

AP - 001

**STAGE 1 & 2
REPORTS**

DATE:

Nov. 14, 1995

SITE CHARACTERIZATION AND RISK ASSESSMENT FOR THE FORMER BRICKLAND REFINERY

Doc. No. REX114A.DOC

VOLUME 2

Prepared for:

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NOV 16 1995

Environmental Bureau
Oil Conservation Division

November 14, 1995

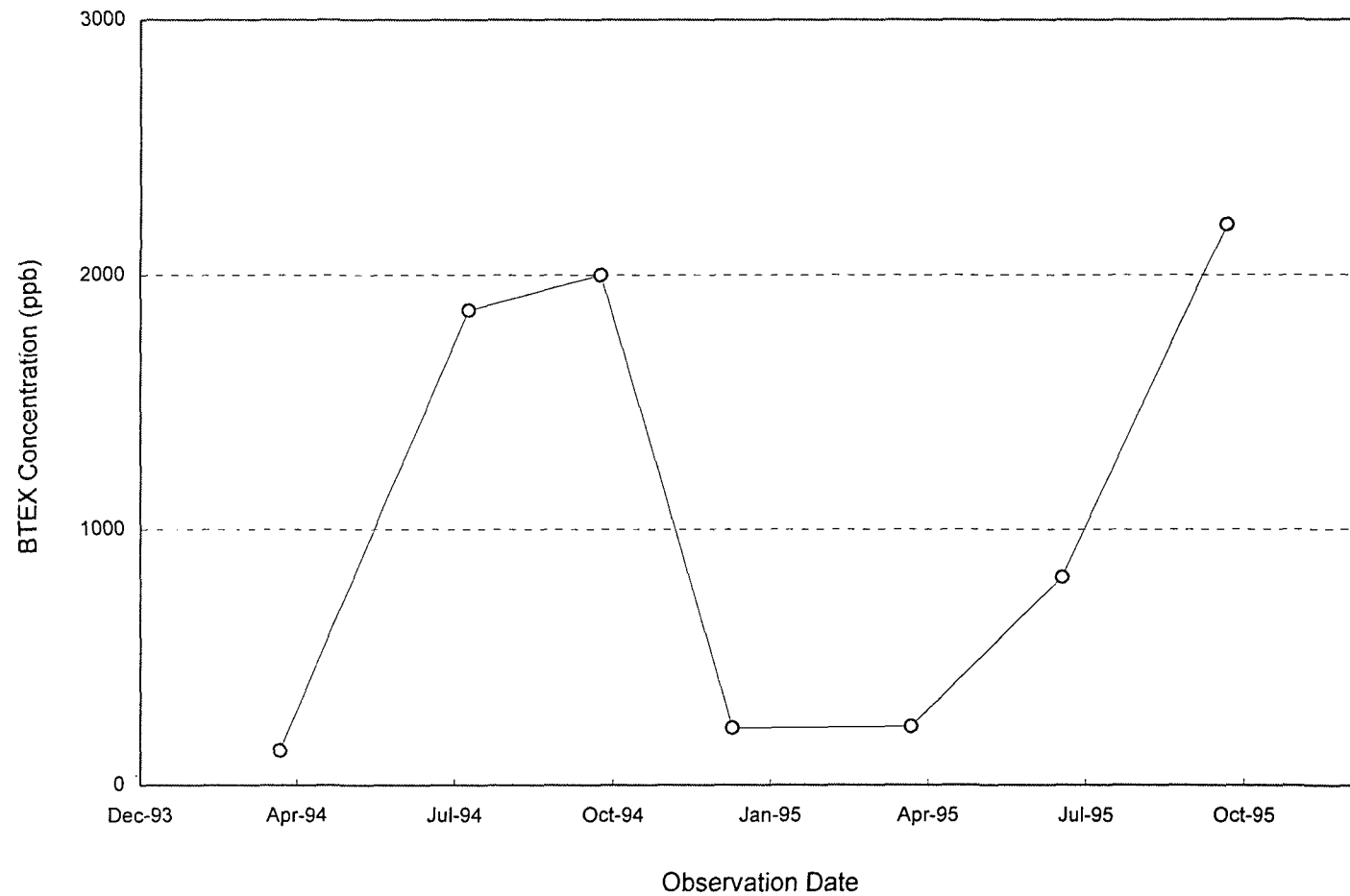


Geoscience Consultants, Ltd.
505 Marquette Ave., NW
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Albuquerque, New Mexico 87102

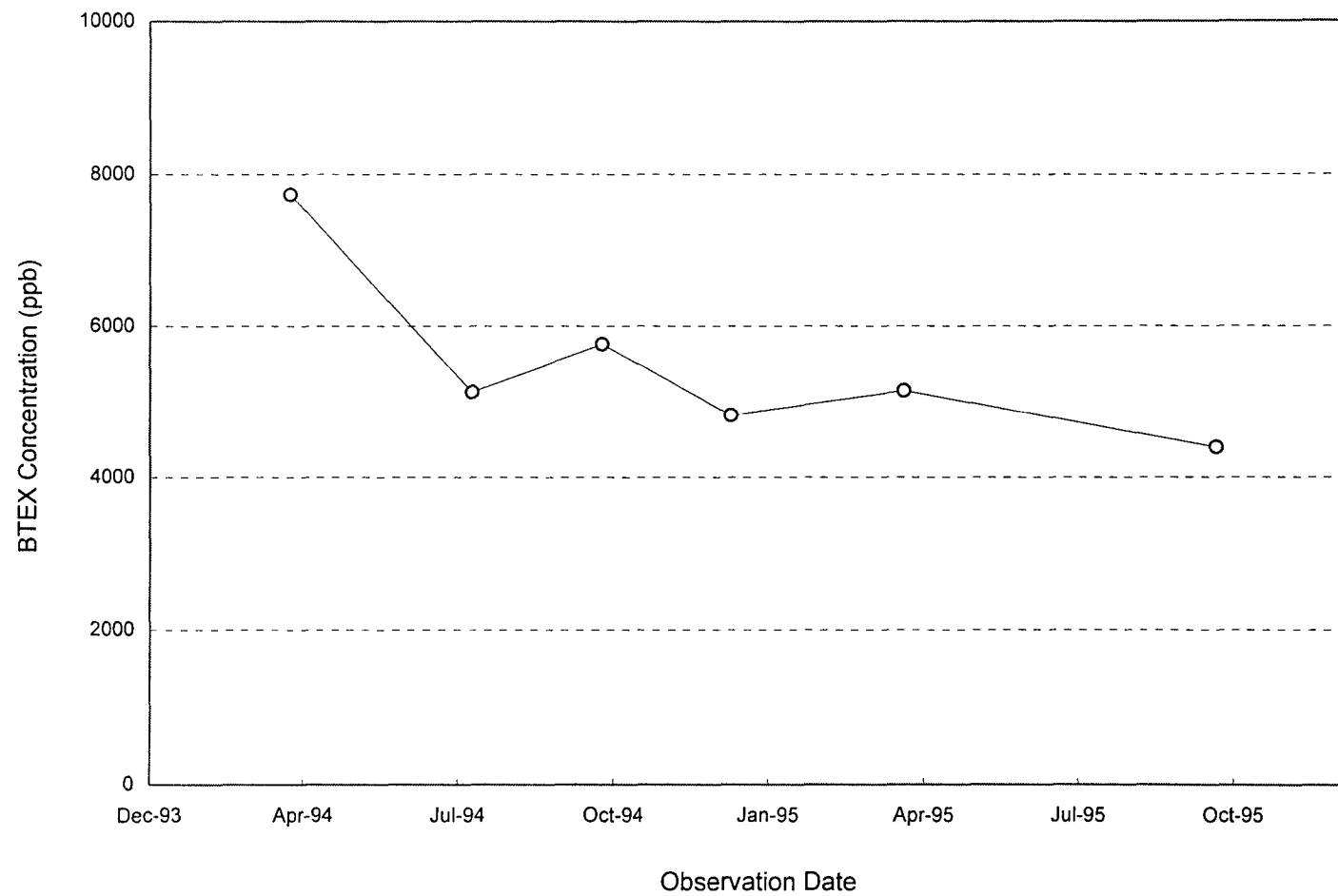
Appendix G

Total BTEX Concentration vs. Time for Selected Groundwater Monitoring Wells

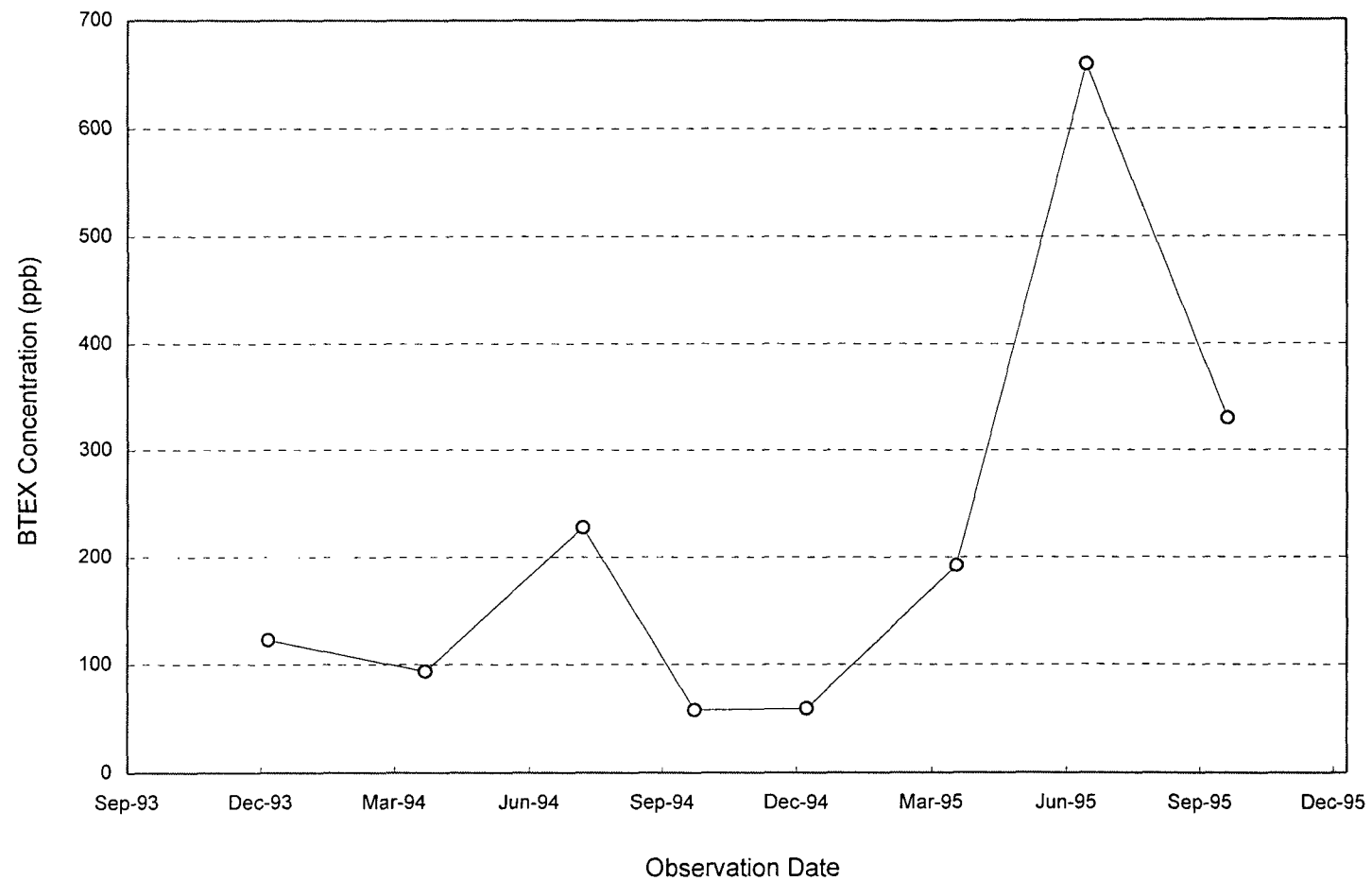
Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-4)



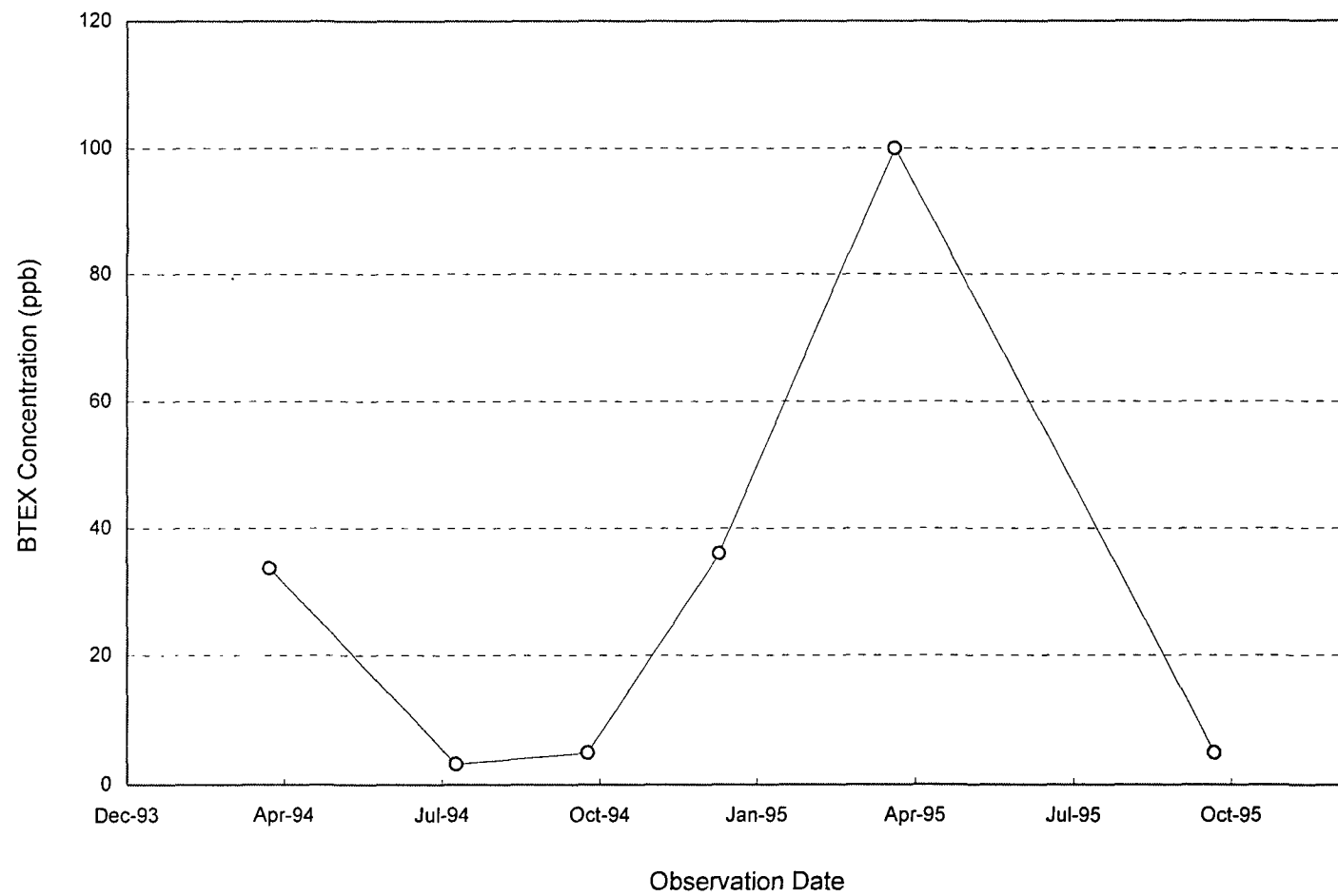
Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-5)



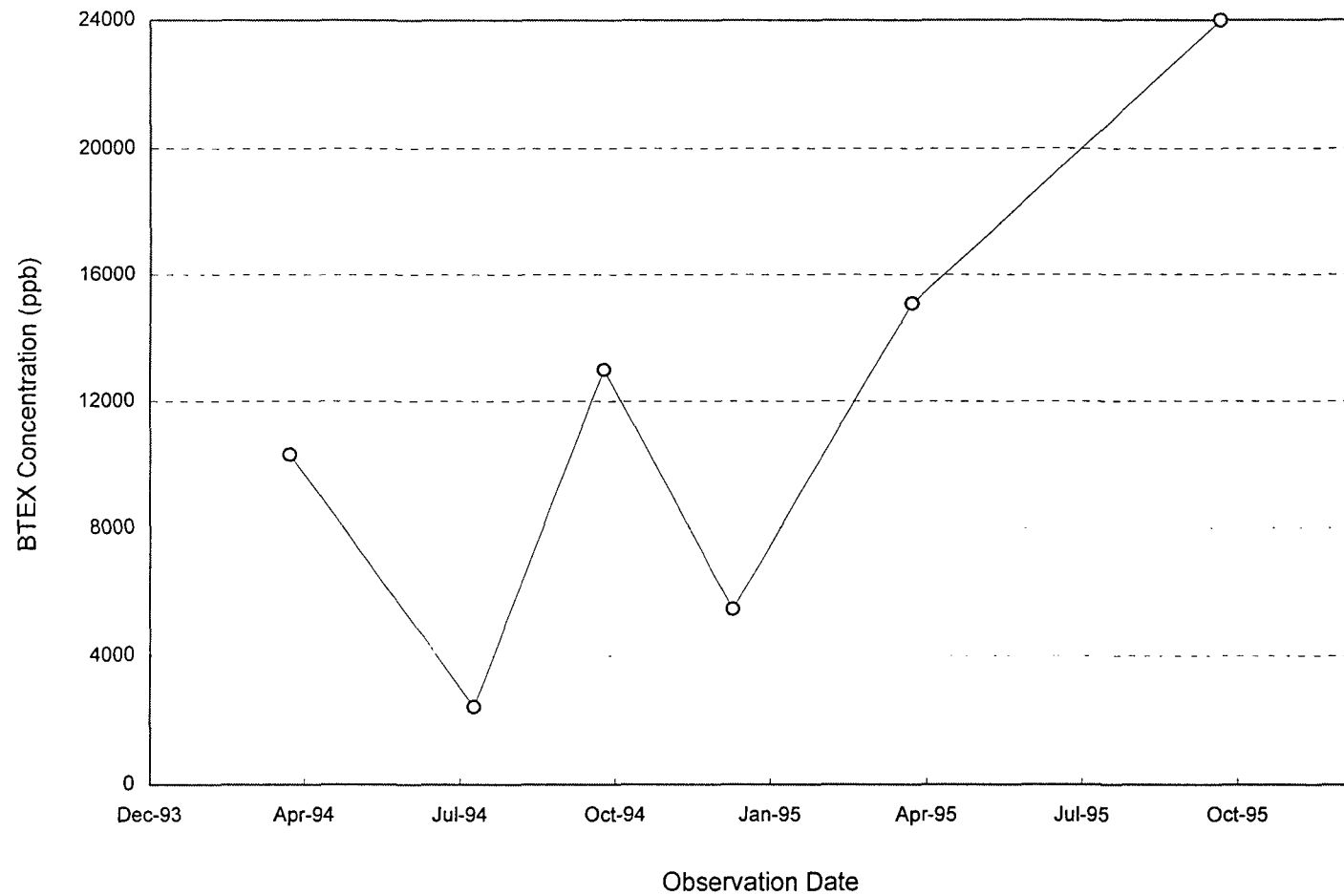
Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-6S)



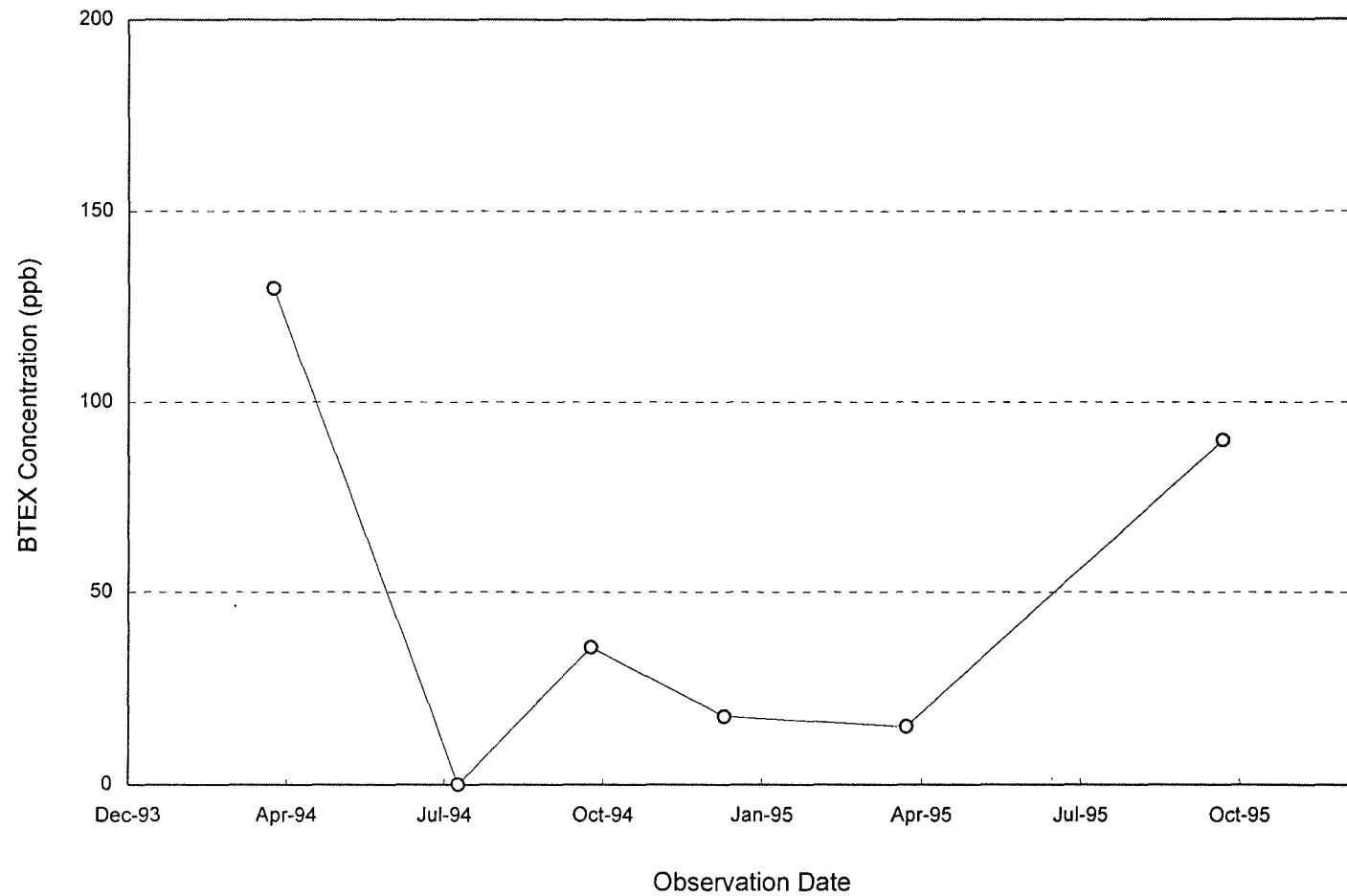
Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-7)



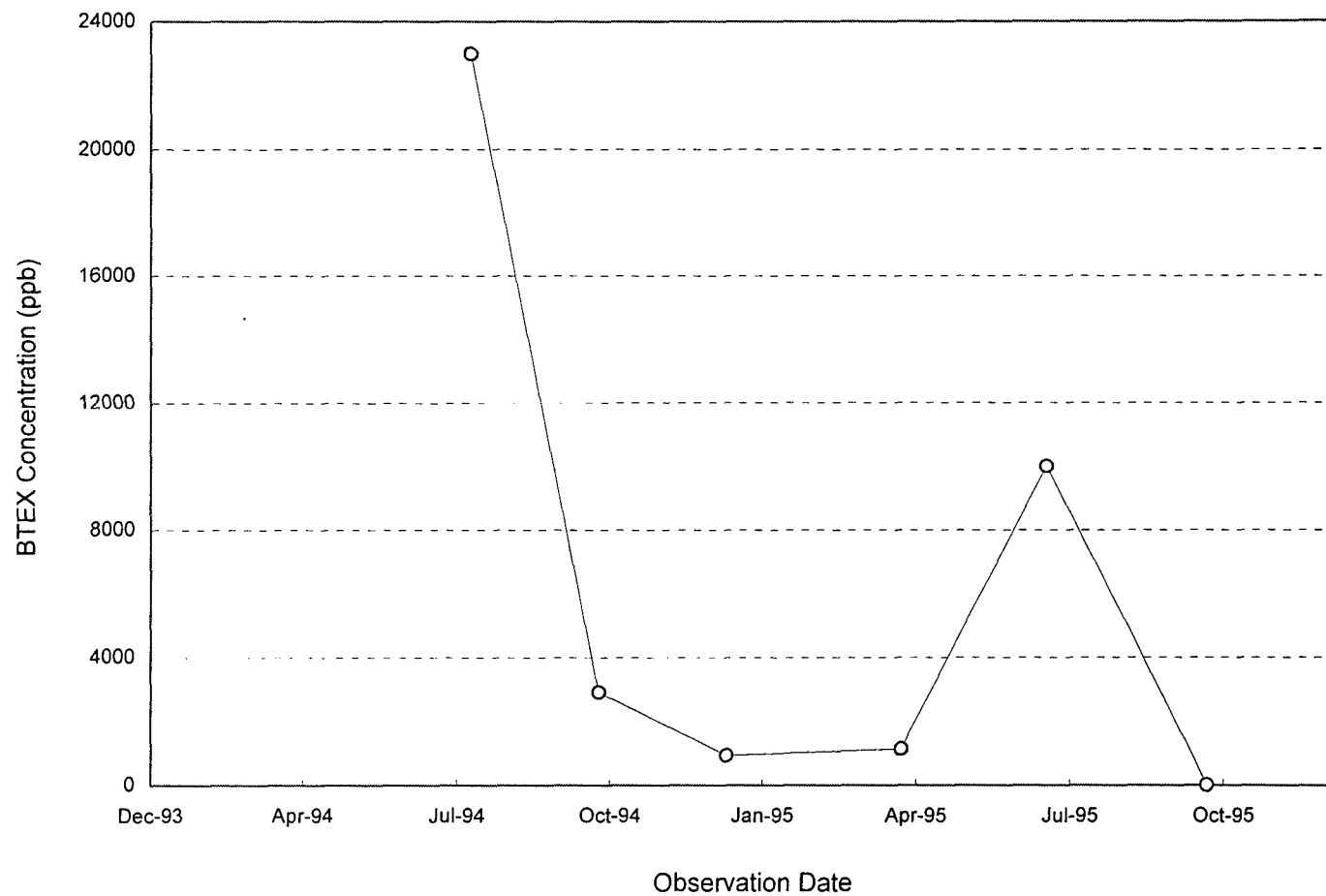
**Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-8)**



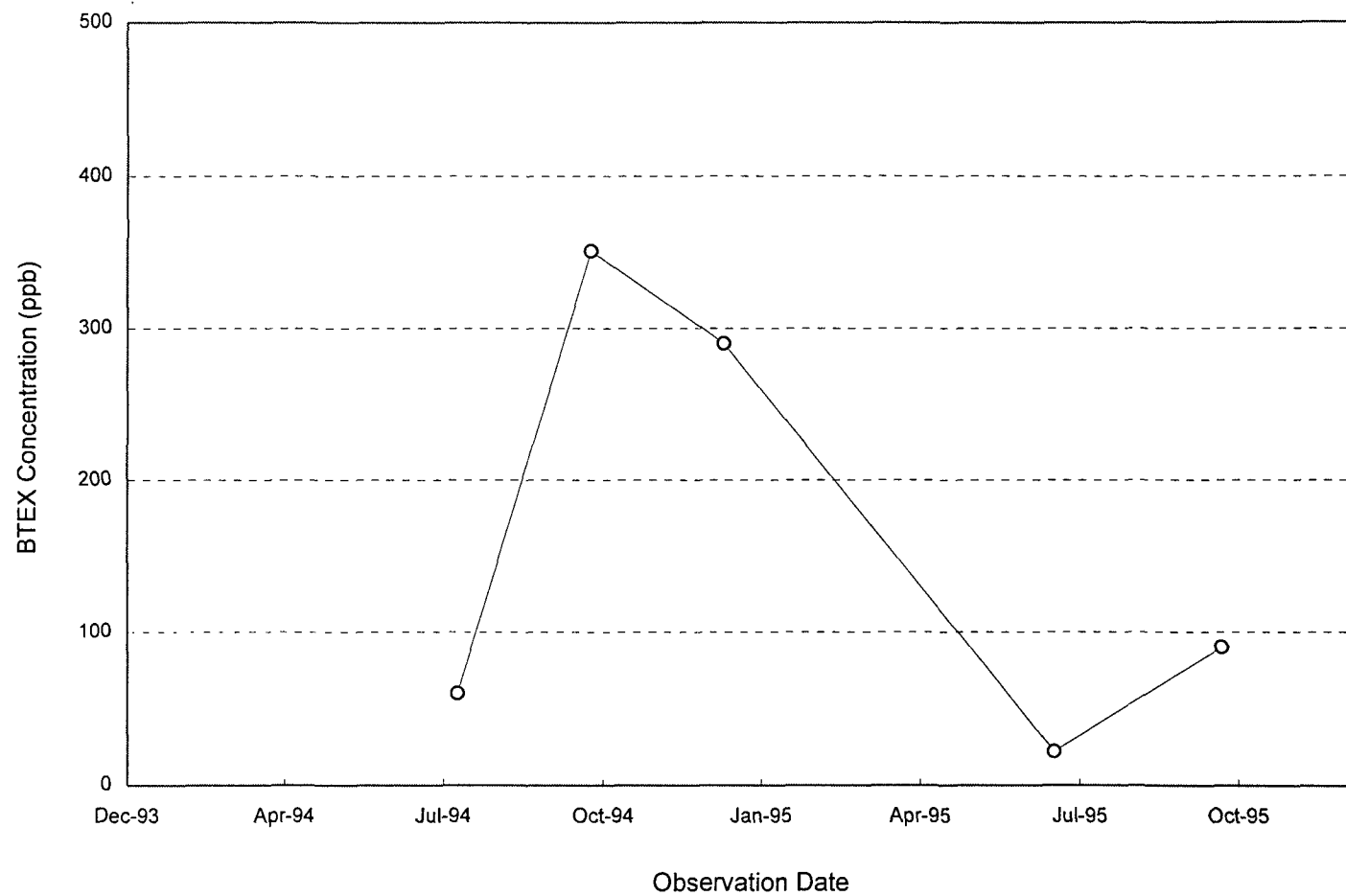
Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-11)



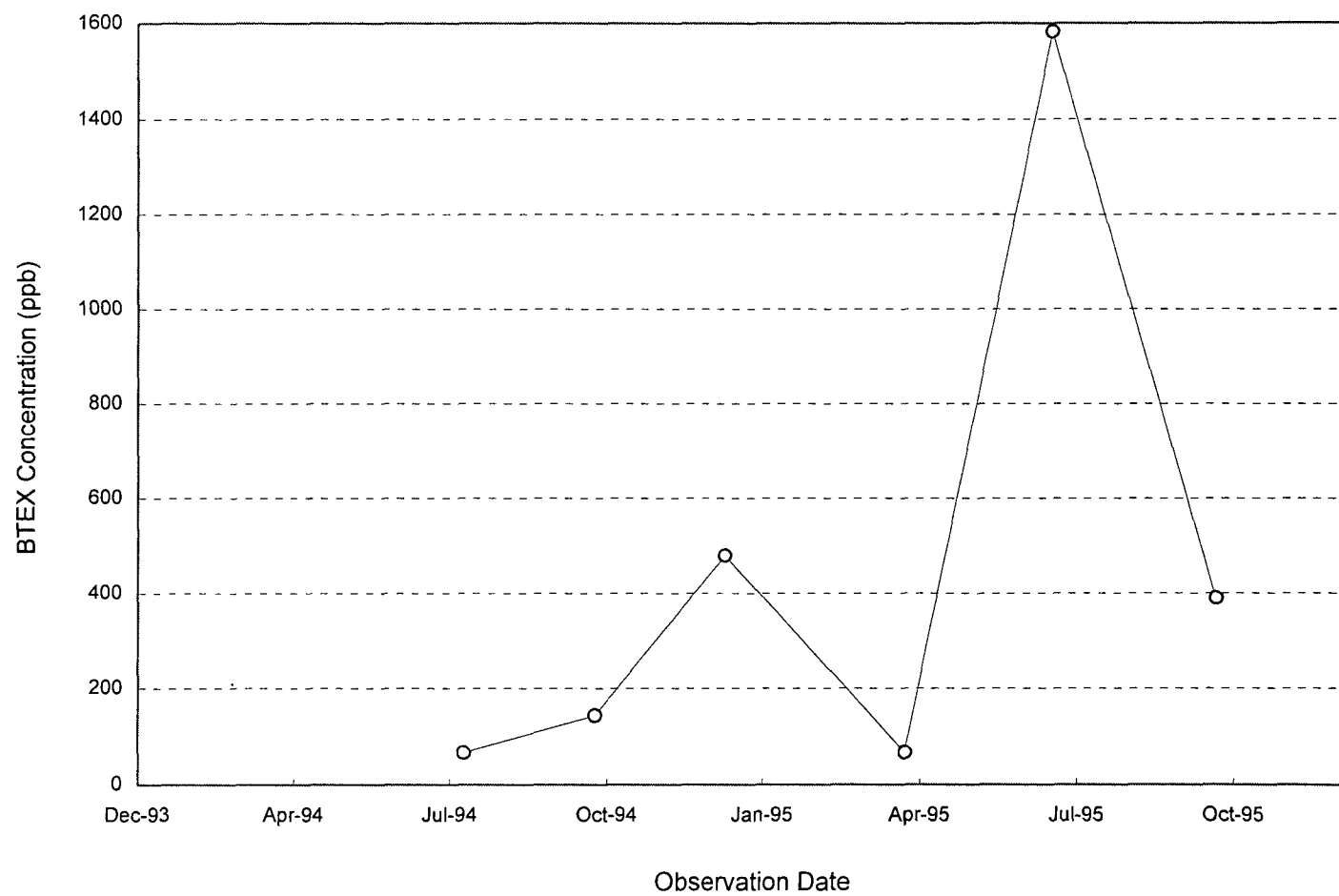
Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-14)



Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-15)



Groundwater Monitoring Wells
Total BTEX Concentration vs Time (MW-17)



Appendix H

PAH Analytical Results for Groundwater Monitoring Wells

Groundwater Monitoring Wells
PAH Analytical Results ($\mu\text{g/L}$) from December 1993 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total PAH
MW-1	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-9S	ND	-	ND
MW-12	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter

ND = Not Detected

MW-2, MW-4, MW-5, MW-6, MW-7, MW-8 and MW-11 were not sampled.

Groundwater Monitoring Wells
PAH Analytical Results ($\mu\text{g/L}$) from March 1994 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/L}$)	Total PAH
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	ND,ND	-	ND,ND
MW-5	1-Methylnaphthalene	79	107
	Naphthalene	28	
MW-6S	ND	-	ND
MW-7	ND	-	ND
MW-8	1-Methylnaphthalene	46	250
	2-Methylnaphthalene	64	
	Naphthalene	140	
MW-9S	ND	-	ND
MW-11	1-Methylnaphthalene	29	29
MW-12	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter
 ND = Not Detected
 MW-6D was not sampled for PAH.

Groundwater Monitoring Wells
PAH Analytical Results (µg/L) from June 1994 Sampling Event

Well ID	Analytes Detected	Results (µg/l)	Total PAH
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	ND	-	ND
MW-5	1-Methylnaphthalene	78	117
	2-Methylnaphthalene	12	
	Naphthalene	27	
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-7	ND	-	ND
MW-8	Naphthalene	93	93
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-12	ND	-	ND
MW-14	1-Methylnaphthalene	160	570
	2-Methylnaphthalene	180	
	Naphthalene	230	
MW-15	1-Methylnaphthalene	61	117
	2-Methylnaphthalene	41	
	Naphthalene	15	
MW-16	ND	-	ND
MW-17	ND	-	ND

Note: µg/L = Micrograms per liter
 ND = Not Detected

Groundwater Monitoring Wells
PAH Analytical Results ($\mu\text{g/L}$) from September 1994 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total PAH
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	ND	-	ND
MW-5	1-Methylnaphthalene	110	191
	2-Methylnaphthalene	32	
	Naphthalene	49	
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-7	ND	-	ND
MW-8	1-Methylnaphthalene	61	366
	2-Methylnaphthalene	75	
	Naphthalene	230	
MW-9S	ND	-	ND
MW-11	Fluorene	12	233
	1-Methylnaphthalene	120	
	2-Methylnaphthalene	18	
	Naphthalene	35	
	Phenanthrene	32	
	Pyrene	16	
MW-12	ND	-	ND
MW-14	1-Methylnaphthalene	26	40
	2-Methylnaphthalene	14	
MW-15	1-Methylnaphthalene	62	126
	2-Methylnaphthalene	11	
	Naphthalene	53	
MW-16	ND	-	ND
MW-17	1-Methylnaphthalene	20,14	58,37
	2-Methylnaphthalene	14,10	
	Naphthalene	24,13	

Note: $\mu\text{g/L}$ = Micrograms per liter
 ND = Not Detected
 20,14 = Duplicate samples

Groundwater Monitoring Wells
PAH Analytical Results ($\mu\text{g/L}$) from December 1994 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total PAH
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	ND	-	ND
MW-5	1-Methylnaphthalene	71	139
	2-Methylnaphthalene	22	
	Naphthalene	46	
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-7	ND	-	ND
MW-8	1-Methylnaphthalene	42	236
	2-Methylnaphthalene	54	
	Naphthalene	140	
MW-9S	ND	-	ND
MW-11	1-Methylnaphthalene	69	148
	Phenanthrene	21	
	Pyrene	58	
MW-12	ND	-	ND
MW-14	ND	-	ND
MW-15	1-Methylnaphthalene	47	84
	Naphthalene	37	
MW-16	ND	-	ND
MW-17	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter
 ND = Not Detected

Groundwater Monitoring Wells
PAH Analytical Results ($\mu\text{g/L}$) from March 1995 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total PAH
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-5	1-Methylnaphthalene	65	117
	2-Methylnaphthalene	15	
	Naphthalene	37	
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-8	1-Methylnaphthalene	50	180
	2-Methylnaphthalene	42	
	Naphthalene	88	
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-14	ND	-	ND
MW-15	ND	-	ND
MW-17	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter

ND = Not Detected

MW-1, MW-2, MW-4, MW-7, MW-12 and MW-16 were not sampled for PAH.

Groundwater Monitoring Wells
PAH Analytical Results ($\mu\text{g/L}$) from June 1995 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total PAH
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-6S	Naphthalene	15	15
	Naphthalene	10	10
MW-6D	ND	-	ND
MW-9S	ND	-	ND
MW-14	1-Methylnaphthalene	12	12
MW-15	ND	-	ND
MW-17	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter

ND = Not Detected

MW-1, MW-2, MW-4, MW-5, MW-7, MW-8, MW-11, MW-12 and MW-16 were not sampled for PAH.

Groundwater Monitoring Wells
PAH Analytical Results ($\mu\text{g/L}$) from September 1995 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total PAH
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-5	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-8	Naphthalene	140	140
MW-9S	ND	-	ND
MW-11	1-Methylnaphthalene	140	140
MW-14	ND	-	ND
MW-15	ND	-	ND
MW-17	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter

ND = Not Detected

MW-1, MW-2, MW-4, MW-7, MW-12 and MW-16 were not sampled for PAH.

Brickland Refinery Site PAH Sample Analytes and Detection Limits for EPA Method 8270

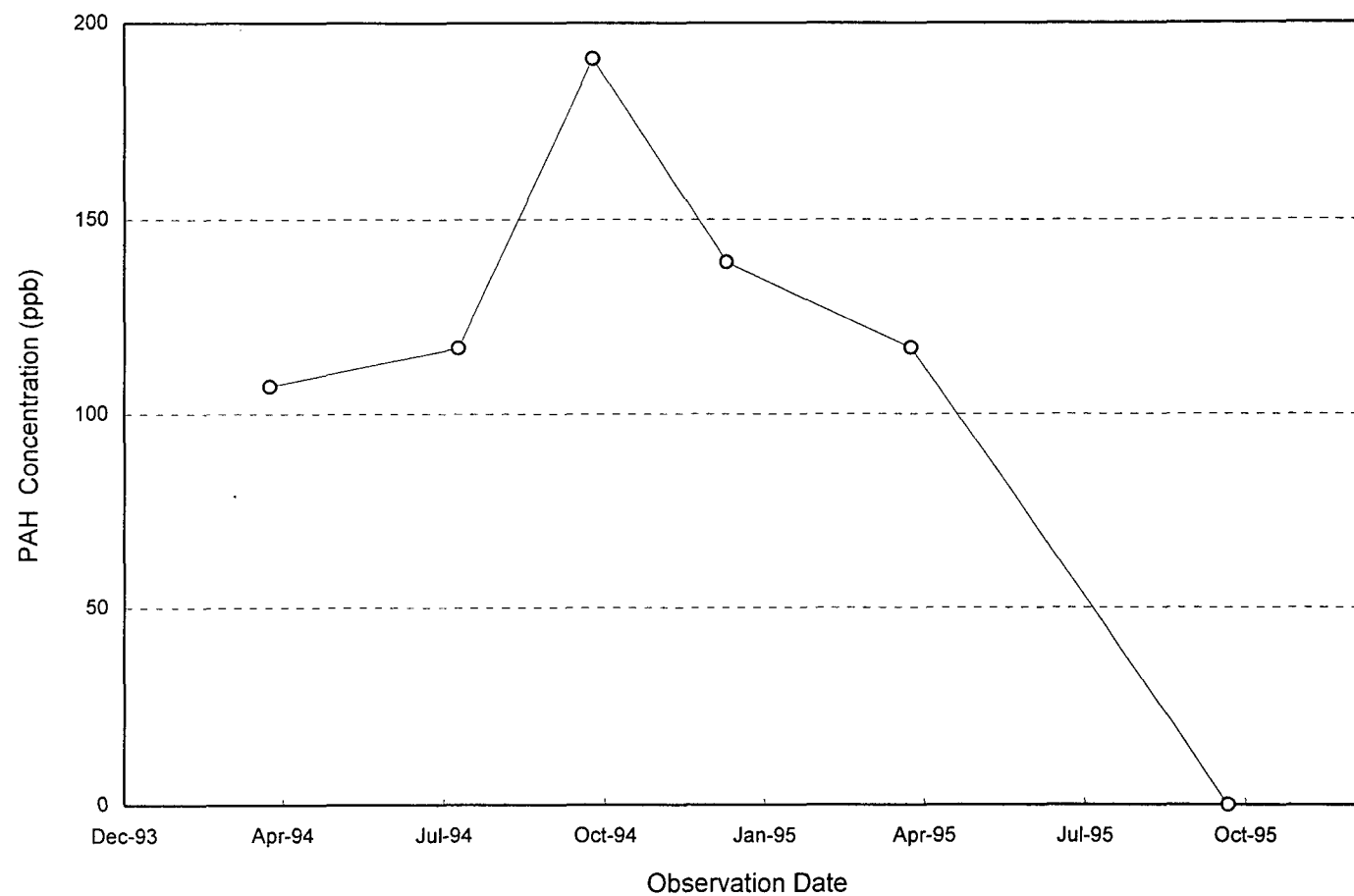
Analyte	Detection Limits($\mu\text{g/L}$)
Acenaphthene	10
Acenaphthylene	10
Anthracene	10
Benzo(a)anthracene	10
Benzo(b)fluoranthene	10
Benzo(k)fluoranthene	10
Benzo(g,h,i)perylene	10
Benzo(a)pyrene	10
Chrysene	10
Dibenzo(a,h)anthracene	10
Fluoranthene	10
Fluorene	10
Indeno(1,2,3-cd)pyrene	10
1-Methylnaphthalene	10
2-Methylnaphthalene	10
Naphthalene	10
Phenanthrene	10
Pyrene	10

Note: $\mu\text{g/L}$ = Micrograms per liter

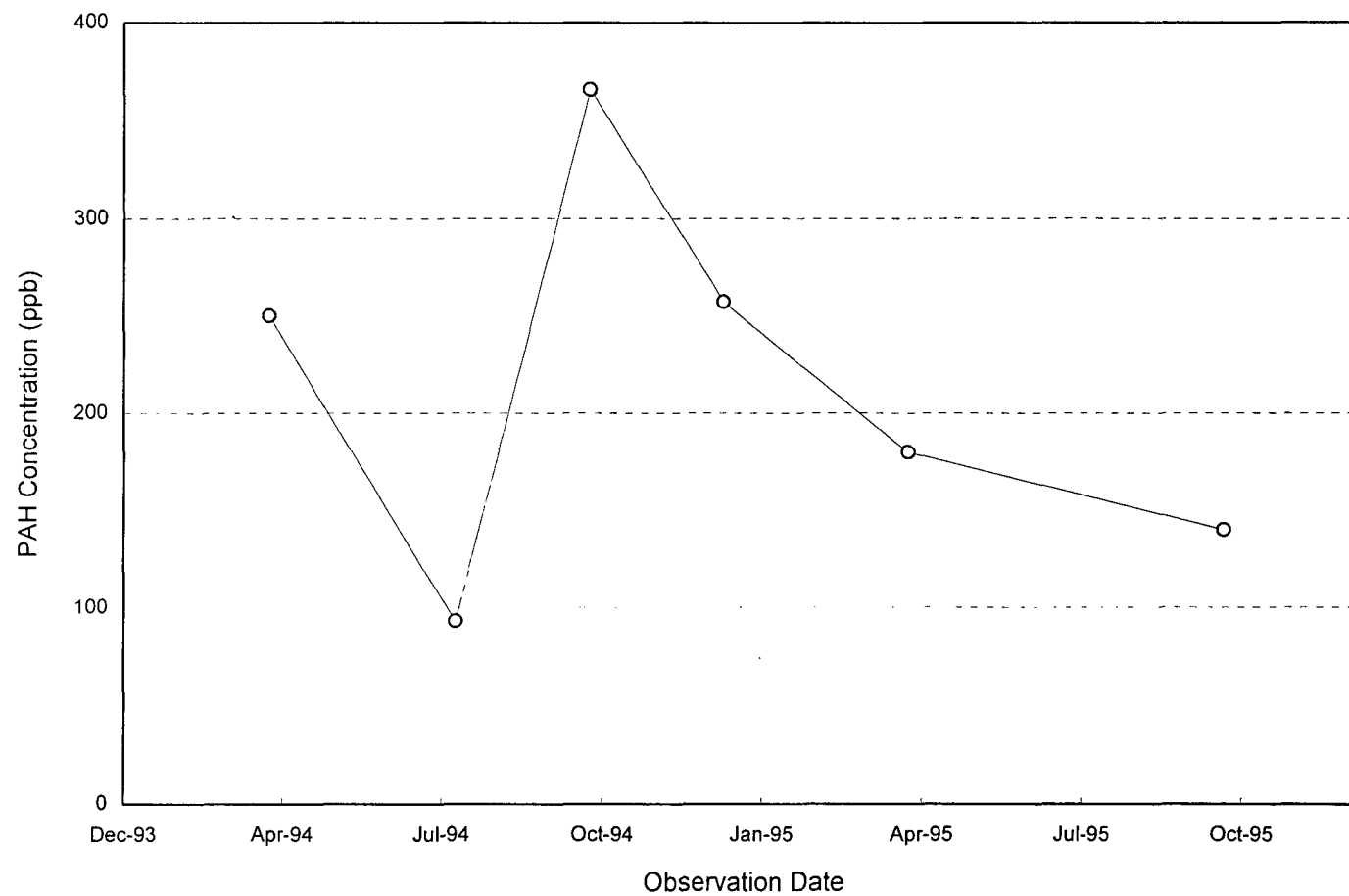
Appendix I

Total PAH Concentration vs. Time for Selected Groundwater Monitoring Wells

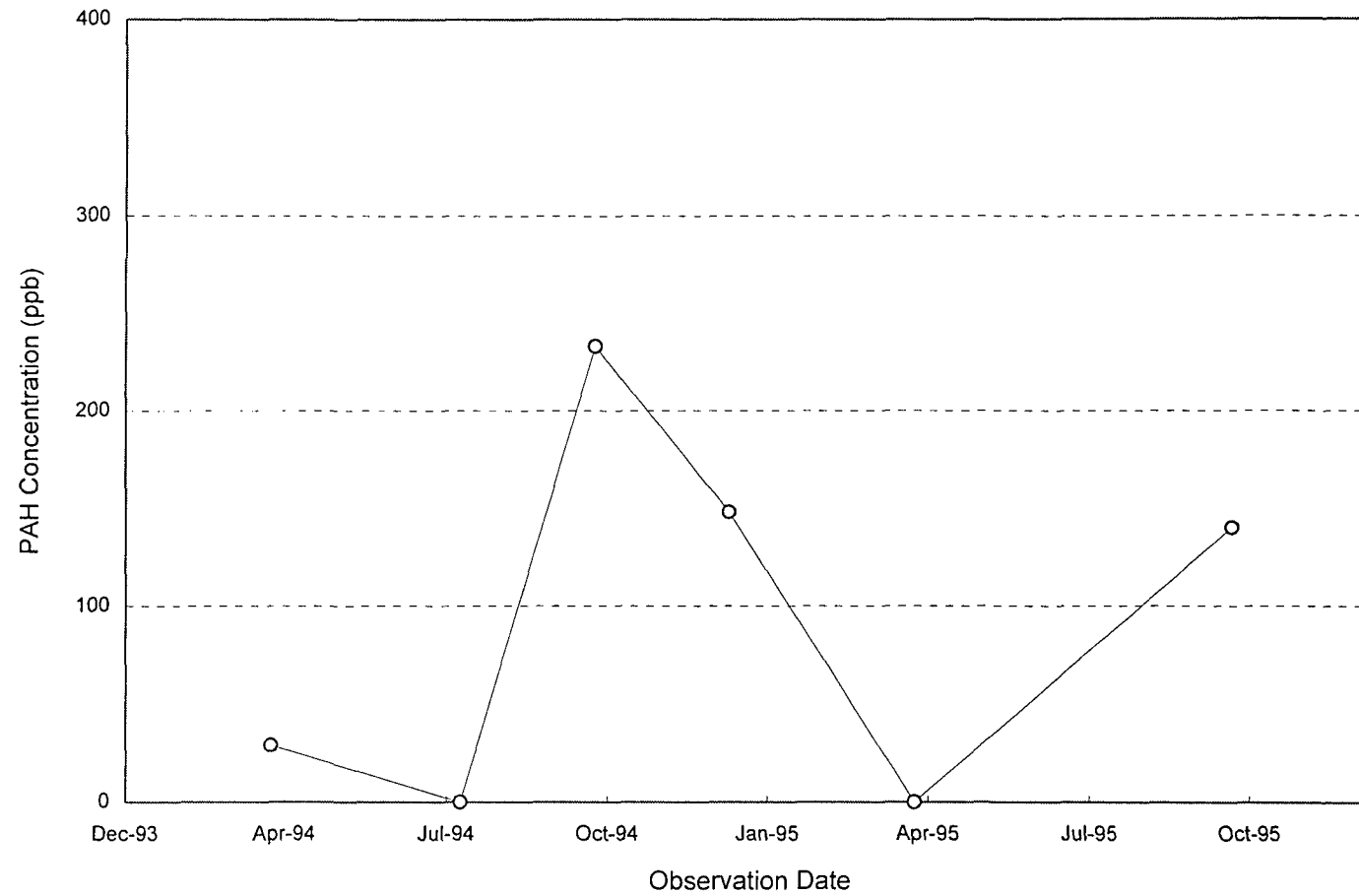
Groundwater Monitoring Wells
Total PAH Concentration vs. Time (MW-5)



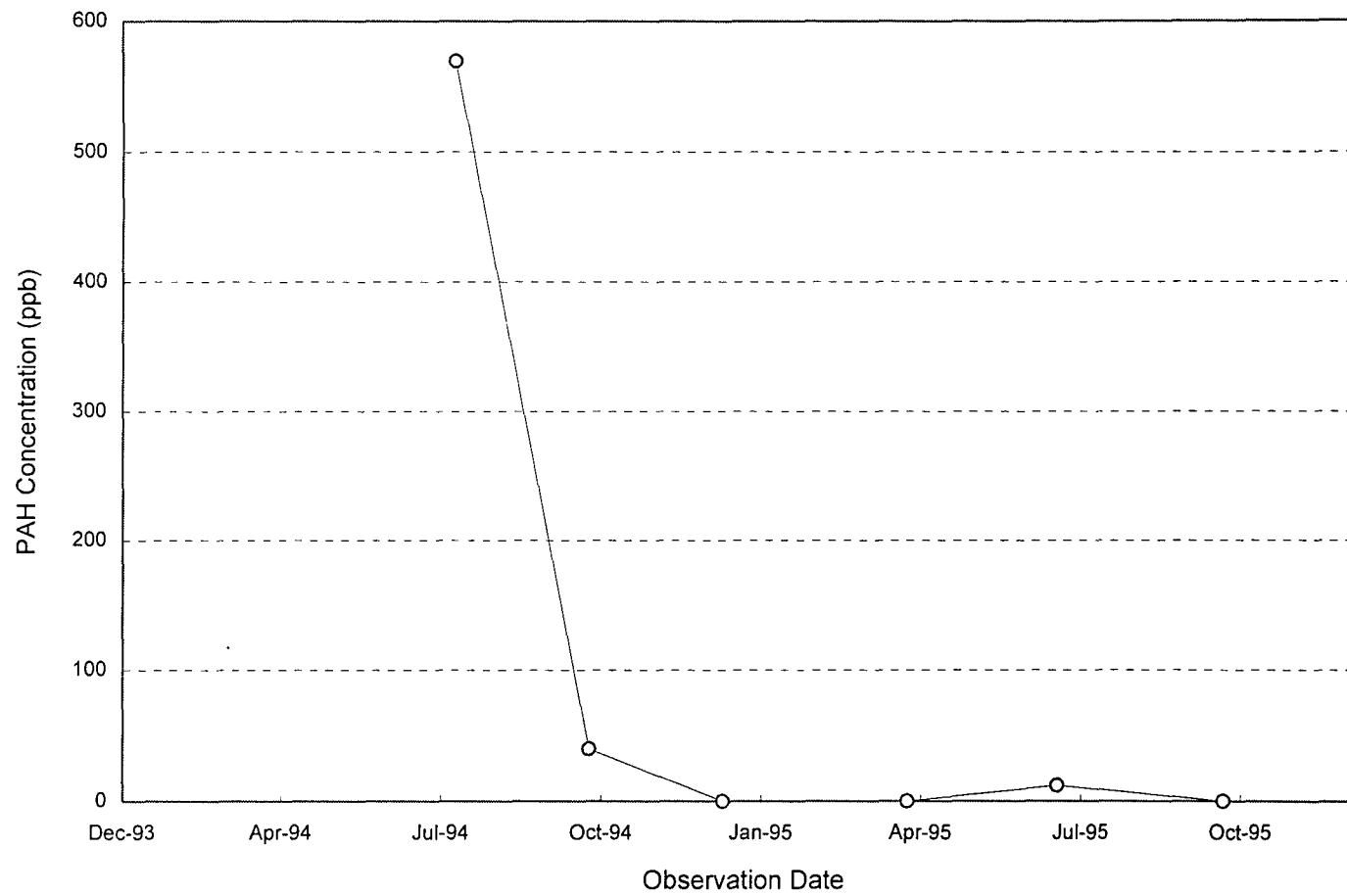
Groundwater Monitoring Wells
Total PAH Concentration vs. Time (MW-8)



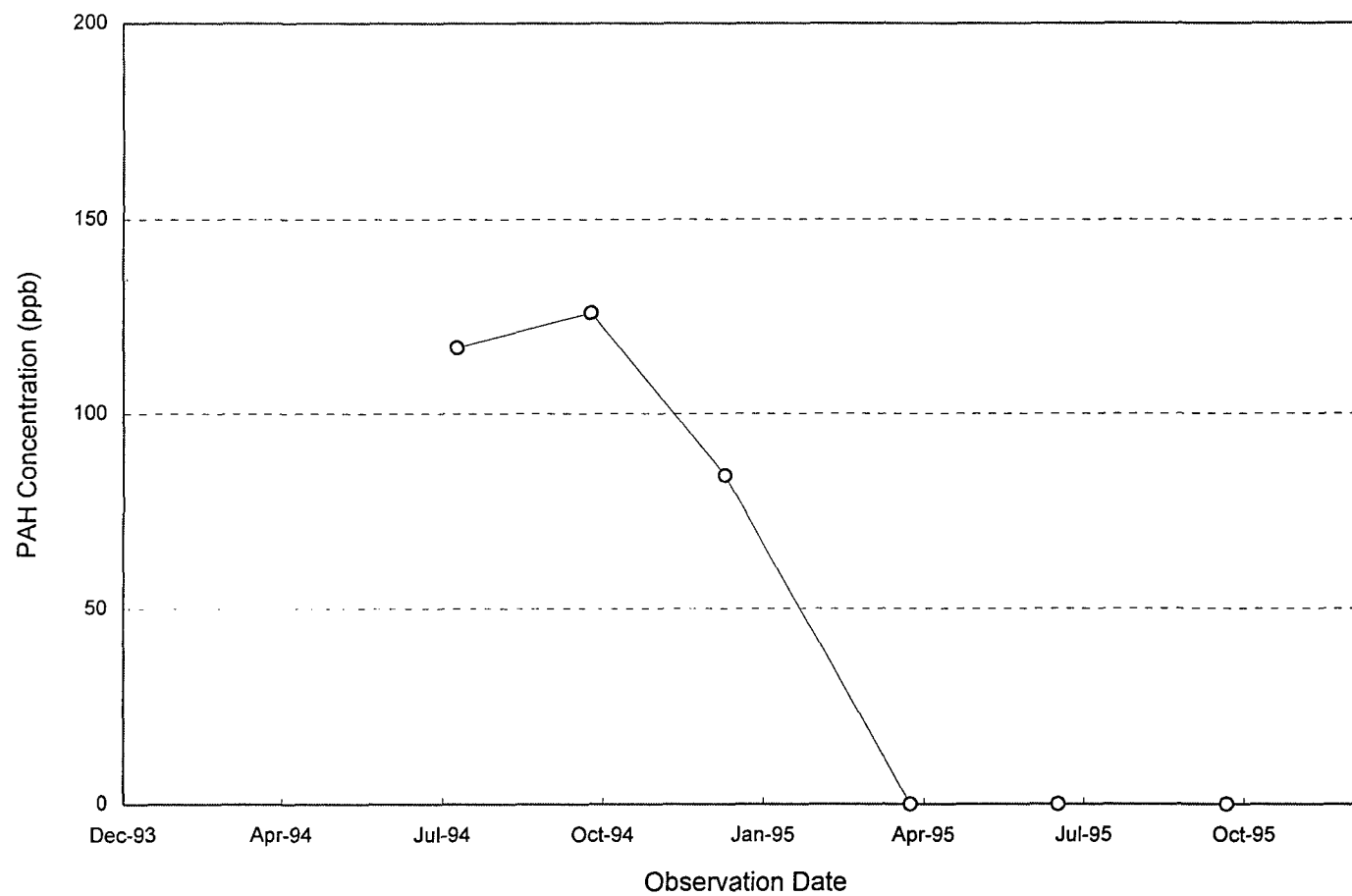
Groundwater Monitoring Wells
Total PAH Concentration vs. Time (MW-11)



**Groundwater Monitoring Wells
Total PAH Concentration vs. Time (MW-14)**



Groundwater Monitoring Wells
Total PAH Concentration vs. Time (MW-15)



Appendix J

Phenols Analytical Results for Groundwater Monitoring Wells

Groundwater Monitoring Wells
Phenols Analytical Results ($\mu\text{g/L}$) from March 1994 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/L}$)	Total Phenols
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	ND,ND	-	ND,ND
MW-5	2,4-Dimethylphenol	16	16
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-7	ND	-	ND
MW-8	2,4-Dimethylphenol	96	96
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-12	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter
 - ND = Not Detected

Groundwater Monitoring Wells
Phenols Analytical Results (µg/L) from June 1994 Sampling Event

Well ID	Analytes Detected	Results (µg/l)	Total Phenols
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	ND	-	ND
MW-5	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-7	ND	-	ND
MW-8	2,4-Dimethylphenol	56	166
	Phenol	110	
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-12	ND	-	ND
MW-14	Phenol	300	300
MW-15	ND	-	ND
MW-16	ND,ND	-	ND,ND
MW-17	ND	-	ND

Note: µg/L = Micrograms per liter
ND = Not Detected

Groundwater Monitoring Wells
Phenols Analytical Results ($\mu\text{g/L}$) from September 1994 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/L}$)	Total Phenols
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	ND	-	ND
MW-5	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-7	ND	-	ND
MW-8	2,4-Dimethylphenol	110	110
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-12	ND	-	ND
MW-14	Phenol	20	20
MW-15	ND	-	ND
MW-16	ND	-	ND
MW-17	ND,ND	-	ND,ND

Note: $\mu\text{g/L}$ = Micrograms per liter
 ND = Not Detected

Groundwater Monitoring Wells
Phenols Analytical Results (µg/L) from December 1994 Sampling Event

Well ID	Analytes Detected	Results (µg/l)	Total Phenols
MW-1	ND	-	ND
MW-2	ND	-	ND
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-4	Phenol	18	18
MW-5	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-7	ND	-	ND
MW-8	ND	-	ND
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-12	ND	-	ND
MW-14	Phenol	54	54
MW-15	ND	-	ND
MW-16	ND	-	ND
MW-17	ND	-	ND

Note: µg/L = Micrograms per liter
 ND = Not Detected

Groundwater Monitoring Wells
Phenols Analytical Results ($\mu\text{g/L}$) from March 1995 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/L}$)	Total Phenols
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-5	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-8	2,4-Dimethylphenol	87	87
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-14	Phenol	28	28
MW-15	ND	-	ND
MW-17	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter

ND = Not Detected

MW-1, MW-2, MW-4, MW-7, MW-12 and MW-16 were not sampled for Phenols.

Groundwater Monitoring Wells
Phenols Analytical Results ($\mu\text{g/L}$) from June 1995 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total Phenols
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-9S	ND	-	ND
MW-14	Phenol	19	19
MW-15	ND	-	ND
MW-17	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter

ND = Not Detected

MW-1, MW-2, MW-4, MW-5, MW-7, MW-8, MW-11, MW-12 and MW-16 were not sampled for Phenols.

Groundwater Monitoring Wells
Phenols Analytical Results ($\mu\text{g/L}$) from September 1995 Sampling Event

Well ID	Analytes Detected	Results ($\mu\text{g/l}$)	Total Phenols
MW-3S	ND	-	ND
MW-3D	ND	-	ND
MW-5	ND	-	ND
MW-6S	ND	-	ND
MW-6D	ND	-	ND
MW-8	ND	-	ND
MW-9S	ND	-	ND
MW-11	ND	-	ND
MW-14	ND	-	ND
MW-15	ND	-	ND
MW-17	ND	-	ND

Note: $\mu\text{g/L}$ = Micrograms per liter

ND = Not Detected

MW-1, MW-2, MW-4, MW-7, MW-12 and MW-16 were not sampled for Phenols.

Brickland Refinery Site Phenols Sample Analytes and Detection Limits for EPA Method 8270

Analyte	Detection Limits ($\mu\text{g/L}$)
2,4,6-Trichlorophenol	10
2,4-Dichlorophenol	10
2,4-Dimethylphenol	10
2,4-Dinitrophenol	50
2-Chlorophenol	10
2-Nitrophenol	10
4,6-Dinitro-2-methylphenol	50
4-Chloro-3-methylphenol	10
4-Nitrophenol	50
Pentachlorophenol	50
Phenol	10

Note: $\mu\text{g/L}$ = Micrograms per liter

Appendix K

**WQCC Metals and Inorganics Analytical Results for
Groundwater Monitoring Wells**

Groundwater Monitoring Wells
WQCC Metals Analytical Results (mg/L) from December 1993 Sampling Event

Well ID	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Zinc
NM WQCC Std.	5.0	0.1	1.0	0.01	ND 0.05	ND	1.0	1.0	ND	0.2	0.002	ND	0.2	ND 0.2	0.1	10.0
Detection Limit	0.05	0.05	0.01	0.005	0.01	0.03	0.01	0.03	0.05	0.01	0.0002	0.05	0.04	0.1	0.01	0.01
MW-1	NA	0.07	0.14	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-3S	NA	ND	0.08	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	0.1	ND	NA
MW-3D	NA	ND	0.04	ND	ND	ND	0.02	NA	ND	NA	ND	ND	0.04	0.1	ND	0.01
MW-6S	NA	ND	0.04	ND	ND	ND	0.02	NA	ND	NA	ND	ND	0.04	0.1	ND	0.01
MW-6D	NA	ND	0.05	0.029	ND	ND	0.02	NA	ND	NA	ND	ND	0.04	ND	ND	0.02
MW-9S	NA	ND	0.07	0.014	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	0.01
MW-12	NA	ND	0.04	0.005	ND	ND	ND	NA	ND	NA	ND	ND	0.05	ND	0.03	ND

Note: ND = Not Detected

NA = Not Analyzed

mg/L = Milligrams per liter

MW-2, MW-4, MW-5, MW-7, MW-8 and MW-11 were not sampled.

Groundwater Monitoring Wells
WQCC Metals Analytical Results (mg/L) from March 1994 Sampling Event

Well ID	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Zinc
NM WQCC Std.	5.0	0.1	1.0	0.01	0.05	0.05	1.0	1.0	0.05	0.2	0.002	1.0	0.2	0.05	0.05	10.0
Detection Limit	0.05	0.05	0.01	0.005	0.01	0.03	0.01	0.03	0.05	0.01	0.0002	0.05	0.04	0.1	0.01	0.01
MW-1	NA	0.07	0.11	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-2	NA	ND	0.01	ND	0.01	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-3S	NA	ND	0.08	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-3D	NA	ND	0.04	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-4	NA	0.07	0.05	ND	0.01	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
	NA	ND	0.05	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-5	NA	ND	0.31	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	0.1	ND	ND
MW-6S	NA	0.27	1.07	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-6D	NA	ND	0.02	ND	ND	ND	ND	NA	ND	NA	ND	ND	0.04	ND	ND	ND
MW-7	NA	0.08	0.22	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	0.01
MW-8	NA	0.22	0.52	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	0.2	ND	0.01
MW-9S	NA	ND	0.04	ND	ND	ND	ND	NA	ND	NA	0.0002	ND	ND	ND	ND	ND
MW-11	NA	0.1	1.0	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	ND	ND	ND
MW-12	NA	0.08	0.03	ND	ND	ND	ND	NA	ND	NA	ND	ND	ND	0.2	ND	0.02

Note: ND = Not Detected
 NA = Not Analyzed
 mg/L = Milligrams per liter

Groundwater Monitoring Wells
WQCC Metals Analytical Results (mg/L) from June 1994 Sampling Event

Well ID	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Zinc
NM WQCC Std.	5.0	0.1	1.0	0.01	0.05	0.05	1.0	1.0	0.05	0.2	0.002	1.0	0.2	0.05	0.05	10.0
Detection Limit	0.05	0.05	0.01	0.005	0.01	0.03	0.01	0.03	0.05	0.01	0.0002	0.05	0.04	0.1	0.01	0.01
MW-1	1.2	ND	0.18	ND	ND	ND	0.01	1.96	ND	1.42	ND	ND	ND	ND	ND	0.01
MW-2	ND	ND	ND	ND	ND	ND	ND	1.83	ND	7.47	ND	ND	ND	ND	ND	ND
MW-3S	2.32	ND	0.13	ND	ND	ND	0.01	3.91	ND	1.12	ND	ND	ND	ND	ND	0.09
MW-3D	0.23	ND	0.04	ND	ND	ND	ND	2.41	ND	3.25	ND	ND	ND	ND	ND	ND
MW-4	ND	ND	0.2	ND	ND	ND	ND	1.78	ND	3.21	ND	ND	ND	ND	ND	ND
MW-5	ND	ND	0.25	ND	ND	ND	ND	0.06	ND	0.01	ND	ND	ND	ND	ND	ND
MW-6S	0.08	0.08	1.16	ND	ND	ND	ND	4.78	ND	1.08	ND	ND	ND	ND	ND	ND
MW-6D	0.06	ND	0.03	ND	ND	ND	ND	1.30	ND	4.20	ND	ND	ND	ND	ND	ND
MW-7	0.07	ND	0.35	ND	ND	ND	ND	1.92	ND	0.80	ND	ND	ND	ND	0.01	ND
MW-8	0.12	0.08	0.70	ND	ND	ND	0.01	5.79	ND	0.23	ND	ND	ND	ND	ND	0.02
MW-9S	ND	ND	0.04	ND	ND	ND	ND	4.80	ND	3.20	ND	ND	ND	ND	ND	ND
MW-11	0.10	0.07	1.10	0.009	ND	ND	0.01	4.68	ND	0.67	ND	ND	ND	ND	0.01	0.01
MW-12	ND	ND	0.02	ND	ND	ND	ND	3.89	ND	5.90	ND	ND	ND	ND	ND	0.01
MW-14	ND	0.05	0.67	ND	ND	ND	ND	4.78	ND	4.13	ND	ND	0.07	ND	ND	ND
MW-15	0.32	ND	0.28	ND	ND	ND	ND	0.52	ND	1.06	ND	ND	ND	ND	ND	ND
MW-16	ND	ND	0.31	ND	ND	ND	ND	ND	ND	2.77	ND	ND	ND	ND	ND	ND
MW-17	0.05	ND	1.24	ND	ND	ND	ND	0.21	ND	3.16	ND	ND	0.05	ND	ND	ND

Note: ND = Not Detected
mg/L = Milligrams per liter

Groundwater Monitoring Wells
WQCC Metals Analytical Results (mg/L) from September 1994 Sampling Event

Well ID	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Zinc
NM WQCC Std.	5.0	0.1	1.0	0.01	0.05	0.05	1.0	1.0	0.05	0.2	0.002	1.0	0.2	0.05	0.05	10.0
Detection Limit	0.05	0.05	0.01	0.005	0.01	0.03	0.01	0.03	0.05	0.01	0.0002	0.05	0.04	0.1	0.01	0.01
MW-1	0.11	ND	0.13	ND	ND	ND	ND	0.08	ND	1.12	ND	ND	ND	0.1	ND	ND
MW-2	0.12	0.05	0.03	ND	ND	ND	ND	0.05	ND	8.07	ND	ND	ND	ND	ND	0.03
MW-3S	0.19	0.08	0.08	ND	ND	ND	ND	0.16	ND	0.51	ND	ND	ND	ND	ND	ND
MW-3D	0.1	ND	0.06	ND	ND	ND	ND	0.1	ND	2.75	ND	ND	ND	ND	0.01	0.02
MW-4	0.11	0.11	0.39	ND	ND	ND	ND	0.86	ND	3.21	ND	ND	ND	ND	ND	0.01
MW-5	0.12	0.08	0.18	ND	ND	ND	ND	0.17	ND	0.03	ND	ND	ND	ND	ND	0.02
MW-6S	0.1	0.48	0.98	ND	ND	ND	ND	4.68	ND	0.59	0.0003	ND	ND	ND	0.01	0.02
MW-6D	0.09	ND	0.05	ND	ND	ND	ND	0.28	ND	3.1	ND	ND	ND	ND	ND	0.02
MW-7	0.11	0.28	0.36	ND	ND	ND	ND	0.97	ND	0.87	0.0005	ND	ND	ND	ND	ND
MW-8	0.21	0.18	0.74	ND	ND	ND	0.01	5.1	ND	0.18	ND	ND	ND	ND	0.01	0.03
MW-9S	0.12	ND	0.06	0.006	ND	ND	ND	4.66	ND	3.11	ND	ND	ND	ND	0.01	0.01
MW-11	0.12	0.15	1.03	0.009	ND	ND	ND	4.27	ND	0.75	0.0003	ND	ND	ND	ND	0.01
MW-12	0.23	ND	0.11	0.009	0.05	ND	0.01	5.85	ND	10.8	ND	0.05	ND	0.4	0.03	0.04
MW-14	0.2	0.17	0.78	ND	ND	ND	ND	13.1	ND	7.59	0.0009	ND	ND	ND	0.02	0.02
MW-15	0.42	0.14	0.78	ND	ND	ND	ND	2.33	ND	2.9	ND	ND	ND	ND	0.02	0.01
MW-16	0.12	0.05	0.09	ND	ND	ND	ND	2.05	ND	5.21	ND	ND	0.06	ND	ND	0.02
MW-17	0.22	0.16	2.11	ND	ND	0.03	ND	9.7	ND	8.48	ND	ND	ND	ND	0.02	0.02
	0.20	0.44	1.81	ND	0.01	0.03	0.01	9.41	ND	7.64	ND	ND	ND	0.01	0.02	0.02

Note: ND = Not Detected
mg/L = Milligrams per liter

Groundwater Monitoring Wells
WQCC Metals Analytical Results (mg/L) from December 1994 Sampling Event

Well ID	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Zinc
NM WQCC Std.	5.0	0.1	1.0	0.01	0.05	0.05	1.0	1.0	0.05	0.2	0.002	1.0	0.2	0.05	0.05	10.0
Detection Limit	0.05	0.05	0.01	0.005	0.01	0.03	0.01	0.03	0.05	0.01	0.0002	0.05	0.04	0.1	0.01	0.01
MW-1	0.10	ND	0.12	ND	ND	ND	0.02	0.03	ND	0.21	0.0002	ND	ND	ND	ND	ND
MW-2	ND	ND	ND	ND	ND	ND	0.01	0.18	ND	1.95	ND	ND	ND	ND	ND	ND
MW-3S	0.13	ND	0.08	ND	ND	ND	0.01	0.12	ND	0.06	ND	ND	ND	ND	ND	ND
MW-3D	0.09	ND	0.04	0.006	ND	ND	0.01	0.08	ND	1.27	ND	ND	ND	ND	ND	ND
MW-4	0.12	ND	0.17	ND	ND	ND	ND	1.99	ND	2.43	ND	ND	ND	ND	ND	ND
MW-5	0.06	0.13	0.22	ND	ND	ND	ND	0.09	ND	0.03	ND	ND	ND	ND	ND	ND
MW-6S	0.08	0.08	0.73	ND	ND	ND	ND	1.88	ND	0.46	ND	ND	ND	ND	ND	0.01
MW-6D	0.07	ND	0.03	ND	ND	ND	0.01	0.11	ND	2.19	ND	ND	ND	ND	ND	ND
MW-7	0.10	ND	0.41	ND	ND	ND	ND	0.45	ND	0.64	0.0006	ND	ND	ND	ND	ND
MW-8	0.19	0.14	0.68	ND	ND	ND	0.02	2.06	ND	0.18	ND	ND	ND	ND	ND	ND
MW-9S	0.06	ND	0.04	0.005	ND	ND	ND	2.25	ND	2.30	ND	ND	ND	ND	ND	ND
MW-11	0.09	0.05	0.84	ND	ND	ND	ND	1.58	ND	0.51	ND	ND	ND	ND	ND	ND
MW-12	0.08	ND	0.03	ND	ND	ND	0.02	1.10	ND	6.18	ND	ND	ND	ND	ND	ND
MW-14	0.08	ND	0.22	ND	ND	ND	ND	10.3	ND	5.46	0.0024	ND	ND	ND	ND	ND
MW-15	0.36	ND	0.38	ND	ND	ND	ND	3.69	ND	1.66	ND	ND	ND	ND	0.09	ND
MW-16	0.11	ND	0.07	ND	ND	ND	ND	1.70	ND	4.15	ND	ND	0.05	ND	ND	ND
MW-17	0.10	ND	0.42	ND	ND	ND	ND	8.47	ND	3.37	ND	ND	ND	ND	ND	ND

Note: ND = Not Detected
mg/L = Milligrams per liter

Groundwater Monitoring Wells
WQCC Metals Analytical Results (mg/L) from September 1995 Sampling Event

Well ID	Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Zinc
NM WQCC Std.	5.0	0.1	1.0	0.01	0.05	0.05	1.0	1.0	0.05	0.2	0.002	1.0	0.2	0.05	0.05	10.0
Detection Limit	0.05	0.05	0.01	0.005	0.01	0.03	0.01	0.03	0.05	0.01	0.0002	0.05	0.04	0.1	0.01	0.01
MW-14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA

Note: ND = Not Detected
mg/L = Milligrams per liter
Only MW-14 was sampled for metals.

Groundwater Monitoring Wells
Major Cations/Anions Analytical Results (mg/L) from March 1994 Sampling Event

Well ID	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Chloride	Nitrate (N)	Sulfate
NM WQCC Std.	None	None	None	None	None	250	10	600
Detection Limit	1.0	0.1	0.1	5.0	5.0	25	0.1	50
MW-1	109	27.2	14	175	456	133	ND	123
MW-2	1130	401	72	3750	728	5680	ND	2280
MW-3S	143	70.6	13.3	1390	624	2030	ND	720
MW-3D	473	246	36	3830	468	4720	ND	2630
MW-4	740	262	57	2920	924	4010	ND	1820
	755	247	69	2930	908	4330	ND	2100
MW-5	402	180	24.2	2880	1860	5280	ND	505
MW-6S	244	104	19.4	1550	1690	5280	ND	505
MW-6D	510	218	25	3520	475	5600	ND	2360
MW-7	300	72.3	22.1	1620	1320	2220	ND	755
MW-8	46.5	33.9	10.2	1560	2680	1210	ND	20
MW-9S	305	104	13.7	1450	628	1280	ND	1800
MW-11	79	62.3	18.3	1050	1620	959	0.2	ND
MW-12	1380	495	55	4340	532	8260	ND	1920

Note: ND = Not Detected
mg/L = Milligrams per liter

Groundwater Monitoring Wells
Major Cations/Anions Analytical Results (mg/L) from June 1994 Sampling Event

Well ID	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Chloride	Nitrate (N)	Sulfate
NM WQCC Std.	None	None	None	None	None	250	10	600
Detection Limit	1.0	0.1	0.1	5.0	5.0	25	0.1	50
MW-1	106	31.0	13.7	105	488	39.3	0.3	150
MW-2	1080	500	125	3040	769	6770	0.3	2790
MW-3S	157	75.9	28	1040	756	2630	0.4	1010
MW-3D	460	220	61	2760	473	6560	0.1	2550
MW-4	430	217	66	2050	1350	4300	2.8	932
MW-5	500	160	58	2230	1710	5450	0.3	962
MW-6S	259	101	40	1120	2020	2090	0.4	84
MW-6D	530	188	62	3100	739	3990	10	2420
MW-7	248	66.8	37	710	1330	1210	0.3	575
MW-8	89.9	36.1	20.0	1150	2670	1380	0.5	60
MW-9S	245	87.3	27	1090	820	1350	1.4	2010
MW-11	116	69.5	29	820	1830	927	1.3	18
MW-12	910	380	76	3300	672	7200	0.2	2350
MW-14	165	81.3	11.4	730	1490	910	ND	200
MW-15	57.7	16.4	23	458	723	436	ND	294
MW-16	237	96.7	35	1500	1100	1910	ND	1510
	243	99.5	30	1490	1090	1870	ND	1780
MW-17	218	63.8	38	610	1100	1350	0.3	318

Note: ND = Not Detected
mg/L = Milligrams per liter

Groundwater Monitoring Wells
Major Cations/Anions Analytical Results (mg/L) from September 1994 Sampling Event

Well ID	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Chloride	Nitrate (N)	Sulfate
NM WQCC Std.	None	None	None	None	None	250	10	600
Detection Limit	1.0	0.1	0.1	5.0	5.0	25	0.1	50
MW-1	113	31.7	10.6	135	427	115	ND	136
MW-2	985	470	98	3140	671	9600	0.3	2440
MW-3S	97.3	41.9	8.6	1050	692	1240	0.1	620
MW-3D	396	224	21	3230	460	4750	ND	2330
MW-4	370	225	65	2340	1470	4360	0.4	364
MW-5	620	186	60	3040	1630	4310	ND	904
MW-6S	155	125	25	2980	2550	1650	ND	130
MW-6D	411	190	21	3270	506	5000	ND	2150
MW-7	320	73	41.5	1230	1300	1580	0.1	548
MW-8	47.2	38.2	29.8	1550	2930	1450	0.1	73
MW-9S	322	95.6	32	1510	830	1500	ND	1760
MW-11	201	72.2	39.4	950	2100	792	0.6	22
MW-12	1380	585	104	4100	512	8860	ND	2140
MW-14	625	154	42	1800	1160	3190	ND	986
MW-15	99.1	16.8	23.1	950	2420	442	0.2	142
MW-16	261	108	33.5	1510	1130	1950	0.9	2340
MW-17	241	77	36.4	136	1590	2110	0.1	239
	237	76.3	36.7	800	1650	1930	ND	198

Note: ND = Not Detected
mg/L = Milligrams per liter

Groundwater Monitoring Wells
Major Cations/Anions Analytical Results (mg/L) from December 1994 Sampling Event

Well ID	Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Chloride	Nitrate (N)	Sulfate
NM WQCC Std.	None	None	None	None	None	250	10	600
Detection Limit	1.0	0.1	0.1	5.0	5.0	25	0.1	50
MW-1	86.9	25.8	5.7	137	464	116	0.3	139
MW-2	950	391	37	3130	688	3240	0.3	2470
MW-3S	97.7	39.8	8.5	985	854	1250	0.3	573
MW-3D	367	207	17	3210	464	4800	0.7	2270
MW-4	298	219	27	2360	1020	4680	ND	3060
MW-5	503	184	21	3070	1830	2430	1.1	705
MW-6S	150	82.3	14	1840	2710	2180	ND	209
MW-6D	379	177	16	3410	525	5210	1	2490
MW-7	229	77.4	15	1100	1500	1570	5.1	333
MW-8	60	36.4	13.1	1870	2940	831	5.5	72
MW-9S	225	88.9	11	1520	866	1440	0.4	978
MW-11	93.4	60.8	12	985	1980	924	0.2	35
MW-12	975	366	27	4060	586	14000	3.1	2490
MW-14	413	154	19	1720	1510	2430	ND	1460
MW-15	68.5	18	11	1290	2700	379	0.2	92
MW-16	224	98.3	15	1870	1160	1980	ND	1840
MW-17	278	80	13	2090	1700	2430	ND	407

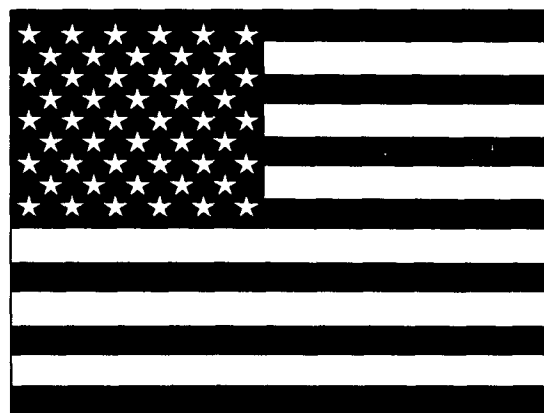
Note: ND = Not Detected
mg/L = Milligrams per liter

Appendix L

International Boundary Water Commission Report

Binational Study Regarding
the Presence of Toxic Substances in the Rio Grande/Rio Bravo
and its Tributaries Along the Boundary Portion
Between the United States and Mexico

*Estudio Binacional sobre
la Presencia de Sustancias Toxicas en el Rio Bravo/Rio Grande
y sus Afluentes, en su Porcion Fronteriza
Entre Mexico y Estados Unidos*



Final Report, September 1994
Informe Final, Septiembre de 1994

AUTHORITY

This study and report were undertaken by the United States and México pursuant to the International Boundary and Water Commission Minute 289 entitled, "Observation of the Quality of the Waters Along the United States and México Border", dated November 13, 1992.

PARTICIPATING AGENCIES

United States

Environmental Protection Agency
Texas Natural Resources Conservation
Commission
Texas Parks & Wildlife Department
Texas Department of Health

México

National Water Commission
Secretaria de Desarrollo Social

International

International Boundary and Water Commission, United States and México

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Forward

This report is issued by the Governments of México and the United States through their sections of the International Boundary and Water Commission, the National Water Commission of México and the U.S. Environmental Protection Agency. The governments of both countries thank the State of Texas, specifically the Texas Natural Resource Conservation Commission, the Texas Parks and Wildlife Department and the Texas Department of Health, for their participation in the study.

Copies of this report in English may be obtained from the Environmental Protection Agency Region 6 Office, 1445 Ross Avenue, Suite 1200, Dallas, Texas 75202-2733 or the International Boundary and Water Commission, 4171 North Mesa Street, Suite 310, El Paso, Texas 79902-1422.

Copies of this report in Spanish may be obtained from the Comisión Internacional de Límites y Aguas, Ave. Universidad No. 2180, Zona Chamizal, C.P. 32310 Cd. Juárez, Chih. or the following agencies of the Comisión Nacional del Agua: Gerencia Regional Norte, Sub Gerencia de Administracion del Agua, Comisión Nacional del Agua, Boulevard Revolucion No. 2343 Ote., C. P. 27000 Torreon, Coah., Tel. 18-9939, 18-9945; Gerencia de Calidad, Reuso del Agua e Impacto Ambiental, Ave. San Bernabe #549, Col. San Jeronimo Licice, México, D.F., C.P. 10200, tel. 595-2344, 683-1740.

EXECUTIVE SUMMARY

Over the last 15 years development has flourished along the México/U.S. border. Immigration to the area has led to substantial population growth in the cities, and given rise to many small, unincorporated communities. During this period, the population of the border region, a 200 km (124 mile) wide strip centered on the international boundary, has doubled to more than six million people (Emerson and Bourbon, 1991).

Economic growth, partially fueled by over 1,400 maquiladora (product assembly) plants that now exist along the border, has been accompanied by an increased potential for water quality degradation. Sewage treatment is inadequate in many communities on both sides of the border. In addition to potential impacts from oxygen-demanding substances, pathogenic microorganisms, and toxicants associated with sewage, other water quality concerns exist. One relates to the potential for pesticide contamination in farming regions around El Paso/Ciudad Juárez, Presidio/Ojinaga, Eagle Pass/Piedras Negras, and the lower Rio Grande/Río Bravo valley. Another is the threat of toxic chemical contamination posed by operation of the maquiladoras (Lewis et al., 1991) and other industries located on both sides of the border.

In the past few years, much local, state, and national media attention from both countries has focused on purported water quality problems in the Rio Grande/Río Bravo, particularly the potential for toxic chemical contamination associated with the proliferation of maquiladoras. At a 1991 public hearing on the proposed Integrated Border Environmental Plan, much public concern was voiced regarding environmental conditions along the river, and especially over the limited amount of toxic substances data available for the Rio Grande/Río Bravo.

In February 1992 the United States and México issued the Integrated Environmental Plan for the Mexican-U.S. Border Area (First Stage, 1992-1994). The plan calls for the two countries to work together to solve environmental problems in the border area. Specifically, the plan calls for the two countries to identify areas where any transboundary water source or potential transboundary water source is contaminated or where there is an identifiable threat of contamination.

In response to the need for comprehensive information, the two countries agreed to an intensive water quality investigation of the Rio Grande/Río Bravo from El Paso/Ciudad Juárez to Brownsville/Matamoros. Coordination between the two countries was conducted by the Mexican and U.S. sections of the International Boundary and Water Commission (IBWC). The IBWC developed IBWC Minute number 289, dated November 13, 1992, which approved the study design and addressed binational cooperation for the water quality investigation. Study participants included the Texas Natural Resource Conservation Commission, Texas Parks and Wildlife Department, Texas Department of Health, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. National Park Service, International Boundary and Water Commission - U.S. & México Sections, Comisión Nacional del Agua, and Secretaría de Desarrollo Social.

The main objective of the study was to screen the system for the occurrence and impact of toxic chemicals. The goals were to clarify concerns about present conditions in the river, and to

determine if existing water quality controls are adequate. The study was conducted during 1992-93 and involved sampling at 19 mainstem sites and 26 tributaries along the reach of the river which forms the international boundary between the U.S. and México (see attached map and station descriptions). This study did not include sample collection from International Amistad and Falcon International Reservoirs.

Sampling and analysis were conducted by each country according to their respective analytical capabilities. Thus, the U.S. evaluation included determinations of toxic chemical concentrations in water (45 sites), sediment (45 sites), and fish tissue (18 mainstem sites, 6 tributaries); toxicity testing of water and sediment (45 sites); and bioassessments of fish communities (18 mainstem sites, 7 tributaries) and benthic macroinvertebrate communities (18 mainstem sites). México concurrently collected samples of water and sediment and conducted analyses for conventional parameters and heavy metals (45 sites).

Valid analytical results were obtained by the U.S. for 153 toxic chemicals in water, 145 in sediment, and 140 in tissue. A total of 48 toxic chemicals were detected, 30 of which exceeded the screening levels established by U.S. investigators. Valid results were obtained by México for 9 conventional parameters in water and 12 heavy metals in both water and sediment. A total of nine toxicants were identified, all of which exceeded Mexican standards.

Few potential toxic chemical-related problems were observed in the mainstem. Only 5 toxic chemicals exceeded U.S. screening levels in water, 8 in sediment, and 12 in tissue. A total of six toxic chemicals were identified by México in the mainstem, exceeding Mexican standards for aquatic life. In the toxicity tests, significant adverse effects occurred in just 2 of 114 determinations, from samples collected upstream from El Paso/Ciudad Juárez and downstream from Laredo/Nuevo Laredo. Fish and macrobenthic communities generally were healthy; however, 5 of 36 stations, listed below, exhibited aquatic community characteristics reflecting a moderate or high probability of toxic chemical impact (numbers in parentheses are station identifiers).

- Downstream from El Paso/Ciudad Juárez (2)
- Downstream from Eagle Pass/Piedras Negras (10)
- Downstream from Laredo/Nuevo Laredo (12)
- Downstream from Anhele Drain South of Las Milpas (16)
- Arroyo Los Olmos (12d)

Biotic integrity at the main stem sites indicated that if toxic impacts were occurring, the effects were relatively slight. No instances of severe aquatic life use impairment were observed.

Potential problems were more prevalent in tributaries, which was not surprising since some of them transport wastewater in relatively undiluted form. According to U.S. results, 17 toxic chemicals exceeded screening levels in water, 15 in sediment, and 8 in tissue. In addition, samples from 14 of the 26 tributaries produced significant adverse effects in at least one phase of the toxicity tests. Results from México's analyses indicated eight potentially toxic chemicals that exceeded their water quality standards.

Regarding human health issues, no short-term risks were indicated for the 24 sites that were subjected to edible fish tissue analysis, in that there were no exceedances of U.S. Food & Drug Administration action levels. However, low-level human health criteria were exceeded in water and/or edible fish tissue at 22 of the 45 sites. For 17 of these sites, slight human health risks could result from regular, long-term consumption of untreated water and/or fish. Significant risks were observed for the other five sites. However, because all five are sewage effluent-dominated tributaries, these waters are nonpotable and conventional water quality is not conducive for support of viable fish populations..

All available information was used to identify sites and chemicals of potential concern, to facilitate water quality management decisions and future monitoring efforts. The 30 chemicals identified by the U.S. that exceeded screening levels were considered to be of potential concern, and were assigned an approximate level of importance based on occurrence. A high priority group included residual chlorine, methylene chloride, toluene, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc, chlordane, p,p' DDE, dieldrin, gamma-bhc (lindane), total PCB's, and cyanide. A medium priority group consisted of non-ionized ammonia, parachlorometa cresol, phenol, and diazinon. A low priority group was comprised of phenolics recoverable, chloroform, antimony, thallium, bis(2-ethylhexyl) phthalate, diethyl phthalate, and di-n-butyl phthalate. Results obtained by México were in agreement with the aforementioned priorities.

Regarding sites of potential concern, mainstem stations and tributary stations were addressed separately. The following stations include those that exhibited either high potential or slight to moderate potential for toxic chemical impacts. Unlisted sites exhibited negligible evidence of toxic chemical impacts.

Mainstem Sites

High Potential for Toxic Chemical Impacts

- Downstream from El Paso/Ciudad Juárez (2)
- Downstream from Laredo/Nuevo Laredo (12)

Slight to Moderate Potential for Toxic Chemical Impacts

- Upstream from Río Conchos confluence near Presidio/Ojinaga (3)
- Downstream from Eagle Pass/Piedras Negras (10)
- Downstream from Anzalduas Dam (14)
- Below Anhele Drain South of Las Milpas (16)

Tributaries

High Potential for Toxic Chemical Impacts

- El Paso Public Service Board Haskell R. Street Wastewater Treatment Plant (1a)
- Ciudad Juárez Discharge Canal (2a)

Manadas Creek (10a)
Zacate Creek (11a)
Arroyo El Coyote (11c)
Anhelo Drain (15a)

Slight to Moderate Potential for Toxic Chemical Impacts

Río Conchos (3a)
Arroyo de Las Vacas (7b)
Unnamed Tributary South of Eagle Pass/Piedras Negras (9a)
Arroyo Los Olmos (12d)

Based on the degree of toxic chemical contamination and volume of inflow, the Haskell R. Street Wastewater Treatment Plant (1a) and Ciudad Juárez sewage discharge canal (2a) appeared to have a high potential for adversely affecting the Rio Grande/Río Bravo. The Río Conchos (3a), San Felipe Creek (7b), Zacate Creek (11a), and Anhelo Drain (15a) have a slight to moderate potential for adversely affecting the river. Remaining tributaries present little or no potential for significant impacts to the Rio Grande/Río Bravo based on data collected during the study.

Also, a binational study is proposed during 1994 and 1995 that will examine the prevalence and magnitude of toxic chemicals in fish tissue collected from International Falcon and Amistad Reservoirs.

Follow-up binational studies were recommended for the purposes of better defining the degree of impact, assessing temporal variation, and further identifying sources of toxic chemicals. The studies, listed below, would be conducted during 1994 and 1995, pending international agreement through the U.S. and México sections of IBWC.

Additional surveillance would be conducted at the six mainstem and ten tributary sites where a slight-to-moderate or high potential for toxic chemical impact was indicated, including expanded monitoring in the vicinities of El Paso/Ciudad Juárez (2) and Laredo/Nuevo Laredo (12)

Intensive surveys would be performed on tributaries of potential concern that support significant aquatic life habitat, i.e., Río Conchos (3a) and San Felipe Creek (7b)

Toxic chemical concentrations in fish tissue would be reassessed in the Rio Grande/Río Bravo stations at Foster Ranch (6), upstream from Del Rio/Ciudad Acuña (7), upstream from Eagle Pass/Piedras Negras (9), and upstream from the old Laredo/Nuevo Laredo International Bridge (11), and

Toxic chemical concentrations in fish tissue would be assessed in the headwaters of International Amistad and Falcon Reservoirs.

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Forward

This report is issued by the Governments of México and the United States through their sections of the International Boundary and Water Commission, the National Water Commission of México and the U.S. Environmental Protection Agency. The governments of both countries thank the State of Texas, specifically the Texas Natural Resource Conservation Commission, the Texas Parks and Wildlife Department and the Texas Department of Health, for their participation in the study.

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INTRODUCTION

Over the last 15 years development has flourished along the México/U.S. border. Immigration to the area has led to substantial population growth in the cities, and given rise to many small, unincorporated communities, or colonias. During this period, the population of the border region, a 200 km (124 mile) wide strip centered on the international boundary extending from the Pacific Ocean to the Gulf of Mexico, has doubled to more than six million people (Emerson and Bourbon, 1991).

Economic growth, partially fueled by over 1,400 maquiladora (product assembly) plants that now exist along the border, has been accompanied by an increased potential for water quality degradation. Sewage treatment is inadequate in many communities on both sides of the border. In addition to potential impacts from oxygen-demanding substances, pathogenic microorganisms, and toxicants associated with sewage, other water quality concerns exist. One relates to the potential for pesticide contamination in farming regions around El Paso/Ciudad Juárez, Presidio/Ojinaga, Eagle Pass/Piedras Negras, and the lower Rio Grande/Río Bravo valley. Another is the threat of toxic chemical contamination posed by operation of the maquiladoras (Lewis *et al.*, 1991) and other industries located on both sides of the border.

In the past few years, much local, state, and national media attention from both countries has focused on purported water quality problems in the Rio Grande/Río Bravo, particularly the potential for toxic chemical contamination associated with the proliferation of maquiladoras. At a 1991 public hearing on the proposed Integrated Border Environmental Plan, much public concern was voiced regarding environmental conditions along the river, and especially over the limited amount of toxic substances data available for the Rio Grande/Río Bravo.

In February 1992 the United States and México issued the Integrated Environmental Plan for the Mexican-U.S. Border Area (First Stage, 1992-1994). The plan calls for the two countries to work together to solve environmental problems in the border area. Specifically, the plan calls for the two countries to identify areas where any transboundary water source or potential transboundary water source is contaminated or where there is an identifiable threat of contamination.

In response to the need for comprehensive information, the two countries agreed to an intensive water quality investigation of the Rio Grande/Río Bravo from El Paso/Ciudad Juárez to Brownsville/Matamoros. Coordination between the two countries was conducted by the Mexican and U.S. sections of the International Boundary and Water Commission (IBWC). The IBWC developed IBWC Minute number 289, dated November 13, 1992, which approved the study design and addressed binational cooperation for the water quality investigation. Study participants included the Texas Natural Resource Conservation Commission, Texas Parks and Wildlife Department, Texas Department of Health, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. National Park Service, International Boundary and Water Commission - U.S. & México Sections, Comisión Nacional del Agua, and Secretaría de Desarrollo Social.

The main objective of the study was to screen the system for the occurrence and impact of toxic chemicals. The goals were to clarify concerns about present conditions in the river, and to determine if existing water quality controls are adequate. The study was conducted during 1992-93 and involved sampling at 19 mainstem sites and 26 tributaries along the reach of the river which forms the international boundary between the United States and México (Table 1). This study did not include sample collection from International Amistad and Falcon Reservoirs.

Historical Information

Water quality and biological data for the U.S. portion of the Rio Grande/Río Bravo basin were summarized by TNRCC (1992a). The Comisión Nacional del Agua (CNA) also has conducted water quality analyses based on physical, chemical, and bacteriological parameters from 1976 to 1993. An evaluation of this data is found in Appendix D. Conclusions regarding conventional water quality are addressed elsewhere in the present report (see "Conventional Water Quality" under "RESULTS AND DISCUSSION").

Literature relative to biotic integrity in the Rio Grande/Río Bravo, some of which addressed influential environmental factors, also was reviewed in the 1992 report. Possible toxic chemical impacts were mentioned for several locations, but little supporting evidence was provided. Regarding toxic chemicals, the 1992 evaluation included all available information generated by U.S. agencies. For the international portion of the river, the data base was described, data were evaluated, toxic chemicals of potential concern were identified, potential sources of toxic chemicals were addressed, possible impacts were considered, and conclusions were drawn. Potential concerns were revealed for four locations.

