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CONTRIBUTIONS BY POINT
SOURCE RELEASES TO
MODELED VINYL CHLORIDE
CONCENTRATIONS NEAR THE
STAUFFER CHEMICAL COMPANY
LONG BEACH VINYL CHLORIDE MONOMER
AND POLYVINYL CHLORIDE PRODUCTION PLANT

For THE STAUFFER CHEMICAL COMPANY

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October 18, 1979

Stauffer Chemical Company
Nyala Farm Road
Westport, Connecticut 06880

Attention: Mr. Gary L. Ford, Esq.

Gentlemen:

We hereby submit 11 copies of this report documenting the methodology and results of dispersion modeling analyses of vinyl chloride emissions from the Long Beach VCM/PVC plant. The purpose of this analysis is to evaluate the effects on maximum 24-hour ground level concentrations of vinyl chloride from variations in the specification of emission rates from point sources in the VCM/PVC plant.

The range of modeled emission rates included both the current level and the level coinciding with the proposed Rule 1005.1 of the South Coast Air Quality Management District. The results of the modeling analysis indicate that further controls imposed upon the point sources will not have a significant effect on ambient vinyl chloride concentrations, and this is corroborated by various sensitivity tests performed.

If you should have any questions, please call at your convenience.

Yours very truly,

DAMES & MOORE

Paul D. Gutfreund
Principal Air Quality
Meteorologist

George C. Howroyd
Staff Atmospheric
Scientist

PDG:GCH/tls
Enclosures

cc: Herb Langner, Long Beach, California (7)

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1. INTRODUCTION AND SUMMARY

The State of California's South Coast Air Quality Management District (SCAQMD) is currently considering proposed regulations to increase control of point source vinyl chloride (VC) emissions from chemical plants at which this material is handled. Section f(1) of the proposed regulation SCAQMD Rule No. 1005.1 would apply to all VC point sources exclusive of releases due to "leaks and waste water." The purpose of this report is to assess the consequences on ambient VC concentrations of additional controls of this type as might be applied to the vinyl chloride monomer (VCM) and polyvinyl chloride (PVC) manufacturing plant owned and operated by the Stauffer Chemical Company in Long Beach, California. The VC point sources which would be subject to control under the proposed new regulation are referred to herein as "eligible point sources."

Dames & Moore had previously performed extensive analyses of the emissions and atmospheric dispersion of VC from Stauffer Chemical's VCM/PVC plant and from the contiguous PVC production plant belonging to the BF Goodrich Chemical Division (BFG). These analyses were reported in a major report of April 1978, referred to herein as the Dames & Moore 1978 Report. The technical aspects of the present study are very similar to the previous work, with the same EPA-approved dispersion modeling codes (the RAM suite of codes) and meteorological data (1964 surface data from the Long Beach Airport) being used. Current emissions data for VC were supplied to Dames & Moore by Stauffer Chemical.

The dispersion modeling exercise performed in this study produced the following results due to VC emissions from the Stauffer Chemical VCM/PVC plant:

1. The maximum ambient 24-hour VC concentration calculated was 49.89 ppb, which was predicted at a receptor site within 50 m of the western boundary of the Stauffer plant. This maximum

value was found to be primarily the result of fugitive emissions.

2. The modeling of specific variations in the total eligible point source emissions, ranging from 1 g/hr (proposed by SCAQMD) to 591 g/hr (the current rate) to 1200 g/hr (twice the current rate), was found to result in only small changes in the maximum predicted ground level VC concentration.
3. The maximum 24-hour average contribution from the total of the eligible point sources, as currently controlled, was found to be less than 3 ppb at a receptor site within 50 m of the northern boundary of the Stauffer Plant.

These results indicate that the contribution to the ambient VC concentrations made by the emissions from the Stauffer eligible point sources is not significant in comparison to the total concentration, and may in fact be difficult to detect. This statement holds true either under the current eligible point source emission rates, or under potential stricter control of these emission rates. Therefore, the dispersion modeling exercise indicates that no significant reduction in the ambient VC levels can be attained by increased control imposed upon the eligible point sources located at this facility.

