RESULTS USING REVISED MODEL

We ran LeadSpread with various combinations of possible site-specific inputs to illustrate its responses to changes in key variables. The following tables illustrate some of these predictions. In each table, the non-default model inputs are highlighted. Poster 342 shows model response to stepwise changes in key input parameters.

TYPICAL CHILD

INPUTS					OUTPUTS			
Lead in soil (mg/kg)	Home-grown food (% diet)	Lead in water (µg/L)	Airborne Lead (µg/m³)	PM_{10} (µg/m³)	Blood lead (µg/dL) 95th percentile	Blood lead (µg/dL) 99th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 95th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 99th percentile
20	7%	15	0.028	1.5	3.8	5.2	247	146
1000	7%	15	0.028	1.5	30.6	42.3	247	146
20	0%	15	0.028	1.5	3.6	5.0	435	255
20	7%	5	0.028	1.5	2.4	3.3	298	197
20	7%	15	0.1	1.5	4.0	5.5	240	139
20	7%	15	0.028	50	3.8	5.2	246	145

PICA CHILD

INPUTS					OUTPUTS			
Lead in soil (mg/kg)	Home-grown food (% diet)	Lead in water (µg/L)	Airborne Lead (µg/m³)	PM_{10} (µg/m³)	Blood lead (µg/dL) 95th percentile	Blood lead (µg/dL) 99th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 95th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 99th percentile
20	7%	15	0.028	1.5	4.1	5.7	159	94
1000	7%	15	0.028	1.5	45.8	63.3	159	94
20	0%	15	0.028	1.5	3.9	5.4	218	128
20	7%	5	0.028	1.5	2.4	3.3	191	126
20	7%	15	0.1	1.5	4.3	5.9	154	89
20	7%	15	0.028	50	4.1	5.7	158	94

ADULT (RESIDENTIAL EXPOSURE)

INPUTS					OUTPUTS			
Lead in soil (mg/kg)	Home-grown food (% diet)	Lead in water (µg/L)	Airborne Lead (µg/m³)	PM_{10} (µg/m³)	Blood lead (µg/dL) 95th percentile	Blood lead (µg/dL) 99th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 95th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 99th percentile
20	7%	15	0.028	1.5	2.5	3.5	1062	676
1000	7%	15	0.028	1.5	9.6	13.2	1062	676
20	0%	15	0.028	1.5	2.5	3.4	3793	2407
20	7%	5	0.028	1.5	1.3	1.8	1230	844
20	7%	15	0.1	1.5	2.8	3.8	1026	640
20	7%	15	0.028	50	2.5	3.5	1037	660

ADULT (OCCUPATIONAL EXPOSURE)

INPUTS				OUTPUTS			
Lead in soil (mg/kg)	Lead in water (µg/L)	Airborne Lead (µg/m³)	PM_{10} (µg/m³)	Blood lead (µg/dL) 95th percentile	Blood lead (µg/dL) 99th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 95th percentile	Soil concentration (mg/kg) Corresponding to 10 µg/dL 99th percentile
20	15	0.028	1.5	2.4	3.3	5,452	3,468
1000	15	0.028	1.5	3.8	5.2	5,452	3,468
20	5	0.028	1.5	1.2	1.7	6,320	4,335
20	15	0.1	1.5	2.6	3.6	5,322	3,337
20	15	0.028	50	2.4	3.3	5,011	3,187

VALIDATION

We compared the revised LeadSpread predictions under baseline conditions (20 mg Pb/kg soil; 15 µg Pb/L drinking water) with National Health and Nutrition Examination Survey (NHANES III) regional survey data (USDHHS, 1996). The results, shown below, indicate reasonable agreement between LeadSpread predictions and NHANES III data for children 1-2 or 1-6 years of age living in post-1973 housing in the Western United States.

Indicator	Median Blood lead concentration (µg/dL)
LeadSpread with 20 mg Pb/kg soil and 15 µg Pb/L drinking water	1.7
NHANES III data for the Western United States:	
Children 1-6 years	2.2
Children 1-2 years	2.6
Children 1-6 living in post-1973 housing	1.7
Children 1-2 living in post-1973 housing	1.9

CONCLUSIONS

The California DTSC has revised its lead risk assessment spreadsheet model (LeadSpread) for predicting distributions of blood lead concentration in adults and in children 1-2 years old. The revised model predicts slightly lower blood lead concentrations with all parameters set at default values. Blood lead predictions using the revised version of LeadSpread agree reasonably well with NHANES III data for children 1-2 or 1-6 years of age living in post-1973 housing in the Western United States.

REFERENCES

Bolger, P. M., N.J. Yess, E.L. Gunderson, T.C. Troxell, and C. D. Carrington, 1996. Identification and Reduction of Sources of Dietary Lead in the United States, Food Additives and Contaminants 13: 53-60.

California Air Resource Board, Technical Support Division, 1999. California Air Quality Data for 1997.

Cowherd, C., G. Muleski, P. Englehart, and D. Gillette, 1985. Rapid Assessment of Exposure to Particulate Emission from Surface Contamination. EPA/600/8-85/002. (NTIS #PB85-1922197AS).

U.S. Department of Health and Human Services, 1996. National Health and Nutrition Examination Survey III, Phase 2.

U. S. Environmental Protection Agency, 1997. Exposure Factors Handbook.

U. S. Environmental Protection Agency, 1998. Guidance for Dermal Risk Assessment.

U.S. Food and Drug Administration, 1999. Personal Communication from M. Bolger.

U.S. Food and Drug Administration, 1995-97. Total Diet Study.

White, P.D., P. VanLeeuwen, B.D. Davis, M. Maddaloni, K.A. Hogan, A.H. Marcus, and R.W. Elias, 1998. Environ. Health Perspectives 106, Suppl. 6: 1513.

SAMPLE SPREADSHEETS

Although the basic equations remain essentially the same, version 7 of the spreadsheet, employs new formatting and layout. It also collapses multiple terms into "pathway exposure factors" (PEF), and removes embedded factors from equations, making them visible in dedicated cells. The two versions of the spreadsheet are compared below.

Leadspread Version 6

LEAD RISK ASSESSMENT SPREADSHEET
CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

INPUT

MEDIUM	LEVEL
LEAD IN AIR (ug/m^3)	0.12
LEAD IN SOIL (ug/g)	400.0
LEAD IN WATER (ug/l)	15
PLANT UPTAKE? 1=YES 0=NO	1
RESPIRABLE DUST (ug/m^3)	50

OUTPUT

	percentiles					PRG-90	PRG-95
	50th	90th	95th	98th	99th	(ug/g)	(ug/g)
BLOOD Pb, ADULT (ug/dl)	2.1	4.5	5.5	6.4	7.1	845.4	1254.0
BLOOD Pb, CHILD (ug/dl)	7.0	10.5	12.6	14.3	15.6	121.7	254.3
BLOOD Pb, PICA CHILD (ug/dl)	27.7	42.4	41.2	55.5	62.6	11.8	31.5
BLOOD Pb, INDUSTRIAL (ug/dl)	2.2	3.4	4.5	4.5	4.5	4203.1	6241.1

EXPOSURE PARAMETERS

	units	residential adults	residential children	residential children with pica	industrial adults
General					
Days per week	days/wk	7	7	7	5
Dermal Contact					
Skin area	cm^2	3700	2800	2800	5800
Soil adherence	mg/cm^2	0.5	0.5	0.5	0.5
Route-specific constant	(ug/dl)/(ug/day)	0.00011	0.00011	0.00011	0.00011
Soil Ingestion					
Soil ingestion	mg/day	25	55	790	25
Route-specific constant	(ug/dl)/(ug/day)	0.0176	0.0704	0.0704	0.0176
Inhalation					
Breathing rate	m^3/day	20	10	10	20
Route-specific constant	(ug/dl)/(ug/day)	0.082	0.192	0.192	0.082
Water Ingestion					
Water ingestion	l/day	1.4	0.4	0.4	1.4
Route-specific constant	(ug/dl)/(ug/day)	0.04	0.16	0.16	0.04
Food Ingestion					
Food ingestion	kg/day	2.2	1.3	1.3	2.2
Route-specific constant	(ug/dl)/(ug/day)	0.04	0.16	0.16	0.04
Dietary concentration	ug/kg	15.4	15.4	15.4	15.0
Lead in produce	ug/kg	180.0	180.0	180.0	

PATHWAYS, ADULTS

Pathway	Residential Blood Pb ug/dl	Residential percent of total	Industrial Blood Pb ug/dl	Industrial percent of total	Concentration in medium
SOIL CONTACT:	0.05	3%	0.08	4%	400 ug/g
SOIL INGESTION:	0.18	6%	0.13	6%	400 ug/g
INHALATION:	0.33	10%	0.22	11%	0.20 ug/m^3
WATER INGESTION:	0.84	27%	0.84	39%	15 ug/l
FOOD INGESTION:	1.70	54%	0.85	41%	15.4 ug Pb/kg diet

PATHWAYS, CHILDREN

Pathway	Typical Blood Pb ug/dl	Typical percent of total	with pica Blood Pb ug/dl	with pica percent of total	Concentration in medium
SOIL CONTACT:	0.06	1%	0.06	0%	400 ug/g
SOIL INGESTION:	1.55	22%	22.25	80%	400 ug/g
INHALATION:	0.35	5%	0.35	1%	0.20 ug/m^3
WATER INGESTION:	0.96	14%	0.96	3%	15 ug/l
FOOD INGESTION:	4.02	58%	4.02	15%	18.4 ug Pb/kg diet

LeadSpread Version 7

LEAD RISK ASSESSMENT SPREADSHEET
CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

USER'S GUIDE to version 7

INPUT

MEDIUM	LEVEL
Lead in Air (µg/m³)	0.028
Lead in Soil/Dust (µg/g)	20.0
Lead in Water (µg/l)	15
% Home-grown Produce	7%
Respirable Dust (µg/m³)	1.5

OUTPUT

	Percentile Estimate of Blood Pb (µg/dl)					PRG-99	PRG-95
	50th	90th	95th	98th	99th	(µg/g)	(µg/g)
Blood Pb, adult	1.2	2.1	2.5	3.1	3.5	676	1083
Blood Pb, child	1.8	3.2	3.8	4.6	5.2	146	247
Blood Pb, pica child	1.9	3.5	4.1	5.0	5.7	94	159
Blood Pb, occupational adult	1.1	2.0	2.4	2.9	3.3	3475	5464

EXPOSURE PARAMETERS

	units	adults	children
Days per week	days/wk	7	
Days per week, occupational		5	
Geometric Standard Deviation		1.6	
Blood lead level of concern (µg/dl)		10	
Skin area, residential	cm²	5700	2900
Skin area occupational	cm²	2800	
Soil adherence	µg/cm²	70	200
Dermal uptake constant	(µg/dl)/(µg/day)	0.0001	
Soil ingestion	mg/day	50	100
Soil ingestion, pica	mg/day		200
Ingestion constant	(µg/dl)/(µg/day)	0.04	0.16
Bioavailability	unitless	0.44	
Breathing rate	m³/day	20	6.8
Inhalation constant	(µg/dl)/(µg/day)	0.08	0.192
Water ingestion	l/day	1.4	0.4
Food ingestion	kg/day	1.9	1.1
Lead in market basket	µg/kg	3.1	
Pb in home-grown produce	µg/kg	8.0	

PATHWAYS

ADULTS	Residential			Occupational		
	Pathway contribution			Pathway contribution		
Pathway	PEF	µg/dl	percent	PEF	µg/dl	percent
Soil Contact	3.8E-5	0.00	0%	1.4E-5	0.00	0%
Soil Ingestion	8.8E-4	0.02	2%	6.3E-4	0.01	1%
Inhalation, bkgrnd		0.05	4%		0.03	3%
Inhalation	2.5E-6	0.00	0%	1.8E-6	0.00	0%
Water Ingestion		0.84	72%		0.84	75%
Food Ingestion, bkgrnd		0.22	19%		0.23	21%
Food Ingestion	2.4E-3	0.05	4%			0%

CHILDREN	typical			with pica		
	Pathway contribution			Pathway contribution		
Pathway	PEF	µg/dl	percent	PEF	µg/dl	percent
Soil Contact	5.6E-5	0.00	0%		0.00	0%
Soil Ingestion	7.0E-3	0.14	8%	1.4E-2	0.26	15%
Inhalation	2.0E-6	0.00	0%		0.00	0%
Inhalation, bkgrnd		0.04	2%		0.04	2%
Water Ingestion		0.96	55%		0.96	51%
Food Ingestion, bkgrnd		0.50	28%		0.50	27%

12

PROGRAM IN ARSENIC HEALTH EFFECTS RESEARCH

School of Public Health and

Center for Occupational and Environmental Health

University of California, Berkeley

Program Director

Allan H Smith, MD, PhD, Professor of Epidemiology, ahsmith@uclink4.berkeley.edu

Research Team

Mary Lou Biggs, MPH, Research Associate, mlbiggs@u.washington.edu
Rajiv Bhatia, MD, MPH, Research Associate, rajiv_bhatia@dph.sf.ca.us
Joyce Chung, MPH, Doctoral Student in Epidemiology, jochung@uclink4.berkeley.edu
Reina Haque, MPH, Ph.D. Candidate, rhaque@socrates.berkeley.edu
Alexandra Hernandez, BA, Graduate Student Researcher, halexa@uclink4.berkeley.edu
Claudia Hopenhayn-Rich, PhD, Research Associate, cmhope0@pop.uky.edu
Peggy Lopipero, MPH, Research Associate, plopipero@earthlink.net
Lee Moore PhD, MPH Research Fellow, lmoore@cc.uscf.edu
Sandra Nuñez, BA, Research Associate, nunez@uclink4.berkeley.edu
Craig Steinmaus, MD, MPH, Research Associate, kingboho@pol.net

Co-Investigators at University of California, Berkeley

Gladys Block, PhD, Professor of Epidemiology and Public Health Nutrition
Steve Selvin, PhD, Professor of Biostatistics
Martyn Smith, PhD, Professor of Environmental Toxicology; Director, NIEHS Superfund Basic Research Program at the University of California, Berkeley

Collaborating Institutions and Research Scientists: (see page 3)

Mailing Address

School of Public Health
Division of Environmental Health Sciences
University of California, Berkeley
140 Warren Hall
Berkeley, California 94720-7360

Telephone: (510) 843-1736
Fax: (510) 843-5539

CONTENTS

I. INTRODUCTION

The purpose of this document is to present the Program in Arsenic Health Effects Research based at the University of California, Berkeley. These research activities began nearly ten years ago with a risk assessment for arsenic in drinking water. The realization that potential risks were high led to a program of arsenic research, including epidemiologic studies of various designs which are being undertaken among exposed populations in several countries.

II. MAJOR ACCOMPLISHMENTS

- Provided definitive evidence (from studies conducted in Argentina and Chile) that arsenic is a potent cause of human bladder cancer.
- Provided definitive evidence (from studies conducted in Argentina and Chile) that arsenic is a potent cause of human lung cancer.
- Demonstrated results which indicate that epidemiological and experimental human data do not support the methylation hypothesis.
- Showed that with exposure to water containing around 600 μg/L, 1 in 10 adult cancer deaths may be due to arsenic-caused cancers, the highest environmental cancer risk ever reported.
- Identified a dose-response relationship between arsenic exposure and bladder cell micronuclei, a genotoxic marker of effect.
- Identified a preliminary dose-response relationship between arsenic concentration in well water in India and the occurrence of keratoses and hyperpigmentation.
- Studies currently underway in India, Chile and the US, will allow projection of cancer risks with individual exposure data.

III. COLLABORATING INSTITUTIONS AND RESEARCH SCIENTISTS

United States

University of Washington, Seattle. *Professor David A. Kalman*, Director, Environmental Health Laboratory and Trace Organics Analysis Center, Department of Environmental Health.

University of California, San Francisco. *Professor Frederic Waldman*, Department of Laboratory Medicine, Division of Molecular Cytometry, and *Professor John K. Wiencke*, Department of Epidemiology and Biostatistics.

University of Colorado, Denver. *Professor Michael J. Kosnett*, Division of Clinical Pharmacology and Toxicology, Health Sciences Center.

Chile

Instituto de Salud Pública, Santiago, Chile. Ing. *Nella Marchetti*, Depto. de Salud Ocupacional y Contaminación Ambiental (currently at the Comisión Nacional del Medio Ambiente).

Dra. Catterina Ferreccio, Universidad Catolica, Santiago, Chile.

Servicio de Salud Antofagasta, Chile. *Dr. Mario Goycolea Chaparro and Dr. Alex Arroyo Meneses* (currently Secretario Regional del Ministerio de Salud in Region II).

Argentina

Universidad Católica de Córdoba, *Professor Ruben Sambuelli, Dean Esteban Trakal*.

Dr. Omar Rey, Pathologist, Villa María; *Dr. Luis Sotelo*, Pathologist, Bell Ville; *Ing. Celia Loza*, Soil Chemist, Belle Ville, Cordoba, Argentina.

Dr. Analia Fuchs, Centro de Investigaciones Epidemiológicas, Academia Nacional de Medicina, Buenos Aires; *Dr. Remo Bergoglio*, Universidad Nacional de Córdoba and Academia de Ciencias Médicas de Córdoba, Córdoba; *Dr. Enrique E. Tello*, Universidad Nacional de Córdoba, Facultad de Ciencas Médicas, Córdoba; *Dr. Hugo Nicolli*, Instituto de Geoquímica, BuenosAires

India

Institute of Post Graduate Medical Education and Research, Calcutta, India. Dr. *D.N. Guha Mazumder, Dr. Nilima Gosh, Dr. Binoy K. De, Dr. Amal Santra.*

IV. FUNDING SOURCES

The main source of funding, which initiated the research program, has been the National Institute of Environmental Health Sciences (NIEHS) Superfund Basic Research Program at the University of California, Berkeley (Professor Martyn Smith, Director). NIEHS has funded the completed projects in Nevada and Chile and is currently funding the Argentina projects, No. P42-ES04705.

Seed funding for several projects has been provided through the NIEHS Center at Berkeley (Professor Bruce Ames, Director). No. P30-ES01896.

The initial risk assessment project was supported by the California Department of Health Services (Now the California Environmental Protection Agency or Cal/EPA).

The Nevada/California bladder cancer case-control study is funded by NIEHS Grant No: ES07459.

The planning of low exposure epidemiological studies was funded by the American Water Works Association Research Foundation (AWWARF).

The collaborative work with the Post Graduate Medical Institute in analysis of the cross-sectional study of arsenic-caused skin lesions was supported in part by the U.S. Environmental Protection Agency (EPA) National Center for Environmental Assessment.

The Dose-Response Study of Arsenic-Caused Skin Lesions in West Bengal, India, is funded by the U.S. EPA, No. R-826137-01-0.

The first planning of the Nevada/California bladder cancer case-control study was funded by a grant from the U.S. EPA.

Support for several students who worked on these projects was received from the Health Effects Component of the University of California Toxic Substances Teaching and Research Program.

Dr. Lee Moore has been supported by a research fellowship from the National Institute of Health (NIH) and the American Cancer Society.

The Center for Occupational and Environmental Health (COEH), University of California, Berkeley, provides salary support for Professors Allan Smith and Martyn Smith. COEH has also provided seed funding for early projects.

IV. CURRENT RESEARCH PROJECTS

1. Bladder cancer case-control study in Córdoba, Argentina

This study is in progress with an office and staff based in Villa María, Córdoba. The study is defined by 3 major components; 1) Arsenic and bladder cancer dose-response: Bladder cancer cases and age-sex matched population controls from the County of Unión are being interviewed in detail including lifelong residential histories, sources of drinking water and smoking histories. Water samples are being collected from both the current residences and previous residences where possible. Historical data on arsenic measurements in public water supplies are also being collected. We will conduct dose-response analyses incorporating individual exposure data, and examine the possible synergistic effect of cigarette smoking. 2) Metabolism: First-morning urine samples are being collected from cases and controls. Analysis of inorganic arsenic and its methlyated metabolites will be conducted in the laboratory of Professor David Kalman, University of Washington. Cases and controls will be compared to see if they differ in arsenic methylation patterns. 3) Molecular epidemiology: Tumor DNA is being analyzed for genetic alterations using a three-tiered approach: First, screening of the entire genome for gains and losses using comparative genomic hybridization (CGH); Second, specific analyses of chromosomes 9 and 17p for loss of heterozygosity using PCR-based methods; Third, analysis of the p53 gene for mutations using polymerase chain reaction-single-strand conformation (PCR-SSCP). The frequency and pattern of these genetic alterations in bladder tumors of arsenic exposed and unexposed cases is being compared, and the potential synergistic action of arsenic on genotoxic effects of cigarette smoking is being assessed. In addition, susceptibility differences between cases and controls is being investigated by identifying the presence or absence of the glutathione S-transferases GSTM1 and GSTT1 null genotypes in buccal cells and by comparing urinary arsenic methylation patterns.

2. Bladder cancer case-control study in Nevada and California

The California/Nevada bladder cancer study is a population-based, case-control study that will examine the hypothesis that bladder cancer is caused by ingestion of arsenic in drinking water at relatively low concentrations. The study population includes residents of Kings County in California, and six counties in Nevada (Churchill, Mineral, Lyon, Douglas, Storey and Carson). These counties were chosen because they include water supplies containing close to 100 µg/L of arsenic, the highest level of arsenic found in major water supplies in the U.S.. Other water supplies in the study region contain less than 10 µg/L and thus provide a marked contrast in exposure. Two hundred bladder cancer cases diagnosed between 1994 and 2000 will be identified from the California and Nevada Tumor Registries. Random digit dial (RDD) will be used to identify 400 controls who will be frequency matched to cases by sex and 5-year age groups. Structured personal telephone interviews will be administered to obtain lifetime residential history and detailed information on current and past water consumption patterns. Information will also be obtained regarding cigarette smoking (which may be synergistic with arsenic in causing bladder cancer), chlorination of drinking water, diet, and occupational history. Although carcinogenicity of arsenic at 100 µg/L is uncertain, this study has over 90% statistical power to detect a relative risk of 2.0 which was predicted by linear extrapolation of data from studies in Taiwan.

3. Argentina mortality study

Mortality from internal cancers was identified in areas of the Province of Córdoba, Argentina, which in the past had high levels of arsenic in drinking water. The results concerning bladder cancer have been published (see publication 15). The analyses concerning mortality from other cancers is completed and a manuscript describing the results has been published (see publication 26). Increased rates of kidney and lung cancer were found in the exposed areas, as were the already reported increases in bladder cancer.

4. Dose-response study of arsenic-caused skin lesions in West Bengal, India

Research is being conducted in collaboration with Professor D.N. Guha Mazumder and his research team at the Institute of Post Graduate Education and Research (IPGMER) in Calcutta, India. Our group collaborated with the analysis of data from a large cross-sectional survey of about 7000 people in an arsenic-exposed region in West Bengal. The dose-response analysis linking cases of skin keratoses and hyperpigmentation to arsenic water levels has been recently published (see publication 27). The next phase is a case-control study nested in the same survey, which focuses on participants with skin lesions who had drinking water arsenic levels of less than 500 µg/L. Detailed interviews concerning water sources and fluid consumption, diet, smoking and medical history are being completed for each participant. Water samples are obtained from all drinking water sources. Each participant receives a physical examination for skin lesions and other signs, portable spirometry, and blood and urine samples are obtained to assess micronutrients and arsenic metabolism. The study is funded by the U.S. EPA.

V. RESEARCH PUBLICATIONS WITH SUMMARIES OF KEY FINDINGS

1. Frost F, Harter L, Milham S, Royce R, Smith AH, Hartley J, Enterline P. Lung cancer among women residing close to an arsenic-emitting copper smelter. Arch Env Health **42:148-52, 1987.**

Lung cancer mortality. This project was conducted with the Chronic Disease Epidemiology Section of the Washington State Division of Health. Overall lung cancer mortality rates were not increased among women living near the smelter. However, case-control analysis using an index of exposure based on distance of residence from the smelter showed increasing lung cancer odds ratios from 1 up to 1.6 for those in the highest quintile of potential exposure. The results are consistent with a small elevated lung cancer risk for women who resided close to the smelter for a period of over 20 years. (Note: There is an error in Table 6 - the lines for cases and controls are transposed).

2. Hertz-Picciotto I, Smith AH, Holzman D, Lipsett M, Alexeef G. Synergism between occupational arsenic exposure and smoking in the induction of lung cancer. Epidemiol 3:23-31, 1992.

Synergy. Data were assembled from epidemiological studies concerning inhalation of inorganic arsenic and cigarette smoking. It was concluded that the evidence for synergism between the two exposures was compelling. Various potential mechanisms for synergy were discussed.

3. Smith AH, Hopenhayn-Rich C, Bates MN, Goeden HM, Hertz-Picciotto I, Duggan HM, Wood R, Smith MT, Kosnett MJ. Cancer risks from arsenic in drinking water. Env Health Persp 97:259-67, 1992.

Risk assessment. Evidence that ingestion of inorganic arsenic in drinking water might cause bladder, kidney, lung and liver cancer was examined, and potential cancer risks were calculated for various levels of exposure. It was estimated that at the current standard of 50μg/L, the lifetime risk of dying from one of these cancers could be as high as 13 per 1000 persons. It was noted that existing studies did not support a threshold based on arsenic methylation. It was concluded that although further research was needed to validate the findings of the risk assessment, measures should be taken to reduce arsenic levels in drin king water.

4. Bates MN, Smith AH, Hopenhayn-Rich C. Arsenic ingestion and internal cancers: a review. Am J Epidemiol 135:462-76, 1992.

Internal cancers. A detailed review of epidemiological studies concerning arsenic ingestion and internal cancers was presented. The most informative studies were from Taiwan and it was concluded that these and other studies strongly suggest that ingested inorganic arsenic does cause cancers of the bladder, kidney, lung and liver, and possibly other sites.

5. Hopenhayn-Rich C, Smith AH, Goeden H. Human studies do not support the methylation threshold hypothesis for the toxicity of inorganic arsenic. Env Res 60:161-77, 1993.

Metabolism. The validity of the methylation threshold hypothesis was examined on the basis of published studies. The results indicated that epidemiological and experimental human data does not support the inorganic arsenic methylation threshold hypothesis. Regardless of the absorbed dose of inorganic arsenic, there was always some unmethylated inorganic arsenic present in the urine, even at background exposure levels. It was noted that lack of evidence for a methylation threshold based on the human exposure levels studied did not exclude the possibility of other threshold mechanisms. In addition, the considerable variation in methylation of inorganic arsenic observed between individuals was noted to warrant further study.

6. Hertz-Picciotto I, Smith AH. Observations on the dose-response curve for arsenic exposure and lung cancer. Scand J Work Env Health 19: 217-26, 1993.

Lung cancer dose-response. Information from published studies concerning arsenic inhalation and lung cancer risks was analyzed. It was found that all of the studies with quantitative data were consistent with a supralinear dose-response relationship. Various factors which might be distorting the true biological dose-response were assessed. These included the fact that the workers thought to be most highly exposed might actually have had lower exposures than previously quantified by air sampling as a result of non-random sampling and the possible use of respirators when air levels were highest. It was noted that there was a linear dose-response relationship in one study, which used urine arsenic measurements to assess exposure.

7. Smith AH, Hopenhayn-Rich C, Warner M, Biggs ML, Moore L, Smith MT. Rationale for selecting exfoliated bladder cells micronuclei as potential biomarkers for arsenic genotoxicity. J Toxicol Env Health 40: 223-34, 1993.

Molecular epidemiology. Biological markers of effect of toxic human exposures have the potential to allow exploration of dose-response relationships at levels of exposure lower than those which can be assessed by traditional epidemiological studies involving the ultimate disease end-point. In this paper we give reasons for proposing that exfoliated bladder cell micronuclei might be a good marker for carcinogenic effects of ingestion of inorganic arsenic. Based on studies in Taiwan, it was noted that the highest internal cancer relative risks involved bladder cancer. Bladder cells can be collected from urine, and originate from a target organ of particular importance for arsenic effects. We described several studies from our group, which used bladder cell micronuclei as biomarkers, noting the important potential contribution of intervention studies incorporating cessation of exposure.

8. Warner M, Moore L, Smith MT, Kalman D, Fanning E, Smith AH. Increased micronuclei in exfoliated bladder cells of persons who chronically ingest arsenic contaminated water in Nevada. Cancer Epidemiol Biom & Prev 3:583-90, 1994.

Molecular epidemiology. This study involved 18 subjects in Nevada whose well water contained on average 1312 μg/L of arsenic, and 18 age and sex matched controls whose well water averaged 16 μg/L. Exposed subjects had a 1.8 fold increase in bladder cell micronuclei, but the differences were largely confined to males. The absence of findings for females was thought to be due to the fact that women exfoliate large numbers of cells into urine, while men exfoliate predominantly transitional cells, which are the cells involved in bladder cancer. No increase was found in buccal cell micronuclei among the arsenic exposed group.

9. Engel RR, Hopenhayn-Rich C, Receveur O, Smith AH. Vascular effects of chronic arsenic exposure: a review. Epidemiol Rev 16:184-209, 1994.

Vascular disease. Existing literature concerning vascular effects from chronic exposure to inorganic arsenic was reviewed in this publication containing 177 citations. It was concluded that there was good epidemiologic evidence indicating that chronic arsenic consumption at high levels is a cause of severe peripheral vascular disease with resulting gangrene and amputations of the limbs. We hypothesized that marginal zinc status might explain the differential occurrence of these conditions in populations ingesting large doses of arsenic. It was also concluded that it was plausible, though epidemiologic evidence is limited, that arsenic might cause increases in vascular mortality beyond that found in patients with severe peripheral vascular disease.

10. Engel RR, Smith AH. Arsenic in drinking water and mortality from vascular disease: an ecologic analysis in 30 U.S. counties. Arch Environ Hlth 49: 418-27, 1994.

Vascular disease. An investigation was made of the ecological relationship between arsenic concentrations in drinking water and mortality from circulatory disease in 30 U.S. counties from 1968 to 1984. Mean arsenic levels ranged from 5.4 to 91.5 μg/L. The standardized mortality ratios (SMRs) for diseases of arteries, arterioles, and capillaries for counties exceeding 20 μg/L were 1.9 (90% CI 1.7-2.1) for females and 1.6 (CI 1.5-1.8) for men. The SMRs for congenital anomalies of the heart and circulatory system were also elevated. Possible problems with the ecological study design and explanations for potentially spurious results were discussed. It was concluded that further investigation of vascular effects of arsenic exposure was warranted.

11. **Smith AH, Hopenhayn-Rich C, Biggs ML, Moore L, Dale J, Warner M, Bates M, Engel R. Epidemiological study designs to address potential high bladder cancer risks from arsenic in drinking water. In: Chappell WR, Abernathy CO, Cothern CR, eds. Arsenic: Exposure and Health. Northwood: Science and Technology Letters, 109-17, 1994.**

Epidemiological study designs. Various study designs were described which could be used to further investigate effects of arsenic ingestion from drinking water, including ecological studies, cohort studies, and biomarker studies. It was noted that small biomarker studies could be conducted relatively rapidly, and that the effect of interventions could be assessed for biomarkers in cells with short half-lives. However, interpretation of biomarker studies is difficult, consequently, traditional epidemiological study designs have an important role. It was concluded that the potential risks of bladder cancer from ingesting inorganic arsenic in drinking water warranted a concerted epidemiological approach using a variety of different study designs.

