Health Risk Assessment
of the
B.K.K. Landfill, West Covina, California

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INTERIM REPORT

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In June 1990, a draft copy of the "Health Risk Assessment of the B.K.K. Landfill, West Covina, California" was reviewed by members of the Air Quality Advisory Committee, a technical subcommittee of the Interagency Steering Committee of the B.K.K. Landfill. The Department of Health Services expresses appreciation to the committee members for their critique of the draft report. Comments and suggestions were incorporated into this interim report.

Statistical evaluation of the data in the 1984 Extended Monitoring Program of the risk characterization was performed by Joel Swartz, Ph.D., Environmental Epidemiology and Toxicology Branch.

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GLOSSARY OF TERMS

ANALYSIS OF VARIANCE - A statistical technique that isolates and assesses the contribution of one or more factors to the variation in an outcome of interest. In analysis of variance (ANOVA), independent categorical variables (factors) are investigated for their influence on the dependent continuous random variable (outcome). Assumptions underlying ANOVA are: independence of the values, normality of the errors in the values, and equal variance for all observations.

AMBIENT AIR - Outdoor air.

AMBIENT AIR QUALITY STANDARD - A standard adopted by CARB in consideration of public health, safety, and welfare, including, but not limited to, health, illness, irritation to the senses, aesthetic value, interference with visibility, and effects on the economy; standards may vary from one air basin to another; standards relating to health effects are based on the recommendations of DHS (California Health and Safety Code Section 39606). An ambient air quality standard applies at the boundary of a facility. In 1978, CARB adopted an ambient air quality standard for vinyl chloride of 10 parts per billion (ppb) for a 24-hour average. The standard represented the limit of detection for vinyl chloride at that time.

CARB - California Air Resources Board

CAPCOA - California Air Pollution Control Officers Association

CERCLA - In 1980, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) which established broad federal authority to deal with releases or threats of releases of hazardous substances. CERCLA, also known as Federal Superfund, was amended in 1986.

CH2MHILL - A consulting engineering firm contracted by EPA in October 1985 to conduct an exposure assessment of the B.K.K. Landfill.

CHRONIC REFERENCE DOSE - An estimate of the daily exposure to humans, including sensitive populations, that is likely to be without an appreciable risk of adverse health effects during the lifetime (70-years). Developed by EPA, the chronic reference dose is specifically designed to be protective for long-term exposures; the subchronic reference dose is used with short-term exposures.

CLASS I LANDFILL - A classification system for landfills in California developed by state agencies. All landfills require a permit to operate. Class I landfills may accept hazardous waste, subject to federal and state regulations for hazardous waste management units.

CLASS III LANDFILL - A landfill that accepts only non-hazardous waste (municipal refuse and dewatered sludge). Class III landfills are regulated by state and local agencies.

DHS - California Department of Health Services

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DHS-EETB - California Department of Health Services, Environmental Epidemiology and Toxicology Branch

DHS-TSCP - California Department of Health Services, Toxic Substances Control Program

EPA - United States Environmental Protection Agency

HEALTH RISK ASSESSMENT - An analysis of the potential adverse health effects associated with exposure to hazardous substances based upon four systematic components: hazard identification, exposure assessment, dose-response ass ssment, and risk characterization.

INDIVIDUAL EXCESS LIFETIME CANCER RISK - An upper-bound estimate of the probability of an individual developing cancer due to a lifetime (70-year) exposure to the level in question of a carcinogen.

LANDFILL GAS - Methane, carbon dioxide, and trace gases generated by the anaerobic decomposition of buried organic wastes (both municipal and hazardous wastes). These gases serve as a transport medium for volatile organic compounds deposited or generated onsite. Landfill gas that is not collected by a gas collection system is released to ambient air, or migrates laterally through the soil before being released to the air or groundwater.

LEACHATE - Any liquid, including suspended components in the liquid, that percolates through or drains from buried wastes.

LINEARIZED MULTISTAGE MODEL - A mathematical model used to estimate the probability of incidence of disease by extrapolating from high dose animal studies to low level human exposures. This model is commonly used in quantitative carcinogenic risk assessments where the chemical agent is assumed to be a complete carcinogen and the risk is assumed to be proportional to the dose in the low region. This model yields estimates of risk that are conservative, representing a plausible upper limit for the risk.

MAXIMUM CONTAMINANT LEVEL - The enforceable drinking water standard, based on health and technical feasibility.

MAXIMUM LIKELIHOOD ESTIMATE - The best fit dose-response line from a set of data.

POPULATION EXCESS CANCER BURDEN - An upper-bound estimate of the increase in cancer cases in a population as a result of a defined exposure to a carcinogen.

RCRA - In 1976, Congress passed the Resource Conservation and Recovery Act (RCRA) which controls the generation, treatment, storage, and disposal of solid and hazardous waste. The Act, referred to as "cradle-to-grave" regulation of solid and hazardous waste, was amended in 1980 and 1984.

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RCRA PART B PERMIT APPLICATION - Requires owners and operators of hazardous waste facilities to submit detailed information about a facility, such as: a description of the procedures, structures or equipment used to prevent runoff and contamination of water supplies; a topographic map showing surface waters, surrounding land uses (residential, commercial, agricultural, recreational); a wind rose; and injection and withdrawal wells onsite and offsite. Contents of Part A and Part B of the Application are specified in the California Code of Regulations, Title 22, Division 4, Chapter 30, Sections 66390 and 66391.

SAM WORK PLAN - The Site Assessment and Mitigation (SAM) Work Plan for the Class I Hazardous Waste Management Unit, developed by consultants to the B.K.K. Landfill in coordination with regulatory agencies. Provisions of the SAM Work Plan address ongoing monitoring requirements of the B.K.K. Landfill.

SCAQMD - South Coast Air Quality Management District

SLOPE FACTOR - An upper-bound estimate of the probability of developing cancer per unit intake of a chemical over a lifetime (70-year). The slope factor is usually, but not always, the upper 95th percent confidence limit of the slope of the dose-response curve and is expressed as $(mg/kg\text{-}day)^{-1}$.

THRESHOLD - A dose level below which a response attributable to a particular substance will not occur.

TOXIC AIR CONTAMINANT - An air pollutant which may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health. As established by legislation in 1983, and in consultation with DHS, CARB is implementing a program which first identifies and then controls toxic air contaminants (California Health and Safety Code Section 39650 *et seq*, Food and Agriculture Code Section 14021 *et seq*).

UNIT RISK - A measure of the carcinogenic potential of a substance, expressed in terms of risk per unit concentration of the substance in the medium where human contact occurs. The inhalation unit risk is an estimate of the probability of developing cancer as a result of constant exposure over 70 years to 1 $\mu g/m^3$ of a substance in air.

UPPER 95 PERCENT CONFIDENCE LIMIT - The statistical upper bound of the excess cancer risk derived from low dose extrapolation models.

VOC - Volatile organic compound

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EXECUTIVE SUMMARY

In October 1985, the United States Environmental Protection Agency (EPA) contracted CH2MHill to conduct an exposure assessment of the B.K.K. Landfill, West Covina, California with the understanding that the California Department of Health Services (DHS) would perform a quantitative health risk assessment based on the data collected and evaluated. In August 1988, CH2MHill completed its seven-volume report, entitled "B.K.K. Landfill Environmental Exposure Characterization Report, West Covina, California." The report was reviewed by EPA, DHS, a technical peer review subcommittee, and a citizens advisory committee.

This health risk assessment of the B.K.K. Landfill was prepared by the Hazardous Waste Toxicology Section of the California Department of Health Services, Health Hazard Assessment Division. The health risk assessment is concerned primarily with the risk of developing cancer from a 70-year exposure to the concentrations of carcinogens detected in air around the B.K.K. Landfill between 1982 through 1987. Air monitoring data from this period met retrospective quality assurance review for use in a quantitative risk characterization. The health risk assessment is divided into five parts:

- INTRODUCTION, which introduces the health risk assessment and summarizes the history of the B.K.K. Landfill;

- HAZARD IDENTIFICATION, which gives information about the indicat r chemicals (carcinogens and noncarcinogens) detected in groundwater, surface water, and air in and around the B.K.K. Landfill;

- EXPOSURE ASSESSMENT, which describes the population in the vicinity of the B.K.K. Landfill, evaluates the pathways of exposure t neighboring residents, and describes the air monitoring programs used in the risk characterization;

- DOSE-RESPONSE ASSESSMENT, which identifies the chronic reference doses for noncarcinogens and the inhalation unit risk values for carcinogens used in the risk characterization;

- RISK CHARACTERIZATION, which estimates the individual excess lifetime cancer risk and the population excess cancer burden from a 70-year exposure to the concentrations of carcinogens detected in air around the B.K.K. Landfill between 1982 through 1987. A summary of the three previous health risk assessments of the B.K.K. Landfill is provided in the Appendix for informational purposes.

The B.K.K. Landfill in West Covina, California, operated a Class I landfill (that is, a landfill permitted for disposal of hazardous waste) from approximately 1972 to December 1984. During that time, the B.K.K. Landfill was the largest Class I hazardous waste land disposal facility in California and the primary hazardous waste disposal facility for the Los Angeles area. The Class I landfill began as 40 acres in 1972, expanded to 140 acres in 1975,

and by 1984 encompassed approximately 170 acres of the 583-acre facility. Acreage in excess of the 140 acres includes a buffer zone of the adjoining non-hazardous waste disposal area. Approximately 3.4 million tons of hazardous waste were deposited at the facility. Seventy-two percent of the waste was liquid hazardous waste such as acid solutions, alkaline solutions, solvents, and wastes containing vinyl chloride. Hazardous wastes were buried in drums, injected into wells, co-mingled with non-hazardous waste, r solidified (mixed) with onsite soil.

The surrounding land was relatively undeveloped when the B.K.K. Landfill opened as a municipal waste disposal facility in 1963. Since that time, residential neighborhoods were developed to the north, west, south, and southeast. By 1985, EPA estimated the population within a one-mile radius from the center of the landfill to be approximately 40,000 persons (EPA, 1985). Beginning in 1969, neighboring residents complained about odors, surface water runoffs, spills, and dust releases from the facility.

Since 1979, studies, investigations, and hearings have been conducted in response to complaints from residents and concerns of regulatory agencies. Environmental monitoring at the B.K.K. Landfill detected volatile organic compounds in air, groundwater, and surface water in and around the facility. Vinyl chloride, a human carcinogen, was detected in ambient air at concentrations above California's ambient air quality standard of 10 parts per billion (ppb). EPA issued orders in 1984 and 1986 to the B.K.K. Corporation citing hazardous waste violations. On November 30, 1984, the B.K.K. Landfill stopped accepting hazardous waste. Under the direction of EPA and State

agencies, the B.K.K. Landfill completed closure of the Class I landfill in March 1989, and is conducting a Site Assessment and Mitigation (SAM) Work Plan. A Class III (non-hazardous waste) land disposal facility continues to operate on approximately 150 acres of the remaining 413 acres.

EPA contracted the engineering firm of CH2MHill to conduct an exposure assessment to evaluate whether contaminants released from the B.K.K. Landfill presented a health risk to neighboring residents in comparison to background exposure concentrations. CH2MHill's report evaluated groundwater, surface water, and air monitoring data for 1975 to March 1986. The CH2MHill rep rt had several important conclusions about plausible past routes of exposure: 1) although groundwater below the B.K.K. Landfill is contaminated, groundwater is not used for drinking water or irrigation; 2) human exposure could have potentially occurred through ingestion or dermal contact with contaminated surface water released from the B.K.K. Landfill, but exposure would have been limited and infrequent; and 3) air monitoring data indicated an exposure pathway for neighboring residents.

The hazard identification section and the exposure assessment section of this health risk assessment summarize information presented and evaluated by CH2MHill in its 1988 report. The dose-response section identifies the toxicity values (reference doses and unit risk values current through June 1989) used in the quantitative risk characterization. The risk characterization section estimates the risk of adverse health effects associated with exposure to the concentrations of contaminants (carcinogens

and noncarcinogens) detected in offsite surface water and air for residents living near the B.K.K. Landfill.

Because it is assumed that no threshold exists for substances that induce cancer, the risk characterization is concerned primarily with the risk of developing cancer from a 70-year exposure to the concentrations of carcinogens detected in air around the B.K.K. Landfill between 1982 through 1987. Individual excess lifetime (70-year) cancer risks are estimated using data from three site-specific air monitoring programs and one Los Angeles basin air monitoring program evaluated by CH2MHill, and one air modeling program of site data used by the California Air Resources Board (CARB). The population excess cancer burden is estimated for residents within a one-mile radius of the landfill.

Ambient vinyl chloride monitoring data represent the most appropriate data to assess the excess cancer risk associated with the B.K.K. Landfill because vinyl chloride is a human carcinogen and is not commonly detected in the Los Angeles air basin. Carcinogens such as benzene, perchloroethylene, and trichloroethylene are detected in ambient air both at the B.K.K. Landfill and in the Los Angeles basin (SCAQMD, 1987). These compounds may present an additional cancer risk to people living around the B.K.K. Landfill, but it is not possible with the present data to distinguish between exposure due to ambient levels and exposure due to the B.K.K. Landfill. Vinyl chloride is rarely detected in ambient air and therefore more clearly represents exposure associated with the B.K.K. Landfill.

Based on the 1987 ambient vinyl chloride concentrations and the methods and assumptions used in this health risk assessment, the individual excess lifetime cancer risk associated with exposure to the carcinogen detected in air around the B.K.K. Landfill is estimated to be approximately 1 to 2 individuals in 100,000 persons. This assumes everyone is exposed to vinyl chloride at the 1987 concentrations for an entire 70-year lifetime. In the population of 40,000 persons living within a one-mile radius of the B.K.K. Landfill, less than one additional case of cancer would be expected to occur from this exposure.

Currently, DHS and CARB are reevaluating the data on the carcinogenicity of vinyl chloride, in recent and past literature, for the purpose of identifying vinyl chloride as a toxic air contaminant. When this process is completed, a new unit risk value for vinyl chloride will be established. The new value is likely to be about 29 times greater than the value used in this health risk assessment. When this new value is adopted, DHS will prepare an addendum to this health risk assessment, reflecting the changed unit risk value for vinyl chloride, updating toxicity values, and adding air monitoring data collected since 1987.

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INTRODUCTION

Nature of Health Risk Assessments

Health risk assessments estimate potential adverse health effects associated with exposure to toxic and hazardous compounds based upon four systematic components: hazard identification, exposure assessment, dose-response assessment, and risk characterization. Each component refines the analysis and all four together are the assessment. Results of a health risk assessment are conditional on the methods and assumptions used, and the limitations and uncertainties identified. Health risk assessments are derived from the knowledge and technology available at a particular time, and consequently need to be continually reviewed to ensure consistency with scientific advances.

Purpose and Scope of this Health Risk Assessment

The purpose of this health risk assessment is to estimate, for residents living near the B.K.K. Landfill, the risk associated with exposure to the concentrations of contaminants detected in environmental monitoring of the facility through 1987. This 1990 health risk assessment updates a 1982 joint agency assessment (DHS-TSCP/CARB/SCAQMD, 1983) and is expected to be updated when reevaluation of the cancer potency of vinyl chloride is completed.

Information on the history of the B.K.K. Landfill, the choice of indicator chemicals, and the exposure assessment was taken primarily from Volume I of CH2MHill's seven-volume report to EPA. For a more detailed discussion of the

history, indicator chemicals, or exposure assessment, the reader is referred to that report (CH2MHill, Volume I, 1988). The CH2MHill report was reviewed by EPA, DHS, a technical peer review subcommittee, and a citizens advisory subcommittee.

Figures and tables taken from CH2MHill's report and other reports are individually referenced.

History of the B.K.K. Landfill, West Covina, California

The B.K.K. Landfill, operated by B.K.K. (Kenneth B. Kazarian) Corporation, is located within the corporate boundary of the City of West Covina, California, 18 miles east of downtown Los Angeles in Los Angeles County (Figure 1). In 1963, the B.K.K. Landfill opened on 130 acres in the San Jose Hills as a municipal waste landfill for the disposal of household and commercial refuse and inert solids such as construction debris. A land use permit was obtained from the City of West Covina, and waste discharge requirements were prescribed by the Los Angeles Regional Water Quality Control Board.

In 1971, the City of West Covina approved an expansion of the facility from 130 acres to the present 583 acres, and permitted the disposal of hazardous waste onsite. In 1972, the B.K.K. Landfill opened a 40-acre Hazardous Waste Management Unit (that is, a Class I landfill) and began accepting hazardous waste. In 1975, the Class I Hazardous Waste Management Unit expanded by an additional 100 acres (Figure 2).

Th B.K.K. Landfill was the largest Class I hazardous waste land disposal facility in California and the primary commercial hazardous waste disposal facility for the Los Angeles area. Annual summaries of hazardous wastes deposited at the facility are available for the years 1975 through 1984. These summaries record that approximately 3.4 million tons of hazardous waste were deposited at the B.K.K. Landfill. Seventy-two percent of the waste was liquid hazardous waste. Wastes accepted in the greatest quantities were: acid solutions, alkaline solutions, contaminated soils, drilling muds, oil and oil sludges, tank bottom sediments, and other (unspecified) hazardous waste (Table 1). Hazardous wastes were deposited onsite by four methods: buried in drums, injected into wells, co-mingled with solid non-hazardous waste, and "solidified" (mixed) with onsite soil.

In 1963, the B.K.K. Landfill was located in a relatively undeveloped area of the San Gabriel Valley. In 1971, a residential neighborhood was sited approximately 2,000 feet from the northern border. By 1975, residential zoning and land use permits in West Covina allowed the construction of homes up to the property line on the southern and southeastern borders (Figure 3).

Migration of hazardous waste constituents from the landfill occurred. Anaerobic decomposition of the waste generated landfill gas which served as a transport medium for volatile organic compounds (VOCs) deposited onsite to migrate to ambient air. Hydrogeologic investigations found contamination in groundwater under the facility.

TABLE 1
(Environmental Solutions, Inc.)

TABLE 1.4
HAZARDOUS WASTE TYPES DEPOSITED IN BKK LANDFILL(1)(2)
(1975-1984)

(TONS)

WASTE TYPE	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	TOTAL
Acid Sludge							299	1,817			2,116
* Acid Solution	19,300	33,497	41,756	71,615	83,440	112,755	66,526	31,483	22,649	312	483,333
Acid Solution w/Metals									13,942	24	13,966
Acid Solution w/o Metals									2,984	146	3,130
Acid Solution - Neutralized							5,395	21,063			26,458
Adhesive							210	378	481	406	1,475
Alkaline Sludge							1,361	3,064			4,425
* Alkaline Solution	49,598	62,761	70,747	69,782	69,396	79,487	45,899	40,732	18,219	6,177	512,798
Alkaline Solution w/Metals									18021	9,149	27,170
Alkaline Solution w/o Metals									12,595	3,176	15,771
Alkaline Solution - Neutralized							281				281
Alkali Solids								1,025			1,025
Alum Sludge							269	3,713	6,312	7,090	17,384
A. P. I. Generator Sludge							919	21,254			22,173
Aqueous Solution w/Metals									30,292	19,863	50,155
Aqueous Soluiton w/>10% Organics									4,729	6,664	11,393
Asbestos-Containing Wastes								1,783	2,506	2,659	6,948
Ashes								150	1,692	286	2,128
Baghouse Waste								2,511	2,868	1,890	7,269
Bilge Water							721	1,073			1,794
Bio. Waste Other Than Sewage									404	278	682
Blasting Sand								3,881			3,881
Brine	685	172	329	1,121	648	673					3,628
Cannery Waste	9,046	22,998	17,380	3,895	1,641	367					55,327
Catalyst							5,393	8,974	5,870	3,623	23,860
Chemical Toilet Waste	220	45	34	34	31	213	69	11			657
Chemicals, Unused							91	485	834	894	2,304
Containers, Empty								1,073	966	1,111	3,150
Contaminated Equipment								6,523			6,523
* Contaminated Soil and Sand	708	289	585				185	79,927	299,417	76,929	458,540
Cyanide Waste				1,421	3,978	4,488	4,256	1,257			15,400
Degreasing Sludge									1,285	1,157	2,442
Detergent and Soap							2,645	1,332	2,065	1,733	7,775
Distillation Bottoms							564	1,235	2,243	237	4,279
* Drilling Mud	17,288	12,316	13,773	41,650	27,319	19,153	25,388	7,394	10,210	1,392	175,883
FCC Waste							59	4,323	8,411	5,678	18,471
Filter Cake							206	2,238			2,444
Filters, spent								304			304
Flux								14			14
Fly Ash								30			30
Gasoline and Water							2,084	1,590			3,674
Glaze Sludge							11	542			553
Glue							55	63			118
Hair Pulp								131			131
Heavy Metal Solution							2,263	7,221			9,484
Heavy Metal Sludge							240	6,342			6,582
Ink and Solvent							716	971			1,687

(1)Source: BKK annual waste summaries, 1975 through 1984.
(2)Blanks in the table result from change in waste classification.

*Deposited in the greatest quantity during this period.
Reference: Modified from CH$_2$M Hill (March 6, 1986).

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TABLE 1.4
HAZARDOUS WASTE TYPES DEPOSITED IN BKK LANDFILL (1)(2)
(1975-1984)
(Continued)

(TONS)

WASTE TYPE	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	TOTAL
Ink Sludge							76	541			617
Ink Wastewater							423	1,215			1,638
Laboratory Chemicals							186	253			439
Latex Waste	714	3,107	446	6,482	5,433	1,586			658	606	19,032
Lime Sludge							3,055	10,304	10,679	2,737	26,775
Machine Tool Coolant							3,528	3,582			7,110
Metal Sludge									22,857	15,393	38,250
Metal Dust and Machining Waste							1,376	529	406	293	2,604
Mud and Water	17,754	51,486	29,259	65,816	44,457	38,426	1,177				248,375
* Oil	24,630	11,229	9,467	27,405	22,276	14,137	1,204	471	3,650	1,369	115,838
* Oil Sludge							2,568	9,516	70,711	26,345	109,140
Oil and Water							35,201	35,631			70,832
Oil-Containing Waste, Unspecified									24,703	18,462	43,165
Organic Liquids									1,690	303	1,993
Organic Monomer Waste									131	281	412
Organic Solids									534	927	1,461
* Paint Waste	3,377	5,401	6,372	7,414	6,952	5,092	3,628	17,604	15,256	11,643	82,739
Paper Sludge/Pulp									53	59	112
Pesticides	904	534	130	189	290	358	353	238	245	169	3,410
Pesticide Containers								24	79	42	145
Pesticide Rinsewater							263	26	301	124	714
Pharmaceuticals							35	578	53	61	727
Phenolic Waste							82	32			114
Phosphate Sludge									528	877	1,405
Photoprocessing Waste							823	1,445	1,099	1,680	5,047
Plating Sludge							1,870	5,949			7,819
Plating Solution, Acid							5,848	3,583			9,431
Plating Solution, Alkaline							879	2,480			3,359
Polychlorinated Biphenyls								7	49	65	121
Resin Waste							1,158	11,320	3,377	1,142	16,997
Scrubber Waste							550	1,103	982	79	2,714
Solvent, Halogenated							1,046	9,498	1,392	585	12,521
* Solvent, Hydrocarbon							813	853	652	122	2,440
* Solvent, Oxygenated							188	171	1,281	224	1,864
* Solvent, Mixed							19,418	14,662	17,612	960	52,652
Solvent, Unspecified	3,447	6,424	9,211	16,649	17,139	27,340					80,210
Spill Cleanup							856	3,925			4,781
Stretford Solution							1,583	4,640			6,223
Sulfide Sludge							211	625	2,589	3,054	6,479
Sump Sediment							12,734	25,920			38,654
* Tank Bottom Sediment	24,205	52,742	57,661	100,434	124,448	146,152	13,088	39,964	44,471	11,733	614,898
Tanning Sludge							155	1,097			1,252
Tetraethyl Lead Sludge	88	91	35	25	60	24		32	150	8	513
Wastewater Treatment Sludge				3,250	15,863	290	6,344	16,674	5,170	2,221	49,809
Other Liquids							989	3,143	26,248	13,191	43,571
Misc. Sludge Waste									12,522	1,970	14,492
Other Hazardous Waste	6,769	5,805	2,302	1,501	4,890	8,966			20,037	74,451	124,721
TOTALS	178,733	268,897	259,487	418,683	428,261	459,507	287,813	493,539	759,660	342,050	3,896,630

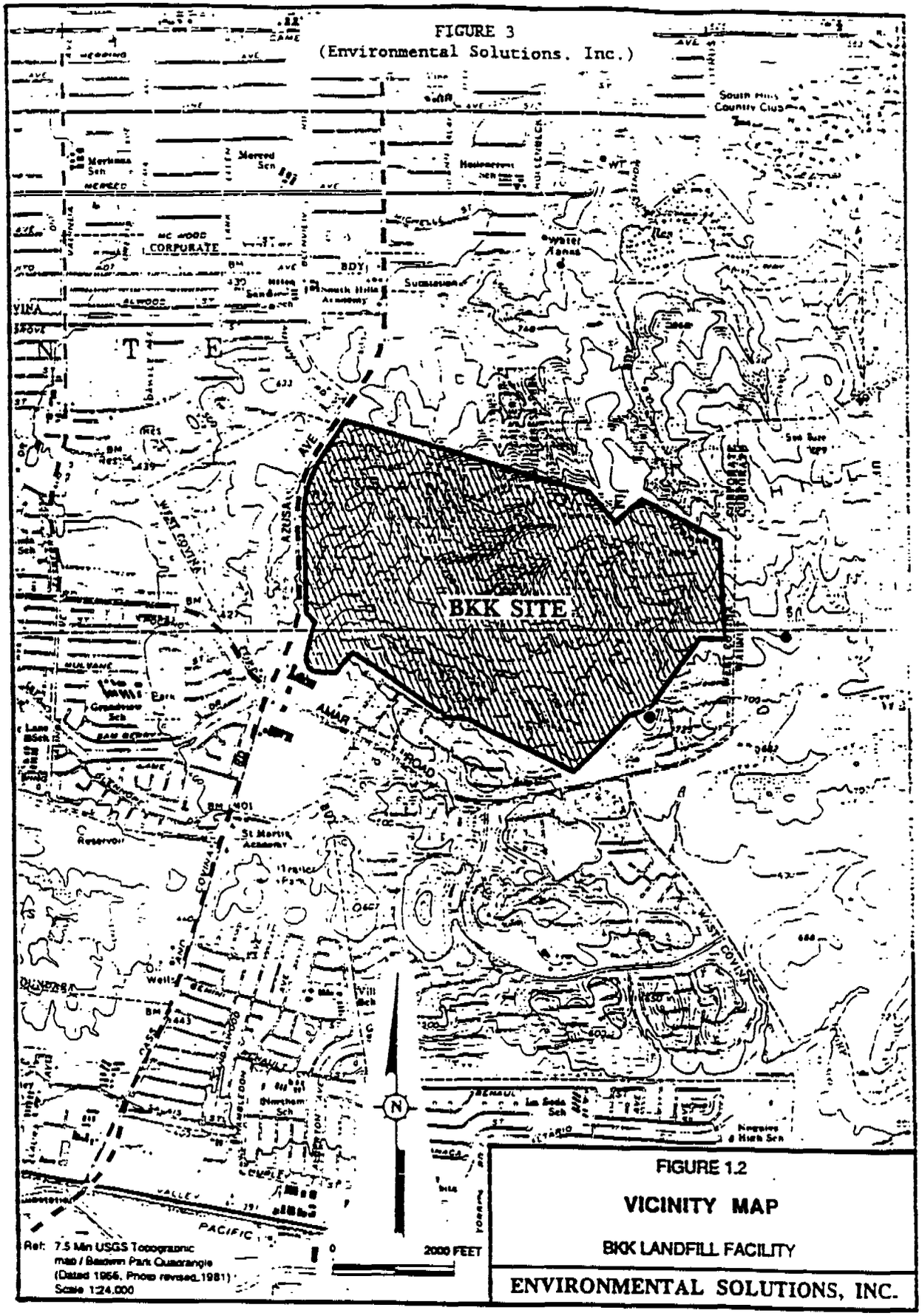
(1)Source: BKK annual waste summaries, 1975 through 1984.
(2)Blanks in the table result from change in waste classification.

*Deposited in the greatest quantity during this period.

Reference: Modified from CH2M Hill (March 6, 1986).

Source: Environmental Solutions, Inc., Table 1.4, "BKK Landfill Site Assessment and Mitigation Work Plan, Book I, Subsurface: Site Characterization," March 15, 1988, pgs. 1-22 and 1-23.

FIGURE 3
(Environmental Solutions, Inc.)



Source: Environmental Solutions, Inc., Figure 1.2, "BKK Landfill Site Assessment and Mitigation Work Plan, Book I, Subsurface: Site Characterization," March 15, 1988, P. 1-3.

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The first odor complaint against the B.K.K. Landfill was reported to the South Coast Air Quality Management District (SCAQMD) in 1969. The number of odor complaints reported to SCAQMD increased to 278 in 1979, 537 in 1980 and 936 in 1981. Neighboring residents have been concerned for many years about odors and hazardous waste releases in surface water runoff, spills, and dust from the B.K.K. Landfill, and have voiced general health concerns about living near a hazardous waste facility. Since 1979 various studies, investigations, and hearings have been conducted in response to complaints from residents and concerns of regulatory agencies.

In 1980, SCAQMD began monitoring ambient air in the vicinity of the B.K.K. Landfill for odorous organic compounds. In 1981 vinyl chloride, an odorless gas and a human carcinogen, was detected in concentrations above California's ambient air quality standard of 10 ppb. In June 1981, the California Department of Health Services-Toxic Substances Control Program (DHS-TSCP) banned further disposal of waste containing vinyl chloride from the B.K.K. Landfill, and SCAQMD established a program to monitor ambient air around the B.K.K. Landfill for vinyl chloride.

The following nine agencies formed an interagency task force in 1981 to coordinate activities associated with the B.K.K. Landfill:

- California Department of Health Services (the Toxic Substances Control Program and Public Health)
- Los Angeles Regional Water Quality Control Board
- United States Environmental Protection Agency

- California Waste Management Board
- South Coast Air Quality Management District
- City of West Covina
- County of Los Angeles Department of Public Works
- County of Los Angeles Department of Health Services
- County of Los Angeles Sanitation Districts.

In 1983, EPA requested a Resource Conservation and Recovery Act (RCRA) Part B Permit Application from the B.K.K. Landfill. During a facility inspection and permit application review later that year, EPA found several violations regarding groundwater monitoring, bulk liquid disposal, and ignitable/reactive waste disposal.

In April 1984, EPA issued B.K.K. Corporation a RCRA Section 3013 Order of Consent, requiring a comprehensive investigation of onsite and offsite contamination. In July 1984, 19 homes along the southern perimeter were evacuated as a result of lateral subsurface migration of landfill gas. EPA issued B.K.K. Corporation a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 106 Order, requiring mitigation of landfill gas emissions and leachate migration. EPA and DHS monitored indoor air in homes, and reoccupancy criteria were developed by DHS Epidemiologic Studies and Surveillance Section (DHS, 1984). All evacuated homes were allowed to be reoccupied by December 1984.

On November 30, 1984, the B.K.K. Landfill withdrew its RCRA permit application, stopped accepting hazardous waste, and began closure of the Hazardous Waste Management Unit. At that time, the size of the Class I unit was defined as 170 acres, which includes a buffer zone from the adjoining non-hazardous waste disposal area.

In 1986, EPA again issued orders to B.K.K. Corporation: a RCRA Section 7003 Order finding that an imminent and substantial endangerment to human health may have been present from handling and disposal practices at the B.K.K. Landfill; and a RCRA Section 3013 Order finding that a substantial hazard to human health or the environment may have been present from air and groundwater contamination and the proximity of drinking water sources in the area. The B.K.K. Corporation retained Environmental Solutions, Inc. to pr pare a SAM Work Plan in response to the EPA orders and in conjunction with federal, state, and local regulatory agencies.

In March 1989, closure of the Class I Hazardous Waste Management Unit was completed with the placement of the final cover and collection systems as stipulated in federal and state regulations. As part of the post-closure permit, monitoring will continue at B.K.K. Landfill, and may continue for 30 years from the date of closure. A Class III (non-hazardous waste) land disposal facility continues in operation on approximately 150 acres of the remaining 413 acres.

SAM Work Plan activities completed in 1989 included: a "phase I" site hydrogeologic characterization, a landfill gas analysis, flare source testing, a soil and sediments sampling program, an ambient air gas and particulat monitoring program, and an air tracer test. An odor study, an elevated subsurface temperature and carbon monoxide sampling program, and a surface emissions program were in progress. Final SAM Work Plan reports are due in December 1990.

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HAZARD IDENTIFICATION

The hazard identification component of a health risk assessment determines whether or not chemicals present at a site may pose a hazard to human health, and whether the health hazard is carcinogenic or noncarcinogenic. Noncarcinogenic effects may result from acute or chronic exposures, and threshold levels are established below which no adverse health effect is expected. It is assumed that no threshold exists for carcinogens. This section identifies the indicator chemicals (carcinogens and noncarcinogens) detected in groundwater, surface water, and air in and around th B.K.K. Landfill.

Indicator Chemicals Detected at the B.K.K. Landfill

CH2MHill prepared a list of all chemicals detected in groundwater, surface water, and air around the B.K.K. Landfill (CH2MHill, 1988). To focus on the contaminants of primary concern, CH2MHill applied the indicator chemical selection process, outlined by EPA in the "Superfund Public Health Evaluation Manual (1986)", and identified carcinogen and noncarcinogen indicator chemicals (Table 2).

The indicator chemical selection process directs attention to the contaminants of primary concern to human health and the environment, while not excluding any chemical that may cause harm to human health or the environment. Criteria used in the selection process are: the measured concentration of the

TABLE 2 (CH2MHill)

LISTING OF CHEMICALS DETECTED AND INDICATOR CHEMICALS

FOR GROUNDWATER, SURFACE WATER, AND AIR*

BKK LANDFILL, WEST COVINA, CALIFORNIA

A: GROUNDWATER

CHEMICALS DETECTED

VOLATILE ORGANICS

1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethane
1,1-Dichloroethylene
1,2-Dichlorobenzene
1,2-Dichloroethane
1,2-Dichloropropane
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2-Butanone
Acetone
Benzene
Bromomethane
Carbon tetrachloride
Chlorobenzene
Chloroethane
Chloroform
cis-1,2-Dichloroethylene
trans-1,2-Dichloroethylene
Ethylbenzene
Methylene Chloride
Xylenes
o-Chlorotoluene
Perchloroethylene
Propylbenzene
Styrene
Toluene
Trichloroethylene
Trichloromonofluoromethane
Vinyl Chloride

SEMI-VOLATILES

1,2,4-Trichlorobenzene
1,3,5-Trimethylbenzene
2 Hexanone
2,4-Dimethylphenol
bis(2-Chloroethyl)ether
bis(2-Chloroisopropyl)ether
bis(2-Ethylhexyl)phthalate
Dibutylphthalate
Diethylphthalate
Dimehtylnitrosamine
di-Octylphthalate
Isophorone
Napthalene
n-Nitrosodimethylamine
Phenol
Phenols (total)
Tetrahydrofuran

INORGANICS

Arsenic
Barium
Boron
Cadmium
Chromium(total)
Cobalt
Copper
Cyanide
Fluoride
Iron
Lead
Manganese
Mercury
Nickel
Nitrates
Selenium
Silver
Zinc

INDICATOR CHEMICALS

NON-CARCINOGENS

VOLATILE ORGANICS
1,1,1-Trichloroethane
1,1-Dichloroethane
1,2-Dichlorobenzene
2-Butanone
Chlorobenzene
cis-1,2-Dichloroethylene
trans-1,2-Dichloroethylene
Ethylbenzene
o,p-Xylene
Toluene

SEMI-VOLATILES
Phenols, (total)
Phenol

INORGANICS
Barium
Cadmium
Copper
Fluoride
Lead
Manganese
Mercury
Silver
Zinc

CARCINOGENS

VOLATILE ORGANICS
1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane
1,1-Dichloroethylene
1,2-Dichloroethane
Benzene
Carbontetrachloride
Chloroform
Methylene Chloride
Perchloroethylene
Trichloroethylene
Vinyl Chloride

SEMI-VOLATILES
bis(2-Chloroethyl)ether
n-Nitrosodimethylamine

INORGANICS
Arsenic

*Chemicals detected represent those found in the landfill gas;
the indicator chemicals represent those analyzed in the monitoring programs

SYNONYMS

2-Butanone = Methylethylketone
2-Hexanone = Methylbutylketone
n-Nitrosodimethylamine = Dimethylnitsosamine
Methylene Chloride = Dichloromethane
Perchloroethylene = Tetrachloroethylene

TABLE 2 (Continued)
LISTING OF CHEMICALS DETECTED AND INDICATOR CHEMICALS
B: SURFACE WATER

CHEMICALS DETECTED	INDICATOR CHEMICALS
	NON-CARCINOGENS
VOLATILE ORGANICS	VOLATILE ORGANICS
1,2-Dichlorobenzene	1,1,1-Trichloroethane
1,1,1-Trichloroetnane	1,1-Dichloroetnane
1,1,2-Trichloroethane	1,2-Dichlorobenzene
1,1-Dichloroethane	Chlorobenzene
1,1-Dichloroethylene	Ethyl Benzene
1,2-Dichloroethane	Xylenes
Acetone	Toluene
Benzene	
Bromodichloromethane	SEMI-VOLATILES
Chlorobenzene	Phenol (total)
Chlorodibromomethane	
Chloroform	INORGANICS
cis-1,2-Dichloroetnylene	Cadmium
trans-1,2-Dichloroethylene	Chromium (total)
Dichlorometnane	Copper
Ethylbenzene	Cyanide
Xylenes	Lead
o-Chlorotoluene	Nickel
Perchloroethylene	Selenium
Styrene	Zinc
Propylbenzene	
Toluene	
Trichloroethylene	CARCINOGENS
Vinyl chloride	VOLATILE ORGANICS
	1,1,2-Trichloroetnane
SEMI-VOLATILES	1,2-Dichloroethane
1,3,5-Trimethylbenzene	Benzene
1,4-Dichlorobenzene	Chloroform
Acenaphthene	Methylene Chloride
bis(2-Ethylhexyl)phthalate	Perchloroethylene
Dibutyl phthalate	Trichloroethylene
di-Octylphthalate	Vinyl Chloride
Nitrosodiphenylamine	
Phenols (total)	INORGANICS
	Arsenic
INORGANICS	
Arsenic	
Cadmium	
Chromium (total)	
Copper	
Cyanide	
Lead	
Nickel	
Selenium	
Silver	
Zinc	

The indicator chemicals represent those analyzed in the monitoring programs

SYNONYMS

2-Butanone = Methylethylketone

2-Hexanone = Methylbutylketone

n-Nitrosodimethylamine = Dimethylnitrosamine

Methylene Chloride = Dichloroethane

Perchloroethylene = Tetrachloroethylene

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TABLE 2 (Continued)
LISTING OF CHEMICALS DETECTED AND INDICATOR CHEMICALS
C: AIR*

CHEMICALS DETECTED	INDICATOR CHEMICALS
	NON-CARCINOGENS
VOLATILE ORGANICS	VOLATILE ORGANICS
1,1-Dichloroethane	1,1,1-Trichloroethane
1,1-Dichloroethylene	Chlorobenzene
1,2-Dichloroethane	trans-1,2-Dichloroethylene
1,3-Dichloropropene	
1,1,1-Trichloroethane	
1,1,2-Trichloroethane	CARCINOGENS
2,3-Dimethylbutane	VOLATILE ORGANICS
Benzene	1,1-Dichloroethylene
Carbon Tetrachloride	1,2-Dichloroethane
Chlorobenzene	Benzene
Chloroethane	Carbon Tetrachloride
Chloroform	Chloroform
Cyclohexane	Perchloroethylene
cis-1,2-Dichloroethylene	Trichloroethylene
trans-1,2-Dichloroethylene	Vinyl Chloride
Hexane	
Isopropylbenzene	
Iso-octane	
Methane	
Methylcyclohexane	
Methycyclopentane	
Methylene Chloride	
Nonane	
n-Propylbenzene	
Perchloroethylene	
Toluene	
Trichloroethylene	
Vinyl Chloride	
Xylene (total)	
BASE/NEUTRALS	
1,4-Dichlorobenzene	
Dichlorobenzene	
ACID EXTRACTABLES	
2-Butanol	

*Chemicals detected represent those found in the landfill gas;
the indicator chemicals represent those analyzed in the monitoring programs

SYNONYMS
2-Butanone = Methylethylketone
2-Hexanone = Methylbutylketone
n-Nitrosodimethylamine = Dimethylintrosamine
Methylene Chloride = Dichloromethane
Perchloroethylene = Tetrachloroethylene

Source: CH2MHill, Table 5-4, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, p. 5-22.

chemical; the toxicity of the chemical; and the physical/chemical properties of the chemical, which determine fate and transport in environmental media. Consequently, indicator chemicals represent the most toxic, mobile, and persistent chemicals at a site as well as those in the greatest concentrations.

Carcinogens Detected at the B.K.K. Landfill

EPA evaluates available data on the carcinogenic effects of chemicals from two sources: human epidemiologic investigations and long-term animal tests. EPA applies to the data a "weight of evidence" judgment on the likelihood that the chemical is a human carcinogen (EPA, 1986; EPA, 1989). The evidence is characterized separately for human studies and animal studies as sufficient, limited, inadequate, no data or no evidence. For example, the weight-of-evidence for human studies is as follows:

- sufficient evidence of carcinogenicity, which indicates that there is a causal relationship between the chemical and human cancer;
- limited evidence of carcinogenicity, which indicates that a causal interpretation is credible, but that alternative explanations, such as chance, bias, or confounding, could not adequately be excluded;
- inadequate evidence, which indicates that either there were few pertinent data, or that available studies, while showing evidence of association, did not exclude chance, bias, or confounding and therefore a causal interpretation is not credible;

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- no data, which indicates that data are not available;

- no evidence, which indicates that no association between an exposure and an increased risk of cancer was found in well-designed and well-documented epidemiologic studies.

Based on the "weight of evidence", EPA classifies carcinogens as follows:

- A: Human carcinogen, i.e., sufficient evidence of carcinogenicity in humans;
- B1: Probable human carcinogen, i.e., sufficient evidence of carcinogenicity in animals with limited evidence in humans;
- B2: Probable human carcinogen, i.e., sufficient evidence of carcinogenicity in animals with inadequate evidence in humans;
- C: Possible human carcinogen, i.e., limited evidence of carcinogenicity in animals with inadequate evidence in humans;
- D: Not classifiable as to human carcinogenicity, i.e., inadequate evidence of carcinogenicity in animals with no evidence in humans;
- E: Evidence of noncarcinogenicity for humans.

The "weight of evidence" classifications for the carcinogens detected in groundwater, surface water, and air around the B.K.K. Landfill are A, B2, and C. The sites of carcinogenic effects for these chemicals include the liver, lung, skin, kidney, breast, and stomach. Table 3 presents this information for the carcinogens detected around the B.K.K. Landfill, based on toxicological data current through June 1989.

TABLE 3

CARCINOGENS DETECTED IN GROUNDWATER, SURFACE WATER, AND AIR

BKK LANDFILL WEST COVINA, CALIFORNIA

Carcinogen	CAS#[a]	EPA[b] Class	Cancer Site
Arsenic (inorganic)	-	A	lung, skin
Cadmium	-	B1	lung, prostate, mammary
Chromium(VI)	-	A	lung
Lead	-	B2	kidney, lung, nervous system
Nickel	-	A	lung, nasal
Benzene	71-43-2	A	hematopoietic system (leukemia)
Bis-2-chloroethyl ether	111-44-4	B2	liver
Carbon Tetrachloride	56-23-5	B2	liver
Chloroform	67-66-3	B2	kidney, liver
1,2-Dichloroethane	107-06-2	B2	stomach, breast, uterus circulatory system, lung, liver
1,1-Dichloroethylene	75-35-4	C	kidney, breast, lung
Methylene chloride	75-09-26	B2	liver, breast lung, hematopoietic system (leukemia)
N-nitrosodimethylamine	62-75-9	B2	liver, lung, kidney, circulatory system
Perchloroethylene	127-18-4	C	liver
1,1,2,2-Tetrachloroethane	79-34-5	C	liver
1,1,2-Trichloroethane	79-00-5	C	liver, kidney, adrenal, spelen, circulatory system
Trichloroethylene	79-01-6	B2	lymph, liver
Vinyl chloride	75-01-4	A	liver

a= Chemical abstract service number

b= EPA weight of evidence classification: A, sufficient evidence in humans; B1, sufficient evidence in animals, limited in humans; B2, sufficient evidence in animals, inadequate in humans; C, limited evidence in animals, inadequate in humans. Taken from EPA's Integrated Risk Information System (IRIS), June 1989. With the exception of 1,1-dichloroethylene and certain lead compounds, the above carcinogens are listed as known to the State of California to cause cancer for purposes of the Health and Safety Code Section 25249.5 et seq.