2. VINYL CHLORIDE EMISSIONS

2.1 GENERAL

Vinyl chloride (VC) emissions data representative of the current operation of the Stauffer Chemical VCM/PVC plant were supplied to Dames & Moore by Stauffer Chemical Company personnel. In the case of fugitive emissions from valves and flanges scattered throughout an area of the plant, the total fugitive emission rate developed in the previous study (Dames & Moore, 1978) was used. The spatial distribution of the fugitive sources was modified from that presented in the Dames & Moore 1978 study.

The list of VC emission sources modeled in this study is presented in Table 2-1, and the locations of the sources relative to the boundary of the Stauffer plant are presented in Figure 2-1. The sources fall into two categories, which are discussed in turn in the following sections:

1. Eligible point sources, which would be regulated under the proposed Section f(1) of SCAQMD Rule No. 1005.1.
2. Area sources, which include fugitive emissions from leaks in valves and flanges which operate in VC service.

TABLE 2-1

VINYL CHLORIDE EMISSION RATES AND RELEASE PARAMETERS USED IN MODELING ANALYSES

Source Type Name	Source ID No.	VC Emission Rates (mg/s)				Exit Height (m)	Exit Diam (m)	Exit Temp (K)	Exit Velocity (m/s)
		Scenario 1	Scenario 2	Scenario 3 ^a	Scenario 4				
Eligible Point Sources									
Incinerator 642	1	.001	.489	.965	1.95	13.0	.61	337.4	5.66
Incinerator 1525	2	.001	.474	.935	1.89	15.0	.61	337.4	10.51
PVC No. 1	3	.000	.015	.030	.061	11.0	.25	327.6	5.83
PVC No. 2	4	.000	.020	.040	.081	11.0	.25	327.6	5.83
PVC No. 3	5	.000	.060	.120	.243	11.0	.48	327.6	10.36
Blend Tank	6	.001	.368	.727	1.457	14.8	.22	355.4	8.74
Blend Tank	7	.000	.008	.016	.032	11.6	.13	355.4	8.74
Dryer	8	.168	50.3	99.3	201.6	3.1	.84	338.7	6.78
Dryer	9	.053	16.07	31.70	64.35	7.6	1.54	338.7	11.40
Dryer	10	.036	10.80	21.31	43.26	20.7	.61	338.7	24.30
Centrifuge	11	.000	.007	.014	.028	11.3	.25	338.7	.20
Centrifuge	12	.000	.008	.016	.032	18.3	.20	338.7	.15
Silos	13	.003	.927	1.83	3.71	22.0	.74	310.0 ^b	.85
Silos	14	.003	.927	1.83	3.71	24.0	.49	310.0 ^b	.85
Silos	15	.000	.108	.213	.432	24.0	.53	310.0 ^b	.85
Lab Vent	16	.009	2.680	5.300	10.759	5.5	.60	310.0 ^b	1.10
Centrifuge	17	.001	.007	.014	.028	7.9	.25	338.7	.20
Total, Eligible Point Sources		0.278 (1 g/hr)	83.26 (300 g/hr)	164.35 (591 g/hr)	333.63 (1200 g/hr)				
Area Sources		UCC 022367							
Area 1	216.300		216.300	216.300	216.300	6.0 ^c			
Area 2	186.900		186.900	186.900	186.900	6.0 ^c			
Area 3	79.400		79.400	79.400	79.400	6.0 ^c			
Plant Total Emissions			482.9 (1738.4 g/hr)	565.9 (2037.2 g/hr)	646.95 (2329.0 g/hr)	816.23 (2938.4 g/hr)			

^aRepresents current emission levels at the Stauffer Chemical Long Beach Plant.^bComputer codes require that all release temperatures be higher than the highest ambient temperature encountered. Therefore all ambient temperature releases were set to a stack temperature of 310.0 K.^cEffective stack height for area sources.