The first was the segment of the Rio Grande/Río Bravo in El Paso/Ciudad Juárez (represented by station 2 in the present study), where flow is dominated by municipal wastewater effluent during low flow periods. Local macrobenthic community integrity was very low during a 1976-77 study, with toxic pollutants thought to be partially responsible. In addition, periodic toxicity testing by USEPA/TNRCC since 1992 has shown significant adverse effects in water on two occasions, and in sediment eluate on one occasion (Table 18). Whereas there have been indications of impacts by toxicants, the toxic chemical data base is limited, so concrete conclusions were not possible at the time of the 1992 evaluation.

The second was the segment of the Rio Grande/Río Bravo downstream from the Río Conchos confluence to a point 16 km (10 miles) downstream (represented by station 4 in the present study), where elevated concentrations of DDE, DDD, DDT, endrin, dieldrin, and PCB's were observed in sediment and/or fish tissue during special studies in the late 1970's. Upstream/downstream sampling identified inflow from the Río Conchos as the primary contributor, most clearly with respect to DDE and DDT. Data from the late 1980's indicated that contaminant levels, particularly for DDE and DDT, had diminished substantially. Periodic toxicity testing since 1992 has revealed only one instance of significant adverse effects (Table 18). The 1992 report concluded that existing pesticide concentrations probably are not significantly impairing biotic integrity in the reach, and more than likely do not pose an

appreciable human health hazard, but that a possibility remains that predatory fish, birds, and wildlife may be moderately affected through accumulation and biomagnification of pesticide residues.

The third was the segment of the Rio Grande/Río Bravo from Laredo/Nuevo Laredo to the headwaters of International Falcon Reservoir (represented by station 12 in the present study). The basis was chemical data and field observations from a monitoring station 14 km (9 miles) downstream from Laredo, where copper, selenium, and chlordane in fish tissue had exceeded screening criteria. Also, on several occasions fish collected at the site had exhibited an elevated incidence of physical abnormalities. Whether toxic chemicals were responsible was unknown. A potential for slight toxic impact has been shown in periodic toxicity testing since 1991, as significant adverse effects have occurred on two occasions (Table 18). Nonetheless, recent studies have shown that the local species assemblage is fairly diverse, indicating that environmental conditions are reasonably healthy and that fish community integrity is not being appreciably impaired by toxic chemicals or other ecological factors.

The fourth was the segment of the Rio Grande/Río Bravo immediately upstream from International Anzalduas Dam near Mission/Reynosa (represented by station 14 in the present study), where elevated levels of DDT, DDE, and toxaphene in fish tissue were documented by the U.S. Fish and Wildlife Service (USFWS) during 1967-79. In a 1988 USFWS report, an evaluation of temporal trends for tissue data from the site (1970-86) showed that DDT and DDE steadily declined, while toxaphene exhibited a slight increase. Data for the site in a 1988 U.S. Geological Survey report included several instances where DDE and toxaphene exceeded screening criteria in fish tissue. TNRCC fish tissue monitoring for DDT, DDD, DDE, and toxaphene in this segment has shown only one exceedance, by DDD. Although no specific impacts by pesticide residues have been documented in the International Anzalduas Dam area, a potential appears to exist for adverse effects on piscivorous fish, birds, and wildlife.

To summarize the 1992 evaluation, the overall conclusion for the basin was that toxic chemical contamination and associated impacts were relatively insignificant at that point in time. However, it was emphasized that the toxic chemical data base was rather limited for some segments, mainly with regard to parametric and/or matrix coverage. Recommendations for filling data gaps were offered, and were taken into account in the design of the present study.

Study Area

The Rio Grande/Río Bravo originates in the San Juan Mountains of southern Colorado, flows southward through New Mexico, and enters Texas about 32 km (20 miles) northwest of El Paso/Ciudad Juárez. From there to the Gulf of Mexico, the river forms the international boundary between the United States and México. The river extends for about 3,059 km (1901 miles), with the U.S./México reach being about 2,053 km (1276 miles) in length. The watershed encompasses about 924,300 square kilometers (357,000 square miles). Of that total, about 231,317 square kilometers (89,317 square miles) in the United States and 227,149 square kilometers (87,698 square miles) in México contribute streamflow to the Rio Grande/Río Bravo; the remaining area drains internal (endorheic) basins. The U.S. portion of the basin below El

Paso/Ciudad Juárez contains 125,580 square kilometers (48,300 square miles), of which 100,880 square kilometers (38,800 square miles) contribute streamflow to the river.

The study was conducted on the U.S./México reach of the river, that portion extending from the New Mexico/Texas/Chihuahua border to the Gulf of Mexico (Figure 1). Population along the reach is centered in five transborder metropolitan areas: El Paso/Ciudad Juárez (1,303,130); Eagle Pass/Piedras Negras (116,829); Laredo/Nuevo Laredo (341,312); McAllen, Edinburg, Mission/Reynosa (416,776); and Brownsville/Matamoros (365,017). The economy of the area is based on wholesale and retail trade, oil and gas production, agriculture, manufacturing, tourism, and international trade.

The river is an important natural resource for industry, agriculture, domestic water supply, recreation and aesthetic enjoyment, and wildlife and aquatic life habitat. Most of the major tributaries, and some of the lesser ones, are also of significance in these respects. Substantial agricultural areas where river water is diverted for irrigation include the El Paso/Ciudad Juárez area, Eagle Pass/Piedras Negras area, and Rio Grande/Río Bravo valley downstream from International Falcon Dam. Through the reach from Laredo/Nuevo Laredo to the mouth, the river constitutes the primary drinking water source for up to 98% of the population in both countries.

In western Texas, a substantial reach extending from near Redford/El Mulato to near Terlingua/Nuevo Lajitas forms the southern boundary of the Big Bend Ranch State Natural Area. Immediately downstream, another long reach lies within the U.S. Big Bend National Park, and constitutes a major feature of that facility. The U.S. portion of the reach from the eastern boundary of the park to International Amistad Reservoir is a designated National Wild and Scenic River segment. International Amistad Reservoir and International Falcon Reservoir, two large mainstem impoundments constructed primarily for water conservation management and floodwater control, are major tourist attractions. Amistad is a designated National Recreational Area, and Falcon is the site of Falcon State Park, Texas. In the lower Rio Grande/Río Bravo valley, the river and its riparian environment are prominent features within a number of parks and refuges. In Texas these include Bentsen State Park, Anzalduas Park, Santa Ana National Wildlife Refuge, Anacua State Wildlife Management Area, Sabal Palm Sanctuary, and the Lower Rio Grande/Río Bravo Valley National Wildlife Refuge, the latter comprised of 30 small, separate tracts. Cumulatively, these parks and refuges are heavily utilized for recreation, and are inhabited by significant assemblages of plants, birds, wildlife, and aquatic life, including various rare and endangered species, and species that occur only peripherally in the United States. The States of México that border the river are Chihuahua, Coahuila, Nuevo Leon and Tamaulipas.

Various characteristics of the study area are important to an understanding of the river's ecology. These include climatic, hydrologic, geologic, physiographic, and biotic features.

Climate in the northern portion of the basin generally is hot and arid, but becomes increasingly tropical in a southward direction. Annual rainfall averages about 20 cm (8 inches) at El Paso/Ciudad Juárez, 46 cm (18 inches) at Del Rio/Ciudad Acuña, 51 cm (20 inches) at Laredo/Nuevo Laredo, and 65 cm (26 inches) at Brownsville/Matamoros.

The system is complex hydrologically. At the New Mexico/Texas/Chihuahua border, low flow in fall and winter is derived from alluvial seepage and delayed irrigation return flows. Higher flow during the spring/summer irrigation season originates from reservoir releases in New Mexico. Most of the flow reaching El Paso/Ciudad Juárez is diverted for irrigation at the American Dam (U.S.) and International Dam (México). Perennial flow reappears through the lower portion of El Paso, sustained by a large municipal wastewater discharge from the El Paso Public Service Board Haskell R. Street wastewater treatment plant. A short distance downstream, most of the flow is diverted for irrigation at the Riverside Diversion Dam (U.S.). The long reach from there to the Río Conchos confluence is seasonally intermittent. Base flows are derived mainly from irrigation returns, with small contributions from alluvial seepage and springflow from mountain creeks and arroyos.

Inflow from the Río Conchos (México), the largest tributary in the U.S./México reach, typically dominates flow through the next stretch, which assumes the Río Conchos' water quality and biological characteristics (Davis, 1980). The volume of flow contributed by the Río Conchos is dependent upon releases from Chihuahua reservoirs. Flow in the Rio Grande/Río Bravo is perennial from the mouth of the Río Conchos to the Gulf of Mexico. No overly significant inflows or diversions exist between the Conchos and International Amistad Reservoir near Del Rio/Ciudad Acuña. Two major U.S. tributaries, the Pecos and Devils rivers, contribute inflow to International Amistad Reservoir. Downstream from Amistad, instream flow volume is dependent on releases from the reservoir, and to a lesser extent on the amount of inflow contributed by tributaries, primarily San Felipe Creek, Sycamore Creek, Pinto Creek, and Las Moras Creek (U.S.), and the Río San Diego, Río San Rodrigo, and Río Escondido (México).

Major diversions for irrigation and electric power generation, and return flows, result in increasingly variable instream flow conditions downstream from Eagle Pass/Piedras Negras. In the Laredo/Nuevo Laredo area, instream flow is augmented by substantial volumes of domestic wastewater entering from both sides of the river. Downstream, the river is impounded by International Falcon Dam, and below there instream flows are governed by releases from the reservoir and by the volume of inflow from three Mexican tributaries, the Río Salado, Río Alamo, and Río San Juan. At International Anzalduas Dam near Mission/Reynosa, large volumes of water typically are diverted for domestic and agricultural usage in México. From there to the Gulf of Mexico, instream flow generally progressively decreases due to multiple small withdrawals, but is highly variable depending on releases from International Anzalduas Dam, operations of wastewater dischargers and municipal water supply systems, and irrigation return flows.

Based on geologic, physiographic, climatic, and biotic characteristics, the river is divisible into three distinctive reaches. The upper reach extends from El Paso/Ciudad Juárez to Big Bend Village/La Linda, and lies within the Chihuahuan biotic province (analogous to the Southern Deserts ecoregion). This reach is physiographically complex, and has three natural geological sections.

The Bolson Section from El Paso/Ciudad Juárez to Ft. Quitman/Banderas lies in a large bolson of Quaternary alluvial deposits, in terrain marked by arroyos, bad-land topography, dunes, and blow sand, with thin scrub brush and grass cover. Tertiary mountainous outcrops border the

river valley on the Mexican side. The river through this section is principally a sand-bed stream. Channel width averages about 40 m (131 feet), and the mean gradient is 0.6 m/km (0.1 feet/mile). The river is channelized/leveed through much of the section, and there are no major tributaries.

The Presidio/Ojinaga section, from Ft. Quitman/Banderas to 16 km (10 miles) southeast of Redford/El Mulato, is topographically rugged, with mountains and basalt-capped mesas exhibiting precipitous fronts along the river valley except in a bolson at the Río Grande/Río Bravo-Río Conchos confluence. Vegetation is sparse except in the river bottom where salt cedar and mesquite thrive. The bed load is principally coarse gravel to small boulder, although sand and fine gravel predominate in localized areas. Riverbed width is about 40 m (131 feet) and the mean gradient is 0.8 m/km (0.2 feet/mile). The Río Conchos is the only major tributary.

The complex terrain of the upper Canyon Section, from 16 km (10 miles) southeast of Redford/El Mulato to Big Bend Village/La Linda, alternates between level bolsons and elevated horst blocks, intrusive uplifts, and anticlinal mountains, through which the river has cut deep canyons. Vegetation is scant, except for dense salt cedar and mesquite along the river. Bed load material is mainly sand and gravel, ranging from fine sand to large cobbles. Stream width varies from 15 m (49 feet) in constrictive canyons to 40 m (131 feet) in bolsons, and the mean gradient is 0.9 m/km (0.2 feet/mile). Although no major tributaries exist, discharge increases through the section due to springflow.

The lower Canyon Section extends from Big Bend Village/La Linda to just south of Del Rio/Ciudad Acuña, and lies in a transitional zone between three biotic provinces: the Chihuahuan to the west, Balconian to the east, and Tamaulipan to the south (analogous to the Southern Deserts, Central Texas Plateau, and Southern Texas Plains ecoregions, respectively). The river throughout is incised in hilly Cretaceous limestones of the Stockton and Edwards plateaus. Desert shrub, mesquite, oak, and juniper cover thickens downstream with increasing rainfall, and extensive stands of cane grass and Bermuda grass grow along the stream margins. Streambed composition is similar to that in the upper Canyon Section. Stream width is variable, with a maximum of 100 m (328 feet) at Del Rio/Ciudad Acuña, and the mean gradient is 0.7 m/km (0.1 feet/mile). Principal tributaries are the Pecos and Devils rivers, which converge with the Río Grande/Río Bravo below Langtry/San Ignacio to form International Amistad Reservoir.

Downstream of Del Rio/Ciudad Acuña, the river emerges from the Edwards Plateau and enters the Río Grande/Río Bravo embayment, a broad, mesquite-chaparral syncline plunging gently to the south. This constitutes the lower reach, or Coastal Plains Section, which extends to the Gulf of Mexico. The area is encompassed by the Tamaulipan biotic province (analogous to the Southern Texas Plains ecoregion). Strong neotropical biotic influences are exerted, in contrast to the Chihuahuan and Balconian provinces where nearctic influences predominate. The topography is flat to gently rolling, with local relief rarely exceeding 90 m (295 feet). Vegetative cover, predominated by thorny brush species, increases to the south as the climate changes from semiarid near Del Rio/Ciudad Acuña to subtropical near Brownsville/Matamoros. The river is entrenched as much as 15 m (49 feet) into Tertiary formations. Bed load material between Del Rio/Ciudad Acuña and International Falcon Reservoir is principally small gravel and sand. Downstream from International Falcon Dam, it grades to fine sand and then to sandy

silt as the Gulf of Mexico is approached. The channel generally is wide, in the range of 100-150 m (328-492 feet). The mean gradient decreases from 0.7 m/km (0.1 feet/mile) near Del Rio/Ciudad Acuña to 0.2 m/km (0.04 feet/mile) near Laredo/Nuevo Laredo, and approaches sea level near Brownsville/Matamoros. Significant tributaries include Sycamore Creek, Pinto Creek, and Las Moras Creek (U.S.), and the Río San Diego, Río San Rodrigo, Río Escondido, Río Salado, Río Alamo, and Río San Juan (México).

STUDY DESCRIPTION

The study was designed on the basis of several interagency planning meetings, and comments from numerous internal and external reviews of early drafts of the work plan. Agencies with principal involvement in project planning included: UNITED STATES - Texas Natural Resource Conservation Commission (TNRCC), Texas Parks and Wildlife Department (TPWD), Texas Department of Health (TDH), U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), U.S. National Park Service (USNPS), U.S. Section, International Boundary and Water Commission (USIBWC); MÉXICO - Sección Mexicana de La Comisión Internacional de Límites y Aguas (CILA), Comisión Nacional del Agua (CNA), Secretaría de Desarrollo Social (SEDESOL). The binational sampling team was comprised of representatives from TNRCC, TPWD, USEPA, USIBWC, CILA, and CNA.

Quality Assurance

The study was conducted in accordance with a USEPA-approved quality assurance project plan (TNRCC, 1992b). Specified data quality objectives were achieved. Results of data quality evaluations are presented in Appendix C.

Sampling Sites

A total of 45 sites were sampled (Table 1; Figure 1), 19 of which were on the mainstem. Sixteen mainstem sites were established to bracket areas where the greatest likelihood for toxic chemical contamination was thought to exist. These included sites upstream and downstream from El Paso/Ciudad Juárez, Presidio/Ojinaga, Del Rio/Ciudad Acuña, Eagle Pass/Piedras Negras, Laredo/Nuevo Laredo, International Anzalduas Dam, Hidalgo/Reynosa, and Brownsville/Matamoros. Single stations were established in the U.S. at Big Bend National Park and in the U.S. at Foster Ranch near Langtry/San Ignacio, to characterize conditions in remote, ecologically important reaches. A supplemental station was established at the mouth of Lozier Canyon to provide a baseline for future assessments of the effects of inflows from the canyon.

Twenty-six inflows to the river, collectively categorized as tributaries, were sampled (13 in the U.S.; 13 in México). These were selected based on size, geographical proximity to the mainstem areas of principal interest, and suspected potential for contributing toxicants to the mainstem. Each tributary was sampled in the lowermost reach, but far enough above the mouth to avoid mainstem backwaters.

Types of Analyses

The 18 major mainstem sites were subjected to measurements of selected conventional parameters in water; determinations of toxic chemical concentrations in water, sediment, and fish tissue; toxicity testing of water and sediment; and bioassessments of fish and benthic

macroinvertebrate communities. Analyses performed at the supplemental mainstem site (5b) and all tributaries included measurements of selected conventional parameters in water; determinations of toxic chemical concentrations in water and sediment; and toxicity testing of water and sediment. Certain tributaries, mostly those that were large enough to permit boat electrofishing, were also subjected to determinations of toxic chemical concentrations in fish tissue, and/or bioassessments of fish communities (stations 3a, 6a, 6b, 7b, 8d, 9b, 12d).

México conducted analyses on conventional parameters and metals on the water and sediment samples.

Parametric Coverage

In addition to toxic chemical parameters, water samples were analyzed for ammonia, total organic carbon, total hardness, total suspended solids, total dissolved solids, chloride, sulfate, turbidity, pH, temperature, specific conductance, dissolved oxygen, and residual chlorine; sediment for particle size composition, total organic carbon, and acid volatile sulfide; and fish tissue for percent lipid content. A total of 161 toxicants were targeted for analysis in all sample matrices (Table 2). These included priority pollutants identified in the U.S. Code of Federal Regulations (CFR) Part 423 Appendix A, except for dioxin and asbestos, plus the following non-priority pollutants: 11 pesticides for which numerical criteria have been established by the State of Texas and approved by the U.S., 19 pesticides recommended for inclusion by USEPA Region 6, and three chemicals shown by Lewis et al. (1991) to have a potential for affecting the Rio Grande/Río Bravo. For water, the targeted list of toxicants totalled 163, due to inclusion of two potentially toxic conventional parameters, ammonia and residual chlorine. Numbers of parameters for which valid analytical data were obtained are summarized in the Data Completeness section of Appendix C.

Sample Handling

Recommended storage, preservation, and holding time requirements were observed during transport and analysis of water, sediment, and tissue samples (see Table 3). All samples were stored and shipped on ice. Ice chests containing the samples and appropriate chain-of-custody forms were sealed with tape, and shipped to the laboratories via overnight freight.

Laboratory Analyses

Split samples of water, sediment, and tissue were collected for analyses by labs in the U.S. and México. All U.S. analyses of water, sediment, and fish tissue were performed by the Texas Department of Health (TDH) Environmental Chemistry Laboratory, Austin, Texas. TDH performed analyses of environmental samples according to a USEPA-approved quality assurance/quality control plan (Twidwell et al., 1991).

México conducted lab analyses on its samples in the CNA Laboratories in Chihuahua, Chih., Torreon, Coah., Tampico, Tamps., Monterrey, N.L., and México, D.F., as well as in the laboratories of ATLATEC, S.A., in Monterrey, N.L. With regard to the evaluation of the results, México used Mexican standards for water quality.

Methods employed by both labs are presented in Table 4.

Data Evaluation

U.S. toxic chemical data were evaluated using screening level concentrations listed in Tables 7, 8, and 9. For water, screening values were derived from the following sources, in order of priority: (1) State of Texas criteria for protection of aquatic life and human health (TNRCC, 1991); (2) U.S. federal water quality criteria (USEPA, 1986, and subsequent updates thereto); (3) chemical concentrations that have been considered for U.S. federal criteria (USEPA, 1980a-1980n); (4) national 85th percentile values (Greenspun and Taylor, 1979); and (5) chemical concentrations from supplemental sources. All sources from which screening levels were adopted are documented in footnotes to Tables 7 and 8. This array of information allowed incorporation of at least one screening value for every toxic chemical detected in water (Table 13).

México evaluated data using Mexican water quality standards. The Mexican water quality standards are listed in Table 7.

For U.S. sediment data, preferential screening values involved national interim or draft sediment quality criteria (USEPA, 1989, 1991). However, as these are available for only a few chemicals, sediment data were primarily screened using contaminant threshold concentrations for protection of aquatic biota (USEPA, 1985a). These were derived by USEPA in a manner similar to the equilibrium partitioning approach (USEPA, 1989), employing an equilibrium partitioning assumption and USEPA aquatic life water quality criteria. The original values are

based on an assumption that sediment contains four percent organic carbon. For the present study, threshold values presented by USEPA (1985) were modified using total organic carbon data from Table 11:

$$\text{site-specific screening level concentration} = \frac{\text{mg/kg TOC in sample}}{40,000 \text{ mg/kg TOC}} \times \text{USEPA threshold concentration}$$

For sediment contaminants for which threshold values were not developed in the 1985 USEPA study, screening level concentrations were obtained from additional sources, as identified in footnotes to Tables 7 and 9. National 85th percentile values (Greenspun and Taylor, 1979) were also utilized if available.

U.S. edible fish tissue data were screened for human health risks using USFDA (1993) action or tolerance limits, USEPA (1993) values for establishment of fish advisories, and TDH (1992) risk assessment levels. Whole fish tissue data were primarily evaluated using national 85th percentiles (Schmitt and Brumbaugh, 1990), state 85th percentiles (TNRCC, 1994), national mean concentrations (Schmitt *et al.*, 1990; USEPA, 1992), and predator protection limits developed by various agencies. All sources from which screening levels were derived are identified in footnotes to Table 7.

Biological Techniques

Toxicity Testing

U.S. toxicity testing was performed by the USEPA Region 6 Laboratory in Houston, Texas, according to procedures described by Weber *et al.* (1989). Accuracy and precision were ensured through conformance with standard USEPA quality assurance/quality control procedures.

U.S. sediment eluates were prepared by combining a subsample from the homogenized sediment sample with appropriate culture water. The sediment and water were combined in a sediment-to-water ratio of 1:4 on a volume basis by volumetric displacement. After combining, the mixture was tumbled end-over-end for approximately 24 hours, after which the mixture was allowed to settle for an additional 24 hours at 3-4 °C. After settling, the eluate was siphoned off and filtered through a 1.5 μ glass fiber filter before testing was initiated.

U.S. water and sediment eluate samples were evaluated using two different toxicity tests. The first was the *Ceriodaphnia dubia* Seven-Day Survival and Reproduction Test (USEPA Method 1002.0). Neonates less than 24 hours old were utilized for testing. One neonate was added to each of ten replicates for the control (culture water) and the 100% test water or sediment eluate sample. Test chambers were 30 mL beakers containing 15 mL of test or control water. The organisms were fed once daily. Test solutions were renewed on days two, four, and six. Mortality, number of young produced, dissolved oxygen, and temperature were monitored and recorded daily. At the termination of the tests, mortality and reproduction data were analyzed statistically ($p = 0.05$) using Fisher's Exact Test and the t test, respectively, to determine differences between control organisms and those exposed to the test solutions.

The second was the Fathead Minnow, *Pimephales promelas*, Seven-Day Embryo/Larval Survival and Teratogenicity Test (USEPA Method 1001.0). Embryos less than 36 hours old were utilized for testing. Ten embryos were added to each of three replicates for the control (culture water) and the 100% test water or sediment eluate sample. Test chambers were 400 mL Nalgene culture dishes containing 250 mL of test or control water. Feeding was not required during the exposure period. Test solutions were renewed on days two, four, and six. Mortality (deformed larvae were counted as dead), dissolved oxygen, and temperature were monitored and recorded daily. At the termination of the tests, mortality data were analyzed statistically ($p = 0.05$) using the t test, to determine differences between control organisms and those exposed to the test solutions.

Macrobenthic Community Assessment

Macrobenthic organisms were collected using two techniques. At sites where rocky-bottomed riffles were present, a composite of three to five subsamples were taken with a Surber square foot sampler. Where riffles were lacking, snag (submerged woody debris) sampling was employed. Snags of 2.54 cm (1 inch) diameter or less were cut into pieces using lopping shears, with enough material collected to fill two 1-qt. Mason jars. At two sites, both types of samples were collected for purposes of comparison.

Benthic samples were preserved in 5% formalin, returned to the lab, and washed in a U.S. Standard No. 30 soil sieve. Snags were scrubbed with a soft-bristle brush, and after all organisms were removed, the surface area of each snag was determined. Organisms were picked from debris at 12X magnification using a dissecting microscope, enumerated, and identified to the lowest possible taxonomic level.

Macrobenthic data were evaluated using two techniques, to provide a crosscheck. The first was the Mean Point Score (MPS), the method routinely used by TNRCC for assessing macrobenthic community integrity. The MPS involves six metrics, five of which relate to community structure (species richness, standing crop, Ephemeroptera-Plecoptera-Trichoptera or EPT index, diversity, and equitability). The sixth relates to community function, and is comprised of three submetrics (number of functional feeding groups, prevalence of the most abundant functional feeding group, and cumulative prevalence of organisms that feed on fine particulate organic matter). Each metric value is assigned from 1 to 4 points using criteria developed by TNRCC (Twidwell and Davis, 1989). Point scores correspond to aquatic life use subcategories (4 = exceptional; 3 = high; 2 = intermediate; 1 = limited). The point score assigned the community function metric represents the lowest indicated by any of the three submetrics. The MPS is calculated by dividing the sum of the individual point scores by six. An aquatic life use subcategory rating is derived from the following MPS criteria ranges: > 3.50 = exceptional; $2.50-3.50$ = high; $1.50-2.49$ = intermediate; < 1.50 = limited.

The second technique was the Invertebrate Community Index (ICI) developed by Ohio EPA (1987), which utilizes ten community structure metrics (taxa richness, mayfly taxa richness, caddisfly taxa richness, dipteran taxa richness, percent mayfly composition, percent caddisfly composition, percent tribe Tanytarsini midge composition, percent other dipteran and non-insect

composition, percent tolerant organisms, and EPT index). Each metric value is assigned a point score (0, 2, 4, or 6), and the scores are summed to arrive at the ICI value. An aquatic life use subcategory rating is derived from the following ICI criteria ranges: 45-60 = exceptional; 35-44 = high; 11-34 = intermediate; 0-10 = limited.

Fish Community Assessment

U.S. fish community evaluations were conducted by the TPWD Freshwater Studies Program. Boat electrofishing and seining were employed in tandem at all mainstem sites as well as at sites on selected tributaries (Figure 1). The goal was to collect a representative sample of the fish species present in proportion to their relative abundances. Attempts were made to sample all major habitat types in a study reach. Electrofishing was conducted with a boat-mounted, boom electrode powered by a 7.5 kV generator producing pulsed DC current. Duration was at least 15 minutes per site, with sampling occurring in a downstream direction. Attempts were made to net all observed fish. As a complementary technique, seining was typically used to sample habitats where boat electrofishing would not be as effective (*e.g.*, shallow riffles and bars). Two straight seines were used for most collecting: 30 feet by 6 feet by 1/4 inch delta weave mesh and 15 feet x 6 feet x 3/8 inch delta weave mesh. The number of seine hauls depended on available habitat and varied from four to 11. All fishes collected by both methods were examined for deformities, lesions, and tumors. Seine samples and voucher specimens of larger fishes were fixed in 10% formalin and later transferred to 75% ethanol. Fishes were identified or field identifications were verified in the laboratory employing a variety of references, including Hubbs *et al.* (1991). Common and scientific names follow Robins *et al.* (1991).

Several approaches were used to evaluate the fish community for potential anthropogenic influences, and reflect different levels of screening. An initial screen was provided by descriptively evaluating the occurrence of species in this study and determining whether patterns of presence or absence of fish species indicated any long-term trends. That evaluation was followed by comparisons to historic data. A second level screen involved evaluating species richness and composition and then employing a similarity index, a measure of the similarity of species composition between two sampling sites (Odum, 1971). This index varies from zero, with no species in common between sites, to 1.0, with all species in common. The equation employed was:

$$S = 2C / (A + B),$$

where S = index of similarity, A = number of species in sample A, B = number of species in sample B, and C = number of species common to both samples. Given the fact that the study design employed sites upstream and downstream from major sister cities, any substantial change in species composition between the samples could indicate impacts (in the absence of sampling bias or physical habitat related differences). A third level of screening involved calculating a community index derived from the Index of Biotic Integrity (IBI) presented by Karr *et al.* (1986), and evaluating individual metrics as well as observing the cumulative score.

Developing an IBI type index for the Rio Grande/Río Bravo and its tributaries was problematic given the wide range of habitats, faunal changes, and hydrologic modifications encountered over the more than 2,000 km (1,243 miles) of river covered by the study. Despite these problems, an attempt was made to present a preliminary IBI, though much more emphasis was placed on interpretation of individual metrics than the total score. These metrics should be considered provisional until they can be applied to additional data sets to determine if they respond in a predictable fashion to direct or indirect impacts to the fish community. Two different series of IBI metrics were calculated corresponding to communities identified through preliminary analysis of faunal patterns. These groupings encompassed the following areas: mainstem Rio Grande/Río Bravo upstream of International Falcon Reservoir and tributaries including the Río Conchos, Pecos River, Devils River, San Felipe Creek, Río San Rodrigo, and Río Escondido (stations 1-12, 3a, 6a, 6b, 7b, 8c, and 9b); and the mainstem Rio Grande/Río Bravo downstream of International Falcon Reservoir and including Arroyo Los Olmos (12-18, 12d). More indices could have been derived given the differences noted by Hubbs *et al.* (1977) upstream and downstream of the Río Conchos and the distinct fauna found in the tributaries. However, since the goal of this effort was to evaluate communities relative to the potential presence of toxic chemicals, it was appropriate to simplify the criteria and employ only one set of metrics for the entire area above International Falcon Reservoir. This approach was reinforced by the overall study design, which emphasized differences between sites upstream and downstream of major sister cities rather than a longitudinal comparison of all sites. Furthermore, the middle river tributaries (3a, 6a, 6b, 7b, 8c, and 9b) comprise distinct habitats and were analyzed separately from the mainstem sites. In summary, IBI scores were not and should not be compared among these groups since the composition and rationale of the metrics as well as the habitats varied widely.

This IBI was substantially modified from Karr *et al.* (1986) given the variation of Rio Grande/Río Bravo fish communities from those in the midwestern United States from which the index was originally developed. Modifications were based upon examination of this data set, suggestions by Karr *et al.* (1986) and Miller *et al.* (1988), and previous experience in applying IBI to Texas streams (Linam and Kleinsasser, 1987; Kleinsasser and Linam, 1989; Hornig *et al.*, in press). Criteria were developed using historical data (Trevino-Robinson, 1959; Hubbs *et al.*, 1977; Edwards and Contreras-Balderas, 1991), a summary of fauna in the Rio Grande/Río Bravo basin (Smith and Miller, 1986), and data from a project designed to develop biological criteria for stream communities within the state's ecoregions (Bayer *et al.*, 1992).

The metrics employed for the mainstem upstream of International Falcon Reservoir and the Río Conchos are summarized in Table 5 along with the rating criteria. The number of metrics was much reduced from that proposed by Karr *et al.* (1986), with only three of the original ones being employed in this study. The original metrics were the total number of species, total number of individuals, and percentage of diseased individuals. Though Miller *et al.* (1988) caution against reducing the number of metrics, the Rio Grande/Río Bravo fauna is somewhat depauperate and cannot be appropriately evaluated using simple modifications. Consequently, we followed the approach of Moyle *et al.* (1986), who used a reduced series of metrics to evaluate the depauperate fauna of the Sacramento-San Joaquin drainage in California.

Metrics evaluating the contribution of percids, centrarchids, and catostomids were eliminated in favor of a single metric representing the number of minnow species other than the introduced common carp. Centrarchids and percids were eliminated because native species from those groups are fewer in the Rio Grande/Río Bravo when compared to the fauna of more eastern drainages (Smith and Miller, 1986). Suckers are also somewhat depauperate in the mainstem of the Rio Grande/Río Bravo, with only four species being commonly collected and those species having differing responses to man-induced environmental stress. Cyprinid species have historically been species rich throughout the Rio Grande/Río Bravo basin and dominated the diversity of the Rio Grande/Río Bravo ichthyofauna (Smith and Miller, 1986). We have observed them to be reliable indicators of environmental change in our other studies of Texas streams and rivers (Linam and Kleinsasser, 1987; Kleinsasser and Linam, 1989). Hughes and Gammon (1987) used cyprinids as a target group in an IBI study of the Willamette River in Oregon, citing the responsiveness of that family to deterioration of habitat structure (see also Minckley, 1973; Moyle, 1976). Ramsey (1968) proposed that many species in the minnow family could be good indicators of water quality, though he cautioned that specific habitat requirements for many species are unknown.

Metrics relating to tolerance were eliminated given the naturally harsh environmental conditions in the Rio Grande/Río Bravo basin. The number of intolerant species and proportion of green sunfish [=tolerant species (Karr *et al.*, 1986)] were replaced with a single metric, the percentage of individuals in the most abundant species, as an indication of whether a single species was dominating the fish community at a site.

The hybrid metric (Karr *et al.*, 1986) has rarely provided much information about degradation in previous studies employing IBI in Texas and was replaced in this study with the percentage of individuals as introduced species. Miller *et al.* (1988) indicated that the hybrid metric has been difficult to apply in most regions and reviewed the problems associated with it. Use of a metric dealing with introduced species provides another means of evaluating perturbations, since these species may become populous in altered habitats. This metric has previously been used by Crumby *et al.* (1990), and, as cited by Miller *et al.* (1988), the proportion of introduced individuals often increases with increasing habitat degradation (see Moyle and Nichols, 1973; Courtenay and Hensley, 1980; Leidy and Fielder, 1985). Hubbs (1982) indicates that the survival of exotics can be enhanced by other perturbations and used impoundments as an example. The term "introduced species" as employed here, refers to species not native to the Rio Grande/Río Bravo basin, recognizing, however, that certain species native to the basin such as inland silverside (*Menidia beryllina*) have increased their ranges through introductions. The status (introduced or not) of the species we collected are listed in Table 6 and result from consulting Hubbs (1982), Smith and Miller (1986), and Hubbs *et al.* (1991).

Trophic metrics--proportion of insectivorous cyprinids, proportion of top carnivores, and proportion of omnivores--were not employed because of concerns about collecting fishes in their relative abundances in a large, turbid river system.

Metrics and criteria used to evaluate the mainstem Rio Grande/Río Bravo downstream of International Falcon Reservoir, and Arroyo Los Olmos, are listed in Table 5. They are similar to those used on the upstream reach of the river, but were modified to take into account the

proportionate numbers of euryhaline species that have become common downstream. Consequently, a metric was added to account for the percentage of the sample as estuarine/marine species. Designation of these species is listed in Table 6 and follows Edwards and Contreras-Balderas (1991), though estuarine and marine species were combined into one group. Criteria were adapted from historical information in Trevino (1955) and summarized in Edwards and Contreras-Balderas (1991). This metric measures the species shift from the native, riverine community to one increasingly represented by euryhaline species. The number of minnow species was eliminated, recognizing that they were historically an important group in the lowermost reach. However, all sites downstream of International Falcon Reservoir would have scored poorly using that metric, making it insensitive in differentiating between sites. In addition, it was beneficial to keep the number of metrics the same in upstream and downstream reaches. However, if the primary intent of the study had been to consider historical changes in the fauna, it would have been included.

Though it departs from the conventions of others (Trevino-Robinson, 1959; Hubbs *et al.*, 1977; Smith and Miller, 1986; and the description of the Study Area in the present report), in discussing fish communities the upper reach is defined as the area upstream of International Amistad Reservoir; the middle reach, the area from International Amistad Dam to International Falcon Reservoir; and the lower reach, the area from International Falcon Dam to the mouth.

Finally, it should be noted that a single sample evaluation of the fish community can provide an indication of potential problems, but only at a screening level. In short, further sampling and evaluation would be needed to validate and define the extent of potential problem sites noted in this study.

RESULTS AND DISCUSSION

Sampling was accomplished through four field surveys: El Paso/Ciudad Juárez to Big Bend National Park/San Vicente, November 11-15, 1992; Rio Grande City/Camargo to Brownsville/Matamoros, January 11-14, 1993; Langtry/San Ignacio to Eagle Pass/Piedras Negras, February 8-12, 1993; and Eagle Pass/Piedras Negras to Rio Grande City/Camargo, March 22-26, 1993. Sampling dates for individual sites are presented in Table 10. Survey sequence was based on prevalence of favorable weather and hydrological conditions.

The study focused on instream conditions associated with low flow. As such, demonstrable instream effects primarily reflected influences by point source discharges. Instream flows (Table 10) were within targeted ranges at 18 of the 19 Rio Grande/Río Bravo sampling sites. Flow at station 13, (Rio Grande/Río Bravo at Los Ebanos/Valadeces), was about four times the preferred level, due to releases from International Falcon Reservoir. Despite a request, the release could not be shut down because of irrigation needs in México. The existence of high flow downstream from International Falcon Reservoir was not considered a major detriment. Station 13, the only sampling site in the affected reach, was an upstream control site where no appreciable toxic chemical-related problems were anticipated. Most of the flow there would have consisted of water released from International Falcon Reservoir, whether the discharge had been 28 or 113 cms (1,000 or 4,000 cfs). In addition, most of the water released from the reservoir was being diverted at International Anzalduas Dam, and desired low flow conditions were prevalent at the remaining survey sites.

There were slight differences in the analytical results between the two countries, possibly as a result of the differences in methodology and instrumentation.

Conventional Water Quality

Previous information (TNRCC, 1992a) and data from the present study (Table 10) were reviewed to provide an indication of conventional water quality. CNA also has conducted water quality analyses based on physical, chemical, and bacteriological parameters from 1976 to 1993. An evaluation of this data is found in Appendix D.

Mainstem

TNRCC (1992a) summarized ten years of U.S. water quality data (1982-1991) for 12 Rio Grande/Río Bravo monitoring sites that bracket six major U.S./México sister cities. Potential human health risks due to bacteriological contamination were evident for five of the six downstream sites. Nutrient concentrations were somewhat elevated in these same areas. Inflows of treated and untreated sewage and nonpoint source runoff from the sister cities were considered responsible. Average dissolved oxygen concentrations, however, exceeded 5 mg/L throughout the longitudinal gradient, with no major depressions at sites downstream from the sister cities. Only 16 of 1,257 instantaneous dissolved oxygen measurements, or about 1%, were less than 5 mg/L. Most of the depressed values occurred at the site upstream from Presidio/Ojinaga, and in the reach downstream from International Falcon Reservoir, and were attributed mainly to

sluggish current velocity/low atmospheric reaeration rates associated with extreme low flows. One other item of potential concern involved periodic exceedances of total dissolved solids criteria upstream from Presidio/Ojinaga and downstream from Brownsville/Matamoros.

Data from the present study for chloride, sulfate, total dissolved solids, pH, temperature, and dissolved oxygen were evaluated using Texas Surface Water Quality Standards (TNRCC, 1991). Criteria were not achieved in only two instances, as chloride and total dissolved solids were elevated at station 3, and sulfate and total dissolved solids at station 18, the same sites where occurrences of this type have previously been documented by TNRCC (1992a). Dissolved oxygen concentrations were greater than 5 mg/L at all sites. Total organic carbon data were reviewed as an indicator of organic enrichment. Levels were relatively low at all sites, ranging from 3-11 mg/L. Concentrations at ten of the 19 sites were 5 mg/L or less.

Thus, indications are that conventional water quality in the Rio Grande/Río Bravo is reasonably good, except for locally elevated levels of fecal coliform bacteria, nutrients, and total dissolved solids. The river evidently is able to assimilate the oxygen-demanding load it receives without the development of substantial dissolved oxygen depression.

CNA evaluated water quality in the Rio Grande/Río Bravo from 1976 to 1993, (Appendix D). CNA obtained results similar to TNRCC's relative to the quality of the waters of the Rio Grande/Río Bravo during this period.

Tributaries

Data for the same parameters mentioned above were evaluated to provide an indication of conventional water quality in the tributaries that were sampled (Table 10). The lower Pecos River (6a), Devils River (6b), and San Felipe Creek (7b) are designated segments, and are governed by specific water quality criteria (TNRCC, 1991). All conventional parameter criteria were achieved at these sites, except in the Pecos River where chloride and sulfate levels were slightly elevated.

Nondesignated segments are presumed to support a high aquatic life use and are expected to meet a 5 mg/L minimum dissolved oxygen concentration (TNRCC, 1991). Of the 23 tributaries in this category, four exhibited dissolved oxygen concentrations less than 5 mg/L (2a, Ciudad Juárez sewage discharge canal; 9a, unnamed tributary 3.6 km (2.2 miles) downstream from Piedras Negras; 11c, Arroyo el Coyote; 15a, Anhelito Drain). The observed concentrations were noteworthy in light of the season of occurrence and prevalence of low water temperatures, and reflected a potential for anoxic conditions during summertime. These four tributaries transport domestic effluent from Ciudad Juárez, Piedras Negras, Nuevo Laredo, and Reynosa, respectively.

Five of the 23 sites exhibited total organic carbon concentrations greater than 20 mg/L, including the four just mentioned, plus station 11a (Zacate Creek). The concentrations ranged from 22-49 mg/L, reflecting a degree of organic enrichment. Organic loading to the mainstem appears minimal for 9a and 11c, which had inflow volumes less than 0.06 cms (2 cfs), slight for 15a

(0.45 cms or 16 cfs), and substantial for 2a (1.7 cms or 61 cfs). At the first mainstem sites downstream from these tributaries, only the one below 2a (station 3) exhibited a total organic carbon concentration perceptibly above baseline levels.

Four of the 23 sites exhibited total dissolved solids concentrations that were elevated compared to the maximal level observed in the mainstem (1,820 mg/L at station 3) (10a, Manadas Creek; 11b, Chacon Creek; 12a, Río Salado; 12d, Arroyo Los Olmos). The Pecos River (station 6a) also was in this category, although the criterion for that segment was not exceeded. The recorded levels (2,920-7,480 mg/L) would be expected to have deleterious effects on freshwater aquatic life. Three of these tributaries (10a, 11b, 12d) appeared to contribute little total dissolved solids to the mainstem, as corresponding flows were less than 0.06 cms (2 cfs). The opposite appeared true for the other two (6a, 12a), as their flows were substantial (6.2 and 1.0 cms, or 218 and 37 cfs, respectively).

In conclusion, conventional water quality in tributaries generally was good, with several exceptions.

Toxic Chemicals in Water

U.S. water samples from all 45 stations were analyzed for toxic chemicals. Thirty-five of the 153 toxic chemicals for which valid analytical results were generated occurred at detectable levels (Tables 10 and 13). Seventeen of the 35 exhibited possible screening level exceedances (Table 14). These, together with the number of sites involved, were: un-ionized ammonia (4); residual chlorine (2); parachlorometa cresol (1); phenol (1); phenolics recoverable (1); chloroform (1); antimony (1); arsenic (9); chromium (1); mercury (2); selenium (8); silver (5); thallium (1); diazinon (2); bis(2-ethylhexyl) phthalate (1); diethyl phthalate (1); and cyanide (2).

Mainstem

The number of toxic chemicals detected by U.S. data ranged from two at stations 9, 10, and 15 to eight at station 2. At 16 of the 19 sites, five or fewer toxic chemicals were detected (Table 13).

U.S. data indicated elevated toxic chemical concentrations were uncommon in the mainstem (Table 15). There were only six instances where possible screening level exceedances occurred, involving five toxic chemicals (Table 14): residual chlorine, acute and chronic, station 2; arsenic, national 85th percentile, stations 4 and 5; selenium, chronic, station 11; silver, acute and chronic, station 12; and cyanide, chronic, station 14. No station exhibited elevated concentrations for more than one chemical.

The presence of residual chlorine at station 2 (downstream from El Paso/Ciudad Juárez) probably contributed to the impoverished condition of the macrobenthic community at the site. Although the concentration was too low to quantify, it probably was greater than the acute

aquatic life criterion, in light of chlorine's extreme toxicity. The primary source was the El Paso Public Service Board Haskell R. Street wastewater treatment plant discharge (station 1a), which enters 13.8 km (8.6 miles) upstream. The effluent, which is chlorinated for disinfection purposes, contained a residual chlorine concentration of 1.2 mg/L, and the discharge volume was substantial (1.3 or 45 cfs, equivalent to 24% of the flow at station 2).

Arsenic levels at stations 4 (downstream from Presidio/Ojinaga) and 5 (mouth of Santa Elena Canyon), 14.4 and 15.8 $\mu\text{g/L}$, respectively, did not appear to be impacting the river. There were no significant effects in the toxicity tests, and resident fish and macrobenthic communities were healthy. This is not surprising, since the screening level that was exceeded, the national 85th percentile, is not based on biological effects. Both concentrations were far less than the chronic aquatic life criterion of 190 $\mu\text{g/L}$. The principal source of arsenic evidently was the Río Conchos (station 3a), which enters 18.7 km (11.6 miles) upstream from station 4. That tributary exhibited the highest arsenic level in the study (20.6 $\mu\text{g/L}$), and contributed a large volume of inflow (15 cms or 530 cfs, equivalent to 66% of the flow at station 4). Alamito Creek (station 3b), entering 0.6 km (0.4 miles) upstream from station 4, contained 10.6 $\mu\text{g/L}$ of arsenic. However, its contribution was negligible, in light of the low inflow volume (0.03 cms or 1.1 cfs, equivalent to 0.1% of the flow at station 4).

Arsenic in surface waters is primarily derived from natural processes (dissolution of arsenates from metallic ore-bearing rocks; soil erosion), air pollution (fossil fuel combustion), industrial wastewaters, and arsenical pesticides (Irwin, 1989; McKee and Wolf, 1963). Arsenic levels at stations 4 and 5 appear to be naturally-derived to an extent, judging from the somewhat elevated level in Alamito Creek, a minimally-impacted stream, plus the fact that the concentration at station 5 was slightly higher than at station 4, despite an absence of likely anthropogenic inputs through the intervening reach. Baseline concentrations in the Río Conchos may be similarly derived; however, the presence of arsenical pesticides entering in agricultural runoff may be responsible for the magnitude of the concentration that was observed there. The Río Conchos in the past has been shown to contribute other agriculturally-derived pesticides to the Rio Grande/Río Bravo (TNRCC, 1992a).

The slight exceedance of the chronic aquatic life criterion by selenium at station 11 (above Laredo/Nuevo Laredo) did not appear ecologically important, as no adverse impacts were indicated by toxicity testing or bioassessment results. There were no obvious sources of selenium that would have affected the site. Although this was the only mainstem station where selenium was elevated, seven tributaries had concentrations that exceeded screening levels. Interestingly, six of these eight sites, including station 11, were geographically clustered from just upstream of Laredo/Nuevo Laredo to Rio Grande City/Camargo.

Selenium occurs at naturally high levels in soils in other parts of the United States. It has numerous industrial applications, and may be present in industrial wastewaters. Other potential sources include atmospheric fallout from coal-fired power plant emissions (including washoff from land surfaces where fallout is deposited), municipal sewage from industrial communities, and insecticide sprays (Irwin, 1989; McKee and Wolf, 1963).

The concentration of silver at station 12 (downstream from Laredo/Nuevo Laredo) was greater than acute and chronic aquatic life criteria; whether this was an actual exceedance is uncertain, because the criteria are based on the free ion form while the measured concentration represented total dissolved silver. Nevertheless, a possibility exists that the observed silver concentration may have been partially responsible for depressed fish and macrobenthic community integrity at the site. There were no conspicuous sources, as levels in the three proximal, upstream tributaries that were sampled (stations 11a, 11b, 11c) were below detection. However, there are a number of other inflows between stations 11 and 12 (Buzan, 1990) that could have been involved.

Silver generally does not occur in significant concentrations in natural waters. Various forms of silver have industrial applications, including the production of jewelry, silverware, metallic alloys, and ink; for electroplating; in the processing of food and beverages; and in photography. Silver in surface waters typically is derived from wastes generated by these processes (McKee and Wolf, 1963).

Although the cyanide concentration at station 14 (downstream from International Anzalduas Dam) was greater than the chronic aquatic life criterion, no appreciable impacts were evident. There were no significant effects in the toxicity tests, and resident macrobenthic and fish community integrity was relatively high (although fish exhibited a slightly elevated incidence of physical abnormalities). Regarding sources, there were no obvious inputs that would have contributed cyanide to the site. Cyanide enters surface waters in effluents from gas works, coke ovens, gas-scrubber processes of steel mills, metal cleaning/electroplating operations, and chemical industries (McKee and Wolf, 1963).

Tributaries

U.S. data indicates toxic chemicals were more prevalent in tributaries than in the mainstem. This is not surprising since some of the tributaries transport wastewater in relatively undiluted form. The number of toxic chemicals detected ranged from one at station 8d to 17 at station 1a. More than five toxic chemicals were detected at eight of the 26 sites (Table 13).

There were 37 instances where screening levels possibly were exceeded, involving 17 toxic chemicals (Table 14): un-ionized ammonia, acute and chronic, station 2a; chronic, stations 7a, 9a, and 11c; residual chlorine, acute and chronic, station 1a; parachlorometa cresol, national 85th percentile, station 2a; phenol, national 85th percentile, station 2a; phenolics recoverable, national 85th percentile, station 2a; chloroform, national 85th percentile, station 1a; antimony, human health and national 85th percentile, station 10a; arsenic, human health, stations 1a, 2a, 9a, 11c, and 15a; national 85th percentile, stations 3a and 3b; chromium, chronic, station 12a; mercury, human health, stations 2a and 15a; selenium, chronic, stations 5a and 11a; chronic and national 85th percentile, station 11c; human health, chronic, and national 85th percentile, stations 9b, 12a, 12b, and 12c; silver, acute and chronic, stations 7b, 8a, 8b, and 8e; thallium, human health, station 10a; diazinon, acute and chronic, stations 11a and 12d; bis(2-ethylhexyl) phthalate, chronic and national 85th percentile, station 11c; diethyl phthalate, chronic, station 15a; and cyanide, chronic, station 12d. The number of chemicals that occurred at elevated

Chlordane was detected at five sites. A substantial concentration occurred at station 1a (El Paso Public Service Board Haskell R. Street wastewater treatment plant effluent), although it did not exceed the aquatic life threshold value. Threshold values were exceeded at the other four sites (11a - Zacate Creek; 11b - Chacon Creek; 11c - Arroyo el Coyote; 15a - Anheló Drain). Stations 11a and 11b evidently were not adversely affected, as no significant effects occurred in sediment eluate toxicity tests. The opposite was true for stations 11c and 15a, and chlordane appeared to be a primary factor. It may also have been partially responsible for the apparent absence of fish from Anheló Drain. Likely sources of chlordane were urban runoff from Laredo (11a, 11b), and a combination of urban runoff and domestic effluent from Nuevo Laredo (11c) and Reynosa (15a). None of the tributaries appeared to affect the Rio Grande/Río Bravo, as chlordane was below detection at all mainstem sites.

DDE levels in excess of the national 85th percentile at stations 10a (Manadas Creek), 11a (Zacate Creek), and 12d (Arroyo Los Olmos) did not appear to have adverse impacts, as no significant effects were observed in the sediment eluate toxicity tests. Contributions to the Rio Grande/Río Bravo were imperceptible, as no elevated DDE concentrations occurred anywhere in the mainstem.

Dieldrin exceeded the national 85th percentile by a slight margin at station 11a (Zacate Creek). Implications for local impact and effects on the mainstem were the same as for DDE.

Two phthalate esters occurred at elevated concentrations: bis(2-ethylhexyl) phthalate at station 11c (Arroyo el Coyote), and di-n-butyl phthalate at station 12d (Arroyo Los Olmos). National 85th percentiles were exceeded by factors of 7.3X and 6.9X, respectively. Bis(2-ethylhexyl) phthalate was considered a potential cofactor in the manifestation of sediment eluate toxicity at station 11c. No such effects were evident for di-n-butyl phthalate at station 12d. Inputs to the Rio Grande/Río Bravo appeared negligible, as neither chemical exceeded screening levels in the mainstem.

Toxic Chemicals in Fish Tissue

Fish tissue samples from the 18 major mainstem sites and six tributaries were analyzed for toxic chemicals (Table 12). In all, 94 tissue samples were collected, including 45 fillet samples and 49 whole fish samples. Of the 140 toxic chemicals for which valid analytical results were obtained, 29 occurred above detection limits, including 16 organic chemicals and 13 inorganic chemicals (Table 13). Twelve toxic chemicals exceeded screening levels (Table 14). These, together with the number of sites involved, were: cadmium (1); chromium (6); copper (20); lead (2); mercury (17); selenium (23); zinc (14); chlordane (1); total DDT (5); dieldrin (2); gamma-bhc (lindane) (1); and total PCB's (6).

Copper, selenium, and zinc were above detection limits in all U.S. samples, and p,p' DDE was detected in most samples (Table 13). Aluminum, arsenic, cadmium, chromium, mercury, and nickel were detected in more than half of the samples. Methylene chloride, lead, and thallium were occasionally detected. Chlordane, p,p' DDD, arochlor 1248, arochlor 1254, cyanide, and silver were infrequently detected. The remaining chemicals rarely occurred at detectable levels.

Several organic chemicals for which no screening criteria are available were detected (Table 13). Possible sources include field or laboratory contamination of samples, chlorinated municipal effluent, and industrial effluent.

Methylene chloride was detected in 27 samples. It has been documented as a field contaminant of water and sediment samples (USEPA, 1982), and has been identified as a possible laboratory contaminant by TDH staff. It is commonly used as an organic solvent, and is a constituent of chemical paint strippers. Methylene chloride was detected in samples from stations 6, 6a, 6b, 7, 8, 8d, 9, 9b, 10, 11, 13, 14, 15, 17, and 18. It was not detected in water or sediment at any of these sites. No municipal or industrial effluent influences are present at a number of these sites, and it is likely that most of the methylene chloride detected in tissue was an artifact of laboratory contamination.

Toluene was detected in three samples collected downstream from Laredo/Nuevo Laredo (station 12) and downstream from Hidalgo/Reynosa (station 16). At station 12, the concentration in sediment exceeded the aquatic life threshold value. However, toluene was not detected in water or sediment at station 16. Toluene is a solvent associated with industrial effluent, is a component of petroleum products, and can be a field or laboratory contaminant (USDOE, 1993).

1,2-dichlorobenzene was detected in four samples. It can occur as a result of mixing of chlorinated effluent and organic compounds, such as benzene, in the water column (USEPA, 1982; Joel Lusk, U.S. Fish and Wildlife Service, personal communication). This contaminant was detected only at station 2 (downstream from El Paso/Ciudad Juárez), in whole body and fillet samples of carp and channel catfish. Although 1,2-dichlorobenzene was not detected in water or sediment from that site, it was present in water and sludge from station 1a, the El Paso Public Service Board Haskell R. Street wastewater treatment plant outfall, located 13.8 km (8.6 miles) upstream. Thus, the discharge from that facility may contribute to body burdens at station 2.

The remaining parameters were detected in only one or two samples, including chloroform downstream from Hidalgo/Reynosa (station 16); trichlorofluoromethane downstream from International Anzalduas Dam (station 14) and downstream from Brownsville/Matamoros (station 18); and 1,1,1-trichloroethane at the mouth of Santa Elena Canyon (station 5). These chemicals are potentially associated with the combination of chlorinated municipal effluent and organic compounds in water, and stations 16 and 18 are downstream of cities. None of them were detected in water or sediment from the sites listed. Also, they are possible field or laboratory contaminants, so their presence may not reflect actual concentrations in fish tissues (USEPA, 1982; USDOE, 1993).

Hexachlorobenzene was detected in one sample collected downstream from Laredo/Nuevo Laredo (station 12). It is used as a pesticide, and also occurs as a breakdown product of and impurity in other pesticides. Additionally, it may be generated as a byproduct during the chlorination of wastewater (USEPA, 1992; Cain, 1993). It was not detected in water or sediment at station 12.

The last of the organic chemicals for which no screening levels exist, bis(2-ethylhexyl) phthalate,

was measured at 99 mg/kg (99 times the detection limit) in a sample from station 4 (downstream from Presidio/Ojinaga). It generally is derived from industrial effluent, but may also be a field or laboratory contaminant associated with plastic (USDOE, 1993; Verschuieren, 1983). The fact that it was not detected in water or sediment from station 4 suggests that sample contamination may have been responsible for the occurrence.

Edible Fish Tissue

Data from fillet samples were evaluated for potential human health risks using USFDA action or tolerance levels, USEPA screening levels, and TDH risk assessment values (Table 7). No USFDA action or tolerance levels were exceeded. However, there were a number of instances where USEPA fish tissue values were exceeded, and one instance where the TDH risk assessment value for selenium was exceeded (Table 14).

Total DDT and total PCB concentrations exceeded USEPA fish tissue values in 11.1% and 13.3% of the fillet samples, respectively. Because the detection limit for PCB's (0.04 mg/kg) is greater than the USEPA value (0.01 mg/kg), the number of samples shown to exceed the screening level may be conservative. Mercury and dieldrin screening values were exceeded twice, and chlordane and selenium screening levels once. Possible sources of these contaminants include irrigation return flows/agricultural runoff (DDT, dieldrin, selenium), nonpoint sources in urban areas (chlordane, PCB's), and nonpoint sources related to previous land use, including mining, coal-fired power plants, and waste disposal sites (mercury, selenium, PCB's).

Elevated pesticide and PCB concentrations were noted only in blue catfish, channel catfish, and carp. As these chemicals are lipophilic, they are more likely to bioaccumulate in fish with higher lipid content, such as carp and catfish (Kanazawa, 1981; Irwin, 1988; Inmon *et al.*, 1993). Metals, however, were elevated in largemouth bass and white bass at a limited number of sites.

Dieldrin exceeded the USEPA fish tissue value upstream from Del Rio/Ciudad Acuña (station 7) and in San Felipe Creek (station 7b). Although not produced in or imported to the U.S. since 1985, dieldrin continues to enter aquatic systems in agricultural runoff (USEPA, 1992). Total PCB's also exceeded the USEPA value at these two sites, as well as further downstream, below Del Rio/Ciudad Acuña (station 8), and upstream and downstream from Eagle Pass/Piedras Negras (stations 9 and 10). PCB's have been used extensively as lubricants, insulators, and coolants, and occur in the environment throughout the U.S. (Eisler, 1986a; USEPA, 1992). Neither chemical was detected in water or sediment from these sites.

Total DDT exceeded the USEPA fish tissue value upstream from the Río Conchos confluence (station 3), in the Río Conchos (station 3a), upstream from Del Rio/Ciudad Acuña (station 7), and in San Felipe Creek (station 7b), then in the lower reaches of the mainstem, downstream from International Anzalduas Dam (station 14), downstream from Hidalgo/Reynosa (station 16), and upstream from Brownsville/Matamoros (station 17). DDT or its metabolites, DDE and DDD, were detected in sediment samples from stations 2a and 3a. Large volumes of irrigation return flow which enter the river via the Río Conchos and downstream from International

Anzalduas Dam are the probable source of pesticide residues in fish tissue (Gamble *et al.*, 1988; Irwin, 1989; TNRCC, 1992a; USEPA, 1992).

Mercury exceeded the USEPA fish tissue value in the Rio Grande/Río Bravo upstream and downstream from Hildago/Reynosa (stations 15 and 16). It was detected in water and sediment from Anhelito Drain (station 15a), with the concentration in water exceeding human health criteria. Mercury input from that tributary may contribute to tissue residues at stations 15 and 16.

Selenium exceeded the TDH risk assessment value only at station 6, near Langtry/San Ignacio. The concentration in sediment also was substantial (2.23 mg/kg); although screening levels were not exceeded, the value was greater than 1-2 mg/kg, the background level for aquatic sediments identified by Eisler (1985) and Lemly (1985). Chlordane also exceeded the screening level (USEPA fish tissue value) at one site, downstream from Laredo/Nuevo Laredo (station 12). Chlordane was detected in sediment from several proximal tributaries (stations 11a, 11b, and 11c), and associated inputs probably are at least partially responsible for elevated chlordane levels in fish tissue at station 12.

San Felipe Creek (station 7b) and the Río Conchos (station 3a) were the only tributaries where contaminant concentrations in fish tissue exceeded human health screening levels. Contaminant levels in fish from the El Paso/Ciudad Juárez and Big Bend areas did not exceed human health criteria, nor did residues in fish collected upstream from Laredo/Nuevo Laredo, upstream from International Anzalduas Dam, and in the Brownsville/Matamoros area.

The mainstem upstream from Del Rio/Ciudad Acuña (station 7) had three contaminants in edible fish tissue that exceeded human health screening levels (total DDT, total PCB's, dieldrin) (Figure 2). Fish from stations 3, 3a, 6, 7b, 8, 9, 10, 12, 14, 15, and 16 contained one or two contaminants that exceeded human health screening values. No exceedances occurred at the remaining sites.

Whole Fish Tissue

Two types of screening were used to evaluate data from whole fish tissue samples.

Body Burdens.—This evaluation phase utilized screening levels derived by USFWS (national 85th percentiles and national geometric means), USEPA (national means), and TNRCC (state 85th percentiles). Information from supplemental sources also was used. All screening values employed, and the sources from which they were adopted, are presented in Table 7. Appropriate screening values were not available for aluminum, nickel, silver, thallium, or cyanide.

Zinc exceeded the USFWS national 85th percentile in 14 instances (Table 14). Only whole carp samples were involved. Zinc is a component of fish scales, and fish with large scales typically contain substantial concentrations (Joel Lusk, USFWS, personal communication). Since zinc

was elevated only in samples where large scales were analyzed, the observed concentrations probably do not represent abnormally high levels.

Copper exceeded the USFWS national 85th percentile at most mainstem sites, and in all tributaries except the Río Conchos (Table 14). Copper generally was above detection limits in sediment, and in water was detected at nine mainstem sites and 11 tributaries. Copper is associated with mining, plumbing, and electrical industries (Phillips and Russo, 1978; Moore and Ramamoorthy, 1984; USEPA, 1985b). As many of the tributaries are dominated by springflow, the copper levels in fish tissue may be a result of naturally elevated concentrations in water and soil.

Selenium exceeded the USFWS national 85th percentile in two reaches of the river. The first was from upstream of the Río Conchos confluence (station 3) to upstream of Del Rio/Ciudad Acuña (station 7), including three tributaries, the Río Conchos, Pecos, and Devils rivers (stations 3a, 6a, 6b). Concentrations again were high at sites upstream from Laredo/Nuevo Laredo, upstream from International Anzalduas Dam, and upstream from Hidalgo/Reynosa (stations 11, 13, 15). Levels were highest in the mainstem from station 3 to station 7, and in the Río Conchos.

Selenium concentrations in sediment exceeded 2 mg/kg at stations 1a, 5, 6, 10, 11c, 12, and 12d. Selenium was detected at lower concentrations at stations 1a, 5, 5a, 5b, 6a, 11, 12a, 12b, and 12c. In addition, concentrations in water exceeded the aquatic life chronic criterion at stations 5a and 11. These occurrences generally coincided with areas where selenium was elevated in fish tissue.

In rural areas, especially in the arid western U.S., the most likely source of selenium is irrigation return flows or runoff from agricultural land (Phillips and Russo, 1978; Presser and Barnes, 1985; CWRCB, 1988; TNRCC, 1992a). In urban areas, coal-fired power plants may contribute selenium, via air deposition of fly ash, or return of cooling waters associated with fly or bottom ash (Phillips and Russo, 1978; EPRI, 1986; Maier *et al.*, 1988).

Mercury concentrations occasionally exceeded the USFWS national 85th percentile, primarily in the lower half of the study area. Affected sites were upstream from Eagle Pass/Piedras Negras, the Río Escondido, upstream from Laredo/Nuevo Laredo, upstream from International Anzalduas Dam, and downstream from Hidalgo/Reynosa (stations 9, 9b, 11, 13, 16). The mercury concentration in water exceeded screening levels at station 15a, and concentrations in sediment were greater than 0.1 mg/kg at stations 9a, 10a, and 15a.

Mining for metals (including mercury) and coal historically has occurred through much of the Rio Grande/Río Bravo watershed (TNRCC, 1992a). The Mexican city of Piedras Negras ("black rock") is named for the abundant coal deposits in the area. Mercury is a trace contaminant associated with mining, and runoff from active or abandoned mining sites is a probable contributor of trace metals. Additionally, mercury may be associated with coal-fired power plants, discarded batteries, and discharges from older sewage treatment plants (Phillips and Russo, 1978; Eisler, 1987; TNRCC, 1992a; USEPA, 1992).

Lead exceeded the USFWS national 85th percentile upstream from Eagle Pass/Piedras Negras (station 9). Lead is a cumulative toxin, affecting growth, reproduction, development, metabolism, and behavior in multiple species. It is associated with atmospheric deposition from automobile exhausts and smelter stacks, discarded batteries and paints, and metal alloys (Phillips and Russo, 1978; Moore and Ramamoorthy, 1984; Irwin, 1988). It was not detected in water at the site, and was not elevated in sediment. Potential sources in the vicinity were not apparent.

Cadmium exceeded the USFWS national 85th percentile upstream from El Paso/Ciudad Juárez (station 1). Cadmium is associated with lead and zinc deposits, smelters, fossil fuels, and industrial wastes (Eaton, 1974; Brown and Lemay, 1977). It was not detected in water and was not elevated in sediment from the site. No potential sources were evident.

Aluminum concentrations generally were above detection limits (Table 13), and ranged from 1.9 to 797 mg/kg. Aluminum levels in fish are strongly influenced by the consumption of soil by bottom feeders, such as carp and catfish (Brumbaugh and Kane, 1985; Joel Lusk, USFWS, personal communication). Predatory species, such as largemouth bass, smallmouth bass, and white bass, never contained more than 3.2 mg/kg in this study. There was no apparent relationship between aluminum concentrations in sediment and whole fish. The concentrations that were observed in tissue did not appear to indicate environmental contamination.

Nickel concentrations ranged from 0.079 to 6.93 mg/kg, and were maximal (0.38 to 6.93 mg/kg) at stations 1, 2, 13, and 16. However, levels in other fish samples from the same sites were substantially lower. Intermediate concentrations (0.142 to 0.249 mg/kg) occurred in fish from stations 2, 3, 5, 6a, 6b, 7, 8, 8d, 9b, 11, 13, 14, and 15. Low concentrations (0.079 to 0.126 mg/kg) were found in fish from stations 1, 4, 6, 6a, 7, 7b, 8, 8d, 13, 14, 15, 16, and 18. Although nickel concentrations in sediment exceeded aquatic life threshold values at most sites (Table 14), there was no apparent correlation with levels observed in fish tissue. Potential sources of nickel include metal plating, alloys, and coal combustion (Phillips and Russo, 1978).

Silver was infrequently detected in whole fish (Table 13), with concentrations ranging from 0.035 to 0.088 mg/kg. A degree of clustering was evident, with detectable levels occurring upstream and downstream from Eagle Pass/Piedras Negras, in the Río Escondido, and upstream and downstream from Laredo/Nuevo Laredo (stations 9, 9b, 10, 11, 12). Additionally, both samples collected downstream from Hidalgo/Reynosa (station 16) contained detectable silver concentrations.

Although silver concentrations in water and sediment did not exceed screening levels at stations 9, 9b, 10, 11, or 16, the concentration in water at station 12 was high enough to potentially exceed acute and chronic aquatic life criteria (Table 14). Industrial effluents associated with metals, metal alloys, and electroplating are a potential source of silver (Phillips and Russo, 1978).

Thallium also was infrequently detected, with concentrations ranging from 0.038 to 0.053 mg/kg. It was found in fish from stations 7b, 8, 13, 15, and 16. Thallium is a byproduct of iron, cadmium, and zinc processing, is associated with alloys, and has been used as a rodenticide

and insecticide (Doull *et al.*, 1980). No water or sediment screening values for thallium were exceeded at these sites.

Cyanide was detected in two samples, from stations 7b and 14. The measured concentrations were 2.0 mg/kg, which is only slightly greater than the detection limit (1.0 mg/kg). Cyanide in water exceeded the acute aquatic life criterion downstream from International Anzalduas Dam (station 14), but elevated levels were not noted in water or sediment from station 7b.

Several organic chemicals exceeded screening criteria. Arochlor 1248 concentrations were greater than the USFWS national geometric mean upstream from Eagle Pass/Piedras Negras (station 9), and upstream from Laredo/Nuevo Laredo (station 11). PCB's were not detected in water or sediment from these sites. The sources of PCB's in tissue were not apparent.

Chlordane exceeded the TNRCC state 85th percentile in one sample collected downstream from Laredo/Nuevo Laredo (station 12). It was widely used in urban areas as a pesticide until sales were banned in the United States in 1988. However, it is highly persistent in the environment, and still sometimes occurs in reaches of rivers downstream from cities (USEPA, 1992). The probable source of chlordane at station 12 is urban/industrial runoff from Laredo/Nuevo Laredo.

Gamma-bhc (lindane) exceeded the USEPA national mean upstream from the Río Conchos confluence (station 3). It was not detected in water or sediment from that site. Although usage of this pesticide has been restricted in the U.S. since 1985, substantial agricultural activity in the area is the probable source (Irwin, 1989; TNRCC, 1992a; USEPA, 1992).

To summarize the occurrence of toxic chemicals based on body burden screening, five contaminants in fish tissue exceeded screening levels at station 9, four at station 11, and three at station 13 (Figure 3). Eleven sites exhibited screening level exceedances for two contaminants (1, 3, 4, 5, 6a, 6b, 7, 9b, 10, 12, 16), and ten sites for one contaminant (2, 3a, 6, 7b, 8, 8d, 14, 15, 17, 18).

Predator Protection Limits.—Whole fish tissue data were subjected to a second type of screening using predator protection limits (PPL's) (Table 7). These limits are maximum concentrations recommended by USFWS, USEPA, and others for protection of predatory fish and wildlife from the effects of ingesting contaminants in prey organisms.

For chromium, mercury, and selenium, PPL's are lower than 85th percentile values used in body burden screening. Thus, some values for these contaminants which did not exceed 85th percentiles did exceed PPL's. Also, the PPL for total PCB's is < 0.1 mg/kg; to be able to estimate exceedances, a value of 0.1 mg/kg was employed. Therefore, the potential for effects by PCB's on predatory species may be underestimated.

Selenium concentrations exceeded the PPL at every site except downstream from Brownsville/Matamoros (station 18). Selenium can affect reproduction in fish and predatory birds (Eisler, 1985; Lemly, 1985; Gillespie and Baumann, 1986; Ohlendorf *et al.*, 1986; Hoffman and Heinz, 1988; Ohlendorf, 1989). Although whole body concentrations of selenium were greater than the PPL throughout the system, highest concentrations were from upstream

of the Río Conchos confluence to Del Rio/Ciudad Acuña, and fish in that area may constitute a more serious threat to predators. See previous discussions regarding potential sources of selenium.

Similarly, mercury often exceeded the PPL. The only areas where concentrations were less than the PPL included sites upstream from the Río Conchos confluence (stations 1-3), on the Pecos and Devils rivers (stations 6a and 6b), downstream from Del Rio/Ciudad Acuña (station 8), and downstream from Brownsville/Matamoros (station 18). See previous discussions regarding potential sources, and occurrences in water and sediment at these sites.

Chromium occasionally exceeded the PPL. Concentrations in fish from the Pecos River, the Río Escondido, upstream and downstream from Laredo/Nuevo Laredo, downstream from International Anzalduas Dam, and downstream from Hidalgo/Reynosa were high enough to be a potential risk to fish-eating predators. Chromium was detected in water from several tributaries in these areas, including 6a, 9a, 12a, and 15a. Chromium levels in sediment from stations 11, 14, and 16 exceeded aquatic life threshold values. General sources of chromium include wastewater discharges from metal plating, chemical, power plant, and industrial facilities (Eisler, 1986b).

Total PCB's exceeded the PPL upstream from Eagle Pass/Piedras Negras and upstream from Laredo/Nuevo Laredo (stations 9 and 11). PCB's were not detected in water or sediment at these sites. There is extensive documentation regarding bioaccumulation of PCB's and subsequent effects on organisms. PCB's are persistent, bioaccumulative, and carcinogenic, and are known to cause reproductive failure in mammals (Parslow and Jefferies, 1973; Neidermyer and Hicky, 1976; Addison and Brodie, 1977; Eisler, 1986a; USEPA, 1992).

The PPL for lead was exceeded only downstream from El Paso/Ciudad Juárez (station 2). Lead was also elevated in sediment at that site, exceeding the aquatic life threshold value (Table 14). It also occurred at a high concentration in sludge from station 1a, the El Paso Public Service Board Haskell R. Street wastewater treatment plant outfall, located 13.8 km (8.6 miles) upstream, implicating that facility as a probable contributor of lead to station 2. See previous discussions regarding biological effects and potential sources.

To summarize indications of toxic chemical contamination from predator protection limit screening, the following sites had three or four contaminants that exceeded PPL's in whole fish tissue: upstream from Eagle Pass/Piedras Negras, the Río Escondido, upstream and downstream from Laredo/Nuevo Laredo, downstream from International Anzalduas Dam, and downstream from Hidalgo/Reynosa (stations 9, 9b, 11, 12, 14, 16) (Figure 4). Stations 2, 3a, 4, 5, 6, 6a, 7, 7b, 8d, 10, 13, and 15 had two contaminants that exceeded PPL's, while the remaining sites had zero or one (1, 3, 6b, 8, 17, 18).

Toxicity Testing

Toxicity testing was performed on water and sediment eluate samples from all 45 sites. The results are presented in Tables 14 and 15. Reference toxicant tests were conducted throughout

the study, the results of which were within established acceptable limits based on previous tests with the subject organisms (Terry Hollister, USEPA Laboratory-Houston, personal communication).

Mainstem

In toxicity testing of water, significant adverse effects were seen in only one instance. This involved the sample from station 1, where 100% mortality occurred in *Ceriodaphnia dubia*. As that site was the upstream control station for the El Paso/Ciudad Juárez reach, this occurrence was surprising. Five toxic chemicals were present at quantifiable levels, but none exceeded screening levels. Thus, no causative agent was identified. Local fish and macrobenthic communities were healthy, indicating that toxic impacts are not persistent. Supplemental data for the site suggest that the occurrence may have been an aberration, as no significant effects have been observed in periodic toxicity testing conducted since 1993 (Table 18).

Toxicity testing of sediment eluates also revealed only one instance of significant adverse effects. This was in the sample from station 12, downstream from Laredo/Nuevo Laredo, where 100% mortality occurred in fathead minnow embryo/larvae. Seventeen toxic chemicals were detected in sediment, the highest number for any mainstem station. Concentrations of methylene chloride, toluene, and nickel were in excess of aquatic life threshold values, and probably were at least partially responsible for the observed effects. However, other chemicals, acting synergistically or additively, may also have been involved. Fish and macrobenthic communities at the site were moderately impaired; the observance of sediment eluate toxicity indicates that toxic properties of local sediments were among the causative factors. Periodic toxicity testing since 1991 has documented two other instances of significant adverse effects, involving one water sample and one sediment eluate sample (Table 18).

A total of 114 toxicity determinations were made on mainstem samples (*Ceriodaphnia dubia* survival in water and sediment, *C. dubia* reproduction in water and sediment, and fathead minnow embryo/larval survival in water and sediment, at each of 19 sites). That significant effects occurred in only two of 114 possible instances was an important finding regarding toxic chemical impacts in the Rio Grande/Río Bravo, indicating that such effects are rare during low flow conditions.

Supplemental toxicity testing data, referenced for stations 1 and 12 above, exist for seven other mainstem locations (Table 18). Most of the sites are located below major sister cities, to monitor impacts in areas susceptible to toxic chemical contamination. In addition to occurrences mentioned for station 12, significant adverse effects have been seen in water and/or sediment eluate samples from stations 2, 4, and 10. Thus, a potential for toxic effects exists at those three sites, despite the fact that toxicity was not seen there during the present study.

Tributaries

Toxicity was much more prevalent than for the mainstem, as samples from 14 of the 26 stations produced significant adverse effects in at least one phase of the toxicity tests. The 14 affected sites are discussed individually below.

Station 1a, the El Paso Public Service Board Haskell R. Street wastewater treatment plant outfall, exhibited the most severe degree of toxicity in the study. One hundred percent mortality occurred in *Ceriodaphnia dubia* and fathead minnow embryo/larvae in both the water and sludge sample. Chemistry data for the water sample reflected the presence of 17 toxic chemicals, the highest number in the study. Residual chlorine, chloroform, and arsenic were elevated, but only the former exceeded an aquatic life screening level. The residual chlorine concentration was 63 times greater than the acute criterion, and undoubtedly was the main cause of water toxicity. In sludge, copper, mercury, selenium, silver, and zinc concentrations exceeded national 85th percentiles, and two other chemicals for which no screening levels exist occurred at comparatively high concentrations (parachlorometa cresol, phenol). Effects by copper, mercury, and zinc probably were negligible, as the observed concentrations were considerably less than aquatic life threshold values. Selenium and silver do not have threshold values; however, the margin by which they exceeded national 85th percentiles was slight for selenium (1.3X), but extreme for silver (11.8X). The parachlorometa cresol concentration was the second highest observed, while the detection of phenol was the only such occurrence in the study. Thus, among potential causes of toxicity in the sludge sample, selenium may have played a minor role, while silver, parachlorometa cresol, and phenol possibly had major involvement.

The water sample from station 2a, the Ciudad Juárez sewage discharge canal, induced 100% mortality in *C. dubia* and fathead minnow embryo/larvae. Twelve toxicants were detected, six of which exceeded screening levels (un-ionized ammonia, parachlorometa cresol, phenol, phenolics recoverable, arsenic, mercury). Un-ionized ammonia, the only one that exceeded an aquatic life screening level (at a concentration 2.6 times greater than the acute criterion), evidently was the primary causative agent.

One hundred percent mortality occurred in *C. dubia* in sediment eluate from station 3a, the Río Conchos. Twelve toxicants were detected in sediment. Arsenic, chromium, and nickel exceeded aquatic life threshold values and were potential causative agents. However, the arsenic concentration stood out, as the amount by which it exceeded the threshold value was the greatest in the study. The amounts by which chromium and nickel exceeded threshold values, on the other hand, were comparable to amounts for sites where sediment toxicity was not observed. Fish community integrity was relatively high at the site (although specimens exhibited a slightly elevated incidence of physical abnormalities), indicating that any instream toxic stresses that were being exerted were not appreciably affecting resident aquatic life.

In the water sample from station 6a, the Pecos River, *C. dubia* reproduction was significantly reduced. Five toxicants were detected, but none exceeded screening levels. The causative agent evidently was total dissolved solids, as the observed concentration approximated the range known to induce stress in *C. dubia* (Terry Hollister, USEPA Region 6 Laboratory-Houston, personal

communication). The local fish community was healthy, indicating that no appreciable instream impacts were occurring.

Ceriodaphnia dubia reproduction was also significantly reduced in samples from the next three sites. However, the effects probably were not ecologically important. The effect occurred in water and sediment eluate from station 6b, Devils River. Three toxicants were detected in water and 11 in sediment, but none exceeded screening levels. Fish community integrity was high at the site, providing evidence that no toxic impacts were occurring in the river.

For station 7a, Arroyo de las Vacas, only the water sample was involved. Of four toxicants that were detected, only un-ionized ammonia appeared important. The measured concentration was equivalent to the chronic aquatic life criterion, and probably was responsible for the observed effect.

For station 7b, San Felipe Creek, the effect occurred only in the water sample. Two toxic chemicals were detected; one of these, silver, exceeded aquatic life screening levels and was the probable causative agent. The observed concentration was considerably greater than at any other site. The local fish community was relatively healthy, indicating that any toxic effects that may have been occurring in the creek were not severe.

In the water sample from station 9a, an unnamed tributary 3.6 km (2.2 miles) south of Eagle Pass/Piedras Negras, *C. dubia* reproduction was significantly reduced, and 100% mortality occurred in fathead minnow embryo/larvae. Seven toxic chemicals were detected, two of which occurred at elevated levels. The arsenic concentration exceeded the human health criterion, but was much lower than applicable aquatic life criteria. Un-ionized ammonia, on the other hand, was over four times greater than the chronic aquatic life criterion, and most likely was responsible for the observed effects.

In the water sample from station 10a, Manadas Creek, *C. dubia* survival and reproduction were significantly reduced. Four toxic chemicals were detected, two of which occurred at concentrations above screening levels. Antimony and thallium exceeded human health criteria, with antimony also exceeding the national 85th percentile. However, concentrations of both were well below aquatic life criteria. The probable causative agent was total dissolved solids, as the observed concentration was within the range known to adversely affect *C. dubia* (Terry Hollister, USEPA Laboratory-Houston, personal communication).

The water sample from station 11a, Zacate Creek, produced 100% mortality in *C. dubia*. Eight toxicants were present at detectable concentrations, two of which exceeded screening levels. The selenium concentration exceeded the chronic aquatic life criterion, but only by a very slight amount, and its impact probably was minimal. The diazinon concentration, however, was two times greater than the acute screening value, and evidently was the main causative factor.

One hundred percent mortality occurred in *C. dubia* exposed to water from station 11b, Chacon Creek. Five toxic chemicals were detected, but none exceeded screening levels. Adverse effects were attributable to total dissolved solids, which were at a level known to be highly stressful to *C. dubia* (Terry Hollister, USEPA Laboratory-Houston, personal communication).

For station 11c, Arroyo el Coyote, *C. dubia* survival and reproduction were negatively affected in the water sample. Ten toxic chemicals were detected, four of which exceeded screening levels. Arsenic exceeded the human health criterion, but not the aquatic life criteria. Un-ionized ammonia, selenium, and bis(2-ethylhexyl) phthalate exceeded chronic aquatic life criteria by factors of 6.2X, 2.1X, and 3.3X, respectively. Thus, un-ionized ammonia appears to have been the main cause of water toxicity, with selenium and bis(2-ethylhexyl) phthalate involved in lesser roles. In the sediment eluate, 100% mortality occurred in both *C. dubia* and fathead minnow embryo/larvae. Seventeen toxic chemicals were detected in sediment, with zinc, chlordane, and bis(2-ethylhexyl) phthalate exceeding screening levels. Zinc exceeded the national 85th percentile, but was far less than the aquatic life threshold value. Chlordane exceeded the aquatic life threshold value by a factor of 1.9X. No aquatic life threshold value exists for bis(2-ethylhexyl) phthalate, but the concentration was very high, exceeding the national 85th percentile by 7.3X and the next highest level in the study by 8X. One other chemical for which no screening level exists, parachlorometa cresol, also was conspicuously elevated, exceeding the next highest level in the study by 2.3X. Thus, indications are that chlordane, bis(2-ethylhexyl) phthalate, and parachlorometa cresol were potentially important in the manifestation of sediment eluate toxicity.

Significant adverse effects were recorded for the water sample from station 12d, Arroyo Los Olmos, as 100% mortality occurred in both *C. dubia* and fathead minnow embryo/larvae. Seven toxic chemicals were detected, with two exceeding screening levels. Cyanide exceeded the chronic aquatic life criterion by a factor of 1.8X, and may have been marginally involved in the observed effects. Diazinon exceeded the acute aquatic life criterion by 26.3X, and evidently had a major causative role. Total dissolved solids probably contributed to the impact on *C. dubia*, as the concentration was in the range known to adversely affect that organism (but below the level known to stress fathead minnow embryo/larvae) (Terry Hollister, USEPA Laboratory-Houston, personal communication). Local fish community structure reflected a moderate probability that some form of instream impact was occurring.

In the water sample from station 15a, Anhelo Drain, *C. dubia* reproduction was significantly reduced. Sixteen toxic chemicals were detected, with arsenic, mercury, and diethyl phthalate exceeding screening levels. Of the three, only diethyl phthalate exceeded an aquatic life screening level, with a concentration 2.7 times greater than the chronic criterion. In the sediment eluate, fathead minnow embryo/larval survival was significantly reduced. Fourteen toxic chemicals were detected in sediment, but only chlordane exceeded screening levels, with a concentration 3.7 times greater than the aquatic life threshold value. Fish apparently were absent from the drain, as an attempt to collect samples for tissue analysis produced no specimens. This was reflective of severe instream stress, but whether toxic or conventional pollutants were primarily responsible was not clear.

Macrobenthic Community Assessment

Macrobenthic bioassessments were performed at the 18 major mainstem stations (Table 19). One hundred and ninety-nine taxa were collected, a high total that reflected physiographic complexity and varying zoogeographical influences along the longitudinal gradient.

Prior to interpreting the data, sample collecting techniques and data evaluation methods (described in the "Biological Techniques" section) were reviewed to evaluate their relative abilities to characterize macrobenthic integrity.

Evaluation of Collecting Techniques

Because snag sampling had not previously been used in TNRCC studies, a comparison to Surber sampling was performed. This involved the employment of both collecting techniques at two stations. At station 8, macrobenthic integrity was higher in the Surber sample, as indicated by greater species richness, diversity, equitability, and EPT index, plus a more optimally-sized standing crop. This was not reflected by TNRCC Mean Point Scores (MPS's), which were identical. It was, however, by the Ohio Invertebrate Community Index (ICI); although both ICI values were within the range associated with an intermediate aquatic life use rating, that for the Surber sample was 36% greater than that for the snag sample.

At station 12, a similar relationship was evident, for the same reasons. However, in this case both rating techniques clearly indicated better integrity in the Surber sample. The MPS for the Surber sample was 23% greater than that for the snag sample, the latter being reduced by one subcategory (from high to intermediate). The ICI reflected an intermediate use rating for both samples; however, the value for the Surber sample was 57% greater than that for the snag sample.

Thus, the two sampling methods resulted in slightly different indications of macrobenthic integrity. Surber sampling produced 0-23% greater MPS's, and 36-57% greater ICI's, than did snag sampling. Two natural factors relating to physical habitat probably are instrumental in this relationship. First, rocky-bottomed substrates from which Surbers were taken were more physically complex than snags, which had relatively smooth surfaces. This afforded a greater variety of microhabitats, which would be expected to support a more diverse macrobenthic assemblage. Second, current velocity associated with Surber sample habitats typically was considerably greater, as snags generally occurred in slackwaters along the shorelines. Maximal macrobenthic diversity in streams typically is associated with relatively swift current velocity (Hynes, 1970).

However, a possibility also exists that snag communities were more affected by certain environmental stresses, such as toxicants, than were riffle communities, in relation to aforementioned hydrological variability. Kerans *et al.* (1992) showed that effects of environmental stresses on certain invertebrate metrics are manifested to a greater degree in slackwater habitats than in riffles. Potential stresses may be ameliorated in riffles by the effects of high reaeration, continuous flushing, and low degree of accumulation of (potentially contaminated) fine particulates on the substrate, whereas the reverse appears true for slackwaters.

The evaluation revealed an inherent tendency for Surber sampling to sometimes produce more favorable indications of macrobenthic integrity than snag sampling. However, supplemental information suggests that environmental stresses may compound innate differences. Therefore,

in interpreting the data, indications of reduced macrobenthic integrity from snag sampling were not automatically discounted. Rather, the possibility that environmental stresses might be involved was closely scrutinized.

Comparison of Data Evaluation Methods

In a TNRCC study of 81 minimally-impacted ecoregion stream sites, the MPS indicated exceptional or high ratings at a 15% greater frequency than did the ICI (Bayer *et al.*, 1992). Thus, intrinsic differences in the way the techniques function appear to account for this amount of divergence.

In the present study, the MPS produced an aquatic life use rating one subcategory higher than did the ICI in nine instances. Ratings were consistent in the other 11 cases. Therefore, the MPS resulted in a higher aquatic life use rating 45% of the time.

Thus, the frequency of divergence for the Rio Grande/Río Bravo exceeded what would be expected in minimally-impacted streams by 30%. This may reflect differing sensitivities of the two techniques in situations where toxicants or certain other types of environmental stresses occur, with the ICI producing harsher indications. There is evidence from other TNRCC studies that the MPS is very sensitive to the effects of organic enrichment, but less so to toxic stresses (Davis, 1991), which precipitated employment of both techniques in the present study.

Comparison of the two rating methods showed that the MPS can be expected to sometimes give a more favorable impression of macrobenthic integrity than the ICI, with the gap widening where certain types of environmental impact occur. Accordingly, in cases where the ICI was reduced relative to the MPS, the potential for inherent variation, and the possibility of stress-induced divergence, were given equal consideration in interpreting the data.

Macrobenthic Integrity

A high aquatic life use is in effect for 17 of the 18 macrobenthic stations. The only deviation is for station 2, where a limited aquatic life use is applicable (TNRCC, 1991).

An important finding was that no limited aquatic life use ratings were indicated by either rating method. Such a rating usually reflects severe instream impact.

The 18 sampling stations were placed into four categories based on indications of macrobenthic integrity. Category 1 included seven sites, for which both rating methods indicated attainment of a high or exceptional aquatic life use (stations 4, 6, 7, 9, 10, 11, 14). Determinations for all seven were based on Surber samples. Ranges and means for rating method values and principal metrics included: MPS, 3.17-3.67, 3.45; ICI, 36-46, 40.3; species richness, 33-65, 49.6; standing crop, 443-22,637, 5,794 individuals/m²; diversity, 3.88-4.51, 4.16; equitability, 0.71-0.80, 0.74; EPT index, 10-20, 15; prevalence of dominant functional feeding group, 23.31-42.97, 31.60%.

All but the lowermost of these seven sites were between the Río Conchos confluence and International Falcon Reservoir, and five were clustered in the reach between Langtry/San Ignacio and Laredo/Nuevo Laredo. Thus, zoogeographical factors appeared to be partially responsible for superior macrobenthic integrity, *i.e.*, overlap of influences within a transitional zone between three biotic provinces (see "Study Area" section, and discussion by Davis, 1980).

Macrobenthic integrity at station 6 stood out from all other sites. It was the only site categorized as exceptional by both rating methods, and the MPS and ICI values were the highest in the study. This was fostered by the remoteness of the area, together with general environmental and zoogeographical considerations discussed for category 1 sites.

Levels of integrity at category 1 sites reflected optimal environmental conditions, lack of effects by toxic chemicals or other detrimental factors, and full attainment of the designated high aquatic life use. Supplemental information supported this assessment, as no significant effects occurred in water or sediment eluate toxicity tests (Tables 16 and 17), and few toxic chemicals exceeded screening levels (Table 13). Such conditions were not surprising for the three sites that were upstream control stations (station 7, Del Rio/Ciudad Acuña reach; station 9, Eagle Pass/Piedras Negras reach; station 11, Laredo/Nuevo Laredo reach), or for station 6 which was in a remote reach. For the other three, however, which were downstream sites in reaches where potential contaminant sources exist (station 4, Presidio/Ojinaga; station 10, Eagle Pass/Piedras Negras; station 14, International Anzalduas Dam), the findings were particularly noteworthy in indicating that effects of pollutants introduced from those areas were negligible.

Category 2 consisted of six sites which partially attained a high aquatic life use (stations 1, 2, 5, 8, 13, 16). These were rated high by the MPS but intermediate by the ICI. Ranges and means for rating method values and principal metrics included: MPS, 2.50-3.17, 2.76; ICI, 22-30, 26.6; species richness, 15-51, 36.3; standing crop, 495-35,642, 10,687 individuals/m²; diversity, 2.78-3.79, 3.37; equitability, 0.58-0.71, 0.66; EPT index, 5-10, 6.9; prevalence of dominant functional feeding group, 29.62-77.15, 48.00%.

Stations 1 and 13 were upstream control sites for the El Paso/Ciudad Juárez reach and the International Anzalduas Dam reach, respectively. As such, no appreciable instream impacts were anticipated. Respective MPS values of 3.00 and 3.17 were in the mid- to upper portion of the range associated with a high aquatic life use, while ICI values of 30 were only slightly below the minimum associated with a high use. These were the highest values observed in the study for snag samples.

The inherent tendency for snag samples to slightly underrate macrobenthic integrity could account for the amount by which ICI values fell short of the high range at these two sites. In addition, physical macrohabitat characteristics were not particularly suitable for macrobenthos at either site, and indications of slightly depressed macrobenthic integrity could have been a product of physical habitat limitations. Station 1 had a monotonous, sandy substrate, and was located in a channelized reach subject to episodic scour and refill. The harsh nature of the aquatic environment at this site has been described by Davis (1980). Station 13 also had a homogenous, predominantly sand substrate, plus various other limitations as discussed for stations 15, 17, and 18 below. In addition, instream flow at both sites, which is dependent on

upstream reservoir releases, is highly variable and sometimes changes abruptly, resulting in wide physicochemical fluctuations.

The indicated level of macrobenthic integrity at station 5 was slightly lower than at stations 1 and 13, even though Surber sampling was employed. The MPS was in the lower portion of the high use subcategory range, and the ICI was in the middle of the intermediate use subcategory range. In those respects, it resembled characteristics for stations 2, 8, and 16. However, it was lumped with stations 1 and 13 for the following reasons. It was located in a remote reach far removed from any wastewater discharges or other likely sources of contamination. Physical habitat characteristics in the immediate vicinity were very poor, as has been described by Davis (1980), primarily with respect to extreme substrate embeddedness and lack of microhabitat diversity. This condition evidently is induced by inflow from Terlingua Creek, which enters immediately upstream from the collecting area, during spates. That the physical nature of the substrate was the primary factor limiting macrobenthic integrity was substantiated by additional field observations. Subsequent to sampling activities in the area, communication with the fisheries team revealed that conditions were substantially different a kilometer or so downstream, where fish collecting was performed. No embeddedness was evident, and large invertebrates such as Megaloptera, which were absent from the macrobenthic sample, were collected in abundance during seining.

Based on physical habitat, sampling technique, macrobenthic integrity, and geographical considerations, it was concluded that the potential that toxic chemical-induced environmental stress was occurring at stations 1, 5, and 13 was very slight. Associated data substantiated this conclusion, as few toxic chemicals exceeded screening levels (Table 15) and no adverse effects were seen in sediment eluate toxicity tests. In addition, no significant effects occurred in toxicity testing of water from stations 5 and 13 (Tables 16 and 17). Although *Ceriodaphnia dubia* survival was significantly reduced in water from station 1, no potential causative agents were identified, and the healthy condition of local fish and macrobenthic communities indicated that instream toxicity is not persistent.

Indications of macrobenthic integrity at the remaining sites in category 2 were summarized in the second paragraph preceding. All three were downstream sites in reaches where potential contaminant sources exist (station 2, El Paso/Ciudad Juárez; station 8, Del Rio/Ciudad Acuña; station 16, Hidalgo/Reynosa).

At station 2, low flow is dominated by the El Paso Public Service Board Haskell R. Street wastewater treatment plant effluent. In addition, physical habitat is poor, due to the effects of stream channelization, lack of substrate complexity, and other factors (as described by Davis, 1980). Based on these considerations, a limited aquatic life use has been designated for the segment (TNRCC, 1991). In an effort to eliminate physical habitat effects, Surber samples were collected from localized, gravel-bottomed riffles about 2 km (1.2 miles) downstream, immediately below Riverside Diversion Dam. The results showed that although the designated limited aquatic life use was attained, macrobenthic integrity was considerably reduced compared to levels that would be expected in unimpacted situations. Furthermore, absolute MPS and ICI values were somewhat lower than at the upstream control site, despite the fact that station 1 data

was based on snag sampling. A degree of organic enrichment was indicated by the prevalence of miners (organisms that feed on deposited fine particulate organic matter), primarily oligochaetes which are highly tolerant of such conditions. Whereas organic enrichment may have contributed to depressed macrobenthic integrity, a possibility that effects by toxic chemicals may also have been involved was not ruled out.

Station 8 was subjected to Surber and snag sampling. Regarding the Surber sample, the physical habitat was not ideal, but consisted of runs about 0.3 m (1 foot) deep over coarse gravel partially embedded in sand and silt. Also, a degree of organic enrichment was indicated by the prevalence of miners, mostly tolerant species of oligochaetes. Comparison to data from the control site (station 7) reflected a moderate reduction in macrobenthic integrity, which was partially attributable to less-suitable physical habitat. For the snag sample, the ICI value was the second lowest observed in the study, and was appreciably less than that for the Surber, as was reflected by reductions in individual metrics such as species richness and EPT index. Whereas physical habitat limitations, organic enrichment, and inherent variability among sampling techniques and rating methods may have contributed to indications of reduced macrobenthic integrity, a possibility also existed that slight effects by toxic chemicals may have been occurring.

Indications of macrobenthic integrity at station 16 were influenced by the same limiting factors discussed for station 13, as physical habitat characteristics and the employment of snag sampling were common to both sites. Other limitations are addressed in the discussion for stations 15, 17, and 18 below. Another possible detriment was slight organic enrichment, which was reflected by the large standing crop and predominance by miners. Cumulatively, these factors undoubtedly contributed to indications of reduced macrobenthic integrity. In fact, there were strong indications that unsuitable physical habitat conditions were the primary determinant, as macrobenthic integrity actually was better than at the upstream control site (station 15). However, in light of the fact that this was the downstream station for the Hidalgo/Reynosa reach, where potential contaminant sources exist, together with the level of macrobenthic integrity that was observed, a possibility also existed that slight effects by toxic chemicals may have been occurring.

With ample consideration ascribed to physical habitat characteristics, sampling techniques, macrobenthic integrity, geographical location, chemical data, and toxicity testing results, it was concluded that the potential that toxic chemical-induced environmental stress was occurring was slight for stations 8 and 16, but moderate for station 2. At stations 8 and 16, few toxic chemicals exceeded screening levels, and no significant effects occurred in water or sediment eluate toxicity tests. At station 2, no significant effects were seen in the toxicity tests, but a number of toxic chemicals occurred at elevated concentrations, most notably in sediment (Table 15). For all three sites, however, observed levels of macrobenthic integrity indicated that if toxic stresses were being manifested, the effects were relatively minor.

Category 3 consisted of four sites where an intermediate use was indicated by both rating methods (stations 3, 15, 17, 18). Thus, the designated high aquatic life use level was not attained. However, the degree by which they failed to do so was relatively slight (with the exception of the MPS value for station 3). The main difference between these sites and those

in category 2 was that MPS values were slightly lower and fell into the upper end of the intermediate use range (while ICI values were comparable, in most cases actually being slightly higher). Ranges and means for rating method values and principal metrics included: MPS, 1.50-2.33, 2.12; ICI, 27-30, 28.3; species richness, 19-34, 28.3; standing crop, 4,869-42,517, 16,078 individuals/m²; diversity, 1.50-3.43, 2.78; equitability, 0.11-0.69, 0.51; EPT index, 5-8, 6.5; prevalence of dominant functional feeding group, 54.36-95.73, 69.10%.