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EXPOSURE ASSESSMENT

The exposure assessment component of a health risk assessment identifies and describes the population at risk, and the types, frequency, magnitude, and duration of exposures. This section describes the population in the vicinity of the B.K.K. Landfill, evaluates the pathways of exposure to neighboring residents, and tabulates the air monitoring programs which will be used in the risk characterization. For a more detailed analysis of the exposure assessment, the reader is referred to Volume I of CH2MHill's report (CH2MHill, 1988).

In October 1985, EPA contracted CH2MHill to conduct an exposure assessment as a technical enforcement support activity. The regulatory basis for the assessment was RCRA Section 3019, Subsection (b) and the procedural basis was the Superfund Public Health Evaluation Manual (EPA, 1986). The report, completed in 1988, included data available through March 1986 and consisted of the following volumes: Volume I - Text; Volume II - Plates; Appendices Volume 1 (groundwater data), Volume 2 (groundwater data), Volume 3 (groundwater data), Volume 4 (groundwater and surface water data), Volume 5 (surface water, air, and soils data).

Limited environmental monitoring data for the B.K.K. Landfill and the surrounding area have been collected since 1975, specifically: groundwater data are available from 1975 to the present; surface waters have been sampled since 1980; landfill gas, ambient air, and odor studies have been conducted

onsite and offsite since 1979. In 1984, ten onsite soil samples were analyzed for particle size only; one offsite residential soil sample was analyzed for volatile organic compounds and none were detected.

CH2MHill's objectives for the exposure characterization were:

1. to compile and evaluate existing environmental monitoring data collected onsite and near the B.K.K. Landfill;

2. to provide detailed analyses of the data to assess whether exposure to contaminants released from the B.K.K. Landfill posed either an immediate or a long-term risk to human health or the environment, in comparison to background exposure concentrations.

Data analyses included both:

- retrospective quality assurance review of the environmental monitoring data, and
- fate and transport evaluation of the contaminants in groundwater, surface water, and air.

Population in the Vicinity of the B.K.K. Landfill

In 1963, when the B.K.K. Corporation received its permit, the landfill was located in a relatively undeveloped area of the San Gabriel Valley. In 1967, the California Department of Finance estimated a population of approximately

67,000 in West Covina to the north and west of the facility, and a population of approximately 4,500 in Walnut to the east. In 1988, the Department of Finance estimated a population of 94,000 in West Covina and 25,000 in Walnut.

CH2MHill identified the age and sex distribution of the population in whole census tracts around the B.K.K. Landfill (Figure 4, Tables 4 and 5). Ethnicity, occupation, and socioeconomic status were not characterized. Demographics, prepared by CH2MHill from the 1980 U. S. population census, indicated that the residential communities in and around the B.K.K. Landfill consisted primarily of young adults, families with children, and women of childbearing age. CH2MHill examined sensitive population groups within a one-mile radius of the landfill boundary and identified 12 elementary schools, 2 child care centers, and 1 nursing home (Figure 5).

The population within a one-mile radius around the landfill was estimated for use in previous risk assessments and in the exposure assessment. In 1982, three agencies jointly conducted the first health risk assessment (DHS-TSCP/CARB/SCAQMD, 1983) and identified a population of 7,700 people at a distance of one mile from the B.K.K. Landfill property line. This population was derived by dividing the assessor's plot maps into quadrants corresponding to four monitoring stations (A, B, D, and F), and estimating the population within each quadrant using 1980 census data. In 1985, EPA identified a population of 40,000 people within a one-mile radius from the center of the landfill (EPA 1985). The difference in population numbers reflect different estimation methods rather than real population increase. This 1990 health

FIGURE 4
(CH2MHill)

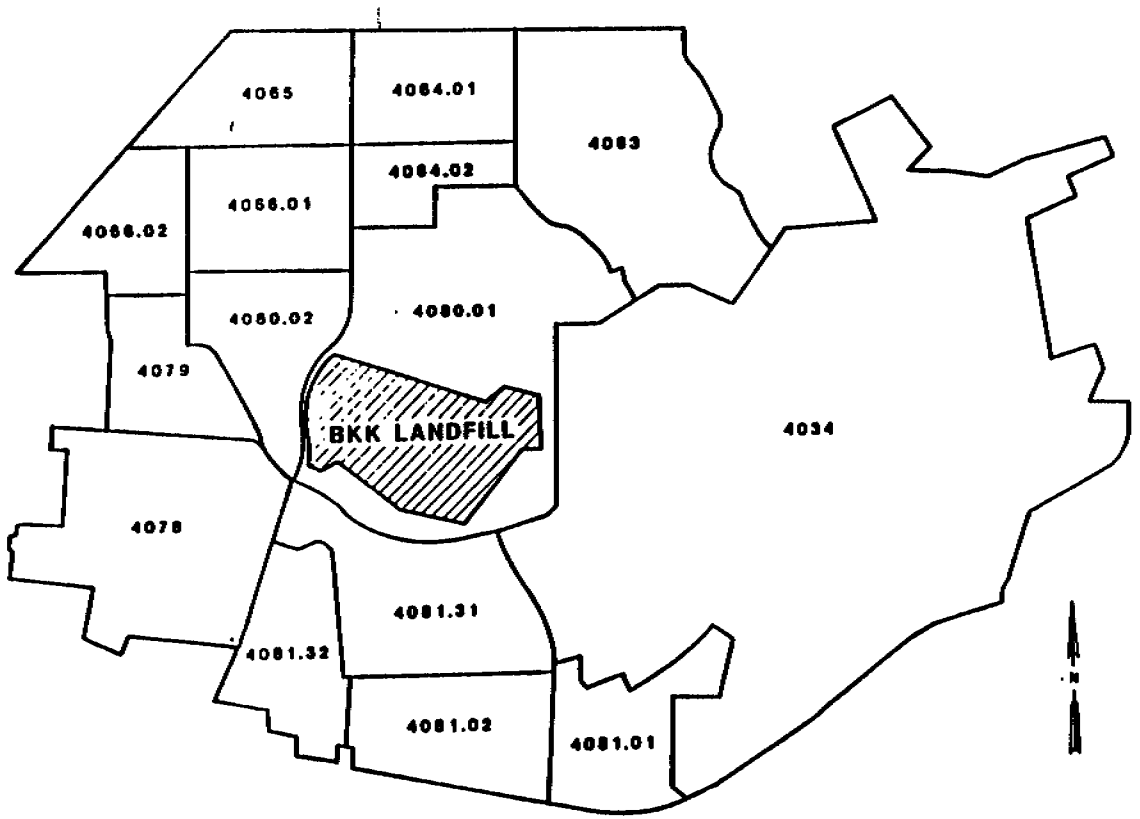


FIGURE 6-3
POPULATION CENSUS TRACTS IN
THE VICINITY OF THE BKK LANDFILL
BKK LANDFILL ENVIRONMENTAL EXPOSURE
CHARACTERIZATION

Source: CH2MHill, Figure 6-3, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, p. 6-22.

R&S15191?

TABLE 4
(CH2MH111)

Table 6-4
SUMMARY OF POPULATION CENSUS TRACT DATA FOR THE VICINITY OF THE BKK LANDFILL

Population Group	Location Relative to BKK Landfill (Census Tract No. Below)														
	Contains BKK	South			East-Southeast		West-Southwest			Northwest			North		Northeast
	4080.01	4081.31	4081.32	4081.02	4034	4081.01	4078	4079	4080.02	4066.01	4066.02	4065	4064.01	4064.02	4063
I. All Groups															
Total	5,324	10,535	8,101	7,101	13,478	6,025	7,107	5,015	6,885	4,759	3,998	5,444	4,424	1,898	3,836
Children (0-4)	564	1,254	844	725	1,364	534	589	484	388	255	324	364	277	91	110
Children (5-9)	377	1,057	940	821	1,262	568	711	468	365	292	280	367	311	93	188
Children (10-14)	300	756	1,061	897	1,483	674	873	535	405	394	343	380	413	176	301
Children (15-19)	389	624	1,057	840	1,398	622	964	547	505	574	460	509	559	235	503
Adults (20-24)	671	1,043	666	661	714	507	613	375	596	389	366	604	340	108	508
Adults (25-64)	2,875	5,573	3,223	2,986	6,185	2,948	3,160	2,433	2,438	2,552	1,969	2,833	2,257	1,081	1,971
Adults (65+)	148	228	310	271	272	172	197	181	158	303	256	367	267	123	265
Median Age	27.7[a]	27.1	21.0	22.1[a]	26.6	26.2[a]	23.3[a]	26.3[a]	26.0[a]	33.1[a]	29.8[a]	29.3	30.8	36.8	33.1[a]
II. Females															
Total	2,693	5,287	4,097	3,619	6,246	3,997	3,576	2,537	2,469	2,406	2,000	2,815	2,226	970	1,893
Females (0-19)	822	1,861	1,917	1,595	3,504	1,376	1,547	1,013	816	733	668	796	766	297	568
Females (20-34)	1,003	2,151	893	960	1,691	867	895	668	860	501	464	828	450	149	414
Females (35-64)	792	1,145	1,115	913	1,016	860	1,028	757	757	1,003	714	953	892	457	775
Females (65+)	76	130	171	151	155	94	106	100	100	169	154	238	140	67	136

[a]Represents the average median age for the census tract, because medians are calculated separately for populations within each city boundary within each census tract.

Source: Based on 1980 Census (U.S. Dept. of Commerce, 1983).

LASUPER8/036

Source: CH2MHill, Table 6-4, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, p. 6-21.

TABLE 5
(CH2MHill)

Table 6-5

POTENTIALLY SENSITIVE POPULATION SUBGROUPS FROM CENSUS TRACTS IN THE VICINITY OF THE BKK LANDFILL

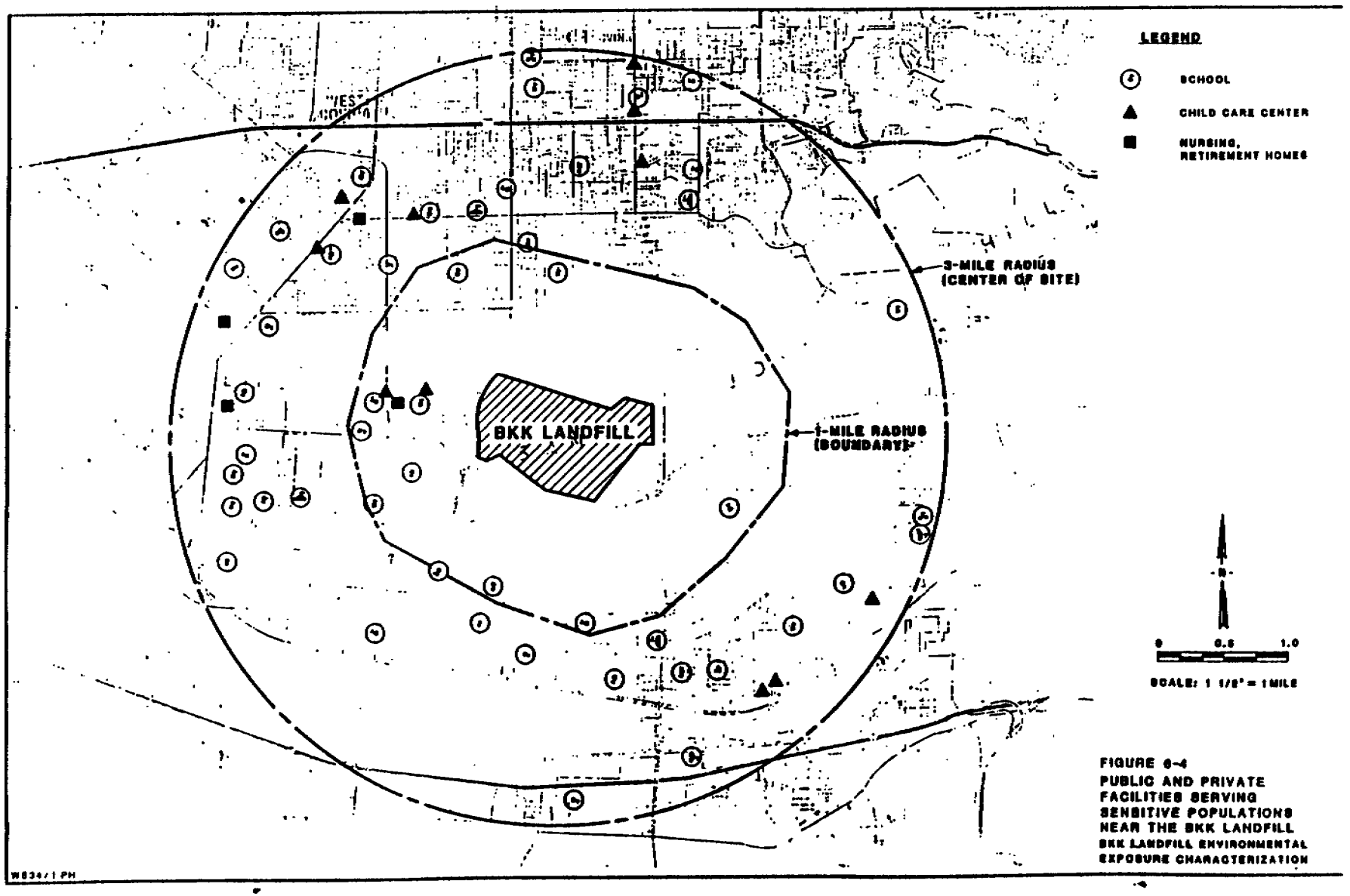
Regions (Located Relative to BKK)	Census Tract No.	Percent of Census Tract Populations by Subgroups				Total No. of Females of Child-Bearing Age (15-44 yrs)	Census Tract Total No.	Region Total No.
		Infants (0-4 yrs)	Children (5-14 yrs)	Females of Child-Bearing Age (15-44 yrs)	Senior Adults (65+ yrs)			
Contains BKK	4080.01	10.6	12.7	28.4	2.8	1,511	5,324	5,324
South	4081.31	11.9	17.2	29.5	2.2	3,109	10,535	
	4081.32	10.4	24.7	24.0	3.8	1,943	8,101	
	4081.02	10.0	23.8	24.7	3.8	1,781	7,201	25,837
East-Southeast	4081.01	8.9	20.6	23.9	2.8	1,443	6,025	
	4034	9.3	22.0	27.8	2.2	3,465	12,478	18,503
Northeast	4063	7.9	12.8	24.8	6.4	950	3,826	3,826
North	4064.01	6.3	16.4	23.3	6.0	1,031	4,424	
	4064.02	4.8	14.2	20.6	6.5	391	1,898	6,322
Northwest	4065	6.7	13.7	25.5	7.1	1,391	5,444	
	4066.01	5.4	14.4	23.6	6.4	1,124	4,759	
	4066.02	8.1	15.6	22.3	6.4	891	3,998	14,201
West	4080.02	7.9	15.7	29.2	3.2	1,418	4,855	
	4079	9.7	20.0	25.7	3.6	1,287	5,015	9,900
Southwest	4070	8.3	22.3	25.4	2.8	1,804	7,107	7.107

Source of Data: 1980 Census (U.S. Dept. of Commerce, 1983)

LASUPER8/031

Source: CH2MHill, Table 6-5, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, p. 6-29.

FIGURE 5
(CH2MHILL)



Source: CH2MHill, Figure 6.4, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, p. 6-27.

risk assessment uses EPA's population estimate of 40,000 people within a one-mile radius of the landfill.

Pathways of Exposure to Neighboring Residents

Pathways of exposure to humans include environmental media (air, water, soil, and food) and routes of exposure (ingestion, dermal contact, and inhalation). CH2MHill prepared a schematic (Figure 6) to illustrate existing and potential pathways of exposure to contaminants from the B.K.K. Landfill. All the pathways together represent the total exposure from the site. Analysis of each individual pathway represents the exposure to different populations, such as onsite workers or neighboring residents.

Groundwater Although groundwater below the B.K.K. Landfill has been contaminated, contaminants from the landfill have not been detected in the municipal drinking water supply wells, located one to three miles from the facility. Mitigation measures and monitoring schedules stipulated in the SAM Work Plan are designed to detect if contaminants migrate to municipal drinking water supply wells, at which time EPA and/or the State would issue a corrective action order. Groundwater in the vicinity is not used for irrigation. Seeps near the B.K.K. Landfill may have provided a potential source of exposure to contaminated groundwater in the past during rainy seasons. Seeps were dewatered by extraction wells, and have been dry since 1984.

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FIGURE 6
(CH2MHill)

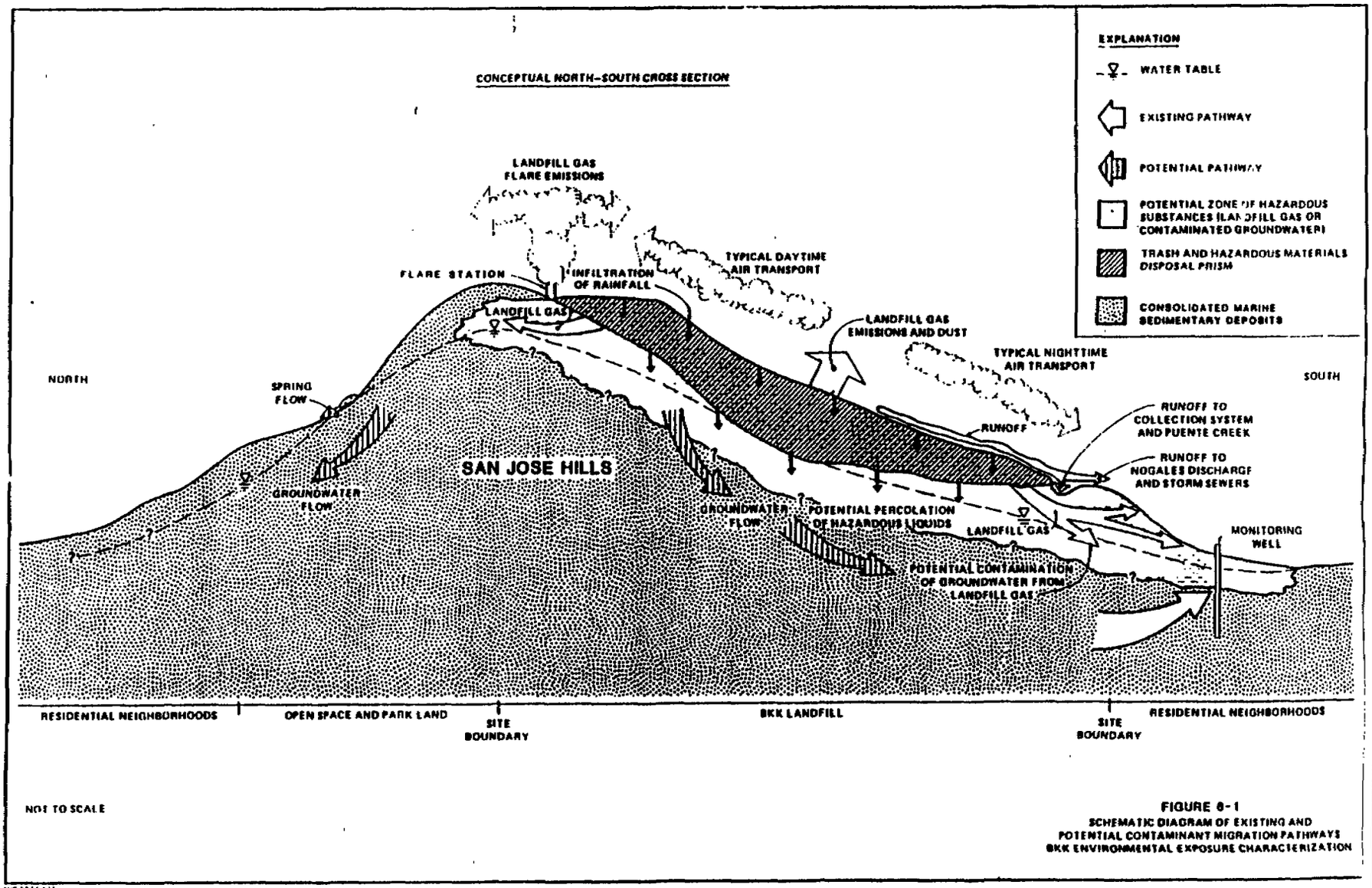

FIGURE 8-1
SCHEMATIC DIAGRAM OF EXISTING AND POTENTIAL CONTAMINANT MIGRATION PATHWAYS
BKK ENVIRONMENTAL EXPOSURE CHARACTERIZATION

Source: CH2MHill, Figure 6.1, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, p. 6-3.

Surface Water Three surface water drainage areas exist around the B.K.K. Landfill: Vine Creek Drainage to the north, Nogales Street Storm Drain/Giano Channel Drainage to the southeast, and Puente Creek Drainage to the southwest. Measured and estimated concentrations of contaminants in surface water originating from the landfill were less than the Clean Water Act criteria for acute toxicity in freshwater organisms; drainages are ephemeral and do not support permanent populations of aquatic organisms (CH2MHill, 1988). Human exposure could have potentially occurred through ingestion or dermal contact with contaminated surface water released from th B.K.K. Landfill. Unfortunately, no quantitative estimate of exposure can be made based on the available information. Median values of indicator chemicals detected in offsite surface water are given in Table 6. The volume of runoff discharge from the Nogales Street Storm Drain/Giano Channel Drainage was reduced 95 percent in November 1986, at which time drains and containment measures were constructed on the landfill.

Soil Soil from only one residential yard located on Miranda Street was analyzed in July, 1984 for VOC's and none were detected.

Air Fifteen separate air sampling programs were conducted between 1979 to 1986. These programs included odor studies, landfill gas emissions monitoring, flare gas testing, periodic and continuous ambient air monitoring, and indoor air monitoring. CH2MHill tabulated the 15 programs, dates, and methods (Table 7). Sampling stations located in residential neighborhoods

TABLE 6

INDICATOR CHEMICALS DETECTED IN OFFSITE SURFACE WATER, 1981-1985

BKK LANDFILL, WEST COVINA, CALIFORNIA

Indicator Chemical	Median Value[a] (ppb)	Location
Non-Carcinogens		
Trans-1,2-Dichloroethylene	2.4	storm drain, Azusa Avenue
1,1,1-Trichloroethane	3.4	storm drain, Azusa Avenue
1,1-Dichloroethane	56	runoff discharge, Nogales Street
1,2-Dichlorobenzene	ND[b]	Galster Park Spring
Chlorobenzene	1.08	storm drain, Azusa Avenue
Ethyl benzene	ND[b]	Galster Park Spring
Xylenes	0.2	storm drain, north of entrance gate
Toluene	0.2	storm drain, north of entrance gate
Phenol	3,900	Hidden Valley Spring
Copper	40	south fork, Puente Creek
Cyanide	3	GTE manhole, Amar and Woodgate
Selenium	41	Galster Park spring
Zinc	17,000	Carmen's Pond discharge
Carcinogens		
Arsenic	89[b]	runoff discharge, Nogales Street
Cadmium	2	Hidden Valley Spring
Chromium	5	storm drain, Azusa Avenue
Lead	12	storm drain, Nogales and Shakespeare
Nickel	100	seep above Miranda Street
1,1,2-Trichloroethane	14	runoff discharge, Nogales Street
1,2-Dichloroethane	230	runoff discharge, Nogales Street
1,1-Dichloroethylene	3.2	seep above Miranda Street
Benzene	ND[b]	Galster Park Spring
Chloroform	1.7	storm drain, north of entrance gate
Methylene Chloride	71	runoff discharge, Nogales Street
Perchloroethylene	3.3	runoff discharge, Nogales Street
Trichloroethylene	2.1	runoff discharge, Nogales Street
Vinyl Chloride	40	seep above Miranda Street

a: Median values taken from Table 3-18 BKK Landfill Comparison of Contaminants Detected In Offsite Surface Water With State And Federal Standards, "BKK Landfill Environmental Exposure Characterization Report West Covina, California," CH2MHill, 1988, Volume I, pgs. 3-90 to 3-94.

b: Taken from Table 5-21 Maximum Values of Indicator Chemicals In Surface Water Samples Collected From the Vincinity of the BKK Landfill, CH2MHill, 1988, Volume I, pgs. 5-125 to 5-127.
ND = Not Detected.

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TABLE 7
(CH2MHill)

Table 3-19
SUMMARY OF AIR QUALITY RELATED DATA COLLECTIONS
FOR THE BKK LANDFILL AND VICINITY

Sampling Program	Sampling Period	Sampled By	Sampling Activities	Sample Analyses
Investigation of Odorous and Volatile Compounds for BKK Landfill	Nov. 1979 - June 1980	Univ. of So. Cal, Environ. Engineering Dept.	Onsite: o Suction pump sampling using a Tenax-GC trap for Volatile Organics o Suction pump sampling for H_2S	o GC/MS speciation of organics (limited)
BKK Odor Study	Dec. 1980	Euteck Inc.	Onsite: o Landfill gas sampling	o GC analysis of gas samples
BKK Flare Station No. 1 Source Testing	April, May, and June 1980	SCAQMD	Onsite: o 2 liter bulb sampling of gas collection system inlet and gas outlet (at the flare); and ambient samples onsite and offsite	o GC/MS analysis for Vinyl Chloride
Ambient Air Monitoring Program	June 1981 - present	SCAQMD	Offsite: o 24-hour Tedlar bag samplings at various locations around the site o Two long-term stations and 12 mid- or short-term stations used to evaluate station sitings	o GC analysis for Vinyl Chloride only o 10 ppm detection limit for 6/81 through 12/82 o 2 ppm detection limit for 1/83 through present

Table 3-19
(Continued)

Sampling Program	Sampling Period	Sampled By	Sampling Activities	Sample Analyses
BKK Expanded Monitoring Program	July 19, - Oct. 15, 1982	SCAQMD, ARB, and DOHS-TSCD	Offsite: o 24-hour Tedlar bag samplings at 5 stations near the site and one control site	o GC/MS analysis for eight volatile organic compounds
Directional Ambient Air Sampling and Micrometeorological Survey	July-Aug. 1982	SCAQMD	Onsite: o Nine directionally controlled portable bag samplers, and eight portable wind recorders	o GC analysis for Vinyl Chloride only
BKK Flare Station No. 1 Source Testing	Oct. 1982	ARB	Onsite: o Grab samples in Tedlar bags from the inlet line and from four burners o Four composite samples of ambient air (2-to 3-hour composites) upwind and downwind of disposal areas	o GC/MS analysis for six volatile organic compounds
BKK Flare Station No. 1 Source Testing	Oct. 1983	Science Applications Inc. for BKK	Onsite o Samples collected at the main header to the flare station (inlet); sample collection method unknown (to be determined	o GC/MS analysis, 23 volatile organic compounds detected
Ambient Air Monitoring During Drilling at Barrier 2	May and June 1984	BKK	Onsite: o Eight-hour composite and grab samples in Tedlar bags; from one upwind and two downwind stations to the drill site	o GC analysis for Vinyl Chloride only

Table 3-19
(Continued)

Sampling Program	Sampling Period	Sampled By	Sampling Activities	Sample Analyses
Emergency Response Sampling	July 17-24, 1984	SCAQMD	Offsite:	
			o HNU/OVA and flask samples indoor and at subsurface areas around selected evacuated homes	o Flask samples analyzed for Vinyl Chloride and Methane
Indoor Air Sampling	July, Aug., and Sept. 1984	DOHS-TSCD	Offsite:	
			o Bulb and flask samples from under the sinks of 21 homes taken periodically	o Bulb and flask samples analyzed for 14 volatile organics, 3 inert gases, and CO_2 (Analyses by ARB and SCAQMD)
Extended Monitoring Program	Aug. Sept., Oct. 1984	SCS Eng. for DOHS and EPA	Offsite:	
			1- Collected 24-hour composite air samples (Tedlar bags) from indoors at 10 Priority I homes and 1 control	o Analysis for 10 volatile organic compounds using GC/MS
			2- Collected 24-hour charcoal tube samples from indoors at 51 Priority II homes and 10 control	o Analysis for Vinyl Chloride
			3- Continuous OVA monitoring in homes to parallel the composite sample collections	o For total hydrocarbons
			4- Periodic flask samples collected when OVA readings exceeded 100 ppm indoors	o Analysis for 10 volatile organics
			5- Subsurface probes (deep and shallow) monitoring with OVA meter, and flask collections when readings exceeded 1000 ppm	o Flask samples analyzed for 10 volatile compounds

Table 3-19
(Continued)

Sampling Program	Sampling Period	Sampled By	Sampling Activities	Sample Analyses
Ambient Air Collections During Excavation of the Ephemeral Pond	March 1985	BKK	Onsite:	
			o Tedlar bag samples collected both during days of excavation and days without excavation	o GC analysis for Vinyl Chloride and Methane (analysis by Truesdail Labs)
Surface Emissions Monitoring Program	April 1985 (1st Sampling)	BKK	Onsite:	
			o Integrated gas samples, each collected over a 100'x500' area using a flow metering pump into a Tedlar bag; with a total of approximately 150 acres sampled onsite	o Analysis for methane by BKK; and quantitative speciation of approximately 10 percent of samples by Truesdail Labs for 30 volatile organic (14 detected)
	Oct.-Nov. 1985	BKK	o Repeat of the 1st sampling, with approximately 150 acres sampled onsite	o Analysis for methane by BKK; and quantitative speciation of approximately 10 percent of samples by West Coast Analytical Lab for 49 compounds (21 detected)
BKK Flare Station No. 1	Oct. 1985	Certified Testing Laboratories for BKK	Onsite	
			o Grab samples (3) into Tedlar bags from the inlet line and from one outlet (burner)	o GM/MS analysis for 13 volatile organic compounds and polychlorinated biphenyls and related dioxin derivatives (data under review at this time

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Source: CH2MHill, Table 3-19, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, Pgs. 3-97 to 3-100.

detected VOC's and indicated air as an exposure pathway for neighboring residents.

Air Monitoring/Modeling Programs Used in the Quantitative Risk Characterization

CH2MHill's retrospective quality assurance review identified 4 of the 15 air monitoring programs as relevant to quantitative analysis. Three of the four programs monitored ambient air around the B.K.K. Landfill; the fourth program monitored ambient air in the Los Angeles basin, in which the B.K.K. Landfill is located. Data from these four programs are used in the risk characterization and described in that section.

CARB used the 1987 ambient vinyl chloride monitoring data from the landfill in an air dispersion model to estimate population exposure to vinyl chloride for the purpose of proposing to identify vinyl chloride as a toxic air contaminant. The risk characterization uses CARB's modeled data and describes the program in that section.

Table 8 summarizes the programs and data used in the quantitative risk characterization.

TABLE 8

AIR MONITORING/MODELING PROGRAMS USED IN THE QUANTITATIVE RISK CHARACTERIZATION OF THE B.K.K. LANDFILL, WEST COVINA, CA

Program	Data Station(s)	Chemical(s) Monitored	Methods	Summary Statistic(s)
SCAQMD 1983-1987 Ambient Vinyl Chloride Monitoring Program	A, B, MY; located in residential neighborhoods south, southeast of the landfill	Vinyl chloride (detection limit 2 ppb)	24-hour continuous; Tedlar bags; GC analysis; daily 6/81-1990	Monthly and annual geometric means, calculated by DHS from SCAQMD's daily measurements
DHS-TSCP/CARB/SCAQMD 1982 Expanded Monitoring Program	A; considered in 1982 as the location for "worst-case" meteorologic conditions	9: vinyl chloride, perchloroethylene, trichloroethylene, 1,2-dichloroethane, chloroform, benzene, chlorobenzene, trans-1,2-dichloroethene, 1,1-dichloroethene	24-hour continuous; Tedlar bags; Sunday through Thursday, July 19-October 15; GC analysis, split samples analyzed by CARB lab and SCAQMD lab	Arithmetic means, taken from Table II, DHS-TSCP/CARB/SCAQMD 1983 report (a)
EPA-DHS 1984 Extended Monitoring Program	Indoor air 10 Priority I evacuated homes	9: vinyl chloride, perchloroethylene, trichloroethylene, 1,1-dichloroethene, 1,2-dichloroethane, chloroform, benzene, carbon tetrachloride, 1,1,1-trichloroethane	24-hour composite; Tedlar bags; GC-MS analysis	Median values, taken from Table 6-13 and Volume 5 Appendix H-2 CH2MHill 1988 report (b)
SCAQMD - CARB 1985 Los Angeles Basin Air Toxics Monitoring Program	El Monte, CARB	11: benzene, carbon tetrachloride, chloroform, ethylene dibromide, ethylene dichloride, methylene chloride, perchloroethylene, toluene, 1,1,1-trichloroethane, trichloroethylene, vinyl chloride	not described in SCAQMD 1987 report	Annual average taken from Table V-1 SCAQMD 1987 report (c)
CARB Modeling of 1987 Ambient Vinyl Chloride Monitoring Data	A, B, MY	vinyl chloride (detection limit 2 ppb)	SCAQMD's data: 24-hour continuous; Tedlar bags; GC analysis	Range of modeled concentrations, taken from Table II-5, CARB 1990 report (d)

TABLE 8
(continued)

Abbreviations:

SCAQMD = South Coast Air Quality Management District
DHS-TSCP = Department of Health Services-Toxic Substances Control Program
CARB = California Air Resources Board
EPA = U. S. Environmental Protection Agency
GC = gas chromatography
GC-MS = gas chromatography-mass spectrometry

a: DHS-TSCP/CARB/SCAQMD, "Ambient Air Monitoring and Health Risk Assessment for Suspect Human Carcinogens Around the BKK Landfill in West Covina," March 1983.

b: CH2MHill, "BKK Landfill Environmental Exposure Characterization Report West Covina, California," Volume I Text and Volume 5 Appendix H-2, August 15, 1988.

c: SCAQMD, "The Magnitude of Ambient Air Toxics Impacts From Existing Sources in the South Coast Air Basin," 1987 Air Quality Management Plan Revision, Working Paper No. 3, June 1987.

d: CARB, "Technical Support Document, Proposed Identification of Vinyl Chloride as a Toxic Air Contaminant," Draft Report Executive Summary and Part A, May 1990.

DOSE-RESPONSE ASSESSMENT

The dose-response assessment defines the relationship between the "dose" (intake) of a chemical and the probability of a response, such as induction of a carcinogenic effect. EPA uses the term intake instead of dose because the information required to estimate "dose" (that is, the amount of a chemical absorbed and subsequently distributed to target organs) is usually not known. Numerical expressions of a chemical's dose-response relationship are called toxicity values: reference doses are values for noncarcinogenic effects; slope factors and unit risks are values for carcinogenic effects. This section identifies the chronic reference doses and inhalation unit risk values, current through June 1989, used in the risk characterization.

Chronic Reference Doses

Information about the amount of a chemical that produces a toxic response and the type of toxic response produced at a given dose level is obtained quantitatively from studies in experimental animals or observations in human epidemiologic investigations. Noncarcinogenic effects may result from acute or chronic exposures, and threshold levels are established below which no adverse health effect is expected. EPA has derived reference doses for chemicals based on different routes of exposure. The chronic reference dose (RfDc) is an estimate of the daily exposure to humans, including sensitive populations, that is likely to be without appreciable risk of adverse effects during a lifetime. Reference doses for carcinogens refer to effects other than the risk of cancer. Table 9 lists the reference doses for indicator

TABLE 9

REFERENCE DOSES[a] FOR INDICATOR CHEMICALS DETECTED IN OFFSITE SURFACE WATER AND AIR

BKK LANDFILL, WEST COVINA, CA

Indicator Chemical	RfDc-O mg/kg-day	RfDc-O ppb	RfDc-I mg/kg-day	RfDc-I $\mu g/m^3$
Non-Carcinogens				
Trans-1,2-Dichloroethylene[c]	2E-2	700	-	70
1,1,1-Trichloroethane	9E-2	3,150	3E-1	1,050
1,1-Dichloroethane	1E-1	3,500	1E-1	350
1,2-Dichlorobenzene	9E-2	3,150	4E-2	140
Chlorobenzene	2E-2	700	5E-3	17.5
Ethyl Benzene	1E-1	3,500	-	350
Xylenes	2E+0	70,000	3E-1 mg/m^3	300
Toluene	3E-1	10,500	2E+0 mg/m^3	2,000
Phenol	6E-1	21,000	-	2,100
Copper	1E-0	1,300	-	130
Cyanide	2E-2	700	-	70
Selenium	2E-3	105	1E-3	3.5
Zinc	2E-1	7,000	-	700
Carcinogens				
Arsenic	1E-3	35	-	3.5
Cadmium	5E-4	17.5	-	1.75
Chromium	-	MCL-50[b]	-	-
Lead	-	MCL-50[b]	-	-
Nickel	2E-2	700	-	70
Benzene	-	MCL-1[b]	-	-
Carbon Tetrachloride	7E-4	24.5	-	2.45
Chloroform	1E-2	350	-	35
1,2-Dichloroethane	-	MCL-0.5[b]	-	-
1,1-Dichloroethylene	9E-3	315	-	31.5
Methylene Chloride	6E-2	2,100	-	210
Perchloroethylene	1E-2	350	-	35
1,1,2-Trichloroethane	4E-3	140	-	14
Trichloroethylene	-	MCL-5[b]	-	-
Vinyl Chloride	-	MCL-0.5[b]	-	d

a: Oral and Inhalation Chronic Reference Doses (RfDc-O, RfDc-I) in mg/kg-day are taken from Table A, "Health Effects Assessment Summary Tables, Third Quarter FY 1989," EPA July 1989, OERR 9200.6-303-(89-3). Chronic Reference Doses in ppb and $\mu g/m^3$ are calculated using conversion factors of 70 kg, 2 liters/day, and 20 m^3/day.

b: MCL = Maximum Contaminant Level in Drinking Water, California Code of Regulations, Title 22, Division 4, Chapter 15, Sections 64435 and 64444.5.

c: Trans-1,2-Dichloroethylene was reportedly not detected in ambient air in the 1982 Expanded Monitoring Program (DHS-TSCP/CARB/SCAQMD, 1983); CH2MHill included data for the chemical in its 1988 report (Volume 5, Appendix H-2, CH2MHill, 1988).

d: Noncarcinogenic effects of vinyl chloride occur at concentrations in air near or above 10,000 ppb which is much greater than ambient levels detected near the BKK Landfill, West Covina ("Technical Support Document, Proposed Identification of Vinyl Chloride as a Toxic Air Contaminant, Draft Report Part B," CARB May 1990, pg. 1-2).

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chemicals detected in offsite surface water and/or air around the B.K.K. Landfill. For those chemicals detected around the landfill that do not have a reference dose, the maximum contaminant level in drinking water is listed.

Inhalation Unit Risk Values

Cancer is considered a multistage process, and it is assumed that no threshold exists for substances that induce cancer. For carcinogens, risks are estimated as probabilities. Mathematical models used to derive estimates of risk associated with carcinogens are generally based on theories of carcinogenesis. EPA normally uses the linearized multistage model to extrapolate from observed high dose animal studies to expected low level environmental exposures. Values obtained from this extrapolation are expressed as slope factors or unit risks for a lifetime (70 years) exposure. Generally, after the data are fit to the appropriate mathematical model, the upper 95 percent confidence limit of the slope of the resulting dose-response curve is calculated. This value is known as the slope factor and represents an upper 95 percent confidence limit on the probability of a response per unit intake of a chemical over a lifetime. In some cases, slope factors based on human dose-response data use a "best" estimate (that is, the best fit dose-response line from a set of data) instead of the upper 95 percent confidence limit. The slope factor, expressed as $(mg/kg\text{-}day)^{-1}$, is used when calculating the risk from actual daily dose in mg/kg to an individual.

The unit risk is the risk per unit concentration of a chemical in the medium where human contact occurs. The unit risk, expressed as ppm^{-1}, ppb^{-1}, or

$(ug/m^3)^{-1}$, is used when calculating the risk from ambient air concentrations to which an individual is exposed.

EPA recommends that numerical estimations of risk be coupled with the "weight-of-evidence" classification of a carcinogen.

Risk assessors may arrive at different values for a carcinogen because they select different data sets or different extrapolation models. This health risk assessment uses the unit risk values derived by either EPA's Carcinogen Assessment Group or DHS's Air Toxics Section, and contained in California's "Air Toxics Assessment Manual, Table 3.15" (CAPCOA, 1987). Table 10 presents the unit risk values and the corresponding "weight-of-evidence" classification for the carcinogens detected at the B.K.K. Landfill.

TABLE 10

INHALATION UNIT RISK (IUR) VALUES FOR CARCINOGENS DETECTED AT BKK LANDFILL, WEST COVINA, CALIFORNIA

Carcinogen	AGENCY[a]	IUR[a] $(\mu g/m^3)^{-1}$	EPA[b] Class
Arsenic (inorganic)	EPA	4.3E-3	A
Cadmium	DHS	1.2E-2	B1
Chromium(VI)	DHS	1.5E-1	A
Lead	-	-	B2
Nickel	EPA	4.8E-4	A
Benzene	DHS	5.3E-5	A
Bis-2-chloroethylether	EPA	3.3E-4	B2
Carbon Tetrachloride	DHS	4.2E-5	B2
Chloroform	EPA	2.3E-5	B2
1,2-Dichloroethane	DHS	2.2E-5	B2
1,1-Dichloroethylene	EPA	5.0E-5	C
Methylene Chloride	DHS	1.0E-6	B2
N-Nitrosodimethylamine	EPA	1.4E-2	B2
Perchloroethylene	EPA	5.8E-7	C
1,1,2,2-Tetrachloroethane	EPA	5.8E-5	C
1,1,2-Trichloroethane	EPA	1.6E-5	C
Trichloroethylene	EPA	1.3E-6	B2
Vinyl Chloride	EPA	2.7E-6	A

a: Reference documents for the values listed were derived by the Environmental Protection Agency (EPA) or the Department of Health Services, Health Hazard Assessment Division, Air Toxics Section (DHS), and are given with Table 3.15, "Air Toxics Assessment Manual," California Air Pollution Control Officers Association, October 1987 pgs. 3.5-24 to 3.5-28. Values are current through June 1989.

b: EPA weight of evidence classification: A, sufficient evidence in humans; B1, sufficient evidence in animals, limited in humans; B2, sufficient evidence in animals, inadequate in humans; C, limited evidence in animals, inadequate in humans. Taken from EPA's Integrated Risk Information System (IRIS), June 1989.

RISK CHARACTERIZATION

Risk characterization integrates the three previous components of a health risk assessment (hazard identification, exposure assessment, and dose-response assessment), to provide a numerical estimation of risk and a framework to relate the significance of the risk. This section estimates, for residents living near the B.K.K. Landfill, the risks associated with exposure to the concentrations of contaminants detected in offsite surface water and air. Individual excess lifetime cancer risks are calculated for carcinogens detected in three site-specific air monitoring programs, one Los Angeles basin air monitoring program, and one air modeling program. The population excess cancer burden is also estimated. Limitations and uncertainties of the estimated risk are discussed, and the significance of the risk estimate is explained.