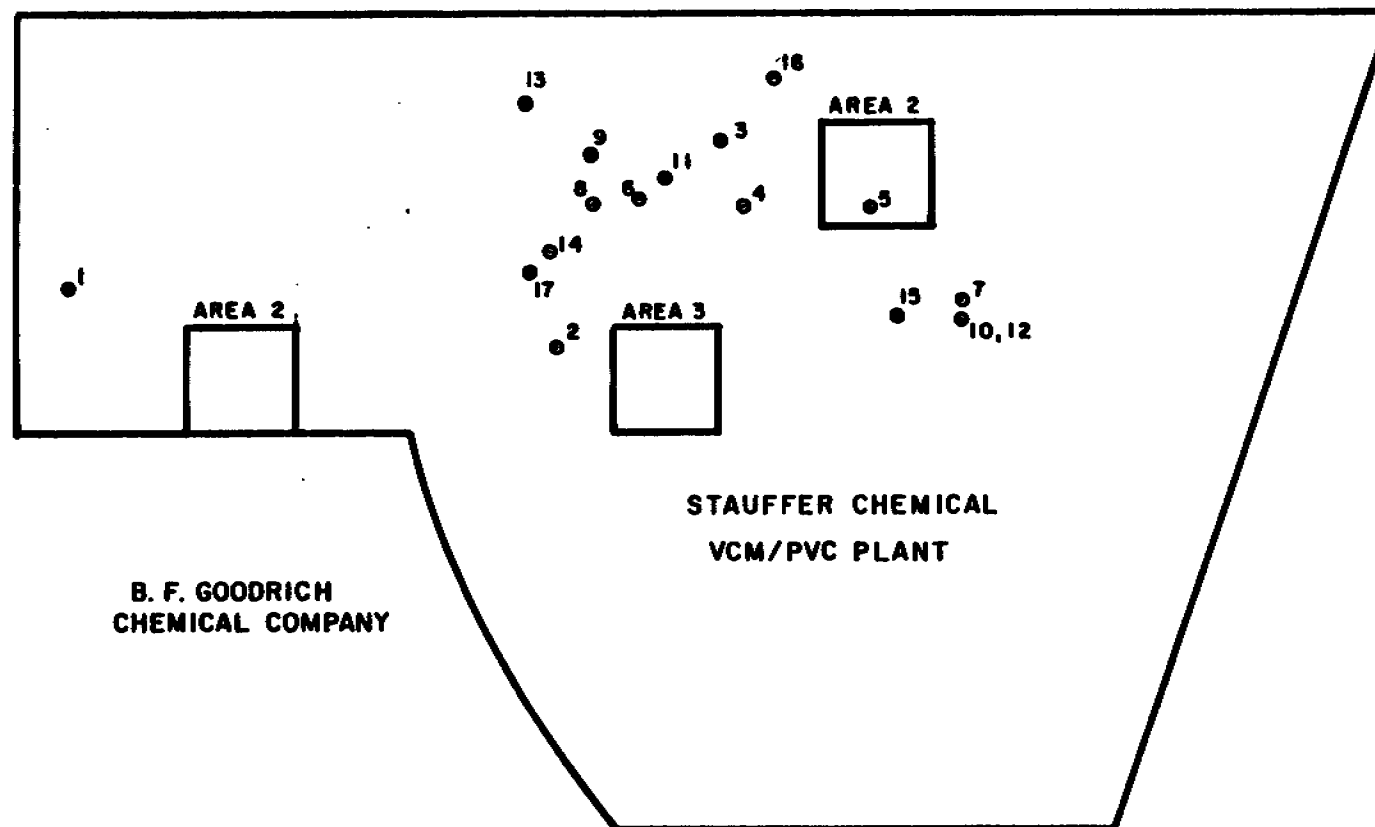


Figure 2-1. Relative Location of Vinyl Chloride Emission Sources at the Stauffer Chemical Company Long Beach Plant. Numbered Sources are Identified in Table 2-1.

2.2 ELIGIBLE POINT SOURCES

There are 17 eligible point sources, for which distinct emission rates under four separate emissions scenarios are presented in Table 2-1. Scenario 3 represents the actual current point source emissions from the plant, while the other scenarios represent scaled point source emissions under the assumption of various levels for the total plant point source emission rate.