Station 3 was in a remote area far removed from any obvious contaminant sources, and for that reason was established as the upstream control site for the Presidio/Ojinaga reach. The Surber sample from the site exhibited anomalously low diversity, equitability, and MPS, as well as next-to-lowest species richness in the study. In addition, functional feeding group composition was more imbalanced than at any other site. The main contributing factor was the presence of dominant numbers of filter-feeding, facultative blackfly larvae (*Simulium* nr *bivittatum*). Although values for certain metrics resulted in a depressed MPS, the ICI was more normal, in the upper half of the range associated with an intermediate aquatic life use. Also, sensitive species were fairly well represented, as reflected by the EPT index value. Thus, the degree by which macrobenthic integrity was suppressed was not as severe as was implied by the MPS.

Numerous elements contribute to poor macrobenthic habitat in the station 3 area, as discussed by Davis (1980). Among these are: elevated dissolved solids resulting from evapotranspiration and irrigation return flows in the reach from El Paso/Ciudad Juárez to Presidio/Ojinaga; excessive turbidity and sedimentation; predominance of fine sediment and high degree of embeddedness of stones on the substrate; wide physicochemical fluctuations promoted by highly variable flow; and seasonal intermittency of flow. Collectively, these factors result in reduced physical habitat complexity/suitability, and generally stressful environmental conditions. Optimal macrobenthic integrity would not be expected under such conditions.

Of the other sites in category 3, two were upstream control sites (station 15, Hidalgo/Reynosa reach; station 17, Brownsville/Matamoros reach), and the other was a downstream site (station 18, Brownsville/Matamoros reach). All three were subjected to snag sampling, and resultant indications of macrobenthic integrity were very consistent. Habitat characteristics also were relatively similar. Low gradient and stream channel morphometry result in physical homogeneity, *i.e.*, the river typically is wide and deep, and lacks riffles and runs. The substrate is monotonous, comprised mainly of sand and silt. Instream flow is highly variable (see Study Area description), resulting in wide physicochemical fluctuations. Cumulatively, these factors act to create relatively poor macrobenthic habitat.

Based on physical habitat, sampling technique, macrobenthic integrity, and geographical considerations, it was concluded that the potential that toxic chemicals were exerting instream stress at stations 3, 15, 17, and 18 was slight. Further evidence supporting this conclusion included the relative insignificance of toxic chemical concentrations (Table 15), and the lack of significant effects in water and sediment eluate toxicity tests (Tables 16 and 17).

Category 4 contained a single site, station 12, which did not fit previous patterns. Both sampling techniques were employed, and respective indications of macrobenthic integrity were considerably different. For the Surber sample, the MPS indicated a high use, but the ICI, the

lowest observed for Surber samples, was in the lower half of the intermediate use range. For the snag sample, both rating methods reflected an intermediate use; however, the MPS was the lowest observed for snag samples, and the ICI was the lowest recorded for any sample by a substantial margin. As three of the four ratings were in the intermediate range, it was concluded that the designated high aquatic life use was not attained. Ranges and means for rating method values and principal metrics included: MPS, 2.17-2.67, 2.42; ICI, 14-22, 18; species richness, 27-41, 34; standing crop, 14,801-18,300, 16,551 individuals/m²; diversity, 3.28-3.89, 3.59; equitability, 0.69-0.73, 0.71; EPT index, 2-5, 3.5; prevalence of dominant functional feeding group, 63.15-70.99, 67.07%.

Rocky-bottomed riffles were common in the area, and overall physical habitat characteristics were favorable. Nevertheless, sensitive species were poorly represented, as was reflected by low EPT index values (that from the Surber being the lowest observed for Surber samples, while that from snags was the lowest seen for any sample). The scope of reduction was broad, as the Surber EPT index value represented a 71% decrease from that at the control site (station 11).

A degree of organic enrichment was indicated by the predominance of miners, mainly tolerant species of oligochaetes and chironomids, and by the relatively large standing crops. This probably was partially responsible for reduced macrobenthic integrity.

The site was the downstream station for the Laredo/Nuevo Laredo reach, where the potential for contaminant introduction is high. Based on this consideration, together with the prevalence of favorable physical habitat, the observed level of macrobenthic integrity, and the paucity of sensitive species, it was concluded that the potential that toxic chemical-induced environmental stress was occurring at the site was high. This presumption is supported by the fact that significant effects occurred in the sediment eluate toxicity test (Table 17). Nonetheless, the level of macrobenthic integrity observed indicated that if toxic stresses were being manifested, the effects were not severe.

In conclusion, the 18 major mainstem stations were grouped according to the potential that macrobenthic communities were being affected by toxic chemicals, as follows.

indicated potential	station(s)
none	4, 6, 7, 9, 10, 11, 14
very slight	1, 5, 13
slight	3, 8, 15, 16, 17, 18
moderate	2
high	12

Fish Community Assessment

A total of 53 species of fish were collected from 18 sites on the mainstem Rio Grande/Río Bravo and seven tributaries sampled during this study. The initial inspection of the fish community data revealed several major faunal breaks that could be defined by differences in fish species occurrence. One division occurred surrounding the Río Conchos, with another at International Amistad Reservoir. The final one was observed surrounding International Falcon Reservoir. These trends appear more related to changes in stream hydrology than other factors.

Collections from stations 1 and 2, upstream and downstream of El Paso/Ciudad Juárez, contained similar species to those found in the Texas portion of the upper Rio Grande/Río Bravo by previous researchers (Hubbs *et al.*, 1977; Bestgen and Platania, 1988). Species considered common in the upper river by Hubbs *et al.* (1977) were gizzard shad (*Dorosoma cepedianum*), red shiner (*Cyprinella lutrensis*), common carp, river carpsucker (*Carpiodes carpio*), channel catfish, western mosquitofish (*Gambusia affinis*), and green sunfish (*Lepomis cyanellus*). Subsequently, Bestgen and Platania (1988) indicated that those species were still common and added bull head minnow (*Pimephales vigilax*) and longear sunfish (*Lepomis megalotis*). Collected during the study, but not reported by Hubbs *et al.* (1977) or Bestgen and Platania (1988), was an introduced species, walleye (*Stizostedion vitreum*), from station 1. Hubbs *et al.* (1977) characterized Rio Grande/Río Bravo fauna upstream of the Río Conchos as widely distributed and salt tolerant.

The influence of the Río Conchos (3a) on species assemblages in the Rio Grande/Río Bravo became apparent at station 3, upstream of the confluence, and continued downstream to International Amistad Reservoir. Hubbs *et al.* (1977) discussed the Río Conchos influence and the influx of species that occur in the Rio Grande/Río Bravo beginning in the reach that contains the confluence of the two rivers. The faunal differences upstream and downstream of the Río Conchos also appear to be longstanding (Hubbs *et al.*, 1977).

In this study, International Amistad Reservoir presented a distinct boundary between a slightly turbid upstream reach influenced by stream modifications, irrigation return flows, runoff, and the Río Conchos (stations 3, 3a, 4, 5, and 6) and a downstream reach influenced by clear inflows of water from the reservoir and to a lesser degree, by springflow emanating from tributaries on both sides of the border. Modification of this downstream habitat through changes in flow patterns and reduced turbidity (Table 10) has apparently created a longitudinal gap in the occurrence of some fish species. Several members of the fish community were observed upstream of the reservoir and further downriver, around Eagle Pass/Piedras Negras and Laredo/Nuevo Laredo (stations 9, 10, 11, and 12), but were absent immediately downstream of International Amistad Reservoir at stations 7 and 8. Tamaulipas shiner (*Notropis braytoni*) was collected at stations 3, 3a, 4, 5, and 6 upstream of the reservoir and station 11 downstream, being absent from intervening sites. Other species demonstrating a similar pattern were Rio Grande shiner (*Notropis jemezianus*), collected at stations 5, 6, 9, 9b, and 11; speckled chub (*Macrhybopsis aestivalis*), collected at stations 3, 3a, 4, 5, 6, 6a, 11, and 12; and blue sucker (*Cycleptus elongatus*), collected at stations 3a, 4, 5, and 12. Longnose dace (*Rhinichthys cataractae*) was observed at stations 3a, 4, 5, and 6, but not downstream. River carpsucker and blue catfish were present upstream of International Amistad and downstream of International

Falcon Reservoirs, but were absent from the entire middle reach. Platania (1991) observed similar patterns of occurrence for Tamaulipas shiner, Rio Grande shiner, speckled chub, and longnose dace. Those four species, plus river carpsucker and blue catfish were all collected in the vicinity of stations 7 and 8 prior to the impoundment of International Amistad Reservoir (Trevino-Robinson, 1959). Coupled with the absence of certain species downstream of Amistad, was the presence of "stream" or "creek" oriented fishes (Smith and Miller, 1986) in the mainstem at stations 7, 8 and 9. The occurrence of roundnose minnow (*Dionda episcopa*) and Rio Grande darter (*Etheostoma grahami*) in a big river habitat illustrates the influence of Amistad and associated spring-fed tributaries on the Rio Grande/Río Bravo in that reach. Other species largely unique to the middle reach and tributaries were Texas shiner (*Notropis amabilis*), gray redhorse (*Moxostoma congestum*), and smallmouth bass (*Micropterus dolomieu*).

International Falcon Reservoir provides a break between the river's freshwater middle reach and a lowermost reach that becomes increasingly brackish toward the river's mouth. Estuarine and marine species were present at all sites downstream of the reservoir, but assumed the greatest proportions of the fish community at the two lowermost stations, 17 and 18, which are at river kilometer 155.8 and 78.3, respectively. Species representing this estuarine and marine fauna were American eel (*Anguilla rostrata*), Atlantic needlefish (*Strongylura marina*), gulf killifish (*Fundulus grandis*), sheepshead minnow (*Cyprinodon variegatus*), Amazon molly (*Poecilia formosa*), sailfin molly (*Poecilia latipinna*), mountain mullet (*Agonostomus monticola*), striped mullet (*Mugil cephalus*), and bigmouth sleeper (*Gobiomorus dormitor*). Based upon the collection from Arroyo Los Olmos (12d), whose confluence is more than 330 km (205 miles) upstream from the Rio Grande/Río Bravo mouth, brackish water species move far upriver during periods of reduced flow probably following changing salinity gradients. Estuarine or marine species accounted for approximately 96 percent of the total collection for Arroyo Los Olmos. That site had very high conductivities. A collection from the next downstream station on the mainstem was not dominated by brackish water species, possibly because flows were elevated at the time of sampling. Absent from our collections throughout the reach downstream of International Falcon Reservoir were several minnow species—Tamaulipas shiner, Rio Grande shiner, and speckled chub—which were historically observed in this area (Trevino-Robinson, 1959), suggesting a shift in the fish community. Edwards and Contreras-Balderas (1991) observed the elimination of freshwater restricted species downstream of Brownsville/Matamoros and replacement by estuarine and marine forms. They also noted an increase in the proportion of estuarine species between International Anzalduas Dam and Brownsville/Matamoros. Changes in both segments were attributed primarily to decreasing stream flows and concurrent increases in salinity. They also speculated that increases in chemical pollution were affecting indigenous species in concert with changes in stream flow. Species such as largemouth bass and white bass also become common downstream of International Falcon Reservoir, undoubtedly because of the influence of the reservoir fisheries.

In summary, hydrologic modifications have largely shaped the present Rio Grande/Río Bravo fish community. Upstream of the Río Conchos, where flow is undependable, species assemblages are small and adapted to highly variable conditions. The Río Conchos provides a reliable supply of water and habitat for species that characterize the river downstream to International Amistad Reservoir. The reservoir reduces turbidity and alters water quality and along with spring system influences, causes a shift in the fish community towards a clear water,

small stream assemblage. Further downstream around Eagle Pass/Piedras Negras and Laredo, some characteristic community members observed upstream of Amistad are again present. International Falcon Reservoir and subsequent diversions serve to reduce flows downstream, with estuarine and marine species invading further upstream. Any evaluation of fish communities for the purposes of ascertaining pollutant impacts must be conducted within the context of these altered faunal patterns.

Fish Community Measures - El Paso/Ciudad Juárez to International Falcon Reservoir (Stations 1-12, 3a)

Species Richness, Composition, and Similarity.—Species number (Figure 5) ranged from nine to 19 species at Rio Grande/Río Bravo sites upstream of International Falcon Reservoir and on the Río Conchos. The median value was 12. The Río Conchos (3a) sample contained noticeably more species (18) than surrounding sites. Hubbs *et al.* (1977) noted this same trend. Sites with fewer species than the median (stations 1-3) were all upstream of the Río Conchos with one exception, station 7, downstream of International Amistad Reservoir, which had the lowest number of species. The collection from station 9, upstream of Eagle Pass/Piedras Negras, had the most species of any site between El Paso/Ciudad Juárez and International Falcon Reservoir. The most notable variation in species richness between sites bracketing the major sister cities came at stations 9 and 10, with a difference of seven species. Species present upstream but not downstream were roundnose minnow, Rio Grande shiner, Mexican tetra (*Astyanax mexicanus*), flathead catfish (*Pylodictis olivaris*), smallmouth bass, largemouth bass, and Rio Grande darter. Several of those species—the two minnows and darter—are among the more habitat sensitive species in the mainstem, suggesting the potential for impacts based upon community composition. Texas shiner was collected at station 10, but not station 9. These changes were not well reflected in the similarity index (Table 21) given the fact that the two sites also had many species in common. It should be noted, however, that station 9 shared higher similarity to an intervening tributary, the Río Escondido (9b), than to station 10.

The only other drop in species number between upstream and downstream sites came at station 2 relative to station 1 and amounted to a decrease of one, although the community composition was slightly different. Flathead catfish, walleye, and bluegill (*Lepomis macrochirus*) were collected at station 1, but not station 2, whereas white bass and largemouth bass were taken downstream but not upstream. From an impact analysis standpoint, little can be ascribed to the community differences between those sites, and the index of similarity value for those collections was the highest in the study when comparing upstream-downstream sites in the mainstem (Table 21).

Increases in species richness were observed at downstream stations relative to upstream when comparing stations 7 and 8, four species; 11 and 12, three species; and 3 and 4, two species. Collected at station 7 but not 8 were Texas shiner, smallmouth bass, and Rio Grande cichlid (*Cichlasoma cyanoguttatum*), whereas spotted gar (*Lepisosteus oculatus*), blacktail shiner (*Cyprinella venusta*), roundnose minnow, gray redhorse, channel catfish, green sunfish, and largemouth bass were taken downstream but were absent upstream. Similarity between the sites

was relatively low (Table 21). These community changes probably reflect the fish community's state of flux given the aforementioned influence of International Amistad Reservoir.

Though the increase in species richness was not large at station 12 relative to 11, the similarity between the two stations was low (Table 21). Western mosquitofish, Tamaulipas shiner, Rio Grande shiner, and flathead catfish were all collected upstream, but were absent downstream, whereas the reverse was true for blue sucker, gray redhorse, Mexican tetra, white bass, warmouth (*Lepomis gulosus*), longear sunfish, and largemouth bass. Physical habitat was substantially more diverse at station 12 and consisted of more backwaters, snags, and instream vegetation, which would tend to favor additional centrarchid species. A specific habitat favoring blue sucker, boulder fields with swift velocities, was also observed downstream. The low similarity and elimination of the two shiner species, however, suggest potential impacts from intervening inputs of wastewater from Laredo/Nuevo Laredo.

The difference in species richness at stations 3 and 4 was minor and index of similarity between the two sites was high (Table 21). Present upstream but not downstream were fathead minnow (*Pimephales promelas*) and Mexican tetra, whereas gizzard shad, blue sucker, longnose dace, and longear sunfish were collected downstream but were absent upstream. Two of these species, longnose dace and blue sucker, were not observed upstream of the Río Conchos and their absence from station 3 may reflect the lack of reliable flows upstream of the confluence and the influence of irrigation return flows. The river was turbid (110 jtu) at station 3 and was of high conductivity (2,640 μ mhos/cm). That situation also precluded effective electrofishing and may have biased the sample slightly, providing a somewhat tenuous comparison between upstream and downstream sites. However, species richness and composition comparisons for stations 3 and 4 do not suggest substantial impact from intervening pollutant inputs.

Species richness was the same at stations 5 and 6 with community similarity being moderate. Present at station 5 but not 6 were blue sucker, blue catfish, flathead catfish, and blue tilapia (*Tilapia aurea*). Those found downstream but absent upstream were smallmouth buffalo (*Ictiobus bubalus*), white bass, largemouth bass, and freshwater drum (*Aplodinotus grunniens*). Physical habitat, particularly substrate, at station 5 was different from that at station 6. Many cobble riffles were present, with some rubble and small boulders at station 5, whereas station 6 had smaller substrate particle sizes, mainly gravel and sand with some cobble. Those conditions may have favored blue sucker at station 5 over 6, whereas the proximity of International Amistad Reservoir downstream probably explains the presence of white bass and largemouth bass at station 6.

Index of Biotic Integrity.—Index of Biotic Integrity (IBI) scores for sites upstream of International Falcon Reservoir and in the Río Conchos ranged from 13 to 24 out of a possible 30 points (Table 22). The median value for those sites was 18. Stations with a score in the bottom two quartiles were 3a, 5, 6, 7, 8, 12. Station 12, downstream from Laredo/Nuevo Laredo, posted the lowest score in this reach (IBI=13). Species richness was rated high, though the site was downrated slightly for a reduced number of minnow species. Other areas in which it was downrated were for dominance by a single species, red shiner, which made up 60% of the sample; a relatively low catch rate; an elevated number of introduced individuals, primarily

common carp; and the highest incidence of deformities, lesions, and tumors of any sample collected in the study. We noted deformities, lesions, and tumors in 10.9% of the electrofishing catch at this site and 2.75% of the total catch.

Stations 7 and 8 also had scores that were less than the median (14 and 17, respectively). As noted earlier, the collection from station 7 contained the fewest species in the study and only one minnow species, Texas shiner. The catch rate was the lowest in the river upstream of International Falcon Reservoir and the second lowest in the overall study. In addition, the number of introduced individuals-common carp and smallmouth bass-was elevated. Station 8 had moderate species richness and two minnow species, roundnose minnow and blacktail shiner, the latter being an introduction. Catch rate was again relatively low and the number of introduced individuals was elevated and consisted of common carp and blacktail shiner. As already noted, those sites, particularly station 7, demonstrated modified faunal patterns related to the presence of International Amistad Reservoir. Though a potential for contaminant impact is present at station 8 through point sources upstream, it is largely impossible to differentiate from the aforementioned influences.

Stations 5 and 6 were downrated for incidence of deformities, lesions, and tumors and relatively low catch rates. Station 5 was also downrated for a high incidence of introduced individuals, primarily common carp. The station 6 sample was dominated by more than 65% red shiner, which caused it to receive a less than optimal rating. Both of these sites contained many characteristic Rio Grande/Río Bravo species, however, including speckled chub, Tamaulipas shiner, Rio Grande shiner, and longnose dace. Given the presence of those species, the remoteness of the sites, and a low potential for pollutant inputs, the probability of contaminant impact appears very slight.

The final site with a score less than the median was the Río Conchos (3a). This site had high species richness relative to surrounding sites on the Rio Grande/Río Bravo, though the collection was downrated for the percentage of introduced fishes, primarily represented by common carp. Several sensitive minnow species were observed, including speckled chub, Tamaulipas shiner, and longnose dace. However, this site also had the third highest incidence of deformities, lesions, and tumors in the study. When only electrofishing samples were considered, 4.5 % of the catch had some physical anomaly.

In evaluating differences between paired samples bracketing the major sister cities, two (stations 3 and 4 and stations 7 and 8) had higher IBI scores downstream rather than upstream. Sampling difficulties noted earlier may have influenced the score at station 3 as well as return flow impacts on water quality. In addition, the influx of species from the Río Conchos (3a) may have reduced dominance by a single species at station 4, the sole metric that improved over station 3. The situation at stations 7 and 8 has already been discussed.

Three paired sites had lower downstream values. Station 12 was nine points lower than station 11, station 10 was four points lower than station 9, and station 6 was two points lower than station 5. No difference was noted between stations 1 and 2. Though station 12 had more species than 11, two characteristic minnow species-Rio Grande shiner and Tamaulipas shiner-were absent downstream. As noted earlier station 12 also had a greater dominance by one

species, a lower catch rate, and a higher incidence of disease. The substantial decrease in IBI scores between stations 11 and 12, the low similarity index value, and the overall depressed score for station 12 indicates a high probability of pollutant impact. The drop in IBI scores between stations 9 and 10 is also supported by the aforementioned decrease in species richness, and suggests a moderate probability of pollutant impact. Given the small variation between the scores at stations 5 and 6 and the lack of pollutant inputs, the potential for impact is very slight.

In summary, based upon a variety of fish community measures station 12 has a high probability of pollutant impact; station 10, a moderate probability; and station 3a, a slight probability. In the latter case, the presence of fin deformities was the primary indicator, though Bestgen and Platania (1988) noted impacts in the Rio Grande/Río Bravo at their sites downstream of the Río Conchos. Downstream of the Río Conchos, they observed decreases in fish density and noted thick deposits of anoxic silt. Station 3 demonstrated very slight impacts that may relate to irrigation return flows. Stations 5 and 6 demonstrated some potential for contaminant impact, but as noted, that probability appears very slight. Finally, the situation at stations 7 and 8 preclude any definitive evaluation. Stations 1, 2, 4, 9 and 11 demonstrated no potential for contaminant impact based upon the fish community evaluation.

Fish Community Measures - International Falcon Reservoir to Brownsville/Matamoros (Stations 12d, 13-18)

Species Richness, Composition, and Similarity.—Downstream of International Falcon Reservoir, species richness ranged from 11 to 21, with the lowest numbers at stations 16 and 12d (11 species) and station 18 (12 species). Species richness was highest (21 species) at stations 13 and 14, the first stations downstream of International Falcon Reservoir, having been augmented by estuarine fishes, introduced species, and gamefish. Richness was noticeably lower at stations 12d, 16, and 18. Comparing sites bracketing the major sister cities, a difference of seven species was noted between stations 15 and 16 and six species between 17 and 18. In the former instance, none of the species present upstream and absent downstream are particularly sensitive to pollution impacts, though the magnitude of difference in species number suggests an effect. Species present at station 15 but not 16 were longnose gar (*Lepisosteus osseus*), gizzard shad, bullhead minnow, smallmouth buffalo, western mosquitofish, white bass, Rio Grande cichlid, blue tilapia, and striped mullet. Present downstream but not upstream were blue catfish and gulf killifish. Similarity (Table 21) was moderate.

The situation at stations 17 and 18 was somewhat similar, with a clear pattern not evident in considering species present at 17 but not 18. Those present at the upstream site but absent downstream were spotted gar, gizzard shad, threadfin shad (*Dorosoma petenense*), red shiner, Mexican tetra, blue catfish, western mosquitofish, white bass, redear sunfish (*Lepomis microlophus*), and mountain mullet. Those present at station 18 but absent at 17 were sheepshead minnow, Amazon and sailfin mollies, and Rio Grande cichlid. The downstream species are more estuarine in nature, suggesting a generally higher salinity in the reach. However, several of the species that dropped out between the two sites are tolerant of brackish conditions and the assemblage at station 18 contains freshwater elements, including longear sunfish and largemouth bass. Similarity was the lowest in the study (Table 21).

Though stations 13 and 14 had the same number of species, several differences were apparent. Upstream but not downstream were Atlantic needlefish, sailfin molly, redbreast sunfish (*Lepomis auritus*), green sunfish, freshwater drum, Rio Grande cichlid, and threadfin shad. Species observed at station 14 but not 13 were American eel, river carpsucker, blue catfish, western mosquitofish, mountain mullet, striped mullet, and bigmouth sleeper. No particular pattern in terms of species sensitivity is apparent from those differences. However, the number of estuarine/marine species appears slightly greater downstream of International Anzalduas Dam (station 14), which presents a migrational barrier at times. Similarity (Table 21) between the two sites was moderate.

Station 12d had what appeared to be a highly modified community given its location several hundred kilometers inland and the presence of 96% euryhaline species. Conductivity was elevated (Table 10) which undoubtedly accounts for the brackish nature of the community. The collection was dominated by Amazon molly.

Index of Biotic Integrity.—All of the upstream sites had higher IBI scores than their downstream counterparts (Table 23). The largest difference was at station 16, which had a six point lower IBI than station 15. Station 14 was four points lower than station 13, primarily because of the second highest incidence of deformities, lesions, and tumors in the study. Station 18's IBI score dropped three points from the score at 17. Station 12d's score was comparable to the downstream stations.

Station 16 posted a slightly depressed IBI from station 15, because of the already mentioned drop in species richness and a greater domination of the sample by a single species, Mexican tetra. As noted earlier, these sites had lower similarity. In fact, the fish community at station 15 was more similar to station 17 than to station 16. That factor, coupled with the lowered IBI score and the sharp drop in species richness compared to surrounding sites, suggests probable contaminant impact at station 16.

The lower IBI score at station 14 relative to 13 was the result of an increased number of individuals with deformities, lesions, and tumors. The percentage was the second highest in the study. Similarity was relatively high for the two sites and species richness at station 14 was the second highest in the study. Consequently, the only indicator pointing to potential impact is the percentage of diseased individuals. Based only upon that finding, the potential for pollutant impact appears slight.

The decrease in IBI score at station 18 relative to station 17 is difficult to evaluate in terms of probable pollution impacts. The site was downrated from station 17 for lower than optimal species richness and the elevated percentage of estuarine and marine species. The latter metric suggests that the community changes observed at station 18 are "real", but partitioning the influences of decreased flows from contaminant impacts would require additional study.

Station 12d was downrated because of the aforementioned dominance by euryhaline species, which exceeded even that of the lowermost site, station 18. The site was also downrated for dominance by a single species. Seine catch rates were high compared to mainstem sites, but that

may relate more to the lack of flow and small size of the stream, a circumstance making collecting more efficient. Given the modified nature of the community, the potential for impact appears moderate.

In summary, of the sites downstream of International Falcon Reservoir, 12d and 16 appear to have a moderate potential for impact, with station 14 having a slight probability. The only indicator pointing to station 14, however, is the presence of fishes with deformities, lesions, or tumors. Station 18 is difficult to interpret given the aforementioned factors. Stations 13, 15, and 17 demonstrate no impact attributable to contaminants, based upon this evaluation.

Fish Community Measures - Middle Reach Tributaries (Stations 6a, 6b, 7b, 8d, 9b)

Species Richness, Composition, and Similarity.—Species richness in the middle reach tributaries ranged from 12 to 23 (Figure 5), with the fewest number in the Pecos River (6a) and San Felipe Creek (7b). In the latter case, seining sites were sparse in the reach sampled, which may have influenced the collection. The Río Escondido (9b) and Río San Rodrigo (8d) had the greatest number of species with 23 and 18, respectively. The Devils River (6b) collection contained 15 species. Similarity (Table 21) among the tributaries was generally low and in the range of 0.333 to 0.667, with the widely varying habitats probably responsible. A major exception was a value of 0.829 between the Río Escondido and San Rodrigo. The Pecos River was most dissimilar to the other tributaries with 75% of its fauna comprised of cyprinid species and no centrarchids being represented. Several native minnow species were observed, including proserpine shiner (*Cyprinella proserpina*), speckled chub, Texas shiner, and Tamaulipas shiner. Centrarchid species were numerous in the Río Escondido and Río San Rodrigo with six and seven species, respectively. The collections from those two streams included several characteristic minnow species such as roundnose minnow and Texas shiner in both streams and Rio Grande shiner in the Río Escondido. Four centrarchid species were in the Devils River collection along with several unique minnow species, including proserpine shiner and sand shiner (*Notropis stramineus*), the latter only being taken from this site. San Felipe Creek had only two minnow species—proserpine and blacktail shiner—and two centrarchid species. Blacktail shiner, an introduced species, was quite abundant throughout the middle reaches of the river. Gray redbhorse, a catostomid, was also common at all of these tributary sites. Rio Grande darter was found in the Pecos River, Río Escondido, and Río San Rodrigo.

Index of Biotic Integrity.—IBI scores ranged from 18 to 23 (Table 24), with the lowest score at San Felipe Creek (7b). That site was downrated for lower than optimal species richness, few minnow species (one of which is introduced), lower than optimal catch rates, and a high percentage of introduced species, primarily carp and blue tilapia. All of the tributaries were downrated for a high percentage of introduced species. The IBI score for San Felipe Creek, together with low species richness and few numbers of minnow species, would appear to indicate a slight potential for impact. Also notable is the lack of Rio Grande darter, which Trevino-Robinson (1959) collected at several stations on San Felipe Creek. Platania (1991), however, collected additional minnow species and Rio Grande darter further upstream in Hinds Spring, a tributary to San Felipe Creek. He also observed roundnose minnow and Texas shiner

immediately downstream of the spring pool in Del Rio. Consequently, any impacts would appear to be in the lowermost reach of the creek.

The Pecos River (6a) had the second lowest IBI based upon slightly depressed species richness, low catch rate, and high number of introduced species, primarily blacktail shiner. The Pecos did have the highest number of minnow species of all sites in the study, several of which are relatively sensitive to habitat degradation. The low catch rate may have in part related to elevated conductivity (4,330 μ mhos) making electrofishing difficult. Elevated conductivity undoubtedly also selects against certain species that might otherwise populate the area. The source of conductivity is partially natural, from brine springs, and also partially attributable to man's activities. However, the potential for impact appears very slight.

Based upon this evaluation of the middle river tributaries, San Felipe Creek (7b) has slight potential for contaminant impact; the Pecos River (6a), very slight potential; and the remainder of the tributaries (6b, 8d, and 9b), no potential.

A summary of all of the fish community data yielded the following ratings for potential impacts:

indicated potential	station(s)
inconclusive	7, 8, 18
none	1, 2, 4, 6b, 8d, 9, 9b, 11, 13, 15, 17
very slight	3, 5, 6, 6a
slight	3a, 7b, 14
moderate	10, 12d, 16
high	12

Integration of Data

The final aspect of the evaluation was to integrate available information to identify sites and chemicals of potential concern. The objective was prioritization for purposes of water quality management and future monitoring.

Sites of Potential Concern

Sites were grouped according to potential for toxic chemical impact, based on cumulative information. Mainstem and tributary sites were treated separately, since the scope of evaluation was different for the two.

Mainstem.—Sites were ranked for 17 individual components belonging to seven categories, as described below.

Water chemistry: (1) number of toxic chemicals detected; (2) number of toxic chemicals that exceeded screening levels; (3) mean factor by which screening levels were exceeded.

Sediment chemistry: (4), (5), and (6), same as for water chemistry.

Tissue chemistry: (7), (8), and (9), same as for water chemistry.

Toxicity testing of water: (10) *Ceriodaphnia dubia* mortality, percent greater than in the control; (11) *Ceriodaphnia dubia* reproduction, percent less than in the control; (12) fathead minnow embryo/larval mortality, percent greater than in the control.

Toxicity testing of sediment eluates: (13), (14), and (15), same as for toxicity testing of water.

Macrobenthic community evaluation: (16) indicated potential for effects by toxic chemicals.

Fish community evaluation: (17) indicated potential for effects by toxic chemicals.

Station 5b, (Rio Grande/Río Bravo downstream from mouth of Lozier Canyon), was excluded because no tissue data, macrobenthic data, or fish community data were generated for that site. For a parameter that exceeded multiple screening levels, the exceedance factor utilized was that associated with the most stringent screening level. Ranks based on evaluations of macrobenthic communities and fish communities were multiplied by a factor of three to give all categories equal weight. Rankings for individual components were added for each site, and the rank sums were divided by the appropriate number of components. The latter step was necessary because fish community evaluations were inconclusive for stations 7, 8, and 18, and could not be used in the ranking. Thus, the divisor was 18 for stations 7, 8, and 18, and 21 for the other 15 stations. A final ranking was derived from the respective quotients (Table 25).

The ranking was used along with supplemental information to group the mainstem sites according to potential for toxic chemical impact. Accessory information included USEPA/TNRCC TOXNET data (Table 18), and other historical data relative to toxic chemicals (see "Historical Information" section). The term "impact" as applied here refers to adverse effects on aquatic life, or human health hazards associated with regular consumption of water and/or fish.

Groupings were based on eight characteristics. Sites for which at least six characteristics reflected a potential for toxic chemical impact were placed in the first group. The first group, for which a high potential for toxic chemical impact was indicated, included stations 2 and 12. Both were downstream from areas where appreciable amounts of wastewater enter the river (El

Paso/Ciudad Juárez, and Laredo/Nuevo Laredo, respectively). These sites were characterized by: significant effects in water and/or sediment eluate toxicity tests, and/or in multiple instances in the USEPA/TNRCC TOXNET program (Table 18); four or more toxic chemicals that exceeded screening levels in water and/or sediment; exceedance of human health criteria in water and/or tissue by one or more toxic chemicals; moderate to high potential for instream impact as indicated by macrobenthic and fish communities; a high ranking, from 1.0 to 3.0; and indications of toxic chemical effects from historical data sources. Station 12 exhibited all of these characteristics. Station 2 did not exhibit any human health criteria exceedances, nor did the local fish community reflect any impact. Indications are that toxic effects at that site may be selective for invertebrates, as suggested by macrobenthic community structure and the fact that TOXNET effects have involved *Ceriodaphnia dubia*, but not fathead minnow embryo/larvae (Table 18).

Characteristics of the remaining sites were too diverse for specific limits to be established; the following general characteristics were used for grouping purposes: significant effects in water and/or sediment eluate toxicity tests, in the present study or the TOXNET program; four toxic chemicals that exceeded screening levels in water and/or sediment; exceedance of human health criteria in water and/or tissue by one or more toxic chemicals; moderate potential for instream impact as indicated by macrobenthic or fish communities; a ranking from 2.0 to 9.0; and indications of toxic chemical effects from historical data sources. Sites exhibiting three or more of these characteristics were placed in the second group; those exhibiting two or less were placed in the third group.

The second group, for which a slight to moderate potential for toxic chemical impact was indicated, included stations 3, 10, 14, and 16. The latter three were downstream from areas where a substantial potential for toxic chemical input exists (Eagle Pass/Piedras Negras, International Anzalduas Dam, and Hidalgo/Reynosa, respectively), while station 3 was the upstream control site for the Presidio/Ojinaga reach. Characteristics placing these sites into the second group consisted of the following. Station 3 had four toxic chemicals that exceeded screening levels in water and/or sediment, one chemical that exceeded human health criteria in tissue, and a relatively high ranking (5.0). Station 10 had one toxic chemical that exceeded human health criteria in tissue, a moderate potential for toxic chemical impact as indicated by the fish community, and two instances of significant toxic effects from the TOXNET program. Station 14 had four toxic chemicals that exceeded screening levels in water and/or sediment, one toxic chemical that exceeded human health criteria in tissue, a relatively high ranking (6.5), and implications of toxic effects from historical information. Station 16 had two toxic chemicals that exceeded human health criteria in tissue, a moderate potential for toxic chemical impact as indicated by the fish community, and a relatively high ranking (4.0).

The third group, for which little or no potential for toxic chemical impact was indicated, included stations 1, 4, 5, 6, 7, 8, 9, 11, 13, 15, 17, and 18. Not surprisingly, the group was dominated by upstream control sites (1, 7, 9, 11, 13, 15, 17) and remote sites (5, 6). Three, however, were downstream sites (4, 8, 18), and associated characteristics indicate that effects of toxic chemical inputs from the Presidio/Ojinaga, Del Rio/Ciudad Acuña, and Brownsville/Matamoros areas are minimal.

Three of the sites in the third group (4, 7, 8) exhibited two of the aforementioned characteristics, five (1, 5, 6, 9, 15) exhibited one of the characteristics, and four (11, 13, 17, 18) exhibited none of the characteristics. Stations 7 and 8 displayed exceedances of human health criteria in tissue, 8 had a slightly elevated ranking (8.0), and 7 had a high ranking (2.0). The latter mainly resulted from elevated levels of a variety of toxic chemicals in fish tissue. This may be related to hypolimnetic releases from International Amistad Reservoir, as there are no known extrinsic inputs of contaminants between the dam and station 7. The only adverse indications for station 4 were from historical data, involving one instance of significant effects in the TOXNET program (Table 18), and documentation of elevated pesticide levels during the 1970's and early 1980's (TNRCC, 1992a). There were no indications of toxic chemical-related problems at station 4 during the present study.

Among sites having one negative characteristic, stations 6, 9, and 15 exhibited exceedances of human health criteria in fish tissue, station 5 ranked relatively high (6.5), due mainly to exceedances of screening levels by metals in fish tissue, and station 1 displayed significant effects in toxicity testing of water. The latter occurrence may have been an aberration. No causative agent was apparent in the accompanying chemical data, and no other finding gave any indication of toxic chemical impact. Furthermore, there have been no significant effects in five samples collected for the TOXNET program (Table 18).

Tributaries.—Sites were ranked for each of 12 components belonging to four categories (water chemistry, sediment chemistry, toxicity testing of water, and toxicity testing of sediment eluates, as described for mainstem sites). Toxic chemical data for fish tissue, and bioassessment data for macrobenthic and fish communities, were not employed in the ranking because they were not generated for all tributary sites. For a parameter that exceeded multiple screening levels, the exceedance factor utilized was that associated with the most stringent screening level. Rankings for the 12 components were added for each site, and a final ranking was derived from the rank sums (Table 26).

The ranking was used along with supplemental information to group the tributaries according to potential for toxic chemical impact. Accessory information included exceedances of human health criteria in tissue (available for six sites), and observations on the condition of fish communities (available for eight sites). The term "impact" as applied here refers to adverse effects on aquatic life within the tributaries themselves, or human health hazards associated with regular consumption of water and/or fish from these systems. Potential effects tributary inflows exert on the Rio Grande/Río Bravo are considered separately.

The first group, for which a high potential for toxic chemical impact was indicated, included stations 1a, 2a, 10a, 11a, 11c, and 15a. These were characterized by: significant effects in water and/or sediment eluate toxicity tests, for which probable toxic chemical causative agents were identified; four or more toxic chemicals that exceeded screening levels in water and/or sediment; exceedance of human health criteria in water and/or tissue by one or more toxic chemicals, by factors > 5X; high potential for instream impact as indicated by fish community attributes (if the fish community was assessed); and a high ranking, from 1.0 to 7.0. Stations 1a, 2a, and 15a exhibited all of these characteristics, and stations 10a, 11a, and 11c, all but

one. Divergences were: 10a, total dissolved solids as the probable cause of toxicity testing effects; 11a, no exceedance of human health criteria; and 11c, exceedance of human health criteria by a factor $< 5X$.

The second group, for which a slight to moderate potential for toxic chemical impact was implied, consisted of stations 3a, 7b, 9a, and 12d. Traits of this group were: significant effects in water and/or sediment eluate toxicity tests, for which probable toxic chemical causative agents were identified; two or three toxic chemicals that exceeded screening levels in water and/or sediment; exceedance of human health criteria in water and/or tissue by one or more toxic chemicals, by a factor of 2 to $3X$; slight or moderate potential for instream impact as reflected by the condition of the fish community (if the fish community was assessed); and a moderate ranking, from 8.0 to 14.0. Stations 3a and 9a exhibited all of these traits, station 12d all but one, and station 7b all but two. Deviations were: 12d, a ranking higher than 8.0; and 7b, fewer than two toxic chemicals that exceeded screening levels in water and/or sediment, and exceedance of human health criteria by a factor $> 3X$.

The third group, for which little or no potential for toxic chemical impact was indicated, was comprised of stations 3b, 5a, 6a, 6b, 7a, 8a, 8b, 8c, 8d, 8e, 9b, 11b, 12a, 12b, 12c, and 12e. These displayed the following attributes: no significant effects in water or sediment eluate toxicity tests, significant effects attributable to total dissolved solids, or significant effects regarded as ecologically unimportant; two or fewer toxic chemicals that exceeded screening levels in water and/or sediment; no exceedance of human health criteria, or exceedance only by selenium in water by a factor $\leq 1.4X$; very slight or no potential for instream impact as indicated by the fish community (if the fish community was assessed); and a low ranking, from 15.0 to 26.0. Stations 6a, 6b, 7a, 8a, 8b, 8c, 8d, 9b, and 12e exhibited all of these characteristics, stations 3b, 5a, 12b, and 12c all but one, and stations 8e, 11b, and 12a all but two. Divergences were: 3b, 5a, and 12b, more than two toxic chemicals that exceeded screening levels in water and/or sediment; 12c, a ranking higher than 15.0; and 8e, 11b, and 12a, more than two toxic chemicals that exceeded screening levels in water and/or sediment, and a ranking higher than 15.0.

During low-flow conditions such as were prevalent during the study, the potential for adverse effects on the Rio Grande/Río Bravo is related to the above grouping and the volume of inflow. Among tributaries in the first group, the potential appears to be high for 1a and 2a (1.3-1.7 cms or 45-61 cfs), moderate for 11a and 15a (0.17-0.45 cms or 5.9-16 cfs), and slight for 10a and 11c (< 0.06 cms or 2 cfs). The potential associated with tributaries in the second group is slight to moderate for 3a and 7b (4-15 cms or 141-530 cfs), and very slight for 9a and 12d (< 0.03 cms or 1 cfs). Tributaries in the third group would not be expected to affect the mainstem, regardless of inflow volume.

A possibility exists that tributaries in the first and second group may exert greater relative effects during high flow events, due to scouring of contaminated bottom sediments. However, this has not been documented.

Toxic Chemicals of Potential Concern

The 30 toxic chemicals that exceeded screening levels are considered to be of potential concern in the Rio Grande/Río Bravo system. These chemicals were assigned an approximate level of importance based on their occurrence.

A high priority group includes 19 chemicals that exceeded screening levels in the mainstem.

residual chlorine	lead	chlordan
methylene chloride	mercury	p,p' DDE
toluene	nickel	dieldrin
arsenic	selenium	gamma-bhc (lindane)
cadmium	silver	total PCB's
chromium	zinc	cyanide
copper		

A medium priority group includes four chemicals that exceeded screening levels at multiple tributary sites.

un-ionized ammonia	phenol	diazinon
parachlorometa cresol		

A low priority group includes seven chemicals that exceeded screening levels at only one tributary site.

phenolics recoverable	thallium	diethyl phthalate
chloroform	bis(2-ethylhexyl) phthalate	di-n-butyl phthalate
antimony		

Identification of these 30 chemicals is very consistent with earlier indications for the system. In its review of historical water quality data for the Rio Grande/Río Bravo basin, TNRCC (1992a) identified toxic chemicals of potential concern. All but five of those (endrin, hexachlorobenzene, toxaphene, 2,4,5-T, total PAH's) are included in the preceding list. 2,4,5-T, historically elevated in the lower Pecos River, was not analyzed in the present study, but the other four were. Neither endrin nor toxaphene was detected in any matrix. Hexachlorobenzene was detected in tissue at one site (station 12), but did not exceed screening levels. Of fifteen PAH's that were analyzed, naphthalene was the only one that occurred above detection limits, in water from stations 1a and 15a, but again, screening levels were not exceeded. Thus, the subject chemicals were not shown to be problematic during the present study, and for that reason were not included in the preceding list.

RECOMMENDATIONS

Follow-up monitoring should be conducted at sites of potential concern as identified in the present study. The objectives would be to reexamine or better define the degree of impact, to assess temporal variation, and, in some cases, to try to further identify sources of toxic chemicals. Surveillance should be conducted at sites where a slight-to-moderate or high potential for toxic chemical impact was shown to exist (mainstem stations 2, 3, 10, 12, 14, 16; tributary stations 1a, 2a, 3a, 7b, 9a, 10a, 11a, 11c, 12d, 15a). Except for cases addressed below, the scope of evaluation should be the same as that employed in the present study (see "Types of Analyses" under "STUDY DESCRIPTION").

Expanded monitoring is recommended for the two mainstem locations where a high potential for toxic chemical impact was indicated (station 2, downstream from El Paso/Ciudad Juárez; station 12, downstream from Laredo/Nuevo Laredo). In reevaluating the station 2 area, three stations should be sampled, including 1a, 2, and a new mainstem site located a short distance upstream from 1a. The purpose of sampling the new site would be to try to distinguish the effects of upstream urban influences from those of the El Paso Public Service Board Haskell R. Street wastewater treatment plant discharge. The scope of evaluation at the new site should include toxic chemical analyses and toxicity testing of water and sediment. Bioassessments and analysis of contaminants in fish tissue are not recommended for the new site because physical habitat in the vicinity is extremely poor (channelized, concrete-lined streambed). Addition of another mainstem site downstream from station 2 would serve no purpose, because all flow in the river typically is diverted a short distance downstream, at Riverside Diversion Dam.

In reevaluating the station 12 area, sampling should be performed at station 12, at a new site downstream from station 12, and in local tributaries sampled during the present study (10a, 11a, 11b, 11c). A number of additional inflows exist in the vicinity (Buzan, 1990), and as many of these as possible should also be sampled in an effort to identify toxic chemical inputs. The new mainstem site should be established 10-15 km (6.2-9.3 miles) downstream from station 12, to examine longitudinal variation and to further define the extent of impact of toxic chemicals emanating from Laredo/Nuevo Laredo.

Another recommendation is that the Río Conchos (3a) and San Felipe Creek (7b), the only tributaries of potential concern that support significant aquatic life habitat, should be subjected to intensive surveillance. Multiple sites along the gradient of each stream should be evaluated similarly to the way mainstem stations were evaluated in the present study. Point source discharges should also be sampled, and evaluated as were tributaries during the present study.

Finally, surveillance to specifically evaluate toxic chemical concentrations in fish tissue (whole body and edible portions) is recommended for six locations. Four are sites where the potential for overall toxic chemical impact was shown to be low in the present study, but which did exhibit elevated numbers of toxic chemicals that exceeded screening levels, or anomalously high concentrations of certain contaminants, in fish tissue (stations 6, 7, 9, 11). These should be reevaluated to further characterize possible risks to fish communities, predatory species that feed on fish, and human health. Additionally, contaminant levels in fish tissue should be evaluated

at a minimum of one site in International Amistad Reservoir and one site in International Falcon Reservoir, neither of which was sampled during the present study. Both support significant sport fisheries, and baseline data is needed to characterize existing tissue contaminant levels. The most important locations, if single sites were utilized, would be in the extreme upper end of each reservoir, where the potential for contamination is greatest in association with riverine inflow.

REFERENCES CITED

- Addison, R.F. and P.F. Brodie. 1977. Organochlorine residues in maternal blubber, milk, and pup blubber from grey seals (*Halichoerus grypus*) from Sable Island, Nova Scotia. *Journal of the Fisheries Research Board of Canada* 34: 937-941.
- APHA (American Public Health Association). 1992. *Standard Methods for the Examination of Water and Wastewater*, 18th Edition. American Public Health Association, Washington, D.C.
- Arthur, J.W., J.A. Zischke, K.N. Allen, and R.O. Hermanutz. 1983. Effects of diazinon on macroinvertebrates and insect emergence in outdoor experimental channels. *Aquatic Toxicology* 4: 283-301.
- Bayer, C.W., J.R. Davis, S.R. Twidwell, R. Kleinsasser, G. Linam, K. Mayes, and E. Hornig. 1992. Texas Aquatic Ecoregion Project: An Assessment of Least Disturbed Streams. Draft report, Texas Natural Resource Conservation Commission, Austin.
- Belcher, R.C. 1975. The geomorphic evolution of the Rio Grande. *Baylor Geological Studies Bulletin* 29.
- Bestgen, K.R. and S.P. Platania. 1988. The ichthyofauna and aquatic habitats of the Rio Grande from the New Mexico-Texas border to Big Bend National Park. Report to the U.S. Fish and Wildlife Service Office of Endangered Species, Albuquerque, NM.
- Blair, W.F. 1950. The biotic provinces of Texas. *Texas Journal of Science* 2: 93-117.
- Braumbaugh, W.G. and D.A. Kane. 1985. Variability of aluminum concentrations in organs and whole bodies of smallmouth bass (*Micropterus dolomieu*). *Environmental Science and Technology* 19: 828-831.
- Brown, T.L. and H.E. Lemay. 1977. *Chemistry: The Central Science*. Prentice-Hall, Inc., NJ.
- Buzan, D.L. 1990. Intensive Survey of Rio Grande Segment 2304. Rept. No. IS 90-03, Texas Natural Resource Conservation Commission, Austin.
- Cain, B.W. 1993. Contaminant Assessment of the Upper Texas Coast. U.S. Fish and Wildlife Service, Houston, TX.
- Courtenay, W.R. Jr., and D.A. Hensley. 1980. Special problems associated with monitoring exotic species. Pp. 281-308 in: C.H. Hocutt and J.R. Stauffer, Jr., editors. *Biological Monitoring of Fish*. D.C. Heath, Lexington, MA.
- Crumby, W.D., M.A. Webb, F.J. Bulow, and H.J. Cathey. 1990. Changes in biotic integrity of a river in north-central Tennessee. *Transactions of the American Fisheries Society* 119: 885-893.

- CWRCB (California Water Resources Control Board). 1988. Selenium in California. Volume 1: History, chemistry, biology, uses, management. Rept. No. 88-10-I-WR, California Water Resources Control Board, Sacramento, CA.
- Davis, J.R. 1980. Species composition and diversity of benthic macroinvertebrates in the upper Rio Grande, Texas. *Southwestern Naturalist* 25: 137-150.
- Davis, J.R. 1991. Analysis of Fish Kills and Associated Water Quality Conditions in the Trinity River, Texas. IV. Assessment of Biotic Integrity. Rept. No. LP 91-03, Texas Natural Resource Conservation Commission, Austin.
- Doull, J., C.D. Klassen, and M.O. Amdur. 1980. Casarett and Doull's Toxicology: The Basic Science of Poisons. MacMillan Publishing Co., Inc., New York, NY.
- Eaton, J.G. 1974. Chronic cadmium toxicity to the bluegill (*Lepomis macrochirus* Rafinesque). *Transactions of the American Fisheries Society* 100: 729-735.
- Edwards, R.J. and S. Contreras-Balderas. 1991. Historical changes in the ichthyofauna of the lower Rio Grande (Rio Bravo del Norte), Texas and Mexico. *Southwestern Naturalist* 36: 201-212.
- Eisler, R. 1985. Selenium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85.
- Eisler, R. 1986a. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85.
- Eisler, R. 1986b. Chromium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85.
- Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85.
- Emerson, P.M. and E.W. Bourbon. 1991. The Border and Free Trade. Report to the North American Institute, Santa Fe, NM. Environmental Defense Fund, Austin, TX.
- EPRI (Electric Power Research Institute). 1986. Speciation of selenium and arsenic in natural waters and sediment. Volume 2: arsenic speciation. Report No. EA-4641, Electric Power Research Institute.
- Gamble, L.R., G. Jackson, and T.C. Muarar. 1988. Organochlorine, trace element, and petroleum hydrocarbon contaminants investigation of the lower Rio Grande valley, Texas, 1985-1986. U.S. Fish and Wildlife Service, Corpus Christi, TX.
- Gillespie, R.B. and P.C. Baumann. 1986. Effects of high tissue concentrations of selenium on reproduction by bluegills. *Transactions of the American Fisheries Society* 115: 208-213.

- Greenspun, R.L. and P.L. Taylor. 1979. Nonparametric and Comparison-to-Criteria Approaches to Analyzing Ambient Water, Fish, and Sediment Residue Data for the Metals, Pesticides, and Several of the Non-Pesticide Organics Priority Pollutants. U.S. Environmental Protection Agency, Washington, D.C.
- Hem, J.D. 1970. Study and Interpretation of the Chemical Characteristics of Natural Water, Second Edition. Geological Survey Water-Supply Paper 1473, U.S. Geological Survey, Washington, D.C.
- Hoffman, D.J. and G.H. Heinz. 1988. Embryotoxic and teratogenic effects of selenium in the diet of mallards. *Journal of Toxicology and Environmental Health* 24: 477-490.
- Hornig, C.E., C. Bayer, S. Twidwell, J.R. Davis, L.J. Kleinsasser, G. Linam, and K. Mayes. In press. Development of regionally-based biological criteria in Texas. In: W. Davis and T. Simon, editors. *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*. Lewis Publishers, Inc., Chelsea, MI.
- Hubbs, C.L. 1940. Fishes from the Big Bend Region of Texas. *Transactions of the Texas Academy of Science* (1938-1939) 23: 3-12.
- Hubbs, C. 1982. Occurrence of exotic fishes in Texas waters. The Pearce ~ Sellards Series No. 36. Texas Memorial Museum, Austin.
- Hubbs, C., R.R. Miller, R.J. Edwards, K.W. Thompson, E. Marsh, G.P. Garrett, G.L. Powell, D.J. Morris, and R.W. Zerr. 1977. Fishes inhabiting the Rio Grande, Texas and Mexico, between El Paso and the Pecos confluence. Pp. 91-97 in: R.R. Johnson and D.A. Jones, editors. *Importance, preservation, and management of riparian habitat*. U.S. Department of Agriculture, Forest Service General Technical Report RM-43.
- Hubbs, C., R.J. Edwards, and G.P. Garrett. 1991. An annotated checklist of the freshwater fishes of Texas, with keys to identification of species. *Texas Journal of Science* 43(4): supplement.
- Hughes, R.M. and J.R. Gammon. 1987. Longitudinal changes in fish assemblages and water quality in the Willamette River, Oregon. *Transactions of the American Fisheries Society* 116: 196-209.
- Hynes, H.B.N. 1970. *The Ecology of Running Waters*. University of Toronto Press, Toronto.
- Inmon, L.E., S.B. Smith, and C.F. Facemire. 1993. Contamination of the Sulfur River Wildlife Management Area and watershed in and near Texarkana, Arkansas and Texas. Publication No. VI-91-4254, U.S. Fish and Wildlife Service, Vicksburg, MS.
- Irwin, R.J. 1988. Impacts of toxic chemicals on Trinity River fish and wildlife. Contaminants Report, Ecological Services, U.S. Fish and Wildlife Service, Fort Worth, TX.

- Irwin, R.J. 1989. Toxic chemicals in fish and wildlife at Big Bend National Park, Texas. Contaminants Report, Ecological Services, U.S. Fish and Wildlife Service, Fort Worth, TX.
- Kanazawa, J. 1981. Measurement of the bioconcentration factors of pesticides by freshwater fish and their correlation with physicochemical properties or acute toxicities. *Pesticide Science* 12: 417-424.
- Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: A method and its rationale. Special publication 5, Illinois Natural History Survey, Champaign, IL.
- Kerans, B.L., J.R. Karr, and S.A. Ahlstedt. 1992. Aquatic invertebrate assemblages: spatial and temporal differences among sampling protocols. *Journal of the North American Benthological Society* 11: 377-390.
- Kleinsasser, L.J. and G.W. Linam. 1989. Water quality and fish assemblages in the Trinity River, Texas, between Fort Worth and Lake Livingston. Resource Protection Division, Texas Parks and Wildlife Department, Austin.
- Leidy, R.A. and P.L. Fielder. 1985. Human disturbance and patterns of fish species diversity in the San Francisco Bay drainage, California. *Biological Conservation* 33: 247-267.
- Lemly, A.D. 1985. Toxicology of selenium in a freshwater reservoir: Implications for environmental hazard evaluation and safety. *Ecotoxicology and Environmental Safety* 10: 314-338.
- Lewis, S.J., M. Kaltofen, and G. Ormsby. 1991. Border Trouble: Rivers in Peril. A Report on Water Pollution Due to Industrial Development in Northern Mexico. National Toxic Campaign Fund, Boston, MA.
- Linam, G.W. and L.J. Kleinsasser. 1987. Fisheries use attainability study for the Bosque River. Resource Protection Division, Texas Parks and Wildlife Department, Austin.
- Maier, K.J., R.S. Ogle, and A.W. Knight. 1988. The selenium problem in lentic ecosystems. *Lake and Reservoir Management* 4(2).
- McKee, J.E. and H.W. Wolf. 1963. Water Quality Criteria, Second Edition. Publ. No. 3-A, California State Water Resources Control Board, Sacramento, CA.
- Miller, D.L., P.M. Leonard, R.M. Hughes, J.R. Karr, P.B. Moyle, L.H. Schrader, B.A. Thompson, R.A. Daniels, K.D. Fausch, G.A. Fitzhugh, J.R. Gammon, D.B. Halliwell,

- P.L. Angermeir, and D.J. Orth. 1988. Regional applications of an index of biotic integrity for use in water resource management. *Fisheries* 13: 12-20.
- Minckley, W.L. 1973. *Fishes of Arizona*. Sims Printing Co., Phoenix, AZ.
- Moore, J.W. and S. Ramamoorthy. 1984. *Heavy Metals in Natural Waters*. Springer-Verlag, New York, NY.
- Moyle, P.B. 1976. *Inland fishes of California*. University of California Press, Berkeley, CA.
- Moyle, P.B. and R.D. Nichols. 1973. Ecology of some native and introduced fishes of the Sierra Nevada foothills in central California. *Copeia* 1973: 478-490.
- Moyle, P.B., L.R. Brown, and B. Herbold. 1986. Final report on development and preliminary tests of indices of biotic integrity for California. Final report to the U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.
- Neidermyer, W.J. and J.J. Hickey. 1976. Chronology of organochlorine compounds in Lake Michigan fish, 1929-66. *Pesticide Monitoring Journal* 10: 92-95.
- Norberg-King, T., M. Lukasewycz, and J. Jenson. 1989. Results of Diazinon Levels in POTW Effluents in the United States. National Effluent Toxicity Assessment Center Technical Report 14-89, USEPA Environmental Research Laboratory, Duluth, MN.
- Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Saunders Co., Philadelphia, PA.
- Ohio EPA (Environmental Protection Agency). 1987. *Biological Criteria for the Protection of Aquatic Life. Volume II. Users Manual for Biological Field Assessment of Ohio Surface Waters*. Doc. No. 0046e/0013e, Division of Water Quality Monitoring and Assessment, Ohio Environmental Protection Agency, Columbus, OH.
- Ohlendorf, H.M., D.J. Hoffman, M.K. Saiki, and T.W. Aldrich. 1986. Embryonic mortality and abnormalities of aquatic birds: Apparent impacts of selenium from irrigation drainwater. *The Science of the Total Environment* 52: 49-63.
- Ohlendorf, H.M. 1989. Bioaccumulation and effects of selenium in wildlife. Pp. 133-177 in: *Selenium in Agriculture and the Environment*. Soil Science Society of America Special Publication No. 23, Madison, WI.
- Omernik, J.M. 1985. Aquatic ecoregions of the conterminous United States. *Annals of the Association of American Geographers* 77: 118-225.
- Parslow, J.L.F. and D.J. Jefferies. 1973. Relationship between organochlorine residues in livers and whole bodies of guillemots. *Environmental Pollution* 5: 26-31.

- Phillips, G.R. and R.C. Russo. 1978. Metal Bioaccumulation in Fishes and Aquatic Invertebrates: A Literature Review. Rept. No. EPA 600/3-78-103, U.S. Environmental Protection Agency, Duluth, MN.
- Platania, S.P. 1991. The ichthyofauna of the Rio Grande drainage, Texas and Mexico, from Boquillas to San Ygnacio. Final Report to the U.S. Fish and Wildlife Service, Arlington, TX.
- Presser T.S. and I. Barnes. 1985. Dissolved constituents including selenium in waters in the vicinity of Kesterson Wildlife Refuge and the West Grassland, Fresno and Merced counties, California. Water Resources Investigation Rept. 85-4220, U.S. Geological Survey, Menlo Park, CA.
- Ramsey, J.S. 1968. Freshwater fishes. Pp. Y1-Y15 in: F.K. Parrish, editor. Keys to water quality indicative organisms: Southeastern United States. Federal Water Pollution Control Administration, Washington, D.C.
- Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. American Fisheries Society Special Publication 20, Bethesda, MD.
- Roques, P., B. Kubala, and D. Buzan. 1991. Water Quality Monitoring Procedures Manual. Surface Water Quality Monitoring Team, Texas Natural Resource Conservation Commission, Austin.
- Schmitt, C.J. and W.G. Brumbaugh. 1990. National Contaminant Biomonitoring Program: Concentrations of arsenic, cadmium, copper, lead, mercury, selenium, and zinc in U.S. freshwater fish, 1976-1984. Archives for Environmental Contamination and Toxicology 19: 731-747.
- Schmitt, C.J., J.L. Zajicek, and P.H. Peterson. 1990. National Contaminant Biomonitoring Program: Residues of organochlorine chemicals in U.S. freshwater fish, 1976-1984. Archives for Environmental Contamination and Toxicology 19: 748-781.
- Smith, M.L. and R.R. Miller. 1986. The evolution of the fishes of the Rio Grande basin as inferred from its fish fauna. Pp. 457-485 in: C.H. Hocutt and E.O. Wiley, editors. The Zoogeography of North American Freshwater Fishes. John Wiley and Sons, New York, NY.
- TDH (Texas Department of Health). 1992. Human health risk assessment for selenium in fish tissues of specimens taken from Brandy Branch, Martin Lake, and Welsh reservoirs. Interoffice memorandum, Texas Department of Health, Austin.
- TNRCC (Texas Natural Resource Conservation Commission). 1991. Texas Surface Water Quality Standards. Texas Natural Resource Conservation Commission, Austin. 138 pp.

- TNRCC (Texas Natural Resource Conservation Commission). 1992a. Regional Assessment of Water Quality in the Rio Grande Basin. Rept. No. GP 92-02, Texas Natural Resource Conservation Commission, Austin.
- TNRCC (Texas Natural Resource Conservation Commission). 1992b. Work Plan/Quality Assurance Project Plan, Rio Grande Toxic Substances Study. Watershed Management Division, Texas Natural Resource Conservation Commission, Austin.
- TNRCC (Texas Natural Resource Conservation Commission). 1993. Drinking Water Standards for Texas. Texas Natural Resource Conservation Commission, Austin.
- TNRCC (Texas Natural Resource Conservation Commission). 1994. Percentiles, Ranges, and Averages for Some Parameters in the Texas Surface Water Quality Monitoring Data Base. Watershed Management Division, Texas Natural Resource Conservation Commission, Austin.
- Trevino, D.T. 1955. The ichthyofauna of the lower Rio Grande river, from the mouth of the Pecos River to the Gulf of Mexico. M.S. thesis, Department of Zoology, University of Texas, Austin.
- Trevino-Robinson, D.T. 1959. The ichthyofauna of the lower Rio Grande, Texas and Mexico. *Copeia* 1959: 253-256.
- Twidwell, S.R. and J.R. Davis. 1989. An Assessment of Six Least Disturbed Unclassified Texas Streams. Rept. No. LP 89-04, Texas Natural Resource Conservation Commission, Austin.
- Twidwell, S.R., C.E. Bohmfalk, and J. DuPont. 1991. Quality Assurance Project Plan for the Texas Water Commission for Environmental Monitoring and Measurement Activities. Texas Natural Resource Conservation Commission, Austin.
- USDOE (U.S. Department of Energy). 1993. Air Force Plant 4 preliminary assessment: Site inspection and remedial investigation report, Vol. 1. USDOE Contract DE-AC04-86ID12584.
- USEPA (U.S. Environmental Protection Agency). 1980a. Ambient Water Quality Criteria for Phenol. Rept. No. EPA 440/5-80-066, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980b. Ambient Water Quality Criteria for Chloroform. Rept. No. EPA 440/5-80-033, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980c. Ambient Water Quality Criteria for Halomethanes. Rept. No. EPA 440/5-80-051, U.S. Environmental Protection Agency, Washington, D.C.

- USEPA (U.S. Environmental Protection Agency). 1980d. Ambient Water Quality Criteria for Tetrachloroethylene. Rept. No. EPA 440/5-80-073, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980e. Ambient Water Quality Criteria for Chlorinated Ethanes. Rept. No. EPA 440/5-80-029, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980f. Ambient Water Quality Criteria for Naphthalene. Rept. No. EPA 440/5-80-059, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980g. Ambient Water Quality Criteria for Benzene. Rept. No. EPA 440/5-80-018, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980h. Ambient Water Quality Criteria for Chlorinated Benzenes. Rept. No. EPA 440/5-80-028, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980i. Ambient Water Quality Criteria for Toluene. Rept. No. EPA 440/5-80-075, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980j. Ambient Water Quality Criteria for Ethylbenzene. Rept. No. EPA 440/5-80-048, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980k. Ambient Water Quality Criteria for Antimony. Rept. No. EPA 440/5-80-020, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980l. Ambient Water Quality Criteria for Thallium. Rept. No. EPA 440/5-80-074, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980m. Ambient Water Quality Criteria for Phthalate Esters. Rept. No. EPA 440/5-80-067, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1980n. Ambient Water Quality Criteria for Chlorinated Phenols. Rept. No. EPA 440/5-80-032, U.S. Environmental Protection Agency, Washington, D.C.

- USEPA (U.S. Environmental Protection Agency). 1982. Fate of Priority Pollutants in Publicly Owned Treatment Works. Rept. No. EPA 440/1-82-303, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1985a. National Perspective on Sediment Quality. U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1985b. Ambient Water Quality Criteria for Copper - 1984. Rept. No. EPA 440/1-84-331, U.S. Environmental Protection Agency, Washington, DC.
- USEPA (U.S. Environmental Protection Agency). 1986. Quality Criteria for Water - 1986. Rept. No. EPA 440/5-86-001, Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1989. Briefing Report to the EPA Science Advisory Board on the Equilibrium Partitioning Approach to Generating Sediment Quality Criteria. Rept. No. EPA 440/5-89-002, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1991. Proposed Sediment Quality Criteria for the Protection of Benthic Organisms: Dieldrin. U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1992. National Study of Chemical Residues in Fish. Rept. No. EPA 823-R-92-008a & b, U.S. Environmental Protection Agency, Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1993. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Rept. No. EPA 823-R-93-002, U.S. Environmental Protection Agency, Washington, D.C.
- USFDA (U.S. Food and Drug Administration). 1993. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. U.S. Food and Drug Administration, Washington, D.C.
- Verschueren, K. 1983. Handbook of Environmental Data on Organic Compounds, 2nd Edition. Van Nostrand Reinhold Co., New York, NY. 576 pp.
- Weber, C.I., W.H. Peltier, T.J. Norberg-King, W.B. Horning II, F.A. Kessler, J.R. Menkedick, T.W. Neiheisel, P.A. Lewis, D.J. Klemm, Q.H. Pickering, E.L. Robinson, J.M. Lazorchak, L.J. Wymer, and R.W. Freeburg. 1989. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Rept. No. EPA 600/4-89-001, Environmental Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH.

APPENDIX A

Tables

Table 1
List of Sampling Stations

Map Code	Station Description
<u>Mainstem Stations</u>	
1	Rio Grande at Courchesne Bridge (Hwy. 273) in El Paso, 2.7 km upstream from American Dam, at river km 2,020.8
2	Rio Grande at Zaragosa International Bridge in El Paso, at river km 1,992.8
3	Rio Grande 5.0 km upstream from Rio Conchos confluence near Presidio, at river km 1,552.2
4	Rio Grande below Rio Conchos confluence, 14.4 km downstream from Presidio/Ojinaga International Bridge, at river km 1,528.5
5	Rio Grande at mouth of Santa Elena Canyon in Big Bend National Park, at river km 1,424.7
5b*	Rio Grande immediately downstream from mouth of Lozier Canyon, 44 km southeast of Dryden, at river km 1,062.7
6	Rio Grande at Foster Ranch near Langtry, at river km 1,058.2
7	Rio Grande 0.4 km upstream from Del Rio/Ciudad Acuna International Bridge, at river km 903.2
8	Rio Grande 6.4 km downstream from Del Rio/Ciudad Acuna International Bridge, at river km 896.8
9	Rio Grande 1.0 km upstream from Eagle Pass/Piedras Negras International Bridge, at river km 799.8
10	Rio Grande 14 km downstream from Eagle Pass/Piedras Negras International Bridge, near irrigation canal lateral 50, at river km 785.8
11	Rio Grande at Laredo water treatment plant, 5.1 km upstream from old Laredo/Nuevo Laredo International Bridge (U.S. 81), at river km 585.9
12	Rio Grande at pipeline crossing, 13.2 km downstream from old Laredo/Nuevo Laredo International Bridge (U.S. 81), at river km 567.6
13	Rio Grande at Los Ebanos, 54.7 km upstream from Anzalduas Dam, at river km 328.8
14	Rio Grande 0.8 km downstream from Anzalduas Dam, at river km 273.3
15	Rio Grande at Hidalgo/Reynosa International Bridge (U.S. 281), at river km 256.7
16	Rio Grande below Anhele Drain south of Las Milpas, at river km 244.1
17	Rio Grande 6.3 km downstream from San Benito pumping plant and 15.3 km southwest of San Benito, at river km 155.8
18	Rio Grande 0.3 km downstream from El Jardin pumping plant and 11.2 km downstream from Brownsville/Matamoros International Bridge (U.S. 77), at river km 78.3

Table 3 (continued)
Sample Specifications

Parameters	Sample Volume/ Type of Container	Preservation	Holding Time
•toxicity testing	one 1 gal. cubitainer ^a	ice	7 days
^a - containers pretreated by rinsing with site water ^b - containers pretreated by rinsing with 10% metals-grade HNO ₃ , followed by type 2 deionized water ^c - containers pretreated by manufacturer ^d - containers pretreated by rinsing with methylene chloride, then baked at 40 °C overnight to remove traces of solvent ^e - initially, 100 mg sodium thiosulfate added if residual chlorine present ^f - initially, 0.6 g ascorbic acid added if residual chlorine present			

Table 4
Methods Utilized by Texas Department of
Health Environmental Chemistry Laboratory

Analyte	Matrix	Preparation/Digestion/ Extraction Method	Analytical Method	Method Description
GRAIN SIZE ANALYSIS	sediment			fraction separation and gravimetric determination
INORGANICS				
acid volatile sulfide	sediment	sample screened	Method 9030A	distillation, titrimetric
ammonia	water	sample filtered	EPA 350.1	colorimetric, automated phenate
chloride	water	sample filtered	EPA 325.2	colorimetric, automated ferricyanide AAII
cyanide	water	distillation	EPA 335.2	total, spectrophotometric
	sediment	sample screened	EPA 335.2	total, spectrophotometric
	tissue		EPA 335.2	total, spectrophotometric
lipid content	tissue	sample ground	AOAC 15 ed. 964.12	digestion
phenolics recoverable	water	distillation/extraction with chloroform	EPA 420.1	spectrophotometric, manual 4-AAP with distillation
	sediment	sample screened	EPA 420.1	spectrophotometric, manual 4-AAP with distillation
	tissue		EPA 420.1	spectrophotometric, manual 4-AAP with distillation
sulfate	water	sample filtered	EPA 9036	automated methylthymol blue method
total dissolved solids	water	sample filtered	EPA 160.1	residue, filterable, gravimetric, dried @ 180 °C
total hardness	water	sample filtered	EPA 130.2	titrimetric, EDTA
total organic carbon	water		EPA 415.1	combustion or oxidation
	sediment	sample screened, dried	EPA 415.1	combustion or oxidation
total suspended solids	water		EPA 160.2	residue, non-filterable, gravimetric, dried @ 103-105 °C
turbidity	water		EPA 180.1	nephelometric
METALS				
aluminum	water		EPA 200.7	ICP
	sediment	EPA SW Method 3050	EPA 200.7	ICP
	tissue	modification of EPA SW Method 200.3	EPA 200.7	ICP
antimony	water	EPA 3005	EPA 204.2	GFAA

Table 4 (continued)
Methods Utilized by Texas Department of
Health Environmental Chemistry Laboratory

Analyte	Matrix	Preparation/Digestion/ Extraction Method	Analytical Method	Method Description
arsenic	water	SM 3113B	EPA 206.2	GFAA
	sediment	EPA SW Method 3050	EPA 206.2	GFAA
	tissue	modification of EPA SW Method 200.3	EPA 206.3	hydride
beryllium	water		EPA 200.7	ICP
	sediment	EPA SW Method 3050	EPA 200.7	ICP
	tissue	modification of EPA SW Method 200.3	EPA 200.7	ICP
cadmium	water		EPA 213.2	GFAA
	sediment	EPA SW Method 3050	EPA 213.2	GFAA
	tissue	modification of EPA SW Method 200.3	EPA 213.2	GFAA
chromium	water		EPA 200.7	ICP
	sediment	EPA SW Method 3050	EPA 200.7	ICP
	tissue	modification of EPA SW Method 200.3	EPA 218.2	GFAA
copper	water		EPA 200.7	ICP
	sediment	EPA SW Method 3050	EPA 200.7	ICP
	tissue	modification of EPA SW Method 200.3	EPA 220.2	GFAA
lead	water		EPA 239.2	GFAA
	sediment	EPA SW Method 3050	EPA 239.2	GFAA
	tissue	modification of EPA SW Method 200.3	EPA 239.2	GFAA
mercury	water	EPA 245.1	EPA 245.1	manual cold vapor
	sediment	EPA SW Method 3050	EPA 245.5	manual cold vapor
	tissue	modification of EPA SW Method 200.3	EPA 245.6	manual cold vapor
nickel	water		EPA 200.7	ICP
	sediment	EPA SW Method 3050	EPA 200.7	ICP
	tissue	modification of EPA SW Method 200.3	EPA 249.2	GFAA
selenium	water	SM 3113B	EPA 270.2	GFAA
	sediment	EPA SW Method 3050	2,3-diaminonaphthalene	fluorometric

Table 4 (continued)
Methods Utilized by Texas Department of
Health Environmental Chemistry Laboratory

Analyte	Matrix	Preparation/Digestion/ Extraction Method	Analytical Method	Method Description
selenium	tissue	EPA SW Method 3050	2,3-diaminonaphthalene	fluorometric
silver	water		EPA 200.7	ICP
	sediment	EPA SW Method 3050	EPA 272.2	GFAA
	tissue	modification of EPA SW Method 200.3	EPA 272.2	GFAA
thallium	water		EPA 279.2	GFAA
	sediment	EPA SW Method 3050	EPA 279.2	GFAA
	tissue	modification of EPA SW Method 200.3	EPA 279.2	GFAA
zinc	water		EPA 200.7	ICP
	sediment	EPA SW Method 3050	EPA 200.7	ICP
	tissue	modification of EPA SW Method 200.3	EPA 200.7	ICP
VOLATILE ORGANICS	water	EPA 5030, purge & trap	EPA 8260	GC/MS
	sediment	EPA 5030, methanol extraction, purge & trap	EPA 8260	GC/MS
	tissue	EPA Region VII Lab sonication	EPA 8260	GC/MS
SEMIVOLATILE ORGANICS	water	EPA 3520, continuous liquid/liquid	EPA 8270	GC/MS
	sediment	EPA 3540, Soxhlet extraction	EPA 8270	GC/MS
	tissue	EPA 3540, Soxhlet extraction; EPA 3640, GPC cleanup	EPA 8270	GC/MS
INSECTICIDES	water	EPA 3510, separatory funnel	EPA 8080	GC-ECD
	sediment	EPA 3540, Soxhlet extraction; EPA 3620, cleanup florasil fractionation	EPA 8080	GC-ECD
	tissue	USFDA PAM Method 211, blender extraction; EPA 3640, GPC cleanup; EPA 3620, cleanup florasil fractionation	EPA 8080	GC-ECD
HERBICIDES	water	EPA 3510, separatory funnel, diazomethane esterification	EPA 8150	GC-ECD
	sediment	EPA 8150, shaker, separatory funnel, diazomethane esterification	EPA 8150	GC-ECD
CARBAMATES	water	dilution, direct injection	EPA 531	HPLC post column derivatization

Table 7 (continued)
Screening Level Concentrations

Parameter	Water				Sediment			Tissue		
	Human Health		Aquatic Life		National 85th Percentile ¹ (mg/kg)	Other (mg/kg)	National 85th Percentile ¹ (mg/kg)	Whole Body		Edible Tissue 28 (mg/kg)
	National 85th Percentile ¹ (µg/L)	Consumption of Fish and Water 23 (µg/L)	Consumption of Fish Only 24 (µg/L)	Acute Value (µg/L)	Chronic Value (µg/L)					
beryllium	NA	NA	NA	NA	NA	NV	3	NA	NA	NA
cadmium	6	10 ¹⁹	NV	SS	SS	SS	6.6	0.05 ³³ , 0.5 ³²	0.05 ³³ , 0.5 ³²	10
chromium, total	20	50 ¹⁹	NV	NV	NV	SS	60	0.39	0.2 ³² , 1.2 ³⁴	NV
trivalent	NV	33,300 ²⁵	673,000 ²⁵	SS	SS	NM	NM	NM	NM	NM
hexavalent	NV	50 ²⁵	NV	16 ¹⁹	11 ¹⁸	NM	NM	NM	NM	NM
copper	20	1,300 ¹⁴	NV	SS	SS	SS	52	1.0 ³³	1.0 ³³	NV
lead	20	5 ¹⁹	25 ¹⁹	SS	SS	SS	110	0.22 ³⁵ , 0.3 ³²	0.22 ³⁵ , 0.3 ³²	NV
mercury	1.3	0.0122 ¹⁹	0.0122 ¹⁹	2.4 ¹⁹	1.3 ¹⁹	SS	0.77	0.63	0.1 ³² , 0.17 ³³	0.6; 1.0 ²⁹
nickel	20	610 ¹⁴	4,600 ¹⁴	SS	SS	SS	44	0.6	0.5 ³² , 0.73 ³³	0.6; 1.0 ²⁹
selenium	10	10 ¹⁹	NV	20 ¹⁹	5 ¹⁹	SS	3.5	0.83	0.5 ³² , 0.73 ³³	50; 2.0 ²⁶
silver	10	50 ¹⁹	NV	0.92 ¹⁹	0.49 ¹⁹	NV	3	0.80	NV	NV
thallium	NV	1.7 ¹⁴	6.3 ¹⁴	NV	20 ¹⁶	NV	NV	NV	NV	NV
zinc	80	5,000 ²⁵	NV	SS	SS	SS	170	28	34.2 ³³	NV
PESTICIDES										
chlordane*	NA	NA	NA	NA	NA	SS	77 µg/kg	0.47	0.04 ³⁴ , 36	0.08 ³⁶ , 0.3 ²⁹ , 36
chlorpyrifos	NA	NA	NA	NA	NA	SS	NV	NA	NA	NA
p,p' DDD*	NA	NA	NA	NA	NA	SS	22 µg/kg	0.64	0.1 ³⁴ , 1.0 ²⁷ , 32	0.3 ²⁷
p,p' DDE*	NA	NA	NA	NA	NA	SS	18 µg/kg	2.9	1.21 ³⁴ , 1.0 ²⁷ , 32	5.0 ²⁷ , 29
p,p' DDT*	NA	NA	NA	NA	NA	NA	NA	2.0	0.11 ²⁴ , 1.0 ²⁷ , 32	5.0 ²⁷ , 29
diazinon	NV	NV	NV	0.35 ²	0.30 ³	NA	NA	NA	NA	NA
dieldrin*	NA	NA	NA	NA	NA	SS	5.5 µg/kg	0.28	0.01 ³⁴ , 0.1 ³²	0.007
gamma-bhc (lindane)*	0.1	4 ¹⁹	16 ¹⁹	2 ¹⁹	0.08 ¹⁹	NA	NA	NV	0.0027 ³⁵	0.08
PCB's AND RELATED COMPOUNDS										
arochlor 1248*	NA	NA	NA	NA	NA	NA	NA	NV	0.06 ³¹ , <0.1 ³⁰ , 32	0.01 ³⁰
arochlor 1254*	NA	NA	NA	NA	NA	NA	NA	9.6	0.21 ³¹ , <0.1 ³⁰ , 32	2.0 ²⁹ , 30 0.01 ³⁰ 2.0 ²⁹ , 30

Table 7 (continued)
Screening Level Concentrations

Parameter	Water				Sediment		Tissue		
	Human Health		Aquatic Life		National 85th Percentile ¹ (mg/kg)	Other (mg/kg)	Whole Body		
	National 85th Percentile ¹ (µg/L)	Consumption of Fish and Water ²³ (µg/L)	Consumption of Fish Only ²⁴ (µg/L)	Acute Value (µg/L)	Chronic Value (µg/L)		National 85th Percentile ¹ (mg/kg)	Other (mg/kg)	Edible Tissue ²⁸ (mg/kg)
PHthalate ESTERS									
bis(2-ethylhexyl) phthalate*	5	18 ¹⁴	59 ¹⁴	940 ¹⁷	3 ¹⁷	NV	NV	NV	NV
diethyl phthalate	20	23,000 ¹⁴	120,000 ¹⁴	940 ¹⁷	3 ¹⁷	NA	NA	NA	NA
di-n-butyl phthalate	NA	NA	NA	NA	NA	350 µg/kg	NA	NA	NA
GENERAL INORGANICS									
cyanide	0.068 mg/L	0.7 mg/L ¹⁴	220 mg/L ¹⁴	0.046 mg/L ¹⁹	0.011 mg/L ¹⁹	18	NV	NV	NV

¹ - from Greenspan and Taylor, 1979

² - from Norberg-King *et al.*, 1989 (represents 48 hr. LC50 value for *Ceriodaphnia dubia*)

³ - from Arthur *et al.*, 1983 (represents lowest recorded adverse effect level, which resulted in lowered emergence and elevated drift of stream insects)

⁴ - from USEPA, 1980 a

⁵ - from USEPA, 1980 b

⁶ - from USEPA, 1980 c

⁷ - from USEPA, 1980 d

⁸ - from USEPA, 1980 e

⁹ - from USEPA, 1980 f

¹⁰ - from USEPA, 1980 g

¹¹ - from USEPA, 1980 h

¹² - from USEPA, 1980 i

¹³ - from USEPA, 1980 j

¹⁴ - national criterion (USEPA, 1986)

¹⁵ - from USEPA, 1980 k

¹⁶ - from USEPA, 1980 l

¹⁷ - from USEPA, 1980 m

¹⁸ - drinking water maximum contaminant level (TNRCC, 1993)

¹⁹ - state criterion (TNRCC, 1991)

²⁰ - from USEPA, 1980 n

²¹ - minimum concentration reported to kill fish (McKee and Wolf, 1963)

²² - concentration reported to adversely affect bluegill sunfish within a ten hour period (McKee and Wolf, 1963)

²³ - applicable to all mainstem stations, and tributary stations 3a, 3b, 5a, 6a, 6b, 7b, 8a, 8b, 8c, 8d, 8e, 9b, 10a, 11a, 11b, 12a, 12b, 12c, 12d, 12e

²⁴ - applicable to tributaries dominated by treated or untreated domestic sewage effluent, which are not regarded as potential drinking water supplies (1a, 2a, 7a, 9a, 11c, 15a)

²⁵ - established as a national criterion, but later withdrawn in National Toxics Rule (USEPA, 1986)

²⁶ - from a risk assessment by TDH (1992)

²⁷ - value is for total DDT (sum of DDD + DDE + DDT)

Table 7 (continued)
Screening Level Concentrations

28	-	from Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (USEPA, 1993)
29	-	action or tolerance level (USFDA, 1993)
30	-	value is for total PCBs (sum of all atochlors)
31	-	geometric mean from the USFWS National Contaminant Biomonitoring Program (Schmitt <i>et al.</i> , 1990)
32	-	U.S. Fish and Wildlife Service predator protection limit
33	-	85th percentile value from the USFWS National Contaminant Biomonitoring Program (Schmitt and Brumbaugh, 1990)
34	-	85th percentile value from the TNRCC Surface Water Quality Monitoring program (TNRCC, 1994)
35	-	mean concentration from National Study of Chemical Residues in Fish (USEPA, 1992)
36	-	value is for total chlordane (sum of trans + cis isomers)
NV	-	no value exists
NA	-	not applicable because parameter was not detected in this matrix
NM	-	parameter was not measured in this matrix
SS	-	criterion is site-specific; see Table 8 for water, Table 9 for sediment
*	-	parameter identified as a carcinogen; human health criteria based on risk factor of 10^{-5}

Table 7 (continued)
 México Water Quality Standards
 Criteria in Water for Specific Toxic Materials
 Aquatic Life Protection

Parameter	México Fresh Water Aquatic Life Criteria*
Aldrin	3
Aluminum	50
Arsenic	200
Cadmium	@exp(0.785[ln(hardness)]-3.490)
Chlordane	2
Chromium (Hex)	10
Copper	@exp(0.8545[ln(hardness)]-1.465)
Cyanide**	5
DDT	1
Dieldrin	2
Endosulfan	0.2
Endrin	0.02
Heptachlor	0.5
Hexachlorocyclohexane (Lindane)	2.5
Lead	@exp(1.273[ln(hardness)]-4.105)
Mercury	0.01
Nickel	@exp(0.846[ln(hardness)]+1.1645)
Total PCB's	0.01
Parathion	0.04
Pentachlorophenol	0.5
Selenium	8
Silver, as free ion	@exp(1.72[ln(hardness)]-6.52)
Toxaphene	0.0002
2,4,5 Trichlorophenol	10
Zinc	@exp(0.8473[ln(hardness)]+10.36)

* All Values Listed or Calculated in Micrograms per Liter - Hardness Concentrations are
 Input as Milligrams per Liter

** Amenable to Chlorination

95-B

Table 8
Site-Specific Screening Level Concentrations for Water^a

Parameter	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
CONVENTIONAL ^b (mg/L)												
ammonia (unionized) m,n	0.096/0.018	0.302/0.041	NA	0.151/0.029	0.127/0.025	NA	NA	NA	NA	NA	0.123/0.024	0.146/0.028
METALS (µg/L) ^b												
cadmium c,d,s	NA	NA	146/3.1	NA	NA	NA	NA	NA	NA	NA	NA	NA
chromium, trivalent e,f,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
copper g,h,s	NA	33.4/21.1	65.2/38.8	NA	NA	46.4/28.5	13.0/9.0	65.8/39.1	NA	NA	NA	62.2/37.1
lead i,j,s	477/18.6	173/6.7	NA	433/16.9	715/27.9	NA	NA	NA	475/18.5	NA	NA	NA
nickel k,l,s	NA	2,332/259	NA	4,300/478	5,999/667	3,131/348	NA	4,290/477	4,573/508	NA	NA	NA
zinc o,p,s	NA	193/174	351/318	355/322	496/449	NA	82.3/74.5	355/321	378/342	NA	NA	336/304

Table 8 (continued)
Site-Specific Screening Level Concentrations for Water^a

Parameter	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
CONVENTIONALS (mg/L)												
ammonia (unionized) m,n	0.099/0.016	0.131/0.025	NA	0.092/0.010	NA	0.118/0.023	0.157/0.030	NA	NA	NA	NA	NA
METALS (µg/L) ^b												
cadmium c,d,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
chromium, trivalent e,f,s	10,404/1,240	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
copper g,h,s	NA	34.1/21.5	45.2/27.8	62.3/37.2	NA	NA	NA	NA	NA	NA	33.9/21.4	NA
lead i,j,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
nickel k,l,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
zinc o,p,s	NA	NA	253/229	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 8 (continued)
Site-Specific Screening Level Concentrations for Water^a

Parameter	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
CONVENTIONALS (mg/L)												
ammonia (unionized) m,n	0.135/0.017	NA	NA	NA	NA	0.202/0.037	NA	0.148/0.014	0.224/0.041	NA	0.283/0.041	0.302/0.041
METALS (µg/L) ^b												
cadmium c,d,s	NA	137/3.0	NA	807/10.3	107/2.5	71.6/1.9	1,017/12.2	NA	NA	613/8.6	NA	155/3.3
chromium, trivalent e,f,s	6,816/812	NA	NA	NA	NA	NA	NA	NA	NA	14,280/1,702	NA	NA
copper g,h,s	NA	61.8/37.0	NA	272/142	50.5/30.7	36.0/22.6	330/169	NA	NA	NA	NA	68.9/40.8
lead i,j,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
nickel k,l,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4,466/496
zinc o,p,s	NA	NA	NA	NA	NA	206/187	NA	NA	NA	NA	NA	NA

Table 8 (continued)
Site-Specific Screening Level Concentrations for Water^a

Parameter	Station									
	12d	12e	13	14	15	15a	16	17	18	
CONVENTIONAL (mg/L)										
ammonia (unionized) m,n	0.016/0.020	0.114/0.015	0.152/0.029	NA	NA	0.102/0.013	0.143/0.028	NA	NA	
METALS (µg/L) b										
cadmium c,d,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	
chromium, trivalent c,f,s	NA	NA	NA	NA	NA	7,533/898	NA	NA	NA	
copper g,h,s	109/61.7	NA	47.1/28.9	46.5/28.6	NA	104/59.2	48.6/29.7	63.2/37.7	77.4/45.3	
lead i,j,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	
nickel k,l,s	NA	NA	NA	NA	NA	NA	NA	NA	NA	
zinc o,p,s	557/504	534/484	NA	NA	NA	534/484	270/244	342/309	NA	

NA - not applicable because parameter was below the detection limit at this site

a - values in table represent criteria for protection of freshwater aquatic life, presented as acute value/chronic value

m - calculated according to equations described by USEPA (1984)

n - values for this parameter represent national criteria (USEPA, 1986)

s - values for this parameter represent state criteria (TNRCC, 1991)

b - metals criteria calculated using hardness concentrations from Table 8, according to following equations:

$$c = e^{(1.128[\ln(\text{hardness})]-1.6774)} \quad i = e^{(1.273[\ln(\text{hardness})]-1.460)}$$

$$d = e^{(0.7852[\ln(\text{hardness})]-3.490)} \quad j = e^{(1.273[\ln(\text{hardness})]-4.705)}$$

$$e = e^{(0.8190[\ln(\text{hardness})]+3.688)} \quad k = e^{(0.8460[\ln(\text{hardness})]+3.3612)}$$

$$f = e^{(0.8190[\ln(\text{hardness})]+1.561)} \quad l = e^{(0.8460[\ln(\text{hardness})]+1.1645)}$$

$$g = e^{(0.9422[\ln(\text{hardness})]-1.3844)} \quad o = e^{(0.8473[\ln(\text{hardness})]+0.8604)}$$

$$h = e^{(0.8545[\ln(\text{hardness})]-1.386)} \quad p = e^{(0.8473[\ln(\text{hardness})]+0.7614)}$$

Table 9
Site-Specific Screening Level Concentrations for Sediment*

Parameter	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
HALOGENATED ALIPHATICS (µg/kg)												
methylene chloride ^a	110	NA	139	315	230	NA	550	NA	NA	NA	NA	NA
MONOCYCLIC AROMATICS (µg/kg)												
toluene ^b	550	39,350	695	1,575	1,150	NA	2,750	NA	NA	NA	NA	NA
1,2-dichlorobenzene ^c	NA	11,018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-dichlorobenzene ^c	NA	11,018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
METALS (mg/kg)												
arsenic ^d	1.82	130	2.29	5.20	3.80	2.39	9.08	4.46	5.36	4.54	3.96	13.6
cadmium ^e	1.71	122	2.15	4.88	3.57	2.25	8.53	4.19	5.04	4.26	3.72	12.8
chromium ^f	1.38	98.4	1.74	3.94	1.81	2.88	6.88	3.38	4.06	3.44	3.00	10.3
copper ^g	7.48	535	9.45	21.4	15.6	9.86	37.4	18.4	22.1	18.7	16.7	56.1
lead ^h	7.26	519	9.17	20.8	15.2	9.57	36.3	17.8	21.5	18.2	15.8	54.5
mercury ⁱ	0.04	3.15	0.06	0.13	0.09	0.06	0.22	0.11	0.13	0.11	0.10	0.33
nickel ^j	1.10	78.7	1.39	3.15	2.30	1.45	5.50	2.70	3.25	2.75	2.40	8.25
zinc ^k	41.8	2,991	52.8	120	87.4	55.1	209	103	124	105	91.2	314
PESTICIDES (µg/kg)												
chlordane ^l	NA	78.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
chlorpyrifos ^{oo}	NA	507	NA	20.3	NA	NA	NA	NA	NA	NA	NA	NA
p,p' DDD ^m	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
p,p' DDE ⁿ	NA	NA	NA	4,410	NA	2,030	NA	NA	NA	NA	NA	NA
dieldrin ^{ooo}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PHTHALATE ESTERS (µg/kg)												
di-n-butyl phthalate ^o	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 9 (continued)
Site-Specific Screening Level Concentrations for Sediment*

Parameter	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
HALOGENATED ALIPHATICS (µg/kg)												
methylene chloride ^a	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MONOCYCLIC AROMATICS (µg/kg)												
toluene ^b	NA	15,750	1,435	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-dichlorobenzene ^c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-dichlorobenzene ^c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
METALS (µg/kg)												
arsenic ^d	32.9	52.0	4.74	52.1	31.7	12.1	80.4	43.6	5.78	22.1	5.42	11.4
cadmium ^e	30.9	48.8	4.45	48.9	29.8	11.4	75.6	40.9	5.43	20.8	5.09	10.7
chromium ^f	24.9	39.4	3.59	39.4	24.0	9.19	60.9	33.0	4.38	16.8	4.11	8.63
copper ^g	136	214	19.5	215	131	50.0	332	180	23.8	91.1	22.3	46.9
lead ^h	132	208	18.9	208	127	48.5	322	174	23.1	88.4	21.7	45.5
mercury ⁱ	NA	NA	0.11	1.26	NA	0.29	NA	1.06	0.14	NA	0.13	0.28
nickel ^j	20.0	31.5	2.87	31.6	19.2	7.35	48.8	26.4	3.50	13.4	3.29	6.90
zinc ^k	758	1,197	109	1,199	730	279	1,853	1,003	133	509	125	262
PESTICIDES (µg/kg)												
chlordane ^l	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
chlorpyrifos ^o	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
p,p' DDD ^m	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9,660
p,p' DDE ⁿ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
dieldrin ^o	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PHTHALATE ESTERS (µg/kg)												
di-n-butyl phthalate ^o	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 9 (continued)
Site-Specific Screening Level Concentrations for Sediment*

Parameter	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
HALOGENATED ALIPHATICS (µg/kg)												
methylene chloride ^a	NA	NA	NA	NA	NA	NA	NA	NA	530	NA	NA	NA
MONOCYCLIC AROMATICS (µg/kg)												
toluene ^b	6,025	NA	NA	NA	NA	NA	NA	47,750	2,650	NA	NA	NA
1,2-dichlorobenzene ^c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-dichlorobenzene ^c	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
METALS (mg/kg)												
arsenic ^d	19.9	14.4	7.05	11.6	7.82	12.8	7.10	158	8.75	9.82	10.2	11.1
cadmium ^e	18.7	13.6	6.63	10.9	7.35	12.0	6.67	148	8.23	9.22	9.61	10.4
chromium ^f	15.1	10.9	5.34	8.81	5.93	9.69	5.38	119	6.63	7.44	7.75	8.38
copper ^g	81.9	59.5	29.1	47.9	32.2	52.7	29.2	649	36.0	40.5	42.2	45.6
lead ^h	79.5	57.8	28.2	46.5	31.1	51.2	28.4	630	35.0	39.3	40.9	44.2
mercury ⁱ	0.48	0.35	0.17	0.28	0.19	0.31	0.17	3.82	0.21	0.24	0.25	0.27
nickel ^j	12.1	8.75	4.28	7.05	4.74	7.75	4.30	95.5	5.30	5.95	6.20	6.70
zinc ^k	458	333	162	268	180	295	163	3,629	201	226	236	255
PESTICIDES (µg/kg)												
chlordane ^l	NA	NA	NA	NA	NA	7.8	4.3	95.5	NA	NA	NA	NA
chlorpyrifos ^m	NA	NA	NA	NA	NA	NA	NA	615	NA	NA	NA	NA
p,p' DDD ⁿ	NA	NA	NA	NA	NA	5,038	NA	NA	NA	NA	NA	NA
p,p' DDE ^a	16,870	12,250	NA	9,870	6,636	10,850	6,020	NA	7,420	NA	NA	NA
dieldrin ^o	NA	NA	NA	NA	NA	140	NA	NA	NA	NA	NA	NA
PHTHALATE ESTERS (µg/kg)												
di-n-butyl phthalate ^o	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 9 (continued)
Site-Specific Screening Level Concentrations for Sediment*

Parameter	Station									
	12d	12e	13	14	15	15a	16	17	18	
HALOGENATED ALIPHATICS (µg/kg)										
methylene chloride ^a	NA	NA	NA	NA	NA	NA	NA	NA	NA	
MONOCYCLIC AROMATICS (µg/kg)										
toluene ^b	NA	NA	NA	NA	NA	4,475	NA	NA	NA	
1,2-dichlorobenzene ^c	NA	NA	NA	NA	NA	NA	NA	NA	NA	
1,4-dichlorobenzene ^c	NA	NA	NA	NA	NA	NA	NA	NA	NA	
METALS (mg/kg)										
arsenic ^d	24.6	11.8	5.69	2.37	3.47	14.8	2.85	4.29	3.22	
cadmium ^e	23.1	11.1	5.35	2.22	3.26	13.9	2.68	4.03	3.02	
chromium ^f	18.6	8.94	4.31	1.79	2.63	11.2	2.16	3.25	2.44	
copper ^g	101	48.6	23.5	9.76	14.3	60.9	11.8	17.7	13.3	
lead ^h	98.3	47.2	22.8	9.47	13.9	59.1	11.4	17.2	12.9	
mercury ⁱ	0.60	0.29	0.14	0.06	0.08	0.36	0.07	0.10	0.08	
nickel ^j	14.9	7.15	3.45	1.44	2.11	8.95	1.73	2.60	1.95	
zinc ^k	566	272	131	54.5	80.0	340	65.7	98.8	74.1	
PESTICIDES (µg/kg)										
chlordane ^l	NA	NA	NA	NA	NA	9.0	NA	NA	NA	
chlorpyrifos ^m	NA	NA	NA	NA	NA	NA	NA	NA	NA	
p,p' DDD ⁿ	NA	NA	NA	NA	NA	NA	NA	NA	NA	
p,p' DDE ⁿ	20,860	NA	NA	NA	NA	NA	NA	NA	NA	
dieldrin ^o	NA	NA	NA	NA	NA	NA	NA	NA	NA	
PHTHALATE ESTERS (µg/kg)										
di-n-butyl phthalate ^o	1.49x10 ⁶	NA	NA	NA	NA	NA	NA	NA	NA	

NA - not applicable because parameter was below the detection limit at this site

* values for all parameters except chlorpyrifos and dieldrin calculated as described in "Physicochemical Methods" section, using total organic carbon data from Table 9, and the following threshold concentrations (from USEPA, 1985a):

a - 2 mg/kg	f - 25 mg/kg	k - 760 mg/kg
b - 10 mg/kg	g - 136 mg/kg	l - 0.02 mg/kg
c - 2.8 mg/kg	h - 132 mg/kg	m - 13 mg/kg
d - 33 mg/kg	i - 0.8 mg/kg	n - 28 mg/kg
e - 31 mg/kg	j - 20 mg/kg	o - 2,000 mg/kg

** values derived from interim sediment quality criterion of 3.22 µg/g organic carbon (USEPA, 1989), normalized using total organic carbon data from Table 9

*** values derived from proposed national criterion of 9.0 µg/g organic carbon (USEPA, 1991), normalized using total organic carbon data from Table 9

Table 10
Analytical Data - Water

Parameter	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
DATE	111292	111192	111192	111292	111392	111392	111392	111492	111592**	111592	020893	020893
TIME	0900	1600	1000	1400	1000	1200	1600	0900	1200	1200	1040	1322
CONVENTIONAL												
ammonia (NH ₃ -N) (mg/L)	0.09	20.82	<0.02	17.67	0.19	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	0.09
ammonia (un-ionized) (mg/L) ^t	0.006	0.028	<0.001	0.395	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002
chloride (mg/L)	202	378	238	293	500	65	21	227	237	9	223	213
dissolved oxygen (mg/L)	9.8	5.9	6.8	0.3	8.9	9.6	11.2	8.8	9.3	8.8	10.4	10.7
flow (cfs)	185	45	186	61	278	530	1.1	798	722	2.8	847	847
pH (std. units)	8.6	6.3	7.7	7.9	8.4	8.1	8.6	8.2	8.4	8.1	7.9	8.0
residual chlorine (mg/L)	0.0	1.2	<0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
specific conductance (umhos/cm)	1,700	1,830	1,760	1,810	2,640	962	525	1,620	1,680	1,305	1,550	1,540
sulfate (mg/L)	445	175	406	206	510	262	49	368	386	560	347	369
temperature (°C)	8.4	27.4	15.1	15.7	12.5	15.7	23.4	13.9	14.5	17.5	12.8	14.5
total dissolved solids (mg/L)	1,200	1,100	1,240	1,180	1,820	680	318	1,120	1,190	1,030	1,060	1,030
total hardness (mg/L)	400	180	366	371	550	255	66	370	399	386	344	348
total organic carbon (mg/L)	5	15	6	49	11	4	1	7	8	1	8	9
total suspended solids (mg/L)	54	5	120	96	358	20	5	97	109	7	116	155
turbidity (ju)	1.8	2.4	23	12	110	3.5	0.4	22	28	1.4	32	21
PHENOLS AND CRESOLS (µg/L)												
parachlorometa cresol	<5.5	<13	<5.8	27	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<6.9	<5.6
pentachlorophenol	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
phenol (C ₆ H ₅ OH) single compound	<11	<13	<12	15	<14	<12	<11	<11	<11	<11	<12	<12
phenolics recoverable	<2.0	10	<2.0	36.8	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	*	*
2-chlorophenol	<11	<13	<12	<12	<14	<12	<11	<11	<11	<11	<12	<12
2-nitrophenol	<11	<13	<12	<12	<14	<12	<11	<11	<11	<11	<12	<12
2,4-dichlorophenol	<11	<13	<12	<12	<14	<12	<11	<11	<11	<11	<12	<12
2,4-dimethylphenol	<11	<13	<12	<12	<14	<12	<11	<11	<11	<11	<12	<12
2,4-dinitrophenol	<22	<26	<23	<23	<28	<23	<22	<22	<22	<22	<23	<23
2,4,6-trichlorophenol	<11	<13	<12	<12	<14	<12	<11	<11	<11	<11	<12	<12
4-nitrophenol	<22	<26	<23	<23	<28	<23	<22	<22	<22	<22	<23	<23
4,6-dinitro-ortho-cresol	<22	<26	<23	<23	<28	<23	<22	<22	<22	<22	<23	<23
ETHERS (µg/L)												
bis(2-chloroethoxy) methane	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
bis(2-chloroethyl) ether	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
bis(2-chloroisopropyl) ether	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
4-bromophenyl phenyl ether	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
4-chlorophenyl phenyl ether	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
HALOGENATED ALIPHATICS (µg/L)												
bromodichloromethane	<2.0	2.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
bromoform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
carbon tetrachloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
chloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
chloroform	<2.0	37.5	2.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dibromochloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dichlorodifluoromethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
hexachlorobutadiene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
hexachlorocyclopentadiene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
hexachloroethane	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
methyl bromide	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methylase chloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
tetrachloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
trichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
trichlorofluoromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
vinyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,1-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,1-trichloroethane	<2.0	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2-trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2,2-tetrachloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-dichloropropane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-trans-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-trans-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-cis-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
POLYCYCLIC AROMATIC												
HYDROCARBONS (µg/L)												
acenaphthene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
acenaphthylene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
anthracene/phenanthrene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
benzo(A) anthracene 1,2-benzanthracene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
benzo(B) fluoranthene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
benzo(OH) perylene 1,12-benzoperylene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
benzo(K) fluoranthene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6
benzo-A-pyrene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.7	<5.6

Table 10 (continued)
Analytical Data - Water

Parameter	Station										
	1	1a	2	2a	3	3a	3b	4	5	5a	6
chrysene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
fluoranthene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
fluorene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
indeno(1,2,3-CD) pyrene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
naphthalene	<2.0	6.9	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
pyrene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
1,2,5,6-dibenzanthracene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
MONOCYCLIC AROMATICS (µg/L)											
benzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
chlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
ethylbenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
hexachlorobenzene	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
nitrobenzene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
styrene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
toluene	<2.0	<2.0	<2.0	7.5	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
xylene	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
1,2-dichlorobenzene	<2.0	5.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2,4-trichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,4-dichlorobenzene	<2.0	2.5	<2.0	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
2,4-dinitrotoluene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
2,6-dinitrotoluene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
NITROSAMINES AND OTHER N COMPOUNDS (µg/L)											
acrylonitrile	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
benzidine	<11	<13	<12	<12	<14	<12	<11	<11	<11	<11	<12
n-nitrosodi-N-propylamine	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
n-nitrosodimethylamine	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
n-nitrosodiphenylamine	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
1,2-diphenylhydrazine	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
3,3-dichlorobenzidine	<11	<13	<12	<12	<14	<12	<11	<11	<11	<11	<12
METALS (µg/L)											
aluminum	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
antimony	1.5	5.8	6.3	3.2	5.6	6.3	1.4	5.0	4.1	1.7	1.9
arsenic	2.6	7.1	4.4	4.6	8.1	20.6	10.6	14.4	15.8	<0.7	5.5
beryllium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.8
cadmium	<0.10	<0.10	0.21	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
chromium	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
copper	<1.6	8.8	4.2	<1.6	<1.6	2.1	2.1	2.4	<1.6	<1.6	<1.6	1.8
lead	1.1	2.8	<1.0	1.2	1.6	<1.0	<1.0	<1.0	1.8	<1.0	<1.0	<1.0
mercury	<0.13	<0.13	<0.13	0.14	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
nickel	<4.7	5.9	<4.7	8.1	15.4	9.6	<4.7	19.6	10.6	<4.7	<4.7	<4.7
selenium	<2.4	3.7	<2.4	<2.4	<2.0	<2.0	<2.4	<2.4	3.0	5.5	4.9	<4.0
silver	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.7	<2.7
thallium	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
zinc	<5.0	20.7	9.7	6.4	5.2	<5.0	6.4	14.0	7.6	<5.0	<5.0	5.3
PESTICIDES (ug/L)												
aldicarb	<10	<10	<10	<10	<10	<10	<10	<5	<5	<5	<10	<10
aldrin	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
alpha benzene hexachloride	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
atrazine	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
beta benzene hexachloride	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
carbaryl	<10	<10	<10	<10	<10	<10	<10	<5	<5	<5	<10	<10
carbofuran	<10	<10	<10	<10	<10	<10	<10	<5	<5	<5	<10	<10
chlordane	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
chlorfenvinphos	<0.07	<0.07	<0.07	<0.14	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
chlorobutanol	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorpyrifos	<0.6	<0.6	<0.6	<1.2	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
p,p' DDD	<0.15	<0.15	<0.15	<0.30	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
p,p' DDE	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
p,p' DDT	<0.15	<0.15	<0.15	<0.30	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
delta benzene hexachloride	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
diazinon	<0.3	<0.3	<0.3	<0.6	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
dibromochloropropane (dbcp)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dicamba	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-dichlorophenoxyacetic acid (2,4-D)	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
dicofof (telthane)	<2.0	<2.0	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dieldrin	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
dinoseb	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
endosulfan alpha	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endosulfan beta	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endosulfan sulfate	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endrin	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endrin aldehyde	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
gamma-bhc (lindane)	<0.03	<0.03	<0.03	<0.06	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
guthion	<3.0	<3.0	<3.0	<6.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
heptachlor	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
heptachlor epoxide	<0.06	<0.06	<0.06	<0.12	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06

Table 10 (continued)
Analytical Data - Water

Parameter	Station										
	1	1a	2	2a	3	3a	3b	4	5	5a	6
isophorone	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
malathion	<0.4	<0.4	<0.4	<0.8	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
methionyl	<10	<10	<10	<10	<10	<10	<10	<5	<5	<5	<10
methoxychlor	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
metolachlor	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
mirex	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
parathion	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
picloram	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
simazine	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
toxaphene	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4,5-TP (silver)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PCB's AND RELATED COMPOUNDS (µg/L)											
arochlor 1016	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1221	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1232	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1242	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1248	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1254	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1260	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-chloronaphthalene	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
PHTHALATE ESTERS (µg/L)											
bis(2-ethylhexyl) phthalate	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
di-n-butyl phthalate	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
di-n-octyl phthalate	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
diethyl phthalate	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
dimethyl phthalate	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
n-butyl benzyl phthalate	<5.5	<6.3	<5.8	<5.6	<6.9	<5.8	<5.3	<5.5	<5.4	<5.4	<5.6
GENERAL INORGANICS (mg/L)											
cyanide	0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

a - not measured, but approximately equivalent to flow at station 6
 f - calculated from total ammonia concentration according to equations described by USEPA (1984)
 • - lab unable to produce satisfactory results
 •• - for semi-volatile organics, no sample obtained on this date due to a field error; data for this chemical group based on resampling by U.S. National Park Service (01/20/93; 1300 hrs.)

