9.0

SOURCE TESTS - DUPONT DeNEMOURS AND COMPANY

9.1 SITE OVERVIEW

Summary

Dupont, Antioch produces Freon 11 and 12 from carbon tetrachloride feed according to the reactions:

$$CCl_4 + HF \rightarrow CCl_3F + HCl \qquad \text{(F-11)}$$
$$CCl_4 + 2HF \rightarrow CCl_2F_2 + 2HCl \qquad \text{(F-12)}$$

Carbon tetrachloride (CT) is off-loaded primarily from bottom emptying railroad rail cars and stored in a tank vented to the atmosphere. Process feed pumps tranport CT into a reactor which is operated in a continuous manner. Reactor output is fed into a distillation column with recycle back to the reactor.

Emission sources of CT are expected to be the storage tank and the fugitive emissions from valves, flanges and pump seals.

Facilities Descriptions

Tank cars containing 200 x 10^3 lbs of CT are off-loaded into a 570 x 10^3 lbs capacity storage tank on the order of 250 times per year. CT is fed from the tank car by bottom unloading and pumped into the storage tank. A feed pump delivers CT to the reactor where it is reacted with hydrogen fluoride. Since the HF is highly corrosive, considerable care is taken to contain all reactants. Material is output to the distillation column and chlorocarbons are recycled to the reactor from the column bottom. Beyond this point there are no enriched CT streams as hydrogen chloride absorbing, caustic scrubbing, and scrubbing and distillation are accomplished.

The single CT storage tank has a 3-inch U-leg vent to the atmosphere and thus has no vapor recovery system. Fittings associated with CT flow are inspected for leaks and maintained according to plant practices and Bay Area Air Quality District rules on volatile organic emissions. The total number of fittings are less than 100.

It is felt that the single most important source of CT emissions is the storage tank. There are two kinds of emission from storage tanks: (a) loss due to tank breathing and (b) working loss due to tank cleaning and filling. Dupont has made measurements of head space concentrations of CT during tank filling and also performed theoretical calculations based on vapor pressure. These compliment one another and are 18,800 and 24,000 lbs/yr respectively. Specifically for the calculations the vapor pressure was taken at 20° C bulk liquid temperature. According to AP-42, the relationship between working loss and vapor pressure is given by:

$$L_W = 2.4 \times 10^{-2} \; M P \; K_n \; K_C$$

where: M = molecular weight

P = true vapor pressure at bulk liquid conditions (psia)

K_n = turnover fraction $\left(\frac{\text{annual throughput}}{\text{tank capacity}}\right)$

K_C = crude oil fraction (=1 for CT)

L_W = working loss (lb)/10^3 gal

Dupont did not predict the loss due to normal tank breathing during the year. Vapor is expelled from two primary mechanisms: (1) thermal expansion of existing vapors and (2) vapor expansion caused by barometric pressure changes. The AP-42 emission formula (EPA, 1981) is:

$$L_B = 6.19 \times 10^{-5} \; M \left(\frac{P}{14.7-P}\right)^{0.68} D^{1.73} H^{0.51} T^{0.5} F_p C \; K_C$$

where - L_B = breathing loss lb/day

M = molecular wt.

P = true vapor pressure at bulk liquid condition (psia)

D = tank diameter (ft)

H = average vapor space height (ft)

T = average ambient temperature change, diurnal (°F)

F_p = paint factor

C = small tank adjustment factor

K_C = crude oil factor

The formula is estimated to be within ± 10% of actual measured values. Fugitive emissions from leaks in the relatively few (approximately 100) valves, flanges and pump fittings are likely to be of secondary importance to the storage tank emissions. These, however, will be directly measured in the field monitoring.

9.2 MEASUREMENT APPROACH

Top priority is the determination of storage tank emissions. This can be done for tank working loss by obtaining and analyzing head space samples during tank car unloading. It was proposed to insert a sampling tube into tank head space and collect a time integrated sample over the off-loading period. The sample would then be transferred to the La Jolla laboratory of SAI and analyzed directly by gas chromatography. Normal tank breathing can be determined sufficiently precisely (± 10%) by utilizing AP-42 with accurate tank dimensions and meteorology.

Since relatively few fugitive source components exist, it unlikely that such emissions would be significant with respect to the storage tanks. However, it would be cost effective to screen 100% of the fittings with the Foxboro OVA since a team would be on site to perform the tank measurements. The fugitive screening approach would follow the procedure described in Section 7.2.

9.3 DETERMINATION OF EMISSIONS

9.3.1 Fugitive Releases

Approximately 110 devices were screened and six leaks above the established threshold of 20 ppm were recorded. Table 9.3-1 summarizes the screening data and mass emission projections. Since carbon tetrachloride is poorly detected by the OVA and TLV instruments factors between approximately 5 and 14 were applied, based on response functions to determine the upper bound of the leak rate mass emissions. Total fugitive emissions range between 58 and 610 lb/year.

9.3.2 Storage Tank Emissions

Head space samples were taken during the nearly six hour off-loading interval in order to directly determine the CT concentration in the displaced

Table 9.3-1

DUPONT MASS EMISSION PREDICTION FROM OVA SCREENING VALVES

Device/ Location	OVA Response (ppm)	SAI Response Factor	Actual Conc. (ppm)	a	b	Se	IRc	Source Function	Leak Rate lb/yr	Upper Bound Leak Rate lb/yr
Gate Valve Storage Tank Pump Area	300	0.09	3333.	4.66	0.09	0.74	296.	D	9.5	70
Gate Valve Storage Tank Pump Area	700	0.09	7778.				320.		10.2	140
Gate Valve Feed Pump Exit Area	350	0.09	3889.				300.		9.7	81.5
Gate Valve Feed Pump Exit	700	0.09	7778				320.		10.2	140
Gate Valve	600	0.09	6667.				315.		10.0	127
Valve-Reactor Heat Exchanger	200	0.09	2222				285.		9.3	52

All measurement are for 100% CT streams

air space. Saturation concentration at 20°C is approximately 12%. Measured values were 6.9 and 7.4%. These values resulted from gas chromatographic analyses of transferred samples from the 100 liter Tedlar bag time integrated sample. For the tank car displacement of 2008 ft^3 the total CT emitted, based on the average, is 2008 x 0.072 = 144 ft^3.

Then for a density of $\rho = PM/RT$

$$\rho = \frac{(1)(154)}{(.082)(293)} = 6.4 \text{ g/L} = 0.4 \text{lb/ft}^3$$

Therefore the displacement weight of CT per off-load is equal to 144 ft^3 x 0.4 lb/ft^3 = 57.6lb. For 250 off-loadings annually we have 14,400 lbs. This compares with DuPont's measurements of 9.3% vapor content and 18,800 lb/yr emissions. Saturation vapor pressure concentration emission would yield 24,000lb.

Breathing loss from the tank can be calculated from AP-42 as:

$$L_B(\text{lb/day}) = 6.19 \times 10^{-5} M \left(\frac{P}{14.7-P}\right)^{0.68} D^{1.73} H^{0.51} T^{0.5} F_p C K_c$$

$$= (6.19 \times 10^{-5})(154)\left(\frac{1.73}{14.7-1.73}\right)^{0.68} (15.5)^{1.73}$$

$$(15)^{0.51} (26)^{0.5} (1)(1)(1),$$

$$= 5.63 \text{ lb/day}$$

where a working range of 200 x 10^3 to 400 x 10^3 lbs were used to determine an average liquid height. Annually emissions would be 2057 lb. Therefore working losses dominate the total emissions from the plant.

Summary

The upper and lower bounds of carbon tetrachloride emission were determined as 21,467 lb/year (upper bound on fugitives; DuPont measurement of storage tank working emissions; normal tank breathing) and 16,515 lb/year (lower bound on fugitives; SAI measurement of storage tank working emissions; normal tank breathing).

10.0

SOURCE TESTS - STAUFFER CHEMICAL COMPANY

10.1 SITE OVERVIEW

Summary

Stauffer is located in the Carson area of Los Angeles County. It is a manufacturer of polyvinyl chloride from the monomer (VCM) which is produced on site. Stauffer is the only California producer of ethylene dichloride (EDC) which is converted to VCM. The VCM is regulated by several standards including Cal. OSHA, EPA (emission standard) and CARB (ambient).

During Phase I, the plant was inspected and possible emission sources were identified. These consisted of EDC storage tanks, fugitive emissions from valves, flanges and pumps, process water content, gas incinerator effluents and the loading of outbound tankers.

Since the completion of Phase I several events have transpired which affected the test program to determine facility emissions. These were:

- the completion of a vent gas incineration system tied to all significant EDC storage tank breathers.
- the completion of a comprehensive study by SAI staff to develop a nationwide material balance for EDC.
- inactivity in EDC importation for the plant and elimination of EDC exportation from the plant.

Based upon this input and the plant inspection of February 3, 1981, it was expected that a plant emission factor for EDC can be determined with relatively little uncertainty. It is further expected that significant atmospheric release of EDC due to plant operation may not occur at the plant itself but rather offsite. These would arise from two sources - the process water discharge from the plant and several off site EDC storage tanks.

Facilities Description

Ethylene dichloride is being produced at Stauffer by two processes: direct chlorination and oxychlorination. In the former, EDC is produced by direct chlorination of ethylene in the presence of an $FeCl_3$ catalyst. In the latter process EDC is produced by the oxychlorination of ethylene with hydrogen chloride and oxygen in the presence of a catalyst, typically $CuCl_2$.

The plant purifies EDC after the primary reactions by separation and distillation. Product is stored and used as feed for VCM production. All sources agree that emission of EDC is of concern in its production/storage process stages and of little importance in VCM production steps. (JRB, 1980).

At the time of plant inspection some storage of EDC existed at three leased storage tanks located at the Port of Los Angeles. Material has not been withdrawn from these tanks during the last year and there had been discussion to consolidate material into a single tank.

All process components handling EDC storage are now tied to a closed ventilation - incineration system. It is expected that virtually all chlorinated hydrocarbons including EDC will be effectively destroyed since the system must demonstrate VCM concentrations are reduced below 1 ppm. Firebox temperature is 2200^{O}F and residence time greater than 1.5 seconds under heaviest flow conditions. Note that by way of comparison combustion performance data for PCB's are 99.995% destruction at 1832^{O}F and 1 second residence time and 99.999994 at 2 seconds and 2372^{O}F (N. Flynn, SAI, Personal Communication).

Fugitive emissions from valves and flanges are monitored by the plant according to the requirements of SCAQMD Rule 466.1. Pumps and compressor follow Rule 466. Emission and control requirements for vinyl chloride are specified by Rules 1005 and 1005.1. EDC concentrations in wastewater are monitored several times daily in the primary EDC steam stripper stream and once daily in the composite plant outflow stream. Daily water discharge limits are 25 ppm with typical monthly averages being in the 8 ppm vicinity. The discharge limit is embodied in the discharge permit (number 5061) with the Los Angeles County Sanitation District.

There are a number of points at which the EDC can be released to the atmospnere and they are similar for both direct chlorination and oxychlorination. These include the following along with their emissions factors for direct chlorination:

A.	chlorinator vent	2×10^{-5} mass per unit mass EDC produced
B.	light end column vent	2×10^{-5}
C.	distillation column vent	2×10^{-5}
D.	storage tank breathing	7×10^{-5}

E.	storage tankworking loss	$2.7x10^{-6}$
F.	fugitive emission	$6.x10^{-5}$
G.	wastewater	$1.5x10^{-3}$

Emission factors are similar for oxychlorination processes.

Emission factor values are taken from the literature (JRB, 1980) and assume 98% efficiency for incineration (A-E). It is also assumed above that EDC emissions to water are 29% of emission to air and that in wastewater treatment 100% of EDC discharged to water is released to air. These emission factors were used to prioritize releases but were clearly crude approximations to the plant. Because of the incineration system it was anticipated that factors A-E would be reduced. Factor F might be reduced since a monitoring program had been in force almost one year. Factor G and the off site storage tanks, which are not tied into an incinerator system might dominate emissions.

Emission limits and concomitant regulations embodied in Rule 1005 of the SCAQMD have necessitated the incineration system. Ninety gas chromatograph probes are located throughout the plant including the stack of the primary incinerator. Concentrations of VCM are reported essentially below the regulatory limit of 10 ppm and in fact below the limit of detection somewhat less than 0.1 ppm.

10.2 MEASUREMENT APPROACH

The objective of the program is to determine a plant emissions for EDC. It is not acceptable to develop such information based upon published industry wide estimates of plant control efficiencies. Fortunately, it was possible to design a monitoring and calculational program to determine EDC emissions for the site and not absorb a disproportionate share of program resources.

There are three modes of release from the plant and a fourth offsite.

- Post-Process Incineration

Processes A-E of Section 10.1 are all vented into the plant incineration system. The concentration of VCM continuously measured in the stack as gas output represents a reasonable upper limit to apply for EDC concentrations since its efficiency of incineration is at least equal to that

of VCM. Therefore, knowledge of the system airflow and VCM concentration are the necessary and sufficient conditions for determining the bounds of EDC release. The plant expressed willingness to provide these data in order to support the calculations.

- Fugitive Emissions - Valves, Flanges, Seals and Other Sources

Fugitive emission from the valves, pumps and flanges can be determined more precisely than was anticipated since Stauffer has completed a comprehensive leak inventory of all such components in compliance with Rule 466, 466.1, and 1005. The inventory delineates all leaks uncovered by their three man crew throughout the year and indicates the screening level in ppmv and component identity. In consultation with Stauffer we will be able to identify the total number of components associated with EDC handling systems (700), the distribution of substance composition streams, the distribution and incidence of leaks by hardware component type and leak rate. We will utilize this information to provide historical data to compliment our Foxboro OVA sampling at the site. Based upon this monitoring we predict an EDC mass emission rate for the fugitive releases. The plant has agreed to provide the necessary information. We propose to meet with plant personnel prior to the start of monitoring and finalize the sampling strategy to accomplish 100% coverage of the lines of highest EDC composition. The sampling approach and calculation of mass emission are described in Section 7.2.

- Wastewater

From examination of the emission factors derived from published literature (see Section 10.1) it is clear that EDC release from wastewater to air is potentially several orders of magnitude higher than any other plant source. Based upon plant measured concentrations of 8 ppm EDC in water a more realistic emission factor would be 2.4×10^{-4} mass/unit mass EDC produced. Clearly this could still be the dominant source. Furthermore, the release point would be expected to be located between the plant and the sanitary district treatment site which is 5 km.from the plant at 24501 S. Figueroa. We believe it is necessary to independently confirm the average 24 hour EDC concentration in the discharge water by obtaining the refrigerated composite sample. We have identified the lines of interest and received agreement to sample and analyze for EDC in the stream. We propose to draw a duplicate sample from the compositor and analyze for its EDC content. This will be

compared with Stauffer's parallel analysis. It is not reliable to obtain direct readings of EDC by survey instrument in the air above the water flow since concentrations at any single point will be in the near ambient range.

Emissions will be calculated using the plant's volumetric daily flow and assuming that complete degassing of the effluent will eventually occur. This assumption is based upon the relative volatility of EDC and the distances involved. However, it should be noted that no direct experimental or monitoring data is available with which to confirm this. The composition of the discharge stream is unknown since it merges into a large multisource flow. Conversation with the L.A. County Sanitation District (J. Milne) reveals the stream to be both exposed and covered. Vents exist where EDC measurements could be made to assess gross leakage at key points.

We will obtain samples of several plant process discharge streams in 40 ml bottles with no head space. Transit time from sample collection to analysis will be minimized and will not exceed 24 hours. This time frame is conservative although EDC is a volatile material and will undergo concentration degradation and outgassing. Analysis will be performed in the SAI Trace Environmental Chemistry Laboratory utilizing purge and trap analysis FID gas chromatography. A trial analysis was conducted and the EDC characteristic peak was distinctive down to the ppb level. Therefore, the analysis should easily confirm concentrations in the 8 ppm range.

- Offsite Storage Tanks

Three EDC leased storage tanks are located offsite at the Port of Los Angeles and are owned by another firm. Annual emissions from the tanks were very roughly estimated based on AP-42 (JRB, 1980) as 44 kkg/year based on preliminary estimates of stored quantites

Considering the magnitude of this source these storage tanks must be investigated. We will gather information about their configuration and control in order to calculate their emissions.

10.3 DETERMINATION OF EMISSIONS

10.3.1 Incinerator

Vinyl chloride concentration is monitored at approximately 90 locations throughout the plant (Langner, 1981) including the incinerator output. Concentrations are reported by Stauffer as less than 0.1 ppm at a flow rate between 10,000 and 12,000 SCFM. Although no direct monitoring of EDC is conducted, it is possible to conservatively bound the concentration of EDC at 0.1 ppm. That concentration is a suitable choice since it represents a conservative bound on the VCM levels measured near the stack output. Furthermore, the molar volume will be taken as 22.4 L rather than the higher value it would have because of the slightly elevated temperature at the detector location.

Using 12,000 SCFM one has the annual emission of EDC as 12×10^3 SCFM x 28.3 L/SCF x 5.26×10^5 min/yr x $\frac{1 \text{mole}}{22.4 \text{L}}$ x 97g/mole x 10^{-7} v/v

$= 77.3 \times 10^3$ g

Therefore incinerator emissions of EDC are thought to be bounded by 77.3 kg or 170 lb/year.

10.3.2 Fugitive Emissions

Seven hundred (700) sources were surveyed comprising nearly 100% of EDC service. All accessible plant areas with streams containing greater than 1% EDC were screened except for a small number of devices located in areas where active maintenance was being conducted. It is believed unnecessary to perform any emission factor adjustment since it is estimated that greater than 95% of the requisite components were screened.

Three leaks above an arbitrary OVA reading threshold of 20 ppm were detected. Table 10.3-1 summarizes their screening valves, calculation parameters and mass emission numbers. The upper bound leak rate was determined to be close to twice the nominal leak rate which accounted for the response factor of approximately 0.5 by Radian for TLV detection of EDC (Brown, 1980).

Stauffer found and reported approximately 10 leaks in the EDC service during 9 months previous to the plant testing. Assuming nominal leak

Table 10.3-1

STAUFFER CHEMICAL MASS EMISSIONS PREDICTION FROM OVA SCREENING VALUES

Device/ Location	OVA Response (ppm)	SAI Response Ractor	Actual Conc. (ppm)	a	b	Se	IRc	Source Function	Leak Rate lb/yr	Upper Bound lb/yr
Gate Valve Unit P1559A	300	1.1	273	-0.35	0.96	0.17	153	D	6	11
Valve Heavy Ends Column Unit 14439	500	1.14	439	"	"	"	241	C	1	1
Compressor Seal EDC Storage Unit T1062	2000	∿1.1	1818	"	"	"	939	A	93	187.

All emissions 100% EDC (1,2-Dichloroethane)

values, in the neighborhood of 2000 lbs. total could be emitted annually. Therefore it appears that major reductions in the mass emissions were achieved by the company run inspection program and the fugitive emission source has now become of secondary importance as a fraction of total plant emissions.

10.3.3 Wastewater Discharge

Wastewater samples were collected in duplicate from four sites within the plant for determination of ethylene dichloride (EDC) concentration. The samples were collected in EPA standard 40 ml VOA vials on July 1, 1981. Analyses were performed using standard purge and trap techniques coupled with flame ionization detection gas chromatography. The results are given in the table below.

Sample description	EDC concentration range (µg/ml)	EDC concentration average (µg/ml)	Approximate flow (gpm)
PVC Interceptor Box	8.2 - 10.8	9.5	200
EDC Stripper, number 2 Chlorination area, C1404	0.11 - 0.14	0.12	25
Final collection site for pH adjustment, P663	34.9 - 38.2	36.6	350
Final discharge site, sanitary sewer	6.2 - 25.4	15.8	500

The water in the PVC Interceptor Box was warm and represents washings from the PVC reactor which travels to the Interceptor Box in a concrete drainage ditch. Water from the EDC stripper was very hot, and because of its heat was difficult to collect. The heat of the water may in part account for the relatively low concentration of EDC here as the EDC would out-gas from the hot water more readily. The final collection site for pH adjustment is a large concrete container with mixers in it located just prior to the final discharge site. Water at the final discharge site is being constantly aerated due to the speed that it flows through the concrete drainage trough. This aeration could account for the relatively large range in the EDC conotent found here. The average EDC concentration at the final discharge site is below the daily discharge requirement of 25 µg/ml EDC.

Plant personnel indicated monthly average readings are typically on the order of 8 ppm but daily averages can reach greater than 20 µg/ml. In addition L.A. County Sanitation District staff (J. Milne, 1981) indicated that an on-site impoundment pond can become laden with EDC during certain abnormal operating periods and discharge variances are requested by Stauffer. This might occur on the order of once each year and therefore is not expected to significantly impact average annual discharge values. It is not expected at this time that evaporative emissions from this pond are significant except infrequently during upset conditions and spill control operations. Program staff were unaware of any periods when EDC content in the ponds could be appreciable and therefore no sampling was performed.

Utilizing the average of the two final discharge concentration readings (15.8 micrograms/ml) and 500 gpm flow one has 34,600 lb/year of EDC released into the sanitary sewer. For the purposes of calculating population exposures from plant releases it will be assumed that the EDC is locally emitted from the wastewater streams. There are no monitoring data available with which to develop a more accurate release profile.

However, emissions of EDC from the plant wastewater discharge can be calculated according to the method of Mackay (1975) as modified by Dilling (1977). It should be noted that this must be considered an estimate since conditions of flow and the presence of other substances will influence emission rates.

Using Dilling (1977) for nonaerated flow first recalculate Henry's law constant (dimensionless-mg of chemical per liter of air divided by mg of chemical per liter of water) as:

$$H_i = \frac{16.04\ P_i^* M_{wi}}{TS_i}$$

where

H_i = Henry's law constant, dimensionless,
P_i^* = the compound's pure component vapor pressure in mm Hg at T,
M_{wi} = the molecular weight,
T = the absolute temperature of the wastewater in K,
S_i = the compound's solubility in mg/liter at T.

Then for EDC

$$H_i = \frac{(16.04)(72)(99)}{(294)(8690)} = 0.0447 \quad \text{with}$$

the solubility of EDC in water given at 20°C is 8690 and the vapor pressure 1.4 psi (72mm) at 70°F.

The overall liquid mass-transfer coefficient K_{il} is given by Dilling (1975) as

$$K_{il} = \frac{(221.1)(0.6)}{\left(\frac{1.042}{H_i} + 100\ (M_{wi})\right)^{1/2}} \text{ in m/hr}$$

$$= 0.108 \text{ m/hr}$$

Then from Mackay the percent desorption is given by:

$$\frac{C_i}{C_o} = \exp\ (-K_{il}\ t/L), \text{ where}$$

C_i = the concentration at time t of EDC
C_o = the initial concentration
L = the liquid depth (m)
t = the retention time (in hr) of the liquid in the wastewater system.

Retention time is based upon a flow velocity range of 3 ft/sec as estimated by the Los Angeles County Sanitation District (J. Milne) over a distance of approximately 5 km to the Joint Water Pollution Control Plant. Sewer flow depth throughout the entire route have been estimated by J. Milne as typically 1 foot (0.30m) to the Davison Pump Plant and 3 feet (0.9m) to the Joint Treatment Plant distances assumed to be 1 mile and 2 miles respectively. Transit time becomes between 0.5 and 1.0 hours sequentially. Then computing the net emission reduction as the product of each leg:

$$\frac{C_i}{C_o} = \exp\left|(-0.108)\left(\frac{0.5}{0.30}\right)\right| \times \exp\left|(-0.108)\left(\frac{1.0}{0.9}\right)\right| = 0.74$$

Therefore, 26% of the EDC is emitted between the plant and the Joint Water Pollution Control Plant. Residence time and conditions at the plant account

for additional releases and residual content is further emitted between the plant and the ocean discharge point. Wherever the flow is retained, aerated, or shallow, emissions will be accentuated.

10.3.4 Offsite Storage Tank Emissions

There are three storage tanks leased by Stauffer for EDC storage located at 22nd and Gaffey Sts. in San Pedro. These tanks are used for long term storage rather than providing feed on a routine basis. Therefore breathing loss rather than working loss is of concern. All tanks are white, two being 67 ft in diameter while the third is 57 ft. All are 40 ft 3 inches high and have capacities of either 1,050,000 (2) or 840,000 gallons. The tanks are cone roof type and are not tied into vapor recovery systems. The South Coast Air Quality Management District has based their estimate of emissions on the specification of 7 1/2 foot vapor level. Using the AP-42 formula for breathing loss with the vapor pressure of EDC at 20°C and an average diurnal temperature variation of 26°F one has for each of the two larger tanks:

$$L_B = (6.19 \times 10^{-5})\, M \left(\frac{P}{14.7-P}\right)^{.68} D^{1.73} H^{.51} T^{.5} F_p C K_c$$

$$= (6.19 \times 10^{-5})\, (98.9) \left(\frac{1.16}{14.7-1.16}\right)^{.68} (67)^{1.73} (7.5)^{.51} (26)^{.5} (1)\,(1)$$

$$= 23.6 \text{ lb/day}$$

Thus for the two larger tanks L_B = 47.2 lb/day
For the third tank D=57 and L_B = 17.8 lb/day.
The total emissions become 23,724 lb/year. Since the plant is in the process of shutdown it is not clear what the liquid levels currently are. Note that if the material in the three tanks were combined into one, total emissions would be reduced markedly. Exposure to a population from this site was determined separately since it is located over six miles from the plant.

11.0

ASSESSMENT OF POPULATION EXPOSURE

11.1 OVERVIEW

A major program goal was to compare emissions from the various sources and identify and rank any "hot spots" in California where the general population was exposed to elevated concentrations of carcinogens. A simple Gaussian dispersion model was therefore used to obtain order-of-magnitude estimates of exposure of the general population surrounding each source. Since this was essentially a screening study, use of more sophisticated models was not appropriate.

It cannot be emphasized too strongly that most California residents are exposed to emissions of hazardous substances from a variety of natural and manmade sources. Urban dwellers are typically exposed to greater concentrations than rural residents; however, all are subjected to so called "background" levels from multiple sources. In order to place stationary source exposures in perspective, the typical ambient levels of each substance were identified from the literature and compared with the concentrations due to the emissions from each plant. Exposures were thus expressed both as absolute quantities and as increments above "background."

Comparison of plants presents a further difficulty in that various substances are being considered. No attempt was made to evaluate the relative importance of exposure to two different substances, such as chloroform versus carbon tetrachloride, other than by ambient concentration.

11.2 DATA SOURCES

11.2.1 Meteorological Data

The dispersion model to be described in Section 11.3 required input of annual average wind speed and frequency of occurrence of wind from each compass direction. These data were obtained for most of the sites from the South Coast Air Quality Management District (SCAQMD). In other cases (Kaiser, Johns-Manville, Dow and DuPont), only daily average wind speed and frequency data were available. In all cases, we used data from the meteorological station nearest the modeled emission source. Table 11.2-1 summarizes the

Table 11.2-1
METEOROLOGICAL DATA BASE

Plant	Observation Site (Distance from Plant)	Data Source	Period of Observation	Remarks
Allied Chemical, El Segundo	Lennox (3 miles)	SCAQMD	1971-1974	Averaged hourly readings available
Stauffer Chemical, Carson	Long Beach (3 miles)	SCAQMD	1962-1974	Averaged hourly readings available; offsite storage tanks approxiamtely 5 miles from meteorology site
Dow, Pittsburg DuPont, Antioch	Pittsburg (<5 miles to Antioch)	Dow	1956-1974	Daily and averaged winnd rose only-no hourly data available
Kaiser Steel, Fontana	Fontana <3 miles	SCAQMD	1978-1979	Two years of hourly/daily data printout made available (33000 entries); daily averages estimated as only practical alternative
Johns Manville, Stockton	Stockton (1 mile)	NOAA	1941-1970	No hourly data, estiamtes based on monthly prevalence of directions and speed
RSR, City of Industry	Whittier (4 miles)	SCAQMD	1969-1973	Averaged hourly readings available

meteorological data base for each site. Wind speed and wind direction frequency data used in the model are provided in Appendix G.

11.2.2 Population Data

In order to assess population exposure in the same way for all the sources, we defined a 10-square mile "impact area" arround each plant. This size was chosen since it was found in most cases to include all distances at which incremental ground level concentrations due to plant emissions would exceed general urban ambient levels for the pollutant in question. In most cases, the plant was placed at the center of the impact area. Where winds were predominantly from one sector or a few adjacent sectors, or where an unpopulated area (e.g., the Pacific Ocean) adjoined one side of a plant, the impact area was defined to lie immediately downwind of the site.

Once the impact areas were defined, we obtained Thomas Brothers maps of all census tracts within them. These maps are provided in Appendix H. Census tract populations were obtained from the 1980 U.S. Census. The population of each tract was assumed to lie at the centroid, except when the tract was large and most of the population was concentrated away from the centroid; in the latter case, the best-defined population center was used. Radial and angular distances from the sources to the population centers were then determined.

11.3 DISPERSION MODELING APPROACH

In order to estimate population exposures in the census tracts surrounding each source, a simple Gaussian dispersion model was used. Use of a more sophisticated model was inappropriate given the uncertainty in our emission rate estimates. It is questionable whether any real gain in accuracy would have resulted.

The well-known Gaussian dispersion formula is (Porter, 1976):

$$C = \frac{10^6 Q}{\pi u \sigma_z \sigma_y} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \qquad (11.3\text{-}1)$$

where C = ground level concentration in ($\mu g/m^3$)

Q = emission rate (g/s)

u = average wind speed at the physical stack height (m/s)

σ_z = standard deviation of the vertical concentration distribution

σ_y = standard deviation of the horizontal concentration distribution

H = effective stack height (m)

y = is the crosswind distance from the plume centerline to the receptor point (m)

This equation was assumed to provide hourly average ground level concentrations (Ranzieri, 1982). The values for the standard deviations σ_y and σ_z are functions of the downwind distance, x:

$$\sigma_z = ax^b \qquad (11.3\text{-}2)$$

$$\sigma_y = cx^d \qquad (11.3\text{-}3)$$

where a, b, c, and d are constants that fit the function to the empirical curves presented in Turner (1970). The wind speed at physical stack height is given by the equation:

$$u = u_o\left(\frac{h_s}{h_o}\right)^p \qquad (11.3\text{-}4)$$

where

u = wind speed at physical stack height (m/s)

u_o = measured wind speed (m/s)

h_s = physical stack height (m)

h_o = the height at which the known wind speed was measured (m) and

p = an empirical constant which varies with stability class*

Lacking data on the heights at which the all known wind speeds were measured, we followed common practice and assumed a value of 10 m for h_o.

Trial calculations showed the value of the plume rise for all the sources except RSR, Johns-Manville and the Kaiser final cooler cooling tower to be negligible (i.e. less than one meter). Plume rise formulas developed by Christiansen (1975) and cited by Porter (1976) were used for the exceptions. The rise was assumed to be momentum-dominated for RSR, Johns-Manville and Kaiser cooling tower, and bouyancy-dominated for the Kaiser coke ovens.

As was discussed above, the radial and angular distances from a source to each surrounding census tract were determined. Wind direction and

*See Busse, 1973

speed data, meanwhile, were obtained for each of the 16 major compass points. To calculate the concentration at a given point, it was first necessary to determine the compass sector in which the point lay. Figure 11.3-1 gives an example for a census tract at r km from a source and at 30 degrees from a reference angle, which we defined as north (0 degrees). As seen in the figure, this point lies in a sector bounded by the NNE (22.5 degrees) and NE (45 degrees) compass directions. The calculation was performed once for every hour of the day since annually averaged values of hourly wind speed were available. The following schedule of hourly stability clas was determined to be consistent with the relationships summarized by Turner (1967), given the observed distribution of wind speeds at our meteorologoical measurement stations. The schedule was modified slightly at the suggestion of the ARB (Ranzieri, 1982).

Hour	Class	Hour	Class
0	F	13	B
1	F	14	B
2	F	15	B
3	F	16	B
4	F	17	B
5	F	18	DN
6	F	19	DN
7	DD	20	F
8	B	21	F
9	B	22	B
10	B	23	B
11	B		
12	B		

Using the above equations and adjustments, the concentration at the point of interest was then calculated as the sum of the concentrations resulting from plumes having the bounding compass directions as centerlines. If the angular distance to the point was congruent with a compass direction, then only one calculation was necessary. Let $C(\theta_1,t_i)$ and $C(\theta_2,t_i)$ be the concentrations calculated at hour i for compass directions θ_1 and θ_2, respectively. As discussed in Section 11.2, our meteorological data in most cases included the frequency of wind direction for each hour of the day. Let $f(\theta_1, t_i)$ and $f(\theta_2,t_i)$ be the probabilities of occurrence of wind in the

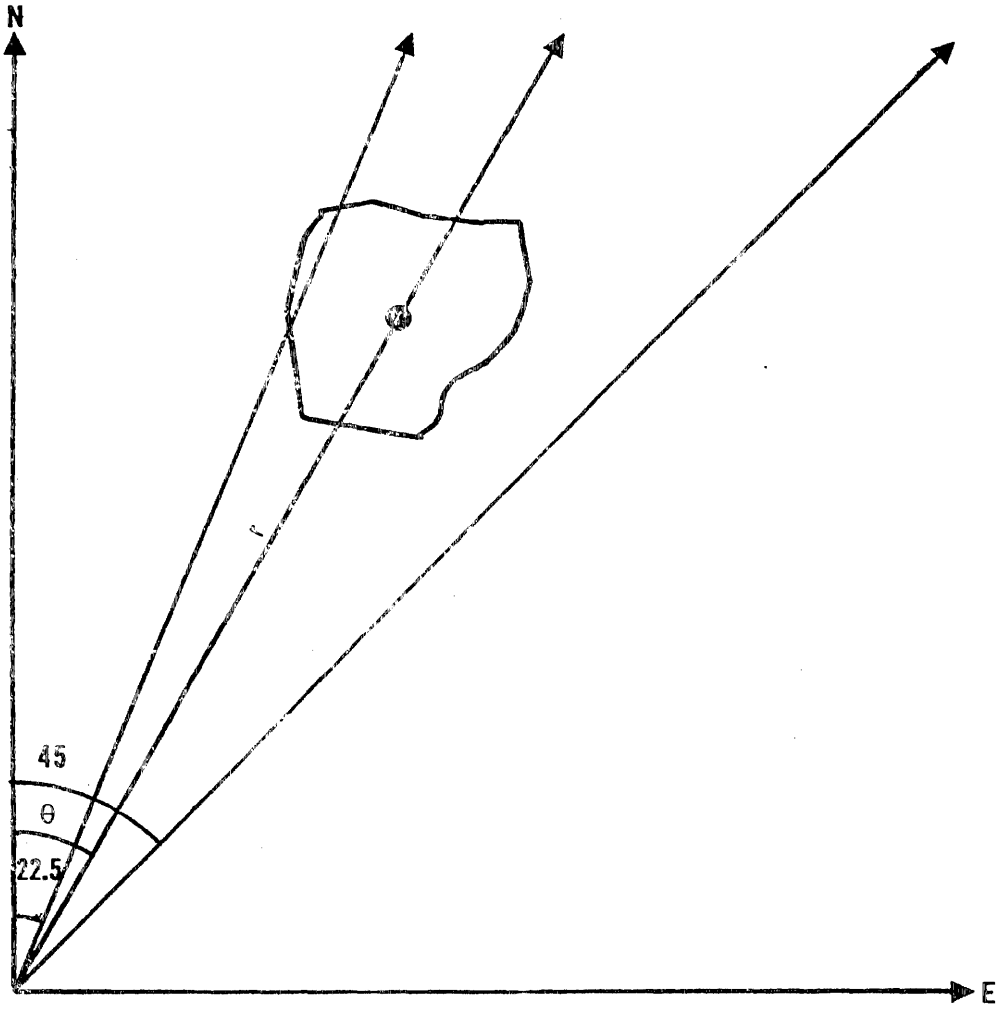

Figure 11.3-1 Determination of Compass Position of Census Tract Centroid.

directions θ_1 and θ_2, respectively at hour i. Then the expected value of the concentration at the point in question at hour i is:

$$C(t_i) = f(\theta_1,t_i)C(\theta_1,t_i) + f(\theta_2,t_i)C(\theta_2,t_i) \qquad (11.3\text{-}5)$$

The average annual exposure was then calculated as the average exposure on this composite day:

$$C = (1/24) \sum_{i=0}^{23} C(t_i) \qquad (11.3\text{-}6)$$

The model was programmed in Applesoft BASIC on an Apple II microcomputer having 48 K bytes of random access memory and a disk storage capability. The program, which is included as Appendix I, was compiled with an On-Line Systems, Inc. Expediter II BASIC compiler, in order to decrease running time.

11.4 POPULATION EXPOSURE FROM SURVEYED SOURCES

11.4.1 Modeling Results

Using the modeling parameters listed in Table 11.4-1, the incremental population exposure due to each of the stationary sources was computed. Tables 11.4-2 through 11.4-12 show the modeled annual average incremental exposure for each census tract around each plant. Census tract numbers appear on the maps in Appendix H). The cumulative population column specifies the total population exposed to all concentrations equal to or greater than the corresponding source weighted concentration entry of the table. Figures 11.4-1 through 11.4-11 illustrate the cumulative population exposure versus incremental concentration above ambient background concentrations. Table 11.4-13 lists ranges of typical urban ambient concentrations for each substance. These were used to assess the incremental contribution of the plant emissions. Table 11.4-14 summarizes the incremental population exposure due to each source. These were based upon annual average source strengths and do not reflect transients in emissions or worst case meteorolgoical conditions. Note that no attempt was made to assess the potential health effects or risks to the public due to the resultant combined exposure.

Table 11.4-1

VALUES OF MODELING PARAMETERS USED FOR POPULATION EXPOSURE ESTIMATES

Source	Initial Source Height(m)	Plume Rise Domination	Exit Velocity (m/s)	Exit Temperature (^{o}K)	"Stack" Radius (m)	Emission Rate (g/s)
RSR/Quemetco	18 3	Momentum	17.8	NN[a]	0.54	5.1×10^{-4} (As)
Kaiser Steel Corp.						
- Coke Ovens	19	Buoyancy	1.0	589	1.33[c]	0.12 (PAH) 1.25 (benzene)
- Cooling Tower	15	Momentum	2.7	NN[a]	3.38[c]	3.23 (benzene)
Johns Manville	30	Momentum	11.9	NN[a]	0.43	2.8×10^{-3} (asbestos)
Dow Chemical	10	NC[b]	NC	NC	NA	0.38 - 0.47 (perc & carbon tet)
Allied Chemical	10	NC	NC	NC	NC	0-0.0047 (chloroform) 0.053 - 0.084 (carbon tet) 0.026 - 0.044 (combined)
Dupont	10	NC	NC	NC	NC	0.024 - 0.031 (carbon tet)
Stauffer Chemical						
- Onsite Tanks	0	NC	NC	NC	NC	0.50 (EDC)
- Offsite Tanks	0	NC	NC	NNC	NC	0.34 (EDC)

[a] NN = Not necessary for calculation of plume rise.

[b] NC = Plume rise not calculated.

[c] Effective radius assumed equal to that of a circle having the same horizontal area as the source.