The current Scenario 3 emissions total of 591 g/hr was determined by measured quantities of VC released in the following ways:

1. Controlled PVC reactor openings (sources 3, 4, and 5 in Table 2-1). This represents an average measured value for the most recent six months of operation of the plant.
2. Continuous emissions from two incinerators (Sources 1 and 2 in Table 2-1).
3. The difference in VC concentrations measured in the product stream between the stripper and the final shipping point is used to determine the amount of VC released from points downstream of the stripper. This results in a total of 565 g/hr being emitted from sources 6-15 and 17. This total emission rate was apportioned among these point sources by Stauffer Chemical personnel.
4. Emissions of VC released from the lab vent (source 16 in Table 2-1) as a result of routine product stream sampling operations in the laboratory.

For the other Scenarios 1, 2, and 4 the same distribution of emission rates for point sources as for Scenario 3 was assumed, but with the total emissions from the eligible point sources scaled to 1 g/hr, 300 g/hr, and 1200 g/hr, respectively.

Note that the emission rates presented in Table 2-1 are in units of mg/s, rather than in the commonly-used larger unit of g/s. This was done in the interest of presenting conveniently large numbers to

represent the small VC emission rates. Also, the number of digits displayed in Table 2-1 should not be taken to imply that the emission rates are known to the indicated precision. The arithmetic was carried out to the place for which two significant digits were displayed for the smallest emission rates (one significant digit for Scenario 1). This guaranteed that the apportionment of the total emission rate could be done consistently and uniformly for all the scenarios. None of the emission rates in Table 2-1 are actually known to more than two significant digits.

2.3 AREA SOURCES

In the Dames & Moore 1978 Report an estimate of fugitive emissions from a count of valves and flanges in VC service indicated a Stauffer Chemical plant total area emission rate of 0.4826 g/s (1737 g/hr). This total figure has been retained as the best available estimate of fugitive emissions to date.

In the present analyses, the fugitive emissions are apportioned to three square areas (identified in Figure 2-1) each containing approximately 1400 m². These areas are centered on the plant locations where VC is handled, namely the PVC reactors (Area 1), VCM units 1 and 2 (Area 2) and VCM unit 3 (Area 3). As in the previous study, it was assumed that 45 percent of the total fugitive emissions are released from Area 1, 39 percent are released from Area 2, and 16 percent from Area 3.

3. MODELING METHODOLOGY

The modeling methodology used in this study is very similar to that reported in detail in the Dames & Moore 1978 study. Briefly, model calculations were performed using codes from the EPA-approved RAM suite of dispersion modeling codes (USEPA, 1978). Meteorological data used were the 1964 hourly surface record taken at the Long Beach Airport, 8 km from the Stauffer Chemical site, and seasonal mixing-height values for Santa Monica, California, as presented in Holzworth, 1972. Consideration was restricted in this study to calculated concentrations for the 24-hour averaging period, at selected receptor locations representing nearby residences, schools, and points along the perimeter of the plant site.

The RAM codes provide optional use of either rural or urban dispersion parameters. The Dames & Moore 1978 Report showed that the use of the rural dispersion parameters is the more conservative choice in modeling the PVC plant, because the maximum concentrations are primarily due to the low-level area releases of VC. For these low-level sources, the rural parameters produce higher calculated concentrations than do the urban parameters. Therefore, most of the modeling done for this study used the rural dispersion characteristics. Sensitivity checks were performed using the urban parameters to recalculate maximum concentrations determined using the rural dispersion calculations, as described in Section 4.

Since the proposed Section f(1) of SCAQMD Rule No. 1005.1 would affect only a certain class of point sources, two main types of calculations were performed. The first type of calculation included all known sources of VC emissions from the plant, with various scenarios representing different levels of emissions from the eligible point sources. This type of calculation represents the effects, due to regulation of the eligible sources, on the maximum ambient VC concentrations from the plant. In the second type of calculation, only the eligible point sources were included in the emissions inventory, and the same scenarios as for the first type were considered. This represents

the effects, due to regulation of the eligible sources, on the concentrations to which the eligible sources contribute maximally.

The receptor points at which the concentrations were calculated are listed in Table 3-1, and their locations relative to the Stauffer Chemical VCM/PVC plant and the contiguous BFG PVC plant are indicated in Figure 3-1. Receptor 30 represents the location of the ambient VC monitor operated by the SCAQMD at Cormier Chevrolet Company.

Representative RAM computer input and output listings used in this study are given in the Appendix.