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
DATE	02/08/93	02/09/93	02/10/93	02/10/93	02/09/93	02/10/93	02/11/93	02/11/93	02/11/93	02/12/93	02/12/93	03/22/93
TIME	1645	0920	1640	1505	1502	1000	1735	0930	1000	1125	1210	0752
CONVENTIONALS												
ammonia (NH ₃ -N) (mg/L)	0.02	0.02	<0.02	1.86	<0.02	0.06	0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ammonia (unionized) (mg/L) ^f	<0.001	<0.001	<0.001	0.010	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
chloride (mg/L)	1,120	15	118	75	17	108	52	24	106	20	17	122
dissolved oxygen (mg/L)	10.2	9.1	11.7	6.6	8.3	9.4	10.0	9.9	9.0	9.4	10.3	8.2
flow (cfs)	218	323	b	18	141	1,172	19	142	25	19	1,244	993
pH (std. units)	7.6	7.9	8.1	7.2	7.7	7.7	7.9	7.8	7.8	7.7	8.1	8.1
residual chlorine (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
specific conductance (umhos/cm)	4,330	400	978	977	451	936	541	508	404	403	934	990
sulfate (mg/L)	650	10	210	182	20	191	71	205	33	33	16	204
temperature (°C)	12.7	13.7	15.2	18.3	21.6	14.0	16.3	14.0	12.4	16.5	14.8	18.0
total dissolved solids (mg/L)	2,920	208	630	636	202	606	298	296	622	215	214	678
total hardness (mg/L)	890	184	248	349	202	255	193	225	256	178	183	281
total organic carbon (mg/L)	1	5	4	8	2	4	3	2	5	2	3	3
total suspended solids (mg/L)	<5	6	<5	40	18	7	5	<5	21	<5	141	15
turbidity (ntu)	0.4	0.2	0.3	5.5	1.2	0.8	1.3	1.8	2.2	1.2	14	4.4
PHENOLS AND CRESOLS (µg/L)												
parachlorometa cresol	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
pentachlorophenol	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
phenol (C ₆ H ₅ OH) single compound	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
phenolics recoverable	*	*	*	*	*	*	*	*	*	*	*	*
2-chlorophenol	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
2-nitrophenol	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
2,4-dichlorophenol	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
2,4-dimethylphenol	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
2,4-dinitrophenol	<24	<23	<22	<23	<22	<22	<22	<23	<23	<22	<21	<23
2,4,6-trichlorophenol	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
4-nitrophenol	<24	<23	<22	<23	<22	<22	<22	<23	<23	<22	<21	<23
4,6-dinitro-ortho-cresol	<24	<23	<22	<23	<22	<22	<22	<23	<23	<22	<21	<23
ETHERS (µg/L)												
bis(2-chloroethoxy) methane	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
bis(2-chloroethyl) ether	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
bis(2-chloroisopropyl) ether	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
4-bromophenyl phenyl ether	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
4-chlorophenyl phenyl ether	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
HALOGENATED ALIPHATICS (µg/L)												
bromodichloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
bromoform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
carbon tetrachloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
chloroethane	<5.0	<5.0	<2.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
chloroform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dibromochloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dichlorodifluoromethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
hexachlorobutadiene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
hexachlorocyclopentadiene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
hexachloroethane	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
methyl bromide	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methylene chloride	<2.0	<2.0	<2.0	4.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
tetrachloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
trichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
trichlorofluoromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
vinyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,1-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,1-trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2-trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2,2-tetrachloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-dichloropropane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-trans-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-trans-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-cis-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
POLYCYCLIC AROMATIC												
HYDROCARBONS (µg/L)												
acetylnaphthalene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
acenaphthylene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
anthracene/phenanthrene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
benzo(A) anthracene 1,2-benzanthracene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
benzo(B) fluoranthene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
benzo(GH) perylene 1,12-benzoperylene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
benzo(K) fluoranthene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
benzo-A-pyrene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
chrysene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
fluoranthene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
fluorene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
indeno(1,2,3-CD) pyrene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
naphthalene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
pyrene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
1,2,5,6-dibenzanthracene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
MONOCYCLIC AROMATICS (µg/L)												
benzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
chlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
ethylbenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
benzochlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
nitrobenzene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
styrene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
toluene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
xylene	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
1,2-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2,4-trichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,4-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
2,4-dinitrotoluene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
2,6-dinitrotoluene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
NITROSAMINES AND OTHER N COMPOUNDS (µg/L)												
acrylonitrile	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
benzidine	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
n-nitrosodi-N-propylamine	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
n-nitrosodimethylamine	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
n-nitrosodiphenylamine	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
1,2-diphenylhydrazine	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
3,3-dichlorobenzidine	<12	<12	<11	<12	<11	<11	<11	<12	<12	<11	<11	<12
METALS (µg/L)												
aluminum	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
antimony	3.8	2.6	5.2	2.8	1.4	1.0	1.6	1.7	2.3	1.6	3.9	3.0
arsenic	<2.0	<2.0	4.8	<2.0	<2.0	4.8	<2.0	<2.0	5.3	<2.0	<2.0	5.3
beryllium	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
cadmium	<0.12	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.13	<0.10	<0.10	<0.13
chromium	5.1	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
copper	<1.6	1.8	2.4	1.8	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	1.8	<1.6
lead	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
mercury	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
nickel	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7
selenium	4.0	<8.0	<8.0	<4.0	<8.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
silver	<2.7	<2.7	<2.7	<2.7	4.8	<2.7	2.9	2.9	<2.7	<2.7	3.4	<2.7
thallium	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
zinc	<5.0	<5.0	16.7	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PESTICIDES (µg/L)												
aldicarb	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
aldrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
alpha benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
atrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
beta benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
carbaryl	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
carbofuran	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
chlordane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
chlorfenvinphos	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
chlorothalonil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorpyrifos	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
p,p' DDD	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
p,p' DDE	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
p,p' DDT	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
delta benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
diazinon	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
dibromochloropropane (dbcp)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dicamba	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-dichlorophenoxyacetic acid (2,4-D)	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
dicofol (kethane)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dieldrin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
dinoseb	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
endosulfan alpha	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endosulfan beta	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endosulfan sulfate	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endrin aldehyde	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
gamma-bhc (lindane)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
guthion	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
heptachlor	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
heptachlor epoxide	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
isophorone	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
malathion	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
methomyl	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
methoxychlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
metolachlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
mirex	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
parathion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
picloram	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
simeazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
toxaphene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4,5-TP (silver)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PCB's AND RELATED COMPOUNDS (µg/L)												
arochlor 1016	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1221	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1232	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1242	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1248	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1254	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1260	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-chloronaphthalene	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
PHTHALATE ESTERS (µg/L)												
bis(2-ethylhexyl) phthalate	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
di-n-butyl phthalate	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
di-n-octyl phthalate	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
diethyl phthalate	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
dimethyl phthalate	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
n-butyl benzyl phthalate	<5.9	<5.6	<5.4	<5.6	<5.4	<5.5	<5.4	<5.7	<5.6	<5.5	<5.3	<5.8
GENERAL INORGANICS (mg/L)												
cyanide	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

b - not measured, but approximately equivalent to flow at station 8

c - calculated from total ammonia concentration according to equations described by USEPA (1984)

d - lab unable to produce satisfactory results

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
DATE	032293	032293	032393	032393	032493	032393	032493	032593	032493	032693	032593	032693
TIME	1116	1330	0845	1614	0835	1753	1640	1000	1343	1200	1700	1805
CONVENTIONALS												
ammonia (NH ₃ -N) (mg/L)	7.07	<0.02	<0.02	<0.02	<0.02	0.13	<0.02	8.82	0.24	<0.02	0.02	0.02
ammonia (NH ₃ -N) (mg/L) ^f	0.070	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.087	0.010	<0.001	0.001	0.001
chloride (mg/L)	535	86	121	868	125	93	1,530	333	131	333	70	636
dissolved oxygen (mg/L)	3.7	8.7	7.7	9.1	8.3	8.3	11.4	0.4	7.9	9.3	6.4	15.5
flow (cfs)	0.7	74	1,172	1.3	c	5.9	0.7	1.8	1,384	37	d	1.0
pH (std. units)	7.4	7.8	7.9	8.0	8.0	7.8	7.9	7.3	8.0	8.0	8.0	8.0
residual chlorine (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
specific conductance (umhos/cm)	2,610	893	989	6,000	1,013	796	8,760	2,130	1,054	3,460	587	2,800
sulfate (mg/L)	287	135	206	2,350	213	187	3,310	475	223	1,550	54	438
temperature (°C)	20.1	20.0	18.4	20.4	20.0	20.8	22.6	23.2	20.7	24.9	24.1	28.3
total dissolved solids (mg/L)	1,720	588	618	5,100	660	530	7,480	1,450	696	3,050	364	1,830
total hardness (mg/L)	531	346	285	1,670	279	195	2,050	484	291	1,310	166	388
total organic carbon (mg/L)	22	1	3	12	3	33	14	28	4	4	7	6
total suspended solids (mg/L)	28	14	15	19	19	111	36	79	22	33	88	41
turbidity (jtu)	3.0	5.0	3.6	7.3	6.4	58	14	35	5.8	18	51	5.2
PHENOLS AND CRESOLS (µg/L)												
parachlorometa cresol	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	13	<5.2	<5.5	<5.4	<5.4
pentachlorophenol	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
phenol (C ₆ H ₅ OH) single compound	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
phenolics recoverable	*	*	*	*	*	*	*	*	*	*	*	*
2-chlorophenol	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
2-nitrophenol	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
2,4-dichlorophenol	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
2,4-dimethylphenol	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
2,4-dinitrophenol	<23	<22	<22	<22	<22	<22	<21	<22	<21	<22	<22	<22
2,4,6-trichlorophenol	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
4-nitrophenol	<23	<22	<22	<22	<22	<22	<21	<22	<21	<22	<22	<22
4,6-dinitro-ortho-cresol	<23	<22	<22	<22	<22	<22	<21	<22	<21	<22	<22	<22
ETHERS (µg/L)												
bis(2-chloroethoxy) methane	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
bis(2-chloroethyl) ether	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
bis(2-chloroisopropyl) ether	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
4-bromophenyl phenyl ether	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
4-chlorophenyl phenyl ether	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
HALOGENATED ALIPHATICS (µg/L)												
bromodichloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
bromoform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
carbon tetrachloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
chloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
chloroform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dibromochloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dichlorodifluoromethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
hexachlorobutadiene	<5.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
hexachlorocyclopentadiene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
hexachloroethane	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
methyl bromide	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methylene chloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
tetrachloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
trichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
trichlorofluoromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
vinyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,1-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,1-trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2-trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,2,2-tetrachloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-dichloropropane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-trans-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-trans-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-cis-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
POLYCYCLIC AROMATIC												
HYDROCARBONS (µg/L)												
acenaphthene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
acenaphthylene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
anthracene/phenanthrene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
benzo(A) anthracene 1,2-benzanthracene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
benzo(B) fluoranthene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
benzo(GH) perylene 1,12-benzoperylene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
benzo(K) fluoranthene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
benzo-A-pyrene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
chrysene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
fluoranthene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
fluorene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
indeno(1,2,3-CD) pyrene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
naphthalene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
pyrene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
1,2,5,6-dibenzanthracene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
MONOCYCLIC AROMATICS (µg/L)												
benzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
chlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
ethylbenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
hexachlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
nitrobenzene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
styrene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
toluene	3.8	<2.0	<2.0	<2.0	<2.0	<2.0	9.0	6.0	<2.0	<2.0	<2.0	<2.0
styrene	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	6.8	<6.0	<6.0	<6.0	<6.0
1,2-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2,4-trichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,3-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,4-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	7.0	<2.0	<2.0	<2.0	<2.0
2,4-dinitrotoluene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
2,6-dinitrotoluene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
NITROSAMINES AND OTHER N COMPOUNDS (µg/L)												
acrylonitrile	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
benzidine	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
n-nitrosodi-N-propylamine	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
n-nitrosodimethylamine	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
n-nitrosodiphenylamine	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
1,2-diphenylhydrazine	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
3,3'-dichlorobenzidine	<12	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
METALS (µg/L)												
aluminum	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	30
antimony	2.5	1.3	3.1	78.0	4.4	8.9	8.3	4.1	1.5	3.3	5.3	5.3
arsenic	3.9	<2.0	2.7	<10	3.6	2.2	<10.0	2.1	2.7	<10.0	<2.0	3.6
beryllium	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
cadmium	<0.10	0.40	<0.13	0.37	0.15	0.12	0.19	<0.10	<0.12	0.19	<0.10	0.19
chromium	3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	<3.6	15.0	<3.6	<3.6

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
copper	<1.6	2.7	<1.6	1.6	1.6	6.1	1.8	<1.6	<1.6	<1.6	<1.6	3.8
lead	<1.0	<1.0	<1.0	<4.0	<1.0	<1.0	<4.0	<1.0	<1.0	<4.0	<1.0	<1.0
mercury	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
nickel	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	7.9
selenium	4.6	14.4	<4.0	<8.0	5.4	5.1	1.4	10.7	<4.0	10.3	13.7	11.2
silver	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	2.9	<2.7	<2.7	<2.7
thallium	1.0	<0.8	<0.8	2.2	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	1.0
zinc	<5.0	<5.0	<5.0	<5.0	<5.0	5.5	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PESTICIDES (µg/L)												
aldicarb	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
aldrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
alpha benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
atrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
beta benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
carbaryl	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
carbofuran	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
chlordane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
chlorfenvinphos	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
chlorothalonil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorpyrifos	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
p,p' DDD	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
p,p' DDE	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
p,p' DDT	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
delta benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
diazinon	<0.3	<0.3	<0.3	<0.3	<0.3	0.7	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
dibromochloropropane (dbcp)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dicamba	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-dichlorophenoxyacetic acid (2,4-D)	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
dicofol (kelthane)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dieldrin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
dinoseb	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
endosulfan alpha	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endosulfan beta	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endosulfan sulfate	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
endrin aldehyde	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
gamma-bhc (lindane)	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
guthion	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
heptachlor	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
heptachlor epoxide	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06

Table 10 (continued)
Analytical Data - Water

Parameter	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
isophorone	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
malathion	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
methomyl	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
methoxychlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
metolachlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
mirex	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
parathion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
picloram	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
simeazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
toluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4,5-TP (silvex)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PCB'S AND RELATED COMPOUNDS (µg/L)												
arochlor 1016	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1221	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1232	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1242	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1248	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1254	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
arochlor 1260	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-chloronaphthalene	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
PHTHALATE ESTERS (µg/L)												
bis(2-ethylhexyl) phthalate	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	10	<5.2	<5.5	<5.4	<5.4
di-n-butyl phthalate	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
di-n-octyl phthalate	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
diethyl phthalate	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
dimethyl phthalate	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
n-butyl benzyl phthalate	<5.6	<5.3	<5.4	<5.5	<5.4	<5.3	<5.3	<5.4	<5.2	<5.5	<5.4	<5.4
GENERAL INORGANICS (mg/L)												
cyanide	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

c - not measured, but approximately equivalent to flow at station 12
d - no flow, but perennial pools present, from which samples were taken
f - calculated from total ammonia concentration according to equations described by USEPA (1984)
* - lab unable to produce satisfactory results

Table 10 (continued)
Analytical Data - Water

Parameter	Station									
	12d	12e	13	14	15	15a	16	17	18	
DATE	011193	011293	011193	011293	011293	011393	011393	011493	011493	
TIME	1045	1400	1400	1415	1700	1730	1000	1000	1500	
CONVENTIONALS										
ammonia (NH ₃ -N) (mg/L)	0.02	0.09	0.02	<0.02	<0.02	0.03	0.02	<0.02	<0.02	
ammonia (unionized) (mg/L) ^f	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
chloride (mg/L)	1,370	381	127	123	128	530	125	171	234	
dissolved oxygen (mg/L)	8.9	9.1	10.2	11.9	11.3	1.3	9.8	10.0	10.3	
flow (cfs)	0.8	38	4,180	990	e	16	940	95	150	
pH (std. units)	7.8	7.4	8.1	8.1	8.0	7.4	7.8	7.8	7.8	
residual chlorine (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
specific conductance (umho/cm)	6,860	3,130	1,220	1,180	1,200	3,310	1,394	1,610	1,970	
sulfate (mg/L)	1,050	710	218	235	236	430	249	266	350	
temperature (°C)	11.5	17.7	15.1	15.9	15.9	16.1	15.8	15.9	16.7	
total dissolved solids (mg/L)	4,100	1,970	690	680	690	1,810	740	850	1,070	
total hardness (mg/L)	630	600	259	256	260	600	268	354	439	
total organic carbon (mg/L)	7	3	5	4	4	39	6	7	7	
total suspended solids (mg/L)	48	57	43	22	19	43	43	45	39	
turbidity (ftu)	13	22	10	7.3	8.3	9.3	7.0	10	10	
PHENOLS AND CRESOLS (µg/L)										
parachloromethyl cresol	<6.0	<5.5	<5.6	<5.4	<5.3	8.5	<5.5	<5.6	<5.7	
pentachlorophenol	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
phenol (C ₆ H ₅ OH) single compound	<12	<11	<12	<11	<11	<12	<11	<12	<12	
phenolics recoverable	<2.0	<2.0	<2.0	<2.0	<2.0	16	5	*	*	
2-chlorophenol	<12	<11	<12	<11	<11	<12	<11	<12	<12	
2-nitrophenol	<12	<11	<12	<11	<11	<12	<11	<12	<12	
2,4-dichlorophenol	<12	<11	<12	<11	<11	<12	<11	<12	<12	
2,4-dimethylphenol	<12	<11	<12	<11	<11	<12	<11	<12	<12	
2,4-dinitrophenol	<24	<22	<23	<22	<22	<23	<22	<23	<23	
2,4,6-trichlorophenol	<12	<11	<12	<11	<11	<12	<11	<11	<12	
4-nitrophenol	<24	<22	<23	<22	<22	<23	<22	<23	<23	
4,6-dinitro-ortho-cresol	<24	<22	<23	<22	<22	<23	<22	<23	<23	
ETHERS (µg/L)										
bis(2-chloroethoxy) methane	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
bis(2-chloroethyl) ether	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
bis(2-chloroisopropyl) ether	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
4-bromophenyl phenyl ether	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	

Table 10 (continued)
Analytical Data - Water

Parameter	Station									
	12d	12e	13	14	15	15a	16	17	18	
4-chlorophenyl phenyl ether	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
HALOGENATED ALIPHATICS (µg/L)										
bromodichloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
bromoform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
carbon tetrachloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
chloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
chloroform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
dibromochloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
dichlorodifluoromethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
hexachlorobutadiene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
hexachlorocyclopentadiene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
hexachloroethane	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
methyl bromide	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
methyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
methylene chloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
tetrachloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	2.7	<2.0	<2.0	<2.0	
trichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
trichlorofluoromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
vinyl chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
1,1-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,1-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,1,1-trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,1,2-trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,1,2,2-tetrachloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,2-dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,2-dichloropropane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,2-trans-dichloroethylene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,3-trans-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,3-cis-dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
POLYCYCLIC AROMATIC										
HYDROCARBONS (µg/L)										
acenaphthene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
acenaphthylene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
anthracene/phenanthrene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
benzo(A) anthracene 1,2-benzanthracene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
benzo(B) fluoranthene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
benzo(OH) perylene 1,12-benzoperylene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
benzo(K) fluoranthene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
benzo-A-pyrene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	

Table 10 (continued)
Analytical Data - Water

Parameter	Station									
	12d	12e	13	14	15	15a	16	17	18	
chrysene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
fluoranthene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
fluorene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
indeno(1,2,3-CD) pyrene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
naphthalene	<2.0	<2.0	<2.0	<2.0	<2.0	4.4	<2.0	<2.0	<2.0	
pyrene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
1,2,5,6-dibenzanthracene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
MONOCYCLIC AROMATICS (µg/L)										
benzene	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	<2.0	<2.0	<2.0	
chlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
ethylbenzene	<2.0	<2.0	<2.0	<2.0	<2.0	2.9	<2.0	<2.0	<2.0	
hexachlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
nitrobenzene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
styrene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
toluene	<2.0	<2.0	<2.0	<2.0	<2.0	5.0	<2.0	<2.0	<2.0	
xylene	<6.0	<6.0	<6.0	<6.0	<6.0	18.1	<6.0	<6.0	<6.0	
1,2-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,2,4-trichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,3-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
1,4-dichlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	<2.0	<2.0	<2.0	
2,4-dinitrotoluene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
2,6-dinitrotoluene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
NITROSAMINES AND OTHER N COMPOUNDS (µg/L)										
acrylonitrile	<10	<10	<10	<10	<10	<10	<10	<10	<10	
benzidine	<12	<11	<12	<11	<11	<12	<11	<12	<12	
n-nitrosodi-N-propylamine	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
n-nitrosodimethylamine	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
n-nitrosodiphenylamine	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
1,2-diphenylhydrazine	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
3,3'-dichlorobenzidine	<12	<11	<12	<11	<11	<12	<11	<12	<12	
METALS (µg/L)										
aluminum	<20	<20	<20	<20	<20	<20	<20	<20	<20	
antimony	4.0	4.5	5.4	1.2	2.9	2.9	4.6	5.9	1.8	
arsenic	3.4	<4.0	1.8	2.3	2.1	2.6	2.6	4.2	2.8	
beryllium	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	
cadmium	<0.12	<0.10	<0.12	<0.10	<0.10	<0.10	<0.12	<0.12	<0.10	
chromium	<3.6	<3.6	<3.6	<3.6	<3.6	3.6	<3.6	<3.6	<3.6	

Table 10 (continued)
Analytical Data - Water

Parameter	Station									
	12d	12e	13	14	15	15a	16	17	18	
copper	1.8	<1.6	3.0	2.1	<1.6	2.1	1.8	2.8	2.1	
lead	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
mercury	<0.25	<0.25	<0.25	<0.25	<0.25	0.29	<0.25	<0.25	<0.25	
nickel	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	
selenium	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	<8.0	
silver	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	
thallium	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	
zinc	5.1	5.1	<5.0	<5.0	<5.0	5.8	5.8	5.8	<5.0	
PESTICIDES (µg/L)										
aldicarb	<15	<15	<15	<15	<15	<10	<10	<10	<10	
aldrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
alpha benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	
atrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
beta benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	
carbaryl	<15	<15	<15	<15	<15	<10	<10	<10	<10	
carbofuran	<15	<15	<15	<15	<15	<10	<10	<10	<10	
chlordane	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
chlorfenviaphos	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	
chlorobalonil	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
chlorpyrifos	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	
p,p' DDD	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	
p,p' DDE	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
p,p' DDT	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	
delta benzene hexachloride	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	
diazinon	9.2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	
dibromochloropropane (dbcp)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
dicamba	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
2,4-dichlorophenoxyacetic acid (2,4-D)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
dicofol (tclthane)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
dieldrin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
dinoseb	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
endosulfan alpha	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
endosulfan beta	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
endosulfan sulfate	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
endrin	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
endrin aldehyde	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
gamma-bhc (lindane)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	
guthion	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
heptachlor	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
heptachlor epoxide	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	

Table 10 (continued)
Analytical Data - Water

Parameter	Station									
	12d	12e	13	14	15	15a	16	17	18	
isophorone	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
malathion	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
methomyl	<15	<15	<15	<15	<15	<10	<10	<10	<10	
methoxychlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
metolachlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
mirex	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
parathion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
picloram	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
simazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
toxaphene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
2,4,5-TP (nivet)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
PCB's AND RELATED COMPOUNDS (µg/L)										
arochlor 1016	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
arochlor 1221	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
arochlor 1232	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
arochlor 1242	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
arochlor 1248	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
arochlor 1254	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
arochlor 1260	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
2-chloronaphthalene	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
PHTHALATE ESTERS (µg/L)										
bis(2-ethylhexyl) phthalate	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
di-n-butyl phthalate	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
di-n-octyl phthalate	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
diethyl phthalate	<6.0	<5.5	<5.6	<5.4	<5.3	8.0	<5.5	<5.6	<5.7	
dimethyl phthalate	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
n-butyl benzyl phthalate	<6.0	<5.5	<5.6	<5.4	<5.3	<5.6	<5.5	<5.6	<5.7	
GENERAL INORGANICS (mg/L)										
cyanide	0.02	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.01	<0.01	

e - not measured, but approximately equivalent to flow at station 16

f - calculated from total ammonia concentration according to equations described by USEPA (1984)

g - lab unable to produce satisfactory results

e - not measured, but approximately equivalent to flow at station 16

f - calculated from total ammonia concentration according to equations described by USEPA (1984)

• - lab unable to produce satisfactory results

Table 10 (continued)

Analytical Data - Water
Comisión Nacional del Agua

CUADRO 1.1 RESULTADOS DE FISICO-QUIMICOS ETAPA 1

ESTACION	pH	CONDUCTIVIDAD ELECTRICA μ mhos/cm	CLORUROS mg/L	SOL 1009 DISUELTOS mg/L	DUREZA mg/L	SULFATOS mg/L	NITROGENO AMONIALCAL mg/L	OXIGENO DISUELTO mg/L
1	8.2	1700	202	1136	350	488	0	9.8
1a	6.4	1831	362	1240	358	182	19	5.9
2	7.6	1760	232	1100	357	484	1.6	6.4
2a	7.8	1810	290	1132	360	196	17.7	0.31
3	8.1	2640	496	1604	491	586	0	8.9
3a	8.2	962	64	596	281	250	0	9.6
3b	8.8	459	21	120	97	82	0	11.2
4	8.1	1620	212	1168	380	441	0	8.77
5	8.4	1680	233	882	329	511	0.0	9.3
5a	8.1	1305	8.4	968	388	655	0.0	8.8

MAXIMOS
PERMISIBLES
NORMAS
MEXICANAS:

UIDA ACUATICA	6-9						0.06	MIN 5.0
CONSUMO HUMANO	6-9	1000	250	500		500	1	MIN 4.0
RIEGO AGRICOLA	6-9	≈ 1000	147.5	≈ 500		130	5.0	MIN 3.2
USO PECUARIO	6-9	1000		1000		100	2.0	MIN 4.0

■ NOTA: LOS VALORES DE CONDUCTIVIDAD ELECTRICA
> 500 NO EFECTOS NOCIOSOS EN NINGUN CULTIVO.
500-1000 NO EFECTOS EN CULTIVOS SENSIBLES.
1000-2000 PARA COSECHAS QUE REQUIEREN RIEGO ESPECIAL.
2000-5000 PARA PLANTAS TOLERANTES EN SUELOS PERMEABLES.

CUADRO 1.2 RESULTADOS DE ANALISIS DE METALES PESADOS EN AGUA ETAPA 1

ESTACION	PLATA µg/L	COBRE µg/L	NIQUEL µg/L	SELENIO µg/L	ZINC µg/L
1	147 #35	44 #34	53.5 #455	0.3	21.1
1a	201 #36	51 #35	65 #455	1.8	23.5
2	189 #36	41 #35	62.5 #463	0.8	12.7
2a	275 #38	31 #36	79.5 #475	0.1	9.3
3	196 #63	47 #46	57 #606	0.1	16.7
3a	192 #24	49 #29	64 #379	0.8	5.9
3b	198 #4	116 #11	95.5 #154	0.2	6.5
4	189 #4	48 #37	93.5 #488	0.4	7.1
5	171 #31	50 #33	74 #432	2.2	3.8
5a	159 #42	47 #38	54.5 #496	2.2	4.7

MAXIMOS
PERMISIBLES
NORMAS
MEXICANAS:

VIDA ACUATICA	#	#	#	#	#
CONSUMO HUMANO	50	1000	10	10	5000
RIEGO AGRICOLA		200	200	20	2000
USO PECUARIO		500	1000	50	50000

NR = NO SE REPORTARON VALORES

CUADRO 2.1 RESULTADOS DE ANALISIS FISICO-QUIMICOS ETAPA 2

ESTACION	pH	CONDUCTIVIDAD ELECTRICA µ mhos/cm	CLORUROS mg/L	SOLIDOS DISUELTOS mg/L	SOLIDOS SUSPENDIDOS mg/L	DUREZA mg/L	SULFATOS mg/L	NITROGENO AMONIAICAL mg/L	OXIGENO DISUELTO mg/L	TURBIDIDAD NTU	FENOL mg/L	CIANUROS mg/L
12d	7.82	6280	1445	4526	6	638	1070	0.08	8.1	37.1	0.003	<0.02
12e	7.4	3130	397	2108	65	543	688	0.08	9.1	28.4	<0.001	<0.02
13	8	1010	132	821	50	262	21.4	0.05	10	8.8	<0.001	<0.02
14	8.1	1086	130	712	27	251	192	0.03	11.85	11.8	0.002	<0.02
15	8	1072	135	962	35	261	224	0.03	11.3	11.3	<0.001	<0.02
15a	7.43	3310	542	2149	59	590	360	9.75	1.31	56.1	0.01	<0.02
16	7.8	1394	147	808	53	270	218	0.27	9.71	17.5	<0.001	<0.02
17	7.8	1610	175	850	35	343	298	0.17	10.02	17.3	0.036	<0.02
18	7.6	1970	237	946	39	411	339	0.09	10.27	13.4	0.012	<0.02

MAXIMOS
PERMISIBLES
NORMAS
MEXICANAS:

VIDA ACUATICA	6-9							0.06	MIN 5.0		0.1	0.005
CONSUMO HUMANO	6-9	1000	250	500			500	1	MIN 4.0		0.3	0.02
RIEGO AGRICOLA	6-9	1000	147.5	500			130	5.0	MIN 3.2		-	-
USO PECUARIO	6-9	1000	1000	1000			100	2.0	MIN 4.0		-	-

■ NOTA: LOS VALORES DE CONDUCTIVIDAD ELECTRICA
> 500 NO EFECTOS NOCIOS EN NINGUN CULTIVO.
500-1000 NO EFECTOS EN CULTIVOS SENSIBLES.
1000-2000 PARA COSECHAS QUE REQUIEREN MANEJO ESPECIAL.
2000-5000 PARA PLANTAS TOLERANTES EN SUELOS PERMEABLES.

CUADRO 2.2 RESULTADOS DE ANALISIS DE METALES PESADOS EN AGUA ETAPA 2

ESTACION	PLATA µg/L	ARSENICO µg/L	CADMIO µg/L	CROMO µg/L	COBRE µg/L	MERCURIO µg/L	NIQUEL µg/L	PLOMO µg/L	SELENIO µg/L	ZINC µg/L
12a	<30 #98	15.5	130.5 #4.9	<40 #58	<40 #58	10	<50 #756	<80 #34	<0.5	<10
12b	<30 #75	1.9	53.9 #4.3	<40	<40 #50	9	<50 #660	<80 #27	<0.5	<10
13	<30 #21	2.5	3.6 #2.4	<40	<40 #27	5	<50 #356	<80 #11	<0.5	<10
14	<30 #20	2.5	5.4 #2.3	<40	<40 #26	0.4	<50 #343	<80 #10	<0.5	<10
15	<30 #21	2.6	3.7 #2.4	<40	<40 #27	0.4	<50 #355	<80 #11	<0.5	<10
15a	<30 #86	2.4	3.9 #4.6	<40	<40 #54	9	<50 #708	<80 #30	<0.5	<10
16	<30 #22	2.6	1.7 #2.5	<40	<40 #28	7	<50 #365	<80 #11	<0.5	<10
17	<30 #34	3.2	2 #3.0	<40	<40 #34	7.5	<50 #447	<80 #15	<0.5	<10
18	<30 #46	2.9	4.4 #3.4	<40	<40 #40	7	<50 #521	<80 #19	<0.5	<10

MAXIMOS
PERMISIBLES
NORMAS
MEXICANAS:

UJDA ACUATICA	#	200	#	10	#	0.01	#	#	8	
CONSUMO HUMANO	50	50	10	50	1000	1	10	50	10	5000
RIEGO AGRICOLA		100	10	100	200		200	5000	20	2000
USO PECUARIO		200	20	100	500	3	1000	100	50	50000

CUADRO 3.1 RESULTADOS DE FISICO-QUIMICOS ETAPA 3

ESTACION	pH	CONDUCTIVIDAD ELECTRICA µ mhos/cm	CLORUROS mg/L	SOLIDOS DISUELTOS mg/L	DUREZA mg/L	SULFATOS mg/L	NITROGENO AMONIAICAL mg/L	OXIGENO DISUELTO mg/L
5a	8.0	1637	215	1204	389	386	0.128	10.39
6	7.9	1860	225	1201	381	371	0.195	10.23
6a	8.0	1017	1061	3114	938	978	0.193	10.23
6b	7.9	385	10	331	236	16	0.064	9.1
7	8.1	1042	115	747	289	230	0.387	11.7
7a	7.7	923	78	705	389	197	1.548	6.6
7b	7.0	399	12	330	280	21	0	8.4
8	8.0	1128	103	657	301	210	0.129	9.4
8a	8.1	421	58	371	276	45	0.064	9.9
8b	7.8	400	39	231	277	67	0.129	9.9
8c	7.9	574	43	312	113	29	0.064	9
8d	7.8	345	44	262	298	18	0.387	9.4
8e	8.1	894	44	680	297	192	0.064	10.3

MAXIMOS
PERMISIBLES
NORMAS
MEXICANAS:

VIDA ACUATICA	6-9						0.06	MIN 5.0
CONSUMO HUMANO	6-9	1000	250	500		500	1	MIN 4.0
RIEGO AGRICOLA	6-9	1000	147.5	1000		130	5.0	MIN 3.2
USO PECUARIO	6-9	1000		1000		100	2.0	MIN 4.0

■ NOTA: LOS VALORES DE CONDUCTIVIDAD ELECTRICA
> 500 NO EFECTOS NOCIOSOS EN NINGUN CULTIVO.
500-1000 NO EFECTOS EN CULTIVOS SENSIBLES.
1000-2000 PARA COSECHAS QUE REQUIEREN MANEJO ESPECIAL.
2000-5000 PARA PLANTAS TOLERANTES EN SUELOS PERMISIBLES.

CUADRO 3.2 RESULTADOS DE METALES PESADOS EN AGUA ETAPA 3

ESTACION	PLATA µg/L	ARSENICO µg/L	CADMIO µg/L	CROMO µg/L	COBRE µg/L	MERCURIO µg/L	NIQUEL µg/L	PLOMO µg/L	SELENIO µg/L	ZINC µg/L
5b	5.5 #42	10.6	2.9 #3.3	<10.0	35 #37	0.2	15 #498	6 #18	<1.0	281
6	7.5 #41	7.0	4.7 #3.3	<10.0	42 #37	0.3	26 #493	16 #18	<1.0	95
6a	13.8 #190	3.7	5.1 #6.6	<10.0	39 #80	0.5	14 #1048	17 #55	<1.0	0
6b	2 #18	0.9	1.6 #2.2	<10.0	30 #25	0	8 #327	12 #10	<1.0	0
7	3 #25	1.6	2.1 #2.6	<10.0	26 #29	0.2	10 #387	16 #12	<1.0	14
7a	6 #42	<1.0	1.8 #3.3	<10.0	35 #38	0.2	7 #498	13 #18	<1.0	0
7b	2.5 #24	<1.0	1.6 #2.6	<10.0	35 #29	0.4	11 #377	13 #12	<1.0	1
8	3.2 #27	<1.0	2.1 #2.7	<10.0	28 #30	1.3	11 #401	16 #13	<1.0	3
8a	2.2 #23	<1.0	1.2 #2.5	<10.0	25 #28	0.4	0 #373	12 #12	<1.0	2
8b	2.8 #23	<1.0	1.2 #2.5	<10.0	23 #28	0.3	0 #373	10 #12	<1.0	5.3
8c	2.7 #5.0	<1.0	1.1 #1.2	<10.0	24 #13	0.3	6 #174	5 #4.0	<1.0	2
8d	0.5 #27	<1.0	2.0 #2.7	<10.0	25 #30	0.3	3 #397	9 #13	<1.0	10
8e	2.2 #26	<1.0	2.1 #2.7	<10.0	32 #30	0.4	3 #396	14 #13	<1.0	2

MAXIMOS
PERMISIBLES
NORMAS
MEXICANAS:

UJDA ACUATICA	50	200	10	10	1000	0.01	10	50	8	5000
CONSUMO HUMANO	100	50	10	50	200	1	200	5000	20	2000
RIEGO AGRICOLA	200	200	20	100	500	3	1000	100	50	50000

CUADRO 4.1 RESULTADOS DE ANALISIS FISICOQUIMICOS EN AGUA ETAPA 4

ESTACION	pH	CONDUCTIVIDAD ELECTRICA p micro/cm	CLORUROS mg/L	SOLIDOS DISUELTOS mg/L	SOLIDOS SUSPENDIDOS mg/L	DUREZA mg/L	SULFATOS mg/L	NITROGENO AMONIACAL mg/L	ORTOGANO DISUELTO mg/L	TURBIDIDAD NTU	FENOLIS mg/L	CINCUROS mg/L
3	8.52	1060	127	688	20	272	230	0.032	7.44	3	0.017	<0.02
9a	7.53	2840	527	1752	56	841	269	0.93	3.63	21	0.054	<0.02
9b	8.1	926	85	616	14	382	128	0.335	7.9	8	0.045	<0.02
13	8.09	1060	117	680	52	284	179	0.141	6.04	4	0.018	<0.02
10a	8.64	6333	841	5144	54	1585	2130	3	7.37	13	0.033	<0.02
11	8.40	1080	132	672	14	285	121	0.076	7.1	2	0.057	<0.02
11a	8.20	801	57	582	284	209	225	0.215	6.8	150	0.148	<0.02
11b	8.40	9400	1563	7324	104	2003	2620	0	5.1	21	0.05	<0.02
11c	7.33	2130	367	1136	118	491	452	7.508	0.44	41	0.045	<0.02
12	8.50	1110	130	724	22	282	231	0.352	7.1	7	0.005	<0.02
12a	8.30	3640	367	2632	256	1328	1263	0.506	9.6	35	0.026	<0.02
12b	7.97	587	82	408	112	178	62	0	6.38	85	0.051	<0.02
12c	8.17	2220	714	1802	120	355	359	0.061	16.36	40	0.026	<0.02

PARQUES
DETERMINABLES
NORMAS
MEXICANAS:

VIDA ACUATICA	6-9							0.06	MIN 5.0		0.1	0.005
CONSUMO HUMANO	6-9	1000	250	500			500	1	MIN 4.0		0.3	0.02
RIEGO AGRICOLA	6-9	= 1000	147.5	4500			130	9.0	MIN 3.2		---	---
USO RECREATIVO	6-9	1000		1000			100	2.0	MIN 4.0		---	---

* NOTAS: LOS UNIDADES DE CONDUCTIVIDAD ELECTRICA
> 500 NO EFECTOS NOTICIOS EN NINGUN CULTIVO.
500-1000 NO EFECTOS EN CULTIVOS SIMILES.
1000-2000 PARA COSECHAS QUE REQUIEREN MANEJO ESPECIAL.
2000-5000 PARA PLANTAS TOLERANTES EN SUELOS PERMEABLES.

CUADRO 4.2 RESULTADOS DE METALES PESADOS EN AGUA ETAPA 4

ESTACION	PLATA µg/L	ARSENICO µg/L	CADMIO µg/L	CROMIO µg/L	COBRE µg/L	MERCURIO µg/L	NIQUEL µg/L	PLOMO µg/L	SELENIO µg/L	ZINC µg/L
9	<30 #23	5.1	12.4 #2.5	<10	<10 #28	<0.5	<50 #368	<80 #11	<0.5	<10
9a	<30 #24	3.1	46 #4.3	<10	<10 #50	<0.5	<50 #658	<80 #27	<0.5	<10
9b	<30 #41	1.8	4.7 #3.2	<10	<10 #37	<0.5	<50 #490	<80 #18	<0.5	<10
10	<30 #24	3.8	3.8 #2.6	<10	<10 #29	<0.5	<50 #381	<80 #12	<0.5	<10
10a	<30 #470	4.7	59 #9.9	<10	<10 #125	<0.5	<50 #1633	<80 #107	<0.5	<10
11	<30 #25	4.7	5 #2.6	<10	<10 #29	<0.5	<50 #387	<80 #12	<0.5	<10
11a	<30 #14	2.9	5 #2.0	<10	<10 #22	<0.5	<50 #294	<80 #8	<0.5	<10
11b	<30 #703	1.1	140.7 #11.9	<10	<10 #153	<0.5	<50 #1950	<80 #144	<0.5	<10
11c	<30 #63	1.1	32.2 #4.0	<10	<10 46	<0.5	<50 #606	<80 #24	<0.5	<10
12	<30 #24	2.4	0.9 #2.6	<10	<10 #29	<0.5	<50 #381	<80 #12	<0.5	<10
12a	<30 #347	1.2	5.6 #8.6	<10	<10 #108	<0.5	<50 #1406	<80 #86	<0.5	<10
12b	<30 #11	1.0	5.4 #1.8	<10	<10 #19	<0.5	<50 #257	<80 #7	<0.5	<10
12c	<30 #44	2.6	66 #3.4	<10	<10 #39	<0.5	<50 #508	<80 #19	<0.5	<10

MAXIMOS
PERMITIDOS
NORMAS
MEXICANAS:

USO ACUATICA	#	200	#	10	#	0.01	#	#	8	#
CONSUMO HUMANO	50	50	10	50	1000	1	10	50	10	5000
RIEGO AGRICOLA		100	10	100	200		200	5000	20	2000
USO PECUARIO		200	20	100	500	3	1000	100	50	50000

Table 11
Analytical Data - Sediment

Parameter ^a	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
DATE	111292	111192	111192	111292	111392	111392	111392	111492	111592	111592	020893	020893
TIME	0900	1600	1000	1400	1000	1200	1600	0900	1200	1200	1040	1322
CONVENTIONALS												
acid volatile sulfide (mg/kg)	51	3,140	79	362	83	10	137	34	91	72	65	244
total organic carbon (mg/kg)	2,200	157,400	2,780	6,300	4,600	2,900	11,000	5,400	6,500	5,500	4,800	16,500
particle size distribution (% of dry wt.)												
clay, <0.0039 mm	5	13	8	5	26	9	9	5	28	40	6	20
silt, 0.0039-0.0625 mm	6	75	10	12	66	24	28	15	64	58	19	67
sand, 0.0625-2.0 mm	90	12	82	83	8	67	63	80	8	2	75	13
gravel, >2.0 mm	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
PHENOLS AND CRESOLS (µg/kg)												
parachlorometa cresol	<700	14,100	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
pentachlorophenol	<5.0	<25	<25	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
phenol (C ₆ H ₅ OH) single compound	<1,400	4,600	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
phenolics recoverable												
2-chlorophenol	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
2-nitrophenol	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
2,4-dichlorophenol	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
2,4-dimethylphenol	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
2,4-dinitrophenol	<2,800	<18,000	<5,300	<18,000	<3,500	<2,900	<3,500	<2,700	<4,100	<4,900	<2,900	<4,300
2,4,6-trichlorophenol	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
4-nitrophenol	<2,800	<18,000	<5,300	<18,000	<3,500	<2,900	<3,500	<2,700	<4,100	<4,900	<2,900	<4,300
4,6-dinitro-ortho-cresol	<2,800	<18,000	<5,300	<18,000	<3,500	<2,900	<3,500	<2,700	<4,100	<4,900	<2,900	<4,300
ETHERS (µg/kg)												
bis(2-chloroethoxy) methane	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
bis(2-chloroethyl) ether	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
bis(2-chloroisopropyl) ether	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
4-bromophenyl phenyl ether	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
4-chlorophenyl phenyl ether	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
HALOGENATED ALIPHATICS (µg/kg)												
bromodichloromethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
bromoform	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
carbon tetrachloride	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
chloroethane	<800	<1,100	<800	<1,200	<1,000	<700	<1,000	<800	<1,300	<1,500	<800	<1,400

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
chloroform	<400	<500	600	900	400	<300	<400	<300	<600	<600	<400	<600
dibromochloromethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
dichlorodifluoromethane	<800	<1,100	<800	<1,200	<1,000	<700	<1,000	<800	<1,300	<1,500	<800	<1,400
hexachlorobutadiene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
hexachlorocyclopentadiene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
hexachloroethane	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
methyl bromide	<800	<1,100	<800	<1,200	<1,000	<700	<1,000	<800	<1,300	<1,500	<800	<1,400
methyl chloride	1,800	<500	3,200	4,000	2,300	<300	1,200	<300	<600	<600	<400	<600
methylene chloride	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
tetrachloroethylene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
trichloroethylene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
trichlorofluoromethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
vinyl chloride	<800	<1,100	<800	<1,200	<1,000	<700	<1,000	<800	<1,300	<1,500	<800	<1,400
1,1-dichloroethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,1-dichloroethylene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,1,1-trichloroethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,1,2-trichloroethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,1,2,2-tetrachloroethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,2-dichloroethane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,2-dichloropropane	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,2-trans-dichloroethylene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,3-trans-dichloropropene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,3-cis-dichloropropene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
POLYCYCLIC AROMATIC												
HYDROCARBONS (µg/kg)												
acenaphthene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
acenaphthylene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
anthracene/phenanthrene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
benzo(A) anthracene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
benzo(B) fluoranthene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
benzo(OH) perylene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
benzo(K) fluoranthene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
benzo-A-pyrene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
chrysene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
fluoranthene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
fluorene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
indeno(1,2,3-CD) pyrene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
naphthalene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
pyrene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
1,2,5,6-dibenzanthracene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
MONOCYCLIC AROMATICS (µg/kg)												
benzene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
chlorobenzene	<400	600	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
ethylbenzene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
hexachlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
nitrobenzene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
styrene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
toluene	500	900	1,300	2,400	800	<300	800	<300	<600	<600	<400	<600
xylene	<1,000	<1,300	<1,000	<1,400	1,200	<800	<1,200	<900	<1,600	<1,800	<1,000	<1,700
1,2-dichlorobenzene	<400	500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,2,4-trichlorobenzene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,3-dichlorobenzene	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
1,4-dichlorobenzene	<400	1,000	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
2,4-dinitrotoluene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
2,6-dinitrotoluene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
NITROSAMINES AND OTHER												
N COMPOUNDS (µg/kg)												
acrylonitrile	<1,600	<2,200	<1,600	<2,300	<2,000	<1,400	<2,000	<1,500	<2,600	<2,900	<1,700	<2,700
benzidine	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
n-nitrosodiphenylamine	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
n-nitrosodimethylaniline	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
n-nitrosodiphenylamine	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
1,2-diphenylhydrazine	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
3,3-dichlorobenzidine	<1,400	<8,800	<2,700	<8,800	<1,800	<1,500	<1,800	<1,400	<2,100	<2,500	<1,500	<2,200
METALS (mg/kg)												
aluminum	3,560	4,640	5,340	4,210	12,000	5,950	5,540	5,990	15,100	19,500	7,340	15,800
antimony	1.73	7.74	2.57	1.93	7.93	8.77	3.05	4.47	8.74	7.63	5.18	7.70
arsenic	0.22	<0.43	0.28	0.26	0.73	0.29	0.55	0.37	0.77	0.85	0.44	0.68
beryllium	0.10	2.40	0.35	0.25	0.37	0.24	0.11	0.26	0.37	0.41	0.26	0.29
cadmium	4.79	45.10	7.75	5.32	9.64	5.95	7.08	6.66	10.40	15.40	8.62	12.60
chromium	4.61	292.00	19.20	12.50	12.00	5.90	2.82	6.13	10.10	15.50	4.79	8.23
copper	4.20	80.60	12.40	7.80	10.40	9.53	7.00	7.80	10.70	9.40	8.91	12.30
lead	0.02	1.51	0.06	0.06	0.02	0.04	0.03	0.05	0.04	0.04	0.03	0.05
mercury	3.34	16.70	4.40	4.05	12.50	7.21	3.27	6.21	11.60	18.90	6.60	9.44
nickel	0.70	4.49	0.96	1.11	1.75	1.69	1.08	1.47	2.28	1.85	1.60	2.23
selenium	<0.08	35.50	0.24	0.61	<0.07	<0.08	<0.07	<0.07	<0.08	<0.11	0.02	<0.15
silver	<0.30	<0.70	<0.41	<0.39	<0.26	<0.29	<0.22	<0.25	<0.34	<0.48	<0.21	0.37
thallium	15.3	392.0	26.9	33.2	48.3	32.0	28.7	43.0	50.4	68.3	38.7	50.3
zinc												

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station											
	1	1a	2	2a	3	3a	3b	4	5	5a	5b	6
PESTICIDES (µg/kg)												
aldicarb	<1.0	•	<1.0	•	<1.0	•	<1.0	•	<1.0	•	<1.0	•
aldrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
alpha benzene hexachloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
atrazine	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
beta benzene hexachloride	•	•	•	•	•	•	•	•	•	•	•	•
carbaryl	•	•	•	•	•	•	•	•	•	•	•	•
carbofuran	<6.0	67.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
chlordane	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
chlorfenvinphos	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
chlorobalonil	<1.0	22.0	<1.0	7.7	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
chlorpyrifos	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
p,p' DDD	<3.0	<3.0	<3.0	6.5	<3.0	3.5	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
p,p' DDE	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
p,p' DDT	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
delta benzene hexachloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
diazinon	<400	<500	<400	<500	<400	<300	<400	<300	<600	<600	<400	<600
dibromochloropropane (dbcp)	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0
dicamba	<5.0	<250	<250	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,4-dichlorophenoxyacetic acid (2,4-D)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dicofol (fethane)	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0
dieldrin	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
dinoseb	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
endosulfan alpha	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
endosulfan beta	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
endosulfan sulfate	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
endrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
endrin aldehyde	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
gamma-bhc (lindane)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
guthion	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
heptachlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
heptachlor epoxide	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<800	<1,100
isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
malathion	•	•	•	•	•	•	•	•	•	•	•	•
methomyl	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
methoxychlor	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
metolachlor	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
mirex	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
parathion	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
picloram	<10	<50	<50	<50	<10	<10	<10	<10	<10	<10	<10	<10
simazine	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station										
	1	1a	2	2a	3	3a	3b	4	5	5a	6
toluene	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
2,4,5-TP (silver)	<10	<50	<50	<10	<10	<10	<10	<10	<10	<10	<10
PCB's AND RELATED COMPOUNDS (µg/kg)											
arochlor 1016	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1221	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1232	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1242	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1248	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1254	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1260	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2-chloronaphthalene	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<1,100
PHTHALATE ESTERS (µg/kg)											
bis(2-ethylhexyl) phthalate	<700	<4,400	<1,400	8,100	<900	<800	<900	<700	<1,100	<1,300	<1,100
di-n-butyl phthalate	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<1,100
di-n-octyl phthalate	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<1,100
dichyl phthalate	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<1,100
dimethyl phthalate	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<1,100
n-butyl benzyl phthalate	<700	<4,400	<1,400	<4,400	<900	<800	<900	<700	<1,100	<1,300	<1,100
GENERAL INORGANICS (mg/kg)											
cyanide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

^a - all concentrations expressed in terms of dry weight of sediment
• - lab unable to produce satisfactory results

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station											
	6a	6b	7	7a	7b	8	8a	8b	8c	8d	8e	9
DATE	020893	020993	021093	021093	020993	021093	021193	021193	021193	021293	021293	032293
TIME	1645	0920	1640	1505	1502	1000	1735	0930	1000	1125	1210	0752
CONVENTIONALS												
acid volatile sulfide (mg/kg)	186	44	71	978	20	163	222	147	13	18	11	171
total organic carbon (mg/kg)	39,900	63,000	5,740	63,100	38,400	14,700	97,500	52,800	7,000	26,800	6,570	13,800
particle size distribution (% of dry wt.)												
clay, <0.0039 mm	4	15	10	25	6	10	25	8	20	10	20	10
silt, 0.0039-0.0625 mm	9	53	31	67	19	39	47	34	37	28	48	16
sand, 0.0625-2.0 mm	85	32	59	8	72	50	22	57	18	61	32	68
gravel, >2.0 mm	2	<1	<1	<1	3	1	6	1	25	1	<1	6
PHENOLS AND CRESOLS (µg/kg)												
parachlorometa creol	<800	<1,900	<800	<1,500	<900	<1,000	<1,800	<1,000	<1,000	<800	<800	<900
pentachlorophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
phenol (C ₆ H ₅ OH) single compound	<1,500	<3,700	<1,600	<3,000	<1,800	<1,900	<3,500	<2,000	<1,900	<1,600	<1,500	<1,700
phenolics recoverable												
2-chlorophenol	<1,500	<3,700	<1,600	<3,000	<1,800	<1,900	<3,500	<2,000	<1,900	<1,600	<1,500	<1,700
2-nitrophenol	<1,500	<3,700	<1,600	<3,000	<1,800	<1,900	<3,500	<2,000	<1,900	<1,600	<1,500	<1,700
2,4-dichlorophenol	<1,500	<3,700	<1,600	<3,000	<1,800	<1,900	<3,500	<2,000	<1,900	<1,600	<1,500	<1,700
2,4-dimethylphenol	<1,500	<3,700	<1,600	<3,000	<1,800	<1,900	<3,500	<2,000	<1,900	<1,600	<1,500	<1,700
2,4-dinitrophenol	<3,000	<7,400	<3,100	<5,900	<3,500	<3,700	<6,900	<3,900	<3,700	<3,200	<2,900	<3,400
2,4,6-trichlorophenol	<1,500	<3,700	<1,600	<3,000	<1,800	<1,900	<3,500	<2,000	<1,900	<1,600	<1,500	<1,700
4-nitrophenol	<3,000	<7,400	<3,100	<5,900	<3,500	<3,700	<6,900	<3,900	<3,700	<3,200	<2,900	<3,400
4,6-dinitro-ortho-cresol	<3,000	<7,400	<3,100	<5,900	<3,500	<3,700	<6,900	<3,900	<3,700	<3,200	<2,900	<3,400
ETHERS (µg/kg)												
bis(2-chloroethoxy) methane	<800	<1,900	<800	<1,500	<900	<1,000	<1,800	<1,000	<1,000	<800	<800	<900
bis(2-chloroethyl) ether	<800	<1,900	<800	<1,500	<900	<1,000	<1,800	<1,000	<1,000	<800	<800	<900
bis(2-chloroisopropyl) ether	<800	<1,900	<800	<1,500	<900	<1,000	<1,800	<1,000	<1,000	<800	<800	<900
4-bromophenyl phenyl ether	<800	<1,900	<800	<1,500	<900	<1,000	<1,800	<1,000	<1,000	<800	<800	<900
4-chlorophenyl phenyl ether	<800	<1,900	<800	<1,500	<900	<1,000	<1,800	<1,000	<1,000	<800	<800	<900
HALOGENATED ALIPHATICS (µg/kg)												
bromodichloromethane	<400	<800	<400	<800	<500	<500	<1,000	<500	<500	<400	<400	<500
bromoform	<400	<800	<400	<800	<500	<500	<1,000	<500	<500	<400	<400	<500
carbon tetrachloride	<400	<800	<400	<800	<500	<500	<1,000	<500	<500	<400	<400	<500
chloroethane	<900	<1,900	<900	<2,000	<1,100	<1,200	<2,400	<1,200	<1,200	<1,000	<900	<1,100

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
MONOCYCLIC AROMATICS (µg/kg)												
benzene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
chlorobenzene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
ethylbenzene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
hexachlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
nitrobenzene	<1,000	<1,000	<800	<1,000	<900	<4,100	<400	<16,000	<800	<900	<1,000	<1,200
styrene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
toluene	2,000	<500	<400	<500	<400	<400	<400	33,000	4,400	<500	<500	<600
xylenes	<1,400	<1,400	<1,100	<1,500	<1,200	<1,200	<1,100	<2,600	<1,100	<1,300	<1,500	<1,800
1,2-dichlorobenzene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
1,2,4-trichlorobenzene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
1,3-dichlorobenzene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
1,4-dichlorobenzene	<500	<500	<400	<500	<400	<400	<400	<900	<400	<500	<500	<600
2,4-dinitrotoluene	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
2,6-dinitrotoluene	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
NITROSAMINES AND OTHER N COMPOUNDS (µg/kg)												
acrylonitrile	<2,300	<2,300	<1,800	<2,500	<2,000	<2,000	<1,800	<4,200	<1,800	<2,200	<2,500	<3,000
benzidine	<1,900	<1,900	<1,500	<2,000	<1,700	<8,100	<1,600	<32,000	<1,600	<1,800	<2,000	<2,300
n-nitrosodi-N-propylamine	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
n-nitrosodimethylamine	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
n-nitrosodiphenylamine	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
1,2-diphenylhydrazine	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
3,3-dichlorobenzidine	<1,900	<1,900	<1,500	<2,000	<1,700	<8,100	<1,600	<32,000	<1,600	<1,800	<2,000	<2,300
METALS (mg/kg)												
aluminum	7,220	9,410	4,290	11,100	7,250	7,560	8,880	10,900	5,470	16,500	19,100	10,200
antimony	4.74	4.05	3.05	5.20	4.99	4.02	6.11	2.60	3.22	4.42	4.62	4.72
arsenic	0.50	0.51	0.27	0.64	0.40	0.42	0.54	0.55	0.32	0.61	0.73	0.46
beryllium	0.42	0.25	0.06	0.24	0.23	0.16	0.16	2.31	0.27	0.33	0.19	0.46
cadmium	11.70	7.60	4.00	11.10	6.35	8.87	9.22	18.00	5.97	12.90	17.50	7.81
chromium	11.60	7.34	2.32	8.46	5.17	15.10	5.21	27.80	6.91	8.48	7.25	7.34
copper	30.10	13.20	7.56	18.60	13.50	50.70	18.40	32.40	15.10	14.60	14.90	12.10
lead	0.14	0.06	0.03	0.13	0.04	0.09	0.05	0.04	0.06	0.03	0.04	0.02
mercury	8.66	7.34	3.60	10.60	6.97	8.36	8.55	10.90	6.19	12.20	13.30	9.66
nickel	<0.21	1.64	2.64	1.33	1.58	0.66	1.14	2.23	2.43	1.29	1.08	1.37
selenium	0.93	0.14	<0.07	<0.10	<0.09	0.09	<0.07	0.30	0.21	<0.06	<0.07	<0.07
silver	0.61	0.16	<0.13	0.25	0.16	<0.18	<0.14	<0.24	<0.15	0.17	0.17	0.17
thallium	112.0	40.5	21.9	67.9	34.6	154.0	58.9	184.0	53.5	47.8	57.8	38.2
zinc												

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
PESTICIDES (µg/kg)												
aldicarb	•	•	•	•	•	•	•	•	•	•	•	•
aldrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
alpha benzene hexachloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
atrazine	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
beta benzene hexachloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
carbaryl	•	•	•	•	•	•	•	•	•	•	•	•
carbofuran	•	•	•	•	•	•	•	•	•	•	•	•
chlordane	<3.0	<3.0	<3.0	<3.0	<3.0	59.0	172.0	185.0	<3.0	<3.0	<3.0	<3.0
chlorfenviaphos	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
chlorobalonil	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
chlorpyrifos	<10	<10	<10	<10	<10	<10	<10	94.0	<10	<10	<10	<10
p,p' DDD	<3.0	<3.0	<3.0	<3.0	<3.0	8.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
p,p' DDE	12.5	6.5	<1.5	22.0	6.0	27.0	13.0	<1.5	7.0	<1.5	<1.5	<1.5
p,p' DDT	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
delta benzene hexachloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
diazinon	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
dibromochloropropane (dbcp)	<500	<500	<400	<400	<400	<400	<400	<900	<400	<500	<500	<600
dicamba	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dichlorophenoxyacetic acid (2,4-D)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
dicofol (kethane)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
diclirin	<2.0	<2.0	<2.0	<2.0	<2.0	6.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dinoseb	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
endosulfan alpha	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
endosulfan beta	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
endosulfan sulfate	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
endrin	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
endrin aldehyde	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
gamma-bbc (lindane)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
guthion	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
heptachlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
heptachlor epoxide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
isophorone	<1,000	<1,000	<800	<900	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
malathion	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methomyl	•	•	•	•	•	•	•	•	•	•	•	•
methoxychlor	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
metolachlor	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
nirex	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
parathion	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
picloram	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
simazine	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station											
	9a	9b	10	10a	11	11a	11b	11c	12	12a	12b	12c
toxaphene	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
2,4,5-TP (silvert)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
PCB's AND RELATED COMPOUNDS (µg/kg)												
arochlor 1016	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1221	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1232	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1242	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1248	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1254	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1260	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2-chloronaphthalene												
PTHALATE ESTERS (µg/kg)												
bis(2-ethylhexyl) phthalate	1,400	<1,000	<800	<1,000	<900	<4,100	<800	65,000	<800	<900	<1,000	<1,200
di-n-butyl phthalate	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
di-n-octyl phthalate	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
diethyl phthalate	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
dimethyl phthalate	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
n-butyl benzyl phthalate	<1,000	<1,000	<800	<1,000	<900	<4,100	<800	<16,000	<800	<900	<1,000	<1,200
GENERAL INORGANICS (mg/kg)												
cyanide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

^a - all concentrations expressed in terms of dry weight of sediment
 • - lab unable to produce satisfactory results

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station							
	12d	12e	13	14	15	15a	16	17 18
DATE	011193	011293	011193	011293	011293	011293	011393	011493
TIME	1045	1400	1400	1415	1700	1730	1000	1000
CONVENTIONALS								
acid volatile sulfide (mg/kg)	740	130	68	76	81	890	53	48
total organic carbon (mg/kg)	29,800	14,300	6,900	2,870	4,210	17,900	3,460	3,900
particle size distribution (% of dry wt.)								
clay, <0.0039 mm	29	5	12	5	1	15	7	4
silt, 0.0039-0.0625 mm	66	38	32	12	4	41	17	24
sand, 0.0625-2.0 mm	5	45	56	83	95	44	76	86
gravel, >2.0 mm	<1	2	<1	<1	<1	<1	<1	<1
PHENOLS AND CRESOLS (µg/kg)								
parachlorometa cresol	<1,700	<1,100	<800	<800	<700	<1,900	<800	<700
pentachlorophenol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
phenol (C ₆ H ₅ OH) single compound	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,400
phenolics recoverable								
2-chlorophenol	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,400
2-nitrophenol	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,400
2,4-dichlorophenol	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,400
2,4-dimethylphenol	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,400
2,4-dinitrophenol	<6,500	<4,300	<3,200	<2,900	<2,700	<7,400	<3,000	<2,800
2,4,6-trichlorophenol	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,400
4-nitrophenol	<6,500	<4,300	<3,200	<2,900	<2,700	<7,400	<3,000	<2,800
4,6-dinitro-ortho-cresol	<6,500	<4,300	<3,200	<2,900	<2,700	<7,400	<3,000	<2,800
ETHERS (µg/kg)								
bis(2-chloroethoxy) methane	<1,700	<1,100	<800	<800	<700	<1,900	<800	<700
bis(2-chloroethyl) ether	<1,700	<1,100	<800	<800	<700	<1,900	<800	<700
bis(2-chloroisopropyl) ether	<1,700	<1,100	<800	<800	<700	<1,900	<800	<700
4-bromophenyl phenyl ether	<1,700	<1,100	<800	<800	<700	<1,900	<800	<700
4-chlorophenyl phenyl ether	<1,700	<1,100	<800	<800	<700	<1,900	<800	<700
HALOGENATED ALIPHATICS (µg/kg)								
bromodichloromethane	<900	<600	<400	<400	<300	<500	<400	<400
bromoform	<900	<600	<400	<400	<300	<500	<400	<400
carbon tetrachloride	<900	<600	<400	<400	<300	<500	<400	<400
chloroethane	<2,000	<1,400	<1,000	<900	<800	<1,200	<900	<800

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station									
	12d	12e	13	14	15	15a	16	17	18	
chloroform	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
dibromochloromethane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
dichlorodifluoromethane	<2,000	<1,400	<1,000	<900	<800	<1,200	<900	<800	<800	<800
hexachlorobutadiene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
hexachlorocyclopentadiene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<800	<800
hexachloroethane	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<800	<800
methyl bromide	<2,000	<1,400	<1,000	<900	<800	<1,200	<900	<800	<800	<800
methyl chloride	<2,000	<1,400	<1,000	<900	<800	<1,200	<900	<800	<800	<800
methylethyl chloride	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
tetrachloroethylene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
trichloroethylene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
trichlorofluoromethane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
vinyl chloride	<2,000	<1,400	<1,000	<900	<800	<1,200	<900	<800	<800	<800
1,1-dichloroethane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,1-dichloroethylene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,1,1-trichloroethane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,1,2-trichloroethane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,1,2,2-tetrachloroethane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,2-dichloroethane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,2-dichloropropane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,2-trans-dichloroethylene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,3-trans-dichloropropane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
1,3-cis-dichloropropane	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400
POLYCYCLIC AROMATIC										
HYDROCARBONS (µg/kg)										
acenaphthene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
acenaphthylene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
anthracene/phenanthrene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
benzo(A) anthracene 1,2-benzanthracene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
benzo(B) fluoranthene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
benzo(OH) perylene 1,12-benzoperylene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
benzo(K) fluoranthene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
benzo-A-pyrene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
chrysene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
fluoranthene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
fluorene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
indeno(1,2,3-CD) pyrene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
naphthalene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
pyrene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
1,2,5,6-dibenzanthracene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station										
	12d	12e	13	14	15	15a	16	17	18		
MONOCYCLIC AROMATICS (µg/kg)											
benzene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
chlorobenzene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
ethylbenzene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
hexachlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
nitrobenzene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700	<700
styrene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
toluene	<900	<600	<400	<400	<300	600	<400	<400	<400	<400	<400
xylene	<2,500	<1,700	<1,200	<1,000	<1,000	<1,400	<1,100	<1,000	<1,000	<1,000	<1,000
1,2-dichlorobenzene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
1,2,4-trichlorobenzene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
1,3-dichlorobenzene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
1,4-dichlorobenzene	<900	<600	<400	<400	<300	<500	<400	<400	<400	<400	<400
2,4-dinitrotoluene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700	<700
2,6-dinitrotoluene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700	<700
NITROSAMINES AND OTHER N COMPOUNDS (µg/kg)											
acrylonitrile	<4,100	<2,700	<2,000	<1,700	<1,600	<2,300	<1,800	<1,700	<1,600	<1,600	<1,600
benzidine	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,500	<1,400	<1,400	<1,400
n-nitrosodi-N-propylamine	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700	<700
n-nitrosodimethylamine	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700	<700
n-nitrosodiphenylamine	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700	<700
1,2-diphenylhydrazine	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700	<700
3,3-dichlorobenzidine	<3,300	<2,200	<1,600	<1,500	<1,400	<3,700	<1,500	<1,500	<1,400	<1,400	<1,400
METALS (mg/kg)											
aluminum	15,900	8,560	5,990	4,750	2,100	7,650	6,260	3,870	3,310	•	•
antimony	10.30	2.55	4.86	2.62	3.44	2.95	2.80	3.81	2.88	•	•
arsenic	0.69	0.42	0.33	0.24	0.14	0.43	0.31	0.25	0.23	•	•
beryllium	0.36	0.25	0.15	0.06	0.04	0.27	0.16	0.12	0.12	•	•
cadmium	16.20	7.11	6.10	4.90	2.64	8.78	6.26	4.89	3.64	•	•
chromium	14.50	6.10	3.70	2.05	1.09	11.00	3.32	2.21	2.20	•	•
copper	24.90	5.91	6.60	4.50	4.35	9.34	5.72	4.36	4.02	•	•
lead	0.06	0.03	0.05	0.01	0.02	0.11	0.03	0.03	0.02	•	•
mercury	11.70	8.41	5.56	4.16	2.31	7.41	5.06	4.28	3.66	•	•
nickel	2.21	1.37	1.12	1.19	1.11	1.54	1.61	1.25	1.29	•	•
selenium	<0.15	<0.11	<0.11	<0.09	<0.09	1.01	<0.09	<0.08	<0.09	•	•
silver	0.48	0.31	0.19	<0.19	<0.19	<0.23	0.16	0.18	<0.16	•	•
thallium	67.6	28.0	23.9	18.5	12.9	39.8	27.2	18.8	16.9	•	•
zinc											

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station									
	12d	12e	13	14	15	15a	16	17	18	
PESTICIDES (µg/kg)										
aldicarb	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
aldrin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
alpha benzene hexachloride	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
atrazine	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
beta benzene hexachloride	•	•	•	•	•	•	•	•	•	•
carbaryl	•	•	•	•	•	•	•	•	•	•
carbofuran	•	•	•	•	•	•	•	•	•	•
chlorfane	<3.0	<3.0	<3.0	<3.0	<3.0	33.0	<3.0	<3.0	<3.0	<3.0
chlorfenvinphos	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
chlorothalonil	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
chlorpyrifos	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
p,p' DDD	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
p,p' DDE	35.0	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
p,p' DDT	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
delta benzene hexachloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
diazinon	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
dibromochloropropane (dbcp)	<900	<600	<400	<400	<400	<400	<400	<400	<400	<400
dicamba	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dichlorophenoxyacetic acid (2,4-D)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
dicofol (ketthane)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
dielzin	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
dinoseb	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
endosulfan alpha	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
endosulfan beta	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
endosulfan sulfate	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
endrin	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
endrin aldehyde	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
gamma-bhc (lindane)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
guthion	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
heptachlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
heptachlor epoxide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
isophorone	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
malathion	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
metbomyl	•	•	•	•	•	•	•	•	•	•
methoxychlor	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
metolachlor	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
mirex	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
parathion	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0	<6.0
pictorin	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
siamazine	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50

Table 11 (continued)
Analytical Data - Sediment

Parameter ^a	Station									
	12d	12e	13	14	15	15a	16	17	18	
toluene	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
2,4,5-TP (silver)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
PCB's AND RELATED COMPOUNDS (µg/kg)										
arochlor 1016	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1221	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1232	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1242	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1248	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1254	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
arochlor 1260	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2-chloronaphthalene	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
PHTHALATE ESTERS (µg/kg)										
bis(2-ethylhexyl) phthalate	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
di-n-butyl phthalate	2,400	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
di-n-octyl phthalate	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
diethyl phthalate	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
dimethyl phthalate	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
n-butyl benzyl phthalate	<1,700	<1,100	<800	<800	<700	<1,900	<800	<800	<700	<700
GENERAL INORGANICS (mg/kg)										
cyanide	3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

^a - all concentrations expressed in terms of dry weight of sediment
 • - lab unable to produce satisfactory results

Table 11 (continued)

Analytical Data - Sediment
Comisión Nacional del Agua

CUADRO 1.3 RESULTADOS DE ANALISIS DE METALES PESADOS EN SEDIMENTOS ETAPA 1

ESTACION	PLATA mg/kg	COBRE mg/kg	NIQUEL mg/kg	ZINC mg/kg
1	0.93	4.69	2.70	8.68
1a	5.2	129.6	11.50	40.65
2	1.69	15.30	3.80	19.19
2a	1.43	8.74	3.00	24.20
3	1.56	4.91	6.00	11.18
3a	2.1	2.90	4.70	8.04
3b	1.52	0.86	4.30	4.69
4	1.66	2.85	3.90	10.61
5	1.66	1.21	5.40	6.79
5a	2.31	3.79	6.50	9.89

CUADRO 2.3 RESULTADOS DE ANALISIS DE METALES PESADOS EN SEDIMENTOS ETAPA 2

ESTACION DE MONITOREO	ARSENICO mg/kg	CADMIO mg/kg	COBRE mg/kg	MERCURIO mg/kg	NIQUEL mg/kg	PLATA mg/kg	PLOMO mg/kg	ZINC mg/kg	SELENIO mg/kg	CROMO mg/kg
12d	0.045	1.15	5.16	<0.0083	17.16	<0.5	22.33	42.33	0.03	7.55
12e	1.850	1.5	4.5	<0.0063	19.98	<0.5	15.66	38.50	0.06	9.00
13	4.056	1.15	5.16	<0.0083	24.00	<0.5	21.50	35.50	<0.0083	15.15
11	8.47	1.5	3.33	<0.0083	21.33	<0.5	21.00	35.50	<0.0083	9.50
15	2.41	1.33	5.83	<0.0083	18.50	0.53	20.50	35.50	<0.0083	9.50
13a	3.77	1.66	3.00	<0.0083	20.56	<0.5	25.16	27.00	<0.0083	8.15
16	4.82	1.66	5.16	<0.0083	25.50	0.83	26.50	53.83	<0.0083	13.55
17	4.07	1.66	4.33	0.015	22.56	<0.5	23.30	38.50	<0.0083	14.55
18	4.52	1.5	6.33	<0.0083	19.83	<0.5	21.50	34.65	<0.0083	5.65

CUADRO 3.3 RESULTADOS DE ANALISIS DE METALES PESADOS EN SEDIMENTOS ETAPA 3

ESTACION	ARSENICO mg/kg	CADMIO mg/kg	COBRE mg/kg	MERCURIO mg/kg	NIQUEL mg/kg	PLATA mg/kg	PLOMBO mg/kg	ZINC mg/kg	SELENIO mg/kg	CROMO mg/kg
5b	3.215	0.306	1.025	0.09	1.82	0.963	3.638	0.694	<.006	<.063
6	0.925	0.306	0.738	0.08	1.606	0.931	3.6	0.706	<.006	<.063
6a	4.205	0.288	0.681	0.09	1.469	0.919	3.606	0.55	<.006	<.063
6b	1.233	0.288	0.688	0.06	1.575	0.925	3.438	0.6	<.006	<.063
7	0.833	0.294	0.656	0.06	2.044	0.919	3.575	0.744	<.006	<.063
7a	1.982	0.431	0.775	0.06	1.863	1.081	3.55	1.663	<.006	<.063
7b	0.745	0.288	0.631	0.07	1.756	0.919	3.419	0.431	<.006	<.063
8	0.925	0.3	0.513	0.05	1.619	0.875	3.4	0.419	<.006	<.063
8a	1.233	0.313	0.544	0.05	1.656	0.881	3.444	0.756	<.006	<.063
8b	1.233	0.306	0.919	0.07	1.456	0.925	3.619	0.713	<.006	<.063
8c	1.119	0.3	0.706	0.07	2.013	0.913	3.5	0.519	<.006	<.063
8d	1.02	0.295	0.513	0.05	1.923	0.815	2.845	0.431	<.006	<.063
8e	1.045	0.295	0.544	0.05	0.823	0.823	2.633	0.431	<.006	<.063

CUADRO 4.3 RESULTADOS DE ANALISIS DE METALES PESADOS EN AGUA EN SEDIMENTOS ETAPA 4

ESTACION DE MONITOREO	ARSENICO mg/kg	CADMIO mg/kg	COBRE mg/kg	MERCURIO mg/kg	NIQUEL mg/kg	PLATA mg/kg	PLOMBO mg/kg	ZINC mg/kg	SELENIO mg/kg	CROMO mg/kg
9	3.31	1.33	3.83	<0.0083	15.83	<0.5	40	28.83	0.043	7.51
9a	2.860	1.33	9	0.053	20.66	1.11	28.83	129.15	0.015	15.16
9b	1.96	1.00	5.33	<0.0083	15.83	<0.5	18.15	61.66	0.015	6.00
10	3.47	0.83	3.16	<0.0083	13.83	<0.5	18.15	144.33	0.03	6.00
10a	3.01	1.15	6.83	0.023	18.50	0.53	28.33	57.83	0.03	12.50
11	4.62	1.50	6.00	<0.0083	20.66	<0.5	25.16	46.16	0.023	14.66
11a	2.56	1.50	5.83	<0.0083	16.50	<0.5	33.50	57.33	0.023	6.00
11b	4.82	1.15	6.33	0.015	15.83	<0.5	16.66	111.65	<0.0083	10.33
11c	2.56	1.50	6.33	<0.0083	19.83	<0.5	17.66	36.50	0.08	13.65
12	2.41	1.00	6.00	<0.0083	13.83	<0.5	16.33	48.00	<0.0083	11.00
12a	3.77	1.00	6.83	<0.0083	18.50	<0.5	17.66	40.50	0.03	14.66
12b	2.56	1.33	5.33	0.015	20.66	<0.5	19.16	50.00	0.015	15.66
12c	3.01	1.50	6.00	<0.0083	18.50	<0.5	17.33	34.65	0.045	10.33

Table 12
Analytical Data - Tissue

Parameter ^a	Station/Species											
	1			2			3			3a		
	carp, whole	carp, filets	channel catfish, whole	carp, whole	carp, filets	channel catfish, whole	channel catfish, filets	carp, filets	channel catfish, whole	carp, whole	carp, filets	
NUMBER OF SPECIMENS IN SAMPLE	5	5	5	5	5	7	1	1	18	5	5	
DATE	111292	111292	111292	111192	111192	111192	111192	111392	111392	111392	111392	
TIME	0830	0830	0830	0830	0830	0830	0830	0830	0830	1230	1230	
CONVENTIONALS lipid content (%)	3.2	1.8	4.0	3.0	2.4	**	1.2	1.6	3.5	2.2	3.0	
PHENOLS AND CRESOLS (mg/kg)												
parachlorometa cresol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	
pentachlorophenol	<20	<20	<4.0	<20	<20	<20	<4.0	<4.0	<20	<4.0	<4.0	
phenol (C ₆ H ₅ OH) single compound	<10	<10	<2.0	<10	<10	<10	<2.0	<2.0	<10	<2.0	<2.0	
phenolica recoverable	*	*	*	*	*	*	*	*	*	*	*	
2-chlorophenol	<10	<10	<2.0	<10	<10	<10	<2.0	<2.0	<10	<2.0	<2.0	
2-nitrophenol	<10	<10	<2.0	<10	<10	<10	<2.0	<2.0	<10	<2.0	<2.0	
2,4-dichlorophenol	<10	<10	<2.0	<10	<10	<10	<2.0	<2.0	<10	<2.0	<2.0	
2,4-dinitrophenol	<10	<10	<2.0	<10	<10	<10	<2.0	<2.0	<10	<2.0	<2.0	
2,4,6-trichlorophenol	<20	<20	<4.0	<20	<20	<20	<4.0	<4.0	<20	<4.0	<4.0	
4-nitrophenol	<10	<10	<2.0	<10	<10	<10	<2.0	<2.0	<10	<2.0	<2.0	
4,6-dinitro-ortho-cresol	<20	<20	<4.0	<20	<20	<20	<4.0	<4.0	<20	<4.0	<4.0	
ETHERS (mg/kg)												
bis(2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	
bis(2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	
bis(2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	
4-bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	
4-chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	
HALOGENATED ALIPHATICS (mg/kg)												
bromodichloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
bromoform	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
carbon tetrachloride	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
chloroethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
chloroform	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
dibromochloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
dichlorodifluoromethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species									
	1		2		3		3a			
	carp, whole	carp, filets	channel catfish, whole	channel catfish, filets	carp, whole	carp, filets	channel catfish, whole	channel catfish, filets	carp, whole	carp, filets
benzoborbutadiene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
benzoborocyclopentadiene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
benzoborothane	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
methyl bromide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methylacetylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
tetrachloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
vinyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,1-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,1-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2,2-tetrachloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloropropane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-trans-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-trans-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-cis-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
POLYCYCLIC AROMATIC										
HYDROCARBONS (mg/kg)										
acetylene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
acetylene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
anthracene/phenanthrene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
benzo(A) anthracene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
benzo(B) fluoranthene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
benzo(GH) perylene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
benzo(K) fluoranthene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
benzo-A-pyrene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
chrysene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
fluoranthene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
fluorene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
indeno(1,2,3-CD) pyrene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
naphthalene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
pyrene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0
1,2,5,6-dibenzanthracene	<5.0	<5.0	<5.0	<1.0	<5.0	<1.0	<5.0	<1.0	<1.0	<1.0

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	1			2			3			3a		
	carp, whole	carp, fillets	channel catfish, whole	channel catfish, fillets	carp, whole	carp, fillets	channel catfish, whole	channel catfish, fillets	carp, fillets	channel catfish, whole	carp, whole	carp, fillets
MONOCYCLIC AROMATICS (mg/kg)												
benzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ethylbenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
nitrobenzene	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
styrene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
toluene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
xylene	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
1,2-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	0.04	0.06	0.05	0.03	<0.02	<0.02	<0.02	<0.02
1,2,4-trichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,4-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
2,4-dinitrotoluene	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
2,6-dinitrotoluene	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
NITROSAMINES AND OTHER N COMPOUNDS (mg/kg)												
acrylamide	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
benzidine	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0	<2.0
n-nitrosodi-N-propylamine	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
n-nitrosodimethylamine	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
n-nitrosodiphenylamine	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
1,2-diphenylhydrazine	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
3,3'-dichlorobenzidine	<1.0	<1.0	<1.0	<2.0	<1.0	<1.0	<1.0	<2.0	<2.0	<1.0	<2.0	<2.0
METALS (mg/kg)												
aluminum	27.6	<1.0	6.7	<1.2	8.3	<1.0	9.6	<1.0	<1.0	41.0	16.8	<1.0
antimony	•	•	•	•	•	•	•	•	•	•	•	•
arsenic	0.053	0.040	<0.026	<0.028	0.044	0.049	0.064	<0.028	<0.028	<0.027	<0.028	<0.028
beryllium	<0.038	<0.037	<0.036	<0.048	<0.033	<0.037	<0.035	<0.034	<0.035	<0.034	<0.035	<0.038
cadmium	0.066	0.017	0.036	0.003	0.003	0.011	0.040	0.004	0.003	0.004	0.028	0.001
chromium	<0.040	0.046	<0.037	<0.039	0.120	0.030	<0.040	0.035	<0.157	0.104	0.047	<0.040
copper	1.850	0.759	0.661	0.243	1.630	0.792	1.070	0.213	0.681	0.778	0.884	0.622
lead	<0.152	<0.148	<0.140	<0.189	0.171	<0.145	0.324	<0.136	<0.137	0.057	<0.137	<0.150
mercury	0.046	0.110	<0.023	0.062	<0.016	0.031	<0.023	0.019	0.190	0.057	0.140	0.089
nickel	0.108	<0.074	0.847	<0.095	0.176	<0.073	6.930	0.409	0.095	0.246	<0.069	<0.075
selenium	0.530	0.312	0.491	0.285	0.537	0.530	0.402	0.225	0.584	1.290	1.120	1.640
silver	<0.196	<0.187	<0.193	<0.194	<0.179	<0.181	<0.196	<0.188	<0.195	<0.175	<0.181	<0.199

Table 12 (continued)

Parameter ^a	station/species											
	1			2			3			3a		
	carp, whole	carp fillets	channel catfish, whole	channel catfish, fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish, fillets	carp fillets	channel catfish, whole	carp, whole	carp fillets
thallium	<0.060	<0.077	<0.074	<0.175	<0.075	<0.078	<0.080	<0.078	<0.079	<0.075	<0.116	<0.119
zinc	47.0	7.6	18.4	4.3	37.2	8.9	18.7	3.4	7.7	20.3	23.3	10.8
PESTICIDES (mg/kg)												
aldicarb	.	.	.	.	.	.	.	.	.	.	.	.
aldrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
alpha benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
atrazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
beta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
carbaryl	.	.	.	.	.	.	.	.	.	.	.	.
carbofuran	.	.	.	.	.	.	.	.	.	.	.	.
chlorthane	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chlordane	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
chlorfenviphos	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
chlorobalonil	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chloryrifos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDD	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDE	0.260	0.180	0.160	0.080	0.058	0.040	0.100	0.065	0.300	0.028	0.041	0.840
p,p' DDT	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
delta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
diazinon	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibromochloropropane (dbcp)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
dicamba	.	.	.	.	.	.	.	.	.	.	.	.
2,4-dichlorophenoxyacetic acid (2,4-D)	.	.	.	.	.	.	.	.	.	.	.	.
dicofol (telthiane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
dieldrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
dioxeb	.	.	.	.	.	.	.	.	.	.	.	.
endosulfan alpha	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan beta	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan sulfate	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin aldehyde	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
gamma-hch (lindane)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
guthion	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
heptachlor	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
heptachlor epoxide	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
isophorone	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0
malathion	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
methomyl	.	.	.	.	.	.	.	.	.	.	.	.
methoxychlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species									
	1			2			3			3a
	carp, whole	carp, filets	channel catfish, whole	channel catfish, filets	carp, whole	carp, filets	channel catfish, whole	channel catfish, filets	carp, whole	carp, filets
metolachlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
nitrex	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
parathion	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
picloram	.	.	.	.	.	.	.	.	.	.
simazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
tosephene	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
2,4,5-TP (nitrex)	.	.	.	.	.	.	.	.	.	.
PCB's AND RELATED COMPOUNDS (mg/kg)										
arochlor 1016	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1221	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1232	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1242	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1248	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1254	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1260	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
2-chloronaphthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PHTHALATE ESTERS (mg/kg)										
bis(2-ethylhexyl) phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-octyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
diethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-butyl benzyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
GENERAL INORGANICS (mg/kg)										
cyanide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

^a - all concentrations expressed in terms of wet weight of tissue

• - lab unable to produce satisfactory results

•• - could not be analyzed due to insufficient sample volume

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	station/species												
	4				5				6				
	carp, whole	carp fillets	blue catfish, whole	blue catfish, fillets	carp, whole	carp fillets	blue catfish, whole	blue catfish, fillets	carp, whole	carp fillets	white bass, whole	white bass fillets	6a carp, whole
NUMBER OF SPECIMENS IN SAMPLE	4	5	2	2	5	5	2		5	5	5	5	5
DATE	111492	111492	111492	111492	111592	111592	111592		020893	020893	020893	020893	020893
TIME	0930	0930	0930	0930	1030	1030	1030		1030	1030	1030	1030	1400
CONVENTIONALS													
lipid content (%)	2.3	0.3	1.5	<0.1	2.4	2.5	<0.1		14.3	3.0	1.6	*	8.5
PHENOLS AND CRESOLS (mg/kg)													
parachlorometa cresol	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0		<5.0	<5.0	<5.0	<5.0	<5.0
peatachlorophenol	<20	<4.0	<4.0	<4.0	<20	<4.0	<4.0		<20	<20	<20	<20	<20
phenol (C ₆ H ₅ OH) single compound	<10	<2.0	<2.0	<2.0	<10	<2.0	<2.0		<10	<10	<10	<10	<10
phenolics recoverable	*	*	*	*	*	*	*		*	*	*	*	*
2-chlorophenol	<10	<2.0	<2.0	<2.0	<10	<2.0	<2.0		<10	<10	<10	<10	<10
2-nitrophenol	<10	<2.0	<2.0	<2.0	<10	<2.0	<2.0		<10	<10	<10	<10	<10
2,4-dichlorophenol	<10	<2.0	<2.0	<2.0	<10	<2.0	<2.0		<10	<10	<10	<10	<10
2,4-dimethylphenol	<10	<2.0	<2.0	<2.0	<10	<2.0	<2.0		<10	<10	<10	<10	<10
2,4-dinitrophenol	<10	<4.0	<4.0	<4.0	<20	<4.0	<4.0		<20	<20	<20	<20	<20
2,4,6-trichlorophenol	<10	<2.0	<2.0	<2.0	<10	<2.0	<2.0		<10	<10	<10	<10	<10
4-nitrophenol	<20	<4.0	<4.0	<4.0	<20	<4.0	<4.0		<20	<20	<20	<20	<20
4,6-dinitro-ortho-cresol	<20	<4.0	<4.0	<4.0	<20	<4.0	<4.0		<20	<20	<20	<20	<20
ETHERS (mg/kg)													
bis(2-chloroethyloxy) methane	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0		<5.0	<5.0	<5.0	<5.0	<5.0
bis(2-chloroethyl) ether	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0		<5.0	<5.0	<5.0	<5.0	<5.0
bis(2-chloroisopropyl) ether	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0		<5.0	<5.0	<5.0	<5.0	<5.0
4-bromophenyl phenyl ether	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0		<5.0	<5.0	<5.0	<5.0	<5.0
4-chlorophenyl phenyl ether	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0		<5.0	<5.0	<5.0	<5.0	<5.0
HALOGENATED ALIPHATICS (mg/kg)													
bromodichloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
bromoforn	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
carbon tetrachloride	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
chloroethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05
chloroform	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
dibromochloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
dichlorodifluoromethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species									
	4		5		6		6a			
	carp, whole	carp, fillets	blue catfish, whole	blue catfish, fillets	carp, whole	carp, fillets	blue catfish, whole	blue catfish, fillets	white bass, whole	white bass, fillets
hexachlorobutadiene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorocyclopentadiene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
hexachloroethane	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
methyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methyl bromide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methylethyl chloride	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
tetrachloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichlorofluoromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
vinyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,1-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,1-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2,2-tetrachloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-trans-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-trans-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-cis-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
POLYCYCLIC AROMATIC										
HYDROCARBONS (ng/kg)										
acenaphthene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
acenaphthylene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
anthracene/phenanthrene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
benzo(A) anthracene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
benzo(B) fluoranthene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
benzo(GH) perylene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
benzo(K) fluoranthene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
benzo-A-pyrene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
chrysene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
fluoranthene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
fluorene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
indeno(1,2,3-CD) pyrene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
naphthalene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
pyrene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0
1,2,5,6-dibenzanthracene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<1.0	<5.0	<5.0