12. **Bates MN, Smith AH, Cantor KP. Case-control study of bladder cancer and arsenic in drinking water. Am J Epidemiol 141: 523-30, 1995.**

Bladder cancer. Cases and controls from the National Bladder Cancer Study were used in this project, which was conducted in collaboration with Dr. Ken Cantor of the National Cancer Institute. Information concerning arsenic levels in drinking water was added to this dataset for respondents from Utah. Water levels ranged from 0.5 to 160 μg/L, but only three towns were served with water containing over 20 μg/L of arsenic. There was no overall association of inorganic arsenic with the risk of bladder cancer at these levels of exposure. However, among cigarette smokers, time window analysis yielded some evidence for a dose-response relationship for exposure to arsenic in drinking water 10-39 years prior to diagnosis with bladder cancer. The possibility was raised that smoking potentiates the effect of arsenic in causing bladder cancer. However, the discrepancy between these findings at such low exposure levels, and predictions based on studies in Taiwan and England, also raised the possibility of bias in the data. It was concluded that further carefully conducted studies in exposed populations were needed.

13. **Smith AH, Hopenhayn-Rich C, Biggs ML, Kalman D. Re: Arsenic risk assessment (letter). Env Health Persp 103:13-15, 1995.**

Risk assessment. Heather Carlson-Lynch, Barbara Beck and Pamela Boardman of McLaren/Hart Environmental Engineering Corporation and Gradient Corporation wrote a letter which was highly critical of two of our published studies (Hopenhayn-Rich et al, 1993, and Smith et al, 1992, above). In the letter to the editor, we demonstrated that none of the criticisms raised was valid.

14. Moore L, Smith AH, Hopenhayn-Rich C, Biggs ML, Warner ML, Kalman D, Smith MT. Increased bladder cell micronuclei found in two populations environmentally exposed to arsenic in drinking water. Clin Chem 41:1915-17, 1995.

Molecular epidemiology. Summary findings from the Nevada bladder cell micronucleus study, with preliminary results from the Chile study, were reported. It was concluded that results from both the North and South American studies provided evidence that arsenic is genotoxic to human bladder epithelium. Further details are given in Warner et al, 1994 (publication 13) and Moore et al. 1997 (publication 15).

15. Hopenhayn-Rich C, Biggs ML, Fuchs A, Bergoglio R, Tello E, Nicolli H, Smith AH. Bladder cancer mortality associated with arsenic in drinking water in Argentina. Epidemiol. 7:117-124, 1996.

Bladder cancer. Bladder cancer mortality for the years 1986-1991 was investigated in Córdoba, Argentina in an ecological study comparing counties categorized as previously having high, medium and low water levels of arsenic. The average water arsenic level in the two high exposure counties for arsenic contaminated water sources was 178 µg/L. Clear trends in bladder cancer mortality were shown up to standardized mortality ratios (SMRs) of 2.14 for men (95% CI 1.78-2.53) and 1.82 for women (95% CI 1.19-2.64) in the two high exposure counties. The clear trends found in a population with a different ethnic composition and a high protein diet support the evidence from Taiwan that arsenic in drinking water is a cause of human bladder cancer. While it was made clear that exposure was not uniform within counties, it was noted the findings were roughly consistent with risks which might be predicted from the Taiwan studies.

16. Hopenhayn-Rich C, Biggs ML, Fuchs A, Bergoglio R, Tello E, Nicolli H, Smith AH. Arsenic and bladder cancer mortality. The Authors Reply. Epidemiol 7:557-58, 1996.

Bladder cancer. Kenneth G. Brown and Barbara D. Beck wrote a letter critical of the above study in which we were accused of making incorrect assumptions, errors and unwarranted conclusions. In this reply, we noted that we were surprised by their accusations of errors that did not, indeed, exist. However, we agreed with their statement, "the study does affirm the association of high concentrations of inorganic arsenic with increased mortality from bladder cancer, in this instance among the ethnically mixed Córdoba population, in the absence of nutritional deficiency or evidence of other substances such as humic or fluorescent substances".

17. Moore L, Warner ML, Smith AH, Kalman D, Smith MT. Use of the fluorescent micronucleus assay to detect the genotoxic effects of radiation and arsenic in human exfoliated epithelial cells. Env and Molecular Mutagen 27:176-84, 1996.

Molecular epidemiology. A new rapid method was used, which involves fluorescent in situ hybridization (FISH) to determine the mechanism of micronucleus formation in epithelial tissues exposed to carcinogenic agents (as previously described in Titenko-Holland N, Moore LE, Smith MT. Measurement and characterization of micronuclei in exfoliated human cells by fluorescence in situ hybridization with a centromeric probe. Mutat Res 271:69-77, 1992.) The findings concerning micronuclei in exfoliated bladder cells obtained from arsenic-exposed subjects in Nevada suggested that arsenic may have both clastogenic and weak aneuploidogenic properties.

18. Hopenhayn-Rich C, Biggs ML, Smith AH, Kalman D, Moore LE. Methlyation study in a population environmentally exposed to high arsenic water. Env Health Persp 104:620-28, 1996.

Metabolism. Arsenic methylation patterns were investigated in this cross-sectional study of two towns in Chile. One hundred and twenty two people exposed to high levels of arsenic were compared to 98 people in a neighboring town with low levels of arsenic. Arsenic levels in drinking water were 600 ug/L and 15ug/L, respectively. The corresponding mean urinary arsenic levels were 580 μg/L and 60 μg/L, of which 18.4% and 14.9% were inorganic arsenic respectively. The main differences were found in the monomethyarsonate (MMA) to dimethylarsinate (DMA) ratio; high exposure, smoking, and being male were associated with higher MMA/DMA, while longer residence in the exposed town, Atacameno ethnicity, and being female were associated with lower MMA/DMA. Overall, there was no evidence of a threshold for methylation capacity, even at very high exposures. This study, which is the largest study conducted involving metabolites of arsenic to date, confirmed conclusions made in our earlier publications that the methylation threshold hypothesis was not valid.

19. Hopenhayn-Rich C, Biggs ML, Kalman D, Moore LE, Smith AH. Arsenic methylation patterns before and after changing from higher to lower concentrations of arsenic in drinking water. Env Health Persp 104:1200-07, 1996.

Metabolism. Presented are the results of an intervention study of 73 participants (from the above cross-sectional study in Chile), who were provided with water of lower arsenic content (45 μg/L) for two months. Total urinary arsenic levels fell from an average of 636 μg/L to 166 μg/L. There was a small decrease from 17.8% to 14.6% in the percent of urinary arsenic in inorganic form consistent with what might be predicted from the cross-sectional study. Other factors such as smoking, gender, age, years of residence, and ethnicity were associated mainly with changes in the MMA/DMA ratio. The main difference was found for smokers, where practically all of the smokers showed a decrease in the MMA/DMA ratio, while much more variability was seen for non-smokers. It was noted that the changes in the observed percent inorganic arsenic and in the MMA/DMA ratio did not support an exposure based threshold for arsenic methylation in humans. The last two studies (cross-sectional and intervention) also indicate that most of the inter-individual variability in the distribution of urinary metabolites remains unexplained.

20. Wright C, Lopipero P, Smith AH. Meta-analysis and Risk Assessment. In: Topics in Environmental Epidemiology. Eds. Steenland K and Savitz DA, Oxford University Press, 1996.

Risk assessment. Although arsenic is not discussed in this chapter, it is pertinent here because it includes issues and methods concerning the use of epidemiologic studies to estimate population risks at low levels of exposure. It was noted that apparent nonlinearity at low exposure points in studies can be fitted with statistical models that have a profound impact on risk extrapolations to lower doses. However, the empirical evidence for nonlinearity may be extremely weak, and there are often no good biological reasons for rejecting linearity. For these and other reasons, we stated that it would be preferable to use the linear relative risk model for quantitative risk assessment using epidemiologic data, *unless there are good reasons to reject it* (i.e. clear evidence of nonlinearity).

21. Moore LE, Smith AH, Hopenhayn-Rich C, Biggs ML, Kalman DA, Smith MT. Micronuclei in exfoliated bladder cells among individuals chronically exposed to arsenic in drinking water. Cancer Epidemiol Biom & Prev 6:31-6, 1997.

Molecular epidemiology. Using the same towns as the methylation study in Chile described in the previous publication summary, this cross-sectional study was confined to male participants in view of the extensive exfoliation of squamous cells as well as transitional bladder cells which occurs in females. There were 70 high-exposure participants (average urinary arsenic 616 µg/L) and 55 low-exposure participants (average urinary arsenic 66 µg/L). The prevalence of micronuclei increased three-fold (95% CI 1.9-4.6) from the lowest exposure quintile (less than 53.8 µg/L arsenic in urine) to those in the second highest exposure quintile (414-729 µg/L urinary arsenic). Surprisingly, those in the highest exposure quintile (more than 729 µg/L urinary arsenic) did not have any increase in micronucleus prevalence. This finding is not fully explained, but could be due to cytostasis or cytotoxicity at these high exposure levels. The centromeric probe classification of micronuclei suggested that chromosome breakage was the major cause of micronucleus formation. It is noteworthy that the prevalence of micronuclei in bladder cells was elevated even in the second to lowest quintile of exposure (urinary arsenic levels between 53.9 and 137.3 µg/L, prevalence ratio 2.1, 95% CI 1.4-3.4), which raises the possibility that arsenic has genotoxic effects on bladder cells at relatively low levels of exposure.

22. Biggs ML, Kalman DA, Moore LE, Hopenhayn-Rich C, Smith MT, Smith AH. Relationship of urinary arsenic to intake estimates and a biomarker of effect, bladder cell micronuclei. Mut Res 386:185-95, 1997.

Exposure assessment. The primary purpose of this study was to investigate methods for ascertaining arsenic exposure for use in biomarker studies. The study population was the same as the population in the metabolism and bladder cell micronucleus study conducted in Chile. Exposures were assessed by an interviewer-administered questionnaire concerning volumes and sources of fluid intake. Urinary inorganic arsenic measurements including methylated species were measured in first-morning samples. Creatinine was measured to allow for adjustment for overly concentrated urine. As expected, creatinine adjusted urinary arsenic concentrations had a stronger relationship with the questionnaire-based estimates of arsenic intake than the unadjusted urinary concentrations. Interestingly, the unadjusted urinary arsenic measures had the stronger relationship with bladder cell micronucleus prevalence. This finding is plausible since the unadjusted urinary arsenic concentrations may better reflect target site dose to the bladder, which is exposed to the actual concentration of arsenic in urine.

23. Aposhian HV, Arroyo A, Cebrian M, Del Razo LM, Hurlbut KM, Dart RC, Gonzalez-Ramirez D, Kreppel H, Speiske H, Smith AH, et al. DMPS-Arsenic Challenge Test: I-Increased Urinary Excretion of Monomethylarsonic Acid in Humans Given Dimercaptopropane Sulfonate. J Pharm Exp Ther 282:192-200, 1997.

Chelation study. Directed by Professor Vasken Aposhian of the University of Arizona, this study involved a small subset of participants from our studies in Chile: 13 from the high-exposure town and 11 from the low-exposure town. Each participant was given 300 mg of the chelating agent 2,3-dimercaptone-1-sulfonic acid (DMPS). As expected, urinary arsenic concentrations increased in the 24-hour period after taking DMPS. Interestingly, the increase was considerably more pronounced for MMA than for inorganic arsenic and DMA. In our view, it is difficult to interpret these findings, since the tissue binding strengths of the various arsenic species may vary, and they may have different affinities for the chelating agent. For these and other reasons, urinary arsenic levels in chronically exposed persons remain the best indicators of body dose.

24. Moore, LE, Smith AH, Hopenhayn-Rich C, Biggs ML, Kalman DA, Smith MT. Decrease in bladder cell micronucleus prevalence after intervention to lower the concentration of arsenic in drinking water. Cancer Epidemiol Biomark and Prev 6:1051-6, 1997.

Molecular epidemiology. Water low in arsenic content (45 μg/L) was provided to 34 highly exposed participants in the cross-sectional study in Chile (publication 21 above). Mean urinary arsenic levels in this sub-group decreased from 742 to 225 μg/L during the intervention. Bladder cell micronucleus (MNC) prevalence decreased from 2.63/1000 to 1.79/1000 cells post-intervention ($p<0.05$). When the analysis was limited to individuals previously having subcytotoxic urinary arsenic levels (<700 μg/L), the change between pre- and post-intervention MNC was more pronounced: from 3.54 to 1.47/100 cells respectively ($p=0.002$). The primary changes occurred among smokers, suggesting that smoker's bladder cells could be more susceptible to genotoxic damage caused by arsenic. The reduction in bladder cell MNC prevalence with reduction in inorganic arsenic intake provides further evidence that arsenic is genotoxic to bladder cells.

25. Smith AH, Goycolea M, Haque R, Biggs ML. Marked increase in bladder and lung cancer mortality in a region of Northern Chile due to arsenic in drinking water. Am J Epidemiol, 147:660-69, 1998.

Cancer mortality. Studies in Taiwan and Argentina suggest that ingestion of inorganic arsenic from drinking water results in increased risks of internal cancers, in particular bladder and lung cancer. The authors investigated cancer mortality in a population of around 400,000 people in a region of Northern Chile (Region II) exposed to high arsenic levels in drinking water in past years. Arsenic concentrations from 1950 to the present were obtained. Population-weighted average arsenic levels reached 570 µg/L between 1955 to 1969, and decreased to less than 100 µg/L by 1980. Standardized mortality ratios (SMRs) were calculated for the years 1989 to 1993. Increased mortality was found for bladder, lung, kidney and skin cancer. Bladder cancer mortality was markedly elevated with an SMR of 6.0 [95% confidence interval 4.8-7.4] for men, and 8.2 [6.3-10.5] for women. Lung cancer SMRs were 3.8 [3.5-4.1] for men, and 3.1 [2.7-3.7] for women. Smoking survey data and mortality rates from chronic obstructive pulmonary disease provided evidence that smoking did not contribute to the increased mortality from these cancers. The findings provide additional evidence that ingestion of inorganic arsenic in drinking water is indeed a cause of bladder and lung cancer. It was estimated that arsenic might account for 7% of all deaths among those aged 30 and over. If so, the impact of arsenic on the population mortality in Region II of Chile is greater than any reported to date from environmental exposure to a carcinogen in a major population.

26. Hopenhayn-Rich C, Biggs ML, Smith AH. Lung and kidney cancer mortality associated with arsenic in drinking water in Cordoba, Argentina. Int J Epidemiol 27: 561-69, 1998.

Bladder cancer. Studies in Taiwan have found dose-response relations between arsenic ingestion from drinking water and cancers of the skin, bladder, lung, kidney and liver. To investigate these associations in another population, we conducted a study in Cordoba, Argentina, which has a well-documented history of arsenic exposure from drinking water. Mortality from lung, kidney, liver and skin cancers during the period 1986-1991 in Cordoba's 26 counties was investigated, expanding the authors' previous analysis of bladder cancer in the province. Counties were grouped a priori into low, medium and high arsenic exposure categories based on available data. Standardized mortality ratios (SMRs) were calculated using all of Argentina as the reference population. We found increasing trends for kidney and lung cancer mortality with arsenic exposure, with the following SMRs, for men and women respectively: kidney cancer, 0.87,1.33, 1.57 and 1.00, 1.36, 1.81; lung cancer, 0.92,1.54,1.77 and 1.24, 1.34, 2.16 (in all cases, $p<0.001$ in trend tests), similar to the previously reported bladder cancer results (0.80, 1.28, 2.14 for men, 1.22, 1.39, 1.81, for women). There was a small positive trend for liver cancer but mortality was increased in all three exposure groups. Skin cancer mortality was elevated for women in the high-exposure group, while men showed a puzzling increase in the low-exposure group. The results add to the evidence that arsenic ingestion increases the risk of lung and kidney cancers. In this study, the association between arsenic and mortality from liver and skin cancers was not clear.

27. Guha Mazumder DN, Haque R, Gosh N, De BK, Santra A, Chakraborty D, Smith AH. Arsenic levels in drinking water and the prevalence of skin lesions in West Bengal, India. Int J Epidemiol 27:871-77, 1998.

Skin lesions. A cross-sectional survey was conducted investigating the arsenic-caused skin lesions of keratoses and hyperpigmentation in West Bengal, India. There were 7683 participants who were examined and interviewed, and whose drinking water arsenic levels were measured. Water concentrations ranged up to 3400 ug/L of arsenic but over 80% of participants were consuming water containing less than 500 ug/L. The prevalence of keratoses was strongly related to water arsenic levels rising to 8.5 per 100 for females, and 10.7 per 100 for men, drinking water containing over 800 ug/L. However 12 cases with keratoses (2 females and 10 males) were drinking water containing less than 100 ug/L of arsenic. Findings were similar for hyperpigmentation with strong dose-response relationships, and with 29 cases drinking water containing less than 100ug/L. Calculation by dose per body weight showed that men had roughly two to three times the prevalence of both keratoses and hyperpigmentation compared to women ingesting the same dose of arsenic from drinking water. Subjects who were below 80% of the standard body weight for their age and sex had 1.6 fold increase in prevalence of keratoses, and a 1.2 fold increase in prevalence of hyperpigmentation suggesting that malnutrition might play a small role in increasing susceptibility. The surprising findings concerning cases with apparently low exposure need to be confirmed in studies with more detailed exposure assessment. Further research is also needed concerning susceptibility factors which might be present in the exposed population.

28. Steinmaus C, Moore LE, Hopenhayn-Rich C, Biggs ML, Smith AH. Arsenic in drinking water and bladder cancer. Cancer Invest. In press 1998.

Millions of people throughout the world are drinking water containing inorganic arsenic. Although initially controversial, the association between high exposures to ingested arsenic and bladder cancer is now well established. Unfortunately, the dose-response relationship, especially at low to moderate doses such as those found in the U.S., remains unclear. Attempts to define these risks and establish new drinking water regulations have been controversial, primarily due to questions regarding the risk assessment process used to establish these standards. Epidemiological studies involving low- to moderate- dose exposures will help to define these risks and aid in the establishment of appropriate drinking water regulations. In addition, genetic biomarker studies may provide information on the mechanistic and susceptibility issues of arsenic induced carcinogenesis, and thus may also help elucidate dose-response relationships at low doses. However, until a new arsenic drinking water standard is implemented, most evidence suggests that populations currently exposed to arsenic in drinking water will continue to have substantially elevated cancer risks. Waiting for more precise data before a new standard is applied will only prolong these risks. Therefore, until further research can be completed, an interim drinking water arsenic standard similar to the World Health Organization recommendation of 10 µg/L, may be appropriate.

29. **Smith, AH, Arroyo A, Guha Mazumder DN, Kosnett MJ, Hernandez A, Beeris M, Smith MT, More LE. Arsenic-induced skin lesions among Atacameño people in Northern Chile despite good nutrition and centuries of exposure. Submitted, 1999.**

It has been suggested that the indigenous Atacameño people in Northern Chile might be protected from the health effects of arsenic in drinking water because of many centuries of exposure. Here we report on the first intensive investigation of arsenic-induced skin lesions in this population. Eleven families were selected from the village of Chiu Chiu which is supplied with water containing between 750 and 800 ug/L of inorganic arsenic. For comparison, 8 families were also selected from a village where the water contains around 10 ug/L. After being transported to the nearest city so that assessment could be done blind as to drinking water source, participants were examined by four physicians with experience in studying arsenic-induced lesions. Four of the six men from the exposed village who had been drinking the contaminated water for more than 20 years were diagnosed with skin lesions due to arsenic, but no women were found to have definite lesions. A 13 year old girl was found to have definite skin pigmentation changes due to arsenic, and a 19 year old boy had both pigmentation changes and keratoses on the palms and soles. Family interviews identified a wide range of fruit and vegetable consumption among affected participants, plus weekly intake of red meat and chicken. However, the prevalence of skin lesions found among men and children was as high or higher than reported with corresponding arsenic drinking water concentrations in both Taiwan and West Bengal, India, populations in which extensive malnutrition has been thought to increase susceptibility.

Last updated August 17,1999

Screening For Environmental Concerns At Sites With Contaminated Soil and Groundwater

Volume 1: Summary Tier 1 Lookup Tables

Prepared by:
California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, California 94612

INTERIM FINAL - July 2003
(updated 9/4/03)

Contact:
Roger D. Brewer, Ph.D.
Associate Engineering Geologist
Telephone: 1-510-622-2374
E-mail: rdb@rb2.swrcb.ca.gov

OR

Sampath Rangarajan
Water Resources Control Engineer
Telephone: 1-510-622-2381
E-mail: sr@rb2.swrcb.ca.gov

California Regional Water Quality Control Board
San Francisco Bay
1515 Clay Street, Suite 1400
Oakland, California 94612

DISCLAIMER

This document, *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (July 2003), is a technical report prepared by staff of the California Regional Water Quality Board, Bay Area Region (Board staff). This document is not intended to establish policy or regulation. The Environmental Screening Levels presented in this document and the accompanying text are specifically not intended to serve as: 1) a stand-alone decision making tool, 2) guidance for the preparation of baseline ("Tier 3") environmental assessments, 3) a rule to determine if a waste is hazardous under the state or federal regulations, or 4) a rule to determine when the release of hazardous chemicals must be reported to the overseeing regulatory agency.

The information presented in this document is not final Board action. Board staff reserve the right to change this information at any time without public notice. This document is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation in the State of California. Staff in overseeing regulatory agencies may decide to follow the information provided herein or act at a variance with the information, based on an analysis of site-specific circumstances.

This document will be periodically updated as needed. Please send comments, edits, etc. in writing to the above contacts. Board staff overseeing work at a specific site should be contacted prior to use of this document in order to ensure that the document is applicable to the site and that the user has the most up-to-date version available. This document is not copyrighted. Copies may be freely made and distributed. It is cautioned, however, that reference to the screening levels presented in this document without adequate review of the accompanying narrative could result in misinterpretation and misuse of the information.

Table of Contents

3 TIER 2 AND 3 ENVIRONMENTAL RISK ASSESSMENTS

4

FIGURES

TABLES (ENVIRONMENTAL SCREENING LEVELS)

APPENDICES (IN VOLUME 2)

Executive Summary

This document presents Environmental Screening Levels (ESLs) for chemicals commonly found in soil and groundwater at sites where releases of hazardous chemicals have occurred. The ESLs replace screening levels presented in the previous edition of this document, entitled *Application of Risk-Based Screening Levels (RBSLs) And Decision Making to Sites With Impacted Soil and Groundwater* (December 2001). The change in terminology from "Risk-Based" screening levels to "Environmental" screening levels is intended to better convey the broad scope of the document and clarify that some screening levels are not "risk-based" in a strict toxicological definition of this term.

The ESLs are considered to be conservative. Under most circumstances, and within the limitations described, the presence of a chemical in soil, soil gas or groundwater at concentrations below the corresponding ESL can be assumed to not pose a significant, long-term (chronic) threat to human health and the environment. Additional evaluation will generally be necessary at sites where a chemical is present at concentrations above the corresponding ESL. Active remediation may or may not be required, however, depending on site-specific conditions and considerations. This document may especially be beneficial for use at sites with limited impacts, where the preparation of a more formal environmental assessment may not be warranted or feasible due to time and cost constraints.

The ESLs were developed to address environmental protection goals presented in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995) of the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These goals include:

Surface Water and Groundwater:
- Protection of drinking water resources;
- Protection of aquatic habitats;
- Protection against adverse nuisance conditions.

Soil:
- Protection of human health;
- Protection of groundwater;
- Protection of terrestrial biota;
- Protection against adverse nuisance conditions.

The ESLs are presented in a series of four lookup tables. Each table reflects a specific combination of soil, groundwater and land-use characteristics that strongly influence the magnitude of environmental concerns at a given site. This allows the user to select ESLs that are most applicable to a given site.

The ESL document presents a "tiered" approach to environmental risk assessments. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. In a "Tier 2" risk assessment, a selected component(s) of the Tier 1 ESL is modified with respect to site-specific considerations. An example may be the adjustment of a screening level for direct exposure with respect to an approved, alternative target risk level. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 ESL. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments. Risk assessment models and assumptions that depart significantly depart from those used to develop the Tier 1 ESLs are described in a more traditional, "Tier 3" risk assessment. The Tier 1 methodology can, however, still provide a common platform to initiate a Tier 3 risk assessment and help ensure that all potentially significant environmental concerns are considered.

> **The Tier 1 ESLs presented in the lookup tables are NOT regulatory "cleanup standards".** Use of the ESLs and this document in general is intended to be entirely optional on the part of the regulated facility and subject to the approval of the case manager in the overseeing regulatory agency. The presence of a chemical at concentrations in excess of an ESL does not necessarily indicate that adverse impacts to human health or the environment are occurring; this simply indicates that a potential for adverse risk may exist and that additional evaluation is warranted. ESLs presented for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels (e.g., many petroleum-related compounds). Use of the ESLs as cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more site-specific risk assessment.
>
> Reliance on only the Tier 1 ESLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health, sites where physical conditions differ drastically from those assumed in development of the ESLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed. (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where significant concerns may exist. Notification to the Natural Resource Trustee Agencies (including the state Department of Toxics Substances Control and Department of Fish and Game and the federal Fish and Wildlife Service, Department of the Interior and National Oceanic and Atmospheric Administration) may also be required, particularly if the release of a hazardous substance may impact surface waters.

The ESLs should NOT be used to determine when impacts at a site should be reported to a regulatory agency. All releases of hazardous substances to the environment should be reported to the appropriate regulatory agency in accordance with governing regulations. The lookup tables will be updated on a regular basis, as needed, in order to reflect changes in the referenced sources as well as lessons gained from site investigations and field observations.

1

Introduction

1.1 Purpose

Preparation of detailed environmental risk assessments for sites impacted by releases of hazardous chemicals can be a time consuming and costly effort that requires expertise in a multiple of disciplines, including toxicology, geology, ecology, chemistry, physics and engineering, among others. For small-business owners and property owners with limited financial resources, preparation of such risk assessments can be time and cost-prohibitive.

As a means to partially address this problem, this document presents a series of conservative Environmental Screening Levels (ESLs) for soil, groundwater and soil gas that can be directly compared to environmental data collected at a site. Correlative screening levels for surface water are also provided. Screening levels for over 100 commonly detected contaminants are given in a series of "lookup" tables. The tables are arranged in a format that allows the user to take into account site-specific factors that help define environmental concerns at a given property.

Within noted limits, risks to human health and the environment can be considered to be insignificant at sites where concentrations of chemicals of concern do not exceed the respective ESLs. The presence of chemicals at concentrations above the ESLs does not necessarily indicate that a significant risk exists at the site. It does, however, generally indicate that additional investigation and evaluation of potential environmental concerns is warranted.

The introductory text of this document is kept intentionally brief with a focus on theh use of the ERLs rather than technical details about their derivation. The latter is provided in the appendices of Volume 2.

1.2 Tiered Approach to Environmental Risk Assessments

This document presents a three-tiered approach to environmental risk assessment. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. A detailed understanding of the derivation of the screening levels is not required for use at this level.

Under "Tier 2", selected components of the models used to develop the Tier 1 ESLs are modified with respect to site-specific data or considerations. Examples include adjustment of the assumed depth to impacted groundwater in the Tier 1 indoor-air impact model or use of an approved, alternative target risk level for direct-exposure concerns. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 ESLs. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments.

Under Tier 3, the user employs alternative models and modeling assumptions to develop site-specific screening or final cleanup levels or quantitatively evaluate the actual risk posed to human and/or ecological receptors by the impacted media. Consideration of the methodologies and potential environmental concerns discussed in this document is still encouraged, however. This will help increase the comprehensiveness and consistency of Tier 3 risk assessments as well as expedite their preparation and review.

1.3 Comparison To Existing Screening Levels

Both Region IX of the U.S. Environmental Protection Agency (USEPA 2002) and the City of Oakland (Oakland 2000) have prepared lookup tables of Environmental Screening Levels for soil and water. The lookup tables presented in this document represent an expansion of this work to reflect the broader scope of environmental concerns put forth in the Regional Water Quality Control Board (RWQCB) Basin Plan (RWQCBSF 1995). Differences and similarities between the ESL document and lookup tables prepared by the other programs are summarized below.

1.3.1 USEPA Region IX PRGs

The U.S. Environmental Protection Agency (USEPA) Region IX "Preliminary Remediation Goals" or "PRGs" are intended to address human health concerns regarding direct exposure with impacted soils (USEPA 2002). The equations used to develop the USEPA PRGs are generally consistent with human health risk assessment guidance prepared by the Department of Toxic Substances Control, including the CalTOX model (CalEPA 1994a) and the documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). As noted in Chapter 3, use of the CalTOX model and other CalEPA guidance documents and models may be necessary where more detailed risk assessments are required.

As discussed in the USEPA Region IX document, the PRGs are intended to address human direct-exposure with impacted soil and "...do not consider impact to groundwater or address ecological concerns." (USEPA 2002). Expansion of the USEPA PRGs in the lookup tables presented in this document includes:

- Modification of soil PRGs to reflect CalEPA-specific toxicity factors;
- Adjustment of PRGs for noncarcinogens to reflect a target hazard quotient of 0.2 to address potential cumulative health concerns;
- Addition of direct-exposure screening levels for construction and trench workers' exposure to subsurface soils;
- Addition of soil and groundwater screening levels for indoor-air impact concerns;
- Addition of groundwater screening levels for the protection of aquatic habitats/surface water quality;
- Use of a more rigorous leaching model to develop soil screening levels for protection of groundwater quality;
- Addition of soil screening levels for urban area, ecological concerns;
- Addition of soil and groundwater "ceiling levels" to address gross contamination and general resource degradation concerns; and
- Addition of soil and groundwater screening levels for Total Petroleum Hydrocarbons (TPH).

Use of the USEPA Region IX PRGs in the RWQCB lookup tables is discussed further in Section 3.2 of Appendix 1. A copy of the PRG background document is provided in Appendix 2.

1.3.2 City of Oakland Screening Levels

A brief comparison of the RWQCB and the City of Oakland approaches to the development of environmental screening levels is provided in Table 1-1. Since 1999, the City of Oakland has presented environmental screening levels for soil and groundwater through its Urban Land Redevelopment (ULR) Program. The ULR Program is a collaborative effort by the City of Oakland and the principal agencies charged with enforcing environmental regulations in Oakland to facilitate the cleanup and redevelopment of contaminated properties (Oakland 2000). It includes innovative institutional mechanisms for tracking residual contamination and ensuring long-term compliance with risk management plans. The ULR Program is coordinated by the City and is specific to Oakland sites.

The City of Oakland approach is based on the guidelines prescribed in *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1995). The Guidance Document, Technical Background Document and other information on the Oakland ULR program is available on the internet at www.oaklandpw.com/ulrprogram. Modifications have been made to better address child exposure and recreational water use scenarios. In addition, many input values reflect Oakland-specific geologic, hydrogeologic and climatic conditions (Oakland Technical Background 2000 and updates). These values may not be appropriate for other areas within the RWQCB's jurisdiction.