Risk Characterization of Exposure to Contaminants Detected in Offsite Surface Water Near the B.K.K. Landfill

Most indicator chemicals detected in offsite surface water near the B.K.K. Landfill were detected in concentrations below their thresholds for noncarcinogenic effects (Table 11). Four indicator chemicals were detected in concentrations above their reference dose or maximum contaminant level: zinc was detected at 17,000 ppb; arsenic, at 89 ppb; 1,2-dichloroethane, at 230 ppb; and vinyl chloride, at 40 ppb. Surface waters near the B.K.K. Landfill are not used for drinking water. Any exposure to contaminated

TABLE 11

COMPARISON OF INDICATOR CHEMICALS DETECTED IN OFFSITE SURFACE WATER, 1981-1985
TO ORAL CHRONIC REFERENCE DOSES
BKK LANDFILL, WEST COVINA, CA

Indicator Chemical	Median Value[a] ppb	RfDc-Oral[b] ppb
Non-Carcinogens		
Trans-1,2-Dichloroethylene	2.4	700
1,1,1-Trichloroethane	3.4	3,150
1,1-Dichloroethane	56	3,500
Chlorobenzene	1.08	700
Xylenes	0.2	70,000
Toluene	0.2	10,500
Phenol	3,900	21,000
Copper	40	1,300
Cyanide	3	700
Lead	12	MCL-50[c]
Selenium	41	105
Zinc	17,000	7,000
Carcinogens		
Arsenic	89[d]	35
Cadmium	2	17.5
Chromium	5	MCL-50[c]
Lead	12	MCL-50[c]
Nickel	100	700
1,1,2-Trichloroethane	14	140
1,2-Dichloroethane	230	MCL-0.5[c]
1,1-Dichloroethylene	3.2	315
Chloroform	1.7	350
Methylene Chloride	71	2,100
Perchloroethylene	3.3	350
Trichloroethylene	2.1	MCL-5[c]
Vinyl Chloride	40	MCL-0.5[c]

a: Median Values are taken from Table 3-18, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," CH2MHill, 1988, Volume I, pgs. 3-90 to 3-94. (Table 6 of this report).

b: Chronic Reference Doses (RfDc-Oral) were calculated from chronic reference doses listed in Table A, "Health Effects Assessment Summary Tables Third Quarter FY 1989," EPA July 1989 (Table 9 of this report).

c: MCL = Maximum Contaminant Level in Drinking Water, California Code of Regulations, Title 22, Division 4, Chapter 15, Sections 64435 and 64444.5.

d: Maximum value taken from Table 5-21, CH2MHill, 1988, Volume I, pgs. 5-125 to 5-127.

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surface water would have been infrequent, much less than two liters a day, and of limited duration. The risk associated with exposure to the concentrations of these contaminants in offsite surface water near the B.K.K. Landfill is n t considered significant. No numerical estimate of risk is made because no quantitative estimate of exposure can be made from the available information.

Risk Characterization of Noncarcinogens Detected in Air Near the B.K.K. Landfill

From the limited sampling in air monitoring programs around th B.K.K. Landfill, only two noncarcinogen indicator chemicals were detected in air, both below their reference dose. 1,1,1-Trichloroethane was detected in 10 Priority I homes during the 1984 Extended Monitoring Program at a median value of 4 ppb; the inhalation chronic reference dose is approximately 192 ppb. Trans-1,2-dichloroethylene, originally reported not detected in the 1982 Expanded Monitoring Program (DHS-TSCP/CARB/SCAQMD, 1983), was reported by CH2MHill (Volume 5, Appendix H-2, CH2MHill, 1988); the median value was 1 ppb and the inhalation chronic reference dose is approximately 18 ppb.

Noncarcinogenic effects of vinyl chloride occur at concentrations in air near or above 10,000 ppb, which is much greater than ambient levels detected around the B.K.K. Landfill (CARB, Part B, 1990).

Because the concentrations of contaminants detected in ambient air around the landfill do not exceed their thresholds for chronic reference doses, impacts from noncarcinogenic adverse health effects are not anticipated.

Risk Characterization of Carcinogens

No threshold is assumed for carcinogens, therefore, this risk characterization estimates the risk of developing cancer from exposure to the carcinogens detected in air around the B.K.K. Landfill between 1982 through 1987. Data is taken from the following programs, which are summarized in Table 8 of the exposure assessment section:

Site-specific programs (see Figure 7)

- SCAQMD's 1983-1987 Ambient Vinyl Chloride Monitoring Program
- DHS-TSCP/CARB/SCAQMD's 1982 Expanded Monitoring Program
- EPA and DHS's 1984 Extended Monitoring Program

Los Angeles air basin program

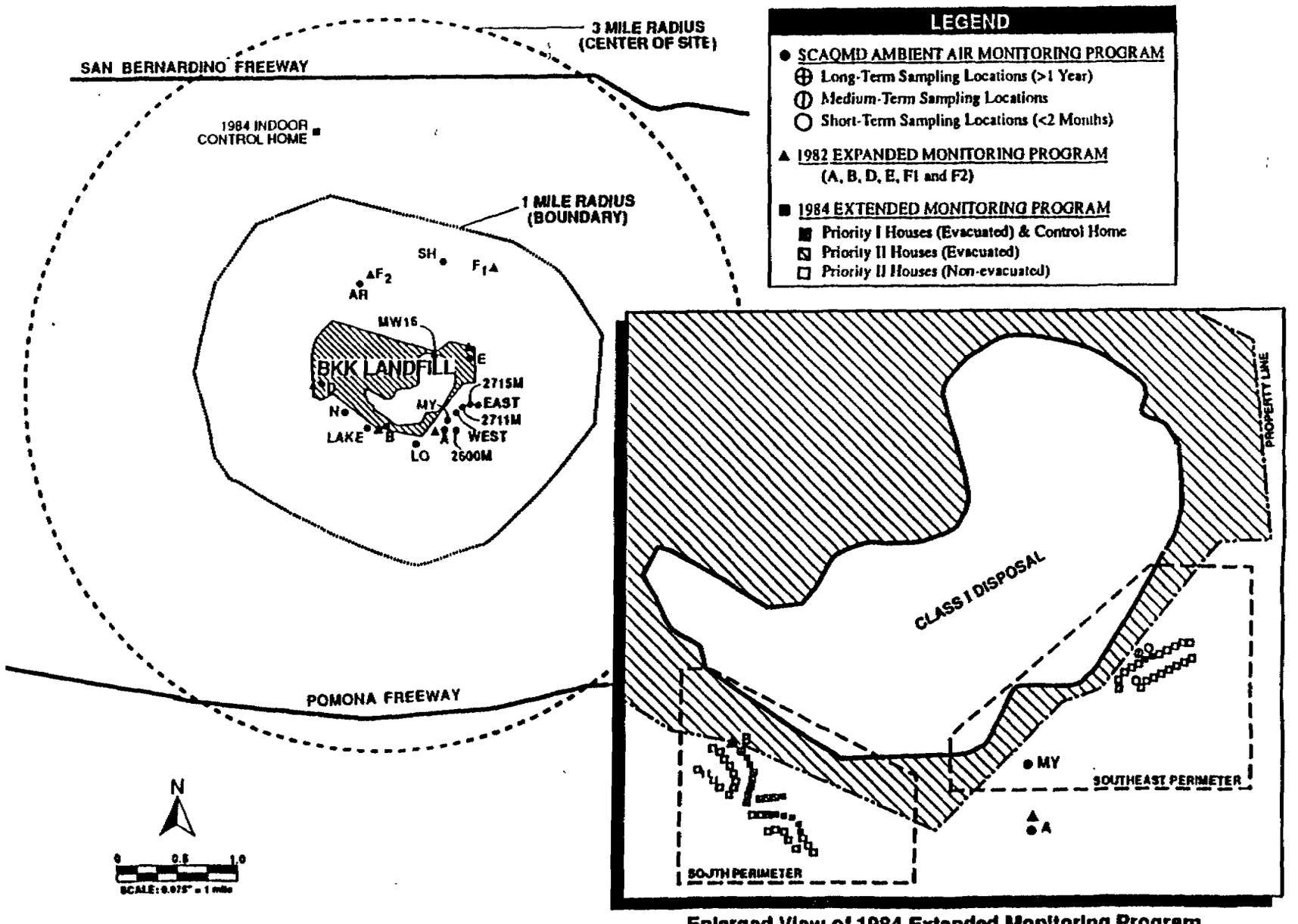
- CARB and SCAQMD's 1985 Los Angeles Basin Air Toxics Monitoring Program

Modeling program

- CARB's Modeling of 1987 Ambient Vinyl Chloride Concentrations Around the B.K.K. Landfill.

Two measures are used to estimate the risk: the "individual excess lifetime cancer risk" and the "population excess cancer burden". These risk estimates are statistical concepts which represent plausible upper bound estimates of the probability of developing cancer due to lifetime (70-year) exposure. Th individual excess lifetime cancer risk implies that an individual remains in the same location for an entire lifetime, and that the concentrations of carcinogens remain unchanged. The population excess cancer burden represents the plausible upper limit on the number of excess cases of cancer which could occur in a population after exposure for a specific period of time.

FIGURE 7: Air Monitoring Programs, BKK Landfill, West Covina, CA (Based on CH2MHill Fig. 5-21 and Plat 15)



Enlarged View of 1984 Extended Monitoring Program

Source: CH2MHill, "BKK Landfill Exposure Characterization Report, West Covina, California," August 15, 1988, Volume I, p. 5-165 (Figure 5.21) and Volume II, Plate 15.

Numerical Estimations of Risk

1. Numerical Estimation - Individual Excess Lifetime Cancer Risk

The risk calculation is expressed as:

$$ECR = C \times YR \times EF \times RF \times UR \times 1/LT$$

Where

ECR - Excess lifetime cancer risk

C - Concentration in $\mu g/m^3$ of the carcinogen; parts per billion were converted to micrograms per cubic meter ($\mu g/m^3$) as follows (assuming 25°C and 760 mm Hg pressure):

$$\mu g/m^3 = \frac{ppb \times \text{molecular weight}}{24.45\ m^3/\mu mole}$$

YR - Years of residence associated with exposure

EF - Exposure factor, i.e., percent of time spent at home

RF - Retention factor, i.e., percent of measured concentration absorbed in the lungs

UR - Unit risk value

LT - Human individual lifetime in years.

Assumptions for this calculation are the following:

- persons have an average adult body weight of 70 kg and breathe 20 m^3 of air per day;
- persons are at home 80 percent of the time (that is, the residential scenario assumes an annual exposure fraction of 292/365 days);
- persons retain 100 percent of the measured concentration;
- persons have an average 70 years lifetime.

a. Risk Characterization Using SCAQMD's 1983-1987 Ambient Vinyl Chloride Monitoring Program Data

In 1977, SCAQMD measured ambient air at four plants which manufactured or used vinyl chloride in the Los Angeles Basin: Keysor-Century in Saugus; Union Carbide in Torrance; and B.F. Goodrich and Stauffer Chemical in Carson (SCAQMD, 1982). The B.K.K. Landfill received wastes containing vinyl chloride from these plants. In 1981, SCAQMD conducted limited sampling of landfill gas emissions at the B.K.K. Landfill and detected vinyl chloride at concentrations above the California ambient air quality standard of 10 ppb. Because vinyl chloride is a human carcinogen, it became the landfill gas contaminant of primary concern. Vinyl chloride is the only contaminant for which there are continuous monitoring data from 1981 to the present.

SCAQMD began monitoring in residential neighborhoods around the B.K.K. Landfill: Station A, established in 1981, was located at the intersection of Marlena and Nogales Streets, 450 feet southeast of the property line; Station B, established in 1981, was located on Lynn Court, immediately adjacent to the southern property line; Station MY, established in June 1984, was located on Myra Court, 150 feet southeast of the property line. Because the detection limit for vinyl chloride was lowered from 10 ppb to 2 ppb in 1983, comparison with data prior to 1983 is limited.

Samples were collected as 24-hour continuous daily samples in Tedlar bags and analyzed at SCAQMD's laboratory by gas chromatography.

Table 12 presents the monthly and annual geometric means of vinyl chloride at Stations A, B, and MY for the years 1983 through 1987. DHS staff calculated the geometric means from SCAQMD's daily measurements. Measurements of vinyl chloride below the detection limit of 2 ppb were assumed to be at the detection limit. Figure 8 was generated from this data, and shows that both the maximum value of vinyl chloride detected and the frequency of detection have declined since 1985.

Applying the present risk calculation to the 1987 annual geometric mean of vinyl chloride from Station MY (the highest value), and assuming a 70-year exposure to this level of vinyl chloride, the individual excess lifetime cancer risk is estimated to be 1.5×10^{-5}, or approximately 1 to 2 in 100,000.

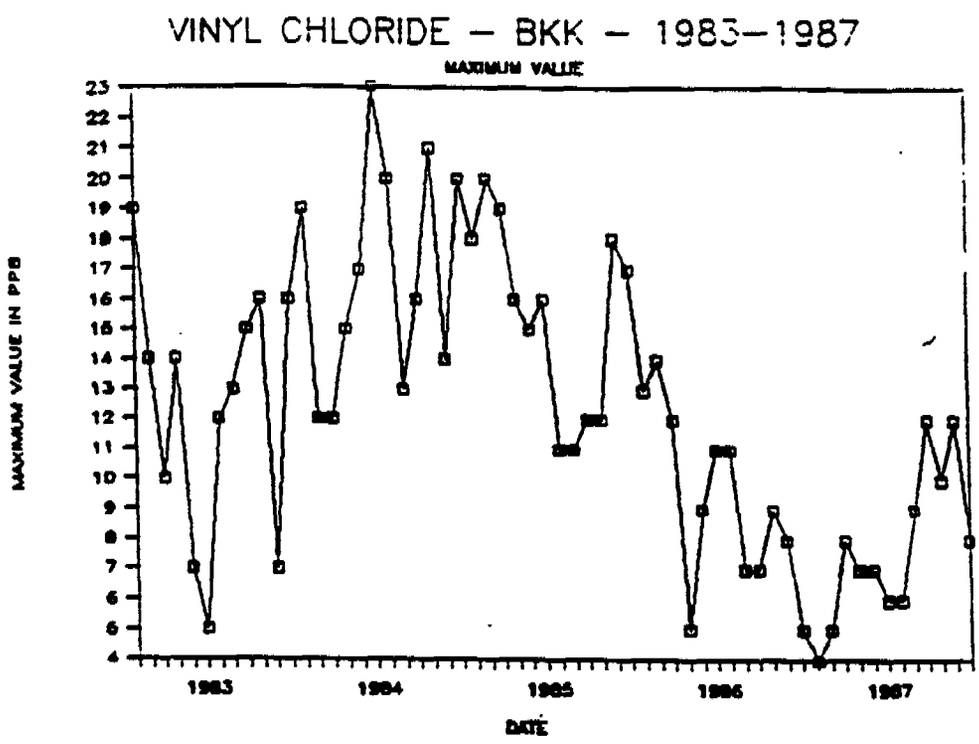
TABLE 12

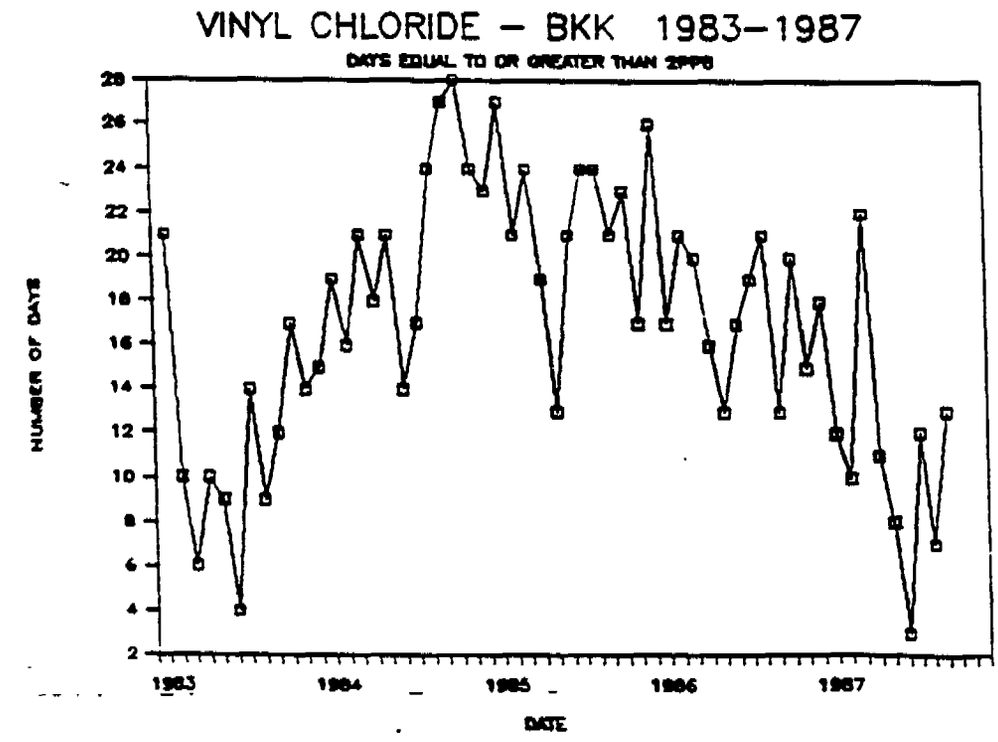
VINYL CHLORIDE IN AMBIENT AIR (ppb) - 1983-1987
MONTHLY AND ANNUAL GEOMETRIC MEANS
SCAQMD MONITORING STATIONS AROUND BKK LANDFILL, WEST COVINA, CA

MONTH	STATION	1983	1984	1985	1986	1987
JAN	A	3.8	3.1	3.9	2.7	2
FEB		3.6	2.8	3.4	2.6	2.1
MAR		2.3	3	4.7	2.6	2.3
APR		2.1	2.5	3	2.3	2.6
MAY		2.6	3.2	2.6	2.3	2.1
JUNE		2.3	2.8	2.9	2.5	2.1
JULY		3.4	ND	2.9	2.6	2.3
AUG		2.5	3.7	4	2.3	2.2
SEPT		3.5	4.7	3.2	2.2	2.6
OCT		2.9	4.4	3.2	2.2	2.4
NOV		2.2	3.7	2.6	2.1	2.1
DEC		2.7	3.6	3.7	2	2.4
ANNUAL		2.8	3.3	3.3	2.4	2.3
JAN	B	3.4	7	3	2.1	2.1
FEB		2.8	3.7	3.1	2.5	2
MAR		2.5	3.9	2.5	2.2	2
APR		2.4	3.5	2.5	2	2.1
MAY		2.1	4.6	2.3	2.1	2
JUNE		2.1	3.5	2.3	2.1	2
JULY		3.7	ND	2.3	2.2	2
AUG		3.1	2.3	2.7	2.1	2.2
SEPT		2.5	2.7	2.5	2.2	2
OCT		3.4	3.6	2.8	2.1	2
NOV		3.4	5.1	2.3	2	2
DEC		4.2	3.8	2.8	2	2
ANNUAL		2.9	3.8	2.6	2.1	2.0
	MY					
JAN			ND	6.6	3.1	2.3
FEB			ND	4.4	3.8	2.4
MAR			ND	4.5	3.2	2.9
APR			ND	3.8	2.3	3
MAY			ND	3	2.7	2.6
JUNE			ND	3.9	3.2	2.3
JULY			ND	4.1	3.2	2
AUG			4.1	4.8	3.2	2.8
SEPT			4.5	4	2.6	3.2
OCT			5.3	3.9	2.6	2.6
NOV			5.1	3.9	3.3	3.1
DEC			3.8	6.3	2.8	3.1
ANNUAL			4.5	4.3	3.0	2.7
ANNUAL TOTALS		2.8	3.9	3.3	2.5	2.3

NOTE: DHS staff calculated monthly and annual geometric means from SCAQMD's daily measurements of vinyl chloride. ND = No data was received. Measurements below the detection limit of 2 ppb were assumed to be at the detection limit. Station A = Marlena & Nogales Streets; Station B = Lynn Court; and Station MY = Myra Court, established June 1984.

FIGURE 8
VINYL CHLORIDE IN AMBIENT AIR
1983-1987 STATION A MONTHLY MONITORING DATA
BKK LANDFILL, WEST COVINA, CA





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NOTE: DHS staff generated these figures from daily measurements of vinyl chloride by SCAQMD at Station A.

If a value of 1 ppb (that is, half the detection limit) is substituted for values of vinyl chloride below the detection limit, the 1987 geometric means by station would be: A, 1.4 ppb; B, 1.1 ppb; and MY, 1.4 ppb. The annual geometric mean of all three stations would be 1.3 ppb. Using the value from Station MY, 1.4 ppb or 3.6 $\mu g/m^3$, the individual excess lifetime cancer risk would be 7.8×10^{-6}, or approximately 8 in 1,000,000.

Vinyl chloride emissions from the B.K.K. Landfill appear to have changed over time. Years used to compare the changes in vinyl chloride emissions are:

- 1982, at which time the first health risk assessment was conducted;
- 1983, at which time the detection limit for vinyl chloride was lowered to 2 ppb;
- 1984, at which time homes were evacuated due to subsurface migrati n of landfill gas, leading to an improved landfill gas collection system;
- 1987, at which time mitigation measures were further lowering vinyl chloride emissions from the facility.

Table 13 evaluates the 70-year risk over these changing exposure periods. A one-year exposure period is defined for data from 1983 through 1986. The 1982 data represent the following: the initial seven-year period for which waste disposal records are available (1975-1982); the landfill expansion from 40 acres to 140 acres; and

TABLE 13

INDIVIDUAL EXCESS LIFETIME CANCER RISK[a]

SCAQMD AMBIENT VINYL CHLORIDE MONITORING PROGRAM

BKK LANDFILL, WEST COVINA, CALIFORNIA

	1982[b] $\mu g/m^3$ (ppb)	1983[c] $\mu g/m^3$ (ppb)	1984[d] $\mu g/m^3$ (ppb)	1985[d] $\mu g/m^3$ (ppb)	1986[d] $\mu g/m^3$ (ppb)	1987[d] $\mu g/m^3$ (ppb)	Total
C_{vc}	18.6 (7.3)	7.2 (2.8)	11.5 (4.5)	11.0 (4.3)	7.7 (3.0)	6.9 (2.7)	
YR	7	1	1	1	1	59	70
ECR	4.0×10^{-6}	2.2×10^{-7}	3.5×10^{-7}	3.4×10^{-7}	2.4×10^{-7}	1.3×10^{-5}	1.8×10^{-5}

a: Calculated by ECR = C_{vc} x YR x EF x RF x UR x 1/LT where

- ECR = Excess lifetime cancer risk
- C_{vc} = Concentration in $\mu g/m^3$ of vinyl chloride
- YR = Years of residence associated with exposure
- EF = Exposure factor, i.e. percent of time at home (80%)
- RF = Retention factor, i.e. percent of measured concentration absorbed in the lungs (100%)
- UR = Unit risk value for vinyl chloride: 2.7×10^{-6} $(\mu g/m^3)^{-1}$, taken from Table 3.15, "Air Toxics Assessment Manual," California Air Pollution Control Officer's Association, October 1987, p. 3.5-28. Value current through June 1989.
- LT = Human individual lifetime in years (70)

b: Mean value, Station A, Table II, "Ambient Air Monitoring and Health Risk Assessment for Suspect Human Carcinogens Around the BKK Landfill in West Covina," DHS-TSCP/CARB/SCAQMD, March 1983, p. 16 (Appendix B of this report).

c: DHS staff calculated the annual geometric mean from daily measurements of vinyl chloride by SCAQMD at Stations A and B (Table 12 of this report).

d: DHS staff calculated the annual geometric mean from daily measurements of vinyl chloride by SCAQMD at Station MY (Table 12 of this report).

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the increased residential construction along the southern border. The 1987 measurements are projected for the remaining 59-year period, although mitigation measures may be expected to lower vinyl chloride emissions. Applying the present risk calculation to the data specified in Table 13, the individual excess lifetime cancer risk ov r the changing exposure periods is estimated to be 1.8×10^{-5}, or approximately 2 in 100,000.

b. Risk Characterization Using DHS-TSCP/CARB/SCAQMD's 1982 Expanded Monitoring Program Data

During July to October 1982, DHS-TSCP, CARB and SCAQMD conducted a 90-day study to monitor ambient air around the B.K.K. Landfill for nine VOCs. The study was the first health risk assessment of the landfill. A summary of the report as well as a copy of the report are provided in the Appendix.

Three monitoring stations were located in residential neighborhoods around the landfill (A and B to the south; F to the north); two monitoring stations were located on the landfill (D at the entrance, E at the highest elevation); and SCAQMD's monitoring station in Pico Rivera, nine miles to the southwest, was selected as the control station C. The selection of Pico Rivera as a residential control site has since been questioned because of the influence from industrial emission sources in Pico Rivera. In 1982 it was considered to be the closest established monitoring station for which routine data had been

collected over a period of years, and an upwind location. Stations A, B, D, E, and F are shown in Figure 7. The study defined the exposure period as the previous seven years (1975-1982) reflecting the seven year period for which waste disposal records were available, the landfill expansion from 40 acres to 140 acres, and the increased residential construction along the southern border.

Continuous 24-hour samples were collected in Tedlar bags Sunday through Thursday. Split samples were taken and analyzed by two laboratories, SCAQMD's laboratory and CARB's southern laboratory branch (Haagen-Smit). Of the nine compounds monitored, seven were detected. Mean values from each laboratory were reported.

CH2MHill's 1988 report has conflicting information about the program's data for benzene. DHS-TSCP/CARB/SCAQMD reported that benzene was detected by one laboratory which had a detection limit of 2 ppb, but not by the second laboratory which had a detection limit of 20 ppb. Benzene was included in their health risk assessment. CH2MHill listed the detection limits for benzene from the two laboratories as 10 ppb and 20 ppb, and excluded benzene from its exposure assessment. CH2MHill did not document the discrepancy between the 2 ppb and 10 ppb detection limit for the one laboratory.

For this risk characterization, data from Station A are used. Topographic and meteorologic data suggested that the location of

Station A received higher contaminant levels than the other stations (B, D, E, and F), and represented a "worst-case" scenario.

Applying the present risk calculation to the 1982 Station A measured data, assuming the seven-year exposure period defined in the program (1975-1982) and an additive effect of the carcinogens, the individual excess lifetime cancer risk is estimated to be 1 in 10,000. This estimate includes the benzene data reported by one laboratory. Deleting the benzene data because of the discrepancies in detection limits reduces the estimated risk to approximately 5 in 100,000 (Table 14).

c. Risk Characterization Using EPA and DHS' 1984 Extended Monitoring Program Data (Indoor Air Monitoring, Priority I Evacuated Homes)

In July 1984, 19 homes along the southern and southeastern perimeter of the B.K.K. Landfill were evacuated when methane, from lateral subsurface migration of landfill gas, was detected at concentrations above the lower explosive limit (50,000 ppm). The Southern California Gas Company detected and identified the methane gas from the landfill during a routine survey (every four years for residential distribution piping systems). The landfill gas served as a transport medium for VOC's deposited at the facility. EPA and DHS developed the "Extended Monitoring Program" to investigate the hazards: 10 homes and 1 control home were designated Priority I, requiring indoor air monitoring for 9 VOC's and total hydrocarbons; 51 occupied homes and

TABLE 14

INDIVIDUAL EXCESS LIFETIME CANCER RISK[a]

DHS-TSCP/CARB/SCAQMD 1982 EXPANDED MONITORING PROGRAM

BKK LANDFILL, WEST COVINA, CA

Carcinogen	Molecular Weight	C-Station A[b] ppb	C-Station A[b] µg/m3	Unit Risk[c] $(\mu g/m^3)^{-1}$	Cancer Risk	EPA[d] Class
Chloroethene (Vinyl Chloride)	62.5	7.3	18.6	2.7E-6	4.0E-6	A
Perchloroethylene (PCE)	165.85	3.7	25.0	5.8E-7	1.2E-6	C
Trichloroethene (TCE)	131.4	1	5.37	1.3E-6	5.6E-7	B2
1,1-Dichloroethene (Vinylidene Chloride)	96.95	1.3	5.15	5.0E-5	2.1E-5	C
1,2-Dichloroethane (Ethylene Dichloride)	98.96	3	12.1	2.2E-5	2.1E-5	B2
Trichloromethane (Chloroform)	119.39	0.5	2.44	2.3E-5	4.5E-6	B2
Benzene	78.11	4.8	15.3	5.3E-5	6.5E-5	A
Total Excess Lifetime Cancer Risk Including Benzene						1.2E-4
Total Excess Lifetime Cancer Risk Excluding Benzene						5.2E-5

a: Calculated by ECR = C x YR x EF x RF x UR x 1/LT where

- ECR = Excess lifetime cancer risk
- C = Concentration in $\mu g/m^3$
- YR = Years of residence associated with exposure (7)
- EF = Exposure factor, i.e. percent of time at home (80%)
- RF = Retention factor, i.e. percent of measured concentration absorbed in the lungs (100%)
- UR = Unit risk value
- LT = Human individual lifetime in years (70)

b: Mean values, Station A, Table II, "Ambient Air Monitoring and Health Risk Assessment for Suspect Human Carcinogens Around the BKK Landfill in West Covina," DHS-TSCP/CARB/SCAQMD, March 1983, pg. 16. (Appendix B of this report).

c: Values taken from Table 3.15 of the "Air Toxics Assessment Manual," California Air Pollution Control Officers Association, October 1987, pgs. 3.5-24 to 3.5-28. Values current through June 1989.

d: EPA weight of evidence classification: A, sufficient evidence in humans; B1, sufficient evidence in animals, limited in humans; B2, sufficient evidence in animals, inadequate in humans; C, limited evidence in animals, inadequate in humans. Taken from EPA's Integrated Risk Information System (IRIS), June 1989.

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10 control homes were designated Priority II, requiring monitoring for vinyl chloride; and 90 subsurface landfill gas probes were installed onsite and offsite to monitor for total hydrocarbon levels.

Field technical support and data quality assurance support for the program were provided by the EPA FIT contractor (Ecology and Environment, Inc.). Laboratory analyses were done by West Coast Analytical Laboratories. Data management support was provided by an EPA contractor, Tech Law.

Priority I homes were monitored in October 1984 for the following nine VOC's: chloroform, 1,1-dichloroethylene, benzene, carbon tetrachloride, 1,2-dichloroethane, 1,1,1-trichloroethane, perchloroethylene, trichloroethylene, and vinyl chloride. Composite 24-hour samples were collected in Tedlar bags and analyzed by gas chromatography-mass spectrometry.

Data for Priority II homes were not available and not discussed by CH2MHill. CH2MHill prepared Table 15 as a summary of the data for the Priority I homes and the control home, and recorded the data for the program in Volume 5 Appendix H-2. CH2MHill did not list benzene, as seen in Table 15, because detections were attributed to laboratory contamination. No documentation or explanation of the laboratory contamination was provided. Data for benzene is added as a footnote to Table 15. Carbon tetrachloride and chloroform were not detected in any of the ten Priority I homes, and are not included in the risk

TABLE 15 (CH2MHILL)

Table 6-13
SUMMARY OF 1984 INDOOR MONITORING IN PRIORITY I HOMES AND A CONTROL HOME

Chemicals	Priority I Homes (10) (ppb v/v)			Control Home (ppb v/v)		
	No.[a]	Median	Maximum	No.	Median	Maximum
1,1-Dichloroethylene	75	<1	2	4	<1	<1
1,2-Dichloroethane	75	3	14	4	<1	<1
1,1,1-Trichloroethane	75	4	14	4	3	4
Carbon Tetrachloride	75	<1	<1	4	<1	<1
Chloroform	75	<1	<1	4	<1	<1
Perchloroethylene	75	2.5	21	4	1.5	2
Trichloroethylene	75	1.5	6	4	<1	<1
Vinyl Chloride	75	<4	7	4	<4	<4

Notes:
Data source is the 1984 Extended Monitoring Program.
Values presented with < symbol are detection limits.
[a]Number of samples.

Source: CH2MHill, Table 6-13, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California." August 15, 1988, Volume I, P. 6-45.

Benzene data in CH2MHill Volume 5, Appendix H-2, 1988, are the following: Priority I homes - 70 samples, median value 7 ppb, maximum value 29 ppb; Control home - 2 samples, 4 and 6 ppb.

Carbon tetrachloride and chloroform were not detected in any of the 10 Priority I homes.

A detection limit of 4 ppb for vinyl chloride is not substantiated by recorded values in Volume 5, Appendix H-2.

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characterization; the values in Table 15 for carbon tetrachloride and chloroform are the detection limits for the compounds. A detection limit of 4 ppb for vinyl chloride in Table 15 is not substantiated by recorded values in Volume 5, Appendix H-2: a value of 1 ppb is recorded for one home and a value of 2 ppb is recorded for thr e homes.

Because the concentrations detected in the Priority I homes appear somewhat similar to the concentrations detected in the control home, analysis of variance (ANOVA) was performed to determine if there was a difference. ANOVA is a statistical technique that investigates the contribution of one or more factors to the variation in an outcome of interest. For the seven compounds detected in the Priority I homes (vinyl chloride, 1,1-dichloroethylene, 1,2-dichloroethane, 1,1,1-trichloroethane, perchloroethylene, trichloroethylene, and benzene), 3-way ANOVA shows that concentrations detected in the Priority I homes were significantly higher than concentrations detected in the control home ($p < 0.039$). Excluding benzene, 2-way ANOVA of the six compounds shows a significant difference in the concentrations detected in the Priority I homes ($p < 0.006$). Both analysis controlled for sample date/calendar period, indicating that the difference was not due to the day the sample was taken. (Appendix E contains a more detailed description of the analyses.) Whether or not there were additional sources of the compounds within the homes cannot be determined from the available data.

Table 16 applies the present risk calculation to the six carcinogens detected in the Priority I homes. (1,1,1-Trichloroethane, a Class D carcinogen, is not included in the risk calculation; the inhalation reference dose is 192 ppb.) A one-year exposure period of January to December 1984 is assumed since all evacuated homes were allowed to be reoccupied by December, and elevated levels of methane and landfill gas may have been present for a short time prior to being detected by the routine survey. Assuming an additive effect of the carcinogens, the individual excess lifetime cancer risk is estimated to be 2 in 100,000 including benzene, and approximately 6 in 1,000,000 excluding benzene.

d. Risk Characterization Using CARB and SCAQMD's 1985 Los Angeles Basin Air Toxics Monitoring Program Data

Pursuant to California's toxic air contaminant program (Health and Safety Code, Section 39650 *et seq*), CARB and SCAQMD initiated programs in 1985 to monitor selected VOC's at specific locations within the Los Angeles basin. Results were reported in "The Magnitude of Ambient Air Toxics Impacts From Existing Sources in the South Coast Air Basin" (SCAQMD, 1987). Air monitoring stations for SCAQMD were located in Anaheim, Azusa, Burbank, and Lennox; monitoring stations for CARB were located in El Monte, Long Beach, Los Angeles, Rubiodoux and Upland (Figure 9). Compounds selected for monitoring were: benzene, carbon tetrachloride, 1,2-dibromomethane, 1,2-dichloroethane, methylene chloride, perchloroethylene, toluene, 1,1,1-trichloroethane,

TABLE 16

INDIVIDUAL EXCESS LIFETIME CANCER RISK[a]

EPA and DHS 1984 EXTENDED MONITORING PROGRAM

BKK LANDFILL, WEST COVINA, CA

Carcinogen	Molecular Weight	Median[b] ppb	Median[b] µg/m3	Unit Risk[c] $(\mu g/m^3)^{-1}$	Cancer Risk	EPA[d] Class
Vinyl Chloride	62.5	4	10.2	2.7 E-6	3.1 E-7	A
Perchloroethylene	165.85	2.5	17.0	5.8 E-7	1.1 E-7	C
Trichloroethene	131.4	1.5	8.1	1.3 E-6	1.2 E-7	B2
1,1-Dichloroethene	96.95	1	4.0	5.0 E-5	2.3 E-6	C
1,2-Dichloroethane	98.96	3	12.1	2.2 E-5	3.0 E-6	B2
Benzene	78.11	7	22.4	5.3 E-5	1.4 E-5	A
Total Excess Lifetime Cancer Risk Including Benzene						2.0 E-5
Total Excess Lifetime Cancer Risk Excluding Benzene						5.8 E-6

a: Calculated by ECR = C x YR x EF x RF x UR x 1/LT where

ECR = Excess lifetime cancer risk

C = Concentration in $\mu g/m^3$

YR = Years of residence associated with exposure (1)

EF = Exposure factor, i.e. percent of time at home (80%)

RF = Retention factor, i.e. percent of measured concentration absorbed in the lungs (100%)

UR = Unit risk value

LT = Human individual lifetime in years (70)

b: Median values taken from Table 6-13, "BKK Landfill Environmental Exposure Characterization Report, West Covina, California," CH2MHill, 1988, Volume I, p. 6-45.

c: Values taken from Table 3.15, of the "Air Toxics Assessment Manual," California Air Pollution Control Officers Association, October 1987, pgs. 3.5-24 to 3.5-28. Values current through June 1989.

d: EPA weight of evidence classification: A, sufficient evidence in humans; B1, sufficient evidence in animals, limited in humans; B2, sufficient evidence in animals, inadequate in humans; C, limited evidence in animals, inadequate in humans. Taken from EPA's Integrated Risk Information System (IRIS), June 1989.

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FIGURE 9
(SCAQMD)

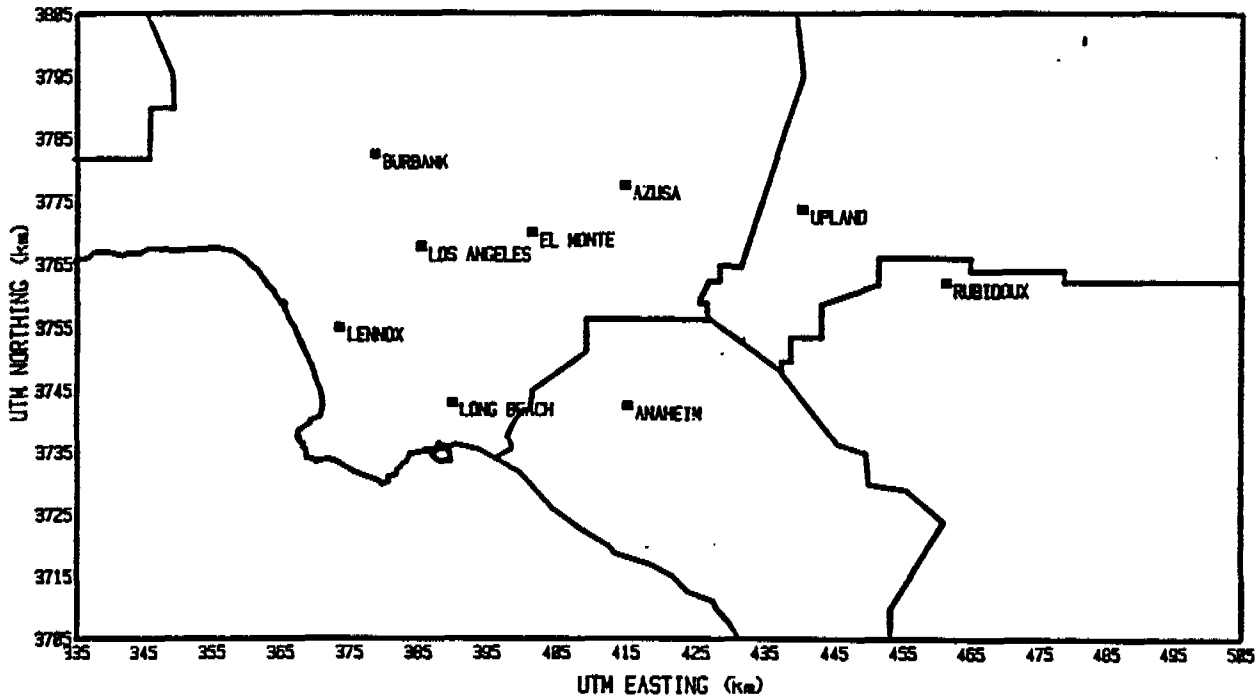

FIGURE V-1

AMBIENT AIR TOXIC MONITORING SITES IN THE SOUTH COAST AIR BASIN

Source: South Coast Air Quality Management District, Figure V-1, "The Magnitude of Ambient Air Toxics Impacts From Existing Sources in the South Coast Air Basin," June 1987, p. V-2.

R&S151958

trichloroethylene, chloroform, and vinyl chloride, (Table 17). Values obtained from these programs provide "background" levels in the Los Angeles air basin. Sampling methods and analysis were not described in the report.

CH2MHill used data from the four SCAQMD monitoring stations in its 1988 report. This risk characterization uses data from CARB's El Monte station. Of all nine locations shown in Figure 9, El Monte appeared to be more representative of ambient air conditions which might exist around the B.K.K. Landfill. The Azusa station was not considered representative because of its proximity to mountains.

With the exception of vinyl chloride, the carcinogens detected in ambient air near the B.K.K. Landfill have also been detected in ambient air in the Los Angeles basin. For the carcinogens detected near the B.K.K. Landfill, Table 18 applies the present risk calculation to the annual average ambient concentrations of those carcinogens also detected at El Monte Station in the Los Angeles basin. Assuming a 70-year exposure and an additive effect of the carcinogens, the individual excess lifetime cancer risk for the area near the El Monte Station is estimated to be approximately 7 in 10,000.

Benzene emissions have the greatest cancer risk impact in the Los Angeles basin, corresponding to an upper-bound risk of 1 in 10,000 to 1 in 1,000 (SCAQMD, 1987). Benzene emissions are attributed almost

TABLE 17
(SCAQMD)

TABLE V-1

1985 ANNUAL AVERAGE AMBIENT AIR CONCENTRATIONS OF VARIOUS TOXIC ORGANIC GASES IN THE SOUTH COAST AIR BASIN[a]

(concentration in ppbv)

Pollutant	SCAQMD				ARB				
	Ana-heim	Azusa	Burbank	Lennox	El Monte	Long Beach	LA	Rubi-doux	Upland
BENZENE									
Ave. Conc.	1.7-2.8	1.0-2.6	2.0-3.0	1.7-2.8	4.9	4.1	4.2	2.5	3.4
Std. Dev.	1.6	.92	1.3	1.5	2.6	1.9	2.2	1.3	1.4
Detection Limit[b]	2.0-4.0	1.0-4.0	1.0-3.0	2.0-3.0	.5	.5	.5	.5	.5
Sample Size/# < DL[c]	24/10	21/13	23/9	23/10	39/0	25/0	23/0	24/0	22/0
Data Category[d]	B	B	B	B	A	A	A	A	A
CARBON TETRACHLORIDE									
Ave. Conc.	.12	.12	.10	.11	.095	.10	.11	.099	.12
Std. Dev.	.038	.036	.023	.033	.024	.014	.016	.015	.073
Detection Limit	.016	.016	.016	.016	.004	.004	.004	.004	.004
Sample Size/# < DL	22/0	19/0	20/0	20/0	36/0	22/0	21/0	20/0	20/0
Data Category	A	A	A	A	A	A	A	A	A
CHLOROFORM									
Ave. Conc.	.045-.30	.053-.29	.018-.24	.063-.27	.063	.082	.11	.053	.071
Std. Dev.	*[e]	*	*	*	.023	.025	.090	.028	.045
Detection Limit	.02-1.0	.02-1.0	.077-.5	.077-.89	.02	.02	.02	.02	.02
Sample Size/# < DL	22/21	19/18	20/20	20/18	36/0	22/0	21/0	20/0	20/0
Data Category	C	C	C	C	A	A	A	A	A
ETHYLENE DIBROMIDE									
Ave. Conc. (ppt)	5-100	0-100	0-100	0-100	3-6	4-8	2-6	2-6	3-5
Std. Dev. (ppt)	*	*	*	*	4	9.0	2.0	1.4	1.0
Detection Limit (ppt)	100	100	100	100	5	5	5	5	5
Sample Size/# < DL	22/21	19/19	20/20	20/20	36/26	22/15	21/14	20/16	20/9
Data Category	C	C	C	C	B	B	B	B	B
ETHYLENE DICHLORIDE									
Ave. Conc.	0-17	0-14	0-18	1.0-18					
Std. Dev.	*	*	*	*					
Detection Limit	2.1-28	4.0-28	4.0-28	4.0-28					
Sample Size/# < DL	22/22	19/19	20/20	20/19					
Data Category	C	C	C	C					

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TABLE V-1 (continued)

Pollutant	SCAQMD				ARB				
	Ana-heim	Azusa	Burbank	Lennox	El Monte	Long Beach	LA	Rubi-doux	Upland
METHYLENE CHLORIDE									
Ave. Conc.					5.1	4.6-4.7	3.5	2.2-2.3	2.7-2.8
Std. Dev.					2.6	2.9	2.0	1.9	1.7
Detection Limit					.006	.006	.006	.006	.006
Sample Size/# < DL					36/0	22/1	21/0	20/4	20/3
Data Category					A	A	A	B	B
PERCHLOROETHYLENE									
Ave. Conc.	3.1	2.0	2.7	2.3	1.6	1.0	1.2	.46	.70
Std. Dev.	2.4	1.8	1.6	2.5	.86	.56	.91	.32	.45
Detection Limit	.2	.2	.2	.2	.01	.01	.01	.01	.01
Sample Size/# < DL	22/0	19/0	20/0	20/0	36/0	22/0	21/0	20/0	20/0
Data Category	A	A	A	A	A	A	A	A	A
TOLUENE									
Ave. Conc.	4.0-5.6	2.5-4.9	5.6-6.7	3.5-5.3					
Std. Dev.	2.9	2.3	3.0	4.2					
Detection Limit	3.0-6.0	3.0-7.0	5.0	.40-5.0					
Sample Size/# < DL	24/8	21/11	23/5	23/11					
Data Category	B	B	B	B					
1,1,1-TRICHLOROETHANE									
Ave. Conc.	2.3	2.6	3.3	2.5	7.1	3.0	2.4	1.1	1.6
Std. Dev.	1.4	1.7	1.7	1.5	4.7	2.1	2.6	.73	1.1
Detection Limit	.23	.23	.23	.23	.02	.02	.02	.02	.02
Sample Size/# < DL	22/0	19/0	20/0	20/0	36/0	22/0	21/0	20/0	20/0
Data Category	A	A	A	A	A	A	A	A	A
TRICHLOROETHYLENE									
Ave. Conc.	.23-.35	.16-.33	.30-.45	.20-.23	.40	.29	.34	.10	.37
Std. Dev.	.23	.26	.72	.22	.25	.20	.22	.06	.17
Detection Limit	.20-.90	.11-.90	.12-.22	.12-.15	.02	.02	.02	.02	.02
Sample Size/# < DL	22/7	19/8	20/7	20/15	36/0	22/0	21/0	20/0	20/0
Data Category	B	B	B	B	A	A	A	A	A
VINYL CHLORIDE									
Ave. Conc.	0-2.0	0-2.0	0-2.0	0-2.0					
Std. Dev.	*	*	*	*					
Detection Limit	2.0	2.0	2.0	2.0					
Sample Size/# < DL	24/24	21/21	24/24	24/23					
Data Category	C	C	C	C					

R&S151961

TABLE V-1 (continued)

Pollutant	S C A Q M D				A R B				
	Ana-heim	Azusa	Burbank	Lennox	El Monte	Long Beach	LA	Rubi-doux	Upland
BENZO(A)PYRENE (from EPA monitoring network)									
Ave. Conc. (ng/m^3)	.75						.75		
Std. Dev.	.17						.0079		
Det. Lim. (ng/m^3)	.33						.33		
Sample Size/# < DL	21/0						18/0		
Data Category	A						A		

[a] Blanks indicate no data available. Ranges of arithmetic annual averages defined as follows: first estimate is the average assuming all sub-detection limit observations equal zero; second estimate is the average assuming all sub-detection limit observations are equal to the detection limit concentration.