TABLE 3-1
RECEPTOR LOCATIONS

<u>Receptor Type</u>	<u>Receptor Number</u>	<u>UTM Coordinates</u>	
		<u>East</u>	<u>North</u>
Residence	1	385.03	3743.39
Residence	2	386.62	3742.88
Residence	3	384.52	3743.19
Residence	8	383.22	3742.21
School	11	385.22	3744.47
School	15	383.32	3743.65
School	17	387.92	3741.87
Receptor	29	385.25	3743.21
Receptor	30 ^a	385.63	3743.21
Receptor	31	385.58	3743.17
Receptor	32	385.80	3742.88
Receptor	33	385.63	3742.88
Receptor	34	385.41	3743.02
Receptor	35	385.33	3743.02
Receptor	36	385.92	3743.02
Receptor	37	385.48	3742.78

^a Cormier Chevrolet location of SCAQMD VC monitor.

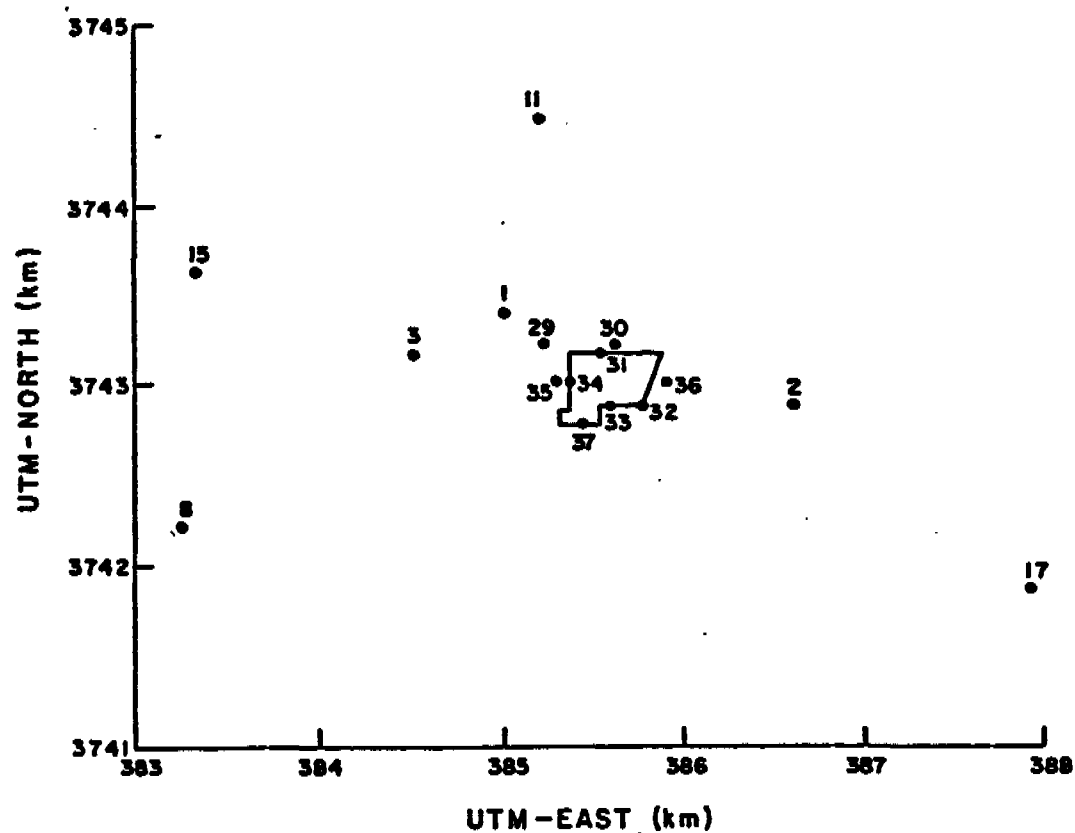


FIGURE 3-1. LOCATIONS OF RECEPTOR POINTS CLOSE TO THE VCM/PVC COMPLEX CONSISTING OF THE STAUFFER CHEMICAL AND BFG PLANTS. IDENTIFYING NUMBERS CORRESPOND TO THOSE IN TABLE 3-1.