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species									
	4		5		6		6a			
	carp, whole	carp, fillets	blue catfish, whole	blue catfish, fillets	carp, whole	carp, fillets	blue catfish, whole	carp, whole	carp, fillets	white bass, whole
MONOCYCLIC AROMATICS (ng/kg)										
benzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ethylbenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
nitrobenzene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
styrene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
toluene	<0.06	<0.06	<0.02	<0.02	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
xylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2,4-trichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,4-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
2,4-dinitrotoluene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
2,6-dinitrotoluene	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
NITROSAMINES AND OTHER N COMPOUNDS (ng/kg)										
acrylonitrile	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
benzidine	<10	<2.0	<2.0	<2.0	<10	<10	<2.0	<10	<10	<10
n-nitrosodi-N-propylamine	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
n-nitrosodimethylamine	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
n-nitrosodiphenylamine	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
1,2-diphenylhydrazine	<5.0	<1.0	<1.0	<1.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
3,3-dichlorobenzidine	<10	<2.0	<2.0	<2.0	<10	<10	<2.0	<10	<10	<10
METALS (ng/kg)										
aluminum	46.6	<1.0	8.4	<1.2	23.3	1.5	14.5	16.2	1.8	2.8
antimony	0.080	<0.027	0.047	0.041	0.054	0.054	0.050	0.070	0.049	0.062
arsenic	<0.034	<0.039	<0.039	<0.047	<0.035	<0.036	<0.038	<0.040	<0.039	0.036
beryllium	0.033	0.002	0.003	0.003	0.044	0.001	0.007	0.010	<0.017	<0.009
cadmium	0.133	<0.038	0.079	0.023	0.022	<0.039	0.101	0.082	0.038	0.059
chromium	1.240	0.397	0.311	0.258	1.630	0.626	0.546	0.694	0.799	0.798
copper	0.107	<0.154	<0.077	<0.094	0.070	<0.144	0.119	<0.078	<0.078	<0.079
lead	0.150	0.150	0.075	0.130	0.150	0.110	0.053	<0.069	<0.082	0.163
mercury	0.040	0.140	0.079	0.122	<0.068	0.107	0.174	0.104	<0.075	0.126
nickel	1.060	1.300	0.441	0.367	1.380	1.440	0.619	0.830	1.440	1.610
selenium	<0.183	<0.192	<0.189	<0.187	<0.187	<0.197	<0.195	<0.066	<0.065	<0.066
silver										

Table 12 (continued)

[illegible]

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species												
	4			5			6			6a			
	carp, whole	carp fillets	blue catfish, whole	blue catfish fillets	carp, whole	carp fillets	blue catfish, whole	carp, whole	carp fillets	white bass, whole	white bass fillets	carp, whole	carp, whole
metolachlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
mirex	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
parathion	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
picloram	•	•	•	•	•	•	•	•	•	•	•	•	•
simazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
toxaphene	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
2,4,5-TP (silver)	•	•	•	•	•	•	•	•	•	•	•	•	•
PCB's AND RELATED COMPOUNDS (mg/kg)													
arochlor 1016	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1221	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1232	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1242	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1248	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1254	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1260	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
2-chloronaphthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PHTHALATE ESTERS (mg/kg)													
bis(2-ethylhexyl) phthalate	<5.0	<1.0	<1.0	99.7	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-butyl phthalate	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-octyl phthalate	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
diethyl phthalate	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
dimethyl phthalate	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-butyl benzyl phthalate	<5.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
GENERAL INORGANICS (mg/kg)													
cyanide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.0	<1.0	<1.0

^a - all concentrations expressed in terms of wet weight of tissue

• - lab unable to produce satisfactory results

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	6a			6b			7			7b		
	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	carp, whole	carp fillets
NUMBER OF SPECIMENS IN SAMPLE	5	1	2	4	5	5	5	5	5	5	5	5
DATE	020893	020893	020893	020993	020993	020993	020993	021093	021093	021093	020993	020993
TIME	1400	1400	1400	0930	0930	0930	0930	1430	1430	1430	1500	1500
CONVENTIONAL lipid content (%)	3.1	6.0	1.1	2.5	3.6	0.9	0.8	9.7	11.2	2.0	7.3	15.2
PHENOLS AND CRESOLS (mg/kg)												
parachloroneta cresol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
pentachlorophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
phenol (C ₆ H ₅ OH) single compound	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
phenolics recoverable	*	*	*	*	*	*	*	*	*	*	*	*
2-chlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-nitrophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dimethylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dinitrophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2,4,6-trichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-nitrophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
4,6-dinitro-ortho-cresol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
ETHERS (mg/kg)												
bis(2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
bis(2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
bis(2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4-bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4-chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
HALOGENATED ALIPHATICS (mg/kg)												
bromodichloromethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
bromoform	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
carbon tetrachloride	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
chloroethane	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05
chloroform	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
dibromochloromethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
dichlorodifluoromethane	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species													
	6a				6b				7				7b	
	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	carp, whole	carp fillets	carp fillets	
hexachlorobutadiene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
hexachloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
methyl bromide	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	
methyl chloride	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	
methylene chloride	***	<0.02	<0.02	<0.02	<0.02	0.12	<0.02	***	0.03	0.03	<0.02	<0.02	<0.02	
tetrachloroethylene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
trichloroethylene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
trichlorofluoromethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
vinyl chloride	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	
1,1-dichloroethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,1-dichloroethylene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,1,1-trichloroethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,1,2-trichloroethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,1,2,2-tetrachloroethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,2-dichloroethane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,2-dichloropropane	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,2-trans-dichloroethylene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,3-trans-dichloropropene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
1,3-cis-dichloropropene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	
POLYCYCLIC AROMATIC														
HYDROCARBONS (mg/kg)														
acenaphthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
acenaphthylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
anthracene/phenanthrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
benzo(A) anthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
benzo(B) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
benzo(GHI) perylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
benzo(K) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
benzo-A-pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
chrysene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
fluorene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
indeno(1,2,3-CD) pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
naphthalene	<5.0	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
1,2,5,6-dibenzanthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	6a			6b			7			7b		
	carp fillets	channel catfish whole	channel catfish fillets	carp whole	carp fillets	channel catfish whole	channel catfish fillets	carp whole	carp fillets	smallmouth bass whole	carp whole	carp fillets
MONOCYCLIC AROMATICS (mg/kg)												
benzene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
chlorobenzene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
ethylbenzene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
nitrobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
styrene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
toluene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
xylene	***	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	***	<0.06	<0.06	<0.06	<0.06
1,2-dichlorobenzene	<5.0	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<5.0	<0.02	<0.02	<0.02	<0.02
1,2,4-trichlorobenzene	<5.0	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<5.0	<0.02	<0.02	<0.02	<0.02
1,3-dichlorobenzene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
1,4-dichlorobenzene	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02
2,4-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,6-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
NITROSAMINES AND OTHER N COMPOUNDS (mg/kg)												
acrylonitrile	***	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	***	<0.1	<0.1	<0.1	<0.1
benzidine	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
n-nitrosodi-N-propylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,2-diphenylhydrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
3,3-dichlorobenzidine	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
METALS (mg/kg)												
aluminum	<0.9	7.3	1.1	13.9	<1.0	2.5	5.7	39.8	1.6	2.3	<1.0	2.0
antimony	0.137	0.027	<0.020	0.044	0.037	<0.020	<0.020	0.109	0.024	<0.019	0.019	0.147
arsenic	<0.037	<0.040	<0.040	<0.034	<0.039	<0.039	<0.040	<0.039	<0.038	<0.037	<0.040	<0.040
beryllium	<0.008	0.018	<0.009	0.021	<0.017	<0.010	<0.010	0.042	0.042	<0.009	<0.009	<0.009
cadmium	<0.039	0.041	<0.040	0.126	<0.039	0.052	<0.040	0.113	<0.038	<0.037	0.091	<0.040
chromium	1.120	0.436	0.365	1.220	1.560	0.396	0.323	2.040	1.530	0.776	1.670	1.310
copper	0.081	<0.080	<0.040	0.076	<0.078	<0.078	<0.039	<0.077	<0.039	<0.082	0.037	<0.080
lead	<0.083	<0.085	0.149	0.092	0.173	<0.077	0.120	<0.066	0.081	0.162	<0.076	<0.074
mercury	<0.076	0.087	0.134	0.162	0.190	0.146	0.087	0.142	<0.075	0.099	0.101	<0.080
nickel	1.280	0.515	1.090	0.961	0.946	0.637	0.873	1.040	0.865	1.040	0.648	0.704
selenium	<0.066	<0.066	<0.064	<0.066	<0.066	<0.065	<0.065	<0.064	<0.065	<0.066	<0.061	<0.066
silver												

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species									
	6a					6b				
	cap fillets	channel catfish, whole	channel catfish, fillets	cap, whole	cap, fillets	channel catfish, whole	channel catfish, fillets	cap, whole	cap, fillets	smallmouth bass, whole
	7a	7b	7c	7d	7e	7f	7g	7h	7i	7j
thallium	<0.037	<0.040	<0.040	<0.034	0.073	<0.039	<0.040	<0.039	<0.038	<0.037
zinc	14.7	9.9	4.2	45.1	7.5	13.8	3.7	42.4	15.8	16.9
pesticides (mg/kg)										
aldicarb	•	•	•	•	•	•	•	•	•	•
aldrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
alpha benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
atrazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
beta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
carbaryl	•	•	•	•	•	•	•	•	•	•
carbofuran	•	•	•	•	•	•	•	•	•	•
chlorodane	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chlorfenvinphos	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
chlorothalonil	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
chlorpyrifos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDD	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDE	0.070	<0.005	0.110	0.030	0.061	0.008	0.022	0.130	0.300	0.042
p,p' DDT	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
delta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
diazinon	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibromochloropropane (dbcp)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
dicamba	•	•	•	•	•	•	•	•	•	•
2,4-dichlorophenoxyacetic acid (2,4-D)	•	•	•	•	•	•	•	•	•	•
dicofol (felthane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
dieldrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
dinoseb	•	•	•	•	•	•	•	•	•	•
endosulfan alpha	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan beta	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan sulfate	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin aldehyde	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
gamma-bhc (lindane)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
guthion	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
heptachlor	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
heptachlor epoxide	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
malathion	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
methomyl	•	•	•	•	•	•	•	•	•	•
methoxychlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	6a				6b				7			
	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	carp, whole	carp fillets
metolachlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
mirex	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
parathion	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
pictoram	•	•	•	•	•	•	•	•	•	•	•	•
simazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
toxaphene	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
2,4,5-TP (silver)	•	•	•	•	•	•	•	•	•	•	•	•
PCB's AND RELATED COMPOUNDS (ng/kg)												
arochlor 1016	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1221	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1232	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1242	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1248	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1254	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.110	<0.040	<0.040	0.130
arochlor 1260	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
2-chloronaphthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
PHTHALATE ESTERS (mg/kg)												
bis(2-ethylhexyl) phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-octyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
diethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-butyl benzyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
GENERAL INORGANICS (mg/kg)												
cyanide	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

^a - all concentrations expressed in terms of wet weight of tissue

• - lab unable to produce satisfactory results

*** - sample lost due to lab accident

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	7b				8				8d			
	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	smallmouth bass fillets	carp, whole	carp fillets
NUMBER OF SPECIMENS IN SAMPLE	5	5	5	5	5	5	2	1	5	1	5	5
DATE	02/09/93	02/09/93	02/10/93	02/10/93	02/10/93	02/10/93	02/11/93	02/11/93	02/11/93	02/11/93	03/22/93	03/22/93
TIME	1500	1500	1000	1000	1000	1000	1130	1130	1130	1130	0830	0830
CONVENTIONAL lipid content (%)	2.0	0.9	6.3	16.4	10.6	5.1	3.3	**	3.2	**	10.9	6.2
PHENOLS AND CRESOLS (ng/kg)												
parachlorometa cresol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
pentachlorophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	**	<20	<20
phenol (C ₆ H ₅ OH) single compound	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
phenolics recoverable	*	*	*	*	*	*	*	*	*	*	*	*
2-chlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
2-nitrophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
2,4-dichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
2,4-dimethylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
2,4-dinitrophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	**	<20	<20
2,4,6-trichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
4-nitrophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	**	<20	<20
4,6-dinitro-ortho-cresol	<20	<20	<20	<20	<20	<20	<20	<20	<20	**	<20	<20
ETHERS (ng/kg)												
bis(2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
bis(2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
bis(2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
4-bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
4-chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
HALOGENATED ALIPHATICS (ng/kg)												
bromodichloromethane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
bromoform	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
carbon tetrachloride	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chloroethane	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
chloroform	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
dibromochloromethane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
dichlorodifluoromethane	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	7b				8				8d			
	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	smallmouth bass fillets	carp, whole	carp fillets
hexachlorobutadiene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
hexachloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
methyl bromide	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methyl chloride	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methylenes chloride	<0.02	<0.02	<0.02	0.03	***	0.23	<0.02	0.11	0.02	0.02	0.03	<0.02
tetrachloroethylene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichloroethylene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichlorofluoromethane	<0.05	<0.05	<0.05	<0.05	***	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
vinyl chloride	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1-dichloroethane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1-dichloroethylene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,1-trichloroethane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2-trichloroethane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2,2-tetrachloroethane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloroethane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloropropane	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-trans-dichloroethylene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-trans-dichloropropene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-cis-dichloropropene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
POLYCYCLIC AROMATIC												
HYDROCARBONS (ng/kg)												
acenaphthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
acenaphthylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
anthracene/phenanthrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
benzo(A) anthracene 1,2-benzanthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
benzo(B) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
benzo(GHI) perylene 1,12-benzoperylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
benzo(K) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
benzo-A-pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
chrysene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
fluorene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
indeno(1,2,3-CD) pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
naphthalene	<0.02	<0.02	<0.02	<0.02	<5.0	<0.02	<5.0	<0.02	<5.0	<0.02	<5.0	<0.02
pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
1,2,5,6-dibenzanthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/species											
	7b			8			8d			9		
	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	smallmouth bass fillets	carp, whole	carp fillets
MONOCYCLIC AROMATICS (mg/kg)												
benzene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorobenzene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ethylbenzene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
nitrobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
styrene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
toluene	<0.06	<0.06	<0.06	<0.06	***	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
1,2-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<5.0	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2,4-trichlorobenzene	<0.02	<0.02	<0.02	<0.02	<5.0	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,4-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	***	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
2,4-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
2,6-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
NITROSAMINES AND OTHER N COMPOUNDS (mg/kg)												
acrylonitrile	<0.1	<0.1	<0.1	<0.1	***	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
benzidine	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
n-nitrosodi-N-propylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
n-nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
n-nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
1,2-diphenylhydrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
3,3-dichlorobenzidine	<10	<10	<10	<10	<10	<10	<10	<10	<10	**	<10	<10
METALS (mg/kg)												
aluminum	1.9	<1.0	8.3	5.3	50.9	<1.0	29.8	1.4	2.6	**	30.6	<2.0
antimony	*	*	*	*	*	*	*	*	*	*	*	*
arsenic	<0.020	<0.020	0.094	0.071	0.144	0.064	0.101	0.061	<0.020	**	0.229	0.225
beryllium	<0.040	<0.040	<0.040	<0.040	<0.038	<0.040	<0.039	<0.038	<0.040	**	<0.044	<0.044
cadmium	<0.010	<0.010	<0.010	0.011	<0.009	<0.010	0.036	<0.009	<0.011	**	0.039	<0.009
chromium	0.054	<0.040	0.084	<0.040	0.141	<0.040	0.125	<0.039	0.070	**	0.113	<0.041
copper	0.525	0.172	1.590	1.810	0.823	0.493	1.740	1.290	0.429	**	2.390	1.060
lead	<0.083	<0.046	<0.079	<0.077	0.058	<0.080	0.065	<0.100	<0.077	**	0.111	0.075
mercury	0.153	0.119	<0.076	<0.064	<0.077	<0.084	0.097	0.204	0.161	**	0.227	0.266
nickel	0.116	0.104	0.102	<0.080	0.233	0.085	0.183	<0.076	0.123	**	<0.119	<0.120
selenium	0.680	0.704	0.669	0.675	0.559	0.324	0.593	0.611	0.562	**	0.275	0.844
silver	<0.067	<0.066	<0.063	<0.065	<0.064	<0.069	<0.065	<0.097	<0.065	**	0.035	<0.033

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	7b			8			8d			9		
	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	smallmouth bass fillets	carp, whole	carp fillets
thallium	0.046	<0.040	<0.036	<0.040	0.038	<0.040	<0.039	<0.039	<0.040	**	<0.037	<0.040
zinc	15.2	4.3	31.8	24.4	16.2	5.4	48.8	6.2	14.5	**	61.5	12.5
PESTICIDES (mg/kg)												
aldicarb	*	*	*	*	*	*	*	*	*	*	*	*
aldrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
alpha benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
atrazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
beta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
carbaryl	*	*	*	*	*	*	*	*	*	*	*	*
carbofuran	*	*	*	*	*	*	*	*	*	*	*	*
chlordane	0.034	<0.010	0.026	0.033	<0.010	0.028	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chlorfenvinphos	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
chlorothalonil	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
chlorpyrifos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDD	<0.010	<0.010	<0.010	0.028	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDE	0.071	0.009	0.033	0.170	0.110	0.043	0.020	0.013	0.110	0.013	0.320	0.240
p,p' DDT	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
delta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
diazinon	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibromochloropropane (dbcp)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
dicamba	*	*	*	*	*	*	*	*	*	*	*	*
2,4-dichlorophenoxyacetic acid (2,4-D)	*	*	*	*	*	*	*	*	*	*	*	*
dicofol (kelthane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
dieldrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
dinoseb	*	*	*	*	*	*	*	*	*	*	*	*
endosulfan alpha	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan beta	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan sulfate	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin aldehyde	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
gamma-bhc (lindane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
guthion	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
heptachlor	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
heptachlor epoxide	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
malathion	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
methomyl	*	*	*	*	*	*	*	*	*	*	*	*
methoxychlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	7b			8			8d			9		
	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	smallmouth bass, whole	smallmouth bass fillets	carp, whole	carp fillets
metolachlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
mirex	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
parathion	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
picloram	.	.	.	.	.	.	.	.	.	.	.	.
simazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
toxaphene	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
2,4,5-TP (silvest)	.	.	.	.	.	.	.	.	.	.	.	.
PCB's AND RELATED COMPOUNDS (mg/kg)												
arochlor 1016	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1221	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1232	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1242	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1248	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	0.360	<0.040
arochlor 1254	0.088	<0.040	<0.040	0.110	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1260	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
2-chloronaphthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
PHTHALATE ESTERS (mg/kg)												
bis(2-ethylhexyl) phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
di-n-octyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
diethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
n-butyl benzyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	**	<5.0	<5.0
GENERAL INORGANICS (mg/kg)												
cyanide	2.0	6.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	**	<1.0	<1.0

^a - all concentrations expressed in terms of wet weight of tissue
 . - lab unable to produce satisfactory results
 .. - could not be analyzed due to insufficient sample volume
 ... - sample lost due to lab accident

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	9			9b			10			11		
	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	largemouth bass, whole	channel catfish, whole	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets
NUMBER OF SPECIMENS IN SAMPLE	5	5	3	3	3	2	5	5	2	3	5	5
DATE	032293	032293	032293	032293	032293	032293	032293	032293	032293	032293	032493	032493
TIME	0830	0830	1100	1100	1100	1100	1500	1500	1500	1500	0830	0830
CONVENTIONALS												
lipid content (%)	10.3	10.3	9.5	4.2	0.7	7.6	8.9	9.4	11.8	7.3	4.4	1.4
PHENOLS AND CRESOLS (mg/kg)												
parachlorometa cresol	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
peatachlorophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
phenol (C ₆ H ₅ OH) single compound	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
phenolics recoverable	*	*	*	*	*	*	*	*	*	*	*	*
2-chlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-nitrophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dimethylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2,4-dinitrophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
2,4,6-trichlorophenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-nitrophenol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
4,6-dinitro-ortho-cresol	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
ETHERS (mg/kg)												
bis(2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
bis(2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
bis(2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4-bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
4-chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
HALOGENATED ALIPHATICS (mg/kg)												
bromodichloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
bromoform	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
carbon tetrachloride	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chloroethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
chloroform	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
dibromochloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
dichlorodifluoromethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	9			9b			10			11		
	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	largemouth bass, whole	channel catfish, whole	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets
hexachlorobutadiene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
hexachloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
methyl bromide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methylene chloride	<0.02	0.10	<0.02	0.11	0.09	0.12	<0.02	<0.02	<0.02	0.07	0.03	<0.02
tetrachloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichlorofluoromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
vinyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,1-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,1-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2,2-tetrachloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloropropane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-trans-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-trans-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-cis-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
POLYCYCLIC AROMATIC												
HYDROCARBONS (mg/kg)												
acenaphthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
acenaphthylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
anthracene/phenanthrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(A) anthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(B) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(GH) perylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(K) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo-A-pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
chrysene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
fluorene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
indeno(1,2,3-CD) pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
naphthalene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,2,5,6-dibenzanthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species									
	9					10				
	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	largemouth bass, whole	channel catfish, whole	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets
MONOCYCLIC AROMATICS (mg/kg)										
benzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ethylbenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
nitrobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
styrene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
toluene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
xylene	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
1,2-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2,4-trichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,4-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
2,4-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,6-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
NITROSAMINES AND OTHER N COMPOUNDS (mg/kg)										
acrylonitrile	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
benzidine	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
n-nitrosodi-N-propylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-nitrosodimethylaniline	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,2-diphenylhydrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
3,3-dichlorobenzidine	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
METALS (mg/kg)										
aluminum	13.4	<2.0	28.5	2.7	<2.0	15.7	31.0	<2.0	9.6	<2.0
antimony	0.100	<0.020	0.230	0.129	<0.020	0.031	0.211	0.166	0.093	0.161
arsenic	<0.044	<0.048	<0.046	<0.047	<0.048	<0.047	<0.044	<0.044	<0.043	<0.049
beryllium	0.009	<0.009	0.008	<0.009	<0.009	0.008	0.034	<0.008	0.009	0.027
cadmium	<0.040	<0.040	0.079	<0.040	0.292	0.038	0.061	<0.040	<0.090	0.081
chromium	0.363	0.233	1.350	0.737	0.388	0.193	1.590	0.869	0.234	0.374
copper	0.243	<0.077	0.108	<0.085	<0.083	0.170	<0.091	<0.090	<0.091	1.990
lead	0.117	0.166	0.170	0.304	0.375	0.098	0.132	0.185	0.082	0.171
mercury	<0.120	<0.120	<0.116	<0.117	0.202	<0.120	<0.118	<0.139	<0.119	0.321
nickel	0.547	0.279	0.410	0.537	0.772	0.351	0.808	0.793	0.618	0.203
selenium	<0.033	<0.034	0.042	0.049	<0.033	<0.035	0.039	<0.034	<0.033	0.859
silver										<0.034

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	9			9b			10			11		
	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	largemouth bass, whole	channel catfish, whole	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets
thallium	<0.040	<0.039	<0.035	<0.040	<0.039	<0.038	<0.039	<0.040	<0.039	<0.040	<0.039	<0.040
zinc	14.1	5.1	29.4	10.7	15.2	10.4	49.3	13.2	9.4	4.5	15.2	7.9
PESTICIDES (mg/kg)												
aldicarb	•	•	•	•	•	•	•	•	•	•	•	•
aldrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
alpha benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
atrazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
beta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
carbaryl	•	•	•	•	•	•	•	•	•	•	•	•
carbofuran	•	•	•	•	•	•	•	•	•	•	•	•
chlordane	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chlorfenvinphos	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
chlorobalonil	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
chlorpyrifos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDD	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDE	0.140	0.055	0.120	0.100	0.140	0.051	0.240	0.220	0.051	0.049	0.096	0.083
p,p' DDT	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
delta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
diazinon	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibromochloropropane (dbcp)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
dicamba	•	•	•	•	•	•	•	•	•	•	•	•
2,4-dichlorophenoxyacetic acid (2,4-D)	•	•	•	•	•	•	•	•	•	•	•	•
dicofol (kethane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
diclorin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
dinoseb	•	•	•	•	•	•	•	•	•	•	•	•
endosulfan alpha	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan beta	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan sulfate	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin aldehyde	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
gamma-bbc (lindane)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
guthion	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
heptachlor	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
heptachlor epoxide	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
malathion	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
methomyl	•	•	•	•	•	•	•	•	•	•	•	•
methoxychlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	11			12			13			14		
	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	largemouth bass, whole	largemouth bass fillets	channel catfish, whole	carp, whole
benzochlorobutadiene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
benzochlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzochloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
methyl bromide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methylene chloride	0.09	0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02
tetrachloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichlorofluoroethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
vinyl chloride	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,1-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2,2-tetrachloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloropropane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-trans-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-trans-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-cis-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
POLYCYCLIC AROMATIC												
HYDROCARBONS (ng/kg)												
acetylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
acetylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
anthracene/phenanthrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(a) anthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(b) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(g,h,i) perylene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo(k) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
benzo-A-pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
chrysene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
fluorene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
indeno(1,2,3-CD) pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
naphthalene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,2,5,6-dibenzanthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	11			12			13			14		
	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	largemouth bass, whole	largemouth bass fillets	channel catfish, whole	carp, whole
MONOCYCLIC AROMATICS (mg/kg)												
benzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ethylbenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorobenzene	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
nitrobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
styrene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
toluene	<0.02	<0.02	0.03	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
xylene	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
1,2-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2,4-trichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,4-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
2,4-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
2,6-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
NITROSAMINES AND OTHER N COMPOUNDS (mg/kg)												
acrylonitrile	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
benzidine	<10	<10	<10	<10	<10	<10	<2.0	<10	<10	<10	<10	<10
n-nitrosodi-N-propylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,2-diphenylhydrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
3,3-dichlorobenzidine	<10	<10	<10	<10	<10	<10	<2.0	<10	<10	<10	<10	<10
METALS (mg/kg)												
aluminum	147.0	<2.0	35.5	2.0	170.0	<2.0	<1.9	<2.0	<1.9	<1.7	4.4	9.3
antimony	•	•	•	•	•	•	•	•	•	•	•	•
arsenic	0.029	<0.020	0.089	0.108	0.095	<0.020	0.112	0.044	<0.027	<0.025	<0.027	0.070
beryllium	<0.047	<0.048	<0.046	<0.048	<0.047	<0.048	<0.042	<0.043	<0.042	<0.039	<0.043	<0.045
cadmium	0.023	<0.009	0.012	<0.009	<0.009	<0.010	0.010	<0.009	<0.005	<0.004	0.015	0.018
chromium	0.083	0.044	0.487	0.061	0.159	<0.040	0.049	0.098	0.122	0.050	0.085	0.052
copper	0.496	0.263	1.710	0.845	0.608	0.181	1.190	0.684	0.289	0.279	0.369	1.290
lead	<0.084	<0.087	0.201	<0.083	0.149	<0.079	<0.113	<0.117	<0.113	<0.104	<0.115	<0.079
mercury	0.170	0.115	0.125	0.228	0.116	0.146	<0.066	0.090	0.235	0.375	<0.067	<0.069
nickel	<0.119	<0.118	<0.118	<0.120	<0.120	<0.160	0.205	1.100	0.380	1.910	0.116	<0.079
selenium	0.471	0.202	0.657	0.673	0.375	0.279	0.662	0.807	0.901	0.654	0.334	0.696
silver	<0.033	<0.035	0.049	<0.044	0.037	<0.034	<0.034	<0.033	<0.034	<0.035	<0.036	<0.033

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species									
	11		12		13		14		channel catfish, whole	channel catfish, filets
	channel catfish, whole	channel catfish, filets	carp, whole	carp, filets	channel catfish, whole	channel catfish, filets	carp, whole	carp, filets	channel catfish, whole	channel catfish, filets
thallium	<0.039	<0.040	<0.039	<0.039	<0.039	<0.040	0.053	0.040	<0.039	<0.040
zinc	15.2	5.4	76.0	11.8	11.8	5.2	24.8	6.5	13.1	33.8
PESTICIDES (mg/kg)										
aldicarb	•	•	•	•	•	•	•	•	•	•
aldrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
alpha benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
atrazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
beta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
carbaryl	•	•	•	•	•	•	•	•	•	•
carbofuran	•	•	•	•	•	•	•	•	•	•
chlorthane	<0.010	<0.010	0.140	0.200	<0.010	0.062	<0.010	<0.010	<0.010	<0.010
chlorfenvinphos	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
chlorothalonil	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
chlorpyrifos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDD	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDE	0.280	0.043	0.100	0.200	0.120	0.033	0.094	0.036	0.093	0.180
p,p' DDT	<0.010	<0.010	<0.010	<0.010	0.016	<0.010	<0.010	<0.010	<0.010	<0.010
delta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
diazinon	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibromochloropropane (dbcp)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
dicamba	•	•	•	•	•	•	•	•	•	•
2,4-dichlorophenoxyacetic acid (2,4-D)	•	•	•	•	•	•	•	•	•	•
disofol (trichlorane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
dieldrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
dimoseb	•	•	•	•	•	•	•	•	•	•
endosulfan alpha	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan beta	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan sulfate	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin aldehyde	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
gamma-bhc (lindane)	<0.002	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
guthion	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
heptachlor	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
heptachlor epoxide	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0
malathion	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
methomyl	•	•	•	•	•	•	•	•	•	•
methoxychlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	11			12			13			14		
	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	channel catfish, whole	channel catfish fillets	carp, whole	carp fillets	largemouth bass, whole	largemouth bass fillets	channel catfish, whole	carp, whole
metolachlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
nitrex	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
parathion	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
picloram	.	.	.	.	.	.	.	.	.	.	.	.
simazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
toxaphene	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
2,4,5-TP (silver)	.	.	.	.	.	.	.	.	.	.	.	.
PCB's AND RELATED COMPOUNDS (mg/kg)												
arochlor 1016	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1221	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1232	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1242	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1248	0.100	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1254	0.180	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
arochlor 1260	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
2-chloronaphthalene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
PHTHALATE ESTERS (mg/kg)												
bis(2-ethylhexyl) phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-butyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
di-n-octyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
diethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
dimethyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
n-butyl benzyl phthalate	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<5.0
GENERAL INORGANICS (mg/kg)												
cyanide	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	<1.0	<1.0	<1.0	<1.0

^a - all concentrations expressed in terms of wet weight of tissue
 • - lab unable to produce satisfactory results

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	14				15				16			
	carp fillets	channel catfish, whole	blue catfish fillets	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish whole
NUMBER OF SPECIMENS IN SAMPLE	5	2	1	5	5	3	4	5	5	3	3	5
DATE	011293	011293	011293	011293	011293	011293	011293	011293	011293	011693	011693	011693
TIME	1245	1245	1245	1245	1245	1600	1600	1600	1600	1030	1030	1030
CONVENTIONALS lipid content (%)	0.1	*	3.3	0.9	0.4	1.5	0.5	0.5	0.4	5.8	1.7	4.2
PHENOLS AND CRESOLS (mg/kg)												
parachlorometa cresol	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
pentachlorophenol	<20	<20	<20	<20	<20	<40	<20	<20	<4.0	<20	<20	<4.0
phenol (C ₆ H ₅ OH) single compound	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
phenolics recoverable	*	*	*	*	*	*	*	*	*	*	*	*
2-chlorophenol	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
2-nitrophenol	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
2,4-dichlorophenol	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
2,4-dimethylphenol	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
2,4-dinitrophenol	<20	<20	<20	<20	<20	<40	<20	<20	<4.0	<20	<20	<4.0
2,4,6-trichlorophenol	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
4-nitrophenol	<20	<20	<20	<20	<20	<40	<20	<20	<4.0	<20	<20	<4.0
4,6-dinitro-ortho-cresol	<20	<20	<20	<20	<20	<40	<20	<20	<4.0	<20	<20	<4.0
ETHERS (mg/kg)												
bis(2-chloroethoxy) methane	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
bis(2-chloroethyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
bis(2-chloroisopropyl) ether	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
4-bromophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
4-chlorophenyl phenyl ether	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
HALOGENATED ALIPHATICS (mg/kg)												
bromodichloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
bromoform	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
carbon tetrachloride	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chloroethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
chloroform	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
dibromochloromethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
dichlorodifluoromethane	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	14				15				16			
	carp fillets	channel catfish, whole	blue catfish fillets	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish whole
hexachlorobutadiene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorocyclopentadiene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
hexachlorocubane	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
methyl bromide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
methylene chloride	<0.02	0.04	<0.02	0.04	0.02	0.11	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
tetrachloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
trichlorofluoromethane	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
vinyl chloride	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,1-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,1-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2-trichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1,2,2-tetrachloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloroethane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichloropropane	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-trans-dichloroethylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-trans-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-cis-dichloropropene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
POLYCYCLIC AROMATIC												
HYDROCARBONS (ng/kg)												
acetylbiphenyl	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
acetylphenyl	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
anthracene/phenanthrene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
benzo(A) anthracene 1,2-benzanthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
benzo(B) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
benzo(GH) perylene 1,12-benzoperylene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
benzo(K) fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
benzo-A-pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
chrysene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
fluoranthene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
fluorene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
indeno(1,2,3-CD) pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
naphthalene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
pyrene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
1,2,5,6-dibenzanthracene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/species											
	14			15			16					
	carp filets	channel catfish, whole	blue catfish filets	largemouth bass, whole	largemouth bass filets	carp, whole	carp filets	largemouth bass, whole	largemouth bass filets	carp, whole	carp filets	channel catfish whole
MONOCYCLIC AROMATICS (mg/kg)												
benzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
chlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ethylbenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
nitrobenzene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
styrene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
toluene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
xylene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,2,4-trichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,3-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,4-dichlorobenzene	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
2,4-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
2,6-dinitrotoluene	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
NITROSAMINES AND OTHER N COMPOUNDS (mg/kg)												
acrylamide	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
benzidine	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
n-nitrosodi-N-propylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
n-nitrosodimethylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
n-nitrosodiphenylamine	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
1,2-diphenylhydrazine	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
3,3'-dichlorobenzidine	<10	<10	<10	<10	<10	<20	<10	<10	<2.0	<10	<10	<2.0
METALS (mg/kg)												
aluminum	<2.0	51.5	<1.9	<1.8	<1.9	4.1	<2.0	<2.3	<1.9	81.8	<1.9	70.6
antimony	0.050	0.074	<0.027	0.048	<0.027	0.037	<0.028	<0.027	<0.027	0.073	0.033	0.052
arsenic	<0.045	<0.039	<0.043	<0.040	<0.043	<0.044	<0.044	<0.043	<0.042	<0.041	<0.044	<0.044
beryllium	<0.005	0.012	<0.004	0.004	<0.004	0.010	<0.005	<0.005	<0.009	0.012	<0.004	0.007
cadmium	<0.005	0.0268	<0.039	0.081	0.051	<0.040	<0.039	0.148	<0.040	0.499	<0.080	0.197
chromium	0.040	0.708	0.266	0.917	0.255	0.962	1.010	0.423	0.245	1.370	0.741	1.370
copper	0.531	0.104	<0.075	<0.072	<0.077	<0.079	<0.078	<0.076	<0.075	0.096	0.176	0.116
lead	<0.080	0.193	0.548	<0.056	0.271	0.128	0.319	0.102	0.756	0.208	0.628	0.126
mercury	0.193	0.139	0.548	<0.056	0.271	0.128	0.319	0.102	0.756	0.208	0.628	0.126
nickel	<0.080	0.223	<0.077	0.082	<0.077	0.082	<0.078	0.249	0.072	0.489	<0.086	0.112
selenium	0.626	0.396	0.115	0.725	0.650	0.540	0.637	0.789	0.565	0.658	0.560	0.439
silver	<0.032	**	<0.033	<0.032	<0.033	<0.032	<0.032	<0.033	<0.034	0.088	<0.034	0.036

Table 12 (continued)
Analytical Data - Tissue

Parameter ^a	Station/Species											
	14				15				16			
	carp fillets	channel catfish, whole	blue catfish fillets	largemouth bass, whole	largemouth bass fillets	carp whole	carp fillets	largemouth bass, whole	largemouth bass fillets	carp, whole	carp fillets	channel catfish whole
thallium	0.039	<0.036	<0.039	<0.047	0.061	<0.040	0.057	0.039	0.055	0.040	<0.039	<0.039
zinc	7.2	25.9	4.6	12.1	4.3	42.4	11.1	13.9	5.0	43.0	13.5	14.4
PESTICIDES (mg/kg)												
aldicarb	•	•	•	•	•	•	•	•	•	•	•	•
aldrin	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
alpha benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
atrazine	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
beta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
carbaryl	•	•	•	•	•	•	•	•	•	•	•	•
carbofuran	•	•	•	•	•	•	•	•	•	•	•	•
chlorodane	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chlorfenviaphos	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
chlorobalonil	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
chlorthrifos	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDD	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
p,p' DDB	0.044	0.150	0.370	0.110	0.022	0.150	0.110	0.110	0.093	0.190	0.290	0.103
p,p' DDT	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
delta benzene hexachloride	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
diazinon	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibromochloropropane (dbcp)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
dicamba	•	•	•	•	•	•	•	•	•	•	•	•
2,4-dichlorophenoxyacetic acid (2,4-D)	•	•	•	•	•	•	•	•	•	•	•	•
dicofol (telthane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
diclirin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
dimoseb	•	•	•	•	•	•	•	•	•	•	•	•
endosulfan alpha	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan beta	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endosulfan sulfate	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
endrin aldehyde	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
gamma-hch (lindane)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
guthion	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
heptachlor	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
heptachlor epoxide	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
isophorone	<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<1.0	<5.0	<5.0	<1.0
malathion	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
methomyl	•	•	•	•	•	•	•	•	•	•	•	•
methoxychlor	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030

Table 13
Toxic Chemicals That Occurred at Detectable Levels

Parameter	Matrix Detected In*		
	Water	Sediment	Tissue
CONVENTIONALS			
ammonia (unionized)	22/45 (48.9%)		
residual chlorine	2/45 (4.4%)		
PHENOLS AND CRESOLS			
parachlorometa cresol	3/45 (6.7%)	5/45 (11.1%)	
phenol (C ₆ H ₅ OH) single compound	1/45 (2.2%)	1/45 (2.2%)	
phenolics recoverable	4/17 (23.5%)		
HALOGENATED ALIPHATICS			
bromodichloromethane	1/45 (2.2%)		
chloroform	2/45 (4.4%)	1/45 (2.2%)	1/92 (1.1%)
methylene chloride	1/45 (2.2%)	6/45 (13.3%)	27/92 (29.3%)
tetrachloroethylene	1/45 (2.2%)		
trichlorofluoromethane			2/92 (2.2%)
1,1,1-trichloroethane	1/45 (2.2%)		1/92 (1.1%)
POLYCYCLIC AROMATIC HYDROCARBONS			
naphthalene	2/45 (4.4%)		
MONOCYCLIC AROMATICS			
benzene	1/45 (2.2%)		
chlorobenzene		1/45 (2.2%)	
ethylbenzene	1/45 (2.2%)		
hexachlorobenzene			1/94 (1.1%)
toluene	5/45 (11.1%)	12/45 (26.7%)	3/94 (3.3%)
xylene	2/45 (4.4%)	1/45 (2.2%)	
1,2-dichlorobenzene	1/45 (2.2%)	1/45 (2.2%)	4/94 (4.2%)
1,4-dichlorobenzene	4/45 (8.9%)	1/45 (2.2%)	
METALS			
aluminum	1/45 (2.2%)	45/45 (100%)	54/93 (58.1%)
antimony	45/45 (100%)		
arsenic	30/45 (66.7%)	45/45 (100%)	59/93 (63.4%)
beryllium		40/45 (88.9%)	
cadmium	8/45 (17.8%)	45/45 (100%)	50/92 (54.3%)
chromium	4/45 (8.9%)	45/45 (100%)	53/92 (57.6%)
copper	23/45 (51.1%)	45/45 (100%)	93/93 (100%)
lead	5/45 (11.1%)	45/45 (100%)	26/93 (27.9%)
mercury	2/45 (4.4%)	40/45 (88.9%)	70/93 (75.3%)
nickel	7/45 (15.6%)	45/45 (100%)	47/92 (51.1%)
selenium	14/45 (31.1%)	44/45 (97.8%)	93/93 (100%)
silver	5/45 (11.1%)	12/45 (26.7%)	9/92 (9.8%)
thallium	4/45 (8.9%)	18/45 (40.0%)	18/93 (19.4%)
zinc	15/45 (33.3%)	45/45 (100%)	93/93 (100%)

Table 13 (continued)
Toxic Chemicals That Occurred at Detectable Levels

Parameter	Matrix Detected In*		
	Water	Sediment	Tissue
PESTICIDES			
chlordane		5/45 (11.1%)	10/94 (10.6%)
chlorpyrifos		3/45 (6.7%)	
p,p' DDD		1/45 (2.2%)	6/94 (6.4%)
p,p' DDE		11/45 (24.4%)	93/94 (98.9%)
p,p' DDT			3/94 (3.2%)
diazinon	2/45 (4.4%)		
dieldrin		1/45 (2.2%)	2/94 (2.1%)
gamma-bhc (lindane)	1/45 (2.2%)		2/94 (2.1%)
PCB's AND RELATED COMPOUNDS			
arochlor 1248			7/94 (7.4%)
arochlor 1254			6/94 (6.4%)
PHthalate ESTERS			
bis(2-ethylhexyl) phthalate	1/45 (2.2%)	3/45 (6.7%)	1/94 (1.1%)
diethyl phthalate	1/45 (2.2%)		
di-n-butyl phthalate		1/45 (2.2%)	
GENERAL INORGANICS			
cyanide	7/45 (15.6%)	1/45 (2.2%)	13/94 (13.8%)

* - values represent number of samples parameter was detected in/number of samples for which valid analytical results were obtained, followed by percent detection in parentheses

Table 14
Summary of Screening Level Exceedances, by Parameter*

Parameter	Station	Matrix	Screening Level(s) Exceeded	Exceedance Factor
unionized ammonia	2a	water	aquatic life acute	2.6X
			aquatic life chronic	13.6X
	7a	water	aquatic life chronic	1.0X
	9a	water	aquatic life chronic	4.1X
	11c	water	aquatic life chronic	6.2X
residual chlorine	1a	water	aquatic life acute	63.2X
			aquatic life chronic	109.1X
	2	water	aquatic life acute ^a	1.1X ^a
			aquatic life chronic ^a	1.8X ^a
parachlorometa cresol	1a	sediment	third highest level observed ^b	10.8X ^b
	2a	water	national 85th percentile	1.1X
	11c	sediment	second highest level observed ^c	2.3X ^c
phenol	1a	sediment	d	d
	2a	water	national 85th percentile	1.2X
phenolics recoverable	2a	water	national 85th percentile	1.5X
chloroform	1a	water	national 85th percentile	1.4X
methylene chloride	1	sediment	aquatic life threshold	16.4X
	2	sediment	aquatic life threshold	23.0X
	2a	sediment	aquatic life threshold	12.7X
	3	sediment	aquatic life threshold	10.0X
	3b	sediment	aquatic life threshold	2.2X
	12	sediment	aquatic life threshold	2.3X
toluene	2	sediment	aquatic life threshold	1.9X
	2a	sediment	aquatic life threshold	1.5X
	12	sediment	aquatic life threshold	1.7X
antimony	10a	water	national 85th percentile human health	1.4X 5.6X
arsenic	1a	water	human health	5.1X
	2	sediment	aquatic life threshold	1.1X
	2a	water	human health	3.3X
	3	sediment	aquatic life threshold	2.1X
	3a	water	national 85th percentile	2.1X
		sediment	aquatic life threshold	3.7X
	3b	water	national 85th percentile	1.1X
	4	water	national 85th percentile	1.4X
		sediment	aquatic life threshold	1.0X
	5	water	national 85th percentile	1.6X
		sediment	aquatic life threshold	1.6X
	5a	sediment	aquatic life threshold	1.7X
	5b	sediment	aquatic life threshold	1.3X
	9a	water	human health	2.8X
	11c	water	human health	1.5X
	14	sediment	aquatic life threshold	1.1X
	15a	water	human health	1.9X
cadmium	1	tissue (carp)	USFWS 85th percentile	1.3X
chromium	1	sediment	aquatic life threshold	3.5X
	2	sediment	aquatic life threshold	4.5X
	2a	sediment	aquatic life threshold	1.4X
	3	sediment	aquatic life threshold	3.4X
	3a	sediment	aquatic life threshold	3.3X
	3b	sediment	aquatic life threshold	1.03X

Table 14 (continued)
Summary of Screening Level Exceedances, by Parameter*

Parameter	Station	Matrix	Screening Level(s) Exceeded	Exceedance Factor
chromium	4	sediment	aquatic life threshold	2.0X
	5	sediment	aquatic life threshold	2.6X
	5a	sediment	aquatic life threshold	4.5X
	5b	sediment	aquatic life threshold	2.9X
	6	sediment	aquatic life threshold	1.2X
	6a	tissue (carp)	USFWS predator protection limit	1.1X
	7	sediment	aquatic life threshold	2.3X
	7a	sediment	aquatic life threshold	1.1X
	8	sediment	aquatic life threshold	1.01X
	8c	sediment	aquatic life threshold	3.0X
	8e	sediment	aquatic life threshold	2.3X
	9b	tissue (largemouth bass)	USFWS predator protection limit	1.46X
	10a	sediment	aquatic life threshold	1.3X
	11	sediment	aquatic life threshold	1.1X
		tissue (carp)	USFWS predator protection limit	1.9X
	11b	sediment	aquatic life threshold	1.7X
	12	tissue (carp)	USFWS predator protection limit	2.4X
	12a	water	aquatic life chronic ^a	1.4X ^a
		sediment	aquatic life threshold	1.7X
	12b	sediment	aquatic life threshold	2.3X
	13	sediment	aquatic life threshold	1.4X
	14	sediment	aquatic life threshold	2.7X
		tissue (channel catfish)	USFWS predator protection limit	1.3X
	15	sediment	aquatic life threshold	1.0X
	16	sediment	aquatic life threshold	2.9X
		tissue (carp)	USFWS predator protection limit	2.5X
	17	sediment	aquatic life threshold	1.5X
	18	sediment	aquatic life threshold	1.5X
copper	1	tissue (carp)	USFWS 85th percentile	1.9X
	1a	sediment	national 85th percentile	5.6X
	2	sediment	aquatic life threshold	2.0X
		tissue (carp)	USFWS 85th percentile	1.6X
	4	tissue (carp)	USFWS 85th percentile	1.2X
	5	tissue (carp)	USFWS 85th percentile	1.6X
	6a	tissue (carp)	USFWS 85th percentile	1.2X
	6b	tissue (carp)	USFWS 85th percentile	1.2X
	7	tissue (carp)	USFWS 85th percentile	2.0X
	7b	tissue (carp)	USFWS 85th percentile	1.7X
	8	tissue (carp)	USFWS 85th percentile	1.6X
	8d	tissue (carp)	USFWS 85th percentile	1.7X
	9	tissue (carp)	USFWS 85th percentile	2.4X
	9b	tissue (carp)	USFWS 85th percentile	1.4X
	10	tissue (carp)	USFWS 85th percentile	1.6X
	11	tissue (carp)	USFWS 85th percentile	2.0X
	12	tissue (carp)	USFWS 85th percentile	1.7X
	13	tissue (carp)	USFWS 85th percentile	1.2X
	14	tissue (carp)	USFWS 85th percentile	1.3X
	16	tissue (carp)	USFWS 85th percentile	1.4X
		tissue (channel catfish)	USFWS 85th percentile	1.4X
lead	17	tissue (largemouth bass)	USFWS 85th percentile	1.1X
	18	tissue (carp)	USFWS 85th percentile	1.1X
		tissue (largemouth bass)	USFWS 85th percentile	1.3X
lead	2	sediment	aquatic life threshold	1.4X
		tissue (channel catfish)	USFWS predator protection limit	1.1X
	9	tissue (channel catfish)	USFWS 85th percentile	1.1X
mercury	1a	sediment	national 85th percentile	2.0X
	2	sediment	aquatic life threshold	1.0X
	2a	water	human health	11.5X
	3a	tissue (carp)	USFWS predator protection limit	1.4X

Table 14 (continued)
Summary of Screening Level Exceedances, by Parameter*

Parameter	Station	Matrix	Screening Level(s) Exceeded	Exceedance Factor
mercury	4	tissue (carp)	USFWS predator protection limit	1.5X
	5	tissue (carp)	USFWS predator protection limit	1.5X
	6	tissue (white bass)	USFWS predator protection limit	1.6X
	7	tissue (smallmouth bass)	USFWS predator protection limit	1.6X
	7b	tissue (largemouth bass)	USFWS predator protection limit	1.5X
	8d	tissue (smallmouth bass)	USFWS predator protection limit	1.6X
	9	tissue (carp)	USFWS 85th percentile	1.3X
			USFWS predator protection limit	2.3X
		tissue (channel catfish)	USFWS predator protection limit	2.4X
	9b	tissue (carp)	USFWS 85th percentile	1.0X
		tissue (channel catfish)	USFWS predator protection limit	1.7X
		tissue (largemouth bass)	USFWS 85th percentile	2.2X
	10a	tissue (carp)	USFWS predator protection limit	1.3X
	11	tissue (carp)	USFWS 85th percentile	1.01X
			USFWS predator protection limit	1.7X
		tissue (channel catfish)	USFWS 85th percentile	1.0X
			USFWS predator protection limit	1.7X
	12	tissue (carp)	USFWS predator protection limit	1.3X
		tissue (channel catfish)	USFWS predator protection limit	1.2X
	13	tissue (largemouth bass)	USFWS 85th percentile	1.4X
			USFWS predator protection limit	2.4X
	14	tissue (channel catfish)	USFWS predator protection limit	1.4X
	15	tissue (largemouth bass)	USEPA fish tissue value	1.3X
		tissue (largemouth bass)	USFWS predator protection limit	1.02X
		tissue (carp)	USFWS predator protection limit	1.3X
	15a	water	human health	23.8X
	16	tissue (carp)	USEPA fish tissue value	1.05X
		tissue (carp)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	2.1X
		tissue (channel catfish)	USFWS predator protection limit	1.3X
	17	tissue (largemouth bass)	USFWS predator protection limit	1.6X
nickel	1	sediment	aquatic life threshold	3.0X
	2	sediment	aquatic life threshold	3.2X
	2a	sediment	aquatic life threshold	1.3X
	3	sediment	aquatic life threshold	5.4X
	3a	sediment	aquatic life threshold	5.0X
	4	sediment	aquatic life threshold	2.3X
	5	sediment	aquatic life threshold	3.6X
	5a	sediment	aquatic life threshold	6.9X
	5b	sediment	aquatic life threshold	2.8X
	6	sediment	aquatic life threshold	1.1X
	7	sediment	aquatic life threshold	2.2X
	8	sediment	aquatic life threshold	1.1X
	8c	sediment	aquatic life threshold	3.1X
	8c	sediment	aquatic life threshold	2.3X
	10a	sediment	aquatic life threshold	1.5X
	11	sediment	aquatic life threshold	1.5X
	11a	sediment	aquatic life threshold	1.1X
	11b	sediment	aquatic life threshold	2.0X
	12	sediment	aquatic life threshold	1.2X
	12a	sediment	aquatic life threshold	2.1X
	12b	sediment	aquatic life threshold	2.2X
	12c	sediment	aquatic life threshold	1.4X
	12c	sediment	aquatic life threshold	1.2X
	13	sediment	aquatic life threshold	1.6X
	14	sediment	aquatic life threshold	2.9X
	15	sediment	aquatic life threshold	1.1X
	16	sediment	aquatic life threshold	2.9X
	17	sediment	aquatic life threshold	1.7X
	18	sediment	aquatic life threshold	1.9X

Table 14 (continued)
Summary of Screening Level Exceedances, by Parameter*

Parameter	Station	Matrix	Screening Level(s) Exceeded	Exceedance Factor
selenium	1	tissue (carp)	USFWS predator protection limit	1.1X
	1a	sediment	national 85th percentile	1.3X
	2	tissue (carp)	USFWS predator protection limit	1.1X
	3	tissue (channel catfish)	USFWS 85th percentile	1.8X
			USFWS predator protection limit	2.6X
	3a	tissue (carp)	USFWS 85th percentile	1.5X
			USFWS predator protection limit	2.2X
	4	tissue (carp)	USFWS 85th percentile	1.5X
			USFWS predator protection limit	2.1X
	5	tissue (carp)	USFWS 85th percentile	1.9X
			USFWS predator protection limit	2.8X
		tissue (blue catfish)	USFWS predator protection limit	1.2X
	5a	water	aquatic life chronic	1.1X
	6	tissue (white bass)	TDH risk assessment value	1.1X
		tissue (carp)	USFWS 85th percentile	1.1X
			USFWS predator protection limit	1.7X
		tissue (white bass)	USFWS 85th percentile	2.2X
			USFWS predator protection limit	3.2X
	6a	tissue (carp)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	1.7X
		tissue (channel catfish)	USFWS predator protection limit	1.03X
	6b	tissue (carp)	USFWS 85th percentile	1.3X
			USFWS predator protection limit	1.9X
		tissue (channel catfish)	USFWS predator protection limit	1.3X
	7	tissue (carp)	USFWS 85th percentile	1.4X
			USFWS predator protection limit	2.1X
		tissue (smallmouth bass)	USFWS 85th percentile	1.4X
			USFWS predator protection limit	2.1X
	7b	tissue (carp)	USFWS predator protection limit	1.3X
		tissue (largemouth bass)	USFWS predator protection limit	1.4X
	8	tissue (carp)	USFWS predator protection limit	1.3X
		tissue (channel catfish)	USFWS predator protection limit	1.1X
	8d	tissue (carp)	USFWS predator protection limit	1.2X
		tissue (smallmouth bass)	USFWS predator protection limit	1.1X
	9	tissue (channel catfish)	USFWS predator protection limit	1.1X
	9b	water	aquatic life chronic	2.9X
			national 85th percentile	1.4X
			human health	1.4X
		tissue (largemouth bass)	USFWS predator protection limit	1.5X
	10	tissue (carp)	USFWS predator protection limit	1.6X
		tissue (channel catfish)	USFWS predator protection limit	1.2X
	11	water	aquatic life chronic	1.1X
		tissue (carp)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	1.7X
	11a	water	aquatic life chronic	1.02X
	11c	water	aquatic life chronic	2.1X
			national 85th percentile	1.1X
	12	tissue (carp)	USFWS predator protection limit	1.3X
	12a	water	aquatic life chronic	2.1X
			national 85th percentile	1.03X
			human health	1.03X
	12b	water	aquatic life chronic	2.7X
			national 85th percentile	1.4X
			human health	1.4X
	12c	water	aquatic life chronic	2.2X
			national 85th percentile	1.1X
			human health	1.1X
	13	tissue (largemouth bass)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	1.8X
		tissue (carp)	USFWS predator protection limit	1.3X

Table 14 (continued)
Summary of Screening Level Exceedances, by Parameter*

Parameter	Station	Matrix	Screening Level(s) Exceeded	Exceedance Factor
selenium	14	tissue (carp)	USFWS predator protection limit	1.4X
		tissue (largemouth bass)	USFWS predator protection limit	1.5X
	15	tissue (largemouth bass)	USFWS 85th percentile	1.1X
			USFWS predator protection limit	1.6X
	16	tissue (carp)	USFWS predator protection limit	1.1X
	18	tissue (largemouth bass)	USFWS predator protection limit	1.3X
silver	1a	sediment	national 85th percentile	11.8X
	7b	water	aquatic life acute ^f	5.2X ^f
			aquatic life chronic ^f	9.8X ^f
	8a	water	aquatic life acute ^f	3.2X ^f
			aquatic life chronic ^f	5.9X ^f
	8b	water	aquatic life acute ^f	3.2X ^f
			aquatic life chronic ^f	5.9X ^f
	8c	water	aquatic life acute ^f	3.7X ^f
			aquatic life chronic ^f	6.9X ^f
	12	water	aquatic life acute ^f	3.2X ^f
thallium	10a	water	human health	1.3X
zinc	1	tissue (carp)	USFWS 85th percentile	1.4X
	1a	sediment	national 85th percentile	2.3X
	2	tissue (carp)	USFWS 85th percentile	1.1X
	4	tissue (carp)	USFWS 85th percentile	1.2X
	5	tissue (carp)	USFWS 85th percentile	1.3X
	6a	tissue (carp)	USFWS 85th percentile	1.9X
	6b	tissue (carp)	USFWS 85th percentile	1.3X
	7	tissue (carp)	USFWS 85th percentile	1.2X
	7b	tissue (carp)	USFWS 85th percentile	1.5X
	8b	tissue (carp)	USFWS 85th percentile	1.4X
	9	tissue (carp)	USFWS 85th percentile	1.8X
	10	tissue (carp)	USFWS 85th percentile	1.4X
	11c	sediment	national 85th percentile	1.1X
	12	tissue (carp)	USFWS 85th percentile	2.2X
	15	tissue (carp)	USFWS 85th percentile	1.2X
	16	tissue (carp)	USFWS 85th percentile	1.3X
chlordane	11a	sediment	aquatic life threshold	7.6X
	11b	sediment	aquatic life threshold	40.0X
			national 85th percentile	2.2X
	11c	sediment	aquatic life threshold	1.9X
			national 85th percentile	2.4X
	12	tissue (carp)	USEPA fish tissue value	2.5X
p,p' DDE		tissue (carp)	Texas 85th percentile	3.5X
	15a	sediment	aquatic life threshold	3.7X
	10a	sediment	national 85th percentile	1.2X
	11a	sediment	national 85th percentile	1.5X
	12d	sediment	national 85th percentile	1.9X
DDT (total)	3	tissue (carp)	USEPA fish tissue value	1.0X
	3a	tissue (carp)	USEPA fish tissue value	2.8X
	7	tissue (carp)	USEPA fish tissue value	1.1X
	14	tissue (blue catfish)	USEPA fish tissue value	1.2X
	16	tissue (channel catfish)	USEPA fish tissue value	1.1X
diazinon	11a	water	aquatic life acute	2.0X
			aquatic life chronic	2.3X
	12d	water	aquatic life acute	26.3X

Table 14 (continued)
Summary of Screening Level Exceedances, by Parameter*

Parameter	Station	Matrix	Screening Level(s) Exceeded	Exceedance Factor
diazinon	12d	water	aquatic life chronic	30.7X
dieldrin	7	tissue (carp)	USEPA fish tissue value	1.6X
	7b	tissue (carp)	USEPA fish tissue value	1.3X
	11a	sediment	national 85th percentile	1.1X
gamma-bhc (lindane)	3	tissue (channel catfish)	USEPA national mean	1.5X
PCB's (total)	7	tissue (carp)	USEPA fish tissue value	11X
	7b	tissue (carp)	USEPA fish tissue value	13X
	8	tissue (carp)	USEPA fish tissue value	11X
	9	tissue (carp)	USEPA fish tissue value	36X
		tissue (channel catfish)	USEPA fish tissue value	17X
		tissue (carp)	USFWS geometric mean	14X
			USFWS predator protection limit	8.4X
		tissue (channel catfish)	USFWS geometric mean	3.0X
			USFWS predator protection limit	1.8X
	10	tissue (carp)	USEPA fish tissue value	4.4X
	11	tissue (channel catfish)	USFWS geometric mean	1.7X
			USFWS predator protection limit	2.8X
bis(2-ethylhexyl) phthalate	11c	water	aquatic life chronic	3.3X
			national 85th percentile	2.0X
		sediment	national 85th percentile	7.3X
diethyl phthalate	15a	water	aquatic life chronic	2.7X
di-n-butyl phthalate	12d	sediment	national 85th percentile	6.9X
cyanide	12d	water	aquatic life chronic	1.8X
	14	water	aquatic life chronic	1.8X

- * - includes certain chemicals for which screening levels do not exist, but which occurred at conspicuously high concentrations
- a - represents a potential exceedance; instream concentration, which was too low to quantify, was estimated at 20 µg/L
- b - no screening level exists, but observed concentration was conspicuously elevated, being the second highest in the study and exceeding the third highest by a factor of 10.8X
- c - no screening level exists, but observed concentration was conspicuously elevated, being the greatest in the study and exceeding the second highest by a factor of 2.3X
- d - no screening level exists, but observed concentration was conspicuously elevated; this was the only site in the study where parameter was detected in this matrix
- e - represents a potential exceedance; screening level concentration is for hexavalent chromium, whereas measured concentration represented total dissolved chromium
- f - represents a potential exceedance; screening level concentration is for silver in free ion form, whereas measured concentration represented total dissolved silver

Table 15
Summary of Screening Level Exceedances, by Station*

Station	Parameter	Matrix	Screening Level(s) Exceeded	Exceedance Factor
1	methylene chloride	sediment	aquatic life threshold	16.4X
	cadmium	tissue (carp)	USFWS 85th percentile	1.3X
	chromium	sediment	aquatic life threshold	3.5X
	copper	tissue (carp)	USFWS 85th percentile	1.9X
	nickel	sediment	aquatic life threshold	3.0X
	selenium	tissue (carp)	USFWS predator protection limit	1.1X
	zinc	tissue (carp)	USFWS 85th percentile	1.4X
1a**	residual chlorine	water	aquatic life acute	63.2X
			aquatic life chronic	109.1X
	parachlorometa cresol	sediment	third highest level observed ^b	10.8X ^b
	phenol	sediment		
	chloroform	water	national 85th percentile	1.4X
	arsenic	water	human health	5.1X
	copper	sediment	national 85th percentile	5.6X
	mercury	sediment	national 85th percentile	2.0X
	selenium	sediment	national 85th percentile	1.3X
	silver	sediment	national 85th percentile	11.8X
	zinc	sediment	national 85th percentile	2.3X
2	residual chlorine	water	aquatic life acute ^a	1.1X ^a
			aquatic life chronic ^a	1.8X ^a
	methylene chloride	sediment	aquatic life threshold	23.0X
	toluene	sediment	aquatic life threshold	1.9X
	arsenic	sediment	aquatic life threshold	1.1X
	chromium	sediment	aquatic life threshold	4.5X
	copper	sediment	aquatic life threshold	2.0X
		tissue (carp)	USFWS 85th percentile	1.6X
	lead	sediment	aquatic life threshold	1.4X
		tissue (channel catfish)	USFWS predator protection limit	1.1X
	mercury	sediment	aquatic life threshold	1.0X
	nickel	sediment	aquatic life threshold	3.2X
	selenium	tissue (carp)	USFWS predator protection limit	1.1X
	zinc	tissue (carp)	USFWS 85th percentile	1.1X
2a**	unionized ammonia	water	aquatic life acute	2.6X
			aquatic life chronic	13.6X
	parachlorometa cresol	water	national 85th percentile	1.1X
	phenol	water	national 85th percentile	1.2X
	phenolics recoverable	water	national 85th percentile	1.5X
	methylene chloride	sediment	aquatic life threshold	12.7X
	toluene	sediment	aquatic life threshold	1.5X
	arsenic	water	human health	3.3X
	chromium	sediment	aquatic life threshold	1.4X
	mercury	water	human health	11.5X
	nickel	sediment	aquatic life threshold	1.3X
3	methylene chloride	sediment	aquatic life threshold	10.0X
	arsenic	sediment	aquatic life threshold	2.1X
	chromium	sediment	aquatic life threshold	3.4X
	nickel	sediment	aquatic life threshold	5.4X
	selenium	tissue (channel catfish)	USFWS 85th percentile	1.8X
			USFWS predator protection limit	2.6X
	DDT (total)	tissue (carp)	USEPA fish tissue value	1.0X
3a	gamma-bhc (lindane)	tissue (channel catfish)	USEPA national mean	1.5X
	arsenic	water	national 85th percentile	2.1X
		sediment	aquatic life threshold	3.7X
	chromium	sediment	aquatic life threshold	3.3X
	mercury	tissue (carp)	USFWS predator protection limit	1.4X
	nickel	sediment	aquatic life threshold	5.0X
	selenium	tissue (carp)	USFWS 85th percentile	1.5X

Table 15 (continued)
Summary of Screening Level Exceedances, by Station*

Station	Parameter	Matrix	Screening Level(s) Exceeded	Exceedance Factor
3a	selenium	tissue (carp)	USFWS predator protection limit	2.2X
	DDT (total)	tissue (carp)	USEPA fish tissue value	2.8X
3b**	methylene chloride	sediment	aquatic life threshold	2.2X
	arsenic	water	national 85th percentile	1.1X
	chromium	sediment	aquatic life threshold	1.03X
4	arsenic	water	national 85th percentile	1.4X
		sediment	aquatic life threshold	1.0X
	chromium	sediment	aquatic life threshold	2.0X
	copper	tissue (carp)	USFWS 85th percentile	1.2X
	mercury	tissue (carp)	USFWS predator protection limit	1.5X
	nickel	sediment	aquatic life threshold	2.3X
	selenium	tissue (carp)	USFWS 85th percentile	1.5X
			USFWS predator protection limit	2.1X
	zinc	tissue (carp)	USFWS 85th percentile	1.2X
5	arsenic	water	national 85th percentile	1.6X
		sediment	aquatic life threshold	1.6X
	chromium	sediment	aquatic life threshold	2.6X
	copper	tissue (carp)	USFWS 85th percentile	1.6X
	mercury	tissue (carp)	USFWS predator protection limit	1.5X
	nickel	sediment	aquatic life threshold	3.6X
	selenium	tissue (carp)	USFWS 85th percentile	1.9X
			USFWS predator protection limit	2.8X
		tissue (blue catfish)	USFWS predator protection limit	1.2X
	zinc	tissue (carp)	USFWS 85th percentile	1.3X
5a**	arsenic	sediment	aquatic life threshold	1.7X
	chromium	sediment	aquatic life threshold	4.5X
	nickel	sediment	aquatic life threshold	6.9X
	selenium	water	aquatic life chronic	1.1X
5b**	arsenic	sediment	aquatic life threshold	1.3X
	chromium	sediment	aquatic life threshold	2.9X
	nickel	sediment	aquatic life threshold	2.8X
6	chromium	sediment	aquatic life threshold	1.2X
	mercury	tissue (white bass)	USFWS predator protection limit	1.6X
	nickel	sediment	aquatic life threshold	1.1X
	selenium	tissue (white bass)	TDH risk assessment value	1.1X
		tissue (carp)	USFWS 85th percentile	1.1X
			USFWS predator protection limit	1.7X
		tissue (white bass)	USFWS 85th percentile	2.2X
			USFWS predator protection limit	3.2X
6a	chromium	tissue (carp)	USFWS predator protection limit	1.1X
	copper	tissue (carp)	USFWS 85th percentile	1.2X
	selenium	tissue (carp)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	1.7X
		tissue (channel catfish)	USFWS predator protection limit	1.03X
	zinc	tissue (carp)	USFWS 85th percentile	1.9X
6b	copper	tissue (carp)	USFWS 85th percentile	1.2X
	selenium	tissue (carp)	USFWS 85th percentile	1.3X
			USFWS predator protection limit	1.9X
		tissue (channel catfish)	USFWS predator protection limit	1.3X
	zinc	tissue (carp)	USFWS 85th percentile	1.3X
7	chromium	sediment	aquatic life threshold	2.3X
	copper	tissue (carp)	USFWS 85th percentile	2.0X

Table 15 (continued)
Summary of Screening Level Exceedances, by Station*

Station	Parameter	Matrix	Screening Level(s) Exceeded	Exceedance Factor
7	mercury	tissue (smallmouth bass)	USFWS predator protection limit	1.6X
	nickel	sediment	aquatic life threshold	2.2X
	selenium	tissue (carp)	USFWS 85th percentile	1.4X
			USFWS predator protection limit	2.1X
		tissue (smallmouth bass)	USFWS 85th percentile	1.4X
			USFWS predator protection limit	2.1X
	zinc	tissue (carp)	USFWS 85th percentile	1.2X
	DDT (total)	tissue (carp)	USEPA fish tissue value	1.1X
	dieldrin	tissue (carp)	USEPA fish tissue value	1.6X
	PCBs (total)	tissue (carp)	USEPA fish tissue value	11X
7a**	unionized ammonia	water	aquatic life chronic	1.0X
	chromium	sediment	aquatic life threshold	1.1X
7b	copper	tissue (carp)	USFWS 85th percentile	1.7X
	mercury	tissue (largemouth bass)	USFWS predator protection limit	1.5X
	selenium	tissue (carp)	USFWS predator protection limit	1.3X
		tissue (largemouth bass)	USFWS predator protection limit	1.4X
	silver	water	aquatic life acute ^f	5.2X ^f
			aquatic life chronic ^f	9.8X ^f
	zinc	tissue (carp)	USFWS 85th percentile	1.5X
	dieldrin	tissue (carp)	USEPA fish tissue value	1.3X
	PCBs (total)	tissue (carp)	USEPA fish tissue value	13X
8	chromium	sediment	aquatic life threshold	1.01X
	copper	tissue (carp)	USFWS 85th percentile	1.6X
	nickel	sediment	aquatic life threshold	1.1X
	selenium	tissue (carp)	USFWS predator protection limit	1.3X
		tissue (channel catfish)	USFWS predator protection limit	1.1X
	PCBs (total)	tissue (carp)	USEPA fish tissue value	11X
8a**	silver	water	aquatic life acute ^f aquatic life chronic ^f	3.2X ^f 5.9X ^f
8b**	silver	water	aquatic life acute ^f aquatic life chronic ^f	3.2X ^f 5.9X ^f
	zinc	tissue (carp)	USFWS 85th percentile	1.4X
8c**	chromium	sediment	aquatic life threshold	3.0X
	nickel	sediment	aquatic life threshold	3.1X
8d	copper	tissue (carp)	USFWS 85th percentile	1.7X
	mercury	tissue (smallmouth bass)	USFWS predator protection limit	1.6X
	selenium	tissue (carp)	USFWS predator protection limit	1.2X
		tissue (smallmouth bass)	USFWS predator protection limit	1.1X
8e**	chromium	sediment	aquatic life threshold	2.3X
	nickel	sediment	aquatic life threshold	2.3X
	silver	water	aquatic life acute ^f aquatic life chronic ^f	3.7X ^f 6.9X ^f
9	copper	tissue (carp)	USFWS 85th percentile	2.4X
	lead	tissue (channel catfish)	USFWS 85th percentile	1.1X
	mercury	tissue (carp)	USFWS 85th percentile	1.3X
			USFWS predator protection limit	2.3X
		tissue (channel catfish)	USFWS predator protection limit	2.4X
	selenium	tissue (channel catfish)	USFWS predator protection limit	1.1X
	zinc	tissue (carp)	USFWS 85th percentile	1.8X
	PCBs (total)	tissue (carp)	USEPA fish tissue value	36X
		tissue (channel catfish)	USEPA fish tissue value	17X
		tissue (carp)	USFWS geometric mean	14X
			USFWS predator protection limit	8.4X

Table 15 (continued)
Summary of Screening Level Exceedances, by Station*

Station	Parameter	Matrix	Screening Level(s) Exceeded	Exceedance Factor
9	PCBs (total)	tissue (channel catfish)	USFWS geometric mean USFWS predator protection limit	3.0X 1.8X
9a**	unionized ammonia	water	aquatic life chronic	4.1X
	arsenic	water	human health	2.8X
9b	chromium	tissue (largemouth bass)	USFWS predator protection limit	1.46X
	copper	tissue (carp)	USFWS 85th percentile	1.4X
	mercury	tissue (carp)	USFWS 85th percentile	1.0X
		tissue (channel catfish)	USFWS predator protection limit	1.7X
		tissue (largemouth bass)	USFWS 85th percentile	2.2X
	selenium	water	aquatic life chronic	2.9X
			national 85th percentile	1.4X
			human health	1.4X
		tissue (largemouth bass)	USFWS predator protection limit	1.5X
10	copper	tissue (carp)	USFWS 85th percentile	1.6X
	selenium	tissue (carp)	USFWS predator protection limit	1.6X
		tissue (channel catfish)	USFWS predator protection limit	1.2X
	zinc	tissue (carp)	USFWS 85th percentile	1.4X
	PCBs (total)	tissue (carp)	USEPA fish tissue value	4.4X
10a**	antimony	water	national 85th percentile	1.4X
			human health	5.6X
	chromium	sediment	aquatic life threshold	1.3X
	mercury	tissue (carp)	USFWS predator protection limit	1.3X
	nickel	sediment	aquatic life threshold	1.5X
	thallium	water	human health	1.3X
	p,p' DDE	sediment	national 85th percentile	1.2X
11	chromium	sediment	aquatic life threshold	1.1X
		tissue (carp)	USFWS predator protection limit	1.9X
	copper	tissue (carp)	USFWS 85th percentile	2.0X
	mercury	tissue (carp)	USFWS 85th percentile	1.01X
			USFWS predator protection limit	1.7X
		tissue (channel catfish)	USFWS 85th percentile	1.0X
			USFWS predator protection limit	1.7X
	nickel	sediment	aquatic life threshold	1.5X
	selenium	water	aquatic life chronic	1.1X
		tissue (carp)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	1.7X
	PCBs (total)	tissue (channel catfish)	USFWS geometric mean	1.7X
			USFWS predator protection limit	2.8X
11a**	nickel	sediment	aquatic life threshold	1.1X
	selenium	water	aquatic life chronic	1.02X
	chlordan	sediment	aquatic life threshold	7.6X
	p,p' DDE	sediment	national 85th percentile	1.5X
	diazinon	water	aquatic life acute	2.0X
			aquatic life chronic	2.3X
	dieldrin	sediment	national 85th percentile	1.1X
11b**	chromium	sediment	aquatic life threshold	1.7X
	nickel	sediment	aquatic life threshold	2.0X
	chlordan	sediment	aquatic life threshold	40.0X
			national 85th percentile	2.2X
11c**	unionized ammonia	water	aquatic life chronic	6.2X
	parachlorometa cresol	sediment	second highest level observed*	2.3X*
	arsenic	water	human health	1.5X
	selenium	water	aquatic life chronic	2.1X

Table 15 (continued)
Summary of Screening Level Exceedances, by Station*

Station	Parameter	Matrix	Screening Level(s) Exceeded	Exceedance Factor
11c**	selenium	water	national 85th percentile	1.1X
	zinc	sediment	national 85th percentile	1.1X
	chlordanes	sediment	aquatic life threshold	1.9X
			national 85th percentile	2.4X
	bis(2-ethylhexyl) phthalate	water	aquatic life chronic	3.3X
		sediment	national 85th percentile	2.0X
12			national 85th percentile	7.3X
	methylene chloride	sediment	aquatic life threshold	2.3X
	toluene	sediment	aquatic life threshold	1.7X
	chromium	tissue (carp)	USFWS predator protection limit	2.4X
	copper	tissue (carp)	USFWS 85th percentile	1.7X
	mercury	tissue (carp)	USFWS predator protection limit	1.3X
		tissue (channel catfish)	USFWS predator protection limit	1.2X
	nickel	sediment	aquatic life threshold	1.2X
	selenium	tissue (carp)	USFWS predator protection limit	1.3X
	silver	water	aquatic life acute ^f	3.2X ^f
			aquatic life chronic ^f	5.9X ^f
	zinc	tissue (carp)	USFWS 85th percentile	2.2X
	chlordanes	tissue (carp)	USEPA fish tissue value	2.5X
		tissue (carp)	Texas 85th percentile	3.5X
12a**	chromium	water	aquatic life chronic ^a	1.4X ^a
		sediment	aquatic life threshold	1.7X
	nickel	sediment	aquatic life threshold	2.1X
	selenium	water	aquatic life chronic	2.1X
			national 85th percentile	1.03X
			human health	1.03X
	di-n-butyl phthalate	sediment	national 85th percentile	6.9X
12b**	chromium	sediment	aquatic life threshold	2.3X
	nickel	sediment	aquatic life threshold	2.2X
	selenium	water	aquatic life chronic	2.7X
			national 85th percentile	1.4X
			human health	1.4X
12c**	nickel	sediment	aquatic life threshold	1.4X
	selenium	water	aquatic life chronic	2.2X
			national 85th percentile	1.1X
			human health	1.1X
12d**	p,p' DDE	sediment	national 85th percentile	1.9X
	diazinon	water	aquatic life acute	26.3X
			aquatic life chronic	30.7X
	cyanide	water	aquatic life chronic	1.8X
12e**	nickel	sediment	aquatic life threshold	1.2X
13	chromium	sediment	aquatic life threshold	1.4X
	copper	tissue (carp)	USFWS 85th percentile	1.2X
	mercury	tissue (largemouth bass)	USFWS 85th percentile	1.4X
			USFWS predator protection limit	2.4X
	nickel	sediment	aquatic life threshold	1.6X
	selenium	tissue (largemouth bass)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	1.8X
		tissue (carp)	USFWS predator protection limit	1.3X
14	arsenic	sediment	aquatic life threshold	1.1X
	chromium	sediment	aquatic life threshold	2.7X
		tissue (channel catfish)	USFWS predator protection limit	1.3X
	copper	tissue (carp)	USFWS 85th percentile	1.3X
	mercury	tissue (channel catfish)	USFWS predator protection limit	1.4X

Table 15 (continued)
Summary of Screening Level Exceedances, by Station*

Station	Parameter	Matrix	Screening Level(s) Exceeded	Exceedance Factor
14	nickel	sediment	aquatic life threshold	2.9X
	selenium	tissue (carp)	USFWS predator protection limit	1.4X
		tissue (largemouth bass)	USFWS predator protection limit	1.5X
	DDT (total)	tissue (blue catfish)	USEPA fish tissue value	1.2X
	cyanide	water	aquatic life chronic	1.8X
15	chromium	sediment	aquatic life threshold	1.0X
	mercury	tissue (largemouth bass)	USEPA fish tissue value	1.3X
			USFWS predator protection limit	1.02X
		tissue (carp)	USFWS predator protection limit	1.3X
	nickel	sediment	aquatic life threshold	1.1X
	selenium	tissue (largemouth bass)	USFWS 85th percentile	1.1X
			USFWS predator protection limit	1.6X
			USFWS predator protection limit	1.1X
	zinc	tissue (carp)	USFWS predator protection limit	1.1X
		tissue (carp)	USFWS 85th percentile	1.2X
15a**	arsenic	water	human health	1.9X
	mercury	water	human health	23.8X
	chlordane	sediment	aquatic life threshold	3.7X
	diethyl phthalate	water	aquatic life chronic	2.7X
16	chromium	sediment	aquatic life threshold	2.9X
		tissue (carp)	USFWS predator protection limit	2.5X
	copper	tissue (carp)	USFWS 85th percentile	1.4X
		tissue (channel catfish)	USFWS 85th percentile	1.4X
	mercury	tissue (carp)	USEPA fish tissue value	1.05X
		tissue (carp)	USFWS 85th percentile	1.2X
			USFWS predator protection limit	2.1X
		tissue (channel catfish)	USFWS predator protection limit	1.3X
	nickel	sediment	aquatic life threshold	2.9X
	selenium	tissue (carp)	USFWS predator protection limit	1.3X
	zinc	tissue (carp)	USFWS 85th percentile	1.3X
	DDT (total)	tissue (channel catfish)	USEPA fish tissue value	1.1X
17	chromium	sediment	aquatic life threshold	1.5X
	copper	tissue (largemouth bass)	USFWS 85th percentile	1.1X
	mercury	tissue (largemouth bass)	USFWS predator protection limit	1.6X
	nickel	sediment	aquatic life threshold	1.7X
18	chromium	sediment	aquatic life threshold	1.5X
	copper	tissue (carp)	USFWS 85th percentile	1.1X
		tissue (largemouth bass)	USFWS 85th percentile	1.3X
	nickel	sediment	aquatic life threshold	1.9X
	selenium	tissue (largemouth bass)	USFWS predator protection limit	1.2X

* - includes certain chemicals for which screening levels do not exist, but which occurred at conspicuously high concentrations

** - tissue not analyzed at this site

a - represents a potential exceedance; instream concentration, which was too low to quantify, was estimated at 20 µg/L

b - no screening level exists, but observed concentration was conspicuously elevated, being the second highest in the study and exceeding the third highest by a factor of 10.8X

c - no screening level exists, but observed concentration was conspicuously elevated, being the greatest in the study and exceeding the second highest by a factor of 2.3X

d - no screening level exists, but observed concentration was conspicuously elevated; this was the only site in the study where parameter was detected in this matrix

e - represents a potential exceedance; screening level concentration is for hexavalent chromium, whereas measured concentration represented total dissolved chromium

f - represents a potential exceedance; screening level concentration is for silver in free ion form, whereas measured concentration represented total dissolved silver

Table 16
Toxicity Testing Results - *Ceriodaphnia dubia*

Sta- tion	Date	Water						Sediment					
		mortality			reproduction			mortality			reproduction		
		con. ^a	sam. ^a	sig. ^b	con. ^c	sam. ^c	sig. ^b	con. ^a	sam. ^a	sig. ^b	con. ^c	sam. ^c	sig. ^b
<u>Mainstem Stations</u>													
1	11/12/92	0	100	y	18.7	---	---	10	0	n	18.4	19.5	n
2	11/11/92	0	0	n	18.7	15.9	n	10	0	n	18.4	18.9	n
3	11/13/92	0	0	n	18.7	19.3	n	10	0	n	18.4	18.2	n
4	11/14/92	0	10	n	18.7	17.4	n	10	0	n	18.4	21.5	n
5	11/15/92	0	0	n	18.7	18.4	n	10	0	n	18.4	19.2	n
5b	2/8/93	0	0	n	21.6	21.4	n	0	0	n	20.4	20.6	n
6	2/8/93	0	0	n	21.6	20.3	n	0	0	n	20.4	20.2	n
7	2/10/93	0	10	n	21.6	18.7	n	0	0	n	20.4	22.6	n
8	2/10/93	0	0	n	21.6	20.2	n	0	0	n	20.4	22.5	n
9	3/22/93	0	0	n	22.1	21.9	n	0	0	n	20.9	20.5	n
10	3/23/93	0	10	n	22.1	20.5	n	0	0	n	20.9	22.3	n
11	3/24/93	0	0	n	22.1	18.5	n	0	0	n	20.9	21.7	n
12	3/24/93	0	0	n	22.1	21.5	n	0	0	n	20.9	20.3	n
13	1/11/93	0	0	n	20.1	18.6	n	0	0	n	20.7	24.6	n
14	1/12/93	0	0	n	20.1	19.3	n	0	0	n	20.7	18.5	n
15	1/12/93	0	0	n	20.1	19.9	n	0	10	n	20.7	18.4	n

Table 16 (continued)
Toxicity Testing Results - Ceriodaphnia dubia

Sta- tion	Date	Water						Sediment					
		mortality			reproduction			mortality			reproduction		
		con. ^a	sam. ^a	sig. ^b	con. ^c	sam. ^c	sig. ^b	con. ^a	sam. ^a	sig. ^b	con. ^c	sam. ^c	sig. ^b
16	1/13/93	0	0	n	20.1	20.5	n	0	0	n	20.7	20.6	n
17	1/14/93	0	20	n	20.1	20.4	n	0	0	n	20.7	19.6	n
18	1/14/93	0	0	n	20.1	19.1	n	0	0	n	20.7	19.1	n
Tributary Stations													
1a	11/11/92	0	100	y	18.7	---	---	10	100	y	18.4	---	---
2a	11/12/92	0	100	y	18.7	---	---	10	0	n	18.4	20.1	n
3a	11/13/92	0	0	n	18.7	19.4	n	10	100	y	18.4	---	---
3b	11/13/92	0	0	n	18.7	20.8	n	10	0	n	18.4	20.8	n
5a	11/15/92	0	10	n	18.7	17.0	n	10	0	n	18.4	19.2	n
6a	2/8/93	0	0	n	21.6	5.4	y	0	0	n	20.4	25.5	n
6b	2/9/93	0	0	n	21.6	16.0	y	0	0	n	20.4	16.1	y
7a	2/10/93	0	0	n	21.6	16.0	y	0	0	n	20.4	21.6	n
7b	2/9/93	0	0	n	21.6	15.3	y	0	0	n	20.4	19.8	n
8a	2/11/93	0	0	n	21.6	19.7	n	0	0	n	20.4	19.8	n
8b	2/11/93	0	0	n	21.6	20.8	n	0	0	n	20.4	20.1	n
8c	2/11/93	0	10	n	21.6	21.4	n	0	10	n	20.4	23.0	n
8d	2/12/93	0	0	n	21.6	22.2	n	0	0	n	20.4	18.7	n
8e	2/12/93	0	0	n	21.6	20.5	n	0	0	n	20.4	19.9	n

Table 16 (continued)
Toxicity Testing Results - *Ceriodaphnia dubia*

Sta- tion	Date	Water						Sediment					
		mortality			reproduction			mortality			reproduction		
		con. ^a	sam. ^a	sig. ^b	con. ^c	sam. ^c	sig. ^b	con. ^a	sam. ^a	sig. ^b	con. ^c	sam. ^c	sig. ^b
9a	3/22/93	0	0	n	22.1	16.5	y	0	0	n	20.9	18.5	n
9b	3/22/93	0	0	n	22.1	20.1	n	0	0	n	20.9	21.6	n
10a	3/23/93	0	50	y	22.1	9.6	y	0	20	n	20.9	18.6	n
11a	3/23/93	0	100	y	22.1	---	---	0	10	n	20.9	18.3	n
11b	3/24/93	0	100	y	22.1	---	---	0	0	n	20.9	22.9	n
11c	3/25/93	0	40	y	22.1	4.3	y	0	100	y	20.9	---	---
12a	3/26/93	0	0	n	22.1	20.9	n	0	0	n	20.9	24.4	n
12b	3/25/93	0	0	n	22.1	21.9	n	0	0	n	20.9	23.4	n
12c	3/26/93	0	0	n	22.1	21.2	n	0	0	n	20.9	20.5	n
12d	1/11/93	0	100	y	20.1	---	---	0	10	n	20.7	20.3	n
12e	1/12/93	0	0	n	20.1	17.9	n	0	10	n	20.7	23.0	n
15a	1/13/93	0	20	n	20.1	2.1	y	0	0	n	20.7	18.7	n

^a - percentage of organisms affected

^b - whether or not test results were significantly different from the control ($p > 0.95$) (y = yes; n = no)

^c - mean number of young produced per female

(abbreviations: con. = control; sam. = sample; sig. = significance)

Table 17
Toxicity Testing Results - Pimephales promelas

Station	Date	Water		Sediment		
		control ^a	sample ^a significance ^b	control ^a	sample ^a significance ^b	
<u>Mainstem Stations</u>						
1	11/12/92	7	0	7	0	n
2	11/11/92	7	10	7	10	n
3	11/13/92	7	0	7	3	n
4	11/14/92	7	3	7	10	n
5	11/15/92	7	3	7	0	n
5b	2/8/93	3	3	7	0	n
6	2/8/93	3	3	7	7	n
7	2/10/93	3	7	7	7	n
8	2/10/93	3	0	7	0	n
9	3/22/93	7	0	3	3	n
10	3/23/93	7	0	3	0	n
11	3/24/93	7	7	3	100	Y
12	3/24/93	7	7	7	7	n
13	1/11/93	7	3	7	0	n
14	1/12/93	7	0	7	3	n
15	1/12/93	7	3	7	0	n
16	1/13/93	7	0	7	7	n
17	1/14/93	7	10	7	7	n

Table 17 (continued)
Toxicity Testing Results - Pimephales promelas

Station	Date	Water			Sediment		
		control ^a	sample ^a	significance ^b	control ^a	sample ^a	significance ^b
18	1/14/93	7	0	n	7	0	n
<u>Tributary Stations</u>							
1a	11/11/92	7	100	y	7	100	y
2a	11/12/92	7	100	y	7	27	n
3a	11/13/92	7	3	n	7	7	n
3b	11/13/92	7	10	n	7	7	n
5a	11/15/92	7	0	n	7	3	n
6a	2/8/93	3	7	n	7	0	n
6b	2/9/93	3	7	n	7	17	n
7a	2/10/93	3	10	n	7	0	n
7b	2/9/93	3	7	n	7	10	n
8a	2/11/93	3	7	n	7	0	n
8b	2/11/93	3	0	n	7	10	n
8c	2/11/93	3	3	n	7	10	n
8d	2/12/93	3	3	n	7	7	n
8e	2/12/93	3	7	n	7	0	n
9a	3/22/93	7	100	y	3	17	n
9b	3/22/93	7	3	n	3	3	n

Table 17 (continued)
Toxicity Testing Results - Pimephales promelas

Station	Date	Water			Sediment		
		control ^a	sample ^a	significance ^b	control ^a	sample ^a	significance ^b
10a	3/23/93	7	7	n	3	10	n
11a	3/23/93	7	20	n	3	7	n
11b	3/24/93	7	10	n	3	7	n
11c	3/25/93	7	17	n	3	100	y
12a	3/26/93	7	0	n	3	10	n
12b	3/25/93	7	0	n	3	17	n
12c	3/26/93	7	7	n	3	10	n
12d	1/11/93	7	100	y	7	3	n
12e	1/12/93	7	13	n	7	10	n
15a	1/13/93	7	20	n	7	40	y

^a - percentage of organisms affected; effects include the combined number of dead (unhatched) embryos, dead larvae, and organisms exhibiting terata and abnormal swimming behavior

^b - whether or not test results were significantly different from the control ($p > 0.95$) (y = yes; n = no)

Table 18
Summary of Rio Grande Toxicity Testing Results
from USEPA/TNRCC TOXNET Program, 1991-Present*

Station	Number of Water Toxicity Tests Conducted	Number of Sediment Eluate Toxicity Tests Conducted	Significant Effects
1	3	2	none
2	7	4	<i>Ceriodaphnia dubia</i> reproduction reduced in one water sample; <i>Ceriodaphnia dubia</i> survival reduced in one water sample; <i>Ceriodaphnia dubia</i> reproduction reduced in one sediment eluate sample
4	7	3	fathead minnow survival reduced in one water sample
32.7 km downstream from sta. 8	4	3	none
10	8	3	<i>Ceriodaphnia dubia</i> reproduction reduced in two water samples
12	8	3	<i>Ceriodaphnia dubia</i> reproduction reduced in one water sample; <i>Ceriodaphnia dubia</i> survival reduced in one sediment eluate sample
16	4	3	none
11.2 km upstream from sta. 18	4	0	none
18	4	3	none

* - testing performed by USEPA Region 6 Laboratory, Houston; methodologies and test organisms same as in present study

Table 19
Benthic Macroinvertebrate Data

Parameter	Station									
	1	2	3	4	5	6	7	8	9	10
DATE	111292	111192	111392	111492	111592	020893	021093	021093	032293	032393
TIME	0900	1600	1000	0900	1200	1322	1640	1000	0752	0845
SAMPLING METHOD	snags	Surber	Surber	Surber	Surber	Surber	Surber	snags	Surber	Surber
COMMUNITY INDICES										
Number of Species	42	32	19	50	15	33	64	51	50	65
Number of Individuals/m ²	17,054	2,446	4,869	9,273	495	910	3,985	6,656	1,408	22,637
Diversity	3.53	3.38	0.46	4.00	2.78	3.93	4.51	3.42	4.05	4.49
Redundancy	0.36	0.35	0.93	0.30	0.37	0.27	0.27	0.41	0.33	0.26
Equilability	0.65	0.68	0.11	0.71	0.71	0.78	0.75	0.60	0.72	0.75
EPT Index	7	7	7	15	6	13	15	10	15	20
TNRCC Mean Point Score	3.00	2.83	1.50	3.17	2.83	3.67	3.33	2.50	3.50	3.33
Ohio ICI	30	26	27	43	24	46	36	30	42	41
FUNCTIONAL FEEDING GROUPS (% of community)										
Grazers	2.41	3.52	1.62	10.20	7.25	22.45	20.80	7.89	42.97	9.76
Gatherers	17.37	22.54	1.77	16.65	43.48	27.28	20.86	9.71	26.71	17.33
Filterers	37.16	4.84	95.73	36.83	3.62	35.74	8.02	4.72	6.80	19.95
Miners	19.75	47.70	0.13	24.07	25.72	3.94	25.52	60.00	14.63	27.83
Shredders	10.34	14.16	0.13	3.54	16.30	0.94	22.14	15.95	3.64	13.29
Predators	12.97	7.25	0.61	8.72	3.62	9.65	2.66	1.72	5.25	11.84

TAXON	NUMBER OF INDIVIDUALS/m ²									
COELENTERATA <i>Hydra</i> sp.	12							41		
TURBELLARIA <i>Dugesia digitata</i>		469		3			328	443	41	610
NEMERTEA <i>Prostoma rubrum</i>	12		4				40	19	2	7

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	1	2	3	4	5	6	7	8	8	10
NEMATODA				24			5	185	15	36
unidentified species									2	
HIRUDINEA										
<i>Helobdella stagnalis</i>								4	10	
<i>Helobdella triseriata</i>										
OLIOCHAETA										
<i>Aelosoma</i> sp.									41	4
<i>Branchiura sowerbyi</i>										
<i>Chaetogaster cristallinus</i>								17	56	
<i>Chaetogaster diaphanus</i>									36	
<i>Chaetogaster diastrophus</i>										
<i>Dero digitata</i>										
<i>Dero trifida</i>	29	65						6		
<i>Hydrodrilus templetoni</i>		99						646	10	
<i>Limnodrilus hoffmeisteri</i>		459						2,521		
<i>Limnodrilus</i> sp.		17	3				8		10	4
<i>Limnodrilus udekemianus</i>							51	129		
Lumbricidae										
<i>Nais behningi</i>									2	
<i>Nais parvulus</i>	147			3			100	19	4	7
<i>Nais simplex</i>								6	10	
<i>Nais variabilis</i>	252			3			277	88	203	36
<i>Pristina acquiseta</i>										
<i>Pristina americana</i>										
<i>Pristina leidy</i>										
<i>Pristina osborni</i>									2	
<i>Pristina sima</i>										
<i>Sparganophilus lamellicornis</i>		17		22			22	136	4	47
<i>Stephanosomana irvandruna</i>		4					5	41		
<i>Waspia mobilis</i>								13		
GASTROPODA										
<i>Clethrionomys clathrensis</i>							16	2		
<i>Cochliopoda riograndensis</i>							140	424	381	
<i>Elmidae comalensis</i>							8	2	30	14
<i>Ferrissia rivalaris</i>	6	4								
<i>Melanoides granifera</i>										
<i>Physella virgata</i>	12	13					116		10	4
<i>Pygospio spinosus</i>										

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	1	2	3	4	5	6	7	8	8	10
PELECYPODA										
<i>Cordicula fluminea</i>							239	108	60	563
<i>Pisidium castellanum</i>							11	78		
<i>Pisidium compressum</i>							3	121		
AMPHIPODA										
<i>Hyalicla azteca</i>							718	870	3,877	
CLADOCERA										
<i>Daphnia</i> sp.								17		
COPEPODA										
<i>Macrocyclus</i> sp.									10	
DECAPODA										
<i>Palaeomonetes vulgaris</i>										
MYSIDACEA										
<i>Neomysis</i> sp.										
OSTRACODA										
<i>Canadensis</i> sp.							3			
<i>Cypridopsis vidua</i>							3	2	10	
<i>Herpetocypris</i> sp.							5	2	5	
<i>Ilyocypris</i> sp.							3			4
<i>Limnocythere</i> sp.							3			
<i>Senecypris</i> sp.							3			
HYDRACARINA										
<i>Auracides</i> sp.							16			
<i>Brachypoda</i> sp.										
<i>Hydracites</i> sp.							3			
<i>Sperthum</i> sp.										
unidentified species			3							
COLEOPTERA										
Chrysomelidae										
<i>Cyphom</i> sp.										
<i>Dubiraphia</i> sp.								6		
<i>Enochrus</i> sp.										
<i>Helichus subarcticus</i>										
				293		51				

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	1	2	3	4	5	6	7	8	9	10
<i>Heterelmis</i> sp.				57		5				4
<i>Heacyllopus ferrugineus</i>							3	6		43
<i>Hydrochus</i> sp.			7							
<i>Laccophilus at terminalis</i>										
<i>Leurochus luteus</i>						3	48		6	90
<i>Macrelmis lezanus</i>				3			118		19	179
<i>Microcylopus pusillus</i>			7	3				249		
<i>Oxihobius</i> sp.	6									
<i>Paracymus</i> sp.			4				38	2		7
<i>Paracymus subcupreus</i>										
<i>Psiphonius lezanus</i>			4					20		
Saldidae										
Staphylinidae										
<i>Stenelmis cheryl</i>									4	
<i>Stenelmis occidentalis</i>							3		9	32
<i>Stenelmis</i> sp.				35		5		5		
DIPTERA										
<i>Ablabesmyia mallochii</i>										
<i>Ablabesmyia</i> sp.										
<i>Atrichopogon</i> sp.										
<i>Axarus</i> sp.							91			
<i>Brachydeutera</i> sp.				3						
<i>Cardiocladius</i> sp.		90								
Chironomini genus A		9								
Chironomini genus B										
<i>Chironomus decorus</i> gr.		127								
<i>Cladotanytarsus manicus</i> gr.	53									
<i>Cladotanytarsus</i> sp. gr. A										
<i>Cladotanytarsus vanderwulpi</i> gr.	53									
<i>Conchapelopia</i> sp.										
<i>Cricotopus (Cricotopus) bicinctus</i> gr.	2,054	28		83	18		13			
<i>Cricotopus (Cricotopus) tremulus</i> gr.	1,180	659	11	248	136	8	221	320		
<i>Cricotopus (Cricotopus) trifascia</i> gr.							35	11		
<i>Cricotopus (Stictodius) intersectus</i> gr.										
<i>Cryptochironomus fulvus</i> gr.				124		5			4	187
<i>Dasythella</i> sp.										
<i>Dicranodipes neomodicus</i>	205			164	18		11		17	
<i>Dicranodipes nervosus</i> Type I										
<i>Dicranodipes</i> sp.	106									
<i>Einfeldia</i> sp. gr. C						5				

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	1	2	3	4	5	6	7	8	9	10
<i>Geranomyia</i> sp.							22			
<i>Glyptotendipes</i> sp. gr. A										
<i>Goeldichironomus holopraeinus</i> gr.										
<i>Goeldichironomus pictus</i> gr.										32
<i>Hemerodromia</i> sp.	59	4								
<i>Labrundinia neopilosella</i>	106									
<i>Labrundinia</i> sp.										
<i>Limnophila</i> sp.							3			
<i>Limnophora</i> sp.										
<i>Nannochloris distinctus</i>										
<i>Nannochloris minutus</i>										
<i>Nannochloris rectinervis</i>										
<i>Nannochloris</i> sp.	53			40		8			13	
<i>Orthocladus (Eudacryocladus) sp.</i>										187
<i>Orthocladus (Euorthocladus) sp.</i>										187
<i>Orthocladus (Orthocladus) sp. clarif.</i>										93
<i>Orthocladus (Orthocladus) as dentifer</i>										
<i>Orthocladus (Orthocladus) sp.</i>	358						323	93	4	
<i>Parachironomus arcuatus</i> gr.							22	140	24	
<i>Parachironomus frequens</i> gr.							22			1,389
<i>Paracletidius</i> sp.										
<i>Paracletidius campidolus</i> gr.	53							41		
<i>Paracletidius as bathophila</i>	822	9	4	826	179	5	8	24	41	1,019
<i>Pedionomus boeckae</i>										
<i>Pentaneura</i> sp.	153						8	11	6	370
<i>Polyphemus convictus</i>		9	4	455	11	5		24	26	2,591
<i>Polyphemus illinoensis</i>	258							61	4	
<i>Polyphemus as scalenium</i> sp. B	153					5		11		187
<i>Problezia</i> sp.								41		
<i>Pseudochironomus</i> sp.							8			
<i>Rhectochironomus exiguus</i> gr.							8			1,482
<i>Sarcophaga</i> sp.										1,738
<i>Simulium as bivalentium</i>	6	6	4,600	22	14	24				14
<i>Simulium as trivittatum</i>	12									
<i>Simulium as viliatum</i>		4								
<i>Simulium</i> sp.							5	9	4	90
<i>Stenochironomus</i> sp.	358			40						
<i>Tabanus</i> sp.										4
<i>Tanytarsus glabratus</i> gr.	53	54		702						
<i>Tanytarsus guerini</i> gr.	106	17								
<i>Tanytarsus as coffmani</i>										

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	1	2	3	4	5	6	7	8	9	10
<i>Telopelopia</i> sp.	1,491			40	7	5				
<i>Thienemanniella</i> cf. <i>flava</i>	153									
<i>Thienemanniella</i> cf. <i>xena</i>	516	9		83		5		142		
<i>Thienemanniella</i> sp.								41		
<i>Thienemannimyxa</i> sp.										276
<i>Tribelos</i> sp.										
EPHEMEROPTERA										
<i>Acanitrella carolina</i>				32	7	38	151	24	5	187
<i>Acanitrella insigniflans</i>		52								
<i>Baetis ephippialus</i>			4							
<i>Baetodes edmundsi</i>			4	11			8			4
<i>Brachyercus</i> sp.										
<i>Caenis latipennis</i>										
<i>Callibaetis</i> sp.					4					
<i>Camelobaetis mexicanus</i>			4				27	2	4	4
<i>Centropilum</i> sp.			7							
<i>Choroterpes</i> (<i>Neochoroterpes</i>) <i>mexicanus</i>			126	65	11	43			54	
<i>Fallcon quillert</i>	393	24	7	59	43	3	215	82	17	147
<i>Heplogenia</i> sp.	235	6								
<i>Limnephila sicca manca</i>				3			3		4	233
<i>Lepidophyes apache</i> gr.										
<i>Lepidophyes packeri</i>							3	4	39	14
<i>Rhythrogena</i> sp.						16				
<i>Sironema</i> sp.										
<i>Thraulodes gonzalesi</i>				172	7	54	30	9	200	29
<i>Traverella presidiana</i>				794		86	16			
<i>Tricorythodes albilineatus</i> gr.	1,056	15		307		151	86	26	71	395
<i>Tricorythodes curvatus</i> gr.										22
HEMIPTERA										
<i>Ambrysus circumcinctus</i>				19						11
<i>Belostomatia</i> sp.			4							
<i>Cryptorhynchus hungerfordi</i>							5		2	68
<i>Corixidae</i>						3	3			7
<i>Limnocoris luzi</i>										
<i>Merrigala</i> sp.										
<i>Rhagovella</i> sp.		2	4	439						
LEPIDOPTERA										
<i>Paraponyx</i> sp.										