Table 11.4-2

ESTIMATED POPULATION EXPOSURE TO ARSENIC FROM RSR SECONDARY LEAD SMELTER, CITY OF INDUSTRY

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)	Source-Weighted Concentration (ng/m^3) Low	High	Census Tract Population	Cumulative Persons Exposed
4068.0	0.578	0.068	0.29	3,532	117,268
4074.0	0.696	0.082	0.35	1,533	113,736
4069.0	0.696	0.082	0.35	6,369	112,203
4067.0	0.705	0.083	0.36	7,079	105,834
4071.01	0.720	0.084	0.37	4,357	98,755
4075.0	0.823	0.097	0.42	5,442	94,398
4086.01	0.829	0.097	0.42	7,099	88,956
4084.01	0.832	0.098	0.42	3,531	81,857
4085.01	0.878	0.10	0.45	2,472	78,326
4073.0	0.963	0.11	0.49	7,220	75,854
4071.02	0.965	0.11	0.49	4,547	68,634
4070.0	1.103	0.13	0.56	8,158	64,087
4082.02	1.110	0.13	0.56	2,112	55,929
4077.0	1.113	0.13	0.56	8.893	53,817
4076	1.855	0.22	0.94	6,267	44,924
4072	1.873	0.22	0.95	6,195	38,657
4340	2.101	0.25	1.1	9,168	32,462
4083.01	2.150	0.25	1.1	3,809	23,294
4085.02	2.223	0.26	1.1	6,496	19,485
4083.02	3.073	0.36	1.6	3,356	12,989
4083.03	3.149	0.37	1.6	3,893	9,633
4084.02	3.984	0.47	2.0	5,740	5,740

Table 11.4-3

ESTIMATED POPULATION EXPOSURE TO BENZENE FROM KAISER STEEL CORPORATION STEEL MILL, FONTANA

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)		Source-Weighted Concentration (ng/m^3)	Census Tract Population	Cumulative Persons Exposed
	Cool. Tower	Coke Oven			
20.0	0.162	0.162	0.73	39,428	72,196
28.0	0.721	0.779	3.3	4,404	32,768
23.0	0.921	0.957	4.2	5,698	28,364
24.0	1.292	1.678	6.3	6,058	22,666
31.0	1.496	1.626	6.9	4,890	166,608
22.0	1.433	1.997	7.1	5,773	11,718
25.0	2.483	3.155	12.0	5,945	5,945

Table 11.4-4

ESTIMATED POPULATION EXPOSURE TO CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBONS FROM KAISER STEEL CORPORATION STEEL MILL, FONTANA

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)	Source-Weighted Concentration (ng/m^3)	Census Tract Population	Cumulative Persons Exposed
20	0.162	19	39,428	72,196
28	0.779	93	4,404	32,768
23	0.957	115	5,698	28,364
31	1.626	195	4,890	22,666
24	1.678	201	6,058	17,776
22	1.997	240	5,773	11,718
25	3.155	379	5,945	5,945

Table 11.4-5
ESTIMATED POPULATION EXPOSURE TO ASBESTOS FROM
JOHNS-MANVILLE PLANT, STOCKTON

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)	Source-Weighted Concentration (pg/m^3)	Census Tract Population	Cumulative Persons Exposed
51.03	0.559	1.6	5,435	15,907
24.0	1.038	2.9	4,909	10,472
23.0	1.076	3.0	3,816	5,563
28.0	2.150	6.0	1,747	1,747

Table 11.4-6
ESTIMATED POPULATION EXPOSURE TO CARCINOGENS FROM TWO
CHEMICAL PLANTS IN CONTRA COSTA COUNTY, CALIFORNIA

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)	Source-Weighted Concentration (ng/m^3)		Census Tract Population	Cumulative Persons Exposed
		Low	High		
		Dow, Pittsburg (carbon tetrachloride and perchloroethylene)			
3060.0	1.511	945	1335	7,817	20,309
3131.02	1.550	978	1372	1,696	12,492
3050.0	1.920	1211	1692	5,241	10,796
3072.01	2.207	1393	2030	2,986	5,555
3072.02	2.241	1410	2068	2,569	2,569
		DuPont, Antioch (carbon tetrachloride)			
3020.0	2.471	59.0	77.0	7,098	7,098

Table 11.4-7

ESTIMATED POPULATION EXPOSURE TO CHLOROFORM FROM ALLIED CHEMICAL PLANT, EL SEGUNDO

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)	Source-Weighted Concentration (ng/m^3)	Census Tract Population	Cumulative Persons Exposed
6500.02	1.174	6	6,276	161,278
6037.02	1.626	8	4,859	155,002
6005.02	1.634	8	3,078	150,143
6041.0	1.650	8	5,065	147,065
6037.01	1.676	8	6,181	142,000
6205.01	1.842	9	5,716	135,819
6020.02	1.889	9	2,893	130,103
6040.0	1.932	9	7,077	127,210
6205.02	2.108	10	6,667	120,133
6208.0	2.190	10	7,074	113,466
6025.03	2.224	10	4,612	106,392
6025.01	2.339	11	5,886	101,780
6038.0	2.359	11	5,754	95,894
6021.01	2.422	11	7,430	90,184
6025.02	2.785	13	4,983	82,710
6021.02	2.816	13	6,561	77,727
6039.0	3.102	15	5,564	71,166
6024.01	3.425	16	7,453	65,602
6209.02	3.630	17	3,142	58,149
6204.0	4.361	20	3,835	55,007
6024.02	4.473	21	5,296	51,172
6022.0	4.677	22	4,662	45,876
6209.01	6.036	28	2,651	41,214
6023.01	6.833	32	5,494	38,563
6201.0	7.835	37	7,482	33,069
6200.0	8.899	42	6,210	25,587
6023.02	11.547	54	3,352	19,377
6203.02	21.153	99	6,546	16,025
6203.03	22.574	106	4,250	9,479
6202.0	24.521	115	1,185	5,229
6203.01	43.056	202	4,044	4,044

Table 11.4-3

ESTIMATED POPULATION EXPOSURE TO CARBON TETRACHLORIDE FROM ALLIED CHEMICAL PLANT, EL SEGUNDO

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)	Source-Weighted Concentration (ng/m^3) Low	High	Census Tract Population	Cumulative Persons Exposed
6500.02	1.174	62	99	6,276	161,278
6037.02	1.626	86	140	4,859	155,002
6005.02	1.634	87	140	3,078	150,143
6041.0	1.650	87	140	5,065	147,065
6037.01	1.676	89	140	6,181	142,000
6205.01	1.842	98	160	5,716	135,819
6020.02	1.889	100	160	2,893	130,103
6040.0	1.932	100	160	7,077	127,210
6205.02	2.108	110	180	6,667	120,133
6208.0	2.190	120	180	7,074	113,466
6025.03	2.224	120	190	4,612	106,392
6025.01	2.339	120	200	5,886	101,780
6038.0	2.359	120	200	5,754	95,894
6021.01	2.422	130	200	7,430	90,184
6025.02	2.785	150	230	4,983	82,710
6021.02	2.816	150	240	6,561	77,727
6039.0	3.102	160	260	5,564	71,166
6024.01	3.425	180	290	7,453	65,602
6209.02	3.630	190	300	3,142	58,149
6204.0	4.361	230	370	3,835	55,007
6024.02	4.473	240	380	5,296	51,172
6022.0	4.677	250	390	4,662	45,876
6209.01	6.036	320	510	2,651	41,214
6023.01	6.833	360	570	5,494	38,563
6201.0	7.835	420	660	7,482	33,069
6200.0	8.899	470	750	6,210	25,587
6023.02	11.547	610	970	3,352	19,377
6203.02	21.153	1,100	1,800	6,546	16,025
6203.03	22.574	1,200	1,900	4,250	9,479
6202.0	24.521	1,300	2,100	1,185	5,229
6203.01	43.056	2,300	3,600	4,044	4,044

Table 1..4-9

ESTIMATED POPUATION EXPOSURE TO CARBON TETRACHLORIDE AND CHLOROFORM FROM ALLIED CHEMICAL PLANT, EL SEGUNDO

(Six months/year assumed for each feedstock)

Census Tract	Concentration for 1 g/s Emission Rate ($\mu g/m^3$)	Source-Weighted Concentration (ng/m^3) Low	High	Census Tract Population	Cumulative Persons Exposed
6500.02	1.174	31	52	6,276	161,278
6037.02	1.626	42	72	4,859	155,002
6005.02	1.634	42	72	3,078	150,143
6041.0	1.650	43	73	5,065	147,065
6037.01	1.676	44	74	6,181	142,000
6205.01	1.842	48	81	5,716	135,819
6020.02	1.889	49	83	2,893	130,103
6040.0	1.932	50	85	7,077	127,210
6205.02	2.108	55	93	6,667	120,133
6208.0	2.190	57	96	7,074	113,466
6025.03	2.224	58	98	4,612	106,392
6025.01	2.339	61	100	5,886	101,780
6038.0	2.359	61	100	5,754	95,894
6021.01	2.422	63	110	7,430	90,184
6025.02	2.785	72	120	4.983	82,710
6021.02	2.816	73	120	6,561	77,727
6039.0	3.102	81	140	5,564	71,166
6024.01	3.425	89	150	7,453	65,602
6209.02	3.630	94	160	3,142	58,149
6204.0	4.361	110	190	3,835	55,007
6024.02	4.473	120	200	5,296	51,172
6022.0	4.677	120	210	4,662	45,876
6209.01	6.036	160	270	2,651	41,214
6023.01	6.833	180	300	5,494	38,563
6201.0	7.835	200	350	7,482	33,069
6200.0	8.899	230	390	6,210	25,587
6023.02	11.547	300	510	3,352	19,377
6203.02	21.153	550	930	6,546	16,025
6203.03	22.574	590	990	4,250	9,479
6202.0	24.521	640	1,100	1,185	5,229
6203.01	43.056	1,200	1,900	4,044	4,044

Table 11.4-10

ESTIMATED POPULATION EXPOSURE TO CARBON TETRACHLORIDE FROM ALLIED CHEMICAL PLANT, EL SEGUNDO, DURING SIX-HOUR OFFLOADING FROM MIDNIGHT TO 6 A.M.

Census Tract	Source-Weighted Concentration[a] ($\mu g/m^3$)	Census Tract Population	Cumulative Persons Exposed
6500.02	2.6	6,276	161,278
6037.02	3.6	4,859	155,002
6005.02	4.1	3,078	150,143
6041.0	3.7	5,065	147,065
6037.01	3.7	6,181	142,000
6205.01	4.3	5,716	135,819
6020.02	4.7	2,893	130,103
6040.0	4.3	7,077	127,210
6205.02	4.9	6,667	120,133
6208.0	4.9	7,074	113,466
6025.03	5.1	4,612	106,392
6025.01	5.1	5,886	101,780
6038.0	5.2	5,754	95,894
6021.01	6.0	7,430	90,184
6025.02	6.1	4,983	82,710
6021.02	7.0	6,561	77,727
6039.0	6.8	5,564	71,166
6024.01	7.5	7,453	65,602
6209.02	8.0	3,142	58,149
6204.0	10.0	3,835	55,007
6024.02	10.0	5,296	51,172
6022.0	11.0	4,662	45,876
6209.01	13.0	2,651	41,214
6023.01	15.0	5,494	38,563
6201.0	17.0	7,482	33,069
6200.0	19.0	6,210	25,587
6023.02	25.0	3,352	19,377
6203.02	45.0	6,546	16,025
6203.03	47.0	4,250	9,479
6202.0	50.0	1,185	5,229
6203.01	91.0	4,044	4,044

[a] Assuming 1.0 g/s emission rate from 0000 to 0600 hours.

Table 11.4-1.

ESTIMATED POPUATION EXPOSURE TO ETHYLENE DICHLORIDE

FROM STAUFFER CHEMICAL PLANT, CARSON

Census Tract	Concentration for 1 g/s Emission Rate	Source-Weighted Concentration ($\mu g/m^3$)	Census Tract Population	Cumulative Persons Exposed
5724.0	1.801	0.90	1,153	58,821
5440.0	2.190	1.1	6,085	57,688
5438.01	5.048	2.5	3,683	51,583
5727.0	5.069	2.5	4,499	47,900
5726.0	5.944	3.0	4,068	43,401
5723.0	6.674	3.3	5,764	39,333
5725.0	7.892	3.9	2,892	33,569
5439.01	11.917	6.0	3,732	30,677
5437.03	14.197	7.1	3,295	26,945
5438.02	14.687	7.3	6,153	23,650
5433.03	17.273	8.6	6,578	17,497
5439.02	19.230	9.6	3,329	10,919
5437.02	20.801	11.0	4,683	7,590
5437.01	23.220	12.0	2,907	2,907

Table 11.4-12

ESTIMATED POPUATION TO ETHYLENE DICHLORIDE FROM

STAUFFER CHEMICAL OFF-SITE STORAGE

Census Tract	Concentration for 1 g/s Emission Rate	Source-Weighted Concentration ($\mu g/m^3$)	Census Tract Population	Cumulative Persons Exposed
2961.0	1.926	0.65	1,029	60,873
2966.0	3.921	1.1	4,043	59,844
2965.0	4.497	1.5	3,171	55,801
2962.0	4.561	1.6	5,518	52,630
2964.0	4.709	1.6	6,143	47,112
6099.0	7.657	2.6	1,988	40,969
2971.0	8.404	2.9	6,079	38,981
2967.0	9.887	3.4	1.949	32,902
2974.0	14.249	4.8	3,989	30,953
2968.0	17.235	5.9	3,311	26,964
2969.0	28.211	9.6	6,043	23,653
2973.0	39.992	14.0	2,587	17,610
2975	44.669	15.0	3,303	15,023
2976	402.159	140.0	4,960	11,720
2972.0	408.785	140.0	6,760	6,760

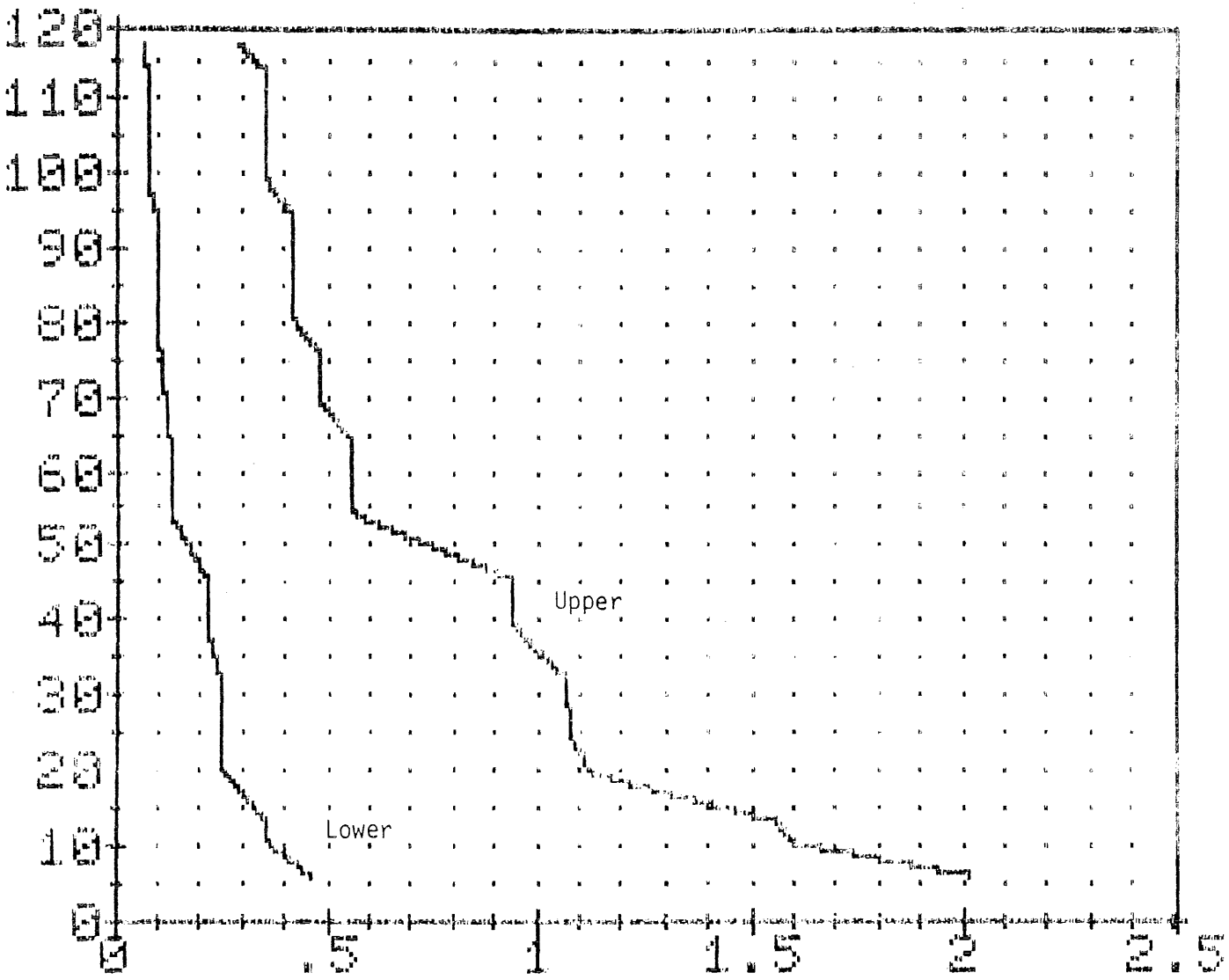

Figure 11.4-1 Cumulative Population Exposure to Arsenic from RSR Secondary Lead Smelter, City of Industry. (Curves Correspond to Upper and Lower Bounds on Emission Rate Estimate.)

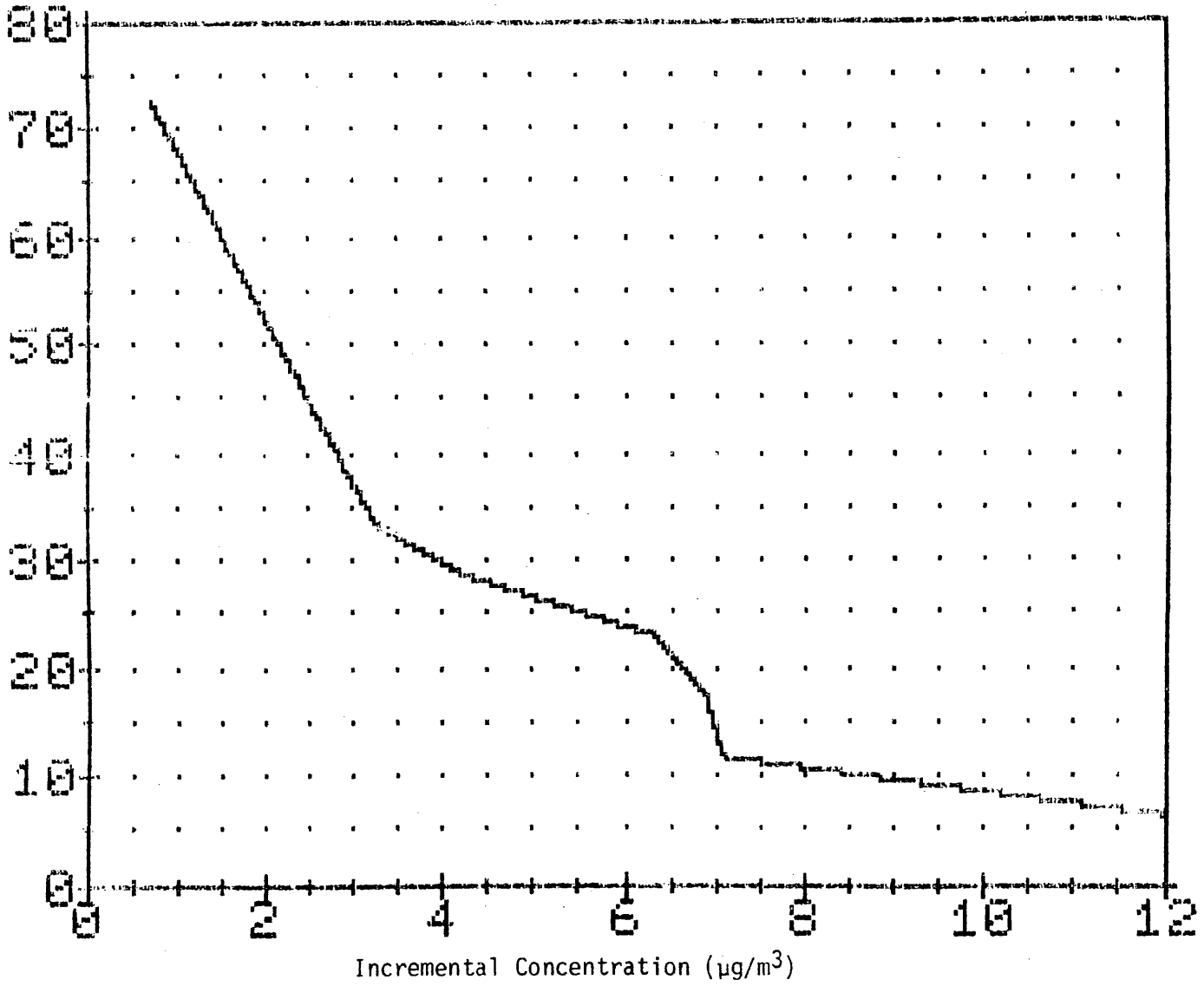

Figure 11.4-2 Cumulative Population Exposure to Benzene From Cooling Tower and Coke Ovens at Kaiser Steel Corporation Steel Mill, Fontana

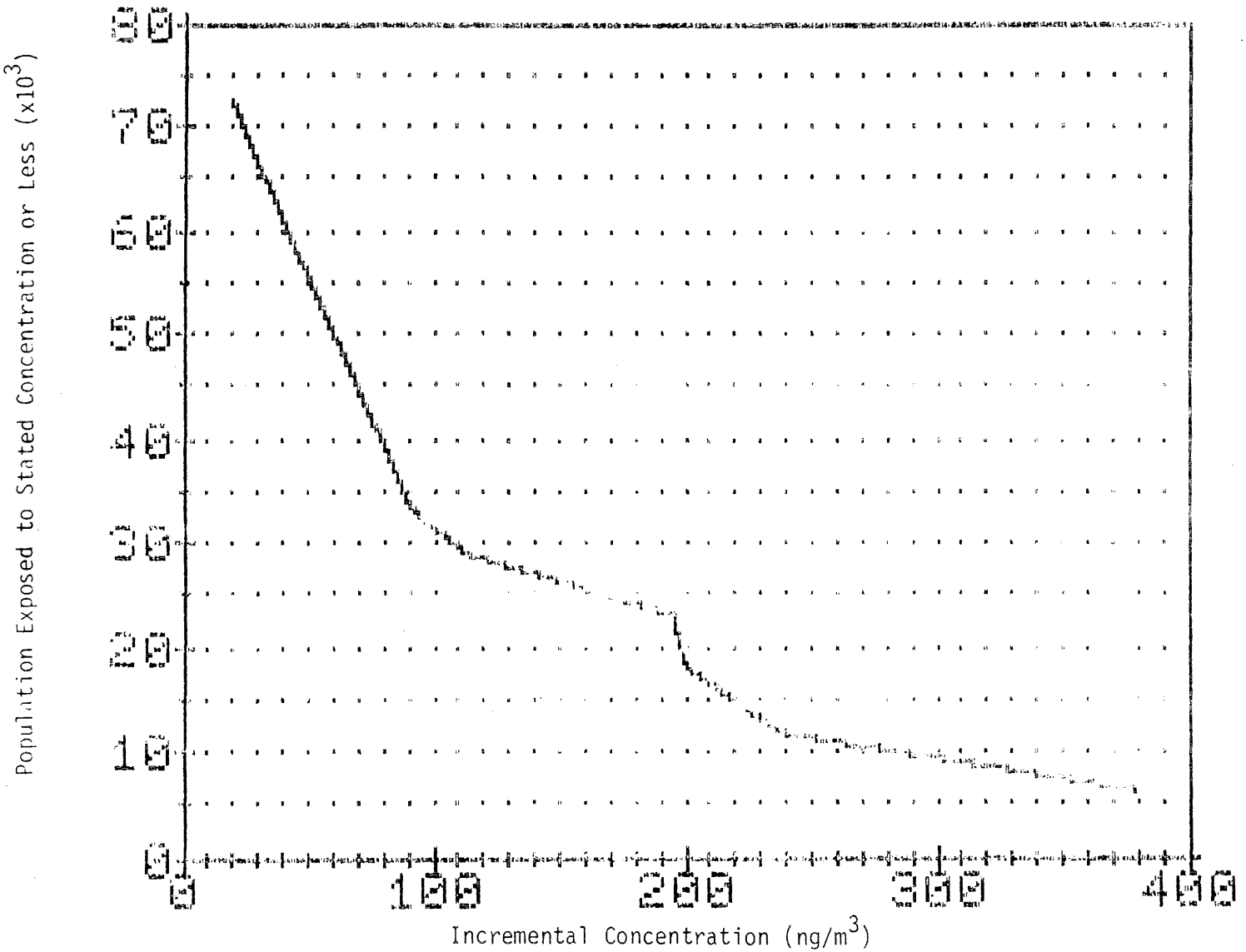

Figure 11.4-3 Cumulative Population Exposure to Carcinogenic Polycyclic Aromatic Hydrocarbons From Coke Ovens at Kaiser Steel Corporation Steel Mill, Fontana

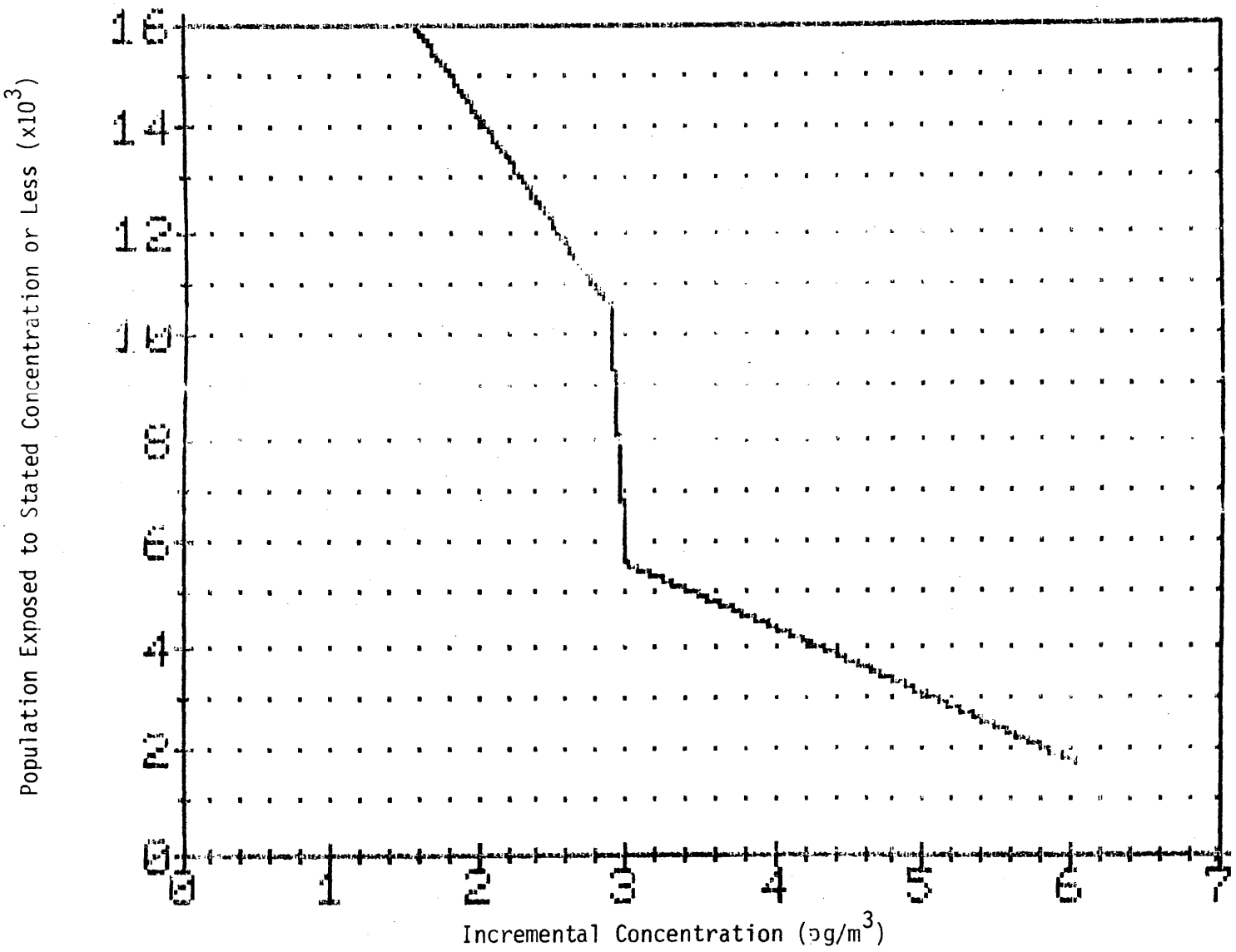

Figure 11.4-4 Cumulative Population Exposure to Asbestos From Johns-Manville Plant, Stockton

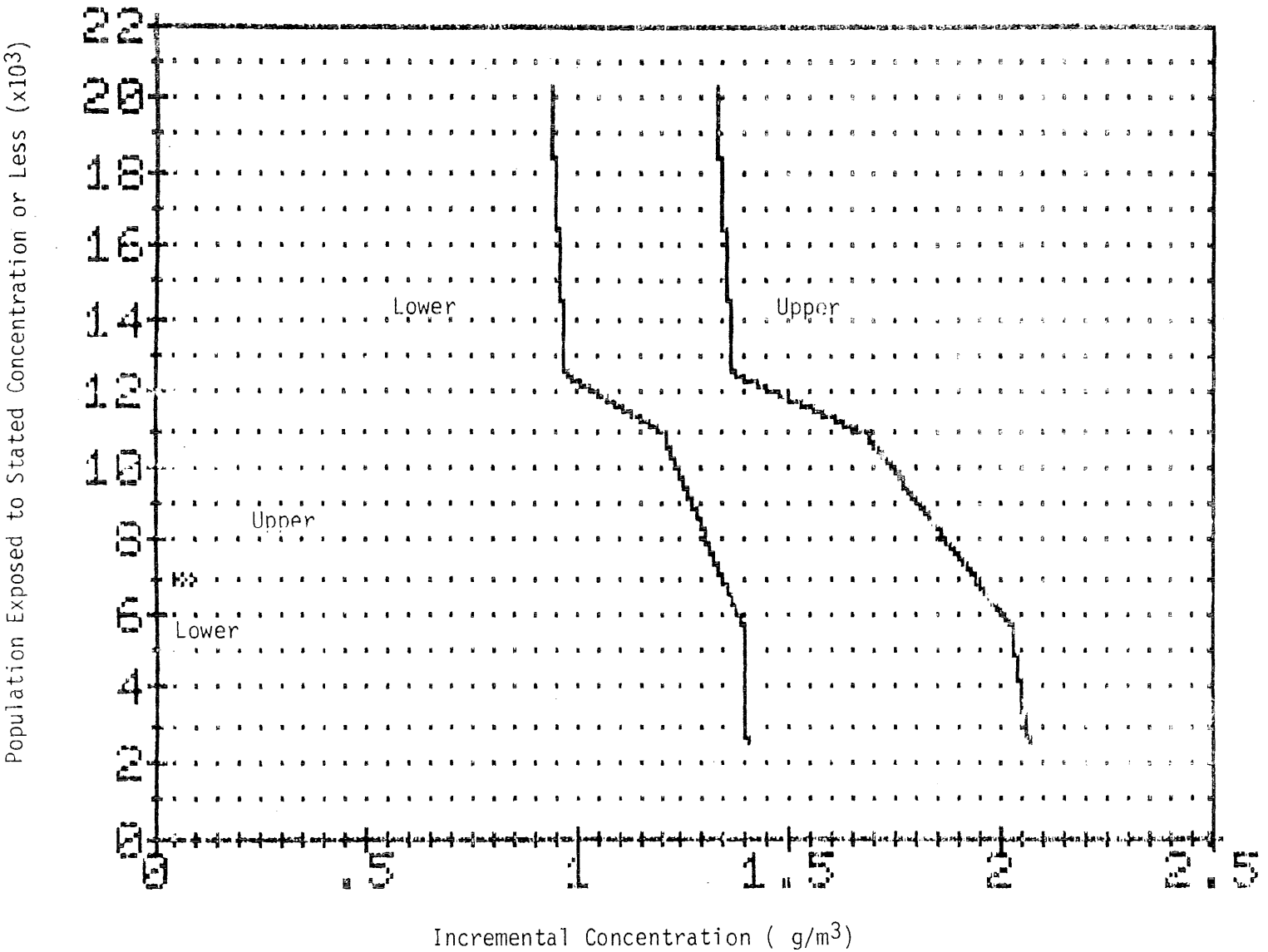

Figure 11.4-5. Cumulative Population Exposure to Perchloroethylene and Carbon Tetrachloride From Dow, Pittsburg (Solid Lines) and to Carbon Tetrachloride From DuPont, Antioch (Xs). Results For Upper Lower Bounds on Emission Estimates Are Shown.

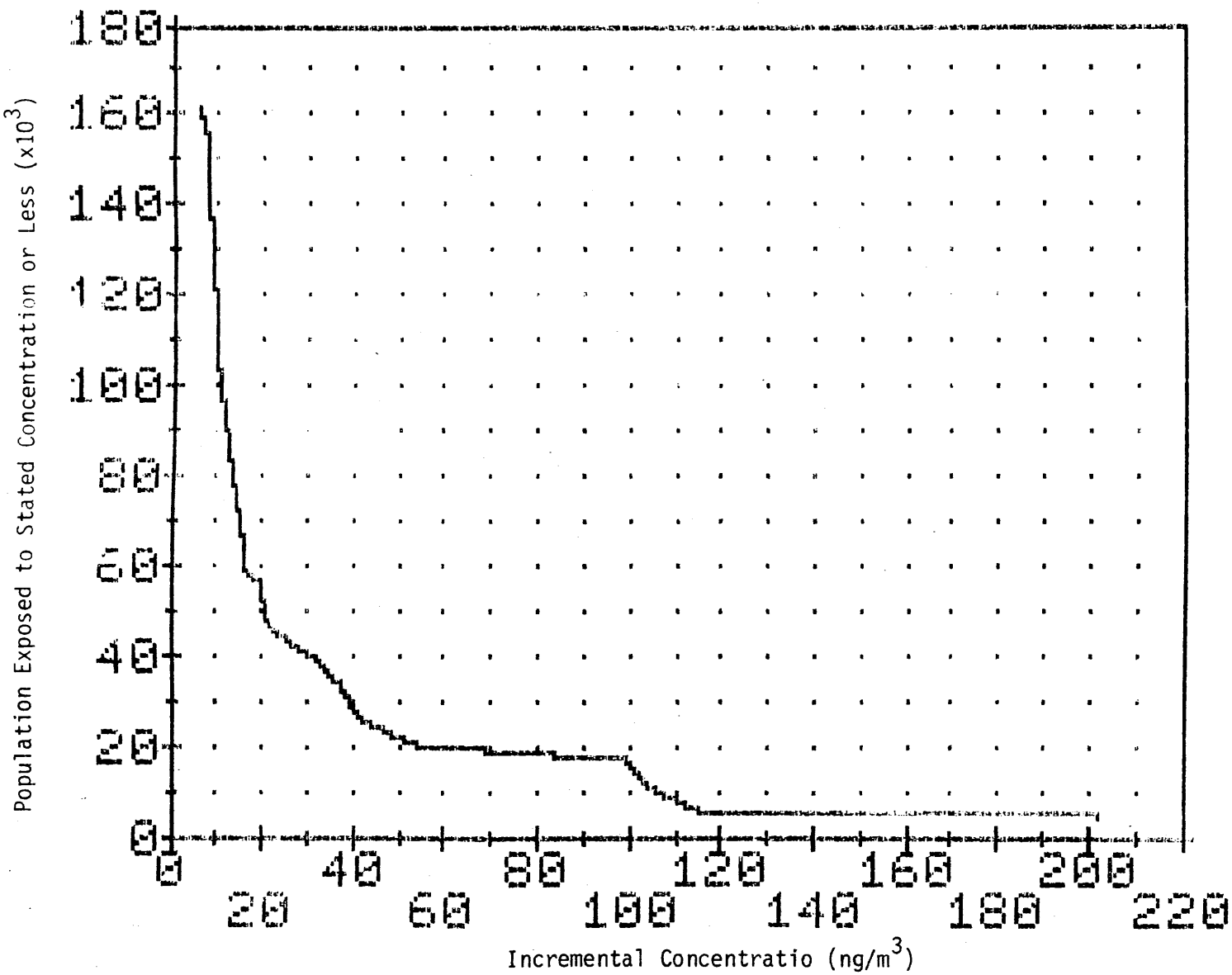

Figure 11.4-6 Cumulative Population Exposure to Chloroform From Allied Chemical, El Segundo

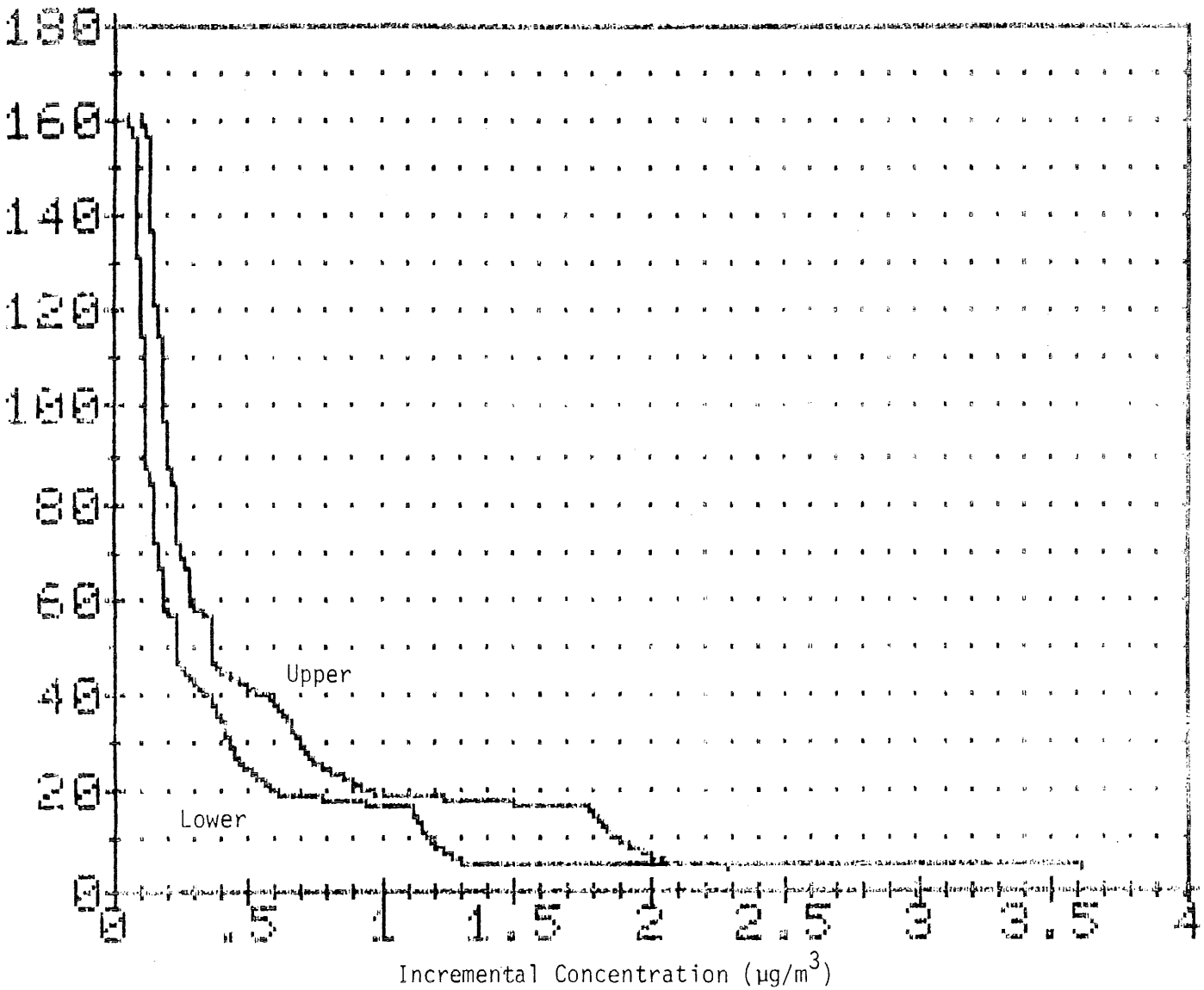

Figure 11.4-7 Cumulative Population Exposure to Carbon Tetrachloride From Allied Chemical, El Segundo. (Curves Corresond to Upper and Lower Bounds on Emission Rate Estimate.)