Standard deviations were calculated using only the observations above detection limits; if more than 90 percent of the observations were below detection limits, standard deviations were not calculated.

[b] Detection limits for some SCAQMD-measured pollutants reported as range because limits changed from sample to sample depending on analytical conditions. See text for further explanation.

[c] "Sample Size/# < DL" = (the total number of samples taken over the year) / (total number of these samples with concentrations below minimum detectable limits).

[d] Data Category codes for SCAQMD and ARB data are defined as: A - Most of the data above detection limits (>90%), C - Very few of the data points are above detection limits (<10%), and B - Several data points fall above and below detection limits.

[e] * standard deviation not calculated for Data Category C.

Source: South Coast Air Quality Management District, Table V-1, "The Magnitude of Ambient Air Toxics Impacts From Existing Sources in the South Coast Air Basin," 1987 Air Quality Management Plan Revision Working Paper No. 3, June 1987, Pgs. V-4 to V-6.

R&S151962

TABLE 18

INDIVIDUAL EXCESS LIFETIME CANCER RISK[a]

CARCINOGENS DETECTED AT EL MONTE STATION, 1985 LOS ANGELES BASIN AIR TOXICS MONITORING PROGRAM AND ALSO DETECTED NEAR THE BKK LANDFILL, WEST COVINA, CA

Cercinogen	Molecular Weight	El Monte[b] ppb	El Monte[b] $\mu g/m^3$	Unit Risk[c] $(\mu g/m^3)^{-1}$	Cancer Risk	EPA[d] Class
Benzene	78.11	4.9	15.7	5.3 E-5	6.7 E-4	A
Vinyl Chloride	62.5	-	-	2.7 E-6	-	A
Perchloroethylene	165.85	1.6	10.9	5.8 E-7	5.1 E-6	C
Trichloroethylene	131.4	0.40	2.1	1.3 E-6	2.2 E-6	B2
1,2-Dichloroethane	98.96	-	-	2.2 E-5	-	B2
Chloroform	119.39	0.06	.3	2.3 E-5	5.5 E-6	B2
Total Excess Lifetime Cancer Risk						6.8 E-4

a: Calculated by ECR = C x YR x EF x RF x UR x 1/LT where

- ECR = Excess lifetime cancer risk
- C = Concentration in $\mu g/m^3$
- YR = Years of residence associated with exposure (70)
- EF = Exposure factor, i.e. percent of time at home (80%)
- RF = Retention factor, i.e. percent of measured concentration absorbed in the lungs (100%)
- UR = Unit risk value
- LT = Human individual lifetime in years (70)

b: Values taken from El Monte Station, Table V-1, "1985 Annual Average Ambient Air Concentrations of Various Toxic Organic Gases in the South Coast Air Basin," SCAQMD, 1987, pgs. V-4 to V-6.

c: Values taken from Table 3.15 "Air Toxics Assessment Manual," California Air Pollution Control Officers Association, October 1987, pgs. 3.5-24 to 3.5-28. Values current through June 1989.

d: EPA weight of evidence classification: A, sufficient evidence in humans; B1, sufficient evidence in animals, limited in humans; B2, sufficient evidence in animals, inadequate in humans; C, limited evidence in animals, inadequate in humans. Taken from EPA's Integrated Risk Information System (IRIS), June 1989.

R&S151963

equally to mobile sources (motor vehicles) and area sources (gasoline marketing, stationary gasoline engines, crude oil production, and agricultural burning). In two earlier characterizations, (the 1982 Expanded Monitoring Program and the 1984 Extended Monitoring Program) benzene could be excluded from the risk calculation because of discrepancies with the data. The data in this characterization suggest that risks presented by exposure to benzene are more significant from ambient sources than from the B.K.K. Landfill.

e. Risk Characterization Using CARB's Modeling of 1987 Ambient Vinyl Chloride Concentrations Around the B.K.K. Landfill

CARB used monitoring data from the B.K.K. Landfill in an air dispersion model to estimate population exposure to vinyl chloride for the purpose of proposing to identify vinyl chloride as a toxic air contaminant (CARB, 1990, Draft Document). CARB is the state agency responsible for identification of toxic air contaminants. A toxic air contaminant is subject to a different regulatory process than an ambient air quality standard. A toxic air contaminant is an air pollutant which may cause or contribute to increased morbidity r mortality, or which may pose a present or potential human health hazard (California Health and Safety Code Section 39655). Identification of vinyl chloride as a toxic air contaminant allows CARB to develop control strategies that reduce vinyl chloride air levels far below 10 ppb.

CARB used the Industrial Source Complex Short Term (ISCST) Gaussian model to estimate vinyl chloride concentrations and expos d population. This model does not allow direct inference of distance. In this model, the B.K.K. Landfill was represented as an area source in the center of a grid of 41 one-square-kilometer cells (that is, a grid of approximately 25 square-miles). For each square-kilometer cell, annual average vinyl chloride concentrations were estimated using SCAQMD's 1981 meteorological data from Walnut Station, and SCAQMD's 1987 ambient vinyl chloride monitoring data from Station A, B, and MY (Table 19). Population estimates for each square-kilometer cell were determined from 1985 population census estimates. The 1,681 grid cells and associated population estimates were sorted from high to low by modeled vinyl chloride concentrations. Grid cell populations were then summed to determine the cumulative population exposed to a certain level of modeled vinyl chloride concentration. Table 20 shows the results of CARB's modeling.

Using CARB's modeled vinyl chloride concentrations, and applying th present risk calculation, the individual excess lifetime cancer risk ranges from 7 in 100,000,000 for exposure to 0.01 ppb of vinyl chloride to 4 in 100,000 for exposure to 7 ppb of vinyl chloride (Table 21).

TABLE 19
(CARB)

TABLE II-1

SUMMARY STATISTICS FOR THE JANUARY 1987 THROUGH DECEMBER 1987 MONITORING DATA FOR VINYL CHLORIDE NEAR BKK LANDFILL
(Concentrations reported in parts per billion (ppb))

	Station 1	Station 2	Station 3
Number of samples	337	337	345
Percent of Samples Below the LOD[a]	73	90	55
Estimated Concentration for[b] Samples Below the LOD	1.0	1.0	1.1
Estimated Mean[b] Concentration	1.7	1.2	2.6
Maximum 24-Hour Concentration[c]	7	8	15

a - The SCAQMD's limit of detection (LOD) for vinyl chloride is 2 ppb.
b - Gleit's method was used to estimate the concentration of samples below the LOD.
c - California's Ambient Air Quality Standard for vinyl chloride is 10 ppb for a 24-hour averaging period.

Source: California Air Resources Board, Table II-1, "Technical Support Document, Proposed Identification of Vinyl Chloride as a Toxic Air Contaminant, Draft Report, Executive Summary and Part A," Stationary Source Division, May 1990, p. A-7.

Stations 1, 2, and 3 are Stations A, B, and MY respectively.

R&S151966

TABLE 20
(CARB)

TABLE II-5

RANGE OF CUMULATIVE POPULATION EXPOSED TO VINYL CHLORIDE NEAR BKK

Vinyl Chloride Concentration (ppb)	Range of Cumulative Population Exposed		
	Lower-Bound Estimate[a]		Upper-Bound Estimate[b]
0.01	2.026.000	-	2.154.000
0.05	732.000	-	1.970.000
0.1	374.000	-	1.431.000
1.0	17.000	-	131.000
2.0	0	-	54.000
3.0	0	-	28.000
4.0	0	-	20.000
5.0	0	-	14.000
6.0	0	-	7.000
7.0	0	-	2.500

a - The exposure estimate is based on a vinyl chloride emission rate of 0.75 micrograms meter^{-2} sec.$^{-1}$

b - The exposure estimate is based on a vinyl chloride emission rate of 3.32 micrograms meter^{-2} sec.$^{-1}$

Source: California Air Resources Board, Table II-5, "Technical Support Document, Proposed Identification of Vinyl Chloride as a Toxic Air Contaminant, Draft Report, Executive Summary and Part A", Stationary Source Division, May 1990, p. A-14.

Modeled data is for an area approximately 25 miles-by-25 miles around the B.K.K. Landfill, West Covina, California.

R&S151967

TABLE 21

INDIVIDUAL EXCESS LIFETIME CANCER RISK[a]

CARB MODELING OF 1987 AMBIENT VINYL CHLORIDE CONCENTRATIONS

NEAR BKK LANDFILL, WEST COVINA, CA

Modeled Vinyl Chloride Concentration[b]		Cancer Risk
ppb	$\mu g/m^3$	
.01	.03	6.5E-8
0.1	0.3	6.5E-7
1.0	2.6	5.6E-6
2.0	5.1	1.1E-5
7.0	17.9	3.9E-5

a: Calculated by ECR = C_{VC} x YR x EF x RF x UR x 1/LT where

- ECR = Excess lifetime cancer risk
- C_{VC} = Concentration in $\mu g/m^3$ of vinyl chloride
- YR = Years of residence associated with exposure (70)
- EF = Exposure factor, i.e. percent of time at home (80%)
- RF = Retention factor, i.e. percent of measured concentration absorbed in the lungs (100%)
- UR = Unit risk value for vinyl chloride: 2.7×10^{-6} $(\mu g/m^3)^{-1}$, taken from Table 3.15, "Air Toxics Assessment Manual", California Air Pollution Control Officer's Association, October 1987, p. 3.5-28. Value current through June 1989.
- LT = Human individual lifetime in years (70)

b: Modeled vinyl chloride concentrations in ppb are taken from Table II-5, "Technical Support Document, Proposed Identification of Vinyl Chloride As A Toxic Contaminant, Draft Report, Executive Summary and Part A," CARB Stationary Source Division, May 1990, pg. A-14.

R&S151968

2. Numerical Estimation - Population Excess Cancer Burden

The population excess cancer burden is calculated by multiplying the individual excess lifetime cancer risk in an exposed area by the population in the exposed area.

The individual excess lifetime cancer risks estimated in the risk characterization scenarios of the B.K.K. Landfill are:

- 1987 Ambient Vinyl Chloride Monitoring, Station MY 1.5×10^{-5}
- 1982-1987 Ambient Vinyl Chloride Monitoring 1.8×10^{-5}
- 1982 Expanded Monitoring Program, excluding benzene 5.2×10^{-5}
- 1984 Extended Monitoring Program, excluding benzene 5.8×10^{-6}
- Modeling of 1987 Ambient Vinyl Chloride 6.5×10^{-8} to 3.9×10^{-5}

In 1985, EPA estimated the population within a one-mile radius of the center of the B.K.K. Landfill to be approximately 40,000 persons (EPA, 1985). In actual fact, not all 40,000 persons are exposed to the levels of vinyl chloride suggested in these scenarios. Most residents are exposed to lower levels. CARB's Table 19 shows that in 1987 the proportions of samples below the detection limit of 2 ppb was 73 percent, 90 percent, and 55 percent for Stations A, B, and MY respectively.

Based on the risk characterization scenarios, the most appropriate individual excess lifetime cancer risk to estimate population excess cancer burden is derived from monitored data at Station MY. Using the individual excess lifetime cancer risk of 1.5×10^{-5} associated with 1987 ambient vinyl chloride monitoring at Station MY, and the estimated

populati n within a one-mile radius of the B.K.K. Landfill, the estimated population excess cancer burden is 0.6. That is, in a population of 40,000 persons less than one additional case of cancer would be associated with exposure to vinyl chloride at 2.7 ppb for an entire 70-year period.

Limitations and Uncertainties

A risk number is an estimate of the risk of adverse health effects conditional on the methods and assumptions of the risk characterization, and the limitations and uncertainties of the data collection.

CH2MHill addressed the limitations and uncertainties of the data collection in its exposure characterization (CH2MHill, 1988). These included the following:

- only a few air monitoring data sets were judged to be appropriate for quantitative risk assessment based on a retrospective quality assurance review;
- 24-hour air samples were collected, providing data on average air emissions only;
- air monitoring data are primarily from residential stations in the south and southeast which represent nighttime ("worst-case"), air flow.
- detection limits for vinyl chloride and benzene have changed, limiting direct comparison of data over time;

- not all analytes were measured in all media, and some media (soil, particulates) were rarely sampled;
- demographics are based on the 1980 U. S. population census data and projections, although there has been considerable development around the B.K.K. Landfill.

Limitations of this health risk assessment include the following:

- use of data from 1982 through 1987 only;
- use of different summary statistics (that is, geometric means, arithmetic means, medians, and annual averages);
- use of June 1989 toxicity values.

Uncertainties inherent in this health risk assessment include:

- the assumptions stated at the beginning of the risk characterization;
- the choice of unit risk values.

The Class I Hazardous Waste Management Unit stopped accepting hazardous waste by December 1984, and was capped and closed in March 1989. Mitigation measures stipulated in the SAM Work Plan may be expected to reduce vinyl chloride emissions to levels and frequences below those detected in 1987.

Significance of the Risk

Excess lifetime cancer risk is estimated in order to assess the potential impact of a particular exposure in addition to the relatively constant background level of cancer risk. An individual has approximately a one in three (3×10^{-1}) risk of developing cancer during his or her lifetime.

The ambient vinyl chloride monitoring data represent the most appropriate data to assess the excess cancer risk associated with the B.K.K. Landfill because vinyl chloride is not commonly detected in the Los Angeles air basin. Carcinogens such as benzene, perchloroethylene, and trichloroethylene are detected in ambient air both at the B.K.K. Landfill and in the Los Angeles basin. These compounds may present an additional cancer risk to people living near the B.K.K. Landfill but it is not possible with the present data to distinguish between exposure due to ambient levels and exposure due to the B.K.K. Landfill. Vinyl chloride is rarely detected in the ambient air, and therefore vinyl chloride more clearly represents the increased exposure associated with the B.K.K. Landfill.

Based on the 1987 ambient vinyl chloride concentrations, and the methods and assumptions used in this health risk assessment, the individual excess lifetime cancer risk associated with exposure to the carcinogen detected in air around the B.K.K. Landfill is estimated to be approximately 1 to 2 individuals in 100,000 persons. This assumes everyone is exposed to vinyl chloride at the 1987 concentrations for an entire 70-year lifetime. Most residents are exposed to lower levels of vinyl chloride and most

residents are not likely to stay at one place an entire lifetime. Mitigation measures stipulated in the SAM Work Plan may be expected to reduce vinyl chloride emissions from the B.K.K. Landfill.

Currently, DHS and CARB are reevaluating the data on the carcinogenicity of vinyl chloride, in recent and past literature, for the purpose of identifying vinyl chloride as a toxic air contaminant, pursuant to the Health and Safety Code Section 39650 *et seq*. When this process is completed, a new unit risk value for vinyl chloride will be established. The new value is likely to be about 29 times greater than the value used in this health risk assessment. When this new value is adopted, DHS will prepare an addendum to this risk assessment, reflecting the changed unit risk value for vinyl chloride, updating toxicity values, and adding air monitoring data collected since 1987.

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R&S151975

APPENDIX A

SUMMARY OF THE THREE PREVIOUS HEALTH RISK ASSESSMENTS OF THE B.K.K. LANDFILL, WEST COVINA, CALIFORNIA

Three previous health risk assessments have been performed evaluating residential exposure to seven carcinogens detected in ambient air around the B.K.K. Landfill. Risk estimates varied due to different assumptions and methods of risk calculation, as described in the following paragraphs. Copies of the three risk assessments are provided as Appendices A, B, and C. The seven carcinogens evaluated were: vinyl chloride, benzene, trichloroethylene (TCE), 1,1-dichloroethylene (vinylidene chloride), perchloroethylene (PCE), 1,2-dichloroethane (ethylene dichloride), and trichloromethane (chloroform).

1. "Ambient Air Monitoring and Health Risk Assessment for Suspect Human Carcinogens Around the BKK Landfill in West Covina", Department of Health Services-Toxic Substances Control Program/California Air Resources Board/South Coast Air Quality Management District (DHS-TSCP/CARB/SCAQMD), March 1983. (Appendix B)

   During July to October 1982, DHS-TSCP, CARB, and SCAQMD conducted a 90-day study to monitor ambient air around the B.K.K. Landfill for nine volatile organic compounds in response to continued concerns from neighboring residents. Twenty-four hour ambient air samples were collected in Tedlar bags on Sunday through Thursday at six sample stations. Figure 7 of this report (and Figure I of Appendix A) shows the locations of the stations: Stations A and B were located in residential areas south of the landfill, reflecting nighttime air drainage patterns; Station D was located at the entrance to th landfill; Station E was located at the highest elevation within the landfill, reflecting daytime transport; Station F was initially located in a residential area on the northeast side and on August 26, 1982, it was moved to the northwest in response to odor complaints from that area. Station C was located in Pico Rivera, nine miles southwest (upwind) of the facility, to estimate background levels. Stations A, B, D, and E were within 400 to 1,000 feet of the waste disposal area while Station F was 2,500 and 6,000 feet from the facility. The data given for Station F are an equally weighted average of the two locations. Split samples were taken and analyzed by two laboratories, SCAQMD's laboratory and CARB's southern laboratory branch, (Haagen-Smit).

   DHS considered the nine volatile organic compounds to be known or potential human carcinogens: vinyl chloride, benzene, perchloroethylene, trichloroethylene, 1,1-dichloroethylene, chloroform, 1,2-dichloroethane, chlorobenzene, and trans-1,2-dichloroethene. The report stated that chlorobenzene and trans-1,2-dichloroethene were not detected. The remaining seven chemicals were detected in concentrations near the analytical limit of detection. Elevated levels of the seven were found around the B.K.K. Landfill compared to the control community of Pico Rivera. Stations A, B, and D had consistently more elevated levels than Stations E and F.

The risk assessment focused solely on the risk of cancer because the chemicals were detected in concentrations considered below their threshold for non-carcinogenic, toxic effects -- even at the highest concentrations detected. Excess cancer risks were derived by subtracting the average concentration of each substance at Station C from the average concentration of that substance at the B.K.K. Landfill monitoring site. The exposure period was defined as the previous seven years, 1975 to 1982, since that time reflected the beginning of recorded waste deposits, the landfill expansion from 40 acres to 140 acres, and the increased residential construction along the southern border. The report did not identify slope factors or unit risk values used in the risk calculation. Individual excess lifetime (70-year) cancer risk was based on the following assumptions:

- no dilution in the measured concentrations at Stations A-F;
- exposure for 24 hrs/day, 365 days/year, for 7 years (1975-1982);
- 100 percent absorption in the lungs.

The maximum individual excess lifetime cancer risk attributable to emissions from the B.K.K. Landfill for the previous 7 years was estimated to be approximately 5 per 100,000 (5×10^{-5}).

The population living within a one-mile radius of the B.K.K. Landfill property line was estimated to be approximately 7,700 persons. This number was derived by dividing the county assessor's plot maps into quadrants corresponding to monitoring Stations A, B, D, and F, and estimating the population within each quadrant from the 1980 census data. The population excess cancer burden was calculated for the population within each quadrant using the mean concentration difference for the respective station, then summing the derived excess number of cancers. No additional cases of cancer were suggested.

2. "Estimates of Carcinogenic Risk in the Vicinity of the BKK Landfill", K. S. Crump and Co., Inc., March 1986. (Appendix C)

In March 1986, K. S. Crump, as a consultant to attorneys for the B.K.K. Landfill, performed a risk assessment on the seven carcinogens detected in the DHS-TSCP/CARB/SCAQMD 1983 report. Crump identified epidemiologic data that he used to derive a human potency estimate for benzene, and the animal toxicologic data that he used in the linearized multistage extrapolation model to derive human potency estimates for the six other compounds. Exposure concentrations were taken from two air monitoring programs: the SCAQMD 1981-1985 ambient vinyl chloride monitoring program of the B.K.K. Landfill, supplemented by a University of Southern California 1980 residential monitoring program around the B.K.K. Landfill. The following assumptions were used:

- average air concentrations, from 12 SCAQMD stations and 4 USC stations;
- exposure for 24 hours per day, 365 days per year, for 8 years (1978-1985).

According to Crump's methods, the lowest maximum likelihood estimate of total risk from all seven carcinogens was 2.5 x 10^{-6} and the highest upper 95 percent confidence limit estimate of total risk was 11 x 10^{-6} (Table 11 of Appendix B). If typical year-round occupancy of a home were no more than 12 hours/day, Crump estimated the risk to range between 1.25 to 6 per million people exposed.

3. "Risk Assessment for Exposure to Ambient Air in the Vicinity of the BKK Landfill in West Covina, 1978-1985", K. T. Bogen and M. T. Smith, April 1986. (Appendix D)

In April 1986, Bogen and Smith, as consultants to attorneys for the B.K.K. Landfill, performed a risk assessment on the seven carcinogens detected in the DHS-TSCP/CARB/SCAQMD 1983 report. Bogen and Smith identified relevant animal bioassay data and used a Monte Carlo Potency Analysis (MCPA) method to derive potency distributions for the seven carcinogens. The MCPA method uses the multistage model of cancer, but rather than a single upper-bound confidence value for potency, Monte Carlo simulation produced complete distributions for potency estimation error. The following assumptions were applied by Bogen and Smith to the data in the 1983 DHS-TSCP/CARB/SCAQMD report:

- 50 percent dilution in the measured concentrations at Stations A, B, D, and F due to dispersion in ambient air;
- exposure for 15 hours/day, 365 days/year, for 7 years (1978-1985);
- 50 percent absorption in the lungs, based on a study cited by Bogen and Smith.

Potency distributions were generated for each compound and each monitoring station and, again using a Monte Carlo procedure, the corresponding potencies were added to obtain a distribution of total increased risk from all seven compounds. From the latter distribution, Bogen and Smith selected the 50th percentile value of 2.2 x 10^{-6} as a "best" estimate of increased lifetime cancer risk for the average individual living near the B.K.K. Landfill for the seven-year period. The "best" estimate value is a risk value as likely as not to overestimate the true level of average increased individual risk. Assuming the population of 7,700 exposed individuals from the DHS-TSCP/CARB/SCAQMD 1983 report, Bogen and Smith calculated a population excess cancer burden of 0.01 cases.

TABLE 22

SUMMARY OF THE THREE PREVIOUS HEALTH RISK ASSESSMENTS
OF THE BKK LANDFILL, WEST COVINA, CA

Report	Assumptions[a]	Methods	Excess Cancer Risk
"Ambient Air Monitoring and Health Risk Assessment for Suspect Human Carcinogens Around the BKK Landfill in West Covina." DHS-TSCP/CARB/SCAQMD 1983	- no dilution in 1982 measured concentrations at Stations A B C D E F - exposure for 24 hrs/day 365 days/yr, 7 yrs (1975-82) - 100% absorption in the lungs	individual excess lifetime cancer risk and population excess cancer burden	5×10^{-5}
"Estimates of Carcinogenic Risk in the Vicinity of the BKK Landfill." K.S. Crump & Co. 1986	- average air concentrations from 12 SCAQMD Stations and 4 USC Stations - exposure for 24 hrs/day 365 days/yr, 8 yrs (1978-85)	maximum likelihood and upper 95% confidence limit estimate	$2.5\text{-}11 \times 10^{-6}$
"Risk Assessment for Exposure to Ambient Air in the Vicinity of the BKK Landfill in West Covina, 1978-1985." Bogen & Smith 1986	- 50% dilution in 1982 measured concentrations at Stations A B D & F - exposure for 15 hrs/day 365 days/yr, 7 yrs (1978-85) - 50% absorption in the lungs	Monte Carlo potency analysis method and Monte Carlo procedure; "best" estimate	2.2×10^{-6}

a: All three health risk assessments evaluated residential exposure to concentrations of the following seven carcinogens: vinyl chloride, benzene, trichloroethylene, perchloroethylene, 1,1-dichloroethylene, 1,2-dichloroethane, and chloroform.

R&S15198I

APPENDIX B

Ambient Air Monitoring And Health Risk Assessment for Suspect Human Carcinogens Around the BKK Landfill in West Covina

By

California Department of Health Services
Toxic Substances Control Division

California Air Resources Board
Haagen-Smit Laboratory Division

and

South Coast Air Quality Management District

March, 1983

CONTENTS

R&S151985

SUMMARY AND CONCLUSIONS

1. The ambient air concentrations of nine volatile compounds were monitored at five residential locations surrounding the BKK Corporations's hazardous waste landfill in the City of West Covina for a three month period (July 19 - October 15, 1982). These concentrations were compared to a control monitor located nine miles from the landfill site in a residential/commercial area of Pico Rivera. Those monitored substances include: chloroethene (vinyl chloride), tetrachloroethene (Perc), trichloroethene (TCE), 1,1-dichloroethene (vinylidene chloride), 1,2-dichloroethane (ethylene dichloride), benzene, chlorobenzene, trichloromethane (chloroform), and trans-1,2-dichloroethene. The California Department of Health Services considers all of these substances potential human carcinogens.

2. There continues to be periodic exceedences of the State Ambient Air Standard for vinyl chloride of 0.01 ppm (10 ppb). The concentrations of vinyl chloride as well as the frequency of exceedences are significantly lower than during the same period in 1981. This may be the result of the mitigation measures taken at the landfill since June 1981.

3. Relative to the Pico Rivera control station, air monitoring in the residential community around the BKK landfill shows elevated levels of chloroethene (vinyl chloride), as well as tetrachloroethene (Perc), trichloroethene (TCE), 1,1-dichloroethene (vinylidene chloride), 1,2-dichloroethane (ethylene dichloride), and benzene. Many of these compounds are found at detectable levels in other areas of the Los Angeles air basin. There is some data available which suggests that Perc, TCE and benzene occur at comparable levels in some areas of the L.A. air basin.

4. Since the stations around the site are not known to be near other sources of emissions of these compounds (dry cleaning establishments, plastics products manufacturers, metal finishing industries, etc.), the data suggest that the BKK site is a source of these compounds. The elevated levels of the chlorinated compounds in particular indicate a need for mitigation measures such as expansion of the landfill gas gathering system, upgraded maintenance programs, and changes in handling of wastes containing these compounds.

5. Further action is also mandated by the continued, periodic exceedences of the State's Ambient Air Quality Standard for vinyl chloride of 0.01 ppm (10 ppb).

6. All of the substances, even at the highest observed concentrations, are

believed to be present in concentrations well below their threshold for toxic, non-carcinogenic action.

7 At the low level of exposure experienced by residents adjacent to the BKK landfill, it is not possible to accurately calculate excess cancer risks. However, worst-case estimates of the individual excess cancer risks (maximizing both the exposure period and the concentrations) suggests that those residents living immediately adjacent to the landfill, and who are also subject to both down wind and air drainage emissions from the site, may have accumulated excess risks to date of 5/100,000. This risk exceeds the level at which the Department attempts to control excess risks (1/1,000,000). Assumptions built into these calculations lead the Department to believe that these numbers represent a maximum risk and that the acutual risk is lower.

8. Based on an estimate of exposed population within a one mile radius of the landfill site boundary, no additional cases of cancer are to be expected from exposure to date.

9. The individual cancer risks are at a relatively low level, and do not constitute a public health emergency.

10. Monitoring should be continued to determine the effectiveness of the remedial actions taken, and to further define: 1) The specific on-site sources of emissions, 2) The diurnal variation of concentrations and, 3) The dilution of these concentrations with distance from the landfill.

INTRODUCTION

BACKGROUND

In October, 1980, odor complaints from residents in the neighborhood surrounding the BKK landfill in West Covina prompted the South Coast Air Quality Management District (SCAQMD) to monitor for odorous organic compounds in the vicinity of the site. In May, 1981, vinyl chloride was detected in the samples from this monitoring. A subsequent air survey confirmed the existence of vinyl chloride at concentrations exceeding the California Air Resources Board (ARB) Ambient Air Quality Standard of 0.01 ppm (24-hour average). The SCAQMD announced its findings in June, 1981..

Because of these exceedences, the California Department of Health Services (DHS) immediately banned further disposal of wastes containing vinyl chloride at the BKK Landfill. An evaluation of the vinyl chloride data by the DHS indicated that although the levels posed no immediate health hazard to the surrounding population, they were of sufficient concern to warrant prompt efforts to reduce these emissions from the landfill.

Also in May, 1981, an interagency task force consisting of the SCAQMD, DHS, City of West Covina, Los Angeles County Health Department, State Solid Waste Management Board, and the California Regional Water Quality Control Board (Los Angeles Region) was formed to develop a program to reduce the odor emissions from the site. This task force implemented a series of actions to expand the landfill's gas recovery system, and to improve the efficiency of the waste gas incineration system. As a result of these efforts, the frequency of exceedences of the vinyl chloride standard, and of odor complaints, decreased significantly through the first half of 1982. These data were presented at a public meeting in the City of West Covina on July 1, 1982.

Continued citizen concerns regarding their exposure to volatile carcinogens from the site and the need to determine the overall effectiveness of the emission mitigation measures prompted a sub-group of the task force consisting of DHS, ARB, and SCAQMD to embark on an expanded monitoring program.

PURPOSE

This study has three purposes: 1) To evaluate the effectiveness of the mitigation measures already taken, and to determine whether or not further measures are necessary to control emissions from the site, 2) To determine if other volatile carcinogens besides vinyl chloride, known to have been disposed at the site in the past, are also present in the community at levels that would represent a public health concern, and 3) To provide a more comprehensive data base for assessment of the health risk posed by emissions of carcinogens from the BKK landfill in West Covina.

COMPOUNDS SELECTED FOR MONITORING

Previous sampling of the landfill gas by SCAQMD, ARB, Euteck, Inc., and the University of Southern California indicated the presence at significant concentrations of suspected or known human carcinogens other than vinyl chloride. As with vinyl chloride, the presence of these compounds can be associated with the prior disposal of hazardous wastes at the site. Nine volatile compounds identified by these organizations were selected for monitoring based on their concentrations, carcinogenic potential, and the analytical capabilities of laboratories involved, These compounds are listed in Table I, along with information on their uses, waste sources, and concentration in the landfill gas. DHS considers all nine compounds to be known or suspect human carcinogens.

METHODOLOGY

SAMPLING STRATEGY

A meteorological survey previously conducted at the BKK landfill and adjacent residential areas indicated that the daytime predominant wind direction was from the southwest to the northeast. However, eddies were observed throughout the landfill, which is located in rough terrain on the south slopes of the San Jose Hills. Radiational cooling results in nighttime air drainage on the north and south slopes of the landfill, with wind flow from the south on the north slopes and from the north on the south slopes.

The data from the meteorological survey were correlated with odor complaints from the residential areas to determine the location of sampling sites which would reflect the maximum exposure of residents to toxic and hazardous gases emitted from the landfill. Six sites were selected and identified alphabetically from A to F (See Figure I). Two (E & F) reflected the daytime transport of contaminants, three (A, B and D) the nighttime transport, and one (C) was a control site nine miles away from the landfll in Pico Rivera.

Sites A and B were located in residential areas on the south side of the landfill and F in a residential area on the northeast side. Stations A and B were established by SCAQMD in May, 1981 as part of its vinyl chloride monitoring program. On August 26, 1982, site F was relocated to a residential area Northwest of the landfill because of odor complaints from this area. Sampling at this site was continued until the end of the program.

Site D was located at the entrance to the landfill on Azusa Avenue to sample emissions diverted by the recently constructed berms on the southerly boundary of the site. These berms were designed to contain emissions while creating mechanical mixing and dilution of the toxic compounds.

Site E was located at the highest elevation within the landfill itself, about 300 yards from the flares.

The control site C was located at the SCAQMD Pico Rivera air monitoring station. This site was selected to reflect contaminant concentrations in an area not influenced by the BKK Landfill. It was also selected because it is the closest monitoring station to the site where more routine data has been collected over a period of years. The data from this site was not intended to reflect ambient air concentrations of these toxic compounds in the Los Angles air basin.

A study period of three months (July 19 - October 15, 1982) was selected to provide an adequate data base. This period covered the warmest part of the year for the West Covina area.

Samples were collected five days per week, Sunday through Thursday. This frequency allowed sampling on one day with no activity on-site (Sunday), and on four days of normal landfill operations. On this schedule, samples were analyzed, during periods of normal laboratory operations with a minimum of storage prior to laboratory analysis.

Samples were collected in Tedlar bags continuously over a 24-hour period. This period was chosen over a shorter 12-hour or 4 hour period because it was necessary to determine the total daily dose of these compounds that one would receive. It is also the time basis for the ARB's ambient air quality standard for vinyl choride: 0.01 ppm. Tedlar bags were selected over other sampling methods such as absorbant tubes because of the greater confidence that the bag samples would provide an accurate picture of these compounds in the air. This sampling period and method allowed comparison of the data from this program with data collected by the SCAQMD from May, 1981 to June, 1982. It is also accepted methodology by the U.S. Environmental Protection Agency, ARB, and SCAQMD for determining compliance with the vinyl chloride standard.

An average of two samples per day were split between the two laboratories, SCAQMD and CARB (Haagen-Smit) Laboratory. Each laboratory withdrew a subsample directly from the septum opening of the Tedlar bag.

The effectiveness of Tedlar bags for sampling chlorobenzene was unknown at the initiation of the study period. Charcoal tubes were consequently selected as the medium for collecting these samples. Availability of equipment and laboratory capacity limited sampling to two per day; one at the control station C and one at Station A or B. Chlorobenzene sampling was initiated about midway through the study period, and analysis was performed by the DHS Air and Industrial Hygiene Laboratory in Berkeley.

ANALYTICAL METHODS

Chloroethene (vinyl chloride) and benzene were analyzed using a gas chromatograph (GC) equipped with a flame ionization detector (FID).

Other chlorinated compounds, 1,1-dichloroethene, trans-1,2-dichloroethene, 1,2-dichloroethane, trichloromethane (chloroform), trichloroethene (TCE) and tetrachloroethene (Perc) were analyzed usng a GC equipped with an electron capture detector (ECD). All compounds were quantified wth an electronic integrator.

RESULTS AND DISCUSSION

METEOROLOGY

Comparison of meteorological conditions during the three-month sampling period with the same period in previous years was necessary in order to determine whether the sampling results were influenced unduly by some abnormal weather condition. Since ambient temperature differentials are responsible for diffusion and wind flow, and temperatures have been recorded by the National Weather Service in the San Gabriel Valley for the past twenty years, this was selected as one of the meteorological variables to examine. Winds at the BKK site also determine the local transport of the contaminants. Therefore, the winds at Site A (because of its exposure to the landfill) were compared for this three-month sampling period to those recorded in 1981.

The temperature study indicated that there was no significant difference between the average temperatures recorded during this three-month period and the 20-year average for the same three-month period.

Frequency distributions for wind direction and speed were computed for the same three months in 1981 and 1982. Those directions which would impact Site A from the landfill were summarized. No significant difference was exhibited between the frequencies for 1981 and 1982.

AMBIENT AIR RESULTS

Table II summarizes all of the data collected during the study period. Chlorobenzene and trans-1,2-dichloroethene were not detected at any of the sampling stations during the study period, and are therefore not listed. The detection limits for each compound are shown in Table III. Statistical analysis of the split sample results revealed that the data from the two laboratories are not well correlated. The differences between the two laboratories was not unexpected, since the concentrations measured in this survey were close to the limit of detection of the analytical methods. Therefore the mean concentration for each compound was calculated separately for each laboratory and station. The first number of each pair merely represents the lower of the two means from the laboratories, and the second number is the higher mean value. Values reported as less than the limit of detection were set equal to the detection limit for purposes of calculating the mean concentrations. This treatment of the data allowed a conservative or worst case estimate of exposure for these compounds. It is recognized that in reality, these values can range anywhere from zero to the limit of detection.

The ratio of the mean ambient air concentrations at stations A-F (those station adjacent to the landfill) to the concentrations at the control station are shown in Table IV. These ratios were calculated separately for data from each laboratory.

Figures II through VIII show the ranges and means for each compound in a formatwhich allows the absolute concentration ranges to be plotted for each compoundstation, and laboratory during the study period.

DISCUSSION

It is apparent from Table IV that the mean concentrations at Stations A, B, and and D are consistently higher than those at the control station for all compounds except chloroform. At Station E, only TCE and ethylene dichloride appear consistantly to exceed the control station value. Satation F concentrations exceed control station averages for Perc, TCE and vinylidene chloride. These trends are also illustrated by Figures II through VIII. It should be noted that such large ranges in concentration are not a reflection of the impercision of the sampling and analytical methods, but are indicative of the wide daily fluctuations of concentrations in the air near the monitoring stations. It should also be noted that the data from station F are actually an equally weighted composite from two locations, F_1 and F_2. These observations suggest that the BKK landfill may be a significant source of emissions of these compounds into the community.

The levels of all compounds detected were consistently higher at stations A, B, and D than at Stations E and F. Since stations A, B, and D are located in areas where nightime air drainage from the landfill is know to occur, it is likely that these elevated concentrations can be attributed to this phenomenon. The low levels at stations E and F, which are located in areas not subject to the same flow patterns, further emphasize the importance of nightime air drainage as the primary mode by which landfill emissions impact the community. This type of air movement does not allow as much dispersion as that which occurs in the daylight hours.

DISCUSSION OF HEALTH EFFECTS

Introduction

What are the expected health effects from exposure to these substances at the concentrations observed in the area directly adjacent to the BKK landfill? For those substances that can give non-carcinogenic acute and chronic toxic effects, such as liver, kidney or nerve damage, for low concentrations there is good evidence for a biological threshold, or a "no observed effect level". This means that concentrations below this threshold do not cause adverse health effects. All of the substances, even at the highest observed concentrations, are believed to be present in concentrations well below their threshold for toxic, non-carcinogenic action. This gives a safety margin of from 100-to-1000 fold in the concentrations before these substances even approach levels which could cause adverse health effects. It is for this reason that this report concentrates solely on the risk of cancer.

Carcinogenic Risk Assessment

The chance of getting cancer is calculated using risk assessment techniques. Risk assessment is a science that predicts the probability or likelihood of an event occurring. It attempts to estimate the chances of cancer occuring in a specified population, from a specified dose of a substance in a given time period. Several facets go into risk assessment: the carcinogenic potency of the substance, calculation of dosage from exposure data and the number of people exposed (population at risk) and their individual dosages.

In order to evaluate the health impact of those emissions due to the BKK site, use was made of the simple difference of the concentrations, i.e., the average concentration of each substance in the Pico Rivera Station was subtracted from the average concentration of that substance in the residential monitoring site. Thus, the derived risks are considered excess risks, or risks in addition to those typically incurred away from the influence of the BKK landfill site.

The stations selected for monitoring were those that in the past gave very high concentrations, suggesting that they are in the path of a drainage channel. In the absence of information on the length, width and depth of the drainage areas, the dilution with distance (both lateral and down-hill), the concentrations of the initial drainages and the fraction of material that is carried by drainage and wind dispersions, it is not possible to accurately estimate either exposures or the population at risk. However, it is possible to estimate the upper limit or bound to this risk using a number of conservative assumptions. Some of the major assumptions are shown in Table V.

The lifetime incremental, worst-case estimated risk for residents adjacent to the BKK site, is based on the maximum possible period of exposure (24 hours/day, 7 days/week and 52 weeks/year). The exposures were projected from the observed 3-month monitoring period (August-October) for a maximum possible

exposure period of seven years. Vinyl chloride is the only compound that air monitoring data is available for preceeding the current monitoring period. In order to adjust the data for both seasonal variations and to correct for the increased control measures that had been installed at the BKK site, the six other compounds were increased in proportion to their ratio to vinyl chlorice for the prior monitoring periods.

These calculations suggest that the maximum possible excess risk, is approximately 5 per hundred thousand (5/100,000). This is the maximum increased lifetime risk of contracting cancer for those residents who have been subject to the emissions from the BKK landfill site for the past seven years. Thus, we can say with some certainty that the risk of getting cancer, attributable to exposure from emissions from the BKK landfill is no greater than this; while in fact, the true excess risk of cancer is probably lower.

Population Comparisons

The maximum individual excess risk can be better understood as applied to the exposed population. The accumulated individual excess risk multiplied by the population at risk (the number of people exposed to these concentrations) defines the maximum number of excess cancers expected during the lifetime of the exposed population. This results in an estimation of the additional cases of cancer expected during the lifetime of the exposed population due to the emissions from the BKK landfill site.

The total population, at distances of up to one mile from the BKK property line, were considered to be at risk (a total of approxmately 7700 people). This population was derived by dividing the assessor's plot maps into quadrants, corresponding to Monitoring Stations: A, B, D, and F. The population within each quadrant was estimated using the latest census data of 1980. The exposure of the population within each quadrant was assumed equal to that measured at the respective monitoring station. The total population within each quadrant was multiplied by the mean concentration difference for its respective monitoring station, and the derived excess number of cancers was summed.

These calculations suggest that there should be no additional cases of cancer attributable to exposure from emissions from the BKK landfill during the lifetime of the population from exposure to date.

The Department of Health Services has made a conscientious attempt to calculate the worst-case estimate of risk. In those cases where there are insufficient data, the most conservative assumptions were used. As further information becomes available, such as, drainage patterns and dispersion rates, this additional data will be incorporated into the risk calculations. Although a small possibility exists that further information might increase the risk estimate, to the best of our knowledge, this new information should lower our worst-case risk estimates and provide a more accurate and realistic indication of risk.

It is important that the provided risk estimates NOT be considered as static or "as engraved in stone." They are expected to change as further information become available. These revisions will be made to better refine the risk and not to obscure the true impact. Such refinements wil be communicated to the residents of West Covina as they become available.

Several critical points should be kept in mind:

1. Since the biological mechanism of cancer is not known, mathematical models can only provide a best scientific "guess" of the dose-response relations at dosages much less than those employed in the bioassays. However, it is believed that at very low dosages, the shape of the dose-response curve is concave upward. Thus, a linear model will provide the upper-limit for the risk for the experimental observations (see Figure IX).

2. The use of the upper-confidence values for the experimental results, then provides an added margin of safety to insure that the upper-risk level is also based on the maximum possible number of cancers that statistically could occur from the experimental studies (see Figure X).

