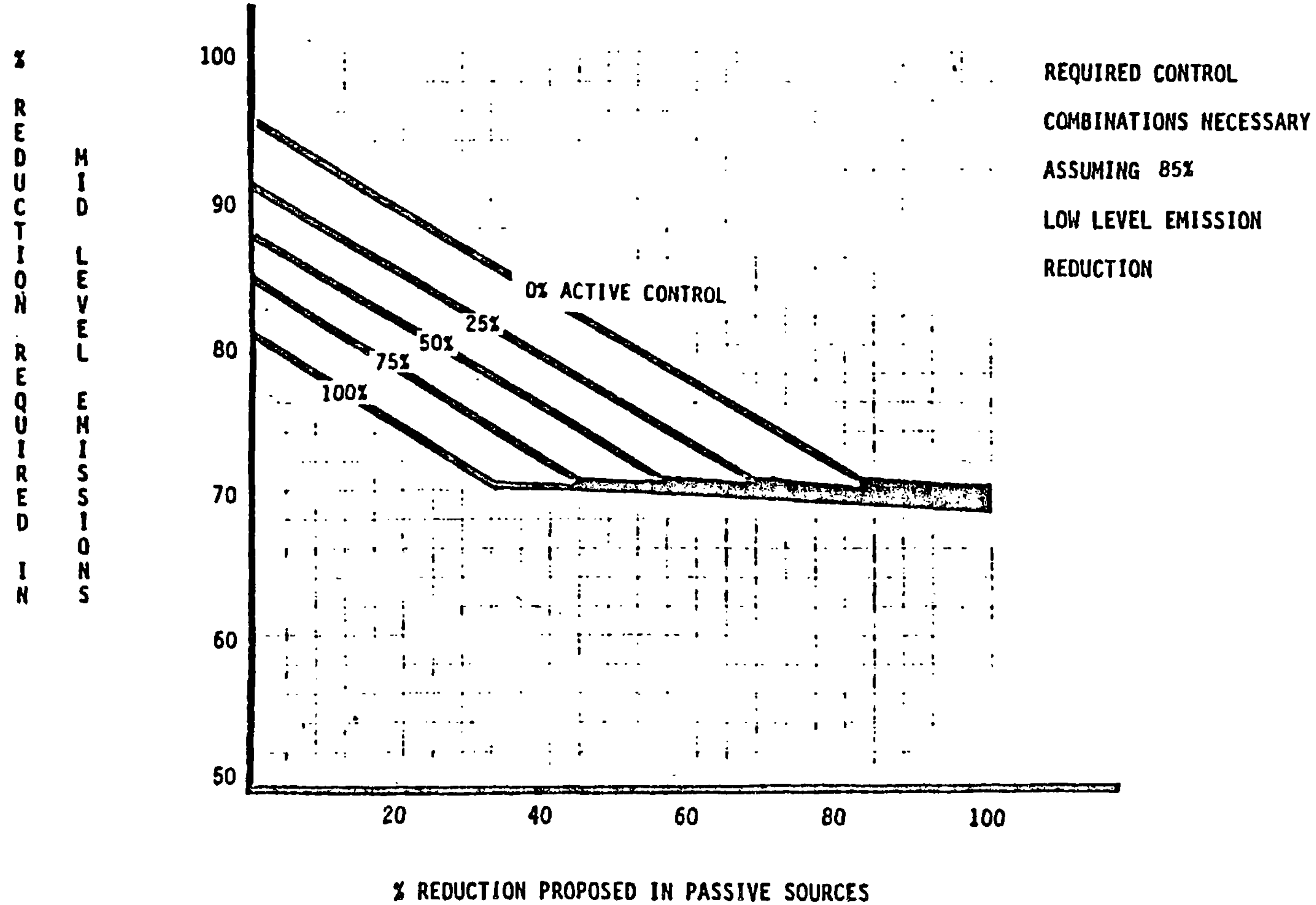


Figure 6.2c. Attainment Curve for 90% Improvement in Low-level Smelter Emissions

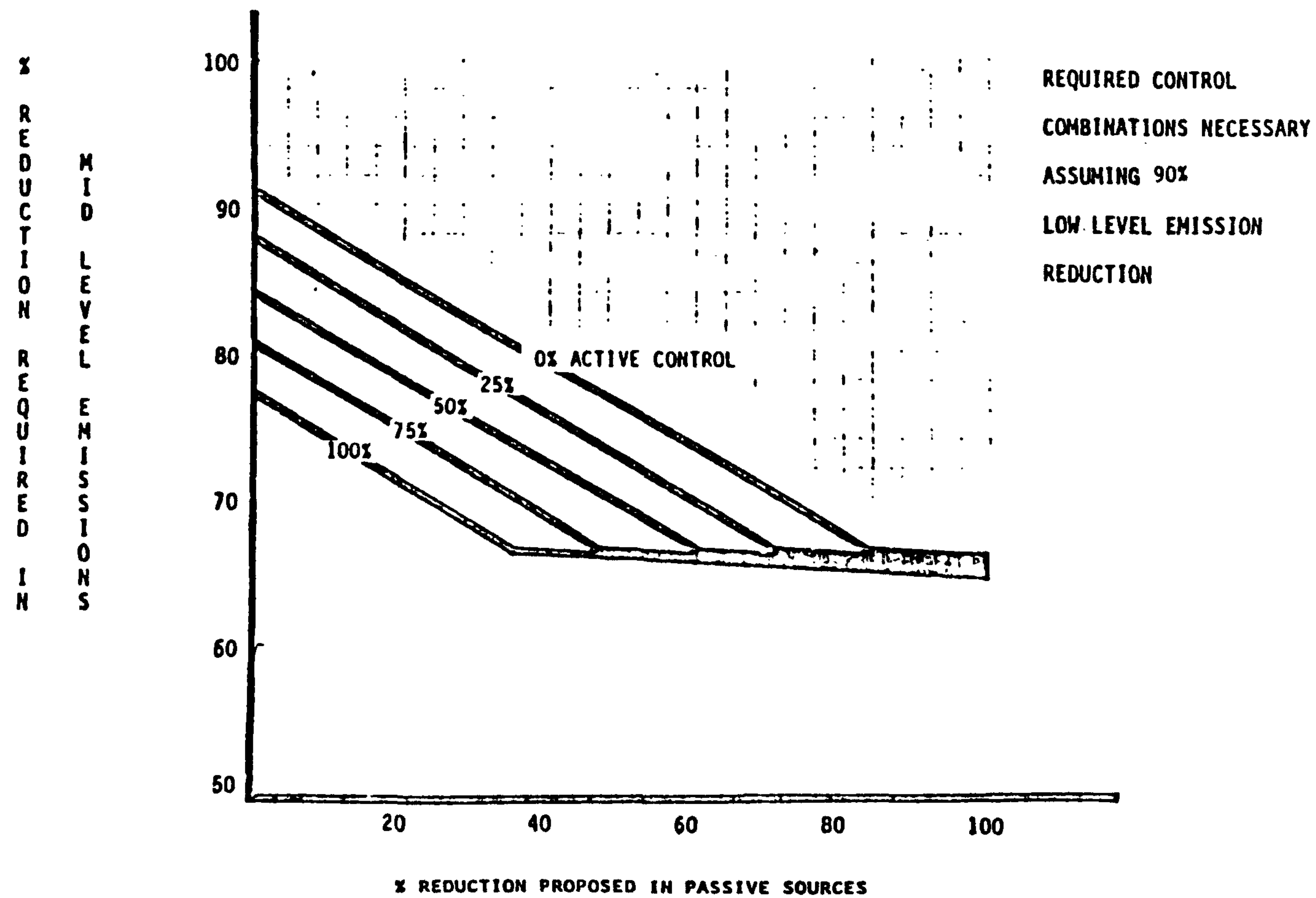


Figure 6.2d. Attainment Curve for 95% Improvement in Low-level Smelter Emissions

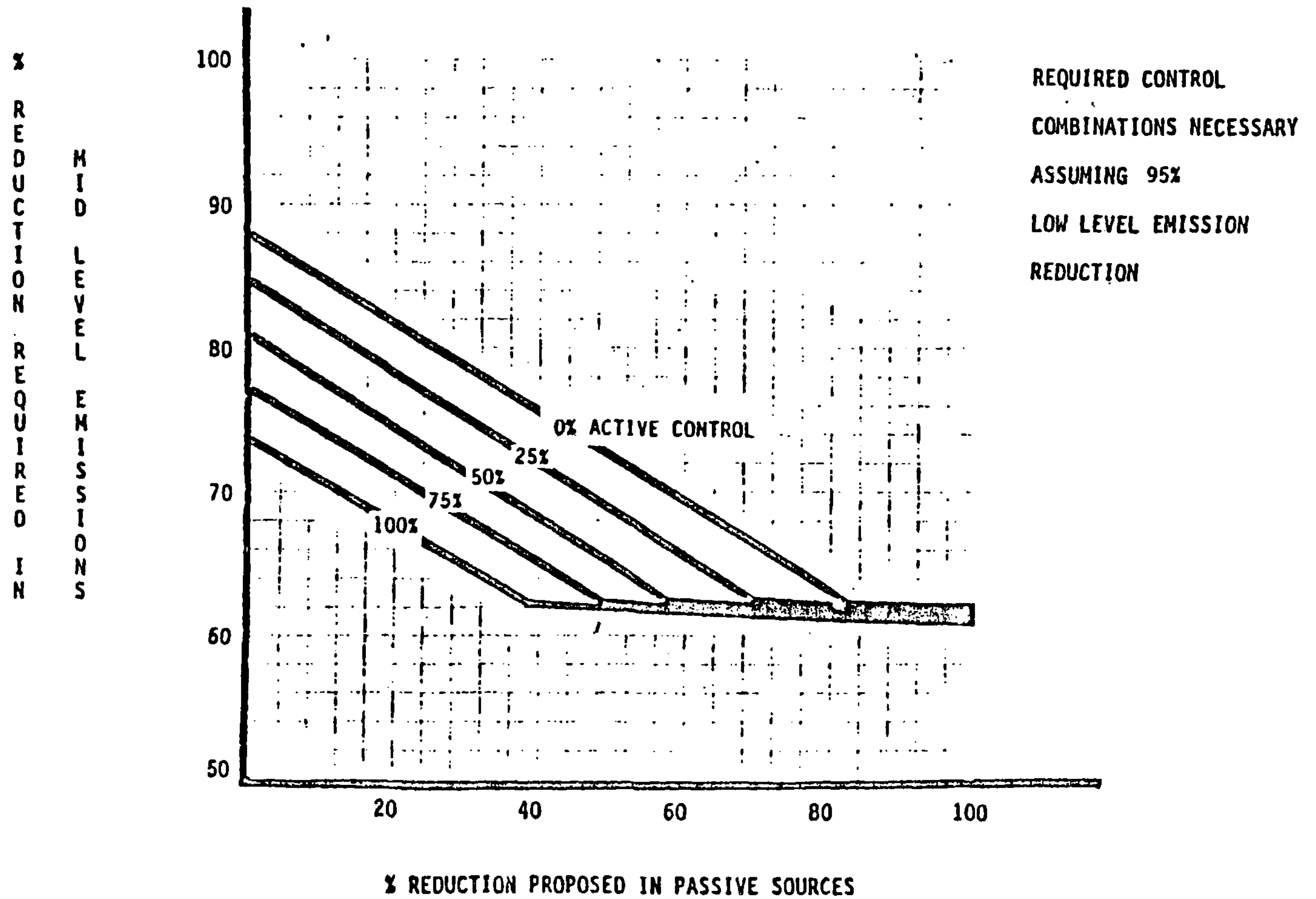


Figure 6.2e. Attainment Curves for Total Elimination of Low-level Smelter Emissions

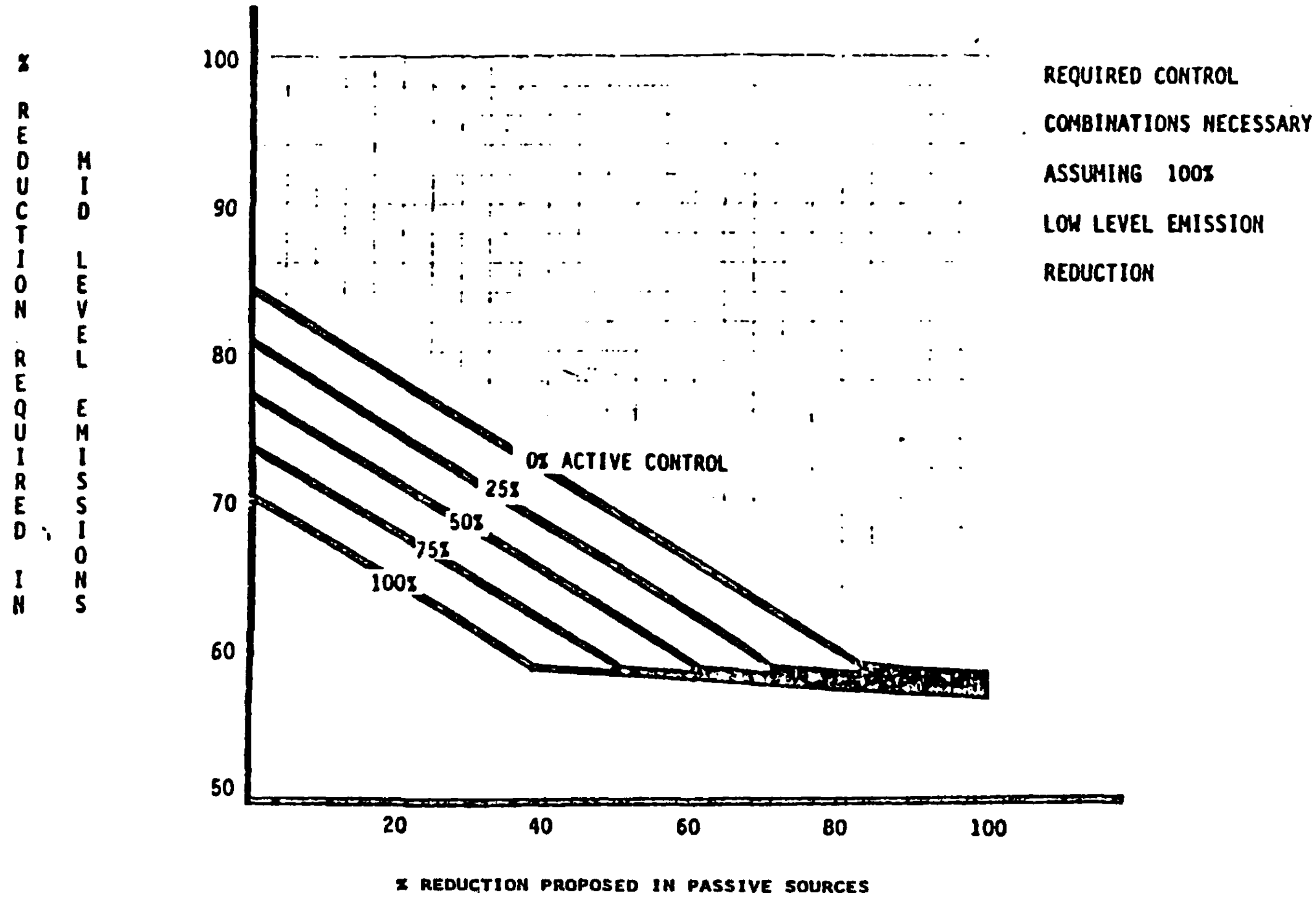


Table 6.1. Tabulation of Possible Causes for Extreme Air Quality Excursions

SUSPECT CAUSE		STATION CAT	KIN	PNH	SMV	SKS	KMC	KCH	OSB	WAL	EAST	WEST	TOTAL
DRAINAGE WINDS		0	0	1	3	2	0	0	0	0	0	6	6
STAGNATION		2	3	7	7	6	4	3	2	2	11	25	36
LOW WIND SPEEDS		2	0	1	2	4	1	1	2	1	5	7	12
STRIKE/STARTUP		1	0	8	6	3	1	2	1	0	4	18	22
UNACCOUNTED		1	2	8	6	6	11	6	9	9	35	23	58
# DAYS	THESE DAYS	4	5	25	24	21	17	12	14	12	55	79	134
SUM	THESE DAYS	11.4	20.9	163.4	369.8	485.1	233.1	211.5	100.3	42.1	587	1050.6	1626.2
MEAN	THESE DAYS	2.9	4.2	6.5	15.4	23.1	13.7	17.2	7.2	3.5	10.7	13.3	12.1
# DAYS	ALL DAYS	165	140	150	169	167	164	145	172	161	642	791	1433
SUM	ALL DAYS	74.7	76.1	273.7	805.3	1093.3	659.6	614.2	222.0	111.6	1607	2323	3930
MEAN	ALL DAYS	.45	.54	1.8	4.8	6.6	4.0	4.2	1.3	.7	2.5	2.9	2.7

condition was several days of extreme readings during the strike of 1977, and the startup period following for which no meteorological data were recorded. The second factor included days of extreme atmospheric stability or stagnation. The third situation was severe synoptic drainage winds affecting stations to the west of the smelter, and the last included periods of low wind speeds in the middle atmospheric levels. No meteorological or operational factor could be found to explain the extreme values on the remainder of the excursion days.