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4. RESULTS

4.1 PRIMARY RESULTS

The primary results produced by this modeling study are presented in Table 4-1. All of the concentrations reported in Table 4-1 are 24-hour average concentrations calculated using the rural RAM codes. The results of both Type 1 calculations (based on the entire Stauffer Chemical plant VC emissions inventory) and Type 2 calculations (based on eligible point source releases only) are presented in Table 4-1.

The procedure used to generate the concentrations presented was as follows:

1. A run using Scenario 3 emissions (present emissions) was made on the entire year of meteorological data.
2. The results of 1) were used to determine eight worse-case days, defined by the 4 highest 24-hour concentrations calculated for the entire plant emission inventory and the 4 highest 24-hour concentrations calculated for the eligible point sources alone, using the 16-receptor field.
3. For each of the days identified in 2), the calculation was performed using Scenario 1 emission rates.
4. For the day of the highest concentration found in 2), the calculation was performed using all four scenarios of emission rates (for both the entire plant emission inventory as well as for the eligible point sources alone).

Examination of Table 4-1 reveals the following characteristics of the results, which are pertinent to regulation of the eligible point sources within the range of total emissions considered:

1. The maximum concentrations due to all VC emissions from the Stauffer Chemical plant (Type 1 calculations) occur on or very near the plant site boundary, and are relatively insensitive to the emission rates for the eligible point sources. This reflects the fact that the relatively larger emission rates

TABLE 4-1
VINYL CHLORIDE DISPERSION MODELING RESULTS
STAUFFER CHEMICAL VCM/PVC PLANT, LONG BEACH, CALIFORNIA

Day of Meteorological Conditions (1964 Data)		Receptor	Predicted 24-Hour VC Concentration (ppb) by Scenario Number			
			1 (1 g/hr) ^a	2 (300 g/hr) ^a	3 (present) (591 g/hr) ^a	4 (1200 g/hr) ^a
1. Entire Plant Emission Inventory						
Day	70	35	49.55	49.72	49.89	50.24
	263	35	40.78		40.79	
	365	35	36.39		37.09	
	207	35	36.39		36.40	
	231	Sp ^b	9.87		10.23	
	218	Sp ^b	39.76	39.76	39.76	39.76
	206	Sp ^b	14.19		15.41	
	102	30	21.49		24.13	
2. "Eligible" Point Sources Only						
Day	231	30	.0051	1.53	2.96	6.01
	218	30	.0047		2.74	
	206	30	.0047		2.67	
	102	30	.0043		2.64	

^aRepresents total eligible point source emissions for the indicated scenario. Total fugitive emission rate is 1737 g/hr.

^bSpecial Receptor Location identified by the model.

associated with the low-level fugitive releases are the primary contributors to the maximum concentrations. A variation by a factor of 1200 in the total eligible point source emission rate produces a variation in the maximum concentration of only a few ppb..

2. The maximum concentrations due to the eligible point sources alone (Type 2 calculations) are relatively much smaller than those predicted for the entire plant inventory. For example, for Scenario 3 the ratio of the maximum 24-hour Type 1 concentration (all sources) to the maximum Type 2 concentration (eligible point sources only) is about 17.
3. In changing from the current eligible point source emission rate of 591 g/hr (Scenario 3) to a potential proposed rate of 1 g/hr (Scenario 1), the Type 2 (eligible point sources only) maximum 24-hour concentration can be expected to be reduced from 2.96 ppb VC to 0.0051 ppb VC.

These salient features of the modeling results indicate that increased control of the VC emissions from the eligible point sources will not result in a significant reduction in the maximum ambient VC concentrations. Increased control of eligible point sources from the current level of 591 g/hr to 1 g/hr could be expected to reduce the maximum ambient concentrations at most by values of the order of 3 ppb. This concentration difference is negligible in comparison to the total ambient 24-hour maximum concentrations of approximately 50 ppb or larger.

Note that the procedure used was designed to show representative changes rather than to be exhaustive. Concentrations for Scenario 2 and Scenario 4 were not calculated for any except the worst-case day for each of the Type 1 and Type 2 calculations, thus leaving some blank entries in Table 4-1. The values for these instances may be estimated to sufficient accuracy by linear interpolation and extrapolation from the Scenario 1 and Scenario 3 results for the same day. For example, the Scenario 2 concentration for Day 263 (Type 1) is 40.79 ppb, and the Scenario 4 concentration for Day 218 (Type 2) is about 5.56 ppb.