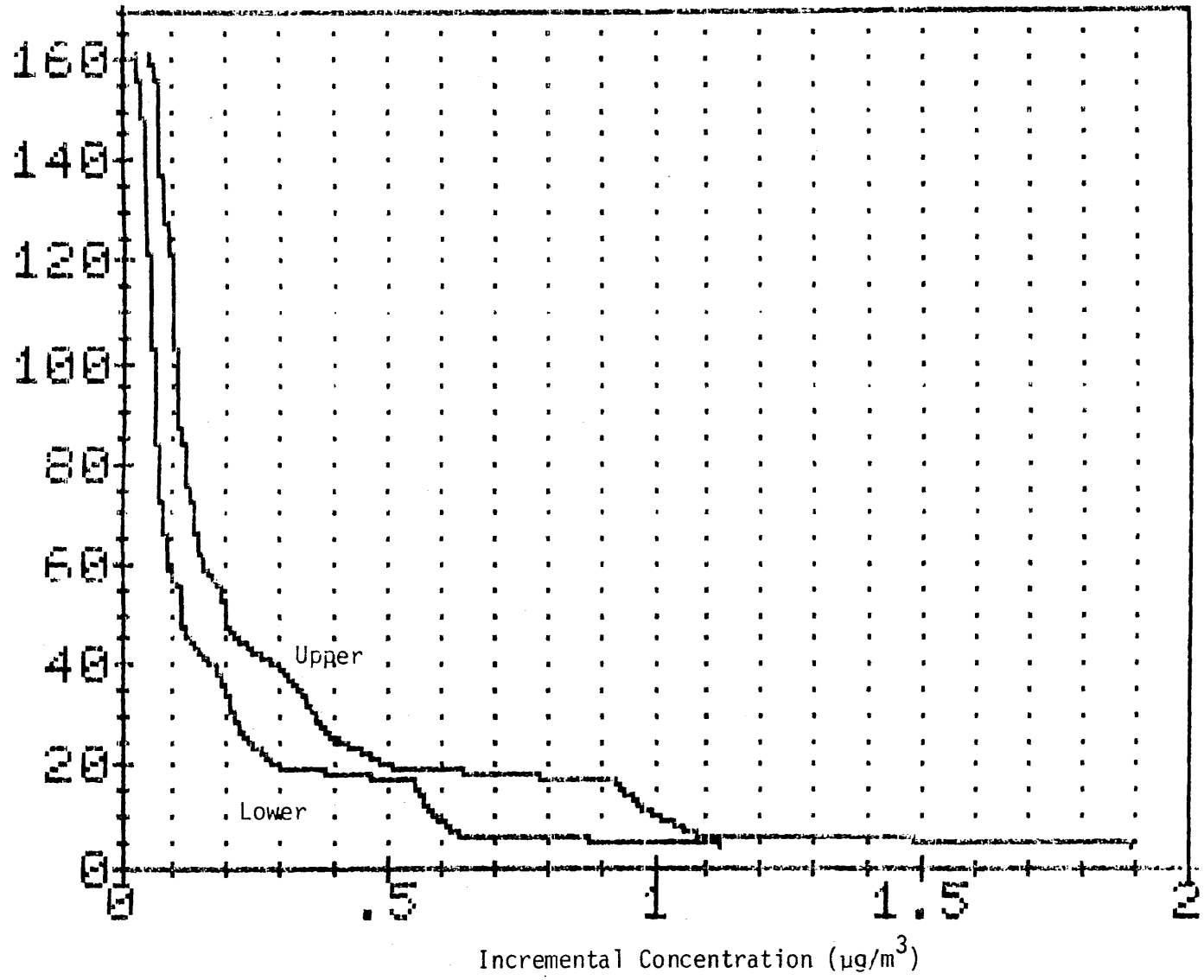

Figure 11.4-8 Cumulative Population Exposure to Carbon Tetrachloride and Chloroform From Allied Chemical, El Segundo, Assuming six-months Operation With Each Feedstock. (Curves Correspond to Upper and Lower Bounds on Emission Rate Estimate.)

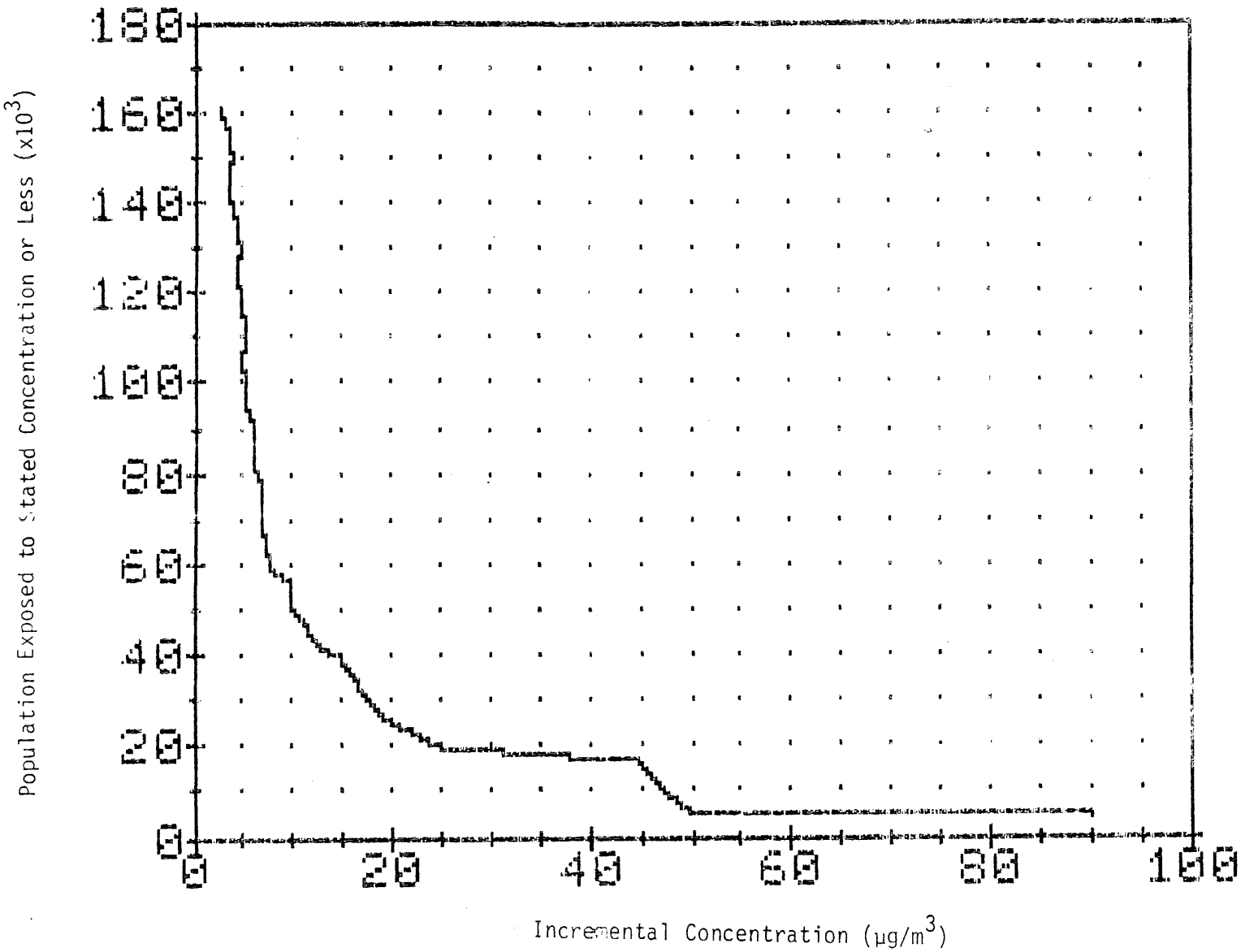

Figure 11.4-9 Cumualtive Population Exposure to Carbon Tetrachloride From Allied Chemical, El Segundo, During Offloading From Midnight to 6 a.m.

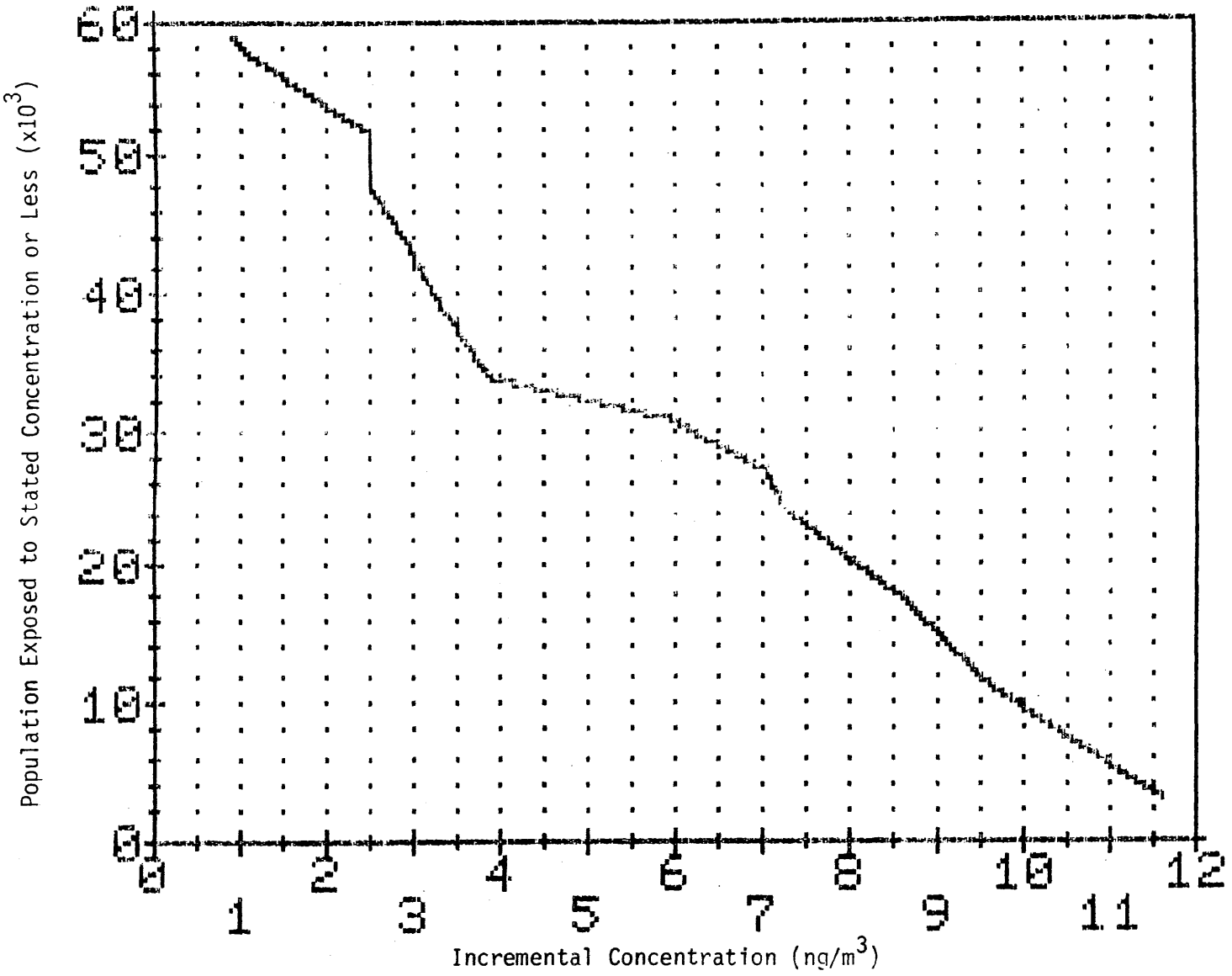

Figure 11.4-10 Cumulative Population Exposure to Ethylene Dichloride From Stauffer Plant, Carson.

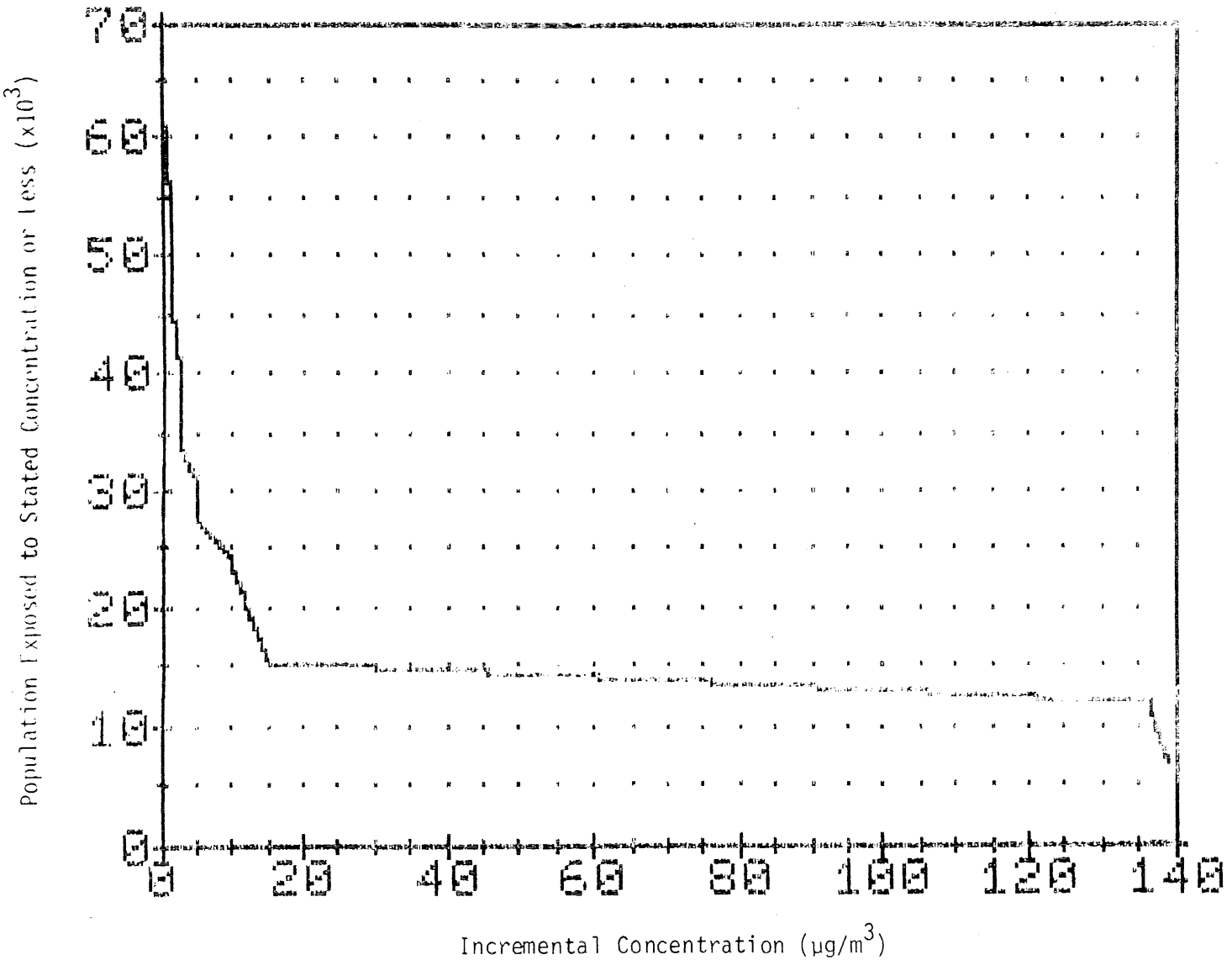

Figure 11.4-11 Cumulative Population Exposure to Ethylene Dichloride From Stauffer Off-Site Storage Tanks.

Table 11.4-13

TYPICAL URBAN AMBIENT LEVELS OF STUDY CARCINOGENS

Substance	Ambient Concentration	Environment	Reference
Arsenic	4-6 ng/m^3	General urban	Braman, 1976
	20-90 ng/m^3	Heavy industrial	National Research Council, 1976
Cadmium	3 ng/m^3	Typical urban	EPA, 1977
	<0.4 ng/m^3	Remote areas	EPA, 1977
Asbestos	200-5,700 fibers/m^3	Typical urban	Murchio, 1978
	20-100 fibers/m^3	Desert	Murchio, 1978
Ethylene Dichloride	3.7 ppb	Dominguez, CA	Barber, 1977
	trace	8 N.J. industrial sites	Pellizzari, 1977
	0.08, 0.11, 0.51ppb	Oakland, Upland, Los Angeles	Pellizzari, 1979
Chloroform	0.1 ppb	Urban background	Barber, 1977; Holzer 1977
	0.02 ppb	rural background CA & elsewhere	Barber, 1977; Grimrud, 1975; Russell, 1977
	1.88 ppb	8 industrial sites, N.J.	Pellizzari, 1977
	0.8 ppb	Tuscaloosa, AL (average)	Holzer, 1977
	0.7 ppb (ave)	Riverside, CA	Singh, 1982
Carbon Tetrachloride	0.11 ppb	rural background	Barber, 1977; Russell, 1977; Grimrud, 1975
	0.13 ppb	Los Angeles average	Barber, 1977
	5.95 ppb	Torrance, CA	Pellizzari, 1977
	0.22 ppb (ave)	Southern California (60 readings)	Simmonds, 1974
	0.175 ppb (ave)	Riverside, CA	Singh, 1982
Perchloroethylene	0.7 ppb	Los Angeles average	Barber, 1977;
	<0.04 ppb	Rural background Russell, 1977	Barber, 1977 Grimrud, 1975;
	1.25 ppb	Los Angeles average	Simmonds, 1974
	.36	Riverside, CA	Singh, 1982

Table 11.4-13
TYPICAL URBAN AMBIENT LEVELS OF STUDY CARCINOGENS
(continued)

Substance	Ambient Concentration	Environment	Reference
Benzene	1.1 ppb	8 N.J. industrial sites	Pellizzari, 1977
	0.6-34 ppb	28 samples in industrial areas with benzene consumption facilities	R.T.I., 1977
	4.2 ppb	Torrance, CA	Pellizzari, 1977
	16-60 ppb	Tuscaloosa, AL	Holzer, 1977
	0.2-1.3 ppb	National Forest	Holzer, 1977
	13 ppb	1000 samples-Toronto	Pilar, 1973
	4.8 ppb	Azusa, CA	EPA, 1980a
	6.7 ppb	El Monte, CA	EPA, 1980a
	5.5 ppb	Long Beach, CA	EPA, 1980a
	6.3 ppb	Upland, CA	EPA, 1980a
	8.2 ppb	Los Angeles, CA	Calvert, 1976
	3.9 ppb	Riverside, CA	Singh, 1982
Benzo(a)pyrene	0.31-2.1 ng/m^3	Los Angeles, 1971	Colucci, 1971
	0.46 ng/m^3	Los Angeles, 1976	Gordon, 1976
Benzo(e)pyrene	0.90 ng/m^3	Los Angeles, 1976	Gordon, 1976
Benz(a)anthracene	0.5-2.8 ng/m^3	Los Angeles, 1971	Colucci, 1971
	0.18 ng/m^3	Los Angeles, 1976	Gordon, 1976
Chrysene	0.60 ng/m^3	Los Angeles, 1976	Gordon, 1976
Indeno [1,2,3-cd]pyrene	1.34 ng/m^3	Los Angeles, 1976	Gordon, 1976

Table 11.4-14

INCREMENTAL POPULATION EXPOSURE TO CARCINOGENS FROM STATIONARY SOURCES

Site	Substance	Typical Urban Background Level	Population Exposed to 100% Increment Over Background	Population Exposed to 50% Increment Over Background
Allied+	Chloroform	0.1 - 0.7 ppb (>497 ng/m^3)	0	0
Allied+	Carbon Tetrachloride	0.15 ppb (942ng/m^3)	<4,044	25,587 - 41,214
Dow+	Perchloroethylene	0.7 ppb (4830 ng/m^3)	0	0
Dow+	Carbon Tetrachloride	0.15 ppb (942 ng/m^3)	10,796 - 20,309	20,309
Du Pont	Carbon Tetrachloride	0.15 ppb (942 ng/m^3)	0	0
Jonns Manville	Asbestos	1000 fibers/m^3 (313 ng/m^3)	0	0
Kaiser	Benzene	10ppb (32,500 ng/m^3)*		
Kaiser	PAH 5 compounds	3.5 ng/m^3	72,196	72,196
Kaiser	Cadmium	3 ng/m^3	0	0
Kaiser	Arsenic	4 ng/m^3	0	0
RSR	Arsenic	4 ng/m^3	0	0
Stauffer	Ethylene Dichloride	0.51 ppb (2100 ng/m^3)	92,552	117,532

+ Assumes all year operation on either feedstock. If plant operates 50% on each feed, the population exposed to greater than 50% increment over background goes to 16,025 - 19,377 and 4,044 - 16,025 for 100%.

* Ambient concentrations of benzene vary over one order of magnitude in the literature and therefore make this calculation questionable. For Kaiser therefore the carcinogenic PAH assessment was used to evaluate incremental population exposure above background.

+ The partition of emissions from Dow are 78% carbon tetrachloride and 22% perchloroethylene by weight.

11.4.2 Comparison of Incremental and Background Concentrations

Those sites which elevate background concentrations greater than 50% to surrounding population are discussed below.

11.4.2.1 Stauffer Chemical

The Stauffer chemical plant has two principal sources of EDC emissions, the off-site storage tanks and the waste water discharge stream. Each contributes about equally to the population exposure figures as shown in Tables 11.3-11 and 11.4-12. The ambient measurments by Pellizzari (1979) of 2100 ng/m^3 as the Los Angeles background was used as the typical urban background. Pellizzari notes that urban readings generally remain under 2500 ng/m^3 while plant proximity concentration have been observed as high as 700,000 ng/m^3. Other ambient data noted by Pellizzari are Birmingham, Alabama 205-400; Phoenix, Arizona 157-5870; Dominguez, California 14,814; Calvert City, Kentucky 6600. The latter two are associated with EDC plants. Data taken in service stations and traffic areas in various cities range from 300-3640 ng/m^3. As previously mentioned the Stauffer plant is discontinuing operations. These two sources should be examined as part of any possible start-up permitting activity.

11.4.2.2 Kaiser Steel Corporation

The Kaiser steel plant polycyclic aromatic hydrocarbon (PAH) emissions arise from the coke oven operations. Comparison of the cumulative population exposure Figure 11.4-3 and Table 11.4-4 with the specified background levels for urban areas illustrates the breadth of the exposure distribution. The five known PAH carcinogens that were isolated in the coke oven emissions were quantified in the ambient air of Los Angeles by Gordon, 1976:

Benzo[a]pyrene	0.46 ng/m^3
Benzo[e]pyrene	0.90
Benz[a]anthracene	0.18
Chrysene	0.60
Indeno [1,2,3-cd]pyrene	1.34

Although these concentrations are low compared with a number of other cities cited in the literature and represent a very limited data base, the predicted concentrations from the Kaiser plant generally exceed these levels by a

significant margin i.e. greater than 30,000 are predicted to be exposed to greater than 10 x the ambient background of 3.5 ng/m^3. It is likely that benzene exposures in the area are also elevated over ambient however, since background concentrations of benzene show large variation, no population calculation was specified.

11.4.2.3 Dow

Carbon tetrachloride releases from Dow constitute approximately 78% of the total CT plus perc emissions in Table 11.4-6 and were found to elevate urban background concentrations greater than 50% in five census tracts. Emissions are predominately from storage and check tank working and brething releases.

11.4.2.4 Allied Chemical

The Allied plant was modeled several ways since the plant can operate with chloroform or carbon tetrachloride feed. The cases presented in Tables 11.4-7 and 11.4-8 represent annual operation with either feed. Partial year operation with each feed can be scaled from the individual annual modes and is presented for equal half year operation in Table 11.4-9. As with the Du Pont plant carbon tetrachloride emissions arise from feed tank working loss. Table 11.4-10 illustrates peak exposures predicted to arise during an off loading cycle. As expected concentrations in that six hour period far exceed annual average values. Insufficient data were available to contrast levels with background transient concentrations.

12.0

AVAILABLE CONTROL TECHNIQUES

Alternative control approaches for the most significant emission sources among the various plants are described in the following subsections. Emphasis has been placed in dealing with those sources of greatest absolute magnitude (lb/yr) and those constituting the largest increment to the background concentration of the emitted substance. No attention will be given to the secondary sources within each plant or to the case of Johns-Manville since the major source is less than 200 lb/yr and is not predicted to raise background exposure levels to the general population. Furthermore all emission sources at Kaiser Steel which were directly dealt with in this program are related to the coke oven operations. These facilities are to be closed down and all primary steel mill operations discontinued. Kaiser forecasters have predicted further deterioration of the plant economics and the phased closure has been accelerated for primary steel making operations. Note that this closure is essentially irreversible since differential expansion and contraction of the coke oven structure occurs in the cooling process and it would be improbable that ovens could be reheated without extensive rebuilding at major expense.

12.1 STORAGE TANK EMISSIONS - STAUFFER, DOW, DUPONT AND ALLIED

At all four sites emissions from storage tanks constitute either the primary or near dominant (Stauffer) source of carcinogen release and/or general population exposure. Currently the tanks of interest at each site are permitted by the local Air Quality Districts however they do not require emission control systems for various reasons. The estimated releases, grounds for exemption, and other pertinent information are given in Table 12.1-1.

In order to appreciate the practical alternatives for emission controls the provisions of SCAQMD Rule 463 are listed below which specify the acceptable alternatives for tanks requiring controls i.e. tanks having capacities greater than 39,630 gal. with substances of true vapor pressure

Table 12.1-1

STORAGE TANK SUMMARIES

Site	Approx. Capacity(gal)	Substance	Emission Mode	Vapor Pressure	Grounds for Exemption
Stauffer Off-Site Tanks (3) (San Pedro)	1.05×10^6 (2) $.84 \times 10^6$ (1)	Ethylene Dichloride	Tank breathing	1.4 at 70°F psi	Exempt from control requirements to SCAQMD Rule 463 since vapor pressure does not exceed 1.5 lb at storage conditions.
Allied (El Segundo) - Raw Material Feed Storage	<39,630	Carbon Tetrachloride	Tank working Tank breathing	1.78 psi at 68°F	Exempt from Rule 463 since tank capacity is under 39,630 gal. (150 m^3)
Dow (Pittsburg)-Product Check Tanks (4)	18,000 each	Perchlore-thylene and Carbon Tetra-chloride	PERC-working PERC-breathing CT-working CT-breathing	1.78 psi at 68°F(CT) 0.39 psi at 68°F(perc)	Exempt from Regulation Rule 85300 because tank capacity is under 39,630 gal. and/or substances are not classified as organic liquids.
Dow - product storage	700,000 300,000	CT perc	Tank breathing Tank breathing		
DuPont (Antioch) - Raw Material Feed Storage	30,000 working 42,636 liquid full	Carbon Tetrachloride	Tank working Tank breathing	1.78 psi at 68°F	Exempt from Rule 85300 because substance is not classified as an organic liquid according to Regulation-Rule 8120

exceeding 1.5 psi at storage conditions.

- floating roof tanks
- fixed roof tanks with an internal floating type cover
- a vapor recovery system with vapor collection and return (or disposal) processing exceeding 95% efficiency.

In a chemical plant a typical vapor recovery system (K.R. Evans, SCAQMD) might consist of a collection manifold to a recovery system (such as a vapor sphere) to a compression system and subsequently to absorption and recovery systems. The absorption system consisting possibly of scrubber, stripper, or activated carbon.

In dealing with specific carcinogenic substances such as vinyl chloride highly efficient vapor control system performance has sometimes been stipulated necessitating incineration systems.

For the cases of concern realistic alternatives are as follows: Stauffer Off-Site Tanks - There are a number of options which can markedly reduce emissions from these tanks from the calculated value of over 20×10^3 lb/yr. One alternative is to consolidate the material in the three tanks. One of the large tanks can contain the currently stored material and reduce emissions to approximately 13.0×10^3 lb/yr. Another alternative is to transfer all EDC to a single floating roof tank. Various types of such tanks exist and are reviewed in the EPA report Organic Chemical Manufacturing Volume 3: Storage, Fugitive, and Secondary Sources EPA-450/3-80-025 e.g. internal and external floating roofs and a variety of seal design configurations. Generally such designs would be expected to reduce emissions to the order of one-fourth to one-fifth the current level. Cost of installing a contact single seal internal floating roof was estimated by B.B. Lumquist, Pentrex, for EPA as $27,770 in 1980 dollars for 70 ft diameter tank. Cost to build an external floating roof tank was estimated by G. Stilt of Pittsburg Des Moines for EPA as $140,000 for D=67 H=40ft. Another common approach is to utilize carbon adsorption. This works well with nonpolar hydrocarbons as VOC is removed from the vapor phase. A basic system consists of two carbon beds and a regeneration system. Regeneration is typically performed with steam or vacuum. Figure 12.1-1 illustrates the systems (Basdekis, 1980). Steam raises the VOC vapor pressure. The resulting steam-VOC mixture is condensed and

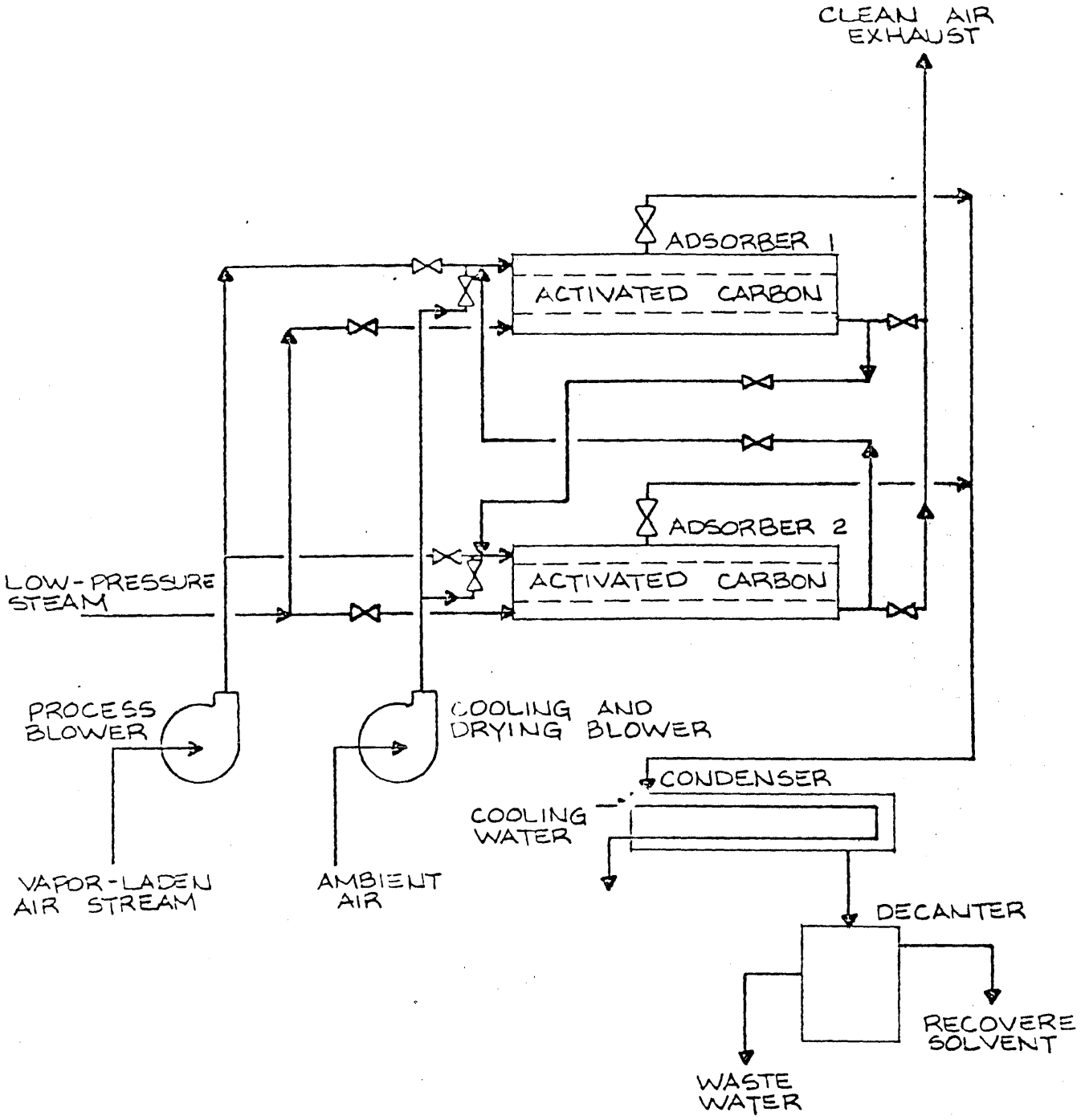

Figure 12.1-1 Activated-Carbon Adsorption System

routed to a separator, decanted and returned to storage. In vacuum regeneration VOC vapor is desorbed by pulling a vacuum on the carbon bed then condensed and returned. System efficiency is estimated at 96% reduction from fixed roof levels (EPA 450/3-80-025).

Refrigerated vent condensers are one of the most common emission reduction processes for controlling fixed-roof storage tank VOC. Figure 12.1-2 illustrates a unit (Erikson, 1980) efficiency of recovery is rated between 60-90% for the vapor pressure range of concern. For such a large tank the capital costs would be high. Figure 12.1-3 illustrates EPA estimates (EPA,1980b) for the condenser section. Condenser system area would be in excess of 1000 ft^2.

It should be noted that Stauffer Chemical has announced the closure of its VC/PVC plant. Previously they had planned to purge the off-site tanks of EDC. Since any future possible plant start-up will necessitate a comprehensive SCAQMD review this document can assist in evaluating proposed control measures.

Allied and DuPont Feed Tanks - In both of these cases the more significant quantity of emissions arise from tank working, i.e. during the off-loading activity, rather than tank breathing. Control measures taken for working emissions are thus of primary concern. Therefore, no detailed discussion will be provided on the alternatives for control of breathing emissions. Additionally both tanks are in the range of 20,000 gallons which is a capacity where floating roof tanks are almost nonexistent. Out of 670 floating roof tanks surveyed by EPA less then 1.5% were smaller than 30,000 gallons in capacity. Therefore, the utilization of any floating roof concept and seal combination will not be considered.