Three of these factors are accounted for to some degree in the model. The stagnation and drainage wind regimes and low wind speeds in the middle atmospheric levels were empirical qualifiers in the regression equation. Passive source estimates predict significant impacts with drainage wind, and extreme stability is treated by nearly a constant dispersion parameter. These factors, however, do not predict as high an impact as was observed. Perhaps the remaining two categories can suggest why. During the strike the smelter was operated intermittently by salaried personnel and considerable construction of pollution control facilities was carried on by outside contractors. Following resolution of the labor difficulties, new pollution control facilities were in use. It may be possible that less than efficient operation was practiced during these periods resulting in exaggerated emission rates. Furthermore, those days for which no meteorological explanation of the high values can be found are likely caused by abnormal emissions. Additional investigation of company operation records and upset reports may be worthwhile in establishing this point.

The remainder of the discussion here will contend with the impact, rather than the cause, of these days. The top part of Table 6.1 shows the number of extreme days in each category for each station, for each direction, and total tabulation. It can be noted that to the west of the smelter about 8% of the severe days can be attributed to drainage winds, 32% to stagnation and extreme stability, 9% to low wind speeds, 23% to the strike/startup period, and 33% are unknown. In the easterly direction drainage winds have no effect as the monitors are upwind of the smelter. A similar percentage of extremes were attributed to low wind speeds and extreme stabilities. The strike period, however, did not seem to affect eastern stations to the degree that occurred to the west. This may be attributable to less than twenty-four operations of the smelter and the wind direction associated with the operation shift. The suspected cause of over 60% of the extreme concentrations east of the smelter is unknown.

The lower part of Table 6.1 shows the effect of these days on the total impact measured at each station. The number of extreme days at each monitor is shown together with the mean and total lead impact. These values are compared to those for all days. This shows that, at non-attainment stations, from 8 to 17% of the days account for 35 to 60% of the total impact. These days have about 4 times more impact on the quarterly mean than does an average day.

Any attainment strategy must consider these days and their extraordinary impact. Deductive reasoning concludes that those severe excursions whose cause cannot be found in the meteorology are likely due to excess smelter emissions. These excess emissions are, in turn, likely due to upsets, malfunctions, and startup/shutdown conditions. Further work in this area and the development of an effective program for preventing or minimizing is requisite to formulation of a viable attainment strategy.

6.3 DISCUSSION

There are numerous combinations of source reduction scenarios that will achieve the national standard according to results of this study. However, there are certain minimum requirements and generalizations that can be made. In order for any attainment strategy to be successful, the extreme excursions suspected resultant from process upsets, malfunctions, and startup/shutdowns must be addressed. Either additional studies should be undertaken to confirm the cause of these high concentrations, or a comprehensive program and accompanying regulation controlling these situations should be established.

Given that severe excursions are successfully addressed, the attainment curves can be used to ascertain further requirements. Under any circumstances at least 78% reduction in low-level emissions will be necessary. Assuming an 85% reduction in low-level emissions, significant improvements in ambient concentrations can be achieved by reducing the active and passive components. Remembering that Kellogg Medical Center is the limiting situation regarding passive and active sources, improvements in those sources affecting this monitor may be worthwhile. Those sources are sinter product handling outside the smelter, McKinley Avenue, the airport area, the fairgrounds/lumberyard area, and the tailings pond embankment area. With significant improvement in these areas and 85% reduction of low-level sources, perhaps an 80 to 85% control in mid-level sources would be necessary.

Examination of Table 4.3 shows that blast furnace upsets are the dominant source in mid-level emissions. This same source is suspected as being the largest contributor to the startup-upset extreme excursions. If these upsets were eliminated, achievement of the standard would likely be much easier.

One additional point should be considered in developing an attainment strategy. All the attainment curves are based on at least a 78% low-level emission reduction required at Silver King School. Were the smelter owner to purchase all property between the Smelterville monitor and the plant, this requirement might be significantly reduced.

All these factors deserve consideration. However, in general, given the current conditions, meeting the national standard will require:

1. A comprehensive control program for upset, malfunction, and startup/shutdown situations.

2. Eighty to 85% reduction in low-level and mid-level emissions through elimination or rerouting discharges to the tall stack.

3. Moderate effort to reduce active emission arising from by-product handling outside the smelter, company roads, and McKinley Avenue.

4. Stabilization, covering, or revegetation of bare soils around Linfor Lumber, Smelterville fairgrounds, the airport, and the smelter tailings pond embankments.

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APPENDIX A

REFERENCED MAP DISPLAYS

Figure A: TOWNS, RIVER, VALLEY, MONITORS

Figure B: ELEVATION, ROADS, VALLEY

Figure C: ACTIVES, PTSOURCE, SPECSITE

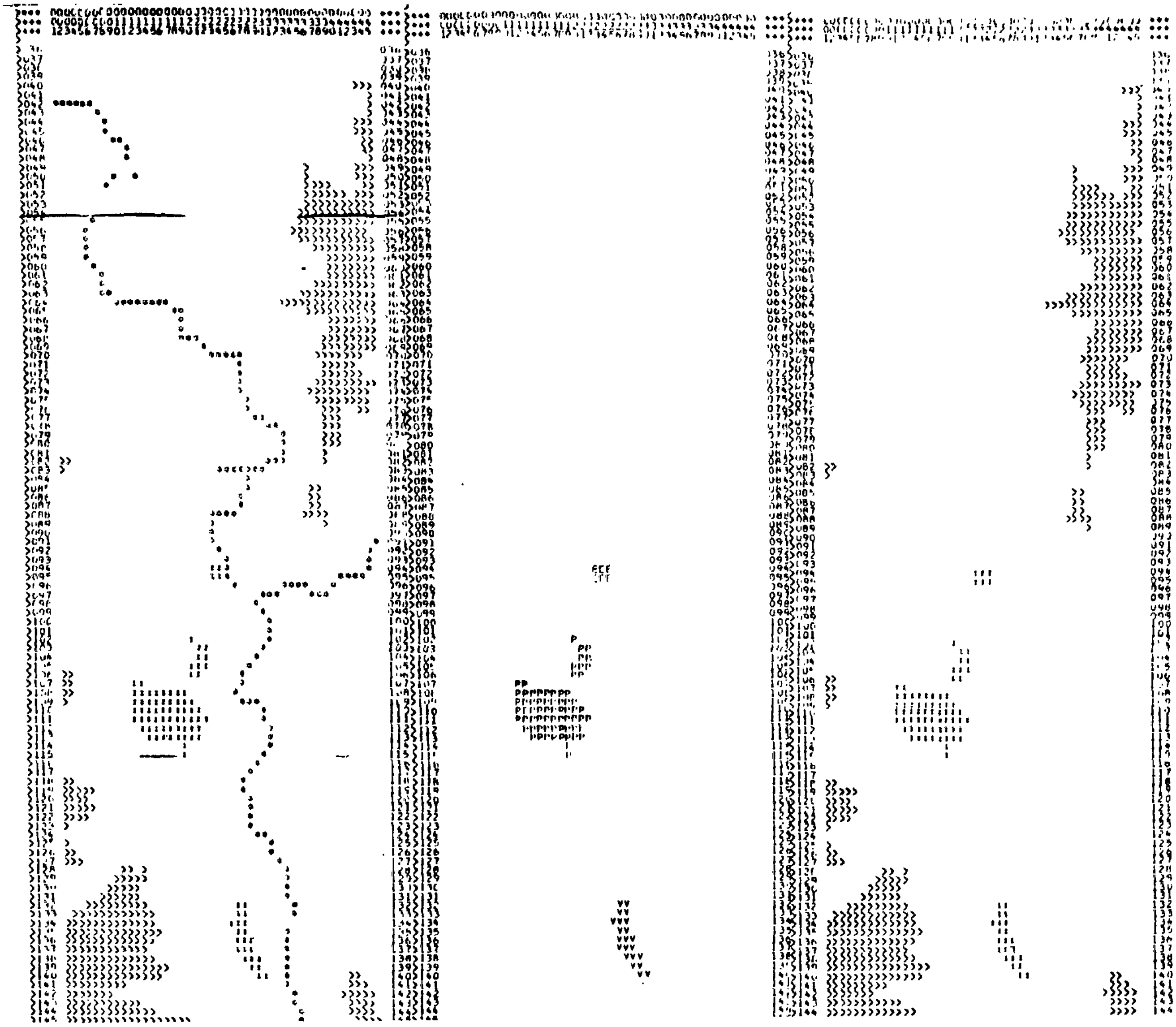
Figure D: SOILPB, SOILCD

Figure E: DOEPASS, PEDCOPAS, PESPASS, COVERMAP, PASSIVES

Notes for Figure A

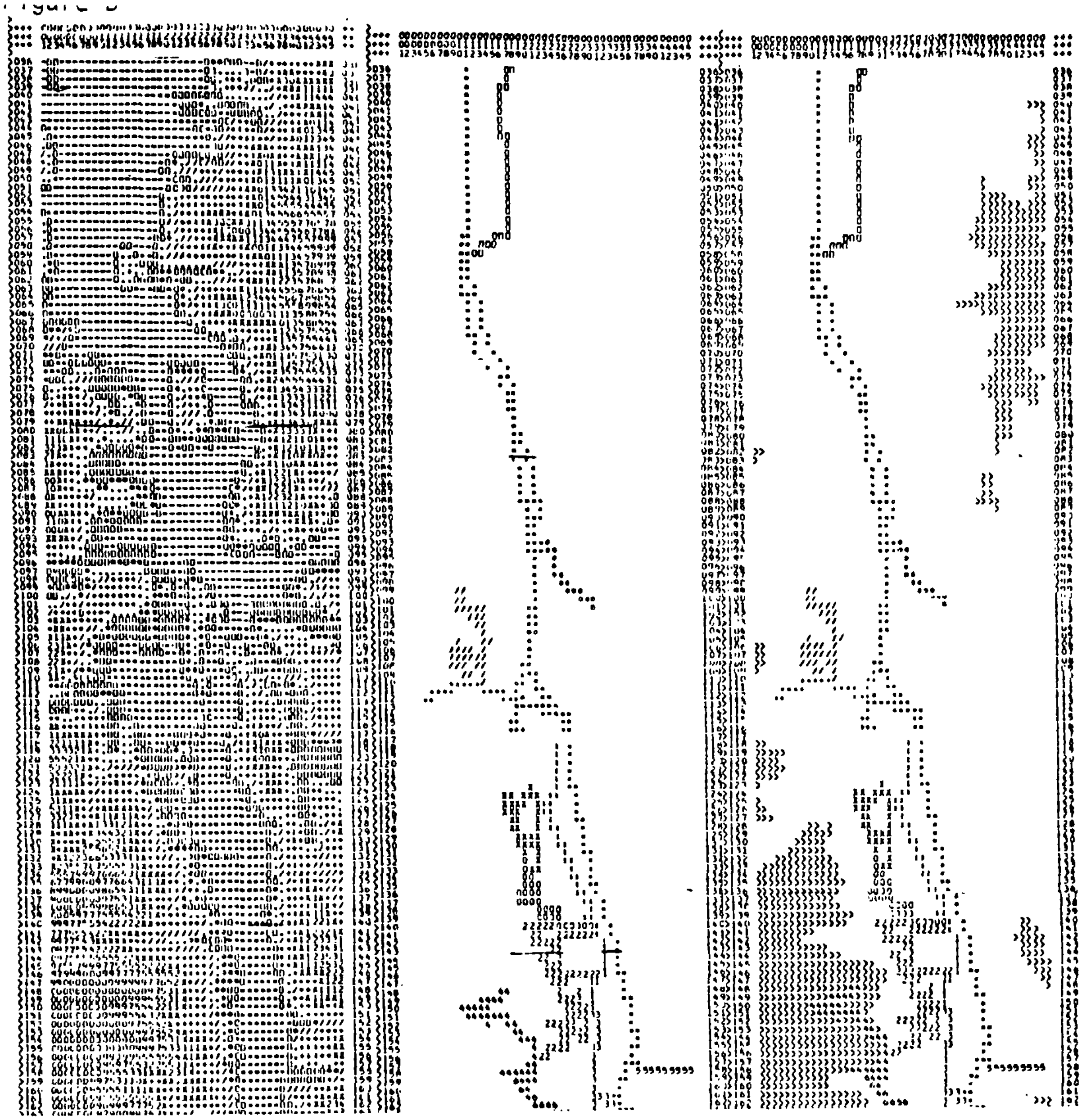
The first map demonstrates the map VALLEY overlaid by the river and urban locations. The second map depicts the urban locations through the map TOWNS. The third map superimposes the monitor locations from the map MONITORS.

Figure A



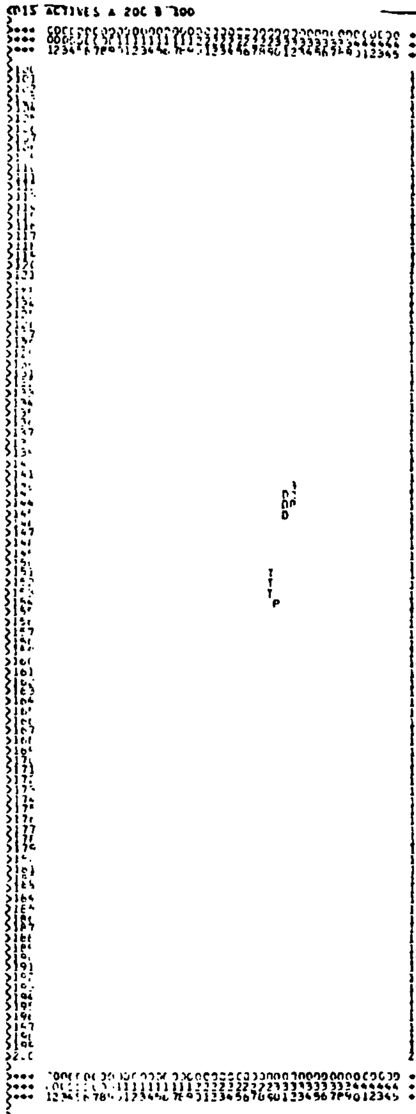
Notes for Figure B

These three maps are first the sliced version of the ELEVATION maps. It is divided into twenty levels representing 100-foot intervals from 2000 to 4000 feet in elevation. The next map shows the ROADS in the valley and in the third map values above 3200 feet elevation are masked out for VALLEY to illustrate the relative location of the roads.



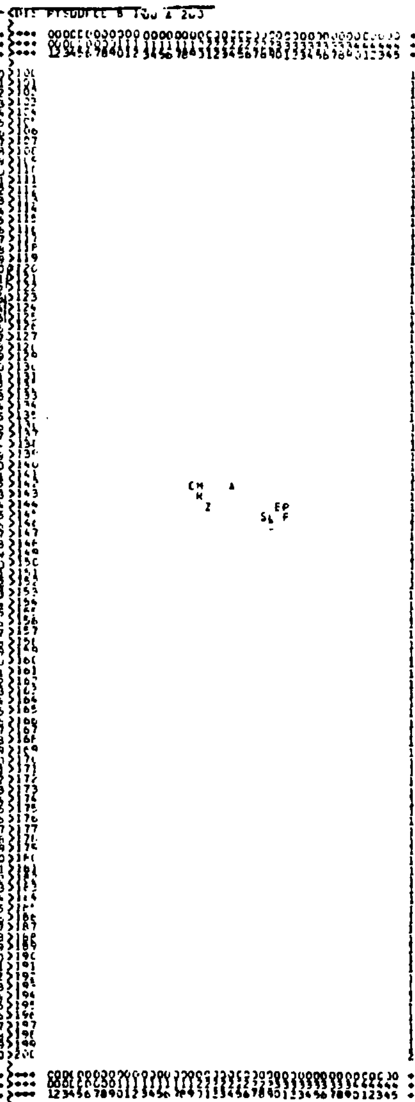
Notes for Figure C

These three maps show the locations of the Active and Point Source locations, and the sites deserving special source considerations in the passive analyses. The point source labels are by process unit as defined in Chapter VIII. ACTIVES, PTSOURCE, and SPECSITE are described in Chapter VI of the parent document.