3. It is not possible to calculate the actual risks at these low concentrations. Thus, it is very important that people understand that the presented risk numbers only represent the worst possible risk. It is expected that the true risks are lower than these numbers

4. These worst-case estimates of risk suggest that there should be no additional cases of cancer due to exposure to the emissions from the BKK landfill. The Department of Health Services does NOT recommend any special medical precautions or treatment for those residents adjacent to the landfill site.

TABLE I. COMPOUNDS SELECTED FOR MONITORING

COMPOUND (SYNONYM)	USES AND PROBABLE WASTE SOURCES	CONCENTRATION RANGE IN LANDFILL GAS (ppm)
Chloroethene (Vinyl Chloride)	Manufacture of PVC and other co-polymers; organic synthesis; adhesives for plastics; refregerant; manufacture of vinyl chloride also a significant waste source.	83 - 12800[a]
1,1 - Dichloroethene (Vinylidene Chloride)	Copolymerized with vinyl chloride to manufacture types of saran; adhesives for synthetic fibers.	N.D. - 1200[b]
Trans-1,2-Dichloroethene (Acetylene Dichloride)	General solvent for organic materials, dye extraction, perfumes, lacquers, thermo-plastics, organic synthesis.	N.D. - 800[b]
Trichloroethene (TCE)	Metal degreasing, extraction solvent for oils, fats, waxes; solvent dyeing; dry cleaning; refrigerant and heat exchange fluid; organic synthesis; fumigant; cleaning and drying electronic parts.	N.D. - 1000[b]
Tetrachloroethene (Perc)	Dry cleaning solvent; vapor-degreasing solvent; drying agent for metals; heat exchange medium; manufacture of fluoro-carbons.	N.D. - 1500[b]

TABLE 1 (CONTINUED)

COMPOUND (SYNONYM)	USES AND PROBABLE WASTE SOURCES	CONCENTRATION RANGE IN LANDFILL GAS (ppm)
1,2-Dichloroethane (Ethylene Dichloride)	Manufacture of vinyl chloride; organic synthesis; anti-knock agent in gasoline; paint, varnish, and finish removers; metal degreasing; soaps and scouring compounds; wetting and penetrating agent; ore flotation.	N.D. - 5000[b]
Trichloromethane (Chloroform)	Manufacture of fluorocarbon refrigerants and propellants; dyes & drugs; general solvent; fumigant; insecticides.	5.1[c] 0.038 (Ambient air)[d]
Benzene	Manufacture of styrene, phenol, synthetic detergents, cyclohexane for nylon, aniline DDT, various other insecticides, funigants; solvent; paint remover; rubber cement; anti-knock agent in gasoline.	10 - 2000[b]
Chlorobenzene	Manufacture of chloronitrobenzene, DDT, aniline; intermediate and solvent for organic synthesis.	N.D. - 500[b]

Footnotes:

a. Analytical Research Laboratories, Inc. "Report for BKK/Stauffer Chemical." June 17, 1981.

b. Euteck, Inc. "BKK Landfill Odor Study Final Report." Prepared for City of West covina. February 27, 1981.

c. South Coast Air Quality Management District. "Report on Vinyl Chloride Emissions from a Class I Landfill Operation." Source Test Report C-81-96 A & B. June 10, 1981.

d. University of Southern California. "Investigation of Odorous and Volatile Compounds for BKK Class I Landfill Site in the City of West Covina." Prepared for BKK Corporation. July, 1981.

TABLE II

Summary of Ambient Air Data[a] (ppb)

	Station					
	A	B	C	D	E	F
Chloroethene (Vinyl Chloride	7.1-7.3	4.5-5.5	2-3	3.8-4.1	2.0-3	2-3
Tetrachloroethene (Perc)	2.1-3.7	1.8-2.9	1.4-2.4	2.3-3.0	1.5-2.1	1.5-3.4
Trichloroethene (TCE)	0.8-1.0	0.8-1.8	0.2-0.3	1.6-1.7	0.6-0.8	0.8-1.2
1,1-Dichloroethene (Vinylidene Chloride)	1.1-1.3	0.7-1.0	0.1-0.3	0.7-0.8	0.1-0.4	0.3-0.4
1,2-Dichloroethane (Ethylene Dichloride)	1.3-3.0	0.8-2.8	0.4-0.7	0.8-2.8	0.7-0.9	0.4-1.1
Trichloromethane (Chloroform)	0.3-0.5	0.3-0.6	0.2-0.6	0.6-1.0	0.2	0.2
Benzene[b]	4.8	4.6	3.6	4.6	3.0	3.0

a. Each pair of values represents the means of the two laboratory data sets calculated for the entire study period. On those days when a compound was not detected, its concentration was assumed to be equal to the limit of detection.

b. One set of data used. All of the second set were below the limit of detection.

TABLE III

Detection Limits for Compounds

Compound	Range of Detectability (ppb)
Chlorethene (Vinyl Chloride)	2-3
Tetrachloroethene (Perc)	0.1-0.2
Trichlorethene (TCE)	0.1-0.2
1,1-Dichloroethene (Vinylidene Chloride)	0.1-0.3
1,2-Dichloroethane (Ethylene Dichloride)	0.2-0.4
Trichloromethane (Chloroform)	0.02-0.1
Trans-1,2-Dichloroethene	1-3
Chlorobenzene	10[a]
Benzene	2-20

a. Sampling by charcoal tube and analysis by one laboratory.

TABLE IV

Ratio of Ambient Air Concentrations of Station A-F to Control Station Station C[a]

	Station					
	A	B	C	D	E	F
Chloroethene (Vinyl Chloride)	2.4-3.6	1.8-2.3	1.0	1.4-1.9	1.0	1.0
Tetrachloroethene (Perc)	1.5	1.2	1.0	1.2-1.6	0.9-1.1	1.4-2.1
Trichloroethene (TCE)	2.9-3.9	3.0-7.2	1.0	6.3-6.6	2.1-3.0	2.8-5.0
1,1-Dichloroethene (Vinylidene Chloride)	3.6-11	2.4-9.3	1.0	2.7-6.5	1.0-1.3	1.5-3.0
1,2-Dichloroethane (Ethylene Dichloride)	3.3-4.5	1.9-4.3	1.0	1.9-4.3	1.3-1.7	1.0-1.7
Trichloromethane (Chlorform)	0.4-2.7	1.0-1.4	1.0	1.7-3.1	0.4-1.1	0.4-1.0
Benzene[b]	1.4	1.3	1.0	1.3	0.8	0.8

a. Ratios are calculated for each laboratory separately and expressed as a range.

b. One laboratory data set available.

Table V

Conservative Assumptions used by the California Department of Health Services to Estimate Cancer Risks from BKK Emissions

Animal Bioassay Studies

1. Use the most sensitive site, sex and animal species.

2. Use the upper 95.7% confidence value for the experimental data.

3. Assume all tumors (benign and malignant) are indicators of carcinogenic risk.

4. Use linear extrapolation for determining the risks at low dosages.

Individual Risk Estimates

1. Use the measured concentration for each station as the human exposure, with no allowance for dilution with distance (down-wind or laterial).

2. Assume an exposure for a full 24 hours/day, 7 days/week, and 52 weeks/year (with no allowance for leaving residence or air conditioning in residence).

3. Assume 100% absorption for human exposure.

4. Selection of monitoring stations in drainage pathways.

Population at Risk

1. Assume maximum housing tract population at time of issuance of permit to occupy.

2. Assume exposure from measured value at each monitoring Station with no allowance for dilution with distance (down-wind or laterial).

3. No allowance for population being outside of expected drainage patterns.

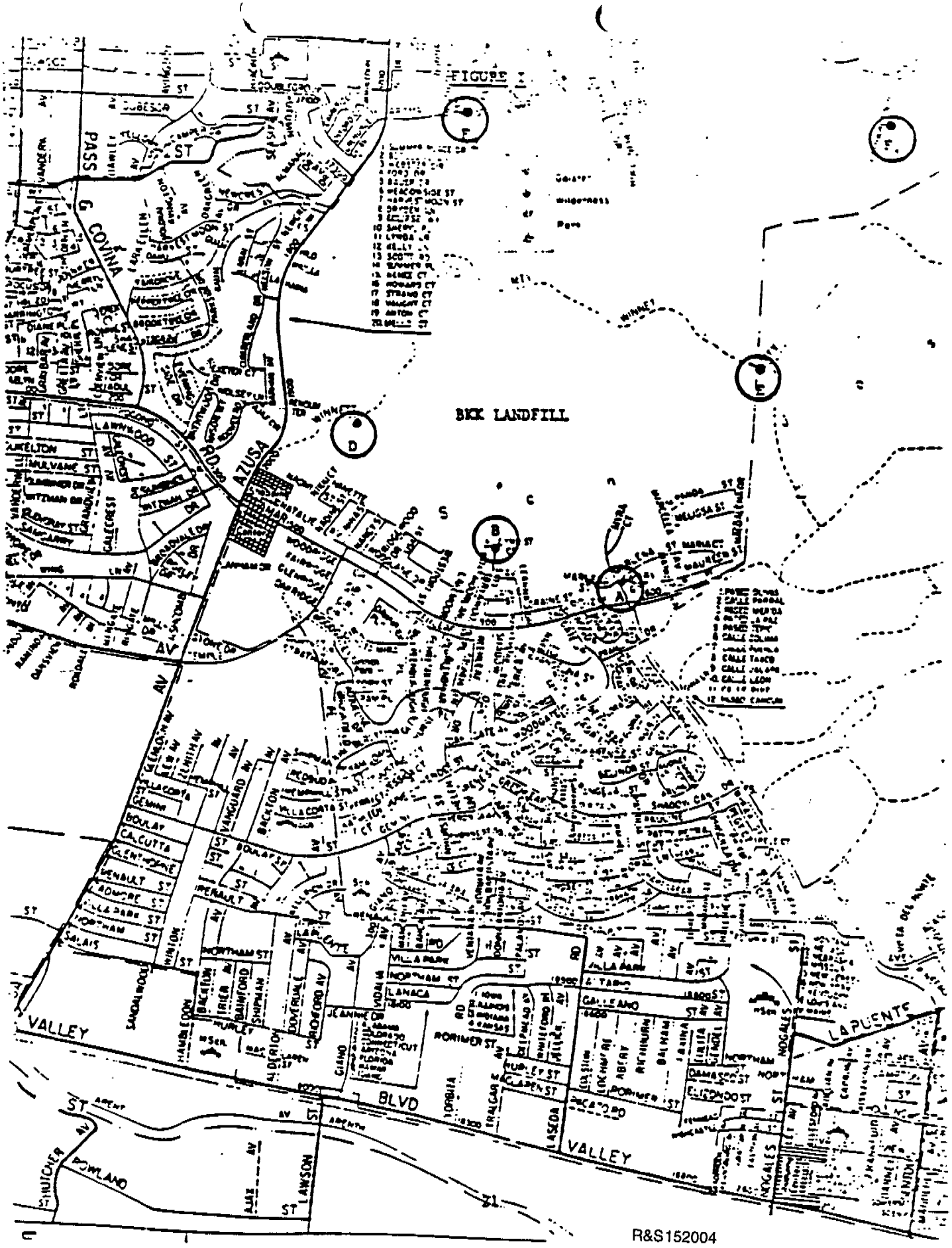


FIGURE
BKK LANDFILL
PASS
COVINA
AZUSA
RD
VALLEY
BLVD
LAWSON
POMLAND
LAPUENTE
VALLEY

R&S152004

Figure II

Range and Mean for
CHLOROETHENE (VINYL CHLORIDE)

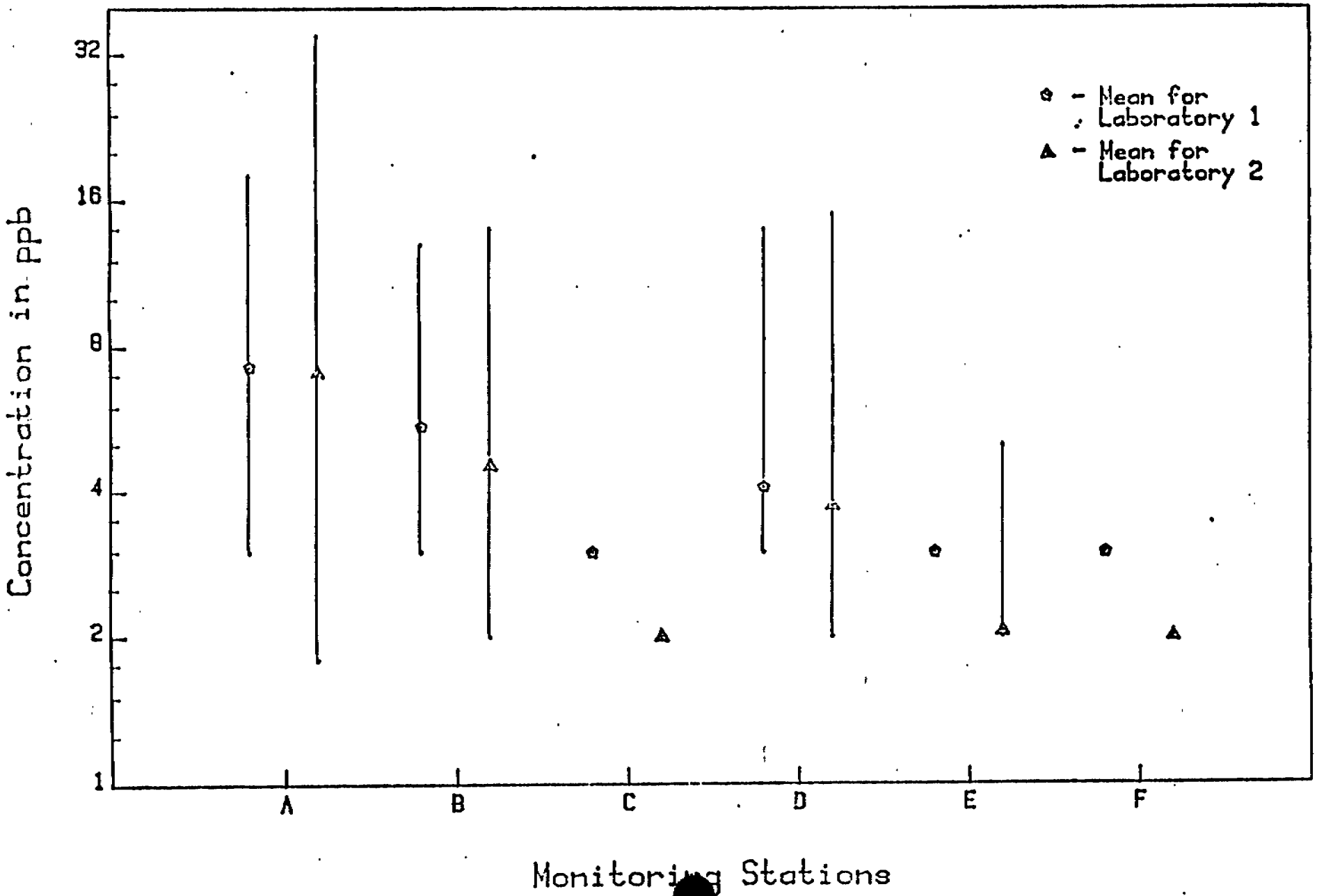


Figure III

Range and Mean for
TRICHLOROETHYLENE (TCE)

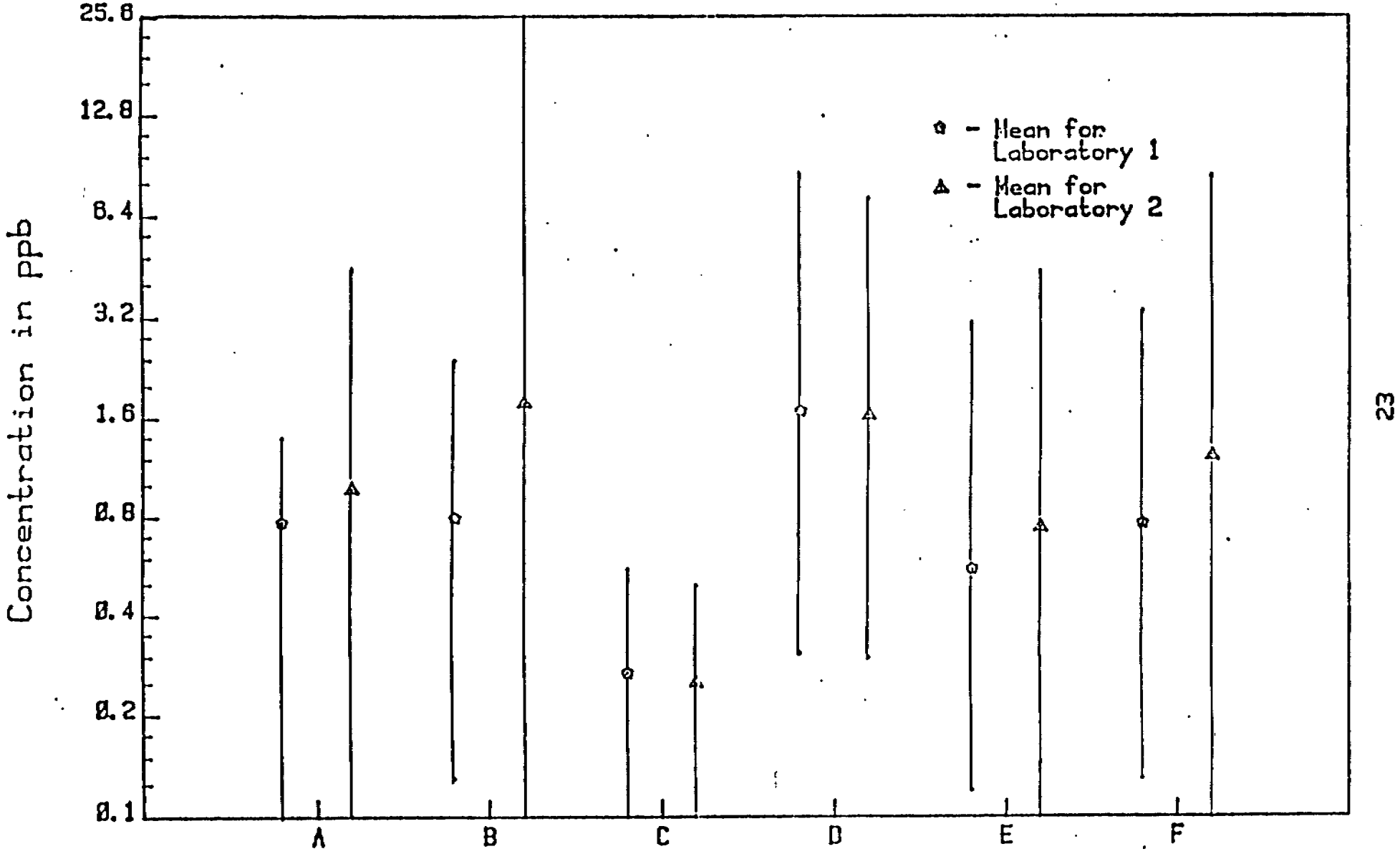


Figure IV

Range and Mean for
TETRACHLOROETHENE (PERC)

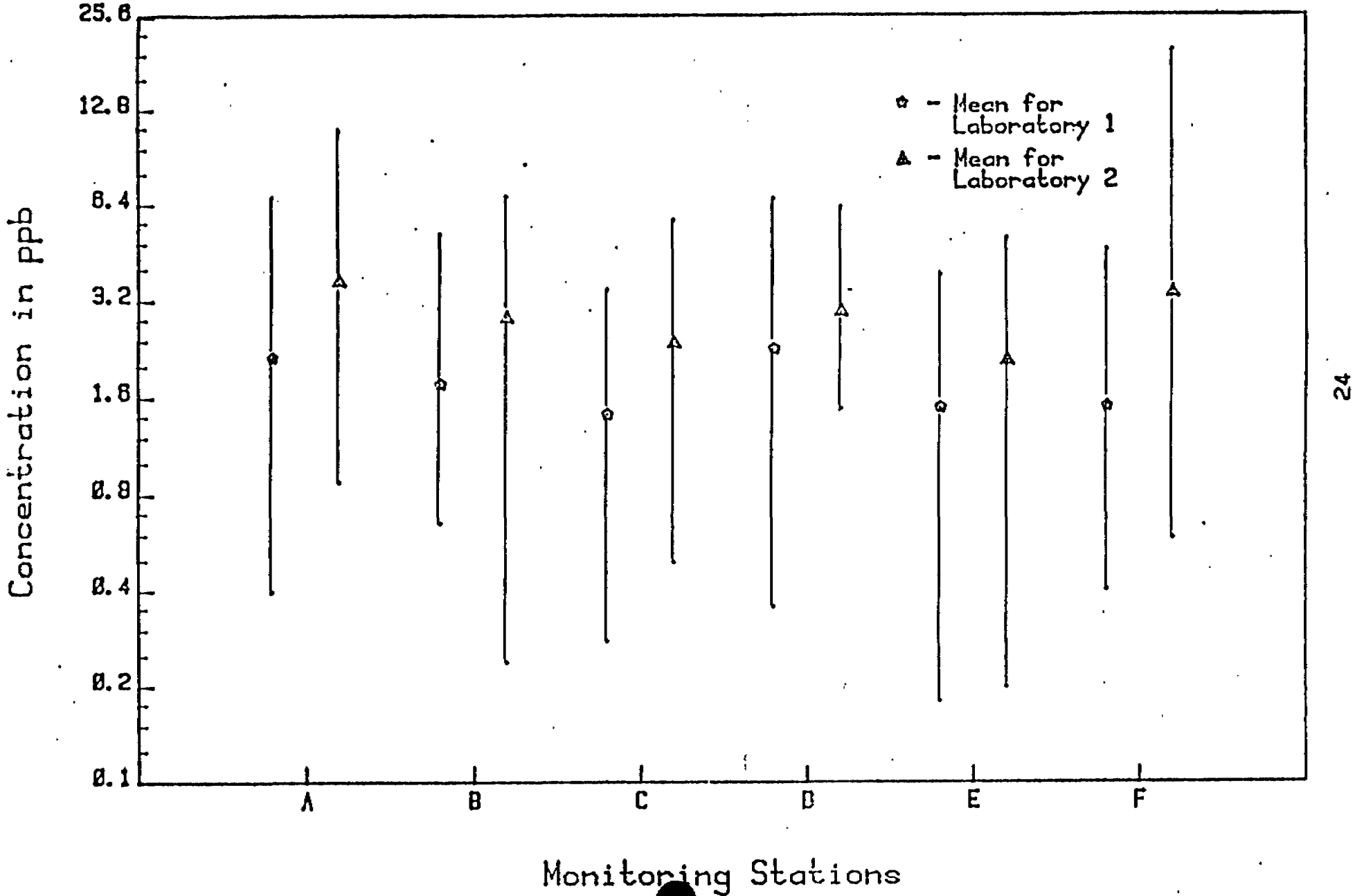


Figure V

Range and Mean for
1, 2-DICHLOROETHANE (ETHYENE DICHLORIDE)

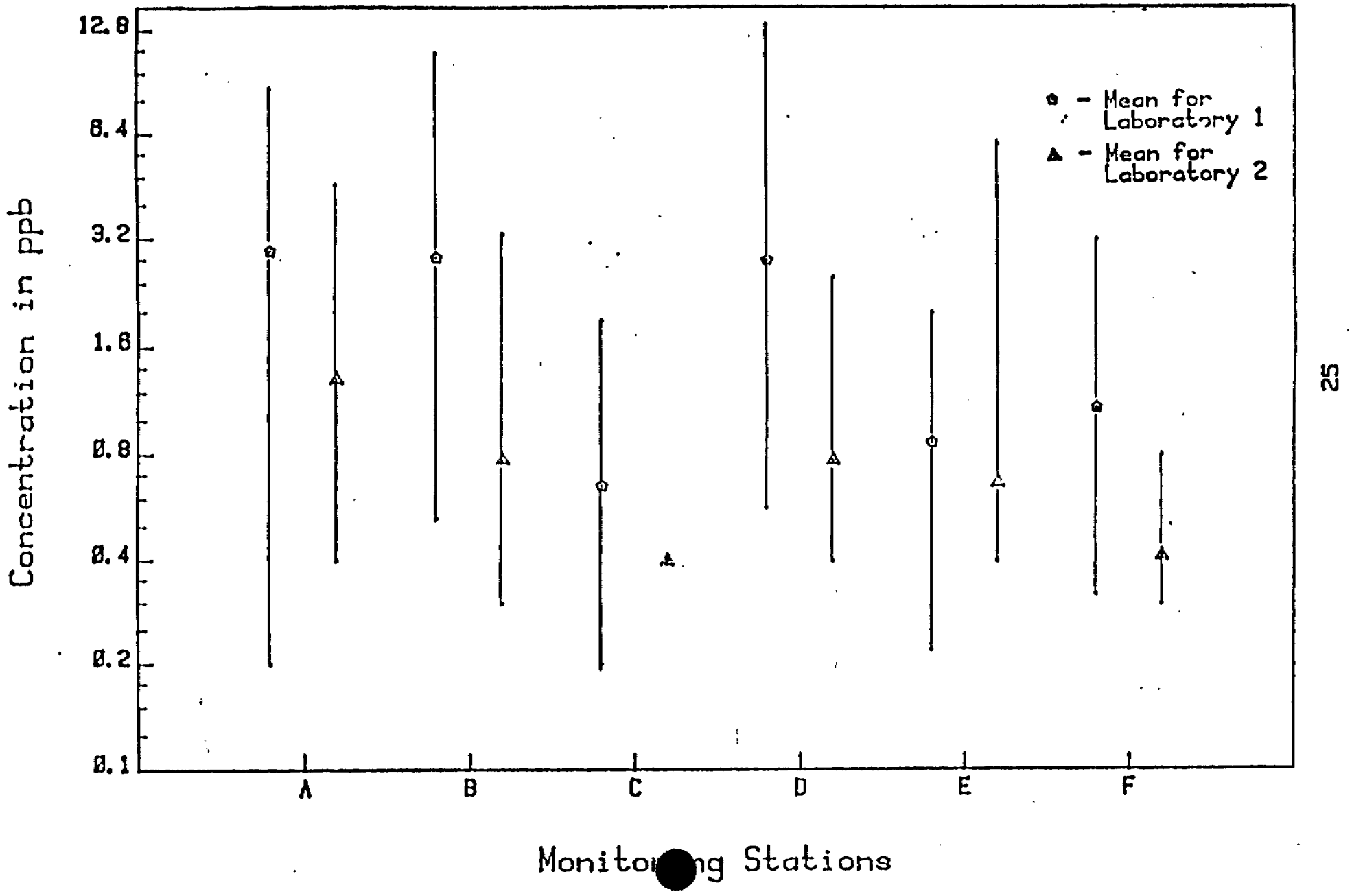


Figure VI

Range and Mean for
1, 1-DICHLOROETHENE (VINYLIDENE CHLORIDE)

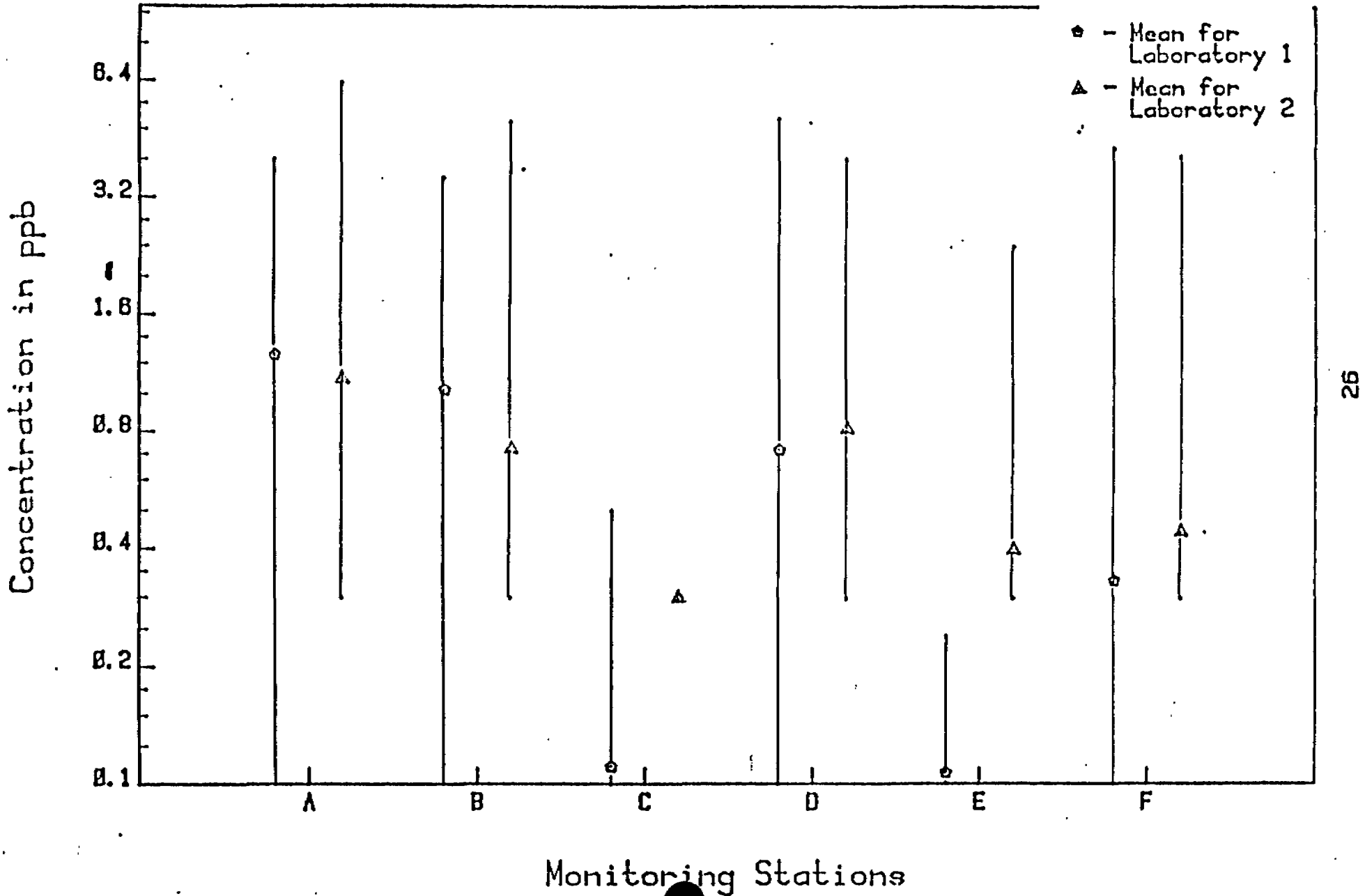


Figure VII

Range and Mean for TRICHLOROMETHANE (CHLOROFORM)

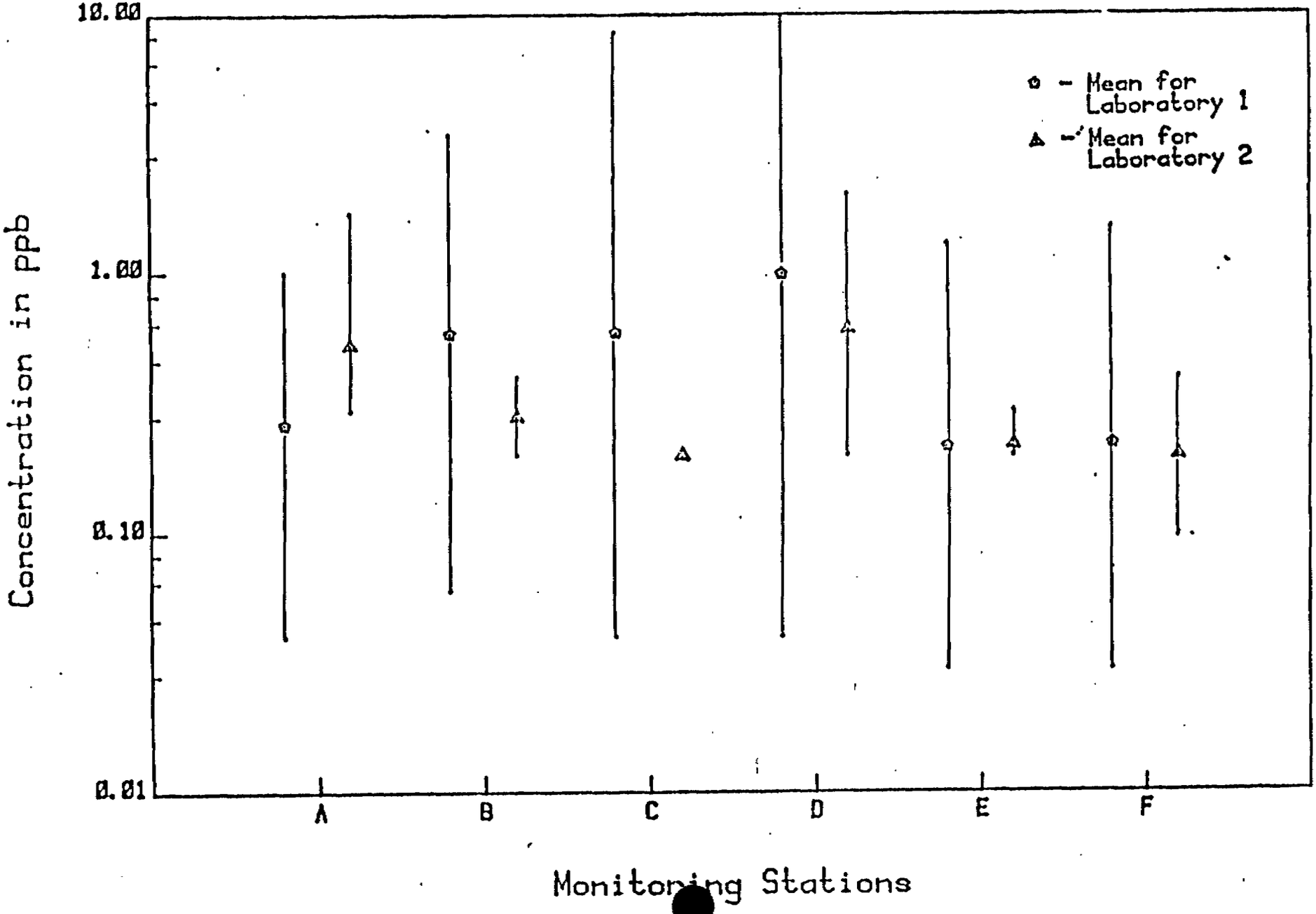


Figure VIII

Range and Mean for
BENZENE

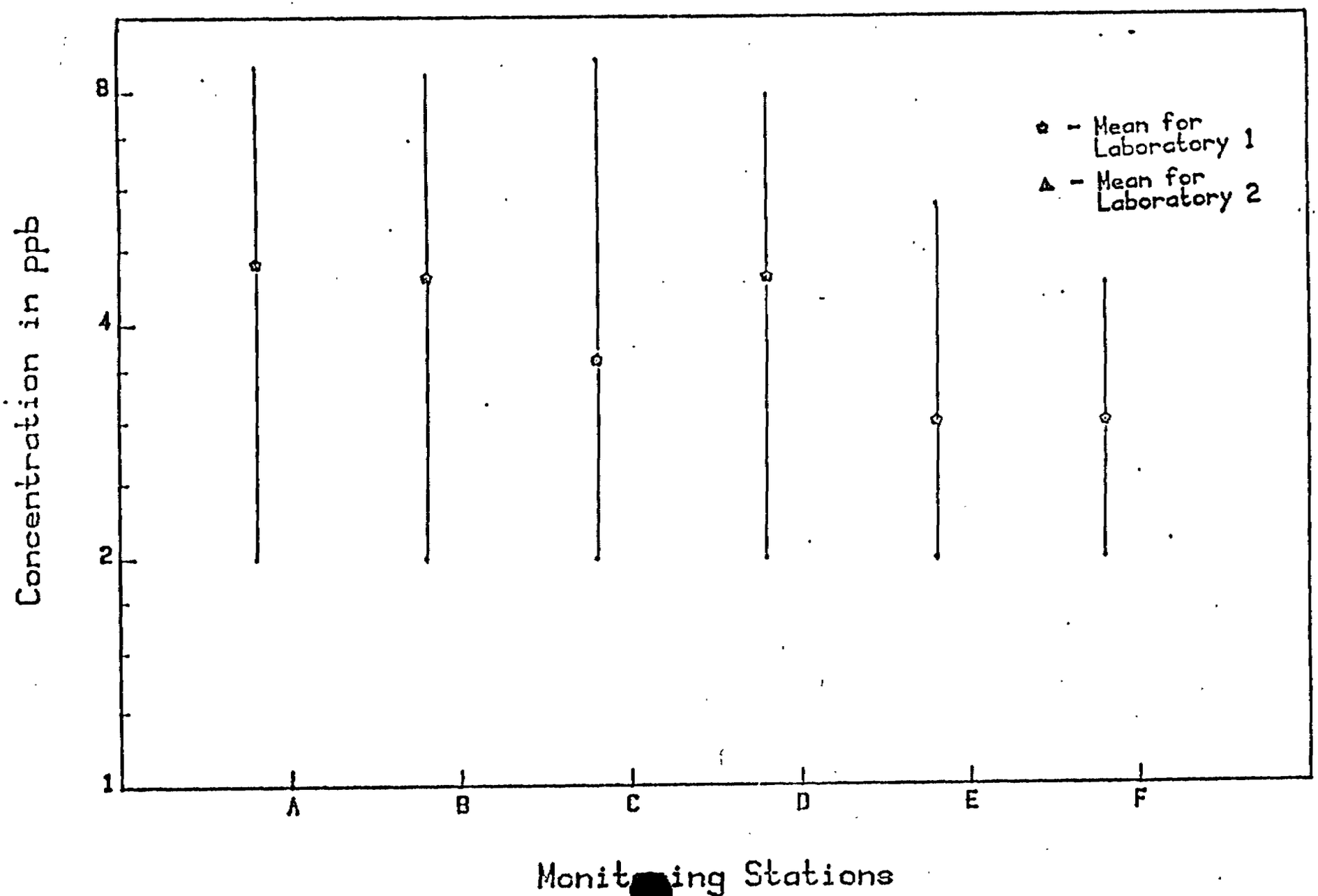


FIGURE IX

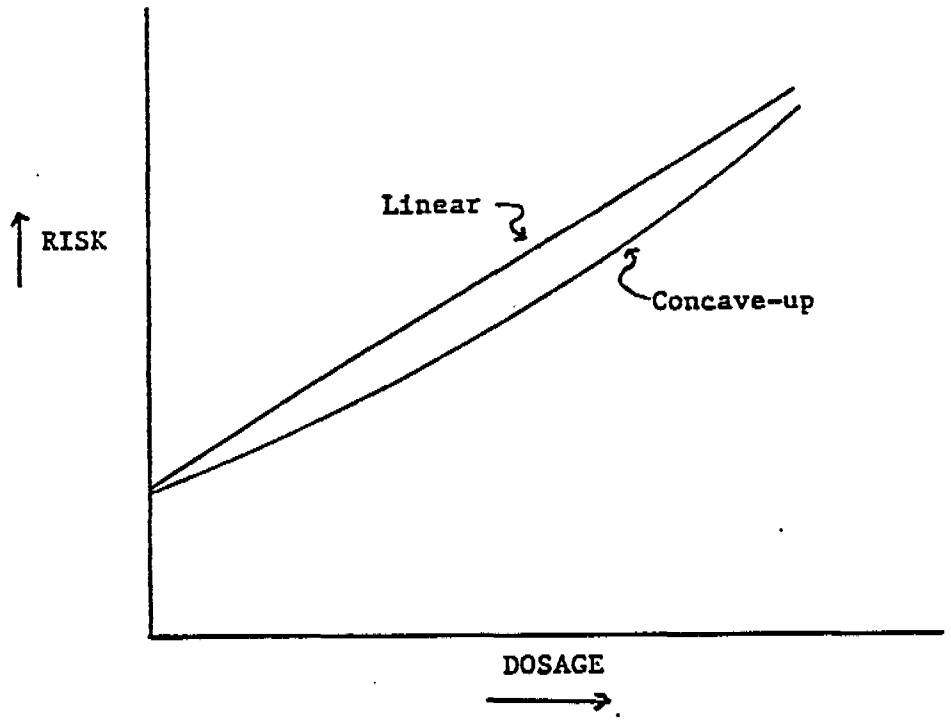
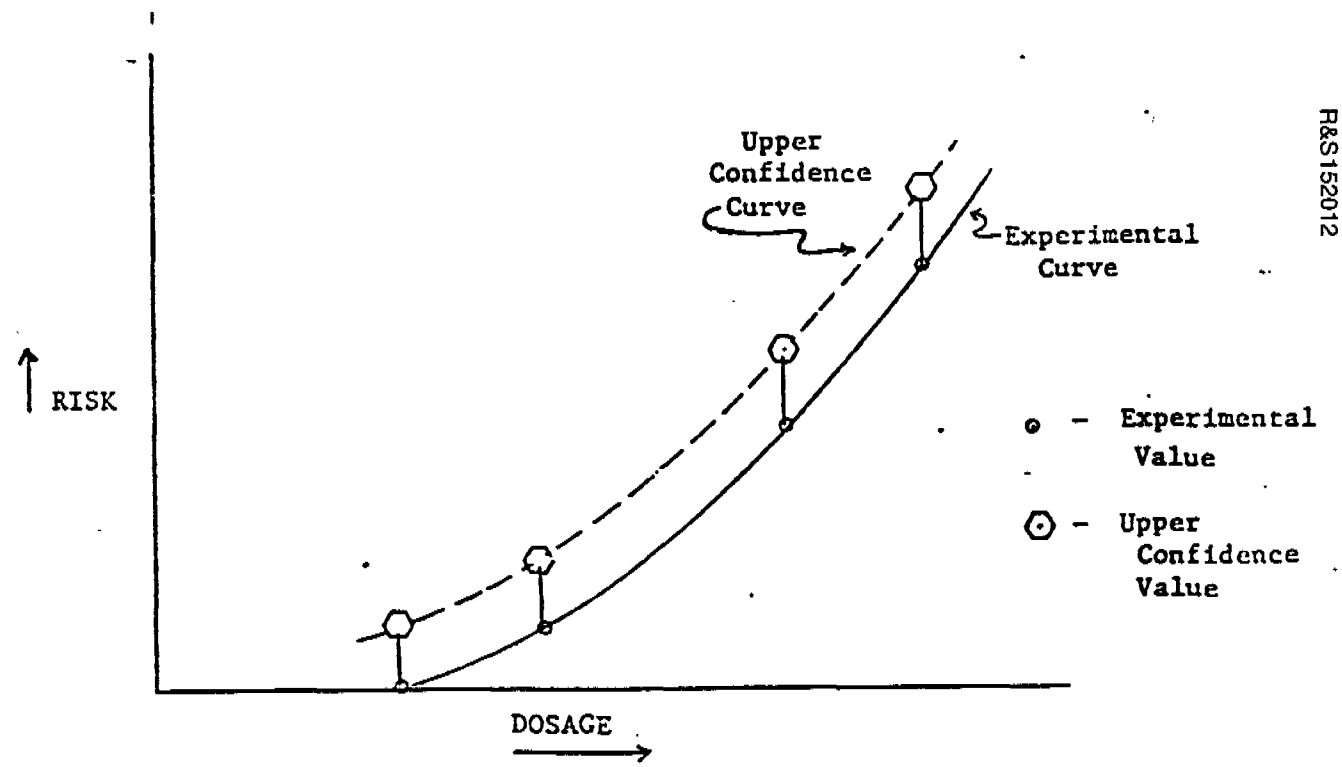


FIGURE X



R&S152012

APPENDIX C

ESTIMATES OF CARCINOGENIC RISK

IN THE VICINITY OF THE BKK LANDFILL

K S CRUMP and Co., Inc.
1201 Gaines Street
Ruston, La. 71270

March 1, 1986

Introduction

This document presents estimates of carcinogenic risk from seven volatile organic chemicals detected in the air around the BKK landfill in West Covina, California. These estimates were derived from epidemiologic and toxicologic data on these chemicals and air monitoring data from the site. The multistage mod l of cancer (Crump, 1985) was applied to animal data. This model is the model generally used by regulatory agencies, including the EPA, to obtain conservative upper limits to cancer risk. F r the one chemical in which human data were utilized (benzene), a linear dose response model used to estimate benzene risk for OSHA regulations (Crump and Allen, 1984) was utilized.