Commmercially it is estimated by DuPont that carbon tetrachloride feed costs approximately $0.17/lb (E. Taylor, personal communication). Therefore, less than $2500 is lost to DuPont annually as a result of working level emissions and less from Allied. Thus, it is unlikely that any appreciable economic incentive exists to develop a vapor recovery system. However, a candidate system could be patterned after the chloroform feed-storage unit currently at Allied. This is a dedicated vapor balance system. Chloroform is off-loaded from tank cars and stored in a closed unvented tank. As the storage tank is filled the air space displaced is fed

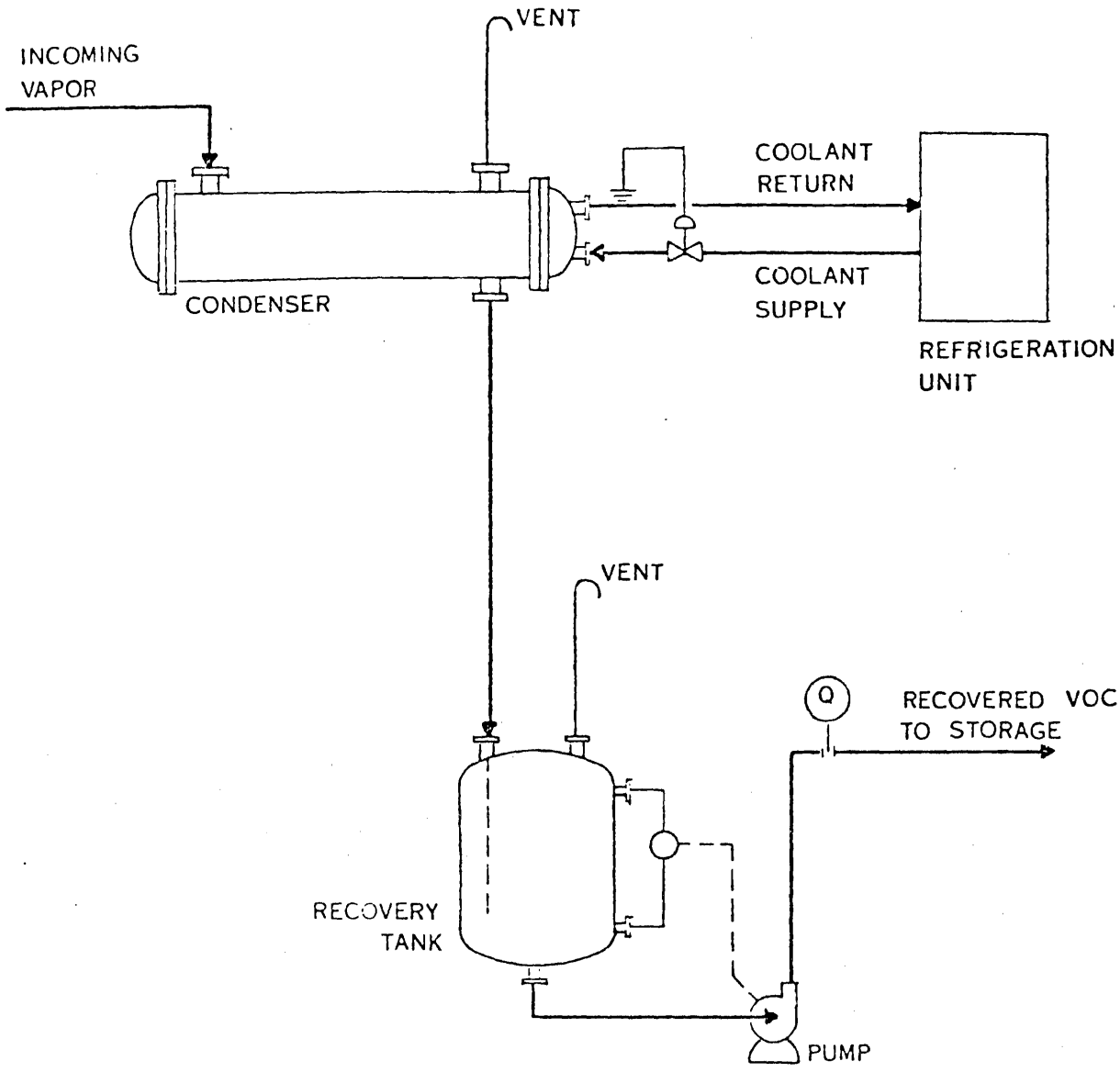

Figure 12.1-2 Refrigerated Vent Condenser System

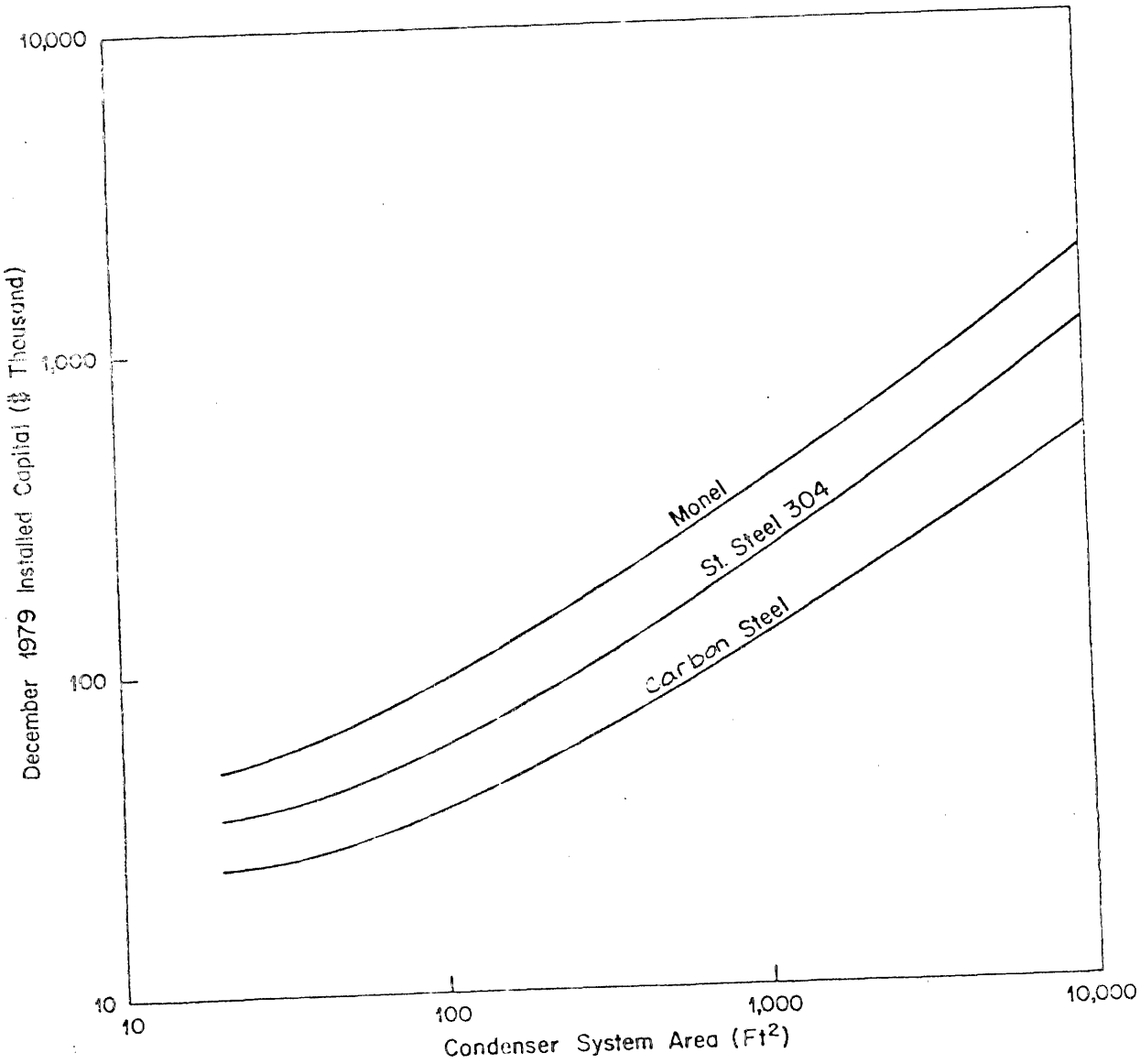

Figure 12.1-3 Installed Capital Cost vs Condenser Area for Various Materials of Construction for a Complete Condenser Section

back to the tank car. Also in this case the storage tank is not vented in its normal breathing mode and is part of a closed feed system to the reactor.

Vapor recovery system alternatives which are particularly effective in loading and handling include refrigeration, adsorption and/or absorption. Control efficiencies are estimated in the range of 90-95% (EPA, 1980b) and, of course, depend on the specific substance and equipment used. Carbon adsorption systems were discussed above. The smallest capacity carbon adsorption system priced by EPA (EPA, 1980b) has 2 vertical beds of carbon (900 lbs - 4ft diameter by 3 ft depth) with an installed capital cost of $135,000 based on December 1979 dollars.

Dow Tanks - Dow has two pair of product check tanks which alternately are filled and off-loaded. Emissions from these tanks were calculated based upon operating cycle (3 day fill) saturation vapor pressure and physical characteristics. Direct head-space testing was planned however it could not be accomodated because of restricted access due to unscheduled maintenance on the field test day.

Dow has indicated that they are studying the option of installing a vapor control/recovery system in these and their larger product storage tanks. The extent of their engineering and assessment work is unknown as are their current plans. It may be possible to incorporate a vapor balance design into the system whereby the displaced vapor is transferred to another process point within the system. Alternatively a vapor recovery system such as carbon adsorption is feasible. However, since emissions for the check tanks are primarily due to working loss, the use of a conservation vent or an adjustment of its operational differential pressure would be ineffective for the reduction of the bulk of such emissions. Furthermore, since check tank size is relatively small no consideration was given to conversion to a floating roof configuration for those tanks. Conversion would be possible for the large storage tanks.

12.2 WASTEWATER EMISSIONS - STAUFFER

Emissions of EDC through wastewater discharge are the largest single source identified at the plant sites. The discharge limit was set at 25 ppm by the Los Angeles County Sanitation District and was established with the occupational limit in mind of 50 ppm over an 8 hour work shift at the District

treatment center. There had been some discussion between parties of possibly raising the discharge limit since it is felt by Stauffer that dilution of the stream is sufficient to allow it. It should be noted however tha NIOSH has recommended the permissible exposure limit be reduced to 5 ppm averaged over a work period of 10 hours per day, 40 hours per week with a ceiling level of 15 ppm averaged over a 15-minute period.

It is not certain at what rate EDC will be released from the wastewater stream. At the plant discharge points wastewater is both hot and aerated thus favoring release. No measurements have been taken downstream of the plant after considerable dilution has occured. The distance to the water treatment plant is approximately 5 km at which point anerobic digestion is conducted. It is presumed that all EDC will be released before final ocean discharge.

A possible emission control process for reduction of the EDC in the effluent is by process adjustments or additions. For example process modifications to the EDC stripping stage could dramatically reduce discharge levels. A control alternative is the use of activated carbon or XAD-2 resin to recover EDC in the discharge stream. Tests of Gulf South Research Institute on XAD-2 and activated carbon (Coco, 1980) show high recovery yields for nonpolar organic carcinogens under a range of concentrations. Viable suggested alternatives by Smith included regeneration of the trapping materials and even consideration of burning the concentrate carbon media (at greater than 1000 ppm).

Control approaches to reduce emissions from so called secondary sources in general and waste water emissions in particular fall into four categories - waste source control, resource recovery, alternative disposal and add-on controls. Alternative control processes which were considered but appear to be inappropriate to this case include: chemical means e.g. neutralization, precipitation, coagulation and chemical oxidation; thermal destruction of the unconcentrated waste stream is impractical; biological treatment e.g. aeration and biomass-wastewater contact, generally relates to the treatment of soluble degradable organics in the concentration range between 0.01 and 1%; terminal storage e.g. landfilling, surface impoundment and deep well injection are either inapplicable or impractical. Therefore in summary the possible control approaches for this case include the improvement

of separation efficiencies in steam stripping; the internal recycle of waste streams; and the adsorption by activated carbon. The design configuration, efficiency and cost obviously depend upon numerous plant specific factors and their determination would require detailed analyses.

The wastewater system of a model chemical production plant based upon the average properties of a composite of 30 chemicals was evaluated for EPA by IT Enviroscience (EPA, 1980b). Included prominantly among the 30 was EDC with the highest uncontrolled secondary emission wastewater release rate i.e., 9 percent of the production and 34 percent of the emission. Cost and impact analyses were evaluated for alternative control systems to reduce secondary VOC emissions from wastewater. Four systems were considered: a carbon adsorption system (CAS) for recovery of the VOC from the wastewater, a cover to reduce secondary VOC emissions from the wastewater clarifier, a cover for the clarifier plus a carbon desorption system; and a cover for the clarifier plus a CAS system using a fume incinerator. The scale of the model system was greatly in excess of the Stauffer plant thus further making detailed comparison impractical. However emission reduction factors were given as 99% and cost effectiveness per 10^6g reduction generally ranged between $450 to 1733. These factors would likely grossly underestimate the system cost if scaled down to the range of the Stauffer plant i.e. the order of 34,600 lb annual discharge.

The alternative approaches of improved steam stripping efficiency and internal recycling of the stripper discharge stream with a reduction in makeup requirements could decrease net EDC wastewater content release.

12.3 CONTROLS FOR SECONDARY LEAD SMELTER STACK EMISSIONS

Given our finding of low (16 kg/yr) emissions of arsenic from the reverberatory furnace at RSR, it would appear that the arsenic content of the lead feedstock is low and/or that the plant's system for reducing lead emissions is also quite effective for arsenic. RSR, it will be recalled from Section 3.2, uses a quenching chamber and baghouse filters to remove particulate matter and a carbonate scrubber to remove sulfur dioxide.

There are no federal new source performance standards for lead emissions per se; however, the Standards of Performance for Secondary Lead Smelters (40 CFR 60.122) limit total particulate emission from a blast furnace

or reverberatory furnace to 50 mg/m^3. According to Augenstein et al. (1978), who reviewed the technology for controlling lead emissions from these sources, baghouse filters or wet scrubbers are generally used to control particulate emissions. When fabric filters are used to control blast furnace emissions, they are normally preceded by an afterburner, which incinerates hydrocarbons that would otherwise blind the fabric. Afterburners are not necessary for reverberatory furnace emission, since the excess air and temperature are usually sufficient to oxidize the hydrocarbons.

According to Augenstein et al., "shaker-type baghouse filters are the most effective means of controlling lead fume emissions from secondary furnace operations." Collection efficiencies can exceed 99 percent. One advantage to this control approach is that lead oxide dust can be recovered easily and recycled in the smelter. Flue gases must be cooled to below 300 ^{o}F for dacron bags and to below 500 ^{o}F for fiberglass bags (High et al., 1977).

Although wet scrubbers are effective under some circumstances in controlling lead emissions, it is more difficult to recover the lead oxide for recycling. In addition, sulfur dioxide present in the flue gases becomes oxidized to sulfuric acid and can cause corrosion problems. For this reason, sodium carbonate, or other basic reagents are added to the scrubber solution.

Although it concerns a gold smelter, an approach described by Marchant and Meek (1980), provides an example of an arsenic control alternative which might be applicable to secondary lead smelters. At the Campbell Red Lake Gold Smelter in Balmerton, Ontarion, Canada, Smelter gases are first passed through a hot electrostatic precipitator (ESP). The ESP is heated so that the arsenic (which is principally in the form of As_2O_3) remains gaseous and is not yet collected. This exclusion of arsenic allows the ESP to recover particulate gold more easily. The ESP exhaust is then quenched with ambient air to condense the arsenic trioxide. Baghouse filters then remove the arsenic, along with other particulate matter.

12.4 CONTROLS FOR STEEL MILL EMISSIONS

Given the imminent and irreversible cessation of coking activities at Kaiser Steel Corporation, a review of technologies for controlling emissions from the coke ovens and the coke byproduct recovery plant was not deemed to be necessary. This is the only primary steel mill in California.

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Rapid Screening and Identification of Airborne Carcinogens of Greatest Concern in California

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This paper describes a method for establishing a priority list of airborne carcinogens within a state jurisdiction. In this case it was necessary to identify, from among hundreds of potential candidates, the five to ten materials of greatest potential concern in California as airborne carcinogens.

Because no previous inventory of carcinogens in California existed, published lists, rankings, and assessments of national scope were used to identify candidates. By systematic manipulation and comparison of these data sources, 47 materials of some notoriety were chosen for closer scrutiny. This selection was pared to 22 candidates largely by eliminating those which had very little production and use in California. (Substances primarily used as pesticides were excluded from the scope of this study.) The remaining candidates were then ranked by additive and multiplicative algorithms and by a panel of experts. The results of these rankings were combined to produce a single selection of 11 priority candidates. In alphabetical order, they are arsenic, asbestos, benzene, cadmium, carbon tetrachloride, chloroform, ethylene dibromide, ethylene dichloride, N-nitrosoamines, perchloroethylene, and polycyclic aromatic hydrocarbons. In continuing studies, a baseline emissions inventory is being prepared, and a source testing program is being designed.

In recent years, concern has grown over the possibility that certain materials released to the atmosphere through industrial and commercial activity may be responsible for a significant portion of the incidence of cancer in the general population. This concern is manifested at the federal level in the National Emission Standards for Hazardous Air Pollutants (NESHAP), which limit emissions of the known carcinogens asbestos, beryllium, and vinyl chloride.[1]

Only a few states, including New Jersey and California, have begun efforts to identify airborne carcinogens of concern to the general public for the purpose of setting state emission regulations for these substances. After reviewing national use data for known and suspected carcinogens, New Jersey selected ten volatile organic compounds and five heavy metals to be examined further, and is currently measuring ambient atmospheric concentrations of these substances in a variety of areas. In the second year of the study, the state has increased the volatile organics studied to 20 and begun measuring heavier organics associated with particulates.[2] In California, a very different approach was taken.

Overview of California's Approach

The California Air Resources Board (CARB) is sponsoring a three-stage study of airborne emissions of carcinogens from anthropogenic activities. The first stage, which is the subject of this paper, was to identify roughly five to ten materials which, of the hundreds of known or suspected airborne carcinogens, are most likely to be of greatest concern to California's general population. Also of interest were those which, in order to satisfy occupational health and safety regulations, might be transferred from the workplace air to the outside atmosphere. The second stage, which is now underway, includes pinpointing of emission sources for each of the carcinogens of importance, quantification of emissions, and design of source-testing methods. A subsequent stage will consist of source testing and measuring public exposures to those substances for which data are unavailable. The basis for regulatory action, if appropriate, will include the results of this program and other related research.

Screening of Candidate Carcinogens

The National Institute for Occupational Safety and Health (NIOSH), lists 1905 chemicals which have reported neoplastigenic or carcinogenic effects and 510 which have otherwise received attention for their neoplastigenic potential.[3] The need to select five to ten materials from such a large number of potential candidates dictated that we devise a way to rapidly eliminate from further consideration the vast majority of the substances. Given the paucity of published data on most of the candidate substances, the screening method was designed to make best use of readily

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available information. The screening process was as follows: (1) eight complications of known and suspected carcinogens were reviewed and those substances which were not used in California, were highly unstable in air, or were very doubtfully carcinogenic were eliminated; (2) after more detailed information was obtained for the remaining 25 substances, candidates were rated by two different analytical methods; (3) an expert panel was convened to review dossiers on the candidates and to independently rank them; (4) from the eight to eleven substances ranked highest by all three approaches, eleven were selected for the emission identification and source-testing design stages of the CARB effort.

Initial Screening of Potential Candidate Carcinogens

65 compounds were selected from 642 industrial organic air pollutants compiled by MITRE Corporation for the U.S. Environmental Protection Agency (USEPA).[4] In that study, pollutants were scored by multiplying four explicitly defined rating factors: annual U.S. production, fraction of production lost to the environment, volatility, and toxicity. To adapt this work to our purpose, we first selected the 114 substances listed as being carcinogenic or neoplastigenic. Then, the scores of each of these compounds under the criteria "annual U.S. production," "fraction of production lost," "volatility," and "carcinogenicity" were multiplied together. Selected for further consideration were those substances which had a product score above 50. Another 15 substances listed as being carcinogenic but lacking information for one of the other rating factors were also selected. This list of 65 was then compared with seven other lists of carcinogens.[5-11] Materials common to the reduced MITRE list and at least one of the other lists were chosen for further consideration. Added as candidates were those substances which are regulated as occupational carcinogens by the Occupational Safety and Health Administration (OSHA), and certain inorganic carcinogens.[9] Finally, substances were added which, in our judgment, should be investigated but had been eliminated at this point. Examples of these are bis(chloromethyl)-ether, epichlorohydrin, and hydrazine.

Next, the refined list, which now contained 47 substances or chemical groups, was pared further by another rapid screening process. Eliminated were all candidates (1) whose production and/or use in California was very low (under 10^5 lb/yr) and was not thought likely to pose a risk to a localized population; (2) which are very unstable in air; or (3) which should not, on the basis of current evidence, be considered carcinogenic. The result of the initial screening was a list of 22 candidate materials, which is presented in Table I.

Table I. Substances reviewed in detail.

Candidate Substances	
Arsenic	Inorganic lead
Asbestos	Alkyl lead
Benzene	Maleic anhydride
Cadmium	Nickel
Carbon tetrachloride	Nitrosamines
Chloroform	Perchloroethylene
Chromium	Phenol
1,4-Dioxane	Polycyclic aromatic hydrocarbons
Epichlorohydrin	Propylene oxide
Ethylene dibromide	Trichloroethylene
Ethylene dichloride	Vinyl chloride
Rejected Substances	
Provisionally Rejected Substances	
Acrylonitrile	
Formaldehyde	
Vinylidene chloride	
Occupationally Controlled Carcinogens	
2-Acetylaminofluorine	4-Dimethylaminoazobenzene
Benzidine	Ethyleneimine
4-Biphenylamine (4-aminodiphenyl)	4,4'-Methylene bis(2-chloroaniline) (MOCA)
Bis(chloromethyl)ether, Chloromethyl methyl ether	α-Naphthylamine, β-Naphthylamine
Dibromochloropropane (DBCP)	4-Nitrobiphenyl
3,3'-Dichlorobenzidine	β-Propiolactone
Other Rejected Substances	
Acetamide	Diphenylamine
Aniline	Hydrazines
Auramine	Isonicotinic acid hydrazide
Beryllium	Nitrobenzene
Diethyl sulfate, Dimethyl sulfate	

Ranking Candidates by Additive and Multiplicative Algorithms

Many screening or ranking systems fall into one of two categories: additive and multiplicative. Some systems are a combination of the two, while others combine an "objective" approach with subjective evaluation of the results.[12] The 22 substances surviving the initial screening were ranked independently by the two approaches. If the same substance rated highly under both systems, its importance to California was judged to be more likely than if it had scored highly in only one method.

Additive Approach. In the additive approach, the user identifies one or more criteria and rates each alternative substance against each criterion, while simultaneously deciding the relative importance of the criteria. Eq. (1) shows its mathematical formulation.

$$\text{Rating for pollutant } i = \sum_{j=1}^{m} W_j R_{ij} \qquad (1)$$

Each criterion, or rating factor (R_j) is assigned a value for each pollutant i, and each rating factor is weighted (by W_j) according to its importance relative to the other criteria. The score for pollutant i under criterion j is the product of the rating under that criterion and the corresponding criterion weight. The overall rating for pollutant i is then the sum of the scores under all the criteria.

The additive approach has several virtues, the main one being that it forces the user to make all assumptions explicit. In the process of setting up such a ranking system, new insights into the problem under consideration may be gained. Once the system is set up, it is relatively easy to use. Where data for scoring pollutants are unavailable, artificial scales can be constructed to quantify subjective factors. Finally, the sensitivity of the results to the system's subjective aspects may be measured. For example, one can determine the effect of changing criteria weights upon the final pollutant ranking. Similarly, an appreciation may be gained of the significance of the range of uncertainty for a particular required data element by varying rating factor values.

A fundamental problem with the approach is that there is no logical basis for adding the individual scores assigned under the criteria, other than the assumption that this simulates, or even improves upon, the user's thought process. A major operational problem is that of weighting the criteria. A common practice is to give all criteria equal weight, but that is in itself a statement about the relative importance of the criteria.

Multiplicative Approach. In the multiplicative approach, the rating for each alternative is the product of the ratings under each criterion:

$$\text{Rating for pollutant } i = \prod_{j=1}^{m} R_{ij} \quad (2)$$

A multiplicative approach can have some advantages over additive ones. First, in some cases the ratings can be physical parameters such as concentrations or volatilities; there is then no need to weight the criteria and hence less controversy over subjective judgments. Second, multiplication generally provides a wider range of scores than does addition, allowing clearer discrimination among alternatives. Finally, this approach provides results which are more intuitively acceptable. As an example of this last point, suppose that exposure and "harmfulness" levels for candidate substance are each converted to values on a 0 to 10 scale and that a certain substance is both extremely toxic and extremely rare. An additive approach would give the compound a rating of 0 + 10 = 10, which is equivalent to that of a moderately prevalent substance (rated, say, at 5) which is moderately harmful (rated also at 5). A multiplicative approach, on the other hand, would rate the first substance at 0 and the second at 25.

Criteria. The six criteria used in the additive and multiplicative ranking procedures are defined in Table II. Assignment of values to the R_{ij} was based upon data gathered from published literature, personal communications, and panel discussion, and has been fully documented.[13]

Because the purpose of this exercise was to determine the relative importance of the suspected candidate carcinogens, R_1 was scaled to the most heavily used candidate substance, benzene, whose annual production and use in California is nearly 10^9 lb. Materials with a use under 10^5 lb/yr would be rated zero for R_1 and rejected. However,before rejecting a substance by this criterion, we considered whether its emissions could in particular circumstances result in high exposures to a localized population.

R_2 takes into account the fact that the chemical industry is in continual change. Substances of concern today may be phased out, while the use of others may rise dramatically, increasing their importance as pollutants. Information on developments which could likely result in a change in the growth rate was factored into the choice of a value for R_2. As an example, asbestos consumption in California has been stable in recent years. However, the pending phaseout of asbestos in motor vehicle friction materials will hasten the decline in asbestos consumption; hence we assigned a value of 1 for R_2.

Ideally one could use pollutant emission as a criterion. However, in this case emissions were to be estimated in detail only for the five to ten carcinogens finally selected. Therefore a measure of emission potential was used, based upon knowledge of the substance's manufacture and use, for R_4. The highest rating went to substances which are widely used, especially in consumer products. A slightly lower rating went to substances which are routinely emitted from industrial processes during production and use. Some materials are employed in such a way that emissions are quite low even though tight emission control may not be required by law. Materials in this category were assigned a value of two for R_3. Substances which, under federal or state regulations, may not be discharged to the exterior environment but which could be discharged by accident received the lowest rating.

Each candidate was evaluated on the basis of its propensity to decompose in ambient air. Materials with half-lives greater than eight hours were considered moderately to highly stable and rated five for R_4. Low to moderate stability was assigned to substances with half-lives between zero and eight hours. Compounds known to exist in air for only a few minutes would be rated zero

Table II. Definitions of the criteria used.

R_1: Present use in California	
100% of max. (10^9 lb/yr)	5
10% of max. (10^8 lb/yr)	4
1% of max. (10^7 lb/yr)	3
0.1% of max. (10^6 lb/yr)	2
0.01% of max. (10^5 lb/yr)	1
<0.01% of max. (<10^5 lb/yr)	0
R_2: Growth in California use	
+ 20%	5
+10% to +20%	4
Positive growth to +10%	3
Stable or unknown	2
Decline	1
Being phased out	0
R_3: Emission potential	
Widespread use in consumer products	5
Relatively poor control over emissions	4
Relatively good control over emissions	2
Tightly controlled	1
R_4: Stability in ambient Air[a]	
Moderate to high stability ($t_{1/2}$ > 8 hr)	5
Low to moderate stability ($t_{1/2}$ ~0–8 hr)	3
Unstable ($t_{1/2}$ ~ few minutes)	0
R_5: Dispersion Potential	
Emitted largely as vapor or fine particulate	5
Emitted largely as coarse particulate	1
R_6: Evidence of Carcinogenicity	
Known or suspected human carcinogen	5
Known mammalian carcinogen	4
Suspected mammalian carcinogen or known mammalian mutagen	3
Ames test positive	2
Precursor or co-carcinogen	1

[a] $t_{1/2}$ is the half-life

tion state or anion associations may change in the atmosphere, metals do not degrade and were considered stable. Asbestos is likewise stable. Many of the decomposition reactions of organic molecules are mediated by light. Such substances, if released at night, would have several hours to disperse in the surrounding area.

A rapid way of assessing the relative potential of different substances to spread from a release point is to note their physical state under normal ambient conditions. Accordingly, we scored materials emitted as vapors or fine particulates the highest for R_5 and coarse particulates the lowest. Intermediate values are possible for varying amounts of fine and coarse particulate emissions from the same source or from different sources.

There is as yet no widely agreed upon measure of the relative potencies of carcinogens, although some ranking systems have been proposed.[14] Extrapolating data from *in vitro* techniques such as the Ames bacterial mutagenicity test and from laboratory animal studies to humans is problematic. Therefore a less quantitative measure of the carcinogenic potential of each candidate substance was used. The candidates receiving the highest scores for R_6 would be those for which there is strong evidence of carcinogenesis in humans. Examples are asbestos, which is implicated in mesothelioma; vinyl chloride, which has been identified as the agent of liver cancer in exposed workers; and bis-(chloromethyl)ether, shown by epidemiological studies to cause lung cancer in resin workers. The next highest rated substances are those for which human carcinogenicity is unknown but which have produced cancer in one or more mammalian species in laboratory tests. Next are those which have not been shown to be carcinogens, but which have proven to be mutagenic in test animals. Substances for which the only knowledge of carcinogenic potential is a positive Ames test (producing mutations in histidine-requiring strains of *Salmonella*) are rated 2. Finally, substances which are implicated only as precursors or co-carcinogens would be rated lowest.

Substances unequivocally associated with carcinogenesis were considered as carcinogens in this study. Conditions of emission and exposure, including the presence of co-carcinogens, were factored into the evaluation of each candidate where possible. Carcinogenic substances derived from the metabolism of a precursor were considered as carcinogens. However, ubiquitous substances which have been hypothesized to be precursors (e.g., secondary amines, nitrous acid, and nitric oxide, which combine under certain circumstances to

form N-nitrosoamines) were not considered because of uncertainties in the importance of their link to the carcinogenic compound and the practical considerations demanded by the scope of the study.

It was beyond the scope of this study to judge the validity and interpretation of the experimental and epidemiological evidence upon which the carcinogenicity of candidate substances has been established. We accepted the conclusions about carcinogenicity drawn by the International Agency for Research on Cancer or the National Cancer Institute and did not consider dosage or route of administration of tested substances. However, considerations of test validity did enter into the subjective evaluation by the panel of experts.

Weight. In the additive ranking scheme, each rating criterion is weighted according to its importance relative to the other criteria. Little precedent exists for assigning these weights. In our judgment, and as generally agreed by the panel of experts (see below), R_1, R_3, and R_6 are more important than the other criteria. Evidence of carcinogenicity was considered to be the most important criterion of all, so W_6 was assigned a value of 3. W_1 and W_3 were set at 2, and W_2, W_4, and W_5 were set at 1. In order to discern the potential sensitivity of the rankings to the weight assignments, the candidates were also ranked using equally weighted criteria.

Ranking Candidates by Panel of Experts

A nine-member panel of experienced governmental, industrial, and academic scientists, whose disciplines included organic and physical chemistry, industrial hygiene, toxicology, epidemiology, and regulatory control of toxic substances, was convened to provide additional data for our ranking algorithms, to discuss our candidate substances and rejections, to suggest possible new substances for consideration, and to rank the candidates independently of our own ranking. Two weeks before the meeting, panel members were given one-to three-page dossiers on each candidate substance.

At the start of the meeting, before any group discussion, the panel was asked to rate each candidate substance with a score from 0 to 5. Next, each candidate was discussed at length. We provided an overview and summarized critical issues identified up to that point. Through materials brought to the meeting and their personal experience, panel members were able to provide much useful information on the candidates and additional insight into our rating criteria. At the end of the two-day session, the panel again rated the candidates.

Results and Discussion

Final Selection

Table III shows the highest-scoring substances as determined by the additive and multiplicative approaches and by the panel. In the additive approach, a single ranking was obtained by averaging the two rankings resulting from using equal and unequal weights. The rankings of most candidates were unaffected, but carbon tetrachloride, chloroform, chromium, and inorganic lead changed more than three positions. Because uncertainties in the data base preclude imputing significance to small differences in the final ordering, the lists in Table III are presented in alphabetical order. However, it is of interest to point out that benzene consistently ranked highest.

Because some candidates had equal rating scores, we could not choose exactly ten candidates from the additive and multiplicative rankings. Instead, the top nine and eleven were selected from the two exercises, respectively. We also considered the ten substances scored highest by the panel at the end of the session. The final consensus selection consisted of the 11 candidate substances appearing on at least two of the three lists. For the substances included in the consensus ranking, a baseline emissions inventory is being conducted, and a source testing program is being designed.

Rejected Substances

Some comments about certain substances not appearing on the final list are in order, inasmuch as they include known carcinogens and compounds which have received considerable attention in recent years as occupational carcinogens.

Provisionally Rejected Substances. Appended to the consensus ranking (Table III) were vinyl chloride, gasoline and engine exhausts, tobacco smoke, and pesticides. No further action by the CARB is recommended at this time for vinyl chloride because it is already subject to the USEPA emissions standard, a CARB ambient air quality standard, and an OSHA standard.

Gasoline and tobacco smoke were appended to this list because each occurs very widely and contains several of the candidate substances reviewed in this study, some of which are in the final listing. For example, gasoline contains benzene, ethylene dibromide, ethylene dichloride, and alkyl lead compounds, the last three being in leaded grades only. Both gasoline and diesel combustion products include PAH's. Tobacco smoke contains, among other neoplastigenic substances, nitrosamines, PAH's, nickel, arsenic, cadmium, and other heavy metals. Many individuals are involuntarily and, in many situations,

Table III. Highest ranked candidates from each ranking method.[a]

Additive	Multiplicative	Panel of experts	Highest consensus ranking	Highly ranked but no inventory recommended at this time
Asbestos	Arsenic	Arsenic	Arsenic	Vinyl chloride
Benzene	Asbestos	Asbestos	Asbestos	Gasoline and engine exhausts
Cadmium	Benzene	Benzene	Benzene	Tobacco smoke
Ethylene dibromide	Cadmium	Carbon tetrachloride	Cadmium	Pesticides
Ethylene dichloride	Carbon tetrachloride	Chloroform	Carbon tetrachloride	
Nitrosamines	Chloroform	Ethylene Dibromide	Chloroform	
Perchloroethylene	Chromium	Ethylene Dichloride	Ethylene dibromide	
Polycyclic aromatic hydrocarbons (PAH)	Ethylene dichloride	Nitrosamines	Ethylene dichloride	
	Nitrosamines	Perchloroethylene	Nitrosamines	
	Perchloroethylene	PAH	Perchloroethylene	
	PAH		PAH	

[a] Listed alphabetically.

virtually unavoidably exposed to tobacco smoke. Because the sources of gasoline, its combustion products, and tobacco smoke emissions are well known, no specific action was recommended for these materials during the emissions inventory and source testing design stages of the present study. It was considered important, however to draw attention to the general public's exposure to these substances. Pesticides are listed for the same reason, though a detailed examination of pesticides was beyond the scope of this study. Many pesticides are widely used, and some of them are known to be carcinogenic.

Other Rejected Substances. Acrylonitrile and vinylidene chloride were placed in a "provisionally rejected" group because of the panel's suspicion that imports of these compounds to California from Japan may be appreciable, yet are hard to substantiate. Should such imports be verified in the future, these two compounds would take on greater importance. Formaldehyde was also provisionally rejected because the preponderance of evidence indicates that it is not carcinogenic and that bis-(chloromethyl)ether is not formed from formaldehyde in appreciable quantities in industrial environments.[15] The occupationally controlled carcinogens ethyleneimine and beta-propiolactone were rejected in part because of their reactivity in air. At the time of this study, DBCP, a pesticide, was no longer being produced in California and was therefore rejected from further consideration.

Occupational Regulations and Community Exposure

A question of interest to the CARB was whether the regulation of acknowledged occupational carcinogens adversely affects the ambient air outside the workplace. Our general findings can be illustrated by the example of asbestos.

Asbestos is a very widely used material for which no ambient air standard exists. Concentrations in the workplace are limited to an eight-hour time-weighted average concentration of two fibers/cm^3 of air and a ceiling concentration of ten fibers/cm^3. In meeting this standard, exhausting air containing asbestos to the ambient air is not restricted, except by the USEPA's requirement that there shall be no visible emissions containing asbestos particles from such facilities, excluding brake shops.[1] Considering that, under certain conditions, 10^3 asbestos fibers/cm^3 could be emitted without being visible,[16] this standard may allow considerable asbestos emissions. It is unlikely, however, that emissions would actually approach these levels. First, since the OSHA standard cannot generally be achieved by ventilation alone, the generation of asbestos particle in the workplace must be greatly reduced. Second, the air is usually filtered to prevent recirculation of asbestos to a workplace. Asbestos waste must be disposed of in sealed impermeable bags or containers. Thus, under current occupational regulations, the ambient air generally appears to be afforded greater protection than it would without such regulations.[16]

Conclusion

The screening and ranking methodology presented in this paper proved to be a feasible approach to establishing a priority list of airborne carcinogens in California. We feel that it is an efficient means of focusing further efforts on emissions inventories, source testing, and ambient measurement, for it not only identifies all the carcinogens of potential concern, but it also permits the state regulatory agency to direct its research resources toward those substances of particular interest within its jurisdiction.

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Appendix B

Disposition of Miscellaneous Sites

Gould, Inc., Vernon: Secondary Lead Smelter

The emissions of arsenic from the four large secondary lead smelters in California were estimated in the program. This estimate was based upon a uniform fugitive emission factor not well supported by measurement information. Therefore, source monitoring was recommended and Gould, Inc., Vernon, being the largest was singled out. It was however proposed to monitor both Gould and RSR Corp. (Quemetco) in the City of Industry since analysis of the plants revealed significant differences in plant equipment and engineering. The latter being more typical of a modern facility.

As a result of pre-test discussions and plant inspections we became aware that Gould was actively in the process of constructing a new facility which would completely replace the existing one. We have monitored progress on the new site and concluded it would be inappropriate to utilize program resources to conduct field tests at Gould. Emissions from the new Gould facility will be based upon test results from RSR.

PG & E - Pittsburg, PG & E - Salinas, and So. Cal Edison - Long Beach: Oil Fuel Power Plants

It was appropriate to consider the emission of arsenic from power plants during the initial study stages since trace quantities in the fuel oil are known to be emitted. Because of the population distribution in the vicinity of three plants and some unrealistically conservative estimates of emission factors, the facilities appeared among the top seventeen stationary sources of potential concern. However, as a result of a reexamination of emission data it was concluded that an error had been made in the material balance of arsenic - resulting in an emission factor equivalent of a 300% release. No literature was found to justify greater than a 30% transfer function. Thus we estimated, at the outside, the emission factor should be reduced from 0.13 lb per 1000 lb to approximately 0.013 lb and resulting arsenic emissions for the entire state were conservatively estimated to be 1,760 lbs (from 17,600) divided amongst all the state's power plants. Clearly then the four secondary lead smelters estimate of 59,400 lbs of arsenic

emissions per year makes consideration of power plant emissions of arsenic a very low priority.

In a literature review by SAI - Methodology for Ranking Trace Elements in Fossil Fuels According to their Potential Health Impact (Rogozen, 1976) - emissions estimates for 15 trace substances were researched for coal and fuel oil power plant conversion. Source content, combustion process transfer functions and control methodology were considered to develop emission factors. The output to input ratio computed and utilized in the study for arsenic was 0.02 to 0.3 (i.e. transfer function between 2 and 30%) reflecting the wide variety of fuels, processses and controls nationwide. The upper end reflecting both high arsenic coals and poor emission control devices. Clearly neither of those conditions accurately apply to the three sites and thus substantiate the decision not to perform emissions measurements.

Calaveras Asbestos Company - Copperopolis: Asbestos Mining and Milling

In the past (late sixties and early seventies) the Calaveras Asbestos Company came under heavy criticism after inspection measurements revealed serious problems. However significant reduction of emissions have occured prompted by NESHAP regulation and occupational standards. SAI inspected the site in December 1979 under an EPA contract. An emissions inventory was published under that work (Ziskind, 1980) and the bottom line conclusion is that currently no significant emission are being released as a result of blasting which would reach the public. The open pit is some 900 feet deep with blasting at the bottom. Over 80 percent of emissions in the CARB Emission Inventory System were attributed to pit blasting. In fact at its current depth blasted material does not reach the mine surface with the explosive implacement used. Additionally the site is more remote than might be realized. The situation is vastly different today than in the past and currently attention should be paid to the issues of occupational exposure and breakdown of ventilation system controls in the milling operations. We recommended that no further consideration be given to this site for the purposes of this program i.e. identification of significant releases which might be responsible for causing the types of population exposure.

Various Refineries

It was established early in the analysis program that benzene emissions from refinery operations could, in the aggregate, constitute a significant source. Since there are a large number of refineries in California (46 in Los Angeles County itself at the time of examination) with a wide variety of types, sizes, ages, etc., their evaluation could represent a monumental task. It was noted immediately that within the total scope of the study the design and conduct of a refinery testing program which would develop a complete benzene emissions inventory for one site was impractical let alone to characterize emissions from three i.e. those listed among the 17 most significant potential stationary source emitters.

The three refineries were singled out for special attention in the previous phase because they uniquely had components which process materials containing 10 or more percent by weight benzene. (46 FR 1165, Jan 5, 1981 pg. 1491) Estimates by EPA (Federal Register, 1981) indicate that 90 percent or more of the total benzene fugitive emissions arise from such components. Therefore attention is appropriately focused on the three benzene production/consumption refineries: Chevron (Richmond) Arco (Carson) and Chevron (El Segundo). SAI staff considered the possibility of a testing program at one of these refineries and concluded it would not be cost-effective for a number of reasons:

- California is a minor producer and consumer of benzene with approximately 1.5% of the 11.4 billion pounds produced and consumed nationally in 1977. This can be compared with the fact that California has approximately 10% of the nation's population. Benzene exposure to the general population has been partitioned among the various sources. Aproximately 90% of exposure is estimated (SRI, 1978) to be caused by gasoline distribution activities and vehicle emissions in urban areas with nearly all of the balance by benzene handling operations (refineries and chemical plants). In the case of California this percentage will be even more disproportionate because of its greater share of the population and lesser share of the benzene handling. Furthermore since the three refinery sites are heavily urbanized no new rural population segment is being exposed.