The RWQCB has agreed that the Oakland look-up tables are appropriate for use at Oakland sites under the conditions and limitations discussed in the ULR Program Guidance (memo dated August 3, 2001; RWQCBSF 2001b). In particular, sites where surface or groundwater conditions present ecological, aesthetic, taste or odor concerns may require additional analysis. Active remediation to address these concerns may not be necessary at most sites in Oakland that are not near sensitive water bodies, however, due to its highly-developed, urban setting

1.3.3 Hazardous Waste Regulations

California Total Threshold Limit Concentrations (TTLC) criteria for solids and Soluble Threshold Limit Concentration (STLC) criteria for liquids should not in most cases be used as soil and groundwater screening or cleanup levels. The TTLC and STLC criteria are intended to determine the type of landfill a waste material must be sent to (Title 22, Section 66699 - Persistent and Bioaccumulative Toxic Waste). Where TTLC or STLC criteria are exceeded, the waste must in general be sent to a Class I, hazardous waste landfill. The criteria, developed in the 1980s, are only loosely based on human health and environmental considerations. STLC values in general reflect drinking water or surface water goals of the time, although some are clearly out-of-date (e.g. trichloroethylene STLC value of 204 mg/L). TTLC values were derived by simply multiplying the STLC value by ten (organic substances) or one hundred (metals).

In most cases, TTLC values exceed the most conservative environmental screening levels presented in this document. In the case of Endrin and DDT/DDE/DDD, however, the TTLC is somewhat lower than the screening levels for human health concerns. For example, the TTLC for combined DDT/DDE/DDD is 1.0 mg/kg while the residential, direct-exposure soil screening is 1.7 mg/kg. This presents the enigma that while soil impacted below 1.7 mg/kg is not considered to pose a significant risk to human health, it could be classified as a "hazardous waste" if it were excavated and transported offsite for disposal. Again, this is not a difference of opinion about the potential toxic effects of these chemicals, it is merely a reflection of the less rigorous development of the TTLC values.

Unfortunately, it is not anticipated that the TTLC and STLC values will be revised in the near future. To avoid potential future problems with soil disposal and even public perception, it may be prudent to use TTLCs as final cleanup values for sites where the TTLC is less than cleanup values based on actual risk to human health and the environment.

1.3.4 OSHA Standards Permissible Exposure Levels

The National Institute for Occupational Safety and Health (NIOSH) is the Federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury, including exposure to hazardous chemicals in air (NIOSH 2003). NIOSH develops and periodically revises Recommended Exposure Limits (RELs) for hazardous substances in the workplace. The RELs are used to promulgate Permissible Exposure Levels (PELs) under the Occupational Safety and Health Act (OSHA).

OSHA Permissible Exposure Levels (PELs) for indoor air are intended for use in controlled, industrial work areas where employees are aware of potential health hazards associated with the chemicals they are using and are trained to take proper precautions and minimize exposure (NIOSH 2003). OSHA PELs are **not** appropriate for use at commercial/industrial sites where the chemical is not currently being used. This includes sites affected by the migration of offsite releases (e.g., via emissions from a moving plume of contaminated groundwater). Indoor-air protection goals for these sites should be based on long-term (chronic) health risk to workers. Such risk-based goals levels are typically much more stringent than OSHA PELs.

For example, the current OSHA PEL for trichloroethylene (TCE) is 678,000 ug/m^3 (100 ppmv, NIOSH 2003). Comparable risk-based screening levels for uncontrolled, commercial/industrial settings included in this document fall between 2.0 ug/m^3 and 10 ug/m^3 (carcinogenic effects vs noncarcinogenic effects, respectively; refer to Table E and Appendix 1, Table E-3). The PEL is applicable to work areas where TCE is being used and the employees have been properly trained to minimize exposure. The risk-based goals are applicable to all other areas.

1.3.5 RWQCB Basin Plan

The RWQCB Basin Plan ("Basin Plan") presents generic soil screening levels of 1.0 mg/kg total volatile organic compounds (VOCs) and 10 mg/kg semi-volatile organic compounds (SVOCs, RWQCBSF 1995). The Basin Plan states that the need to develop chemical-specific screening is to be evaluated on a site-by-site basis. As can be inferred from the detailed ESLs provided in Appendix 1, the Basin Plan screening level for total VOCs is probably adequate to overly conservative for gasoline-range petroleum fuel mixtures at most sites. Chemical-specific ESLs for benzene and MTBE are less than 1 mg/kg, due to their human toxicity and/or mobility in soil. The prevalence of less toxic and mobile VOCs in gasoline-range fuel mixtures (e.g., toluene, ethylbenzene, xylenes, etc.), however, would generally ensure that a total VOC screening level of 1 mg/kg adequately addresses concerns regarding these compounds in the absence of chemical-specific ESLs. The total VOC screening level is in all likelihood overly conservative for most heavier fuel mixtures that lack significant amounts of benzene and MTBE (e.g., diesel fuel).

For direct-exposure, human health concerns, the Basin Plan screening level of 1 mg/kg for total VOCs as presented in the Basin Plan is adequate to marginally over-conservative for the most commonly detected chlorinated solvents (e.g., tetrachloroethylene, trichloroethane, trichloroethylene, etc.). From a modeling perspective, the screening level may be somewhat under-conservative for potential leaching and groundwater protection concerns (e.g., see Appendix 1, Table G). The model used to generate screening levels for leaching of chemicals from soil conservatively assumes, however, that the impacted soil was situated within one meter of groundwater. At the vast majority of sites where this is the actual case, groundwater has already been impacted by the main mass of chemicals and direct monitoring provides a more accurate evaluation of leaching impacts. For sites where impacted soil is situated greater than 10 meters from groundwater, model-generated screening levels developed by other agencies suggest that a screening level of 1 mg/kg (or more) may be adequate for chlorinated VOCs (e.g., HIDOH 1995).

The Basin Plan screening level of 10 mg/kg for total semi-volatile organic compounds (SVOCs) is probably overly conservative for these compounds for groundwater protection purposes. For soils impacted with carcinogenic SVOCs, the Basin Plan screening level has traditionally been used in conjunction with human-health screening levels presented in the USEPA PRGs. The PRGs are also referenced in this document although with some modifications.

The Basin Plan references a total petroleum hydrocarbon (TPH) soil screening level of 100 mg/kg for the protection of drinking water resources. A similar screening level was developed for use in this document. As noted in the lookup tables and discussed in Appendix 1, however, this screening level is considered to be overly conservative for heavy, residual fuels (fuel oil #6, motor oil, etc.) as well as for use at sites that do not pose a direct threat to drinking water or surface water resources.

1.4 Chemicals Not Listed In Lookup Tables

The lookup tables list 100-plus chemicals most commonly found at sites with impacted soil or groundwater. Inclusion of ESLs for additional chemicals is a relatively straightforward process, provided that adequate supporting data are available. To obtain ESLs for chemicals not listed in the lookup tables, the interested party should contact the RWQCB staff noted at the beginning of this document. Development of ESLs will be carried out in the same manner as done for the listed chemicals. As an alternative, ESLs may be developed by qualified persons and submitted to the overseeing regulatory agency for review (refer to Section 3.0).

1.5 Limitations

The Tier 1 ESLs presented in the lookup tables are NOT required, regulatory "cleanup standards". Use of the ESLs as actual cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more detailed environmental risk assessment. The ESLs are intended to be conservative for use at the vast majority of impacted sites in developed areas. As discussed in Chapter 3, however, use of the Environmental Screening Levels may not be appropriate for final assessment of all sites. Examples include:

- Sites that have a high public profile and warrant a detailed, fully documented environmental risk assessment;
- Sites with less than 3.0m (ten feet) of low permeability soils (clay, silt, etc.) between impacted groundwater and the ground surface (including potential downgradient areas; applies only to use of groundwater screening levels for sites with low permeability, vadose-zone soils);
- Sites with high rainfall and subsequent high surface water infiltration rates (i.e., infiltration >28 inches (720mm) per year),
- Sites where inorganic chemicals (e.g., metals) are potentially mobile in leachate due to soil or groundwater conditions different than those assumed in development of the lookup tables (e.g., low pH at mine sites);
- Conservation areas where impacts pose heightened threats to ecological habitats (e.g., presence of endangered or protected species); and
- Sites where more than three known or suspected carcinogens or more than five chemicals with similar noncarcinogenic health effects have been identified.
- Sites affected by tides, rivers, streams, etc. where there is a potential for erosion and concentration of contaminants in aquatic habitats.

Examples of other site characteristics that may warrant a more detailed environmental risk assessment are discussed in Chapter 3 (refer also to discussion of screening levels in Appendix 1). In such cases, the information provided in this document may still be useful for identification of potential environmental concerns and development of strategies for preparation of a more site-specific risk assessment.

ESLs for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels. For example, final soil

ESLs for Total Petroleum Hydrocarbon (TPH) and many noncarcinogenic, petroleum-related compounds (e.g., xylenes) are driven by the protection of groundwater quality. If long-term monitoring demonstrates that actual impacts to groundwater are insignificant then less stringent soil (and groundwater) screening levels may be warranted. Additional guidance regarding the management of impacted soil and groundwater at petroleum-release sites is provided in the following documents (refer also to overseeing regulatory agency):

- *Interim Guidance on Required Cleanup at Low-Risk Fuel Sites* (RWQCBSF 1996);
- Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates (SWRCB 2000).

Copies of these documents can be obtained from the RWQCB.

Soil ESLs do not consider potential water- or wind-related erosion and deposition of contaminants in a sensitive ecological habitat. This may especially be of concern for metals and pesticides that are only moderately toxic to humans but highly toxic to aquatic and terrestrial biota (e.g., copper). The RWQCB *Erosion and Sediment Control Field Manual* provides practical information on the mitigation of erosion and runoff concerns.

It is conceivable that soil, groundwater and soil gas screening levels for the emission of chlorinated, volatile organic compounds to indoor air concerns may not be adequately conservative in some cases. This is most likely to occur at sites where the vapor permeability of vadose-zone soils is exceptionally high (e.g., highly fractured bedrock, gravels, etc.) and/or where building designs, ventilation systems and local environmental conditions otherwise lead to higher-than-expected vapor flow rates through foundations (e.g., houses with heating systems in basements). As discussed in Appendix 1, conservative target risks are used in part to address these uncertainties.

Table 1-1. Comparison of RWQCB and Oakland Risk-Based Approaches

		RWQCB	[1]Oakland
General Approach	Tiers	One tier of look-up tables. Includes separate screening levels for indoor air concerns based on soil type.	Two tiers of look-up tables: Tier 1 table applicable at any Oakland site; Tier 2 tables (3) account for site-specific soil types (Merritt Sands, sandy silts, and clayey silts) and alternate target risk. Tier 3 spreadsheets provided.
	Target Cancer Risk Level	10^{-6}	10^{-6} for Tier 1; 10^{-5} for Tier 2.
	Target Noncancer Hazard Quotient	0.2 (with option for site specific adjustment)	1.0 (with requirement to address cumulative risk as necessary)
	Ceiling/Nuisance Levels	"Ceiling levels" to address gross contamination concerns, nuisances, free-product mobility, and general resource quality	No "ceiling levels"; recommends removal of mobile or potentially-mobile free product.
	Total Petroleum Hydrocarbons	Screening levels for TPH included	No TPH screening levels.
Soil Pathways	Definition of "Shallow" Soils	0-3 meters below ground surface.	0-1 meter below ground surface.
	Direct Exposure, Inhalation of Volatiles	USEPA PRG model (USEPA 2002). Assumes "infinite" source thickness for volatile organic compounds.	ASTM (1995) model. Assumes infinite source unless mass balance conditions violated based on 1.0 m thick source.
	Ecological Concerns	Screening levels for terrestrial biota included (shallow soils only).	Recommends site-specific analysis when significant ecological habitats are threatened.
	Deep Soils	Direct-exposure soil screening levels for Construction/ Trench Worker exposure scenario.	No screening levels for this scenario; recommends a site-specific analysis as warranted.
Groundwater	Leaching Model	Employs the SESOIL model.	Employs the ASTM (1995) model.
	Leaching of Inorganic Compounds	No soil screening levels; recommends laboratory tests.	Soil screening levels for inorganic compounds, based on a neutral pH.
	Surface Water Protection	Groundwater screening levels for the ecological and aesthetic protection of surface water.	Screening levels for recreational use of groundwater and surface water. Recommends site-specific analysis of ecological and aesthetic concerns as warranted.
Indoor Air	Thickness of Soil Source	Assumes five meters. Recommends site-specific analysis as warranted.	Assumes "infinite" source thickness.
	Convective Flow	Incorporates convective flow in indoor-air impact model.	Does not incorporate convective flow (i.e., assumes no pressure differential) in indoor-air impact model.
	Surface Soil Screening Levels	Includes screening levels for protection of indoor air for both surface and subsurface soils.	Recommends site-specific analysis and controls for shallow soils (<1m) and use of screening levels for deeper soils.
	Soil Gas	Includes screening levels for soil gas.	Not included.

1. *Oakland Risk-Based Corrective Action: Technical Background Document: City of Oakland, Environmental Services Division*, January 2000 (and updates), www.oaklanddpw.com/urlprogram.

2

Tier 1 Lookup Tables

2.1 Organization of Lookup Tables

Environmental risk assessments may be carried out in either a "forward" mode, where actual risks are quantified based on concentrations of a chemical in an impacted media, or "backward" mode, where acceptable concentrations of a chemical in a given media are developed based on specified, target goals. The Environmental Screening Levels (ESLs) presented in this document represents an example of the latter. Tier 1 ESLs for soil and groundwater are summarized in Tables A through E. Each ESL in the tables collectively addresses environmental concerns stated or inferred in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995), prepared by the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These concerns include:

Groundwater Quality:

- Protection of human health
  - Current or potential drinking water resource;
  - Emission of subsurface vapors to building interiors;
- Protection of aquatic habitats (discharges to surface water);
- Protection against nuisance concerns (odors, etc.) and general resource degradation.

Soil Quality:

- Protection of human health
  - Direct/indirect exposure to impacted soil (ingestion, dermal absorption, inhalation of vapors and dust in outdoor air);
  - Emission of subsurface vapors to building interiors;
- Protection of groundwater quality (leaching of chemicals from soil);
- Protection of terrestrial (nonhuman) habitats;
- Protection against nuisance concerns (odors, etc.) and general resource degradation.

Shallow Soil Gas:

- Protection of human health
  - Emission of subsurface vapors to building interiors.

For the purpose of this document, "soil" refers to any unlithified material in the vadose zone that is situated above the capillary fringe of the shallowest saturated unit. A summary of environmental concerns considered in the ESLs is depicted schematically in Figure 1. This is correlative to a "conceptual site model" prepared for a detailed environmental risk assessment. The degree to which any given concern will "drive" environmental risk at a site depends on the actual potential for exposure and the toxicity and mobility of the chemical.

Site characteristics that play an important role in evaluating potential environmental concerns or developing site-specific cleanup levels include:

- Physical location of the impacted soil (e.g., currently or potentially exposed at the ground surface versus isolated in the subsurface);
- Beneficial use of the groundwater immediately underlying the site or otherwise potentially threatened by the release (e.g., drinking water resource threatened versus no drinking water resource threatened);
- Current and anticipated future use of the site (e.g., residential land use permitted or commercial/industrial land use only).

In order to include consideration of these site characteristics in the ESLs, four different tables were prepared (Tables A through D). Each table reflects varying combinations of site characteristics:

- Table A – Shallow soils, potential drinking water resource threatened;
- Table B – Shallow soils, potential drinking water resource not threatened;
- Table C – Deep soils, potential drinking water resource threatened;
- Table D – Deep soils, potential drinking water resource not threatened;

Each of the tables provides separate soil screening levels for residential (i.e., unrestricted) and commercial/industrial land-use scenarios.

For each chemical listed in the lookup tables, screening levels were selected to address each applicable environmental concern under the specified combination of site characteristics. The lowest of the individual screening levels for each concern was selected for inclusion in the summary Tier ESL tables presented in Volume 1 of this document. This ensures that the ESLs presented in these tables are protective of all potential environmental concerns and provides a tool for rapid screening of site data. Where ESLs are exceeded, the detailed tables provided in Appendix 1 can be used to identify the specific environmental concerns that may be present at the site.

An example of the selection of summary, Tier 1 ESLs for tetrachloroethylene (PCE) is presented in Figure 2 (surface soils, drinking water resource threatened, unrestricted land use desired). A more detailed discussion of this example is provided in Appendix 1.

2.2 Use of Lookup Tables

The step-by-step use of the lookup tables is summarized below and discussed in more detail in the following sections. A summary of the process is also provided in Figure 3. An outline and discussion of information that should be included in a Tier 1 environmental risk assessment is provided in Section 2.11.

Step 1 - ESL Updates and Applicability

Check with the overseeing regulatory agency to determine if the ESLs can be applied to the subject site. Ensure that the most up-to-date version of this document is being used (updated every 1-2 years in general).

Step 2: Identify All Chemicals of Potential Concern

An environmental risk assessment must be based on the results of a thorough site investigation, where all chemicals of potential concern have been identified. A summary of the site investigation results should be included in the risk assessment in order for it to be reviewed as a "stand alone" document." A general outline of site investigation information that should be included in a Tier 1 risk assessment is provided in Section 2.11.

Step 3: Select Lookup Table(s)

Determine the designated beneficial use of impacted or threatened groundwater beneath the site. In general, all groundwater must initially be treated as a current or potential source of drinking water (see Section 2.3). Next, determine the depth below ground surface to the top of impacted soil (see Section 2.4). This site information is then used to select the most appropriate lookup table (see Figure 3).

Steps 4: Determine Desired Land Use (soil ESLs only)

ESLs for soil are selected based on the present and desired future use of the site. Two options are provided in the lookup tables, "Unrestricted Land Use Permitted" or "Commercial/Industrial Land Use Only". Screening levels for unrestricted land used are considered to be adequate for residential use of a property. **For evaluation of commercial/industrial properties, it is highly recommended that site data be compared to ESLs for both unrestricted/residential and commercial/industrial land use.** Reference only to ESLs for commercial/industrial land use will in most cases require that a covenant to the deed be prepared that restricts use of the property to these purposes only (see Section 2.9).

Steps 5 and 6: Select Soil and/or Groundwater ESLs

Based on the desired land use(s), select appropriate soil ESLs. ESLs for groundwater are provided in the adjacent column of each table and are not dependent on land use or depth to impacted soil. Correlative screening levels for surface water are also provided. Replace ESLs with naturally occurring, background concentrations of chemicals of concern (e.g., arsenic) or laboratory method reporting levels if higher (see Section 2.8).

Step 7: Determine Extent of Impacted Soil and/or Groundwater

Using the selected ESLs, determine the extent of impacted soil or groundwater and areas of potential environmental concern at the site and offsite, as required. Soil data should be reported on a dry-weight basis (see Appendix 1, Section 6.2). For sites where sample data are limited, it will be most appropriate to compare the maximum-detected concentrations of chemicals of concern to the ESLs. For sites where an adequate number of data points are available, the use of statistical methods to estimate more site-specific exposure point concentrations and evaluate environmental risks may be appropriate. The exposure point concentration is generally selected as the lesser of the maximum-detected concentration and the 95% upper confidence interval of the arithmetic mean of sample data. Guidance for the estimation of exposure point concentrations, use of "non-detect" data, and other issues is provided in the CalEPA documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a), among other sources. As discussed in these documents, sample data collected outside of impacted areas should generally not be included in estimation of exposure point concentrations. **For residential land use scenarios, sample data should be averaged over no more than a 1,000 ft^2 area.**

Steps 8 and 9: Evaluate The Need For Additional Investigation or Corrective Actions; Submit Appropriate Reports

Based on a comparison of available site data to the ESLs, evaluate the need for additional action at the site (e.g. additional site investigation, remedial action, preparation of a more site-specific risk assessment, etc.). This is then summarized in the Tier 1 Environmental Risk Assessment report and workplans for additional corrective actions as needed (see Section 2.11). Decisions for or against additional actions should always be made in conjunction with guidance from the overseeing regulatory agency.

Note that impacts to soil and water from petroleum mixtures are evaluated in terms of both Total Petroleum Hydrocarbon (TPH) and target "indicator chemicals" for the given petroleum mixture. Indicator chemicals typically recommended for petroleum mixtures include (after CalEPA 1996a):

Monocyclic Aromatic Compounds (primarily gasolines and middle distillates)

- benzene
- ethylbenzene
- toluene

- xylene

Fuel additives (primarily gasolines)
- MTBE
- other oxygenates as necessary

Polycyclic Aromatic Compounds (primarily middle distillates and residual fuels)
- methylnaphthalene (1- and 2-)
- acenaphthene
- acenaphthylene
- anthracene
- benzo(a)anthracene
- benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(a)pyrene
- benzo(k)fluoranthene
- chrysene
- dibenzo(a,h)anthracene
- fluoranthene
- fluorene
- indeno(1,2,3)pyrene
- naphthalene
- phenanthrene
- pyrene

The TPH ESLs should be used in conjunction with ESLs for these chemicals. As discussed in Appendix 1, the "middle distillates" category of TPH includes diesel fuel kerosene, stoddard solvent, home heating fuel, jet fuel and similar petroleum mixtures. "Residual fuels" includes heavy petroleum products such as No. 6 fuel oil ("Bunker C"), lubricating oils, "waste oils" and asphalts. Soil and groundwater impacted by releases of waste oil may also require testing for heavy metals and chemicals such as chlorinated solvents and PCBs. Screening levels for these chemicals are included in the lookup tables.

2.3 Groundwater Beneficial Use

As stated in the San Francisco Bay Region *Water Quality Control Plan* ("Basin Plan", RWQCBSF 1995), "Unless otherwise designated by the Regional Board, all groundwaters are considered suitable, or potentially suitable, for municipal or domestic water supply." All groundwater beneath a given site should be initially treated as a potential source of drinking water unless otherwise approved by the RWQCB office. For the purposes of this document, it is also assumed that all shallow groundwater will ultimately discharge to a body of surface water and potentially impact aquatic organisms (see Section 2.7). Soil and groundwater ESLs were therefore developed to be protective of both drinking water resources and aquatic habitats. This is discussed in greater detail in Chapters 2 and 3 of Appendix 1.

The Basin Plan recognizes that site-specific factors may render groundwater unsuitable for potential drinking water purposes. Tables B and D in this document are intended for use at such sites. The ESLs presented in these tables consider the potential discharge of groundwater to surface water but do not consider potential impacts to sources of drinking water. The ESLs also consider "gross contamination" issues such as the presence of free product and aesthetic or odor problems. Use of these tables for screening level environmental risk assessments must be approved by the RWQCB but may not necessarily require regulatory "de-designation" of groundwater beneficial use.

Hydrogeologic criteria presented in the Basin Plan for potential exclusion of a given occurrence of groundwater from consideration as a potential source of drinking water include:

- Total dissolved solids in groundwater is greater than or equal to 3,000 mg/L; OR

- Water bearing unit is not sufficiently permeable to produce an average, sustained yield of 200 gallons of water per day.

Groundwater in coastal areas, geothermal fields, etc., may contain levels of dissolved solids that make the water unsuitable as a potential source of drinking water. In addition, the permeability of soils and sediments that lack a significant amount of coarse-grained material (or fractures, in the case of bedrock) may be too low to allow for an adequate, sustained yield of groundwater. Unconsolidated geologic units that are comprised of less than 20% sand-size (or larger) material or more than 30% clay-size material are typically not considered to be viable "aquifers" or potential sources of useable groundwater (inferred from Fetter 1994). The potential for a given unit of bedrock to serve as a viable source of groundwater similarly depends on the primary and secondary porosity in the rock and the quality of the groundwater. Consideration must also be made for the potential migration of groundwater out of a geologic unit that in itself is insufficiently permeable to be considered to be an aquifer and into a more permeable unit that could serve as a viable source of drinking water.

In general, soil and groundwater screening levels are more stringent for sites that threaten a potential source of drinking water (e.g., compare Tables A and B). This is particularly true for chemicals that are highly mobile in the subsurface and easily leached from impacted soil. For chemicals that are especially toxic to aquatic life (e.g., several long-chain hydrocarbons, pesticides and heavy metals), however, screening levels for sites that threaten drinking water resources may be driven by surface water/aquatic habitat protection concerns. This is discussed in more detail in Appendix 1.

2.4 "Shallow" Versus "Deep" Soils

For the purposes of this document, a depth of three meters (approximately 10 feet) was used to delineate between "shallow" soils, where a potential exists for regular direct exposure of residents and/or office workers, and "deep" soils where only periodic exposure during construction and utility maintenance work is considered likely. This is consistent with guidance presented in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a) and is regarded as the maximum, likely depth that impacted soil could at some point in the future be excavated and left exposed at the surface during typical redevelopment activities. The potential for deeper soils to be brought to the surface in the future should be evaluated on a site-by-site basis based on planned redevelopment or maintenance activities.

The full suite of environmental concerns noted in Figure 1 was considered in development of ESLs for shallow soils. For deep soils, regular exposure of residents or commercial/industrial workers and impacts to terrestrial flora and fauna was not considered. As a result, ESLs for relatively non-mobile chemicals are generally less stringent for deep soils than correlative ESLs for shallow soils (e.g., compare PCB ESLs in Tables A and C). For chemicals that are easily leached from soil or potentially emitted to the air as a volatile gas, however, groundwater and indoor-air protection concerns usually drive selection of the final ESL regardless of the depth of the impacted soil. This is the case for several of the highly volatile, chlorinated organic compounds. As a result, correlative shallow and deep soil ESLs are identical (e.g., compare trichloroethylene ESLs in Tables A and C).

If impacted soil extends across the three-meter dividing line between shallow soil and deep soil, it may be appropriate to use a separate set of screening levels for each zone (e.g., Table A for the shallow soils and Table C for the deep soils). As discussed in Section 2.9, however, the pros and cons of remediating deep soils to shallow soil criteria should be evaluated on a site-by-site basis. This may help avoid concerns regarding future disturbance and reuse of deeper soils.

As another alternative, the less stringent ESLs for deep soils could be applied to shallower soils under a Tier 2 or Tier 3 risk assessment (refer to Chapter 3), provided that appropriate actions to prevent future exposure and unmanaged reuse are taken. Such controls may include (but not necessarily be limited to):

- placement and maintenance of adequate cap or other risk-management measures to eliminate potential direct exposure;

- modeling and/or direct field measurement to evaluate potential impacts to indoor air due to vapor emissions; and

- preparation of a risk management plan and other appropriate institutional controls (e.g., deed restrictions) in order to prevent unauthorized disturbance of the soil in the future and allow for appropriate management of the soil if it is exposed.

Capping of shallow, contaminated soil and other engineered controls used in place of full cleanup are generally not allowed for properties that are to be used for single-family homes. The need to consider these actions at sites with impacted soils situated more than three meters below the ground surface should be discussed with the overseeing regulatory agency on a site-by-site basis.

2.5 Land Use

Land uses are categorized based on the assumed length, duration and magnitude of potential human exposure. The category "Residential Land Use" is intended for use at sites where future land-use restrictions are not desirable or allowed. This includes sites to be used for residences, hospitals, day-care centers and other sensitive purposes (e.g., refer to DTSC 2002). ESLs listed under this category incorporate conservative assumptions regarding long-term, frequent exposure of children and adults to impacted soils in a residential setting (see Appendices 1, Section 3.2 and Appendix 2). In contrast, the land-use category "Commercial/Industrial Use Only" assumes that only working age adults will be present at the site on a regular basis. Direct-exposure assumptions incorporated into the soil ESLs are somewhat less conservative than assumptions used in the residential land-use scenario.

Land use should be selected with respect to the current and foreseeable future use of the site in question. Reference to adopted General Plan zoning maps and local redevelopment plans is an integral part of this process. Use of the lookup tables for sites with other land uses (e.g., agriculture, parkland, etc.) should be discussed with and approved by the overseeing regulatory agency. As the category heading implies, use of the soil ESLs listed under "Commercial/Industrial Use Only" places implicit land-use restrictions on the affected property. While this may be considered acceptable for properties currently zoned for such purposes, the need for such restrictions in the future should be seriously weighed against the cost-benefit of remediating the property to meet the sometimes more conservative but less restrictive ESLs for unrestricted land use. Implications for land-use restriction are discussed in more detail in Section 2.9.

A 2003 amendment to the Porter-Cologne Act (Section 13307.1(c)) requires that formal land-use restrictions be placed on sites that are not remediated to an extent that allows unrestricted future use (e.g., residential, day care, etc.). This rule does not currently apply to sites regulated under the state underground storage tank program. It is anticipated that this rule will be especially applied to non petroleum-impacted sites.

2.6 Threat To Surface Water Habitats

Screening levels for freshwater, marine and estuarine water bodies are presented in Table F. These screening levels consider the same set of environmental concerns as groundwater, with the addition of screening levels for the potential bioaccumulation of chemicals in aquatic organisms and subsequent human consumption of these organisms. Locally, the areas north of the Dumbarton Bridge and west of the Richmond-San Rafael Bridge are considered to be marine. The areas south of the Dumbarton Bridge and east of the Richmond-San Rafael Bridge to the upstream extent of tidal influences are considered to be estuarine. Tidally influenced portions of creeks, rivers and streams flowing into the Bay between these areas should also be considered to be estuarine in screening level assessments.

For the purposes of the Tier 1 lookup tables, it is assumed that impacted or potentially impacted groundwater at all sites could at some time migrate offsite and discharge into a body of surface water. This could occur due to the natural, downgradient migration of groundwater or to human activities such as dewatering of construction sites. For several pesticides and heavy metals, including dieldrin, endrin and endosulfan, aquatic habitat goals are more stringent than drinking water toxicity goals for humans. This is reflected in the final groundwater screening levels (refer also to Appendix 1).

The groundwater screening levels for potential impacts to aquatic habitats do not consider dilution of groundwater upon discharge to a body of surface water. Benthic flora and fauna communities situated below or at the groundwater/surface water interface are assumed to be exposed to the full concentration of chemicals in impacted groundwater. Use of a generic "dilution factor" to adjust the surface water protection screening levels with respect to dilution of groundwater upon discharge to surface water was therefore not considered. Consideration of dilution/attenuation factor and alternative groundwater screening levels for the protection of surface water quality may, however, be appropriate on a site-specific basis.

Consideration of surface water standards for bioaccumulation concerns in groundwater investigations and cleanup actions may be warranted at sites where large plumes of impacted groundwater threaten to cause long-term impacts to important aquatic habitats. The bioaccumulation standards will generally not need to be considered at sites with small, isolated plumes of impacted groundwater located some distance from a body of surface water. Although these plumes could conceivably migrate offsite and discharge into a body of surface water in the distant future, impacts are likely to be short-lived and the plumes are likely to become significantly diluted as they mix with surface water. The need for a more detailed study of potential groundwater impacts on surface water with respect to bioaccumulation of chemicals in aquatic organisms should be evaluated on a site-by-site basis. This may include the need for more stringent soil cleanup levels (to prevent additional leaching) and development of a more comprehensive, ecological risk assessment.

The soil and groundwater screening levels presented in the lookup tables do not directly address the protection of sediment quality. Site-specific concerns could include the accumulation and magnification of concentrations of highly sorptive chemicals in sediment over time due to long-term discharges of impacted groundwater. This may be especially true for groundwater impacted with highly sorptive (lipophyllic) chemicals, including heavy petroleum products.

Potential erosion and runoff of surface soils from impacted sites may also need to be considered, particularly at sites impacted with metals and pesticides that are situated near a sensitive body of surface water. The need for a more detailed, ecological risk assessment of impacts to sediment should be evaluated on a site-by-site basis and discussed with the overseeing regulatory agency.