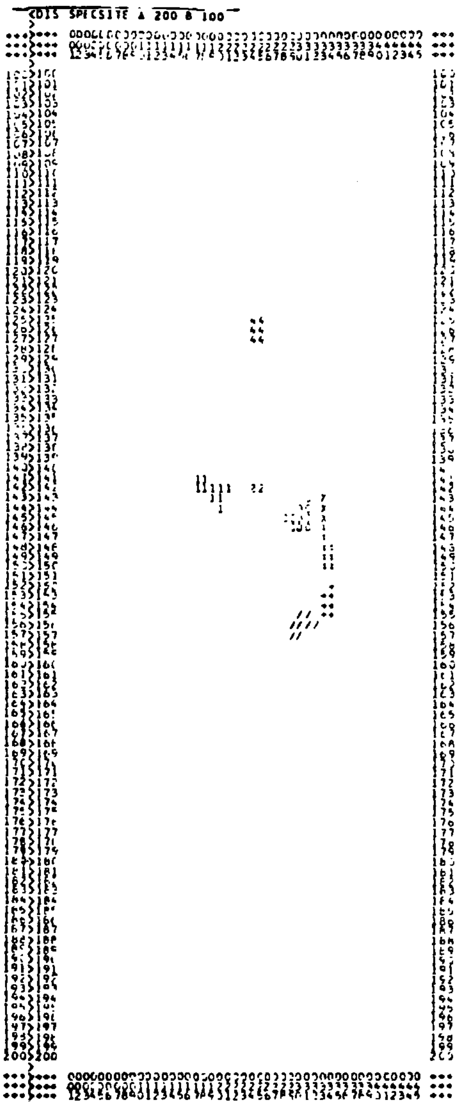
ACTIVES

	0	....	4535 CELLS
EEEEEEEEEE	31	SILICA STORAGE	1 CELLS
DDDDDDDDDD	33	SLAG STORAGE	3 CELLS
PPPPPPPPPP	45	SINTER STORAGE	2 CELLS
TTTTTTTTTT	49	SINTER STORAGE	3 CELLS
RRRRRRRRRR	73	SILICA SLAG PILE	1 CELLS



PTSOURCE

	0	....	4534 CELLS
AAAAAAAAAA	30	PHOSPHATE PLANT	1 CELLS
CCCCCCCCCC	32	ZN CONC AREA	1 CELLS
EEEEEEEEEE	34	ELECTRIC FURNACE	1 CELLS
FFFFFFFFFF	35	ZINC FUMING	1 CELLS
LLLLLLLLLL	41	LURGI & SIZING	1 CELLS
MMMMMMMMMM	42	ZN MELTING AREA	1 CELLS
OOOOOOOOOO	44	ORE PREP/CRUSH	1 CELLS
PPPPPPPPPP	45	PB REFINERY	1 CELLS
RRRRRRRRRR	47	ZP ROASTING	1 CELLS
SSSSSSSSSS	48	MAIN SMELTER ST	1 CELLS
ZZZZZZZZZZ	55	MAIN ZP STACK	1 CELLS



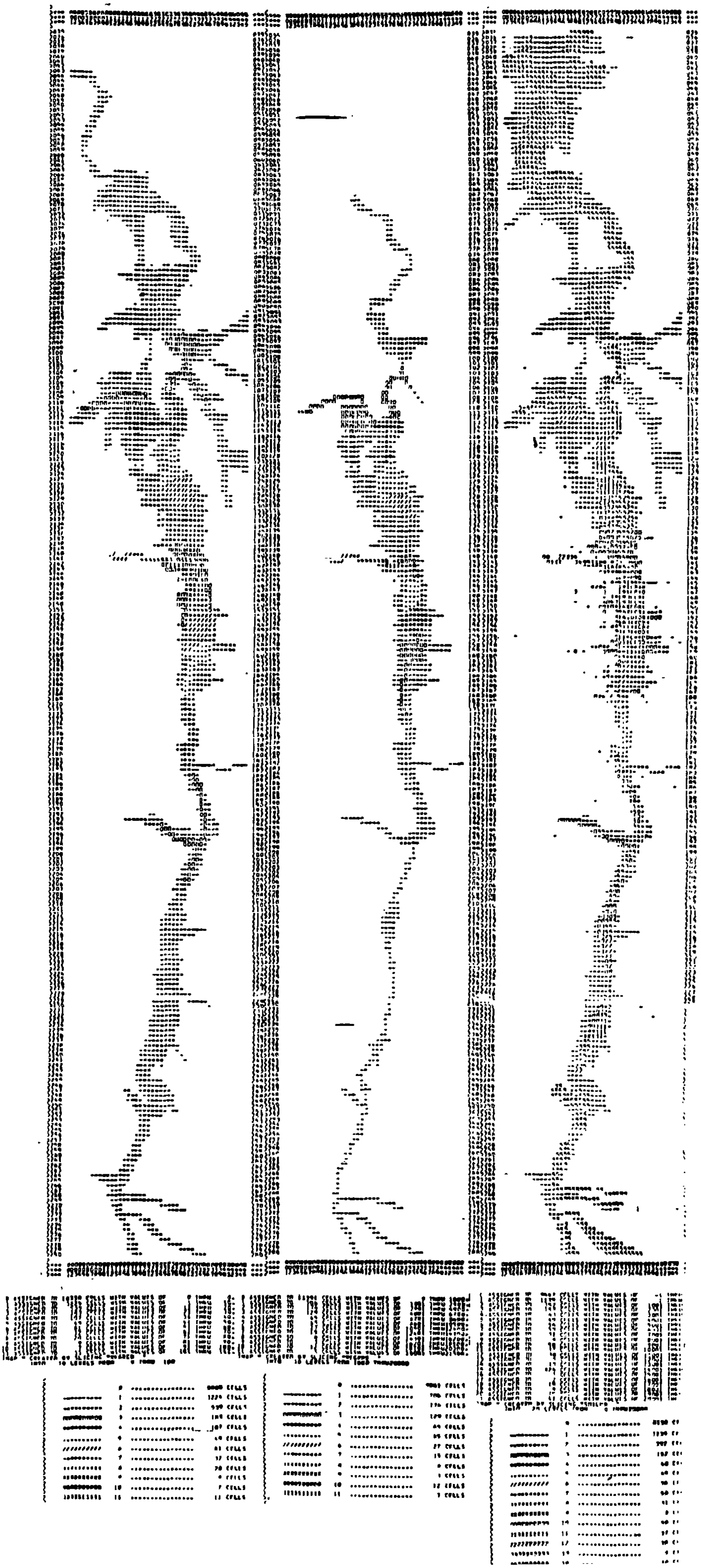
SPECSITE

	0	....	4491 CELLS
//////////	6	BH MILL AREA	8 CELLS
++++++++++	7	EAST TAIL. POND	7 CELLS
::::::::::	8	WEST TAIL. POND	8 CELLS
XXXXXXXXXX	9	BH SLAG PILE	3 CELLS
OOOOOOOOOO	10	BH SMELTER AREA	10 CELLS
1111111111	11	ZINC PLANT AREA	10 CELLS
2222222222	12	FERTILIZER PLANT	2 CELLS
4444444444	14	SF STP PONDS	6 CELLS

Notes for Figure D

This series of maps illustrates a part of the development of the soil contamination maps SOILPB and SOILCD. The first two maps are the soil lead and cadmium estimates developed by the regression models in the report text. They are displayed here using the "slice" technique in which the different levels signified at the top of the legend are displayed via corresponding symbols below. The levels are in ppm metals. The third map is the soil contamination map synthesized from the several soil studies referenced in the report text. It shows soil lead estimates in ppm for the valley sites (river + 200 feet).

Figure 6

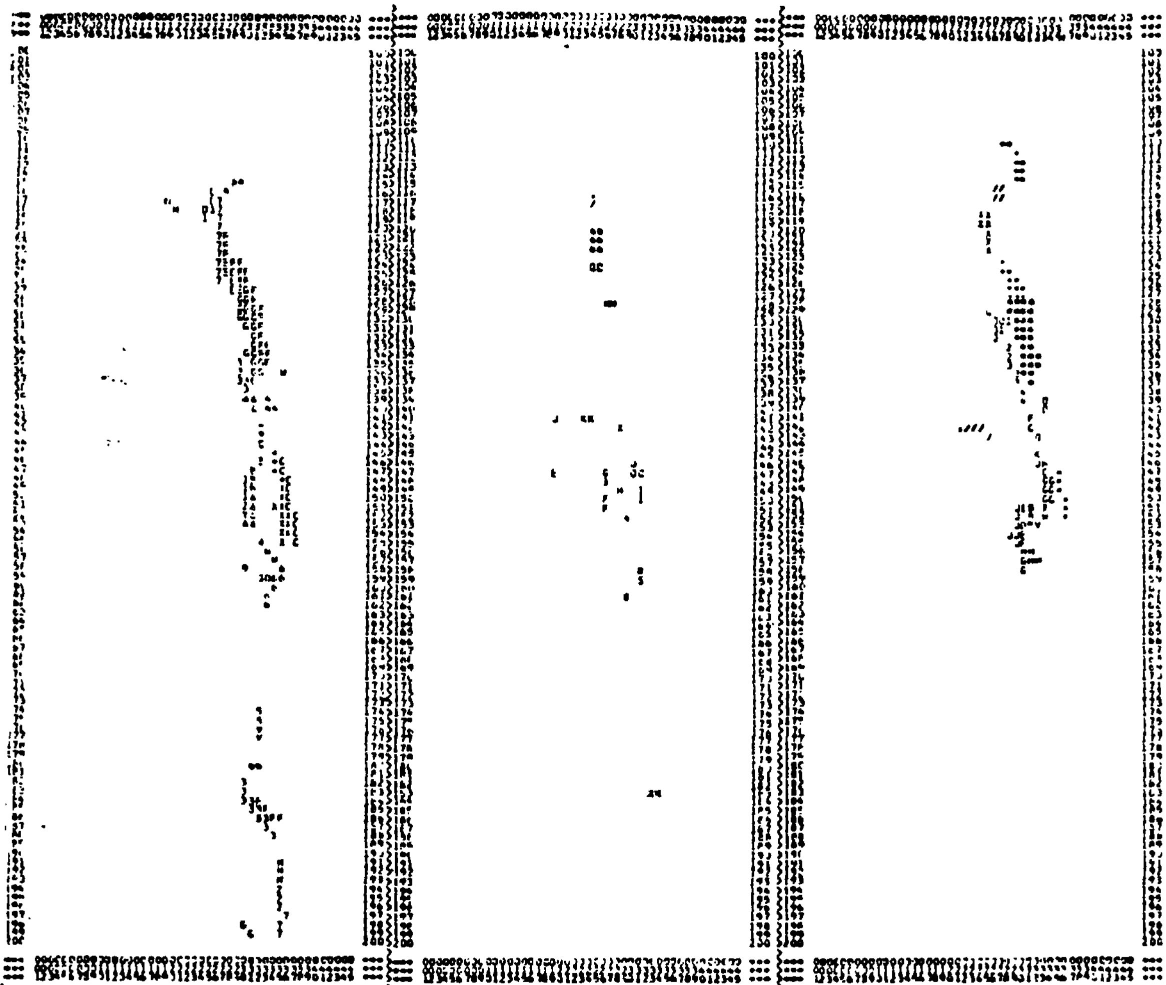


Notes for Figures E1 and E2

The first three maps are the PASSIVE source locations from three studies referenced in the text. The list at the bottom of the maps refers to those in Table 2 as indicated by the variable VAL for PESPASS, (VAL - 100) for PEDCOPAS, and (VAL - 200) for DOEPASS. The next map is the vegetation COVERMAP that depicts the vegetation cover levels for the valley. Some of the areas from this map are used together with the previous three maps to produce the last in this series. That map referred to as

shows all the special passive source areas considered in the valley, and the river.

Figure E.1.



CCEPASS

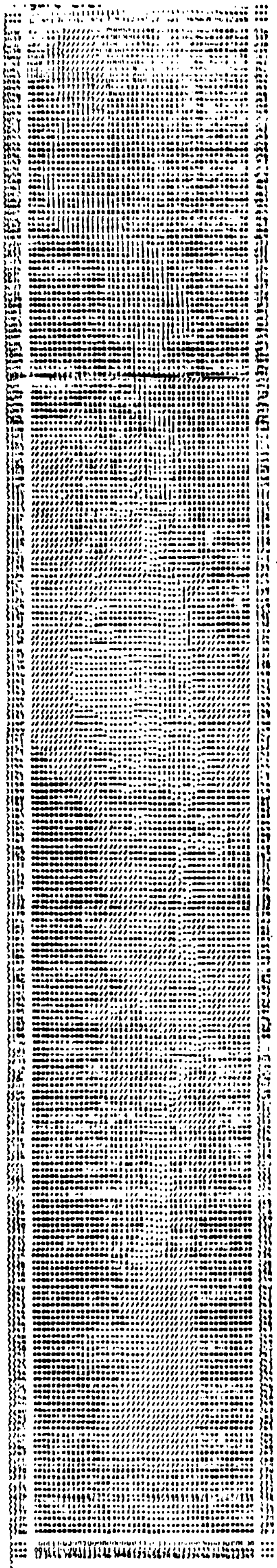
	0	....	4302 CELLS
[illegible]	1	....	1 CELLS
[illegible]	4	....	1 CELLS
[illegible]	7	N GYP POND	4 CELLS
[illegible]	8	N GYP POND SLAG	4 CELLS
1111111111	11	OLD GYP POND	3 CELLS
2222222222	12	SMELT PARK LOT	1 CELLS
3333333333	13	FAIR GROUNDS	5 CELLS
9999999999	15	N OF TRAIL PARK	2 CELLS
[illegible]	16	[illegible] HILLSIDE	2 CELLS
7777777777	17	OLD [illegible]	3 CELLS
[illegible]	19	SHOSHONE APTS	1 CELLS
[illegible]	20	[illegible] AREA	2 CELLS
1111111111	21	SMV SWAMP	2 CELLS
2222222222	22	S OF FREEWAY [illegible]	3 CELLS
3333333333	23	S OF FREEWAY [illegible]	13 CELLS
[illegible]	24	ZAMMETTI AREA	3 CELLS
[illegible]	26	E OF CIA [illegible]	6 CELLS
7777777777	27	S OF FREEWAY [illegible]	10 CELLS
[illegible]	30	[illegible] LUMBER	1 CELLS
[illegible]	31	[illegible]	3 CELLS
CCCCCCCCCC	32	N OF [illegible]	13 CELLS
[illegible]	33	SMV GRAVEL PIT	3 CELLS
[illegible]	34	[illegible]	7 CELLS
[illegible]	35	N OF AIRPORT	19 CELLS
[illegible]	36	AIRPORT AREA	20 CELLS
[illegible]	37	S OF FREEWAY [illegible]	3 CELLS
[illegible]	41	E TRAILER PARK	2 CELLS
[illegible]	42	CIA [illegible]	4 CELLS
[illegible]	43	CIA [illegible] END [illegible]	5 CELLS
[illegible]	54	OLD TOWN SITE	1 CELLS
[illegible]	55	OLD TOWN SITE	1 CELLS
[illegible]	56	CIA SOUTH DIKE	5 CELLS
[illegible]	57	CIA SOUTH ROAD	3 CELLS
CCCCCCCCCC	58	SINTER STORAGE	1 CELLS
[illegible]	61	WEST OF [illegible] PLT	4 CELLS
[illegible]	62	SUNSHINE POND	2 CELLS
[illegible]	64	[illegible] CR CUT	2 CELLS

[illegible]PAS

	0	....	4911 CELLS
[illegible]	5	GRADED AREA [illegible]	1 CELLS
//////////	6	ROCK & GRAV [illegible]	1 CELLS
[illegible]	9	SMV PLAYGROUND	1 CELLS
[illegible]	10	TAILINGS AREA	3 CELLS
3333333333	13	SEDIMENT BASIN	1 CELLS
[illegible]	14	ORE STORAGE AREA	1 CELLS
[illegible]	16	[illegible] FILL	4 CELLS
[illegible]	18	ATLETIC FIELD	1 CELLS
CCCCCCCCCC	32		1 CELLS
[illegible]	33	EQUIP STOR AREA	2 CELLS
[illegible]	34	MINE SPOILS	1 CELLS
[illegible]	35	HILLCUT [illegible] SMELT	2 CELLS
[illegible]	36	SMELTER STORAGE	1 CELLS
[illegible]	37	SMELTER STORAGE	1 CELLS
[illegible]	38	SMELTER STORAGE	2 CELLS
[illegible]	39	[illegible] & FILL	1 CELLS
[illegible]	40	[illegible] & FILL	2 CELLS
[illegible]	43	LUMBER YARD STOR	2 CELLS
[illegible]	46	N END OF STP	2 CELLS
[illegible]	47	REGRADE AREA	1 CELLS
5555555555	48	REGRADE AREA	1 CELLS