Description of health effect data used

For each chemical of interest we chose the most appropriate data sets available for making quantitative risk estimates. Animal bioassay data were used for all chemicals except benzene. Whenever inhalation studies were available, these were chosen over studies applying other routes of exposure. For the one ch mical for which where no inhalation data were available (chloroform), drinking water exposure was judged to be more appropriate than gavage due to the fact that gavage is more stressful to the

animals.

Data sets that provided positive results were used in favor of negative data except in cases where no positive data were available. From the positive data sets, risk was estimated from the data set which gave the largest risk (largest q_1^*, 95% upper limit on the linear term in the multistage model). In cases for which only negative data were available, the data set to model was decided on a case-by-case basis.

Tetrachloroethylene: The tetrachloroethylene data sets chosen for analysis were from a study conducted by the National Toxicology Program (1985). The study utilized F344/N rats and B6C3F$_1$ mice of both sexes with 49 or 50 animals/group. The animals were exposed to tetrachloroethylene by inhalation for 6 hours/day, 5 days/week, for 103 weeks. Mice were exposed to 0, 100, or 200 ppm tetrachloroethylene, while rats were exposed to 0, 200, or 400 ppm.

The data set that gave the highest risk, and was therefore chosen to be modeled, was male mice with hepatocellular carcinoma (Table 1). The incidence of this tumor type in the male mice was 7/49 (number of mice with tumor/number examined for the response) in the control group, 25/49 in the low-dose group, and 26/50 in the high-dose group.

Trichloroethylene: Data sets from two trichloroethylene studies were considered for analysis. A study by Henschler *et al.* (1980) was conducted using male and female mice (strain Han:NMRI) and rats (strain Han:WIST). The animals were divided into groups of 30 animals/sex/dose level. Exposure to trichloroethylene was carried out 5 days/week, 6 hours/day, for 78 weeks, with a total

experimental length of up to 128 weeks. Both rats and mice were exposed to 0, 100, or 500 ppm trichloroethylene.

In an inhalation study by Fukuda *et al.* (1983), groups of 49 or 50 female ICR mice and female SD rats were exposed to trichloroethylene 7 hours/day, 5 days/week for 104 weeks. All animals were exposed to 0, 50, 150, or 450 ppm trichloroethylene.

The data set from these studies that gave the highest risk, and was therefore used to estimate risk, was female mice - total malignant tumor bearing animals from Henschler *et al.* (1980) (Table 2). The incidence of malignant tumors in the female mice was 13/29 (number of animals with tumor/number of animals examined for the response) in the control group, and 22/30 in the l w-dose group, and 22/28 in the high-dose group.

1,2-Dichloroethane: The 1,2-dichloroethane data set chos n for analysis was selected from a study by Maltoni *et al.* (1980). The animals used in this study consisted of male and female Swiss mice and Sprague-Dawley rats. Groups of 90 animals/sex (mice control groups were larger: male - 115; female - 134) were exposed to 1,2-dichloroethane in concentrations of 0, 5, 10, 50, or 250-150 ppm (the 250 ppm concentration was reduced to 150 ppm after tw we ks) for 78 weeks, with total experimental length of 119 weeks for mic and 148 weeks for rats. Exposures were carried out 5 days/week for 7 hours/day. The authors concluded that under the conditions of this study 1,2-dichloroethane did not show carcinogenic effects.

Although data from female rats with non-malignant mammary tumors provided the highest risk, these data exhibited a non-

monotone dose response and did not fit the multistage model. Since this was a negative study, the result for this data set was likely to be spurious; therefore the data set with the next highest risk was chosen for estimating risk. This data set was male rats - total tumor bearing animals (Table 3). The incidence of tumors in the male rats was 8/90 (number of animals with a tumor/number of animals examined) in the control group, 11/90 in the 5 ppm group, 5/90 in the 10 ppm group, 10/90 in the 50 ppm group, and 11/90 in the 250-150 ppm group.

Vinylidene chloride: Data sets from three vinylidene chloride studies were considered for analysis. In a study by Viola and Caputo (1977), male and female Wistar rats were exposed t vinylidene chloride at 0 or 200 ppm for 20 weeks, then 0 or 100 ppm for 31 weeks. The rats were then observed for an additional 53 weeks. The exposures were carried out 5 days/week for 4 hours/day.

Another study by Lee *et al.* (1977) involved the exposure of male and female CD-1 mice to 0 or 55 ppm vinylidene chloride. The animals were divided into groups of 36 mice/sex/dose level and exposed to the vinylidene chloride 5 days/week, 4 hours/day for 52 weeks, with no additional observation period.

Maltoni *et al.* (1982) conducted a study in which male and female Sprague-Dawley rats were exposed to 0, 10, 25, 50, 100, or 150 ppm vinylidene chloride for 52 weeks, with an additional observation period of up to 78 weeks. The animals were divided into groups of 30 or 60 animals with 100 controls/sex. Exposures were carried out 5 days/week for 4 hours/day.

All of the vinylidene chloride data sets considered were negative. Since the studies by Viola and Caputo (1977) and Lee *et al.* (1977) only involved one treatment group and did not observe the animals for their full life spans, we chose to estimate risk from Maltoni *et al.* (1982). The data set chosen from this study was male rats with brain tumors (Table 4). The incidence of tumors in the male rats was 3/100 (number of animals with tumor/number of animals examined) in the control group, and 1/30 in the 10 ppm group, 0/30 in the 25 ppm group, 2/30 in the 50 ppm group, 0/30 in the 100 ppm group, and 0/60 in the 150 ppm group.

Vinyl chloride: The vinyl chloride data set that was chosen for analysis was from studies by Maltoni *et al.* (1981). In this study, Sprague-Dawley rats were exposed to vinyl chloride 4 hours/day, 5 days/week for 52 weeks, with an additional observation period which lasted until the animals' natural deaths. Exposure levels ranged from 1 to 10000 ppm.

The data set that was used for risk assessment was rats with liver angiosarcoma (Table 5). This data came from several studies by Maltoni that employed similar protocols (Crump, 1982). The incidence of this tumor type, along with the respective treatment group, was as follows: 0/461 - control group (number of animals with tumor/number animals examined - treatment group); 0/118 - 1 ppm; 0/119 - 5 ppm; 1/119 - 10 ppm; 5/120 - 25 ppm; 15/354 - 50 ppm; 1/120 - 100 ppm; 6/119 - 150 ppm; 12/120 - 200 ppm; 3/59 - 250 ppm; 6/60 - 500 ppm; 13/60 - 2500 ppm; 13/59 - 6000 ppm. The highest dose group showed a lower response than that obtained at lower doses. This decreased effect could not be explained by the

model and was therefore omitted (Crump, 1982).

Gehring *et al.* (1978) showed that the amount of vinyl chloride metabolized is not a linear function of exposure dose, but follows Michalis-Menton kinetics with metabolized dose being saturated at high doses. This information was used in this analysis; exposure dose was converted to the metabolized doses shown in Table 5, the model was fit using metabolized dose, and the results were then translated back into exposure dose (Crump, 1982).

Chloroform: No inhalation data was available for chloroform. Therefore, the data sets that were chosen for analysis were derived from a recent drinking water study by Jorgenson *et al* (1985). In this study, male Osborne-Mendel rats and female B6C3F$_1$ mice were given drinking water containing 0, 200, 400, 900, or 1800 mg chloroform. Water was available to the animals *ad libitum* for the duration of the study (104 weeks). Two control groups were employed in this study, the difference being that the water intake was restricted for one of the groups. Since the tumor incidence was not significantly different between the two control groups, we combined them as one group.

The data set which gave the highest risk, and was therefore chosen to be modeled, was male rats - all kidney tumors (Table 6). The incidence of this tumor type in the male rats was 6/531 (number animals with tumor/number animals examined) in the control group, 6/313 in the 200 mg/l group, 7/148 in the 400 mg/l group, 3/48 in the 900 mg/l group, and 7/50 in the 1800 mg/l gr up.

Benzene: Risk estimates for benzene were derived from a risk assessment based upon human epidemiological data that was

performed by Crump and Allen (1984) for OSHA. Crump and Allen estimated risk for 40 years of occupational exposure to one ppm benzene using six different models. The highest estimate was 9.5 per thousand and was obtained using a relative risk model with cumulative dose. A more middle-of-the-road estimate was that f 1.5 per thousand, which was obtained using an absolute risk model and weighted cumulative exposure. Therefore two estimates f the potency of benzene for causing leukemia under continuous lifetime exposure are used in this document:

$$(1.5/1000)(365 \text{ days}/240 \text{ days})(70 \text{ years}/40 \text{ years})(2) = 0.0053 \ [\text{ppm}^{-1}],$$

and

$$(9.5/1000)(365 \text{ days}/240 \text{ days})(70 \text{ years}/40 \text{ years})(2) = 0.033 \ [\text{ppm}^{-1}].$$

Upper 95% statistical confidence limits for these potency estimates are also used. The value of 240 days is the number of work days per year assumed in the occupational cohorts from which the risk estimates were derived. The factor of 2 reflects an estimate that the total amount of air breathed by humans in a day is roughly twice what is breathed by workers during work hours.

Methodology for estimating human risk from animal data

The multistage model (Crump, 1985) is used in this analysis for low dose extrapolation with animal data. The multistage model is given by

$$P(d) = 1 - \exp(-q_0 - q_1 d - \ldots - q_k d^k),$$

$q_i \geq 0$, $i = 0,1,\ldots,k$, where d is dose, P(d) is the lifetime probability of cancer at dose d and k, $q_0,\ldots,q_k$ are parameters. In practice, k is set equal to the number of dose groups less on-

The measure of risk used is extra risk above background, defined as

$$[P(d) - P(0)]/[1 - P(0)].$$

Extra risk may be interpreted as the probability of the occurrence of a cancer at a dose d, given that no cancer would have occurred in the absence of a dose. Under the multistage model, the 95% upper limit on extra risk for a dose of d may be adequately approximated by $q_1^* d$, where q_1^* is the 95% upper limit on the coefficient q_1. The multistage model is implemented using the computer program GLOBAL85 developed by Dr. R. B. Howe for K S CRUMP and Co. Parameters of the multistage model are estimated by the method of maximum likelihood (Crump and Howe, 1985) and a likelihood approach is used to estimate q_1^*.

The dose levels used for input into the multistage model are shown in Tables 1-6. These doses were the experimental doses reported in the study except for vinyl chloride, in which case the experimental doses were converted to metabolized doses as discussed earlier. Potency estimates (q_1^*s) used to obtain upper limits to human risk were made under three assumptions: that human

and animal risk are equal when dose is measured in 1) ppm in air; 2) mg/kg body weight/day: and 3) mg/m^2 surface area/day. To estimate human potencies under these assumptions, potency estimates based upon the experimental doses were converted to equivalent units of $[ppm^{-1}]$ assuming the animals had been exposed continuously throughout their life. For example, if animals were exposed by inhalation 6 hours per day, 5 days per week, the potency estimate in $[ppm]^{-1}$ was multiplied by (24 hours/6 hours) and by (7 days/5 days). If the duration of exposure, D, was less than (0.8)(104 weeks) = 83.2 weeks, the potency estimate was als multiplied by 83.2/D, which averages exposure over the first 80% of the animal's natural lifespan. This adjustment corrects for less than lifetime exposure in an experiment and is based upon the supposition that exposure during the last 20% of an animal's life span is unlikely to affect its chances of getting a tumor. The value of 104 weeks that is used to represent typical mice and rat life spans is the current duration of NTP bioassays.

These potency estimates in ppm^{-1} units were then converted, using animal parameters, (body weights, breathing rates, etc.) to units commensurate with the dose units for which human and animal risks were assumed to equate ($[mg/kg/day]^{-1}$, $[mg/m^2/day]^{-1}$ or $[ppm]^{-1}$ - no conversion being required in this latter case). These animal potency estimates were assumed to represent human potency estimates and were then converted using human parameters (body weights, etc.) to the desired units ($[ppm]^{-1}$ and $[mg/kg/day]^{-1}$). Standard parameters for mice, rats, and humans used in these dose conversions are displayed in Table 7. Study-

specific animal parameters were used in place of these standard values whenever available.

Table 8 displays the human potency estimates so calculated, along with similar estimates derived by EPA. The chief differences between the EPA methodology and ours is that EPA did not give priority to inhalation studies (their goal was to derive general potency values and not to estimate risk from a particular route of exposure) and they converted risk from animals to humans on a $mg/m^2/day$ basis. Data on chemicals for which both human and animal data exist suggest that animal and human potencies match more closely when a mg/kg/day basis is used (Crump *et al.*, 1985). We are currently working on a project for EPA to extend this work and preliminary results seem to corroborate this finding.

Potency estimates in Table 8 for benzene were made from human data and consequently no animal-human conversion approach is required. The potencies reported for benzene under the ppm and mg/kg/day conversion approaches are from the absolute risk - weighted cumulative exposure model and those reported under the $mg/m^2/day$ conversion approaches are from the relative risk - cumulative exposure model (Crump and Allen, 1984). Crump and Allen's Table 21 was used to obtain maximum likelihood estimates of risk and that table, in conjunction with their tables 12 and 15, were used to compute q_1^*s appearing in Table 8 and corresponding upper limits of risk.

Exposure estimates

Estimates of exposure were made for the residential area

located south of the landfill, north of Amar Street and roughly east of Westport Street. This appears to be the residential area most heavily impacted by the landfill. Exposures were estimated for the period 1978-1985, which we understand is the period of concern. Estimates were developed using the South Coast Air Quality Management District (SCAQMD) monitoring data only and also by supplementing this data with monitoring data collected by the Engineering Program of the University of Southern California (U.S.C., 1980).

All SCAQMD monitoring stations in the residential area of concern were identified. These are listed in Table 9 along with the numbers of samples for vinyl chloride by year. Except for the three month period from July 19 to October 15, 1982 monitoring data was available from SCAQMD for vinyl chloride only. Exposures to vinyl chloride were recorded by SCAQMD down to a detection limit of 2 ppb during 1983 to 1985 ("fine" recording approach). During 1981 and 1982 SCAQMD recorded vinyl chloride measurements in increments of 10 ppb, with lowest measurements entered as <10 ppb ("coarse" recording approach). For the first six months of 1983 monitoring data were available using both methods of recording. For exposures recorded down to 2 ppb, average exposures were obtained by substituting 1 ppb for values recorded as <2 ppb. The effect of this approach was investigated by repeating some of the analyses substituting 2 ppb for values recorded as less than 2 ppb. Using 2 ppb instead of 1 ppb for values recorded as <2 ppb only increases the estimate of average levels for 1981 through 1985 by 10%. Thus the average levels do

not appear to be sensitive to the approach taken for values recorded as <2 ppb.

To estimate levels recorded as <10 ppb during 1981-1982, the data for 1983 containing both "fine" and "coarse" measurements were used to help estimate average levels for various cat gories of coarse estimates available for 1981-82. Averages of th fine measurements during the first 6 months of 1983 for samples for which the coarse measurement was <10 ppb was used to estimate the average level during 1981-82 for samples recorded as <10 ppb. For measurements recorded as 10 ppb during 1981-82, an average of 12.5 ppb was used because it appeared from the 1983 data that 10 ppb was recorded as the coarse measurement when the fine reading was between 10 and 15 ppb; otherwise the recorded value was used in determining the average levels for 1981-82. The effect of this approach was evaluated by comparing the average estimates obtained for July 19 - October 15, 1982 period with those obtained independently for this period by California Department of Health Services *et al.* (1983) for which they apparently had access to the fine measurements. Our estimated average level for Station A using the approach described above was 10% below their estimate and our estimated level for station B was 33% below theirs. To adjust for this, our estimates for Station A (#2) during 1981-82 were multiplied by 1.1 and our estimates for Station B (#1) wer multiplied by 1.33. Estimates for station #3 and #4 were multiplied by an intermediate value (the square root of the product of these two factors).

These approaches were used to obtain estimates for exposure

to vinyl chloride for each quarter that SCAQMD had collected data. A quarterly estimate was obtained by averaging all of the data obtained during that quarter from the stations listed in Table 9. This provided average levels of vinyl chloride for each quarter, beginning with the second quarter in 1981, through 1985. Average levels throughout a period were estimated by averaging quarterly levels, giving all quarters equal weight. The background level of vinyl chloride was assumed to be 2.5 ppb, which is the average of the values reported for Station C by California Department of Health Services *et al.* (1983, Table II). The level of vinyl chloride attributable to BKK was estimated by subtracting this background level from estimated average levels.

Average quarterly levels for the other six chemicals were estimated from the data in Table II of the California Department of Health Services *et al.* (1983) report by averaging the levels for the chemical of interest at Stations A and B, subtracting the average level at Station C (background level), and multiplying by the ratio of the average level above background for vinyl chloride estimated as described above to the average level above background at Stations A and B for vinyl chloride in Table II of the California Department of Health Services *et al.* report.

The approaches described thus far provide estimates of average exposures to the seven chemicals of interest for the period covering the second quarter of 1981 through 1985. Tw different approaches were employed to estimate exposures from 1978 through the first quarter of 1981. The first method (the "SCAQMD approach") involved assuming that averag levels found for the

period from 1978 through the first quarter of 1981 were equal to the average levels estimated for the earliest year for which SCAQMD monitoring values were available (first quarter 1981 through first quarter 1982).

The second method involved use of monitoring data collected during the spring of 1980 by the Environmental Engineering Program of the University of Southern California (U.S.C., 1980). In this program 54 air samples were taken at several sampling sites and analyzed by GC/MS for a variety of volatile organic chemicals. All of the seven volatile chemicals under consideration were detected in this program except for vinylidene chloride. Sixteen of the samples were collected at the four sampling sites in the residential area under consideration: R1 (4 samples), R2 (6 samples), R3 (2 samples), R4 (4 samples). Average levels for the entire residential area were obtained by averaging the levels of each of the seven chemicals found in these sixteen samples. For each chemical except vinylidene chloride, whenever none was found the lowest value recorded in the sampling program was assumed; it was assumed that no vinylidene chloride was present. The average values so obtained are shown in Table 10.

The large estimate obtained for benzene is due in large part to two very large measurements -- 88 and 67 ppb -- obtained at Station R4 on the same day. Since these large values possibly are not related to BKK, Table 10 also contains an estimate for benzene with these large samples omitted.

In the second method for estimating exposures for the earlier period (the "USC method"), averages from Table 10 obtained using

the USC data are assumed to hold for the period 1978-1980 and the SCAQMD approach is applied only to the period 1981-1985.

Risk estimates

Estimates of risk obtained by applying the results from the multistage model shown in Tables 1-6,8 to the exposures estimated as described in the previous section are shown in Table 11. The 95% upper limit estimates of risk for individual chemicals are obtained by multiplying the average exposures of humans in ppm times the fraction of a normal life span for which these exposures occurred by the appropriate human potency estimate from Table 8 in units of [ppm^{-1}]. The identical approach, except applied t th maximum likelihood estimates of the q's (displayed in Tables 1-6) rather than to the q_1^*s are used to obtain maximum likelihood estimates of risk. Risk estimates pertaining to individual chemicals are summed to obtain estimates of total risk.

The risks shown in Table 11 are based upon the mg/kg/day method for converting from animals to humans. As discussed earlier, data on chemicals for which both animal and human data are available indicate that this dose measure provides the best correlation between estimates of cancer risk derived from human and animal data. To calculate upper limits based upon, say, the $mg/m^2/day$ method of converting from animals to humans, it is only necessary to multiply the upper limit risks in Table 11 by the ratio of the q_1^* in Table 8 derived using the $mg/m^2/day$ conversion method to the corresponding q_1^* derived using the mg/kg/day conversion method.

Discussion

The risk estimates in Table 11 all range between 2.5 and 11 per million. It should be kept in mind that they were derived assuming continuous exposure 24 hours per day for 8 years. Typical year round occupancy of a home is probably no more than 12 hours per day. Thus risks in the range of 1.25 to 6 are more appropriate for the typical occupant. These estimates are conservative in other ways also. All of the upper limits estimates were derived from a linear dose response model; such models are unlikely to underestimate risk, but would likely overestimate risk by a considerable amount if the linear hypothesis is not valid. The estimates determined from animal data were based generally on the single data set from an inhalation exposure study that provided the highest estimate of risk. Adding statistical upper confidence limits on risk from individual chemicals to obtain an upper limit for total risk will give an exaggerated upper confidence limit for total risk.

To place the risks estimated in Table 11 into perspective, it is useful to compare them to risks from other activities. The following comparative risk estimates were made using methods commensurate with those applied in this report:

	Risk/Million
Living in a brick house for life (low-LET radiation)	56
Living in Denver 8 years vs. living in Los Angeles (cosmic radiation)	29
Smoking one pack of cigarettes (lung cancer)	12
Accident during typical 2-day business trip	3

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TABLE 1

Fit of Multistage Model to Vinyl Chloride Data on Rats with Liver Angiosarcoma from Maltoni *et al.* (1981)

Experimental Data[a]		Maximum Likelihood Estimates of Parameters	95% Upper Limit on Risk (q_1^*)	Goodness-of-Fit Test Results		
Metabolized Dose (μg)	Tumor Incidence			chi-square	Degrees of Freedom	p-value
0	0/461	$q_0 = 0$	4.8556E-5	15.7873	10	0.1059
16.9	0/118	$q_1 = 3.833E\text{-}5$[b]				
83.8	0/119	$q_2 = 0$				
165	1/119	$q_3 = 0$				
395	5/120	$q_4 = 0$				
739	15/354	$q_5 = 0$				
1309	1/120	$q_6 = 0$				
1761	6/119	$q_7 = 0$				
2129	12/120	$q_8 = 7.007E\text{-}32$				
2435	3/59	$q_9 = 0$				
3413	6/60	$q_{10} = 0$				
5030	13/60	$q_{11} = 0$				
5403	13/59	$q_{12} = 0$				

[a] Maltoni *et al.* (1982) report the results of several experiments that used a common protocol (designated BT1, BT2, BT6, BT9, BT15), which have been combined for this analysis.

[b] 3.883E-5 means 3.883×10^{-5}.

TABLE 2

Fit of the Multistage Model to Tetrachloroethylene Data on Male Mice with Hepatocellular Carcinoma from National Toxicology Program (1985)

Experimental Data[a]		Maximum Likelihood Estimates of Parameters	95% Upper Limit on Risk (q_1^*)	Goodness-of-Fit Test Results		
Dose Level (ppm)	Tumor Incidence			chi-square	Degrees of Freedom	p-value
0	7/49	q_0 = 1.7677E-1[a]	4.9588E-3	3.0201	1	8.224E-2
100	25/49	q_1 = 3.5523E-3				
200	26/50	q_2 = 0				

[a] 1.7677E-1 means 1.7677×10^{-1}.

TABLE 3

Fit of the Multistage Model to Trichloroethylene Data on Female Mice.
Total Malignant Tumor Bearing Animals from Henschler *et al.* (1980)

Experimental Data[a]		Maximum Likelihood Estimates of Parameters	95% Upper Limit on Risk (q_1^*)	Goodness-of-Fit Test Results		
Dose Level (ppm)	Tumor Incidence			chi-square	Degrees of Freedom	p-value
0	13/29	q_0 = 7.6303E-1[a]	3.6006E-3	2.8603	1	9.0791E-1
100	22/30	q_1 = 1.9002E-3				
500	22/28	q_2 = 0				

[a] 1.7677E-1 means 7.6303×10^{-1}.

TABLE 4

Fit of the Multistage Model to 1,2-Dichloroethane Data on Male Rats.
Total Tumor Bearing Animals from Maltoni *et al.* (1980).

Experimental Data[a]		Maximum Likelihood Estimates of Parameters	95% Upper Limit on Risk (q_1^*)	Goodness-of-Fit Test Results		
Dose Level (ppm)	Tumor Incidence			chi-square	Degrees of Freedom	p-value
0	8/90	q_0 = 9.4636E-2[a]	2.4877E-4	2.5902	3	4.5921E-1
5	11/90	q_1 = 2.4877E-4				
10	5/90	q_2 = 0				
50	10/90	q_3 = 0				
250-150	11/90	q_4 = 0				

[a] 9.4636E-2 means 9.4636×10^{-2}.

TABLE 5

Fit of Multistage Model to Vinylidene Chloride Data on Male Rats with Brain Tumors from Maltoni *et al.* (1982)

Experimental Data[a]		Maximum Likelihood Estimates of Parameters	95% Upper Limit on Risk (q_1^*)	Goodness-of-Fit Test Results		
Dose Level (ppm)	Tumor Incidence			chi-square	Degrees of Freedom	p-value
0	3/100	q_0 = 2.1661E-2[a]	1.3749E-4	6.1087	5	2.9579E-1
10	1/30	q_1 = 0				
25	0/30	q_2 = 0				
50	2/30	q_3 = 0				
100	0/30	q_4 = 0				
150	0/60	q_5 = 0				

[a] 2.1661E-2 means 2.1661×10^{-2}.

TABLE 6

Fit of the Multistage Model to Chloroform Data on Male Rats.
All Kidney Tumors from *Jorgenson et al.* (1985).

Experimental Data[a]		Maximum Likelihood Estimates of Parameters	95% Upper Limit on Risk (q_1^*)	Goodness-of-Fit Test Results		
Dose Level (mg/ℓ)	Tumor Incidence			chi-square	Degrees of Freedom	p-value
0	6/351	q_0 = 1.5845E-2[a]	1.0448E-4	1.0856	2	5.8112E-1
200	6/313	q_1 = 4.4481E-5				
400	7/148	q_2 = 1.7482E-8				
900	3/48	q_3 = 0				
1800	7/50	q_4 = 0				

[a] 1.5845E-2 means 1.5845×10^{-2}.

TABLE 7

Standard Values Used in Dose Conversions

Species	Body Weight (kg)	Breathing Rate (m^3/day)	Natural Life Span (weeks)
Mouse	0.03	0.05	104
Rat	0.35	0.26	104
Human	70.0	20	3640 (70 years)

TABLE 8

Human Potency Estimates (Q_1^*s)

	Dose Measure Assumed to Provide Equivalent Risks in Animals and Human: ppm	mg/kg/day	mg/m²/da
	Units of $(ppm)^{-1}$		
Vinyl chloride	1.11E-02	4.27E-03	2.50E-02
Tetrachloroethylene	2.78E-02	4.76E-03	6.32E-02
Trichloroethylene	2.18E-02	3.73E-03	4.95E-02
Vinylidene chloride	1.81E-03	6.95E-04	4.06E-03
Ethylene dichloride	4.02E-03	1.55E-03	9.05E-03
Chloroform	3.18E-03	1.22E-03	7.16E-03
Benzene	1.56E-02	1.56E-02	1.11E-01
	Units of $(mg/kg/day)^{-1}$		
Vinyl chloride	1.52E-02	5.83E-03	3.41E-02
Tetrachloroethylene	1.43E-02	2.45E-03	3.25E-02
Trichloroethylene	1.42E-02	2.43E-03	3.22E-02
Vinylidene chloride	1.56E-03	5.99E-04	3.50E-03
Ethylene dichloride	3.47E-03	1.34E-03	7.81E-03
Chloroform	2.28E-03	8.75E-04	5.12E-03
Benzene	1.56E-02	1.56E-02	1.11E-01

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TABLE 9

List of SCAQMD Monitoring Stations Used to Estimate Vinyl Chloride Exposures with Number of Measurements Available by Year

Station	1981	1982	1983	1984	1985
1(B)	192	316			
2(A)	192	319			
3	32				
4	56				
A			254	304	321
B			252	305	288
N				33	
East				10	
Bankuthy				1	
Lo				33	
My (Myra Court)				172	122
2711 Miranda				209	306
2715 Miranda				52	
2600 Maureen				13	

TABLE 10

Average Exposures Obtained from Sixteen Air Samples Collected at Four Residential Sites in the Spring of 1980 by the University of California

	ppb
Vinyl chloride	1.25
Tetrachloroethylene	3.43
Trichloroethylene	0.81
Vinylidene chloride	0
Ethylene dichloride	2.24
Chloroform	1.14
Benzene	16.0
Benzene (omitting two large outliers collected on a single day)	7.59

TABLE 11

Estimates of Average Air Concentrations from 1978 to 1985 and Resulting Risks Assuming 24 Hour Per Day Exposure

	Air Concentration (ppb)	Extra Risk per Million Best (ML) Estimate	95% Upper Limit
"SCAQMD Method" for Estimating Average Air Concentrations			
Vinyl chloride	3.637	1.24	1.78
Tetrachloroethylene	0.732	0.25	0.40
Trichloroethylene	0.859	0.17	0.37
Vinylidene chloride	0.833	0	0.07
Ethylene dichloride	1.440	0.07	0.25
Chloroform	0.025	0.001	0.004
Benzene	0.556	0.77	0.99
Total Risk		2.50	3.86
"USC Method" for Estimating Average Air Concentrations			
Vinyl chloride	1.497	0.51	0.73
Tetrachloroethylene	0.874	0.30	0.48
Trichloroethylene	0.564	0.11	0.24
Vinylidene chloride	0.343	0	0.03
Ethylene dichloride	1.227	0.06	0.22
Chloroform	0.287	0.02	0.04
Benzene	5.383	5.65	9.60
Total Risk		6.65	11.33
"USC Method", Eliminating Two High Benzene Measurements			
Benzene	2.212	2.32	3.94
Total Risk		3.32	5.68

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ADDENDUM TO
ESTIMATES OF CARCINOGENIC RISK
IN THE VICINITY OF THE BKK LANDFILL

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Date of Addendum: April 4, 1986

It has been noted that the California Air Resources Board and the Department of Health Services (ARB and DOHS, 1984) estimated that the ambient concentration of benzene in the South Coast Air Basin (SCAB) was 4.6 ppb during 1981 and 1982. According to Figures 1 and 2 of Appendix E of ARB and DOHS (1984), it appears that the ambient concentrations at West Covina were close to the average of 4.6 ppb. The period for which this estimate was made is included in the period of assumed exposure from BKK (1978 to 1985). Also, the data upon which the ARB and DOHS estimate is based is much more extensive than that gathered during the period July - October, 1982 and which was used in our March 1981 document to estimate ambient exposures. Thus we conclude that 4.6 ppb is a more reliable estimate of the ambient exposure to benzene near BKK during 1978 to 1985 than the estimate used in our March 1 document. If 4.6 ppb is used as the ambient level of benzene, the resulting air concentrations above ambient and corresponding risks are contained in the attached revision to Table 11.

The risks estimated for BKK may be compared to the following:

	Deaths/Million
Occupational exposure to passive smoke for 8 years	320
Drinking one diet soft drink per day for life (saccharin)	170
Living in a brick house (low LET radiation)	56
Living in Denver 8 years vs. living in Los Angeles (cosmic radiation)	29
Eating peanut products (aflatoxin, U.S. average consumption)	11
Driving for one month (1000 miles) on Los Angeles freeways (California urban interstate highways)	6.7
One chest x-ray	1.5

Each of these risks was calculated using methods similar to those used for BKK. Details can be made available upon request.

Reference

ARB and DHS (1984). Report to the Scientific Review Panel on Benzene. Prepared by the Staffs of the Air Resources Board and the Department of Health Services. November.

TABLE 11 (Revised)

Estimates of Average Air Concentrations Above Ambient from 1978 to 1985 and Resulting Risks Assuming 24 Hour Per Day Exposure

	Air Concentration (ppb)		Extra Risk per Million	
			Best (ML) Estimate	95% Upper Limit
	Ambient	above Ambient		
"SCAQMD Method" for Estimating Average Air Concentrations				
Vinyl chloride	2.5	3.637	1.24	1.78
Tetrachloroethylene	1.9	0.732	0.25	0.40
Trichloroethylene	0.25	0.859	0.17	0.37
Vinylidene chloride	0.20	0.833	0	0.07
Ethylene dichloride	0.55	1.440	0.07	0.25
Chloroform	0.40	0.025	0.001	0.004
Benzene	4.6	0.0	0.0	0.0
Total Risk			1.78	2.97
"USC Method" for Estimating Average Air Concentrations				
Vinyl chloride	2.5	1.497	0.51	0.73
Tetrachloroethylene	1.9	0.874	0.30	0.48
Trichloroethylene	0.25	0.564	0.11	0.24
Vinylidene chloride	0.20	0.343	0	0.03
Ethylene dichloride	0.55	1.227	0.06	0.22
Chloroform	0.40	0.287	0.02	0.04
Benzene	4.6	4.515	4.74	8.05
Total Risk			5.74	9.78
"USC Method", Eliminating Two High Benzene Measurements				
Benzene	4.6	1.12	1.18	2.00
Total Risk			3.17	3.73

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APPENDIX D

Risk Assessment for Exposure to Ambient Air in the Vicinity of the BKK Landfill in West Covina, 1978-1985

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1. Introduction

The BKK landfill in West Covina has been in operation as a repository for toxic waste since 1976. Some of the residents in the vicinity of the landfill have complained that substances in the landfill are causing them to suffer an increased risk of disease and have asked that the landfill be closed. In 1983, the California Department of Health Services (DHS) *et al.* (DHS 1983) issued a report which contained measurements of the ambient air concentrations of volatile organic compounds, which the Department considered to be potential human carcinogens, and also reported corresponding measurements at a control site located 9 miles away. These measurements were used as a basis for calculation of the excess cancer risk associated with residence near the BKK landfill (DHS 1983, attached as Appendix 1). A review of the DHS 1983 report indicated that it was not possible to reproduce this calculation since no information was given with regard to what animal cancer tests were used or how certain factors, such as meteorological conditions, were accounted for. We were therefore asked to perform our own calculation of the excess cancer risk that may be incurred by residence in the vicinity of the BKK landfill during a 7-year period between 1978 and 1985. Our analysis uses data from exposure monitoring and from animal experiments along with a variety of methods and assumptions that are used by the U.S. Environmental Protection Agency (EPA), plus several new methods that have been developed recently. Section 2 describes these methods, Section 3 reports the results of the calculations we made, and Section 4 discusses these results.

2. Methods

In order to predict increased lifetime cancer risk, it is necessary in this case to calculate both a dose and a carcinogenic potency for each of the compounds to which individuals are purportedly exposed around the BKK landfill.

Dose is, of course, calculated from the available exposure information. Carcinogenic potencies are derived from the selected animal bioassay data. Our assumptions and methods regarding the calculation of exposure and potency are described below.

2.1. Methods & Assumptions Regarding Exposure Assessment

In the absence of detailed information on exposure in the vicinity of the BKK landfill, a number of assumptions were made regarding how to interpret the concentration data available to us as well as how to estimate duration of exposure, dilution of ambient contaminant concentration, absorption of inhaled compounds and, finally, the impact of seasonal concentration variability. These assumptions are described below.

2.1.1. Concentration Data

It is assumed that the mean ambient air concentrations (i.e., the mean value of the 2 [1 in the case of benzene] compound-specific mean concentrations) reported in DHS (1983) equal the actual time-weighted average (TWA) concentrations for the seven compounds measured, over the 7-year period of interest. These data were collected at 4 monitoring stations (Stations A, B, D, and F) located on the perimeter of the BKK landfill, as well as at a control monitoring station located 9 miles away (Station C). It is also assumed that the relative ratios of the latter values accurately reflect the relative contribution of each compound to total exposure over this period, for each monitoring station.

For the purpose of our analysis, we have further assumed that the TWA concentrations at the stations on the perimeter of the BKK landfill and those at the control station are in fact different. That is, we assume that the DHS-reported differences between the mean concentrations for Stations A, B, D and F, on the one hand, and Station C, on the other, are not due purely to chance.

If a proper statistical analysis of the the actual concentration measurement data indicate that the latter differences are in fact due to chance, then the excess risk is of course 0 without reference to any further assumptions. Since the raw concentration data were unavailable to us, we are unable to evaluate the likelihood of this possibility.

Increased concentrations of the 7 contaminants measured by DHS in the BKK vicinity above the corresponding control station values were calculated for stations A, B, D and F in terms of mg/kg/day. These values are given in Appendix 2. Note that for Station F, the mean of the measured values is less than the corresponding control station value for benzene and chloroform.

2.1.2. Exposure Duration

Here we assume that exposed residents are present in the vicinity of the BKK landfill for an average of 15 hours per day, for 365 days per year over a 7-year period.

2.1.3. Concentration Dilution

We assume that concentrations reported on the perimeter of the landfill are dispersed in the ambient air to some degree before being inhaled by the average resident, and that this process reduces the average concentration to which residents are exposed by a factor of 2. We further assume that no additional dilution takes place (e.g., due to filtration by air conditioning).

2.1.4. Absorption

We assume residents' average respiratory intake rate is 20 m^3/day per 70 kg body weight (i.e., 0.2857 m^3/kg/day). In their analysis of cancer risk due to household exposure of chlorinated hydrocarbons, such as those considered here, Cothern *et al.* (1984) make the assumption that 50% of the amount of such compounds contained in inhaled air is absorbed into to blood and is

distributed via circulation, and the balanced is exhaled back into the atmosphere. We follow the Cothern *et al.* assumption of 50% absorption (i.e., 50% retention) of contaminants contained in respired air.

2.1.5. Seasonal Variation in Concentration

It is possible that the release of volatile organic compounds, such as those considered here, from the surface of the BKK landfill may be enhanced with increasing temperature, resulting in increased ambient concentration during the warmer months of the year. We note that the DHS concentration measurements were made between July and October of 1982. Since these months are the warmest of the year in southern California, these measurements may overestimate TWA concentrations at other times of the year. In the absence of other measurements, however, we make the conservative assumption that the DHS measurements accurately reflect TWA concentrations over the multi-year period of interest without seasonal adjustment.

2.2. Methods & Assumptions Regarding Carcinogen Potency Assessment

Since the mid-1960s, the primary basis for judging both carcinogenicity (i.e., carcinogenic potential) *per se* and the carcinogenic potency of particular chemicals to humans, in the absence of adequate epidemiological data, has been data from long-term carcinogen bioassays using laboratory animals. By this means, an assessment of human carcinogenic potency of a compound at very low environmental dose levels begins with an assessment of tumorigenic potency at much higher experimental dose levels in the test species used. This is followed first by an extrapolation of expected response in that species from these experimental dose levels down to the environmental levels of interest, then by an extrapolation of the latter predicted response, in the test species used, to a response in a target human population.

The validity of risk predictions calculated in accordance with the above procedure, of course, is conditional on the validity of key assumptions or "inference bridges" that must be used to bridge fundamental gaps that currently exist in basic scientific knowledge concerning the mechanism of carcinogenesis, the extrapolation of high-dose observations to low-dose predictions for a given species, and the equivalence of tumorigenic doses between different species. Environmental cancer risk assessment cannot proceed without the use of these assumptions, so that much effort has gone into studying how they may standardized for use in a regulatory context (NAS 1983). But this does not mean that the uncertainty associated with these assumptions is in any way irrelevant or negligible, or even that their use will necessarily lead to risk predictions that are consistent with the "best guesses" of a majority of informed scientists/experts.

In certain components of our potency assessment we have made use of some of the assumptions and procedures that have become standard in the context of regulatory carcinogen risk assessment. But in other components of our analysis, we have made use of a range of plausible assumptions (rather than a single conservative assumption) in order to lend a greater degree of objectivity to the analysis. The validity of the final result, however, *remains* conditional on the validity of the residual set of inference bridges we have used for this analysis.

The following subsections discuss the specific methods and assumptions we use for carcinogen potency assessment in the present analysis.

2.2.1. Selection of Animal Data

The animal data we used for each compound were derived from EPA Health Assessment Documents when these were available. In the absence of such documents (for the cases of the 2 known human carcinogens vinyl chloride and

benzene), data from the scientific literature were selected in general accordance with EPA's preferred selection criteria. The latter criteria are *conservative* in the sense that efforts are made to *err on the side of safety* by generally focusing on data obtained for the most sensitive species/strain/sex tested while ignoring the weight of evidence for non-carcinogenicity or for less potent carcinogenicity presented by any remaining data (EPA 1984a).

Below we describe the specific data sources we used in our potency assessment. The actual dose-response input data used and related information appears in Appendix 2.

We note that in the health assessment documents for the five compounds for which EPA has produced such documents to date, animal dose levels used to extrapolate tumorigenic response for given bioassay data sets represent lifetime TWA *metabolized* doses. In these cases, and in the case of vinyl chloride discussed below, dose levels were (linearly) transformed back into an applied dose level that corresponds with expected applied low-level dose, fully in accordance with the pharmacokinetic data relied on in each case for determining metabolized dose. The latter transformation obviates the need to readjust calculated potencies that are based directly on a metabolized dose, rather than on an applied dose such as that calculated for BKK-vicinity residents. (See, however, the discussion of vinylidene chloride bioassay data below.)

We note finally that in certain cases several animal bioassay data sets are discussed and analyzed in EPA health assessment documents, whereas only a subset of these are actually used to calculated potency values recommended for use (albeit, for use in a *regulatory* context) by EPA. We have made use of only data sets relied on by EPA for final potency assessment in these cases.

1. Vinyl Chloride (VCL). No EPA health assessment document exists for VCL at this time. For potency assessment, we used the data of Maltoni and LeFem-

ine (1975) on the induction of zymbal gland tumors, nephroblastomas and liver angiosarcomas in female Sprague-Dawly rats exposed to VCL by inhalation. The experimental exposures in this study (0, 50, 250, 500, 2500, 6000, and 10000 ppm) were converted to lifetime TWA exposures in mg/kg/day using standard assumptions employed by EPA (Anderson *et al.* 1983, EPA 1984a). In addition, the resulting animal TWA doses were adjusted to reflect non-linear metabolism of VCL by rats at these concentrations, in accordance with the pharmacokinetic analysis done by Gehring *et al.* (1978).

2. Perchloroethylene (PCE). Bioassay data on PCE liver carcinogenicity in B6C3F1 mice have been used by EPA to extrapolate carcinogenicity at low doses (EPA 1984b). More recent bioassay data have been produced by the National Toxicology Program which may also be used to evaluate the carcinogenic potential of PCE (NTP 1985). See discussion in Section 2.2.2 regarding our omission of PCE data.

3. Trichloroethylene (TCE). Bioassay data on TCE liver carcinogenicity in B6C3F1 mice have been used by EPA to extrapolate carcinogenicity at low doses (EPA 1985a). See discussion in Section 2.2.2 regarding our omission of TCE data.

4. Vinylidene Chloride (VDCL). We make use of bioassay data on VDCL's capacity to induce kidney adenocarcinomas in male Swiss mice reviewed in EPA (1985b). EPA's derivation of dose data for this bioassay relies on experimental information regarding VDCL metabolism in rats and mice. For potency assessment, EPA assumes 100% metabolism of VDCL, and so uses calculated metabolized dose directly in its potency assessment. However, the metabolic data relied on by EPA for VDCL potency assessment show that 0.035 kg mice and 0.25 kg rats exposed to 10 ppm VDCL for 6 hours metabolize 0.186 mg and 0.723 mg VDCL, respectively. But using EPA's recommended method to calculate mouse

respiration rates in the context of cancer risk assessment (EPA 1984a), the corresponding inhaled amounts (which equal the respective applied doses only if 100% absorption is assumed—see discussion above) are

$$\textit{Mouse:}\quad \left[10\ \text{ppm} \times \frac{97\ \text{g/M}}{24.45\ \text{L/M}}\right] \times \left[0.0345 \left[\frac{0.035}{0.025}\right]^{2/3} \text{m}^3\text{/day} \times \frac{6\ \text{hr}}{24\ \text{hr/day}}\right] = 0.4282$$

$$\textit{Rat:}\quad \left[10\ \text{ppm} \times \frac{97\ \text{g/M}}{24.45\ \text{L/M}}\right] \times \left[0.105 \left[\frac{0.25}{0.113}\right]^{2/3} \text{m}^3\text{/day} \times \frac{6\ \text{hr}}{24\ \text{hr/day}}\right] = 1.768$$

That is, 43% and 45% of applied dose is metabolized by mice and rats exposed to 10 ppm VDCL for 6 hours, respectively. Since metabolic saturation in these species occurs at a much greater dose level than 10 ppm, it may be argued that the appropriate applied dose data to use for mice in analyzing the VDCL bioassay data can be linearly extrapolated down to the ppb range of interest, i.e., that the dose data should be increased by a factor of $\frac{1}{0.43} = 2.3$ over the figures used by EPA. We did *not* correct for this source of potential conservatism in deriving appropriate dose data to use in the analysis of the VDCL bioassay data, but rather used EPA's dose data directly.

5. 1,2-Dichloroethane (DCE). We make use of bioassay data on DCE's capacity to induce hemangiosarcomas in male Osborne-Mendel rats and hepatocellular carcinomas in male B6C3F1 mice reviewed in EPA (1985c).