- California's most heavily urbanized Air Quality Management Districts have already adopted benzene fugitive emission standards comparable and with some features more stringent than the proposed national emission standard. (46 FR 1165, Jan 5, 1981) Thus the conclusion derived above (i.e. refinery emissions are secondary cause of exposure to the urban population) is further reinforced since it is projected that releases from components in benzene service (>10% benzene) will be reduced by 73% by the proposed Federal Standards. The District rules (e.g. South Coast Air Quality Management District #466 and 466.1) are not restricted to benzene per se nor to only components in benzene service. The rules also include flanges in addition to the components called out in the propose national standard.

The EPA estimated that if the proposed emission standard were adopted the maximum annual benzene concentration for a plant would be 3.6 ppb at a distance of 0.1 kilometer away. Comparing this ground level concentration with the general urban background in California of 19 ppb shows the latter to dominate. In recognition of the secondary importance of these three sites it was decided to utilize program resources to develop field data at other sites where little emissions information was available.

APPENDIX C

U.S. Environmental Protection Agency

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METHOD 108 - DETERMINATION OF PARTICULATE AND GASEOUS ARSENIC EMISSION FROM NONFERROUS SMELTERS

1. Applicability and Principle

1.1 Applicability. This method applies to the determination of inorganic arsenic (As) emissions from nonferrous smelters and other sources as specified in the regulations.

1.2 Principle. Particulate and gaseous As emissions are withdrawn isokinetically from the source and collected on a glass mat filter and in water. The collected As is then analyzed by means of atomic absorption spectrophotometry.

2. Apparatus

2.1 Sampling Train. A schematic of the sampling train is shown in Figure 4.2.1 ; it is similar to the Method 5* train of 40 CRF 60, Appendix A. The sampling train consists of the following components:

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* Note: This and all subsequent references to other methods refer to the Methods in 40 CFR 60, Appendix A.

2.1.1 Probe Nozzle, Probe Liner, Pitot Tube, Differential Pressure Gauge, Filter Holder, Filter Heating System, Metering System, Barometer, and Gas Density Determination Equipment. Same as Method 5, sections 2.1.1 to 2.1.6 and 2.1.8 to 2.1.10, respectively.

2.1.2 Impingers. Six impingers connected in series with leak-free ground-glass fittings or any similar leak-free non-contaminating fittings. For the first, third, fourth, fifth and sixth impingers, use the Greenburg-Smith design, modified by replacing the tip with a 1.3-cm-ID (0.5 in.) glass tube extending to about 1.3 cm (0.5 in.) from the bottom of the flask. for the second impinger, use the Greenburg-Smith design with the standard tip. The tester may use modifications (e.g., flexible connections between the impingers, materials other than glass, or flexible vacuum lines to connect the filter holder to the condenser), subject to the approval of the Administrator.

Place a thermometer, capable of measuring temperature to within $1^{o}C$ ($2^{o}F$), at the outlet of the sixth impinger for monitoring purposes.

2.2 Sample Recovery. The following items are needed:

2.2.1 Probe-Liner and Probe-Nozzle Brushes, Petri Dishes, Graduated Cylinder and/or Balance, Plastic Storage Containers, Rubber Policeman, and Funnel. Same as Method 5, sections 2.2.1 and 2.2.4 to 2.2.8, respectively.

2.2.2 Wash Bottles. Polyethylene (2).

2.2.3 Sample Storage Containers. Chemically resistant, polyethylene or polypropylene for glassware washes, 500- or 1000-ml.

2.3 Analysis. The following equipment is needed:

2.3.1 Spectrophotometer. Equipped with an electrodeless discharge lamp and a background corrector to measure absorbance at 193.7 nm. For measuring samples having less than 10 μg As/ml, use a vapor generator accessory.

2.3.2 Recorder. To match the output of the spectrophotometer.

2.3.3 Beakers. 150-ml.

2.3.4 Volumetric Flasks. Glass, 50-, 100-, 200-, 500-, and 1000-ml; and polypropylene, 50-ml.

2.3.5 Erlenmeyer Flasks, 250 ml.

2.3.6 Balance. To measure within 0.5 g

2.3.7 Volumetric Pipets. 1-, 2-, 3-, 5-, 8-, and 10-ml.

2.3.8 PARR Acid Digestion Bomb

2.3.9 Oven.

2.3.10 Hot Plate.

3. Reagents

Unless otherwise specified, use ACS reagent grade (or equivalent) chemicals throughout.

3.1 Sampling. The reagents used in sampling are as follows:

3.1.1 Filters, Silica Gel, Crushed Ice, and Stopcock Grease. Same as Method 5, sections 3.1.1, 3.1.2, 3.1.4, 3.1.5, respectively.

3.1.2 Water. Deionized distilled to meet ASTM Specification D 1193-74, Type 3. When high concentrations of organic matter are not expected to be present, the analyst may omit the $KMnO_4$ test for oxidizable organic matter.

3.1.3 Hydrogen Peroxide (H_2O_2), 10 Percent (W/V). Dilute 294 ml of 30 percent H_2O_2 to 1 liter with deionized distilled water.

3.2 Sample Recovery. 0.1 N sodium hydroxide (NaOH) is required. Dissolve 4.00 g of NaOH in about 500 ml of deionized distilled water in a 1-liter volumetric flask. Then, dilute to exactly 1.0 liter with deionized distilled water.

3.3 Analysis. The reagents needed for analysis are as follows:

3.3.1 Water. Same as 3.1.2.

3.3.2 Sodium Hydroxide, 0.1 N Same as 3.2.

3.3.3 Sodium Boronydride ($NaBH_4$), 5 Percent (W/V). Dissolve 5.00 g of $NaBH_4$ in about 500 ml of 0.1 N NaOH in a 1-liter volumetric flask. Then, dilute to exactly 1.0 liter with 0.1 N NaOH.

3.3.4 Hydrochloric Acid (HCl), Concentrated.

3.3.5 Potassium Iodide (KI), 30 Percent (W/V). Dissolve 300 g of KI in 500 ml of deionized distilled water in a 1-liter volumetric flask. Then, dilute to exactly 1.0 liter with deionized distilled water.

3.3.6 Sodium Hydroxide, 1.0 N. Dissolve 40.00 g of NaOH in about 500 ml of deionized distilled water in a 1-liter volumetric flask. Then, dilute to exactly 1.0 liter with deionized distilled water.

3.3.7 Phenolphthalein. Dissolve 0.05 g of phenolphthalein in 50 ml of 90 percent ethanol and 50 ml of deionized distilled water.

3.3.8 Nitric Acid (HNO_3), Concentrated.

3.3.9 Nitric Acid, 0.8 N. Dilute 52 ml of concentrated HNO_3 to

exactly 1.0 liter with deionized distilled water.

3.3.10 Nitric Acid, 50 Percent (V/V). Add 50 ml concentrated HNO_3 to 50 ml deionized distilled water.

3.3.11 Stock Arsenic Standard, 1 mg As/ml. Dissolve 1.3203 g of primary standard grade As_2O_3 in 20 ml of 0.1 N NaOH. Neutralize with concentrated HNO_3. Dilute to 1.0 liter with deionized distilled water.

3.3.12 Arsenic Working Solution, 1.0 µg As/ml. Pipet exactly 1.0 ml of stock As standard into an acid-cleaned, appropriately labeled 1-liter volumetric flask containing about 500 ml of deionized distilled water and 5 ml of concentrated HNO_3. Dilute to exactly 1.0 liter with dionized distilled water.

3.3.13 Hydrofluoric Acid, Concentrated.

3.3.14 Air. Suitable quality for atomic absorption analysis.

3.3.15 Acetylene. Suitable quality for atomic absorption analysis.

3.3.16 Filter. Paper filters, Whatman No. 41 or equivalent.

4. Procedure

4.1 Sampling. Because of the complexity of this method, testers must be trained and experienced with the test procedures in order to obtain reliable results.

4.1.1 Pretest Preparation. Follow the general procedure given in Method 5, section 4.1.1, except the filter need not be weighed.

4.1.2 Preliminary Determinations. Follow the general procedure given in Method 5, Section 4.1.2, except select the nozzle size to maintain isokinetic sampling rates below 28 liters/min (1.0 cfm).

4.1.3 Preparation of Collection Train. Follow the general procedure given in Method 5, section 4.1.3, except prepare the impingers as follows:

Place 150 ml of deionized distilled water in each of the first two impingers and 200 ml of 10 percent H_2O_2 in the third, fourth, and fifth impingers. Weigh and record the weight of each impinger and liquid. Transfer approximately 200 to 300 g of preweighed silica gel from its container to the sixth impinger. Set up the train as shown in Figure 108-1.

4.1.4 Leak-Check Procedures. Follow the leak-check procedures given in Method 5, sections 4.1.4.1 (Pretest Leak-Check), 4.1.4.2 (Leak-Checks During Sample Run), and 4.1.4.3 (Post-Test Leak-Check).

4.1.5 Arsenic Train Operation. Follow the general procedure given

in Method 5, section 4.1.5, except maintain a temperature of 110° to 135°C (230° to 275°F) around the filter and maintain isokinetic sampling flow rates below 28 liters/min (1.0 cfm). For each run, record the data required on a data sheet such as the one shown in Figure 108-2.

4.1.6 Calculation of Percent Isokinetic. Same as Method 5, section 4.1.6.

4.2 Sample Recovery. Begin proper cleanup procedure as soon as the probe is removed from the stack at the end of the sampling period.

Allow the probe to cool. When it can be safely handled, wipe off all external particulate matter near the tip of the probe nozzle and place a cap over it to prevent loosing or gaining particulate matter. Do not cap off the probe tip tightly while the sampling train is cooling because a vacuum would form in the filter holder.

Before moving the sampling train to the cleanup site, remove the probe from the sample train, wipe off the silicone grease, and cap the open outlet of the probe. Be careful not to lose any condensate that might be present. Wipe off the silicone grease from the filter inlet where the probe was fastened and cap it. Remove the umbilical cord from the last impinger and cap the impinger. If a flexible line is used between the first impinger and the filter holder, disconnect the line at the filter holder and let any condensed water or liquid drain into the impingers. After wiping off the silicone grease, cap off the filter holder outlet and impinger inlet. Use either ground-glass stoppers, plastic caps, or serum caps to close these openings.

Transfer the probe and filter-impinger assembly to a cleanup area that is clean and protected from the wind so that the chances of contaminating or losing the sample is minimized.

Inspect the train before and during disassembly and note any abnormal conditions. Treat the sample as follows:

4.2.1 Container No. 1 (Filter). Carefully remove the filter from the filter holder and place it in its identified petri dish container. Use a pair of tweezers and/or clean disposable surgical gloves to handle the filter. If it is necessary to fold the filter, fold the particulate cake inside the fold. Carefully transfer to the petri dish any particulate matter and/or filter fibers that adhere to the filter holder gasket by using a dry Nylon* bristle brush and/or a sharp-edged blade. Seal the container.

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* Mention of trade names or specific products does not consitute endorsement by the Environmental Protection Agency.

4.2.2 Container No. 2 (Probe). Taking care that dust on the outside of the probe or other exterior surfaces does not get into the sample, quantitatively recover particulate matter or any condensate from the probe nozzle, probe fitting, probe liner, and front half of the filter holder by washing these components with 0.1 N NaOH and placing the wash in a plastic storage container. Measure and record to the nearest ml the total volume of solution in Container No. 2. Perform the rinsing with 0.1 N NaOH as follows:

Carefully remove the probe nozzle and rinse the inside surface with 0.1 N NaOH from a wash bottle. Brush with a Nylon bristle brush and rinse until the rinse shows no visible particles, after which make a final rinse of the inside surface.

Brush and rinse the inside parts of the Swagelok fitting with 0.1 N NaOH in a similar way until no visible particles remain.

Rinse the probe liner with 0.1 N NaOH. While squirting 0.1 N NaOH into the upper end of the probe, tilt and rotate the probe so that all inside surfaces will be wetted with the rinse solution. Let the 0.1 N NaOH drain from the lower end into the sample container. The tester may use a funnel (glass or polyethylene) to aid in transferring the liquid washes to the container. Follow the wash with a probe brush. Holding the probe in an inclined position, insert 0.1 NNaOH into the upper end as the probe brush is being moved with a twisting action through the probe,. Hold the sample container underneath the lower end of the probe, and catch any liquid and particulate matter brushed from the probe. Run the wash through the probe three times or more until no visible particulate matter is carried out with the rinse or until none remians in the probe liner on visual inspection. With stainless steel or metal probes, run the brush through in the above prescribed manner at least six times since metal probes have small crevice in which particulate matter can be entrapped. Rinse the brush with 0.1 N NaOH, and quantitatively collect these washings in the sample container. After the brushing, make a final rinse of the probe as described above.

It is recommended that two people clean the probe to minimize sample losses. Between sampling runs, keep brushes clean and protected from contamination.

After ensuring that all joints have been wiped clean of silicone grease, brush and rinse with 0.1 NN NaOH the inside of the front half of the filter holder. Brush and rinse each surface three times or more if needed to

remove visible particulate. Make a final rinse of the brush and filter holder. Carefully brush and rinse out the glass cyclone, also (if applicable). After all washings and particulate matter have been collected in the sample container, tighten the lid so that liquid will not leak out when it is shipped to the laboratory. Mark the height of the fluid level to determine whether leakage occurs during transport. Label the container to clearly identify its contents.

Rinse the glassware a final time with deionized distilled water to remove residual NaOH before reassembling. Do not save the rinse water.

4.2.3 Container No. 3 (Silica Gel). Note the color of the indicating silica gel to determine whether it has been completely spent and make a notation of its condition. Transfer the silica gel from the sixth impinger to its original container and seal. The tester may use as aids a funnel to pour the silica gel and a rubber policeman to remove the silica gel from the impinger. It is not necessary to remove the small amount of particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use any water or other liquids to transfer the silica gel. If a balance is available in the field, the tester may follow the procedure for Container No. 3 in section 4.5 (Analysis).

4.2.4 Container No. 4 (Arsenic Sample). Clean each of the first two impingers and connecting glassware in the following manner:

1. Wipe the impinger ball joints free of silicone grease and cap the joints.

2. Weigh the impinger and liquid to within $\pm$ 0.5 g. Record in the log the weight of liquid along with a notation of any color or film observed in the impinger catch. The weight of liquid is needed along with the silica gel data to calculate the stack gas moisture content.

3. Rotate and agitate each impinger, using the impinger contents as a rinse solution

4. Transfer the liquid to Container No. 4. Remove the outlet ball-joint cap, and drain the contents through this opening. Do not separate the impinger parts (inner and outer tubes) while transferring their contents to the cylinder.

5. (Note: In steps 5 and 6 below, measure and record the total amount of 0.1 N NaOH used for rinsing.) Pour approximately 30 ml of 0.1 NaOH

into each of the first two impingers and agitate the impingers. Drain the 0.1 N NaOH through the outlet arm of each impinger into Container No. 4. Repeat this operation a second time; inspect the impingers for any abnormal conditions.

6. Wipe the ball joints of the glassware connecting the impingers and the back half of the filter holder free of silicone grease, and rinse each piece of glassware twice with 0.1 N NaOH; transfer this rinse into Container No. 4. (Do not rinse or brush the glass-fritted filter support.) Mark the height of the fluid level to determine whether leakage occurs during transport. Label the container to clearly identify its contents.

4.2.5 Container No. 5 (SO_2 Impinger Sample). Because of the large quantity of liquid involved, the tester may place the solutions from the third, fourth, and fifth impingers in separate containers. However, the tester may recombine them at the time of analysis in order to reduce the number of analyses required. Clean the impingers according to the six-step procedure described under Container No. 4 using deionized distilled water instead 0.1 N NaOH as the rinsing liquid.

4.2.6 Blanks. Save a portion of the 0.1 NaOH used for cleanup as a blank. Take 200 ml of this solution directly from the wash bottle being used and place it in a plastic sample container labeled "NaOH blank." Also save samples of the deionized distilled water an 10 percent H_2O_2, and place in separate containers labeled "H_2O blank" and "H_2O_2 blank," respectively.

4.3 Arsenic Sample Prepartion.

4.3.1 Container No. 1 (Filter). Place the filter and loose particulate matter in a 150-ml beaker. Also, add the filtered material from Container No. 2 (see section 4.3.3). Add 50 ml of 0.1 N NaOH. Then stir and warm on a hot plate at low heat (do not boil) for about 15 min. Filter the solution through the Watman No. 41 filter paper. Wash with hot water and catch the filtrate in a clean 150-ml beaker. Boil the filtrate and evaporate to dryness. Cool, add 5 ml of 50 percent HNO_3, and then warm and stir. Allow to cool. Transfer to a 50-ml volumetric flask, dilute to volume with deionized distilled water, and mix well.

If there are any solids retained by the filter, place the filter in a PARR acid digestion bomb and add 5 ml each of concentrated HNO_3 and HF acids. Seal the bomb and heat it in an oven at 150°C for 5 hours.

Remove the bomb from the oven and allow it to cool. Quantitatively transfer the content of the bomb to a 50-ml polypropylene volumetric flask and dilute to exactly 50 ml with deionized distilled water.

4.3.2 Container No. 4 (Arsenic Impinger Sample).

Note: Prior to analysis, check the liquid level in Containers NO. 2 and NO. 4; confirm as to whether or not leakage occurred during transport on the analysis sheet. If a noticeable amount of leakage occurred, either void the sample or take steps, subject to the approval of the Administrator, to adjust the final results.

Transfer the contents of Container No. 4 to a 500-ml volumetric flask and dilute to exactly 500 ml with deionized distilled water. Pipet 50 ml of the solution into a 150-ml beaker. Add 10 ml of concentrated HNO_3, bring to a boil, and evaporate to dryness. Allow to cool, add 5 ml of 50 percent HNO_3, and then warm and stir. Allow the solution to cool, transfer to a 50-ml volumetric flask, dilute to volume with dionized distilled water, and mix well.

4.3.3 Container No. 2 (Probe Wash). See note in 4.3.2 above. Filter (using Whatman No. 41) the contents of Container No. 2 into a 200-ml volumetric flask. Combine the filtered material with the contents of Container No. 1 (Filter).

Dilute the filtrate to exactly 200 ml with dionized distilled water. Then pipet 50 ml into a 150-ml beaker. Add 10 ml of concentrated HNO_3, bring to a boil, and evaporate to dryness. Allow to cool, add 5 ml of 50 percent HNO_3, and then warm and stir. Allow the solution to cool, transfer to a 50--ml volumetric flak, dilute to volume with deionized distilled water, and mix well.

4.3.4 Filter Blank. Determine a filter blank using two filters from each lot of filters used in the sampling train. Cut each filter into strips and treat each filter individually as directed in section 4.3.1, beginning with the sentence, "Add 50 ml of 0.1 N NaOH."

4.3.5 0.1 N NaOH and Water Blanks. Treat separately 50 ml of 0.1 N NaOH and 50 ml deionized distilled water, as directed under section 4.3.2, beginning with the sentence, "Pipet 50 ml of the solution into a 150-ml beaker."

4.4 Spectrophotometer Preparation. Turn on the power; set the wavelength, slit width, and lamp current; and adjust the background corrector as instructed by the manufacturer's manual for the particular atomic

absorption spectrophotometer. Adjust the burner and flame characteristic as necessary.

4.5 Analysis.

4.5.1 Arsenic Determination. Prepare standard solutions as directed under section 5.1 and measure their absorbances against 0.8 N HNO_3. Then, determine the absorbances of the filter blank and each sample using 0.8 N HNO_3 as a reference. If the sample concentration falls outside the range of the calibration curve, make an appropriate dilution with 0.8 N HNO_3 so that the final concentration falls within the range of the curve. Determine the As concentration in the filter blank (i.e., the average of the two blank values from each lot). Next, using the appropriate standard curve, determine the As concentration in each sample fraction.

4.5.1.1 Arsenic Determination at Low Concentration. The lower limit of flame atomic absorption spectrophotometry is 10 µg As/ml. If the As concentration is a lower level, use the vapor generator, which is available as an accessory component. Follow the manufacturer's instructions in the use of such equipment. Place a sample containing between 0 and 5 µg of As in the reaction tube and dilute to 15 ml with deionized distilled water. Since there is some trial and error involved in this procedure, it may be necessary to screen the samples by conventional atomic absorption until an approximate concentration is determined. After determining the approximate concentration, adjust the volume of the sample accordingly, Pipet 15 ml of concentrated HCl into each tube. Add 1 ml of 30 percent KI solution. Place the reaction tube into a 50°C water bath for 5 min. Cool to room temperature. Connect the reaction tube to the vapor generator assembly. When the instrument response has returned to baseline, inject 5.0 ml of 5 percent $NaBH_4$ and integrate the resulting spectrophotometer signal over a 30-second time period.

4.5.1.2 Mandatory Check for Matrix Effects on the Arsenic Results. Since the analysis for As by atomic absorption is sensitive to the chemical composition and to the physical properties (viscosity, pH) of the sample (matrix effects), check (mandatory) at least one sample from each source using the "Method of Additions."

Three acceptable "Method of Additions" procedures are described in the "General Procedure Section" of the Perkin Elmer Corporation Manual (Citation 2 in section 7). If the results of the Method of Additions procedure on the source sample do not agree to within 5 percent of the value

obtained by the routine atomic absorption analysis, then reanlyze all samples from the source using the Method of Additions procedure.

4.5.2 Container No. 5. (So_2 Impinger Sample). Observe the level of liquid in Container No. 5 and confirm whether any sample was lost during shipping. Note any loss of liquid on the analytical data sheet. If a noticeable amount of leakage occurred, either void the sample or use methods subject to the approval of the Administrator, to adjust the final results.

Transfer the contents of the container(s) No. 5 to 1-liter volumetric flask and dilute to exactly 1.0 liter with deionized distilled water. Pipet 10 ml of this solution into a 250-ml Erlenmeyer flask and add two to four drops of phenolphthalein indicator. Titrate the sample to a faint pink endpoint using 1 N NaOH. Repeat and average the titration volumes. Run a blank with each series of samples.

4.5.3 Container No. 3 (Silica Gel). The tester may conduct this step in the field. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g; record this weight.

5. Calibration

Maintain a laboratory log of all calibrations.

5.1 Standard Solutions. Pipet 1, 3, 5, 8, and 10 ml of the 1.0-mg As/ml stock solution into separate 100-ml volumetric flasks, each containing 5 ml of concentrated HNO_3. Dilute to the mark with deioniized distilled water. If the low-level procedure is used, pipet 1, 2, 3, and 5 ml of 1.0 µg As/ml standard solution into the separate flasks. Then treat them in the same manner as the sample (section 4.3.4).

Check these absorbances frequently against 0.8 N HNO_3 (reagent blank) during the analysis to insure that base-line drift has not occurred. Prepare a standard curve of absorbance versus concentration. (Note: For instruments equipped with direct concentration readout devices, preparation of a standard curve will not be necessary.) In all cases, follow calibration and operational procedures in the manufacturer's instruction manual.

5.2 Sampling Train Calibration. Calibrate the sampling train components according to the indicated sections of Method 5: Probe Nozzle (section 5.1), Pitot Tube Assembly (section 5.2), Metering System (section 5.3), Probe Heater (section 5.4), Temperature Gauges (section 5.5), Leak Check of Metering System (section 5.6), and Barometer (section 5.7).

5.3 1 N Sodium Hydroxide Solution. Standardize the NaOH titrant against 25 ml off standard 1.0 N H_2SO_4.

6. Caiculations

6.1 Nomenclature

B_{ws} = Water in the gas stream, proportion by volume.

C_a = Concentration of A_s as read from the standard curve, µg/ml.

C_{SO2} = Concentration of SO_2, percent of volume.

C_s = Arsenic concentration in stack gas, dry basis, converted to standard conditions, g/dscm (g/dscf).

E_a = Arsenic mass emission rate, g/hr.

F_d = Dilution factor (equals 1 if the sample has not been diluted).

I = Percent of isokinetic sampling.

M_{bi} = Total mass of all six impingers and contents before sampling, g.

M_{fi} = Total mass of all six impingers and contents after sampling, g.

M_n = Total mass of As collected in a specific part of the sampling train, µg

M_{SO2} = Mass of SO_2 collected in the sampling train, g.

M_t = Total mass of A_s collected in the sampling train, µg.

N = Normality of NaOH titrant, meq/ml.

T_m = Absolute average dry gas meter temperature (see Figure 108-2), °K (°R).

V_a = Volume of sample aliquot titrated, ml.

V_m = Volume of gas sample as measured by the dry gas meter, dcm(dcf).

$V_{m(std)}$ = Volume of gas sample as measured by the dry gas meter correlated to standard conditions, scm(scf).

V_{soln} = Total volume of solution in which the SO_2 is contained, liter.

V_{SO2} = Volume of SO_2 collected in the sampling train, dscm(dscf).

V_t = Volume of NaOH titrant used for the sample (average of replicate titrations), ml.

V_{tb} = Volume of NaOH titrant used for the blank, ml.

V_{tot} = Volume of gas sampled corrected to standard conditions, dscm(dscf).

$V_{w(std)}$ = Volume of water vapor collected in the sampling train, corrected to standard conditions, scm(scf).

ΔH = Average pressure differential across the orifice meter (see Figure 108-2), mm H_2O (in. H_2O).

6.2 Calculate the volume of SO_2 gas collected by the sampling train.

$$V_{SO2} = K_1 (V_t - V_{tb}) N (V_{soln}/V_a) \qquad \text{Eq. 108-1}$$

Where:

K_1 = $1.203 \times 10^{-5} m^3/meq.$ for metric units.

K_1 = 4.248×10^{-4} $ft^3/mdq.$ for English units.

6.3 Calculate the sulfur dioxide concentration in the stack gas (dry basis adjusted to standard conditions) as follows:

$$C_{SO2} = \frac{V_{SO2}}{V_{m(std)} + V_{SO2}} \times 100 \qquad \text{Eq. 108-2}$$

6.4 Calculate the mass of sulfur dioxide collected by the sampling train.

$$M_{SO2} = K_2 (V_t - V_{tb}) N (V_{soln}/V_a) \qquad \text{Eq. 108.3}$$

Where:

K_2 = 0.032 g/meq.

6.5 Average dry gas meter temperatures (T_m) and average orifice pressure drop (ΔH). See data sheet (Figure 108-2).

6.6 Dry Gas Volume. Using data from this test, calculate $V_{m(std)}$ by using Eq. 5-1 of Method 5. If necessary, adjust the volume for leakages.

Then, add V_{SO2}.

$$V_{tot} = V_{m(std)} + V_{SO2} \qquad \text{Eq. 108-4}$$

6.7 Volume of water vapor.

$$V_{w(std)} = K_3 (M_{fi} - M_{bi} - M_{SO2}) \qquad \text{Eq. 108-5}$$

Where:

K_3 = 0.001334 m^3/g for metric units.
= 0.047012 ft^3/g for English units.

6.8 Moisture content.

$$B_{ws} = \frac{V_{w(std)}}{V_{tot} + V_{w(std)}} \qquad \text{Eq. 108-6}$$

6.9 Amount of As collected.

6.9.1 Calculate the amount of As collected in each part of sampling train, as follows:

$$M_n = C_a F_d V_{soln} \qquad \text{Eq. 108-7}$$

6.9.2 Calculate the total amount of As collected in the sampling train as follows:

$$M_t = M_n \text{ (filters)} + M_n \text{ (probe)} + M_n \text{ (impingers)} - M_n \text{ (filter blank)} - M_n \text{ (NaOH)} - M_n (H_2O) \qquad \text{Eq. 108-8}$$

6.10 Calculate the As concentration in the stack gas (dry basis, adjusted to standard conditions) as follows:

$$C_s = K_4 (M_t/V_{m(std)} \qquad \text{Eq. 108-9}$$

Where:

$K_4 = 10^{-6}$ g/µg

6.11 Pollutant Mass Rate. Calculate the As mass emission rate using the following equation.

$$E_a = C_s Q_{sd} \qquad \text{Eq. 108-10}$$

The volumetric flow rate, Q_{sd}, should be calculated as indicated in Method 2.

6.12 Isokinetic Variation. Using data from this test, calculate I. Use Eq. 5-8 of Method 5, except substitute V_{tot} for $V_{m(std)}$.

6.13 Acceptable Results. Same as Method 5, section 6.12.

7. Bibliography

1. Same as Citations 1 through 9 of section 7 of Method 5.

2. Perkin Elmer Corporation. Analytical Methods for Atomic Absorption Spectrophotometry. Norwalk, Connecticut. September 1976.

3. Annual Book of ASTM Standards. Part 31; Water, Atmospheric Analysis. American Society for Testing and Materials. Philadelphia, PA. 1974. pp. 40-42.

APPENDIX D

Procedures for Processing and Analysis of PAH in Coke Oven Emissions from Kaiser Steel

Global Geochemistry Corporation

1.0 Samples expected

1.1 Connective tubes between section welded to oven port cover and remainder of sampling system - These are to be stainless steel tubing, disconnected and capped off for each sample. They will be about 10'-15' long.

1.2 Impingers, in series, first two water-filled, third dry - The center tubes will be removed and wrapped in clean foil, and the impingers stoppered as is, for shipping. One set for each sample. Protect from light during shipping.

2.0 Extraction procedure

Sample fractions are to be covered with foil or in opaque containers, with inert gas flush, during storage in freezer. Solvents used in extraction will be B&J glass distilled pesticide grade (low residue). Working bench area will be screened with amber plastic and light bulbs.

2.1 Connective tubes will be rinsed with dichloromethane by partial filling, capping, tilting several times, and draining into a beaker. This will be repeated until the washings are colorless, but at least three times.

2.2 Impinger contents will be transferred to a separatory funnel. The impingers and center tubes will be rinsed into the funnel, using a measured amount of dichloromethane in portions. The funnel is shaken well and the extract drawn. The rinsing and shaking is repeated with two more portions of solvent. The extracts and washings are combined over Na_2SO_4.

A separate portion of the water used for impingers is extracted in the same way.

For each liter of water, 100 ml dichloromethane will be used per extraction, i.e., 300 ml total.

Internal standard is added to the combined extracts at this point

3.0 Concentration of extracts

Bulk solvent is removed on a rotary evaporator in a water bath at not over 40°, stopping short of dryness. The residual volume should be just less than the final volume to which the solution is to be diluted (accurately). The object is a final solution with roughly five mg/ml solids concentration in dichloromethane. After the volume is made up to the mark in a volumetric flask, an aliquot is removed and evaporated on a tared disk in a nitrogen stream and weighed to determine yields. The remaining solution is stored in a vial or ampoule, sealed with a Teflon-lined septum. A split for SAI QA may be made at this point (see Section 4.3 also).

4.0 Gravity column cleanup chromatogram

4.1 Into a 10 mm i.d. column with coarse sinter and Teflon stopcock, 6 g 120 mesh silica gel (activated at 120°) is slurry packed in pentane, cooling the column (by evaporation from a tissue wrapped around it and wet with acetone). This minimizes vapor gaps in the column. A cap of 3g sodium sulfate is added to the top. The column must not dry out before the chromatogram is complete.

4.2 A sample of the extract concentrate is taken. This is to be based on experience of expected PAH contents, but initially would be 5-10 mg. This is exchanged with pentane by adding 10 ml portions of pentane and evaporating over about 100 mg silica to small volume. Three to five portions of pentane are used. The final residue is rinsed onto the column with pentane.

4.3 The chromatogram is developed with four solvent steps:

1. 25 ml pentane
2. 10 ml 20% dichloromethane in pentane
3. 10 ml 50% " " " "
4. 10 ml 50% " " " methanol.

The column volume is approximately 8 cc. This is allowed for while collecting fractions. During the first chromatogram the graduated cylinder collector is observed for visible solvent changes, and a more precise estimate of the column volume.

The four fractions are evaporated in a nitrogen stream at not over 40° to 1.0 ml, then stored under nitrogen in the freezer. The principal constituents

of the fractions will be:

1. Aliphatics
2. Lower molecular weight PAH
3. Higher " " "
4. Polar materials

Fractions 2 and 3 are to be analyzed by HPLC, the others retained for future interest or in case of an incomplete or defective separation. Splits for SAI QA may also be made from these fractions.

5.0 HPLC Analysis

5.1 The column is a reverse phase partition column, C_{18} bonded to microparticle silica, 4 x 250 mm. The solvent system is a gradient from 60/40 acetonitrile/water to 100% acetonitrile, initial slope setting 1.5%/min. The flow rate is one ml/min, the injection sample volume one to ten µl, depending on concentration. Detectors are UV absorbance and fluorescence, in series. The absorbance is set routinely at 296 nm, but may be varied in certain instances to aid in identification of peaks. The fluorescence filters are narrow pass excitation at 360 nm and cut-off emission above 410 nm. Both detectors are recorded simultaneously.

5.2 Reference calibration is based initially on individual chromatograms of single compounds, and routinely interspersed chromatograms of multicomponent reference mixtures. The proposed calibration standards are the following, at minimum:

Phenathrene
Pyrene
Chrysene
Perylene
Benzo(a)pyrene
Benzo (ghi)perylene
Indeno (1,2,3, cd) pyrene
Coronene.

The internal standards (added in Section 2.2) are

9,10-Dimethylanthracene
9-Phenylanthracene
9,10-Diphenylanthracene

6.0 Peak Identification

Significant peaks not recognizable as present in the reference standard will be investigated by alternate methods for identification.

6.1 Stopped-flow examination of UV absorbance for maxima by manual wavelength variation allows checking against known reference spectra (published or measured). This is usually sufficient confirm a component already suspected to be present.

6.2 Collection of the fraction containing the unknown peak allows later determination of the full absorbance and/or the fluorescence spectrum, for comparison with reference compounds.

6.3 If not already run on GC/MS, the sample can be sent to SAI for that purpose, possibly allowing the component to be identified. Since the HPLC elution order is not the same as the GC retention sequence, it may be necessary in ambiguous cases to collect the HPLC fraction and run it separately by GC/MS.

There may be numerous minor constituents not identified. The decision on how many of these to track down and identify will be made in consultation with CARB advisors and with SAI, since at some point the returns are not worth further expense.

6.4 Identified peaks are quantified by comparing their areas to the areas of the known concentrations of reference compounds. A recovery factor based on the added internal standard nearest in elution order to the sample component is then applied; the amount of internal standard originally added to the sample is divided by the amount found in the HPLC analysis. This ratio is the multiplier used to correct for losses in concentration and chromatography steps.

7.0 Quality Assurance

7.1 Transmittal of sample splits to SAI provides for external QA. This should be done with 15% (or one in seven) of all samples.

7.2 Blank water extracts are carried through the same analytical procedure (10% of total).

7.3 The cleanup and HPLC analysis are duplicated on 15% (or one in seven) of all extracts.

7.4 The multicomponent reference is run first every day, then elution volumes and peak areas for each component are plotted on a control chart, to pinpoint developing problems. At least every tenth chromatogram will be this standard. It will also be rerun after any service on the instrument, such as a column change.

APPENDIX E

Gas chromatography/mass spectrometry protocols used by SAI Trace Organic Chemistry Laboratory.

Aliquots of samples received from Global Geochemistry Corporation were analyzed by combined gas chromatography mass spectrometry (GC/MS). Liquid extracts were spiked with an internal standard compound (deuterium-labeled phenanthrene) prior to analysis by gas chromatography mass spectrometry. A Finnigan model 4021 Quadrupole GC/MS system including an Incos data system was used for all analysis. Liquid samples (1 microliter) were injected into a 30-miter x 0.25-mm I.D. SE-54 fused silica open tubular gas chromatography column (J&W Scientific). A programmed GC oven rate of a 4 minute hold at 30°C followed by a 40°C/min temerature increase to 160°C and a 8°C/min temperature increase to 270°C was used for sample analysis. The detector system was a quadrupole mass spectrometer operated in the electron ionization mode at 70eV. The quadrupole mass filter was scanned from 35 to 475 atomic mass units in 0.95 seconds. A hold time of 0.05 seconds was used to stabilize the electronics prior to the next scan. Data were continuously acquired using a Finnigan Incos Data system, which writes time intensity mass spectral data to a magnetic disc. The mass spectrometer was operated under computer control during acquisition. Figures 3.3-7 through 3.3-9 show the total ionization chromatograms for each of the three samples that were analyzed.

Following analyses, the data files were searched for priority pollutant polynuclear aromatic hydrocarbons (PNA's). In addition to the quantitative data reduction used for priority pollutant PNA's, a survey analysis was performed on all significant GC peaks (i.e., signal to noise of greater than 10:1). The survey analysis was based upon a computerized library search of individual background subtracted, peak maxima scans for qualifying GC peaks. The library used for qualitative identification was a combined NIH/EPA National Bureau of Standards library which contains approximately 26,000 entries.

Tables 3.3-11 through 3.3-13 present the results of this survey analysis. As expected, a series of alkyl substituted PNA's were observed in addition to heterocyclic compounds containing nitrogen and sulfur moieties. Further investigation of the mass spectra of the nitrogen substituted identifications confirmed the presence of benzonitrile, isoquinoline and/or quinoline, acridine, carbazole and alkyl substituted pyridines. Ion specific searches for N-nitroso substituted amines were negative.