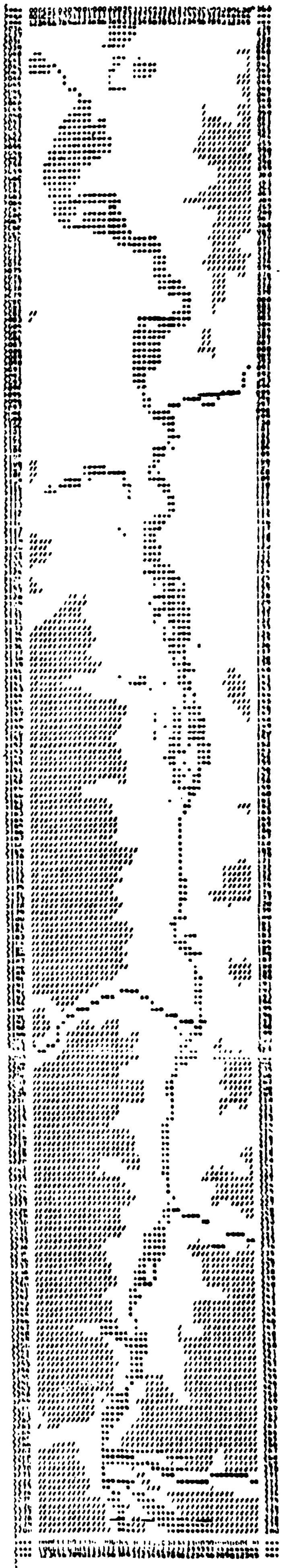
PESPASS

	0	....	[illegible] CELLS	97.3% COVERAGE
[illegible]	2	ACROSS [illegible]	6 CELLS	0.1% COVERAGE
[illegible]	3	[illegible] THEATRE	2 CELLS	[illegible] COVERAGE
[illegible]	4	AIRPORT AREA	20 CELLS	[illegible] COVERAGE
[illegible]	5	[illegible] N AIRPORT	11 CELLS	0.2% COVERAGE
//////////	6	SF PINE CR [illegible]	4 CELLS	0.1% COVERAGE
[illegible]	7	[illegible] ACCESS [illegible]	9 CELLS	0.2% COVERAGE
[illegible]	8	SMV GRAVEL PIT	1 CELLS	0.0% COVERAGE
[illegible]	9	SMV SWAMP	6 CELLS	0.1% COVERAGE
[illegible]	10	E OF STP [illegible]	5 CELLS	0.1% COVERAGE
1111111111	11	PACIFIC CROWN	2 CELLS	[illegible] COVERAGE
2222222222	12	LOG STORAGE	2 CELLS	[illegible] COVERAGE
3333333333	13	FAIRGROUNDS	3 CELLS	0.1% COVERAGE
[illegible]	14	[illegible] LUMBER	2 CELLS	0.0% COVERAGE
CCCCCCCCCC	32	[illegible]	1 CELLS	0.0% COVERAGE
[illegible]	35	[illegible] TANK CAR	1 CELLS	0.0% COVERAGE
[illegible]	36	MAIN GYP POND	7 CELLS	0.2% COVERAGE
[illegible]	37	[illegible] GYP DIKE	1 CELLS	0.0% COVERAGE
[illegible]	39	S OF CIA DIKE	1 CELLS	[illegible] COVERAGE
[illegible]	45	[illegible] AREA S OF CIA	1 CELLS	0.0% COVERAGE
[illegible]	46	[illegible] AREA	1 CELLS	[illegible] COVERAGE
[illegible]	51	SOUTH CIA GYPSUM	[illegible] CELLS	[illegible] COVERAGE
[illegible]	52	GYPSUM PIKE	1 CELLS	0.0% COVERAGE
[illegible]	53	GYPSUM POND	1 CELLS	0.0% COVERAGE
[illegible]	57	OLD [illegible]SITES	3 CELLS	0.1% COVERAGE
[illegible]	59	COKE PILE	1 CELLS	0.0% COVERAGE
[illegible]	60	ZINC RESIDUE	1 CELLS	0.0% COVERAGE
[illegible]	61	N OF [illegible]	1 CELLS	0.0% COVERAGE
[illegible]	62	[illegible]	2 CELLS	0.0% COVERAGE
[illegible]	63	NEAR SHOSH APTS	4 CELLS	0.1% COVERAGE
[illegible]	64	ROSS OIL AREA	1 CELLS	0.0% COVERAGE
[illegible]	65	HILLSIDE [illegible] ROSS	6 CELLS	0.1% COVERAGE
//////////	91	AREA NEAR [illegible]	4 CELLS	0.1% COVERAGE
[illegible]	92	AREA NEAR [illegible]	1 CELLS	0.0% COVERAGE



COVERMAP

----------	1	10-30% COVER	[illegible] CELLS	[illegible] COVERAGE
....	2	30-50% COVER	1137 CELLS	17.18 COVERAGE
0000000000	3	ALLUVIAL DEPOSIT	[illegible] CELLS	[illegible] COVERAGE
**********	4	50-100% COVER	[illegible] CELLS	[illegible] COVERAGE
....	5	0-10% COVER	[illegible] CELLS	[illegible] COVERAGE
//////////	6	[illegible] COVER	[illegible] CELLS	[illegible] COVERAGE



	3	....	[illegible] CELLS	[illegible]
**********	4	....	[illegible] CELLS	1.88
//////////	6	....	[illegible] CELLS	[illegible]
....	7	....	[illegible] CELLS	[illegible]

APPENDIX B

NATIONAL EMISSION DATA SYSTEM

(NEDS) Designation for Bunker Hill
Company Point Sources
(Taken From PES, 1978)

TABLE 1. SMELTER STACKS

Process Units	Process and/or Control	NEDS	Name
S1	11. Crushing Plant Dryer - Scrubber 12. Crushing Plant Dust Collector - Receiving Bins 13. Crushing Plant Rod Mill Scrubber 14. Crushing Plant Conveyor - Baghouse	02 03 04 05	Crushing Plant
S2	15. OPP Ore Preparation Plant Baghouse	06	Ore Preparation Plan
S3	16. Pelletizing Dryer - Scrubber 17. Return Sinter Storage } "D" Scrubber 18. Pelletizing Plant Conv. } "D" Scrubber	07 08	
S4	1. Lurgi-Strong Gas Smelter Acid Plant 2. Lurgi-Weak Gas	01	Lurgi Sinter Machine
S5	19. Lurgi "N" Rotoclone - Sinter Discharge 20. Lurgi "B" Scrubber - Sizing Building 21. Lurgi "C" Scrubber - Sizing Building 22. Lurgi "A" Scrubber - Sinter Rolls - Retrofit Drum	09 10 11 12	Sizing Building
S6	3. Lead Blast Furnace 10. Lead Blast Furnace Feed (Sinter Tunnel)	01	Blast Furnace
S7	26. Zinc Fuming Plant Main Stack - Baghouse 27. Zinc Fuming Plant Granulator - Scrubber	16 17	Zinc Fuming Plant

S8	28. Lead Refinery - Dross Kettles - Scrubber 5. Reverb Norblo Flue to Main Stack 24. Reverb Granulator Scrubber 23. Reverb Speiss Discharge - Baghouse	32 01 17 13	Roof Vent Lead Refinery and Reverb. Furn.
S9	6. Electric Furnace (Copper Dross) Norblo to 25. Electric Furnace Granulator - Scrubber	01 15	
S10	Silver Refinery Duct 7. Retort Room 8. Cupels 9. Monarchs	 01 01 01	Silvery Refinery

NEDS 01 Main Stack

Table 1. ZINC PLANT STACKS

Process Units	Process and/or Control	NEDS	Name
Z1	32. Concentrate Dryer - SO_2 Monitor	33 (New)	(Concentrate Dryer)
	33. Concentrate Silo - (No Control) from Rail Car	19	
Z2 After H/H Scrubber & ESP	Zinc Plant Acid Plant #1 } #1 RSTR.-27, #2 RSTR.-28, #3 RSTR.-29, #4 RSTR.-30, #5 RSTR.-31	18	(Zn Roasting Plant - 5 Roasters
After B/H Scrubber & ESP	Zinc Plant Acid Plant #2 }	18	

	36. Roasting Department Conveyor Scrubber	22	#5 Roaster = 3 Roasters 1-4 Each Acid Plant 3.5 Roasters
Z3	34. #1 Wedge Roaster-Scrubber 39. Melting Department Dross-Baghouse 37. Roaster Dross-Baghouse	20 25 23	Zinc Dross Processing
Z4	35. Residue Dryer - No Cont.-Temp.	21	Residue Dryer
Z5	Scrap Furnace Sky Vent 42. Scrap Furnace Scrubber - Not Hooked Up 40. #2 Melting Furnace Scrubber 41. #3 Melting Furnace Scrubber 41A. #3 Melting Furnace Vents 42A. Alloy Furnace	( ) 28 27 26 ( ) ( )	
Z6	38. Purification Zinc Baghouse (Zinc Dust Prep.)	24	Purification Department
Z7			

Table 1. PHOSPHATE PLANT STACKS

Process Units	Process and/or Control	NEDS	Name
P.1	44. Aerotec Ammonium Phosphate Reactor	30	Separate PWR
P.2	43. Dryer S.F. - Ammonium Phosphate	29	Separate PWR
P.3	45. Doyle Reactor - Phosphoric Acid Reactor	31	Separate PWR

APPENDIX C

SOURCES LISTED BY SOURCE TYPES AND SOURCE STRENGTHS

POINT SOURCES ORDERED BY TOTAL SOURCE STRENGTH

NAME	EMR
SMELTER MAIN ST	79.3
LURGI-M ROTOCLON	35.7
ZN FUMING GRAN	35.7
PELLET DRYER	25.8
ZN FUME MAIN ST	24.6
ZINC MAIN STACK	22.8
AMF REACTOR	13.0
CRUSHPL DRYER	12.9
LURGI B SCRUBBER	9.2
LURGI A SCRUBBER	7.6
#3MELT SCRUBBER	7.3
#2SFOGE SCRUBBER	6.6
LURGI C SCRUBBER	6.0
CONCENT DRYER	4.0
LURGI D SCRUBBER	3.1
AMF DRYER	2.9
DOYLE REACTOR	2.4
#2MELT SCRUBBER	2.2
#1MELT SCRUBBER	2.0
CRUSHPL RODMILL	1.4
CRUSHPL COLLECT	1.3
SCRAP FURNACE	1.3
CRUSHPL BAGHOUSE	1.2
TRIPPER BAGHOUSE	1.1
MELTERS SCRUBBER	0.7
MORROSS BAGHOUSE	0.2
CONCENT DRYER	0.2

POINT SOURCES ORDERED BY LEAD SOURCE STRENGTH

NAME	PBEMR
SMELTER MAIN ST	43.065
LURGI-M ROTOCLON	16.065
PELLET DRYER	7.998
LURGI B SCRUBBER	4.140
LURGI A SCRUBBER	3.420
CRUSHPL DRYER	3.379
LURGI C SCRUBBER	2.700
ZINC MAIN STACK	2.280
ZN FUMING GRAN	1.785
LURGI D SCRUBBER	1.395
#2SFOGE SCRUBBER	1.260
ZN FUME MAIN ST	1.230
CRUSHPL RODMILL	0.434
CRUSHPL COLLECT	0.403
CONCENT DRYER	0.400
CRUSHPL BAGHOUSE	0.372
#3MELT SCRUBBER	0.365
TRIPPER BAGHOUSE	0.341
#2MELT SCRUBBER	0.110
#1MELT SCRUBBER	0.100
MELTERS SCRUBBER	0.070
SCRAP FURNACE	0.065
MORROSS BAGHOUSE	0.020
CONCENT DRYER	0.020
AMF REACTOR	0.000
AMF DRYER	0.000
DOYLE REACTOR	0.000

POINT SOURCES ORDERED BY CADMIUM SOURCE STRENGTH

NAME	CDEMR
SMELTER MAIN ST	5.481
LURGI N SCIDCLON	0.357
ZN FUMING GRAN	0.357
PELLET DRYER	0.258
ZN FUME MAIN ST	0.246
ZINC MAIN STACK	0.228
LURGI B SCRUBBER	0.092
LURGI A SCRUBBER	0.076
#3MELT SCRUBBER	0.073
#1LEDGL SCRUBBER	0.068
LURGI C SCRUBBER	0.060
CONCENT DRYER	0.040
LURGI D SCRUBBER	0.031
#2MELT SCRUBBER	0.022
#2MELT SCRUBBER	0.020
CRUSHPL RODMILL	0.014
CRUSHPL COLLECT	0.013
SCRAP FURNACE	0.013
CRUSHPL BAGHOUSE	0.012
CREPREP BAGHOUSE	0.011
MELTDRS SCRUBBER	0.007
FCCPOSS BAGHOUSE	0.002
CONCENT DRYER	0.002
AMF REACTOR	0.000
CRUSHPL DRYER	0.000
AMF DRYER	0.000
DOYLE REACTOR	0.000

PROCESS FUGITIVE SOURCES ORDERED BY LEAD SOURCE STRENGTH

NAME	EMR	PBFR	CDFR	PBEMR	CDEMR
BLAST FURNACE	30.00	61	0	18.3000	2.7000
CFP EXHST FANS	34.00	31	1	10.5400	0.3400
CPF CON EXH FANS	25.00	34	1	8.5000	0.2500
CAST ROOF FANS	12.40	31	1	3.8440	0.1240
PB REF ROOF VENT	6.70	37	1	2.4790	0.0670
FUMING FUR ROOF	42.00	3	0	1.2600	0.0000
BF ROOF VENTS	1.90	47	1	0.8930	0.0190
ELEC FUR ROOF	4.30	10	0	0.4300	0.0000
SINTER PROD DUMP	0.54	31	1	0.1674	0.0054

ACTIVE SOURCES ORDERED BY LEAD SOURCE STRENGTH

NAME	MAPID	EMR	PBFR	CDFR	PBEMR	CDEMR
SILICA SLAG PILE	73	17.8	5	0	0.890	0.000
SINTER STORAGE	45	1.6	42	1	0.672	0.016
SLAG STORAGE	33	20.2	2	0	0.404	0.000
SLAG STORAGE	33	20.2	2	0	0.404	0.000
SLAG STORAGE.	33	20.2	2	0	0.404	0.000
ST HIWAY PILES	74	30.3	1	0	0.303	0.000
SILICA STORAGE	31	5.0	5	0	0.250	0.000
SINTER STORAGE	49	0.4	42	1	0.168	0.004
SINTER STORAGE	49	0.4	42	1	0.168	0.004
SINTER STORAGE	49	0.4	42	1	0.168	0.004
SINTER STORAGE	45	0.6	0	0	0.000	0.000
COKE STORAGE	45	0.6	0	0	0.000	0.000

PASSIVE SOURCES ORDERED BY TOTAL SOURCE STRENGTH PER UNIT AREA

NAME	MAP	MAPID
ZINC RESIDUE	PESPASS	60
N END OF STP	PEDCOPA	44
TAILING POND OSB	PEDCOPA	23
TAILINGS AREA	PEDCOPA	10
LUMBER YARD STOR	PEDCOPA	43
FAIRGROUNDS	PESPASS	13
FAIR GROUNDS	DOEPASS	13
LOG STORAGE	PESPASS	12
LINFOR LUMBER	DOEPASS	30
MOVIE THEATRE	DOEPASS	24
GRADED AREA FNH	PEDCOPA	5
OUTCROP THEATRE	PESPASS	3
SMV PLAYGROUND	PEDCOPA	9
LINFOR LUMBER	PESPASS	14
AIRPORT AREA	PESPASS	4
AIRPORT AREA	DOEPASS	36
PARK LOT S CONC	PESPASS	58
EQUIP STOR AREA	PEDCOPA	33
SMELTER STORAGE	PEDCOPA	38
AREA NEAR JR HI	PESPASS	1
JR HI AREA	DOEPASS	20
SUNSHINE POND	DOEPASS	62
MASE & ORE GRIND	PESPASS	62
HIWAY FILL	PEDCOPA	16
PACIFIC CROWN	PESPASS	11
CIA NW END A	DOEPASS	53
CIA NW END B	DOEPASS	52
OLD TOWN SITE	DOEPASS	55
OLD TOWN SITE	DOEPASS	54
ORE STORAGE AREA	PEDCOPA	14
ATLETIC FIELD	PEDCOPA	18
LUMBER YARD STOR	PESPASS	.
SHOSHONE APTS	DOEPASS	19
WEST OF ASPH PLT	DOEPASS	61
E TRAILER PARK	DOEPASS	51
SMV SWAMP	PESPASS	9
SMV SWAMP	DOEPASS	21
MOTOCROSS	DOEPASS	34
S OF FREEWAY #27	DOEPASS	27
E OF STP PAGE PD	PESPASS	10
SMV GRAVEL PIT	PESPASS	8
SMV GRAVEL PIT	DOEPASS	33
N OF ORE GRIND	PESPASS	61
COKE PILE	PESPASS	59
S OF FREEWAY #23	DOEPASS	23
N OF TRAIL PARK	DOEPASS	15
INSIDE GYP DIKE	PESPASS	37
AREA NEAR ZP	PESPASS	91

PASSIVE SOURCES ORDERED BY TOTAL SOURCE STRENGTH PER UNIT AREA (CONT.)