2.7 Screening For Indoor-Air Impact Concerns

Volatile chemicals can be emitted from contaminated soil or groundwater and intrude overlying buildings, impacting the quality of indoor air. Heating systems, basements, and strong winds can exacerbate this problem by reducing the internal air pressure and creating a "vacuum effect" that enhances the advective flow of vapors out of the underlying soil and into the building. Additional information on subsurface vapor intrusion into buildings is provided in the USEPA document *User's Guide For The Johnson and Ettinger (1991) Model For Subsurface Vapor Intrusion Into Buildings* (USEPA 2000; refer also to Appendix 1).

The direct collection and analysis of indoor air samples would seem to be an easy way to evaluate this concern. Identification of the source of impacts is complicated, however, by the presence of the same chemicals in many household goods (aerosol sprays, dry-cleaned clothing, cleaners, etc.). In addition, plumes of groundwater impacted with volatile chemicals are known to extend over significant areas and comprehensive testing of every structure over the plume is not practical.

As an alternative, the comparison of site groundwater, soil gas and soil data to conservative screening levels for indoor air concerns is recommended. Screening levels incorporated into this document are based on scientific models for vapor intrusion into buildings as well as a growing body of data from actual field investigations. A detailed discussion of the screening levels is presented in Appendix 1. The following three-phase, sequential approach is recommended for initial evaluation of potential indoor-air impact concerns at sites where shallow groundwater has been impacted by volatile chemicals:

1) Compare groundwater data to appropriate screening levels for indoor air concerns (see Table E-1a of Appendix 1).

2) For areas over the plume where groundwater screening levels for indoor-air concerns are approached or exceeded, collect shallow soil gas samples under (preferred) or adjacent to buildings and compare results to soil-gas screening levels for this concern (refer to Table E in this volume or Table E-2 in Appendix 1).

3) At buildings soil-gas screening levels for indoor-air concerns are approached or exceeded, collect indoor-air samples and compare results to indoor-air screening levels (refer to Table E in this volume or Table E-3 in Appendix 1).

For sites where the vapor permeability of shallow soils has not been evaluated, screening levels for groundwater overlain by highly permeable vadose-zone soils should be used. Imported fill material or disturbed native soils should be considered to be highly permeable unless site-specific data indicates otherwise.

Unless inhibited by very high water tables or other obstacles, soil gas samples should be collected immediately beneath the foundations of existing buildings (e.g., "subslab" or in crawl spaces) or three to five feet below ground surface in open areas where buildings may be constructed in the future. Soil gas samples collected from depths less than three feet are currently considered unreliable due to the increased potential to draw in ambient, surface air. If site-specific modeling of vapor flow rates or indoor-air impacts is to be carried out, the collection of additional geotechnical data at the time soil gas samples are collected should be considered (soil grain-size analysis, moisture content, vapor permeability, etc.).

Soil screening levels for potential indoor-air concerns are incorporated into the summary tables of this volume and presented separately in Table E-1b of Appendix 1. At sites where minor releases of volatile chemicals have occurred (e.g., restricted spills around underground tank fill ports), direct comparison of soil screening levels to site data is generally acceptable. If screening levels are exceeded, a similar approach to that outlined above for impacted groundwater is recommended. The restricted size of soil samples and the difficulty in predicting vapor-phase concentrations of chemicals from soil data limits the use of this data as a stand-alone tool for evaluating indoor-air concerns. **At sites where significant releases of volatile chemicals have occurred, the direct use of soil gas data in conjunction with soil data is strongly recommended.**

Guidance on the collection of indoor air and soil gas samples is provided in the following documents, among other sources:

- *Indoor Air Sampling And Evaluation Guide* (2002): Massachusetts Department of Environmental Protection, Office of Research and Standards, WSC Policy #02-430; http://www.state.ma.us/dep/bwsc/finalpol.htm;

- *Soil Gas Advisory* (January 2003): Department of Toxic Substances Control and Los Angeles Regional Water Quality Control Board; http://www.dtsc.ca.gov/PolicyAndProcedures/SiteCleanup/SMBR_ADV_activesoilgasinvst.pdf.

Additional information on the intrusion of subsurface vapors into buildings will be incorporated into this document as available. Individuals are encouraged to provide comments and suggestions to the contacts listed in the front of this document at anytime.

2.8 Substitution of Laboratory Reporting Limits and Ambient Background Concentrations for ESLs

In cases where an ESL for a specific chemical is less than the laboratory method reporting limit for that chemical (as agreed upon by the overseeing regulatory agency), it is generally acceptable to consider the method reporting limit in place of the screening level. Potential examples include the soil health-based ESLs for dioxin (e.g., 0.0000045 mg/kg for residential exposure).

Background concentrations of metals in soils are presented in the summary lookup tables in cases where they exceed screening levels for human health and environmental concerns. This is particularly an issue for arsenic and thallium in Bay area soils. For example, typical mean background concentrations of arsenic in Bay area soils ranges from approximately 5 mg/kg to 20 mg/kg, with some soils containing up to 40+ mg/kg arsenic (LBNL 2002). These concentrations are well above the health-based, direct-exposure goals for arsenic in soil of 0.39 mg/kg (residential exposure) and 1.6 mg/kg (commercial/industrial exposure) presented in the appendices.

For use in this document, an assumed background level of 5.5 mg/kg arsenic was substituted for toxicity-based goals in the lookup table if higher than the later. A background concentration of 58 mg/kg total chromium in soil is also assumed in the lookup tables. Note that background levels of total chromium can be significantly higher (>1,000 mg/kg) in soils developed over mafic and ultramafic rocks in the Bay area. Refer also to Appendix 1, Section 3.2.4 for additional discussion of this issue.

Figure 4 suggests steps that could be taken when evaluating a site for potential arsenic impacts. The natural background concentration of a chemical in soil or groundwater can vary significantly between and even within sites and is most appropriately evaluated by the collection of on-site samples or by reference to local data collected from past studies. Guidance for estimating background concentrations of chemicals in soil and groundwater is provided in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). Sources of background metal concentration in soils in California include the University of California-Riverside report *Background Concentrations of Trace and Major Elements in California Soils* (UCR 1996) and the Lawrence Berkeley

Laboratory document *Protocol for Determining Background Concentrations if Metals in Soil at Lawrence Berkeley National Laboratory* (LBNL 2002).

A similar approach should be taken for total chromium. Additional review of background total chromium concentrations in soil should be carried out at sites where the screening level of 58 mg/kg is exceeded. If reported levels of total chromium still appear to exceed anticipated site-specific background levels, then soil samples should be tested for Cr VI and Cr III. Data should be compared to screening levels for these specific species of chromium and action taken as needed.

2.9 Implied Land-Use Restrictions Under Tier 1

Allowing the option to tie screening levels or cleanup levels to site-specific land use and exposure conditions can save considerably in investigation and remediation costs. For example, the screening level for polychlorinated biphenyls (PCBs) in surface soils is 0.22 mg/kg in residential areas but up to 7.0 mg/kg (at target risk of 10^{-5}) for commercial/industrial areas. Even higher levels of PCBs could potentially be allowed to remain in place onsite provided that adequate controls to mitigate potential exposure are put into effect (e.g., permanent cap, protection of groundwater, etc.).

The use of final cleanup levels less stringent than those appropriate for unrestricted land use will, however, place restrictions on future use of the property. For example, if a site is remediated using ESLs (or alternative criteria) intended for commercial/industrial land use then the site cannot be used for residential purposes in the future without additional evaluation. In most cases, this will require that a formal covenant to the deed be recorded to restrict future use of the property. As stated in recent provisions in the Porter-Cologne Act (Section 13307.1(c)):

> "...if the state board or the regional board finds that the property is not suitable for unrestricted use...then the state board and regional boards may not issue a closure letter, or make a determination that no further action is required...unless a land restriction is recorded..."

The use of ESLs for deep soils at a site similarly assumes that the impacted soil will remain isolated below the ground surface "for eternity". For single-family, residential areas, future disturbance of soil situated greater than three meters is generally considered to be unlikely (CalEPA 1996a) and use of the ESLs for deep soil below this depth without restrictions may be reasonable (see Section 2.4). During the redevelopment of properties for commercial/industrial or high-density residential use, however, excavation and removal of soils from depths in excess of five or even ten meters could take place (e.g., for underground parking garages, elevator shafts, utilities, etc.). The need to impose enforceable, institutional controls for proper management of deep, impacted soils at properties where the subsurface ESLs (or alternative cleanup levels) are applied should be discussed with the overseeing regulatory agency on a site-by-site basis.

Land-use restrictions inherent in the selection of ESLs from the Tier 1 lookup tables (or assumptions used in site-specific risk assessments) should be kept as minimal as possible. **Concentrations of chemicals in impacted soils left in place at a commercial/industrial site should always be compared to both commercial/industrial AND residential ESLs (or alternative criteria for unrestricted land use).** If the soils in fact meet ESLs for unrestricted land use after cleanup then this should be clearly stated in the site closure report. Recognizing this point may prove important should the site unexpectedly become desirable for other use in the future (e.g., residential, school day care, health care, etc.). **Assumptions that impacted soil at a property will remain isolated at shallow depths under pavement, buildings or some other type of "cap" should likewise be avoided if at all possible.** Such assumptions place significant and oftentimes unnecessary restrictions on the future use and redevelopment of a site. If done, appropriate covenants to the property deed should be prepared and methods to prevent or manage future disturbance of the soil should be clearly described and ensured. A foresighted approach in the use of Tier 1 ESLs or alternative, site-specific cleanup levels will allow more flexibility in future use of a site, help avoid unexpected complications during site redevelopment and minimize the liability of future land owners.

2.10 Cumulative Risks at Sites With Multiple Chemicals of Concern

Risks posed by direct exposure to multiple chemicals with similar health affects are considered to be additive or "cumulative." For example, the total risk of cancer posed by the presence of two carcinogenic chemicals in soil is the sum of the risk posed by each individual chemical. The same is true for chemicals that cause noncarcingenic health effects. A summary of example target health effects for the chemicals listed in the lookup tables is provided in Appendix 1 (Table L).

Use of ESLs for single chemicals is limited to the extent that the screening levels remain protective of human health should other chemicals with similar health effects also be present. Soil ESLs are considered to be adequate for use at sites where no more three carcinogenic chemicals or five chemicals with similar noncarcinogenic ("systemic") health effects are present. This is based on a combination of conservative exposure assumptions and target risk factors in direct-exposure models. Refer to Appendix 1, Section 1.3, for additional discussion of this subject.

2.11 Framework For a Tier 1 Environmental Risk Assessment

Tier 1 environmental risk assessments should serve as "stand alone" documents that provide a good summary of environment impacts at a site and assess the threats posed to human health and the environment by these impacts. The risk assessment can be prepared as a component of a site investigation or remedial action report or as a separate document. Information on each of the topics listed below should be addressed in report that presents the risk assessment, however (after MADEP 1995). Together, this information is intended to provide a basic "conceptual model" of site conditions. The level of detailed required for each topic will vary depending on site-specific considerations.

1. Summarize Past, Current and Anticipated Future Site Activities and Uses:
   - Describe past and current site uses and activities;
   - Describe foreseeable future site uses and activities. **(Always include a comparison of site data to ESLs for unrestricted land use to evaluate need for formal covenants to the deed; see Section 2.9).**
2. Summary of Site Investigation:
   - Identify all types of impacted media;
   - Identify all sources of chemical releases;
   - Identify all chemicals of concern;
   - Identify magnitude and extent of impacts that exceed ESLs to extent feasible and applicable (include maps of site with isoconcentration contours for soil and groundwater);
   - Identify nearby groundwater extraction wells, bodies of surface water and other potentially sensitive ecological habitats;
   - Ensure data are representative of site conditions.
3. Summarize Appropriateness of Use of Tier 1 Lookup Tables and ESLs (see Section 1.5):
   - Do Tier 1 ESLs exist for all chemicals of concern?
   - Does the site have a high public profile and warrant a fully documented, detailed environmental risk assessment?
   - Do soil and groundwater conditions at the site differ significantly from those assumed in development of the lookup tables (e.g., low pH at mine sites)?
   - Do impacts pose a heightened threat to sensitive ecological habitats (e.g., presence of endangered or protected species)?
   - Is the thickness of vadose-zone soils impacted by volatile organic compounds greater than three meters (10 feet, see Section 1.5 and Appendix 1);
   - Have more than three carcinogens or five chemicals with similar noncarcinogenic health effects been identified (see Section 2.10)?

- Other issues as applicable to the site.

4. Soil and Groundwater Categorization (see Sections 2.3 and 2.4):
   - State the regulatory beneficial use of impacted or potentially impacted groundwater beneath the site; discuss the actual, likely beneficial use of groundwater based on measured or assumed quality of the groundwater and the hydrogeologic nature of the soil or bedrock containing the groundwater.
   - Characterize the soil type(s) and location of impacted soil as applicable to the lookup tables (e.g., soil stratigraphy, soil texture and permeability, depth to and thickness of impacted soil, etc.).

5. Exposure Point Concentrations (see Section 2.2, Step 7):
   - Identify maximum concentrations of chemicals present in impacted media.
   - Describe how alternative exposure point concentrations were determined (e.g., 95% UCLs), if proposed, and provide supporting data. **For residential land use scenarios, sample data should be averaged over no more than a 1,000 ft^2 area.**
   - Discuss the need to evaluate groundwater data with respect to surface water standards for potential bioaccumulation of chemicals in aquatic organisms ("Elevated threat to surface water body"), due to the size of the plume, the proximity of the plume to a body of surface water and the potential for minimal dilution of groundwater upon discharge to surface water (see Section 2.7).
   - Discuss how background concentrations of chemicals were determined, if considered for use in the risk assessment (see Section 2.8).

6. Selection of Tier 1 ESLs and Comparison to Site Data (see Section 2.2)
   - Summarize how Tier 1 ESLs were selected with respect to the information provided above and additional assumptions as applicable.
   - Compare site data to the selected summary Tier 1 ESLs (presented in Volume 1) and discuss general results.
   - If desired or recommended, compare site data to detailed ESLs for individual environmental concerns (presented in Volume 2, Appendix 1) and discuss specific, potential environmental concerns present at site.

7. Conclusions (see Section 2.9):
   - Describe the extent of soil and groundwater impacts above Tier 1 ESLs, using maps and cross sections as necessary.
   - Discuss if a condition of potential risk to human health and the environment exists at the site.
   - Discuss if a more site-specific risk assessment is warranted at the site.
   - Present a summary of recommended future actions proposed to address environmental concerns ay the site.
   - Discuss the need to impose land-use restrictions and institutional controls at the site based on the results of the Tier 1 assessment (e.g., requirements for caps,

etc.; need for covenant to deed to restrict land use to commercial/industrial purposes only, etc).

The above list is not intended to be exhaustive or representative of an exact outline required for all Tier 1 risk assessments. Requirements for completion of an adequate site investigation and Tier 1 environmental risk assessment should be discussed with the overseeing regulatory agency.

TABLE B: SHALLOW SOIL (≤3M BGS) - WATER IS NOT A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.9).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.3).

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	2.4E-01	2.4E-01	7.0E+02
ALDRIN	2.9E-02	1.0E-01	2.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.3E+00	4.0E+01	6.0E+00
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	7.5E+02	1.5E+03	1.0E+03
BENZENE	4.4E-02	4.4E-02	1.0E+00
BENZO(a)ANTHRACENE	3.8E-01	1.3E+00	2.7E-02
BENZO(b)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(k)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	3.8E-02	1.3E-01	1.4E-02
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.8E-04	1.8E-04	1.4E-02
BIS(2-CHLOROISOPROPYL)ETHER	5.4E-03	5.4E-03	5.0E-01
BIS(2-ETHYLHEXYL)PHTHALATE	6.6E+01	6.6E+01	4.0E+00
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	1.2E-02	3.9E-02	1.0E+02
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	2.2E-01	3.9E-01	9.8E+00
CADMIUM	1.7E+00	7.4E+00	2.2E+00
CARBON TETRACHLORIDE	1.2E-02	3.5E-02	5.0E-01
CHLORDANE	4.4E-01	1.7E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E-02	2.7E-01	1.0E+02
CHLOROMETHANE	2.9E-01	4.2E-01	2.7E+00
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	5.8E+01	5.8E+01	5.0E+01
CHROMIUM III	7.5E+02	7.5E+02	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	3.8E+00	1.3E+01	2.9E-01
COBALT	4.0E+01	8.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	1.0E+02	5.0E+02	1.0E+00
DIBENZO(a,h)ANTHTRACENE	1.1E-01	3.8E-01	8.5E-03
DIBROMOCHLOROMETHANE	1.9E-02	5.8E-02	1.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	1.1E-03	1.1E-03	2.0E-01
DIBROMOETHANE, 1,2-	3.3E-04	3.3E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
DICHLOROBENZENE, 1,3-	7.2E-01	7.2E-01	6.3E+00
DICHLOROBENZENE, 1,4-	4.7E-02	1.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	7.7E-03	7.7E-03	2.9E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4E+00	1.0E+01	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.7E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	2.0E-01	2.0E-01	5.0E+00
DICHLOROETHANE, 1,2-	4.5E-03	4.5E-03	5.0E-01
DICHLOROETHYLENE, 1,1-	1.0E+00	1.0E+00	6.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.9E-01	1.9E-01	6.0E+00
DICHLOROETHYLENE, Trans 1,2-	6.7E-01	6.7E-01	1.0E+01
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.2E-02	1.2E-01	5.0E+00
DICHLOROPROPENE, 1,3-	3.3E-02	5.9E-02	5.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	6.7E-01	6.7E-01	1.0E+02
DINITROPHENOL, 2,4-	4.0E-02	4.0E-02	1.4E+01
DINITROTOLUENE, 2,4-	8.5E-04	8.5E-04	1.1E-01
1,4 DIOXANE	1.8E-03	1.8E-03	3.0E+00
DIOXIN (2,3,7,8-TCDD)	4.5E-06	1.8E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	2.7E-01	9.6E-01	1.0E+00
HEXACHLOROBUTADIENE	1.0E+00	1.0E+00	2.1E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	2.4E+00	2.4E+00	7.0E-01
INDENO(1,2,3-cd)PYRENE	3.8E-01	1.3E+00	2.9E-02
LEAD	2.0E+02	7.5E+02	2.5E+00
MERCURY	2.5E+00	1.0E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	7.7E-02	7.7E-02	5.0E+00
METHYL ETHYL KETONE	3.9E+00	3.9E+00	4.2E+03
METHYL ISOBUTYL KETONE	2.8E+00	2.8E+00	1.2E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00
MOLYBDENUM	4.0E+01	4.0E+01	3.5E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	[1]Shallow Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
NAPHTHALENE	4.2E+00	4.2E+00	2.1E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	4.4E+00	5.0E+00	1.0E+00
PERCHLORATE	7.0E-03	7.0E-03	7.0E-01
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	7.3E-02	7.3E-02	1.2E+01
TETRACHLOROETHANE, 1,1,1,2-	2.4E-02	2.4E-02	1.3E+00
TETRACHLOROETHANE, 1,1,2,2-	9.0E-03	1.8E-02	1.0E+00
TETRACHLOROETHYLENE	8.8E-02	2.5E-01	5.0E+00
THALLIUM	1.0E+00	1.3E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	5.0E+02	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	7.6E+00	7.6E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.3E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	2.6E-01	4.6E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.7E-01	1.7E-01	5.0E-01
VANADIUM	1.1E+02	2.0E+02	1.5E+01
VINYL CHLORIDE	6.7E-03	1.9E-02	5.0E-01
XYLENES	1.5E+00	1.5E+00	1.3E+01
ZINC	6.0E+02	6.0E+02	8.1E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	Shallow Soil[1]		Groundwater[3] (ug/L)
	Residential[2] Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable

Notes:

1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1a.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.9E+01	1.9E+01	2.3E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	2.9E-02	1.0E-01	1.3E-01
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.3E+00	4.0E+01	3.0E+01
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	7.5E+02	1.5E+03	1.0E+03
BENZENE	1.8E-01	3.8E-01	4.6E+01
BENZO(a)ANTHRACENE	3.8E-01	1.3E+00	2.7E-02
BENZO(b)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(k)FLUORANTHENE	3.8E-01	1.3E+00	4.0E-01
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	3.8E-02	1.3E-01	1.4E-02
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E+00	6.5E+00	5.0E+00
BIS(2-CHLOROETHYL)ETHER	4.0E-03	1.3E-02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.6E-01	6.6E-01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	1.6E+02	5.3E+02	3.2E+01
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	1.2E-02	3.9E-02	1.6E+02
BROMOFORM	6.1E+01	6.9E+01	3.2E+03
BROMOMETHANE	2.2E-01	5.1E-01	1.6E+02
CADMIUM	1.7E+00	7.4E+00	2.2E+00
CARBON TETRACHLORIDE	1.2E-02	3.5E-02	9.5E+00
CHLORDANE	4.4E-01	1.7E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E-02	2.7E-01	3.4E+02
CHLOROMETHANE	2.9E-01	8.1E-01	1.7E+02
CHLOROPHENOL, 2-	1.2E-01	1.2E-01	1.8E+00
CHROMIUM (Total)	5.8E+01	5.8E+01	1.8E+02
CHROMIUM III	7.5E+02	7.5E+02	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	3.8E+00	1.3E+01	3.5E-01
COBALT	4.0E+01	8.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	1.0E+02	5.0E+02	1.0E+00
DIBENZO(a,h)ANTHTRACENE	1.1E-01	3.8E-01	2.5E-01
DIBROMOCHLOROMETHANE	1.9E-02	5.8E-02	1.8E+02

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil: [2]Residential Land Use (mg/kg)	[1]Shallow Soil: Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
1,2-DIBROMO-3-CHLOROPROPANE	1.1E-03	1.1E-03	2.0E-01
DIBROMOETHANE, 1,2-	7.3E-03	2.1E-02	1.6E+02
DICHLOROBENZENE, 1,2-	1.6E+00	1.6E+00	1.4E+01
DICHLOROBENZENE, 1,3-	3.2E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	4.7E-02	1.3E-01	1.5E+01
DICHLOROBENZIDINE, 3,3-	4.0E-01	1.4E+00	2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4E+00	1.0E+01	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.7E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	3.3E-01	9.1E-01	4.7E+01
DICHLOROETHANE, 1,2-	2.5E-02	6.9E-02	2.0E+02
DICHLOROETHYLENE, 1,1-	4.3E+00	4.3E+00	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	1.6E+00	3.6E+00	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	3.1E+00	7.3E+00	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	3.0E+00	3.0E+00
DICHLOROPROPANE, 1,2-	5.2E-02	1.5E-01	1.0E+02
DICHLOROPROPENE, 1,3-	3.3E-02	9.1E-02	4.9E+01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.4E-01	7.4E-01	1.1E+02
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.5E+01
DINITROTOLUENE, 2,4-	8.6E-01	8.6E-01	1.2E+02
1,4 DIOXANE	1.8E+01	3.0E+01	5.0E+04
DIOXIN (2,3,7,8-TCDD)	4.5E-06	1.8E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHYLBENZENE	4.7E+00	1.3E+01	2.9E+02
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	2.7E-01	9.6E-01	3.7E+00
HEXACHLOROBUTADIENE	3.7E+00	2.2E+01	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	1.2E+01	4.1E+01	1.2E+01
INDENO(1,2,3-cd)PYRENE	3.8E-01	1.3E+00	2.9E-02
LEAD	2.0E+02	7.5E+02	2.5E+00
MERCURY	2.5E+00	1.0E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	5.2E-01	1.5E+00	2.2E+03

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
METHYL ETHYL KETONE	1.3E+01	1.3E+01	1.4E+04
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.0E+00	5.6E+00	1.8E+03
MOLYBDENUM	4.0E+01	4.0E+01	2.4E+02
NAPHTHALENE	4.5E+00	4.8E+00	2.4E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	4.4E+00	5.0E+00	7.9E+00
PERCHLORATE	1.2E+00	1.2E+00	6.0E+02
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	1.9E+01	1.9E+01	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+01	1.5E+01	1.0E+02
tert-BUTYL ALCOHOL	1.0E+02	1.1E+02	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	3.1E+00	7.2E+00	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	9.0E-03	2.5E-02	1.9E+02
TETRACHLOROETHYLENE	8.8E-02	2.5E-01	1.2E+02
THALLIUM	1.0E+00	1.3E+01	2.0E+01
TOLUENE	9.3E+00	9.3E+00	1.3E+02
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	4.0E+02	5.0E+02
TPH (middle distillates)	5.0E+02	5.0E+02	6.4E+02
TPH (residual fuels)	5.0E+02	1.0E+03	6.4E+02
TRICHLOROBENZENE, 1,2,4-	7.6E+00	7.6E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.3E-02	9.1E-02	3.5E+02
TRICHLOROETHYLENE	2.6E-01	7.3E-01	3.6E+02
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	6.9E+00	1.0E+01	4.9E+02
VANADIUM	1.1E+02	2.0E+02	1.9E+01

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
VINYL CHLORIDE	6.7E-03	1.9E-02	4.0E+00
XYLENES	1.5E+00	1.5E+00	1.3E+01
ZINC	6.0E+02	6.0E+02	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable

Notes:

1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2.
Source of groundwater ESLs: Refer to Appendix 1, Table F-1b.
Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).
Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**
Groundwater ESLs intended to address surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**
Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).
Refer to appendices for summary of ESL components.
TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE F: SURFACE WATER

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	[1]Freshwater (ug/L)	[4]Marine (ug/L)	[5]Estuarine (ug/L)
ACENAPHTHENE	2.0E+01	2.0E+01	2.0E+01
ACENAPHTHYLENE	3.0E+01	3.0E+01	3.0E+01
ACETONE	7.0E+02	1.5E+03	1.5E+03
ALDRIN	1.4E-04	1.4E-04	1.4E-04
ANTHRACENE	7.3E-01	7.3E-01	7.3E-01
ANTIMONY	6.0E+00	5.0E+02	5.0E+02
ARSENIC	1.4E-01	1.4E-01	1.4E-01
BARIUM	1.0E+03	1.0E+03	1.0E+03
BENZENE	1.0E+00	7.1E+01	7.1E+01
BENZO(a)ANTHRACENE	2.7E-02	2.7E-02	2.7E-02
BENZO(b)FLUORANTHENE	2.9E-02	2.9E-02	2.9E-02
BENZO(k)FLUORANTHENE	2.9E-02	4.9E-02	4.9E-02
BENZO(g,h,i)PERYLENE	1.0E-01	1.0E-01	1.0E-01
BENZO(a)PYRENE	1.4E-02	1.4E-02	1.4E-02
BERYLLIUM	2.7E+00	2.7E+00	2.7E+00
BIPHENYL, 1,1-	5.0E-01	5.0E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.4E-02	1.4E+00	1.4E+00
BIS(2-CHLOROISOPROPYL)ETHER	5.0E-01	6.1E+01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	4.0E+00	5.9E+00	5.9E+00
BORON	1.6E+00	1.6E+00	1.6E+00
BROMODICHLOROMETHANE	1.0E+02	3.2E+03	3.2E+03
BROMOFORM	1.0E+02	3.6E+02	3.6E+02
BROMOMETHANE	9.8E+00	3.2E+03	3.2E+03
CADMIUM	2.2E+00	9.3E+00	9.3E+00
CARBON TETRACHLORIDE	5.0E-01	4.4E+00	4.4E+00
CHLORDANE	5.9E-04	5.9E-04	5.9E-04
CHLOROANILINE, p-	5.0E+00	5.0E+00	5.0E+00
CHLOROBENZENE	2.5E+01	5.0E+01	5.0E+01
CHLOROETHANE	1.2E+01	1.2E+01	1.2E+01
CHLOROFORM	1.0E+02	4.7E+02	4.7E+02
CHLOROMETHANE	2.7E+00	3.2E+03	3.2E+03
CHLOROPHENOL, 2-	1.8E-01	1.8E-01	1.8E-01
CHROMIUM (Total)	5.0E+01	1.8E+02	1.8E+02
CHROMIUM III	1.8E+02	1.8E+02	1.8E+02
CHROMIUM VI	1.1E+01	5.0E+01	5.0E+01
CHRYSENE	4.9E-02	4.9E-02	4.9E-02
COBALT	3.0E+00	3.0E+00	3.0E+00
COPPER	9.0E+00	3.1E+00	3.1E+00
CYANIDE (Free)	5.2E+00	1.0E+00	1.0E+00
DIBENZO(a,h)ANTHTRACENE	8.5E-03	4.9E-02	4.9E-02
DIBROMOCHLOROMETHANE	4.6E+01	4.6E+01	4.6E+01
1,2-DIBROMO-3-CHLOROPROPANE	2.0E-01	2.0E-01	2.0E-01
DIBROMOETHANE, 1,2-	5.0E-02	1.4E+03	1.4E+03
DICHLOROBENZENE, 1,2-	1.0E+01	1.0E+01	1.0E+01
DICHLOROBENZENE, 1,3-	6.3E+00	6.5E+01	6.5E+01

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	[1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
DICHLOROBENZENE, 1,4-	5.0E+00	1.1E+01	1.1E+01
DICHLOROBENZIDINE, 3,3-	2.9E-02	7.7E-02	7.7E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	8.4E-04	8.4E-04	8.4E-04
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	5.9E-04	5.9E-04	5.9E-04
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	5.9E-04	5.9E-04	5.9E-04
DICHLOROETHANE, 1,1-	5.0E+00	4.7E+01	4.7E+01
DICHLOROETHANE, 1,2-	5.0E-01	9.9E+01	9.9E+01
DICHLOROETHYLENE, 1,1-	3.2E+00	3.2E+00	3.2E+00
DICHLOROETHYLENE, Cis 1,2-	6.0E+00	5.9E+02	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	1.0E+01	2.6E+02	2.6E+02
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.0E+00	1.0E+01	1.0E+01
DICHLOROPROPENE, 1,3-	5.0E-01	1.2E+02	1.2E+02
DIELDRIN	2.2E-03	1.9E-03	1.9E-03
DIETHYLPHTHALATE	1.5E+00	1.7E+00	1.7E+00
DIMETHYLPHTHALATE	1.5E+00	1.7E+00	1.7E+00
DIMETHYLPHENOL, 2,4-	1.0E+02	1.1E+02	1.1E+02
DINITROPHENOL, 2,4-	1.4E+01	7.5E+01	7.5E+01
DINITROTOLUENE, 2,4-	1.1E-01	9.1E+00	9.1E+00
1,4 DIOXANE	3.0E+00	5.0E+04	5.0E+04
DIOXIN (2,3,7,8-TCDD)	1.4E-08	1.4E-08	1.4E-08
ENDOSULFAN	5.6E-02	8.7E-03	8.7E-03
ENDRIN	3.6E-02	2.3E-03	2.3E-03
ETHYLBENZENE	3.0E+01	3.0E+01	3.0E+01
FLUORANTHENE	8.1E+00	8.0E+00	8.0E+00
FLUORENE	3.9E+00	3.9E+00	3.9E+00
HEPTACHLOR	2.1E-04	2.1E-04	2.1E-04
HEPTACHLOR EPOXIDE	1.1E-04	1.1E-04	1.1E-04
HEXACHLOROBENZENE	7.7E-04	7.7E-04	7.7E-04
HEXACHLOROBUTADIENE	2.1E-01	4.7E+00	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	6.3E-02	6.3E-02	6.3E-02
HEXACHLOROETHANE	7.0E-01	8.9E+00	8.9E+00
INDENO(1,2,3-cd)PYRENE	2.9E-02	2.9E-02	2.9E-02
LEAD	2.5E+00	8.1E+00	8.1E+00
MERCURY	5.1E-02	2.5E-02	2.5E-02
METHOXYCHLOR	1.9E-02	1.9E-02	1.9E-02
METHYLENE CHLORIDE	5.0E+00	1.6E+03	1.6E+03
METHYL ETHYL KETONE	4.2E+03	8.4E+03	8.4E+03
METHYL ISOBUTYL KETONE	1.2E+02	1.7E+02	1.7E+02
METHYL MERCURY	3.0E-03	3.0E-03	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.1E+00	2.1E+00	2.1E+00
METHYL TERT BUTYL ETHER	5.0E+00	1.8E+02	1.8E+02
MOLYBDENUM	3.5E+01	2.4E+02	2.4E+02
NAPHTHALENE	2.1E+01	2.1E+01	2.1E+01
NICKEL	5.2E+01	8.2E+00	8.2E+00

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	[1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
PENTACHLOROPHENOL	1.0E+00	7.9E+00	7.9E+00
PERCHLORATE	7.0E-01	6.0E+02	6.0E+02
PHENANTHRENE	6.3E+00	4.6E+00	4.6E+00
PHENOL	5.0E+00	1.3E+03	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	1.7E-04	1.7E-04	1.7E-04
PYRENE	2.0E+00	2.0E+00	2.0E+00
SELENIUM	5.0E+00	7.1E+01	7.1E+01
SILVER	3.4E-01	1.9E-01	1.9E-01
STYRENE	1.0E+01	1.1E+01	1.1E+01
tert-BUTYL ALCOHOL	1.2E+01	1.8E+04	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	1.3E+00	9.3E+02	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	1.0E+00	1.1E+01	1.1E+01
TETRACHLOROETHYLENE	5.0E+00	8.9E+00	8.9E+00
THALLIUM	2.0E+00	6.3E+00	6.3E+00
TOLUENE	4.0E+01	4.0E+01	4.0E+01
TOXAPHENE	2.0E-04	2.0E-04	2.0E-04
TPH (gasolines)	1.0E+02	3.7E+03	3.7E+03
TPH (middle distillates)	1.0E+02	6.4E+02	6.4E+02
TPH (residual fuels)	1.0E+02	6.4E+02	6.4E+02
TRICHLOROBENZENE, 1,2,4-	2.5E+01	6.5E+01	6.5E+01
TRICHLOROETHANE, 1,1,1-	6.2E+01	6.2E+01	6.2E+01
TRICHLOROETHANE, 1,1,2-	5.0E+00	4.2E+01	4.2E+01
TRICHLOROETHYLENE	5.0E+00	8.1E+01	8.1E+01
TRICHLOROPHENOL, 2,4,5-	6.3E+01	1.1E+01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	5.0E-01	6.5E+00	6.5E+00
VANADIUM	1.5E+01	1.9E+01	1.9E+01
VINYL CHLORIDE	5.0E-01	5.3E+02	5.3E+02
XYLENES	1.3E+01	1.3E+01	1.3E+01
ZINC	1.2E+02	8.1E+01	8.1E+01

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS [1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable

Notes:

1. Source of Freshwater ESLs: Refer to Appendix 1, Table F-2a
2. Source of Marine ESLs: Refer to Appendix 1, Table F-2b.
3. Source of Estuarine ESLs: Refer to Appendix 1, Table F-2c.