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station										
	1	2	3	4	5	6	7	8	8	9	10
<i>Paragyracis</i> sp.				8		3	19	13	5	2	129
<i>Synclita</i> sp.											
MEGALOPTERA											
<i>Corydalus cornutus</i>				5		5	3				11
NEUROPTERA											
<i>Climacia arcularis</i>											
ODONATA											
<i>Argia</i> sp. A	100	73				35		2		4	4
<i>Argia</i> sp. B							13				
<i>Brechmorhoga mendax</i>				5							25
<i>Enallagma</i> sp.	100			3							
<i>Erpetogomphus</i> sp.	12	6	7	70	7	32	3	2		32	237
<i>Gomphus</i> (<i>Gomphurus</i>) <i>externus</i>											
<i>Heserina</i> sp.	53										
TRICHOPTERA											
<i>Chemalopsyche</i> sp.		4	61	164	4	16	35			4	377
<i>Cynellus fraternus</i>											
<i>Helicopsyche</i> sp.	6						32	2		2	11
<i>Hydropsyche</i> sp.											25
<i>Hydropsyche</i> sp.	23	11		124		3	199	15	41	420	452
<i>Ibityrichia</i> sp.				5							
<i>Lepidomena</i> sp.											126
<i>Mayairichia ayama</i>				22		48					4
<i>Nectopsyche candida</i>											
<i>Nectopsyche gracilis</i>	29			5		3	3	4	30	2	4
<i>Neurichia</i> sp.											
<i>Neureclipsis</i> sp.											
<i>Ochrotrichia</i> sp.				73						41	2,379
<i>Oecetis</i> sp.							8	2		2	68
<i>Polycentropus</i> sp.							3				
<i>Proclitus</i> sp.						16					47
<i>Smicridea</i> sp.	6,215	80		2,204		199				6	1,353

Table 19 (continued)
Benthic Macroinvertebrate Data

Parameter	Station									
	11	12	12	13	14	15	16	17	18	
DATE	032493	032493	032493	011193	011293	011293	011393	011493	011493	
TIME	0835	1343	1343	1400	1415	1700	1000	1000	1500	
SAMPLING METHOD	Surber	Surber	snags	snags	Surber	snags	snags	snags	snags	
COMMUNITY INDICES										
Number of Species	46	41	27	35	39	29	40	34	31	
Number of Individuals/m ²	1,903	14,801	18,300	2,534	443	7,947	35,642	42,517	8,977	
Diversity	3.88	3.89	3.28	3.60	4.24	3.08	3.79	3.10	3.43	
Redundancy	0.34	0.28	0.32	0.36	0.29	0.39	0.29	0.39	0.32	
Equitability	0.70	0.73	0.69	0.70	0.80	0.63	0.71	0.61	0.69	
EPT Index	17	5	2	7	10	8	6	5	6	
TNRCC Mean Point Score	3.50	2.67	2.17	3.17	3.67	2.33	2.50	2.33	2.33	
Ohio ICI	38	22	14	30	36	30	24	28	28	
FUNCTIONAL FEEDING GROUPS (% of community)										
Grazers	22.91	3.45	1.50	8.06	23.31	4.44	1.18	0.92	2.06	
Gatherers	24.59	4.84	6.54	23.15	13.67	6.90	2.19	2.14	3.00	
Filterers	28.97	1.55	0.06	3.84	22.82	5.76	5.77	23.58	32.04	
Miners	7.50	70.99	63.15	29.62	20.47	69.63	77.15	54.36	56.66	
Shredders	3.91	8.09	15.87	21.44	7.92	7.57	10.26	16.52	2.16	
Predators	12.12	11.07	12.88	13.90	11.81	5.69	3.45	2.48	4.06	

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	11	12	12	13	14	15	16	17	18	
NEMATODA										
unidentified species	3	36	104		2			36	459	
HIRUDINEA										
<i>Helobdella stagnalis</i>		32								
<i>Helobdella triseriatis</i>		22								
OLIOCHAETA										
<i>Aelosoma</i> sp.		309	1,122						276	
<i>Branchiura sowerbyi</i>	5									
<i>Chaetogaster cristallinus</i>							2,601			
<i>Chaetogaster diaphanus</i>				6						
<i>Chaetogaster diastrophus</i>										
<i>Dero diglata</i>		850								
<i>Dero trifida</i>		771	1,284				5,723	503	94	
<i>Ilyodrilus templetoni</i>										
<i>Limnodrilus hoffmeisteri</i>		1,543		6						
<i>Limnodrilus</i> sp.										
<i>Limnodrilus udekemianus</i>										
Lumbricidae										
<i>Nais behringi</i>				6	30	706	5,203	11,034	2,100	
<i>Nais pardalis</i>										
<i>Nais simplex</i>				6		94			365	
<i>Nais variabilis</i>		771	4,008	6			3,122	36	1,006	
<i>Pristina aequiseti</i>										
<i>Pristina americana</i>		388								
<i>Pristina leidy</i>		79	162						94	
<i>Pristina osborni</i>				6						
<i>Pristina lima</i>										
<i>Sparganophilus kamensis</i>										
<i>Stephensoniiana trivandranus</i>										
<i>Waspia mobilis</i>		79								
GASTROPODA										
<i>Cincinnatia cincinnatensis</i>	5				2	6				
<i>Cochliophina rogersensis</i>					2					
<i>Elmilia comalensis</i>										
<i>Ferrissia rivularis</i>	11	283	6	6	11	6				
<i>Melanoides granifera</i>										
<i>Physella virgata</i>	13	68	127		2	11	14	148		
<i>Pyrgophorus spinosus</i>					2					

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	11	12	12	13	14	15	16	17	18	
PELECYPODA										
<i>Corbicula fluminea</i>	428	230			6					
<i>Pisidium casertanum</i>										
<i>Pisidium compressum</i>										
AMPHIPODA					17					
<i>Hyallela azteca</i>										
CLADOCERA										
<i>Daphnia</i> sp.										
COPEPODA										
<i>Macrocyclus</i> sp.										
DECAPODA					6					
<i>Palaeomonetes vulgaris</i>										
MYSIDACEA					4					
<i>Neomysis</i> sp.										
OSTRACODA										
<i>Cardania</i> sp.				19						
<i>Cypridopsis vidua</i>										
<i>Herpetocypris</i> sp.										
<i>Ilyocypris</i> sp.				52						
<i>Limnocythere</i> sp.										
<i>Stenocypris</i> sp.										
HYDRACARINA							7			
<i>Atractides</i> sp.										
<i>Brachypoda</i> sp.				6						
<i>Hydrozetes</i> sp.										
<i>Sperchon</i> sp.										
unidentified species										
COLEOPTERA										
<i>Chrysomelidae</i>								4		
<i>Cyphon</i> sp.							74	18		
<i>Dubiraphia</i> sp.									4	
<i>Enochrus</i> sp.										
<i>Helichus suturalis</i>										

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	11	12	12	13	14	15	16	17	18	
<i>Helelmls</i> sp.		4	116	6		6	81			
<i>Hexacyclops ferrugineus</i>										
<i>Hydrochus</i> sp.								4		
<i>Laccophilus ac terminalis</i>										
<i>Leurochus luteus</i>					2					
<i>Macrelms texanus</i>	3				2					
<i>Microcyclus pusillus</i>	3	57	156		4	11	108	112	112	
<i>Ochubellus</i> sp.							7			
<i>Paracymus</i> sp.							14			
<i>Paracymus subcypreus</i>										
<i>Psephenus texanus</i>	5									
Saltidae										
Suphyllidae							54			
<i>Stenelmis cheryl</i>										
<i>Stenelmis occidentalis</i>				6	2		14			
<i>Stenelmis</i> sp.		36								
DIPTERA										
<i>Ablabesmyla malloch</i>				13		254	196			
<i>Ablabesmyla</i> sp.								94	12	
<i>Aurichopogon</i> sp.										
<i>Axarus</i> sp.										
<i>Brachydeutera</i> sp.		29								
<i>Cardiocladius</i> sp.										
Chironomini genus A										
Chironomini genus B								157	171	
<i>Chironomus decorus</i> gr.							196			
<i>Cladomyia</i> sp. gr. A										
<i>Cladomyia</i> sp. gr. B										
<i>Cladomyia</i> sp. gr. C										
<i>Cladomyia</i> sp. gr. D										
<i>Cladomyia</i> sp. gr. E										
<i>Cladomyia</i> sp. gr. F										
<i>Cladomyia</i> sp. gr. G										
<i>Cladomyia</i> sp. gr. H										
<i>Cladomyia</i> sp. gr. I										
<i>Cladomyia</i> sp. gr. J										
<i>Cladomyia</i> sp. gr. K										
<i>Cladomyia</i> sp. gr. L										
<i>Cladomyia</i> sp. gr. M										
<i>Cladomyia</i> sp. gr. N										
<i>Cladomyia</i> sp. gr. O										
<i>Cladomyia</i> sp. gr. P										
<i>Cladomyia</i> sp. gr. Q										
<i>Cladomyia</i> sp. gr. R										
<i>Cladomyia</i> sp. gr. S										
<i>Cladomyia</i> sp. gr. T										
<i>Cladomyia</i> sp. gr. U										
<i>Cladomyia</i> sp. gr. V										
<i>Cladomyia</i> sp. gr. W										
<i>Cladomyia</i> sp. gr. X										
<i>Cladomyia</i> sp. gr. Y										
<i>Cladomyia</i> sp. gr. Z										
<i>Cladomyia</i> sp. gr. AA										
<i>Cladomyia</i> sp. gr. AB										
<i>Cladomyia</i> sp. gr. AC										
<i>Cladomyia</i> sp. gr. AD										
<i>Cladomyia</i> sp. gr. AE										
<i>Cladomyia</i> sp. gr. AF										
<i>Cladomyia</i> sp. gr. AG										
<i>Cladomyia</i> sp. gr. AH										
<i>Cladomyia</i> sp. gr. AI										
<i>Cladomyia</i> sp. gr. AJ										
<i>Cladomyia</i> sp. gr. AK										
<i>Cladomyia</i> sp. gr. AL										
<i>Cladomyia</i> sp. gr. AM										
<i>Cladomyia</i> sp. gr. AN										
<i>Cladomyia</i> sp. gr. AO										
<i>Cladomyia</i> sp. gr. AP										
<i>Cladomyia</i> sp. gr. AQ										
<i>Cladomyia</i> sp. gr. AR										
<i>Cladomyia</i> sp. gr. AS										
<i>Cladomyia</i> sp. gr. AT										
<i>Cladomyia</i> sp. gr. AU										
<i>Cladomyia</i> sp. gr. AV										
<i>Cladomyia</i> sp. gr. AW										
<i>Cladomyia</i> sp. gr. AX										
<i>Cladomyia</i> sp. gr. AY										
<i>Cladomyia</i> sp. gr. AZ										
<i>Cladomyia</i> sp. gr. BA										
<i>Cladomyia</i> sp. gr. BB										
<i>Cladomyia</i> sp. gr. BC										
<i>Cladomyia</i> sp. gr. BD										
<i>Cladomyia</i> sp. gr. BE										
<i>Cladomyia</i> sp. gr. BF										
<i>Cladomyia</i> sp. gr. BG										
<i>Cladomyia</i> sp. gr. BH										
<i>Cladomyia</i> sp. gr. BI										
<i>Cladomyia</i> sp. gr. BJ										
<i>Cladomyia</i> sp. gr. BK										
<i>Cladomyia</i> sp. gr. BL										
<i>Cladomyia</i> sp. gr. BM										
<i>Cladomyia</i> sp. gr. BN										
<i>Cladomyia</i> sp. gr. BO										
<i>Cladomyia</i> sp. gr. BP										
<i>Cladomyia</i> sp. gr. BQ										
<i>Cladomyia</i> sp. gr. BR										
<i>Cladomyia</i> sp. gr. BS										
<i>Cladomyia</i> sp. gr. BT										
<i>Cladomyia</i> sp. gr. BU										
<i>Cladomyia</i> sp. gr. BV										
<i>Cladomyia</i> sp. gr. BW										
<i>Cladomyia</i> sp. gr. BX										
<i>Cladomyia</i> sp. gr. BY										
<i>Cladomyia</i> sp. gr. BZ										
<i>Cladomyia</i> sp. gr. CA										
<i>Cladomyia</i> sp. gr. CB										
<i>Cladomyia</i> sp. gr. CC										
<i>Cladomyia</i> sp. gr. CD										
<i>Cladomyia</i> sp. gr. CE										
<i>Cladomyia</i> sp. gr. CF										
<i>Cladomyia</i> sp. gr. CG										
<i>Cladomyia</i> sp. gr. CH										
<i>Cladomyia</i> sp. gr. CI										
<i>Cladomyia</i> sp. gr. CJ										
<i>Cladomyia</i> sp. gr. CK										
<i>Cladomyia</i> sp. gr. CL										
<i>Cladomyia</i> sp. gr. CM										
<i>Cladomyia</i> sp. gr. CN										
<i>Cladomyia</i> sp. gr. CO										
<i>Cladomyia</i> sp. gr. CP										
<i>Cladomyia</i> sp. gr. CQ										
<i>Cladomyia</i> sp. gr. CR										
<i>Cladomyia</i> sp. gr. CS										
<i>Cladomyia</i> sp. gr. CT										
<i>Cladomyia</i> sp. gr. CU										
<i>Cladomyia</i> sp. gr. CV										
<i>Cladomyia</i> sp. gr. CW										
<i>Cladomyia</i> sp. gr. CX										
<i>Cladomyia</i> sp. gr. CY										
<i>Cladomyia</i> sp. gr. CZ										
<i>Cladomyia</i> sp. gr. DA										
<i>Cladomyia</i> sp. gr. DB										
<i>Cladomyia</i> sp. gr. DC										
<i>Cladomyia</i> sp. gr. DD										
<i>Cladomyia</i> sp. gr. DE										
<i>Cladomyia</i> sp. gr. DF										
<i>Cladomyia</i> sp. gr. DG										
<i>Cladomyia</i> sp. gr. DH										
<i>Cladomyia</i> sp. gr. DI										
<i>Cladomyia</i> sp. gr. DJ										
<i>Cladomyia</i> sp. gr. DK										
<i>Cladomyia</i> sp. gr. DL										
<i>Cladomyia</i> sp. gr. DM										
<i>Cladomyia</i> sp. gr. DN										
<i>Cladomyia</i> sp. gr. DO										
<i>Cladomyia</i> sp. gr. DP										
<i>Cladomyia</i> sp. gr. DQ										
<i>Cladomyia</i> sp. gr. DR										
<i>Cladomyia</i> sp. gr. DS										
<i>Cladomyia</i> sp. gr. DT										
<i>Cladomyia</i> sp. gr. DU										
<i>Cladomyia</i> sp. gr. DV										
<i>Cladomyia</i> sp. gr. DW										
<i>Cladomyia</i> sp. gr. DX										
<i>Cladomyia</i> sp. gr. DY										
<i>Cladomyia</i> sp. gr. DZ										
<i>Cladomyia</i> sp. gr. EA										
<i>Cladomyia</i> sp. gr. EB										
<i>Cladomyia</i> sp. gr. EC										
<i>Cladomyia</i> sp. gr. ED										
<i>Cladomyia</i> sp. gr. EE										
<i>Cladomyia</i> sp. gr. EF										
<i>Cladomyia</i> sp. gr. EG										
<i>Cladomyia</i> sp. gr. EH										
<i>Cladomyia</i> sp. gr. EI										
<i>Cladomyia</i> sp. gr. EJ										
<i>Cladomyia</i> sp. gr. EK										
<i>Cladomyia</i> sp. gr. EL										
<i>Cladomyia</i> sp. gr. EM										
<i>Cladomyia</i> sp. gr. EN										
<i>Cladomyia</i> sp. gr. EO										
<i>Cladomyia</i> sp. gr. EP										
<i>Cladomyia</i> sp. gr. EQ										
<i>Cladomyia</i> sp. gr. ER										
<i>Cladomyia</i> sp. gr. ES										
<i>Cladomyia</i> sp. gr. ET										
<i>Cladomyia</i> sp. gr. EU										
<i>Cladomyia</i> sp. gr. EV										
<i>Cladomyia</i> sp. gr. EW										
<i>Cladomyia</i> sp. gr. EX										
<i>Cladomyia</i> sp. gr. EY										
<i>Cladomyia</i> sp. gr. EZ										
<i>Cladomyia</i> sp. gr. FA										
<i>Cladomyia</i> sp. gr. FB										
<i>Cladomyia</i> sp. gr. FC										
<i>Cladomyia</i> sp. gr. FD										
<i>Cladomyia</i> sp. gr. FE										
<i>Cladomyia</i> sp. gr. FF										
<i>Cladomyia</i> sp. gr. FG										
<i>Cladomyia</i> sp. gr. FH										
<i>Cladomyia</i> sp. gr. FI										
<i>Cladomyia</i> sp. gr. FJ										
<i>Cladomyia</i> sp. gr. FK										
<i>Cladomyia</i> sp. gr. FL										
<i>Cladomyia</i> sp. gr. FM										
<i>Cladomyia</i> sp. gr. FN										
<i>Cladomyia</i> sp. gr. FO										
<i>Cladomyia</i> sp. gr. FP										

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	11	12	12	13	14	15	16	17	18	
<i>Geranomys</i> sp.								166	6	
<i>Chydolendipes</i> sp. gr. A				6	2					
<i>Goeldichironomus holoprasinus</i> gr.				13			3,189	7,978	24	
<i>Goeldichironomus pictus</i> gr.					2					
<i>Hemerodromia</i> sp.	3			13	2				94	
<i>Labrundinia neopilosella</i>			98							
<i>Labrundinia</i> sp.					17		7		6	
<i>Limnophila</i> sp.							20			
<i>Limnophora</i> sp.					50		1,993	1,564	159	
<i>Nanocladius distinctus</i>	5	366								
<i>Nanocladius minutus</i>										
<i>Nanocladius rectinervis</i>			301		99			939	488	
<i>Nilothauma</i> sp.										
<i>Orthocladus</i> (<i>Eudactylocladius</i>) sp.					2		196			
<i>Orthocladus</i> (<i>Eurothocladus</i>) sp.										
<i>Orthocladus</i> (<i>Orthocladus</i>) or <i>clarki</i>		2,077	98							
<i>Orthocladus</i> (<i>Orthocladus</i>) or <i>denifer</i>	11	1,711	602	39	50	657	797			
<i>Orthocladus</i> (<i>Orthocladus</i>) sp.										
<i>Parachironomus arcuatus</i> gr.			98					157	94	
<i>Parachironomus frequens</i> gr.										
<i>Paracletus</i> sp.										
<i>Paracletopelma campolobis</i> gr.										
<i>Parakiefferiella</i> or <i>batophila</i>										
<i>Pedionomus bectae</i>								157		
<i>Pentaneura</i> sp.										
<i>Polyphemus convictus</i>	51	2,935	405	58	2		196			
<i>Polyphemus illinoense</i>	135	610	5,633	512	2	508	1,993	2,503	53	
<i>Polyphemus</i> or <i>scalaeum</i> sp. B										
<i>Probrezia</i> sp.										
<i>Pseudochironomus</i> sp.	57	244								
<i>Rheotanytarsus exiguus</i> gr.				13	17	155	1,196	157		
<i>Sarcophaga</i> sp.							7			
<i>Simulium</i> or <i>bivittatum</i>										
<i>Simulium</i> or <i>trivittatum</i>										
<i>Simulium</i> or <i>vitatum</i>										
<i>Simulium</i> sp.			6	13						
<i>Stenochironomus</i> sp.			405					315	118	
<i>Tabanus</i> sp.										
<i>Tanytarsus glabrescens</i> gr.										
<i>Tanytarsus guertus</i> gr.				19		811	797	36	65	
<i>Tanytarsus</i> or <i>coffmani</i>						50				

Table 19 (continued)
Benthic Macroinvertebrate Data

Taxon	Station									
	11	12	12	13	14	15	16	17	18	
<i>Tetropelopia</i> sp.							196	625		
<i>Thienemannella</i> cf. <i>fusca</i>						408	399			
<i>Thienemannella</i> cf. <i>xena</i>			301	19						
<i>Thienemannella</i> sp.				84					24	
<i>Thienemannimyia</i> sp.										
<i>Tribelos</i> sp.										
EPHEMEROPTERA										
<i>Acentrella carolina</i>										
<i>Acentrella insignificans</i>										
<i>Baetis ephippialus</i>										
<i>Baetodes edmundsi</i>										
<i>Brachycercus</i> sp.	105	4							6	
<i>Caenis latipennis</i>								13		
<i>Callibaetis</i> sp.										
<i>Camelobaetidius mexicanus</i>	13									
<i>Centropilum</i> sp.										
<i>Choroterpes</i> (<i>Neochoroterpes</i>) <i>mexicanus</i>	51	4		285	15	50	20			
<i>Fallaceon quillerti</i>										
<i>Hepiagenia</i> sp.	62									
<i>Isomyia sicca manca</i>					2					
<i>Lepidophyes apache</i> gr.										
<i>Lepidophyes packert</i>				26		11	7	4		
<i>Rhytrogena</i> sp.				6	6					
<i>Stenonema</i> sp.	374									
<i>Thraulodes gonzalesi</i>	22									
<i>Traverella presidiana</i>	5									
<i>Tricorythodes albilineatus</i> gr.	8	7		318	24	77	203			
<i>Tricorythodes curvatus</i> gr.										
HEMIPTERA										
<i>Ambrysus circumcinctus</i>										
<i>Belostoma</i> sp.	11								36	
<i>Cryptorhincos hungerfordi</i>										
Corixidae	30									
<i>Limnocoris luzi</i>	5	4								
<i>Merrigala</i> sp.										
<i>Rhagovelia</i> sp.										
LEPIDOPTERA										
<i>Parapopovus</i> sp.	3									

TABLE 23. Ratings of Rio Grande sites downstream of Falcon Reservoir and on Arroyo Los Olmos using a modified Index of Biotic Integrity.

Metric	SITES									
	12D	13	14	15	16	17	18			
1. Total number of species	11	3	21	5	21	5	18	5	11	3
2. % of individuals as estuarine/marine species	96.05	1	3.3	5	13.79	5	10.26	5	10.82	5
3. % of individuals in most abundant species	61.98	1	38.21	5	26.60	5	35.19	5	55.67	1
4. Total number of individuals	--		82	1	98	1	74	1	49	1
a. Individuals per hour electrofishing					5	1	33	1	18	1
b. Individuals per seine haul	101	5	--							
Mean		5		1		1	1			
5. % diseased individuals	0.24	5	0.47	5	1.97	1	0.00	5	0.00	5
6. % of individuals as introduced species	0.49	5	8.96	3	10.84	3	3.23	5	3.09	5
Total IBI score	20	24	20	26	20	22	19			

TABLE 24. Ratings of middle reach tributaries on the Rio Grande using a modified Index of Biotic Integrity.

Metric	SITE							
	6A	6B	7B	8D	9B			
1. Total number of species	12	3	15	5	12	3	18	5
2. Number of minnow species	7	5	4	3	2	1	4	3
3. % of individuals in most abundant species	34.81	5	38.84	5	18.52	5	42.68	3
4. Total number of individuals								
a. Individuals per hour electrofishing	110	1	213	3	246	5	350	5
b. Individuals per seine haul	26	1	62	3	2	1	48	3
Mean		1		3		3		4
5. % diseased individuals	0.00	5	0.19	5	0.00	5	0.00	5
6. % of individuals as introduced species	45.19	1	39.59	1	42.59	1	21.08	1
	20	22	18	21	23			

Table 25
Ranking of Mainstem Sites Based on Seventeen
Components of the Toxic Chemical Evaluation*

Station	Station Description	Rank
12	downstream from Laredo/Nuevo Laredo	1.0
7	upstream from Del Rio/Acuna	2.0
2	downstream from El Paso/Juarez	3.0
16	downstream from Hidalgo/Reynosa	4.0
3	upstream from Presidio/Ojinaga	5.0
5	at mouth of Santa Elena Canyon	6.5
14	downstream from Anzalduas Dam	6.5
8	downstream from Del Rio/Acuna	8.0
1	upstream from El Paso/Juarez	9.0
17	upstream from Brownsville/Matamoros	10.0
11	upstream from Laredo/Nuevo Laredo	11.0
4	downstream from Presidio/Ojinaga	12.0
10	downstream from Eagle Pass/Piedras Negras	13.0
6	at Foster Ranch near Langtry	14.5
15	upstream from Hidalgo/Reynosa	14.5
18	downstream from Brownsville/Matamoros	16.0
13	upstream from Anzalduas Dam	17.0
9	upstream from Eagle Pass/Piedras Negras	18.0

* - a rank of "1.0" reflects adverse implications; "18.0" reflects favorable implications

Table 26
Ranking of Tributary Sites Based on Twelve
Components of the Toxic Chemical Evaluation*

Station	Station Description	Rank
1a	El Paso PSB Haskell Street WWTP outfall	1.0
11c	Arroyo el Coyote	2.0
2a	Juarez sewage discharge canal	3.0
11a	Zacate Creek	4.0
12d	Arroyo Los Olmos	5.0
15a	Anhelo Drain	6.0
10a	Manadas Creek	7.0
9a	unnamed tributary 3.6 km below Piedras Negras	8.0
11b	Chacon Creek	9.0
3a	Rio Conchos	10.0
8e	Maverick Canal	11.0
12c	Rio San Juan	12.0
12a	Rio Salado	13.0
7b	San Felipe Creek	14.0
12b	Rio Alamo	15.0
5a	Terlingua Creek	16.0
7a	Arroyo de las Vacas	17.0
12e	Puertecitos Drain	18.0
3b	Alamito Creek	19.0
8c	Las Moras Creek	20.0
6b	Devils River	21.0
8a	Pinto Creek	22.0
9b	Rio Escondido	23.0
8b	Rio San Diego	24.0
6a	Pecos River	25.0
8d	Rio San Rodrigo	26.0

* - a rank of "1.0" reflects adverse implications; "26.0" reflects favorable implications

APPENDIX B

Figures

UNITED STATES

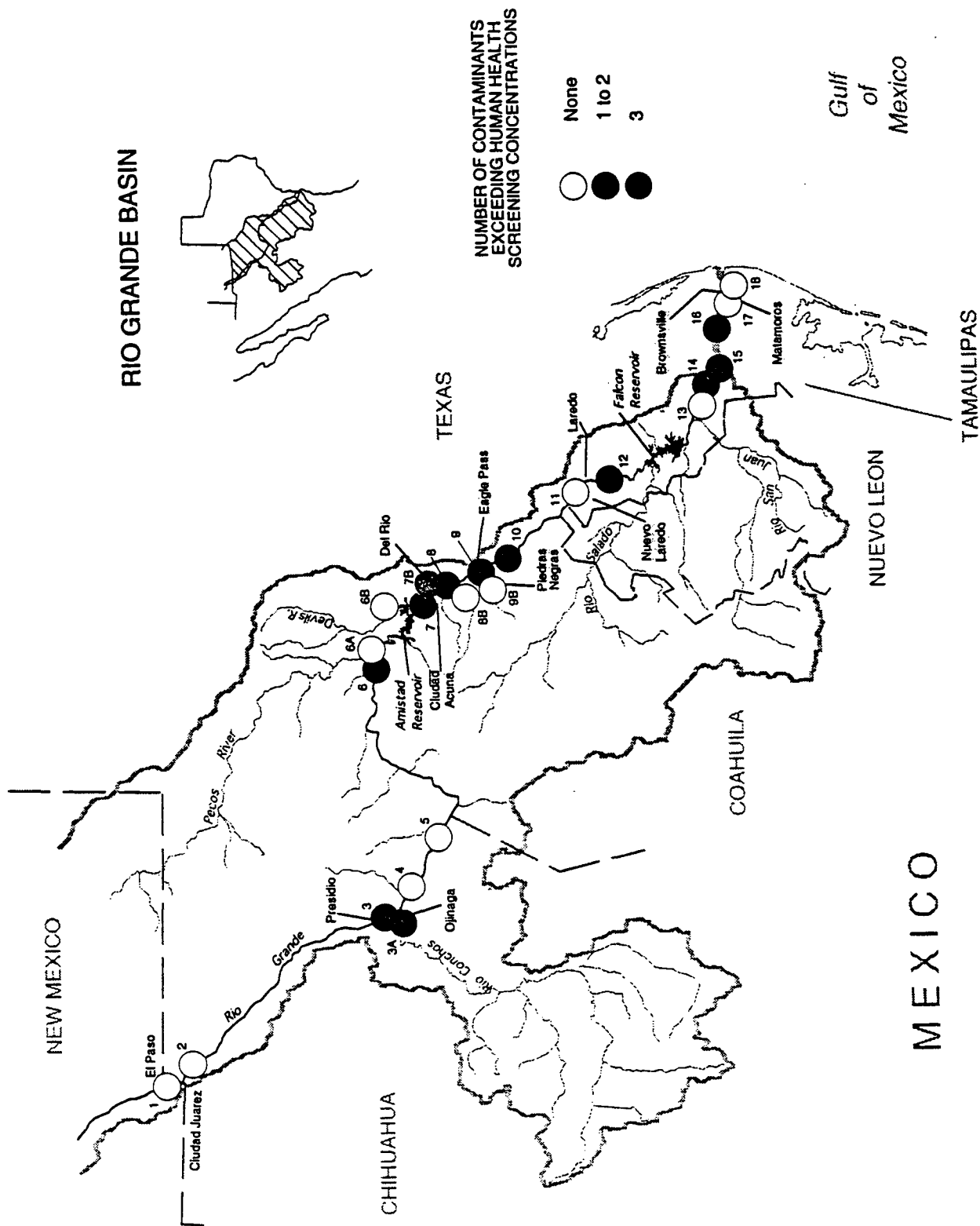
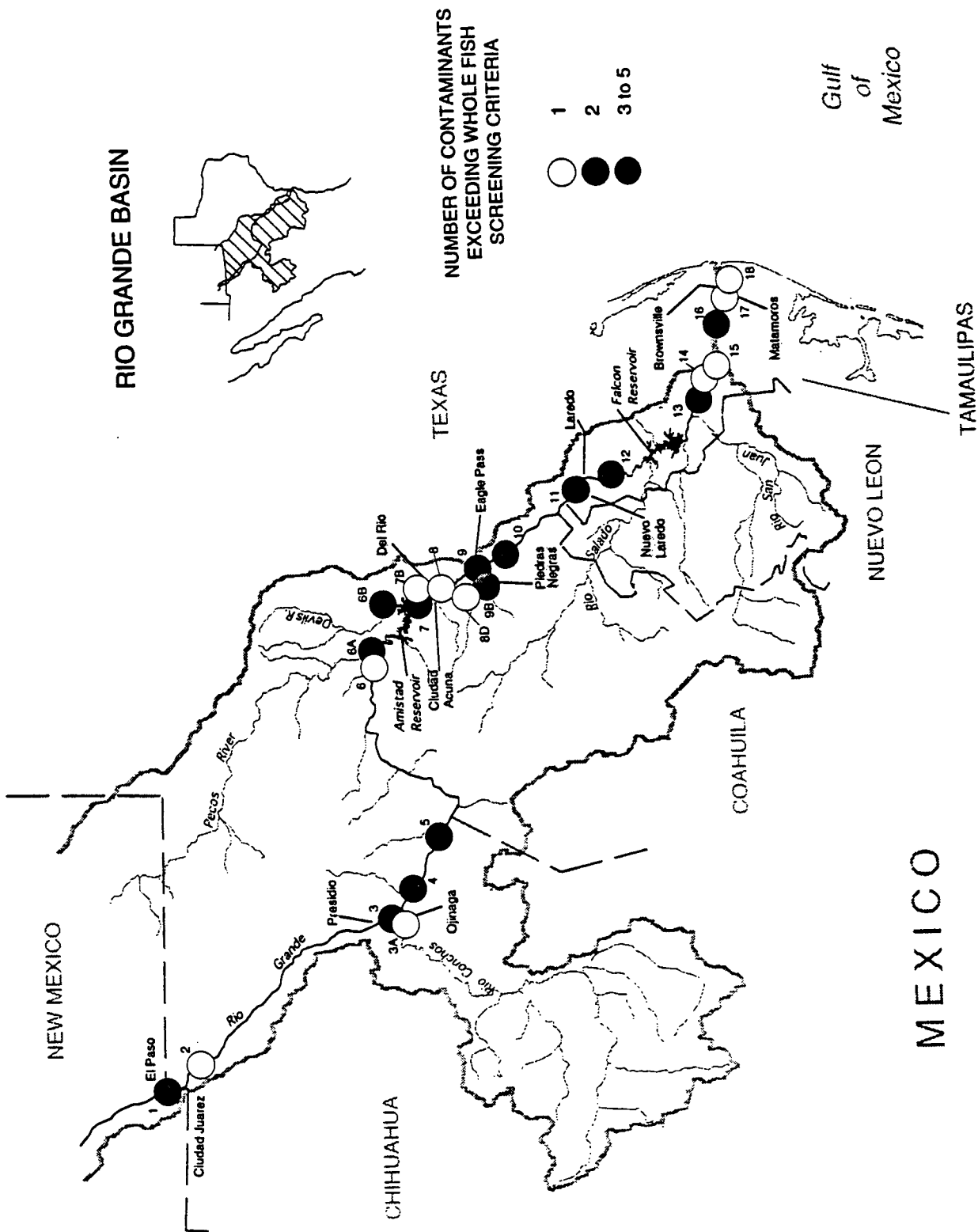


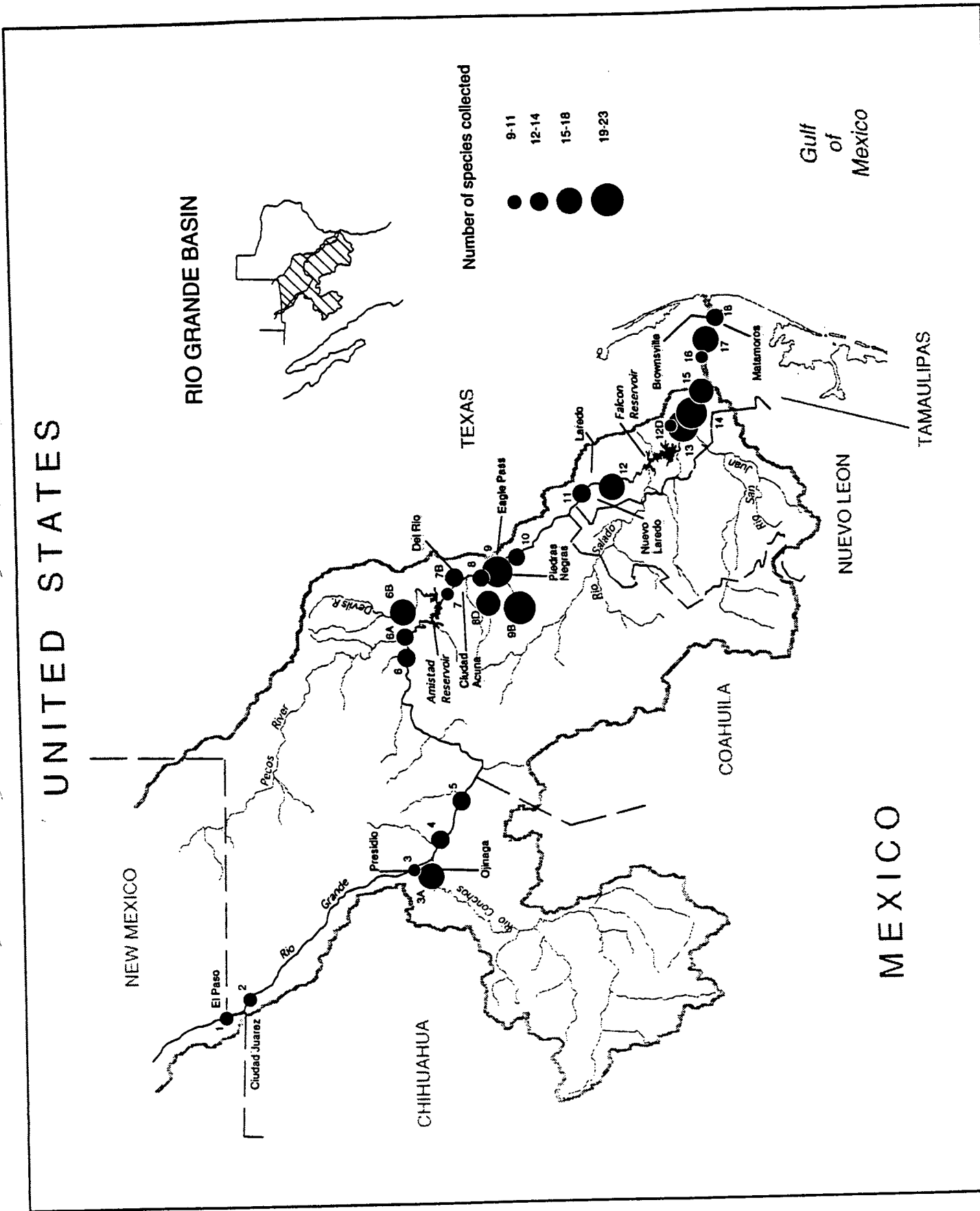
Figure 2. Sites with contaminant concentrations in fish filets exceeding human health screening levels. See table 1 for site descriptions.

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Produced by: River Studies, Resource Protection Division, TPWD (V. 2.3)

Figure 3. Sites with contaminant concentrations in whole fish exceeding 85th percentiles or mean concentrations. See table 1 for site descriptions.



Produced by: River Studies, Resource Protection Division, TPWD (V. 2.2)

Figure 5. Number of fishes collected at selected sites. See table 1 for site descriptions.

APPENDIX C

Quality Assurance Measures

The study was conducted in accordance with a quality assurance project plan (TNRCC, 1992b) approved by USEPA Region 6 on January 4, 1993. Quality assurance procedures are described in detail in that document. An evaluation of specific data quality measures is summarized below.

Field Blanks

Field blanks were analyzed at a frequency of about 10% (one per survey; 4 blanks/45 ambient water samples). Blanks consisted of type 2 deionized water furnished by the lab, carried to the field and handled and preserved identically to ambient water samples. Analyses were performed for volatile organics, semivolatile organics, pesticides, and metals. Results are presented in the following table.

Analytical Data - Field Blanks^a

Parameter ^b	1st survey (Nov. 1992)	2nd survey (Jan. 1993)	3rd survey (Feb. 1993)	4th survey (Mar. 1993)
METALS				
antimony	6.4 (6.4X)	7.8 (7.8X)	7.8 (7.8X)	9.2 (9.2X)
nickel	8.0 (1.7X)	ND	ND	ND
selenium	ND	ND	5.8 (2.9X)	ND
silver	ND	ND	3.4 (3.4X)	ND
zinc	5.5 (1.1X)	ND	ND	ND

^a - values in table represent concentration in $\mu\text{g/L}$, followed in parentheses by factor by which concentration exceeded minimum detection limit

^b - only parameters that occurred above detection limits are included in table

ND - not detected

No organics were detected in any of the blanks, but five metals did occur above detection limits. Nickel, selenium, silver, and zinc each were detected in one blank, while antimony was detected in all four blanks.

Possible factors responsible for metals in the blanks included: (1) pre-contamination of type 2 deionized water furnished by the lab; (2) pre-contamination of metals-grade HNO_3 preservative furnished by the lab; (3) leaching of metals from peristaltic pump tubing, in-line filters, or sample container walls; (4) contamination from the atmosphere or the gloves of sample collectors; and (5) contamination in the lab during analytical procedures.

Judging from the frequency of occurrence, factors (4) or (5) probably were responsible for nickel, selenium, silver, and zinc contamination, while factors (1) through (3) were most likely

responsible for antimony contamination. Further evaluation strongly suggests that type 2 deionized water was the main source of antimony, as concentrations in the blanks exceeded those in ambient water samples. This observation was brought to the attention of the lab, to enable them to check their type 2 deionized water supply for antimony. This will allow corrective action to be taken, if necessary, to eliminate recurrences.

Possible effects of nickel, selenium, silver, and zinc contamination on analytical results are considered negligible, based on minimal frequency of occurrence and relatively low concentrations in the blanks. A similar conclusion applies to antimony. Despite the fact that it occurred at relatively high concentrations in all the blanks, the apparent source was type 2 deionized water, which was not present in ambient water samples and therefore did not affect them.

In conclusion, the field blank evaluation indicated that toxic chemical contamination of ambient water samples during collection, preservation, handling, and lab analysis was minimal, and that the probability that analytical results from the study were appreciably affected by procedural contamination was low.

Precision

Data precision was evaluated through analysis of duplicate water samples, which were employed at a frequency of about 10% (one per survey; 4 duplicates/45 ambient samples). Duplicates represented split samples from selected sites that were collected, handled, and preserved using standard procedures. Parameters analyzed included volatile organics, semivolatile organics, pesticides, and metals. Results are presented in the table below.

Analytical Data - Duplicate Samples

Parameter ^a	Survey/Station	Duplicate Values (µg/L)		Mean (µg/L)	Standard Deviation	Coefficient of Variation ^b (%)	Target Coefficient of Variation (%)
		1	2				
METALS							
antimony	1st/5a	1.7	5.8	3.75	2.05	54.7	6.8
	2nd/17	5.9	1.7	3.8	2.1	55.3	6.8
	3rd/8	1.0	4.9	2.95	1.95	66.1	6.8
	4th/12	1.5	2.1	1.8	0.3	16.7	6.8
arsenic	2nd/17	4.2	3.2	3.7	0.5	13.5	11.2
	3rd/8	4.8	3.7	4.25	0.55	12.9	11.2
	4th/12	2.7	3.2	2.95	0.25	8.5	11.2
copper	2nd/17	2.8	2.4	2.6	0.2	7.7	2.5
	4th/12	<1.6 ^c	1.6	1.6	0	0	2.5
lead	1st/5a	<1.0 ^c	1.2	1.1	0.1	9.1	5.8
nickel	1st/5a	<4.7 ^c	7.3	6.0	1.3	21.7	4.5
selenium	1st/5a	5.5	5.9	5.7	0.2	3.5	6.8
	4th/12	<4.0 ^c	8.7	6.35	2.35	37.0	6.8

Analytical Data - Duplicate Samples (continued)

Parameter ^a	Survey/Station	Duplicate Values (µg/L)		Mean (µg/L)	Standard Deviation	Coefficient of Variation ^b (%)	Target Coefficient of Variation (%)
		1	2				
silver	4th/12	2.9	<2.7 ^c	2.8	0.1	3.6	3.1
zinc	1st/5a	<5.0 ^c	6.4	5.7	0.7	12.3	3.3
	2nd/17	5.8	5.8	5.8	0	0	3.3
						Mean 20.2	
						Max 66.1	
						Min 0	

- ^a - only parameters that occurred above detection limits are included in table
^b - calculated as (100)(standard deviation)/mean
^c - detection limit value was employed in calculations

Eight metals were the only parameters that occurred above detection limits. Coefficients of variation for duplicate values generally exceeded target levels by small to moderate amounts. However, the precision targets are for laboratory duplicates, whereas field duplicates were employed in this study. Because field duplicates are inherently more variable, the degrees by which target levels were exceeded are not considered unacceptable. It was concluded that precision was satisfactory for the purposes of this study.

Accuracy

Blanks, spikes, and quality control samples were analyzed in accordance with requirements of USEPA-accredited laboratories, as described in the quality assurance project plan. Results were not reported by the lab, but any problems incurred were noted on ambient sample forms.

The laboratory was unable to achieve specified accuracy requirements for certain parameters. These instances are denoted by single asterisks in Tables 10, 11, and 12. Corresponding data were not utilized; their omission is accounted for in the "Completeness" subsection below.

There were only two other instances of questionable data accuracy, both involving pesticide concentrations associated with GC/MS semivolatile organics analysis. For one batch of 14 water samples, the endrin spike precision statistic was outside quality control limits. For one batch of 10 sediment samples, aldrin spike recovery was outside quality control limits.

However, pesticides were also analyzed by another technique, Nickel 63 Detector analysis, from which data utilized for this report for almost all of the pesticides, including endrin and aldrin, were derived. The latter technique is more sensitive and utilizes much lower detection limits than the former technique. Since the GC/MS semivolatile organics data in question were not utilized, the aforementioned spike sample excursions were inconsequential.

Completeness

A target of 90% completeness was established in the quality assurance project plan. As shown in the following table, the target level was achieved, with a margin of +3.3%.

Data Completeness Summary

	Water		Sediment		Tissue		Benthos		Nekton	
	T ^a	A ^a	T	A	T	A	T	A	T	A
(A) # of stations	40 ^a	45 ^b	40 ^a	45 ^b	24 ^c	24 ^c	18 ^d	18 ^d	24 ^e	25 ^e
(B) # of samples	40 ^f	45 ^f	40 ^f	45 ^f	96 ^g	94 ^h	18 ^f	20 ⁱ	24 ^f	25 ^f
(C) # of parameters	177 ^j	167 ^k	166 ^l	150 ^k	162 ^m	141 ^k	1 ⁿ	1 ⁿ	1 ^o	1 ^o
(D) # of data points	7,080 ^p	7,482 ^q	6,640 ^p	6,750 ^q	15,552 ^p	13,083 ^q	18 ^p	20 ^q	24 ^p	25 ^q

(E) total # of data points targeted = 29,314

(F) total # of data points achieved = 27,360

OVERALL COMPLETENESS = (F)/(E) X 100 = 93.3%

- ^a - T = targeted; A = achieved
- ^a - 18 major mainstem stations and 22 tributary stations
- ^b - 18 major mainstem stations, one supplementary mainstem station, and 26 tributary stations
- ^c - 18 major mainstem stations and six tributary stations
- ^d - 18 major mainstem stations
- ^e - 18 major mainstem stations and seven tributary stations
- ^f - one sample per station
- ^g - four samples per station
- ^h - number of samples per station varied from one to four, depending on the availability of appropriate fish species
- ⁱ - one sample per station plus two duplicates
- ^j - 161 toxic chemicals, 13 field/conventional parameters, one flow measurement, and two toxicity measurements
- ^k - represents the maximum achieved; varied from sample to sample, depending on how many valid values were reported by the lab
- ^l - 161 toxic chemicals, three conventional parameters, and two toxicity measurements
- ^m - 161 toxic chemicals and one conventional parameter
- ⁿ - represents comprehensive evaluation of macrobenthic community structure
- ^o - represents comprehensive evaluation of nekton community structure
- ^p - (B) X (C)
- ^q - (B) X (C) minus missing data points

Representativeness

Station siting, sampling of an array of media (water, sediment, fish tissue, biota), and use of approved field and analytical methods ensured that measurement data did represent actual instream conditions. The ability to accurately characterize an entire system is dependent on the number of sampling sites and types of analyses employed. In this regard, the study was

meticulously designed to achieve maximal representativeness, within the scope of available resources.

Comparability

Data comparability was ensured through the employment of standard field and laboratory techniques described in the quality assurance project plan. Analytical methods were derived from USEPA approval lists published in the *Federal Register*. Procedures were consistent among surveys, except in rare instances where slight modifications proved necessary. Any divergences are described in the methods section of this report. None were utilized that would have affected data comparability.

APPENDIX D

**Evaluation of Water Quality Data by Comisión Nacional del Agua
(1973 to 1993)**

MEXICO

NATIONAL WATER COMMISSION
SUBDIRECTORATE GENERAL FOR WATER ADMINISTRATION, QUALITY MANAGEMENT,
WATER REUSE, AND ENVIRONMENTAL IMPACT

NATIONAL WATER QUALITY MONITORING NETWORK
EVALUATION OF WATER QUALITY - RIO BRAVO

DESCRIPTION

The Rio Grande basin is located in the states of Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas on the Mexican side, and in the state of Texas on the U.S. side; states in which both governments share the waters. It is therefore important to understand and know the quality of its waters, and for this purpose, the government of Mexico, through its National Water Commission (CNA), has conducted continuous monitoring since the 1970's with monitoring stations registered in the national network.

WATER QUALITY

This document presents the trends from 1976 to 1993 in some of the significant physical and chemical parameters, and in the Indices of Water Quality, relative to the quality of the Rio Grande at 12 stations in the National Monitoring Network, for their classification in accordance with the "Ecological Criteria for Water Quality" of Mexico and the Water Quality Index.

The evaluated monitoring sites are: 1) Cd. Juarez, 2) Ojinaga, 3) Amistad Dam, 4) Acuna, 5) Piedras Negras, 6) Nuevo Laredo, 7) Falcon Dam, 8) Miguel Aleman, 9) Camargo, 10) Reynosa, 11) Nuevo Progreso, and, 12) Matamoros. The locations of these sites are presented in the annexed form, in a table and in a chart.

The parameters analyzed are: Biochemical Oxygen Demand, Chemical Oxygen Demand, Fecal Coliform, Sulfates, Total Dissolved Solids, and Specific Conductivity.

BIOCHEMICAL OXYGEN DEMAND:

The values for this parameter tend to increase during the period 1976 to 1993 in the river reach between Cd. Juarez and Ojinaga to 11 and 15 mg/l; and then decrease to less than 3 mg/l in the following reach to Cd. Acuna, and then continue in a constant average around this value all the way to Matamoros. The water quality is acceptable for most water uses.

CHEMICAL OXYGEN DEMAND:

In the whole reach from Cd. Juarez to Matamoros, the value for this parameter remains at an average of less than 20 mg/l which makes the waters of the Rio Grande acceptable for any use, except in the reach from Cd. Miguel Aleman to Nuevo Progreso where the value increases well above 45 mg/l on average, which restricts certain water uses, principally potable water supply.

FECAL COLIFORM:

The presence of this parameter stands out in most of the monitoring sites, and it is considered that it should not appear in water used for potable water supply purposes, and restricted for other uses.

SULFATES:

In general, sulfates appear on average at a value below 250 mg/l, a value which makes the water acceptable for all uses.

TOTAL DISSOLVED SOLIDS:

The majority of the values, on average, are above 500 mg/l, making this water not acceptable for potable water supply purposes, and, as far as irrigation is concerned, it can only be used for certain special tolerant crops; it is likewise acceptable for cattle.

SPECIFIC CONDUCTIVITY:

For this parameter, the above comments for Total Dissolved Solids also apply.

INDEX OF WATER QUALITY:

In order to know the state of the water regarding its quality and use, CNA applies an Index of Water Quality considering 18 physical, chemical, and bacteriological parameters, which for a better understanding by the general public, ranges from zero (0) for the worst case to 100 for the optimum quality.

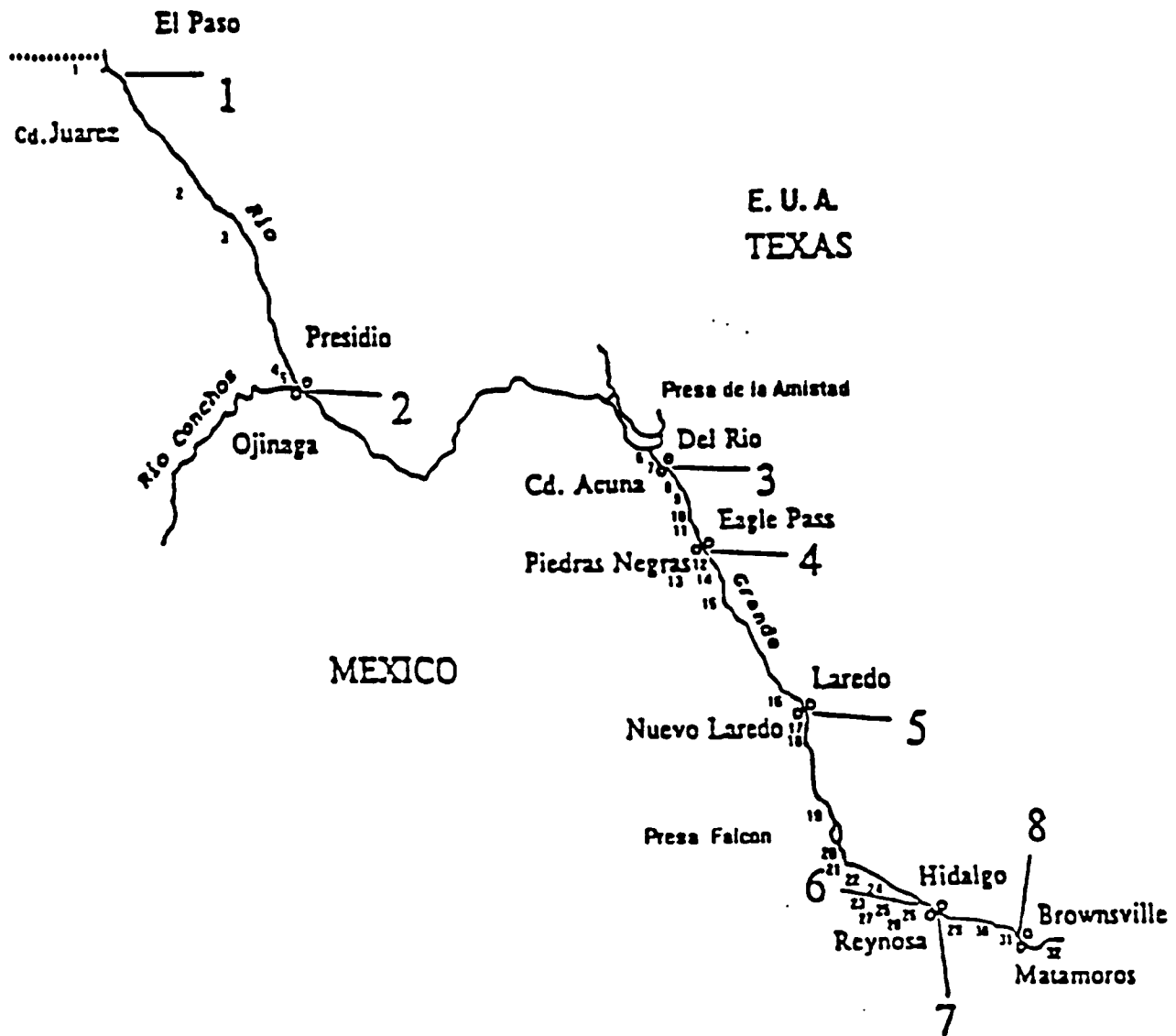
Attached are water quality index results for the 12 monitoring sites for the period 1976-1993, as well as the scale for classifying water uses.

****SEE ATTACHED TABLE AND MAP****

PARAMETROS ADICIONALES : Chihuahua y Temauhtipas (O.D., P-PO₄ T, SAAM, TURB., S.SED. Y N-NO₃).
Chihuahua (TEMP., AGUA, C Y A, P-PO₄ ORTO, ALC.FEN., N-NO₂, ACIDEZ T., HCO₃, STP, SSV, SDV, SDF, SSV, STV, ESTREPT. Y CO₃).
..... ALC.FEN., N-NO₂ Y D.Mg).

MEXICO 1993
COMISION NACIONAL
DEL AGUA

MONITOREO DE LA
CALIDAD DEL AGUA
RIO BRAVO
(RIO GRANDE)



Appendix M

Detailed Risk Assessment

Nomenclature



*Environmental Science
and Engineering*
A BDM International Company

Brickland Refinery
Site Characterization and Risk Assessment

Geoscience Consultants, Ltd.

NOMENCLATURE

U.S. EPA	U.S. Environmental Protection Agency
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
HEAST	Health Effects Assessment Summary Tables (U.S. EPA)
IRIS	Integrated Risk Information System (U.S. EPA)
ATSDR	Agency for Toxic Substances and Disease Registry (U.S. Department of Health and Human Services)
HRA	Health Risk Assessment
DL	Detection Limit
MRL	Method Reporting Limit
QA/QC	Quality Assurance/Quality Control
ppb	part per billion (mass basis)
ppm	part per million (mass basis)
ppmv	part per million (volume basis)
NS	Not Sampled
NA	Not Applicable
ND	Not Detected
q*	cancer potency factor (mg/[kg body mass]/day) ⁻¹
CPF	cancer potency factor (mg/[kg body mass]/day) ⁻¹
CSF	cancer slope factor $\equiv$ cancer potency factor (mg/[kg body mass]/day) ⁻¹
RfD	Reference Dose (U.S. EPA) for ingestion and adjusted for dermal
RfC	Reference Concentration (U.S. EPA) for inhalation
VOC	Volatile Organic Compound
COC	Compounds of Concern
NOAEL	No Observed Adverse Effect Level
LOAEL	Lowest Observed Adverse Effect Level
UCL	Upper Confidence Limit
HI	Hazard Index
HQ	Hazard Quotient
L	liter
dL	deciliter (0.1 L)
mL	milliliter (0.001 L)
m	meter
m	mean
max	maximum
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
WQCC	Water Quality Control Commission
TPH	Total Petroleum Hydrocarbons
PAH	Polycyclic Aromatic Hydrocarbons

Brickland Refinery
Site Characterization and Risk Assessment

Geoscience Consultants, Ltd.

NOMENCLATURE (CONTINUED)

km	kilometer (1,000 m)
cm	centimeter (0.01 m)
mm	millimeter (0.001 m)
g	gram
mg	milligram (0.001 g)
µg	microgram (0.000001 g)
kg	kilogram (1,000 g)
mg/kg	milligram/kilogram (part per million [mass])
ft	foot/feet
fbg	feet below grade
in	inch
s	second
d	day
K	degree-kelvin (temperature: 0 K = 273.15°C)
mmHg	millimeter-mercury (pressure: 1 mmHg = 1/760 atmosphere at sea level)

Definitions

Brickland Refinery
Site Characterization and Risk Assessment

Geoscience Consultants, Ltd.

DEFINITIONS

Exposure	Contact of an organism with one or more substances
Exposure Route	Mode of substance bodily intake: inhalation, dermal sorption, ingestion
Exposure Pathway	Mode of substance transport from source to receptor—through air, soil, water, and food chain
Toxicity	Degree of adverse effect resulting from bodily intake of a substance—derived from a dose-response relationship: numerical value=RfD (non-cancer) and CSF (cancer)
Intrinsic Toxicity	Inherent/Relative toxicity—Toxicity of a substance, at a specified dose, compared to toxicity of all other substances: theoretically independent of dose
Risk	Probability of occurrence of an adverse effect from exposure to one or more toxic substances
Dose	Quantity of substance administered to body over a specified time period—units: mg/kg body mass/d or mg/[(kg body mass)d]
Epidemiology	Study of human populations to determine the cause of illnesses
Biotransformation	Chemical change of a substance caused by microorganisms
Soil-Gas	Gaseous substance between soil particles—source: groundwater, soil particles, free-phase substance
95th Percentile of Population	Two standard deviations from mean of a population of numbers—population may be "normal", "lognormal", or other statistical distribution
95th Percent Upper Confidence Limit (UCL)	The 95th percent UCL of a mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time.
Incremental Risk	Risk from a specific cause over and above the general risk from all causes
Intake Rate	Quantity of substance taken into body per unit time—units: mg/kg body mass/d or mg/[(kg body mass)d]
Henry's Law Constant (H' or H)	Ratio of concentration i in gas phase to concentration i in liquid phase— $[i]_g/[i]_l$
Mole of i	(mass of i)/(molecular mass of i)
Reference Dose (RfD)	U.S. EPA-approved intake rate for a substance unlikely to result in significant adverse effect—mostly acute effects, but chronic also
Acute/Chronic	Short-term/long-term

Appendix M Risk Assessment

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1.0 Overview

Human health risk assessment provides an estimate of the probability of an adverse effect resulting from exposure to one or more toxic substances. These adverse effects are directly related to the substance's intrinsic toxicity and the rate of intake into the body. The purpose of the risk assessment was to provide a technical basis for identifying and prioritizing potential risks associated with the Brickland Refinery site.

The risk assessment protocols in this document conform to the EPA guidelines for conducting human health risk assessments (EPA, 1989, 1990, 1991, 1992a, 1992b, 1992c). The detailed procedures used in conducting the health risk assessment and the results are found here in Appendix M. The following sections provide an explanation of the methodology and a brief summary of the elements of the health risk assessment process.

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2.0 Health Risk Assessment Methodology

Human health risk assessment (HRA) provides an estimate of the probability of an adverse effect resulting from exposure to one or more toxic substances. These adverse effects are directly related to the substance's inherent toxicity and the rate of intake into the body. The process for assessing human health risk from exposure to environmental constituents consists of several steps (See Figure 17). The methodology for assessing human health risk from exposure to environmental constituents consists of the following steps:

- Identify Compounds of Concern
 - Evaluate data from all environmental media from investigations at the site
 - Select chemical data for use in the risk assessment
- Exposure Assessment
 - Evaluate exposure route pathways
 - Identify exposure points and durations
 - Estimate exposure point concentrations
 - Quantify compound intake rate at exposure points
- Toxicity Assessment
 - Identify toxicity values
 - Evaluate non-carcinogenic effects
 - Evaluate carcinogenic effects
- Risk Characterization
 - Risk calculations
 - Combining risks across exposure pathways and multiple components
- Determine Uncertainty and Assumptions

The exposure and risk estimates were evaluated based on current and potential future uses of the site. Current case exposures were evaluated for potential inhalation of volatile compounds detected in soil, groundwater, LNAPL, and inhalation of organic and inorganic compounds adhering to surface soil particles.

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The Current I on-site exposure scenario is restricted to present on-site worker exposures without the implementation of administrative and engineering controls and site health and safety procedures (i.e., use of personnel protection equipment). Current II was evaluated to examine potential worker exposure under similar site conditions but with the addition of administrative controls and health and safety procedures.

Two different future on-site scenarios were developed. Future I on-site conditions assume that current site activities (inactive, industrial) would remain constant throughout the 30-year exposure period. Future II conditions assume construction of a museum on site and that on-site visitors would have direct contact with the volatile emissions originating from soils and groundwater.

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3.0 Identification of Compounds of Concern (COCs)

A site characterization was completed in two phases at the Brickland site beginning in 1989. The data obtained from this study formed the basis for evaluating human health risks associated with exposure to compounds identified at the site.

Soils impacted by past activities at the site are located in the southern two thirds of the site. Hydrocarbons (TPH) have been observed in soils at depths from 6 inches to 12 feet below ground surface (bgs) at concentrations up to 6,200 mg/kg. BTEX and PAHs have also been detected with concentrations in excess of 10,000 µg/kg. Arsenic, barium, chromium, and lead were detected at varying levels in soils. However, these metals appear to be bound within the soil, as evidenced by low TCLP analytical results and insignificant levels in groundwater.

Groundwater has been affected in the southern portion of the site. Free phase hydrocarbons have only been observed in several monitoring wells with thicknesses ranging from several tenths of a foot up to about 3 feet in MW-10. Free-phase hydrocarbons appear to occur in isolated areas primarily associated with saturated sand lenses and are not considered to be continuous. BTEX compounds observed in groundwater coincide with areas where soils have also been impacted by hydrocarbons. Benzene concentrations in groundwater range up to 23,000 ppb. PAHs and phenols have been observed in isolated areas of the southern portion of the site. WQCC metals have been detected sporadically and no apparent trends have been observed. Major cations and anions analyses suggest that the groundwater at the site has high levels of sulfate and chloride, and is attributed to the regional groundwater quality.

3.1 Compounds of Concern in Soil

Metals, VOCs, and PAHs with established health-based criteria that have been detected in soils were included as compounds of potential concern in the HRA. Summary data for these compounds including mean concentrations are shown in Table 4. Concentrations of compounds detected at various depths at one location were averaged to provide mean concentrations. This is a conservative approach since inhalation of soil dust particles from surface soils will not expose receptors to the actual averaged concentrations found in soils over depth. Following U.S. EPA risk assessment guidance documents, a compound detected at least once in an environmental medium was also included in the HRA (EPA, 1989a). Furthermore, it was assumed that the concentration for each sample in which a compound was

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not detected is one-half the detection limit. The mean and maximum concentrations are therefore calculated based not only on the detected concentrations of each compound, but also assuming one-half the sample detection limits for non-detects to provide a greater margin of safety. Total petroleum hydrocarbons (TPH), as such, were not evaluated in the health risk assessment. Instead, the individual compounds of concern found in the LNAPL were evaluated as appropriate.

3.2 Compounds of Concern in Groundwater

Quarterly groundwater samples have been collected from 11 on-site and eight off-site monitoring wells since December 1993. The resulting analytical data were used as the groundwater data base for the health risk assessment. Samples were analyzed for BTEX, metals, PAHs, phenols, and hydrocarbons. Based on frequency of detection and potential for future impacts, four volatile aromatics, two phenols, six PAHs, and eight metals were considered for inclusion in the HRA.

Tables 5 and 6 provide summary information regarding the mean and maximum concentrations in on- and off-site wells for each compound of concern. The greatest quantity of free-phase hydrocarbon (LNAPL) has been observed in monitoring well MW-10. Table 7 summarizes the different constituents found in the free-phase hydrocarbon and their respective concentrations. TPHs detected in groundwater were not considered compounds of potential concern in the HRA, for the reasons explained earlier regarding hydrocarbons in soil.

3.3 Compounds of Concern in Air

Air emissions in the vicinity of the site have not been evaluated. It is believed that the vast majority of organic constituents are locked in the clay rich soils in the vadose zone and migrate into the atmosphere very slowly. Dispersion of particulate matter has also not been investigated and has not been verified by actual atmospheric sampling.

3.4 Compounds of Concern in Surface Water

Analyses of water samples collected from the Rio Grande have not shown any trace of compounds attributable to the Brickland Refinery. Sampling by the International Boundary Water Commission also has not indicated any problem. Monitoring well MW-6S is an off-site groundwater monitoring well located east of

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the southeastern portion of the site. This well is the only off-site well adjacent to the river that has consistently shown the presence of benzene and is the most probable route for groundwater beneath the site to impact the surface waters of the Rio Grande. Benzene is present in this well at an average concentration of 100 parts per billion (ppb). Benzene has not been observed in surface water samples from the Rio Grande, and benzene in MW-6S does not appear to have had an impact on sediments and surface water.

Sediment samples have been analyzed to determine if benzene from the Brickland site is impacting the Rio Grande. Since sampling of the Rio Grande water has failed to detect benzene, direct sampling of soils immediately adjacent to MW-6S and from the nearby river bed was recommended.

Xylenes were the only compound detected in the riverbed sample. It was observed in one sample out of 20 at a low concentration near the detection limit (1 ppb). However, this low level of xylenes is significantly below health-based standards.

3.5 Concentrations for Compounds of Concern (COCs)

The maximum observed concentration of each COC was used as the baseline concentration in the health risk assessment for the following reasons.

Typically, the mean concentration of each compound and a 95th percentile upper confidence limit (UCL) concentration is used to evaluate health risks. The 95th percentile UCL is calculated to ensure that the true mean concentrations are not underestimated (EPA, 1992d) and provides a safety margin for all subsequent risk analysis.

The analytical data collected during the site investigation did not follow a typical log-normal distribution (EPA, 1992d), nor was it normally distributed. Calculation of the 95th percentile UCL for most COCs resulted in values five to ten times higher than the maximum observed concentrations and is likely the result of the variability in the soil and groundwater data. In instances like this, the EPA recommends using the maximum observed concentration to ensure the suggested conservative concentration estimate.

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4.0 Exposure Assessment

The most probable routes of human exposure were identified in this step of the risk assessment. The exposure assessment provides estimates of receptor exposure to the compounds detected at the Brickland Refinery site. The U.S EPA identifies four tasks for the exposure assessment:

- Identification of relevant and significant pathways of residential and worker exposure
- Identification of potential receptor locations
- Estimation of exposure point concentrations for each COC in each medium of concern
- Estimation of chemical intake rate for all exposure routes

Four exposure scenarios were developed for the exposure assessment. These included evaluations of exposure potential for site conditions as they currently exist, with and without the implementation of administrative and engineering controls and health and safety procedures, projected future use assuming no change in site conditions and restricted access (Future I), and future development with public access (Future II).

4.1 Exposure Route-Pathways

An exposure route-pathway describes the course a compound takes from the source to the potential exposure point, and is characterized by the following four elements: (1) a source or media of concern and a mechanism of release (e.g., volatilization, runoff); (2) a retention or transport medium (or media in cases involving transfer of compounds); (3) a potential exposure point for contact with the medium of concern (a receptor location); and (4) an exposure route (e.g., ingestion) at the exposure point. An exposure pathway is considered complete only when each of these elements is present.

In order to identify all possible exposure pathways, anticipated or previously documented activities on or around the site were categorized as occurring either on- or off-site, currently, or in the future. Potential receptors, the environmental media of concern (i.e., soil, groundwater, air, LNAPL), and potential exposure

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routes (i.e., oral, inhalation, dermal) were then identified for each activity. One hundred ninety three route-pathways were evaluated.

Appendix O provides a detailed description of the possible exposure routes-pathways and the rationale for their selection or exclusion. A summary of the rationale used to identify the exposure route-pathways and to eliminate other pathways from further evaluation is described below:

Excluded Route-Pathways

- Inhalation by industrial workers of volatile organics originating from soil-gas, soil particles, groundwater and LNAPL, and organics and inorganics from airborne soil particles due to the implementation of administrative controls, health and safety requirements, and the use of personnel protection equipment.
- Dermal exposure of workers to groundwater during sampling events is prevented by protective clothing.
- Surface water exposure route-pathways were eliminated based on contaminant transport modeling, river sediment sampling and surface water sampling, and results of the IBWC study.
- No receptor locations were identified for ingestion of groundwater and exposure does not exist owing to the absence of off-site and on-site drinking water wells.
- Direct exposure of residents and transient visitors to on-site compounds is unlikely to occur due to administrative controls and security.

Included Routes-Pathways

The following routes-pathways were included in the HRA:

- Inhalation by industrial workers of volatile organics originating from soil-gas, soil particles, groundwater and LNAPL, and organics and inorganics from airborne soil particles without the use of administrative controls, health and safety procedures, and personnel protection equipment.

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- Inhalation by residents (adult and child) of volatile organics originating from soil-gas, soil particles, groundwater and LNAPL, and organics and inorganics from airborne soil particles.

The selected routes-pathways were given an RP (route-pathway) designation, RP1 to RP25. Tables 8 and 9 summarize the exposure pathways that were selected for quantitative evaluation in this risk assessment. Exposure pathways numbered RP1 through RP4 are potentially present at the site under current industrial conditions (Current I). Numbers RP5 through RP8 assume continued normal activities at the site (Future I), and numbers RP9 to RP12 (Future II) assume the site will undergo some development, such as the operation of an on-site museum, and the public will have access. Exposure pathways numbered RP13 and RP14 are potentially present off site under current residential conditions, and numbers RP15 and RP16 are present under current industrial conditions. Similarly, exposure pathways numbered RP17 and RP18 represent off-site under current industrial conditions. Numbers RP19 represents Future I residential off-site, and RP20 to RP21 present Future I industrial conditions. RP22 to RP25 were included to re-evaluate the exposure conditions initially presented in RP1 to RP4, site exposure pathways under current industrial conditions, with the addition of required administrative controls and health and safety requirements (Current II).

4.2 Exposure Points and Durations

Exposure points are the assumed on- and off-site locations where potential receptors may come in contact with compounds of concern. A summary of the exposure points and activity patterns considered is provided below.

Groundwater is not used as a drinking water source in the immediate vicinity. There are no on-site water wells and a review of water well and land use survey indicate that no public, domestic, or industrial water wells are within 0.5-mile radius of the site. Therefore, no exposure points were identified for use of groundwater. Also, future beneficial use of off-site groundwater is unlikely because of the following:

- Municipal water is available.
- Off-site mountains restrict groundwater flow from the site.
- Nearby interstate roadway will make it unlikely that any wells would be installed.

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- The shallow groundwater upgradient of the site is saline and sulfate-rich, suggesting that the shallow aquifer is not suitable as a drinking water source.
- COCs are only in the saline and sulfate-rich shallow groundwater.

Surface water from the Rio Grande is diverted 1 mile downgradient from the site for use by the city of El Paso. Additional, non-quantified usage by Ciudad Juarez occurs as well. However, the IBWC report (Appendix L), river sampling, and river sediment sampling indicate that health based standards for the compounds of concern have not been exceeded. Contaminant transport modeling indicates that future exceedances are highly unlikely (Appendix P). Therefore, there are no demonstrable adverse impacts to Rio Grande water quality from the Brickland site. In addition, surface water runoff from precipitation is minimal due to low annual rainfall and high evapotranspiration. Surface water pathways were therefore not considered.

On-site workers may also be exposed to volatile organics and soil particles during installation and inspection of monitoring well and well points and collection of groundwater samples and measurements of water level elevations. Thus, site workers were considered as potential exposure receptors.

Adjacent land use was characterized as primarily undeveloped or rural. The closest residence is approximately 20 feet from the northern perimeter of the site and additional residences are located to the northwest and within a 1-mile radius. Potential off-site exposure from inhalation of volatile organics and soil particles does exist. Therefore, this was considered a route-pathway.

Since the maximum concentration of each COC was used as the baseline value for determining health risks, the 95th percentile UCL and mean for route-pathway specific HQs, HIs, and lifetime cancer risks were calculated using an alternate U.S. EPA method (EPA, 1989). This procedure involves varying the exposure duration (ED) to evaluate the 95th. percentile UCL and mean exposure risk when using the maximum observed concentration.

4.3 Estimation of Exposure Point Concentrations

Potential current and future inhalation exposure of workers and residents to compounds of concern was estimated during this phase. EPA approved soil and

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air dispersion models (Appendix Q) were used to project current and future concentrations in media at exposure points.

Results of the soil and air dispersion models were used to compute compound intake rates (Section 4.4) and are provided Appendix R.

4.4 Estimation of Compound Intake Rate

Intake rate is calculated using compound specific concentrations and exposure factors (generic equation/algorithm in Appendix Q). A description of the specific algorithms used to calculate compound intake rate is found in Appendices Q-1 to Q-5 and detailed calculations (spreadsheets) are provided in Appendix R. Table 10 summarizes the physical and chemical parameters required to calculate intake rates. Four to six spreadsheets were prepared for each route-pathway and consider non-cancer and cancer effects. Calculated parameters (bold heading) are found in the last two columns on the right. These have been calculated using other listed parameters and their appropriate algorithm from Appendix Q. The last sheet details calculated risks with overall risk numbers in bold. Essentially, if the concentration at an exposure point is known, the intake rate can be calculated directly using exposure parameters. If the concentration at an exposure point is unknown, it is estimated starting on Sheet 1.

- The following is a brief description of the spreadsheet calculations for each selected route-pathway (RP1 to RP4):

RP1: Inhalation of Volatile Organics from Soil Particles

Sheet 1 first calculates the concentration of vapor phase constituents in the soil (C_{isg}) using an algorithm (modified ideal gas equation) that assumes an equilibrium between compounds bonded to soil particles and present in the vapor phase (Appendix Q-2). Then, C_{isg} is used along with the appropriate diffusion rate, soil porosity, depth of compound, and release area to calculate an emission rate (Q_{is}) at the ground surface. The area term (Sheet 1), $A = (1/15 \text{ acre})$, is based on the estimated working area over the volatile emissions release area around the maximum observed benzene concentration (23 ppm) in groundwater. A concentrated value of 20 ppm was used to calculate the isopleth that was used in the area determination. This area term was used in all subsequent RP route-pathways to provide consistent and conservative estimates of exposure potentials. Sheet 2 calculates the compound concentration (C_{iad}) at the exposure point using

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the Q_i s from Sheet 1 and meteorological parameters. Minimal dispersion is assumed. Sheet 3 calculates intake rate using the C_{iad} from Sheet 2 and exposure factors. A mean exposure frequency (EF) equal to 5 d/y is assumed for an industrial worker. An absorption factor, $ABSF = 1$, assumes that once a vapor phase compound enters the lung, it is completely biologically available.

RP2: Inhalation of Volatile Organics from Groundwater

Sheet 1 calculates an emission rate (Q_{iw}) at the ground surface using a mass transport equation across a water-air interface (Appendix Q-3). It is assumed that the only resistance to the transport of the volatiles released from the groundwater to the ground surface is the unsaturated soil porosity. As for RP1, the area term (Sheet 1), $A = (1/15 \text{ acre})$, is based on the estimated working area over the soil-gas release area. Sheet 2 calculates the concentration (C_{iad}) at the exposure point using the Q_{iw} from Sheet 1, the unsaturated soil porosity, and meteorological parameters. Again, minimal dispersion is assumed. Sheet 3 calculates constituent intake rate using the C_{iad} from Sheet 2 and exposure factors. The exposure frequency (EF) is the same as that used in RP1, i.e., equal to 5 d/y for an industrial worker on site.

RP3: Inhalation of Volatile Organics from Free-Phase (LNAPL)

The calculation is similar to that for RP1. As for RP1, the area term (Sheet 1), $A = (1/15 \text{ acre})$, is based on the estimated working area over the volatile emissions release area. C_{isg} is calculated using the same modified ideal gas equation except that the partial pressure (ppi) of each compound is used instead of its intrinsic vapor pressure (pi)(Appendix Q-4). The emission rate (Q_i) at the ground surface is calculated as for RP1. However, because the soil is not considered part of the LNAPL, the mole fraction of the compound in soil (n_{fi}) is set equal to 1. C_{iad} and intake rate are calculated as for RP1.

RP4: Inhalation of Soil Particles

Sheet 1 calculates an intake rate directly from the soil concentration (C_{is}) using an EPA default particle emission factor, $PEF = 2.16E-10 \text{ kg/m}^3$ (Appendix Q-5). This assumes that there is little ground cover (such as vegetation) and that the wind speed is high enough to generate airborne particles. The same EF is used as that for RP1.

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- The following describes the method for calculating the compound intake rate for a future I, on-site, industrial condition (RP5 to RP8):

RP5: Inhalation of Volatile Organics from Soil Particles

The calculation is similar to that for RP1 except that the concentration is estimated for 10 years from current conditions. A time-varying model for volatile emissions (Thibodeaux-Hwang 1982) estimates that the concentration of BTEX after 10 years ($C_{i,t=10y}$) decrease to 1/5 the original concentration ($C_{i,t=0}$). (The volatility of the other compounds present in the soil is too low for significant loss of original quantity over a period of 10 years.) Intake rate is calculated using the same exposure factors as in RP1 Sheet 3).

RP6: Inhalation of Volatile Organics from Groundwater

The calculation is similar to that for RP2 except that compound concentration is estimated for 10 years from current conditions using the same method as for RP5 to estimate the concentration of BTEX 10 years in the future.

RP7: Inhalation of Volatile Organics from Free-Phase (LNAPL)

The calculation is similar to RP3. The loss of LNAPL constituents by volatilization is estimated differently than for RP5 and RP6. For RP7 (Sheet 1), an original emission rate ($Q_{i,t=0}$) is calculated using the measured concentrations ($C_{i,t=0}$) and the algorithm in Appendix Q-4. The time required for complete loss ($t, M_{i=0}$) is estimated using the total quantity of LNAPL and $Q_{i,t=0}$. Assuming a linear volatilization rate, a compound concentration 10 years in the future ($C_{i,t=10y}$) is calculated using compound partial pressures (ppi) derived from Sheet 2 and applying the algorithm from Appendix Q-4 to estimate future the emission rate (Q_i). Again assuming minimal dispersion (conservative) and applying meteorological parameters, C_{iad} is estimated at the ground surface (Sheet 3) and an intake rate is calculated using exposure factors (Sheet 4).

RP8: Inhalation of Soil Particles

The calculation is similar to that for RP4 (i.e., use of a default particle emission factor) and the compound concentration 10 years in the future is estimated as in RP5. An intake rate is calculated using similar exposure factors (Sheet 1).

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- The following describes the method for calculating the compound intake rate for a future II (operating a museum on site), on-site, industrial condition (RP9 to RP12):

RP9: Inhalation of Volatile Organics from Soil Particles

The calculation is similar to that for RP5 (Sheet 1 and Sheet 2) except that the exposure condition is different. It is assumed that a museum worker is on site year-round, i.e., 250 d/y (Sheet 3) for 25-y UCL and 9-y mean. A 10X dispersion ($F_{ia} = 0.1$) is assumed for transport of compounds from the outdoor ground surface to inside the museum via roof air intake (Sheet 3).

RP10: Inhalation of Volatile Organics from Groundwater

The calculation is similar to that for RP6 (Sheet 1 and Sheet 2) but with exposure conditions as in RP9 (Sheet 3). The same 10X dispersion factor ($F_{ia} = 0.1$) is assumed as for RP9.

RP11: Inhalation of Volatile Organics from Free-Phase (LNAPL)

The calculation is similar to that of RP7 except that the Future II condition specifies an on-site museum directly over the site area with the highest concentration of COCs. To be conservative, for LNAPL constituents that were not detected, concentrations were set at half their detection limit. The loss of LNAPL after 10 years is estimated based on the original emission rate ($Q_i, t=0$), the original measured compound concentration ($C_i, t=0$), and the algorithm in Appendix Q-4. (Note that the concentration of benzene is expected to reach zero in about nine years.) The exposure factors are the same as for RP9, i.e., it is assumed that a museum worker is on site year-round ($EF=250$ d/y, Sheet 4). As in RP9, a 10X dispersion factor ($F_{ia}=0.1$) is assumed for transport of constituent from the outdoor ground surface to inside the museum via air roof intake (Sheet 4).

RP12: Inhalation of Soil Particles

The calculation is similar to that for RP8 (Sheet 1) but with exposure conditions as in RP9 and the same 10X dispersion factor ($F_{ia} = 0.1$).

- The following describes the method for calculating the compound intake rate for a current, off-site, residential condition (RP13 and RP14):

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RP13: Inhalation of Volatile Organics from Free-Phase (LNAPL)

The calculation is similar to that for RP3 (Sheet 1 and Sheet 2) except that a 10X dispersion factor ($F_{ia} = 0.1$) is used to account for transport of compounds from on site to an off-site resident assumed to be 10 to 100 m downwind from the site (Sheet 3 and Sheet 5). Also, because this is a residential setting, an exposure frequency, $EF = 350$ d/y is used. Also, intake rate is calculated for a child (1 to 6 years old) and for an adult (7 to 30 years old).

RP14: Inhalation of Soil Particles

The calculation is similar to that for RP4 (Sheet 1 and Sheet 3) except for using a 10X dispersion factor ($F_{ia} = 0.1$) for the same reason as in RP13 and a residential exposure of $EF = 350$ d/y.

- The following describes the method for calculating the compound intake rate for a current, off-site, industrial condition (RP15 and RP18):

RP15: Inhalation of Volatile Organics from Soil Particles

The calculation is similar to that for RP1 (Sheet 1 and Sheet 2) except for using a 10X dispersion factor ($F_{ia} = 0.1$). The industrial exposure frequency is the same, i.e., $E_{fm} = 5$ d/y.

RP16: Inhalation of Volatile Organics from Groundwater

The calculation is similar to that for RP2 (Sheet 1 and Sheet 2). As for RP15, a 10X dispersion factor ($F_{ia} = 0.1$) and an industrial exposure frequency, $E_{fm} = 5$ d/y are used to calculate compound intake rate (Sheet 3).

RP17: Inhalation of Volatile Organics from Free-Phase (LNAPL)

The calculation is similar to that for RP3 except that it is for off-site exposure. Thus, it is assumed that an industrial worker is 10 to 100m from the site and that there is 10X dispersion ($F_{ia}=0.1$, Sheet 3). The industrial exposure is the same as for RP3, i.e., a site-specific $E_{fm}=5$ d/y.

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5.0 Toxicity Assessment

5.1 Overview and Regulatory Guidelines

Although the toxicity of a compound depends on the intake quantity and the duration of intake, it is its inherent toxicity that is the focus of toxicity assessment. Unfortunately, most human toxicity data and information comes from controlled animal studies and some uncertainty is associated with extrapolating the results of these studies to human receptors. However, EPA always takes a very conservative approach in developing health risk standards and much of this uncertainty is accounted for. Health risk data is published by a number of agencies including:

- EPA (including the Integrated Risk Information System [IRIS])
- Health Effects Assessment Summary Table (HEAST): EPA Office of Solid Waste
- The Cancer Assessment Group (CAG)
- International Agency for Research on Cancer (IARC)
- Agency for Toxic Substances and Disease Registry (ATSDR): U.S. Department of Health Services

Two types of toxicity are evaluated in the risk assessment. These include carcinogenic effects (chronic, or long-term) and non-carcinogenic effects (usually acute, or short-term, but also intermediate and chronic). Thus, this report separates risk estimates into these two classifications.

The EPA evaluates lifetime cancer risk by considering the strength of the evidence (the "weight-of-evidence") and dose-response relationships using a model to extrapolate from the relatively high doses administered to experimental animals to the lower exposure concentrations expected for human contact in the environment. A linearized-multistage model (e.g., Global 86) is used to determine the slope of the dose-response curve over the low dose, linear range of the cancer slope factor.

Acceptable incremental lifetime cancer risk may vary depending on its application and use, but generally, U.S. EPA considers a risk of 10^{-6} to be the point of departure where additional considerations may be warranted. Therefore, an incremental lifetime cancer risk of 10^{-6} or less is considered protective of human health and the environment at the Brickland site.

Acceptable non-cancer risk is usually based on Hazard Quotient (HQ) or Hazard Indices (HI) for non-carcinogens, the EPA also uses dose-response data.

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Generally, the most sensitive animal species are given relatively high doses and the highest No-Observable-Adverse-Effect-Level (NOAEL) is selected. Because of uncertainties in these studies (e.g., relating animal data to humans), a safety factor is applied to be sure of protecting human health—typically the NOAEL is divided by 1,000 to obtain an EPA-certified Reference Dose (RfD). Finally, Hazard Quotients (HQ) and Hazard Indices (HI) are calculated from RfDs and intake rates. According to EPA guidelines (EPA 1989a), HIs are added across all exposure route-pathways to determine a total HI. This is conservative because it assumes that all compounds affect the same target organ(s). If a total HI were to exceed 1.0, COCs could be grouped according to critical toxic effects and HIs calculated separately for each effect. An $HQ > 1$ or $HI > 1$ suggests concern for potential non-carcinogenic adverse health effects. HQ and HI are not statistical probabilities but only a qualitative guide of possible hazard.

5.2 Toxicity Data

The available toxicological information for each COC was reviewed based on available reference doses (RfDs) for compounds with non-cancer effects and EPA Carcinogenicity Classification.

Cancer slope factors (CSF) for carcinogens and applicable health-based standards for COCs were identified and are summarized in Table 11. If a value was available for only one route of exposure, then that value was used for all three routes of exposure (i.e. inhalation, ingestion, and adjusted dermal sorption). For this specific site, significant exposure is only by inhalation. If a Reference Dose (RfD) or Reference Concentration (RfC) was not available, then it was estimated by dividing a No-Observable-Adverse-Effect-Level (NOAEL ATSDR) by a safety factor of 1,000.

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6.0 Risk Characterization

6.1 General Procedure

- Non-cancer Risk for One Compound (HQ)
 $HQ = (\text{intake rate}) / RfD \dots\dots\dots (1)$
- Non-cancer Risk for Multiple Compounds (HI)
 $HI = \Sigma (HQ) \dots\dots\dots (2)$
- Non-cancer Risk - All Compounds & Route-Exposure Pathways
 $HI = \Sigma (HI_{pj}) = HI_{p1} + HI_{p2} + HI_{p3} + \dots HI_{pj} \dots (3)$
- Lifetime Cancer Risk (LCR)
 $LCR = (\text{cancer slope factor})(\text{intake rate}) \dots\dots\dots (4)$
- Lifetime Cancer Risk - All Compounds & Route-Exposure Pathways
 $\text{Overall LCR} = \Sigma (R_{pj}) = R_{p1} + R_{p2} + R_{p3} + R_{pj} \dots (5)$

Equations 1 to 5 are the basis for estimating risk. "Intake rate" is determined for each exposure route-pathway and for each compound. Cancer risks are calculated using intake rates and toxicity parameters (cancer slope factors [CSF]). Similarly, non-cancer risks are estimated using intake rates and toxicity parameters (Reference Dose [RfD] for ingestion/dermal sorption or Reference Concentration [RfC] for inhalation). Detailed risk calculation spreadsheets are included in Appendix R.

6.2 Risk Calculations

A summary of the estimated risk calculations is provided in Table 12.

Cancer Risk

Benzene contributes more than 95 percent of the total cancer risk from all COCs detected at the site. A review of the risk assessment results shows the pathway of concern is the inhalation of volatile organics from groundwater. For the UCL, this exposure route pathway results in an incremental cancer risk factor greater than $10E-06$ in Current I Conditions (on site - no controls) - Industrial as RP2, in Future I Conditions (on site) - Industrial as RP6, and in Future II Conditions (on site) - Industrial as RP10.

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Since on-site exposure is the pathway that must be addressed, Current Conditions II was evaluated to determine effective methods to mitigate on-site exposure. It implements on-site administrative and engineering controls to eliminate this pathway. The result is a total incremental cancer risk factor of less than $10E-06$. The recommended on-site institutional controls are discussed in Section 6.0 in the main text.

As discussed in Section 4.3, Future II Conditions assumes a museum on the site and estimates the exposure of museum workers (the population with the highest exposure). Since institutional controls are not practical in this situation, this site should not be developed given the current risk assumptions.

Non-Cancer Risk

Benzene contributes to more than 95 percent of the total non-cancer risk from exposure to all measured compound at the site. The highest non-cancer risk from the summation of four exposure routes-pathways from Current I, on-site, industrial workers is 0.649 for UCL statistical parameters. These risks do not exceed a Hazard Index of 1.0, the upper value the EPA considers unlikely for even sensitive populations to experience any adverse health effects from exposure to environmental COCs.

Lead Risk

To characterize health risks due to lead exposure, estimated blood-lead levels are compared to $10 \mu\text{g/Dl}$, which is the level of lead in blood believed by the EPA to be without adverse effect. An unacceptable health risk is deemed to exist when greater than 5 percent of exposed children are estimated to have blood-lead levels exceeding this value. As shown in Appendix R, the percentage of children (typical) estimated to have blood-lead levels exceeding $10 \mu\text{g/Dl}$ as a result of lead in soil is considerably less than 1 percent, i.e., when calculations are based on the maximum lead-soil concentration (74 mg/kg) obtained. This suggests that there is little or no risk from exposure to lead in soil for current and anticipated future land use at the Brickland Refinery site.

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7.0 References

- EPA 1986, Superfund Public Health Evaluation Manual. Office of Solid Waste and Emergency Response, EPA/540/1-86/060.
- EPA 1989a, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA/540/1-89/002.
- EPA 1988, Superfund Exposure Assessment Manual. EPA/540/1-88/001.
- EPA 1991, Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals). Publication 9285.7-01B.
- EPA 1992a, Dermal Exposure Assessment: Principles and Applications. EPA/600/8-91/011B.
- EPA 1992b, Guidance for Data and Usability in Risk Assessment (Part A). Publication 9285.7-09A, PB92-963356.
- EPA 1992c, Guidance for Data and Usability in Risk Assessment (Part B). Publication 9285.7-09B, PB92-963362.
- EPA 1992d, Supplemental Guidance to RAGS: Calculating the Concentration Term.
- EPA Guidance for Data Usability in Risk Assessment. EPA/540/G-90/008 (1990).
- Book I; Scientific and Technical Standards for Hazardous Waste Sites, Volume I: Site Characterization; Chapter 2 (Standards for Data Validation).
- California Department of Health Services, Toxics Substance Control Program, August 1990.
- EPA Integrated Risk Information System (IRIS). Specific computer printouts for each substance.
- Agency for Toxic Substances and Disease Registry (ATSDR). Specific volumes for each substance.

Appendix M Risk Assessment

Geoscience Consultants, Ltd.
REX114A.APM

- Farino, P. Spawn, M. Jasinsky, and B. Murphy. Evaluation and Selection of Models for Estimating Air Emissions from Hazardous Waste Treatment and Disposal Facilities. EPA (1983).
- Sax and R.J. Lewis, Jr. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold, 7th edition, New York, Volumes 1-3 (1989).
- Gherini, K.V. Summers, R.K. Munson, and W.B. Mills. Chemical Data for Predicting the Fate of Organic Compounds In Water, Volume 1: Technical Basis. Electric Power Research Institute, EA-5818 (1989).
- Gherini, K.V. Summers, R.K. Munson, and W.B. Mills. Chemical Data for Predicting the Fate of Organic Compounds In Water, Volume 2: Database. Electric Power Research Institute, EA-5818 (1988).
- Dragun. The Soil Chemistry of Hazardous Materials. Hazardous Materials Control Research Institute, Silver Spring Maryland (1988).
- Lyman, W.F. Reehl, and D.H. Rosenblatt. Handbook of Chemical Property Estimation Methods, Environmental Behavior of Organic Compounds. American Chemical Society, Washington, D.C. (1990).
- Calabrese and P.T. Kostecki. Petroleum-Contaminated Soils, Volume 2. Lewis Publishers, Chelsea, Michigan (1989).
- Howard. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume 1. Lewis Publishers, Chelsea, Michigan (1989).
- Howard. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume 2. Lewis Publishers, Chelsea, Michigan (1990).
- Gosselin, R.P. Smith, H.C. Hodge, and J.E. Braddock. Clinical Toxicology of Commercial Product, 5th edition, Williams & Wilkins, Baltimore (1981).
- Scientific and Technical Standards for Hazardous Wastes Sites. California Department of Health Services, Book II, Volume 2, 3, and 4, Exposure Assessment, Toxicity Assessment, Risk Characterization, and Soil Remediation Levels, respectively. Toxic Substances Control Program (Draft 1990).

Appendix M Risk Assessment

Geoscience Consultants, Ltd.
REX114A.APM

Konikow, L.F., and J.D. Bredehoeft, 1978. "Computer Model of Two-Dimensional Solute Transport and Dispersion in Groundwater", U.S. Geological Survey, Water-Resources Investigation, Book 7, Chapter C2.

Goode, D.J., and L.F. Konikow, "Modification of a Method-of-Characteristics Solute-Transport Model to Incorporate Decay and Equilibrium-Controlled Sorption or Ion Exchange," U.S. Geological Survey, Water-Resources Investigations Report 89-4030.

Fetter, C.W., 1993. Contaminant Hydrogeology, McMillan Publishing Company, New York, New York.

McWhorter, D.B., and D.K. Sunada, 1988. Groundwater Hydrology and Hydraulics, Water Resources Publications, Littleton, Colorado.