APPENDIX F

Detailed Fiber and Mass Concentration Data - Johns Manville

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: A16B

Manville
D-2 Baghouse
7/23 @ 3:47 -
6:33

TOTAL AREA SCANNED = 18300.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 2.570000 CUBIC METERS
TOTAL FIBERS COUNTED = 26.0 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		23.0	2.0	25.0
PERCENT TOTAL FIBERS		88.462%	7.692%	96.154%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		1.4956E+06	1.3005E+05	1.6257E+06
(FIBERS PER CUB METER OF AIR)		5.8196E+05	5.0605E+04	6.3256E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.7281E+06	1.4181E+07	1.5909E+07
(SQ CM PER CUB METER OF AIR)		6.7240E+05	5.5179E+06	6.1903E+06
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		2.8405E+05	9.8715E+06	1.0156E+07
(PGRAMS PER CUB METER OF AIR)		1.1052E+05	3.8410E+06	3.9516E+06
LENGTH (MICRONS)	MEAN	1.6696	44.3333	6.5923
	STD DEV	0.9411	39.9694	19.2589
	MEAN LOG	0.3268	3.3012	0.6700
	GEOM MN	1.3865	27.1442	1.9542
	COEF VAR	0.9031	1.8088	2.2544
DIAMETER (MICRONS)	MEAN	0.1983	0.7500	0.2619
	STD DEV	0.1050	0.5612	0.2778
	MEAN LOG	-1.7368	-0.6675	-1.6134
	GEOM MN	0.1761	0.5130	0.1992
	COEF VAR	0.6094	1.5768	0.9125
AREA (SQ MIC)	MEAN	1.1554	104.7368	13.1071
	STD DEV	0.9690	76.5366	42.0935
	MEAN LOG	-0.1900	3.7924	0.2695
	GEOM MN	0.8269	44.3610	1.3093
	COEF VAR	1.3499	4.7319	4.0405
VOLUME (CUB MIC)	MEAN	0.0730	24.1981	2.8567
	STD DEV	0.1090	18.2077	9.8828
	MEAN LOG	-3.3884	1.7246	-2.7985
	GEOM MN	0.0338	5.6103	0.0609
	COEF VAR	2.4700	12.5883	7.9909

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A10B

Manville
D-2 Baghouse
7/23 @ 3:47 -
6:33

TOTAL AREA SCANNED = 18300.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 2.570000 CUBIC METERS
TOTAL FIBERS COUNTED = 26.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		25.0	1.0	0.0	0.0	0.0	26.0
PERCENT TOTAL FIBERS		96.154%	3.846%	0.000%	0.000%	0.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		1.6257E+06	6.5027E+04	0.0000E+00	0.0000E+00	0.0000E+00	1.6907E+06
(FIBERS PER CUB METER OF AIR)		6.3256E+05	2.5302E+04	0.0000E+00	0.0000E+00	0.0000E+00	6.5786E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.5909E+07	6.3840E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
(SQ CM PER CUB METER OF AIR)		6.1903E+06	2.4841E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		1.0156E+07	2.2983E+02				
(PGRAMS PER CUB METER OF AIR)		3.9516E+06	8.9426E+01				
LENGTH (MICRONS)	MEAN	6.5923	0.6000	0.0000	0.0000	0.0000	6.3704
	STD DEV	19.2589	0.0000	0.0000	0.0000	0.0000	18.9328
	MEAN LOG	0.6700	-0.5108	0.0000	0.0000	0.0000	0.6262
	GEOM MN	1.9542	0.6000	0.0000	0.0000	0.0000	1.8706
	COEF VAR	2.2544	0.0000	0.0000	0.0000	0.0000	2.2518
DIAMETER (MICRONS)	MEAN	0.2619	0.0500	0.0000	0.0000	0.0000	0.2541
	STD DEV	0.2778	0.0000	0.0000	0.0000	0.0000	0.2755
	MEAN LOG	-1.6134	-2.9957	0.0000	0.0000	0.0000	-1.6646
	GEOM MN	0.1992	0.0500	0.0000	0.0000	0.0000	0.1893
	COEF VAR	0.9125	0.0000	0.0000	0.0000	0.0000	0.9892
AREA (SQ MIC)	MEAN	13.1071	0.0982	0.0000	0.0000	0.0000	12.6253
	STD DEV	42.0935	0.0000	0.0000	0.0000	0.0000	41.3797
	MEAN LOG	0.2695	-2.3210	0.0000	0.0000	0.0000	0.1735
	GEOM MN	1.3093	0.0982	0.0000	0.0000	0.0000	1.1895
	COEF VAR	4.0405	0.0000	0.0000	0.0000	0.0000	4.2643
VOLUME (CUB MIC)	MEAN	2.8567	0.0012	0.0000	0.0000	0.0000	2.7509
	STD DEV	9.8828	0.0000	0.0000	0.0000	0.0000	9.7131
	MEAN LOG	-2.7985	-6.7439	0.0000	0.0000	0.0000	-2.9446
	GEOM MN	0.0609	0.0012	0.0000	0.0000	0.0000	0.0526
	COEF VAR	7.9909	0.0000	0.0000	0.0000	0.0000	8.7798

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: A10A

Manville
D-2 Baghouse
7/23 @ 3:47 -
6:33

TOTAL AREA SCANNED = 18300.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 2.570000 CUBIC METERS
TOTAL FIBERS COUNTED = 19.5 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		13.0	4.5	17.5
PERCENT TOTAL FIBERS		66.667%	23.077%	89.744%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		8.4536E+05	2.9262E+05	1.1380E+06
(FIBERS PER CUB METER OF AIR)		3.2893E+05	1.1386E+05	4.4279E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.5585E+06	1.5970E+07	1.7529E+07
(SQ CM PER CUB METER OF AIR)		6.0643E+05	6.2141E+06	6.8206E+06
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		4.7881E+05	8.5356E+06	9.0144E+06
(PGRAMS PER CUB METER OF AIR)		1.8631E+05	3.3213E+06	3.5076E+06
LENGTH (MICRONS)	MEAN	1.6077	30.2857	11.6450
	STD DEV	0.8508	19.2852	17.8254
	MEAN LOG	0.3430	3.1226	1.3159
	GEOM MN	1.4092	22.7047	3.7280
	COEF VAR	0.6617	1.3045	3.3615
DIAMETER (MICRONS)	MEAN	0.2608	0.7571	0.4345
	STD DEV	0.2046	0.5261	0.4244
	MEAN LOG	-1.5813	-0.4436	-1.1831
	GEOM MN	0.2057	0.6417	0.3063
	COEF VAR	0.9211	0.6882	1.2637
AREA (SQ MIC)	MEAN	1.8436	62.0128	22.9028
	STD DEV	2.5553	43.2570	38.5068
	MEAN LOG	-0.0116	3.8551	1.3417
	GEOM MN	0.9885	47.2344	3.8257
	COEF VAR	1.7962	1.2130	6.9722
VOLUME (CUB MIC)	MEAN	0.2178	11.5080	4.1974
	STD DEV	0.4685	9.6330	7.8760
	MEAN LOG	-3.0611	1.9937	-1.2919
	GEOM MN	0.0468	7.3427	0.2747
	COEF VAR	4.0979	1.9114	15.7316

FIBER AIRD MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: A1OTEM

Manville
D-2 Baghouse
7/23 @ 3:47 -
6:33

TOTAL AREA SCANNED = 96875.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION =1.00000 PARTS
AREA OF TEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 2.573000 CUBIC METERS
TOTAL FIBERS COUNTED = 106.5 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		88.0	4.0	92.0
PERCENT TOTAL FIBERS		82.629%	3.756%	86.385%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		1.0810E+06	4.9135E+04	1.1301E+06
(FIBERS PER CUB METER OF AIR)		4.2012E+05	1.9097E+04	4.3922E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		7.6395E+05	9.7370E+05	1.7377E+06
(SQ CM PER CUB METER OF AIR)		2.9691E+05	3.7843E+05	6.7534E+05
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		8.5506E+04	4.1677E+05	5.0228E+05
(PGRAMS PER CUB METER OF AIR)		3.3232E+04	1.6198E+05	1.9521E+05
LENGTH (MICRONS)	MEAN	1.5633	14.8400	2.2621
	STD DEV	1.1476	7.6277	3.6193
	MEAN LOG	0.1921	2.5992	0.3188
	GEOM MN	1.2118	13.4529	1.3755
	COEF VAR	1.0539	0.5044	1.4301
DIAMETER (MICRONS)	MEAN	0.1176	0.4300	0.1340
	STD DEV	0.0669	0.3280	0.1215
	MEAN LOG	-2.3103	-1.1254	-2.2480
	GEOM MN	0.0992	0.3245	0.1056
	COEF VAR	0.8361	1.0875	0.9534
AREA (SQ MIC)	MEAN	0.7052	22.0736	1.8298
	STD DEV	0.8218	20.4266	6.7355
	MEAN LOG	-0.9243	2.6350	-0.7370
	GEOM MN	0.3968	13.9436	0.4786
	COEF VAR	2.1005	1.5968	2.9580
VOLUME (CUB MIC)	MEAN	0.0301	3.4793	0.2117
	STD DEV	0.0558	3.8957	1.1811
	MEAN LOG	-4.6701	0.1669	-4.4187
	GEOM MN	0.0094	1.1728	0.0120
	COEF VAR	4.3401	4.1845	6.2770

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A10A

Manville
D-2 Baghouse
7/23 @ 3:47 -
6:33

TOTAL AREA SCANNED = 18300.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 2.570000 CUBIC METERS
TOTAL FIBERS COUNTED = 19.5 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		17.5	2.0	0.0	0.0	0.0	19.5
PERCENT TOTAL FIBERS		89.744%	10.256%	0.000%	0.000%	0.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		1.1380E+06	1.3005E+05	0.0000E+00	0.0000E+00	0.0000E+00	1.2680E+06
(FIBERS PER CUB METER OF AIR)		4.4279E+05	5.0605E+04	0.0000E+00	0.0000E+00	0.0000E+00	4.9340E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.7529E+07	3.3963E+04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
(SQ CM PER CUB METER OF AIR)		6.8206E+06	1.3215E+04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		9.0144E+06	2.9877E+03				
(PGRAMS PER CUB METER OF AIR)		3.5076E+06	1.1625E+03				
LENGTH (MICRONS)	MEAN	11.6450	0.6000	0.0000	0.0000	0.0000	10.6409
	STD DEV	17.8254	0.0000	0.0000	0.0000	0.0000	17.2899
	MEAN LOG	1.3159	-0.5108	0.0000	0.0000	0.0000	1.1498
	GEOM MN	3.7280	0.6000	0.0000	0.0000	0.0000	3.1576
	COEF VAR	3.3615	0.0000	0.0000	0.0000	0.0000	3.4784
DIAMETER (MICRONS)	MEAN	0.4345	0.1250	0.0000	0.0000	0.0000	0.4064
	STD DEV	0.4244	0.0250	0.0000	0.0000	0.0000	0.4144
	MEAN LOG	-1.1831	-2.0999	0.0000	0.0000	0.0000	-1.2665
	GEOM MN	0.3063	0.1225	0.0000	0.0000	0.0000	0.2818
	COEF VAR	1.2637	0.2247	0.0000	0.0000	0.0000	1.2810
AREA (SQ MIC)	MEAN	22.9028	0.2611	0.0000	0.0000	0.0000	20.8445
	STD DEV	38.5068	0.0569	0.0000	0.0000	0.0000	37.2874
	MEAN LOG	1.3417	-1.3670	0.0000	0.0000	0.0000	1.0955
	GEOM MN	3.8257	0.2549	0.0000	0.0000	0.0000	2.9907
	COEF VAR	6.9722	0.2481	0.0000	0.0000	0.0000	7.3987
VOLUME (CUB MIC)	MEAN	4.1974	0.0077	0.0000	0.0000	0.0000	3.8165
	STD DEV	7.8760	0.0029	0.0000	0.0000	0.0000	7.6055
	MEAN LOG	-1.2919	-4.9521	0.0000	0.0000	0.0000	-1.6247
	GEOM MN	0.2747	0.0071	0.0000	0.0000	0.0000	0.1970
	COEF VAR	15.7316	0.5000	0.0000	0.0000	0.0000	16.9486

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A1OTEM

Manville
D-2 Baghouse
7/23 @ 3:47 -
6:33

TOTAL AREA SCANNED = 96875.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF TEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 2.573600 CUBIC METERS
TOTAL FIBERS COUNTED = 106.5 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		92.0	10.5	4.0	0.0	0.0	106.5
FRACTION TOTAL FIBERS		86.385%	9.859%	3.756%	0.000%	0.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		1.1301E+06	1.2898E+05	4.9135E+04	0.0000E+00	0.0000E+00	1.3082E+06
(FIBERS PER CUB METER OF AIR)		4.3922E+05	5.0129E+04	1.9097E+04	0.0000E+00	0.0000E+00	5.0845E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.7377E+06	1.0024E+05	1.4169E+04	0.0000E+00	0.0000E+00	0.0000E+00
(SQ CM PER CUB METER OF AIR)		6.7534E+05	3.8958E+04	5.5067E+03	0.0000E+00	0.0000E+00	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		5.0228E+05	8.8639E+03				
(PGRAMS PER CUB METER OF AIR)		1.9521E+05	3.4449E+03				
LENGTH (MICRONS)	MEAN	2.2621	2.5182	1.7000	0.0000	0.0000	2.2673
	STD DEV	3.6193	3.2178	0.5385	0.0000	0.0000	3.5181
	MEAN LOG	0.3188	0.3873	0.4616	0.0000	0.0000	0.3309
	GEOM MN	1.3755	1.4731	1.5866	0.0000	0.0000	1.3922
	COEF VAR	1.4301	1.6174	0.4943	0.0000	0.0000	1.4191
DIAMETER (MICRONS)	MEAN	0.1340	0.1182	0.0525	0.0000	0.0000	0.1295
	STD DEV	0.1215	0.0321	0.0286	0.0000	0.0000	0.1146
	MEAN LOG	-2.2480	-2.1659	-3.0779	0.0000	0.0000	-2.2699
	GEOM MN	0.1056	0.1147	0.0461	0.0000	0.0000	0.1033
	COEF VAR	0.9534	0.2640	0.6385	0.0000	0.0000	0.9218
AREA (SQ MIC)	MEAN	1.8298	0.9132	0.2884	0.0000	0.0000	1.6821
	STD DEV	6.7355	1.0528	0.2072	0.0000	0.0000	6.2803
	MEAN LOG	-0.7370	-0.5778	-1.4539	0.0000	0.0000	-0.7471
	GEOM MN	0.4786	0.5611	0.2337	0.0000	0.0000	0.4737
	COEF VAR	2.9580	1.5507	0.8393	0.0000	0.0000	2.7610
VOLUME (CUB MIC)	MEAN	0.2117	0.0262	0.0050	0.0000	0.0000	0.1856
	STD DEV	1.1811	0.0295	0.0062	0.0000	0.0000	1.0996
	MEAN LOG	-4.4187	-4.1859	-5.9357	0.0000	0.0000	-4.4506
	GEOM MN	0.0120	0.0152	0.0026	0.0000	0.0000	0.0117
	COEF VAR	6.2770	1.7908	1.8076	0.0000	0.0000	5.7284

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: A9B

Manville
D-2 Baghouse
7/23 @ 2:00 - 3:30

TOTAL AREA SCANNED = 30744.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION =1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 1.500000 CUBIC METERS
TOTAL FIBERS COUNTED = 22.0 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		14.5	7.5	22.0
PERCENT TOTAL FIBERS		65.909%	34.091%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		5.6125E+05	2.9030E+05	8.5155E+05
(FIBERS PER CUB METER OF AIR)		3.7417E+05	1.9353E+05	5.6770E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.9374E+06	7.1501E+06	9.0875E+06
(SQ CM PER CUB METER OF AIR)		1.2916E+06	4.7668E+06	6.0584E+06
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		5.2062E+05	1.9863E+06	2.5069E+06
(PGRAMS PER CUB METER OF AIR)		3.4708E+05	1.3242E+06	1.6713E+06
LENGTH (MICRONS)	MEAN	2.8500	22.9500	10.5808
	STD DEV	1.3652	32.7879	22.5877
	MEAN LOG	0.8894	2.6431	1.5639
	GEOM MN	2.4336	14.0562	4.7773
	COEF VAR	0.6527	1.2704	2.0185
DIAMETER (MICRONS)	MEAN	0.3250	0.4400	0.3692
	STD DEV	0.1630	0.0800	0.1481
	MEAN LOG	-1.2742	-0.8376	-1.1063
	GEOM MN	0.2797	0.4328	0.3308
	COEF VAR	0.7835	0.2007	0.6716
AREA (SQ MIC)	MEAN	3.6192	30.5834	13.9901
	STD DEV	2.7467	40.7245	28.5414
	MEAN LOG	0.8205	2.9694	1.6470
	GEOM MN	2.2716	19.4808	5.1914
	COEF VAR	2.0491	1.2767	3.2862
VOLUME (CUB MIC)	MEAN	0.3749	3.2299	1.4730
	STD DEV	0.3808	4.0270	2.8733
	MEAN LOG	-1.9006	0.7264	-0.8902
	GEOM MN	0.1495	2.0675	0.4106
	COEF VAR	4.3226	1.4084	5.7578

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A9B

Manville
D-2 Baghouse
7/23 @ 2:00-
3:30

TOTAL AREA SCANNED = 30744.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 1.500000 CUBIC METERS
TOTAL FIBERS COUNTED = 22.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		22.0	0.0	0.0	0.0	0.0	22.0
PERCENT TOTAL FIBERS		100.000%	0.000%	0.000%	0.000%	0.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		8.5155E+05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	8.5155E+05
(FIBERS PER CUB METER OF AIR)		5.6770E+05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	5.6770E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		9.0875E+06	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
(SQ CM PER CUB METER OF AIR)		6.0584E+06	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		2.5069E+06	0.0000E+00				
(PGRAMS PER CUB METER OF AIR)		1.6713E+06	0.0000E+00				
LENGTH (MICRONS)	MEAN	10.5808	0.0000	0.0000	0.0000	0.0000	10.5808
	STD DEV	22.5877	0.0000	0.0000	0.0000	0.0000	22.5877
	MEAN LOG	1.5639	0.0000	0.0000	0.0000	0.0000	1.5639
	GEOM MN	4.7773	0.0000	0.0000	0.0000	0.0000	4.7773
	COEF VAR	2.0185	0.0000	0.0000	0.0000	0.0000	2.0185
DIAMETER (MICRONS)	MEAN	0.3692	0.0000	0.0000	0.0000	0.0000	0.3692
	STD DEV	0.1481	0.0000	0.0000	0.0000	0.0000	0.1481
	MEAN LOG	-1.1063	0.0000	0.0000	0.0000	0.0000	-1.1063
	GEOM MN	0.3308	0.0000	0.0000	0.0000	0.0000	0.3308
	COEF VAR	0.6716	0.0000	0.0000	0.0000	0.0000	0.6716
AREA (SQ MIC)	MEAN	13.9901	0.0000	0.0000	0.0000	0.0000	13.9901
	STD DEV	28.5414	0.0000	0.0000	0.0000	0.0000	28.5414
	MEAN LOG	1.6470	0.0000	0.0000	0.0000	0.0000	1.6470
	GEOM MN	5.1914	0.0000	0.0000	0.0000	0.0000	5.1914
	COEF VAR	3.2862	0.0000	0.0000	0.0000	0.0000	3.2862
VOLUME (CUB MIC)	MEAN	1.4730	0.0000	0.0000	0.0000	0.0000	1.4730
	STD DEV	2.8733	0.0000	0.0000	0.0000	0.0000	2.8733
	MEAN LOG	-0.8902	0.0000	0.0000	0.0000	0.0000	-0.8902
	GEOM MN	0.4106	0.0000	0.0000	0.0000	0.0000	0.4106
	COEF VAR	5.7578	0.0000	0.0000	0.0000	0.0000	5.7578

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A9A

Manville
D-2 Baghouse
7/23 @ 2:00 -
3:30

TOTAL AREA SCANNED = 25620.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 1.500000 CUBIC METERS
TOTAL FIBERS COUNTED = 21.5 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		19.5	2.0	0.0	0.0	0.0	21.5
PERCENT TOTAL FIBERS		90.698%	9.302%	0.000%	0.000%	0.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		9.0574E+05	9.2096E+04	0.0000E+00	0.0000E+00	0.0000E+00	9.9863E+05
(FIBERS PER CUB METER OF AIR)		6.0383E+05	6.1931E+04	0.0000E+00	0.0000E+00	0.0000E+00	6.6576E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.8762E+07	2.1013E+05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
(SQ CM PER CUB METER OF AIR)		1.2508E+07	1.4008E+05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		6.8002E+06	6.9057E+04				
(PGRAMS PER CUB METER OF AIR)		4.5335E+06	4.6038E+04				
LENGTH (MICRONS)	MEAN	20.4435	1.5500	0.0000	0.0000	0.0000	18.9320
	STD DEV	61.6628	0.9500	0.0000	0.0000	0.0000	59.3671
	MEAN LOG	1.5111	0.3027	0.0000	0.0000	0.0000	1.4964
	GEOM MN	4.5318	1.2247	0.0000	0.0000	0.0000	4.0814
	COEF VAR	2.7047	1.0412	0.0000	0.0000	0.0000	2.7465
DIAMETER (MICRONS)	MEAN	0.3787	0.3090	0.0000	0.0000	0.0000	0.3724
	STD DEV	0.3091	0.2000	0.0000	0.0000	0.0000	0.3025
	MEAN LOG	-1.2548	-1.4979	0.0000	0.0000	0.0000	-1.2742
	GEOM MN	0.2851	0.2236	0.0000	0.0000	0.0000	0.2796
	COEF VAR	1.1362	1.2361	0.0000	0.0000	0.0000	1.1503
AREA (SQ MIC)	MEAN	31.3795	2.2619	0.0000	0.0000	0.0000	29.0501
	STD DEV	96.2564	2.0577	0.0000	0.0000	0.0000	92.6650
	MEAN LOG	1.4468	-0.0627	0.0000	0.0000	0.0000	1.3260
	GEOM MN	4.2495	0.9392	0.0000	0.0000	0.0000	3.7661
	COEF VAR	5.0173	3.5993	0.0000	0.0000	0.0000	5.1797
VOLUME (CUB MIC)	MEAN	4.1547	0.2478	0.0000	0.0000	0.0000	3.8422
	STD DEV	12.1022	0.2431	0.0000	0.0000	0.0000	11.6565
	MEAN LOG	-1.2460	-3.0346	0.0000	0.0000	0.0000	-1.3836
	GEOM MN	0.2894	0.0481	0.0000	0.0000	0.0000	0.2507
	COEF VAR	10.3934	9.2062	0.0000	0.0000	0.0000	10.8558

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: A9A

Manville
D-2 Baghouse
7/23 @ 2:00 -
3:30

TOTAL AREA SCANNED = 25620.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION =1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 1.500000 CUBIC METERS
TOTAL FIBERS COUNTED = 21.5 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		15.0	4.5	19.5
PERCENT TOTAL FIBERS		69.767%	20.930%	90.698%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		6.9672E+05	2.0902E+05	9.0574E+05
(FIBERS PER CUB METER OF AIR)		4.6448E+05	1.3934E+05	6.0383E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.6414E+06	1.7120E+07	1.8762E+07
(SQ CM PER CUB METER OF AIR)		1.0943E+06	1.1413E+07	1.2508E+07
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		3.8184E+05	6.4184E+06	6.8002E+06
(PGRAMS PER CUB METER OF AIR)		2.5456E+05	4.2789E+06	4.5335E+06
LENGTH (MICRONS)	MEAN	2.5750	61.2857	20.4435
	STD DEV	1.0674	100.4628	61.6628
	MEAN LOG	0.8484	3.0259	1.5111
	GEOM MN	2.3359	20.6118	4.5318
	COEF VAR	0.5924	2.8855	2.7047
DIAMETER (MICRONS)	MEAN	0.2506	0.6714	0.3787
	STD DEV	0.1659	0.3574	0.3091
	MEAN LOG	-1.5833	-0.5038	-1.2548
	GEOM MN	0.2053	0.6042	0.2851
	COEF VAR	0.8724	0.5341	1.1362
AREA (SQ MIC)	MEAN	2.2794	97.8943	31.3795
	STD DEV	1.9650	155.1596	96.2564
	MEAN LOG	0.4611	3.6998	1.4468
	GEOM MN	1.5858	40.4406	4.2495
	COEF VAR	1.4599	2.3111	5.0173
VOLUME (CUB MIC)	MEAN	0.2002	13.1936	4.1547
	STD DEV	0.2782	19.0687	12.1022
	MEAN LOG	-2.5598	1.7767	-1.2400
	GEOM MN	0.0773	5.9100	0.2894
	COEF VAR	3.3286	2.3499	10.9934

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: A9TEM

Manville
D-2 Baghouse
7/23 @ 2:00 -
3:30

TOTAL AREA SCANNED = 93744.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF TEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 1.497090 CUBIC METERS
TOTAL FIBERS COUNTED = 70.5 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		61.5	6.0	67.5
PERCENT TOTAL FIBERS		87.234%	8.511%	95.745%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		7.8069E+05	7.6165E+04	8.5685E+05
(FIBERS PER CUB METER OF AIR)		5.2150E+05	5.0878E+04	5.7238E+05
TOTAL STRUCTURAL AREA (SQ CM PER SQ CM OF FILTER)		8.1259E+05	4.1121E+05	1.2238E+06
(SQ CM PER CUB METER OF AIR)		5.4281E+05	2.7469E+05	8.1750E+05
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		1.2081E+05	5.9226E+04	1.8004E+05
(PGRAMS PER CUB METER OF AIR)		8.0702E+04	3.9563E+04	1.2027E+05
LENGTH (MICRONS)	MEAN	1.7484	10.7333	2.8715
	STD DEV	1.1409	5.7341	3.7522
	MEAN LOG	0.3149	2.2653	0.5587
	GEOM MN	1.3702	9.6339	1.7485
	COEF VAR	1.0958	0.5413	1.6075
DIAMETER (MICRONS)	MEAN	0.1525	0.1989	0.1583
	STD DEV	0.0953	0.1088	0.0983
	MEAN LOG	-2.0788	-1.7869	-2.0423
	GEOM MN	0.1251	0.1675	0.1297
	COEF VAR	0.9164	0.8453	0.9213
AREA (SQ MIC)	MEAN	1.0669	5.9241	1.6741
	STD DEV	1.1922	2.8170	2.1945
	MEAN LOG	-0.5659	1.6349	-0.2908
	GEOM MN	0.5679	5.1283	0.7477
	COEF VAR	2.4620	0.8037	3.0012
VOLUME (CUB MIC)	MEAN	0.0612	0.3494	0.0972
	STD DEV	0.1034	0.3280	0.1786
	MEAN LOG	-4.0842	-1.5500	-3.7675
	GEOM MN	0.0168	0.2122	0.0231
	COEF VAR	5.3300	2.0593	6.0932

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A9TEM

Manville
D-2 Baghouse
7/23 @ 2:00 -
3:30

TOTAL AREA SCANNED = 93744.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF TEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 1.497000 CUBIC METERS
TOTAL FIBERS COUNTED = 70.5 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		67.5	3.0	0.0	0.0	0.0	70.5
PERCENT TOTAL FIBERS		95.745%	4.255%	0.000%	0.000%	0.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		5.6685E+05	3.8082E+04	0.0000E+00	0.0000E+00	0.0000E+00	8.9494E+05
(FIBERS PER CUB METER OF AIR)		5.7238E+05	2.5439E+04	0.0000E+00	0.0000E+00	0.0000E+00	5.9782E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		1.2238E+06	7.5772E+04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
(SQ CM PER CUB METER OF AIR)		8.1750E+05	5.0616E+04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		1.8004E+05	1.7826E+04				
(PGRAMS PER CUB METER OF AIR)		1.2027E+05	1.1908E+04				
LENGTH (MICRONS)	MEAN	2.8715	1.9667	0.0000	0.0000	0.0000	2.8353
	STD DEV	3.7522	0.8179	0.0000	0.0000	0.0000	3.6843
	MEAN LOG	0.5587	0.5802	0.0000	0.0000	0.0000	0.5596
	GEOM MN	1.7485	1.7863	0.0000	0.0000	0.0000	1.7500
	COEF VAR	1.6075	0.5693	0.0000	0.0000	0.0000	1.5686
DIAMETER (MICRONS)	MEAN	0.1583	0.2667	0.0000	0.0000	0.0000	0.1627
	STD DEV	0.0983	0.0943	0.0000	0.0000	0.0000	0.1004
	MEAN LOG	-2.0423	-1.3784	0.0000	0.0000	0.0000	-2.0150
	GEOM MN	0.1297	0.2520	0.0000	0.0000	0.0000	0.1332
	COEF VAR	0.9213	0.3865	0.0000	0.0000	0.0000	0.9274
AREA (SQ MIC)	MEAN	1.6741	1.9897	0.0000	0.0000	0.0000	1.6867
	STD DEV	2.1945	1.4550	0.0000	0.0000	0.0000	2.1707
	MEAN LOG	-0.2908	0.4169	0.0000	0.0000	0.0000	-0.2625
	GEOM MN	0.7477	1.5172	0.0000	0.0000	0.0000	0.7691
	COEF VAR	3.0012	1.0775	0.0000	0.0000	0.0000	2.9489
VOLUME (CUB MIC)	MEAN	0.0972	0.1560	0.0000	0.0000	0.0000	0.0996
	STD DEV	0.1786	0.1567	0.0000	0.0000	0.0000	0.1781
	MEAN LOG	-3.7675	-2.4182	0.0000	0.0000	0.0000	-3.7135
	GEOM MN	0.0231	0.0891	0.0000	0.0000	0.0000	0.0244
	COEF VAR	6.0932	1.8669	0.0000	0.0000	0.0000	6.0223

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: ADB

Manville
(downwind)

TOTAL AREA SCANNED = 6975.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.330000 CUBIC METERS
TOTAL FIBERS COUNTED = 4.0 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		2.0	0.0	2.0
PERCENT TOTAL FIBERS		50.000%	0.000%	50.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		3.4122E+05	0.0000E+00	3.4122E+05
(FIBERS PER CUB METER OF AIR)		1.0247E+03	0.0000E+00	1.0247E+03
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		4.9766E+04	0.0000E+00	4.9766E+04
(SQ CM PER CUB METER OF AIR)		1.4945E+04	0.0000E+00	1.4945E+04
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		2.2889E+03	0.0000E+00	2.2889E+03
(PGRAMS PER CUB METER OF AIR)		6.8736E+02	0.0000E+00	6.8736E+02
LENGTH (MICRONS)	MEAN	0.6000	0.0000	0.6000
	STD DEV	0.1000	0.0000	0.1000
	MEAN LOG	-0.5249	0.0000	-0.5249
	GEOM MN	0.5916	0.0000	0.5916
	COEF VAR	0.1832	0.0000	0.1832
D. METER (MICRONS)	MEAN	0.0750	0.0000	0.0750
	STD DEV	0.0150	0.0000	0.0150
	MEAN LOG	-2.6107	0.0000	-2.6107
	GEOM MN	0.0735	0.0000	0.0735
	COEF VAR	0.2247	0.0000	0.2247
AREA (SQ MIC)	MEAN	0.1458	0.0000	0.1458
	STD DEV	0.0082	0.0000	0.0082
	MEAN LOG	-1.9268	0.0000	-1.9268
	GEOM MN	0.1456	0.0000	0.1456
	COEF VAR	0.0582	0.0000	0.0582
VOLUME (CUB MIC)	MEAN	0.0026	0.0000	0.0026
	STD DEV	0.0006	0.0000	0.0006
	MEAN LOG	-5.9878	0.0000	-5.9878
	GEOM MN	0.0025	0.0000	0.0025
	COEF VAR	0.2677	0.0000	0.2677

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: AGB

Manville
(downwind)

TOTAL AREA SCANNED = 6975.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEN MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.330000 CUBIC METERS
TOTAL FIBERS COUNTED = 4.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		2.0	0.0	2.0	0.0	0.0	4.0
PERCENT TOTAL FIBERS		50.000%	0.000%	50.000%	0.000%	0.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		3.4122E+05	0.0000E+00	3.4122E+05	0.0000E+00	0.0000E+00	6.8244E+05
(FIBERS PER CUB METER OF AIR)		1.0247E+05	0.0000E+00	1.0247E+05	0.0000E+00	0.0000E+00	2.0494E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		4.9766E+04	0.0000E+00	3.8832E+04	0.0000E+00	0.0000E+00	0.0000E+00
(SQ CM PER CUB METER OF AIR)		1.4945E+04	0.0000E+00	1.1661E+04	0.0000E+00	0.0000E+00	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		2.2889E+03	0.0000E+00				
(PGRAMS PER CUB METER OF AIR)		6.8736E+02	0.0000E+00				
LENGTH (MICRONS)	MEAN	0.6000	0.0000	0.5000	0.0000	0.0000	0.5500
	STD DEV	0.1000	0.0000	0.1000	0.0000	0.0000	0.1118
	MEAN LOG	-0.5249	0.0000	-0.7136	0.0000	0.0000	-0.6192
	GEOM MN	0.5916	0.0000	0.4899	0.0000	0.0000	0.5384
	COEF VAR	0.1832	0.0000	0.2247	0.0000	0.0000	0.2322
DIAMETER (MICRONS)	MEAN	0.0750	0.0000	0.0650	0.0000	0.0000	0.0700
	STD DEV	0.0150	0.0000	0.0150	0.0000	0.0000	0.0158
	MEAN LOG	-2.6107	0.0000	-2.7607	0.0000	0.0000	-2.6857
	GEOM MN	0.0735	0.0000	0.0632	0.0000	0.0000	0.0682
	COEF VAR	0.2247	0.0000	0.2649	0.0000	0.0000	0.2610
AREA (SQ MIC)	MEAN	0.1458	0.0000	0.1138	0.0000	0.0000	0.1298
	STD DEV	0.0082	0.0000	0.0470	0.0000	0.0000	0.0374
	MEAN LOG	-1.9268	0.0000	-2.2670	0.0000	0.0000	-2.0969
	GEOM MN	0.1456	0.0000	0.1036	0.0000	0.0000	0.1228
	COEF VAR	0.0582	0.0000	0.5522	0.0000	0.0000	0.4285
VOLUME (CUB MIC)	MEAN	0.0026	0.0000	0.0019	0.0000	0.0000	0.0022
	STD DEV	0.0006	0.0000	0.0011	0.0000	0.0000	0.0010
	MEAN LOG	-5.9878	0.0000	-6.4766	0.0000	0.0000	-6.2322
	GEOM MN	0.0025	0.0000	0.0015	0.0000	0.0000	0.0020
	COEF VAR	0.2677	0.0000	0.9596	0.0000	0.0000	0.7515

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: ABA

Manville
(downwind)

TOTAL AREA SCANNED = 6975.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.330000 CUBIC METERS
TOTAL FIBERS COUNTED = 6.0 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT				
(FIBERS)		2.0	0.0	2.0
PERCENT TOTAL FIBERS		33.333%	0.000%	33.333%
FIBER CONCENTRATION				
(FIBERS PER SQ CM OF FILTER)		3.4122E+05	0.0000E+00	3.4122E+05
(FIBERS PER CUB METER OF AIR)		1.0247E+05	0.0000E+00	1.0247E+05
TOTAL SURFACE AREA				
(SQ CM PER SQ CM OF FILTER)		3.8939E+04	0.0000E+00	3.8939E+04
(SQ CM PER CUB METER OF AIR)		1.1693E+04	0.0000E+00	1.1693E+04
MASS CONCENTRATION				
(PGRAMS PER SQ CM OF FILTER)		1.5573E+03	0.0000E+00	1.5573E+03
(PGRAMS PER CUB METER OF AIR)		4.6766E+02	0.0000E+00	4.6766E+02
LENGTH	MEAN	0.6500	0.0000	0.6500
(MICROMETERS)	STD DEV	0.0500	0.0000	0.0500
	MEAN LOG	-0.4338	0.0000	-0.4338
	GEOM MN	0.6481	0.0000	0.6481
	COEF VAR	0.0801	0.0000	0.0801
DIAMETER	MEAN	0.0550	0.0000	0.0550
(MICROMETERS)	STD DEV	0.0250	0.0000	0.0250
	MEAN LOG	-3.0161	0.0000	-3.0161
	GEOM MN	0.0490	0.0000	0.0490
	COEF VAR	0.6330	0.0000	0.6330
AREA	MEAN	0.1141	0.0000	0.1141
(SQ MICR)	STD DEV	0.0467	0.0000	0.0467
	MEAN LOG	-2.2623	0.0000	-2.2623
	GEOM MN	0.1041	0.0000	0.1041
	COEF VAR	0.5450	0.0000	0.5450
VOLUME	MEAN	0.0018	0.0000	0.0018
(CUB MICR)	STD DEV	0.0013	0.0000	0.0013
	MEAN LOG	-6.7076	0.0000	-6.7076
	GEOM MN	0.0012	0.0000	0.0012
	COEF VAR	1.4689	0.0000	1.4689

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: ABA

Manville
(downwind)

TOTAL AREA SCANNED = 6975.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.330000 CUBIC METERS
TOTAL FIBERS COUNTED = 6.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		2.0	0.0	2.0	0.0	2.0	6.0
PERCENT TOTAL FIBERS		33.333%	0.000%	33.333%	0.000%	33.333%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		3.4122E+05	0.0000E+00	3.4122E+05	0.0000E+00	3.4122E+05	1.0237E+06
(FIBERS PER CUB METER OF AIR)		1.0247E+05	0.0000E+00	1.0247E+05	0.0000E+00	1.0247E+05	3.0740E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		3.8939E+04	0.0000E+00	4.8909E+04	0.0000E+00	2.2844E+05	0.0000E+00
(SQ CM PER CUB METER OF AIR)		1.1693E+04	0.0000E+00	1.4687E+04	0.0000E+00	6.8600E+04	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		1.5573E+03	0.0000E+00				
(PGRAMS PER CUB METER OF AIR)		4.6766E+02	0.0000E+00				
LENGTH (MICRONS)	MEAN	0.6500	0.0000	0.5500	0.0000	1.0500	0.7500
	STD DEV	0.0500	0.0000	0.0500	0.0000	0.4500	0.3403
	MEAN LOG	-0.4338	0.0000	-0.6020	0.0000	-0.0527	-0.3628
	GEOM MN	0.6481	0.0000	0.5477	0.0000	0.9487	0.6957
	COEF VAR	0.0801	0.0000	0.0954	0.0000	0.5811	0.4292
DIAMETER (MICRONS)	MEAN	0.0550	0.0000	0.0750	0.0000	0.1900	0.1067
	STD DEV	0.0250	0.0000	0.0250	0.0000	0.0100	0.0632
	MEAN LOG	-3.0161	0.0000	-2.6492	0.0000	-1.6621	-2.4425
	GEOM MN	0.0490	0.0000	0.0707	0.0000	0.1897	0.0869
	COEF VAR	0.6330	0.0000	0.4142	0.0000	0.0541	0.9530
AREA (SQ MIC)	MEAN	0.1141	0.0000	0.1433	0.0000	0.6695	0.3090
	STD DEV	0.0467	0.0000	0.0609	0.0000	0.2297	0.2910
	MEAN LOG	-2.2623	0.0000	-2.0420	0.0000	-0.4639	-1.5894
	GEOM MN	0.1041	0.0000	0.1298	0.0000	0.6289	0.2041
	COEF VAR	0.5450	0.0000	0.5736	0.0000	0.4298	1.4674
VOLUME (CUB MIC)	MEAN	0.0018	0.0000	0.0028	0.0000	0.0285	0.0110
	STD DEV	0.0013	0.0000	0.0019	0.0000	0.0097	0.0136
	MEAN LOG	-6.7076	0.0000	-6.1419	0.0000	-3.6185	-5.4893
	GEOM MN	0.0012	0.0000	0.0022	0.0000	0.0268	0.0041
	COEF VAR	1.4689	0.0000	1.1909	0.0000	0.4230	3.5899

FIBER AND MASS CONCENTRATION
ASBESTOS DETAIL

SAI SAMPLE ID: ASTEM

Manville
(downwind)

TOTAL AREA SCANNED = 96875.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF TEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.330000 CUBIC METERS
TOTAL FIBERS COUNTED = 16.0 FIBERS

		<= 5 MICRON	> 5 MICRON	ALL CHRYSOTILE
FIBER COUNT (FIBERS)		5.0	0.0	5.0
PERCENT TOTAL FIBERS		31.250%	0.000%	31.250%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		6.1419E+04	0.0000E+00	6.1419E+04
(FIBERS PER CUB METER OF AIR)		1.8444E+04	0.0000E+00	1.8444E+04
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		7.9111E+03	0.0000E+00	7.9111E+03
(SQ CM PER CUB METER OF AIR)		2.3757E+03	0.0000E+00	2.3757E+03
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		3.3324E+02	0.0000E+00	3.3324E+02
(PGRAMS PER CUB METER OF AIR)		1.0007E+02	0.0000E+00	1.0007E+02
LENGTH (MICRONS)	MEAN	0.7100	0.0000	0.7100
	STD DEV	0.3878	0.0000	0.3878
	MEAN LOG	-0.4954	0.0000	-0.4954
	GEOM MN	0.6093	0.0000	0.6093
	COEF VAR	0.7604	0.0000	0.7604
DIAMETER (MICRONS)	MEAN	0.0520	0.0000	0.0520
	STD DEV	0.0264	0.0000	0.0264
	MEAN LOG	-3.0850	0.0000	-3.0850
	GEOM MN	0.0457	0.0000	0.0457
	COEF VAR	0.6749	0.0000	0.6749
AREA (SQ MIC)	MEAN	0.1288	0.0000	0.1288
	STD DEV	0.0974	0.0000	0.0974
	MEAN LOG	-2.3994	0.0000	-2.3994
	GEOM MN	0.0916	0.0000	0.0916
	COEF VAR	1.3465	0.0000	1.3465
VOLUME (CUB MIC)	MEAN	0.0021	0.0000	0.0021
	STD DEV	0.0023	0.0000	0.0023
	MEAN LOG	-6.9069	0.0000	-6.9069
	GEOM MN	0.0010	0.0000	0.0010
	COEF VAR	2.6587	0.0000	2.6587