Surface water screening levels lowest of drinking water goal (freshwater only), chronic aquatic habitat goal, goal to address bioaccumulation in aquatic organisms and subsequent consumption by humans, and general nuisance goal (odors, etc.). Refer to Section 2.7 of text for discussion.

Estuarine screening levels lowest of freshwater and marine screening levels.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Section 2.2 and Appendix 1, Chapter 5.

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	2.4E-01	2.4E-01	7.0E+02
ALDRIN	2.9E-02	1.0E-01	2.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.3E+00	4.0E+01	6.0E+00
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	7.5E+02	1.5E+03	1.0E+03
BENZENE	4.4E-02	4.4E-02	1.0E+00
BENZO(a)ANTHRACENE	3.8E-01	1.3E+00	2.7E-02
BENZO(b)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(k)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	3.8E-02	1.3E-01	1.4E-02
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.8E-04	1.8E-04	1.4E-02
BIS(2-CHLOROISOPROPYL)ETHER	5.4E-03	5.4E-03	5.0E-01
BIS(2-ETHYLHEXYL)PHTHALATE	6.6E+01	6.6E+01	4.0E+00
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	1.2E-02	3.9E-02	1.0E+02
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	2.2E-01	3.9E-01	9.8E+00
CADMIUM	1.7E+00	7.4E+00	2.2E+00
CARBON TETRACHLORIDE	1.2E-02	3.5E-02	5.0E-01
CHLORDANE	4.4E-01	1.7E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E-02	2.7E-01	1.0E+02
CHLOROMETHANE	2.9E-01	4.2E-01	2.7E+00
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	5.8E+01	5.8E+01	5.0E+01
CHROMIUM III	7.5E+02	7.5E+02	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	3.8E+00	1.3E+01	2.9E-01
COBALT	4.0E+01	8.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	1.0E+02	5.0E+02	1.0E+00
DIBENZO(a,h)ANTHTRACENE	1.1E-01	3.8E-01	8.5E-03
DIBROMOCHLOROMETHANE	1.9E-02	5.8E-02	1.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	1.1E-03	1.1E-03	2.0E-01
DIBROMOETHANE, 1,2-	3.3E-04	3.3E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
DICHLOROBENZENE, 1,3-	7.2E-01	7.2E-01	6.3E+00
DICHLOROBENZENE, 1,4-	4.7E-02	1.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	7.7E-03	7.7E-03	2.9E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4E+00	1.0E+01	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.7E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	2.0E-01	2.0E-01	5.0E+00
DICHLOROETHANE, 1,2-	4.5E-03	4.5E-03	5.0E-01
DICHLOROETHYLENE, 1,1-	1.0E+00	1.0E+00	6.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.9E-01	1.9E-01	6.0E+00
DICHLOROETHYLENE, Trans 1,2-	6.7E-01	6.7E-01	1.0E+01
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.2E-02	1.2E-01	5.0E+00
DICHLOROPROPENE, 1,3-	3.3E-02	5.9E-02	5.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	6.7E-01	6.7E-01	1.0E+02
DINITROPHENOL, 2,4-	4.0E-02	4.0E-02	1.4E+01
DINITROTOLUENE, 2,4-	8.5E-04	8.5E-04	1.1E-01
1,4 DIOXANE	1.8E-03	1.8E-03	3.0E+00
DIOXIN (2,3,7,8-TCDD)	4.5E-06	1.8E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	2.7E-01	9.6E-01	1.0E+00
HEXACHLOROBUTADIENE	1.0E+00	1.0E+00	2.1E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	2.4E+00	2.4E+00	7.0E-01
INDENO(1,2,3-cd)PYRENE	3.8E-01	1.3E+00	2.9E-02
LEAD	2.0E+02	7.5E+02	2.5E+00
MERCURY	2.5E+00	1.0E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	7.7E-02	7.7E-02	5.0E+00
METHYL ETHYL KETONE	3.9E+00	3.9E+00	4.2E+03
METHYL ISOBUTYL KETONE	2.8E+00	2.8E+00	1.2E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00
MOLYBDENUM	4.0E+01	4.0E+01	3.5E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	[1]Shallow Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
NAPHTHALENE	4.2E+00	4.2E+00	2.1E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	4.4E+00	5.0E+00	1.0E+00
PERCHLORATE	7.0E-03	7.0E-03	7.0E-01
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	7.3E-02	7.3E-02	1.2E+01
TETRACHLOROETHANE, 1,1,1,2-	2.4E-02	2.4E-02	1.3E+00
TETRACHLOROETHANE, 1,1,2,2-	9.0E-03	1.8E-02	1.0E+00
TETRACHLOROETHYLENE	8.8E-02	2.5E-01	5.0E+00
THALLIUM	1.0E+00	1.3E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	5.0E+02	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	7.6E+00	7.6E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.3E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	2.6E-01	4.6E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.7E-01	1.7E-01	5.0E-01
VANADIUM	1.1E+02	2.0E+02	1.5E+01
VINYL CHLORIDE	6.7E-03	1.9E-02	5.0E-01
XYLENES	1.5E+00	1.5E+00	1.3E+01
ZINC	6.0E+02	6.0E+02	8.1E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	Shallow Soil[1]		Groundwater[3] (ug/L)
	Residential[2] Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable

Notes:

1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1a.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

14

April 2004 SCH No. 2003031044

PARAMOUNT REFINERY

CLEAN FUELS PROJECT

FINAL ENVIRONMENTAL IMPACT REPORT

Volume I: Final Environmental Impact Report

Executive Officer
Barry Wallerstein, D. Env.

Deputy Executive Officer
Planning, Rules, and Area Sources
Elaine Chang, DrPH

Assistant Deputy Executive Officer
Planning, Rule Development and Area Sources
Laki Tisopulos, Ph.D., P.E.

Planning and Rules Manager
CEQA and Socioeconomic Analyses
Susan Nakamura

Submitted to:
SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Prepared by:
ENVIRONMENTAL AUDIT, INC.

Reviewed by: James Koizumi - Air Quality Specialist
Steve Smith, Ph.D. - Program Supervisor
Barbara Baird - District Counsel

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT GOVERNING BOARD

TABLE OF CONTENTS
PARAMOUNT REFINERY CLEAN FUELS PROJECT
DRAFT ENVIRONMENTAL IMPACT REPORT

VOLUME I Page No.

VOLUME I

VOLUME I

VOLUME I

VOLUME I Page No.

FIGURES: (cont.)

TABLES:

VOLUME I

Page No.

VOLUME II

Health Risk Assessment

M:\DBS\2150 Paramount\Electronic EIR\Paramount CFP EIR 0.doc

CHAPTER 5

CUMULATIVE IMPACTS

CHAPTER 5.0

CUMULATIVE IMPACTS

A. INTRODUCTION

CEQA Guidelines §15130(a) requires an EIR to discuss cumulative impacts of a project when the project's incremental effect is cumulative considerable, as defined in §15065(c). There are a number of projects proposed for development in the Paramount area that may contribute cumulative regional impacts to those generated by the Paramount Refinery's proposed project. These include reformulated fuels modifications planned by other petroleum refineries in Basin as well as other local projects. Figure 5-1 shows the locations of the six major southern California refineries. The reformulated fuels modifications are to be completed in order to supply reformulated gasoline as required by Executive Order D-5-99 and the resulting CARB RFG Phase 3 requirements. The discussion below lists projects which are reasonably expected to proceed in the foreseeable future, i.e., project information has been submitted to a public agency. Cumulative construction impacts were evaluated herein if the major portion of construction is expected to occur during the same construction period as Paramount's Clean Fuels project.

Public agencies were contacted to obtain information on projects in the Paramount area. Figure 5-2 identifies by number the location of each of the projects discussed below. The number is used to identify the related projects throughout the discussion of cumulative impacts. Localized impacts were assumed to include projects which would occur within the same timeframe as the Paramount's Clean Fuels project and which are in the Paramount area. These projects generally include the RFG Phase 3 project at the British Petroleum (formerly ARCO) refinery; the RFG Phase 3 project at the Conoco-Phillips (formerly Tosco) refinery; the RFG Phase 3 project at the Shell (formerly Equilon) refinery. Regional impacts were assumed to include projects throughout the Basin, e.g., all refineries.

Some of the impacts of the proposed Paramount project would primarily occur during the construction phase, e.g., traffic. Other impacts would primarily occur during the operational phase, e.g., hazards. Other impacts would occur during both phases, e.g., air quality.

B. LOCAL REFINERIES

1) Conoco-Phillips

The Conoco-Phillips Refinery (formerly Tosco and Unocal) is approximately 18 miles southwest of the Paramount Refinery. It consists of facilities at two locations (Wilmington and Carson) approximately three miles apart. The two integrated sites transfer raw, intermediate, and finished materials primarily by pipelines. Finished

A 003742

products are transferred from the Wilmington location via the Torrance Tank Farm pipeline to distribution terminals in the southern California area or to interstate pipelines. The RFG Phase 3 project will involve physical changes only to the Conoco-Phillips Wilmington Plant, located at 1660 W. Anaheim Street, Wilmington, California, 90745.

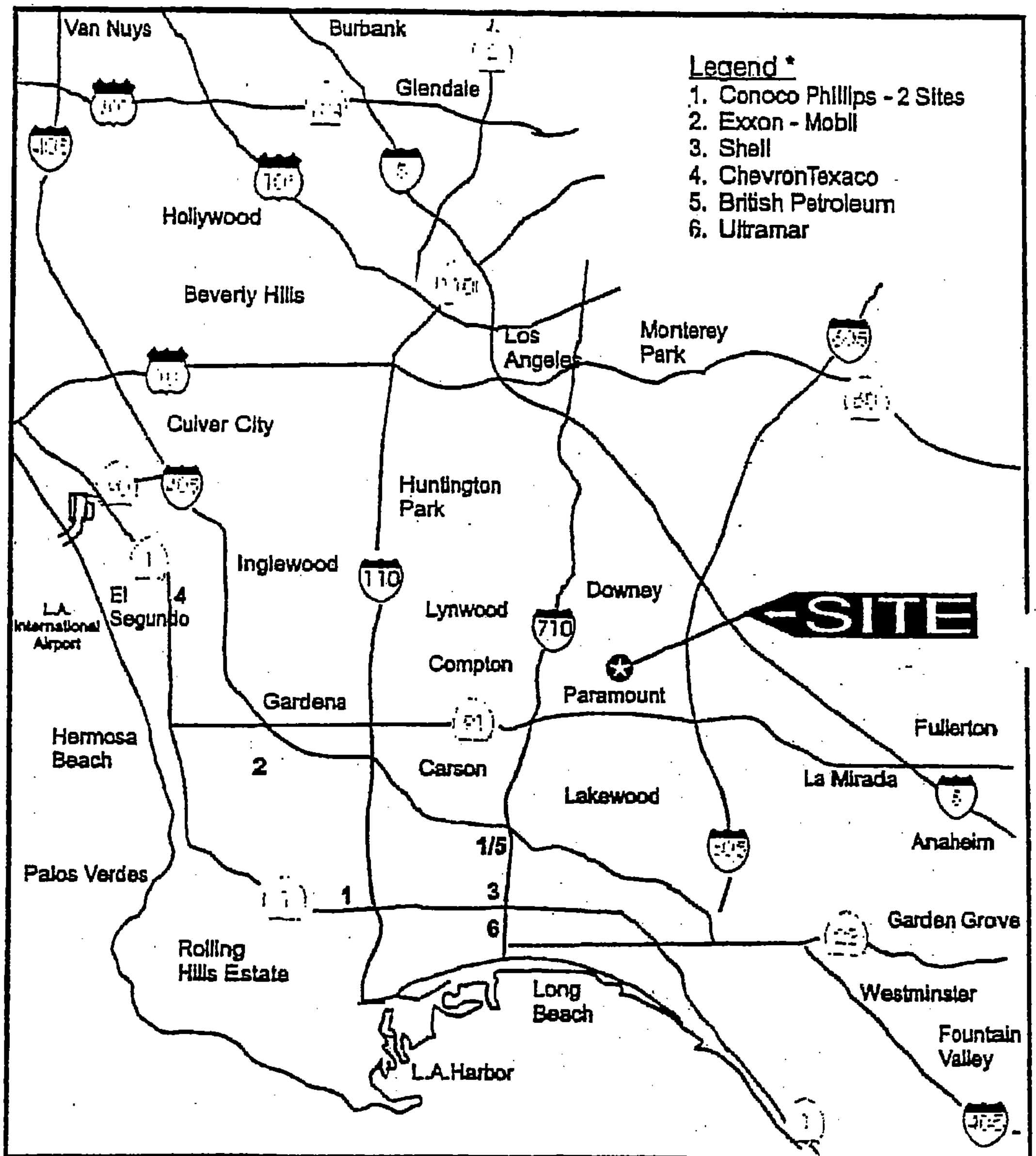
Conoco-Phillips proposed to modify existing process units at the Wilmington Plant in order to produce gasoline in compliance with CARB's Phase 3 requirements (SCAQMD, 2001). No new process units were proposed at the Refinery.

Modifications to the following units are proposed:

- Alkylation Unit (fractionation equipment, refrigeration compressor system, pumps, heaters and exchangers)
- Acid Plant (vapor recovery system)
- Butamer Unit (pumps)
- Catalytic Light Ends Fractionation Unit (fractionation equipment, pumps and piping)
- Rail Car Offloading Facilities
- Butane Storage Tank System
- Storage Tank System
- Utilities (the nitrogen, steam, water, condensate, electrical, hydrocarbon relief, and fresh/spent acid systems).

Associated modifications and additions to storage facilities, pipelines and support facilities are also expected (SCAQMD, 2001). The original CARB Phase 3 project was evaluated in the Final EIR (SCAQMD, SCH No. 2000091056, certified April 5, 2001). An Addendum to the April 5, 2001 Final EIR was prepared to include modifications to the Los Angeles Terminal including expansion of rail service at the terminal to include the unloading of ethanol (SCAQMD 2003b).

In addition to the CARB Phase 3 project, Conoco-Phillips has been issued permits for an Ethanol Import and Distribution Project. In order to produce gasoline without MTBE as required by the Governor's Executive Order and to remain compliant with state and federal reformulated fuel standards, Conoco-Phillips will replace MTBE with ethanol. This project is comprised of modifying existing facilities to permit ethanol to be received into the Marine Terminal for transshipment through the Wilmington Plant for ultimate blending into gasoline at existing, offsite marketing terminals. A Negative Declaration has been completed (SCAQMD, 2000b) and approved for this project. Because this project was found not to have any significant effect on the environment, no cumulative impacts are expected. The ConocoPhillips Refinery is located approximately fifteen miles from the Paramount Refinery so cumulative localized impacts are not expected to occur.



Environmental Audit, Inc.

* Project numbers correspond to the project numbers discussed in the text of Chapter 5.

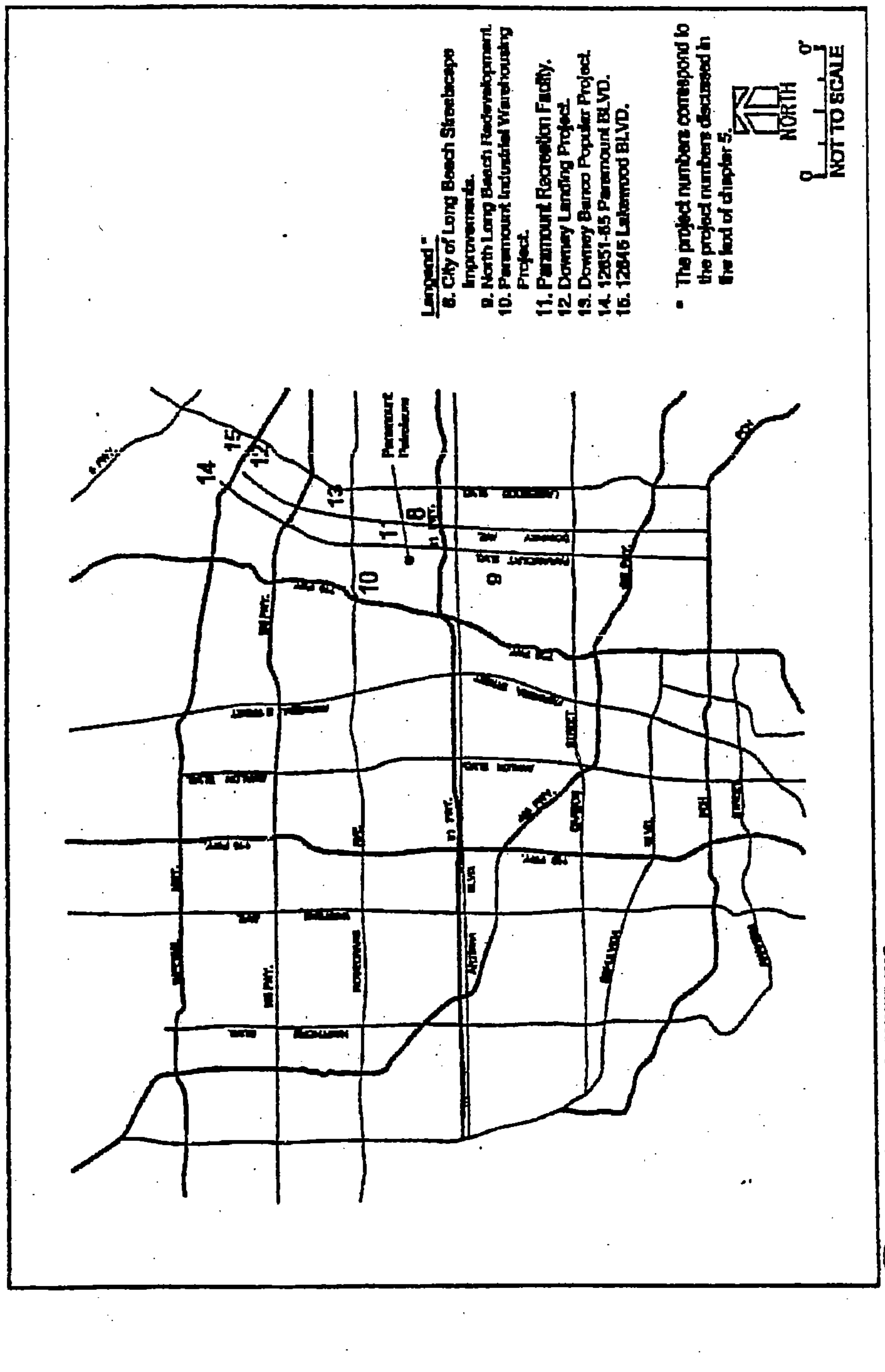
N

REGIONAL MAP SHOWING REFINERIES

Figure 5.

Project No. 2150
N:2150/regions

A 003744



ENVIRONMENTAL AUDIT, INC.

Project No. 2150

RELATED PROJECTS

Figure 5-2

A 003745

2) Exxon-Mobil

The Exxon-Mobil refinery is located at 3700 W. 190th Street in Torrance, about fourteen miles southwest of the Paramount Refinery. The RFG Phase 3 project includes modifications and/or additions to the following equipment:

- Light FCCU – Unsaturated Gas Plant Debutanizer
- Light HDC – Stabilizer, Gasoline Component Isolation Piping
- Deisobutanizer Tower – Butane Handling, KOH Tower
- Alky Feed – Hydrotreating
- Liquefied Petroleum Rail Facilities – Vessels, Loading and Additional Track
- Fuel Ethanol Storage – Tanks, Rail and Off-loading Facilities
- Gasoline Storage – Tanks
- FCC – Hydrotreater Reactors and Heater Modifications
- Alkylate – Additive Water Wash System and Merox System
- Sulfur Contamination Elimination – Overhead Compressor Modifications
- Light FCC Gasoline – Splitter Modifications
- Torrance Loading Rack (add fuel ethanol off-loading rack; modify vapor recovery unit, piping, and manifolds)
- Vernon Terminal (add rail car off-loading system, two truck off-loading areas, gasoline tank, lighting area and drainage system; modify rail spur, loading rack, vapor recovery unit, vapor destruction unit, and two storage tanks)
- Anaheim (Atwood) Terminal (add two truck off-loading areas, storage tank, lighting area and drainage system; modify truck rack)
- One new pentane sphere

Associated modifications and additions to storage facilities, pipelines and support facilities are also expected (SCAQMD, 2001a and SCAQMD 2003c). The Torrance refinery and loading rack, and the Vernon and Anaheim distribution terminals are located at least 10-15 miles from the Paramount Refinery so cumulative localized impacts are not expected to occur.

3) Shell

The Shell refinery (formerly Equilon and Texaco) is located at 2101 East Pacific Coast Highway, Wilmington and is sixteen miles south of the Paramount refinery. Shell's Wilmington Terminal is located adjacent to the southwestern portion of its Refinery at 1926 East Pacific Coast Highway, and the marine terminal is located on Mormon Island at Berths 167-169 within the Port of Los Angeles. The proposed project will also require changes to Shell's other southern California area distribution terminals located in Signal Hill, Carson, Van Nuys, and Colton/Rialto. The RFG Phase 3 project includes the following proposed modifications:

- Alkylation Unit (Contactor and Settler, refrigeration unit, exchangers/pumps, and effluent treating vessels)

- C4 Isomerization Unit (vessels, exchangers, pumps, piping, stabilizer, gas scrubber, and drier)
- Hydrotreater Unit No. 2 (Olefins Saturation Reactor, pretreatment reactor, charge pumps, heat exchangers, trays, stripper reboiler, and control valves)
- Hydrotreater Unit No. 4 (diesel side stripper, feed steam preheater, and heat exchangers)
- Hydrotreater Unit No. 1
- Catalytic Reforming Unit No. 2 (sulfur guard reactor)
- Fractionator Changes (HCU Main Fractionator, FCCU Debutanizer, Feed Prep Tower, Depentanizer, Alky Deisobutanizer, Alky Debutanizer and C4 Isomerization Deisobutanizer, and HCU Depropanizer)
- Refinery Storage Tank modifications
- Storage Tanks (at Wilmington, Carson, Signal Hill, Van Nuys, and Colton/Rialto Terminals)
- Pentane Sphere
- No. 2 (debutanizer tower)
- Flare
- Vapor Recovery Systems
- Carson Terminal (includes storage tanks modifications and a new truck loading rack)
- Lomita Terminal (includes an ethanol railcar unloading facility)
- Signal Hill Terminal (includes storage tank and truck loading rack modifications)
- Colton/Rialto Terminal (includes storage tank and truck loading rack modifications)
- Van Nuys Terminal (includes storage tank and truck loading rack modifications)
- Marine Terminal (includes storage tank modifications)
- Wilmington Terminal (includes storage tank and truck loading rack modifications)

Associated modifications and additions to storage facilities, pipelines and support facilities also are expected (SCAQMD, 2001b and SCAQMD 2002). The Shell refinery is located 16 miles south of the Paramount refinery. The Shell terminal in Signal Hill, is located at least eight miles from the Paramount Refinery and the Van Nuys and Colton/Rialto Terminals are located over 30 miles from the Paramount refinery. Localized cumulative impacts are not anticipated for any of these facilities because of the distance from the Paramount refinery.

4) ChevronTexaco

The ChevronTexaco refinery (formerly Chevron) is located at 324 West El Segundo Boulevard in El Segundo, California, about 18 miles west of the Paramount refinery, which is a sufficient distance away to avoid cumulative localized impacts with the Paramount refinery. The ChevronTexaco refinery has proposed to make changes to the reconfiguration of the Refinery by modifying existing process operating units, constructing and installing new equipment, and providing additional ancillary facilities in order to produce the RFG Phase 3 reformulated gasolines (SCAQMD, 2001c). The proposed new refinery units include:

- Isomax Complex (distillation column, steam reboilers and overhead condensers)
- TAME Plant (steam reboilers and overhead condensers)

- Pentane Storage Sphere
- Pentane Sales (rail loading facilities and railcar storage area)
- TAME Unit (distillation column, reflux pumps, steam reboilers and overhead condensers)
- No. 1 Naphtha hydrotreater (under Option A: one furnace, compressors, exchangers, and pumps. Under Option B: compressors, exchangers, and pumps).
- FCCU Depropanizer
- FCCU Debutanizer
- FCCU Deethanizer (vessels, pumps and exchangers)
- FCCU Propylene Caustic Treating Facilities
- FCCU Butene Caustic Treating Facilities
- FCCU Amine Absorber
- FCCU Relief System (headers)
- FCCU Wet Gas Compressor Insterstage System Upgrades (two exchangers and one vessel)
- Alkylation Plant (two contactors and an acid settler)
- Cooling Tower
- Trim coolers for existing Distillation Columns
- Iso-octene Plant (pressure vessels, exchangers and pumps)
- Two floating roof gasoline component storage tanks

Modifications to existing refinery units are proposed for the following:

- TAME Unit (Depentanizer column)
- No. 1 Naphtha hydrotreater (under Option A: modify one furnace; under Option B: modify two furnaces)
- Deethanizer (column)
- Relief Systems (vapor recovery facilities and flare)
- Main air blower rotor replacement
- Wet Gas Compressor
- Rotor and Gearbox Upgrade
- Recommission Existing Out-of-Service Deisobutanizer
- Retraying Distillation Columns
- MTBE storage tank

The proposed project also includes modifications to the ChevronTexaco Montebello Terminal (storage tank and loading rack modifications and a new ethanol railcar unloading facility), the Van Nuys Terminal (storage tank and loading rack modifications), and the Huntington Beach Terminal (storage tank and loading rack modifications).

Due to the distance separating the ChevronTexaco refinery and terminals from the Paramount refinery, no cumulative impacts are expected during the construction or operation of the proposed project.

5) British Petroleum

The British Petroleum (BP) Refinery (formerly ARCO), located at 1801 E. Sepulveda Boulevard in Carson, is approximately eleven miles south of the Paramount refinery. The BP Carson terminal is located at 2149 E. Sepulveda Boulevard; the Marine Terminal 2 is located at 1300 Pier B Street within the Port of Long Beach. The proposed RFG Phase 3 project will also require changes to BP's other southern California area distribution terminals located in South Gate, Rialto, Long Beach and Signal Hill. The BP refinery has proposed to make changes to the Refinery by modifying existing process operating units, constructing and installing new equipment, and providing additional ancillary facilities in order to produce the RFG Phase 3 reformulated gasolines (SCAQMD, 2001d). The proposed new refinery units include:

- FCCU Gasoline Fractionation (Option #1) – rerun bottoms splitter (splitter tower, heat exchangers, etc.)

Modifications to existing refinery units are proposed for the following:

- Light Hydro Unit (modify heat exchangers; new exchangers, piping pumps and control systems)
- Isomerization Sieve (convert unit to hydrotreater; modifications to heat exchangers, piping and control systems; new reactor, exchangers, pumps and control systems)
- No. 3 Reformer Fractionator and Overhead Condenser (piping and control systems; new pumps)
- Gasoline Fractionation Area (retraying, piping and control systems)
- FCCU Gasoline Fractionation (Option #2) – convert gasoline fractionation area depentanizer to a FCCU bottoms splitter (retraying; new exchangers, flash drum, and product cooling)
- North hydrogen plant (new feed drum, pump and vaporizer)
- MTBE Unit (Option #1) – convert into ISO Octene Unit (modify heat exchangers, piping and control systems; new reactive, steam heater and heat exchangers)
- MTBE Unit (Option #2) – convert into Selective Hydrogenation Unit (modify stripper, reboiler, piping and control systems; new heat exchangers)
- Cat Poly Unit – modify to a Dimerization Unit Hydrotreater reactor system (modify piping and control systems; new pumps, heat exchangers, vessels, piping and control systems)
- Mid-Barrel Unit – modify to a Gasoline Hydrotreater (modify feed and product piping, hydrogen supply system and heat exchanger, controls systems)
- Tank Farm – piping modifications
- Pentane railcar loading facility – modify for pentane off-loading (new repressurizing vaporizer system and two railcar spots)
- Propylene railcar loading facility – modify for butane off- loading.