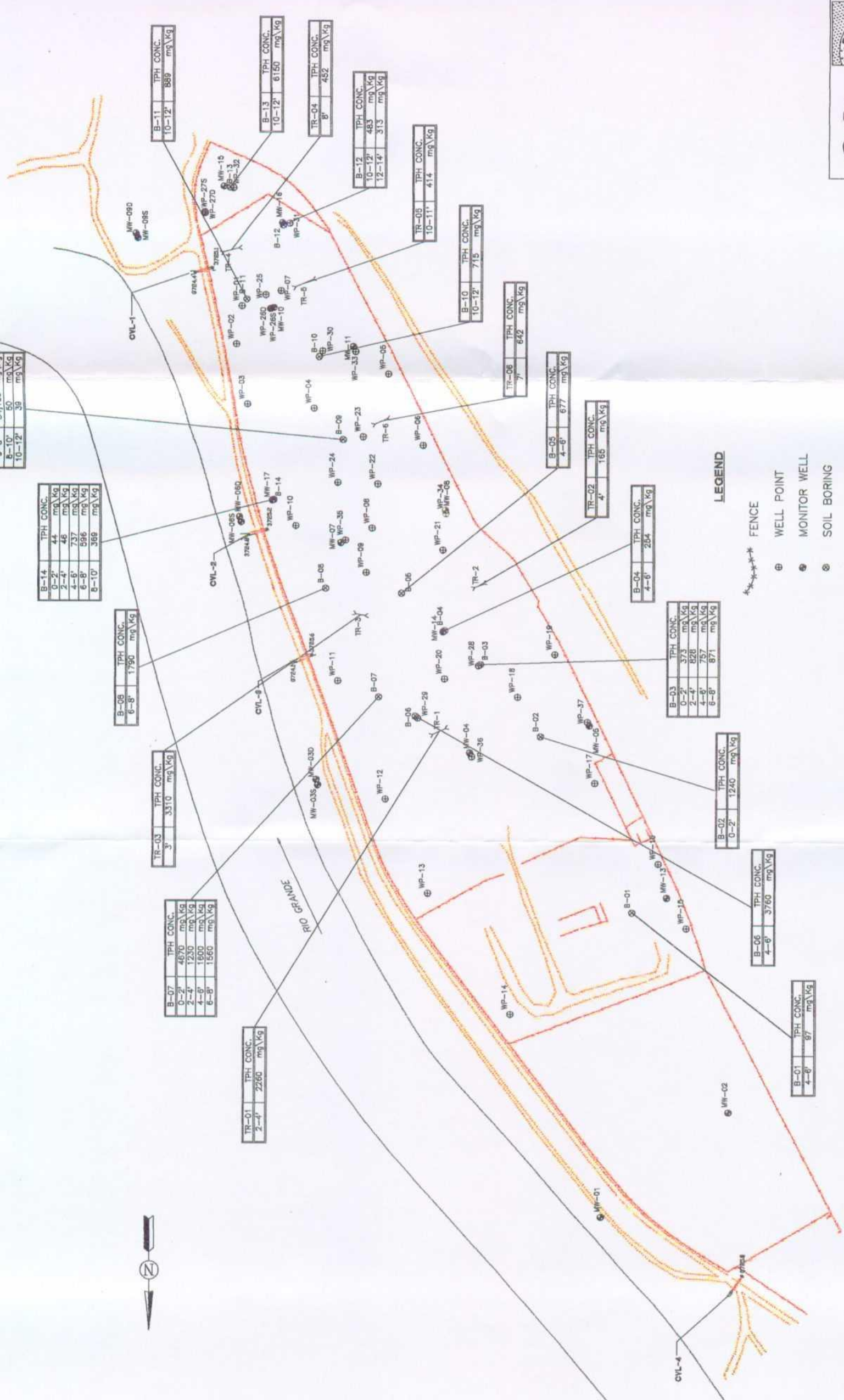
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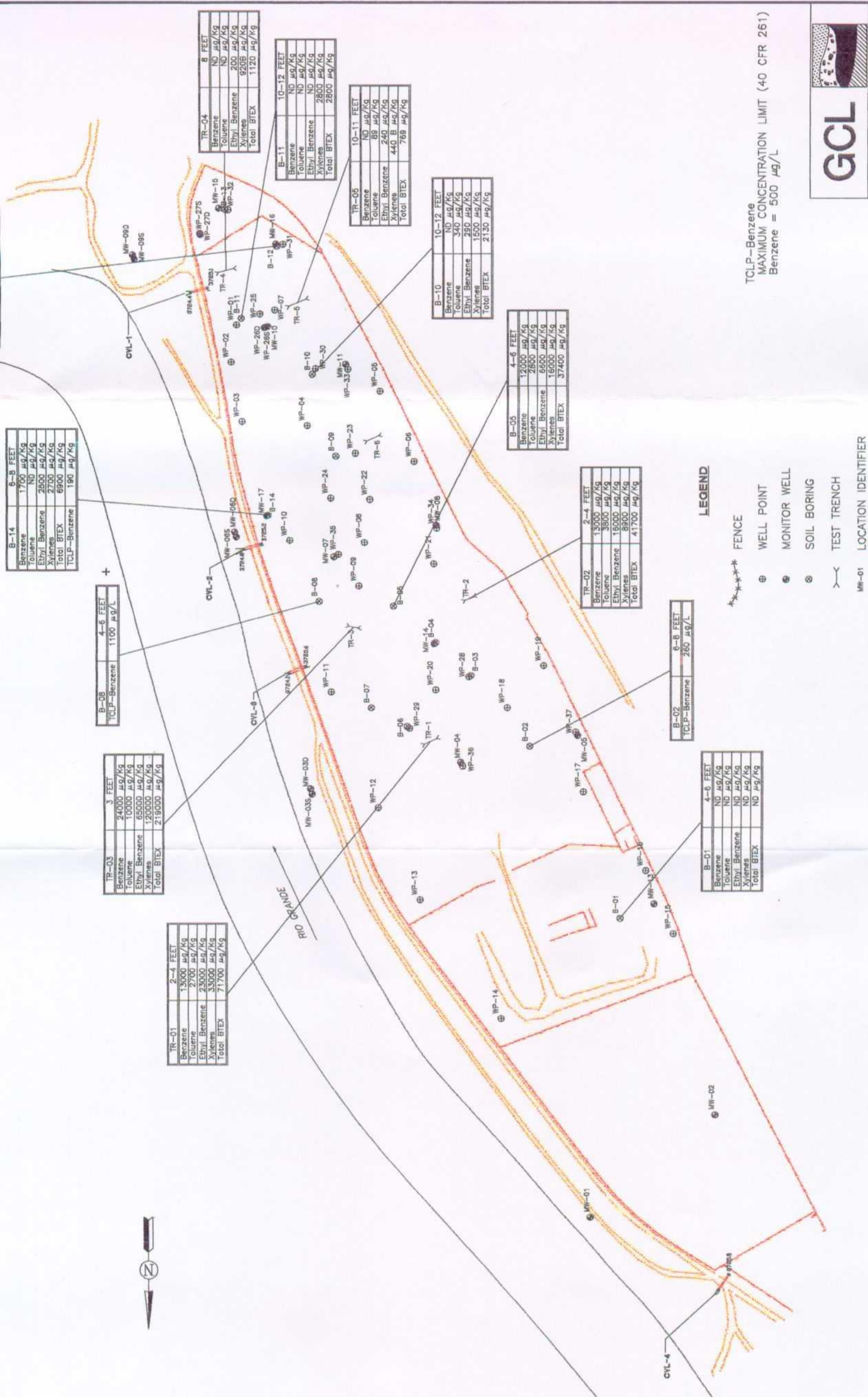
Appendix N

Selected Figures from the Remedial Investigation Report for the Former Brickland Refinery, GCL, 1994

Figure

- E Total Petroleum Hydrocarbon (EPA Method 4181) Soil Sample Results for the Former Brickland Refinery Site (June 1994 Sampling Event)
- F BTEX (EPA Method 8020) and TCLP-Benzene Soil Sample Results for the Former Brickland Refinery Site (June 1994 Sampling Event)
- G Polyaromatic Hydrocarbon (EPA Method 8270) Soil Sample Results for the Former Brickland Refinery Site (June 1994 Sampling Event)
- H RCRA Metals and TCLP Soil Sample Results for the Former Brickland Refinery Site (June 1994 Sampling Event)
- I Bio-Potential Data for the Former Brickland Refinery Site (June 1994 Sampling Event)
- N Estimated Areal Extent of Petroleum Hydrocarbon Contaminated Soils at the Former Brickland Refinery Site





TCLP-Benzene
MAXIMUM CONCENTRATION LIMIT (40 CFR 261)
Benzene = 500 $\mu\text{g}/\text{L}$



MW-01 LOCATION IDENTIFIER

ANALYTE LIST

- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzo(a)anthracene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(ghi)perylene
- Benzo(a)pyrene
- Chrysene
- Dibenzo(a,h)anthracene
- Fluoranthene
- Flourene
- Indeno(1,2,3-cd)pyrene
- 1-Methylnaphthalene
- 2-Methylnaphthalene
- Naphthalene
- Phenanthrene
- Pyrene

10-11 FEET	
1-METHYLNAPHTHALENE	1800 µg/Kg
TOTAL PAH(s)	1600 µg/Kg

6-8 FEET	
1-METHYLNAPHTHALENE	2200 µg/Kg
2-METHYLNAPHTHALENE	3800 µg/Kg
TOTAL PAH(s)	8100 µg/Kg

3 FEET	
1-METHYLNAPHTHALENE	7700 µg/Kg
2-METHYLNAPHTHALENE	11000 µg/Kg
TOTAL PAH(s)	24,300 µg/Kg

2-4 FEET	
1-METHYLNAPHTHALENE	1800 µg/Kg
2-METHYLNAPHTHALENE	5000 µg/Kg
TOTAL PAH(s)	7200 µg/Kg

8 FEET	
1-METHYLNAPHTHALENE	5300 µg/Kg
TOTAL PAH(s)	7000 µg/Kg

B-10 FEET	
1-METHYLNAPHTHALENE	79000 µg/Kg
2-METHYLNAPHTHALENE	160000 µg/Kg
TOTAL PAH(s)	239,000 µg/Kg

10-12 FEET	
1-METHYLNAPHTHALENE	4700 µg/Kg
2-METHYLNAPHTHALENE	3000 µg/Kg
TOTAL PAH(s)	10,000 µg/Kg

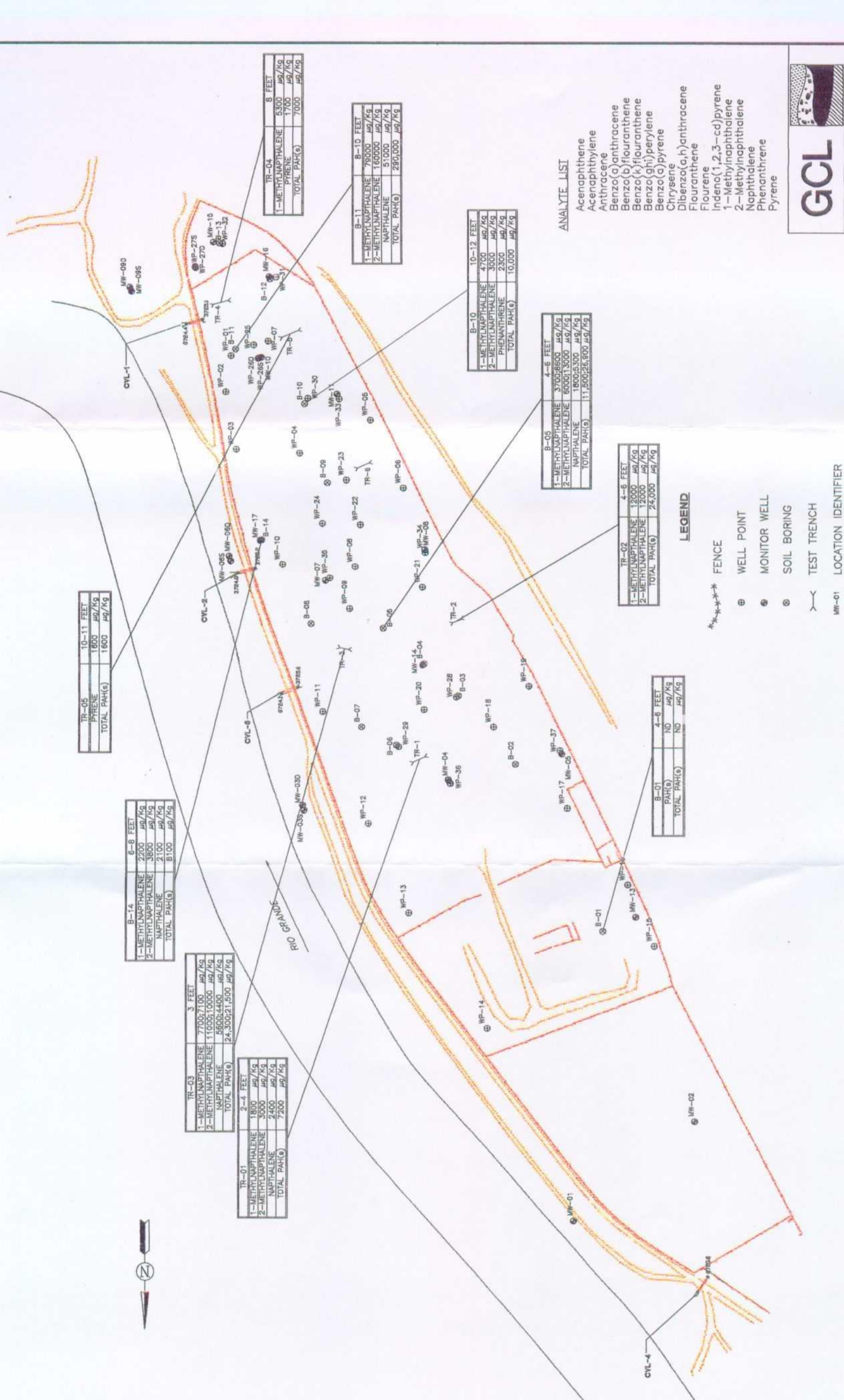
4-6 FEET	
1-METHYLNAPHTHALENE	3700 µg/Kg
2-METHYLNAPHTHALENE	6000 µg/Kg
TOTAL PAH(s)	11,500 µg/Kg

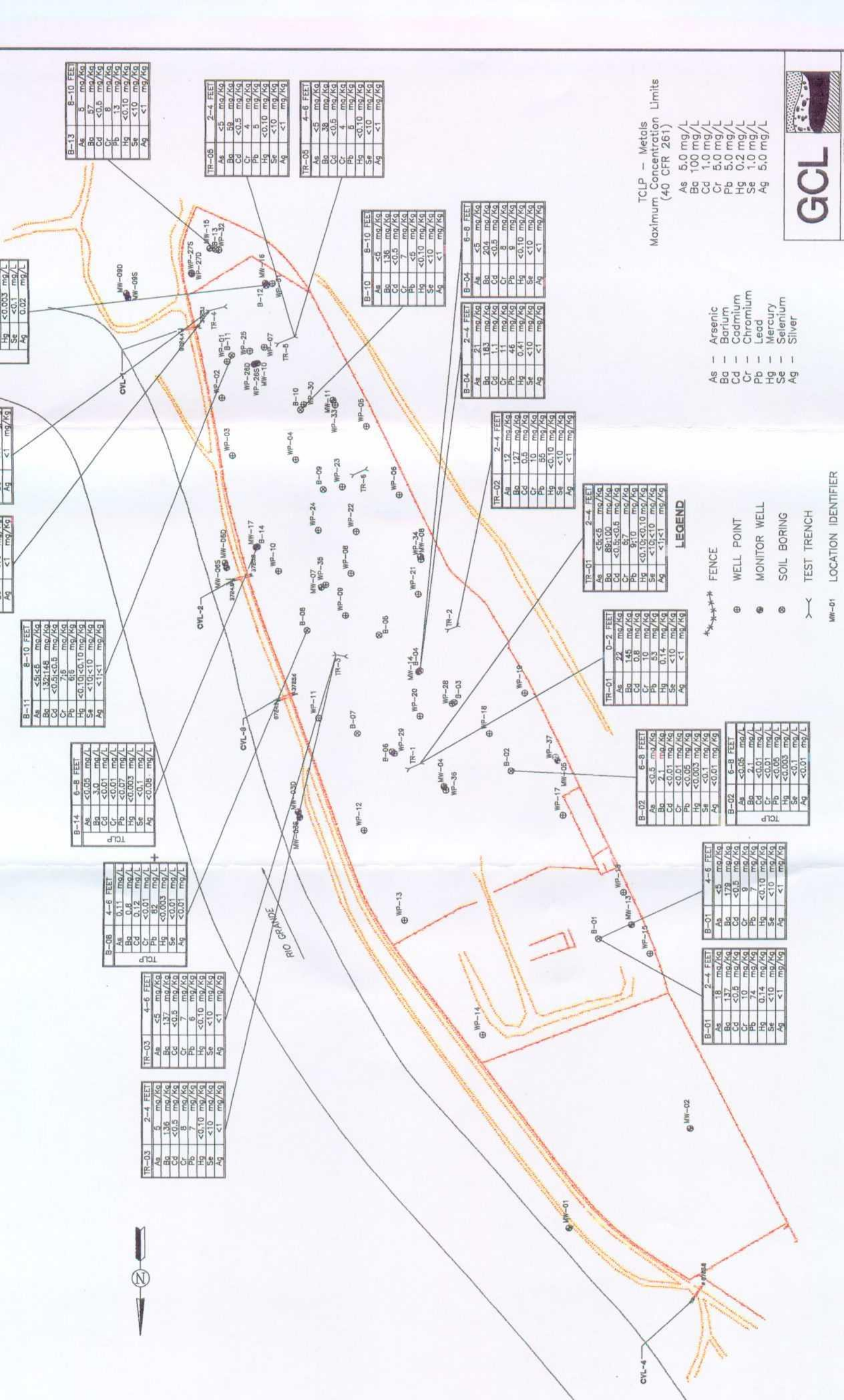
4-6 FEET	
1-METHYLNAPHTHALENE	12000 µg/Kg
2-METHYLNAPHTHALENE	12000 µg/Kg
TOTAL PAH(s)	24,000 µg/Kg

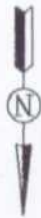
4-6 FEET	
1-METHYLNAPHTHALENE	ND µg/Kg
TOTAL PAH(s)	ND µg/Kg

LEGEND

- ***** FENCE
- ⊕ WELL POINT
- ⊕ MONITOR WELL
- ⊕ SOIL BORING
- > TEST TRENCH
- MW-01 LOCATION IDENTIFIER







B-11	4'-6'	B-10'
pH	7.76	
TOC	0.57%	
Fuel Oil Utilizers	400 colonies/gm	
Gasoline Utilizers	6100 colonies/gm	
Total Heterotrophs	87000 colonies/gm	

B-14	2'-4'
Moisture Content	4.8%

B-08	6'-8'	4'-6'
Moisture Content	25.6%	3.0 mg/L
pH	8.25	5.0 mg/L
TOC	2.01%	NO mg/L

B-07	6'-8'
Fuel Oil Utilizers	<100 colonies/gm
Gasoline Utilizers	<100 colonies/gm
Total Heterotrophs	(600) colonies/gm

B-06	4'-6'
Moisture Content	3.4%
Humic Content	1.3%

TR-04	B-10'
NH ₄	NO mg/L
PO ₄ -P	NO mg/L
NO ₃	NO mg/L

B-13	6'-10'
Moisture Content	13.7%

B-13	6'-2'
NH ₄	1.7 mg/L
PO ₄ -P	1.6 mg/L
NO ₃	2.0 mg/L

B-12	6'-8'
Humic Content	2.7%

TR-05	10'-11'
NH ₄	2.2 mg/L
PO ₄ -P	1.3 mg/L
NO ₃	NO mg/L

B-10	6'-8'
Moisture Content	34.8%

B-09	6'-8'
Moisture Content	28.8%
pH	9.05

B-05	4'-6'
Moisture Content	43.3%

B-03	6'-8'
pH	8.03
TOC	0.10%

B-02	4'-6'
Moisture Content	50.2%

B-01	4'-6'
pH	8.13
TOC	0.32%
Moisture Content	24.8%

B-01	4'-6'
Fuel Oil Utilizers	31000 colonies/gm
Gasoline Utilizers	37000 colonies/gm
Total Heterotrophs	280000 colonies/gm

LEGEND

FENCE

WELL POINT

MONITOR WELL

SOIL BORING

TEST TRENCH

LOCATION IDENTIFIER





LEGEND

- ***** FENCE
- ⊕ WELL POINT
- ⊕ MONITOR WELL
- ⊕ SOIL BORING
- TEST TRENCH

EXPLANATION

- TPH VS. LOCATION
- TPH (mg, kg) SUMMED UP OVER TOTAL DEPTH OF WELL OR TRENCH
- RANGE 97 (B-01) to 9060 (B-07)
- C.I. = 1000 DASHED WHERE INFERRED
- WATER TABLE AT OR BELOW DEPTH OF SAMPLES
- OIL & GREASE CONCENTRATION WITH >10 mg/Kg (EDER SURVEY, 1990)



Appendix O

Exposure Routes-Pathways

SELECTION OF EXPOSURE ROUTE-PATHWAYS

Brickland Refinery Site — Sunland, New Mexico

1.0 CURRENT I CONDITION: ON SITE*

1.2 Industrial (service workers, excavation or drilling contractors)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	soil gas: volatiles in soil particles	yes	— <i>included</i> because there are volatile compounds of concern (COC) in soil and inhalation is possible
	<u>RP1</u> <u>RP2</u> volatile organics: volatiles in groundwater	yes	gas transport from groundwater to ground surface— <i>included</i> because inhalation is possible
	<u>RP3</u> volatile organics: volatiles from LNAPL	yes	— <i>included</i> because residual LNAPL can volatilize and reach ground surface and inhalation is possible
	volatiles in groundwater	no	volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there is no use of groundwater
<i>dermal sorption</i>	volatiles in surface water	no	— <i>excluded</i> because there is no significant discharge of COC from groundwater to surface water*
	<u>RP4</u> soil particles	yes	— <i>included</i> because there are COC in the on-site soil and inhalation of soil dust is possible
	soil	no	— <i>excluded</i> because workers wear protective clothing**
	hand-face wash; bath/shower groundwater	no	assumes that water comes from a well that withdraws groundwater— <i>excluded</i> because there is no use of groundwater
	irrigation groundwater	no	assumes that water comes from a well that withdraws groundwater— <i>excluded</i> because there is no use of groundwater
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COC in groundwater to surface water***

* Current I scenario assumes site conditions as they exist at present

** Face area uncovered only—this is low risk exposure

*** Transport modeling and river sediment sampling indicate that on-site groundwater chemical has reached the Rio Grande, however, extensive dilution results in benzene concentration less than 5 ppb near the site (New Mexico stream standard for benzene is 55 ppb)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	soil	no	— <i>excluded</i> because ingestion of COC in soil would be insignificant (intermittent exposure to on-site workers)
	surface soil on plants	no	— <i>excluded</i> because there is little plant growth
	uptake of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because animals are not raised on site
	uptake by plants through root-zone; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because there is little plant growth
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because there is little plant growth, and commercial animals are not raised on site
	residue from groundwater deposits on plants	no	no bioaccumulation: — <i>excluded</i> because there is no use of groundwater
	tap water	no	assumes drinking water from well that withdraws impacted groundwater— <i>excluded</i> because there is no use of groundwater
	uptake of groundwater by plant roots	no	— <i>excluded</i> because there is little plant growth
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation— <i>excluded</i> because there is no use of groundwater and animal are not raised on site
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COC in groundwater to surface water

SELECTION OF EXPOSURE ROUTE-PATHWAYS

Brickland Refinery Site — Sunland, New Mexico

2.0 FUTURE I CONDITION: ON SITE*

2.2 Industrial (service workers, excavation or drilling contractors)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	<u>RP5</u> soil gas: volatiles in soil particles	yes	— <i>included</i> because there will likely still be volatile COCs in the soil and inhalation of volatiles would be possible
	<u>RP6</u> volatile organics: volatiles in groundwater	yes	gas transport from groundwater to ground surface— <i>included</i> because there will likely be volatile COCs in groundwater and inhalation of volatile emissions would be possible
	<u>RP7</u> volatile organics volatiles from LNAPL	yes	— <i>included</i> because residual LNAPL can volatilize and reach the ground surface and inhalation of these volatiles is possible
	volatiles in groundwater	no	volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there will likely be no use of groundwater
	volatiles in surface water	no	— <i>excluded</i> because there will likely be no significant discharge of COCs from groundwater to surface water over the next 30 years**
	<u>RP8</u> soil particles	yes	— <i>included</i> because there will still be COCs on site in the soil and inhalation of soil particles may occur
<i>dermal sorption</i>	soil	no	— <i>excluded</i> because workers wear protective clothing
	hand-face wash; bath/shower groundwater	no	assumes water comes from a nearby well that withdraws groundwater — <i>excluded</i> because there will likely be no use of groundwater
	irrigation groundwater	no	assumes water comes from a nearby well that withdraws groundwater — <i>excluded</i> because there will likely be no use of groundwater
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years**

* Future I scenario assumes no human remedial or control action will occur

** Transport modeling indicates on-site groundwater chemical will reach the Rio Grande, however, extensive dilution will result in benzene concentration less than 5 ppb near the site (New Mexico stream standard for benzene is 5 ppb)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	soil	no	— <i>excluded</i> because ingestion of soil would be insignificant (intermittent exposure to on-site workers) ✓
	surface soil on plants	no	— <i>excluded</i> because there will likely be little plant growth ✓
	uptake of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because animals are unlikely to be raised on site ✓
	uptake by plants through root-zone; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because there will likely be little plant growth ✓
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because there will likely be little plant growth, and animals are unlikely to be raised on site ✓
	residue from groundwater on plants	no	no bioaccumulation: — <i>excluded</i> because there will likely be no use of groundwater ✓
	tap water	no	assumes drinking water from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of groundwater
	uptake of groundwater by plant roots	no	— <i>excluded</i> because there will likely be little plant growth ✓
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation— <i>excluded</i> because there will likely be little use of groundwater and animals are unlikely to be raised on site
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years

SELECTION OF EXPOSURE ROUTE-PATHWAYS

Brickland Refinery Site — Sunland, New Mexico

3.0 FUTURE II CONDITIONS: ON SITE*

3.2 Industrial (museum staff)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	<u>RP9</u> soil gas: volatiles in soil particles	yes	— <i>included</i> because on-site emissions may enter museum (e.g., intake air vent)
	<u>RP10</u> volatile organics: volatiles in groundwater	yes	gas transport from groundwater to ground surface and through the surface— <i>included</i> because on-site emissions may enter museum (e.g., intake air vent)
	<u>RP11</u> volatile organics: volatiles from LNAPL volatiles in groundwater	yes no	— <i>included</i> because residual LNAPL can volatilize and reach ground surface and enter museum volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there will likely be no use of groundwater
<i>dermal sorption</i>	volatiles in surface water	no	— <i>excluded</i> because there will likely be no significant discharge of COC from groundwater to surface water over the next 30 years**
	<u>RP12</u> surface soil particles	yes	airborne transport of surface soil contamination— <i>included</i> because on-site soil particles may enter museum (e.g., intake air vent)
	surface soil	no	— <i>excluded</i> because indoor concentration of soil particles would likely be negligible for dermal sorption.
	hand-face wash; bath/shower groundwater	no	assumes that water comes from nearby well that withdraws impacted groundwater— <i>excluded</i> because there will likely be no use of ground water
	irrigation groundwater	no	assumes that water comes from nearby well that withdraws impacted groundwater— <i>excluded</i> because there will likely be no use of ground water
	surface water (all pathways)	no	— <i>excluded</i> because no significant discharge of COCs in groundwater to surface water over the next 30 years

* This route-pathway assumes that the site will have a museum near or at the highest concentration location

** Transport modeling indicates that on site groundwater chemicals has reached reach the Rio Grande, however, extensive dilution will result in benzene concentration less than 5 ppb near the site (New Mexico stream standard for benzene is 5 ppb)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	surface soil	no	— <i>excluded</i> because ingestion of soil would be insignificant (intermittent exposure to on-site museum staff)
	surface soil on plants	no	— <i>excluded</i> because there will likely be little plant growth
	ingestion of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because animals are unlikely to be raised on site
	uptake by plants through root-zone; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because plant growth will likely be insignificant
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because animals are unlikely to be raised on site
	residue of groundwater on plants	no	no bioaccumulation: — <i>excluded</i> because there will likely be no use of groundwater
	tap water	no	assumes drinking water from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of groundwater
	uptake of groundwater by plant roots	no	— <i>excluded</i> because there will likely be little plant growth
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation— <i>excluded</i> because there will likely be no use of groundwater and animals are unlikely to be raised on site
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years**

SELECTION OF EXPOSURE ROUTE-PATHWAYS
Brickland Refinery Site — Sunland, New Mexico

4.0 CURRENT CONDITIONS: OFF SITE

4.1 Residential (nearby family homes)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	soil gas: volatiles in soil particles	no	airborne transport of volatile organics— <i>excluded</i> because there are no off-site COCs in soil and dispersion during airborne transport from on site will reduce concentrations at off-site receptors
	<u>volatile organics:</u> volatiles in groundwater	no	vapor transport from groundwater to ground surface— <i>excluded</i> because there are no significant COCs in off-site groundwater and airborne transport of volatiles from on-site groundwater would be dispersed and attenuated
	<u>volatile organics:</u> volatiles from LNAPL	yes	— <i>included</i> because on site residual LNAPL volatiles can be transported to off-site locations
	volatiles in groundwater	no	volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there is no use of off-site groundwater
<i>dermal sorption</i>	volatiles in surface water	no	— <i>excluded</i> because there is no significant discharge of COCs from groundwater to surface water*
	soil particles	yes	— <i>included</i> because transport to off-site locations may occur
	soil	no	— <i>excluded</i> because there is no off-site COCs in soil and dermal sorption from transport of on site soil particles to off-site receptors is insignificant
	hand-face wash; bath/shower groundwater	no	assumes that water comes from nearby well that withdraws groundwater— <i>excluded</i> because there is no use of off-site groundwater
	irrigation groundwater	no	assumes that water comes from nearby well that withdraws groundwater— <i>excluded</i> because there is no use of off-site groundwater
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COCs in groundwater to surface water*

* Transport modeling and river sediment sampling indicate that on-site groundwater chemicals have reached the Rio Grande, however, extensive dilution results in benzene concentrations less than 5 ppb (New Mexico stream standard for benzene is 5 ppb)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	surface soil	no	— <i>excluded</i> because there are no COCs in off-site soil and transport from on site is insignificant
	surface soil on plants	no	— <i>excluded</i> because there are no COCs in off-site soil and transport from on site is insignificant
	ingestion of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because there are no off-site COCs in soil and animals are not raised off site
	uptake by plants through root-zone soil; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because there are no off-site COCs in soil and transport from on site is insignificant
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because there are no off-site COCs in soils and animals are not raised off-site
	residue from groundwater on plants	no	no bioaccumulation: — <i>excluded</i> because there is no use of off-site groundwater
	tap water	no	assumes drinking water from nearby well that withdraws groundwater— <i>excluded</i> because there is no use of off-site groundwater
	uptake of groundwater by plant roots	no	— <i>excluded</i> because concentration of COC in off-site groundwater is not significant
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation — <i>excluded</i> because there is no use of off-site groundwater and animals are not raised off-site
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COCs in groundwater to surface water

SELECTION OF EXPOSURE ROUTE-PATHWAYS
Brickland Refinery Site — Sunland, New Mexico

4.0 CURRENT CONDITIONS: OFF SITE

4.2 Industrial (service workers, excavation, or drilling contractors)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	<u>soil gas:</u> volatiles in soil particles	yes	airborne transport of soil gas— <i>included</i> even though COC in unsaturated soil do not exist off site, transport of on-site soil gas is likely and workers will be outdoors
	<u>volatile organics:</u> volatiles in groundwater	yes	gas transport from groundwater to ground surface— <i>included</i> because transport of soil gas is likely and workers will be outdoors
	<u>RP15</u> <u>RP16</u> <u>RP17</u> <u>volatile organics:</u> volatiles from LNAPL	yes	— <i>included</i> because on-site residual LNAPL volatiles can be transported to off-site locations
<i>dermal sorption</i>	volatiles in groundwater	no	— <i>excluded</i> because off-site exposure would be intermittent gas emission from bath, shower, and other water use (such as spigot and irrigation)— <i>excluded</i> because there is no use of off-site groundwater
	volatiles in surface water	no	— <i>excluded</i> because there is no significant discharge of COC from groundwater to surface water
	soil particles	yes	— <i>included</i> because transport to off-site locations may occur
	soil	no	— <i>excluded</i> because there is no off-site COC in the soil and dermal sorption from transport of on-site soil dust to off-site receptors is insignificant
	hand-face wash; bath/shower groundwater	no	assumes water comes from a well that draws groundwater— <i>excluded</i> because there is no use of off-site groundwater
	irrigation groundwater	no	assumes water comes from a well that draws groundwater— <i>excluded</i> because there is no use of off-site groundwater
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COC in groundwater to surface water

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	soil	no	— <i>excluded</i> because there is no COC in off-site soil and transport from on site is insignificant and exposure is intermittent
	surface soil on plants	no	— <i>excluded</i> because there are no COCs in off-site surface soil and transport from on site is insignificant and exposure is intermittent
	uptake of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because there are no off-site COCs in surface soil and animals are not raised off-site and exposure is intermittent
	uptake by plants through root-zone; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because there are no COCs in off-site soil, transport from on site is insignificant, and exposure is intermittent
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because there are no COCs in off-site soil and animals are unlikely to be raised off site
	residue from groundwater on plants	no	no bioaccumulation: — <i>excluded</i> because there is no use of off-site groundwater
	tap water	no	assumes drinking water from nearby well that withdraws groundwater— <i>excluded</i> because there is no use of off-site groundwater
	ingestion of groundwater by plant roots	no	— <i>excluded</i> because concentration of COCs in off-site groundwater is not significant
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation— <i>excluded</i> because there is no use of off-site groundwater and animals are not raised off site
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COCs in groundwater to surface water

SELECTION OF EXPOSURE ROUTE-PATHWAYS

Brickland Refinery Site — Sunland, New Mexico

5.0 FUTURE I CONDITIONS: OFF SITE

5.1 Residential (nearby family homes)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	<u>volatile organics:</u> volatiles in soil particles	no	airborne transport of volatile organics— <i>excluded</i> because there are no off-site COCs in soil and dispersion during airborne transport from on site will attenuate concentrations
	<u>volatile organics:</u> volatiles in groundwater	no	vapor transport from groundwater to ground surface— <i>excluded</i> because there are no significant COCs in off-site groundwater and airborne transport of volatiles from on-site groundwater would be dispersed and attenuated
	<u>RP19</u> <u>volatile organics:</u> volatiles from LNAPL	yes	— <i>included</i> because on-site residual LNAPL volatiles can be transported to off-site locations and reach nearby residents
<i>dermal sorption</i>	volatiles in groundwater	no	volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there will likely be no use of off-site groundwater
	volatiles in surface water	no	— <i>excluded</i> because there will be no significant discharge of COCs in groundwater to surface water over the next 30 years*
	soil particles	yes	— <i>included</i> because on-site soil may still have COCs and transport from on-site to off-site locations may occur
	soil	no	— <i>excluded</i> because there is no off-site COCs in soil and dermal sorption from transport of on-site soil particles to off-site receptors is insignificant
	hand-face wash; bath/shower groundwater	no	assumes that water comes from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of off-site groundwater
	irrigation groundwater	no	assumes water comes from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of off-site groundwater
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
ingestion	soil	no	— <i>excluded</i> because there are no COCs in off-site soil and transport from on site is insignificant
	surface soil on plants	no	— <i>excluded</i> because there are no COCs in off-site soil and transport from on site will be insignificant
	ingestion of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because there are no COCs in soil off-site and animals are unlikely to be raised off site
	uptake by plants through root-zone; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because there are no off-site COCs in soil and transport from on site will be insignificant
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because there are no off-site COCs in soil and animals are unlikely to be raised off site
	residue from groundwater on plants	no	no bioaccumulation: — <i>excluded</i> because there will likely be no use of off-site groundwater
	tap water	no	assumes drinking water from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of off-site groundwater
	uptake of groundwater by plant roots	no	— <i>excluded</i> because concentration of COCs in off-site groundwater is not significant
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation— <i>excluded</i> because there will likely be no use of off-site groundwater and animals are unlikely to be raised off site
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years.

SELECTION OF EXPOSURE ROUTE-PATHWAYS

Brickland Refinery Site — Sunland, New Mexico

5.0 FUTURE I CONDITIONS: OFF SITE

5.2 Industrial (service workers, excavation or drilling contractors)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	<u>soil gas</u> : volatiles in soil particles	no	airborne transport of volatile organics— <i>excluded</i> because on-site concentration of volatile COCs will likely be reduced by natural processes
	<u>volatile organics</u> : volatiles in groundwater	no	vapor transport from groundwater to ground surface— <i>excluded</i> because on-site concentration of COCs in groundwater will likely be reduced by natural processes
	<u>volatile organics</u> : volatiles from LNAPL	yes	— <i>included</i> because on-site residual LNAPL volatiles can be transported to off-site locations
	volatiles in groundwater	no	volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there will likely be no use of off site groundwater
<i>dermal sorption</i>	volatiles in surface water	no	— <i>excluded</i> because there will be no significant discharge of COCs in groundwater to surface water over the next 30 years
	surface soil particles	no	— <i>excluded</i> because on-site COCs in soil will likely be reduced by natural processes
	soil	no	— <i>excluded</i> because there are no off-site COCs in soil and dermal sorption from transport of on-site soil particles to off-site receptors is insignificant
	hand-face wash; bath/shower groundwater	no	assumes that water comes from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of off-site groundwater
	irrigation groundwater	no	assumes that water comes from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of off-site groundwater
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	soil	no	— <i>excluded</i> because there will be no COCs in off-site soil and transport from on site is insignificant
	surface soil on plants	no	— <i>excluded</i> because there will be no COCs in off-site surface soil and transport from on site will be insignificant
	ingestion of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because there are no off-site COCs in surface soil and animals are unlikely to be raised off site
	uptake by plants through root-zone soil; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because there are no COCs in off-site soil and transport from on site will be insignificant
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because there are no COCs in off-site soil and commercial animals are unlikely to be raised off site
	residue from groundwater on plants	no	no bioaccumulation: — <i>excluded</i> because there will likely be no use of off-site groundwater
	tap water	no	assumes drinking water from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of off-site groundwater
	uptake of groundwater by plant roots	no	— <i>excluded</i> because concentration of COCs in off-site groundwater will not be significant in the next 30 years
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation— <i>excluded</i> because there will likely be no use of off-site groundwater and animals are unlikely to be raised off site
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years

SELECTION OF EXPOSURE ROUTE-PATHWAYS

Brickland Refinery Site — Sunland, New Mexico

5.0 FUTURE I CONDITIONS: OFF SITE

5.3 Visitors (intermittent visits to nearby family homes)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
	soil gas: volatiles in soil particles	no	airborne transport of volatile organics— <i>excluded</i> because transport of on-site volatile organics to off-site locations is insignificant, and there are no COCs in off-site soil, and exposure will be intermittent
	<u>volatile organics</u> : volatiles in groundwater	no	vapor transport from groundwater to ground surface— <i>excluded</i> because there are no significant COCs in off-site groundwater and airborne transport of volatile on-site COCs is likely insignificant and exposure is intermittent
	<u>volatile organics</u> : volatiles from LNAPL	no	— <i>excluded</i> because off-site exposure would be intermittent and off-site nearest resident is considered further away than industrial worker
	volatiles in groundwater	no	volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there will likely be no use of groundwater off site
	volatiles in surface water	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water over the next 30 years
	soil particles	no	— <i>excluded</i> because exposure will be intermittent and nearest resident is considered further away than industrial worker
	soil	no	— <i>excluded</i> because there are no COCs in off-site soil and dermal sorption from transport of on-site soil particles to off-site receptors is insignificant
	hand-face wash; bath/shower groundwater	no	assumes that water comes from nearby well that withdraws groundwater— <i>exclude</i> because there will likely be no use of groundwater
	irrigation groundwater	no	assumes that water comes from nearby well that withdraws groundwater— <i>excluded</i> because there will likely be no use of groundwater
<i>dermal sorption</i>	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COCs in groundwater to surface water

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	soil	no	— <i>excluded</i> because there will be no COC in off-site soil and for ingestion, transport from on site will be insignificant and exposure will be intermittent
	surface soil on plants	no	— <i>excluded</i> because there are no COC in off-site soil and for ingestion, transport from on site will be insignificant, and exposure will be intermittent
	ingestion of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and human mother's milk— <i>excluded</i> because there will be no COC in off-site surface soil, transport from on site will be insignificant, and exposure will be intermittent
	uptake by plants through root-zone; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and human mother's milk— <i>excluded</i> because there will be no COC in off-site soil, transport from on site will be insignificant, and exposure will be intermittent
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) ingestion of human mother's milk— <i>excluded</i> because there will be no COC in off-site soil and commercial animals are unlikely to be raised off site
	residue from groundwater on plants	no	no bioaccumulation: — <i>excluded</i> because there will likely be no use of groundwater off site
	tap water	no	assumes drinking water from well that draws groundwater— <i>excluded</i> because there will likely be no use of groundwater off site
	uptake of groundwater by plant roots	no	— <i>excluded</i> because concentration of COC in off-site groundwater is not significant
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and human mother's milk — <i>excluded</i> because there will likely be no use of off site groundwater, commercial animals unlikely to be raised off site and exposure would be intermittent
	surface water (all pathways)	no	— <i>excluded</i> because there will likely be no significant discharge of COC in groundwater to surface water over the next 30 years

SELECTION OF EXPOSURE ROUTE-PATHWAYS

Brickland Refinery Site — Sunland, New Mexico

6.0 CURRENT II CONDITION: ON SITE*

6.2 Industrial (service workers, excavation or drilling contractors)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>inhalation</i>	source gas-particles from stack/spill	no	— <i>excluded</i> because no stacks and no residual source on ground or pond surface
<u>RP22</u>	<u>soil gas:</u> volatiles in soil particles	no	— <i>excluded</i> because inhalation of volatile compounds of concern (COC) is prevented by use of respirators by workers**
<u>RP23</u>	<u>volatile organics:</u> volatiles in groundwater	no	— <i>excluded</i> because inhalation of volatile organics from groundwater to ground surface is prevented by use of respirators by workers
<u>RP24</u>	<u>volatile organics:</u> volatiles from LNAPL	no	— <i>excluded</i> because inhalation of residual LNAPL that can volatilize and reach ground surface is prevented by use of respirators by workers
	volatiles in groundwater	no	volatile emissions from bath, shower, and other water use (such as tap water and irrigation)— <i>excluded</i> because there is no use of groundwater
<u>RP25</u>	volatiles in surface water	no	— <i>excluded</i> because there is no significant discharge of COC from groundwater to surface water*
	soil particles	no	— <i>excluded</i> because inhalation of soil dust is prevented by use of respirators by workers
<i>dermal sorption</i>	soil	no	— <i>excluded</i> because workers wear protective clothing
	hand-face wash; bath/shower groundwater	no	assumes that water comes from a well that withdraws groundwater— <i>excluded</i> because there is no use of groundwater
	irrigation groundwater	no	assumes that water comes from a well that withdraws groundwater— <i>excluded</i> because there is no use of groundwater
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COC in groundwater to surface water***

* Current I scenario assumes full on-site control

** Use of respirators by workers if permissible exposure limit (PEL) is exceeded or as stipulated in the health and safety plan

*** Transport modeling and river sediment sampling indicate that on-site groundwater chemical has reached the Rio Grande, however, extensive dilution results in benzene concentration less than 5 ppb near the site (New Mexico stream standard for benzene is 55 ppb)

EXPOSURE ROUTE	PATHWAY-CONTAMINANT FORM	PATHWAY SELECTED?	PATHWAY DESCRIPTION: REASON FOR SELECTION/EXCLUSION
<i>ingestion</i>	soil	no	— <i>excluded</i> because ingestion of COC in soil would be insignificant (intermittent exposure to on-site workers)
	surface soil on plants	no	— <i>excluded</i> because there is little plant growth
	uptake of surface soil by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs, and lactation— <i>excluded</i> because animals are not raised on site
	uptake by plants through root-zone; humans eat plants	no	plants can bioaccumulate: human ingestion of fruit, vegetables, crops, and lactation— <i>excluded</i> because there is little plant growth
	ingestion of plants by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: (1) animal ingestion of fruit, vegetables, crops; (2) human ingestion of meat, eggs; (3) lactation— <i>excluded</i> because there is little plant growth, and commercial animals are not raised on site
	residue from groundwater deposits on plants	no	no bioaccumulation: — <i>excluded</i> because there is no use of groundwater
	tap water	no	assumes drinking water from well that withdraws impacted groundwater— <i>excluded</i> because there is no use of groundwater
	uptake of groundwater by plant roots	no	— <i>excluded</i> because there is little plant growth
	ingestion of groundwater by animals (such as cattle, sheep, poultry)	no	animals can bioaccumulate: human ingestion of meat, eggs and lactation— <i>excluded</i> because there is no use of groundwater and animal are not raised on site
	surface water (all pathways)	no	— <i>excluded</i> because there is no significant discharge of COC in groundwater to surface water

Appendix P

Transport Modeling

Appendix P Transport Modeling

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Introduction

One potential exposure pathway at the site is surface water. This pathway exists because shallow groundwater beneath the southern portion of the site flows into the Rio Grande periodically during the year. In this pathway, shallow groundwater will enter the river, mix with upstream river water, and flow downstream to potential receptors. Potential receptors using this surface water as a drinking water supply create the exposure pathway.

To determine the risk to human health from this pathway, the concentration of benzene in the river downstream of the site must be determined. A two-step process is used. First, the benzene concentration in shallow groundwater that enters the river is determined. Second, shallow groundwater that enters the river is mixed with upstream river water to determine a final downstream benzene concentration in the river. Finally, the risk to human health is determined for the surface water pathway assuming oral ingestion, as when used for drinking water.

The benzene concentration entering the river was determined for the following current and future conditions:

Current Conditions: For current conditions, the benzene concentration observed in MW-06S, located adjacent to the river, is assumed to be the concentration in groundwater that enters the river.

Future Conditions: Future conditions assume no remediation occurs and benzene enters the shallow groundwater in either of two scenarios. Representing a *worst case* scenario, the observed benzene concentrations in MW-10, where free phase hydrocarbons are observed, is assumed to represent the benzene concentration in groundwater that enters the river.

Representing a *realistic scenario*, the highest observed benzene concentrations in groundwater, primarily in the western portion of the site, are assumed to remain as a continuous source for the next 30 years. The concentration of benzene in groundwater that enters the river is calculated using an analytical model.

Appendix P Transport Modeling

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Conceptual Site Hydrogeologic Model

Prior to evaluating these scenarios, a conceptual site hydrogeologic model must be formulated. A conceptual model is a simplified "picture" of the hydrogeology of a site using average values, or a range of values, for aquifer properties such as hydraulic conductivity, porosity, aquifer thickness, and hydraulic gradient. Also, the portion of aquifer through which impacted groundwater flows is quantified.

Based on the last four quarters of water level elevations, groundwater flows to the southeast under an average hydraulic gradient of about 0.0010 feet/foot. Groundwater is assumed to flow horizontally within the shallow aquifer. Since the shallow materials are interbedded clays, silts, and sands in this region, groundwater is observed to occur under confined to unconfined conditions, depending on proximity to the fine-grained materials.

Based on the results of slug tests performed in both shallow and deep monitor wells at the site (presented in Appendix D) the average hydraulic conductivity of the upper aquifer material is about 14 feet per day. For clayey to sandy materials, this is a reasonable value. An average effective porosity of 25 percent is assumed to be representative of such a mixture.

Hydrocarbons occur primarily within the upper, fine-grained materials with concentrations the greatest in the shallow monitor wells whose screens are within the upper 15 feet of the aquifer. Hydrocarbons are not detected in deep monitor wells screened within the upper 12 to 35 feet of the aquifer. Consequently, hydrocarbons are assumed to occur within the upper 15 feet of the aquifer.

The following hydrogeologic model was used as a basis for evaluating the various aquifer-to-river pathway scenarios.

Groundwater beneath the site flows to the southeast toward the Rio Grande under confined to unconfined conditions with a hydraulic gradient of 0.001 feet/foot at a velocity of about 20 feet per year. Dissolved-phase hydrocarbons occur within the upper 15 feet of the aquifer and migrate at the velocity of groundwater.

Present Condition Scenario

The present condition scenario assumes that the current benzene concentration in MW-6S (220 ppb, June 1995) is the concentration in groundwater that enters the

Appendix P Transport Modeling

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river. Based on the current benzene concentration contour map, groundwater containing benzene likely flows into the Rio Grande through an approximately 450-foot long section of river bank. This recharge section is centered at MW-6S and lies between MW-08 and MW-09.

To estimate the downstream benzene concentration in the river, the mixing cell equations shown on Figure P-1 are used. A groundwater flow rate of 0.0011 cubic feet per second (cfs) is calculated using the mixing cell equation No. 2 and the following parameters:

- Hydraulic conductivity (K) = 14 feet per day
- Hydraulic gradient (i) = 0.001 feet per foot
- Groundwater flow area (A) = 15 feet deep by 450 feet wide

The downstream benzene concentration is calculated using the mixing cell equation No. 1 with the following parameters:

- Groundwater concentration (C_a) = 220 ppb
- Groundwater flow rate (Q_a) = 0.0011 cfs
- Upstream river flow rate (Q_r) = 700 cfs

The average upstream river flow rate is based on mean daily discharge values, from 1990 to 1995, recorded at the Courchesne Bridge Gaging station location approximately 2,000 feet upstream of the site.

The calculated downstream benzene concentration in the river, assuming complete mixing, is 0.0003 ppb.

This is several orders of magnitude below the state of New Mexico Drinking Water Standard of 5 ppb. Therefore, present conditions at the site do not pose any threat to human health.

Future Conditions - Realistic Case Scenario

The realistic case scenario for future conditions assumes that the highest benzene concentrations observed in monitor wells MW-4, MW-5, MW-8, and MW-14 represent continuous benzene sources for groundwater. Groundwater concentrations are then predicted 30 years into the future. The resulting benzene concentration in groundwater that enters the river is used in the mixing equation to estimate the downstream benzene concentration in the river.

Appendix P Transport Modeling

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Based on the conceptual model for the site, a simple two-dimensional analytical solution to the problem of continuous sources injected into a relatively thin aquifer can be used. The analytical solution is presented in the computer program PLUME2D (Beljin, 1989).

Input requirements for the program include source injection rates, groundwater flow velocity, lateral and longitudinal dispersivity, aquifer thickness, and porosity. For this scenario, the following input parameters were used:

<u>Parameter</u>	<u>Value</u>	<u>Units</u>	<u>Reference</u>
Injection rates	MW-4: .002	lbs/d	calculation
	MW-5: .009	lbs/d	calculation
	MW-8: .017	lbs/d	calculation
	MW-14: .025	lbs/d	calculation
Porosity	25	percent	assumption McWhorter/Sunada, 1977
Groundwater Velocity	0.055	ft/d	calculation
Aquifer Thickness	15	feet	observation
Duration	30	years	assumption
Longitudinal Dispersivity	100	feet	assumption Neuman, 1990
Transverse Dispersivity	10	feet	assumption Neuman, 1990
Retardation Factor	1	-	assumption
Decay	0	-	assumption

The injection rates were selected so that the observed benzene concentration at each well was recreated in the model. Retardation and decay are assumed negligible and are not used in the model. This causes the model to be conservative with regard to the final concentrations in groundwater that enters the river.

Based on the modeling results, benzene concentrations in groundwater that enters the river ranges from 0.07 ppb to 4.7 ppb. Applying the mixing cell model, as described in the present condition scenario, yields a downstream river concentration for benzene of 0.003 ppb, using an average river flow rate of 700 cfs. This is several orders of magnitude below the state of New Mexico Drinking Water Standard of 5 ppb. Therefore, "realistic future case" conditions at the site do not pose any threat to human health.

Appendix P Transport Modeling

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Future Conditions - Worst Case Scenario

The worst case scenario for future conditions assumes that the free phase hydrocarbons observed in monitor wells in the southern portion of the site supply benzene directly to the river. The current benzene concentration in MW-10 (120,000 ppb, August 1995) is assumed to be the concentration in groundwater that enters the river.

The same approach used in the current conditions scenario is used for this scenario. The only exception is the value used for the benzene concentration. Using the value of 125,000 ppb for benzene, the downstream benzene river concentration is 0.20 ppb.

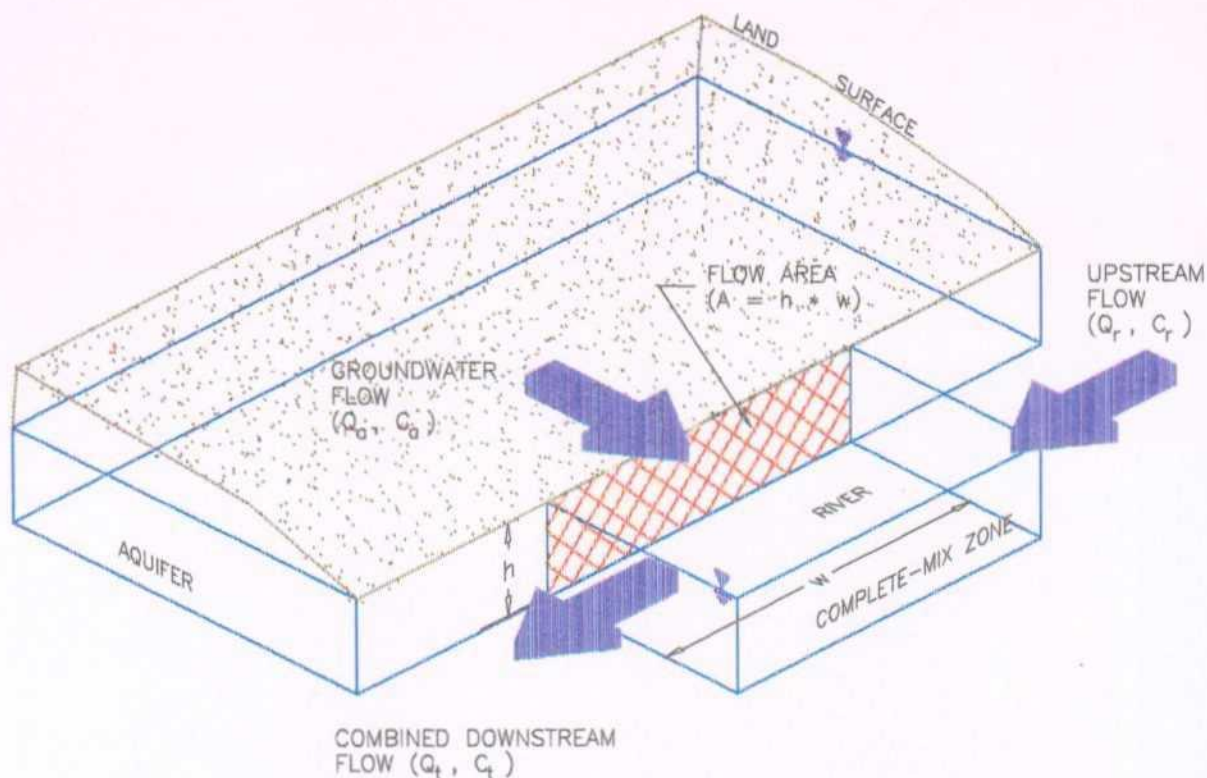
References

Beljin, M.S., 1989. Solute, Analytical Solute Transport Models, IGWMC, Indianapolis, Indiana

McWhorter and Sunada, 1977. Groundwater Hydrology and Hydraulics.

Neuman, S.P., 1990. Universal Scaling of Hydraulic Conductivities and Dispersivities in Geologic Media, Journal of Water Resources, V26, No. 8.

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MIXING ZONE MODEL EQUATION $C_t Q_t = C_r Q_r + C_a Q_a$

WHERE C_t = DOWNSTREAM CONCENTRATION IN RIVER
 Q_t = DOWNSTREAM RIVER FLOW RATE
 C_r = UPSTREAM CONCENTRATION IN RIVER
 Q_r = UPSTREAM RIVER FLOW RATE
 C_a = CONCENTRATION IN GROUNDWATER
 Q_a = GROUNDWATER FLOW RATE

TO FIND DOWNSTREAM CONCENTRATION, ASSUME UPSTREAM CONCENTRATION IS ZERO AND SOLVE EQUATION FOR C_t .

$$C_t = \frac{C_a Q_a}{Q_r + Q_a} \quad \text{NO. 1}$$

TO FIND THE GROUNDWATER FLOW RATE
 USE THE FOLLOWING EQUATION

$$Q = K i A \quad \text{NO. 2}$$

WHERE Q = GROUNDWATER FLOW RATE
 K = AQUIFER HYDRAULIC CONDUCTIVITY
 i = HYDRAULIC GRADIENT
 A = AREA OF FLOW PERPENDICULAR TO FLOW DIRECTION

NOTE : RIVER FLOW RATES TAKEN FROM UPSTREAM GAGING STATION

GCL



CLIENT: REXENE

DATE: 9/13/95

AUTHOR: BAL

CK'D BY: BAL

REV. NO.: 0

DRAWN BY: MP

FILE: MXNGZN

**FIGURE P-1
 MIXING ZONE MODEL**

Appendix Q

Equations for Calculating Intake Rates

Appendix Q-1 GENERIC EQUATION FOR CALCULATING INTAKE RATE OF CONTAMINANTS^a

$$\{\text{intake rate}\}_i = [(Cim)(IRm)(ABSF)(EF)(ED)]/[(BM)(AT)]$$

... (1)

Parameter	Description	Usual Unit	Usual Range of Value
{intake rate} _i	amount of i taken into the body via one or more exposure routes (inhalation, ingestion, dermal contact) and biologically absorbed	mg/[(kg body mass)d]	≥0
Cim	concentration of i in medium m in contact with body	mg/kg (soil); mg/L (water); g/m ³ (air)	≥0 (measured/estimated)
IRm	intake rate of exposure medium m	kg/d or kg/event (soil); L/d, L/event (water); m ³ /d (air)	usually default (unless measured value is available)
Flm	fraction of intake medium m that has contaminant i	unitless	0 to 1.0
ABSF	absorption factor, the fraction of i absorbed by the body and biologically available	unitless	0 to 1.0
EF	exposure frequency	d/y; event/y	0 to 350
ED	exposure duration	y	0 to 30
BM	body mass: averaged over exposure period	kg body mass	10 to 70
AT = ATnc, <i>noncancer</i> AT = ATc, <i>cancer</i>	averaging time: period over which exposure is averaged	d ≡ (ED)(365 d/y), <i>noncancer</i> d ≡ (70 y)(365 d/y), <i>cancer</i>	0 to 10,950 25,550

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^aEquation 1 is essentially the same as that in RAGS/HHEM (1989) except for the additional Flm term.

Appendix Q-2

EQUATION FOR CALCULATING CHEMICAL INTAKE RATE INHALATION OF VOLATILES FROM SOIL PARTICLES^a

$$\{\text{intake rate}\}_i = [(Cia,d)(IRa)(ABSF)(Fla)(EF)(ED)] / [(BM)(AT)]$$

... (2)

Parameter	Description	Value ^b
{intake rate} _i	amount of i taken into the body via inhalation and biologically absorbed	mg / [(kg body mass)d] (estimated)
Cia,d	concentration of i in air at distance d from source	g /m ³ (estimated)
IRa	inhalation rate of air inhalation rate of air	15 m ³ /d (child) 20 m ³ /d (adult)
ABSF	absorption factor, the fraction of i absorbed by the body and biologically available	1.0
Fla	fraction of inhaled air that has constituent of concern i	1.0 for on-site (no resident) 0.1 for off-site (assume 10X dilution) : industrial 0.01 for off-site resident (10 X dilution + 10 X attenuation)
EF*	exposure frequency	350 d/y (residential); 250 d/y (industrial)
ED	exposure duration exposure duration	6 y ucl ; 2 y mean (child: 1–6 y) 24 y ucl ; 7 y mean (adult: 7–30 y) 25 y ucl ; 9 y mean (industrial worker)
BM	body mass body mass —averaged over exposure period	15 kg body mass (child) 70 kg body mass (adult)
AT	averaging time: period over which exposure is averaged	(ED)(365 d / y) for noncancer (70)(365 d/y) = 25,550 d for cancer

* Site specific exposure frequency may be used instead of EPA standard default values

^a Equation 2 through 5 applies to exposure Route-Pathways, RP-1, RP-5, RP-9 and RP-15

^b Unless otherwise stated all values presented are defaults from EPA Risk Assessment Guidance for Superfund (RAGS part A & B), or EPA Exposure Factor Handbook (EPA, 1989)

Assumptions: 1. no physical or chemical interaction of contaminant i with the unsaturated soil

2. equilibrium occurs once a gaseous contaminant reaches the atmosphere just above the surface of the ground

3. no effects from differing size of contaminant molecules

4. no depletion of contaminant source concentration over time

Appendix Q-2 (continued)

$$C_{ia,d} = (1/\pi)(Q_i)/[(\bar{v})(\sigma_x)(\sigma_z)]$$

... (3)

Parameter	Description	Value
$C_{ia,d}$	concentration of i in air at distance d from source	g/m ³ (estimated)
Q_i	emission rate of i from surface of site	g/s (estimated)
$\bar{v}$	mean annual wind velocity	4.2 m/s mean wind speed over El Paso*
σ_x	dispersion coefficient in lateral/crosswind direction	1m
σ_z	dispersion coefficient in vertical direction	1m

* Ref. American Petroleum Institute Decision Support System

$$Q_i = (D_i)(A)(C_{isg})(nfi)(P^{1/3})/(di)$$

... (4)

Parameter	Description	Value
Q_i	emission rate of i from surface of site	g/s (estimated)
D_i	diffusion coefficient of i in air	cm ² /s (chemical specific)
A	exposed surface area of site	5.06E+06 cm ²
C_{isg}	saturation gas concentration of i in soil	5.06E+05 cm ² (current on-site industrial area) g/cm ³ (estimated)
nfi	mole fraction of i in soil: (moles i)/(moles i + moles soil)	0 to 1 (chemical specific)
P	total soil porosity	0.25 (estimated)
di	depth of contamination	100 cm (measured)

Appendix Q-2 (continued)

$$C_{isg} = (p_i)(MM_i)/(RT)$$

... (5)

Parameter	Description	Value
C_{isg}	saturation gas concentration of i in soil	g/cm ³ (estimated)
p_i	vapor pressure of i at temperature T	mmHg (chemical specific)
MM_i	molecular mass of i	unitless (chemical specific)
R	molar gas constant	62,361 mmHg·cm ³ /(mol·K)
T	temperature	K

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Appendix Q - 3 EQUATION FOR CALCULATING CHEMICAL INTAKE RATE INHALATION OF SOIL GAS FROM GROUND WATER ^a

$$\{\text{intake rate}\}_i = [(Ciad)(IRa)(ABSF)(Fla)(CF)(EF)(ED)] / [(BM)(AT)]$$

... (6)

Parameter {intake rate} _i	Description	Value ^b
Ciad	amount of i taken into the body via inhalation and biologically absorbed	mg / [(kg body mass)d] (estimated)
IRa	concentration of i in air at distance d from source	g / m ³ (estimated)
ABSF	inhalation rate of air	15 m ³ /d (child) 20 m ³ /d (adult)
Fla	absorption factor, the fraction of i absorbed by the body and biologically available	1.0
CF	fraction of inhaled air that has constituent of concern i	1.0 for on-site (no resident) 0.1 for off-site (assume 10X dilution) : industrial 0.01 for off-site resident (10 X dilution + 10 X attenuation)
EF*	conversion factor (units)	1,000 mg / g
ED	exposure frequency	350 d / y (residential); 250 d/y (industrial)
BM	exposure duration	6 y ucl ; 2 y mean (child: 1– 6 y) 24 y ucl ; 7 y mean (adult: 7– 30 y) 25 y ucl ; 9 y mean (industrial worker)
AT = ATnc, noncancer AT = ATc, cancer	body mass —averaged over exposure period	15 kg body mass (child) 70 kg body mass (adult)
	averaging time: period over which exposure is averaged	(ED)(365 d / y) noncancer (70 y)(365 d / y) = 25,550 d cancer

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* Site specific exposure frequency may be used instead of EPA standard default values.

^aEquation 6 through 12 applies to Route-Pathway RP-2, RP-6, RP-10 and RP-16.

CF is necessary to handle the units of Ciad.

^b Unless otherwise stated all values presented are defaults from EPA Risk Assessment Guidance for Superfund (RAGS part A & B) or EPA Exposure Factor Handbook (EPA, 1989)

Assumptions: 1. no physical or chemical interaction of contaminant i with the unsaturated soil

2. equilibrium occurs once a gaseous contaminant reaches the atmosphere just above the surface of the ground
3. no effects from differing size of contaminant molecules
4. no depletion of contaminant source concentration over time

Appendix Q - 3 (continued)

$$C_{ia,d} = (1/\pi)(Q_i)/[(\bar{v})(\sigma_x)(\sigma_z)] \quad \dots (7)$$

$$Q_i = (P^{1/3})(Q_{iw}) \quad \dots (8)$$

Parameter	Description	Value
$C_{ia,d}$	concentration of i in air at distance d from source	g/m^3 (estimated)
Q_i	emission rate of i from surface of site	g/s (estimated)
P	soil porosity fraction	0.25 (estimated)
Q_{iw}	emission rate of i from top of ground water	g/s (estimated)
$\bar{v}$	mean annual wind velocity	4.2 m/s mean wind speed over El Paso*
σ_x	dispersion coefficient in lateral/crosswind direction	1m
σ_z	dispersion coefficient in vertical direction	1m

* Ref. American Petroleum Institute Decision Support System

Appendix Q- 3 (continued)

$$Q_{iw} = (K_{oa})(n_{fi})(MM_i)(A) \quad \dots (9)$$

$$1/(K_{oa}) = 1/(K_{li}) + 1/[(K_{gi})(H_i^*)] \quad \dots (10)$$

$$K_{li} = (K_{lo})(T/298)(MM_o/MM_i)^{0.5} \quad \dots (11)$$

$$K_{gi} = (K_{gl})[(T/298)^{1.005}](MM_i/MM_o)^{0.335} \quad \dots (12)$$

Parameter	Description	Value
Q_{iw}	emission rate of i from top of ground water	g/s (estimated)
K_{oa}	overall mass transfer coefficient across water-air interface	(mol/cm ²)/s (estimated)
n_{fi}	mole fraction of i in liquid medium (moles i)/(moles i + moles liquid medium)	0 to 1 (chemical specific)
MM_i	molecular mass of i	unitless (chemical specific)
A	Exposed surface area of site	5.06E+06 cm ²
K_{li}	liquid medium mass transfer coefficient of i	(mol/cm ²)/s (chemical specific)
K_{gi}	gas medium mass transfer coefficient of i	(mol/cm ²)/s (chemical specific)
H_i^{*a}	Henry's law constant of i	unitless (chemical specific)
K_{lo}	liquid mass transfer coefficient of oxygen at 298 K	1.23E-04 (mol/cm ²)/s
T	temperature	degree Kelvin (K)
MMo	molecular mass of oxygen (O ₂)	31.9988
K_{gl}	gas mass transfer coefficient of liquid medium at 298 K	5.80E-05 (mol/cm ²)/s if medium is water (H ₂ O)
MMI	molecular mass of liquid medium	18.0153 if medium is water (H ₂ O)

^a H_i^* can be estimated from the following relationship: $H_i^* = 16.04(MM_i)(P_i)/(T[Si])$, where P_i = vapor pressure of i (mmHg), T = temperature (Kelvin), and S = solubility of i (mg/L).

Appendix Q- 4 EQUATION FOR CALCULATING CHEMICAL INTAKE RATE INHALATION OF VOLATILES FROM LNAPL^a

$$\{\text{intake rate}\}_i = [(Cia,d)(IRa)(ABSF)(Fla)(EF)(ED)] / [(BM)(AT)]$$

... (13)

Parameter {intake rate} _i	Description	Value
Cia,d	amount of i taken into the body via inhalation and biologically absorbed	mg / [(kg body mass)d] (estimated)
IRa	concentration of i in air at distance d from source	g / m ³ (estimated)
ABSF	inhalation rate of air inhalation rate of air	15 m ³ /d (child) 20 m ³ /d (adult)
Fla	absorption factor, the fraction of i absorbed by the body and biologically available	1.0
CF	fraction of inhaled air that has constituent of concern i	1.0 for on-site (no resident) 0.1 for off-site (assume 10X dilution); industrial 0.01 for off-site resident (10 X dilution + 10 X attenuation)
EF*	conversion factor	1,000 mg/g
ED	exposure frequency	350 d/y (residential); 250 d/y (industrial)
BM	exposure duration exposure duration	6 y ucl ; 2 y mean (child: 1-6 y) 24 y ucl ; 7 y mean (adult: 7-30 y) 25 y ucl ; 9 y mean (industrial worker: 9-25 y)
AT = ATnc, noncancer effects AT = ATc, for cancer effects	body mass body mass	15 kg body mass (child) 70 kg body mass (adult)
	averaging time: period over which exposure is averaged	(ED)(365 d / y) noncancer (70 y)(365 d / y) = 25,550 d cancer

* Site specific exposure frequency may be used instead of EPA standard default values.

^a Equation 13 through 17 applies to Route-Pathways RP-3, RP-7, RP-11, RP-13, & RP-17, RP-19, and RP-21

CF is necessary to handle the units of Cia,d

Unless otherwise stated all values presented are defaults from EPA Risk Assessment Guidance for Superfund (RAGS part A & B) or EPA Exposure Factor Handbook (EPA, 1989)

Assumptions: 1. no physical or chemical interaction of contaminant i with the unsaturated soil

2. equilibrium occurs once a gaseous contaminant reaches the atmosphere just above the surface of the ground

3. no effects from differing size of contaminant molecules

4. no depletion of contaminant source concentration over time

Appendix Q- 4 (continued)

$$C_{ia,d} = (1/\pi)(Q_i)/[(\bar{v})(\sigma_x)(\sigma_z)]$$

... (14)

Parameter	Description	Value
$C_{ia,d}$	concentration of i in air at distance d from source	g/m ³ (estimated)
Q_i	emission rate of i from surface of site	g/s (estimated)
$\bar{v}$	mean annual wind velocity	4.2 m/s mean wind speed over El Paso*
σ_x	dispersion coefficient in lateral/crosswind direction	1 m
σ_z	dispersion coefficient in vertical direction	1 m

* Ref. American Petroleum Institute Decision Support System

$$Q_i = (D_i)(A)(C_{isg})(nfi)(P^{4/3})/(d_i)$$

... (15)

Parameter	Description	Value
Q_i	emission rate of i from surface of site	g/s (estimated)
D_i	diffusion coefficient of i in air	cm ² /s (chemical specific)
A	exposed surface area of site	5.06E+06 cm ² 5.06E+05 cm ² (current on-site industrial area)
C_{isg}	saturation gas concentration of i in soil	g/cm ³ (estimated)
nfi	mole fraction of i in soil: (moles i)/(moles i + moles soil)	set equal to 1 ([LNAPL] = 100% by default)
P	total soil porosity	0.25 (estimated)
d_i	depth of constituent of concern	100 cm (measured)

Appendix Q- 4 (continued)

$$C_{isg} = (ppi)(MM_i)/(RT)$$

... (16)

$$ppi = (nfi_{[LNAPL]})(pi)$$

... (17)

Parameter	Description	Value
C _{isg}	saturation gas concentration of i in soil	g/cm ³ (estimated)
n _{fi [LNAPL]}	mole fraction of i in LNAPL: (moles of i) / (moles of i + moles LNAPL)	0 to 1 (chemical specific)
ppi	partial pressure of i at temperature T	mmHg (estimated)
pi	vapor pressure of i at temperature T	mmHg (chemical specific)
MM _i	molecular mass of i	
R	molar gas constant	62,361 mmHg·cm ³ /(mol·K)
T	temperature	K

Appendix Q-5 EQUATION FOR CALCULATING CHEMICAL INTAKE RATE INHALATION OF SURFACE SOIL DUST^a

$$\{\text{intake rate}\}_i = [(Cis)(IRa)(Fla)(ABSF)(PEF)(EF)(ED)] / [(BM)(AT)]$$

... (18)

Parameter	Description	Value
{intake rate} _i	amount of i taken into the body via inhalation and biologically absorbed	mg / (kg body mass) d] (estimated)
Cis	concentration of i in soil	mg / kg (measured)
IRa	inhalation rate of air inhalation rate of air	15 m ³ /d (child) 20 m ³ /d (adult)
Fla ^b	fraction of inhaled air that has constituent of concern i	1.0 for onsite (no resident) 0.1 for offsite (10X dilution); industrial 0.01 for offsite resident (10 X dilution + 10 X attenuation)
ABSF	absorption factor, the fraction of i absorbed by the body and biologically available	1.0
PEF	particle emission factor	2.16E-10 kg / m ³ (default : EPA 1991)
EF*	exposure frequency	350 d/y for residential; 250 d/y for industrial
ED	exposure duration exposure duration exposure duration	6 y for ucl ; 2 y for mean (child : 1-6 y) 24 y for ucl ; 7 y for mean (adult : 7-30y) 25 y for ucl ; 9 y for mean (industrial worker)
BM	body mass body mass —averaged over exposure period	15 kg body mass (child) 70 kg body mass (adult)
AT	averaging time: period over which exposure is averaged	(ED)(365 d / y) for noncancer (70)(365 d / y) = 25,550 d for cancer

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* Site specific exposure frequency may be used instead of EPA standard default values.

^a Equation 18 applies to Route-Pathways RP-4, RP-8, RP-12, RP-14, RP-18, and RP-20

^b For on site, no dilution from transport-dispersion is assumed (Fla = 1.0) ; for off site, a 10 X dilution is assumed because of transport-dispersion; an additional 10 X attenuation is assumed for constituents entering on off-site resident (fla = 0.1 or 0.01). Dispersion modeling has been used to estimate airborne concentrations at receptors distant from source

Appendix R

Calculation of Intake Rate

RP1

SOIL GAS EMISSION RATE (Qis) AT ON SITE GROUND SURFACE FROM SOIL PARTICLES* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Cis,max mg/kg	pi mmHg	MMI	R mmHg(cm ³)/[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi,max	P	di cm	Qis g/s
Organic												
benzene	2.40E+01	9.5E+01	78	62,361	293	4.05544E-04	8.700E-02	2.632E+06	4.800E-05	0.25	100	7.02121E-06
ethylbenzene	6.50E+01	9.5E+00	106	62,361	293	5.51123E-05	6.600E-02	2.632E+06	9.566E-05	0.25	100	1.44258E-06
fluorene	5.10E+01	8.7E-01	128	62,361	293	6.09465E-06	5.900E-02	2.632E+06	6.216E-05	0.25	100	9.26615E-08
naphthalene	7.90E+01	4.5E-02	142	62,361	293	3.49720E-07	4.400E-02	2.632E+06	8.679E-05	0.25	100	5.53669E-09
1-methylnaphthalene**	1.60E+02	4.5E-02	142	62,361	293	3.49720E-07	4.400E-02	2.632E+06	1.758E-04	0.25	100	1.12136E-08
2-methylnaphthalene**	2.30E+00	2.5E-06	178	62,361	293	2.43545E-11	5.200E-02	2.632E+06	2.016E-06	0.25	100	1.05835E-14
phenanthrene												
phenol**												
2,4-dimethylphenol**												
pyrene	1.70E+00	2.5E-06	202	62,361	293	2.76383E-11	4.800E-02	2.632E+06	1.313E-06	0.25	100	7.22085E-15
toluene	1.00E+01	2.8E+01	92	62,361	293	1.41486E-04	7.800E-02	2.632E+06	1.696E-05	0.25	100	7.75816E-07
xylene (sum: o-, m-, p-)	1.20E+02	7.7E+00	106	62,361	293	4.46700E-05	7.200E-02	2.632E+06	1.766E-04	0.25	100	2.35485E-06
Inorganic												
none												

CANCER (c)	Cis,max mg/kg	pi mmHg	MMI	R mmHg(cm ³)/[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi,max	P	di cm	Qis g/s
Organic												
benzene	2.40E+01	9.5E+01	78	62,361	293	4.05544E-04	8.700E-02	2.632E+06	4.800E-05	0.25	100	7.02121E-06
Inorganic												
none												

*Assumption: Qis is constant, i.e., contaminant source is not depleted over time. The calculation of nfi assumes that the soil is 50% clay and 50% sand (MMsoil = 156).

Area = approx. 1/15 of an acre based on soil area occupied by maximum soil concentration.

**Some values of pi and Di are estimated.

RP1

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles
adult

NONCANCER (nc)	Qis g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	7.02121E-06	4.2	1	1	5.32124E-07
ethylbenzene	1.44258E-06	4.2	1	1	1.09330E-07
fluorene					
naphthalene	9.26615E-08	4.2	1	1	7.02264E-09
1-methylnaphthalene	5.53669E-09	4.2	1	1	4.19615E-10
2-methylnaphthalene	1.12136E-08	4.2	1	1	8.49854E-10
phenanthrene	1.05835E-14	4.2	1	1	8.02103E-16
phenol					
2,4-dimethylphenol					
pyrene	7.22085E-15	4.2	1	1	5.47254E-16
toluene	7.75816E-07	4.2	1	1	5.87976E-08
xylene (sum: o-, m-, p-)	2.35485E-06	4.2	1	1	1.78469E-07
Inorganic					
none					

CANCER (c)	Qis g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	7.02121E-06	4.2	1	1	5.32124E-07
Inorganic					
none					

*Mean wind speed (<v>.m) over El Paso = 4.2 m/s (API 1994).

RP1

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles
adult

NONCANCER (nc)	Ciad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc:ucl d	ATc:m d	Intake Rate, ucl		Intake Rate, mean	
													mg/[(kg body mass)d]		mg/[(kg body mass)d]	
Organic																
benzene	5.32124E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	3.33228E-06		2.08268E-06	
ethylbenzene	1.09330E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	6.84650E-07		4.27907E-07	
fluorene																
naphthalene	5.32124E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	3.33228E-06		2.08268E-06	
1-methylnaphthalene	4.19615E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.62773E-09		1.64233E-09	
2-methylnaphthalene	8.49854E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	5.32198E-09		3.32624E-09	
phenanthrene	8.02103E-16	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	5.02295E-15		3.13935E-15	
phenol																
2,4-dimethylphenol																
pyrene	5.47254E-16	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	3.42703E-15		2.14189E-15	
toluene	5.87976E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	3.68204E-07		2.30128E-07	
xylene (sum: o-, m-, p-)	1.78469E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.11762E-06		6.98510E-07	
Inorganic																
none																

CANCER (c)	Ciad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc:ucl d	ATc:m d	Intake Rate, ucl		Intake Rate, mean	
													mg/[(kg body mass)d]		mg/[(kg body mass)d]	
Organic																
benzene	5.32124E-07	2.0E+01	1	1	1,000	8	5	25	9	70	25,550	25,550	1.19010E-06		2.67773E-07	
Inorganic																
none																

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed on site for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen on site work.
EDm = 9 y (national median time at one residence, EPA 1989a).

*Assumption: industrial worker is directly over emission source and dispersion is minimal (Fla = 1, conservative).

RP1

RISK — Brickland Refinery, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.40E+01	3.33228E-06	2.08268E-06	1.0E-03	3.33228E-03	2.08268E-03
ethylbenzene	6.50E+01	6.84650E-07	4.27907E-07	2.9E-01	2.36086E-06	1.47554E-06
fluorene						
naphthalene	5.10E+01	3.33228E-06	2.08268E-06	4.0E-02	8.33071E-05	5.20669E-05
1-methylnaphthalene	7.90E+01	2.62773E-09	1.64233E-09	4.0E-02	6.56932E-08	4.10582E-08
2-methylnaphthalene	1.60E+02	5.32198E-09	3.32624E-09	4.0E-02	1.33049E-07	8.31559E-08
phenanthrene	2.30E+00	5.02295E-15	3.13935E-15	3.0E-02	1.67432E-13	1.04645E-13
phenol						
2,4-dimethylphenol						
pyrene	1.70E+00	3.42703E-15	2.14189E-15	3.0E-02	1.14234E-13	7.13965E-14
toluene	1.00E+01	3.68204E-07	2.30128E-07	1.0E-01	3.68204E-06	2.30128E-06
xylene (sum: o-, m-, p-)	1.20E+02	1.11762E-06	6.98510E-07	2.0E-01	5.58808E-06	3.49255E-06
Inorganic						
none						
				Hazard Index (HI) =	3.42742E-03	2.14214E-03
				HI (adult) =	3.42742E-03	2.14214E-03

CANCER (c)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk mean
Organic						
benzene	2.40E+01	1.19010E-06	2.67773E-07	2.9E-02	3.45129E-08	7.76541E-09
Inorganic						
none						
				Sum Cancer Risk =	3.45129E-08	7.76541E-09
				Cancer Risk (adult) =	3.45129E-08	7.76541E-09

RP2

VOLATILE ORGANICS EMISSION RATE (Qlw) FROM ONSITE GROUNDWATER* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of volatile organics from Groundwater

adult

NONCANCER (nc)	Qlw,max mg/L	MMI	nfi,max	Kgi (mol/cm ²)/s	Kli (mol/cm ²)/s	Hi [†]	Koa (mol/cm ²)/s	A cm ²	Qlw g/s
Organic									
benzene	2.30E+01	78	5.31218E-06	3.49004E-05	7.74597E-05	2.49E-01	7.81360E-06	2.632E+06	8.522736E-03
ethylbenzene	7.00E-02	106	1.18969E-08	3.14923E-05	6.64462E-05	2.87E-01	7.95608E-06	2.632E+06	2.641190E-05
fluorene	1.20E-02	166	1.30231E-09	2.70986E-05	5.30969E-05	2.86E-03	7.73889E-08	2.632E+06	4.404153E-08
naphthalene	2.35E-01	128	3.30750E-08	2.95643E-05	6.04670E-05	5.78E-02	1.66185E-06	2.632E+06	1.852090E-05
1-methylnaphthalene**	1.65E-01	142	2.09333E-08	2.85539E-05	5.74089E-05	1.25E-02	3.54719E-07	2.632E+06	2.775687E-06
2-methylnaphthalene**	1.85E-01	142	2.34706E-08	2.85539E-05	5.74089E-05	1.42E-02	4.02622E-07	2.632E+06	3.532415E-06
phenanthrene	3.20E-02	178	3.23871E-09	2.64723E-05	5.12759E-05	7.11E-03	1.87530E-07	2.632E+06	2.845918E-07
phenol**	3.00E-01	94	5.74956E-08	3.27857E-05	7.05601E-05	5.73E-06	1.87862E-10	2.632E+06	2.672771E-09
2,4-dimethylphenol**	1.10E-01	122	1.62433E-08	3.00436E-05	6.19360E-05	1.61E-06	4.83702E-11	2.632E+06	2.523321E-10
pyrene	5.80E-02	202	5.17271E-09	2.53741E-05	4.81335E-05	2.28E-04	5.78459E-09	2.632E+06	1.591119E-08
toluene	1.60E-01	92	3.13310E-08	3.30228E-05	7.13230E-05	2.84E-01	8.28858E-06	2.632E+06	6.289301E-05
xylene (sum: o-, m-, p-)	1.10E+00	106	1.86951E-07	3.14923E-05	6.64462E-05	3.15E-01	8.63146E-06	2.632E+06	4.502762E-04
Inorganic									
none									

CANCER (c)	Qlw,max mg/L	MMI	nfi,max	Kgi (mol/cm ²)/s	Kli (mol/cm ²)/s	Hi [†]	Koa (mol/cm ²)/s	A cm ²	Qlw g/s
Organic									
benzene	2.30E+01	78	5.31218E-06	3.49004E-05	7.74597E-05	2.49E-01	7.81360E-06	2.632E+06	8.522736E-03
Inorganic									
none									

*Assumption: Qlw is constant, i.e., contaminant source is not depleted over time. Temperature = 293 K (20°C).

Area = approx. 1/15 of an acre based on area of the 20 ppm benzene concentration contour plotted from the results of the 6th quarter monitoring (Q2-1995).

**Value of H[†] is calculated/estimated from vapor pressure, molecular mass, and solubility in water.

RP2

AIRBORNE CONCENTRATION (Ciad) OF VOLATILE ORGANICS AT ON SITE RECEPTOR — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of volatile organics from Groundwater
adult

NONCANCER (nc)	Ciw,max mg/L	Qiw g/s	P	Qi g/s	$\langle v \rangle, m^*$ m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic								
benzene	2.30E+01	8.52274E-03	0.25	1.34225E-03	4.2	1	1	1.01726E-04
ethylbenzene	7.00E-02	2.64119E-05	0.25	4.15961E-06	4.2	1	1	3.15249E-07
fluorene	1.20E-02	4.40415E-08	0.25	6.93611E-09	4.2	1	1	5.25674E-10
naphthalene	2.35E-01	1.85209E-05	0.25	2.91686E-06	4.2	1	1	2.21063E-07
1-methylnaphthalene	1.65E-01	2.77569E-06	0.25	4.37143E-07	4.2	1	1	3.31302E-08
2-methylnaphthalene	1.85E-01	3.53242E-06	0.25	5.56321E-07	4.2	1	1	4.21625E-08
phenanthrene	3.20E-02	2.84592E-07	0.25	4.48204E-08	4.2	1	1	3.39685E-09
phenol	3.00E-01	2.67277E-09	0.25	4.20935E-10	4.2	1	1	3.19018E-11
2,4-dimethylphenol	1.10E-01	2.52332E-10	0.25	3.97398E-11	4.2	1	1	3.01180E-12
pyrene	5.80E-02	1.59112E-08	0.25	2.50586E-09	4.2	1	1	1.89914E-10
toluene	1.60E-01	6.28930E-05	0.25	9.90503E-06	4.2	1	1	7.50683E-07
xylene (sum: o-, m-, p-)	1.10E+00	4.50276E-04	0.25	7.09141E-05	4.2	1	1	5.37444E-06
Inorganic none								

CANCER (c)	Ciw,max mg/L	Qiw g/s	P	Qi g/s	$\langle v \rangle, m^*$ m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic								
benzene	2.30E+01	8.52274E-03	0.25	1.34225E-03	4.2	1	1	1.01726E-04
Inorganic none								

*Mean wind speed ($\langle v \rangle, m$) over El Paso = 4.2 m/s (API 1994).

RP2

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of volatile organics from Groundwater

adult

NONCANCER (nc)	Clad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucl d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	1.01726E-04	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	6.37034E-04	3.98146E-04
ethylbenzene	3.15249E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.97416E-06	1.23385E-06
fluorene	5.25674E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	3.29189E-09	2.05743E-09
naphthalene	2.21063E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.38435E-06	8.65218E-07
1-methylnaphthalene	3.31302E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.07469E-07	1.29668E-07
2-methylnaphthalene	4.21625E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.64031E-07	1.65019E-07
phenanthrene	3.39685E-09	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.12719E-08	1.32949E-08
phenol	3.19018E-11	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.99777E-10	1.24860E-10
2,4-dimethylphenol	3.01180E-12	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.88606E-11	1.17879E-11
pyrene	1.89914E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.18929E-09	7.43303E-10
toluene	7.50683E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	4.70095E-06	2.93809E-06
xylene (sum: o-, m-, p-)	5.37444E-06	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	3.36560E-05	2.10350E-05
Inorganic														
none														

CANCER (c)	Clad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucl d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	1.01726E-04	2.0E+01	1	1	1,000	8	5	25	9	70	25,550	25,550	2.27512E-04	5.11902E-05
Inorganic														
none														

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen on site work.
EDm = 9 y (national median time at one residence, EPA 1989a).

*Assumption: industrial worker is directly over emission source and dispersion is minimal (Fla = 1, conservative).

RP2

RISK — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of volatile organics from Groundwater
adult

NONCANCER (nc)	Ciw,max mg/L	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.30E+01	6.37034E-04	3.98146E-04	1.0E-03	6.37034E-01	3.98146E-01
ethylbenzene	7.00E-02	1.97416E-06	1.23385E-06	2.9E-01	6.80746E-06	4.25466E-06
fluorene	1.20E-02	3.29189E-09	2.05743E-09	4.0E-02	8.22973E-08	5.14358E-08
naphthalene	2.35E-01	1.38435E-06	8.65218E-07	4.0E-02	3.46087E-05	2.16304E-05
1-methylnaphthalene	1.65E-01	2.07469E-07	1.29668E-07	4.0E-02	5.18673E-06	3.24171E-06
2-methylnaphthalene	1.85E-01	2.64031E-07	1.65019E-07	4.0E-02	6.60078E-06	4.12549E-06
phenanthrene	3.20E-02	2.12719E-08	1.32949E-08	3.0E-02	7.09062E-07	4.43164E-07
phenol	3.00E-01	1.99777E-10	1.24860E-10	6.0E-01	3.32961E-10	2.08101E-10
2,4-dimethylphenol	1.10E-01	1.88606E-11	1.17879E-11	2.0E-02	9.43031E-10	5.89394E-10
pyrene	5.80E-02	1.18929E-09	7.43303E-10	3.0E-02	3.96428E-08	2.47768E-08
toluene	1.60E-01	4.70095E-06	2.93809E-06	1.0E-01	4.70095E-05	2.93809E-05
xylene (sum: o-, m-, p-)	1.10E+00	3.36560E-05	2.10350E-05	2.0E-01	1.68280E-04	1.05175E-04
Inorganic						
none						
				Hazard Index (HI) =	6.37303E-01	3.98314E-01
				HI (adult) =	6.37303E-01	3.98314E-01

CANCER (c)	Ciw,max mg/L	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucf	Cancer Risk mean
Organic						
benzene	2.30E+01	2.27512E-04	5.11902E-05	2.9E-02	6.59785E-06	1.48452E-06
Inorganic						
none						
				Sum Cancer Risk =	6.59785E-06	1.48452E-06
				Cancer Risk (adult) =	6.59785E-06	1.48452E-06

VOLATILE ORGANICS EMISSION RATE (Qi) AT ON SITE GROUND SURFACE FROM LNAPL CONTAMINANT — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	Ci mg/kg	pi mmHg	nfi, LNAPL	ppi mmHg	MMI	R mmHg(cm ³)/[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
Organic														
benzene*	6.25E+01	9.5E+01	1.20E-04	1.1E-02	78	62,361	293	4.87432E-08	8.700E-02	2.632E+06	1	0.25	100	1.75812E-05
ethylbenzene	2.10E+02	9.5E+00	2.97E-04	2.8E-03	106	62,361	293	1.63777E-08	6.600E-02	2.632E+06	1	0.25	100	4.48138E-06
fluorene*	4.95E+02	5.5E-03	4.47E-04	2.5E-06	166	62,361	293	2.23500E-11	6.340E-02	2.632E+06	1	0.25	100	5.87465E-09
naphthalene*	4.95E+02	8.7E-01	5.80E-04	5.0E-04	128	62,361	293	3.53537E-09	5.900E-02	2.632E+06	1	0.25	100	8.64771E-07
1-methylnaphthalene**	2.00E+03	4.5E-02	2.11E-03	9.5E-05	142	62,361	293	7.38845E-10	4.400E-02	2.632E+06	1	0.25	100	1.34778E-07
2-methylnaphthalene**	4.95E+02	4.5E-02	5.23E-04	2.4E-05	142	62,361	293	1.82864E-10	4.400E-02	2.632E+06	1	0.25	100	3.33576E-08
phenanthrene	1.30E+03	2.5E-06	1.10E-03	2.7E-09	178	62,361	293	2.68805E-14	5.200E-02	2.632E+06	1	0.25	100	5.75190E-12
phenol* **	4.95E+02	1.0E-01	7.90E-04	7.9E-05	94	62,361	293	4.06365E-10	8.000E-02	2.632E+06	1	0.25	100	1.34778E-07
2,4-dimethylphenol* **	4.95E+02	1.0E-02	6.09E-04	6.1E-06	122	62,361	293	4.06365E-11	6.000E-02	2.632E+06	1	0.25	100	1.01084E-08
pyrene*	4.95E+02	2.5E-06	3.88E-04	9.2E-10	202	62,361	293	1.01591E-14	4.800E-02	2.632E+06	1	0.25	100	2.02167E-12
toluene*	6.25E+01	2.8E+01	1.02E-04	2.9E-03	92	62,361	293	1.44177E-08	7.800E-02	2.632E+06	1	0.25	100	4.68236E-06
xylene (sum: o-, m-, p-)	5.40E+02	7.7E+00	7.64E-04	5.9E-03	106	62,361	293	3.41346E-08	7.200E-02	2.632E+06	1	0.25	100	1.01892E-05
Inorganic														
none														

CANCER (c)	Ci (mg/kg)	pi mmHg	nfi, LNAPL	ppi mmHg	MMI	R mmHg(cm ³)/[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
benzene*	6.25E+01	9.50E+01	1.20E-04	1.1E-02	78	62,361	293	4.87432E-08	8.700E-02	2.632E+06	1	0.25	100	1.75812E-05
Inorganic														
none														

*These substances were not detected. Thus, Ci for these substances was set to half the detection limit.

Ci is used to calculate the partial pressure (ppi) of each COC in the LNAPL phase.

**Some values of pi and Di are estimated.

Assumption: Qi is constant, i.e., contaminant source is not depleted over time. Molecular mass of LNAPL is assumed = 150.

Area = approx. 1/15 of an acre assumed aerial extent of LNAPL.

RP3

AIRBORNE CONCENTRATION (Ciad) OF VOLATILE ORGANICS AT ONSITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	Qi mg/kg	<v>, m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.75812E-05	4.2	1	1	1.33244E-06
ethylbenzene	4.48138E-06	4.2	1	1	3.39635E-07
fluorene	5.87465E-09	4.2	1	1	4.45228E-10
naphthalene	8.64771E-07	4.2	1	1	6.55393E-08
1-methylnaphthalene	1.34778E-07	4.2	1	1	1.02146E-08
2-methylnaphthalene	3.33576E-08	4.2	1	1	2.52811E-09
phenanthrene	5.75190E-12	4.2	1	1	4.35925E-13
phenol	1.34778E-07	4.2	1	1	1.02146E-08
2,4-dimethylphenol	1.01084E-08	4.2	1	1	7.66094E-10
pyrene	2.02167E-12	4.2	1	1	1.53219E-13
toluene	4.66236E-06	4.2	1	1	3.53351E-07
xylene (sum: o-, m-, p-)	1.01892E-05	4.2	1	1	7.72223E-07
Inorganic					
none					

CANCER (c)	Qi,ci g/s	<v>, m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.75812E-05	4.2	1	1	1.33244E-06
Inorganic					
none					

*Mean wind speed (<v>, m) over El Paso = 4.2 m/s (API 1994).

RP3

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	Ciadj	IRa	Fla	ABSF	CF	EFucl	EFm	EDucl	EDm	BM	ATnc:ucl	ATnc:m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic														
benzene	1.33244E-06	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	8.34406E-06	5.21504E-06
ethylbenzene	3.39635E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.12687E-06	1.32930E-06
fluorene	4.45228E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.78812E-09	1.74258E-09
naphthalene	6.55393E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	4.10422E-07	2.56514E-07
1-methylnaphthalene	1.02146E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	6.39661E-08	3.99788E-08
2-methylnaphthalene	2.52811E-09	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.58316E-08	9.89475E-09
phenanthrene	4.35925E-13	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.72987E-12	1.70617E-12
phenol	1.02146E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	6.39661E-08	3.99788E-08
2,4-dimethylphenol	7.66094E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	4.79746E-09	2.99841E-09
pyrene	1.53219E-13	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	9.59491E-13	5.99682E-13
toluene	3.53351E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.21277E-06	1.38298E-06
xylene (sum: o-, m-, p-)	7.72223E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	4.83584E-06	3.02240E-06
Inorganic														
none														

CANCER (c)	Ciadj	IRa	Fla	ABSF	CF	EFucl	EFm	EDucl	EDm	BM	ATc:ucl	ATc:m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic														
benzene	1.33244E-06	2.0E+01	1	1	1,000	8	5	25	9	70	25,550	25,550	2.98002E-06	6.70505E-07
Inorganic														
none														

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen on site work.
EDm = 9 y (national median time at one residence, EPA 1989a).

*Assumption: industrial worker is directly over emission source and dispersion is minimal (Fla = 1, conservative).