6. Chloroform (CLFM). We make use of bioassay data on CLFM's capacity to induce hepatocellular carcinomas in male and female B6C3F1 mice reviewed in EPA (1985d).

7. Benzene (BNZ). No EPA health assessment document exists for BNZ at this time. For potency assessment, we used the data of Maltoni (1983) on zymbal gland tumor induction in female Sprague-Dawly rats exposed to BNZ by ingestion. Metabolism was not taken into account regarding the dose levels in

this data set.

2.2.2. Dose-Response Extrapolation

The extrapolation of observed response in animals at experimental doses to predicted response at low doses can be strongly influenced by the model used to carry out this extrapolation. This is clearly illustrated in Cothern *et al.* (1984). EPA uses the "linearized multistage" model to extrapolate lifetime human cancer risk at very low dose levels based on a given set of animal carcinogenicity bioassay data (Anderson *et al.* 1983, EPA 1984a). This method yields an upper (one-tailed) asymptotic 95% confidence limit of low-dose potency for a given input data set. The uncertainty referred to by this confidence limit is that due *only* to estimation error in fitting the multistage model, where this model is simply assumed to be correct for the purpose of doing a quantitative potency analysis. This dose-response model is such that risk is approximately equal to dose multiplied by potency at very low dose levels, such as the levels we consider here.

In addition, low-dose potency and risk extrapolations generated by the multistage model are conditional on the assumption that the compounds whose potencies are extrapolated are indeed human carcinogens at low doses. While in a regulatory context, a number of *conservative, safety-oriented* assumptions have been adopted to enable analysts to predict the cancer risks which may possibly be associated with exposure to certain compounds (NAS 1983, EPA 1984a), these assumptions do *not* necessarily provide the *most likely* or *most reasonable* estimate of risk given current scientific knowledge. Accordingly, we do not feel that the compounds PCE and TCE should be included in our assessment of the most *likely* risk associated with exposure to emissions from the BKK landfill. This is because both of these compounds are unlikely to be actual human carcinogens at the low doses considered in this analysis. Both

compounds produce tumors in the livers of B6C3F1 mice and do not do so in the livers of rats. The B6C3F1 mouse is extraordinarily susceptible to liver cancer, possibly because of the presence of an oncogene in its liver cell DNA (Fox and Watantabe 1985). Therefore, any agency which produces toxicity in the livers of B6C3F1 mice is more than likely to produce liver tumors by stimulating cell proliferation rather than by causing genetic damage. Recent studies by Mirsalis *et al.* (1985) using both TCE and PCE support this proposition, i.e., that TCE and PCE produce liver cancer in B6C3F1 mice by an epigenetic toxic mechanism. Furthermore, mice do not metabolize TCE in the same manner as humans and do so at a much faster rate than either rats or humans. Since neither TCE nor PCE nor both will produce liver toxicity in humans at the low doses being considered here, they are extremely unlikely to produce liver cancer in the human population concerned.

When more than one data set is used to calculate carcinogenic potency, EPA uses the geometric mean of the calculated asymptotic upper confidence limits based on those data sets as an overall estimate of potency. The latter procedure, for instance, was used in EPA's recent calculation of TCE's carcinogenic potency based on 4 bioassay data sets (2 sexes in 2 different studies) (EPA 1984b).

For the purpose of deriving a lifetime tumorigenic potency assessment which takes a more objective approach to the uncertainties arising in dose-response extrapolation, we have used an alternative to EPA's method, called the Monte Carlo Potency Analysis (MCPA) method, to assess carcinogenic potency under different assumptions, such as regarding which data set to use (or how to do inter-species dose extrapolation, discussed below). The MCPA method uses the same multistage model used by the EPA method. However, the MCPA method relies on Monte Carlo simulation, rather than the more conservative

and approximate asymptotic approach used in the EPA method, and it produces *complete distributions* for potency estimation error, rather than the single upper confidence value for potency produced by the EPA method (Bogen 1986). Our application of the MCPA method to the above-specified dose-response input data was carried out using a version of the program GLOBAL79 used for the analysis of dichotomous tumor response data (Crump and Watson 1979) which was modified to generate complete Monte Carlo distributions of site-specific as well as composite tumorigenic potency based on that data (Bogen 1986).

Time-to-tumor data were not used in our analysis of carcinogenic potency, although it would be possible to do so in the context of our analytical framework using a time-dependent multistage model (Crump and Howe 1984). EPA potency assessments have occasionally used time-to-tumor data with such a model when these data are available and when early mortality in a bioassay is prevalent to the extent that it may lead to distorted estimates of potency. Potency values thus derived tend to yield slightly greater values for potency than are derived using a multistage model that does not incorporate time-to-tumor information. For example, for compounds considered herein that are addressed by EPA health assessment documents, upper confidence limit potency values derived using time-to-tumor information are higher than those derived without this information by a factor of approximately 2 or less. However, the incorporation of time-to-tumor information into potency assessment requires several additional assumptions, such as the selection of an appropriate exponent of time (which corresponds to an assumed number of stages in the multistage carcinogenic process) to use in the more complicated time-to-tumor model (Crump and Howe 1984). This introduce yet additional sources of uncertainty into the analysis. Since the time-dependent and time-independent models yield similar potency estimates in the cases we consider for which a comparison was undertaken by EPA in its health assessment documents, we

have relied only on the time-independent multistage model for our analysis.

Depending on the nature of a particular data set, the question may arise regarding how or whether to combine experimental incidence data for each significant tumor type observed in a given bioassay into data amenable to a quantitative assessment of increased *composite* risk, where here the term "composite" is used to refer to the potential or actual occurrence of *any one or more* types of tumor from among a prespecified set of types. EPA has used a tumor counting procedure that consequently has become widely applied in the context of environmental carcinogen risk assessment. According to EPA, if data exist for two or more significant tumor types in the same study, the number of animals with *at least one* of these types is used as incidence data for quantitative assessment of composite risk when bioassay data must be relied on for this purpose (Anderson *et al.* 1983, EPA 1984a). This procedure has been criticized in that it may lead to results which are inconsistent with the underlying tumor incidence data used for a given potency assessment, and an alternative procedure, "composite potency analysis," is available which always yields consistent potency estimates based on tumor incidence data segregated by tumor type (Bogen 1986). We have made use of composite potency analysis in the context of our assessment of VCL carcinogenic potency, in which case 3 different tumor types were observed to occur with significantly increased incidence in rats.

2.2.3. Inter-Species Dose-Equivalence Extrapolation

Equivalent doses between species may be calculated on the basis of dose per body weight or dose per body surface area. At present it is not known which inter-species dose extrapolation assumption better reflects reality in the context of extrapolating tumor response data in animals to anticipated response in humans, and existing data do not rule out either approach (Hogan

and Hoel 1982). When data from a bioassay using mice, e.g., are used for dose-response extrapolation, the choice of which inter-species dose extrapolation method to use alters the resulting potency calculation by a factor of more than 10. To provide and objective approach to the issue of inter-species dose extrapolation, we used a Monte Carlo approach to combine the potency distributions based on the body weight and surface area methods, under the assumption that each method is equally likely to reflect reality.

2.3. Methods & Assumptions Regarding Risk Calculations

To calculate approximate increased low-dose risk to BKK-vicinity residents, calculated excess doses in mg/kg/day for each of the compounds VCL, VDCL, DCE, BNZ and CLFM at each station were multiplied by the factor

$$\frac{7}{70} \times \frac{15}{24} \times 0.50 \times 0.50 = 0.015625$$

in accordance with the assumptions we made regarding exposure duration, concentration dilution and absorption. These excess doses were then multiplied by the corresponding calculated MCPA potency distributions to yield approximate compound-specific risk distributions for each of the stations A, B, D, and F, in accordance with the approximate linearity of the multistage dose-response model at very low doses. The latter station-specific risk distributions were then summed, using a Monte Carlo procedure, to yield distributions of total increased risk due to all 5 compounds for each station, under the assumption that the carcinogenic potency of the mixture of compounds is in all cases equal to the simple sum of the individual compound-specific potencies. That is, we assumed that there is neither positive nor negative synergism among the carcinogenic potencies of the mixture of compounds considered.

An overall BKK-vicinity risk distribution was then derived by taking a weighted average of the 4 calculated station-specific risk distributions, again

using a Monte Carlo procedure, where the station-specific weights were all assumed to be equal (i.e., all equal to 0.25, resulting in a simple average of the 4 distributions). Finally, from this average distribution of total increased risk, the median value (i.e., the 50th percentile value) was selected to represent a risk value which is as likely as not to overestimate the true level of average increased individual risk which BKK-vicinity residents have incurred over the 7-year period of interest, conditional on the set of assumptions we made in our risk analysis.

3. Risk Analysis Results

Our calculated MCPA potency distributions for each of the compounds VCL, VDCL, DCE, BNZ and CLFM (as well as for the compounds PCE and TCE) are given in Appendix 3. Application of the methods described above using these potency distributions yielded the station-specific distributions of increased risk given in Appendix 3, and the corresponding overall distribution of increased risk is also given in Appendix 3. From the latter distribution, we select the 50th percentile value equal to 1.5×10^{-6}, or approximately one chance in a million, as our best estimate of increased lifetime cancer risk for the average individual due to residence in the vicinity of the BKK landfill for the 7-year period of interest. Assuming a population of 7700 exposed individuals in the BKK landfill vicinity, this results in a corresponding predicted population risk of about 0.01 cases.

4. Discussion

Our calculation indicates that it is highly unlikely that even a single case of cancer would arise from the described BKK landfill exposure scenario. This result is consistent with the DHS report which suggested that 50×10^{-6} represents a "maximum risk" and that "the true excess risk of cancer is probably lower" (DHS 1983, p. 12).

Other various assumptions that could have led to a lower result were not included in our analysis. Such alternative assumptions include factors to take into account (1) seasonal adjustment of concentration data; (2) the possibility that the reported ambient concentration differences are due to chance such that the actual TWA concentrations at the landfill and at the comparison stations are equal and therefore the increased cancer risk is 0; (3) the possibility that the effective dilution factor due to atmospheric mixing might be much greater than the factor of 2 assumed for the average individual in the BKK residential population; or (4) the possibility that perhaps less than 50% of VDCL inhaled by humans will be metabolized even at low doses, in accordance with our analysis in Section 2.2.1.4 of data in EPA (1985b) relied on for VDCL potency assessment.

We did investigate, however, the effect of using alternative assumptions regarding (1) the carcinogenicity of PCE and TCE and (2) the relative population density in BKK-vicinity areas influenced by Stations A, B, D and F. The inclusion of PCE and TCE potencies into our risk analysis, corresponding with a presumption that these compounds are human carcinogens at low doses analogous to the other compounds VCL, VDCL, DCE, BNZ and CLFM, results in an increase in our "best" estimate of increased individual risk from 1.5×10^{-6} to 2.2×10^{-6}, that is, an increase by a factor of only 1.47. This result highlights the fact that increased risk in our analysis is primarily due to the impact of VDCL's carcinogenic potency, which was calculated to be greater than that of the other compounds. In the context of our calculation of overall increased risk using a weighted average of station-specific risks, the effect of changing the station weights from (.25,.25,.25,.25) to (.25,.40,.15,.20) for Stations A, B, D and F, respectively, was negligible.

To put these risks further into perspective it must be understood that a 1×10^{-6} lifetime mortality risk is roughly equivalent to 19 minutes of life expectancy, or put another way, equal to the added risk of death that is incurred by driving a car 100 miles, by riding a bicycle 10 miles, by traveling for 6 minutes by canoe or by smoking 1 or 2 cigarettes (cf. Crouch and Wilson 1982). The latter risk, smoking 1-2 cigarettes, is approximately equivalent in cancer risk to living for two weeks in Los Angeles as a result of air pollution (cf. Ames 1983). Residents living in the vicinity of the BKK landfill therefore experience only a negligible increased cancer risk, similar to that now being used by the U.S. Food and Drug Administration as a benchmark of insignificant health risk requiring no regulatory action (FDA 1985).

At very low doses, individual cancer risk becomes approximately equal to carcinogenic potency multiplied by dose, according to the cancer risk extrapolation model we have used in this analysis. Using the published EPA ("95% upper confidence limit") potency values, this relation allows us to make certain comparisons of estimated excess individual risk associated with different exposure situations. Note that such risk values are only estimates that contain a great deal of uncertainty, and only *a small part* of this uncertainty is meant to be addressed by EPA's use of "upper confidence limit" risk estimates; see, e.g., Anderson *et al.* (1983), Cothern *et al.* (1984) and Bogen (1986). Nevertheless, such risk estimates are useful for comparative purposes, as we have undertaken here.

Firstly, we calculated the excess individual risk due to exposures (15 hours per day) at an average BKK residence (see Tables 2.1 and 2.3). We then compared this risk value of 2.4×10^{-6} with that associated with other typical exposures to some of the compounds listed in Table 2.1 and exposure to other "everyday" carcinogens such as aflatoxin B_1, which is present in all peanut

butter at an average of 2 ppb and which is regulated at 20 ppb (Table 2.4). One peanut butter sandwich per day works out to be at least 10 times worse than residence near BKK, which is similar in risk to drinking ordinary U.S. tap water and much less risky than taking a daily hot tub. This increased individual risk value of 2.4×10^{-6} is also absolutely minimal when compared to the risk incurred by someone working in a dry cleaning shop or in a plant manufacturing vinylidene chloride (Table 2.4). We therefore conclude that exposure of residents to the compounds and ambient concentrations listed in Table 2.1 poses a minimal, negligible cancer risk—a risk that is highly unlikely to result in even a single excess cancer case over the lifetime of the exposed BKK residential population.

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Table 2.1

Increased Exposure Above Measured Control Levels for Air Contaminants Measured at 4 BKK-Vicinity Monitoring Stations

Compound	Increased Exposure in mg/kg/day (assuming 20 m^3/70 kg/day intake) At Monitoring Station: A	B	D	F	Mean
Vinyl Chloride	.0034	.0018	.0011	0.0	.0016
Perchloroethylene	.0019	.00087	.0015	.0011	.0013
Trichloroethylene	.0010	.0016	.0021	.0011	.0015
Vinylidene Chloride	.0011	.00074	.00062	.00017	.0007
1,2-Dichloroethane	.0019	.0014	.0014	.00023	.0012
Benzene	.0011	.00091	.00091	-.00055	.0006
Chloroform	0.0	.00007	.00056	-.00029	.00009

TABLE 2.2

POTENCY ANALYSIS INPUT

KEY: LINE #1 = TITLE
LINE #2 = # ANIMALS PER DOSE GROUP (SURVIVING UNTIL AFTER THE OCCURRENCE OF THE 1ST TUMOR IN THE EXPERIMENT)
LINE #3 = # TUMOR-BEARING ANIMALS PER DOSE GROUP
LINE #4 = # EQUIVALENT APPLIED DOSES FOR EACH DOSE GROUP (IN MG/KG/DAY)

```
VCL MALTONI75 SPR-DAW RATS FEMALE .35KG HEAD MG/KG/D      ZYMBAL GLAND
58,59,59,59,59,60,61
0,0,0,4,2,7,16
0.0,4.225,13.92,19.52,28.76,30.90,31.57

VCL MALTONI75 SPR-DAW RATS FEMALE .35KG HEAD MG/KG/D      NEPHROBLASTOMAS
58,59,59,59,59,60,61
0,1,6,4,6,4,5
0.0,4.225,13.92,19.52,28.76,30.90,31.57

VCL MALTONI75 SPR-DAW RATS FEMALE .35KG HEAD MG/KG/D  LIVER ANGIOSARCOMAS
58,59,59,59,59,60,61
0,1,4,7,3,13,9
0.0,4.225,13.92,19.52,28.76,30.90,31.57

VCL MALTONI75 SPR-DAW RATS FEMALE .35KG HEAD MG/KG/D      COMPOSITE
58,59,59,59,59,60,61
6,16,16,22,32,31,38
0.0,4.225,13.92,19.52,28.76,30.90,31.57

BENZENE MALTONI83 S-D RATS FEMALE .30KG HEAD MG/KG/D      ZYMBAL GLAND
30,30,32
0,2,8
0.0,16.07,80.36

VINYLIDENE CL MALTONI85 SW MICE .035KG HEAD MG/KG/D KIDNEY ADENOSARC.
126,25,119
0,0,28
0.0,0.9827,2.457

DCE NCI78 O-M RATS MALE .5KG              HEAD MG/KG/D  HEMANGIOSARCOMAS
40,46,27
0,9,7
0.0,23.16,42.75

DCE NCI78 B6C3F1 MICE MALE .035KG         HEAD MG/KG/D  HEPATOCARCINOMAS
1.,47,46
1,6,12
0.0,44.35,57.70
```

CHLOROFORM NCI76 B6C3F1 MICE MALE.035KG HEAD MG/KG/D HEPATOCARCINOMAS
50,45
18,44
0.0,79.42,159.4

CHLOROFORM NCI76 B6C3F1 MICE FEMALE.028KG HEAD MG/KG/D HEPATOCARCINOMAS
20,45,41
0,36,39
0.0,137.0,274.5

PCE NCI77 B6C3F1 MICE, MALES HALO (MG/KG/DAY) VIA SAME LIVER
20,48,45
2,32,27
0.0,118.66,163.89

PCE NCI77 B6C3F1 MICE, FEMALES HALO (MG/KG/DAY) VIA SAME LIVER
20,48,45
0,19,19
0.0,97.718,142.76

PCE NTP85 B6C3F1 MICE: MALE HALO MG/KG/DAY VIA SAME,HEP AD/CARC
47,46,50
16,31,40
0.0,119.96,203.02

PCE NTP85 B6C3F1 MICE: FEMALE HALO MG/KG/DAY VIA SAME, HEP CARC
39,40,46
13,36
,124.79,209.89

TCE NTP82 B6C3F1 MICE: MALE HALO MG/KG/DAY VIA SAME HEP CARC
48,50
8,30
0.0,675.830

TCE NTP82 B6C3F1 MICE: FEMALE HALO MG/KG/DAY VIA SAME HEP CARC
48,49
2,13
0.0,680.409

TCE NCI76 B6C3F1 MICE: MALES HALO MG/KG/DAY VIA SAME HEP CARC
20,50,48
1,26,31
0.0,444.595,845.545

TCE NCI76 B6C3F1 MICE: FEMALES HALO MG/KG/DAY VIA SAME HEP CARC
20,50,47
0,4,11
0.0,337.779,655.510

APPENDIX THREE

RISK ANALYSIS OUTPUT

Tumorigenic Potency Distribution Calculated
Assuming Equipotent Doses Can Be Extrapolated
Between Species on a (1) mg per Body Weight (Bw)
Basis or (2) mg per Surface Area (SA) Basis

Percentile	Potency (1/[mg/kg/day]) Calculated Using Extrapolation Assumption: Bw	SA	Percentile
0.4300	0.	0.	0.4300
1.0000	0.0005726795	0.0033490527	1.0000
2.0000	0.0012998717	0.0076017021	2.0000
3.0000	0.0018156092	0.0106181065	3.0000
4.0000	0.0021266260	0.0124365939	4.0000
5.0000	0.0023978178	0.0140225347	5.0000
6.0000	0.0026284026	0.0153710032	6.0000
7.0000	0.0028122789	0.0164463203	7.0000
8.0000	0.0029672480	0.0173525847	8.0000
9.0000	0.0031151413	0.0182174705	9.0000
10.0000	0.0032536136	0.0190272629	10.0000
11.0000	0.0033952545	0.0198555849	11.0000
12.0000	0.0035280201	0.0206320025	12.0000
13.0000	0.0036386538	0.0212789942	13.0000
14.0000	0.0037545366	0.0219566603	14.0000
15.0000	0.0038785900	0.0226821490	15.0000
16.0000	0.0039749783	0.0232456320	16.0000
17.0000	0.0040668273	0.0237946641	17.0000
18.0000	0.0041523678	0.0242832135	18.0000
19.0000	0.0042639095	0.0249355137	19.0000
20.0000	0.0043675330	0.0255418010	20.0000
21.0000	0.0044624414	0.0260965358	21.0000
22.0000	0.0045404690	0.0265528448	22.0000
23.0000	0.0046295142	0.0270735845	23.0000
24.0000	0.0047117588	0.0275545549	24.0000
25.0000	0.0047984691	0.0280616395	25.0000
26.0000	0.0048768963	0.0285202842	26.0000
27.0000	0.0049669673	0.0290470235	27.0000
28.0000	0.0050474182	0.0295175035	28.0000
29.0000	0.0051244469	0.0299679711	29.0000
30.0000	0.0051969453	0.0303919446	30.0000
31.0000	0.0052697374	0.0308176354	31.0000
32.0000	0.0053448598	0.0312569551	32.0000
33.0000	0.0054183519	0.0316867381	33.0000
34.0000	0.0054830536	0.0320651159	34.0000
35.0000	0.0055457177	0.0324315801	35.0000
36.0000	0.0056098541	0.0328066535	36.0000
37.0000	0.0056853541	0.0332481787	37.0000
38.0000	0.0057550259	0.0336556211	38.0000
39.0000	0.0058230604	0.0340534696	39.0000
40.0000	0.0058844727	0.0344126336	40.0000
41.0000	0.0059575381	0.0348402150	41.0000
42.0000	0.0060177930	0.0351922959	42.0000
43.0000	0.0060730837	0.0355203152	43.0000
44.0000	0.0061279945	0.0358367562	44.0000
45.0000	0.0061864941	0.0361788645	45.0000
46.0000	0.0062544625	0.0365764648	46.0000
47.0000	0.0063161105	0.0369366860	47.0000
48.0000	0.0063730385	0.0372697860	48.0000
49.0000	0.0064345961	0.0376297757	49.0000
50.0000	0.0064955465	0.0379862152	50.0000
51.0000	0.0065528918	0.0383215733	51.0000

R&S152074

55.0000	[illegible]	0.0397504456	55.0000
56.0000	.0068528769	0.0400758962	56.0000
57.0000	0.0069182469	0.0404581857	57.0000
58.0000	0.0069725960	0.0407760218	58.0000
59.0000	0.0070274523	0.0410966214	59.0000
60.0000	0.0070795454	0.0414014645	60.0000
61.0000	0.0071384124	0.0417457223	61.0000
62.0000	0.0071989144	0.0420995392	62.0000
63.0000	0.0072529400	0.0424154848	63.0000
64.0000	0.0073079383	0.0427371152	64.0000
65.0000	0.0073671667	0.0430834852	65.0000
66.0000	0.0074252975	0.0434234366	66.0000
67.0000	0.0074962992	0.0438386574	67.0000
68.0000	0.0075497241	0.0441510901	68.0000
69.0000	0.0076115336	0.0445125550	69.0000
70.0000	0.0076629536	0.0448132604	70.0000
71.0000	0.0077161831	0.0451362431	71.0000
72.0000	0.0077770394	0.0454804376	72.0000
73.0000	0.0078272959	0.0457743406	73.0000
74.0000	0.0078862319	0.0461190008	74.0000
75.0000	0.0079470577	0.0464747697	75.0000
76.0000	0.0080047920	0.0468123443	76.0000
77.0000	0.0080706535	0.0471975654	77.0000
78.0000	0.0081326142	0.0475598536	78.0000
79.0000	0.0082012340	0.0479611456	79.0000
80.0000	0.0082558179	0.0482803546	80.0000
81.0000	0.0083270853	0.0487006381	81.0000
82.0000	0.0083982218	0.0491131395	82.0000
83.0000	0.0084746592	0.0495601483	83.0000
84.0000	0.0085414629	0.0499508195	84.0000
85.0000	0.0086164356	0.0503895544	85.0000
86.0000	0.0086858262	0.0507950706	86.0000
87.0000	0.0087648258	0.0512570515	87.0000
88.0000	0.0088466890	0.0517357923	88.0000
89.0000	0.0089489324	0.0523337163	89.0000
90.0000	0.0090379392	0.0528536476	90.0000
91.0000	0.0091302823	0.0533942580	91.0000
92.0000	0.0092368033	0.0540171973	92.0000
93.0000	0.0093518551	0.0546900257	93.0000
94.0000	0.0094750915	0.0554107167	94.0000
95.0000	0.0096185394	0.0562496036	95.0000
96.0000	0.0097883055	0.0572424047	96.0000
97.0000	0.0099880512	0.0584105812	97.0000
98.0000	0.0102364104	0.0598629378	98.0000
99.0000	0.0106925238	0.0625303090	99.0000

R&S152075

PCE [illegible] B6C3F1 MICE, FEMALES MALE (MG/KG/DAY) VIA SAME LIVER
PCE NTP85 B6C3 MICE: MALE HALO MG/KG/DAY IA SAME,HEP AD/CARC
PCE NTP85 B6C3F1 MICE: FEMALE HALO MG/KG/DAY VIA SAME, HEP CARC

Tumorigenic Potency Distribution Calculated
Assuming Equipotent Doses Can Be Extrapolated
Between Species on a (1) mg per Body Weight (Bw)
Basis or (2) mg per Surface Area (SA) Basis

Percentile	Potency (1/[mg/kg/day]) Calculated Using Extrapolation Assumption: BW	SA	Percentile
23.5200	0.	0.	23.5200
24.0000	0.0000631399	0.0008419139	24.0000
25.0000	0.0002477595	0.0032905159	25.0000
26.0000	0.0004065095	0.0053327973	26.0000
27.0000	0.0005406287	0.0071042348	27.0000
28.0000	0.0006775836	0.0089232866	28.0000
29.0000	0.0008084442	0.0105216913	29.0000
30.0000	0.0009508039	0.0124029778	30.0000
31.0000	0.0010622996	0.0140911490	31.0000
32.0000	0.0012121021	0.0157920271	32.0000
33.0000	0.0013783769	0.0182200354	33.0000
34.0000	0.0015607907	0.0207534954	34.0000
35.0000	0.0017147622	0.0223614797	35.0000
36.0000	0.0018365651	0.0239088777	36.0000
37.0000	0.0019815555	0.0262096580	37.0000
38.0000	0.0021057397	0.0275176186	38.0000
39.0000	0.0022612270	0.0296708345	39.0000
40.0000	0.0023447168	0.0310381241	40.0000
41.0000	0.0024843295	0.0326073281	41.0000
42.0000	0.0026001076	0.0346589722	42.0000
43.0000	0.0026968133	0.0360331982	43.0000
44.0000	0.0028273263	0.0368654616	44.0000
45.0000	0.0029609974	0.0390280671	45.0000
46.0000	0.0030838503	0.0408094414	46.0000
47.0000	0.0032178843	0.0419077836	47.0000
48.0000	0.0033036284	0.0438546464	48.0000
49.0000	0.0033742981	0.0451851636	49.0000
50.0000	0.0034405054	0.0462058075	50.0000
51.0000	0.0035401534	0.0471385531	51.0000
52.0000	0.0036381371	0.0481932089	52.0000
53.0000	0.0036876083	0.0497919470	53.0000
54.0000	0.0037836900	0.0509260669	54.0000
55.0000	0.0038175124	0.0517350100	55.0000
56.0000	0.0039036532	0.0527278520	56.0000
57.0000	0.0039779469	0.0537138171	57.0000
58.0000	0.0040559196	0.0543200411	58.0000
59.0000	0.0041189343	0.0555971563	59.0000
60.0000	0.0041798120	0.0560675710	60.0000
61.0000	0.0042497516	0.0569670014	61.0000
62.0000	0.0043027191	0.0578635931	62.0000
63.0000	0.0043729548	0.0585039258	63.0000
64.0000	0.0044210218	0.0596585087	64.0000
65.0000	0.0044639823	0.0602021478	65.0000
66.0000	0.0045630080	0.0613929220	66.0000
67.0000	0.0046134321	0.0620164797	67.0000
68.0000	0.0047130641	0.0625100061	68.0000
69.0000	0.0047519626	0.0634471178	69.0000
70.0000	0.0048404224	0.0644137169	70.0000
71.0000	0.0049026082	0.0649361536	71.0000
72.0000	0.0049709054	0.0663178042	72.0000
73.0000	0.0050370945	0.0668627025	73.0000

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76.0000	0.0052[illegible]3550	0.0659715445	76.0000
77.0000	0.0053[illegible]2083	0.0696585774	77.0000
78.0000	0.0053876548	0.0707354471	78.0000
79.0000	0.0054476908	0.0713223070	79.0000
80.0000	0.0055350373	0.0723741651	80.0000
81.0000	0.0056042066	0.0732360450	81.0000
82.0000	0.0056812912	0.0739837438	82.0000
83.0000	0.0057923449	0.0750207230	83.0000
84.0000	0.0058550616	0.0761620775	84.0000
85.0000	0.0059278943	0.0772702247	85.0000
86.0000	0.0060320524	0.0783423260	86.0000
87.0000	0.0061395695	0.0797456056	87.0000
88.0000	0.0062557189	0.0812087208	88.0000
89.0000	0.0063808989	0.0824906453	89.0000
90.0000	0.0064814021	0.0840217695	90.0000
91.0000	0.0066168713	0.0853406767	91.0000
92.0000	0.0067779957	0.0867500360	92.0000
93.0000	0.0068894438	0.0888896659	93.0000
94.0000	0.0070212791	0.0911299139	94.0000
95.0000	0.0072206082	0.0928635597	95.0000
96.0000	0.0073681385	0.0958132222	96.0000
97.0000	0.0075660926	0.0984796148	97.0000
98.0000	0.0078990255	0.1026449278	98.0000
99.0000	0.0084332814	0.1077851206	99.0000

R&S 152077

TCE NCI76 B6C3F1 MICE: FEMALES HALO MG/KG/DAY VIA SAME HEP CARC
TCE NCI76 B6C3F1 MICE: FEMALES HALO MG/KG/DAY VIA SAME HEP CARC

Tumorigenic Potency Distribution Calculated
Assuming Equipotent Doses Can Be Extrapolated
Between Species on a (1) mg per Body Weight (BW)
Basis or (2) mg per Surface Area (SA) Basis

Percentile	Potency (1/[mg/kg/day]) Calculated Using Extrapolation Assumption: BW	SA	Percentile
11.6000	0.	0.	11.6000
12.0000	0.0000288718	0.0004010605	12.0000
13.0000	0.0000331952	0.0004617967	13.0000
14.0000	0.0000735015	0.0010205493	14.0000
15.0000	0.0000768560	0.0010693242	15.0000
16.0000	0.0001185921	0.0016247210	16.0000
17.0000	0.0001299646	0.0016874671	17.0000
18.0000	0.0001623041	0.0021598854	18.0000
19.0000	0.0001717535	0.0022996233	19.0000
20.0000	0.0001994221	0.0025248800	20.0000
21.0000	0.0002066782	0.0027376411	21.0000
22.0000	0.0002111095	0.0028802075	22.0000
23.0000	0.0002317257	0.0029799310	23.0000
24.0000	0.0002410785	0.0030773962	24.0000
25.0000	0.0002555447	0.0033821820	25.0000
26.0000	0.0002674929	0.0034916122	26.0000
27.0000	0.0002729225	0.0035558483	27.0000
28.0000	0.0002864209	0.0037451424	28.0000
29.0000	0.0002967948	0.0038907297	29.0000
30.0000	0.0003045304	0.0040064328	30.0000
31.0000	0.0003124588	0.0040976494	31.0000
32.0000	0.0003182912	0.0041765687	32.0000
33.0000	0.0003278030	0.0043178336	33.0000
34.0000	0.0003427067	0.0044134185	34.0000
35.0000	0.0003502932	0.0044350801	35.0000
36.0000	0.0003569786	0.0046192929	36.0000
37.0000	0.0003671742	0.0048116501	37.0000
38.0000	0.0003819009	0.0048415521	38.0000
39.0000	0.0003870664	0.0049207699	39.0000
40.0000	0.0003929799	0.0050728549	40.0000
41.0000	0.0004038969	0.0052447678	41.0000
42.0000	0.0004203070	0.0054401890	42.0000
43.0000	0.0004319644	0.0055211429	43.0000
44.0000	0.0004422651	0.0057088500	44.0000
45.0000	0.0004531117	0.0058406456	45.0000
46.0000	0.0004652110	0.0059791701	46.0000
47.0000	0.0004817551	0.0061627184	47.0000
48.0000	0.0005044929	0.0063774111	48.0000
49.0000	0.0005184426	0.0065426948	49.0000
50.0000	0.0005371177	0.0067672594	50.0000
51.0000	0.0005564941	0.0070168427	51.0000
52.0000	0.0005792555	0.0073040705	52.0000
53.0000	0.0006026781	0.0075932685	53.0000
54.0000	0.0006419369	0.0080280732	54.0000
55.0000	0.0006660301	0.0083375992	55.0000
56.0000	0.0006980940	0.0086673899	5 .0000
57.0000	0.0007303558	0.0089960033	57.0000
58.0000	0.0007553491	0.0093287015	58.0000
59.0000	0.0007789282	0.0096417508	59.0000
60.0000	0.0008099292	0.0099793402	60.0000

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62.0000	0.0008 4004	0.010995295	62.01
63.0000	0.0008792258	0.0109503596	63.0000
64.0000	0.0009100983	0.0111167086	64.0000
65.0000	0.0009266917	0.0113879135	65.0000
66.0000	0.0009449993	0.0116341598	66.0000
67.0000	0.0009639515	0.0118264370	67.0000
68.0000	0.0009767214	0.0120875096	68.0000
69.0000	0.0009926786	0.0122434404	69.0000
70.0000	0.0010138333	0.0126162264	70.0000
71.0000	0.0010469393	0.0126998471	71.0000
72.0000	0.0010547247	0.0130673681	72.0000
73.0000	0.0010860262	0.0132064130	73.0000
74.0000	0.0010860262	0.0135276621	74.0000
75.0000	0.0011097921	0.0136578409	75.0000
76.0000	0.0011233648	0.0139594963	76.0000
77.0000	0.0011408036	0.0140514616	77.0000
78.0000	0.0011601131	0.0143212499	78.0000
79.0000	0.0011717480	0.0144456886	79.0000
80.0000	0.0011930985	0.0146767264	80.0000
81.0000	0.0012043820	0.0149525125	81.0000
82.0000	0.0012199678	0.0152541241	82.0000
83.0000	0.0012353265	0.0155025935	83.0000
84.0000	0.0012502574	0.0156682275	84.0000
85.0000	0.0012755778	0.0159120634	85.0000
86.0000	0.0012912479	0.0160874929	86.0000
87.0000	0.0013026590	0.0163902510	87.0000
88.0000	0.0013261532	0.0166165269	88.0000
89.0000	0.0013389986	0.0167716797	89.0000
90.0000	0.0013619312	0.0170479119	90.0000
91.0000	0.0013769770	0.0172618143	91.0000
92.0000	0.0013983441	0.0176176969	92.0000
93.0000	0.0014159299	0.0179115627	93.0000
94.0000	0.0014415835	0.0181849767	94.0000
95.0000	0.0014810615	0.0185676906	95.0000
96.0000	0.0015181559	0.0190631878	96.0000
97.0000	0.0015631353	0.0197035875	97.0000
98.0000	0.0016321145	0.0204428229	98.0000
99.0000	0.0017534167	0.0217668433	99.0000

R&S152079

Tumorigenic Potency Distribution Calculated
Assuming Equipotent Doses Can Be Extrapolated
Between Species on a (1) mg per Body Weight (BW)
Basis or (2) mg per Surface Area (SA) Basis

Percentile	Potency (1/[mg/kg/day]) Calculated using Extrapolation Assumption: BW	SA	Percentile
57.4000	0.	0.	57.4000
58.0000	0.0023508139	0.0296183750	58.0000
59.0000	0.0023508139	0.0296183750	59.0000
60.0000	0.0023508139	0.0296183750	60.0000
61.0000	0.0023508139	0.0296183750	61.0000
62.0000	0.0052523129	0.0661749393	62.0000
63.0000	0.0052523129	0.0661749393	63.0000
64.0000	0.0052523129	0.0661749393	64.0000
65.0000	0.0081231073	0.1023446545	65.0000
66.0000	0.0081231073	0.1023446545	66.0000
67.0000	0.0109638385	0.1381355971	67.0000
68.0000	0.0109638385	0.1381355971	68.0000
69.0000	0.0137751363	0.1735557020	69.0000
70.0000	0.0137751363	0.1735557020	70.0000
71.0000	0.0165575966	0.2086124718	71.0000
72.0000	0.0193118080	0.2433133423	72.0000
73.0000	0.0247377418	0.3116757572	73.0000
74.0000	0.0403775983	0.5087254643	74.0000
75.0000	0.0501255058	0.6315413117	75.0000
76.0000	0.0532984957	0.6715184450	76.0000
77.0000	0.0595352950	0.7500967383	77.0000
78.0000	0.0626006722	0.7887184024	78.0000
79.0000	0.0626006722	0.7887184024	79.0000
80.0000	0.0656318665	0.8269090056	80.0000
81.0000	0.0656318665	0.8269090056	81.0000
82.0000	0.0686295033	0.8646768332	82.0000
83.0000	0.0715944767	0.9020331502	83.0000
84.0000	0.0715944767	0.9020331502	84.0000
85.0000	0.0745273232	0.9389846921	85.0000
86.0000	0.0745273232	0.9389846921	86.0000
87.0000	0.0774288177	0.9755411744	87.0000
88.0000	0.0774288177	0.9755411744	88.0000
89.0000	0.0794975162	1.0016051531	89.0000
90.0000	0.0802996159	1.0117108822	90.0000
91.0000	0.0831080675	1.0470951796	91.0000
92.0000	0.0833316445	1.0499120951	92.0000
93.0000	0.0833316445	1.0499120951	93.0000
94.0000	0.0908618569	1.1447867155	94.0000
95.0000	0.0984939337	1.2409447432	95.0000
96.0000	0.1066254709	1.3459155560	96.0000
97.0000	0.1109157301	1.3974500695	97.0000
98.0000	0.1186809872	1.4978053570	98.0000
99.0000	0.1234383583	1.5552245378	99.0000

Tumorigenic Potency Distribution Calculated
Assuming Equipotent Doses Can Be Extrapolated
Between Species on a (1) mg per Body Weight (Bw)
Basis or (2) mg per Surface Area (SA) Basis

Percentile	Potency (1/[mg/kg/day]) Calculated Using Extrapolation Assumption: Bw	SA	Percertile
32.0550	0.	0.	32.0550
33.0000	0.0001038053	0.0010927507	33.0000
34.0000	0.0004158972	0.0034300131	34.0000
35.0000	0.0006223086	0.0052099419	35.0000
36.0000	0.0008052544	0.0067426893	36.0000
37.0000	0.0010680376	0.0078208055	37.0000
38.0000	0.0012650864	0.0101002e97	38.0000
39.0000	0.0013524315	0.0106902649	39.0000
40.0000	0.0014808926	0.0128090139	40.0000
41.0000	0.0016244322	0.0142214093	41.0000
42.0000	0.0016513069	0.0148719465	42.0000
43.0000	0.0020176996	0.0160176922	43.0000
44.0000	0.0020587973	0.0172541905	44.0000
45.0000	0.0022687374	0.0183555556	45.0000
46.0000	0.0023956872	0.0192078575	46.0000
47.0000	0.0025417092	0.020511377e	47.0000
48.0000	0.0026377053	0.0220622046	48.0000
49.0000	0.0027363470	0.0222374797	49.0000
50.0000	0.0028409075	0.0227661040	50.0000
51.0000	0.0028e41261	0.0244304445	51.0000
52.0000	0.0030001164	0.0251968e89	52.0000
53.0000	0.0031068850	0.0264859651	53.0000
54.0000	0.0033263485	0.0266618678	54.0000
55.0000	0.0034470086	0.0272008087	55.0000
56.0000	0.0035790491	0.0280365832	56.0000
57.0000	0.0036291e92	0.0291268602	57.0000
58.0000	0.0037549126	0.0296260286	58.0000
59.0000	0.0039007415	0.0300076716	59.0000
60.0000	0.0041051777	0.0307655465	60.0000
61.0000	0.0041463746	0.0314085409	61.0000
62.0000	0.0042734761	0.0326598287	62.0000
63.0000	0.0042826235	0.0329465419	63.0000
64.0000	0.0043652970	0.0335101448	64.0000
65.0000	0.0045989049	0.0340721458	65.0000
66.0000	0.0047065211	0.0351662982	66.0000
67.0000	0.0048733628	0.0355613306	67.0000
68.0000	0.0050965096	0.0356993228	68.0000
69.0000	0.0051347017	0.0363942012	69.0000
70.0000	0.0052294575	0.0382859968	70.0000
71.0000	0.0052772732	0.0386370271	71.0000
72.0000	0.0056311530	0.0387365334	72.0000
73.0000	0.0057518049	0.0390550457	73.0000
74.0000	0.0057926e7e	0.0395760536	74.0000
75.0000	0.0059661344	0.0404470563	75.0000
76.0000	0.0063385554	0.0413730331	76.0000
77.0000	0.0064640131	0.0415324e06	77.0000
78.0000	0.0067303958	0.0428e25122	78.0000
79.0000	0.0068540093	0.0434967284	79.0000
80.0000	0.0068751834	0.044339999e	80.0000
81.0000	0.0073733404	0.0445330963	81.0000
82.0000	0.0074477480	0.0450259484	82.0000
83.0000	0.0074609537	0.0455429740	83.0000

85.0000	0.79178447	0.0476443917	85.0000
86.0000	0.0079985833	0.0484076105	86.0000
87.0000	0.0081310458	0.0498319604	87.0000
88.0000	0.0084179109	0.0504848696	88.0000
89.0000	0.0085530840	0.0508543812	89.0000
90.0000	0.0085997019	0.0517573170	90.0000
91.0000	0.0090888273	0.0522902869	91.0000
92.0000	0.0091881417	0.0535886660	92.0000
93.0000	0.0096188542	0.0543918088	93.0000
94.0000	0.0097569674	0.0557134598	94.0000
95.0000	0.0098993011	0.0570824519	95.0000
96.0000	0.0103204176	0.0582462363	96.0000
97.0000	0.0105862909	0.0606013387	97.0000
98.0000	0.0109909372	0.0631922334	98.0000
99.0000	0.0117450356	0.0666660815	99.0000

Tumorigenic Potency Distribution Calculated
Assuming Equipotent Doses Can Be Extrapolated
Between Species on a (1) mg per Body Weight (Bw)
Basis or (2) mg per Surface Area (SA) Basis

Percentile	Potency (1/[mg/kg/day]) Calculated Using Extrapolation Assumption: Bw	SA	Percentile
17.6000	0.	0.	17.3CCC
18.0000	0.0005611179	0.0035775830	18.0CCC
19.0000	0.0010148041	0.0062475200	19.0CCC
20.0000	0.0010154368	0.0062514152	20.0CCC
21.0000	0.0011749854	0.0072336569	21.0CCC
22.0000	0.0013267462	0.0081679663	22.0CCC
23.0000	0.0013267462	0.0081679663	23.0CCC
24.0000	0.0013685476	0.0084252951	24.0CCC
25.0000	0.0014714494	0.0090588015	25.0CCC
26.0000	0.0014714494	0.0090588015	26.0CCC
27.0000	0.0014714494	0.0090588015	27.0CCC
28.0000	0.0014714494	0.0090588015	28.0CCC
29.0000	0.0016097173	0.0099100312	29.0CCC
30.0000	0.0016097173	0.0099100312	30.0CCC
31.0000	0.0016097173	0.0099100312	31.0CCC
32.0000	0.0016097173	0.0099100312	32.0CCC
33.0000	0.0016097173	0.0099100312	33.0CCC
34.0000	0.0017354523	0.0106841046	34.0CCC
35.0000	0.0017420996	0.0107250279	35.0CCC
36.0000	0.0017420996	0.0107250279	36.0CCC
37.0000	0.0017420996	0.0107250279	37.0CCC
38.0000	0.0017420996	0.0107250279	38.0CCC
39.0000	0.0017420996	0.0107250279	39.0CCC
40.0000	0.0017420996	0.0107250279	40.0CCC
41.0000	0.0018690773	0.0115067502	41.0CCC
42.0000	0.0018690773	0.0115067502	42.0CCC
43.0000	0.0018690773	0.0115067502	43.0CCC
44.0000	0.0018690773	0.0115067502	44.0CCC
45.0000	0.0018690773	0.0115067502	45.0CCC
46.0000	0.0019910738	0.0122578079	46.0CCC
47.0000	0.0019910738	0.0122578079	47.0CCC
48.0000	0.0019910738	0.0122578079	48.0CCC
49.0000	0.0020652630	0.0127145443	49.0CCC
50.0000	0.0021053632	0.0129614165	50.0CCC
51.0000	0.0021084659	0.0129805179	51.0CCC
52.0000	0.0021084659	0.0129805179	52.0CCC
53.0000	0.0024735923	0.0152283749	53.0CCC
54.0000	0.0024735923	0.0152283749	54.0CCC
55.0000	0.0024735923	0.0152283749	55.0CCC
56.0000	0.0025360672	0.0156129085	56.0CCC
57.0000	0.0028703806	0.0176711548	57.0CCC
58.0000	0.0028703806	0.0176711548	58.0CCC
59.0000	0.0028703806	0.0176711548	59.0CCC
60.0000	0.0028703806	0.0176711548	60.0CCC
61.0000	0.0032219272	0.0198354088	61.0CCC
62.0000	0.0032400019	0.0199466832	62.0CCC
63.0000	0.0032801141	0.0201936290	63.0CCC
64.0000	0.0032801141	0.0201936290	64.0CCC
65.0000	0.0032801141	0.0201936290	65.0CCC
66.0000	0.0034188544	0.0210477673	66.0CCC
67.0000	0.0036572944	0.0225156955	67.0CCC
68.0000	0.0036572944	0.0225156955	68.0CCC
69.0000	0.0036572944	0.0225156955	69.0CCC
70.0000	[illegible]	[illegible]	[illegible]