4.2 SENSITIVITY TESTS

The results presented in Section 4.1 reflect the application of a very conservative modeling assumption, which for the collection of sources considered involved the use of rural dispersion parameters. This fact had been determined by sensitivity tests conducted during the analyses reported in the Dames & Moore 1978 study. Nonetheless, it is of some interest to compare the results to calculations using the urban dispersion parameters, since the EPA generally favors use of urban dispersion parameters in urban areas such as the Long Beach-Carson neighborhood in which the Stauffer Chemical VCM/PVC plant is located.

The urban-dispersion parameters provide an enhancement of dispersion relative to the rural case due to increased atmospheric turbulence in urban areas. This enhancement of dispersion has different effects on ground-level concentrations due to low-level and to elevated release sources. For low-level releases, the increased dispersion in the urban case generally leads to a reduction in the maximum ground-level concentrations. For elevated sources, the urban case generally leads to maximum ground-level concentrations that are both larger and closer to the source, as compared to the rural results. This effect is due to the enhanced urban dispersion mixing the elevated release down to ground level more quickly. The rural dispersion parameters proved more conservative in the modeling of the Stauffer plant because the low-level fugitive sources were much larger and more significant than were the elevated point sources.

Table 4-2 presents a comparison of the maximum 24-hour concentrations calculated for Scenario 3 using the rural dispersion parameters (from Table 4-1) and those for the same days using the urban dispersion parameters. The results are consistent with the expectations produced by the discussion above:

1. For the case in which the entire emissions inventory is included (i.e., the relatively large low-level fugitive sources are included), the urban calculation results in a slightly

TABLE 4-2

STAUFFER CHEMICAL COMPANY VCM/PVC PLANT, LONG BEACH, CALIFORNIA
VC DISPERSION MODELING SENSITIVITY TESTS(Concentrations in ppb, 1 ppb VC = 2.56 $\mu\text{g}/\text{m}^3$)

<u>Day of Meteorological Record (1964) and Conditions</u>	<u>Receptor Points with Highest Concentration</u>	<u>24-hr VC Concentration^a</u>
1. Entire Plant Emissions Inventory		
Day 070	REC 35	49.89
Day 070- Urban Disp. Param.	REC 34	49.78
2. Eligible Point Sources Only		
Day 218	REC 30	2.74
Day 218- Urban Disp. Param.	REC 30	3.26

^a Calculated for the Scenario 3 emission rates, which represent the present VC emissions from the BFG plant.

reduced concentration: 49.78 ppb compared to 49.89 ppb. The location of the maximum value is also moved closer to the primary sources of emission.

2. For the case in which only the eligible point sources are included, the urban calculation results in a slightly increased concentration: 3.26 ppb compared to 2.74 ppb, both of which were predicted at the same receptor.

The use of the urban dispersion parameters rather than the rural ones does not change the essential points of the conclusions reached in Section 4.1. As presented in Table 4-2 for the urban case, the maximum concentration produced by the low-level fugitive sources is 49.78 ppb, a value approximately 15 times larger than the maximum concentration of 3.26 ppb produced by the eligible point sources alone.

REFERENCES

Dames & Moore, 1978: Dispersion Modeling Analyses of Vinyl Chloride Emissions from the Vinyl Chloride Monomer/Polyvinyl Chloride Production Complex near Long Beach, California, for the BF Goodrich Company and the Stauffer Chemical Company, April 1978.

Holzworth, G. C., 1972: Mixing Heights, and Potential for Urban Air Pollution Throughout the Contiguous United States. USEPA, Office of Air Programs, Research Triangle Park, NC 27711.

USEPA, 1978: Guidelines on Air Quality Models, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. OAQPS 1.2-080.

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APPENDIX

The tables of this appendix present input and output listings for the RAM suite of dispersion modeling codes. These listings are representative samples from the substantial volume of computer runs made in the course of this work. (A total of 25 runs of the various RAM programs were made for this study.) The listings selected for presentation were chosen to illustrate some of the primary results of the study. It should be noted that reference to SO₂ in the output listings actually refers to VC.