Associated modifications and additions to distribution storage facilities, pipelines and support facilities also are expected (SCAQMD, 2001d). The BP Arco Refinery is located about 11 miles from the Paramount Refinery, so cumulative localized impacts are not expected.

6) Ultramar Inc, Valero Refinery

The Ultramar refinery is located at 2042 East Anaheim Street in the Wilmington district of the City of Los Angeles. The Ultramar refinery is about 15 miles south of the Paramount Refinery. In order to produce the RFG Phase 3 project gasoline Ultramar has proposed both new and modified refinery units (SCAQMD, 2000c). The Ultramar's RFG Phase 3 project would include the following new refinery equipment:

- Merox Treater
- Sour Water Stripper – (storage tank, stripper and vapor recovery system)
- Storage Tanks
- Boiler
- Flare
- Cooling Tower

Modifications to the following refinery units were proposed:

- Fluid Catalytic Cracking Unit (FCCU) – (new Gas Concentration Unit Debutanizer, new primary absorber and stripper, new accumulators, pumps, reboiler, distillation columns, vessels and heat exchangers)
- Fluid Catalytic Cracking Unit Liquefied Gas Merox Unit – (new liquefied petroleum gas (LPG) dryer and Selective Hydrogenation Unit, convert existing dryer column to depropanizer)
- Light Ends Recovery Unit – (new debutanizer and depentanizer, convert existing depropanizer to recover butane in Butamer Unit; new vessels, pumps and fin-fans)
- Naphtha Hydrotreater Unit – (modify compressor, new heat exchangers and pumps)
- Olefin Treater – (convert to hydrotreater; new reactor, new stripper, new compressor, changes to piping and new catalyst)
- Gas Oil Hydrotreater – (new pumps, new compressors and modify heater)
- Platformer – (new compressor and depropanizer)
- Butamer Unit – (new column, new heat exchangers, vessels and pumps)
- Storage Tanks
- Flare System

Associated modifications and additions to storage facilities, pipelines and support facilities are also expected (SCAQMD, 2000c). The project also includes modification to existing storage tanks and new storage tanks at the Ultramar Marine Tank Farm, Olympic Tank Farm, and Marine Terminal. The Ultramar Refinery is located about 15 miles from the Paramount Refinery, so no localized cumulative impacts are expected.

7) Third Party Terminals

A number of petroleum companies use third party terminals to distribute their fuel to gasoline stations. The terminals include the Kinder Morgan Orange Terminal, and the Kinder Morgan Colton Terminal. The modifications to the Kinder Morgan Orange and Colton Terminals included the conversion of an existing fixed roof tank to an internal floating roof tank and a change in service of the tank from diesel to ethanol. In addition, new truck unloading racks were added to both the Orange and Colton Terminals.

C. OTHER NEARBY PROJECTS

Other proposed projects within the general vicinity of the Paramount Refinery are described below.

City of Long Beach

8) Street Construction

As part of the ongoing effort by the City of Long Beach to revitalize certain areas, a number of streetscape improvements have been proposed over the next three years. Streetscaping involves landscaping, widening of streets, sidewalk construction and repair, installation of lighting and signage, and construction of medians on streets. Several of these streetscaping activities are currently ongoing or will be conducted in the future within the vicinity of the Paramount Refinery, including the following:

- Atlantic Avenue to Artesia Blvd.
- Artesia Blvd. – Downey Ave. to Obispo Ave.
- Paramount Boulevard – 70th Street and Artesia Blvd.
- Downey Avenue – 70th Street and Artesia Blvd.

(Personal communication, Lee Mayfield, May 2003).

9) North Long Beach Redevelopment Project Area

North Long Beach covers an area of 7,540 acres of land. The majority of the land is within the Redevelopment project area and is located north of I-405 freeway. The area is bordered by the cities of Compton, Paramount and Lakewood. Many of the existing commercial properties in the area are in varying stages of physical deterioration and were built with substandard design and lack adequate parking.

The redevelopment of North Long Beach is already underway and is scheduled to be completed in approximately 2026. Part of the revitalization plan for the area includes converting declining commercial land uses to residential housing or other alternatives, and initiating streetscape improvements (Long Beach, City of, 2002).

City of Paramount

10) Industrial Warehousing Project

An industrial warehousing project located at the intersection of Garfield Avenue and Rosecrans Boulevard is projected to begin construction in approximately August 2004. This project will add 78,605 square feet of warehouse space and is scheduled to be completed within approximately six to eight weeks from commencement (Personal Communication, John Caver, May 2003 and November 2003).

11) Recreation Facility

The City of Paramount plans to build a new recreation center at Progress Park. Progress Park is located at 15500 Downey Ave. The 4,000-square-foot recreation center will replace a 1,400-square-foot preschool that was originally a house built in the 1940s. The new facility will be home to the City's preschool, the Park Pals after-school program, youth and adult recreation classes, the local girls softball league, as well as meetings and counseling sessions for GRIP (Gang Resistance in Paramount) and Neighborhood Watch. In addition, a plaza will be created and there will be extensive landscape and hardscape improvements to the park in the center's vicinity. Construction is scheduled to begin approximately, in April 2004. (Paramount, City of, Press Release, October 2002, Linda Benedetti-Leal and David Johnson, Paramount, City of, Recreation Department, November 2003).

City of Downey

12) Downey Landing

A mixed-use commercial and industrial complex is being proposed in the City of Downey which is located five miles north of the Paramount refinery. The site is bounded by Stewart and Gray roads on the north, Lakewood Boulevard and Clark Avenue on the west, Imperial Highway on the south, and Bellflower Boulevard on the east. The Downey Landing's proposal included multiple uses for 117 acres of the 160 acre site, including a 28-acre retail center that will occupy the northern portion, a movie/TV production studio complex for the central portion, and a business/technology park on the eastern portion. Kaiser Permanente plans a new hospital/medical office complex for 30 acres on the southern portion of the property. The proposed Kaiser Permanente project will include a six-story hospital and a four-story medical office building. The remaining 13 acres of the 160 acres will be reserved for a school/park/learning center.

The final Environmental Impact Report (EIR) (City of Downey, 2002) discusses the impact of the Specific Plan, and contains recommended mitigation measures designed to lessen the extent of identified impacts (City of Downery, 2002).

13) Banco Popular Project

The Banco Project is proposed for the northwest corner of the Rosecrans Avenue/Lakewood Boulevard intersection (13451 Lakewood Boulevard). The project site contains 15,577 square feet and; development will consist of one building containing a 1,200 square foot restaurant and a 2,013 square foot bank. A grading permit has been issued by the City of Downey for the project (Personal Communication Mark Selheim, May 2003).

14) 12651-65 Paramount Boulevard

A residential tract consisting of eight single-family residences is under construction at 12651-65 Paramount Boulevard (Personal Communication Mark Selheim, May 2003).

15) 12645 Lakewood Boulevard

A residential tract consisting of eight single-family residences is proposed for 12645 Lakewood Boulevard (Personal Communication Mark Selheim, May 2003).

City of Bellflower

16) 91 Freeway Ramp Beautification

Landscaping and decorative painting is being performed on the 91 Freeway on/off ramps at Bellflower Boulevard. (City of Bellflower, 2003).

17) Town Center Plaza Project

The Town Center Plaza project is part of the redevelopment plan to revitalize the downtown area of Bellflower. This project will span five acres and feature an outdoor stage, businesses and a train station that would connect to the Metrolink transit system. Environmental clearance is being sought for a two and one half mile bicycle path and walkway on what is currently a railroad track that is scheduled to be removed in the near future. This project is scheduled to begin construction approximately at the end of 2003. (City of Bellflower, 2003).

D. AIR QUALITY

CONSTRUCTION IMPACTS

Construction activities associated with CARB RFG Phase 3 projects at other refineries have or will be essentially completed prior to the commencement of construction activities at the Paramount Refinery. December 31, 2003 is the date when MTBE must be phased out of gasoline sold in California so most of the construction activities at other refineries and terminals have been or will be completed prior to construction of the

Paramount Clean Fuels project. No cumulative construction impacts are expected from other refinery projects.

Air quality impacts due to construction at the Paramount Refinery are considered to be less than significant. It is expected that construction activities associated with several other local projects will occur during the same timeframe as the proposed project including the Industrial Warehousing Project (No. 10), the Recreational Facility (No. 11), the Banco Popular Project (No. 13), and two residential developments (No. 14 and 15). Potential construction emissions have been estimated using the URBEMIS2002 Model. The default assumptions in the URBEMIS2002 Model (Yolo-Solano AQMD, 2003) were used since little information is available regarding these projects (see Appendix B for additional information).

TABLE 5-1

CUMULATIVE PROJECT
PEAK DAY CONSTRUCTION EMISSIONS(1)
(lbs/day)

ACTIVITY	CO	VOC	NOx	SOx	PM10
Paramount Clean Fuels Project	308	32	76	6	118
Industrial Warehouse Project (No. 10)	11	133	1	<1	<1
Recreational Center Project (No. 11)	1	<1	<1	<1	<1
Banco Popular Project (No. 13)	<1	5	<1	<1	<1
Residential Development (No. 14 and 15)	2	66	4	0	<1
Cumulative Emissions	322	236	81	6	118
SCAQMD Thresholds	550	75	100	150	150
Cumulatively Significant (?)	NO	YES	NO	NO	NO

Table 5-1 summarizes the construction emissions of the related projects (projects within approximately one mile of the Refinery) with construction schedules that might coincide with construction of the Paramount Clean Fuels Project. On a cumulative basis, construction emissions would exceed the CEQA thresholds established by the SCAQMD for VOC, assuming the construction projects occur at the same time. Therefore, the cumulative air quality construction impacts are considered significant for VOC emissions. The cumulative air quality construction impacts are less than significant for CO, NOx, SOx and PM10.

OPERATIONAL IMPACTS - CRITERIA POLLUTANTS

The RFG Phase 3 projects at all of the local refineries will increase the criteria pollutants emitted from the refineries. Direct stationary emission sources are generally subject to regulation. The emissions associated with the cumulative CARB Phase 3 projects are shown in Table 5-2. The operation of the CARB Phase 3 projects are expected to exceed

SCAQMD thresholds for CO, VOC, NOx, SOx and PM10, so air quality impacts are significant. No localized increases in air emissions are expected because the refineries and terminals are located a sufficient distances from the Paramount Refinery (see Figure 5-1).

Cumulative impacts associated with other local projects could also occur during the operational phase. Operational emissions from projects other than Paramount are expected to be largely due to mobile source emissions. The operational emissions have been estimated in Table 5-2.

TABLE 5-2

CUMULATIVE PROJECT PEAK DAY OPERATIONAL EMISSIONS(1) (Pounds per day)

SOURCE	CO	VOC	NOx	SOx	PM10
Ultramar CARB Phase 3 Project	514	156	2,164	2,678	287
ConocoPhillips Ethanol Import & Dist Project	9	-54(1)	10	–	1
ConocoPhillips CARB RFG Phase 3	136	22	514	402	43
BP ARCO CARB Phase 3 Project	42	86	49	0	57
Shell CARB Phase 3 Project	2,213	482	2030	71	57
ExxonMobil CARB Phase 3 Project	29	288	138	12	103
ChevronTexaco CARB Phase 3 Project	393	347	3,103	2,498	843
Third Party Terminals	-	4	-	-	-
Paramount Clean Fuels Project	104	66	52	1	69
Industrial Warehouse Project (No. 10)(2)	76	7	10	<1	5
Recreational Center Project (No. 11)(2)	39	3	5	<1	3
Banco Popular Project (No. 13)(2)	109	9	14	<1	8
Residential Development (No. 14 and 15)(2)	80	25	5	<1	10
Cumulative Emissions	**3,744**	**1,441**	**8,094**	**5,662**	**1,486**
SCAQMD Thresholds	550	55	55	150	150
Significant (?)	YES	YES	YES	YES	YES

(1) Negative numbers represent emission reductions.
(2) Based on URBEMIS2002 Model, using default assumptions.

On a regional basis, RFG Phase 3 fuels produced by the refineries are expected to result in a reduction in emissions from mobile sources that utilize the reformulated fuels. Table 5-3 summarizes the expected statewide emission decreases from the mobile sources, which use the reformulated fuels. As a conservative approach, the statewide mobile source emissions reductions are not credited toward mitigation of cumulative impacts.

TABLE 5-3

CARB PHASE 3 EXPECTED STATEWIDE EMISSION CHANGES
(Pounds per Day)

POLLUTANT	1998 Average In-Use Fuel		Future Representative In-Use Fuel Based on Flat Limits		Difference
	2005	2010	2005	2010	2005
NOx	4,200	3,400	-33,200	-27,200	-37,400
Exhaust Hydrocarbons	-16.0 -32,000	-9.3 -18,600	-16.5 -33,000	-9.6 -19,200	-0.5 -1,000
Evaporative Hydrocarbons	-28,800	-22,600	-28,800	-22,600	0
Total Hydrocarbons	-60,800	-41,200	-61,800	-41,800	-1,000

Negative numbers indicate emission reductions. Source: CARB, 1999

Air quality impacts associated with operation of the six RFG Phase 3 projects are considered significant since SCAQMD mass emissions thresholds are expected to be exceeded. Although operations will exceed the significance thresholds, there will be large regional benefits from the use of the reformulated fuels by mobile sources. Emissions of mobile sources will be reduced for NOx and VOCs counteracting the emissions being produced by the refineries and providing an environmental benefit. The emission reductions are expected to be far greater than the direct cumulative emissions from the refineries. In addition, the RFG Phase 3 compliant fuels are expected to result in a 7.2 percent reduction in potency-weighted emissions of toxic air contaminants from mobile sources using the fuel providing additional emissions benefits. Further, the diesel sulfur limit of 15 ppmw will help generate significant air quality benefits by enabling the effective performance of advanced diesel exhaust emissions control technologies that reduce emissions of ozone precursors (NOx and VOCs) and diesel particulate matter.

The cumulative operational emissions associated with projects in the Paramount area are expected to exceed SCAQMD thresholds for CO, VOC, NOx, SOx and PM10. Therefore, cumulative air quality impacts are significant.

OPERATIONAL IMPACTS - TOXIC AIR CONTAMINANTS

In order to determine the cumulative impacts of toxic air contaminants, the emissions from the implementation of the proposed project were analyzed. This is referred to as the post-project scenario and includes all the existing emission sources at the Paramount Refinery, plus the proposed modified emission sources associated with the revised reformulated fuels program. In addition, the potential cumulative impacts associated with the overlap of emissions from other refineries were addressed in the analysis provided below. The other cumulative projects (Projects 8-17) are not expected to emit toxic air contaminants during operations and, therefore, were not included in this analysis.

A comprehensive air dispersion modeling analysis and a Health Risk Assessment (HRA) were performed for the projected refinery emissions following completion of the proposed project. This section discusses the results of the air dispersion modeling and health risk assessment. The procedures used to complete the projected HRA are the same as those used to complete the baseline HRA (see Chapter 3, Air Quality). The HRA is contained in Volume II, which should be consulted for further details.

Hazard Identification

The list of TACs evaluated in the post-project scenario is the same as those identified in the baseline assessment (see Table 3-6).

Emission Estimations and Sources

The estimated mass emissions of toxic air contaminants were based on a combination of the baseline emissions and engineering estimates that reflect operation of the proposed project. For further details on the emission estimates see Chapter 4, Air Quality and Volume II.

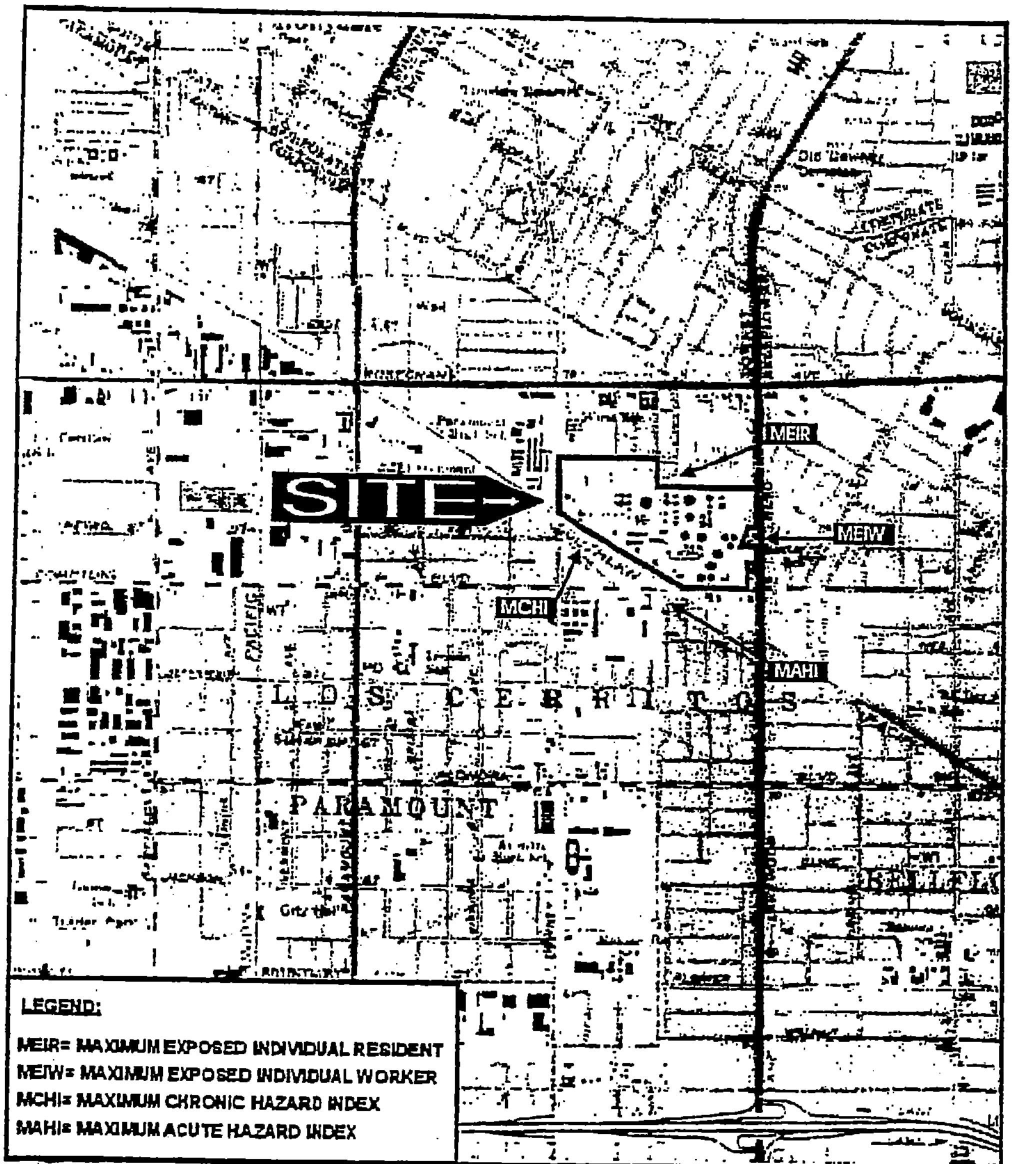
HRA Methodology

The source parameters for the post-project scenario were used as input to the ISCST3 model to determine unitized ground-level concentrations. The output from the ISCST3 model was combined with estimated emissions for each TAC in the ACE2588 model. The ACE2588 model calculated the health risks associated with the post-project scenario. The ISCST3 model used the same assumptions as the baseline model for receptor grids, meteorological data, and so forth. The ACE2588 model used the same assumptions for the post-project scenario as the baseline model for multi-pathway analysis, pathways to exposures, and default exposure assumptions. The model was used to identify the MEIW and MEIR for the post-project scenario. The ACE2588 model calculated both carcinogenic and non-carcinogenic health impacts.

Post-Project HRA Results - Carcinogenic Health Impacts

Maximum Exposed Individual Worker

The predicted maximum cancer risk at the MEIW area due to exposure to projected post-project emissions was calculated to be 2.15E-06 or two per million. The location of the MEIW is the same as that for the baseline scenario and is shown in Figure 5-3. Table 5-4 shows major source contributions to the MEIW. Emissions from Fugitives – Northeast Tank Farms account for about 45 percent of the MEIW cancer risk. Emissions of benzene are responsible for about 75 percent of the MEIW risk (see Table 5-5). The cancer risk at the MEIW does not exceed the cancer risk significance threshold in Table 4-1 and is less than significant.



Environmental Audit, Inc.

PROJECT MAXIMUM IMPACT LOCATIONS
14700 Downey Avenue
Paramount, California

Figure 4-1

Project No. 2150

TABLE 5-4

EMISSION SOURCE CONTRIBUTION TO CANCER RISK FOR POST-PROJECT SCENARIO MEIW

Source No.	Source Name	Percent Contribution
100	Fugitives for Northeast Tank Farm	45.0
111	Heaters H303-306	9.2
130	Fugitives for HDS Units	6.3
89	Fugitives for Crude Unit 1	4.2
92	Fugitives for Jet Fuel Area	3.6
90	Fugitives for Crude Unit 2	3.6
101	Fugitives for Northwest Tank Farm	3.0
116	Fugitives for New BenSat/Isom Unit	2.9
114	COGEN	1.7
102	Fugitives for North-Central Tank Farm	1.1
41	Tank 12502	1.0
19	Flare	1.0

TABLE 5-5

TAC CONTRIBUTION TO CANCER RISK FOR POST-PROJECT SCENARIO MEIW

Toxic Air Contaminant	Cancer Risk	Percent Contribution
Acetaldehyde	4.42E-10	<0.1
Arsenic	1.22E-08	0.6
Benzene	1.58E-06	74.8
1,3-Butadiene	3.81E-09	0.2
Cadmium	1.65E-08	0.8
Carbon Tetrachloride	2.14E-12	<0.1
Chloroform	2.10E-13	<0.1
Chromium (Hex)	1.16E-07	5.5
Ethylene Dibromide	4.36E-12	<0.1
Ethylene Dichloride	7.22E-13	<0.1
Formaldehyde	1.20E-08	0.6
Lead	2.66E-11	<0.1
Methylene Chloride	2.77E-14	<0.1
Nickel	8.75E-10	<0.1
Perchloroethylene	1.26E-09	0.4
PAHs	3.61E-07	17.10
Propylene Oxide	2.03E-16	<0.1
Styrene	4.20E-13	<0.1
Vinyl Chloride	1.61E-12	<0.1
Total	**2.10E-06**	

Maximum Exposed Individual Resident

The predicted maximum cancer risk at the MEIR area due to exposure to projected post-project emissions was calculated to be 9.81E-06 or about ten per million. The location of the MEIR is east of the Refinery and is shown in Figure 5-3. Table 5-6 shows major source contributions to the MEIR. Emissions from Fugitives - HDS Unit account for about 21 percent of the MEIR risk (see Table 5-6). Emissions of benzene are responsible for about 60 percent of the MEIR risk (see Table 5-7).

TABLE 5-6

EMISSION SOURCE CONTRIBUTION TO CANCER RISK FOR POST-PROJECT SCENARIO MEIR

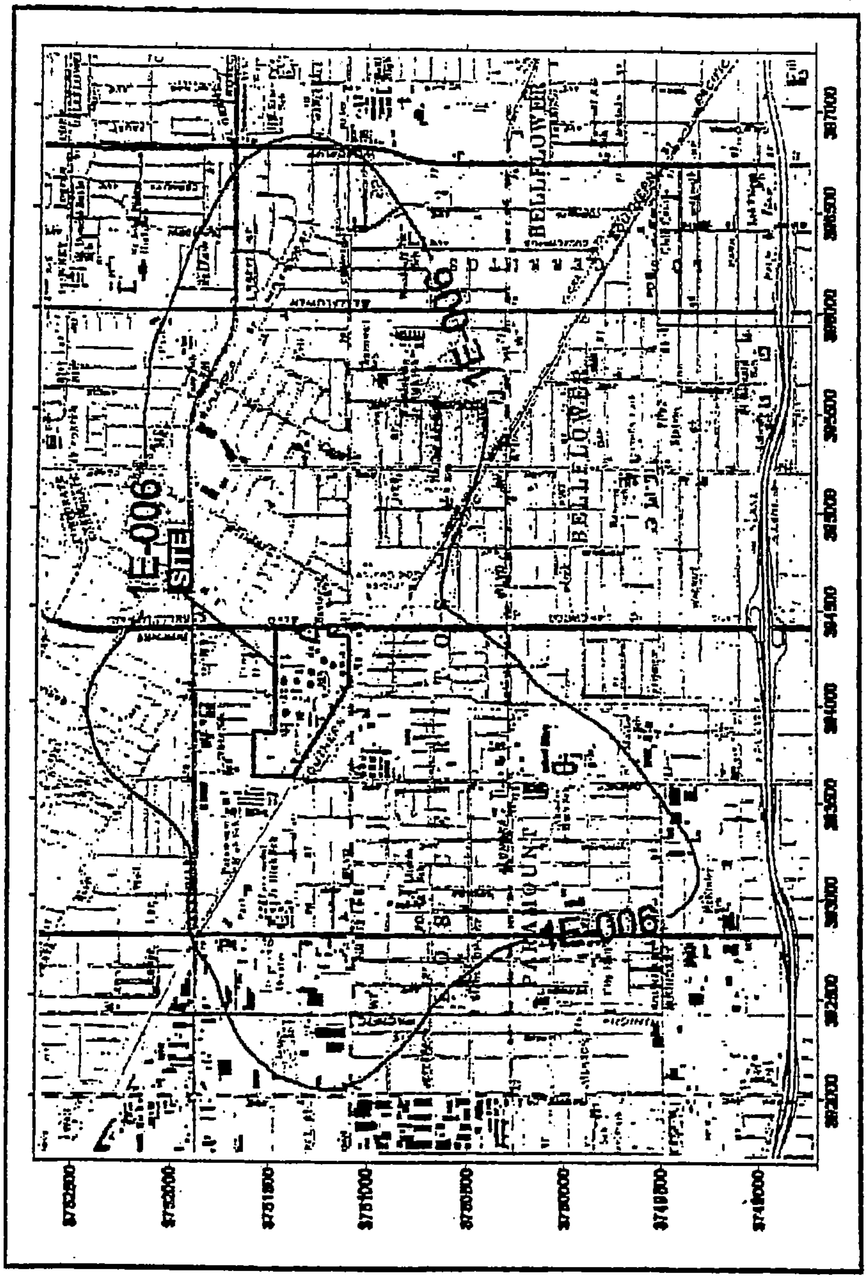
Source No.	Source Name	Percent Contribution
100	Fugitives for Northeast Tank Farm	21.0
89	Fugitives for Crude Unit 1	11.1
111	Heaters H303-306	10.0
90	Fugitives for Crude Unit 2	7.9
130	Fugitives for HDS Units	5.7
92	Fugitives for Jet Fuel Area	4.6
114	COGEN	2.9
101	Fugitives for Northwest Tank Farm	2.8
5	Heater H-601	2.6
116	Fugitives for New BenSat/Isom Unit	2.3
1	Heater H-801	2.2
2	Heater H-802	2.1
4	Heater H-860	1.6
6	Heater H-602	1.4
104	Fugitives for North-Central Tank Farm	1.3
112	Heater H501	1.2
19	Flare	1.2
18	Heater H-907	1.1

TABLE 5-7

TAC CONTRIBUTION TO CANCER RISK FOR POST-PROJECT SCENARIO MEIR

Toxic Air Contaminant	Cancer Risk	Percent Contribution
Acetaldehyde	3.35E-09	<0.1
Arsenic	8.92E-08	0.9
Benzene	5.88E-06	59.9
1,3-Butadiene	2.89E-08	0.3
Cadmium	1.20E-07	1.2
Carbon Tetrachloride	1.62E-11	<0.1
Chloroform	1.59E-12	<0.1
Chromium (Hex)	8.50E-07	8.7
Ethylene Dibromide	3.30E-11	<0.1
Ethylene Dichloride	5.46E-12	<0.1
Formaldehyde	9.04E-08	0.9
Lead	2.01E-10	<0.1
Methylene Chloride	2.10E-13	<0.1
Nickel	6.41E-09	0.1
Perechloroethylene	4.63E-08	0.5
PAHs	2.70E-06	27.5
Propylene Oxide	1.59E-15	<0.1
Styrene	3.18E-12	<0.1
Vinyl Chloride	1.22E-11	<0.1
Total	9.81E-06	

The one per million-cancer risk isopleth for the post-project scenario is shown in Figure 5-3. This isopleth was calculated based on the same assumptions used to calculate the residential cancer risk including a 70-year exposure and multi-pathway assumption. The cancer risk at the MEIR does not exceed the cancer risk significance threshold in Table 4-1 of ten per million and is less than significant. The post project cancer risk is reduced as a result of the project. The reduction is due to the reduced benzene content in products and process streams in order to meet CARB Phase 3 requirements, and the overall reduction of benzene at the facility by the addition of the benzene saturation and isomerization unit, which converts benzene to less toxic components.



Environmental Audit, Inc.

ONE IN A MILLION
POST-PROJECT CANCER RISK ISOPLETH
PARAMOUNT PETROLEUM CORPORATION
PARAMOUNT, CALIFORNIA

Figure 5-4

Project No. 2150

Cancer Burden

The cancer burden for the area surrounding the Paramount Refinery was calculated using the same assumptions as the baseline cancer burden calculations. The total excess cancer burden within the area of influence was predicted to be 0.122 and 0.0054 for the residential and occupational populations, respectively. (See Volume II for further details.) The combined excess cancer risk was predicted to be 0.127. The cancer burden does not exceed the cancer risk significance threshold in Table 4-1 and is less than significant.

Sensitive Receptors

The maximum cancer risk to a sensitive receptor was estimated to be 7.64E-06 or approximately eight per million at the Baxter Elementary School. This risk estimate is conservative as it is based on a 70-year continuous exposure period. The cancer risk at the sensitive receptors does not exceed the cancer risk significance threshold in Table 4-1 and is less than significant.

Post-Project HRA Results - Non-Carcinogenic Health Impacts

Acute Hazard Index

The highest total acute hazard index for any single toxicological endpoint was estimated to be 0.014, at an occupational receptor, for the respiratory system, primarily due to exposure to hydrogen sulfide (44 percent). The acute hazard index does not exceed the significance threshold in Table 4-1 and is less than significant.

Chronic Hazard Index

The highest chronic hazard index for any single toxicological endpoint was estimated to be 0.031, at an occupational receptor, for the respiratory system, primarily due to exposure to benzene (39 percent) and formaldehyde (23 percent). The chronic hazard index does not exceed the significance threshold in Table 4-1 and is less than significant.

The cumulative impacts associated with the post-project scenario would be below the significance criteria for cancer risk at the MEIW and the MEIR for the chronic and acute hazard indices. Further, the proposed project would reduce emissions of some toxic air contaminants, e.g. benzene, thus reducing the overall health risks associated with exposure to Refinery emissions. Therefore, adverse cumulative impacts associated with toxic air contaminants are not expected from the Paramount Clean Fuels Project.

TAC Impacts from Other Cumulative Projects

Based on the available data, the cumulative impacts associated with other proposed Clean Fuels projects (Project Nos. 1 through 7) are not expected to result in significant TAC impacts since the projects are disbursed throughout the southern California area so TAC emissions would not be expected to overlap. The other cumulative projects (Project Nos. 8 through 17) are not expected to generate significant quantities of toxic air contaminants.