NEAR SHOSH APTS	PESPASS	63
PINE CR CUT	DOEPASS	69
MINE SPOILS	PEDCOPA	34
AREA NEAR AMP	PESPASS	92
OLD HOMESITES	PESPASS	57
GYPSUM DIKE	PESPASS	52
NO SIDE MCKINLEY	PESPASS	32
S OF CIA DIKE	PESPASS	39
OLD GYP POND	DOEPASS	11
RIV CH N ZANNETT	DOEPASS	25
GRAVEL STORAGE	PEDCOPA	20
RP AREA S OF CIA	PESPASS	40
H2504 TANK CAR	PESPASS	35
SMELTER STORAGE	PEDCOPA	36
SMELTER STORAGE	PEDCOPA	37
SINTER STORAGE	DOEPASS	58
GRADED AREA	PEDCOPA	21
SOUTH CIA GYPSUM	PESPASS	51
OLD RIV CH MCON	DOEPASS	17
ROCK & GRAV FNH	PEDCOPA	6
SEDIMENT BASIN	PEDCOPA	13
SMELT PARK LOT	DOEPASS	12
MAIN GYP POND	PESPASS	36
ACROSS FRW EH	PESPASS	2
S OF CIA RV/INT	DOEPASS	26
ZANNETTI AREA	DOEPASS	24
RUBBLE & FILL	PEDCOPA	40
RIV ACCESS PINCR	PESPASS	7
N OF BH POND	DOEPASS	32
HILLCUT NE SMELT	PEDCOPA	35
SWEENY POND AREA	PESPASS	46
TERRACED HILLSID	DOEPASS	40
S OF FREEWAY #37	DOEPASS	37
CIA SOUTH ROAD	DOEPASS	57
CIA SOUTH DIKE	DOEPASS	56
ROSS OIL AREA	PESPASS	64
SLAG REMOVAL AR	PESPASS	34
RV CH N AIRPORT	PESPASS	5
N OF AIRPORT	DOEPASS	35
N GYP POND	DOEPASS	7
N GYP POND SLAG	DOEPASS	8
GRAVEL PIT	PEDCOPA	26
RUBBLE & FILL	PEDCOPA	39
S OF FREEWAY #22	DOEPASS	22
REGRAD STR BED	PEDCOPA	22
STREAM BED	PEDCOPA	24
STREAM BED	PEDCOPA	28
SF PINE CR CONFL	PESPASS	6
SF & PINECR CONF	DOEPASS	31
HILLSIDE A ROSS	PESPASS	65
GRAVEL AREA	PESPASS	[illegible]
GYPSUM POND	PESPASS	53

PASSIVE SOURCES ORDERED BY LEAD SOURCE STRENGTH PER UNIT AREA

NAME	MAP	MAPID
ORE STORAGE AREA	PEDCOPA	14
SINTER STORAGE	DOEPASS	58
OLD TOWN SITE	DOEPASS	54
TAILINGS AREA	PEDCOPA	10
ZINC RESIDUE	PESPASS	60
GRADED AREA FNH	PEDCOPA	5
AREA NEAR JR HI	PESPASS	1
JR HI AREA	DOEPASS	20
PARK LOT S CONC	PESPASS	58
WHSE & ORE GRIND	PESPASS	62
SHOSHONE APTS	DOEPASS	19
SMV SWAMP	PESPASS	9
SMV SWAMP	DOEPASS	21
OLD HOMESITES	PESPASS	57
TAILING POND OSB	PEDCOPA	23
SMV PLAYGROUND	PEDCOPA	9
S OF FREEWAY #27	DOEPASS	27
MOTOCROSS	DOEPASS	34
RR AREA S OF CIA	PESPASS	40
E OF STP PAGE PD	PESPASS	10
N OF ORE GRIND	PESPASS	61
FAIRGROUNDS	PESPASS	13
LOG STORAGE	PESPASS	12
MOVIE THEATRE	DOEPASS	24
NEAR SHOSH APTS	PESPASS	63
SMELT PARK LOT	DOEPASS	12
PACIFIC CROWN	PESPASS	11
OLD GYP POND	DOEPASS	11
LUMBER YARD STOR	PEDCOPA	43
LINFOR LUMBER	DOEPASS	30
LINFOR LUMBER	PESPASS	14
OLD TOWN SITE	DOEPASS	55
HIWAY FILL	PEDCOPA	16
AIRPORT AREA	PESPASS	4
AIRPORT AREA	DOEPASS	36
SWEENY POND AREA	PESPASS	46
SMELTER STORAGE	PEDCOPA	36
CIA NW END A	DOEPASS	53
CIA NW END B	DOEPASS	52
LUMBER YARD STOR	PESPASS	[illegible]
N END OF STP	PEDCOPA	44
NO SIDE MCKINLEY	PESPASS	32
EQUIP STOR AREA	PEDCOPA	33
MINE SPOILS	PEDCOPA	34
SMELTER STORAGE	PEDCOPA	37
S OF FREEWAY #23	DOEPASS	23
NSIDE GYP DIKE	PESPASS	37
OUTDOOR THEATRE	PESPASS	3

PASSIVE SOURCES ORDERED BY LEAD SOURCE STRENGTH PER UNIT AREA (CONT.)

AREA NEAR ZP	PESPASS	91
RIV CH N ZANNETT	DOEPASS	25
AREA NEAR AMP	PESPASS	92
FAIR GROUNDS	DOEPASS	13
SMELTER STORAGE	PEDCOPA	38
GYPSUM DIKE	PESPASS	52
ROSS OIL AREA	PESPASS	64
S OF CIA DIKE	PESPASS	39
E TRAILER PARK	DOEPASS	51
#12504 TANK CAR	PESPASS	35
CIA SOUTH ROAD	DOEPASS	57
ATLETIC FIELD	PEDCOPA	18
SOUTH CIA GYPSUM	PESPASS	51
GRADED AREA	PEDCOPA	21
SHV GRAVEL PIT	PESPASS	8
SHV GRAVEL PIT	DOEPASS	33
RUBBLE & FILL	PEDCOPA	40
RIV ACCESS PINCR	PESPASS	7
MAIN GYP POND	PESPASS	36
N OF AIRPORT	DOEPASS	35
RUBBLE & FILL	PEDCOPA	39
ACROSS FRW BH	PESPASS	2
N GYP POND	DOEPASS	7
N GYP POND SLAG	DOEPASS	8
RV CH N AIRPORT	PESPASS	5
S OF FREEWAY #37	DOEPASS	37
OLD RIV CH MCON	DOEPASS	17
N OF TRAIL PARK	DOEPASS	15
S OF FREEWAY #22	DOEPASS	22
E OF CIA FV/INT	DOEPASS	26
CIA SOUTH DIKE	DOEPASS	56
N OF OH POND	DOEPASS	32
ROCK & GRAV PNH	PEDCOPA	6
STREAM BED	PEDCOPA	24
HILLISE A ROSS	PESPASS	65
REGRAD STR BED	PEDCOPA	22
GRAVEL STORAGE	PEDCOPA	20
SF PINE CR CONFL	PESPASS	6
GRAVEL PIT	PEDCOPA	26
WEST OF ASPH PLT	DOEPASS	61
STREAM BED	PEDCOPA	28
SF & PINECR CONF	DOEPASS	31
HILLCUT NE SMELT	PEDCOPA	35
GRAVEL AREA	PESPASS	.
PINE CR CUT	DOEPASS	69
TERRACED HILLSID	DOEPASS	40
SEDIMENT BASIN	PEDCOPA	13
ZANNETTI AREA	DOEPASS	24
COKE PILE	PESPASS	59
SLAG REMOVAL AR	PESPASS	34
GYPSUM POND	PESPASS	53
SUNSHINE POND	DOEPASS	62

PASSIVE SOURCES ORDERED BY CADMIUM SOURCE STRENGTH PER UNIT AREA

NAME	MAP	MAPID
ZINC RESIDUE	PESPASS	60
PARK LOT S CONC	PESPASS	58
NHSE E ORE GRIND	PESPASS	62
OLD TOWN SITE	DOEPASS	54
OP AREA S OF CIA	PESPASS	40
ZINTER STORAGE	DOEPASS	58
N OF ORE GRIND	PESPASS	61
OLD GYP POND	DOEPASS	11
SWEENY POND AREA	PESPASS	46
SMELT PARK LOT	DOEPASS	12
OLD TOWN SITE	DOEPASS	55
OLD HOMESITES	PESPASS	57
NO SIDE MCKINLEY	PESPASS	32
INSIDE GYP DIKE	PESPASS	37
AREA NEAR JR HI	PESPASS	1
JR HI AREA	DOEPASS	20
MOTOCROSS	DOEPASS	34
GYPSUM DIKE	PESPASS	52
LINFOR LUMBER	DOEPASS	30
S OF FREEWAY #27	DOEPASS	27
S OF CIA DIKE	PESPASS	39
ROSS OIL AREA	PESPASS	64
MOVIE THEATRE	DOEPASS	24
LINFOR LUMBER	PESPASS	14
SMV SWAMP	PESPASS	9
SMV SWAMP	DOEPASS	21
H2504 TANK CAR	PESPASS	35
SHOSHONE APTS	DOEPASS	19
SOUTH CIA GYPSUM	PESPASS	51
MAIN GYP POND	PESPASS	36
FAIRGROUNDS	PESPASS	13
LOG STORAGE	PESPASS	12
PACIFIC CROWN	PESPASS	11
NEAR SHOSH APTS	PESPASS	63
AIRPORT AREA	PESPASS	4
AIRPORT AREA	DOEPASS	36
CIA SOUTH ROAD	DOEPASS	57
S OF STORAGE PD	PESPASS	10
FAIR GROUNDS	DOEPASS	13
AREA NEAR ZP	PESPASS	91
HILLISE A ROSS	PESPASS	65
AREA NEAR AMP	PESPASS	92
S OF FREEWAY #23	DOEPASS	23
E TRAILER PARK	DOEPASS	51
CIA SOUTH DIKE	DOEPASS	56
N GYP POND	DOEPASS	7
N GYP POND SLAG	DOEPASS	8
N OF AIRPORT	DOEPASS	35
S OF FREEWAY #37	DOEPASS	37
S OF FREEWAY #22	DOEPASS	22
SLAG REMOVAL AR	PESPASS	34
TERRACED HILLSID	DOEPASS	40
GYPSUM POND	PESPASS	53
ZANNETTI AREA	DOEPASS	54
COKE PILE	PESPASS	59
SUNSHINE POND	DOEPASS	62

APPENDIX D

FINAL RELATIVE IMPACT ESTIMATIONS BY QUARTER AND STATION

Variable Designations

QKOUNT = study quarter (1 = 3/77 . . . 8 = 2/79)

STATION

1 Cataldo
2 Pinehurst
3 Smelterville
4 Silver King
5 Medical Center
6 Kellogg City Hall
7 Osburn
8 Wallace
9 Kingston

AMBPB = Observed Quarterly Lead Mean ($\mu u/m^3$)

SMLOWX = Estimated Low Smelter Contribution ($\mu g/m^3$)

SMMIDX = Estimated Mid Smelter Contribution ($\mu g/m^3$)

ACTX = Estimated Active Source Contribution ($\mu g/m^3$)

PASX = Estimated Passive Source Contribution ($\mu g/m^3$)

TOTX = Estimated Quarterly Lead Mean ($\mu g/m^3$)

FRSMLOW = Fraction of Estimated Mean Due to Low Smelter Sources

FRSMMID = Fraction of Estimated Mean Due to Mid Smelter Sources

FRACT = Fraction of Estimated Mean Due to Active Sources

FRPAS = Fraction of Estimated Mean Due to Passive Sources

STATION=1 QKOUNT=1

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPP	6	0.47150000	0.18823682	0.16500000	0.63800000	0.07684736	2.82900000	0.03543310	39.923
SMLOWX	6	0.05924070	0.01999467	0.03519556	0.08654237	0.00816279	0.35544420	0.00039979	33.752
SMMIDX	6	0.37704325	0.11980829	0.25024072	0.52865443	0.04891153	2.26249947	0.01435403	31.772
ACTX	6	0.11138392	0.10526454	0.00000000	0.25900815	0.04297407	0.66830354	0.01108062	94.506
PASX	6	0.39674874	0.43161768	0.00000000	1.12597319	0.17620718	2.38049241	0.18629382	108.789
TOTX	6	0.94445660	0.52797739	0.28563628	1.66045170	0.21554587	5.66673962	0.27876012	55.903
FRSMLOW	6	0.07925326	0.03877558	0.03823558	0.12845917	0.01583170	0.47551955	0.00150386	48.931
FRSMMID	6	0.52414487	0.28833913	0.21728961	0.87608171	0.11772212	3.14486924	0.08315099	55.015
FRACT	6	0.09414676	0.09527059	0.00000000	0.24391531	0.03889405	0.56488058	0.00907648	101.194
FRPAS	6	0.30245511	0.29112732	0.00000000	0.67811258	0.11885223	1.81473063	0.08475512	96.255
STATION=1 QKOUNT=2									
AMPPP	13	0.86784615	0.62659980	0.23200000	2.28200000	0.17378752	11.28200000	0.39262731	72.202
SMLOWX	13	0.07569831	0.03264918	0.03353015	0.16217722	0.00905525	0.98407800	0.00106597	43.131
SMMIDX	13	0.29693701	0.11075593	0.14008724	0.55630208	0.03071817	3.86018109	0.01226688	37.299
ACTX	13	0.13283682	0.14521675	0.00000000	0.39279825	0.04027643	1.72687870	0.02108849	109.321
PASX	13	0.17168378	0.27579950	0.00000000	0.69428233	0.07649033	2.23188910	0.07606002	160.638
TOTX	13	0.67715591	0.33580476	0.17351739	1.24307998	0.09313548	8.80302689	0.11276484	49.590
FRSMLOW	13	0.13493889	0.06399077	0.04797049	0.22572288	0.01774785	1.75420558	0.00409482	47.422
FRSMMID	13	0.54037764	0.27054173	0.14770889	0.80822492	0.07226127	7.02490934	0.07788199	48.215
FRACT	13	0.16439869	0.20213067	0.00000000	0.55149155	0.05607483	2.13718290	0.04087702	122.982
FRPAS	13	0.16028478	0.25307795	0.00000000	0.57697032	0.07019117	2.08370218	0.06404840	157.893
STATION=1 QKOUNT=3									
AMPPF	16	0.57625000	0.50263366	0.10400000	1.49300000	0.12565842	9.22000000	0.25264060	87.2[illegible]
SMLOWX	16	0.12975367	0.05766496	0.05456642	0.24590514	0.01441599	2.07605879	0.00332513	44.44[illegible]
SMMIDX	16	0.63873988	0.27659600	0.26830974	1.19314019	0.06914900	10.21983808	0.07650535	43.303
ACTX	16	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	16	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	16	0.76849355	0.33415025	0.37237616	1.43904534	0.08353756	12.29589688	0.11165639	43.481
FRSMLOW	16	0.16833583	0.00387537	0.16391596	0.17556573	0.00096884	2.69337326	0.00001502	2.302
FRSMMID	16	0.83166417	0.00387537	0.82443427	0.83604402	0.00096884	13.30662674	0.00001502	0.466
FRACT	16	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	16	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
STATION=1 QKOUNT=4									
AMFPP	23	0.37943479	0.28880204	0.08100000	1.33000000	0.06021939	8.72700000	0.08340662	76.114
SMLOWX	23	0.06539251	0.02472652	0.02353839	0.12705970	0.00515584	1.50402767	0.00061140	37.812
SMMIDX	23	0.33228747	0.10934039	0.13102666	0.54445201	0.02279905	7.64261183	0.01195532	32.905
ACTX	23	0.09605626	0.07186003	0.00000000	0.21758173	0.01498385	2.20929395	0.00516386	74.810
PASX	23	0.73012114	0.62005229	0.00000000	2.13340930	0.12928984	16.79278633	0.38446485	84.925
TOTX	23	1.22385739	0.66952929	0.20764054	2.42597281	0.13960651	28.14871977	0.44826947	54.706
FRSMLOW	23	0.07830348	0.05486644	0.01375454	0.15916096	0.01144044	1.80098004	0.00301033	70.069
FRSMMID	23	0.40920823	0.30296490	0.07586564	0.84678347	0.06317255	9.41178936	0.09178773	74.037
FRACT	23	0.06764852	0.06307067	0.00000000	0.25853063	0.01315114	1.55591598	0.00397791	93.233
FRPAS	23	0.44483977	0.31984215	0.00000000	0.87940363	0.06669170	10.23131462	0.10229900	71.901

STATION=1 QKOUNT=5

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMRPR	26	0.20[illegible]537	0.177[illegible]663	0.05765306	0.87326531	0.03482956	5.42997959	0.03154056	65.037
SPLOWX	26	0.06[illegible]	0.0162[illegible]980	0.03909320	0.11275770	0.00318489	1.71820955	0.00026373	24.574
SPMIDX	26	0.30[illegible]	0.06[illegible]002	0.15915004	0.44424998	0.01276128	7.89571867	0.00423411	21.427
ACTX	26	0.10[illegible]184	0.08[illegible]077	0.00000000	0.24340652	0.01737408	2.84496781	0.00784832	80.963
PASX	26	0.41[illegible]	0.[illegible]565510	0.00000000	1.47250706	0.08543899	10.70568439	0.18979536	105.804
TOTX	26	0.[illegible]	0.[illegible]0576750	0.24515026	2.01181564	0.09997363	23.16458042	0.25986291	57.216
FFSPLOW	26	0.0[illegible]	0.0[illegible]77212	0.03410424	0.17260255	0.00976112	2.58530713	0.00247726	50.055
FFSPMID	26	0.47[illegible]	0.[illegible]7866441	0.17377627	0.84053374	0.05465137	12.46887984	0.07765608	58.108
FFACT	26	0.10[illegible]	0.11142806	0.00000000	0.39176033	0.02185127	2.81061465	0.01241443	103.071
FFPAS	26	0.31[illegible]	0.28[illegible]	0.00000000	0.73192942	0.05624723	8.13519838	0.08225753	91.663