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: ARTEM

Manville
(downwind)

TOTAL AREA SCANNED = 96875.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION =1.00000 PARTS
AREA OF TEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.330000 CUBIC METERS
TOTAL FIBERS COUNTED = 16.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		5.0	1.0	9.0	0.0	1.0	16.0
PERCENT TOTAL FIBERS		31.250%	6.250%	56.250%	0.000%	6.250%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		6.1419E+04	1.2284E+04	1.1053E+05	0.0000E+00	1.2284E+04	1.9654E+05
(FIBERS PER CUB METER OF AIR)		1.8444E+04	3.6889E+03	3.3200E+04	0.0000E+00	3.6889E+03	5.9022E+04
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		7.9111E+03	8.0269E+02	6.8622E+04	0.0000E+00	1.1751E+03	0.0000E+00
(SQ CM PER CUB METER OF AIR)		2.3757E+03	2.4105E+02	2.0607E+04	0.0000E+00	3.5288E+02	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		3.3324E+02	2.3155E+01				
(PGRAMS PER CUB METER OF AIR)		1.0007E+02	6.9533E+00				
LENGTH (MICRONS)	MEAN	0.7100	0.5000	1.2444	0.0000	0.4000	0.9781
	STD DEV	0.3878	0.0000	2.0330	0.0000	0.0000	1.5751
	MEAN LOG	-0.4954	-0.6931	-0.3833	0.0000	-0.9163	-0.4710
	GEOM MN	0.6093	0.5000	0.6816	0.0000	0.4000	0.6244
	COEF VAR	0.7604	0.0000	1.3583	0.0000	0.0000	1.6766
DIAMETER (MICRONS)	MEAN	0.0520	0.0400	0.0867	0.0000	0.0700	0.0719
	STD DEV	0.0264	0.0000	0.0639	0.0000	0.0000	0.0532
	MEAN LOG	-3.0850	-3.2189	-2.7013	0.0000	-2.6593	-2.8509
	GEOM MN	0.0457	0.0400	0.0671	0.0000	0.0700	0.0578
	COEF VAR	0.6749	0.0000	1.0295	0.0000	0.0000	0.8903
AREA (SQ MIC)	MEAN	0.1288	0.0653	0.6207	0.0000	0.0957	0.3995
	STD DEV	0.0974	0.0000	1.3629	0.0000	0.0000	1.0540
	MEAN LOG	-2.3904	-2.7281	-1.8811	0.0000	-2.3469	-2.1223
	GEOM MN	0.0916	0.0653	0.1524	0.0000	0.0957	0.1193
	COEF VAR	1.3465	0.0000	3.1426	0.0000	0.0000	2.3270
VOLUME (CUB MIC)	MEAN	0.0021	0.0006	0.0277	0.0000	0.0015	0.0164
	STD DEV	0.0023	0.0000	0.0682	0.0000	0.0000	0.0527
	MEAN LOG	-6.9069	-7.3725	-6.0274	0.0000	-6.4764	-6.4144
	GEOM MN	0.0010	0.0006	0.0024	0.0000	0.0015	0.0016
	COEF VAR	2.6587	0.0000	6.9467	0.0000	0.0000	4.9161

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A70

Manville
(upwind)

TOTAL AREA SCANNED = 6975.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION = 1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.816000 CUBIC METERS
TOTAL FIBERS COUNTED = 7.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		0.0	0.0	3.0	0.0	4.0	7.0
PERCENT TOTAL FIBERS		0.000%	0.000%	42.857%	0.000%	57.143%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		0.0000E+00	0.0000E+00	5.1183E+05	0.0000E+00	6.8244E+05	1.1943E+06
(FIBERS PER CUB METER OF AIR)		0.0000E+00	0.0000E+00	1.3413E+05	0.0000E+00	1.7884E+05	3.1296E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		0.0000E+00	0.0000E+00	1.0929E+03	0.0000E+00	2.6866E+03	0.0000E+00
(SQ CM PER CUB METER OF AIR)		0.0000E+00	0.0000E+00	2.8639E+04	0.0000E+00	7.0404E+04	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		0.0000E+00	0.0000E+00				
(PGRAMS PER CUB METER OF AIR)		0.0000E+00	0.0000E+00				
LENGTH (MICRONS)	MEAN	0.0000	0.0000	0.6667	0.0000	0.7750	0.7286
	STD DEV	0.0000	0.0000	0.2055	0.0000	0.2487	0.2373
	MEAN LOG	0.0000	0.0000	-0.4594	0.0000	-0.2990	-0.3678
	GEOM MN	0.0000	0.0000	0.6316	0.0000	0.7416	0.6923
	COEF VAR	0.0000	0.0000	0.3035	0.0000	0.3297	0.3761
DIAMETER (MICRONS)	MEAN	0.0000	0.0000	0.0867	0.0000	0.1375	0.1157
	STD DEV	0.0000	0.0000	0.0492	0.0000	0.0415	0.0515
	MEAN LOG	0.0000	0.0000	-2.6431	0.0000	-2.0279	-2.2916
	GEOM MN	0.0000	0.0000	0.0711	0.0000	0.1316	0.1011
	COEF VAR	0.0000	0.0000	0.9392	0.0000	0.3403	0.7757
AREA (SQ MIC)	MEAN	0.0000	0.0000	0.2135	0.0000	0.3937	0.3165
	STD DEV	0.0000	0.0000	0.1341	0.0000	0.2478	0.2253
	MEAN LOG	0.0000	0.0000	-1.8972	0.0000	-1.0955	-1.4391
	GEOM MN	0.0000	0.0000	0.1500	0.0000	0.3344	0.2372
	COEF VAR	0.0000	0.0000	1.6299	0.0000	0.7158	1.3426
VOLUME (CUB MIC)	MEAN	0.0000	0.0000	0.0057	0.0000	0.0146	0.0108
	STD DEV	0.0000	0.0000	0.0050	0.0000	0.0135	0.0116
	MEAN LOG	0.0000	0.0000	-5.9873	0.0000	-4.5964	-5.1925
	GEOM MN	0.0000	0.0000	0.0025	0.0000	0.0101	0.0056
	COEF VAR	0.0000	0.0000	3.9420	0.0000	1.2700	3.0434

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A7A

Manville
(upwind)

TOTAL AREA SCANNED = 6975.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION =1.00000 PARTS
AREA OF SEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.816000 CUBIC METERS
TOTAL FIBERS COUNTED = 8.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		0.0	0.0	6.0	0.0	2.0	8.0
PERCENT TOTAL FIBERS		0.000%	0.000%	75.000%	0.000%	25.000%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		0.0000E+00	0.0000E+00	1.0237E+06	0.0000E+00	3.4122E+05	1.3649E+06
(FIBERS PER CUB METER OF AIR)		0.0000E+00	0.0000E+00	2.6825E+05	0.0000E+00	8.9418E+04	3.5767E+05
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		0.0000E+00	0.0000E+00	8.2979E+05	0.0000E+00	6.9678E+04	0.0000E+00
(SQ CM PER CUB METER OF AIR)		0.0000E+00	0.0000E+00	2.1745E+05	0.0000E+00	1.8259E+04	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		0.0000E+00	0.0000E+00				
(PGRAMS PER CUB METER OF AIR)		0.0000E+00	0.0000E+00				
LENGTH (MICRONS)	MEAN	0.0000	0.0000	1.2167	0.0000	0.6000	1.0625
	STD DEV	0.0000	0.0000	1.2562	0.0000	0.0000	1.1202
	MEAN LOG	0.0000	0.0000	-0.1446	0.0000	-0.5108	-0.2361
	GEOM MN	0.0000	0.0000	0.8654	0.0000	0.6000	0.7697
	COEF VAR	0.0000	0.0000	1.0628	0.0000	0.0000	0.9094
DIAMETER (MICRONS)	MEAN	0.0000	0.0000	0.1183	0.0000	0.1000	0.1137
	STD DEV	0.0000	0.0000	0.0878	0.0000	0.0000	0.0765
	MEAN LOG	0.0000	0.0000	-2.3573	0.0000	-2.3026	-2.3436
	GEOM MN	0.0000	0.0000	0.0947	0.0000	0.1000	0.0960
	COEF VAR	0.0000	0.0000	0.8857	0.0000	0.0000	0.7329
AREA (SQ MIC)	MEAN	0.0000	0.0000	0.8106	0.0000	0.2042	0.6590
	STD DEV	0.0000	0.0000	1.3903	0.0000	0.0000	1.2323
	MEAN LOG	0.0000	0.0000	-1.3005	0.0000	-1.5886	-1.3726
	GEOM MN	0.0000	0.0000	0.2724	0.0000	0.2042	0.2535
	COEF VAR	0.0000	0.0000	2.7116	0.0000	0.0000	2.1348
VOLUME (CUB MIC)	MEAN	0.0000	0.0000	0.0509	0.0000	0.0047	0.0393
	STD DEV	0.0000	0.0000	0.1038	0.0000	0.0000	0.0921
	MEAN LOG	0.0000	0.0000	-5.1008	0.0000	-5.3576	-5.1650
	GEOM MN	0.0000	0.0000	0.0061	0.0000	0.0047	0.0057
	COEF VAR	0.0000	0.0000	5.9117	0.0000	0.0000	4.3543

FIBER AND MASS CONCENTRATION
CUMULATIVE SUMMARY

SAI SAMPLE ID: A7TEM

Manville
(upwind)

TOTAL AREA SCANNED =125000.00 SQ MICRONS
TOTAL AREA OF FILTER = 11.900 SQ CM
TOTAL AREA ASHED = 11.900 SQ CM
ALIQUOT FRACTION =1.00000 PARTS
AREA OF TEM MEMBRANE = 11.90 SQ CM
TOTAL VOLUME OF AIR = 3.816000 CUBIC METERS
TOTAL FIBERS COUNTED = 13.0 FIBERS

		CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NO PATTERN	NON-ASBESTOS	ALL FIBERS
FIBER COUNT (FIBERS)		0.0	1.0	3.0	0.0	9.0	13.0
PERCENT TOTAL FIBERS		0.000%	7.692%	23.077%	0.000%	69.231%	100.000%
FIBER CONCENTRATION (FIBERS PER SQ CM OF FILTER)		0.0000E+00	9.5200E+03	2.8560E+04	0.0000E+00	8.5680E+04	1.2376E+05
(FIBERS PER CUB METER OF AIR)		0.0000E+00	2.4941E+03	7.4843E+03	0.0000E+00	2.2453E+04	3.2432E+04
TOTAL SURFACE AREA (SQ CM PER SQ CM OF FILTER)		0.0000E+00	6.6171E+03	9.0681E+03	0.0000E+00	4.7255E+04	0.0000E+00
(SQ CM PER CUB METER OF AIR)		0.0000E+00	1.7341E+03	2.3763E+03	0.0000E+00	1.2383E+04	0.0000E+00
MASS CONCENTRATION (PGRAMS PER SQ CM OF FILTER)		0.0000E+00	7.0650E+02				
(PGRAMS PER CUB METER OF AIR)		0.0000E+00	1.8516E+02				
LENGTH (MICRONS)	MEAN	0.0000	1.4000	0.6833	0.0000	1.4556	1.2731
	STD DEV	0.0000	0.0000	0.1312	0.0000	1.1383	1.0028
	MEAN LOG	0.0000	0.3365	-0.4013	0.0000	0.1005	0.0028
	GEOM MN	0.0000	1.4000	0.6694	0.0000	1.1057	1.0028
	COEF VAR	0.0000	0.0000	0.2312	0.0000	1.0748	0.9290
DIAMETER (MICRONS)	MEAN	0.0000	0.1500	0.1267	0.0000	0.1111	0.1177
	STD DEV	0.0000	0.0000	0.0525	0.0000	0.0314	0.0381
	MEAN LOG	0.0000	-1.8971	-2.1459	0.0000	-2.2444	-2.1950
	GEOM MN	0.0000	0.1500	0.1170	0.0000	0.1060	0.1114
	COEF VAR	0.0000	0.0000	0.4772	0.0000	0.3823	0.4073
AREA (SQ MIC)	MEAN	0.0000	0.6951	0.3175	0.0000	0.5515	0.5086
	STD DEV	0.0000	0.0000	0.1816	0.0000	0.4449	0.3963
	MEAN LOG	0.0000	-0.3637	-1.3161	0.0000	-0.9406	-0.9829
	GEOM MN	0.0000	0.6951	0.2682	0.0000	0.3904	0.3742
	COEF VAR	0.0000	0.0000	0.7940	0.0000	1.3653	1.2371
VOLUME (CUB MIC)	MEAN	0.0000	0.0247	0.0112	0.0000	0.0162	0.0157
	STD DEV	0.0000	0.0000	0.0100	0.0000	0.0152	0.0139
	MEAN LOG	0.0000	-3.6993	-4.9347	0.0000	-4.6300	-4.6287
	GEOM MN	0.0000	0.0247	0.0072	0.0000	0.0098	0.0098
	COEF VAR	0.0000	0.0000	1.5872	0.0000	2.0391	1.9259

APPENDIX G

Meteorology Summary Data for Study Sites

Period: 1941-1970 Site: Johns Manville-Stockton

Source: Weather Bureau

Meteorology

Direction

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Daily Average																
Wind Speed (mph)	-	-	-	-	-	6.9	6.9	6.9	-	-	-	8.3	8.3	8.3	8.3	-
Direction (Percent)	-	-	-	-	-	1	20	3	-	-	-	3	33	19	20	-

Period: 1969-1973 Meteorology Site: RSR

Sourece: Whittier Station SCAQMD

Average Wind Direction: X

Start Time	S	SSW	SW	WSW	W	WNW	NW	NNW
	123	51	22	43	86	66	43	50
00	7.6	3.2	1.4	2.7	5.3	4.1	2.7	3.1
	115	51	27	38	69	68	40	48
01	7.1	3.2	1.7	2.4	4.3	4.2	2.5	3.0
	116	46	28	32	79	45	45	61
02	7.1	2.9	1.7	2.0	4.9	2.8	2.8	3.8
	96	46	38	29	56	55	33	56
03	6.0	2.9	2.4	1.8	3.5	3.4	2.0	3.5
	92	36	29	25	54	49	31	69
04	5.7	2.2	1.8	1.6	3.4	3.0	1.9	4.3
	96	45	28	19	47	37	40	51
05	5.3	2.8	1.7	1.2	2.9	2.3	2.5	3.2
	109	44	31	25	58	41	47	65
06	6.8	2.7	1.9	1.6	3.6	2.5	2.9	4.0
	145	60	40	34	71	48	37	75
07	9.0	3.7	2.5	2.1	4.4	3.0	2.3	4.7
	182	110	81	52	99	48	57	102
08	11.3	6.8	5.0	3.2	5.5	3.0	3.5	6.3
	257	189	98	102	117	52	65	84
09	16.0	11.8	6.1	6.3	7.3	3.2	4.0	5.2
	284	238	126	142	170	77	48	70
10	17.7	14.8	7.8	8.8	10.6	4.8	3.0	4.4
	276	286	182	168	154	78	53	53
11	17.2	17.8	11.3	10.5	9.6	4.9	3.3	3.3
	280	364	182	173	188	62	41	45
12	17.4	22.6	11.3	10.8	11.7	3.9	2.5	2.8
	245	403	191	230	170	59	40	39
13	15.2	25.0	11.9	14.3	10.6	3.7	2.5	2.4
	274	345	173	252	213	57	35	30
14	17.0	21.4	10.7	15.7	13.2	3.5	2.2	1.9
	257	313	165	285	232	61	49	21
15	16.0	19.4	10.2	17.7	14.4	3.8	3.0	1.3
	257	247	161	255	308	94	55	19
16	15.0	15.3	10.0	15.8	19.1	5.8	3.4	1.2
	235	182	156	244	346	130	67	17
17	14.6	11.3	9.7	15.2	21.5	8.1	4.2	1.1
	215	133	110	202	382	135	68	35
18	13.4	8.3	6.8	12.5	23.7	8.4	4.2	2.2
	186	116	77	138	350	136	59	30
19	11.6	7.2	4.8	8.6	21.7	8.4	3.7	1.9
	198	84	61	92	266	144	43	37
20	11.7	5.2	3.8	5.7	16.5	8.9	2.7	2.3
	157	64	40	94	199	102	55	29
21	9.7	4.0	2.5	5.2	12.4	6.3	3.4	1.8
	155	53	25	62	151	110	30	41
22	9.6	3.3	1.6	3.8	9.4	6.8	1.9	2.5
	127	53	32	53	103	79	44	49
23	7.9	3.3	2.0	3.3	6.4	4.9	2.7	3.0
	4456	3559	2103	2779	3958	1833	1125	1176
	11.5	9.2	5.4	7.2	10.2	4.7	2.9	3.0

Period: 1969-1973 Meteorology Site: RSR

Source: Whittier Station SCAQMD Average Wind Direction X

Start Time	N	NNE	NE	ENE	E	ESE	SE	SSE
	99	111	162	216	202	105	101	130
00	6.1	6.9	10.1	13.4	12.5	6.5	6.3	8.1
	115	122	171	241	213	90	87	115
01	7.1	7.6	10.6	15.0	13.2	5.6	5.4	7.1
	121	129	181	250	218	87	83	91
02	7.5	8.0	11.2	15.5	13.5	5.4	5.2	5.6
	133	150	158	261	219	101	94	95
03	8.3	9.3	9.8	16.2	13.6	6.3	5.2	5.9
	154	144	165	273	205	91	92	102
04	9.6	8.9	10.2	16.9	12.7	5.6	5.7	6.3
	155	172	186	273	194	100	97	81
05	9.6	10.7	11.5	16.9	12.0	6.2	6.0	5.0
	136	149	170	258	201	95	79	101
06	8.5	9.3	10.6	16.0	12.5	5.9	4.9	6.3
	128	128	144	190	192	114	115	87
07	8.0	8.0	9.0	11.8	11.9	7.1	7.2	5.4
	115	79	88	105	146	110	116	129
08	7.1	4.9	5.5	6.5	9.1	6.8	7.2	8.0
	99	36	42	66	108	82	92	129
09	6.2	2.2	2.6	4.1	6.7	5.1	5.1	8.0
	71	21	23	29	67	66	63	113
10	4.4	1.3	1.4	1.8	4.2	4.1	3.9	7.0
	49	17	16	18	63	38	48	107
11	3.1	1.1	1.0	1.1	3.9	2.4	3.0	6.7
	41	10	8	20	36	30	37	91
12	2.5	.6	.5	1.2	2.2	1.9	2.3	5.7
	21	11	7	9	26	25	33	101
13	1.3	.7	.4	.6	1.6	1.6	2.0	6.3
	23	9	12	8	17	17	32	113
14	1.4	.6	.7	.5	1.1	1.1	2.0	7.0
	19	3	11	15	23	17	25	114
15	1.2	.2	.7	.9	1.4	1.1	1.6	7.1
	15	6	8	10	20	27	30	98
16	.9	.4	.5	.6	1.2	1.7	1.9	6.1
	17	11	7	10	10	21	41	98
17	1.1	.7	.4	1.2	1.2	1.3	2.5	6.1
	32	18	19	24	38	32	55	112
18	2.0	1.1	1.2	1.5	2.4	2.0	3.4	7.0
	42	32	34	73	84	55	69	129
19	2.6	2.0	2.1	4.5	5.2	3.4	4.3	8.0
	46	48	59	114	121	81	104	123
20	2.9	3.0	3.7	7.1	7.5	5.0	6.5	7.6
	55	69	82	157	152	88	121	157
21	3.4	4.3	5.1	9.7	9.4	5.5	7.5	9.7
	78	81	122	178	178	94	119	135
22	4.8	5.0	7.6	11.0	11.0	5.8	7.3	8.4
	91	108	127	224	182	87	122	130
23	5.6	6.7	7.9	13.9	11.3	5.4	7.6	8.1
	1855	1664	2002	3031	2924	1653	1834	2681
	4.8	4.3	5.2	7.8	7.6	4.3	4.7	6.9

Period: 1969-1973 Meteorology Site: RSR

Source: Whittier Station SCAQMD Average Wind Speed: X

Start Time	S	SSW	SW	WSW	W	WNW	NW	NNW
	123	51	22	43	86	66	43	50
00	2.4	2.8	2.6	2.5	2.3	2.1	2.5	3.2
	115	51	27	38	69	68	40	48
01	2.3	2.6	2.4	2.5	2.2	2.5	3.2	2.8
	115	46	28	32	79	45	45	61
02	2.4	2.5	2.2	2.4	2.1	2.1	3.3	3.0
	96	46	38	29	56	55	33	56
03	2.7	2.4	2.8	2.7	1.8	2.2	3.1	2.4
	92	36	29	25	54	49	31	69
04	2.8	2.3	2.7	2.8	2.1	2.0	2.8	2.4
	86	45	28	19	47	37	40	51
05	2.7	2.7	2.7	2.3	2.1	1.9	2.2	2.2
	109	44	31	25	58	41	47	65
06	2.5	2.5	2.7	1.8	2.3	2.0	2.2	2.4
	145	60	40	34	71	48	37	75
07	2.5	2.6	2.8	2.6	2.3	2.4	2.8	2.5
	182	110	81	52	89	48	57	102
08	2.6	2.6	2.8	2.9	2.3	2.3	3.0	2.7
	257	189	98	101	117	52	65	84
09	2.9	3.3	3.1	3.3	3.0	2.8	3.8	3.3
	283	238	126	142	170	77	48	70
10	3.5	3.7	3.7	4.1	3.5	3.5	4.8	3.9
	275	286	182	168	154	78	53	53
11	4.1	4.5	4.7	4.9	4.7	4.5	5.6	4.8
	280	363	182	173	188	62	41	45
12	5.0	5.5	5.3	6.3	5.8	5.2	5.5	5.9
	244	403	191	230	170	59	40	39
13	5.8	6.0	6.6	6.8	6.6	6.7	6.3	6.5
	274	345	173	252	213	57	35	30
14	6.1	6.7	6.8	7.5	7.3	7.1	7.5	8.0
	257	313	165	285	232	61	49	21
15	6.5	6.7	7.4	7.7	7.5	6.8	8.9	8.2
	257	247	161	255	308	93	55	19
16	5.9	6.4	6.7	7.5	6.9	7.1	8.2	8.3
	235	182	156	244	345	130	67	17
17	5.3	5.6	6.3	6.2	5.8	5.9	7.3	7.7
	215	133	110	202	381	135	68	35
18	4.8	4.9	5.1	5.0	4.6	5.0	5.4	4.3
	186	116	77	138	350	136	59	29
19	4.2	4.5	4.1	4.1	3.7	3.8	4.2	4.0
	189	84	61	92	266	144	43	37
20	3.5	3.9	3.4	3.1	2.9	3.2	3.6	3.4
	157	64	40	84	199	102	55	29
21	3.1	3.3	3.0	2.7	2.5	2.7	3.5	3.3
	155	53	25	62	151	110	30	41
22	3.0	2.9	3.2	2.7	2.0	2.4	2.6	4.1
	127	53	32	53	103	79	44	49
23	2.6	3.2	2.9	2.4	2.1	2.3	2.4	3.8
	4453	3558	2103	2778	3956	1832	1125	1175
	4.1	4.9	5.0	5.4	4.4	3.9	4.5	3.7

Period: 1969-1973 Meteorology Site: RSR

Source: Whittier Station SCAQMD Average Wind Speed: X

Start Time	N	NNE	NE	ENE	E	ESE	SE	SSE
	99	111	162	216	201	105	101	130
00	2.5	2.5	2.6	2.8	2.8	2.9	2.3	2.5
	115	122	170	241	213	90	87	115
01	2.4	2.7	2.5	2.9	2.7	2.8	2.6	2.4
	121	129	181	250	217	87	83	91
02	2.5	2.5	2.7	2.9	2.7	2.7	2.2	2.7
	133	150	159	261	218	101	84	95
03	2.6	2.5	2.7	2.7	2.7	2.8	2.4	2.3
	154	143	165	273	205	91	92	102
04	2.3	2.3	2.9	2.8	2.6	2.7	2.2	2.4
	155	171	186	273	194	100	97	81
05	2.4	2.6	2.8	2.8	2.7	2.7	2.2	2.1
	136	149	170	258	200	95	79	101
06	2.7	2.7	3.0	2.8	2.8	2.9	2.5	2.4
	128	128	144	190	191	114	115	87
07	2.6	2.8	3.3	3.0	3.0	2.9	3.0	2.9
	115	79	88	105	145	110	116	129
08	2.9	2.7	3.4	3.3	3.2	3.1	3.0	2.7
	99	36	42	66	108	82	82	129
09	3.4	3.4	3.8	3.9	3.9	2.9	3.6	3.1
	71	21	23	29	67	66	53	113
10	3.9	3.9	6.0	5.0	4.6	3.4	4.0	3.5
	49	17	16	18	63	38	48	107
11	4.5	4.5	6.4	5.9	5.1	3.8	3.7	3.9
	41	10	8	20	36	30	37	91
12	4.1	4.8	6.8	6.1	6.6	5.6	4.5	4.2
	21	11	7	9	26	25	33	101
13	4.5	5.1	9.0	7.4	7.6	5.8	4.9	5.1
	23	9	12	8	17	17	32	113
14	5.1	6.8	6.8	6.4	8.3	7.1	4.9	5.6
	19	3	11	15	23	17	25	114
15	6.7	7.0	9.0	6.0	7.1	5.9	4.9	5.7
	15	6	8	10	20	27	30	98
16	5.0	3.2	6.6	8.3	6.6	5.2	4.5	5.8
	17	11	7	19	19	21	41	98
17	4.1	3.0	4.4	6.4	4.8	4.1	4.0	4.8
	32	18	19	24	38	32	55	112
18	2.1	2.6	3.5	4.7	3.5	2.6	3.5	4.0
	42	32	34	73	84	55	69	129
19	2.7	2.3	3.3	2.9	2.8	2.8	2.2	3.7
	46	48	59	114	120	91	104	123
20	2.2	2.4	3.0	3.1	2.8	3.0	2.8	3.4
	55	69	82	157	151	99	121	157
21	2.5	2.6	2.9	3.1	3.0	2.7	2.8	3.1
	78	81	122	178	177	94	118	135
22	2.2	2.7	3.0	3.2	2.9	3.0	2.7	2.7
	91	108	127	224	181	87	122	130
23	2.6	2.5	2.9	3.0	2.8	2.9	2.6	2.6
	1855	1662	2001	3031	2914	1653	1834	2681
	2.8	2.7	3.1	3.1	3.1	3.1	3.0	3.5

Site: Kaiser Steel

Period: 1978-1979

Source: SCAQMD*

Meteorology

Daily Average	Direction															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Wind Speed (mph)	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Direction (Percent)	10	8	2	2	2	2	2	2	2	8	10	10	10	10	10	10

* Two years data provided: Approximately 16,000 hourly speed and direction averages not computerized therefore results estimated

Period: 1971-1974 Site: Allied,

Source: Lennox Station SCAQMD

Meteorology

Average Wind Speed x
Average Wind Direction

Start Time	Direction															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	WNW
00	2.3	2.4	2.2	2.3	2.6	2.7	3.8	2.6	2.1	2.4	2.5	3.2	3.7	3.7	3.3	2.9
01	2.4	2.4	2.1	2.4	2.4	2.6	2.4	2.2	2.1	2.6	2.5	3.4	3.4	3.3	3.0	2.8
02	2.4	2.3	2.1	2.3	2.3	2.6	2.2	2.4	2.4	2.3	2.4	3.4	3.4	3.3	2.8	2.9
03	2.6	2.2	2.1	2.4	2.2	2.6	2.0	1.9	2.4	2.2	2.2	3.2	3.3	3.5	2.8	2.5
04	2.8	2.2	2.0	2.4	2.2	2.3	2.0	2.5	2.2	2.2	2.4	2.8	3.5	3.2	3.1	2.3
05	2.3	2.5	2.1	2.3	2.4	2.4	2.1	2.3	2.2	2.2	2.3	3.0	3.7	3.1	3.1	2.7
06	2.4	2.6	2.5	2.6	2.6	2.7	2.5	2.5	2.4	2.6	2.5	3.3	4.3	3.2	3.7	3.0
07	2.9	3.0	2.6	2.8	2.9	3.0	2.8	2.5	2.8	3.0	3.0	3.3	4.0	3.8	4.0	3.3
08	3.7	3.1	3.0	3.1	3.1	3.1	2.9	3.1	3.0	3.3	3.5	3.9	4.5	3.9	4.6	6.2
09	4.6	3.4	3.0	3.4	3.4	3.6	3.1	3.5	3.5	3.9	4.2	4.6	4.8	4.8	5.3	6.0
10	4.5	3.2	3.4	3.2	3.5	3.6	4.0	3.6	3.7	4.4	5.1	5.6	5.6	5.0	5.9	7.5
11	4.5	3.6	3.7	3.3	3.5	3.9	4.5	4.2	3.7	5.0	5.7	6.4	6.4	5.8	6.1	5.6
12	3.8	2.7	4.5	3.5	3.1	3.8	4.7	4.2	4.0	5.5	6.1	6.9	7.1	6.2	7.0	9.5
13	3.6	3.4	5.2	3.8	3.6	3.6	4.9	4.0	4.9	4.8	6.5	7.1	7.7	6.6	8.6	10.5
14	5.0	2.8	5.2	4.3	5.4	4.8	5.5	4.3	5.1	5.6	5.9	7.2	8.0	6.9	9.2	6.0
15	5.4	ND	6.0	3.6	5.0	5.0	4.8	4.9	3.0	6.0	6.3	7.0	7.8	6.8	8.6	6.0
16	7.0	4.5	4.5	2.7	4.8	5.0	5.3	4.8	3.8	4.7	5.4	6.6	7.3	6.0	8.9	6.0
17	6.5	ND	5.8	1.6	5.0	3.0	3.5	5.1	3.4	4.0	4.7	6.1	6.7	5.2	6.9	4.7
18	8.0	4.3	4.2	3.7	2.2	4.4	3.3	2.9	2.6	3.5	4.3	5.4	6.0	4.8	5.2	6.4
19	5.4	2.8	3.3	3.2	1.9	2.6	3.2	3.6	2.6	3.3	3.7	4.9	5.2	4.8	5.1	3.9
20	3.6	2.1	2.4	2.7	2.2	2.6	2.6	3.4	2.8	2.9	3.3	4.5	4.8	4.0	5.5	4.6
21	4.0	2.5	2.6	2.2	2.3	2.9	2.6	2.8	2.7	2.8	3.0	4.0	4.4	4.0	4.7	4.5
22	3.5	2.2	2.1	2.4	2.2	2.8	2.4	2.5	2.6	2.5	2.7	3.8	4.1	4.3	3.6	3.9
23	3.6	2.5	2.2	2.4	2.2	2.7	2.3	2.8	2.4	2.4	2.7	3.3	4.0	3.9	3.7	2.8
	3.5	2.6	2.5	2.6	2.7	2.9	3.0	3.0	2.8	3.1	4.0	5.7	6.0	4.4	4.3	3.6

Period: 1971-1974 Site: Allied

Source: Lennox Station

Meteorology

Average Wind Speed
Average Wind Direction x

Start Time	Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	WNW
00	2.7	7.1	8.5	8.0	9.2	5.1	3.2	2.9	4.4	7.6	6.8	8.0	11.9	6.0	5.8	2.8
01	2.2	7.1	9.5	9.2	10.8	6.0	2.1	3.7	4.4	6.7	6.3	6.2	9.6	6.1	6.6	3.3
02	2.1	8.4	9.5	9.3	12.5	6.2	3.4	4.7	4.2	5.3	5.6	5.2	8.4	5.7	6.6	2.9
03	2.5	6.6	10.8	9.7	12.9	7.3	4.7	4.1	4.9	4.4	4.8	4.1	8.4	6.7	5.5	2.5
04	2.4	6.4	10.8	10.9	14.3	7.6	5.5	3.7	4.6	4.4	4.3	4.8	6.1	5.9	5.9	2.4
05	2.2	6.2	9.7	11.5	16.4	7.3	5.5	4.5	4.1	3.8	4.7	3.9	6.0	5.7	5.7	2.7
06	1.8	7.6	7.9	12.6	18.1	7.9	4.6	3.8	4.4	4.3	4.3	3.7	5.8	4.4	6.2	2.8
07	1.8	6.5	9.1	12.9	15.9	8.8	5.0	4.4	5.0	4.3	4.2	5.1	7.0	3.0	4.9	2.1
08	1.5	6.1	9.4	11.6	14.4	8.0	6.5	5.5	5.9	3.4	4.8	7.2	9.4	2.3	2.6	1.3
09	1.4	4.0	6.9	7.4	10.8	6.3	5.5	6.2	7.1	4.4	6.7	11.9	14.7	3.3	2.4	1.1
10	1.6	2.6	4.6	4.4	6.6	5.6	5.0	5.7	5.0	3.3	8.0	21.7	19.7	3.0	2.3	.9
11	.9	1.4	3.2	2.5	3.7	2.7	3.8	4.1	4.1	2.3	8.8	31.3	25.1	3.3	2.2	.6
12	1.3	.7	1.9	1.4	2.0	1.7	2.7	2.5	2.3	2.1	10.5	34.6	30.7	3.4	2.0	.2
13	.6	.5	1.2	.8	1.1	.9	1.5	1.2	1.3	2.6	9.3	39.2	34.8	3.4	1.5	.2
14	.3	.4	.9	.5	.7	.7	1.1	.9	1.0	2.2	6.1	41.2	39.2	3.4	1.4	.1
15	.4	ND	.2	.5	.9	.5	1.2	.9	.3	2.0	5.7	41.0	41.6	3.4	1.3	.1
16	.5	.2	.2	.5	.7	.3	1.2	.8	.5	2.3	4.4	39.0	43.8	4.4	1.1	.2
17	.6	ND	.4	.4	.5	.5	.9	.7	1.1	1.9	5.5	37.2	43.5	5.0	1.5	.3
18	.9	.2	.4	.2	1.0	.5	1.2	.9	1.0	2.8	6.0	34.6	42.0	4.9	2.9	.6
19	1.1	.3	.9	.9	.6	1.4	1.1	1.4	3.1	6.0	7.3	28.2	36.8	5.0	4.2	1.6
20	2.0	1.7	1.5	1.2	2.3	1.6	1.3	1.9	5.1	7.6	7.4	23.9	30.5	6.0	3.6	2.2
21	2.0	2.2	2.6	2.9	5.0	2.8	2.6	2.2	6.9	8.7	9.9	16.9	23.4	5.4	4.2	2.3
22	2.4	4.2	5.3	4.0	5.9	4.0	3.4	3.4	6.2	9.8	7.9	14.4	17.5	4.5	4.7	2.7
23	2.3	5.9	8.6	5.9	8.4	4.0	3.7	3.0	6.5	8.0	6.8	9.8	14.9	4.8	5.2	2.2
	1.6	3.6	5.2	5.4	7.3	4.1	3.2	3.0	3.9	4.6	6.5	19.7	22.1	4.5	3.8	1.6

Period: 1962-1974

Site: Stauffer

Source: Long Beach SCAOMD

Meteorology

Average Wind Speed
Average Wind Direction X

Start Time	Direction N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	WNW
00	7.8	7.7	8.9	11.5	11.2	4.6	3.5	5.2	3.8	1.5	1.3	2.1	5.9	12.9	7.3	4.8
01	7.1	8.6	9.6	12.8	12.2	4.5	4.5	4.3	3.8	1.7	1.3	1.9	4.9	11.5	6.0	5.3
02	8.2	8.6	10.9	13.2	11.6	5.8	4.1	3.8	3.1	2.0	1.3	1.5	5.1	10.7	5.0	5.1
03	8.0	10.1	11.4	13.5	12.2	5.9	3.8	3.8	3.4	1.5	1.1	2.0	4.4	9.2	5.0	4.6
04	8.5	10.3	11.9	12.9	12.2	6.4	4.3	3.5	3.1	1.4	1.3	2.0	4.2	8.6	4.4	4.9
05	9.5	10.2	11.1	13.4	13.2	5.9	4.2	3.5	3.2	1.3	1.3	1.7	3.8	8.9	4.5	4.4
06	9.1	10.5	11.2	13.2	13.1	5.9	4.1	3.7	2.7	1.4	1.3	1.4	3.8	8.7	5.5	4.2
07	7.7	9.6	10.4	12.3	13.7	7.0	4.3	4.4	4.0	1.7	1.6	1.8	4.3	7.7	4.9	4.2
08	6.0	7.6	8.3	10.3	13.1	6.3	6.0	6.1	6.8	3.3	2.0	2.4	5.3	8.6	4.2	3.7
09	4.4	5.0	5.7	7.3	11.3	6.5	5.4	7.5	11.3	5.9	3.9	3.6	7.4	8.0	3.8	3.1
10	3.8	2.8	3.3	4.6	8.4	5.4	4.3	7.7	16.5	10.6	4.8	4.1	8.0	8.3	4.0	2.9
11	2.3	1.5	1.7	3.0	5.1	3.7	4.2	7.1	21.2	14.4	6.8	5.5	9.5	8.6	3.8	1.7
12	1.5	.8	1.1	1.7	3.1	2.8	3.1	5.7	23.5	16.6	7.4	6.3	11.4	10.7	3.2	1.2
13	1.0	.4	.8	1.1	1.8	1.7	2.3	4.3	23.7	16.8	7.3	5.6	14.2	14.7	3.4	.8
14	.7	.6	.6	1.0	1.8	1.3	1.4	3.4	20.3	14.2	5.6	5.1	17.9	21.1	4.1	.9
15	.5	.3	.3	.9	1.4	1.0	1.2	3.3	15.0	10.3	4.8	4.7	22.3	27.4	5.8	.7
16	.6	.2	.4	.7	1.5	.9	1.2	3.0	10.8	7.5	3.0	4.6	24.3	33.8	7.0	.7
17	.6	.3	.6	1.0	1.4	1.0	1.0	2.6	7.7	4.9	2.3	3.9	24.7	37.8	9.2	1.0
18	1.2	.6	.8	1.3	1.6	1.1	1.5	2.6	5.7	3.3	1.7	3.2	23.0	39.6	10.7	2.1
19	2.1	1.6	1.8	2.2	2.8	1.5	1.6	3.1	4.7	2.4	1.4	3.0	18.2	36.8	12.8	3.9
20	3.3	3.2	3.5	4.4	3.7	1.9	2.1	3.7	3.8	2.1	1.4	3.0	13.8	32.0	12.8	5.2
21	5.0	3.9	5.3	6.8	6.6	2.8	2.9	4.0	3.5	1.6	1.5	2.5	10.9	24.6	11.5	6.5
22	6.4	5.2	6.6	9.0	8.6	3.5	3.4	4.6	3.6	1.7	1.5	2.6	8.6	18.1	9.9	6.7
23	7.0	6.7	8.1	10.4	10.1	4.0	3.9	4.5	4.1	1.3	1.1	2.7	7.0	14.4	8.2	6.5
	4.7	4.8	5.6	7.0	7.6	3.8	3.3	4.4	8.7	5.4	2.8	3.2	11.0	17.6	6.6	3.5