MITIGATION MEASURES

Mitigation measures for construction activities have been imposed on the various individual projects. There are no additional feasible mitigation measures to further control construction emissions.

The mitigation measures to minimize emissions associated with operation of the related projects include the use of BACT for all new emission sources and modifications to existing sources. The use of BACT would control localized emissions. A BACT review will be completed during the SCAQMD permit approval process for all new/modified sources. In addition, the related refinery projects would provide regional emission benefits by reducing emissions from mobile sources that use the reformulated fuels.

LEVEL OF SIGNIFICANCE AFTER MITIGATION

The cumulative air quality impacts due to construction and operation of the RFG Phase 3 projects exceed the SCAQMD significance thresholds in spite of implementing all feasible mitigation measures. The cumulative impacts of TACs for cancer risk at the MEIR as less than significant. The cumulative impacts associated with the post-project scenario would be below the significance criteria for cancer risk at the MEIW, MEIR, and for the chronic and acute hazard index.

E. HAZARDS AND HAZARDOUS MATERIALS

PROJECT IMPACTS

The cumulative impacts from and between the onsite operation of the refineries' RFG Phase 3 projects (Project Nos. 1-7) are not expected to be significant because of the distance between Paramount and the other facilities. The closest refinery with a clean fuels project to the Paramount Refinery is the BP ARCO Refinery located about 11 miles south of the Paramount Refinery. The impacts associated with the Paramount Refinery proposed project are expected to travel less than 1,000 feet, which would not reach the other local refineries or any of the other cumulative projects. Projects Nos. 8 through 17 are not expected to involve hazardous materials or generate significant hazard impacts. Therefore, no significant cumulative hazard impacts are expected with the other related projects.

MITIGATION MEASURES

The proposed project impacts on hazards are considered significant. However, these impacts will not combine with the impacts of related projects due to the distance between the facilities. A number of existing rules and regulations apply to the Paramount Refinery and other proposed projects. Compliance with these rules and regulations is expected to minimize refinery-related hazards. Compliance with these rules and regulations should also minimize the hazards at other refineries.

LEVEL OF SIGNIFICANCE AFTER MITIGATION

The impacts of the various projects on hazards are not expected to be cumulatively considerable as hazards at or within one project area are not expected to impact or lead to hazards at other facilities or to combine in the same location.

F. TRANSPORTATION/TRAFFIC

For the proposed project, the project's contribution to cumulative transportation/traffic impacts is not significant because the traffic conditions would essentially be the same whether or not the proposed project is implemented, because the proposed project has such minimal effects on traffic conditions as explained below.

Cumulative traffic impacts have been analyzed using the traffic counts taken in 2003 and assuming general growth in the area. Table 5-8 shows the baseline and the cumulative LOS analysis and volume to capacity ratios due to general growth in the area. These ratios were calculated assuming a projected traffic growth of one percent per year and no changes in existing intersection geometrics. Cumulative impacts are not expected to result in significant changes in LOS.

The cumulative traffic analysis for the morning peak hour indicates that there would be no change in the LOS for all but one intersection in the Paramount area. The Lakewood Blvd./Somerset Blvd. intersection is expected to change from LOS A to B, which is not considered significant since traffic flow would not be significantly adversely impacted. Therefore, cumulative impacts on traffic during the morning are less than significant.

The cumulative traffic analysis for the evening peak hour indicates that there would be no change in the LOS for all but one intersection in the Paramount area. The Downey Avenue/Alondra Boulevard intersection is expect to change from LOS C to D. LOS D typically is the level for which a metropolitan area street system is designed. The growth in traffic is less than two percent of the overall traffic at the intersection and is considered less than significant. Therefore, cumulative impacts on traffic during the p.m. operations are less than significant.

On-and-Off Ramp Freeway Traffic During Operations

Two freeways bordering the proposed project were analyzed for traffic impacts during operations. The Century Freeway (I-105) is located approximately six miles north of the proposed project and the Artesia Freeway (SR-91) is approximately 14 miles south. The cumulative traffic analysis included the intersections of Downey Avenue and SR-91, Lakewood Boulevard and SR-91, both of which are south of the Paramount Refinery, and the intersection of Lakewood Boulevard and the I-105, which is north of the Refinery. The analysis indicates that the LOS at these intersections is not expected to change. Therefore, the cumulative impacts at these intersections are expected to be less than significant.

TABLE 5-8

CUMULATIVE TRAFFIC IMPACTS
LEVEL OF SERVICE ANALYSIS AND VOLUME-TO-CAPACITY RATIOS
OPERATIONAL

	BASELINE				CUMULATIVE IMPACTS					
	AM PEAK		PM PEAK		AM PEAK			PM PEAK		
INTERSECTION	LOS	Volume to Capacity Ratio	LOS	Volume to Capacity Ratio	LOS	Volume to Capacity Ratio	Volume to Capacity Ratio Increase	LOS	Volume to Capacity Ratio	Volume to Capacity Ratio Increase
Downey Ave. & Rosecrans Ave.	B	0.662	C	0.761	B	0.674	0.000	C	0.777	0.003
Downey Ave. & Somerset Blvd.	D	0.854	B	0.687	D	0.871	0.001	B	0.701	0.001
Downey Ave. & Alondra Blvd.	B	0.637	C	0.793	B	0.649	0.000	D	0.808	0.000
Downey Ave. & SR91 WB offramp/ SR91 WB on & EB offramps.	C	0.780	B	0.625	C	0.795	0.000	B	0.637	0.000
Downey Ave. & SR91 EB onramp/ SR91 EB offramp.	B	0.661	B	0.622	B	0.673	0.000	B	0.633	0.000
Lakewood Blvd. & I105 EB offramp/ I105 WB offramp.	A	0.560	C	0.749	A	0.573	0.000	C	0.766	0.001
Lakewood Blvd. & Rosecrans Ave.	A	0.562	C	0.745	A	0.577	0.000	C	0.764	0.000
Lakewood Blvd. & Somerset Blvd.	A	0.598	B	0.671	B	0.621	0.000	B	0.685	0.000
Lakewood Blvd.& Alondra Blvd.	A	0.540	C	0.750	A	0.551	0.000	C	0.765	0.000
Lakewood Blvd & SR91 WB on/off ramps SR91 WB onramp	A	0.418	A	0.586	A	0.427	0.000	A	0.598	0.000
Lakewood Blvd & SR91 EB onramp SR91 EB on/off ramps.	A	0.520	B	0.691	A	0.529	0.000	B	0.704	0.000

A 003767

LEVEL OF SIGNIFICANCE

All intersections near the Paramount Refinery are considered to have less than significant cumulative impacts, since free-flowing traffic would continue and is not expected to change. Therefore, the cumulative impacts on traffic during the a.m and p.m. would be considered less than significant.

MITIGATION MEASURES

No significant cumulative impacts have been identified so no mitigation measures are required.

LEVEL OF SIGNIFICANCE AFTER MITIGATION

The traffic impacts associated with the proposed project and other related projects are not expected to be significant or result in adverse traffic impacts that would contribute to the cumulative traffic impacts.

DAR:WORD:2150EDIS

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

July 2003

ToxFAQs™ for Trichloroethylene (TCE)

(Tricloroetileno)

CAS# 79-01-6

This fact sheet answers the most frequently asked health questions about trichloroethylene. For more information, you may call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Trichloroethylene is a colorless liquid which is used as a solvent for cleaning metal parts. Drinking or breathing high levels of trichloroethylene may cause nervous system effects, liver and lung damage, abnormal heartbeat, coma, and possibly death. Trichloroethylene has been found in at least 852 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is trichloroethylene?

Trichloroethylene (TCE) is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers.

Trichloroethylene is not thought to occur naturally in the environment. However, it has been found in underground water sources and many surface waters as a result of the manufacture, use, and disposal of the chemical.

back to top

What happens to trichloroethylene when it enters the environment?

- Trichloroethylene dissolves a little in water, but it can remain in ground water for a long time.
- Trichloroethylene quickly evaporates from surface water, so it is commonly found as a vapor in the air.
- Trichloroethylene evaporates less easily from the soil than

MHMIs
Interaction Profiles
Priority List of Hazardous Substances
Division of Toxicology

from surface water. It may stick to particles and remain for a long time.

- Trichloroethylene may stick to particles in water, which will cause it to eventually settle to the bottom sediment.
- Trichloroethylene does not build up significantly in plants and animals.

back to top

How might I be exposed to trichloroethylene?

- Breathing air in and around the home which has been contaminated with trichloroethylene vapors from shower water or household products such as spot removers and typewriter correction fluid.
- Drinking, swimming, or showering in water that has been contaminated with trichloroethylene.
- Contact with soil contaminated with trichloroethylene, such as near a hazardous waste site.
- Contact with the skin or breathing contaminated air while manufacturing trichloroethylene or using it at work to wash paint or grease from skin or equipment.

back to top

How can trichloroethylene affect my health?

Breathing small amounts may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating.

Breathing large amounts of trichloroethylene may cause impaired heart function, unconsciousness, and death. Breathing it for long periods may cause nerve, kidney, and liver damage.

Drinking large amounts of trichloroethylene may cause nausea, liver damage, unconsciousness, impaired heart function, or death.

Drinking small amounts of trichloroethylene for long periods may cause liver and kidney damage, impaired immune system function, and impaired fetal development in pregnant women, although the extent of some of these effects is not yet clear.

Skin contact with trichloroethylene for short periods may cause skin rashes.

back to top

How likely is trichloroethylene to cause cancer?

Some studies with mice and rats have suggested that high levels of trichloroethylene may cause liver, kidney, or lung cancer. Some studies of people exposed over long periods to high levels of trichloroethylene in drinking water or in workplace air have found evidence of increased cancer. Although, there are some concerns about the studies of people who were exposed to trichloroethylene, some of the effects found in people were similar to effects in animals.

In its 9th Report on Carcinogens, the National Toxicology Program (NTP) determined that trichloroethylene is "reasonably anticipated to be a human carcinogen." The International Agency for Research on Cancer (IARC) has determined that trichloroethylene is "probably carcinogenic to humans."

back to top

Is there a medical test to show whether I've been exposed to trichloroethylene?

If you have recently been exposed to trichloroethylene, it can be detected in your breath, blood, or urine. The breath test, if it is performed soon after exposure, can tell if you have been exposed to even a small amount of trichloroethylene.

Exposure to larger amounts is assessed by blood and urine tests, which can detect trichloroethylene and many of its breakdown products for up to a week after exposure. However, exposure to other similar chemicals can produce the same breakdown products, so their detection is not absolute proof of exposure to trichloroethylene. This test isn't available at most doctors' offices, but can be done at special laboratories that have the right equipment.

back to top

Has the federal government made recommendations to protect human health?

The EPA has set a maximum contaminant level for trichloroethylene in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water.

The EPA has also developed regulations for the handling and disposal of trichloroethylene.

The Occupational Safety and Health Administration (OSHA) has set an exposure limit of 100 parts of trichloroethylene per million parts of air (100 ppm) for an 8-hour workday, 40-hour workweek.

back to top

Glossary

Carcinogenicity: The ability of a substance to cause cancer.

CAS: Chemical Abstracts Service.

Evaporate: To change into a vapor or gas.

Milligram (mg): One thousandth of a gram.

Nonflammable: Will not burn.

ppm: Parts per million.

Sediment: Mud and debris that have settled to the bottom of a body of water.

Solvent: A chemical that dissolves other substances.

back to top

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2003. Managing Hazardous Materials Incidents. Volume III – Medical Management Guidelines for Acute Chemical Exposures: Trichloroethylene (TCE). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological Profile for trichloroethylene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

back to top

Where can I get more information?

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

For more information, contact:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333
Phone: 1-888-42-ATSDR (1-888-422-8737)
FAX: (770)-488-4178
Email: ATSDRIC@cdc.gov

back to top

ATSDR Information Center / ATSDRIC@cdc.gov / 1-888-422-8737

This page was updated on November 22, 2004

ATSDR Home | Search | Index | Glossary | Contact Us
About ATSDR | News Archive | ToxFAQs | HazDat | Public Health Assessments
Privacy Policy | External Links Disclaimer | Accessibility
U.S. Department of Health and Human Services

Terrell Watt, AICP
Terrell Watt Planning Consultants
1937 Filbert Street
San Francisco, CA 94123
terrywatt@att.net
office: 415-563-0543
cell: 415-377-6280

EXPERIENCE

1989 -	**TERRELL WATT PLANNING CONSULTANTS** Planning consulting firm owner
1981-1989	**SHUTE, MIHALY & WEINBERGER** Planning Expert/Paralegal
1981-1983	**MUNDIE & ASSOCIATES** Planning Consultant to public and private clients
1979-1980	**EDAW, INC.** Project Management, Planning Consultant

PROFESSIONAL MEMBERSHIPS AND BOARDS

American Institute of Certified Planners (AICP)
American Planning Association (APA)
Board Member of the Conservation Biology Institute www.consbio.org

EDUCATION

USC GRADUATE SCHOOL OF URBAN AND REGIONAL PLANNING
Masters degree in City and Regional Planning

STANFORD UNIVERSITY
Bachelor's degree in Urban Studies

Since 1989, Terrell Watt, AICP, has owned Terrell Watt Planning Consultants. Ms. Watt's firm specializes in planning and implementation efforts focused on regionally-significant projects that promote sustainable development patterns. Prior to forming her own consulting group, she was the staff planning expert with the environmental and land use law firm Shute, Mihaly & Weinberger. She is an expert in general and specific planning, open space and agricultural land conservation and environmental compliance. Her skills also include public outreach, negotiation and facilitation.

Terrell works with a wide variety of clients throughout California including conservation organizations, government agencies and foundations. Her recent projects include:

- Project Coordinator for the Los Angeles Housing Infill Potential Methodology study, funded by an Environmental Justice Grant from Caltrans and jointly sponsored by the City of Los Angeles, County of Los Angeles and Environment Now.

- Secretary Terry Tamminen's Representative to the California Housing Infill Study Task Force, a Subcommittee to the State's Smart Growth Task Force.

- Planning consultant to the American Farmland Trust providing expertise on the efficacy of general plan's to protect prime farmland in the Central Valley and Central Coast of California.

- Advisor to the Governor's Cabinet on options for restructuring the "smart growth" dialogue.

- Advisor to the Attorney General's office on the status of general plans and housing elements in California.

- Primary consultant to the City of Livermore on the South Livermore Wine County Specific Plan and Transfer of Development Rights Program.

- Consultant to the Institute of Local Self Government for the development of A Local Official's Guide to Funding Open Space Acquisition.

- Consultant to the Planning and Conservation League led coalition of community and environmental groups on California High Speed Rail.

- Member of Mayor Gonzales' San Jose Coyote Valley Task Force to revision the Coyote Valley on behalf of the Silicon Valley Conservation Council.

- Founder and Project Director of the newly forming Association of Infill Housing Builders.

Out of Reach in 2004

Renters' Housing Wage

It costs $1,123/month to rent a decent two bedroom/one bath apartment in Long Beach.[1] The standard for housing affordability is that a family should not pay more than 30% of their earnings on rent. Thus, a working family needs to earn $21.60 per hour – or $44,924 per year – to afford the average two bed/one bath rent in Long Beach.

The minimum wage in California is not enough to pay the rent in Long Beach. At $6.75 per hour, two full-time minimum wage workers supporting a family would have to each work nearly 64 hours per week to afford the average 2 bedroom/one bath rent.

Decent Rental Housing is Out of Reach For

fast food workers	$14,800/year
garment workers	$14,800/year
cashiers	$15,200/year
security officers	$17,100/year
nurses aides	$18,800/year
social worker	$24,900/year
bookkeepers	$26,700/year
janitors (unionized)	$27,500/year
administrative assistants	$30,368/year
carpenters (non-union)	$33,400/year
auto mechanics (non-union)	$33,000/year
legal secretaries	$36,000/year
computer technicians	$37,400/year
grade school teachers	$40,100/year
county sheriff deputies	$43,600/year

[1] 110% of HUD, 2004, proposed fair market rent.
[2] February 2004 Dataquick, as printed in *LA Times*, using the mean of the medians listed for 11 representative Long Beach city zip codes.
[3] This assumes 5% down, an interest rate of 6% and a loan period of 30 years.
* Postsecondary.

Long Beach Housing Wage:

For City of Long Beach renters

$21.60/hour

$44,924/year

For City of Long Beach homebuyers

$47.35/hour

$98,492/year

Homebuyers' Housing Wage

In February 2004, the median-priced home in the city sold for $387,909.[2] The monthly mortgage payment needed to support buying the median priced Long Beach home is $2,209/month ($2,736 once taxes and insurance are included). A family would need to earn at least $98,492 to support this mortgage, assuming they pay no more than 33% of the family's income.[3]

Homeownership is Out of Reach For

firefighters	$45,800/year
registered nurses	$47,700/year
police officers	$49,400/year
computer programmers	$49,858/year
electrical engineers	$53,100/year
union carpenters	$57,200/year
database administrators	$59,000/year
nursing instructor*	$59,300/year
geography instructor*	$63,170/year
computer systems analyst	$64,140/year
education administrator*	$84,000/year

SCANPH
Southern California Association of Non-Profit Housing
3345 Wilshire Blvd, Ste 1005 Los Angeles CA 90010
(213) 480-1249, fax (213) 480-1788
April 2004

Demographic Data for the Community Around Long Beach Memorial:

Long Beach Memorial Medical Center
2801 Atlantic Ave.
Long Beach, CA 90806

Data taken from the 2000 Census

- Zip Code: 90806[1] (12 mile width)
- Total Population for this zip code area: 49,641
  - 9.6 % are children under the age of 5.
  - 34.9% are children under the age of 18.
  - 6.8% are people 65 or over.
  - 27.3% of the population 21-64 years of age have some type of disability status.
- Primarily people of color:
  - 20.5% African American
  - 19.7% API
  - 43.4% Latino or Hispanic
- Significant immigrant population & need for language access:
  - 37.3% foreign born.
  - 59.4% speak a language other than English at home.
- Income:
  - Median family income is $31,050, 38% lower than the national median family income of $50,046.
  - 26.4% of families live below the poverty level, almost 3 times the national average.
  - 28.6% of individuals live below the poverty level, more than twice the national average.
- Housing:
  - 63.3% renter-occupied, 36.7% owner-occupied
  - Median value of single family home is $171,000 compared to $211,500 for California (19% lower than the CA median).

The General Plan Update notes that **the City has experienced a 49.2% increase in severely overcrowded units and that 58.0% of the housing units were built prior to 1960.**[2]

---

[1] Using the zipcode to represent the community surrounding LBMC and the planned expansion provides a better set of data for our purposes than a smaller geographic area.
[2] "Technical Background Report," *General Plan Update*, Ch. 2, p. 2-1.

DRAFT ENVIRONMENTAL IMPACT REPORT

FOR

NORTHSTAR HIGHLANDS

Prepared for:

PLACER COUNTY
Planning Department
11414 B Avenue
Auburn, CA 95603

Prepared by:

PACIFIC MUNICIPAL CONSULTANTS
10461 Old Placerville Road, Suite 110
Rancho Cordova, CA 95827
916.361.8384
Fax: 916.361.1574

JULY 2004

4.2 POPULATION, HOUSING AND EMPLOYMENT

This section analyzes the population, housing, and employment impacts of the proposed project. Within this section are discussions on the population characteristics, housing, and employment opportunities within the planning region..

4.2.1 EXISTING SETTING

REGIONAL AND LOCAL SETTING

The project site is located on the Placer County portion of Martis Valley. This area of the Martis Valley has remained relatively undeveloped aside from a few recreational and residential developments. The majority of the population within the Placer County portion of the Martis Valley is located in three primary development areas, including Northstar-at-Tahoe, Lahontan, and the Ponderosa Palisades, Sierra Meadows, Ponderosa Ranchos, and Martiswood Estates subdivisions located adjacent to the Town of Truckee. However, both Northstar-at-Tahoe and Lahontan provide primarily recreational and seasonal housing; the majority of the permanent populations in the Placer County portion of Martis Valley reside in the Ponderosa Palisades, Sierra Meadows, Ponderosa Ranchos, and Martiswood Estates subdivisions. Other than these development areas, the majority of growth has occurred in Nevada County and the Town of Truckee.

Housing and development restrictions in the Lake Tahoe Basin, as well as area housing costs, have created an affordable housing shortage in the area. Additionally, resort communities tend to generate a large supply of low-paying jobs. Restrictions in the Lake Tahoe Basin were set up to manage the land use and resources of the Lake Tahoe region based on environmental protection and the encouragement of recreation-oriented land uses. The restrictive nature of potential development in the Tahoe Basin has forced surrounding areas to absorb the growth pressures. Housing projects in the Martis Valley area tend to be second home in nature (i.e., seasonal use) and are generally not considered affordable. Affordable housing developments are generally not proposed because of the high land values and the recreational oriented land use of the area.

Within the Tahoe area, a development right of one residential unit is given for each of the 16,000 Parcels in the basin, unless otherwise restricted. This means that multifamily projects must obtain development rights for each additional unit proposed and further land subdivisions are prohibited. Because of the land restrictions and the high land values of the area, affordable housing will continue to be limited (Placer County 1994a).

Population and growth projections for the Martis Valley Community Plan area are difficult to pinpoint based upon the recreational nature of the area and the use of the properties as secondary residences. Buildout figures from the 1975 Martis Valley General Plan, the 1994 Placer County General Plan, and recent development approvals provide a varied array of population and housing figures for the area.

The 1975 Martis Valley General Plan was prepared for an area within both Placer and Nevada Counties. This planning document provided growth projections based upon demographic information at the time. Most of the population figures have not been met. The permanent resident population in the Martis Valley General Plan area was estimated to be approximately 1,200 persons in 1975, with a relatively high percentage of second homes at approximately 80 percent. The average year round population was estimated based on three factors: (1) the seasonal nature of the job market associated with ski areas and construction work; (2) the tourist use and occasional rentals of condominiums; and (3) the intermittent occupancy of second homes (Placer County 1975a).

4.2 Population, Housing and Employment

The permanent population projected to be within the Martis Valley General Plan area for both Nevada and Placer Counties by buildout (1990) was estimated to be 22,000 to 25,000 persons. This estimate was based upon two methods for estimating permanent population. The first method was based upon the following assumptions: (1) the primary homes of moderate cost and mobile homes will serve permanent residents of the area; (2) the rentals of moderate cost will serve transient employees of the area but would generate the equivalent of 80 percent occupancy by permanent residents; and (3) there are 2,000 existing dwelling units that could serve a permanent population. This method of estimation results in a figure of 8,627 primary dwelling units or 25,881 permanent residents at 3.0 persons per dwelling unit. The second method for estimating permanent population was derived from the ratio of four secondary homes to three primary homes in the Tahoe area. The 1975 plan provided for 17,000 dwelling units of all types. Based on the basin ratio, the permanent population of the Martis Valley General Plan area at complete buildout would approach 22,000 persons (Placer County 1975a).

The 1975 Martis Valley General Plan also projected the peak weekend population to be approximately 41,000 persons for the Martis Valley area within Nevada and Placer Counties based upon the continued demand for primary and second homes, a peak occupancy rate of 80 percent, and an average of 3.0 persons per dwelling unit (Placer County 1975a). The rate and intensity of development expected within the Martis Valley portion of Placer County and analyzed within the 1975 Martis Valley General Plan has not taken place to date. The majority of growth since 1975 has occurred within the Nevada County portion of Martis Valley and the Town of Truckee, which was incorporated in 1993. The 2000 census identified census block group 5 of census tract 220.01, containing Martis Valley, as having a permanent population of 1,335 persons. Developments within the Placer County portion of the Martis Valley General Plan area have not added the number of permanent residents projected by the Martis Valley General Plan.

Demographics

Geographic Area

Demographic and employment data for the Martis Valley area are difficult to aggregate since Martis Valley is not a political entity nor a federally or regionally recognized area in terms of long-range planning or U.S. Census data collections. As such, very little data are available that are specific to Martis Valley.

In discussing demographics for the Martis Valley, data from three geographic areas in or relating to Martis Valley have been included. Not all data types (i.e., race, household income, or housing units) are available for each geographic area. The areas include the following:

Martis Valley Census Tract and Block Group

The closest level of data aggregation to the Plan area is a census block group; Census Tract 220.01, Block Group 5 (Martis Valley Block Group), does not fully coincide geographically with the Martis Valley, but provides an approximation for data purposes. Census Tract 220.01 (Martis Valley Census Tract) is a larger geographic unit, but fully encompasses the Martis Valley.

The census tract information for the Placer County portion of Martis Valley does not portray a full representation of the actual demographics for the area. The census information is primarily completed by full-time residents and property owners of the area and appears to have undercounted the dwelling units in the Placer County portion of Martis Valley. A majority of the individuals that have property or houses in Martis Valley use the property for recreational/second houses. Census information includes housing unit data for seasonal use, but does not include any household size, income, employment, or other demographic data for seasonal residents.

Placer High Country Regional Analysis District

The Placer County portion of the Plan area is within the Placer High Country Regional Analysis District (RAD). RADs are sub-County areas for which the Sacramento Area Council of Governments (SACOG) estimates and projects population, household, housing unit, and employment data. The Placer High Country RAD extends from east of the Colfax area to the northwestern border of the Lake Tahoe Basin, bordered to the north by Nevada County and to the south by the El Dorado County line. While the RAD is much larger than the Plan area, it includes data estimates that are more pertinent to the Plan area than Placer County data as a whole.

Placer County

1990 and 2000 census data have been used to provide demographic information for Placer County.

Town of Truckee

1990 and 2000 census data have been used to provide demographics for the Town of Truckee, which is the northern entry point to the Placer County portion of the Martis Valley. While the Town of Truckee provides amenities more targeted toward a population of permanent residents than does the Plan area, the demographics of Truckee are representative of the Martis Valley Plan area.

Population Trends

As shown in **Table 4.2-1**, the permanent population in the Martis Valley increased from 1,000 in 1990 to 1,185 in 2000, an increase of 18.5 percent. Persons in the RAD increased by 15.6 percent while the population of Truckee increased 55.6 percent.

TABLE 4.2-1
POPULATION TRENDS

	Martis Valley Plan Area [1]	Martis Valley Block Group [2]	Martis Valley Census Tract [2]	Placer High Country RAD [3]	Placer County [2]	Town of Truckee [4]
1990	1,000	701	4,013	5,211	172,796	8,912
2000	1,185	1,335	5,501	6,025	248,399	13,864
Change	185	634	1,488	814	75,603	4,952
Percent Change	18.5	90.4	37.1	15.6	43.8	55.6

Sources:
1 *Placer County 1994a; Placer County aggregation of 2000 census data*
2 *2000 Census*
3 *Sacramento Area Council of Governments 2000, 2001*
4 *Town of Truckee 1994, 2000 Census*

Household Trends and Demographics

Households

During the decade from 1990 to 2000, households in the Martis Valley Census Tract increased by 39.8 percent, or 617 households, compared with increases of 69.2 percent and 57.4 percent in the Martis Valley Block Group and the Town of Truckee, respectively. **Table 4.2-2** depicts household trends from 1990 to 2000.

TABLE 4.2-2
HOUSEHOLD TRENDS

	Martis Valley Block Group[1]	Martis Valley Census Tract[1]	Placer High Country RAD[2]	Placer County[1]	Town of Truckee[3]
1990	299	1,550	5,211	64,101	3,271
2000	506	2,167	5,803	93,382	5,149
Change	207	617	592	29,281	1,878
Percent Change	69.2	39.8	11.4	45.7	57.4

Sources:
[1] *1990 Census; 2000 Census*
[2] *Town of Truckee 1994, 2000 Census*
[3] *Sacramento Area Council of Governments 2000, 2001*

Table 4.2-3 contains household size data. In the Martis Valley Block Group, the average persons per residence was 2.63. This rate is used throughout this section in determining the population based on number of units in the Plan area. In Truckee, the average persons per residence were 2.72, only 0.09 higher than the Martis Valley Plan area figure.

TABLE 4.2-3
HOUSEHOLD TRENDS – 2000 CENSUS

Status	Martis Valley Block Group		Martis Valley Census Tract		Town of Truckee	
	Number	Percent	Number	Percent	Number	Percent
1 Person	90	17.8	484	22.3	961	18.6
2 Person	212	41.9	833	38.4	1,903	37.0
3 Person	77	15.2	359	16.6	916	17.8
4 Person	85	16.8	303	14.0	880	17.1
5 Person	23	4.5	123	5.7	310	6.0
6 Person	11	2.2	52	2.4	101	2.0
7 or more persons	8	1.6	13	0.6	78	1.5
Total	506	100	2,167	100	5,149	100
Persons / Household	2.63		2.52		2.72	

Source: 2000 Census

As shown in **Table 4.2-4**, the Martis Valley Census block group had a median income of $52,941 in 1999, which is $5,907 or 10 percent less than the Town of Truckee median income of $58,848.

TABLE 4.2-4
MEDIAN INCOME

Status	Martis Valley Census Tract 220.01	Town of Truckee	Martis Valley Block Group	Placer County
Median 1989 Household Income	$35,121	$36,676	$40,819	$36,676
Median 1999 Household Income	$52,941	$58,848	N/A	N/A

Source: 1990 Census STF3A; Town of Truckee General Plan1994; 2000 Census SF3

Tenure

Tenure describes the proportion of renters to owners; tenure rates for Martis Valley are shown in **Table 4.2-5**. In the Martis Valley, the majority of households own their home, with 83.8 percent of households in the Martis Valley Block Group owning and 77.3 percent of households within the census tract owning. Within the Martis Valley Block Group, renters represent only 16.2 percent of householders while in the Town of Truckee the renter rate is higher at 32.9 percent.

TABLE 4.2-5
HOUSING TENURE – 2000 CENSUS

Status	Martis Valley Block Group		Martis Valley Census Tract		Town of Truckee	
	Number	Percent	Number	Percent	Number	Percent
Owner	424	83.8	1,675	77.3	2,314	67.1
Renter	82	16.2	492	22.7	1,137	32.9
Total	506	100	2,167	100	3,451	100

Source: 2000 Census STF1; Town of Truckee General Plan

Housing Units

The Martis Valley Community Plan area is estimated to have had approximately 1,935 housing units in 2001. The Martis Valley Block Group had 1,545 housing units in 1990; this number increased to 1,745 by 2000. Housing units in the Martis Valley Census Tract increased by 8.5 percent, 428 units, from 1990 to 2000 as depicted in **Table 4.2-6**. Placer County and the Town of Truckee both experienced high rates of development with respective increases of 37.8 and 40.8 percent.

TABLE 4.2-6
HOUSING UNIT TRENDS

	Martis Valley Block Group[1]	Martis Valley Census Tract[1]	Placer High Country RAD[2]	Placer County[1]	Town of Truckee[3]
1990	1,545	5,022	5,610	77,879	6,932
2000	1,756	5,450	6,489	107,302	9,757
Change	211	428	879	29,423	2,825
Percent Change	13.7	8.5	15.7	37.8	40.8

Sources:
[1] *1990 Census; 2000 Census*
[2] *Sacramento Area Council of Governments 2000, 2001*
[3] *Town of Truckee, 1994; 2000 Census*

Housing Unit Occupancy

Table 4.2-7 contains occupancy data and further describes the type of occupancy or vacancy. Vacant homes in the Martis Valley area represent the majority of housing units, with 71.2 percent of homes in the Martis Valley Block Group vacant and 60.2 percent of homes in the census tract vacant. In the Martis Valley Block Group there were six vacant homes for sale or rent during the 2000 Census. The vast majority of unoccupied homes were seasonal, recreational, or other types of vacancies. Only 59 vacant units, 1.8 percent, in the census tract were available for sale or rent. Generally, a vacancy rate beneath 5 percent indicates a lack of choice in the housing market. In Truckee, year-round occupancy at 52.58 percent is higher than that of either the Martis Valley Census Tract or Block Group.