STATION=1 QKOUNT=6

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMRPR	28	0.[illegible]7025	0.[illegible]701009	0.02224490	2.87693878	0.12416324	15.39636735	0.43166226	119.485
SPLOWX	28	0.[illegible]	0.0[illegible]	0.02063035	0.21096246	0.00917439	1.86953405	0.00167098	64.763
SPMIDX	28	0.44[illegible]	0.2[illegible]130149	0.15830612	1.40380379	0.04749152	12.34201019	0.06315244	57.012
ACTX	28	0.02721574	0.0[illegible]393	0.00000000	0.38305211	0.01621164	0.76204078	0.00735868	315.200
PASX	28	0.0337[illegible]	0.12640728	0.00000000	0.56659393	0.02388873	0.94369419	0.01597680	375.058
TOTX	28	0.56[illegible]7426	0.[illegible]651708	0.17893647	1.61466625	0.06737540	15.91727921	0.12710443	62.715
FFSPLOW	28	0.121[illegible]	0.02422865	0.04462083	0.19558360	0.00533471	3.40604796	0.00079686	23.206
FFSPMID	28	0.[illegible]	0.14310[illegible]	0.34344352	0.88626182	0.02704449	23.05902979	0.02047932	17.377
FFACT	28	0.0270[illegible]	0.09054972	0.00000000	0.42527212	0.01711229	0.75857441	0.00819925	334.231
FFPAS	28	0.02772671	0.10181260	0.00000000	0.39270385	0.01924066	0.77634784	0.01036568	367.198

STATION=1 QKOUNT=7

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMRPR	27	0.[illegible]1209	0.61206718	0.05743673	2.39371429	0.12164138	16.27781633	0.35950891	104.841
SPLOWX	27	0.14[illegible]	0.[illegible]62615	0.03635553	1.52368570	0.05400653	3.91474853	0.07875103	193.546
SPMIDX	27	0.711[illegible]	0.[illegible]40	0.22685425	5.14651056	0.17712825	19.21588913	0.84710929	129.322
ACTX	27	0.02[illegible]725	0.07141202	0.00000000	0.23831350	0.01374325	0.78130596	0.00509968	246.782
PASX	27	0.12[illegible]61	0.[illegible]8394934	0.00000000	1.68409787	0.07389878	3.43071749	0.14744782	302.202
TOTX	27	1.01[illegible]115	1.24511105	0.26121278	6.67019625	0.23962304	27.34266111	1.55031847	122.951
FFSPLOW	27	0.13211[illegible]	0.03691255	0.03763470	0.22843191	0.00710392	3.56770872	0.00136254	27.935
FFSPMID	27	0.77[illegible]	0.1920[illegible]	0.20546714	0.86611020	0.03695624	21.02847042	0.03687562	24.656
FFACT	27	0.02072[illegible]	0.0[illegible]	0.00000000	0.24240849	0.01088576	0.55970343	0.00319949	272.864
FFPAS	27	0.0[illegible]3065	0.18239300	0.00000000	0.67724565	0.03510155	1.84411743	0.03326721	267.044

STATION=1 QKOUNT=8

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMRPR	26	0.21377314	0.12252458	0.06[illegible]796	0.44546939	0.02402905	5.55810204	0.01501227	57.315
SPLOWX	26	0.0[illegible]	0.03714609	0.07311708	0.20811037	0.00728495	2.47568679	0.00137983	39.011
SPMIDX	26	0.[illegible]	0.12126717	0.11[illegible]	0.72569776	0.02378245	9.05667124	0.01470573	34.814
ACTX	26	0.10[illegible]	0.08049445	0.00000000	0.30399227	0.01578626	2.61309063	0.00647936	80.091
PASX	26	0.59[illegible]	0.45015377	0.00000000	1.32447441	0.08828242	15.34682797	0.20263842	76.263
TOTX	26	1.1[illegible]	0.[illegible]0520840	0.14617272	1.87357077	0.10404369	29.49227663	0.28145232	46.770
FFSPLOW	26	0.10711097	0.05906507	0.02314808	0.19983565	0.01158440	2.78488509	0.00348916	55.148
FFSPMID	26	0.4112[illegible]	0.[illegible]756744	0.09611422	0.80932960	0.05051313	10.69353082	0.06634099	62.624
FFACT	26	0.07[illegible]	0.07124536	0.00000000	0.30691169	0.01398021	1.96784171	0.00508160	94.185
FFPAS	26	0.40591317	0.25278748	0.00000000	0.81592624	0.05742035	10.55374237	0.06572451	72.131

STATION=2 QKOUNT=1

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	5	2.33640000	1.45274113	0.93700000	4.77300000	0.64968559	11.68200000	2.11045680	62.17
SPLOWX	5	0.34766875	0.26163405	0.05692283	0.65661813	0.11699289	1.73834374	0.06843668	75.24
SMMIDX	5	[illegible]	0.7644[illegible]249	0.38743942	2.46636880	0.34189143	7.04297817	0.58444676	54.27
ACTX	5	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	5	0.19002381	0.22556612	0.00000000	0.55006891	0.10087624	0.95011907	0.05068008	118.70
TOTX	5	[illegible]	1.15549869	0.44466224	3.35011002	0.51673684	9.73144099	1.33506480	59.36
FRSMLOW	5	0.16292281	0.04010536	0.12778873	0.21552731	0.01793566	0.81461405	0.00160844	24.61
FRSMMID	5	[illegible]	0.11662442	0.58229788	0.87221127	0.05214708	3.82634916	0.01359659	15.22
FRACT	5	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	5	0.07140736	0.08300042	0.00000000	0.20217481	0.03711892	0.35703679	0.00688907	116.23

STATION=2 QKOUNT=2

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	10	4.02100000	2.84242289	0.37400000	10.60400000	0.89886253	40.21000000	8.07953844	70.69
SPLOWX	10	0.26615282	0.19071959	0.07702670	0.65322385	0.06031083	2.66152817	0.03637396	71.65
SMMIDX	10	[illegible]	0.42750016	0.3157[illegible]49	1.49736757	0.13518742	8.21227290	0.18275639	52.05
ACTX	10	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	10	0.11170318	0.14327100	0.00000000	0.37584885	0.04531259	1.11703176	0.02053231	128.27
TOTX	10	[illegible]	0.70713317	0.39281519	2.40526319	0.22363412	11.99083282	0.50012218	58.97
FRSMLOW	10	[illegible]	0.03621539	0.13148974	0.27158103	0.01145231	2.08919606	0.00131155	17.33
FRSMMID	10	[illegible]	0.10622665	0.50732623	0.80391110	0.03359188	7.12072730	0.01128414	14.91
FRACT	10	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	10	0.07900766	0.11984130	0.00000000	0.36578503	0.03789715	0.79007664	0.01436194	151.68

STATION=2 QKOUNT=3

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	11	2.75227273	2.23677223	0.33100000	7.11600000	0.67441220	30.27500000	5.00315002	81.
SPLOWX	11	[illegible]	0.22236682	0.13491160	0.94567907	0.06702803	3.61163436	0.04942032	67.
SMMIDX	11	[illegible]	[illegible]	0.66012975	3.41980142	0.22711351	15.50233499	0.56738601	53.4
ACTX	11	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	11	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	11	[illegible]	[illegible]	0.79504036	4.36648049	0.29365726	19.11396435	0.94258042	56.05
FRSMLOW	11	[illegible]	[illegible]	0.16464152	0.21680598	0.00470316	2.01181390	0.00024332	8.52
FRSMMID	11	[illegible]	[illegible]	[illegible]	0.83030848	0.00470316	8.98818610	0.00024332	1.90
FRACT	11	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	11	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=2 QKOUNT=4

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	24	[illegible]	[illegible]	0.16500000	2.13600000	0.12167755	23.88100000	0.35533022	59.90
SPLOWX	24	[illegible]	[illegible]	[illegible]	0.88655273	0.04980025	6.83066675	0.05952155	85.72
SMMIDX	24	[illegible]	0.45204160	[illegible]	1.69404783	0.09227261	22.66805062	0.20434161	47.86
ACTX	24	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	24	[illegible]	[illegible]	0.00000000	0.46551138	0.05673862	6.71495953	0.07726251	99.34
TOTX	24	[illegible]	[illegible]	0.50614994	3.14436008	0.15014292	36.21367689	0.54102950	48.74
FRSMLOW	24	[illegible]	[illegible]	[illegible]	0.44186523	0.01726131	4.13476376	0.00715087	49.08
FRSMMID	24	[illegible]	[illegible]	0.31016890	0.83804908	0.03497447	15.56253062	0.02935712	26.42
FRACT	24	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	24	0.17927940	0.19442466	0.00000000	0.62869129	0.03968881	4.30270562	0.03780484	108.45

STATION=2 QKOUNT=5

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPA	28	0.85733528	1.07123433	0.11657143	5.80571429	0.20244426	24.00539776	1.14754298	124.94
SMLOWX	30	0.43237619	0.31764493	0.07822045	1.32995894	0.05799377	12.97628573	0.10089830	73.38
SMMIDX	30	[illegible]	0.42233397	0.20230030	1.74889293	0.07711093	28.86871491	0.17838288	43.89
ACTX	30	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	30	0.23347363	0.20721950	0.00000000	0.74663440	0.03783293	7.00420883	0.04293992	88.75
TOTX	30	[illegible]	0.64982963	0.46414009	2.78540282	0.11864215	48.85920947	0.42227881	39.90
FRSMLOW	30	[illegible]	0.13612317	0.09812999	0.67711061	0.02485258	7.48511335	0.01852952	54.55
FRSMMID	30	[illegible]	0.19774111	0.12638530	0.83147234	0.03610060	18.71694429	0.03909759	31.69
FRACT	30	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	30	[illegible]	0.11712974	0.00000000	0.41216886	0.02138487	3.79794237	0.01371938	92.52

STATION=2 QKOUNT=6

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPA	25	2.81435510	2.92671226	0.07391633	12.12081633	0.58534045	70.35887755	8.56558613	103.99
SMLOWX	25	0.38565819	0.48206924	0.04549694	2.28255248	0.09641385	9.64145484	0.23239075	124.99
SMMIDX	25	1.34702009	1.18310904	0.32259347	5.95747997	0.23660181	33.67550214	1.39951039	87.82
ACTX	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	25	0.02479801	0.08352618	0.00000000	0.36676641	0.01670524	0.61995035	0.00697662	336.82
TOTX	25	1.75747629	1.48582714	0.36807442	7.18621148	0.29716543	43.93690734	2.20768229	84.54
FRSMLOW	25	0.18801935	0.11201624	0.10113404	0.62496391	0.02240325	4.70048366	0.01254764	59.57
FRSMMID	25	[illegible]	0.11890418	0.37593709	0.89211251	0.02378084	19.85017363	0.01413820	14.97
FRACT	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	25	0.01797371	0.06049855	0.00000000	0.25377451	0.01219971	0.44934272	0.00372082	339.37

STATION=2 QKOUNT=7

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPA	23	[illegible]	[illegible]	0.09217755	11.93142857	0.58054438	54.82742857	7.75173076	116.79
SMLOWX	23	[illegible]	[illegible]	0.10417647	11.57704048	0.49792977	20.62830349	5.70248333	266.25
SMMIDX	23	2.17115934	2.40986910	0.65777664	11.66523240	0.50224014	49.93666488	5.80163868	110.93
ACTX	23	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	23	0.02099297	0.08421734	0.00000000	0.39890904	0.01756053	0.48283825	0.00709256	401.16
TOTX	23	[illegible]	4.77391997	0.76265210	23.24227208	0.98500957	71.04780662	22.31560661	152.92
FRSMLOW	23	0.17765522	0.07848759	0.13751416	0.49810277	0.01636579	4.08607008	0.00616030	44.18
FRSMMID	23	0.81346956	0.08546427	0.50189723	0.86248584	0.01782053	18.70979994	0.00730414	10.50
FRACT	23	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	23	[illegible]	[illegible]	0.00000000	0.17002001	0.00747309	0.20412595	0.00128448	403.81

STATION=2 QKOUNT=8

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPA	26	[illegible]	0.59495671	0.03461224	2.34979592	0.12226112	18.52355102	0.35874674	77.60
SMLOWX	26	[illegible]	0.29029659	0.08541873	1.02374911	0.05693165	11.83847625	0.08427153	63.75
SMMIDX	26	[illegible]	0.51024697	0.32471863	2.42793939	0.10006766	27.64210675	0.26035197	47.99
ACTX	26	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	26	[illegible]	0.28344768	0.00000000	0.85638161	0.05558866	9.61682637	0.08034259	76.63
TOTX	26	[illegible]	0.82652518	0.48356686	3.89406767	0.16209492	49.09740937	0.68314387	43.76
FRSMLOW	26	0.22761291	0.08213458	0.08731614	0.42931698	0.01610792	5.91793568	0.00674609	36.08
FRSMMID	26	[illegible]	0.15055485	0.25834585	0.80103238	0.02952624	15.18642642	0.02266676	25.77
FRACT	26	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	26	0.18829377	0.17014123	0.00000000	0.67433801	0.03336744	4.89563790	0.02894804	90.35

STATION=3 QKOUNT=1

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMBPB	6	6.91133333	4.83697880	1.74000000	15.63200000	1.97468836	41.46800000	23.39636467	69.986
SMLOWX	6	2.21892157	1.99900703	0.10407528	5.74641053	0.81609120	13.31352944	3.99602912	90.089
SMMIDX	6	0.76502336	1.02522510	0.00000000	2.38049322	0.41854640	4.59014015	1.05108651	134.012
ACTX	6	0.06812855	0.07047716	0.00000000	0.19249170	0.02877259	0.40877131	0.00496717	103.449
PASX	6	0.34053589	0.32919264	0.00000000	0.86070983	0.13439233	2.04321533	0.10836780	96.669
TOTX	6	3.39260937	1.87461286	0.63488988	6.30091571	0.76530341	20.35565624	3.51413587	55.255
FRSMLOW	6	0.55300477	0.30434487	0.16393124	0.91199610	0.12424827	3.31802861	0.09262580	55.035
FRSMMID	6	0.34086432	0.38285051	0.00000000	0.83606876	0.15629806	2.04518592	0.14657451	112.318
FRACT	6	0.01570178	0.01331410	0.00000000	0.03054980	0.00543546	0.09421066	0.00017727	84.794
FRPAS	6	0.09042914	0.09427238	0.00000000	0.21466938	0.03848654	0.54257482	0.00888728	104.250

STATION=3 QKOUNT=2

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMBPB	16	8.56881250	6.95046650	0.55000000	26.49600000	1.73761662	137.10100000	48.30898456	81.114
SMLOWX	16	2.77189182	3.71852793	0.14180495	11.74361356	0.92960698	44.35026913	13.82373170	134.133
SMMIDX	16	0.89149605	0.51260684	0.00000000	1.61819557	0.12815171	14.26393679	0.26276577	57.419
ACTX	16	0.07161563	0.12999427	0.00000000	0.48438292	0.03249857	1.14585009	0.01689851	181.517
PASX	16	0.09101642	0.13687612	0.00000000	0.38942634	0.03421653	1.45626277	0.01873234	150.375
TOTX	16	3.82726992	3.64017159	0.55597488	12.33284576	0.91004289	61.23631879	13.25084912	95.111
FRSMLOW	16	0.50656105	0.27382504	0.26179664	1.00000000	0.06845626	8.10497680	0.07498015	54.056
FRSMMID	16	0.44095153	0.27945875	0.00000000	0.75000336	0.06986469	7.05525248	0.07809719	63.376
FRACT	16	0.02194490	0.03871533	0.00000000	0.14162618	0.00967883	0.35111844	0.00149886	176.421
FRPAS	16	0.03053889	0.05674850	0.00000000	0.21715742	0.01419712	0.48862229	0.00322493	165.955

STATION=3 QKOUNT=3

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMBPB	15	7.72633333	8.09896558	0.69600000	30.85500000	2.09114392	115.89500000	65.59324352	104.823
SMLOWX	15	1.97331541	1.88202926	0.35574565	6.39100868	0.48617024	29.59973117	3.54542261	95.420
SMMIDX	15	2.23513636	1.08650964	0.88518643	4.46500958	0.28053553	33.52704544	1.18050276	48.610
ACTX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	15	4.20845177	2.61333545	1.52067210	10.10369146	0.67476548	63.12677661	6.82962670	62.098
FRSMLOW	15	0.40920477	0.16212114	0.23339048	0.76249449	0.04185950	6.13807150	0.02628326	39.619
FRSMMID	15	0.59079523	0.16212114	0.23750551	0.76606012	0.04185950	8.86192850	0.02628326	27.441
FRACT	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=3 QKOUNT=4

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMBPB	25	3.38652000	2.30681729	0.22500000	11.50900000	0.46136746	84.66300000	5.32149826	68.118
SMLOWX	25	1.37302020	1.34068251	0.11433710	4.73869542	0.26813650	34.32550498	1.79742960	97.645
SMMIDX	25	1.02327282	0.62991940	0.00000000	2.01152069	0.12598388	25.58182052	0.39679845	61.559
ACTX	25	0.04027529	0.04921441	0.00000000	0.16823965	0.00984288	1.00688236	0.00242206	122.195
PASX	25	0.37315511	0.38604617	0.00000000	1.24855424	0.07720923	9.32887770	0.14903164	103.455
TOTX	25	2.80972342	1.34825727	0.81274173	5.66450743	0.26965145	70.24308556	1.81779767	47.985
FRSMLOW	25	0.41506685	0.24201681	0.10399239	0.92914214	0.04840336	10.37667143	0.05857214	58.308
FRSMMID	25	0.43868656	0.23672256	0.00000000	0.73736460	0.04734451	10.96716390	0.05603757	53.962
FRACT	25	0.01535931	0.02417865	0.00000000	0.10804857	0.00483373	0.38398263	0.00058412	157.355
FRPAS	25	0.13088727	0.15417459	0.00000000	0.51809657	0.03083572	3.27218185	0.02377104	117.795