Period: 1962-1974

Site: Stauffer

Source: Long Beach

Meteorology

Average Wind Speed ×

Average Wind Direction

Start Time	Direction															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	WNW
00	2.6	2.5	2.3	2.4	2.6	3.0	4.3	3.8	3.5	3.2	3.8	2.9	3.7	3.0	2.5	2.7
01	2.8	2.4	2.3	2.3	2.4	3.1	3.9	3.8	3.8	2.9	2.9	3.1	3.7	2.9	2.5	2.5
02	2.8	2.6	2.4	2.4	2.5	3.1	3.8	3.5	3.5	3.3	3.1	2.7	3.5	2.9	2.5	2.5
03	2.8	2.7	2.3	2.3	2.5	3.2	3.5	3.7	3.3	3.5	2.8	2.8	3.4	2.9	2.5	2.7
04	2.9	2.7	2.3	2.3	2.6	3.0	3.5	3.7	3.2	3.5	2.2	2.7	3.3	2.8	2.9	2.8
05	2.9	2.6	2.4	2.3	2.7	3.0	3.6	3.4	3.3	3.5	2.6	2.7	3.2	3.0	2.8	2.5
06	3.0	2.6	2.5	2.4	2.7	3.2	3.5	3.5	3.7	3.2	3.3	2.6	3.0	3.2	2.6	2.7
07	2.9	2.8	2.7	2.7	2.8	3.3	4.0	3.8	3.3	3.5	4.1	3.3	3.5	3.3	2.9	2.7
08	3.2	3.0	2.8	3.0	3.1	3.4	3.9	3.8	3.7	3.7	3.5	3.0	3.4	3.7	3.5	2.9
09	3.0	3.2	2.8	3.2	3.3	3.6	3.8	4.3	4.3	4.3	3.8	3.2	3.9	4.1	3.9	2.9
10	3.0	3.2	3.3	3.7	3.6	3.9	4.3	4.6	4.8	4.8	4.2	4.4	4.5	4.6	4.0	3.4
11	3.3	3.3	3.4	4.0	4.2	4.3	5.0	4.9	5.2	5.3	5.3	4.6	5.4	5.2	4.9	3.2
12	3.6	3.5	4.3	5.4	5.3	5.5	5.8	5.2	5.7	5.8	5.7	5.6	6.3	6.3	5.8	4.2
13	4.0	4.3	4.5	5.8	6.3	6.9	6.1	5.6	5.8	6.0	6.1	6.5	7.5	7.5	7.2	4.0
14	4.2	3.9	4.4	6.2	6.7	7.5	6.1	5.9	6.0	5.9	6.3	6.8	8.8	8.1	8.4	5.5
15	5.0	5.2	5.5	7.0	6.7	8.1	6.4	6.1	5.8	5.7	5.8	7.3	8.9	8.5	9.1	5.6
16	4.9	4.4	5.4	7.1	6.6	7.3	6.6	5.8	5.6	5.4	5.7	6.9	8.7	8.1	8.4	6.6
17	4.5	5.8	3.7	6.0	6.0	6.0	5.8	5.2	5.4	4.9	4.7	6.3	8.0	7.3	7.1	5.0
18	3.0	2.8	3.7	4.0	4.8	5.3	4.9	5.1	4.9	4.5	3.9	4.7	6.9	6.2	5.5	4.3
19	2.4	2.4	2.8	3.4	3.3	4.8	4.5	4.4	4.4	3.9	3.6	4.0	5.9	5.2	4.5	3.4
20	2.0	2.0	2.1	2.6	2.9	4.3	3.6	4.1	4.3	3.7	3.1	3.7	5.1	4.3	3.9	2.9
21	2.4	2.1	2.1	2.4	2.7	3.5	4.1	4.2	4.1	3.8	2.8	3.5	4.4	3.7	3.1	2.7
22	2.2	2.2	2.2	2.3	2.7	3.4	3.9	4.2	4.1	3.3	3.0	3.4	4.1	3.3	2.9	2.5
23	2.4	2.2	2.3	2.2	2.6	3.2	4.0	3.9	3.7	3.6	2.8	3.4	3.9	3.1	2.6	2.7
	2.8	2.7	2.5	2.7	3.0	3.7	4.2	4.4	5.0	5.1	4.7	4.7	6.3	5.4	4.4	2.9

Period: 1956-1974

Site: DOW and DUPONT

Source: DOW

Meteorology

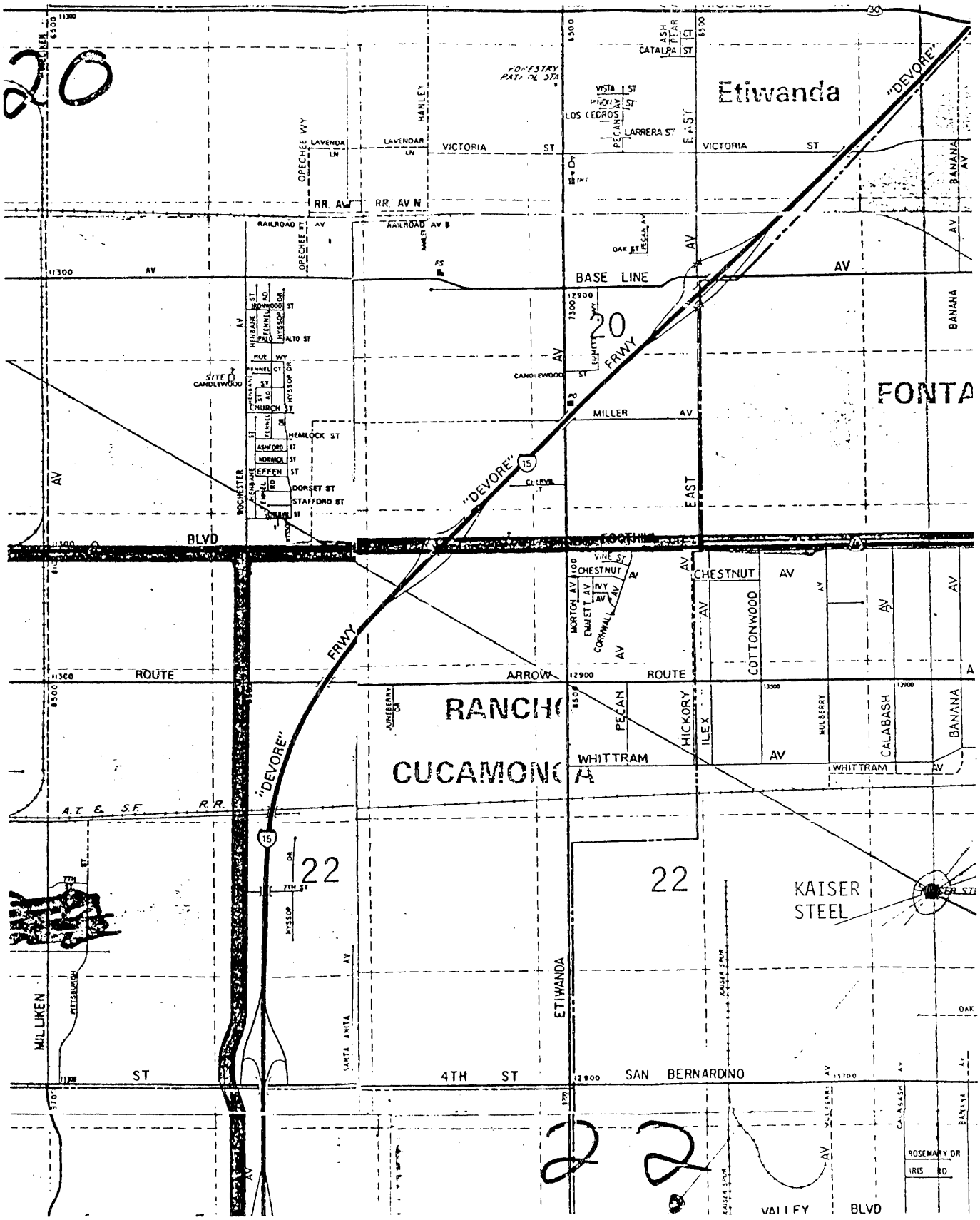
Direction

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Daily Average																
Wind Speed (mph)	3.8	5.2	3.8	4.7	2.5	2.5	3.5	3.7	3.7	4.7	5.0	7.5	9	10	7.7	7.7
Direction (Percent)	3.8	2.5	1.3	1.5	2.5	2.6	7.6	3.6	2.0	2.5	6	10	16	18.8	12.8	6.5

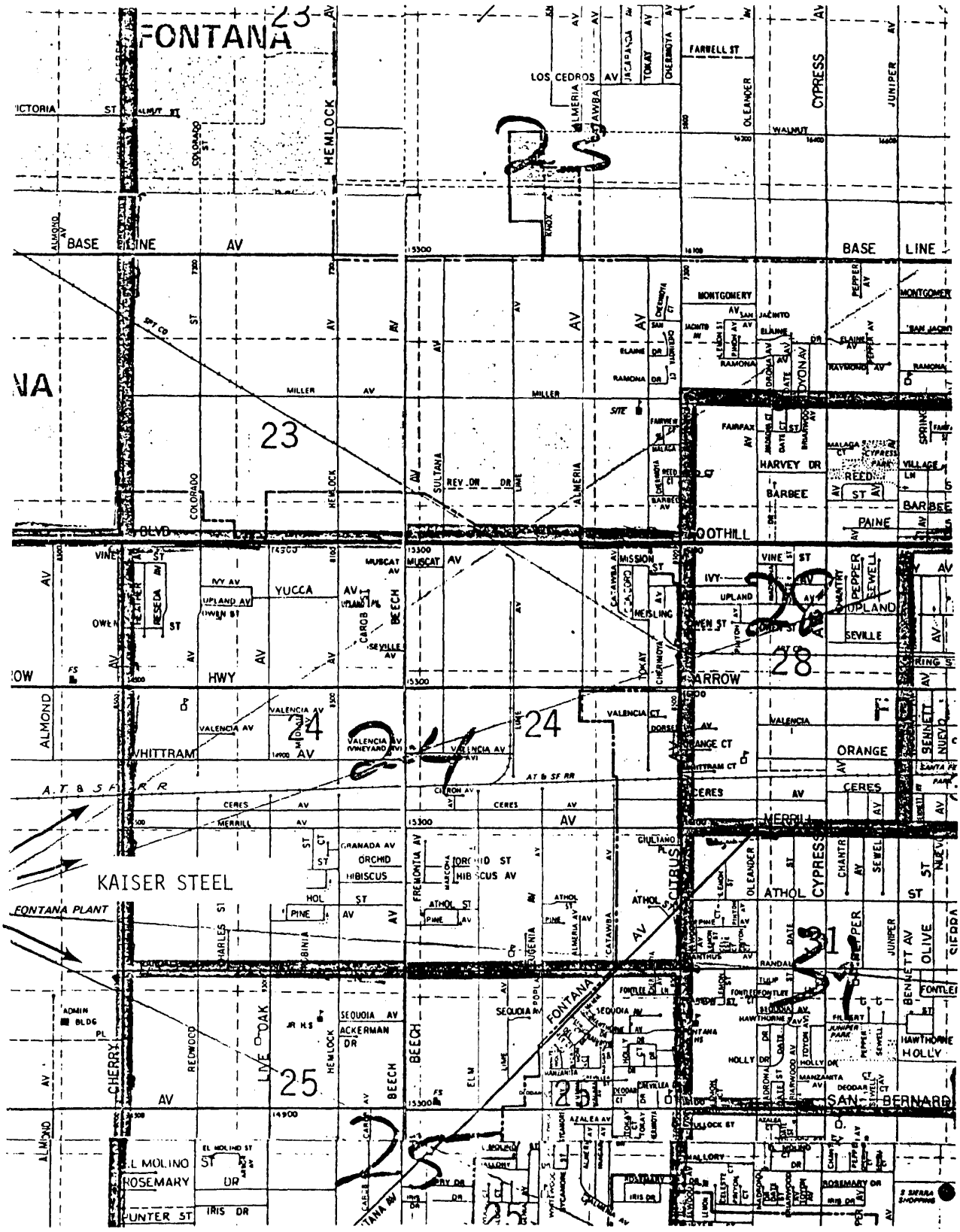
APPENDIX H

Census Tract Maps for Exposure Calculations

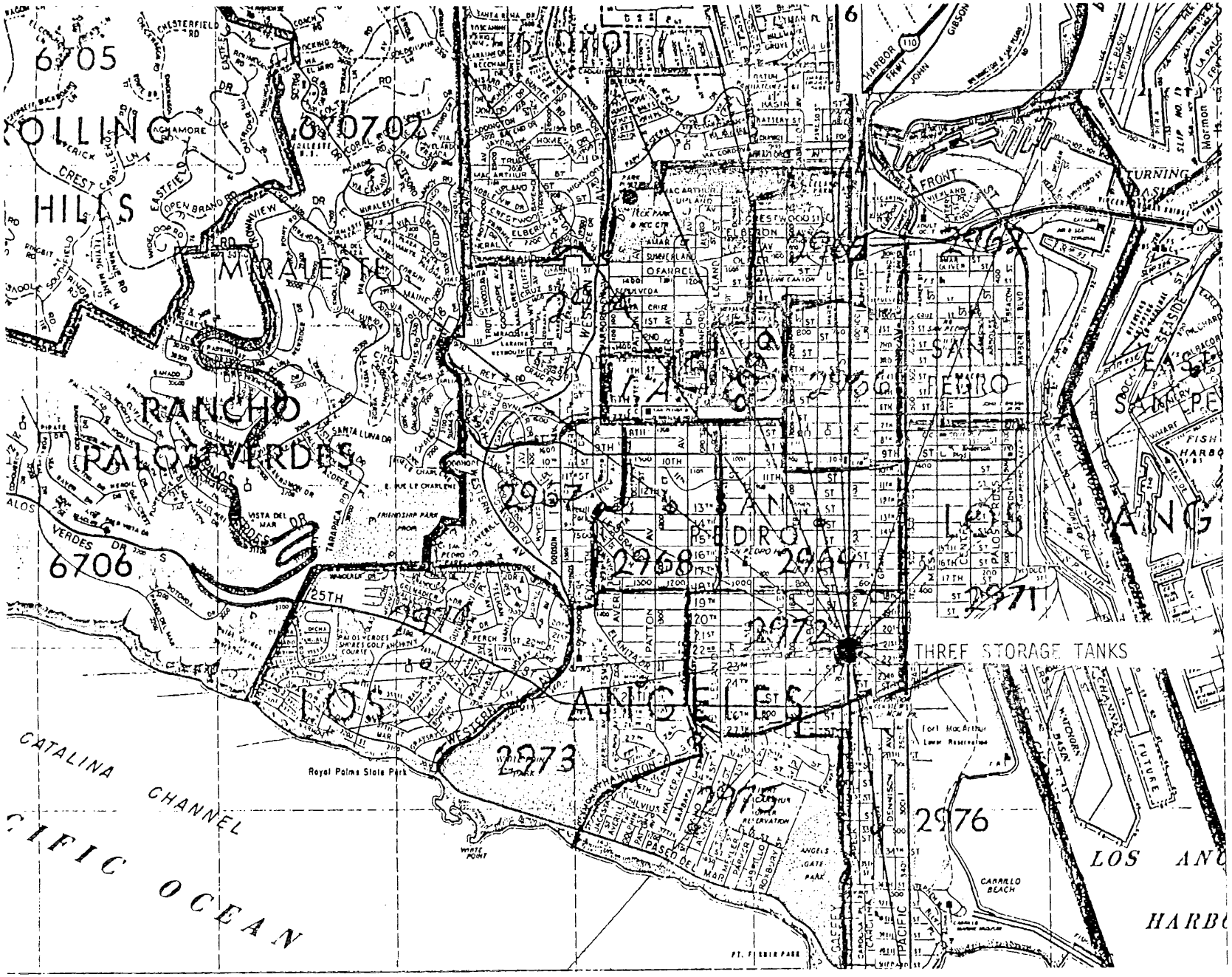
Western Plant Area - Kaiser Steel, Fontana



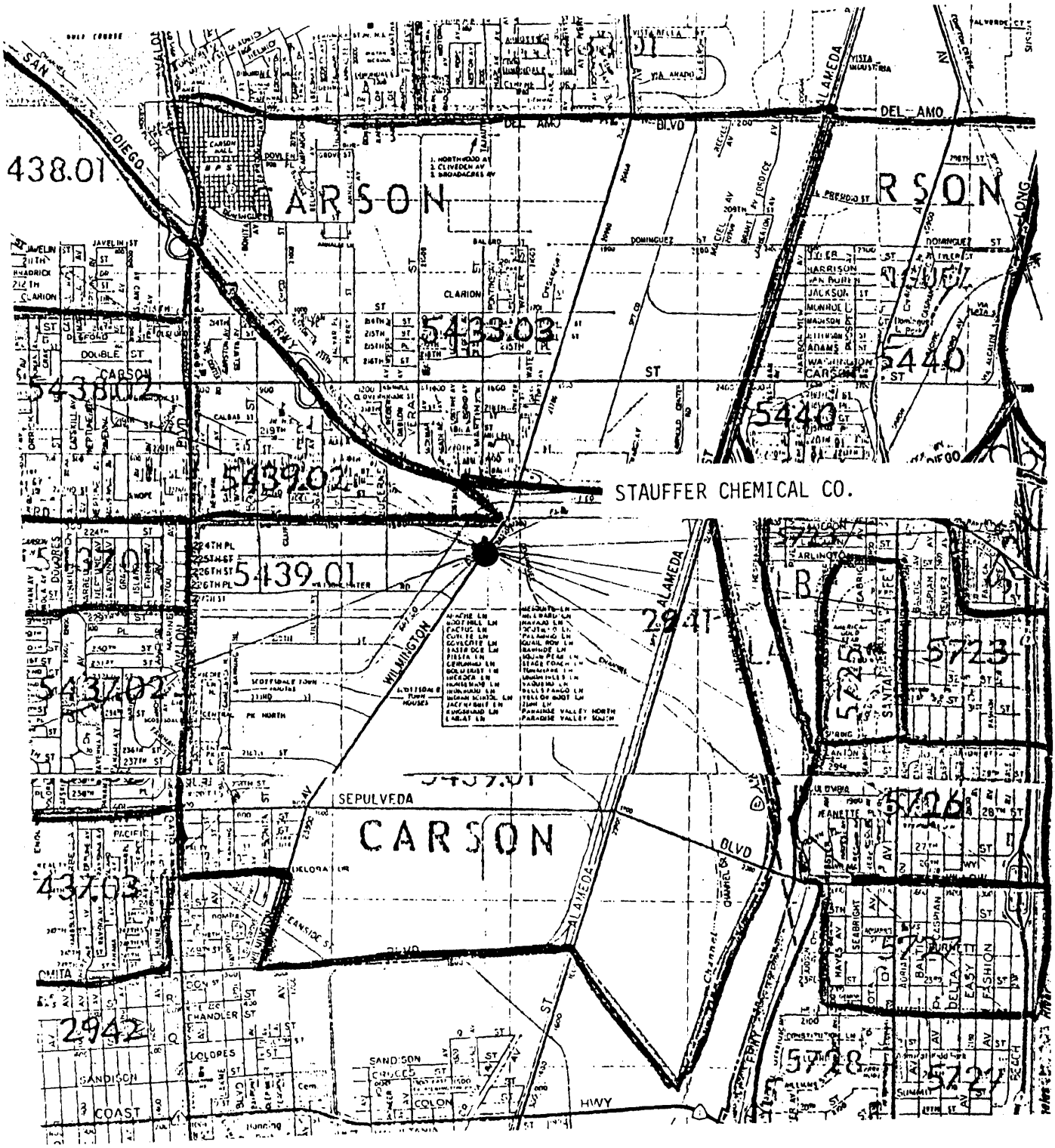
Eastern Plant Area - Kaiser Steel, Fontana



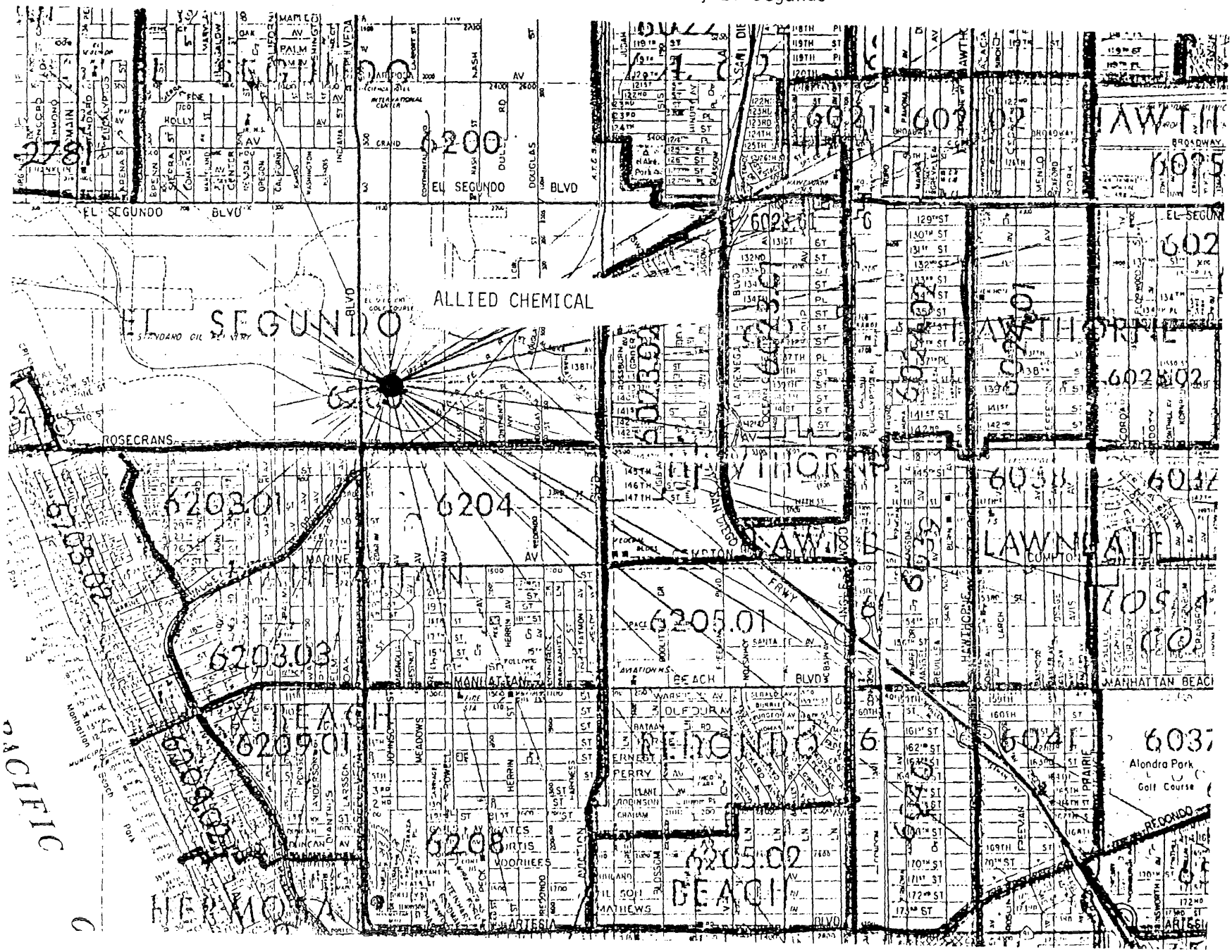
Offsite Storage Tanks - Stauffer Chemical Co., San Pedro



Main Plant Site - Stauffer Chemical Co., Carson

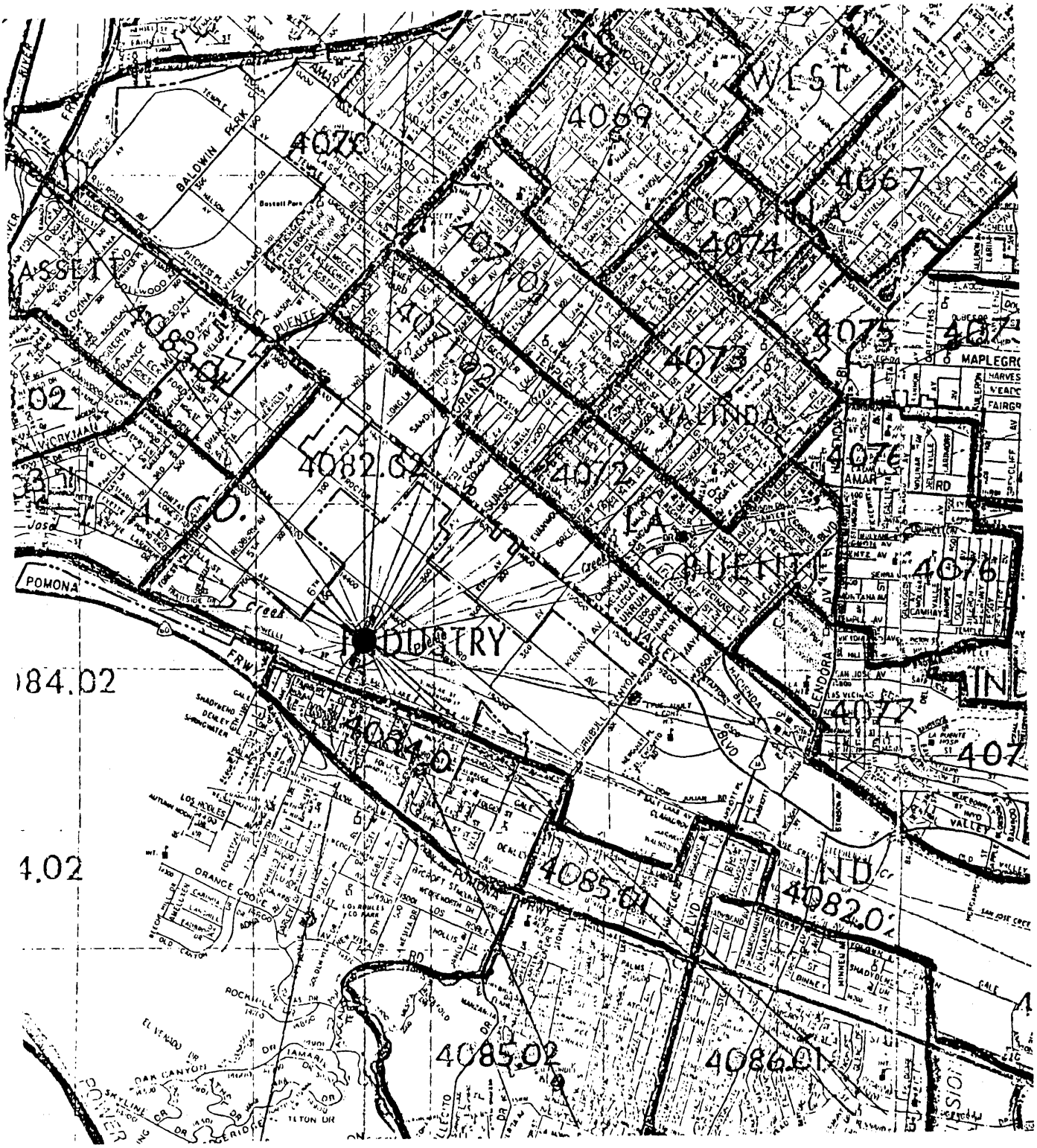


Plant Site - Allied Chemical, El Segundo

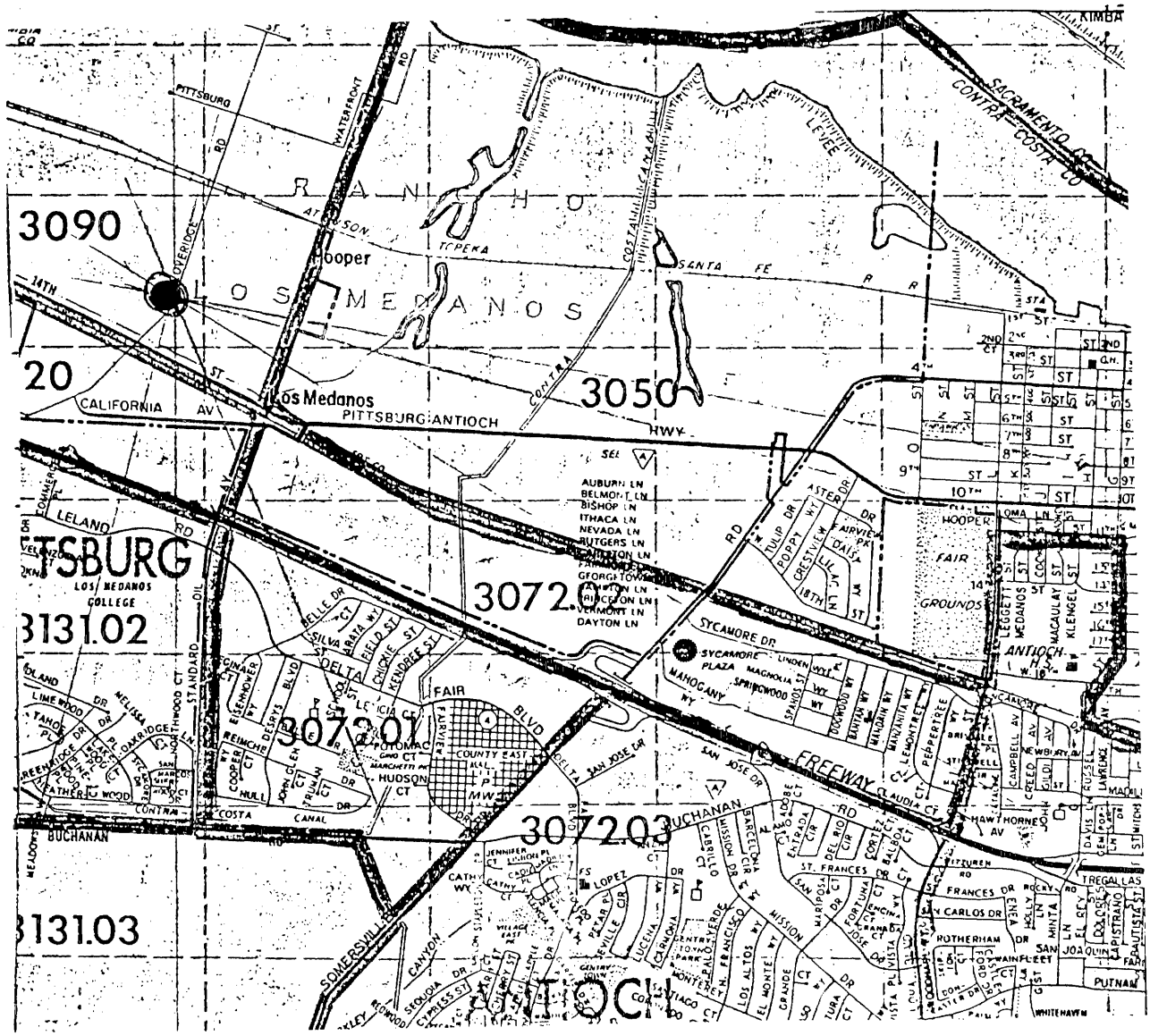


H-6

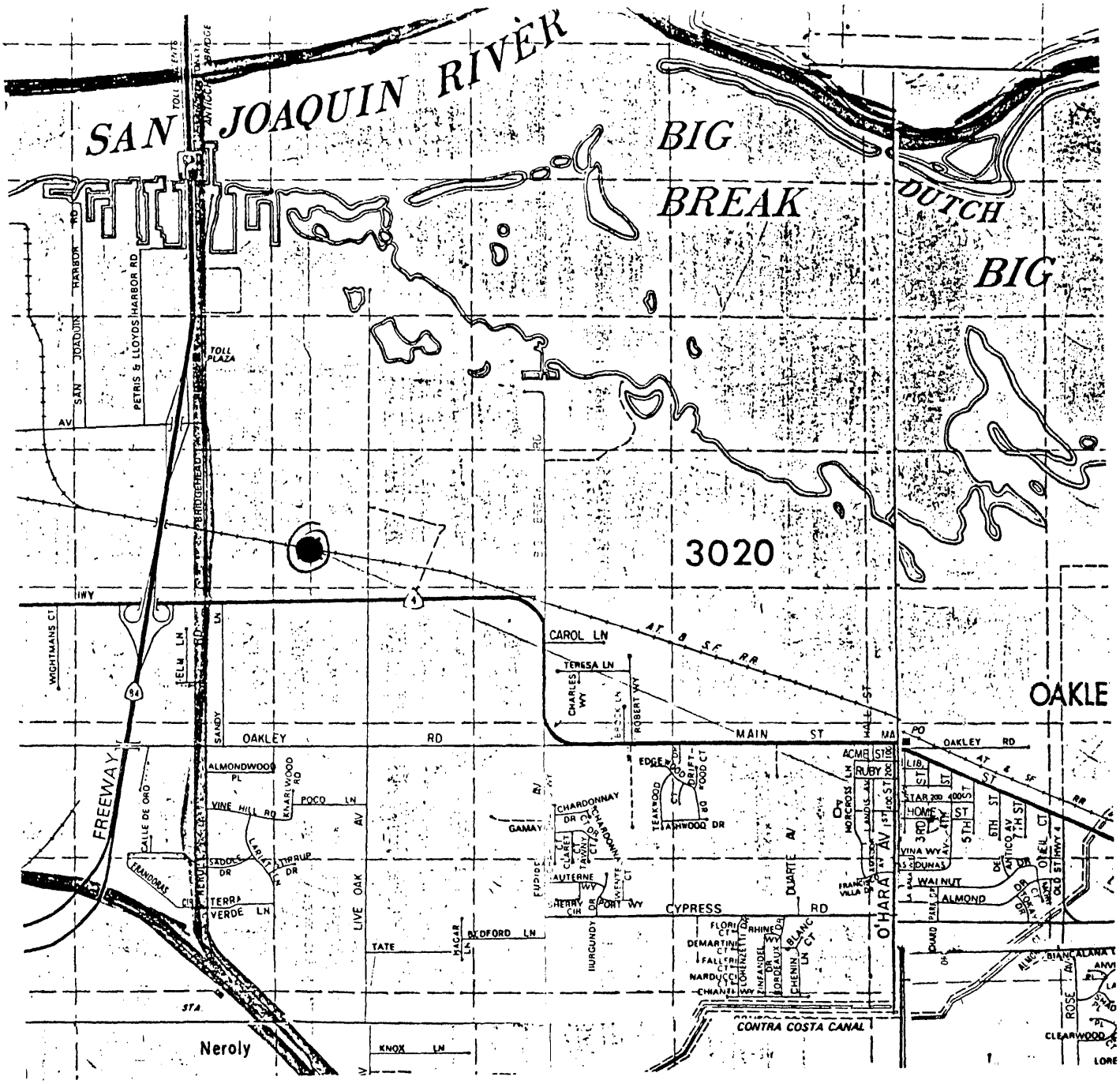
Plant Site RSR Corp., City of Industry



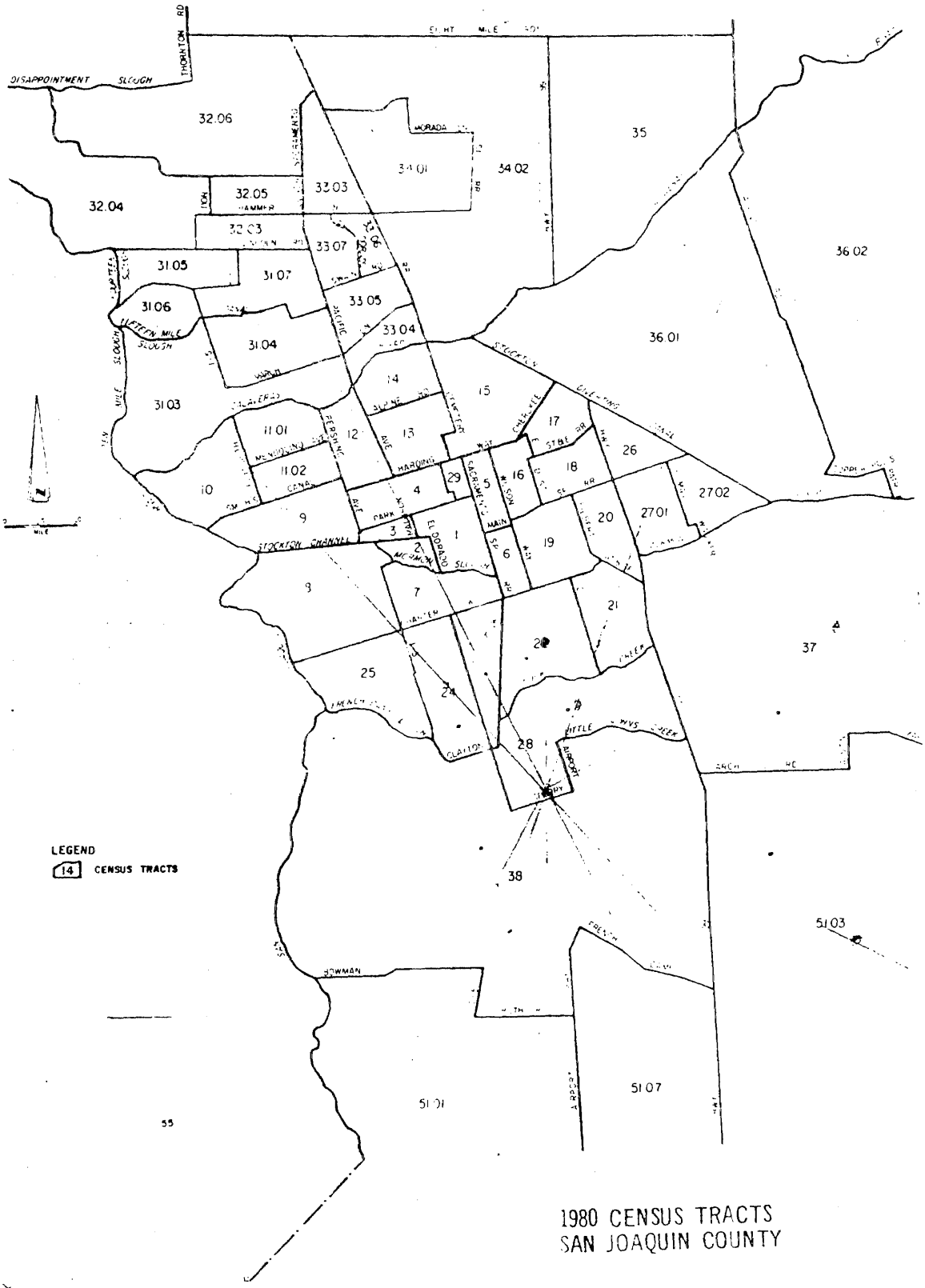
Plant Site - Dow Chemical U.S.A., Pittsburg



Plant Site - Du Pont, Antioch



Plant Site - Johns Manville, Stockton



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