TABLE 4.2-7
HOUSING UNIT OCCUPANCY AND TYPE OF OCCUPANCY OR VACANCY – 2000 CENSUS

Status	Martis Valley Block Group		Martis Valley Census Tract		Town of Truckee	
	Number	Percent	Number	Percent	Number	Percent
Occupied	506	28.8	2,167	39.8	3,271	47.2%
Owner	424	83.8	1,675	77.3	2,134	30.8%
Renter	82	16.2	492	22.7	1,137	16.4%
Vacant	1,250	71.2	3,283	60.2	3,661	52.8%
Seasonal, Recreational	1,209	96.7	3,133	95.4	3,479	50.2%
For Sale or Rent	6	0.5	59	1.8	182	2.6%
Other Vacancy	35	2.8	91	2.9	N/A	N/A
Total	1,756	100	5,450	100	6,932	100%

Source: 2000 Census STF1; Town of Truckee General Plan

Housing Price and Availability

The recent developments within the Martis Valley Community Plan area cater to a second home or recreational home market. These projects are not designed to meet permanent housing needs. The developments are intended to provide seasonal activities that are oriented toward winter or summer.

The residential lots in the Lahontan development are broken down into the following price ranges: forest homesites are from $210,000 to $485,000; view homesites are from $500,000 to $1 million; and golf course homesites are from $475,000 to $800,000. A completed house and lot range from $1 million to $2.5 million. A membership at the Lahontan Golf Course is $125,000 and a social membership is $25,000.

The Northstar development contains homes, condominiums, and lots for sale. Based on a listing of Northstar properties sold from 1999 through April 2000, houses sold ranged in price from $355,000 to $1,924,500. Condominiums sold ranged in price from $115,000 to $425,000 and lots sold ranged in price from $174,500 to $410,000.

Data provided by County staff and used in the Lahontan I and II CEQA documents show that the annual combined owner/renter occupancy rate between 1984 and 1990 ranged from a low of 32.5 percent in 1986 to a high of 43.6 percent in 1990. During this period, the highest occupancy rate was 76.6 percent.

A cursory review of the occupancy rates would indicate that residential units are available for rent within the Plan area. However, the occupancy figures do not take into account that many of the residences are secondary/recreational homes and that the property owners have no intention of occupying the residences on a full-time basis. There is the potential that many of the residences are not available for rental purposes and that many residences that are offered for rent would not be available during the peak season (winter and summer months), when temporary or seasonal employees would need housing. The rental and housing prices within the Martis Valley are also prohibitive for seasonal or temporary housing.

The high priced nature of the Plan area developments precludes employees generated by these projects from living in the area.

Most of the individuals who work and live full time in the Plan area cannot afford to live in the Lahontan and Northstar-at-Tahoe developments. The property and housing prices in the Plan area would be prohibitive for most individuals that work in the vacation or resort industry.

<u>Affordable and Employee Housing Projects</u>

New developments in Martis Valley and surrounding areas have left a void in affordable housing for employees of low and moderate income paying jobs created by these resort communities. The rise in rents and housing values has made it difficult to find housing. The Town of Truckee and Placer County take an active role in ensuring the provision of affordable housing in the area.

Placer County has created a Redevelopment Agency to coordinate countywide affordable housing efforts. The Redevelopment Agency is responsible for the administration of the Community Development Block Grant (CDBG) Program. The Redevelopment Agency has currently secured approximately $1,800,000 in State funding for affordable housing projects in the unincorporated County. In the last two years, more than $800,000 has been committed for housing-related projects located in the Tahoe area. The following affordable housing programs are being initiated for the Tahoe Basin region in Placer County.

- The Kings Beach Housing Rehabilitation Program, funded in 1998 and 2000 through CDBG and the Redevelopment Agency, was initiated to improve affordable housing. The County contracted with Mercy Housing to administer and implement the rehabilitation program. More than $400,000 has been committed to the efforts to package and receive loan approvals in the Tahoe area.
- The County established an affordable housing in-lieu fee for certain projects within North Tahoe. The county has received $84,000 from one project and a commitment of up to $2,000,000 from another (Placer County, 2002).
- The Placer County Redevelopment Agency (RDA) entered into a Memorandum of Understanding with Affordable Housing Development Corporation (AHDC) in 2001 for the purpose of facilitating development of affordable housing. Once AHDC secures a site for development, the RDA provides financial assistance with the project. Currently, AHDC is proposing a 110-unit affordable housing complex in Tahoe Vista called Cedar Grove Apartments.

Northstar-at-Tahoe is leasing both the Hilltop Lodge and five houses in Truckee to accommodate 100 employees. Sawmill Heights, a workforce housing project, is planned at Northstar-at-Tahoe and would provide 96 units.

Within the Town of Truckee, there are several affordable housing projects that provide housing for low and medium income families. The federally funded Truckee Pines development contains 104 units for low-income households. Riverview Homes consists of 39 detached rental units for low and medium income households. Sierra Village is a 72 unit complex and 57 of those units will be for low-income families.

The County of Placer requires new resorts in the Sierra Nevada and Lake Tahoe areas to provide for employee housing equal to 50 percent of the housing demand generated by the project. To meet the County's resort housing requirements, tenants of the project must be (a) Northstar employees or employees working at Northstar, or (b) regional employees whose income does not exceed "moderate" income guidelines for Placer County.

Employment

The Truckee-Tahoe economy is heavily dependent upon the vacation and resort industry, with 28.5 percent of employees in the Martis Valley Census Tract working in retail, arts, entertainment, recreation, accommodation and food service jobs and 30.9 percent of employees in Truckee working in these jobs (Census, 2000). As a result of this emphasis, much of the ongoing development in the region is focused on the more affluent vacation and second home markets. **Table 4.2-8** contains the number of employed residents for the Martis Valley census tract, Placer High Country RAD, and the Town of Truckee.

Employment by occupation is represented for the Martis Valley census tract and Town of Truckee residents, in **Table 4.2-9**. Most of the jobs created by the vacation and resort industry are seasonal and/or relatively low paying support or service positions that do not provide sufficient income to rent or purchase housing in the area.

TABLE 4.2-8
EMPLOYMENT FIGURES

	Martis Valley – Census Tract[1]	Town of Truckee[2]	Placer High Country RAD
1990	2,082	4,961	368
2000	2,972	8,110	1,542
Change	890	3,149	1,174
Percent Change	42.7%	63%	319.0

Source: 1990 Census, 2000 Census
1 SACOG Population Estimates and Housing Unit Inventory, 2000; SACOG Projections, 2001
2 Truckee General Plan, 1994; 2000 figure based on Truckee CDP rate of employment increase from 1990 to 2000, CA Employment Development Department, Labor Market Information Division

However, information regarding place of residence that corresponds to place of employment indicates that 61 percent of the summer employees and 54 percent of the winter employees live and work within Truckee/Martis Valley region (LSC Transportation Consultants, 2002 / Appendix G in Northstar Highlands PEA). Additionally, 25 percent of the summer employees and 34 percent of the winter employees reside in the North Shore area. The remainders of the employees reside in Reno/Sparks/Verdi (5 percent summer/4 percent winter), Incline/Crystal Bay (3 percent summer/4 percent winter), Sierra/Plumas Counties (1 percent summer and winter), and nearby Donner Summit (1 percent summer and winter).

TABLE 4.2-9
EMPLOYMENT BY OCCUPATION

Occupation	Martis Valley – Census Tract[1]		Town of Truckee[2]	
	Number	Percent	Number	Percent
Management, Professional and Related Occupations	1,069	36.0%	2,597	32.0%
Service Occupations	464	15.7%	1,559	19.2%
Sales and Office Occupations	706	24.0%	2,006	24.7%
Farming, Fishing and Forestry, Occupations	12	0.4%	43	0.5%
Construction, Extraction, and Maintenance Occupations	455	15.0%	1,305	16.1%
Production, Transportation, and Material Moving Occupations	266	8.9%	600	7.4%

Sources:
1 2000 Census
2 Town of Truckee General Plan, 1994

Area Employment

The Northstar-at-Tahoe development is a second home or recreational community that has winter and summer sport opportunities. The resort is operated year-round and while it primarily creates part time or seasonal jobs, Northstar also provides full-time year-round employment opportunities. These jobs include cashiers, ski instructors, lift operators, food service, retail sales, golf course maintenance, and other recreational/vacation resort style jobs.

The current employment trend in Martis Valley results from developments that require a seasonal, low-paid labor force, but consist of exclusive housing that workers cannot afford. Developments in Martis Valley will continue to contribute to the regional problem of affordable housing.

4.2.2 REGULATORY FRAMEWORK

LOCAL

Placer County General Plan

The Placer County General Plan contains the policies analyzed in **Table 2** in **Appendix 4.0A** relative to the maintenance, improvement, and development of housing, along with providing a wide range of housing and employment opportunities. While this EIR analyzes the project's consistency with the Placer County General Plan pursuant to CEQA Section 15125(d), the Placer County Planning Commission and/or Board of Supervisors will ultimately make the determination of the project's consistency with this General Plan.

Martis Valley Community Plan

Table 2 in **Appendix 4.0A** analyzes the project's consistency with proposed Martis Valley Community Plan policies related to population, employment, and housing, and presents an evaluation of the consistency of the project with these statements as required by CEQA Guidelines 15125(d). While this EIR analyzes the project's consistency with the Martis Valley Community Plan pursuant to CEQA Section 15125(d), the Placer County Planning Commission and/or Board of Supervisors will ultimately make the determination of the project's consistency with this Community Plan.

4.2.3 IMPACTS AND MITIGATION MEASURES

STANDARDS OF SIGNIFICANCE

A population and housing impact is considered significant if implementation of the project would result in any of the following:

- Result in the exceedance of population projections set forth in the Placer County General Plan.
- Induce substantial growth or concentration of population in an area either directly or indirectly (e.g., through projects in an undeveloped area or extension of major infrastructure) that would be inconsistent with the Placer County General Plan and would result in a physical effect on the environment.
- Displace existing housing, especially affordable housing.
- Displace a large number of people.

- Indirect environmental effects associated with inability to provide for affordable and/or employee housing equal to 50 percent of the demand projected for employees of the project.
- Conflict with Placer County policies associated with population, housing, and employment.

METHODOLOGY

Research on demographic and housing conditions was conducted using existing documents and other information sources. Information was obtained from governmental agencies through their Internet websites. Among these agencies were the U.S. Census Bureau, the Sacramento Area Council of Governments (SACOG), and the California Employment Development Department. The Housing Elements of Placer County and the Town of Truckee were additional sources of information on housing and socioeconomic conditions as well as housing policy.

The Town of Truckee, Town of Mammoth Lakes, and Town of Vail were contacted to obtain employment generation factors and housing policy information for resort areas. Newspaper articles and contacts with local real estate agencies provided more current information on housing prices. Based on an average household size of 2.63 persons for each multifamily housing unit, and 3.96 persons for each employee-housing unit, this would result in a maximum population of 4,883 persons at project buildout.

The proposed project would have no impact regarding displacement of housing because there are currently no housing units on the Highlands project site. Because the proposed project would not displace housing, displacement of people would also not occur.

PROGRAM (HIGHLANDS) IMPACTS AND MITIGATION MEASURES

Temporary Increase in Construction Employment

Impact 4.2.1 Buildout of the proposed project would create a temporary increase in construction employment. This impact is considered **less than significant.**

Buildout of the proposed project would generate temporary construction jobs between the construction period (May through October) of each year from May 2005 to October 2022. Construction of the proposed project would generate up to 450 temporary construction jobs each year at the peak day of construction. However, specific construction employment generation beyond Phase 1 cannot be estimated until subsequent phases have been designed.

The demand for construction workers that would be generated by development of the proposed project could be met by the existing labor force coming from the region containing Placer and Nevada counties. However, construction workers may also be imported from areas outside the region, such as Sacramento and Reno. Construction-related jobs associated with development projects similar to the project do not typically generate a demand for permanent housing. In fact, some construction trades would not be needed on an annual basis. In some years or phases, construction work may be limited to excavation, whereas in other years more finishing or building construction activities may occur. A variety of trades and contractors would be utilized throughout development of Highlands. Depending on the demand for future phases and planning for those phases, there may be years without any construction activity.

It is anticipated that some of the employee housing would be available during the summer season, the peak construction period, for construction employees, since many of the seasonal, ski hill employees generally move elsewhere at this time of year (East West, 2004). The proposed project therefore would not be expected to generate the need for substantial additional permanent housing during the construction period. This impact is considered less than significant. Environmental effects related to commute trips of construction workers, such as those on air quality and traffic, would be temporary and are discussed in the respective sections of this EIR.

Mitigation Measures

None required.

Increase in Population Growth

Impact 4.2.2 Development of the proposed project could result in population growth of up to 4,883 new residents. The residential population generated by the proposed project would not exceed the holding capacity of the Martis Valley Community Plan area (Plan area). This impact is considered **less than significant.**

The proposed project is located within the MVCP area. The County General Plan identified the holding capacity of the Plan area as 21,500 persons, based on development of 8,600 dwelling units. The Martis Valley holding capacity is calculated as 80 percent of the maximum 1994 buildout capacity (Placer County 1994), or 20,209 persons. As the County General Plan does not distinguish between year-round and seasonal or part-time residences, the population is based on full-time occupancy of the residences. Buildout of the proposed project would result in the addition of up to 1,450 multifamily housing units and 270 employee housing units to the Plan area. Based on an average household size of 2.63 persons for each multifamily housing unit, and 3.96 persons for each employee-housing unit, this would result in a maximum population of 4,883 persons at project buildout. However, the population of the Martis Valley is primarily seasonal. Using a year-round occupancy rate of 20 percent for the multifamily housing units, 763 of the residential units would be occupied on a year-round basis at project buildout, resulting in a year-round resident population of 1,832 persons at project buildout, as shown in **Table 4.2-10.**

TABLE 4.2-10
PROJECT BUILDOUT POPULATION GENERATION (2022)

Year-round Residency Rate (%)	Units	Resident Generation [1]	Seasonal Residents[2]	Permanent Residents[2]
100	1,450 multifamily units	2.63 persons per multifamily unit[1]	0	3,814
20[2]	1,450 multifamily units	2.63 persons per multifamily housing unit	3,051	763
100	270 employee housing units	3.96[3] persons per multifamily employee housing unit	0	1,069

Source: Placer County 2002b
[1] *Placer County 2002*
[2] *20 percent year-round residency rate applies only to multifamily units. All residents in employee housing units would be year-round residents.*
[3] *East West Partners 2003*

The total housing units added to the Martis Valley Community Plan area as a result of the buildout of the proposed project represent 16.8 percent (based on 2003 MVCP) of the Martis Valley Community Plan area buildout amount. The project at buildout would not exceed the holding capacity of the Martis Valley Community Plan area.

The increase in the year-round resident population as well as the addition of a seasonal population would result in direct and indirect environmental effects on areas such as noise, community services, traffic, and air quality, which are discussed in the relevant sections of this EIR. Although the proposed project would result in population growth, the Martis Valley Community Plan area is designated for such growth in the County General Plan. Buildout of the proposed project would result in an addition of up to 1,450 multifamily housing units and 270 employee-housing units. In addition, the Northstar resort community, which contains the proposed project site, has been designated for growth in the 1971 Northstar-at-Tahoe Master Plan, the 1975 Martis Valley General Plan, the MVCP, and the Placer County General Plan, and the proposed project is consistent with designations within these plans. Therefore, impacts relating to population growth are considered **less than significant.**

Mitigation Measures

None required.

Jobs/Housing Balance

Impact 4.2.3 The proposed employee housing at project buildout would accommodate 50 percent of the employees employed on the Highlands project site. The proposed project at buildout is considered to be balanced in terms of the jobs/housing ratio required by the County General Plan. However, available employee housing will not be available until project buildout. This impact is considered **potentially significant.**

The residential, ski services, hotel, and public components of the proposed project are expected to generate as many as 701 full-time employee equivalent jobs. These full-time employee equivalent jobs take into account both full-time and part-time jobs. **Table 4.2-11** shows the number of direct jobs that could be expected at buildout of the proposed project using the following ratios. As required by the Housing Element of the County General Plan, the proposed Highlands project is required to provide housing for 50 percent of the employees it generates. **Table 4.2-11** shows the number of employee housing units required, based on 3.96 persons per employee housing unit (East West Partners 2003)(based on the capacity of employee housing for Northstar Village and the projected capacity of Sawmill Heights).

Placer County has developed a draft Employee Housing Ordinance as part of the County's implementation of the programs provided in the 2000-2007 Housing Element. The draft Employee Housing Ordinance would establish employee housing requirements, consistent with Policy A.14, for commercial service, commercial retail, industrial, office, recreation, residential, resort, transient lodging, and timeshare uses at an elevation of 5,000 feet or higher. The employee housing requirement can be met through the following methods: provision of employee housing on-site, provision of employee housing off-site, dedication of land, or payment of an in-lieu fee. Projects would be required to submit a housing mitigation plan that details the type, occupancy, and implementation (e.g., timing, fee payment, offer of dedication) proposed for the project.

The coordinator at the Big Springs Day Lodge would schedule and coordinate anticipated employees for special events. The Big Springs Day Lodge would absorb the employees. No new employees would be generated.

Buildout of the proposed project would result in the development of 1,450 dwelling units, plus 275 employee-housing units. It is conservatively estimated that the proposed condominium and townhome units, with the exception of the proposed employee housing units, would not be affordable to most of the people who would be employed on the project site. However, it is not anticipated that every employee would live on the project site nor that all employees live where they work.

TABLE 4.2-11
EMPLOYMENT GENERATION PROJECT BUILDOUT

Land Use Type	Units	Employment Generation	Jobs	Employee Dwelling Units Needed[1]
Condominium – transient rental	1,450 units	0.33 FTEE/du[1]	479	121
Hotel	255 rooms 12,000 sf	0.33 FTEE/room	84	22
Skier Services	30,000 sf	2.0 FTEE/1,000[2] sf	60	16
Homeowners Association Recreation Center	16,000 sf	2.0 FTEE/1,000 sf	32	8
Spa Facility in Hotel	20,000 sf	2.0 FTEE/1,000 sf	40	10
Intercept Lot	32 peak-hour bus trips	1.00 FTEE/6 peak hour bus trips	6	2
Highlands Project Subtotal			701	177
Village Project			388	98
Total			1,089	275

FTEE – full-time employee equivalent
sf – square feet
du – dwelling unit
[1]Employee housing needs are based on 3.96 persons per employee housing unit (based on design of Sawmill Heights which would accommodate an average of 3.96 employees per housing unit; the number of employees that would live in each unit is based on the number of bedrooms of each unit)
[2]EDAW, 2003; Draft Employee Housing Ordinance, Placer County 2003
Sources: LSC Transportation Consultants 2001, Town of Mammoth Lakes 1999, Town of Vail 1991, Placer County 2002c, East West Partners 2002

The indirect effects of employees traveling to their job site include traffic, and air quality and noise impacts related to traffic. Trips generated by employees of the project are included in the overall trip generation for the project and are discussed in Section 4.4, Transportation and Circulation. Noise and air quality impacts resulting from these trips are included in the discussions of air quality and noise impacts resulting from trips generated by the project and are discussed in the relevant sections of this EIR.

The proposed Highlands would generate approximately 701 jobs. Additional development proposed for the Northstar-at-Tahoe resort community, such as the proposed Northstar Village expansion project, would generate as many as 388 additional jobs for the community. The two projects combined (Northstar Village plus Highlands) would generate approximately 1,089 jobs. One of the objectives of the proposed project is to designate sufficient land to provide appropriate locations for affordable housing to serve Northstar's employees and/or regional employees whose income does not exceed moderate-income guidelines, and to provide housing primarily for Northstar employees, employees working at Northstar, or regional employees whose income does not exceed the moderate-income guidelines. For this reason, it is assumed that employee housing designated within the project site would also accommodate employees generated by the Northstar Village project. Therefore, the totals listed in **Table 4.2-11** also reflect the Northstar Village project. Assuming a rate of 3.96 residents for each of the employee housing units, based on the employees per unit that would be accommodated by Sawmill Heights Employee Housing, the 388 jobs generated by the Northstar Village project will result in the need for an additional 98 employee housing units. To comply with Placer County's requirements for employee housing, Northstar Village will need 49 employee housing units, assuming 3.96 employees per unit.

Assuming that 49 of the Sawmill Heights employee housing units would be occupied by employees generated by the proposed Northstar Village expansion project, the 47 remaining Sawmill Heights Units would be available to accommodate Northstar Highlands employee housing needs. The Highlands would generate 701 employees, which translates into 177 employee housing units needed. To comply with Placer County's requirements for housing resort employees, Northstar Highlands would need to provide 89 employee housing units. This exceeds the units anticipated to be available at Sawmill Heights by 42 units. In addition to the Sawmill Heights units, 174 employee housing units would be available from the future employee housing sites. The 221 total employee housing units available to Northstar Highlands would exceed the 89 employee housing units Northstar Highlands would be required to provide. However, since no timing has been specified for the development of the future employee housing sites, there will be a shortfall of employee housing if future phases of Northstar Highlands are developed in advance of the future employee housing sites or without an employee housing component, resulting in a **potentially significant** impact.

Mitigation Measures

MM 4.2.3 The project applicant shall mitigate potential impacts to employee housing through compliance with the Placer County General Plan Housing Element Policy (2.A.14) requiring new Sierra Nevada and Lake Tahoe projects to house 50 percent of the employee housing demand (e.g., FTEE employees) generated by the project. Prior to the approval of a final map, and with submittals of future tentative maps and/or CUP applications, the project applicant shall submit to Placer County an Employee Housing Mitigation Plan that details the method of providing the required employee housing units, proposed occupancy (rental or for-sale), number of employees served by the employee housing units or, in the case of land dedication or in-lieu fee payment, number of employees credited, site suitability if land dedication is proposed, transportation to and from the project (if employee housing is located off-site), timing of the development of employee housing units, and any incentives requested. For each subsequent development phase, the need for employee housing shall be accommodated by providing the correct ratio of employee housing units.

The employee housing units shall be provided in one of the following ways: (1) provide on-site employee housing, 2) provide off-site employee housing (either through construction of new housing or substantial rehabilitation of an existing structure), 3) dedicate land for employee housing, or 4) pay an in-lieu fee.

Timing/Implementation: *Submitted with future tentative map or CUP application submittals and implemented before issuance of occupancy permits*

Enforcement/Monitoring: *Placer County Planning Department*

Implementation of mitigation measure MM 4.2.3 would reduce the affordable housing and employee-housing imbalance impacts to **less than significant**. The above mitigation measure would bring the project into consistency with policies pertaining to housing in the Martis Valley Community Plan, and the Placer County General Plan. Because the housing units would be consistent with the Plan for the area in which they are built, and because of the limited number of units that are required, impacts of that development with mitigation would be less than significant.

PROJECT (PHASE 1) IMPACTS AND MITIGATION MEASURES

Temporary Increase in Construction Employment

Impact 4.2.4 Construction of the proposed Phase 1 development would generate up to 466 temporary construction jobs (EDAW, 2003), each year at the peak day of construction during Phase 1. Construction would not generate an additional need for permanent housing and would be temporary. This impact is considered **less than significant**.

Refer to Impact 4.2.1 for detailed discussion of this impact. Phase 1 of the proposed Highlands project would generate up to a maximum of 466 temporary construction jobs during the construction period (May through October) each year from May 2005 to October 2010. Some of the employee housing will be utilized during the summer construction periods for contractor employees, since many of the seasonal ski workers will have moved elsewhere. This would provide housing opportunities on-site and reduce traffic and traffic-related effects. The contractors would use Northstar Shuttle and Chondolas to get to and from the jobsite everyday. This issue is also discussed in detail in Section 4.4 Transportation. The proposed project therefore would not generate the need for substantial additional permanent housing during the construction period. This impact is considered **less than significant.**

Mitigation Measures

None required.

Increase in Population Growth

Impact 4.2.5 Phase 1 development could result in population growth of up to 990 persons. The residential population generated by Phase 1 of the proposed project would not exceed the holding capacity of the Martis Valley Community Plan area (Plan area). This impact is considered **less than significant.**

Refer to Impact 4.2.2 for a discussion of the holding capacity of the Martis Valley Plan area. Phase 1 of the proposed project would result in the construction of 232 multifamily housing units and 96 employee housing units, generating 990 persons. However, the population of the Martis Valley is primarily seasonal. At a 20 percent year-round occupancy rate for the multifamily housing units, 46 of the developed multifamily housing units would be occupied on a year-round basis, resulting in a permanent resident population of 502 persons in Phase 1, as shown in **Table 4.2-12.**

As discussed in Program Level impacts, the population growth generated by the proposed project, including Phase 1, would be consistent with the growth designated for the Plan area. Therefore, impacts relating to population growth are considered **less than significant.**

Mitigation Measures

None required.

TABLE 4.2-12
PHASE 1 POPULATION GENERATION (2010)

Year-round Residency Rate (percent)	Units	Resident Generation	Seasonal Residents	Permanent Residents
100	232	2.63 persons/multifamily du	0	610
20	232	2.63 persons/multifamily du	488	122
100	96	3.96 persons/employee housing du	0	380

du - dwelling unit

Creation of Short-Term Jobs/Housing Imbalance

Impact 4.2.6 While Phase 1 of the proposed project would result in the creation of 201 full-time employee equivalent jobs, Phase 1 would provide sufficient employee housing units to accommodate its demand for employee housing. This impact is considered **less than significant.**

Phase 1 developments are expected to generate as many as 201 full-time employee equivalent jobs. These full-time employee equivalent jobs take into account both full-time and part-time jobs. **Table 4.2-13** shows the number of jobs that would be directly generated by the Phase 1 development. As required by the Housing Element of the Placer County General Plan and the MVCP, the proposed Phase 1 development is required to provide housing for 50 percent of the employees it generates. **Table 4.2-11** shows the number of employee dwelling units required, based on 3.96 persons per employee housing unit.

Phase 1 of the proposed project would result in the development of 232 multifamily housing units and 96 employee-housing units. It is conservatively estimated that the proposed housing units in Phase 1 would not be affordable to most of the people who would be employed on the project site. However, it is not anticipated that every employee would live on the project site nor that all employees live where they work.

The indirect effects of employees traveling to their job site include traffic, and air quality and noise impacts related to traffic. Trips generated by employees of the project are included in the overall trip generation for the project and are discussed in Section 4.4, Transportation and Circulation. Noise and air quality impacts resulting from these trips are included in the discussions of air quality and noise impacts resulting from trips generated by the project and are discussed in the relevant sections of this EIR

Phase 1 of the Highlands would generate approximately 201 jobs. Additional development proposed for the Northstar resort community, such as the proposed Northstar Village expansion project, would generate as many as 388 additional jobs in Northstar, resulting in combined job growth of up 589 jobs. It is assumed that employee housing within Phase 1 of the proposed project would also accommodate employees generated by the proposed Northstar Village expansion project. Assuming a rate of 3.96 residents for each of the employee housing units, based on the average number of employees that would live in each unit at Sawmill Heights, the 388 jobs generated by the proposed Northstar Village expansion project would result in the need for an additional 98 employee housing units.

TABLE 4.2-13
PHASE 1 EMPLOYMENT GENERATION

Land Use Type	Units	Employment Generation	Jobs	Employee Dwelling Units Needed[1]
Condominium – transient rental	232 units	0.33 FTEE/du[2]	77	20
Hotel	255-rooms/12,000 sq.ft.	0.33 FTEE/room	84	22
Spa facility in Hotel	20,000 sq. ft	2.0 FTEE/1,000 sf	40	11
Highlands Phase 1			**201**	**51**
Village Project			388	98
Total			589	149

du = dwelling unit
FTEE = full-time employee equivalent
[1]Employee housing needs are based on 3.96 persons per employee housing unit (based on design of Sawmill Heights which would accommodate an average of 3.96 employees per housing unit; the number of employees that would live in each unit is based on the number of bedrooms of each unit)
[2]EDAW, 2003; Draft Employee Housing Ordinance, Placer County 2003
Sources: LSC Transportation Consultants 2001, Town of Mammoth Lakes 1999, Town of Vail 1991, Placer County 2002c, East West Partners 2002

Assuming 49 of the Sawmill Heights employee-housing units would be occupied by employees generated by the proposed Northstar Village expansion project, the 47 remaining Sawmill Heights units would accommodate 50 percent (26 units) of the demand for 51 units generated by Phase 1 of Northstar Highlands. The proposed Phase 1 development would be balanced in terms of jobs/housing ratio, resulting in a **less than significant** impact.

Mitigation Measures

None Required.

4.2.4 CUMULATIVE SETTING, IMPACTS AND MITIGATION MEASURES

CUMULATIVE SETTING

Regionally, Northstar Highlands is part of a larger resort area that is primarily the northwest quadrant of the Lake Tahoe area that includes the communities of Squaw Valley, Alpine Meadows, Town of Truckee, and the Tahoe Basin (e.g. Kings Beach). The cumulative setting for population, housing, and employment includes approved and proposed development within the region (see **Table 4.0-1** and **Figure 4.0-1**) as well as development anticipated under the Martis Valley Community Plan, Town of Truckee General Plan, and resort activities associated with Northstar-at-Tahoe, Lake Tahoe, Alpine Meadows, and Squaw Valley. Affordable housing efforts in the region, as well as regional population, housing, and employment demographics, are detailed under 4.2.1 Existing Setting.

IMPACTS AND MITIGATION MEASURES

Cumulative Population Growth and Housing Need

Impact 4.2.7 Development of the Northstar Highlands project would result in increased population in the Martis Valley region as well as additional need for employee housing inconsistent with Policy A.14 of the Placer County General Plan. This is considered a **cumulative significant** impact.

Cumulative development in the vicinity of the project would increase the population and number of housing units within Placer County. However, development of Northstar Highlands is consistent with the land use designations and growth assumed in the Placer County General Plan, the 1975 Martis Valley General Plan, and the Martis Valley Community Plan. The General Plan has placed the Community Plan designation in the Martis Valley area in order to accommodate anticipated growth. The project's contribution to population growth has been identified and considered within the General Plan EIR as well as the Martis Valley Community Plan EIR.

As described under Impacts 4.2.1 and 4.2.2, development of Northstar Highlands would result in increased population and employment and would contribute to the regional need for affordable housing. The Northstar-at-Tahoe resort provides employee housing at Hilltop Lodge and at homes in Truckee. The proposed project includes construction of 270 employee-housing units, which would accommodate more than 50 percent of the employees generated by the project, as required by Policy 2A.14 of the Placer County General Plan Housing Element. Thus, the proposed project would not contribute to the cumulative demand for affordable employee housing in the Martis Valley area. The environmental impact of creating more jobs than housing occurs primarily through the increase in trips that employees would make to travel to and from their home and place of employment. Employee trips are a component of the trip generation factors based on types of land use and thus are considered in the analysis of transportation/circulation, air quality, and noise impacts of the proposed project in this EIR.