STATION=3 QKOUNT=5

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPP	27	2.41114303	1.93611176	0.45759184	9.34816327	0.37260448	65.10059184	3.74852874	80.299
SMLOWX	28	1.94451415	1.39744444	0.00000000	4.27398184	0.26409218	54.44639614	1.95265096	71.866
SMMIDX	28	[illegible]	[illegible]	0.00000000	1.67474206	0.11147297	15.79583208	0.34793423	104.560
ACTX	28	[illegible]	[illegible]	0.00000000	0.52456410	0.02085346	2.02736696	0.01217627	152.399
PASX	28	0.32996963	[illegible]	0.00000000	0.92538665	0.05451844	9.23914976	0.09322329	87.428
TOTX	28	2.91102661	1.32687866	0.55887090	4.99475239	0.25075650	81.50874454	1.76060697	45.581
FRSMLOW	28	[illegible]	[illegible]	0.00000000	0.93246935	0.05273189	15.85593400	0.07785827	49.150
FRSMMID	28	[illegible]	[illegible]	0.00000000	0.72710635	0.05342977	7.19162286	0.07993272	110.076
FRACT	28	[illegible]	[illegible]	0.00000000	0.13073824	0.00666255	0.73341632	0.00124291	134.594
FRPAS	28	[illegible]	[illegible]	0.00000000	0.90912589	0.04301973	4.17902683	0.05181951	152.521

STATION=3 QKOUNT=6

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPP	27	[illegible]	[illegible]	0.13714296	21.54489796	0.93147379	165.38636735	23.42637252	79.016
SMLOWX	28	[illegible]	[illegible]	0.11513011	14.70577782	0.60801343	72.08063664	10.35104932	124.977
SMMIDX	28	[illegible]	[illegible]	0.00000000	2.50837123	0.15379507	19.18724133	0.66228183	116.759
ACTX	28	[illegible]	[illegible]	0.00000000	0.06497477	0.00292063	0.13567730	0.00023884	318.938
PASX	28	[illegible]	0.10461111	0.00000000	0.46764266	0.02052935	0.95391504	0.01180072	316.862
TOTX	28	[illegible]	[illegible]	0.48443165	14.70577782	0.55128685	92.35747032	8.50968139	88.439
FRSMLOW	28	[illegible]	0.37237696	0.17143974	1.00000000	0.07037263	17.79979816	0.13866460	56.577
FRSMMID	28	[illegible]	[illegible]	0.00000000	0.82816026	0.07063491	9.80266785	0.13970013	106.761
FRACT	28	0.00151816	0.03467291	0.00000000	0.01899856	0.00088310	0.04250840	0.00002184	307.802
FRPAS	28	0.01267949	0.04300498	0.00000000	0.19283865	0.00812718	0.35502559	0.00184943	339.170

STATION=3 QKOUNT=7

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPP	27	[illegible]	3. 1766666	0.67732653	15.95836735	0.73471029	129.12432653	14.57457875	79.828
SMLOWX	28	[illegible]	[illegible]	0.22310553	10.02098334	0.80440110	81.87950699	18.11171161	145.557
SMMIDX	28	[illegible]	[illegible]	0.00000000	2.63069354	0.15090724	34.48305597	0.63764388	64.840
ACTX	28	[illegible]	[illegible]	0.00000000	0.39856118	0.01958258	0.94372271	0.00966875	279.879
PASX	28	[illegible]	[illegible]	0.00000000	0.70164978	0.02983975	1.51053439	0.02493150	292.686
TOTX	28	[illegible]	[illegible]	1.22007524	18.02098334	0.75470388	118.85682005	15.94918271	94.078
FRSMLOW	28	[illegible]	[illegible]	0.18284571	1.00000000	0.04759546	15.04193350	0.06340252	46.871
FRSMMID	28	[illegible]	[illegible]	0.00000000	0.81715429	0.05199866	12.33699090	0.07570809	62.448
FRACT	28	[illegible]	[illegible]	0.00000000	0.09520437	0.00437753	0.24279253	0.00053656	267.135
FRPAS	28	[illegible]	0.03992104	0.00000000	0.18832199	0.00754448	0.37628307	0.00159374	295.495

STATION=3 QKOUNT=8

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPP	26	[illegible]	1.42422126	0.28844990	6.17142857	0.27931277	66.60677551	2.02840620	55.595
SMLOWX	26	[illegible]	[illegible]	0.13646007	7.45860184	0.32466937	60.61721127	2.14066519	71.008
SMMIDX	26	[illegible]	[illegible]	0.00000000	2.48768117	0.10840664	9.71148087	0.30662044	148.262
ACTX	26	[illegible]	0.12497677	0.00000000	0.44869680	0.02549054	3.32952917	0.01619396	101.498
PASX	26	[illegible]	[illegible]	0.00000000	0.58793124	0.03873798	6.97069695	0.03701641	73.675
TOTX	26	3.10111224	[illegible]	0.67521421	7.99552158	0.31569726	80.62891826	2.55128375	51.909
FRSMLOW	26	[illegible]	[illegible]	0.13556653	0.94346739	0.04660307	17.27858313	0.05646801	35.757
FRSMMID	26	[illegible]	0.24246271	0.00000000	0.69603546	0.04755085	5.16989397	0.05978816	121.937
FRACT	26	[illegible]	[illegible]	0.00000000	0.14102062	0.00775453	1.02811980	0.00156345	99.994
FRPAS	26	[illegible]	0.09886269	0.00000000	0.40321740	0.01938857	2.52340310	0.00977383	101.864

STATION=4 QKOUNT=1

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	6	12.48715567	7.17020411	4.71400000	23.22400000	2.92722357	74.92300000	51.41182697	57.421
SMLOWX	6	3.70511069	4.25179065	0.00000000	11.63875890	1.73578627	22.23498411	18.07772377	114.732
SMMIDX	6	0.02906535	0.07119527	0.00000000	0.17439208	0.02906535	0.17439208	0.00506877	244.949
ACTX	6	0.06640079	0.06016456	0.00000000	0.14785502	0.02456208	0.39840477	0.00361977	90.608
PASX	6	0.58991168	0.58808368	0.00000000	1.54419416	0.24008416	3.53947009	0.34584242	99.690
TOTX	6	[illegible]	[illegible]	0.33320993	12.30758074	1.71827427	26.34725105	17.71479884	95.848
FRSMLOW	6	0.67033031	0.37537392	0.00000000	1.00000000	0.15328658	4.02198188	0.14098066	56.013
FRSMMID	6	0.08722834	0.21366491	0.00000000	0.52337001	0.08722834	0.52337001	0.04565270	244.949
FRACT	6	0.01720455	0.01806548	0.00000000	0.04300994	0.00737520	0.10322728	0.00032636	105.004
FRPAS	6	0.22523680	0.36757096	0.00000000	0.95699006	0.15006018	1.35142082	0.13510834	163.193

STATION=4 QKOUNT=2

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	16	12.34618750	8.85632307	0.96800000	26.99200000	2.21408077	197.53900000	78.43445830	71.733
SMLOWX	16	6.87107413	8.67796644	0.22419070	28.71652612	2.16999161	109.93686608	75.34181736	126.327
SMMIDX	16	0.09311546	0.14231254	0.00000000	0.48673970	0.03557821	1.48968767	0.02025294	152.851
ACTX	16	0.09057831	0.13893173	0.00000000	0.48477040	0.03473381	1.44925290	0.01930300	153.387
PASX	16	0.12612577	0.20551612	0.00000000	0.64329054	0.05137953	2.01802536	0.04223770	162.946
TOTX	16	7.18146469	8.65103557	0.44816952	28.71652612	2.16277139	114.89383500	74.84128146	120.474
FRSMLOW	16	0.84191909	0.17055037	0.56023527	1.00000000	0.04263759	13.47006547	0.02908743	20.258
FRSMMID	16	0.09969225	0.15281460	0.00000000	0.49976473	0.03820365	1.59507600	0.02335230	153.286
FRACT	16	0.02513781	0.04680494	0.00000000	0.15423560	0.01170124	0.40220485	0.00219070	186.193
FRPAS	16	0.03329085	0.07974618	0.00000000	0.31780846	0.01993654	0.53265364	0.00635945	239.544

STATION=4 QKOUNT=3

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	15	11.61453333	9.89791377	1.05300000	30.27100000	2.55563035	174.21800000	97.96869698	85.220
SMLOWX	15	5.49135937	5.67265102	0.70406363	17.74978503	1.46467271	82.37039058	32.17899226	103.301
SMMIDX	15	0.20110169	0.24954750	0.00000000	0.69524963	0.06443289	3.01652538	0.06227396	124.090
ACTX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	15	5.69245106	5.53413172	1.12103795	17.74978503	1.42890667	85.38691596	30.62661388	97.219
FRSMLOW	15	0.90197311	0.12788532	0.62804120	1.00000000	0.03301985	13.52959658	0.01635466	14.178
FRSMMID	15	0.09802689	0.12788532	0.00000000	0.37195380	0.03301985	1.47040342	0.01635466	130.459
FRACT	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=4 QKOUNT=4

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	26	6.23330769	4.29061914	1.13900000	18.94200000	0.84145847	162.06600000	18.40936110	68.834
SMLOWX	26	2.32217737	2.50416159	0.00000000	9.70589168	0.49110649	60.37661154	6.27082522	107.837
SMMIDX	26	0.03260570	0.07347602	0.00000000	0.31348639	0.01440983	0.84774822	0.00539873	225.347
ACTX	26	0.04822734	0.05017478	0.00000000	0.16027079	0.00984008	1.25391199	0.00251751	104.038
PASX	26	0.59762871	0.66242796	0.00000000	2.02369705	0.12991281	15.53834648	0.43881080	110.843
TOTX	26	[illegible]	2.76637054	0.40934610	11.29907693	0.52253154	78.01661822	7.65901957	88.794
FRSMLOW	26	0.65659883	0.37623757	0.00000000	1.00000000	0.07378547	17.07156946	0.14155170	57.300
FRSMMID	26	0.02720647	0.05445735	0.00000000	0.16915851	0.01067997	0.70736831	0.00296560	200.163
FRACT	26	0.03587148	0.06988017	0.00000000	0.37560471	0.01370463	0.93265839	0.00488324	194.807
FRPAS	26	0.28032322	0.33472317	0.00000000	0.96657050	0.06564461	7.28840384	0.11203960	119.406

STATION=4 QKOUNT=5

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	28	3.59593105	2.10605656	1.13591837	9.84714286	0.39800728	100.68746939	4.43547424	58.567
SMLOWX	28	2.87129127	2.85486695	0.00000000	10.53945020	0.53951914	80.39615567	8.15026532	99.428
SMMIDX	28	0.01875912	0.06640629	0.00000000	0.32319361	0.01254961	0.52525547	0.00440979	353.995
ACTX	28	0.07359056	0.09797542	0.00000000	0.50536118	0.01851561	2.06025574	0.00959918	133.154
PASX	28	0.59900474	0.53003143	0.00000000	1.57064333	0.10016653	16.77213269	0.28093332	88.485
TOTX	28	3.56263570	2.89241650	0.34470216	11.89793978	0.54661534	99.75379957	8.36607321	81.188
FRSMLOW	28	0.64865326	0.39968145	0.00000000	1.00000000	0.07553270	18.16237121	0.15974527	61.821
FRSMID	28	[illegible]	0.03976808	0.00000000	0.16256197	0.00751546	0.36681343	0.00158150	303.562
FRACT	28	0.03321135	0.04716566	0.00000000	0.19304849	0.00891347	0.92991781	0.00222460	142.017
FRPAS	28	0.30717491	0.36983208	0.00000000	0.96081825	0.06989169	8.60089755	0.13677576	120.398

STATION=4 QKOUNT=6

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	24	[illegible]	3.91567109	0.71673469	13.96734694	0.79928391	143.89302041	15.33248010	65.310
SMLOWX	26	3.67219165	6.32030491	0.00000000	30.22469869	1.23951377	95.47698032	39.94625416	172.113
SMMIDX	26	[illegible]	0.17350606	0.00000000	0.62575327	0.03403008	2.36714619	0.03010921	190.589
ACTX	26	[illegible]	0.03150419	0.00000000	0.11657149	0.00617847	0.28589480	0.00099251	286.507
PASX	26	[illegible]	0.19455865	0.00000000	0.87232361	0.03815805	1.47048875	0.03785696	344.021
TOTX	26	[illegible]	6.26443867	0.00000000	30.22469869	1.27856142	99.60051009	39.24344237	163.529
FRSMLOW	21	0.85556734	0.17639616	0.49161466	1.00000000	0.03849280	17.96691413	0.03111560	20.617
FRSMID	21	0.11301376	[illegible]	0.00000000	0.50811534	0.03757662	2.37328481	0.02965204	152.369
FRACT	21	[illegible]	[illegible]	0.00000000	0.05871592	0.00308528	0.10213995	0.00019990	290.689
FRPAS	21	[illegible]	[illegible]	0.00000000	0.28464968	0.01777398	0.55766111	0.00663420	306.721

STATION=4 QKOUNT=7

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	26	[illegible]	4.88107744	[illegible]	21.51918367	0.95725804	144.21855102	23.82491696	[illegible]
SMLOWX	28	[illegible]	5.77422972	0.00000000	25.90324336	1.09122685	151.93475741	33.34172882	[illegible]
SMMIDX	28	0.10124411	[illegible]	0.00000000	0.52167746	0.03323724	2.83483496	0.03093199	[illegible]
ACTX	28	[illegible]	0.33423677	0.00000000	1.10546519	0.06316481	3.62010641	0.11171422	[illegible]
PASX	28	0.06339705	0.17699057	0.00000000	0.76893716	0.03344807	1.77511751	0.03132566	279.176
TOTX	28	[illegible]	[illegible]	0.00000000	25.90324336	1.10112601	160.16484628	33.94939793	101.861
FRSMLOW	26	[illegible]	0.12979849	0.43455698	1.00000000	0.02545558	23.68326150	0.01684765	14.250
FRSMID	26	0.06779175	[illegible]	0.00000000	0.55544102	0.02551134	1.76258545	0.01692154	191.686
FRACT	26	0.01437149	0.03672434	0.00000000	0.13232695	0.00720224	0.37365884	0.00134868	255.536
FRPAS	26	[illegible]	0.01917046	0.00000000	0.08551149	0.00375964	0.18049421	0.00036751	276.148

STATION=4 QKOUNT=8

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPR	26	[illegible]	2.20688613	0.12734694	9.95102041	0.43280598	95.73132653	4.87034641	59.938
SMLOWX	26	[illegible]	4.69073797	0.00000000	17.76773621	0.91992940	132.74427102	22.00302272	91.875
SMMIDX	26	[illegible]	0.04262996	0.00000000	0.18315043	0.00836042	0.36571058	0.00181731	303.075
ACTX	26	[illegible]	[illegible]	0.00000000	1.89900558	0.09117005	15.01576159	0.21611144	80.494
PASX	26	[illegible]	0.32044869	0.00000000	0.93690382	0.06284516	11.39809773	0.10268736	73.097
TOTX	26	6.13553234	4.86303114	0.35058711	18.85452382	0.95371887	159.52384092	23.64907184	79.260
FRSMLOW	26	[illegible]	0.35249990	0.00000000	1.00000000	0.06913092	18.17242423	0.12425618	50.434
FRSMID	26	0.01773193	0.05286554	0.00000000	0.22163721	0.01036779	0.46103030	0.00279477	298.137
FRACT	26	[illegible]	0.21387561	0.00000000	0.72601969	0.04194446	4.08417033	0.04574278	136.154
FRPAS	26	0.12624520	0.16285360	0.00000000	0.52832878	0.03193822	3.28237515	0.02652130	128.998

STATION=5 QKOUNT=1

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPER	6	6.47066667	4.87196694	0.21000000	14.72300000	1.98897217	38.82400000	23.73606187	75.293
SMLOBX	6	1.30809477	1.46442257	0.05758635	4.05213504	0.59784801	7.84856865	2.14453346	111.951
SMMIDX	6	1.39983196	0.86533869	0.34893576	2.73879985	0.35327300	8.39899175	0.74881087	61.817
ACTX	6	0.04913600	0.06041611	0.00000000	0.16450569	0.02466477	0.29481602	0.00365011	122.957
PASX	6	0.11939905	0.11600142	0.00000000	0.30871245	0.04735738	0.71639431	0.01345633	97.154
TOTX	6	2.87646179	1.92829424	0.49642211	6.09228384	0.78722487	17.25877073	3.71833794	67.037
FRSMLOB	6	0.36839870	0.22867487	0.14159098	0.66621933	0.09335613	2.21039219	0.05229220	62.073
FRSMMID	6	0.57797218	0.25586615	0.27865744	0.85830902	0.10445724	3.46783306	0.06546789	44.270
FRACT	6	0.01428359	0.01654972	0.00000000	0.04380820	0.00675640	0.08570157	0.00027389	115.865
FRPAS	6	0.03934553	0.04365553	0.00000000	0.10506775	0.01782229	0.23607319	0.00190581	110.954