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71.0000	0.00370 .634	0.0228011589	71.0CC
72.0000	0.0037036634	0.0228011589	72.0C00
73.0000	0.0037036634	0.0228011589	73.0CGC
74.0000	0.0037036634	0.0228011589	74.0C0C
75.0000	0.0037449196	0.0230551492	75.0C0C
76.0000	0.0037449196	0.0230551492	76.0CGC
77.0000	0.0040362515	0.0248486977	77.0C0C
78.0000	0.0040562302	0.0249716956	78.0CGC
79.0000	0.0040562302	0.0249716956	79.0C0C
80.0000	0.0040868526	0.0251725316	80.0C0C
81.0000	0.0040868526	0.0251725316	81.0C0C
82.0000	0.0040868526	0.0251725316	82.0CGC
83.0000	0.0041419901	0.0254996661	83.0C0C
84.0000	0.0041419901	0.0254996661	84.0C0C
85.0000	0.0041419901	0.0254996661	85.0C0C
86.0000	0.0042009316	0.0258625317	86.0CGC
87.0000	0.0042009316	0.0258625317	87.0CG0
88.0000	0.0042009316	0.0258625317	88.0C0C
89.0000	0.0044769049	0.0275615286	89.0C0C
90.0000	0.0045356899	0.0279234312	90.0C0C
91.0000	0.0045356899	0.0279234312	91.0C0C
92.0000	0.0049324445	0.0303660035	92.0C0C
93.0000	0.0049989149	0.0307752211	93.0C0C
94.0000	0.0049989149	0.0307752211	94.0C0C
95.0000	0.0054797754	0.0337355807	95.0CGC
96.0000	0.0054797754	0.0337355807	96.0C0C
97.0000	0.0058957078	0.0362962186	97.0C0C
98.0000	0.0059796646	0.0368130678	98.0CGC
99.0000	0.0064061992	0.0394389965	99.0C0C

Tumorigenic Potency Distribution Calculated
Assuming Equipotent Doses Can Be Extrapolated
Between Species on a (1) mg per Body Weight (BW)
Basis or (2) mg per Surface Area (SA) Basis

Percentile	Potency (1/[mg/kg/day]) Calculated Using Extrapolation Assumption: BW	SA	Percentile
26.7750	0.	0.	26.7750
27.0000	0.0000507622	0.0006275531	27.0000
28.0000	0.0002096018	0.0026408150	28.0000
29.0000	0.0004298591	0.0054194015	29.0000
30.0000	0.0005620106	0.0071251397	30.0000
31.0000	0.0009720490	0.0122466804	31.0000
32.0000	0.0012379130	0.0155967139	32.0000
33.0000	0.0014613902	0.0185654219	33.0000
34.0000	0.0016829012	0.0212158430	34.0000
35.0000	0.0021019625	0.0264530219	35.0000
36.0000	0.0023729971	0.0303103067	36.0000
37.0000	0.0026725268	0.0338076092	37.0000
38.0000	0.0029567736	0.0380348600	38.0000
39.0000	0.0035185416	0.0452052057	39.0000
40.0000	0.0036764252	0.0477245301	40.0000
41.0000	0.0038315980	0.0483690921	41.0000
42.0000	0.0042651291	0.0553291105	42.0000
43.0000	0.0046149381	0.0594883114	43.0000
44.0000	0.0047179731	0.0605977401	44.0000
45.0000	0.0047961711	0.0626344010	45.0000
46.0000	0.0050184107	0.0639160499	46.0000
47.0000	0.0054832995	0.0698217377	47.0000
48.0000	0.0057254005	0.0735943988	48.0000
49.0000	0.0058275308	0.0775177330	49.0000
50.0000	0.0060069738	0.0797533020	50.0000
51.0000	0.0063974769	0.0837744325	51.0000
52.0000	0.0067358073	0.0864733309	52.0000
53.0000	0.0068979263	0.0904720202	53.0000
54.0000	0.0070492476	0.0956730917	54.0000
55.0000	0.0070492476	0.0956730917	55.0000
56.0000	0.0071712560	0.0965001956	56.0000
57.0000	0.0073190155	0.0978169367	57.0000
58.0000	0.0076582120	0.1016124487	58.0000
59.0000	0.0080866031	0.1065208668	59.0000
60.0000	0.0082255788	0.1116383746	60.0000
61.0000	0.0082972646	0.1121719629	61.0000
62.0000	0.0083875768	0.1126113012	62.0000
63.0000	0.0084381104	0.1145228744	63.0000
64.0000	0.0084381104	0.1145228744	64.0000
65.0000	0.0086628031	0.1151535809	65.0000
66.0000	0.0088179633	0.1190914735	66.0000
67.0000	0.0091513284	0.1221939400	67.0000
68.0000	0.0094719864	0.1278152466	68.0000
69.0000	0.0094792508	0.1286533326	69.0000
70.0000	0.0095687062	0.1298197508	70.0000
71.0000	0.0095945485	0.1302181631	71.0000
72.0000	0.0099126194	0.1332766947	72.0000
73.0000	0.0099640759	0.1349835545	73.0000
74.0000	0.0099734217	0.1353602707	74.0000
75.0000	0.0099734217	0.1353602707	75.0000
76.0000	0.0101132747	0.1363334507	76.0000
77.0000	0.0102331033	0.1368839483	77.0000
78.0000	[illegible]	[illegible]	[illegible]

80.0000	0.0107[illegible]2278	0.1454702020	80.0[illegible]
81.0000	0.0108 3984	0.1472061574	81.0[illegible]
82.0000	0.0109540522	0.1486694813	82.0000
83.0000	0.0110216215	0.1493060440	83.0000
84.0000	0.0111465789	0.1512824744	84.0000
85.0000	0.0111928107	0.1512824744	85.0000
86.0000	0.0114462450	0.1553495824	86.0000
87.0000	0.0114462450	0.1553495824	87.0000
88.0000	0.0116167953	0.1573326141	88.0000
89.0000	0.0116897561	0.1586545406	89.0000
90.0000	0.0117840376	0.1595713943	90.0000
91.0000	0.0119430088	0.1620917022	91.0000
92.0000	0.0121220453	0.1640242189	92.0000
93.0000	0.0124753751	0.1689127088	93.0000
94.0000	0.0124858618	0.1694593579	94.0000
95.0000	0.0130839720	0.1775769740	95.0000
96.0000	0.0134910503	0.1830649078	96.0000
97.0000	0.0136979064	0.1858780384	97.0000
98.0000	0.0140798213	0.1910927445	98.0000
99.0000	0.0144791398	0.1965127140	99.0000

Bogen/Smith 2/10-13/8c

COMPOUNDS: VCL, VCCL, DCE, ENZ, CLFM

Calculated Distributions of Individual Risk

Percentile	STATION A	STATION B	STATION C	STATION
0.0000	0.	0.	C.	-0.000060
1.0000	0.0000117884	0.0000074320	0.0000068212	-0.0000575
2.0000	0.0000149576	0.0000093685	C.0000084504	-0.0000544
3.0000	0.0000171173	0.0000105254	0.0000094e57	-0.0000515
4.0000	0.0000186231	0.0000114656	0.0000101038	-0.0000491
5.0000	0.0000202142	0.0000123879	C.0000108344	-0.000046E
6.0000	0.0000215941	0.0000130836	0.0000115001	-0.0000450
7.0000	0.0000228705	0.0000137458	C.0000121013	-0.0000432
8.0000	0.0000238056	0.0000143756	G.0000126325	-0.0000415
9.0000	0.0000247567	0.0000149180	0.0000131480	-0.000039E
10.0000	0.0000257650	0.0000155280	0.0000136969	-0.0000381
11.0000	0.0000265681	0.0000159862	0.0000142634	-0.000035E
12.0000	0.0000274636	0.0000165286	C.0000148324	-0.0000340
13.0000	C.0000282500	0.0000169985	0.0000153391	-0.0000324
14.0000	0.0000290385	0.0000175196	0.0000158206	-0.0000305
15.0000	0.0000297792	0.0000180047	C.0000162584	-0.0000282
16.0000	0.0000304257	0.0000183946	C.0000166756	-0.0000259
17.0000	0.0000310246	0.0000188916	C.0000171831	-0.0000237
18.0000	0.0000318354	0.0000193605	0.0000176232	-0.0000215
19.0000	0.0000325451	0.0000198277	C.0000180155	-0.0000190
20.0000	0.0000332134	0.0000203269	C.0000184886	-0.0000166
21.0000	0.0000338986	0.0000208272	0.0000189382	-0.0000144
22.0000	0.0000346417	0.0000213097	C.0000194253	-0.0000125
23.0000	0.0000354209	0.0000218615	0.0000199231	-0.0000115
24.0000	0.0000363165	0.0000224705	C.0000205214	-0.0000094
25.0000	0.0000371377	0.0000228946	C.0000210565	-0.0000079
26.0000	C.0000381047	0.0000235390	C.0000217583	-0.0000064
27.0000	0.0000390199	0.0000242334	0.0000223537	-0.000005E
28.0000	0.0000400237	0.0000250e3E	G.0000230269	-0.0000052
29.0000	0.0000412684	0.0000258034	C.0000236835	-0.0000049
30.0000	0.0000423530	0.0000264956	0.0000244092	-0.0000047
31.0000	0.0000437418	0.0000274218	C.0000252453	-0.0000044
32.0000	0.0000451495	0.0000284245	C.0000261823	-0.0000042
33.0000	0.0000470129	0.0000294835	C.0000271878	-0.0000040
34.0000	0.0000486159	0.0000305580	0.0000283033	-0.0000038
35.0000	0.0000510023	0.0000324262	C.0000297674	-0.0000036
36.0000	0.0000544181	0.0000349360	0.0000318742	-0.0000034
37.0000	0.0000617547	0.0000406851	0.0000359685	-0.0000032
38.0000	0.0000730774	0.0000476779	0.0000423996	-0.0000030
39.0000	0.0000830700	0.0000540435	0.0000480227	-0.0000028
40.0000	0.0000901469	0.0000588070	0.0000517504	-0.0000026
41.0000	0.0000953110	0.0000622014	C.0000541636	-0.0000024
42.0000	C.0000991074	0.0000645162	0.0000563568	-0.0000022
43.0000	0.0001029710	0.0000670357	G.0000585840	-0.0000020
44.0000	0.0001060591	0.0000690965	C.0000604466	-0.0000018
45.0000	0.0001090590	0.0000709e90	C.0000620078	-0.0000016
46.0000	0.0001120632	0.0000727919	0.0000637651	-0.0000014
47.0000	0.0001152435	0.0000746921	C.0000657357	-0.0000012
48.0000	0.0001181696	0.0000765475	G.0000679010	-0.0000010
49.0000	G.0001212229	0.0000785003	G.0000697566	-0.0000008
50.0000	0.0001242888	0.0000803130	0.0000721697	-0.0000006
51.0000	0.0001279027	0.0000823139	0.0000744212	-0.0000004
52.0000	0.0001312018	0.0000845594	C.0000767982	-0.0000002
53.0000	0.0001352057	0.0000868614	C.0000786114	-0.0000001

54.0000	0.0[illegible]2111	0.0000[illegible]723	[illegible]0C0C[illegible]13	-0.0000016
55.0000	0.[illegible]01431934	0.0000908279	.0000865959	-0.0000008
56.0000	0.0001475864	0.0000935064	0.0000896391	-0.0000007
57.0000	0.0001520836	0.0000959528	0.0000931007	-0.0000005
58.0000	0.0001556557	0.0000984862	0.0000967255	-0.0000003
59.0000	0.0001599696	0.0001008645	0.0001006619	-0.0000002
60.0000	0.0001636242	0.0001036360	0.0001055916	-0.0000000
61.0000	0.0001674493	0.0001063234	0.0001093911	0.0000000
62.0000	0.0001712926	0.0001089515	0.0001139939	0.0000002
63.0000	0.0001759144	0.0001116351	0.0001184010	0.0000004
64.0000	0.0001804812	0.0001139389	0.0001228280	0.0000006
65.0000	0.0001854171	0.0001168312	0.0001273081	0.0000009
66.0000	0.0001897237	0.0001198681	0.0001305438	0.0000012
67.0000	0.0001943767	0.0001236307	0.0001347541	0.0000017
68.0000	0.0001991257	0.0001266384	0.0001385609	0.0000025
69.0000	0.0002042394	0.0001302695	0.0001423528	0.0000036
70.0000	0.0002096224	0.0001335875	0.0001464086	0.0000047
71.0000	0.0002152158	0.0001377795	0.0001513642	0.0000057
72.0000	0.0002201937	0.0001406788	0.0001556020	0.0000067
73.0000	0.0002254053	0.0001446686	0.0001594999	0.0000076
74.0000	0.0002316638	0.0001486598	0.0001646039	0.0000083
75.0000	0.0002371676	0.0001524146	0.0001689261	0.0000089
76.0000	0.0002431331	0.0001556880	0.0001732660	0.0000095
77.0000	0.0002497201	0.0001599423	0.0001781289	0.0000101
78.0000	0.0002564164	0.0001643577	0.0001834165	0.0000107
79.0000	0.0002632263	0.0001691098	0.0001890660	0.0000114
80.0000	0.0002728368	0.0001749128	0.0001963395	0.0000126
81.0000	0.0002826490	0.0001810220	0.0002033284	0.0000128
82.0000	0.0002964873	0.0001911310	0.0002111578	0.0000136
83.0000	0.0003144502	0.0002033676	0.0002199315	0.0000151
84.0000	0.0003390945	0.0002190869	0.0002306007	0.0000165
85.0000	0.0003764977	0.0002450238	0.0002500787	0.0000181
86.0000	0.0004330993	0.0002829960	0.0002807505	0.0000223
87.0000	0.0006022413	0.0003958867	0.0003704334	0.0000406
88.0000	0.0009746531	0.0005829628	0.0005154652	0.0000753
89.0000	0.0010024015	0.0006668678	0.0005838092	0.0000946
90.0000	0.0010721035	0.0007140977	0.0006263086	0.0001061
91.0000	0.0011265214	0.0007506026	0.0006576739	0.0001161
92.0000	0.0011779153	0.0007856230	0.0006861812	0.0001253
93.0000	0.0012234695	0.0008155349	0.0007110817	0.0001327
94.0000	0.0012607755	0.0008414389	0.0007358133	0.0001400
95.0000	0.0013030332	0.0008704799	0.0007671033	0.0001503
96.0000	0.0013433116	0.0008952050	0.0007932637	0.0001600
97.0000	0.0014258066	0.0009515447	0.0008353190	0.0001722
98.0000	0.0015840221	0.0010589150	0.0009172775	0.0001911
99.0000	0.0019085926	0.0012688250	0.0010386256	0.0002253

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[illegible] ANALYSIS

Bogen/Smith Feb. 1986

COMPOUNDS: VCL, VOCL, DCE, BNZ, CLFM

STATIONS A,B,D, and F: Weighted Average Individual Risk

Weights:	A .25	A .25	
	B .25	E .40	
	D .25	C .15	
	F .25	F .20	
Percentile			Percentile
0.	0.	C.	0.0000
1.0000	0.0000119460	0.0000132483	1.0000
2.0000	0.0000156075	0.0000164325	2.0000
3.0000	0.0000179668	0.0000188621	3.0000
4.0000	0.0000207219	0.0000218173	4.0000
5.0000	0.0000223633	0.0000233e7	5.0000
6.0000	0.0000254948	0.0000257504	6.0000
7.0000	0.0000278966	0.0000282544	7.0000
8.0000	0.0000300740	0.0000308486	8.0000
9.0000	0.0000322668	0.0000336372	9.0000
10.0000	0.0000337775	0.0000356674	10.0000
11.0000	0.0000359101	0.0000379173	11.0000
12.0000	0.0000375922	0.0000397931	12.0000
13.0000	0.0000396047	0.0000413343	13.0000
14.0000	0.0000412700	0.0000429528	14.0000
15.0000	0.0000427910	0.0000444416	15.0000
16.0000	0.0000443832	0.0000459243	16.0000
17.0000	0.0000459137	0.0000477869	17.0000
18.0000	0.0000475331	0.0000492397	18.0000
19.0000	0.0000491222	0.0000507661	19.0000
20.0000	0.0000505528	0.0000523307	20.0000
21.0000	0.0000521641	0.0000538351	21.0000
22.0000	0.0000534101	0.0000553665	22.0000
23.0000	0.0000551213	0.0000570069	23.0000
24.0000	0.0000567850	0.0000584052	24.0000
25.0000	0.0000583104	0.0000600574	25.0000
26.0000	0.0000595291	0.0000615e65	26.0000
27.0000	0.0000609398	0.0000632521	27.0000
28.0000	0.0000624920	0.0000647120	28.0000
29.0000	0.0000639084	0.0000663750	29.0000
30.0000	0.0000652984	0.0000677963	30.0000
31.0000	0.0000666952	0.0000690913	31.0000
32.0000	0.0000681751	0.0000706720	32.0000
33.0000	0.0000695121	0.0000717976	33.0000
34.0000	0.0000706344	0.0000733206	34.0000
35.0000	0.0000721014	0.0000748485	35.0000
36.0000	0.0000733940	0.0000763210	36.0000
37.0000	0.0000746910	0.0000778514	37.0000
38.0000	0.0000763045	0.0000793699	38.0000
39.0000	0.0000777944	0.0000809702	39.0000
40.0000	0.0000792022	0.0000826075	40.0000
41.0000	0.0000809779	0.0000841434	41.0000
42.0000	0.0000826669	0.0000856116	42.0000
43.0000	0.0000843548	0.0000874245	43.0000
44.0000	0.0000860280	0.0000892e29	44.0000
45.0000	0.0000875945	0.0000909696	45.0000
46.0000	0.0000892188	0.0000927e60	46.0000
47.0000	0.0000912793	0.0000945362	47.0000
48.0000	0.0000933251	0.0000963741	48.0000

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49.0000	0.000[illegible]4158	0.0000980939	49.0000
50.0000	0.0000975545	0.0000999289	50.0000
51.0000	0.0002996262	0.0001021408	51.0000
52.0000	0.0001016491	0.0001046748	52.0000
53.0000	0.0001039926	0.0001071460	53.0000
54.0000	0.0001064349	0.0001097920	54.0000
55.0000	0.0001096245	0.0001126752	55.0000
56.0000	0.0001122482	0.0001150656	56.0000
57.0000	0.0001157567	0.0001176408	57.0000
58.0000	0.0001188060	0.0001207582	58.0000
59.0000	0.0001227197	0.0001234717	59.0000
60.0000	0.0001267467	0.0001271274	60.0000
61.0000	0.0001316333	0.0001309652	61.0000
62.0000	0.0001369030	0.0001349603	62.0000
63.0000	0.0001434428	0.0001390285	63.0000
64.0000	0.0001501922	0.0001438627	64.0000
65.0000	0.0001591538	0.0001485198	65.0000
6.0000	0.0001710379	0.0001543214	66.0000
67.0000	0.0001816358	0.0001592774	67.0000
68.0000	0.0001896090	0.0001641432	68.0000
69.0000	0.0001989361	0.0001704450	69.0000
70.0000	0.0002064036	0.0001776602	70.0000
71.0000	0.0002137381	0.0001852956	71.0000
72.0000	0.0002190300	0.0001941856	72.0000
73.0000	0.0002266648	0.0002053501	73.0000
74.0000	0.0002326950	0.0002179657	74.0000
75.0000	0.0002394111	0.0002308161	75.0000
76.0000	0.0002450625	0.0002499023	76.0000
77.0000	0.0002520022	0.0002657587	77.0000
78.0000	0.0002596123	0.0002859498	78.0000
79.0000	0.0002673615	0.0002999518	79.0000
80.0000	0.0002743790	0.0003112532	80.0000
81.0000	0.0002819232	0.0003220499	81.0000
82.0000	0.0002903360	0.0003327035	82.0000
83.0000	0.0002976524	0.0003409899	83.0000
84.0000	0.0003068053	0.0003483519	84.0000
85.0000	0.0003149464	0.0003574431	85.0000
86.0000	0.0003249839	0.0003657447	86.0000
87.0000	0.0003346745	0.0003751234	87.0000
88.0000	0.0003439268	0.0003841729	88.0000
89.0000	0.0003536567	0.0003944676	89.0000
90.0000	0.0003653216	0.0004060516	90.0000
91.0000	0.0003775376	0.0004197684	91.0000
92.0000	0.0003887416	0.0004345096	92.0000
93.0000	0.0004076859	0.0004516436	93.0000
94.0000	0.0004266342	0.0004724605	94.0000
95.0000	0.0004508652	0.0004960444	95.0000
96.0000	0.0004769169	0.0005232969	96.0000
97.0000	0.0005128299	0.0005591788	97.0000
98.0000	0.0005533487	0.0006160105	98.0000
99.0000	0.0006155258	0.0006927988	99.0000

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Bogen/Smith 2/10-13/88

COMPOUNDS: VCL, PCE, TCE, VDCL, DCE, BNZ, CLFM

Calculated Distributions of Individual Risk

Percentile	STATION A	STATION B	STATION C	STATION F
0.	0.	0.	C.	-0.000044100
1.0000	0.0000167416	C.00C0104513	C.00C0105567	-0.000038111
2.0000	0.0000201954	C.00C0125561	C.000012406o	-0.000032112
3.000C	0.0000225259	0.00C0139631	C.0000137900	-0.000026818
4.0000	C.0000242155	0.00C0148549	0.C00C147735	-0.000021879
5.0C0C	0.000025896l	0.CCC015c690	C.000015c949	-0.000017248
6.0000	0.0000271932	0.00C0164566	C.0000165174	-0.000013116
7.000C	C.0000283096	0.0C00171433	C.0000172849	-0.000008616
8.000C	0.0000295966	0.00C017E3e1	C.000018C432	-0.000004945
9.0C0C	0.0000307031	C.0CC0184297	C.00C0187433	-C.000003748
10.000C	0.0000316542	C.C0C0190747	C.0000193151	-0.000003176
11.000C	0.0000326966	0.C0C0197551	C.0000199449	-0.000002666
12.0000	0.0000338039	0.00C0202387	C.0000205678	-0.000002277
13.0000	0.0000346373	0.00CC207854	C.C000210972	-0.000001956
14.0000	0.0000355356	0.00C0213115	C.0000217091	-0.000001626
15.0000	0.0000363311	0.CCC021800l	C.00C0223280	-0.000001341
16.0000	0.0000370161	0.00C0222389	C.0000227976	-0.000001059
17.000C	0.0000378112	0.C0C0227703	C.0000233639	-0.000000724
18.0000	0.0000385936	0.0CC0232621	C.0000238953	-0.000000432
19.0000	0.0000393749	0.00C023e722	C.0000244075	-0.000000161
20.000C	0.0000401131	0.00C0241711	C.C00C249112	0.000000102
21.000C	0.0000409161	0.0CC024e785	C.00C0253937	C.000000372
22.000C	0.0000418816	C.00C0252247	C.00C02587C8	0.000000653
23.0000	0.0000428108	0.00CC258257	C.CCC0265080	0.000000916
24.0000	0.0000438087	0.00CC265473	C.0000272412	0.000001165
25.0000	0.0000445363	0.00CC27C885	C.00C02789c2	0.000001406
26.0000	0.0000454770	0.00C0277467	C.0000285023	0.000001636
27.0000	0.0000464649	0.00C0284356	C.00C0291974	0.000001873
28.000C	0.0000475088	0.00C0291322	C.0000298928	0.000002108
29.000C	0.0000486140	C.00C0296595	C.00C0305469	0.000002369
30.0000	0.0000497405	C.00CC3057e4	C.00C0313912	0.000002595
31.0000	0.0000513301	C.0000315582	C.0000323318	0.000002827
32.0000	0.0000527962	0.00C032e3C0	C.0000333016	0.000003107
33.000C	0.0000545322	0.00C0338427	C.0000345954	0.000003318
34.0000	C.0000565647	C.00C0351800	C.0000357623	0.000003614
35.0000	0.0000596773	0.00C0366202	C.0000375966	0.000003640
36.C000	C.0000643914	0.00C0397141	C.0000402446	C.000004097
37.0000	0.0000760322	0.00C0464039	C.0000447861	0.000004396
38.0000	0.0000915892	0.00C0579868	C.0000522974	0.000004637
39.0C0C	0.0000990680	0.00C06432E1	C.0000578410	0.000004940
40.0C0C	0.0001044989	0.00C0684469	C.00C0e13447	0.000005204
41.000C	C.0001090098	0.00C0715235	C.0000643256	0.000005536
42.0000	C.0001135631	C.00CC741705	C.C000670281	C.00000582
43.0000	0.0001166602	0.00C0767352	C.00C0691188	0.000006l5
44.0000	0.0001206058	C.00C0792412	C.00C0715299	0.00000652
45.0000	0.0001241229	0.00CC81e281	C.0000741565	0.00000668
46.C000	0.0001284115	C.C000844175	C.00C0769191	C.00000734
47.0000	0.0001323431	C.C0C0875623	C.0000802985	0.000007778
48.000C	0.0001368215	0.C0C09C3963	C.0000835524	C.0000084e
49.CC0C	0.0001420116	0.00C09370C7	C.0000878839	C.00000907
50.0000	C.0001484406	C.00C098C230	C.0000929224	0.00000964
51.0000	C.0001554685	0.00C1027172	0.0000967470	0.00001068
52.0C00	0.0001631516	C.00C10685e6	C.C001058147	0.00001147
53.0000	0.0001714261	0.C0C1112505	C.0001153716	0.00001232

54.0000	0.0001 3800	0.0001151393	0.[illegible]1254001	0.0000131966
55.0000	0.0001881400	0.0001[illegible]271	0.0001351193	0.0000140539
56.0000	0.0001967505	0.0001240139	0.0001430866	0.0000148532
57.0000	0.0002053009	0.0001291605	0.0001507263	0.0000155704
58.0000	0.0002127309	0.0001334420	0.0001572401	0.0000163612
59.0000	0.0002211341	0.0001383014	0.0001637301	0.0000170979
60.0000	0.0002291074	0.0001430019	0.0001705682	0.0000179092
61.0000	0.0002374263	0.0001474257	0.0001769954	0.0000186926
62.0000	0.0002460355	0.0001521993	0.0001830809	0.0000196838
63.0000	0.0002532971	0.0001565996	0.0001894262	0.0000207714
64.0000	0.0002604108	0.0001605321	0.0001961033	0.0000220924
65.0000	0.0002685594	0.0001647855	0.0002022586	0.0000236881
66.0000	0.0002754990	0.0001685263	0.0002082651	0.0000258823
67.0000	0.0002823051	0.0001726795	0.0002145035	0.0000282531
68.0000	0.0002890742	0.0001766196	0.0002197703	0.0000313247
69.0000	0.0002954087	0.0001810707	0.0002253651	0.0000354304
70.0000	0.0003035968	0.0001855113	0.0002309116	0.0000386657
71.0000	0.0003120290	0.0001894472	0.0002371761	0.0000421539
72.0000	0.0003188752	0.0001930911	0.0002419357	0.0000454371
73.0000	0.0003255634	0.0001975205	0.0002471573	0.0000487792
74.0000	0.0003337023	0.0002025943	0.0002538898	0.0000523578
75.0000	0.0003422117	0.0002076196	0.0002599254	0.0000554247
76.0000	0.0003491150	0.0002118553	0.0002654939	0.0000586852
77.0000	0.0003587085	0.0002168571	0.0002716460	0.0000620299
78.0000	0.0003672591	0.0002220305	0.0002784427	0.0000655260
79.0000	0.0003757695	0.0002278990	0.0002854810	0.0000689765
80.0000	0.0003869332	0.0002345239	0.0002941267	0.0000731710
81.0000	0.0003988601	0.0002425033	0.0003031442	0.0000773982
82.0000	0.0004160308	0.0002519356	0.0003141768	0.0000823501
83.0000	0.0004327652	0.0002603519	0.0003244769	0.0000861481
84.0000	0.0004527254	0.0002782873	0.0003377407	0.0000905731
85.0000	0.0004891809	0.0003004160	0.0003560954	0.0000960447
86.0000	0.0005543724	0.0003393321	0.0003845051	0.0001031195
87.0000	0.0007449347	0.0004478697	0.0004589469	0.0001117394
88.0000	0.0009677429	0.0006302872	0.0005836126	0.0001230126
89.0000	0.0010927630	0.0007125543	0.0006540236	0.0001365960
90.0000	0.0011622346	0.0007621924	0.0007014063	0.0001511233
91.0000	0.0012161905	0.0008010886	0.0007320404	0.0001658916
92.0000	0.0012656278	0.0008343418	0.0007656641	0.0001797781
93.0000	0.0013107589	0.0008637734	0.0007958769	0.0001928594
94.0000	0.0013481090	0.0008919118	0.0008218055	0.0002043543
95.0000	0.0013977059	0.0009262862	0.0008550131	0.0002171679
96.0000	0.0014431083	0.0009553564	0.0008847672	0.0002277545
97.0000	0.0015204839	0.0010077254	0.0009340050	0.0002429122
98.0000	0.0016660416	0.0011076273	0.0010001422	0.0002586257
99.0000	0.0018914242	0.0012574432	0.0011262981	0.0002881467

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Bogen/Smith Feb. 1988

COMPOUNDS: VCL, PCE, TCE, VDCL, DCE, BNZ, CLFM

STATIONS A,B,D, and F: Weighted Average Individual Risk

			(test)	(test)
Weights:	A .25	A .25	A .1	A .05
	B .25	E .40	B .1	B .05
	D .25	C .15	D .1	D .05
	F .25	F .20	F .7	F .85

Percentile				
0.	0.	0.	C.	-0.000016440(
1.0000	0.0000204584	0.00C0211545	C.00C0048512	-0.000009031
2.000C	0.0000242386	C.00C0246190	C.00C0087678	-0.000001627
3.0000	0.0000279106	C.00C0275176	C.00C0110357	0.000002743
4.000C	0.0000311852	0.0000304999	C.0000132008	0.000004900
5.0000	0.0000349727	0.00C0341969	0.0000155844	0.000006846
6.000C	0.0000378378	0.00C0381523	C.0000176491	0.000008081
7.000C	0.0000408607	0.00C0413655	C.0000194145	0.000009196
8.000C	0.0000437934	0.00C0443506	C.0000211199	0.000010248
9.0000	0.0000467385	0.00C0476923	C.00C0225700	0.000011389
10.000C	0.0000497234	C.00C0499340	C.0000239269	0.000012379
11.000C	0.0000524977	C.00C0524410	C.0000255765	C.000013360
12.0000	0.0000551247	C.00CC551983	0.0000267758	0.000014179
13.000C	0.0000582948	0.C0C0582593	C.C0C0279610	0.000015041
14.000C	0.C000608146	C.00CC60E122	C.0000293088	0.000015933
15.000C	0.C000633737	0.00CC628670	C.0000304310	0.000016753
16.000C	0.C000656121	0.C0CC653010	C.00C0318560	0.000017698
17.000C	0.00C0674726	0.00C0678034	C.0000330773	0.000018362
18.000C	0.0000695475	C.C0007CC922	C.0000343715	0.000019167
19.0000	0.C000719375	0.00C0719697	C.0000355260	0.000019893
20.000C	0.C000744198	0.00C0741635	0.00C0368745	0.000020576
21.0C0C	0.C000770200	0.00C0766476	C.0000379083	0.000021495
22.000C	0.0000794324	0.C0C07923E2	C.0000390427	0.000022083
23.000C	0.0000816143	C.00C0815102	C.00C0401178	0.000022844
24.000C	0.0000837869	0.00C0834925	C.0000414410	0.000023550
25.0000	0.0000857691	0.C0C0855734	0.0000426145	0.000024236
26.000C	0.0000876149	0.00C0875942	0.0000436528	0.000025141
27.000C	0.C000894127	0.00C0897765	C.0000446584	0.000025931
28.000C	0.C000914198	C.00C0918467	C.00C0458641	0.000026579
29.0000	0.0000935049	0.C0C0943213	C.0000472987	0.000027419
30.0000	C.0000953721	0.C0C0962963	C.0000487736	0.000028136
31.0000	0.0000977037	0.00C0983643	C.0000498835	C.000028886
32.0000	0.0000997545	C.00C1003667	0.0000510056	0.000029719
33.0000	0.0001019075	0.00C1026966	C.0000522020	0.000030649
34.000C	0.0001037152	C.00C1043956	C.0000536194	C.00003158
35.000C	0.C001058274	C.00C1065292	C.00C0548920	0.000032407
36.0C0C	0.0001078090	0.0001084594	C.0000560758	0.00003342
37.0C0C	0.0001097040	0.00C1106679	C.0000575096	C.00003456
38.0000	0.000111776C	0.00C112c516	C.0000590906	0.00003549
39.0000	0.C001136784	0.00C1145845	C.C0006065E0	0.00003664
40.000C	0.0001158186	C.00C1168656	C.00C0620599	0.00003773
41.0000	0.C001180233	C.00C1190925	C.0000636321	C.00003915
42.000C	0.0001203513	0.00C1209054	C.0000654171	0.00004035
43.0000	0.0001228854	C.00C1229395	C.0000671986	0.00004155
44.000C	0.C001252108	0.00C1252725	C.0000689713	0.00004282
45.000C	C.0001275451	0.00C1272ec5	C.00C07C7d90	0.00004437
46.000C	0.C001297198	C.00C1298E62	C.0000727128	0.00004557
47.0000	0.0001325839	0.0001324883	C.0000751161	0.00004736
48.000C	0.0001353098	0.00C1351530	C.0000773350	0.00004891

49.0000	0.[illegible]1378552	C.C0C1377227	.0000793015	C.00005046
50.0000	0.0001407559	C.0001400774	C.0000813439	0.00005207
51.0000	0.0001435693	C.0001427931	C.0000835467	C.00005369
52.0000	0.0001464524	C.0001452163	C.0000854501	0.00005505
53.0000	0.0001493753	C.0001483283	C.0000880011	C.00005654
54.0000	0.0001523748	C.0001506127	C.0000907375	0.00005837
55.0000	0.0001555732	C.0001546627	C.0000928356	0.00005978
56.0000	0.0001596615	0.0001575702	C.0000951295	C.00006126
57.0000	0.0001643265	0.0001612872	C.0000975491	C.00006280
58.0000	0.0001689505	C.0001644625	C.0001002750	C.00006447
59.0000	0.0001730946	C.0001684695	C.0001026761	0.00006627
60.0000	0.0001776716	0.0001723213	C.0001053664	0.00006797
61.0000	0.0001836000	C.0001764668	C.0001076213	C.00006954
62.0000	0.0001892681	0.0001806079	C.0001102704	0.00007118
63.0000	0.0001947449	0.0001853479	C.0001130905	0.00007294
64.0000	0.0002017037	0.0001895807	C.0001158360	C.00007457
65.0000	0.0002095510	C.0001941297	C.0001186579	C.00007663
66.0000	C.0002160812	C.0001996267	C.0001215133	0.00007835
67.0000	0.0002247096	0.0002056536	C.0001243998	0.00008006
68.0000	0.0002307941	C.0002109181	C.0001274853	C.00008165
69.0000	C.0002384554	0.0002172988	C.0001306388	0.00008366
70.0000	0.0002457089	0.0002246247	C.0001334368	0.00008568
71.0000	0.0002528513	0.0002332646	C.0001363476	0.00008778
72.0000	0.0002599996	C.0002420739	C.0001394772	0.00008956
73.0000	0.0002673251	0.0002552182	C.0001426068	0.00009252
74.0000	0.0002743479	0.0002667731	C.0001464428	C.00009471
75.0000	0.0002805328	0.0002807976	C.0001499200	0.00009738
76.0000	0.0002883072	0.0002967754	C.0001533030	0.00010005
77.0000	0.0002966641	0.0003116931	C.0001564815	0.00010316
78.0000	0.0003052506	0.0003275154	C.0001593584	0.00010583
79.0000	0.0003129182	0.0003374013	C.0001628595	0.00010894
80.0000	0.0003204447	0.0003459175	C.0001660865	0.00011245
81.0000	0.0003272209	0.0003627074	C.0001695919	0.00011652
82.0000	0.0003350463	0.0003710674	C.0001732141	0.00012060
83.0000	0.0003432883	0.0003807869	C.0001781006	0.00012479
84.0000	0.0003520433	C.0003905885	C.0001830363	0.00013015
85.0000	0.0003614785	0.0004001783	C.0001869070	0.00013556
86.0000	0.0003710391	0.0004096862	C.0001923460	C.00014155
87.0000	0.0003811896	0.0004183790	C.0001960053	0.00014762
88.0000	0.0003913370	0.0004295794	C.0002011726	C.00015439
89.0000	C.0004007554	0.0004421347	C.0002060741	C.00016091
90.0000	0.0004137709	0.0004544519	C.0002132248	C.00016929
91.0000	0.0004266316	0.0004664131	C.0002214344	0.00017823
92.0000	0.0004428630	0.0004833953	C.0002286343	0.00018657
93.0000	0.0004584003	0.0004998501	C.0002368908	0.00019626
94.0000	0.0004791230	C.0005183414	C.0002455478	C.00020700
95.0000	C.0005015589	C.0005425868	C.0002553466	C.00021815
96.0000	0.0005291854	C.0005745288	C.0002656395	C.00023136
97.0000	0.0005669994	0.0006124660	C.0002801838	0.00024610
98.0000	0.0006076190	0.0006667769	C.0003014875	C.00026437
99.0000	0.0006669510	0.0007551034	C.0003365391	C.00029707

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Table 2.3

Calculation of Increased Annual Carcinogenic Risk to Individuals for Comparative Purposes

Compound	EPA 95% UCL Potency[a] $(mg/kg/day)^{-1}$	Individual Dose[b] (mg/kg/day)	Annual Risk[c] ($\times 10^6$)
Vinyl Chloride	.0175	2.5×10^{-4}	.062
Perchloroethylene	.051	2.0×10^{-4}	.15
Trichloroethylene	.011	2.3×10^{-4}	.036
Vinylidene Chloride	1.16	1.1×10^{-4}	1.9
1,2-Dichloroethane	.091	1.9×10^{-4}	.25
Benzene	.029	9.4×10^{-5}	.039
Chloroform	.007	1.4×10^{-5}	.014
Total =			2.4

[a] EPA potency values are for lifetime exposure and are taken from the EPA's Health Assessment Document for Trichloroethylene (EPA 600/8-82/006F, July 1985) p. 9-133.

[b] Doses derived from "Mean" values presented in Table 2.1, multiplied by the factor (15/24)x(0.5)x(0.5) = 0.15625 to account for partial daily exposure, dilution and partial absorption, as explained in the text.

[c] Annual risk calculated using 70 years as human lifespan.

Table 2.4

Table of Comparative Cancer Risks

Daily Exposure Situation	Person at Risk[a]	Dose (mg/kg/day)	Individual Annual Risk ($\times 10^6$)
BKK Resident	Adult Youth	See Table 2.3 See Table 2.3	2.4 3.4
Drinking 2 liters of average U.S. tap water containing 88 ppb chloroform	Adult	2.45×10^{-3}	2.5
Swimming for 1 hr in a pool	Child	0.01	10
Eating a peanut butter sandwich containing 2 teaspoons of p. buttter @ 2 ppb aflatoxin B_1	Adult Child	0.914×10^{-6} 2.133×10^{-6}	38 88
Worker exposed to 50 ppm perchloroethylene for 8 hr. e.g., in a dry cleaning shop, for 5 days/week	Adult	32.3	~ 810,000
Worker exposed to 5 ppm vinylidene chloride for 8 hr. e.g., in an adhesive manufacturing plant, for 5 days/week	Adult	1.90	~ 890,000

[a] Exposure Assumptions: Adult weighs 70 kg and inhales 20 m^3 of air per day; Youth are aged 0-15 breathing a time-weighted average of 0.4143 m^3/kg/day (equivalent to 29 m^3 per 70 kg per day); and Child weighs 30 kg.

APPENDIX E

ANALYSIS OF VARIANCE OF THE DATA IN EPA AND DHS' 1984 EXTENDED MONITORING PROGRAM

Analysis of variance (ANOVA) is a statistical technique that isolates and assesses the contribution of one or more factors to an outcome of interest. Independent categorical variables (factors) are investigated for their influence on the dependent continuous random variable (outcome). Assumptions underlying ANOVA are: independence of the values, normality of the errors of the values, and equal variance for all observations. Two types of models used with ANOVA are the fixed effects model and the mixed effects model. In the fixed effects model there is one level of effect for each group f observations, and the assumption is that the difference is due to the fixed effect. In the random effects model, the effects are drawn from a prior distribution in which it is not possible to estimate the magnitude of the effects for one group of observations, but it is possible to estimate the overall variance. The mixed effects model contains both fixed and random effects.

For the data in EPA and DHS' 1984 Extended Monitoring Program (CH2MHill, 1988), the independent categorical variables were: "type" (Priority I homes/control home), "agent" (chemicals detected in the Priority I homes), and "sample date/calendar period"; the dependent random variable was "concentrations detected".

Three-way ANOVA was performed on the data in the program for the primary factor of interest, "type" (that is, whether or not there was a difference between the concentrations detected in the Priority I homes and the concentrations detected in the control home). The two other factors investigated to ensure that the difference was not due to their influence were "agent" (vinyl chloride, 1,1-dichloroethylene, 1,2-dichloroethane, 1,1,1-trichloroethane, perchloroethylene, trichloroethylene, and benzene) and "sample date". A mixed effects model was used, with agent and date as random effects. Analysis required log transformation of the values recorded in Volume 5 Appendix H-2. The table below shows that, in 3-way ANOVA, concentrations detected in the Priority I homes were significantly higher than concentrations detected in the control home ($p < 0.039$).

3-WAY MIXED EFFECTS ANALYSIS OF VARIANCE

PARAMETER	ESTIMATE	STANDARD DEVIATION	P VALUE
Error Variance	0.049	0.003	-
Constant	0.354	0.106	0.001
Type	0.053	0.026	0.039
Agent	0.072	0.039	-
Date	0.009	0.004	-

A 2-way fixed effects model ANOVA was also done to verify that the sample date did not affect the primary factor of interest, "type". The analysis was done separately for the early part of the month (calendar period October 1-14) and the later part of the month (calendar period October 15-29). The second factor in the analysis was "agent" (the six compounds detected in the Priority I homes). Benzene was omitted in the 2-way ANOVA because too few data points in the control home precluded its inclusion in the analysis. Values recorded in Volume 5 Appendix H-2 were log transformed for the analysis. The table below shows that, in 2-way ANOVA, concentrations detected in the Priority I homes were significantly higher than concentrations detected in the control home ($p < 0.006$).

2-WAY FIXED EFFECTS ANALYSIS OF VARIANCE
FOR ALL DATES COMBINED

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F VALUE	P VALUE
Agent	4.6203	5	0.9241	15.13	0.0000
Type	0.4713	1	0.4713	7.72	0.0057
Interaction	0.5490	5	0.1098	1.80	0.1117
Error	28.2087	462	0.0611		

DRAFT FOR PUBLIC COMMENT

Air Toxics Hot Spots Program Risk Assessment Guidelines:

PART I Evaluation of Acute Non-Cancer Health Effects

For Distribution by CMA
CHEMSTAR DIVISION
From H. Shah
Ref. No. VC Health Comm.
Date 3/17/95

December, 1994

Office of Environmental Health Hazard Assessment
California Environmental Protection Agency