STATION=5 QKOUNT=2

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPER	14	7.09685714	5.35795713	1.06500000	22.52500000	1.43197428	99.35600000	28.70770459	75.498
SMLOBX	14	1.55471651	2.30739347	0.12565470	8.43971765	0.61696549	21.76603120	5.32404978	148.482
SMMIDX	14	1.52903243	0.75739842	0.49873599	2.61501259	0.20242324	21.40645400	0.57365237	49.534
ACTX	14	0.06324213	0.09146187	0.00000000	0.29562388	0.02444421	0.88538976	0.00836527	144.622
PASX	14	0.05528468	0.09366976	0.00000000	0.27312146	0.02503430	0.77398551	0.00877402	169.432
TOTX	14	3.20227575	2.90947162	0.51839070	11.00489550	0.77758900	44.83186047	8.46502509	90.856
FRSMLOB	14	0.34012792	0.17867336	0.13304441	0.76690575	0.04775246	4.76179062	0.03192417	52.531
FRSMMID	14	0.61168602	0.17902409	0.23309425	0.79033529	0.04784620	8.56360431	0.03204962	29.267
FRACT	14	0.02711839	0.05579686	0.00000000	0.20882543	0.01491234	0.37965750	0.00311329	205.753
FRPAS	14	0.02106767	0.05148801	0.00000000	0.19292997	0.01376075	0.29494737	0.00265102	244.393

STATION=5 QKOUNT=3

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPER	15	6.25660000	4.84302609	1.91390000	16.44300000	1.25046396	93.84900000	23.45490169	77.407
SMLOBX	15	1.20073345	1.11732768	0.24126452	4.01801952	0.28849277	18.01100169	1.24842114	93.054
SMMIDX	15	2.96207214	1.85445015	1.01259492	7.93487750	0.47881697	44.43108209	3.43890534	62.607
ACTX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	15	4.16280292	2.944[illegible]	1.27345944	11.95289702	0.76023379	62.44204378	8.66933130	70.730
FRSMLOB	15	0.25631124	0.06488413	0.14539650	0.39117922	0.01675301	3.84466865	0.00420995	25.315
FRSMMID	15	0.74368876	0.06488413	0.60882078	0.81060350	0.01675391	11.15533135	0.00420995	8.725
FRACT	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=5 QKOUNT=4

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPER	25	2.39940000	1.63468751	0.23400000	5.90800000	0.32693750	59.98500000	2.67220325	68.129
SMLOBX	25	1.01310347	1.23849094	0.06555073	4.31591301	0.24769819	25.32758664	1.53385981	122.247
SMMIDX	25	1.25678538	0.70585980	0.00000000	2.50735772	0.14117196	31.41963439	0.49823806	56.164
ACTX	25	0.03352488	0.0460[illegible]	0.00000000	0.15943108	0.00920639	0.83812200	0.00211694	137.307
PASX	25	0.14084016	0.13533221	0.00000000	0.37980538	0.02706644	3.52100408	0.01831481	96.089
TOTX	25	2.44425388	1.37952229	0.57343481	4.91943548	0.27590446	61.10634711	1.90308175	56.439
FRSMLOB	25	0.31707623	0.22372492	0.10147739	0.92416808	0.04474498	7.92690585	0.05005284	70.559
FRSMMID	25	0.60099063	0.22778422	0.00000000	0.81562130	0.04555684	15.02476570	0.05188565	37.901
FRACT	25	0.01419980	0.02369388	0.00000000	0.09477516	0.00473878	0.35499491	0.00056140	166.861
FRPAS	25	0.06773334	0.09676581	0.00000000	0.35485002	0.01935316	1.69333354	0.00936362	142.863

STATION=7 QKOUNT=5

*VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPB	27	0.44352834	0.33222490	0.05257143	1.36914286	0.06393671	11.97526531	0.11037339	74.905
SPLOWX	27	0.08092047	0.03212032	0.03560879	0.18537726	0.00618156	2.18485263	0.00103171	39.694
SPMIDX	27	0.32756239	0.08788264	0.16660947	0.52810146	0.01691302	8.84418447	0.00772336	26.829
ACTX	27	0.00909967	0.01493377	0.00000000	0.06927520	0.00287400	0.24569117	0.00022302	164.113
PASX	27	0.03227184	0.02956978	0.00000000	0.10476592	0.00569073	0.87134082	0.00087438	91.627
TOTX	27	0.44985441	0.11612451	0.22190143	0.65321861	0.02234913	12.14606909	0.01348606	25.815
FRSMLOW	27	0.17811781	0.04484641	0.12433720	0.34162387	0.00864070	4.80918153	0.00201587	25.207
FRSMMID	27	0.73332111	0.09379016	0.50716989	0.84033345	0.01804992	19.79966962	0.00879659	12.790
FRACT	27	0.01843681	0.02748175	0.00000000	0.11131472	0.00528887	0.49779398	0.00075525	149.059
FRPAS	27	0.07012425	0.06993539	0.00000000	0.22990914	0.01345907	1.89335487	0.00489096	99.731

STATION=7 QKOUNT=6

*VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPA	27	1.16737037	1.16487076	0.06922449	5.55000000	0.22417949	31.51900000	1.35692393	99.786
SPLOWX	27	0.09126024	0.06463461	0.02474615	0.32870927	0.01244856	2.46402636	0.00419410	70.879
SPMIDX	27	0.56422449	0.28333303	0.16988650	1.33464338	0.05452785	15.23406120	0.08027874	50.217
ACTX	27	0.00054454	0.00195270	0.00000000	0.00755185	0.00037772	0.01470258	0.00000385	360.433
PASX	27	0.00105835	0.00549936	0.00000000	0.02857553	0.00105835	0.02857553	0.00003024	519.615
TOTX	27	0.65708762	0.33935403	0.21463465	1.52958398	0.06530871	17.74136566	0.11516116	51.645
FRSMLOW	27	0.13205944	0.02902863	0.10966596	0.25316613	0.00558656	3.56560602	0.00084266	21.981
FRSMMID	27	0.86539182	0.02905854	0.74683387	0.88624545	0.00569278	23.36558921	0.00087501	3.418
FRACT	27	0.00086199	0.00310634	0.00000000	0.01187730	0.00059782	0.02327353	0.00000965	360.371
FRPAS	27	0.00168671	0.00876442	0.00000000	0.04554124	0.00168671	0.04554124	0.00007681	519.615

STATION=7 QKOUNT=7

*VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPB	28	1.93950547	2.30763762	0.13034082	8.39346939	0.43610252	54.30615306	5.32519136	118.981
SPLOWX	28	0.14174315	0.20414667	0.05080077	1.12064296	0.03857991	3.96880411	0.04167545	144.025
SPMIDX	28	0.77824812	0.86969120	0.31889738	4.92498674	0.16435657	21.79094723	0.75636627	111.750
ACTX	28	0.00443410	0.01244585	0.00000000	0.05474781	0.00238228	0.12415488	0.00015491	284.293
PASX	28	0.00742666	0.02440807	0.00000000	0.10531128	0.00461269	0.20794578	0.00059575	328.656
TOTX	28	0.93185200	1.07130048	0.36569810	6.04552970	0.20245676	26.09185601	1.14758473	114.965
FRSMLOW	28	0.13992936	0.01374185	0.11864799	0.19536721	0.00259697	3.91802215	0.00018884	9.821
FRSMMID	28	0.84501676	0.04089415	0.70663257	0.86611441	0.00772827	23.66046930	0.00167233	4.839
FRACT	28	0.00568034	0.01579134	0.00000000	0.06742489	0.00298429	0.15904950	0.00024937	278.001
FRPAS	28	0.00937354	0.03037250	0.00000000	0.13066347	0.00573992	0.26245905	0.00092251	324.027

STATION=7 QKOUNT=8

*VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMFPB	27	0.42230234	0.27755657	0.04147755	0.98918776	0.05341579	11.40216327	0.07703765	65.725
SPLOWX	27	0.10238542	0.02573192	0.06370386	0.19191946	0.00495211	2.76440623	0.00066213	25.132
SPMIDX	27	0.40041276	0.08831239	0.26440341	0.72102352	0.01699573	10.81114444	0.00779908	22.055
ACTX	27	0.01327896	0.01591939	0.00000000	0.05623220	0.00306369	0.35853192	0.00025343	107.852
PASX	27	0.00686325	0.01614353	0.00000000	0.05724540	0.00310682	0.18530781	0.00026061	235.217
TOTX	27	0.52442187	0.12435626	0.34765223	0.97117517	0.02393237	14.15939039	0.01546448	23.713
FRSMLOW	27	0.19502181	0.01460866	0.16448653	0.22918055	0.00281148	5.26558883	0.00021342	7.491
FRSMMID	27	0.76705796	0.03720723	0.67520761	0.81060028	0.00716053	20.71056485	0.00138438	4.851
FRACT	27	0.02587091	0.02527581	0.00000000	0.09674814	0.00486433	0.69851448	0.00063887	97.700
FRPAS	27	0.01204933	0.02848985	0.00000000	0.11148412	0.00548287	0.32533183	0.00081167	236.443

STATION=8 QKOUNT=1

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	6	0.85016667	1.06140490	0.28100000	3.01200000	0.43331878	5.10100000	1.12659097	124.84
SMLOWX	6	0.04131329	0.02504871	0.02302361	0.09032388	0.01022609	0.24787972	0.00062744	60.63
SMMIDX	6	0.26696907	0.15538212	0.14636437	0.48177198	0.06343449	1.60181441	0.02414360	58.20
ACTX	6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FASX	6	0.14400051	0.23856207	0.00000000	0.59794852	0.09739256	0.86400308	0.05691186	165.66
TOTX	6	0.45228287	0.24715335	0.18660434	0.82117676	0.10090483	2.71369722	0.06109071	54.64
FFSMLOW	6	0.10113702	0.04113495	0.03984603	0.13264278	0.01679327	0.60682209	0.00169208	40.67
FFSMMID	6	0.67089599	0.28987380	0.23299331	0.87622237	0.11834048	4.02537591	0.08402682	43.20
FFACT	6	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FFPAS	6	0.22796700	0.33046020	0.00000000	0.72816066	0.13490981	1.36780200	0.10920394	144.96

STATION=8 QKOUNT=2

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	15	1.77566667	1.74114079	0.47100000	6.62500000	0.44956062	26.63500000	3.03157124	98.05
SMLOWX	15	0.06554698	0.03105005	0.03431105	0.15989900	0.00801709	0.98320474	0.00096411	47.37
SMMIDX	15	0.26230142	0.11424157	0.14438874	0.60514783	0.02949705	3.93452123	0.01305114	43.55
ACTX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FASX	15	0.00550720	0.02132927	0.00000000	0.08260793	0.00550720	0.08260793	0.00045494	387.29
TOTX	15	0.33335559	0.14304336	0.17065479	0.76504683	0.03693364	5.00033389	0.02046140	42.91
FFSMLOW	15	0.19503158	0.01486894	0.14595436	0.21541446	0.00383914	2.92547371	0.00022109	7.62
FFSMMID	15	0.78778019	0.05435039	0.59312218	0.80799614	0.01404560	11.81670283	0.00295419	6.90
FFACT	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FFPAS	15	0.01718823	0.06656973	0.00000000	0.25782346	0.01718823	0.25782346	0.00443153	387.29

STATION=8 QKOUNT=3

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	15	0.94013333	0.59834186	0.34100000	2.44800000	0.15449120	14.10200000	0.35801298	63.64
SMLOWX	15	0.09679281	0.04014353	0.04401654	0.20650425	0.01036501	1.45189210	0.00161150	41.47
SMMIDX	15	0.48469095	0.19759703	0.22186199	1.01226919	0.05101933	7.27036418	0.03904458	40.76
ACTX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FASX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	15	0.58148375	0.23772666	0.26590054	1.21877344	0.06137559	8.72225628	0.05650445	40.87
FFSMLOW	15	0.16628856	0.00261549	0.16332881	0.17133810	0.00067542	2.49432842	0.00000684	1.57
FFSMMID	15	0.83371144	0.00261549	0.82866190	0.83667119	0.00067542	12.50567158	0.00000684	0.31
FFACT	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FFPAS	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=8 QKOUNT=4

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V
AMPPB	25	0.47492000	0.27357341	0.11700000	1.28400000	0.05471468	11.87300000	0.07484241	57.60
SMLOWX	25	0.04175057	0.01395389	0.01747497	0.06519091	0.00279078	1.04376420	0.00019471	33.42
SMMIDX	25	0.22000142	0.06838052	0.09795782	0.34773472	0.01367610	5.50003549	0.00467590	31.08
ACTX	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FASX	25	0.21053993	0.30978591	0.00000000	1.07724402	0.06195718	5.26349818	0.09596731	147.13
TOTX	25	0.47229191	0.31757196	0.16743210	1.23985758	0.06351439	11.80729786	0.10085195	67.24
FFSMLOW	25	0.11577420	0.04844900	0.07036205	0.17658141	0.00969980	2.89435507	0.00235215	41.89
FFSMMID	25	0.61386089	0.25751919	0.11109299	0.84805293	0.05150384	15.34652213	0.06631613	41.95
FFACT	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FFPAS	25	0.27036491	0.30517642	0.00000000	0.86884497	0.06103528	6.75912280	0.09313265	112.87

STATION=10 QKOUNT=3

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPH	15	0.65213333	0.48482054	0.15800000	1.69400000	0.12518012	9.78500000	0.23505095	74.321
SMLOWX	15	0.23454736	0.12878222	0.10100299	0.52449918	0.03325143	3.51821034	0.01658486	[illegible]
SMMIDX	15	1.09945251	0.56339930	0.50200724	2.38133956	0.14546907	16.49178768	0.31741877	[illegible]
ACTX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	15	1.33303987	0.69165045	0.60785084	2.90583874	0.17859371	19.99559802	0.47843568	51.884
FRSMLOW	15	0.17423533	0.00733140	0.16616411	0.19047057	0.00189296	2.61352998	0.00005375	4.208
FRSMMID	15	0.82576467	0.00733140	0.80952943	0.83383589	0.00189296	12.38647002	0.00005375	0.0C1
FRACT	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	15	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=10 QKOUNT=4

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPH	25	0.31112000	0.22037852	0.02800000	0.72300000	0.04407570	7.77800000	0.04856669	70.834
SMLOWX	25	0.14510143	0.09169140	0.03428995	0.39711286	0.01833828	3.62753575	0.00840731	63.191
SMMIDX	25	0.62855275	0.26173296	0.14715849	1.24644825	0.05235059	15.71381881	0.06851461	41.64
ACTX	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	25	0.77365419	0.34410760	0.22144844	1.64356111	0.06882152	19.34135456	0.11841004	44.471
FRSMLOW	25	0.17769617	0.04053133	0.15396251	0.33051541	0.00810627	4.44240426	0.00164279	22.80
FRSMMID	25	0.82230383	0.04053133	0.66948459	0.84601749	0.00810627	20.55759574	0.00164279	6.[illegible]
FRACT	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	25	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=10 QKOUNT=5

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPH	28	0.21542347	0.19378908	0.03885714	0.91765306	0.03662269	6.03185714	0.03755421	89.95
SMLOWX	28	0.18352651	0.09737957	0.06109911	0.43334884	0.01840301	5.13874219	0.00948278	53.06
SMMIDX	28	0.62276702	0.21466081	0.25891152	1.04574650	0.04056708	17.43747646	0.04607926	34.4C
ACTX	28	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	28	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	28	0.80629352	0.27563377	0.37440195	1.42191193	0.05208989	22.57621864	0.07597398	34.18
FRSMLOW	28	0.22490066	0.09057137	0.16238608	0.50625328	0.01711770	6.29721835	0.00820444	40.27
FRSMMID	28	0.77509934	0.09057137	0.49374672	0.83761392	0.01711770	21.70278165	0.00820444	11.6C
FRACT	28	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	28	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.

STATION=10 QKOUNT=6

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C.V.
AMPPH	27	1.11934709	1.47535957	0.02710067	5.99387755	0.28393308	30.21157143	2.17668586	131.85
SMLOWX	27	0.18722704	0.18095050	0.02383092	0.72145110	0.03482394	5.05674997	0.03274309	96.61
SMMIDX	27	0.96492582	0.81034066	0.17627663	3.57147318	0.15595013	26.05299106	0.65665199	83.90
ACTX	27	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
PASX	27	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
TOTX	27	1.15221285	0.97047161	0.20008755	4.19021867	0.18676542	31.10974703	0.94179573	84.22
FRSMLOW	27	0.15078694	0.04652505	0.11560460	0.32566742	0.00895452	4.07124744	0.00216495	30.85
FRSMMID	27	0.84921306	0.04652505	0.67433258	0.88439540	0.00895452	22.92875256	0.00216495	5.47
FRACT	27	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.
FRPAS	27	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	.