RP3

RISK — Brickland Refinery, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	Cl mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	6.25E+01	8.34406E-06	5.21504E-06	1.0E-03	8.34406E-03	5.21504E-03
ethylbenzene	2.10E+02	2.12687E-06	1.32930E-06	2.9E-01	7.33404E-06	4.58378E-06
fluorene	4.95E+02	2.78812E-09	1.74258E-09	4.0E-02	6.97031E-08	4.35644E-08
naphthalene	4.95E+02	4.10422E-07	2.56514E-07	4.0E-02	1.02606E-05	6.41285E-06
1-methylnaphthalene	2.00E+03	6.39661E-08	3.99788E-08	4.0E-02	1.59915E-06	9.99470E-07
2-methylnaphthalene	4.95E+02	1.58316E-08	9.89475E-09	4.0E-02	3.95790E-07	2.47369E-07
phenanthrene	1.30E+03	2.72987E-12	1.70617E-12	3.0E-02	9.09955E-11	5.68722E-11
phenol	4.95E+02	6.39661E-08	3.99788E-08	6.0E-01	1.06610E-07	6.66313E-08
2,4-dimethylphenol	4.95E+02	4.79746E-09	2.99841E-09	2.0E-02	2.39873E-07	1.49921E-07
pyrene	4.95E+02	9.59491E-13	5.99682E-13	3.0E-02	3.19830E-11	1.99894E-11
toluene	6.25E+01	2.21277E-06	1.38298E-06	1.0E-01	2.21277E-05	1.38298E-05
xylene (sum: o-, m-, p-)	5.40E+02	4.83584E-06	3.02240E-06	2.0E-01	2.41792E-05	1.51120E-05
Inorganic						
none						
				Hazard Index (HI) =	8.41037E-03	5.25648E-03
				HI (adult) =	8.41037E-03	5.25648E-03

CANCER (c)	Cl mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucf	Cancer Risk mean
Organic						
benzene	6.25E+01	2.98002E-06	6.70505E-07	2.9E-02	8.64206E-08	1.94446E-08
Inorganic						
none						
				Sum Cancer Risk =	8.64206E-08	1.94446E-08
				Cancer Risk (adult) =	8.64206E-08	1.94446E-08

RP4

RISK — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (on site)

INDUSTRIAL

Inhalation of Soil Dust

adult

NONCANCER (nc)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.40E+01	3.24634E-11	2.02896E-11	1.0E-03	3.24634E-08	2.02896E-08
ethylbenzene	6.50E+01	8.79217E-11	5.49511E-11	2.9E-01	3.03178E-10	1.89486E-10
fluorene						
naphthalene	5.10E+01	6.89847E-11	4.31155E-11	4.0E-02	1.72462E-09	1.07789E-09
1-methylnaphthalene	7.90E+01	1.06859E-10	6.67867E-11	4.0E-02	2.67147E-09	1.66967E-09
2-methylnaphthalene	1.60E+02	2.16423E-10	1.35264E-10	4.0E-02	5.41057E-09	3.38160E-09
phenanthrene	2.30E+00	3.11108E-12	1.94442E-12	3.0E-02	1.03703E-10	6.48141E-11
phenol						
2,4-dimethylphenol						
pyrene	1.70E+00	2.29949E-12	1.43718E-12	3.0E-02	7.66497E-11	4.79061E-11
toluene	1.00E+01	1.35264E-11	8.45401E-12	1.0E-01	1.35264E-10	8.45401E-11
xylene (sum: o-, m-, p-)	1.20E+02	1.62317E-10	1.01448E-10	2.0E-01	8.11585E-10	5.07241E-10
Inorganic						
arsenic	2.20E+01	2.97581E-11	1.85988E-11	3.0E-04	9.91937E-08	6.19961E-08
barium	2.04E+02	2.75939E-10	1.72462E-10	7.0E-02	3.94198E-09	2.46374E-09
cadmium	1.10E+00	1.48791E-12	9.29941E-13	5.0E-04	2.97581E-09	1.85988E-09
chromium(III) = 6/7[chromium]	9.43E+00	1.27554E-11	7.97213E-12	1.0E+00	1.27554E-11	7.97213E-12
chromium(VI) = 1/7[chromium]	1.57E+00	2.12365E-12	1.32728E-12	5.0E-03	4.24730E-10	2.65456E-10
lead	7.40E+01					
mercury	4.10E-01	5.54583E-13	3.46614E-13	3.0E-04	1.84861E-09	1.15538E-09
selenium	ND					
silver	ND					
Hazard Index (HI) =				1.52098E-07	1.52098E-07	9.50613E-08
HI (adult) =				1.52098E-07	1.52098E-07	9.50613E-08

CANCER (c)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk mean
Organic						
benzene	2.40E+01	1.15941E-11	2.60867E-12	2.9E+02	3.36228E-13	7.56513E-14
Inorganic						
arsenic	2.20E+01	1.06279E-11	2.39128E-12	1.5E+01	1.59419E-10	3.58692E-11
cadmium	1.10E+00	5.31395E-13	1.19564E-13	6.3E+00	3.34779E-12	7.53252E-13
chromium(VI) = 1/7[chromium]	1.57E+00	7.58446E-13	1.70650E-13	4.2E+01	3.18547E-11	7.16731E-12
Sum Cancer Risk =				1.94957E-10	1.94957E-10	4.38654E-11
Cancer Risk (adult) =				1.94957E-10	1.94957E-10	4.38654E-11

LEAD RISK ASSESSMENT SPREADSHEET

RP-4

[Pb] = maximum = 74 mg/kg

plant uptake on

INPUT				OUTPUT			
MEDIUM	LEVEL				percentiles		
LEAD IN AIR (ug/m ³)*	0.004				50th	90th	95th
LEAD IN SOIL (ug/g)	74			BLOOD Pb, ADULT (ug/dL)	1.1	1.6	1.9
LEAD IN WATER (ug/L)	1E-04			BLOOD Pb, CHILD (ug/dL)	2.7	4.2	4.8
PLANT UPTAKE? 1=YES 0=NO	1			BLOOD Pb, PICA CHILD (ug/dL)	6.5	10.2	11.5
AIRBORNE DUST (ug/m ³)*	50						
EQUATIONS, ADULTS							
Blood Pb Pathway	ug/dL	Route-specific constant		concentration in medium	contact rate		percent of total
SOIL CONTACT:	0.01 =	1E-04 ug/dL/(ug/day) *		74 ug/g *	1.85 g soil/day (5 g/m ² * 0.37 m ²)		1%
SOIL INGESTION:	0.03 =	0.018 ug/dL/(ug/day) *		74 ug/g *	0.03 g soil/day		3%
INHALATION:	0.01 =	1.64 ug/dL/(ug/m ³) *		0.01 ug/m ³			1%
WATER INGESTION:	0.00 =	0.04 ug/dL/(ug/day) *		0 ug/L *	1.4 L water/day		0%
FOOD INGESTION:	0.99 =	0.04 ug/dL/(ug/day) *		11.3 ug Pb/kg diet *	2.2 kg diet/day		94%
EQUATIONS, CHILDREN (TYPICAL)							
Blood Pb Pathway	ug/dL	Route-specific constant		concentration in medium	contact rate		percent of total
SOIL CONTACT:	0.01 =	1E-04 ug/dL/(ug/day) *		74 ug/g *	1.4 g soil/day (5 g/m ² * 0.28 m ²)		0%
SOIL INGESTION:	0.31 =	0.07 ug/dL/(ug/day) *		74 ug/g *	0.06 g soil/day		12%
INHALATION:	0.01 =	1.92 ug/dL/(ug/m ³) *		0.01 ug/m ³			1%
WATER INGESTION:	0.00 =	0.16 ug/dL/(ug/day) *		0 ug/L *	0.4 L water/day		0%
FOOD INGESTION:	2.35 =	0.16 ug/dL/(ug/day) *		11.3 ug Pb/kg diet *	1.3 kg diet/day		87%
EQUATIONS, CHILDREN (PICA)							
Blood Pb Pathway	ug/dL	Route-specific constant		concentration in medium	contact rate		percent of total
SOIL CONTACT:	0.01 =	1E-04 ug/dL/(ug/day) *		74 ug/g *	1.4 g soil/day (5 g/m ² * 0.25 m ²)		0%
SOIL INGESTION:	4.12 =	0.07 ug/dL/(ug/day) *		74 ug/g *	0.79 g soil/day		63%
INHALATION:	0.01 =	1.92 ug/dL/(ug/m ³) *		0.01 ug/m ³			0%
WATER INGESTION:	0.00 =	0.16 ug/dL/(ug/day) *		0 ug/L *	0.4 L water/day		0%
FOOD INGESTION:	2.35 =	0.16 ug/dL/(ug/day) *		11.3 ug Pb/kg diet *	1.3 kg diet/day		36%
EQUATIONS, DIETARY LEAD							
TOTAL DIETARY LEAD = 0	.945 * 10 + 0.055 * Pb in produce (ug/kg) =			11.3 ug/kg			
LEAD IN PRODUCE = 10 ug/kg or 0.00045 * soil lead	d =			33.3 ug/kg			

*Generic Assumption: Total Suspended Particles (TSP) = 50 ug/m³. Lead concentration in air = (50 ug/m³)(74 mg/kg)/(1E-06 kg/mg) = 0.0037 ug/m³.
 Additional Assumption: Total Inhalable Particles = TSP, i.e., 50 ug/m³. Lead concentration in water = 0.0001 ug/L is default, equivalent to nondetect.

RP5

SOIL GAS EMISSION RATE (Qis) AT ON SITE GROUND SURFACE FROM SOIL PARTICLES* — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Cis,t=0,max mg/kg	Cis,t=10y,max mg/kg	pl mmHg	MMI	R mmHg(cm ³ /[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi,max	P	di cm	Qis g/s
Organic													
benzene	2.40E+01	4.80E+00	9.5E+01	78	62,361	293	4.055E-04	8.7E-02	2.632E+06	9.600E-06	0.25	100	1.40424E-06
ethylbenzene	6.50E+01	1.30E+01	9.5E+00	106	62,361	293	5.511E-05	6.6E-02	2.632E+06	1.913E-05	0.25	100	2.88514E-07
fluorene													
naphthalene	5.10E+01	5.10E+01	8.7E-01	128	62,361	293	6.095E-06	5.9E-02	2.632E+06	6.216E-05	0.25	100	9.26605E-08
1-methylnaphthalene**	7.90E+01	7.90E+01	4.5E-02	142	62,361	293	3.497E-07	4.4E-02	2.632E+06	8.679E-05	0.25	100	5.53665E-09
2-methylnaphthalene**	1.60E+02	1.60E+02	4.5E-02	142	62,361	293	3.497E-07	4.4E-02	2.632E+06	1.758E-04	0.25	100	1.12134E-08
phenanthrene	2.30E+00	2.30E+00	2.5E-06	178	62,361	293	2.435E-11	5.2E-02	2.632E+06	2.016E-06	0.25	100	1.05835E-14
phenol**													
2,4-dimethylphenol**													
pyrene	1.70E+00	1.70E+00	2.5E-06	202	62,361	293	2.764E-11	4.8E-02	2.632E+06	1.313E-06	0.25	100	7.22085E-15
toluene	1.00E+01	2.00E+00	2.8E+01	92	62,361	293	1.415E-04	7.8E-02	2.632E+06	3.391E-06	0.25	100	1.55163E-07
xylene (sum: o-, m-, p-)	1.20E+02	2.40E+01	7.7E+00	106	62,361	293	4.467E-05	7.2E-02	2.632E+06	3.532E-05	0.25	100	4.70964E-07
Inorganic													
none													

CANCER (c)	Cis,t=0,max mg/kg	Cis,t=10y,max mg/kg	pl mmHg	MMI	R mmHg(cm ³ /[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi,max	P	di cm	Qis g/s
Organic													
benzene	2.40E+01	4.80E+00	9.5E+01	78	62,361	293	4.055E-04	8.7E-02	2.632E+06	9.600E-06	0.25	100	1.40424E-06
Inorganic													
none													

*Assumption: Based on Thibodeaux-Hwang time-varying model for volatile emissions (1982), concentration of BTEX after 10 years (Cis,t=10y) is 1/5 the original concentration (Cis,t=0). Area = approx. 1/15 of an acre based on soil area occupied by maximum soil concentration. Future I represents site conditions in 10 years with continued normal activity.

**Some values of pl and Di are estimated.

RP5

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles
adult

NONCANCER (nc)	Qis g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.40424E-06	4.2	1	1	1.06424E-07
ethylbenzene	2.88514E-07	4.2	1	1	2.18659E-08
fluorene					
naphthalene	9.26605E-08	4.2	1	1	7.02256E-09
1-methylnaphthalene	5.53665E-09	4.2	1	1	4.19612E-10
2-methylnaphthalene	1.12134E-08	4.2	1	1	8.49840E-10
phenanthrene	1.05835E-14	4.2	1	1	8.02103E-16
phenol					
2,4-dimethylphenol					
pyrene	7.22085E-15	4.2	1	1	5.47254E-16
toluene	1.55163E-07	4.2	1	1	1.17595E-08
xylene (sum: o-, m-, p-)	4.70964E-07	4.2	1	1	3.56934E-08
Inorganic					
none					

CANCER (c)	Qis g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.40424E-06	4.2	1	1	1.06424E-07
Inorganic					
none					

*Mean wind speed (<v>.m) over El Paso = 4.2 m/s (API 1994).

RP5

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Clad g/m ³	IRa m ³ /d	Fla ABSF	CF mg/g	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATnc,ucI		Intake Rate, mean mg/[(kg body mass)d]
										d	d	
Organic												
benzene	1.06424E-07	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	4.16534E-07
ethylbenzene	2.18659E-08	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	8.55808E-08
fluorene												
naphthalene	7.02256E-09	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	2.74856E-08
1-methylnaphthalene	4.19612E-10	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	1.64232E-09
2-methylnaphthalene	8.49840E-10	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	3.32618E-09
phenanthrene	8.02103E-16	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	3.13935E-15
phenol												
2,4-dimethylphenol												
pyrene	5.47254E-16	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	2.14190E-15
toluene	1.17595E-08	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	4.60255E-08
xylene (sum: o-, m-, p-)	3.56934E-08	2.0E+01	1	1,000	8	5	25	9	70	9,125	3,285	1.39700E-07
Inorganic												
none												

CANCER (c)	Clad g/m ³	IRa m ³ /d	Fla ABSF	CF mg/g	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucI		Intake Rate, mean mg/[(kg body mass)d]
										d	d	
Organic												
benzene	1.06424E-07	2.0E+01	1	1,000	8	5	25	9	70	25,550	25,550	5.35543E-08
Inorganic												
none												

*Assumption: industrial worker is directly over emission source and dispersion is minimal (Fla = 1, conservative).

EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed on site for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen on site work.

EDm = 9 y (national median time at one residence, EPA 1989a).

RP6

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from Groundwater

adult

NONCANCER (nc)	Ciw,t=0,max mg/L	Cis,t=10y,max mg/kg	Qiw g/s	P	Qi g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic									
benzene	2.30E+01	4.60E+00	1.70455E-03	0.25	2.68450E-04	4.2	1	1	2.03453E-05
ethylbenzene	7.00E-02	1.40E-02	5.28238E-06	0.25	8.31923E-07	4.2	1	1	6.30498E-08
fluorene	1.20E-02	1.20E-02	4.40415E-08	0.25	6.93611E-09	4.2	1	1	5.25674E-10
naphthalene	2.35E-01	2.35E-01	1.85209E-05	0.25	2.91686E-06	4.2	1	1	2.21063E-07
1-methylnaphthalene	1.65E-01	1.65E-01	2.77569E-06	0.25	4.37143E-07	4.2	1	1	3.31302E-08
2-methylnaphthalene	1.85E-01	1.85E-01	3.53242E-06	0.25	5.56321E-07	4.2	1	1	4.21625E-08
phenanthrene	3.20E-02	3.20E-02	2.84592E-07	0.25	4.48204E-08	4.2	1	1	3.39685E-09
phenol	3.00E-01	3.00E-01	2.67277E-09	0.25	4.20935E-10	4.2	1	1	3.19018E-11
2,4-dimethylphenol	1.10E-01	1.10E-01	2.52332E-10	0.25	3.97398E-11	4.2	1	1	3.01180E-12
pyrene	5.80E-02	5.80E-02	1.59112E-08	0.25	2.50586E-09	4.2	1	1	1.89914E-10
toluene	1.60E-01	3.20E-02	1.25786E-05	0.25	1.98101E-06	4.2	1	1	1.50137E-07
xylene (sum: o-, m-, p-)	1.10E+00	2.20E-01	9.00553E-05	0.25	1.41828E-05	4.2	1	1	1.07489E-06
Inorganic									
none									

CANCER (c)	Ciw,t=0,max mg/L	Cis,t=10y,max mg/kg	Qiw g/s	P	Qi g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic									
benzene	2.30E+01	4.60E+00	1.70455E-03	0.25	2.68450E-04	4.2	1	1	2.03453E-05
Inorganic									
none									

*Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP6

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from Groundwater

adult

NONCANCER (nc)	Ciad g/m ³	IRa m ³ /d	Fla m ² /d	ABSF	CF mg/g	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATnc,ucI		Intake Rate, mean mg/((kg body mass)d)
											d	d	
Organic													
benzene	2.03453E-05	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	1.27407E-04	7.96295E-05
ethylbenzene	6.30498E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3.94833E-07	2.46770E-07
fluorene	5.25674E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3.29189E-09	2.05743E-09
naphthalene	2.21063E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	1.38435E-06	8.65218E-07
1-methylnaphthalene	3.31302E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	2.07469E-07	1.29668E-07
2-methylnaphthalene	4.21625E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	2.64031E-07	1.65019E-07
phenanthrene	3.39685E-09	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	2.12719E-08	1.32949E-08
phenol	3.19018E-11	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	1.99777E-10	1.24860E-10
2,4-dimethylphenol	3.01180E-12	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	1.88606E-11	1.17879E-11
pyrene	1.89914E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	1.18929E-09	7.43303E-10
toluene	1.50137E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	9.40190E-07	5.87619E-07
xylene (sum: o-, m-, p-)	1.07489E-06	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	6.73120E-06	4.20700E-06
Inorganic													
none													

CANCER (c)	Ciad g/m ³	IRa m ³ /d	Fla m ² /d	ABSF	CF mg/g	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucI		Intake Rate, mean mg/((kg body mass)d)
											d	d	
Organic													
benzene	2.03453E-05	2.0E+01	1	1	1,000	8	5	25	9	70	25,550	4.55026E-05	1.02381E-05
Inorganic													
none													

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen onsite work.

EDm = 9 y (national median time at one residence, EPA 1989a).

*Assumption: industrial worker is directly over emission source and dispersion is minimal (Fla = 1, conservative).

RP7

TIME REQUIRED FOR MASS OF SPECIFIC LNAPL CONTAMINANT TO REACH ZERO* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	Q _{i,t=0} mg/kg	A _{i, LNAPL} cm ²	h _{i, LNAPL} cm	V _{i, LNAPL} cm ³	d _{i, LNAPL} g/cm ³	M _{i, t=0} g	Q _{i, t=0} g/s	t _{Mi=0} s	CF s/y	t _{Mi=0} y
Organic										
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	6.757E-05	1.530E+08	3.156E+07	4.847E+00
ethylbenzene	2.10E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.612E-06	4.033E+09	3.156E+07	1.278E+02
fluorene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	2.258E-08	3.626E+12	3.156E+07	1.149E+05
naphthalene*	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.324E-06	2.463E+10	3.156E+07	7.805E+02
1-methylnaphthalene	2.00E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	2.590E-07	1.277E+12	3.156E+07	4.047E+04
2-methylnaphthalene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.282E-07	6.385E+11	3.156E+07	2.023E+04
phenanthrene	1.30E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.105E-11	1.945E+16	3.156E+07	6.163E+08
phenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	5.180E-07	1.580E+11	3.156E+07	5.008E+03
2,4-dimethylphenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.885E-08	2.107E+12	3.156E+07	6.677E+04
pyrene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	7.770E-12	1.054E+16	3.156E+07	3.338E+08
toluene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.792E-05	5.768E+08	3.156E+07	1.828E+01
xylene (mean: o-, m-, p-)	5.40E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.958E-05	4.561E+09	3.156E+07	1.445E+02
Inorganic										
none										

CANCER (c)	Q _{i,t=0} mg/kg	A _{i, LNAPL} cm ²	h _{i, LNAPL} cm	V _{i, LNAPL} cm ³	d _{i, LNAPL} g/cm ³	M _{i, t=0} g	Q _{i, t=0} g/s	t _{Mi=0} s	CF s/y	t _{Mi=0} y
Organic										
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	6.757E-05	1.530E+08	3.156E+07	4.847E+00
Inorganic										
none										

*Assumption: loss of LNAPL is by volatilization only. A more accurate estimate would require updating Q_{i, max} and Q_i (Q_{i, t=0} becoming Q_{i, t=t1}) over shorter time intervals, e.g., 1-month intervals. Thus, the calculated t_{Mi=0} for benzene is probably somewhat too small (the loss of benzene decreases its mole fraction-vapor pressure and therefore, its emission rate); however, the loss of benzene increases the loss rate for the other constituents. Assumption: density of LNAPL = 0.9 g/cm³. Q_{i, t=0} is calculated using the RP3 equations. Area = 1/15 of an acre (assumed) and height (h) of LNAPL = 2.29 ft (June 1995) = 2.29(12)(2.54) = 69.7992 cm.

**These substances were not detected. Thus, C_i for these substances was set to half the detection limit.

RP7

SOIL GAS EMISSION RATE (QI) AT ON SITE GROUND SURFACE FROM LNAPL-CONTAMINANT (future = +10 y)* — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	t,Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL mmHg	MMI mmHg	R mmHg(cm ³)/(mol)Kj	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
Organic															
benzene*	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	78	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
ethylbenzene	1.28E+02	2.10E+02	1.94E+02	9.5E+00	2.74E-04	2.6E-03	106	293	1.510E-08	6.6E-02	2.632E+06	1	0.25	100	4.13069E-06
fluorene*	1.15E+05	4.95E+02	4.95E+02	5.5E-03	4.47E-04	2.5E-06	166	293	2.235E-11	6.3E-02	2.632E+06	1	0.25	100	5.87414E-09
naphthalene*	7.80E+02	4.95E+02	4.89E+02	8.7E-01	5.73E-04	5.0E-04	128	293	3.490E-09	5.9E-02	2.632E+06	1	0.25	100	8.53691E-07
1-methylnaphthalene**	4.05E+04	2.00E+03	2.00E+03	4.5E-02	2.11E-03	9.5E-05	142	293	7.387E-10	4.4E-02	2.632E+06	1	0.25	100	1.34745E-07
2-methylnaphthalene**	2.02E+04	4.95E+02	4.95E+02	4.5E-02	5.23E-04	2.4E-05	142	293	1.828E-10	4.4E-02	2.632E+06	1	0.25	100	3.33411E-08
phenanthrene	6.16E+08	1.30E+03	1.30E+03	2.5E-06	1.10E-03	2.7E-09	178	293	2.668E-14	5.2E-02	2.632E+06	1	0.25	100	5.75190E-12
phenol* **	5.01E+03	4.95E+02	4.94E+02	1.0E-01	7.88E-04	7.9E-05	94	293	4.056E-10	8.0E-02	2.632E+06	1	0.25	100	1.34509E-07
2,4-dimethylphenol* **	6.68E+04	4.95E+02	4.95E+02	1.0E-02	6.09E-04	6.1E-06	122	293	4.063E-11	6.0E-02	2.632E+06	1	0.25	100	1.01069E-08
pyrene*	3.34E+08	4.95E+02	4.95E+02	2.5E-06	3.68E-04	9.2E-10	202	293	1.016E-14	4.8E-02	2.632E+06	1	0.25	100	2.02167E-12
toluene*	1.83E+01	6.25E+01	2.83E+01	2.8E+01	4.62E-05	1.3E-03	92	293	6.530E-09	7.8E-02	2.632E+06	1	0.25	100	2.11154E-06
xylene (sum: o-, m-, p-)	1.45E+02	5.40E+02	5.03E+02	7.7E+00	7.11E-04	5.5E-03	106	293	3.177E-08	7.2E-02	2.632E+06	1	0.25	100	9.48421E-06
Inorganic none															

CANCER (c)	t,Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL mmHg	MMI mmHg	R mmHg(cm ³)/(mol)Kj	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
benzene*	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	78	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
Inorganic none															

*These substances were not detected. Thus, Ci for these substances was set to half the detection limit. Ci is used to calculate the partial pressure (ppi) of each COC in the LNAPL phase. $(C_{i,t=10y}) = (C_{i,t=0})(1 - [10(t,Mi=0)])$. Benzene concentration estimated to reach zero in 10 years $\{(C_{i,t=10y}) = 0\}$.

Area = 1/15 of an acre (1 acre = 4,046.873 m²) assumed aerial extent of LNAPL.

**Some values of pi and Di are estimated.

Assumption: Qi is constant, i.e., contaminant source is not depleted over time. Molecular mass (MMI) of LNAPL is assumed = 150.

RP7

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (on site, future = +10 y)

INDUSTRIAL
Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	Qi mg/kg	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
ethylbenzene	4.13069E-06	4.2	1	1	3.13057E-07
fluorene	5.87414E-09	4.2	1	1	4.45189E-10
naphthalene	8.53691E-07	4.2	1	1	6.46996E-08
1-methylnaphthalene	1.34745E-07	4.2	1	1	1.02121E-08
2-methylnaphthalene	3.33411E-08	4.2	1	1	2.52686E-09
phenanthrene	5.75190E-12	4.2	1	1	4.35925E-13
phenol	1.34509E-07	4.2	1	1	1.01942E-08
2,4-dimethylphenol	1.01069E-08	4.2	1	1	7.65979E-10
pyrene	2.02167E-12	4.2	1	1	1.53219E-13
toluene	2.11154E-06	4.2	1	1	1.60029E-07
xylene (sum: o-, m-, p-)	9.48421E-06	4.2	1	1	7.18790E-07
Inorganic					
none					

CANCER (c)	Qi g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
Inorganic					
none					

*Mean wind speed (<v>.m) over El Paso = 4.2 m/s (API 1994).

RP7

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	Clad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucf d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	0.00000E+00	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	0.00000E+00	0.00000E+00
ethylbenzene	3.13057E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.96043E-06	1.22527E-06
fluorene	4.45189E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.78788E-09	1.74242E-09
naphthalene	6.48996E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	4.05164E-07	2.53227E-07
1-methylnaphthalene	1.02121E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	6.39503E-08	3.99689E-08
2-methylnaphthalene	2.52686E-09	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.58238E-08	9.88986E-09
phenanthrene	4.35925E-13	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	2.72987E-12	1.70617E-12
phenol	1.01942E-08	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	6.38384E-08	3.98990E-08
2,4-dimethylphenol	7.65979E-10	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	4.79674E-09	2.99796E-09
pyrene	1.53219E-13	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	9.59491E-13	5.99682E-13
toluene	1.60029E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	1.00214E-06	6.26337E-07
xylene (sum: o-, m-, p-)	7.18790E-07	2.0E+01	1	1	1,000	8	5	25	9	70	9,125	3,285	4.50123E-06	2.81327E-06
Inorganic														
none														

CANCER (c)	Clad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucf d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	0.00000E+00	2.0E+01	1	1	1,000	8	5	25	9	70	25,550	25,550	0.00000E+00	0.00000E+00
Inorganic														
none														

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen onsite work.

EDm = 9 y (national median time at one residence, EPA 1989a).

Assumption: Industrial worker is directly over emission source and dispersion is minimal (Fla = 1, conservative).

RP7

RISK — Brickland Refinery, New Mexico

FUTURE / CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	C _{i,t} =0 mg/kg	C _{i,t} =10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	1.0E-03	0.00000E+00	0.00000E+00
ethylbenzene	2.10E+02	1.94E+02	1.96043E-06	1.2527E-06	2.9E-01	6.76012E-06	4.22507E-06
fluorene	4.95E+02	4.95E+02	2.7878E-09	1.74242E-09	4.0E-02	6.96970E-08	4.35606E-08
naphthalene	4.95E+02	4.89E+02	4.05164E-07	2.53227E-07	4.0E-02	1.01291E-05	6.33068E-06
1-methylnaphthalene	2.00E+03	2.00E+03	6.39503E-08	3.99689E-08	4.0E-02	1.59876E-06	9.99223E-07
2-methylnaphthalene	4.95E+02	4.95E+02	1.58238E-08	9.8986E-09	4.0E-02	3.95595E-07	2.47247E-07
phenanthrene	1.30E+03	1.30E+03	2.72987E-12	1.70617E-12	3.0E-02	9.09955E-11	5.68722E-11
phenol	4.95E+02	4.94E+02	6.38384E-08	3.98990E-08	6.0E-01	1.06397E-07	6.64983E-08
2,4-dimethylphenol	4.95E+02	4.95E+02	4.79674E-09	2.99796E-09	2.0E-02	2.39837E-07	1.49898E-07
pyrene	4.95E+02	4.95E+02	9.59491E-13	5.99682E-13	3.0E-02	3.19830E-11	1.99894E-11
toluene	6.25E+01	2.83E+01	1.00214E-06	6.26337E-07	1.0E-01	1.00214E-05	6.26337E-06
xylene (sum: o-, m-, p-)	5.40E+02	5.03E+02	4.50123E-06	2.81327E-06	2.0E-01	2.25061E-05	1.40663E-05
Inorganic							
none							
Hazard Index (HI) =					5.18272E-05	3.23920E-05	
HI (adult) =					5.18272E-05	3.23920E-05	

CANCER (c)	C _{i,t} =0 mg/kg	C _{i,t} =10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	2.9E-02	0.00000E+00	0.00000E+00
Inorganic							
none							
Sum Cancer Risk =						0.00000E+00	0.00000E+00
Cancer Risk (adult) =						0.00000E+00	0.00000E+00

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (on site, future = +10 y)

INDUSTRIAL

Inhalation of Surface Soil Dust*

adult

NONCANCER (nc)	Cis,max mg/kg	Cis,t=10y,max mg/kg	Ira m ³ /d	Fia	ABSF	PEF kg/m ³	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATCm d	ATCucd d	Intake Rate, ucl mg/(kg body mass)d	Intake Rate, mean mg/(kg body mass)d
Organic															
benzene	2.40E+01	4.80E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	6.49288E-12	4.05793E-12
ethylbenzene	6.50E+01	1.30E+01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	1.75843E-11	1.09902E-11
fluorene	5.10E+01	5.10E+01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	6.89847E-11	4.31155E-11
naphthalene	7.90E+01	7.90E+01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	1.06859E-10	6.67867E-11
1-methylnaphthalene	1.60E+02	1.60E+02	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	2.16423E-10	1.35264E-10
2-methylnaphthalene	2.30E+00	2.30E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	3.11108E-12	1.94442E-12
phenanthrene															
phenol															
2,4-dimethylphenol															
pyrene	1.70E+00	1.70E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	2.29949E-12	1.43718E-12
toluene	1.00E+01	2.00E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	2.70528E-12	1.69080E-12
xylene (mean: o-, m-, p-)	1.20E+02	2.40E+01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	3.24634E-11	2.02896E-11
Inorganic															
arsenic	2.20E+01	2.20E+01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	2.97581E-11	1.85988E-11
barium	2.04E+02	2.04E+02	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	2.75939E-10	1.72462E-10
cadmium	1.10E+00	1.10E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	1.48791E-12	9.29941E-13
chromium (III) = 6/7(chromium)	9.43E+00	9.43E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	1.27554E-11	7.97213E-12
chromium (VI) = 1/7(chromium)	1.57E+00	1.57E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	2.12365E-12	1.32728E-12
lead**	7.40E+01	7.40E+01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125	5.54583E-13	3.46614E-13
mercury	4.10E-01	4.10E-01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	9,125	9,125		
selenium	ND	ND	ND												
silver	ND	ND	ND												

CANCER (c)	Cis,max mg/kg	Cis,t=10y,max mg/kg	Ira m ³ /d	Fia	ABSF	PEF kg/m ³	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATCm d	ATCucd d	Intake Rate, ucl mg/(kg body mass)d	Intake Rate, mean mg/(kg body mass)d
Organic															
benzene	2.40E+01	4.80E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	25,550	25,550	2.31881E-12	5.21733E-13
Inorganic															
arsenic	2.20E+01	2.20E+01	2.0E+01	1	1	2.2E-10	8	5	25	9	70	25,550	25,550	1.06279E-11	2.39128E-12
cadmium	1.10E+00	1.10E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	25,550	25,550	5.31395E-13	1.19564E-13
chromium (VI) = 1/7(chromium)	1.57E+00	1.57E+00	2.0E+01	1	1	2.2E-10	8	5	25	9	70	25,550	25,550	7.58446E-13	1.70650E-13

*A default PEF = 2.2E-10 kg/m³ is used; for onsite, no dispersion (dilution) is assumed (Fia = 1 is conservative). Future I simulates site conditions 10 years in future with no remedial action.

Assumption: Based on Thibodeaux-Hwang time-varying model for volatile emissions (1982), concentration of BTEX after 10 years (Cis,t=10y) is 1/5 the original concentration (Cis,t=0).

EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d. EDm = 9 y (national median time at one residence, EPA 1989a).

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen onsite work.

**Risk from exposure to lead is estimated using DTSC Lead Risk Assessment Spreadsheet (U.S. EPA Uptake-BioKinetic Model [UBM 1990, 1994, 0.99D]).

RP8

RISK — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (on site, future = +10 y)

INDUSTRIAL
Inhalation of Surface Soil Dust
adult

NONCANCER (nc)	Cis,max mg/kg	Cis,t=10y,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RID mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	2.40E+01	4.80E+00	6.49268E-12	4.05793E-12	1.0E-03	6.49268E-09	4.05793E-09
ethylbenzene	6.50E+01	1.30E+01	1.75843E-11	1.09902E-11	2.9E-01	6.06357E-11	3.78973E-11
fluorene							
naphthalene	5.10E+01	5.10E+01	6.89847E-11	4.31155E-11	4.0E-02	1.72462E-09	1.07789E-09
1-methylnaphthalene	7.90E+01	7.90E+01	1.06859E-10	6.67867E-11	4.0E-02	2.67147E-09	1.66967E-09
2-methylnaphthalene	1.60E+02	1.60E+02	2.16423E-10	1.35264E-10	4.0E-02	5.41057E-09	3.38160E-09
phenanthrene	2.30E+00	2.30E+00	3.11108E-12	1.94442E-12	3.0E-02	1.03703E-10	6.48141E-11
phenol							
2,4-dimethylphenol							
pyrene	1.70E+00	1.70E+00	2.29949E-12	1.43718E-12	3.0E-02	7.66497E-11	4.79061E-11
toluene	1.00E+01	2.00E+00	2.70528E-12	1.69080E-12	1.0E-01	2.70528E-11	1.69080E-11
xylene (mean: o-, m-, p-)	1.20E+02	2.40E+01	3.24634E-11	2.02896E-11	2.0E-01	1.62317E-10	1.01448E-10
Inorganic							
arsenic	2.20E+01	2.20E+01	2.97581E-11	1.85988E-11	3.0E-04	9.91937E-08	6.19961E-08
barium	2.04E+02	2.04E+02	2.75939E-10	1.72462E-10	7.0E-02	3.94198E-09	2.46374E-09
cadmium	1.10E+00	1.10E+00	1.48791E-12	9.29941E-13	5.0E-04	2.97581E-09	1.85988E-09
chromium(III) = 6/7[chromium]	9.43E+00	9.43E+00	1.27554E-11	7.97213E-12	1.0E+00	1.27554E-11	7.97213E-12
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	2.12365E-12	1.32728E-12	5.0E-03	4.24730E-10	2.65456E-10
lead	7.40E+01	7.40E+01					
mercury	4.10E-01	4.10E-01	5.54583E-13	3.46614E-13	1.0E-04	5.54583E-09	3.46614E-09
selenium	ND	ND					
silver	ND	ND					
Hazard Index (HI) =					1.28825E-07	8.05153E-08	
HI (adult) =					1.28825E-07	8.05153E-08	

CANCER (c)	Cis,max mg/kg	Cis,t=10y,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk expected
Organic							
benzene	2.40E+01	4.80E+00	2.31881E-12	5.21733E-13	2.9E-02	6.72456E-14	1.51303E-14
Inorganic							
arsenic	2.20E+01	2.20E+01	1.06279E-11	2.39128E-12	1.5E+01	1.59419E-10	3.58692E-11
cadmium	1.10E+00	1.10E+00	5.31395E-13	1.19564E-13	6.3E+00	3.34779E-12	7.53252E-13
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	7.58446E-13	1.70650E-13	4.2E+01	3.18547E-11	7.16731E-12
Sum Cancer Risk =						1.94688E-10	4.38049E-11
Cancer Risk (adult) =						1.94688E-10	4.38049E-11

RP9

SOIL GAS EMISSION RATE (Qis) AT ON SITE GROUND SURFACE FROM SOIL PARTICLES* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Cis,t=0,max mg/kg	Cis,t=10y,max mg/kg	pi mmHg	MMI	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nf,max	P cm	di cm	Qis g/s
Organic													
benzene	2.40E+01	4.80E+00	9.5E+01	78	62,361	293	4.055E-04	8.7E-02	2.632E+06	9.600E-06	0.25	100	1.40424E-06
ethylbenzene	6.50E+01	1.30E+01	9.5E+00	106	62,361	293	5.511E-05	6.6E-02	2.632E+06	1.913E-05	0.25	100	2.88514E-07
fluorene													
naphthalene	5.10E+01	5.10E+01	8.7E-01	128	62,361	293	6.095E-06	5.9E-02	2.632E+06	6.216E-05	0.25	100	9.26605E-08
1-methylnaphthalene**	7.90E+01	7.90E+01	4.5E-02	142	62,361	293	3.497E-07	4.4E-02	2.632E+06	8.679E-05	0.25	100	5.53665E-09
2-methylnaphthalene**	1.60E+02	1.60E+02	4.5E-02	142	62,361	293	3.497E-07	4.4E-02	2.632E+06	1.758E-04	0.25	100	1.12134E-08
phenanthrene	2.30E+00	2.30E+00	2.5E-06	178	62,361	293	2.435E-11	5.2E-02	2.632E+06	2.016E-06	0.25	100	1.05835E-14
phenol**													
2,4-dimethylphenol**													
pyrene	1.70E+00	1.70E+00	2.5E-06	202	62,361	293	2.764E-11	4.8E-02	2.632E+06	1.313E-06	0.25	100	7.22085E-15
toluene	1.00E+01	2.00E+00	2.8E+01	92	62,361	293	1.415E-04	7.8E-02	2.632E+06	3.391E-06	0.25	100	1.55163E-07
xylene (sum: o-, m-, p-)	1.20E+02	2.40E+01	7.7E+00	106	62,361	293	4.467E-05	7.2E-02	2.632E+06	3.532E-05	0.25	100	4.70984E-07
Inorganic													
none													

CANCER (c)	Cis,t=0,max mg/kg	Cis,t=10y,max mg/kg	pi mmHg	MMI	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nf,max	P cm	di cm	Qis g/s
Organic													
benzene	2.40E+01	4.80E+00	9.5E+01	78	62,361	293	4.055E-04	8.7E-02	2.632E+06	9.600E-06	0.25	100	1.40424E-06
Inorganic													
none													

*Assumption: Based on Thibodeaux-Hwang time-varying model for volatile emissions (1982), concentration of BTEX after 10 years (Cis,t=10y) is 1/5 the original concentration (Cis,t=0). Area = approx. 1/15 of an acre based on soil area occupied by maximum soil concentration.

**Some values of pi and Di are estimated.

RP9

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ONSITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Soil Gas from Soil Particles
adult

NONCANCER (nc)	Qis g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.40424E-06	4.2	1	1	1.06424E-07
ethylbenzene	2.88514E-07	4.2	1	1	2.18659E-08
fluorene					
naphthalene	9.26605E-08	4.2	1	1	7.02256E-09
1-methylnaphthalene	5.53665E-09	4.2	1	1	4.19612E-10
2-methylnaphthalene	1.12134E-08	4.2	1	1	8.49840E-10
phenanthrene	1.05835E-14	4.2	1	1	8.02103E-16
phenol					
2,4-dimethylphenol					
pyrene	7.22085E-15	4.2	1	1	5.47254E-16
toluene	1.55163E-07	4.2	1	1	1.17595E-08
xylene (sum: o-, m-, p-)	4.70964E-07	4.2	1	1	3.56934E-08
Inorganic					
none					

CANCER (c)	Qis g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.40424E-06	4.2	1	1	1.06424E-07
Inorganic					
none					

*Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP9

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Clad	IRa	Fia	ABSF	CF	EF	EDucl	EDm	BM	ATc,ucI	ATc,m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	y	y	kg	d	d	mg/(kg body mass)d	mg/(kg body mass)d
Organic													
benzene	1.06424E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	2.08267E-06	2.08267E-06
ethylbenzene	2.18659E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	4.27904E-07	4.27904E-07
fluorene													
naphthalene	7.02256E-09	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.37428E-07	1.37428E-07
1-methylnaphthalene	4.19612E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	8.21158E-09	8.21158E-09
2-methylnaphthalene	8.49840E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.66309E-08	1.66309E-08
phenanthrene	8.02103E-16	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.56967E-14	1.56967E-14
phenol													
2,4-dimethylphenol													
pyrene	5.47254E-16	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.07095E-14	1.07095E-14
toluene	1.17595E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	2.30127E-07	2.30127E-07
xylene (sum: o-, m-, p-)	3.56934E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	6.98502E-07	6.98502E-07
Inorganic													
none													

CANCER (c)	Clad	IRa	Fia	ABSF	CF	EF	EDucl	EDm	BM	ATc,ucI	ATc,m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	y	y	kg	d	d	mg/(kg body mass)d	mg/(kg body mass)d
Organic													
benzene	1.06424E-07	2.0E+01	0.1	1	1,000	250	25	9	70	25,550	25,550	7.43810E-07	2.67772E-07
Inorganic													
none													

*Onsite visitors would be exposed only intermittently (considerably less than a museum worker). Thus, risk to visitors is not estimated.

*Assumption: 10X dispersion to building roof air intake.

RP9

RISK — Brickland Refinery, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Cis,t=0,max mg/kg	Cis,t=10y,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	2.40E+01	4.800E+00	2.08267E-06	2.08267E-06	1.0E-03	2.08267E-03	2.08267E-03
ethylbenzene	6.50E+01	1.300E+01	4.27904E-07	4.27904E-07	2.9E-01	1.47553E-06	1.47553E-06
fluorene							
naphthalene	5.10E+01	5.100E+01	1.37428E-07	1.37428E-07	4.0E-02	3.43569E-06	3.43569E-06
1-methylnaphthalene	7.90E+01	7.900E+01	8.21158E-09	8.21158E-09	4.0E-02	2.05290E-07	2.05290E-07
2-methylnaphthalene	1.60E+02	1.600E+02	1.66309E-08	1.66309E-08	4.0E-02	4.15773E-07	4.15773E-07
phenanthrene	2.30E+00	2.300E+00	1.56967E-14	1.56967E-14	3.0E-02	5.23224E-13	5.23224E-13
phenol							
2,4-dimethylphenol							
pyrene	1.70E+00	1.700E+00	1.07095E-14	1.07095E-14	3.0E-02	3.56983E-13	3.56983E-13
toluene	1.00E+01	2.000E+00	2.30127E-07	2.30127E-07	1.0E-01	2.30127E-06	2.30127E-06
xylene (sum: o-, m-, p-)	1.20E+02	2.400E+01	6.98502E-07	6.98502E-07	2.0E-01	3.49251E-06	3.49251E-06
Inorganic							
none							
Hazard Index (HI) =					2.09399E-03	2.09399E-03	2.09399E-03
HI (adult) =					2.09399E-03	2.09399E-03	2.09399E-03

CANCER (c)	Cis,t=0,max mg/kg	Cis,t=10y,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk mean
Organic							
benzene	2.40E+01	4.800E+00	7.43810E-07	2.67772E-07	2.9E-02	2.15705E-08	7.76538E-09
Inorganic							
none							
Sum Cancer Risk =					2.15705E-08	2.15705E-08	7.76538E-09
Cancer Risk (adult) =					2.15705E-08	2.15705E-08	7.76538E-09

RP10

SOIL GAS EMISSION RATE (Qiw) FROM ONSITE GROUND WATER* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from Groundwater

adult

NONCANCER (nc)	Qiw,t=0,max mg/L	Cis,t=10y,max mg/kg	MMI	nfi,max	Kgi (mol/cm ²)/s	Kli (mol/cm ²)/s	Hi [†]	Koa (mol/cm ²)/s	A cm ²	Qiw g/s
Organic										
benzene	2.30E+01	4.60E+00	78	1.06249E-06	3.49004E-05	7.74597E-05	2.49E-01	7.81360E-06	2.632E+06	1.704628E-03
ethylbenzene	7.00E-02	1.40E-02	106	2.37947E-09	3.14923E-05	6.64462E-05	2.87E-01	7.95608E-06	2.632E+06	5.282585E-06
fluorene	1.20E-02	1.20E-02	166	1.30236E-09	2.70986E-05	5.30969E-05	2.86E-03	7.73889E-08	2.632E+06	4.404325E-08
naphthalene	2.35E-01	2.35E-01	128	3.30763E-08	2.95643E-05	6.04670E-05	5.78E-02	1.66185E-06	2.632E+06	1.852162E-05
1-methylnaphthalene**	1.65E-01	1.65E-01	142	2.09341E-08	2.85539E-05	5.74089E-05	1.25E-02	3.54719E-07	2.632E+06	2.775795E-06
2-methylnaphthalene**	1.85E-01	1.85E-01	142	2.34716E-08	2.85539E-05	5.74089E-05	1.42E-02	4.02622E-07	2.632E+06	3.532553E-06
phenanthrene	3.20E-02	3.20E-02	178	3.23883E-09	2.64723E-05	5.12759E-05	7.11E-03	1.87530E-07	2.632E+06	2.846029E-07
phenol**	3.00E-01	3.00E-01	94	5.74979E-08	3.27857E-05	7.05601E-05	5.73E-06	1.87862E-10	2.632E+06	2.672875E-09
2,4-dimethylphenol**	1.10E-01	1.10E-01	122	1.62439E-08	3.00436E-05	6.19360E-05	1.61E-06	4.83702E-11	2.632E+06	2.523419E-10
pyrene	5.80E-02	5.80E-02	202	5.17291E-09	2.53741E-05	4.81335E-05	2.28E-04	5.78459E-09	2.632E+06	1.591181E-08
toluene	1.60E-01	3.20E-02	92	6.26643E-09	3.30228E-05	7.13230E-05	2.84E-01	8.28858E-06	2.632E+06	1.257909E-05
xylene (sum: o-, m-, p-)	1.10E+00	2.20E-01	106	3.73917E-08	3.14923E-05	6.64462E-05	3.15E-01	8.63146E-06	2.632E+06	9.005877E-05
Inorganic										
none										

CANCER (c)	Qiw,t=0,max mg/L	Cis,t=10y,max mg/kg	MMI	nfi,max	Kgi (mol/cm ²)/s	Kli (mol/cm ²)/s	Hi [†]	Koa (mol/cm ²)/s	A cm ²	Qiw g/s
Organic										
benzene	2.30E+01	4.60E+00	78	1.06249E-06	3.49004E-05	7.74597E-05	2.49E-01	7.81360E-06	2.632E+06	1.704628E-03
Inorganic										
none										

*Assumption: Based on Thibodeaux-Hwang time-varying model for volatile emissions (1982), concentration of BTEX after 10 years (Cis,t=10y) is 1/5 the original concentration (Cis,t=0). Area = approx. 1/15 of an acre based on area of the 20 ppm benzene concentration contour plotted from the results of the 6th quarter monitoring (Q2-1995).

**Some values of pi and Di are estimated.

RP10

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ONSITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from Groundwater
adult

NONCANCER (nc)	Qiw g/s	P	Qi g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic							
benzene	1.70463E-03	0.25	2.68462E-04	4.2	1	1	2.03462E-05
ethylbenzene	5.28259E-06	0.25	8.31955E-07	4.2	1	1	6.30523E-08
fluorene	4.40432E-08	0.25	6.93638E-09	4.2	1	1	5.25695E-10
naphthalene	1.85216E-05	0.25	2.91697E-06	4.2	1	1	2.21072E-07
1-methylnaphthalene**	2.77579E-06	0.25	4.37160E-07	4.2	1	1	3.31315E-08
2-methylnaphthalene**	3.53255E-06	0.25	5.56342E-07	4.2	1	1	4.21641E-08
phenanthrene	2.84603E-07	0.25	4.48221E-08	4.2	1	1	3.39698E-09
phenol**	2.67288E-09	0.25	4.20951E-10	4.2	1	1	3.19031E-11
2,4-dimethylphenol**	2.52342E-10	0.25	3.97414E-11	4.2	1	1	3.01192E-12
pyrene	1.59118E-08	0.25	2.50595E-09	4.2	1	1	1.89921E-10
toluene	1.25791E-05	0.25	1.98108E-06	4.2	1	1	1.50142E-07
xylene (sum: o-, m-, p-)	9.00588E-05	0.25	1.41834E-05	4.2	1	1	1.07493E-06
Inorganic							
none							

CANCER (c)	Qiw g/s	P	Qi g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic							
benzene	1.70463E-03	0.25	2.68462E-04	4.2	1	1	2.03462E-05
Inorganic							
none							

*Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP10

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from Groundwater
adult

NONCANCER (nc)	Ciad	IRa	Fla	ABSF	CF	EF	EDUcl	EDm	BM	ATnc,ucI	ATnc,m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic													
benzene	2.03462E-05	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	3.98165E-04	3.98165E-04
ethylbenzene	6.30523E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.23390E-06	1.23390E-06
fluorene	5.25695E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.02876E-08	1.02876E-08
naphthalene	2.21072E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	4.32626E-06	4.32626E-06
1-methylnaphthalene**	3.31315E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	6.48367E-07	6.48367E-07
2-methylnaphthalene**	4.21641E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	8.25129E-07	8.25129E-07
phenanthrene	3.39698E-09	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	6.84772E-08	6.84772E-08
phenol**	3.19031E-11	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	6.24327E-10	6.24327E-10
2,4-dimethylphenol**	3.01192E-12	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	5.89417E-11	5.89417E-11
pyrene	1.89921E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	3.71666E-09	3.71666E-09
toluene	1.50142E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	2.93821E-06	2.93821E-06
xylene (sum: o-, m-, p-)	1.07493E-06	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	2.10358E-05	2.10358E-05
Inorganic													
none													

CANCER (c)	Ciad	IRa	Fla	ABSF	CF	EF	EDUcl	EDm	BM	ATc,ucI	ATc,m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic													
benzene	2.03462E-05	2.0E+01	0.1	1	1,000	250	25	9	70	25,550	25,550	1.42202E-04	5.11926E-05
Inorganic													
none													

*Assumption: 10X dispersion (Fla = 0.1) to building roof air intake.

Assumption: museum is directly over emission source (conservative). Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP10

RISK — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from Groundwater
adult

NONCANCER (nc)	C _{iw} , t=0, max mg/L	C _{is} , t=10y, max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	2.30E+01	4.60E+00	3.98165E-04	3.98165E-04	1.0E-03	3.98165E-01	3.98165E-01
ethylbenzene	7.00E-02	1.40E-02	1.23390E-06	1.23390E-06	2.9E-01	4.25483E-06	4.25483E-06
fluorene	1.20E-02	2.40E-03	1.02876E-08	1.02876E-08	4.0E-02	2.57189E-07	2.57189E-07
naphthalene	2.35E-01	4.70E-02	4.32626E-06	4.32626E-06	4.0E-02	1.08156E-04	1.08156E-04
1-methylnaphthalene**	1.65E-01	3.30E-02	6.48367E-07	6.48367E-07	4.0E-02	1.62092E-05	1.62092E-05
2-methylnaphthalene**	1.85E-01	3.70E-02	8.25129E-07	8.25129E-07	4.0E-02	2.06282E-05	2.06282E-05
phenanthrene	3.20E-02	6.40E-03	6.64772E-08	6.64772E-08	3.0E-02	2.21591E-06	2.21591E-06
phenol**	3.00E-01	6.00E-02	6.24327E-10	6.24327E-10	6.0E-01	1.04054E-09	1.04054E-09
2,4-dimethylphenol**	1.10E-01	2.20E-02	5.89417E-11	5.89417E-11	2.0E-02	2.94709E-09	2.94709E-09
pyrene	5.80E-02	1.16E-02	3.71666E-09	3.71666E-09	3.0E-02	1.23889E-07	1.23889E-07
toluene	1.60E-01	3.20E-02	2.93821E-06	2.93821E-06	1.0E-01	2.93821E-05	2.93821E-05
xylene (sum: o-, m-, p-)	1.10E+00	2.20E-01	2.10358E-05	2.10358E-05	2.0E-01	1.05179E-04	1.05179E-04
Inorganic							
none							
Hazard Index (HI) =					3.98451E-01	3.98451E-01	3.98451E-01
HI (adult) =					3.98451E-01	3.98451E-01	3.98451E-01

CANCER (c)	C _{iw} , t=0, max mg/L	C _{is} , t=10y, max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk mean
Organic							
benzene	2.30E+01	4.60E+00	1.42202E-04	5.11926E-05	2.9E-02	4.12385E-06	1.48459E-06
Inorganic							
none							
Sum Cancer Risk =						4.12385E-06	1.48459E-06
Cancer Risk (adult) =						4.12385E-06	1.48459E-06

RP11

TIME REQUIRED FOR MASS OF SPECIFIC LNAPL CONTAMINANT TO REACH ZERO* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	C _{i,t=0} mg/kg	A _{i, LNAPL} cm ²	h _{i, LNAPL} cm	V _{i, LNAPL} cm ³	d _{i, LNAPL} g/cm ³	M _{i, t=0} g	Q _{i, t=0} g/s	t _{i, MI=0} s	CF s/y	t _{i, MI=0} y
Organic										
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	6.757E-05	1.530E+08	3.156E+07	4.847E+00
ethylbenzene	2.10E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.612E-06	4.033E+09	3.156E+07	1.278E+02
fluorene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	2.258E-08	3.626E+12	3.156E+07	1.149E+05
naphthalene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.324E-06	2.463E+10	3.156E+07	7.805E+02
1-methylnaphthalene	2.00E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	2.590E-07	1.277E+12	3.156E+07	4.047E+04
2-methylnaphthalene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.282E-07	6.385E+11	3.156E+07	2.023E+04
phenanthrene	1.30E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.105E-11	1.945E+16	3.156E+07	6.163E+08
phenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	5.180E-07	1.580E+11	3.156E+07	5.008E+03
2,4-dimethylphenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.885E-08	2.107E+12	3.156E+07	6.677E+04
pyrene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	7.770E-12	1.054E+16	3.156E+07	3.338E+08
toluene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.792E-05	5.768E+08	3.156E+07	1.828E+01
xylene (mean: o-, m-, p-)	5.40E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.958E-05	4.561E+09	3.156E+07	1.445E+02
Inorganic										
none										

CANCER (c)	C _{i,t=0} mg/kg	A _{i, LNAPL} cm ²	h _{i, LNAPL} cm	V _{i, LNAPL} cm ³	d _{i, LNAPL} g/cm ³	M _{i, t=0} g	Q _{i, t=0} g/s	t _{i, MI=0} s	CF s/y	t _{i, MI=0} y
Organic										
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	6.757E-05	1.530E+08	3.156E+07	4.847E+00
Inorganic										
none										

*Assumption: loss of LNAPL is by volatilization only. A more accurate estimate would require updating C_{i,max} and Q_i (Q_{i,t=0} becoming Q_{i,t=t}) over shorter time intervals, e.g., 1-month. Thus, the calculated t_{i,MI=0} for benzene is probably somewhat too small (the loss of benzene decreases its mole fraction--vapor pressure and therefore, its emission rate); however, the loss of benzene increases the loss rate for the other constituents. Assumption: density of LNAPL = 0.9 g/cm³. Q_i is calculated using the RP3 equations. Area = 1/15 of an acre (assumed) and height (h) of LNAPL = 2.29 ft (June 1995) = 2.29(12)(2.54) = 69.7992 cm.

**These substances were not detected. Thus, C_i for these substances was set to half the detection limit.

RP11

SOIL GAS EMISSION RATE (Qi) AT ON SITE GROUND SURFACE FROM LNAPL CONTAMINANT (future = +10 y)* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	t, Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL mmHg	MMi mmHg	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
Organic															
benzene	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	62,361	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
ethylbenzene	1.28E+02	2.10E+02	1.94E+02	9.5E+00	2.74E-04	2.6E-03	62,361	293	1.510E-08	6.6E-02	2.632E+06	1	0.25	100	4.13069E-06
fluorene	1.15E+05	4.95E+02	4.95E+02	5.5E-03	4.47E-04	2.5E-06	62,361	293	2.235E-11	6.3E-02	2.632E+06	1	0.25	100	5.87414E-09
naphthalene	7.80E+02	4.95E+02	4.89E+02	8.7E-01	5.73E-04	5.0E-04	62,361	293	3.490E-09	5.9E-02	2.632E+06	1	0.25	100	8.53691E-07
1-methylnaphthalene**	4.05E+04	2.00E+03	2.00E+03	4.5E-02	2.11E-03	9.5E-05	62,361	293	7.387E-10	4.4E-02	2.632E+06	1	0.25	100	1.34745E-07
2-methylnaphthalene**	2.02E+04	4.95E+02	4.95E+02	4.5E-02	5.23E-04	2.4E-05	62,361	293	1.828E-10	4.4E-02	2.632E+06	1	0.25	100	3.33411E-08
phenanthrene	6.16E+08	1.30E+03	1.30E+03	2.5E-06	1.10E-03	2.7E-09	62,361	293	2.668E-14	5.2E-02	2.632E+06	1	0.25	100	5.75190E-12
phenol**	5.01E+03	4.95E+02	4.94E+02	1.0E-01	7.88E-04	7.9E-05	62,361	293	4.056E-10	8.0E-02	2.632E+06	1	0.25	100	1.34509E-07
2,4-dimethylphenol**	6.68E+04	4.95E+02	4.95E+02	1.0E-02	6.09E-04	6.1E-06	62,361	293	4.063E-11	6.0E-02	2.632E+06	1	0.25	100	1.01069E-08
pyrene	3.34E+08	4.95E+02	4.95E+02	2.5E-06	3.68E-04	9.2E-10	62,361	293	1.016E-14	4.8E-02	2.632E+06	1	0.25	100	2.02167E-12
toluene	1.83E+01	6.25E+01	2.83E+01	2.8E+01	4.62E-05	1.3E-03	62,361	293	6.530E-09	7.8E-02	2.632E+06	1	0.25	100	2.11154E-06
xylene (sum: o-, m-, p-)	1.45E+02	5.40E+02	5.03E+02	7.7E+00	7.11E-04	5.5E-03	62,361	293	3.177E-08	7.2E-02	2.632E+06	1	0.25	100	9.48421E-06
Inorganic															
none															

CANCER (c)	t, Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL mmHg	MMi mmHg	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
benzene	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	62,361	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
Inorganic															
none															

*These substances were not detected. Thus, Ci for these substances was set to half the detection limit. Ci is used to calculate the partial pressure (ppi) of each COC in the LNAPL phase. (Ci,t=10y) = (Ci,t=0)(1 - [10/(t,Mi=0)]). Benzene concentration estimated to reach zero in 10 years ((Ci,t=10y) = 0).

Area = 1/15 of an acre (1 acre = 4,046.873 m²) assumed aerial extent of LNAPL.

**Some values of pi and Di are estimated.

Assumption: Qi is constant, i.e., contaminant source is not depleted over time. Molecular mass (MM) of LNAPL is assumed = 150.

RP11

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	Qi mg/kg	<v>, m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
ethylbenzene	4.13069E-06	4.2	1	1	3.13057E-07
fluorene	5.87414E-09	4.2	1	1	4.45189E-10
naphthalene	8.53691E-07	4.2	1	1	6.46996E-08
1-methylnaphthalene	1.34745E-07	4.2	1	1	1.02121E-08
2-methylnaphthalene	3.33411E-08	4.2	1	1	2.52686E-09
phenanthrene	5.75190E-12	4.2	1	1	4.35925E-13
phenol	1.34509E-07	4.2	1	1	1.01942E-08
2,4-dimethylphenol	1.01069E-08	4.2	1	1	7.65979E-10
pyrene	2.02167E-12	4.2	1	1	1.53219E-13
toluene	2.11154E-06	4.2	1	1	1.60029E-07
xylene (sum: o-, m-, p-)	9.48421E-06	4.2	1	1	7.18790E-07
Inorganic					
none					

CANCER (c)	Qi, ucl g/s	<v>, m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
Inorganic					
none					

*Mean wind speed (<v>, m) over El Paso = 4.2 m/s (API 1994).

RP11

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	Clad	IRa	Fla	ABSF	CF	EF	EDucl	EDm	BM	ATc, ucl	ATc, m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic													
benzene	0.00000E+00	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	0.00000E+00	0.00000E+00
ethylbenzene	3.13057E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	6.12636E-06	6.12636E-06
fluorene	4.45189E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	8.71212E-09	8.71212E-09
naphthalene	6.46996E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.26614E-06	1.26614E-06
1-methylnaphthalene	1.02121E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.99845E-07	1.99845E-07
2-methylnaphthalene	2.52686E-09	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	4.94493E-08	4.94493E-08
phenanthrene	4.35925E-13	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	8.53083E-12	8.53083E-12
phenol	1.01942E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.99495E-07	1.99495E-07
2,4-dimethylphenol	7.65979E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.49898E-08	1.49898E-08
pyrene	1.53219E-13	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	2.99841E-12	2.99841E-12
toluene	1.60029E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	3.13169E-06	3.13169E-06
xylene (sum: o-, m-, p-)	7.18790E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.40663E-05	1.40663E-05
Inorganic													
none													

CANCER (c)	Clad	IRa	Fla	ABSF	CF	EF	EDucl	EDm	BM	ATc, ucl	ATc, m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic													
benzene	0.00000E+00	2.0E+01	0.1	1	1,000	250	25	9	70	25,550	25,550	0.00000E+00	0.00000E+00
Inorganic													
none													

*10X attenuation for airborne soil gas entering museum or 10X dispersion to roof intake (Fla = 0.1).

RP11

RISK — Brickland Refinery, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	C _i t=0 mg/kg	C _i t=10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	1.0E-03	0.00000E+00	0.00000E+00
ethylbenzene	2.10E+02	1.94E+02	6.12636E-06	6.12636E-06	2.9E-01	2.11254E-05	2.11254E-05
fluorene	4.95E+02	4.95E+02	8.71212E-09	8.71212E-09	4.0E-02	2.17803E-07	2.17803E-07
naphthalene	4.95E+02	4.89E+02	1.26614E-06	1.26614E-06	4.0E-02	3.16534E-05	3.16534E-05
1-methylnaphthalene	2.00E+03	2.00E+03	1.99845E-07	1.99845E-07	4.0E-02	4.99612E-06	4.99612E-06
2-methylnaphthalene	4.95E+02	4.95E+02	4.94493E-08	4.94493E-08	4.0E-02	1.23623E-06	1.23623E-06
phenanthrene	1.30E+03	1.30E+03	8.53083E-12	8.53083E-12	3.0E-02	2.84361E-10	2.84361E-10
phenol	4.95E+02	4.94E+02	1.99495E-07	1.99495E-07	6.0E-01	3.32491E-07	3.32491E-07
2,4-dimethylphenol	4.95E+02	4.95E+02	1.49898E-08	1.49898E-08	2.0E-02	7.49490E-07	7.49490E-07
pyrene	4.95E+02	4.95E+02	2.99841E-12	2.99841E-12	3.0E-02	9.99470E-11	9.99470E-11
toluene	6.25E+01	2.83E+01	3.13169E-06	3.13169E-06	1.0E-01	3.13169E-05	3.13169E-05
xylylene (sum: o-, m-, p-)	5.40E+02	5.03E+02	1.40663E-05	1.40663E-05	2.0E-01	7.03317E-05	7.03317E-05
Inorganic							
none							
Hazard Index (HI) =					1.61960E-04	1.61960E-04	1.61960E-04
HI (adult) =					1.61960E-04	1.61960E-04	1.61960E-04

CANCER (c)	C _i t=0 mg/kg	C _i t=10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	2.9E-02	0.00000E+00	0.00000E+00
Inorganic							
none							
Sum Cancer Risk =						0.00000E+00	0.00000E+00
Cancer Risk (adult) =						0.00000E+00	0.00000E+00

RP12

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico**FUTURE II CONDITIONS** (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Soil Dust*

adult

NONCANCER (nc)	Cis,max mg/kg	Cis,t=10y,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EF d/y	EDm y	EDucl y	ATc,nc d	ATc,nc d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic													
benzene	2.40E+01	4.80E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	2.02896E-11	2.02896E-11
ethylbenzene	6.50E+01	1.30E+01	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	5.49511E-11	5.49511E-11
fluorene	5.10E+01	5.10E+01	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	2.15577E-10	2.15577E-10
naphthalene	7.90E+01	7.90E+01	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	3.33933E-10	3.33933E-10
1-methylnaphthalene	1.60E+02	1.60E+02	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	6.76321E-10	6.76321E-10
2-methylnaphthalene	2.30E+00	2.30E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	9.72211E-12	9.72211E-12
phenanthrene													
phenol													
2,4-dimethylphenol													
pyrene	1.70E+00	1.70E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	7.18591E-12	7.18591E-12
toluene	1.00E+01	2.00E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	8.45401E-12	8.45401E-12
xylene (sum: o-, m-, p-)	1.20E+02	2.40E+01	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	1.01448E-10	1.01448E-10
Inorganic													
arsenic	2.20E+01	2.20E+01	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	9.29941E-11	9.29941E-11
barium	2.04E+02	2.04E+02	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	8.62309E-10	8.62309E-10
cadmium	1.10E+00	1.10E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	4.64971E-12	4.64971E-12
chromium(III) = 6/7[chromium]	9.43E+00	9.43E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	3.98607E-11	3.98607E-11
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	6.63640E-12	6.63640E-12
lead**	7.40E+01	7.40E+01	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285	1.73307E-12	1.73307E-12
mercury	4.10E-01	4.10E-01	2.0E+01	0.1	1	2.2E-10	250	9	25	9,125	3,285		
selenium	ND	ND											
silver	ND	ND											

CANCER (c)	Cis,max mg/kg	Cis,t=10y,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EF d/y	EDm y	EDucl y	ATc,c d	ATc,c d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic													
benzene	2.40E+01	4.80E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	25,550	25,550	7.24630E-12	2.60867E-12
Inorganic													
arsenic	2.20E+01	2.20E+01	2.0E+01	0.1	1	2.2E-10	250	9	25	25,550	25,550	3.32122E-11	1.19584E-11
cadmium	1.10E+00	1.10E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	25,550	25,550	1.66061E-12	5.97819E-13
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	2.0E+01	0.1	1	2.2E-10	250	9	25	25,550	25,550	2.37014E-12	8.53251E-13

*A default PEF = 2.2E-10 kg/m³ is used. Assumption: 10X dispersion (Fla = 0.1) to building roof air intake.

Assumption: Based on Thibodeaux-Hwang time-varying model for volatile emissions (1982), concentration of BTEX after 10 years (Cis,t=10y) is 1/5 the original concentration (Cis,t=0).

**Risk from exposure to lead is estimated using DTSC Lead Risk Assessment Spreadsheet (U.S. EPA Uptake-Biokinetic Model [UBM 1990, 1994, 0.99D]).

RISK — Brickland Refinery, Sunland Park, New Mexico

FUTURE II CONDITIONS (on site, future = +10 y)

INDUSTRIAL (museum worker)

Inhalation of Soil Dust

adult

NONCANCER (nc)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.40E+01	2.02896E-11	2.02896E-11	3.0E-03	6.76321E-09	6.76321E-09
ethylbenzene	6.50E+01	5.49511E-11	5.49511E-11	1.0E+00	5.49511E-11	5.49511E-11
fluorene						
naphthalene	5.10E+01	2.15577E-10	2.15577E-10	4.0E-02	5.38943E-09	5.38943E-09
1-methylnaphthalene	7.90E+01	3.33933E-10	3.33933E-10	4.0E-02	8.34834E-09	8.34834E-09
2-methylnaphthalene	1.60E+02	6.76321E-10	6.76321E-10	4.0E-02	1.69080E-08	1.69080E-08
phenanthrene	2.30E+00	9.72211E-12	9.72211E-12	3.0E-02	3.24070E-10	3.24070E-10
phenol						
2,4-dimethylphenol						
pyrene	1.70E+00	7.18591E-12	7.18591E-12	3.0E-02	2.39530E-10	2.39530E-10
toluene	1.00E+01	8.45401E-12	8.45401E-12	1.0E-01	8.45401E-11	8.45401E-11
xylene (sum: o-, m-, p-)	1.20E+02	1.01448E-10	1.01448E-10	3.0E-01	3.38160E-10	3.38160E-10
Inorganic						
arsenic	2.20E+01	9.29941E-11	9.29941E-11	3.0E-04	3.09980E-07	3.09980E-07
barium	2.04E+02	8.62309E-10	8.62309E-10	7.0E-02	1.23187E-08	1.23187E-08
cadmium	1.10E+00	4.64971E-12	4.64971E-12	5.0E-04	9.29941E-09	9.29941E-09
chromium(III) = 67[chromium]	9.43E+00	3.98607E-11	3.98607E-11	1.0E+00	3.98607E-11	3.98607E-11
chromium(VI) = 17[chromium]	1.57E+00	6.63640E-12	6.63640E-12	5.0E-03	1.32728E-09	1.32728E-09
lead	7.40E+01					
mercury	4.10E-01	1.73307E-12	1.73307E-12	1.0E-04	1.73307E-08	1.73307E-08
selenium	ND	ND				
silver	ND	ND				
Hazard Index (HI) =				3.88747E-07	3.88747E-07	3.88747E-07
HI (adult) =				3.88747E-07	3.88747E-07	3.88747E-07

CANCER (c)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk expected
Organic						
benzene	2.40E+01	7.24630E-12	2.60867E-12	1.0E-01	7.24630E-13	2.60867E-13
Inorganic						
arsenic	2.20E+01	3.32122E-11	1.19564E-11	1.2E+01	3.98546E-10	1.43477E-10
cadmium	1.10E+00	1.66061E-12	5.97819E-13	1.5E+01	2.49091E-11	8.96729E-12
chromium(VI) = 17[chromium]	1.57E+00	2.37014E-12	8.53251E-13	5.1E+02	1.20877E-09	4.35158E-10
Sum Cancer Risk =				1.63295E-09	1.63295E-09	5.87863E-10
Cancer Risk (adult) =				1.63295E-09	1.63295E-09	5.87863E-10

RP13

AIRBORNE CONCENTRATION (Clad) OF SOIL GAS AT ONSITE RECEPTOR — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

NONCANCER (nc)	Qi mg/kg	<v> m* m/s	sigma-x m	sigma-z m	Clad g/m ³
Organic					
benzene	1.75812E-05	4.2	1	1	1.33244E-06
ethylbenzene	4.48138E-06	4.2	1	1	3.39635E-07
fluorene	5.87465E-09	4.2	1	1	4.45228E-10
naphthalene	8.64771E-07	4.2	1	1	6.55393E-08
1-methylnaphthalene	1.34778E-07	4.2	1	1	1.02146E-08
2-methylnaphthalene	3.33576E-08	4.2	1	1	2.52811E-09
phenanthrene	5.75190E-12	4.2	1	1	4.35925E-13
phenol	1.34778E-07	4.2	1	1	1.02146E-08
2,4-dimethylphenol	1.01084E-08	4.2	1	1	7.66094E-10
pyrene	2.02167E-12	4.2	1	1	1.53219E-13
toluene	4.66236E-06	4.2	1	1	3.53351E-07
xylene (sum: o-, m-, p-)	1.01892E-05	4.2	1	1	7.72223E-07
Inorganic					
none					

CANCER (c)	Qi,ud g/s	<v> m* m/s	sigma-x m	sigma-z m	Clad g/m ³
Organic					
benzene	1.75812E-05	4.2	1	1	1.33244E-06
Inorganic					
none					

*Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP13

RISK — Brickland Refinery, New Mexico

CURRENT CONDITIONS (off site)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

1 to 6 year old child

NONCANCER (nc)	Ci mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	6.25E+01	1.70358E-05	1.70358E-05	1.0E-03	1.70358E-02	1.70358E-02
ethylbenzene	2.10E+02	4.34236E-06	4.34236E-06	2.9E-01	1.49737E-05	1.49737E-05
fluorene	4.95E+02	5.69242E-09	5.69242E-09	4.0E-02	1.42310E-07	1.42310E-07
naphthalene	4.95E+02	8.37946E-07	8.37946E-07	4.0E-02	2.09486E-05	2.09486E-05
1-methylnaphthalene	2.00E+03	1.30597E-07	1.30597E-07	4.0E-02	3.26494E-06	3.26494E-06
2-methylnaphthalene	4.95E+02	3.23229E-08	3.23229E-08	4.0E-02	8.08072E-07	8.08072E-07
phenanthrene	1.30E+03	5.57348E-12	5.57348E-12	3.0E-02	1.85783E-10	1.85783E-10
phenol	4.95E+02	1.30597E-07	1.30597E-07	6.0E-01	2.17662E-07	2.17662E-07
2,4-dimethylphenol	4.95E+02	9.79481E-09	9.79481E-09	2.0E-02	4.89740E-07	4.89740E-07
pyrene	4.95E+02	1.95896E-12	1.95896E-12	3.0E-02	6.52987E-11	6.52987E-11
toluene	6.25E+01	4.51773E-06	4.51773E-06	1.0E-01	4.51773E-05	4.51773E-05
xylene (sum: o-, m-, p-)	5.40E+02	9.87317E-06	9.87317E-06	2.0E-01	4.93658E-05	4.93658E-05
Inorganic none						
				Hazard Index (HI) =	1.71712E-02	1.71712E-02

CANCER (c)	Ci mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucf	Cancer Risk mean
Organic						
benzene	6.25E+01	1.46021E-06	4.86737E-07	2.9E-02	4.23461E-08	1.41154E-08
Inorganic none						
				Sum Cancer Risk =	4.23461E-08	1.41154E-08

RP13

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

7 to 30 year old "adult"

[illegible][illegible]

RP13

RISK — Brickland Refinery, New Mexico

CURRENT CONDITIONS (off site)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

7 to 30 year old "adult"

NONCANCER (nc)	Ci mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	6.25E+01	3.65053E-06	3.65053E-06	1.0E-03	3.65053E-03	3.65053E-03
ethylbenzene	2.10E+02	9.30507E-07	9.30507E-07	2.9E-01	3.20864E-06	3.20864E-06
fluorene	4.95E+02	1.21980E-09	1.21980E-09	4.0E-02	3.04951E-08	3.04951E-08
naphthalene	4.95E+02	1.79560E-07	1.79560E-07	4.0E-02	4.48900E-06	4.48900E-06
1-methylnaphthalene	2.00E+03	2.79852E-08	2.79852E-08	4.0E-02	6.99629E-07	6.99629E-07
2-methylnaphthalene	4.95E+02	6.92633E-09	6.92633E-09	4.0E-02	1.73158E-07	1.73158E-07
phenanthrene	1.30E+03	1.19432E-12	1.19432E-12	3.0E-02	3.98105E-11	3.98105E-11
phenol	4.95E+02	2.79852E-08	2.79852E-08	6.0E-01	4.66419E-08	4.66419E-08
2,4-dimethylphenol	4.95E+02	2.09889E-09	2.09889E-09	2.0E-02	1.04944E-07	1.04944E-07
pyrene	4.95E+02	4.19777E-13	4.19777E-13	3.0E-02	1.39926E-11	1.39926E-11
toluene	6.25E+01	9.68085E-07	9.68085E-07	1.0E-01	9.68085E-06	9.68085E-06
xylene (sum: o-, m-, p-)	5.40E+02	2.11568E-06	2.11568E-06	2.0E-01	1.05784E-05	1.05784E-05
Inorganic						
none						
				Hazard Index (HI) =	3.67954E-03	3.67954E-03
				HI (child + adult) =	2.08507E-02	2.08507E-02

CANCER (c)	Ci mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk uci	Cancer Risk mean
Organic						
benzene	6.25E+01	1.25161E-06	3.65053E-07	2.9E-02	3.62967E-08	1.05865E-08
Inorganic						
none						
				Sum Cancer Risk =	3.62967E-08	1.05865E-08
				Cancer Risk (child + adult) =	7.86428E-08	2.47019E-08

RISK — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

RESIDENTIAL

Inhalation of Soil Dust

1 to 6 year old child

NONCANCER (nc)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RID mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.40E+01	6.62795E-11	6.62795E-11	1.0E-03	6.62795E-08	6.62795E-08
ethylbenzene	6.50E+01	1.79507E-10	1.79507E-10	2.9E-01	6.18989E-10	6.18989E-10
fluorene	5.10E+01	1.40844E-10	1.40844E-10	4.0E-02	3.52110E-09	3.52110E-09
naphthalene	7.90E+01	2.18170E-10	2.18170E-10	4.0E-02	5.45425E-09	5.45425E-09
1-methylnaphthalene	1.60E+02	4.41863E-10	4.41863E-10	4.0E-02	1.10466E-08	1.10466E-08
2-methylnaphthalene	2.30E+00	6.35178E-12	6.35178E-12	3.0E-02	2.11726E-10	2.11726E-10
phenanthrene						
phenol						
2,4-dimethylphenol						
pyrene	1.70E+00	4.69479E-12	4.69479E-12	3.0E-02	1.58493E-10	1.58493E-10
toluene	1.00E+01	2.76164E-11	2.76164E-11	1.0E-01	2.76164E-10	2.76164E-10
xylene (mean: o-, m-, p-)	1.20E+02	3.31397E-10	3.31397E-10	2.0E-01	1.65699E-09	1.65699E-09
Inorganic						
arsenic	2.20E+01	6.07562E-11	6.07562E-11	3.0E-04	2.02521E-07	2.02521E-07
barium	2.04E+02	5.63375E-10	5.63375E-10	7.0E-02	8.04822E-09	8.04822E-09
cadmium	1.10E+00	3.03781E-12	3.03781E-12	5.0E-04	6.07562E-09	6.07562E-09
chromium(III) = 677[chromium]	9.43E+00	2.60423E-11	2.60423E-11	1.0E+00	2.60423E-11	2.60423E-11
chromium(VI) = 177[chromium]	1.57E+00	4.33578E-12	4.33578E-12	5.0E-03	8.67156E-10	8.67156E-10
lead	7.40E+01					
mercury	4.10E-01	1.13227E-12	1.13227E-12	3.0E-04	3.77425E-09	3.77425E-09
selenium	ND					
silver	ND					
Hazard Index (HI) =				3.10534E-07	3.10534E-07	3.10534E-07

CANCER (c)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk expected
Organic						
benzene	2.40E+01	5.68110E-12	1.89370E-12	2.9E-02	1.64752E-13	5.49173E-14
Inorganic						
arsenic	2.20E+01	5.20767E-12	1.73589E-12	1.5E+01	7.81151E-11	2.60384E-11
cadmium	1.10E+00	2.60384E-13	8.67945E-14	6.3E+00	1.64042E-12	5.46805E-13
chromium(VI) = 177[chromium]	1.57E+00	3.71638E-13	1.23879E-13	4.2E+01	1.56088E-11	5.20294E-12
Sum Cancer Risk =				9.55290E-11	9.55290E-11	3.18430E-11

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

RESIDENTIAL

Inhalation of Soil Dust*

7 to 30 year old "adult"

NONCANCER (nc)	Cis,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EFud d/y	EDud y	EDm y	BM kg	ATc,ud d	ATc,m d	Intake Rate, uci mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic													
benzene	2.40E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.42027E-11	1.42027E-11
ethylbenzene	6.50E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	3.84658E-11	3.84658E-11
fluorene	5.10E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	3.01808E-11	3.01808E-11
naphthalene	7.90E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	4.67507E-11	4.67507E-11
1-methylnaphthalene	1.60E+02	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	9.46849E-11	9.46849E-11
2-methylnaphthalene	2.30E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.36110E-12	1.36110E-12
phenanthrene													
phenol													
2,4-dimethylphenol													
pyrene	1.70E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.00603E-12	1.00603E-12
toluene	1.00E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	5.91781E-12	5.91781E-12
xylene (sum: o-, m-, p-)	1.20E+02	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	7.10137E-11	7.10137E-11
Inorganic													
arsenic	2.20E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.30192E-11	1.30192E-11
barium	2.04E+02	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.20723E-10	1.20723E-10
cadmium	1.10E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	6.50959E-13	6.50959E-13
chromium(III) = 6/7[chromium]	9.43E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	5.58049E-12	5.58049E-12
chromium(VI) = 1/7[chromium]	1.57E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	9.29096E-13	9.29096E-13
lead**	7.40E+01												
mercury	4.10E-01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	2.42630E-13	2.42630E-13
selenium	ND												
silver	ND												

CANCER (c)	Cis,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EFud d/y	EDud y	EDm y	BM kg	ATc,ud d	ATc,m d	Intake Rate, uci mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic													
benzene	2.40E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	4.86951E-12	1.42027E-12
Inorganic													
arsenic	2.20E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	4.46372E-12	1.30192E-12
cadmium	1.10E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	2.23186E-13	6.50959E-14
chromium(VI) = 1/7[chromium]	1.57E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	3.18547E-13	9.29096E-14

RISK — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

RESIDENTIAL

Inhalation of Soil Dust

7 to 30 year old "adult"

NONCANCER (nc)	Cis max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.40E+01	1.42027E-11	1.42027E-11	1.0E-03	1.42027E-08	1.42027E-08
ethylbenzene	6.50E+01	3.84658E-11	3.84658E-11	2.9E-01	1.32641E-10	1.32641E-10
fluorene	5.10E+01	3.01808E-11	3.01808E-11	4.0E-02	7.54521E-10	7.54521E-10
naphthalene	7.90E+01	4.67507E-11	4.67507E-11	4.0E-02	1.16877E-09	1.16877E-09
1-methylnaphthalene	1.60E+02	9.46849E-11	9.46849E-11	4.0E-02	2.36712E-09	2.36712E-09
2-methylnaphthalene	2.30E+00	1.36110E-12	1.36110E-12	3.0E-02	4.53699E-11	4.53699E-11
phenanthrene						
phenol						
2,4-dimethylphenol						
pyrene	1.70E+00	1.00603E-12	1.00603E-12	3.0E-02	3.35342E-11	3.35342E-11
toluene	1.00E+01	5.91781E-12	5.91781E-12	1.0E-01	5.91781E-11	5.91781E-11
xylene (sum: o-, m-, p-)	1.20E+02	7.10137E-11	7.10137E-11	2.0E-01	3.55068E-10	3.55068E-10
Inorganic						
arsenic	2.20E+01	1.30192E-11	1.30192E-11	3.0E-04	4.33973E-08	4.33973E-08
barium	2.04E+02	1.20723E-10	1.20723E-10	7.0E-02	1.72462E-09	1.72462E-09
cadmium	1.10E+00	6.50959E-13	6.50959E-13	5.0E-04	1.30192E-09	1.30192E-09
chromium(III) = 677[chromium]	9.43E+00	5.58049E-12	5.58049E-12	1.0E+00	5.58049E-12	5.58049E-12
chromium(VI) = 177[chromium]	1.57E+00	9.29096E-13	9.29096E-13	5.0E-03	1.85819E-10	1.85819E-10
lead	7.40E+01					
mercury	4.10E-01	2.42630E-13	2.42630E-13	3.0E-04	8.08767E-10	8.08767E-10
selenium	ND					
silver	ND					
Hazard Index (HI) =				6.65429E-08	6.65429E-08	6.65429E-08
HI (child + adult) =				3.77076E-07	3.77076E-07	3.77076E-07

CANCER (c)	Cis max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk uct	Cancer Risk expected
Organic						
benzene	2.40E+01	4.86951E-12	1.42027E-12	2.9E-02	1.41216E-13	4.11879E-14
Inorganic						
arsenic	2.20E+01	4.46372E-12	1.30192E-12	1.5E+01	6.69558E-11	1.95288E-11
cadmium	1.10E+00	2.23186E-13	6.50959E-14	6.3E+00	1.40807E-12	4.10104E-13
chromium(VI) = 177[chromium]	1.57E+00	3.18547E-13	9.29096E-14	4.2E+01	1.33790E-11	3.90220E-12
Sum Cancer Risk =				8.18820E-11	8.18820E-11	2.38823E-11
Cancer Risk (child + adult) =				1.77411E-10	1.77411E-10	5.57253E-11

RP15

SOIL GAS EMISSION RATE (Qis) AT ON SITE GROUND SURFACE FROM SOIL PARTICLES* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles
adult

NONCANCER (nc)	Cis,max mg/kg	pi mmHg	MMI	R mmHg(cm ³)/[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi,max	P	di cm	Qis g/s
Organic												
benzene	2.40E+01	9.5E+01	78	62,361	293	4.05544E-04	8.700E-02	2.632E+06	4.800E-05	0.25	100	7.02121E-06
ethylbenzene	6.50E+01	9.5E+00	106	62,361	293	5.51123E-05	6.600E-02	2.632E+06	9.566E-05	0.25	100	1.44258E-06
fluorene												
naphthalene	5.10E+01	8.7E-01	128	62,361	293	6.09465E-06	5.900E-02	2.632E+06	6.216E-05	0.25	100	9.26615E-08
1-methylnaphthalene**	7.90E+01	4.5E-02	142	62,361	293	3.49720E-07	4.400E-02	2.632E+06	8.679E-05	0.25	100	5.53669E-09
2-methylnaphthalene**	1.60E+02	4.5E-02	142	62,361	293	3.49720E-07	4.400E-02	2.632E+06	1.758E-04	0.25	100	1.12136E-08
phenanthrene	2.30E+00	2.5E-06	178	62,361	293	2.43545E-11	5.200E-02	2.632E+06	2.016E-06	0.25	100	1.05835E-14
phenol**												
2,4-dimethylphenol**												
pyrene	1.70E+00	2.5E-06	202	62,361	293	2.76383E-11	4.800E-02	2.632E+06	1.313E-06	0.25	100	7.22085E-15
toluene	1.00E+01	2.8E+01	92	62,361	293	1.41486E-04	7.800E-02	2.632E+06	1.696E-05	0.25	100	7.75816E-07
xylene (mean: o-, m-, p-)	1.20E+02	7.7E+00	106	62,361	293	4.46700E-05	7.200E-02	2.632E+06	1.766E-04	0.25	100	2.35485E-06
Inorganic												
none												

CANCER (c)	Cis,max mg/kg	pi mmHg	MMI	R mmHg(cm ³)/[(mol)K]	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi,max	P	di cm	Qis g/s
Organic												
benzene	2.40E+01	9.5E+01	78	62,361	293	4.05544E-04	8.700E-02	2.632E+06	4.800E-05	0.25	100	7.02121E-06
Inorganic												
none												

*Assumption: Qis is constant, i.e., contaminant source is not depleted over time. The calculation of nfi assumes that the soil is 50% clay and 50% sand (MMsoil = 156).
Area = approx. 1/15 of an acre based on soil area occupied by maximum soil concentration.

**Some values of pi and Di are estimated.

RP15

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Qis g/s	<v>, m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	7.02121E-06	4.2	1	1	5.32124E-07
ethylbenzene	1.44258E-06	4.2	1	1	1.09330E-07
fluorene					
naphthalene	9.26615E-08	4.2	1	1	7.02264E-09
1-methylnaphthalene	5.53669E-09	4.2	1	1	4.19615E-10
2-methylnaphthalene	1.12136E-08	4.2	1	1	8.49854E-10
phenanthrene	1.05835E-14	4.2	1	1	8.02103E-16
phenol					
2,4-dimethylphenol					
pyrene	7.22085E-15	4.2	1	1	5.47254E-16
toluene	7.75816E-07	4.2	1	1	5.87976E-08
xylene (mean: o-, m-, p-)	2.35485E-06	4.2	1	1	1.78469E-07
Inorganic					
none					

CANCER (c)	Qis g/s	<v>, m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	7.02121E-06	4.2	1	1	5.32124E-07
Inorganic					
none					

*Mean wind speed (<v>, m) over El Paso = 4.2 m/s (API 1994).

RP15

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Ciad	IRa	Fla	ABSF	CF	EFucl	EFm	EDucl	EDm	BM	ATc,ucI	ATc,m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic														
benzene	5.32124E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	3.33228E-07	2.08268E-07
ethylbenzene	1.09330E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	6.84650E-08	4.27907E-08
fluorene														
naphthalene	7.02264E-09	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	4.39774E-09	2.74859E-09
1-methylnaphthalene	4.19615E-10	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.62773E-10	1.64233E-10
2-methylnaphthalene	8.49854E-10	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	5.32198E-10	3.32624E-10
phenanthrene	8.02103E-16	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	5.02295E-16	3.13935E-16
phenol														
2,4-dimethylphenol														
pyrene	5.47254E-16	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	3.42703E-16	2.14189E-16
toluene	5.87976E-08	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	3.68204E-08	2.30128E-08
xylene (mean: o-, m-, p-)	1.78469E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	1.11762E-07	6.98510E-08
Inorganic														
none														

CANCER (c)	Ciad	IRa	Fla	ABSF	CF	EFucl	EFm	EDucl	EDm	BM	ATc,ucI	ATc,m	Intake Rate, ucl	Intake Rate, mean
	g/m ³	m ³ /d			mg/g	d/y	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic														
benzene	5.32124E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	25,550	25,550	1.19010E-07	2.67773E-08
Inorganic														
none														

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen onsite work.

EDm = 9 y (national median time at one residence, EPA 1989a).

RP15

RISK — Brickland Refinery, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Soil Gas from Soil Particles

adult

NONCANCER (nc)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.40E+01	3.33228E-07	2.08268E-07	1.0E-03	3.33228E-04	2.08268E-04
ethylbenzene	6.50E+01	6.84650E-08	4.27907E-08	2.9E-01	2.36086E-07	1.47554E-07
fluorene						
naphthalene	5.10E+01	4.39774E-09	2.74859E-09	4.0E-02	1.09943E-07	6.87147E-08
1-methylnaphthalene	7.90E+01	2.62773E-10	1.64233E-10	4.0E-02	6.56932E-09	4.10582E-09
2-methylnaphthalene	1.60E+02	5.32198E-10	3.32624E-10	4.0E-02	1.33049E-08	8.31559E-09
phenanthrene	2.30E+00	5.02295E-16	3.13935E-16	3.0E-02	1.67432E-14	1.04645E-14
phenol						
2,4-dimethylphenol						
pyrene	1.70E+00	3.42703E-16	2.14189E-16	3.0E-02	1.14234E-14	7.13965E-15
toluene	1.00E+01	3.68204E-08	2.30128E-08	1.0E-01	3.68204E-07	2.30128E-07
xylene (mean: o-, m-, p-)	1.20E+02	1.11762E-07	6.98510E-08	2.0E-01	5.58808E-07	3.49255E-07
Inorganic						
none						
				Hazard Index (HI) =	3.34521E-04	2.09076E-04
				HI (adult) =	3.34521E-04	2.09076E-04

CANCER (c)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucf	Cancer Risk mean
Organic						
benzene	2.40E+01	1.19010E-07	2.67773E-08	2.9E-02	3.45129E-09	7.76541E-10
Inorganic						
none						
				Sum Cancer Risk =	3.45129E-09	7.76541E-10
				Cancer Risk (adult) =	3.45129E-09	7.76541E-10

RP16

SOIL GAS EMISSION RATE (Qiw) FROM ON SITE GROUND WATER* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from Groundwater
adult

NONCANCER (nc)	Qiw,max mg/L	MMI	nfi,max	Kgi (mol/cm ²)/s	Kli (mol/cm ²)/s	Hi [†]	Koa (mol/cm ²)/s	A cm ²	Qiw g/s
Organic									
benzene	2.30E+01	78	5.31220E-06	3.49004E-05	7.74597E-05	2.49E-01	7.81360E-06	2.632E+06	8.522781E-03
ethylbenzene	7.00E-02	106	1.18969E-08	3.14923E-05	6.64462E-05	2.87E-01	7.95608E-06	2.632E+06	2.641190E-05
fluorene	1.20E-02	166	1.30231E-09	2.70986E-05	5.30969E-05	2.86E-03	7.73889E-08	2.632E+06	4.404153E-08
naphthalene	2.35E-01	128	3.30750E-08	2.95643E-05	6.04670E-05	5.78E-02	1.66185E-06	2.632E+06	1.852090E-05
1-methylnaphthalene**	1.65E-01	142	2.09333E-08	2.85539E-05	5.74089E-05	1.25E-02	3.54719E-07	2.632E+06	2.775687E-06
2-methylnaphthalene**	1.85E-01	142	2.34706E-08	2.85539E-05	5.74089E-05	1.42E-02	4.02622E-07	2.632E+06	3.532415E-06
phenanthrene	3.20E-02	178	3.23871E-09	2.64723E-05	5.12759E-05	7.11E-03	1.87530E-07	2.632E+06	2.845918E-07
phenol**	3.00E-01	94	5.74956E-08	3.27857E-05	7.05601E-05	5.73E-06	1.87862E-10	2.632E+06	2.672771E-09
2,4-dimethylphenol**	1.10E-01	122	1.62433E-08	3.00436E-05	6.19360E-05	1.61E-06	4.83702E-11	2.632E+06	2.523321E-10
pyrene	5.80E-02	202	5.17271E-09	2.53741E-05	4.81335E-05	2.28E-04	5.78459E-09	2.632E+06	1.591119E-08
toluene	1.60E-01	92	3.13310E-08	3.30228E-05	7.13230E-05	2.84E-01	8.28858E-06	2.632E+06	6.289301E-05
xylene (sum: o-, m-, p-)	1.10E+00	106	1.86951E-07	3.14923E-05	6.64462E-05	3.15E-01	8.63146E-06	2.632E+06	4.502763E-04
Inorganic									
none									

CANCER (c)	Qiw,max mg/L	MMI	nfi,max	Kgi (mol/cm ²)/s	Kli (mol/cm ²)/s	Hi [†]	Koa (mol/cm ²)/s	A cm ²	Qiw g/s
Organic									
benzene	2.30E+01	78	5.31220E-06	3.49004E-05	7.74597E-05	2.49E-01	7.81360E-06	2.632E+06	8.522781E-03
Inorganic									
none									

*Assumption: Qiw is constant, i.e., contaminant source is not depleted over time. Temperature = 293 K (20°C).

Area = approx. 1/15 of an acre based on area of the 20 ppm benzene concentration contour plotted from the results of the 6th quarter monitoring (Q2-1995).

**Value of H[†] is calculated/estimated from vapor pressure, molecular mass, and solubility in water.

RP16

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from Groundwater

adult

NONCANCER (nc)	Qiw,max mg/L	Qiw g/s	P	Ql,uci g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic								
benzene	2.30E+01	8.52278E-03	0.25	1.34225E-03	4.2	1	1	1.01727E-04
ethylbenzene	7.00E-02	2.64119E-05	0.25	4.15961E-06	4.2	1	1	3.15249E-07
fluorene	1.20E-02	4.40415E-08	0.25	6.93611E-09	4.2	1	1	5.25674E-10
naphthalene	2.35E-01	1.85209E-05	0.25	2.91686E-06	4.2	1	1	2.21063E-07
1-methylnaphthalene	1.65E-01	2.77569E-06	0.25	4.37143E-07	4.2	1	1	3.31302E-08
2-methylnaphthalene	1.85E-01	3.53242E-06	0.25	5.56321E-07	4.2	1	1	4.21625E-08
phenanthrene	3.20E-02	2.84592E-07	0.25	4.48204E-08	4.2	1	1	3.39685E-09
phenol	3.00E-01	2.67277E-09	0.25	4.20935E-10	4.2	1	1	3.19019E-11
2,4-dimethylphenol	1.10E-01	2.52332E-10	0.25	3.97398E-11	4.2	1	1	3.01180E-12
pyrene	5.80E-02	1.59112E-08	0.25	2.50586E-09	4.2	1	1	1.89914E-10
toluene	1.60E-01	6.28930E-05	0.25	9.90503E-06	4.2	1	1	7.50683E-07
xylene (sum: o-, m-, p-)	1.10E+00	4.50276E-04	0.25	7.09141E-05	4.2	1	1	5.37444E-06
Inorganic								
none								

CANCER (c)	Qiw,max mg/L	Qiw g/s	P	Ql,uci g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic								
benzene	2.30E+01	8.52278E-03	0.25	1.34225E-03	4.2	1	1	1.01727E-04
Inorganic								
none								

*Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP16

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from Groundwater

adult

NONCANCER (nc)		Clad	IRa	Fla	ABSF	CF	EFucl	EFm	EDucl	EDm	BM	ATnc,ucl	ATnc,m	Intake Rate, ucl	Intake Rate, mean
		g/m ³	m ³ /d			mg/g	d/y	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic															
benzene		1.01727E-04	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	6.37037E-05	3.98148E-05
ethylbenzene		3.15249E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	1.97416E-07	1.23385E-07
fluorene		5.25674E-10	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	3.29189E-10	2.05743E-10
naphthalene		2.21063E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	1.38435E-07	8.65218E-08
1-methylnaphthalene		3.31302E-08	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.07469E-08	1.29668E-08
2-methylnaphthalene		4.21625E-08	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.64031E-08	1.65019E-08
phenanthrene		3.39685E-09	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.12719E-09	1.32949E-09
phenol		3.19019E-11	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	1.99777E-11	1.24860E-11
2,4-dimethylphenol		3.01180E-12	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	1.88606E-12	1.17879E-12
pyrene		1.89914E-10	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	1.18929E-10	7.43303E-11
toluene		7.50683E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	4.70095E-07	2.93809E-07
xylene (sum: o-, m-, p-)		5.37444E-06	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	3.36560E-06	2.10350E-06
Inorganic															
none															

CANCER (c)		Clad	IRa	Fla	ABSF	CF	EFucl	EFm	EDucl	EDm	BM	ATc,ucl	ATc,m	Intake Rate, ucl	Intake Rate, mean
		g/m ³	m ³ /d			mg/g	d/y	d/y	y	y	kg	d	d	mg/[(kg body mass)d]	mg/[(kg body mass)d]
Organic															
benzene		1.01727E-04	2.0E+01	0.1	1	1,000	8	5	25	9	70	25,550	25,550	2.27513E-05	5.11905E-06
Inorganic															
none															

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen onsite work.

EDm = 9 y (national median time at one residence, EPA 1989a).

*Assumption: Industrial worker 10 to 100 m from site and 10X dispersion (Fla = 0.1).

RP16

RISK — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from Groundwater
adult

NONCANCER (nc)	Ciw,max mg/L	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.30E+01	6.37037E-05	3.98148E-05	1.0E-03	6.37037E-02	3.98148E-02
ethylbenzene	7.00E-02	1.97416E-07	1.23385E-07	2.9E-01	6.80746E-07	4.25466E-07
fluorene	1.20E-02	3.29189E-10	2.05743E-10	4.0E-02	8.22973E-09	5.14358E-09
naphthalene	2.35E-01	1.38435E-07	8.65218E-08	4.0E-02	3.46087E-06	2.16304E-06
1-methylnaphthalene	1.65E-01	2.07469E-08	1.29668E-08	4.0E-02	5.18673E-07	3.24171E-07
2-methylnaphthalene	1.85E-01	2.64031E-08	1.65019E-08	4.0E-02	6.60078E-07	4.12549E-07
phenanthrene	3.20E-02	2.12719E-09	1.32949E-09	3.0E-02	7.09062E-08	4.43164E-08
phenol	3.00E-01	1.99777E-11	1.24860E-11	6.0E-01	3.32961E-11	2.08101E-11
2,4-dimethylphenol	1.10E-01	1.88606E-12	1.17879E-12	2.0E-02	9.43031E-11	5.89394E-11
pyrene	5.80E-02	1.18929E-10	7.43303E-11	3.0E-02	3.96428E-09	2.47768E-09
toluene	1.60E-01	4.70095E-07	2.93809E-07	1.0E-01	4.70095E-06	2.93809E-06
xylene (sum: o-, m-, p-)	1.10E+00	3.36560E-06	2.10350E-06	2.0E-01	1.68280E-05	1.05175E-05
Inorganic						
none						
Hazard Index (HI) =				6.37306E-02	3.98316E-02	
HI (adult) =				6.37306E-02	3.98316E-02	

CANCER (c)	Ciw,max mg/L	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/[mg/(kg body mass)/d]	Cancer Risk ucl	Cancer Risk mean
Organic						
benzene	2.30E+01	2.27513E-05	5.11905E-06	2.9E-02	6.59788E-07	1.48452E-07
Inorganic						
none						
Sum Cancer Risk =				6.59788E-07	1.48452E-07	
Cancer Risk (adult) =				6.59788E-07	1.48452E-07	

RP17

SOIL GAS EMISSION RATE (Qi) AT ON SITE GROUND SURFACE FROM LNAPL CONTAMINANT* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant adult

NONCANCER (nc)	Ci mg/kg	pi mmHg	nfi LNAPL	ppi mmHg	MMI	R mmHg(cm ³)/(mol)Kj	T K	Clsg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
Organic														
benzene*	6.25E+01	9.5E+01	1.20E-04	1.1E-02	78	62,361	293	4.87432E-08	8.700E-02	2.632E+06	1	0.25	100	1.75812E-05
ethylbenzene	2.10E+02	9.5E+00	2.97E-04	2.8E-03	106	62,361	293	1.63777E-08	6.600E-02	2.632E+06	1	0.25	100	4.48138E-06
fluorene*	4.95E+02	5.5E-03	4.47E-04	2.5E-06	166	62,361	293	2.23500E-11	6.340E-02	2.632E+06	1	0.25	100	5.87465E-09
naphthalene*	4.95E+02	8.7E-01	5.80E-04	5.0E-04	128	62,361	293	3.53537E-09	5.900E-02	2.632E+06	1	0.25	100	8.64771E-07
1-methylnaphthalene**	2.00E+03	4.5E-02	2.11E-03	9.5E-05	142	62,361	293	7.38845E-10	4.400E-02	2.632E+06	1	0.25	100	1.34778E-07
2-methylnaphthalene**	4.95E+02	4.5E-02	5.23E-04	2.4E-05	142	62,361	293	1.82864E-10	4.400E-02	2.632E+06	1	0.25	100	3.33576E-08
phenanthrene	1.30E+03	2.5E-06	1.10E-03	2.7E-09	178	62,361	293	2.66805E-14	5.200E-02	2.632E+06	1	0.25	100	5.75190E-12
phenol* **	4.95E+02	1.0E-01	7.90E-04	7.9E-05	94	62,361	293	4.06365E-10	8.000E-02	2.632E+06	1	0.25	100	1.34778E-07
2,4-dimethylphenol* **	4.95E+02	1.0E-02	6.09E-04	6.1E-06	122	62,361	293	4.06365E-11	6.000E-02	2.632E+06	1	0.25	100	1.01084E-08
pyrene*	4.95E+02	2.5E-06	3.68E-04	9.2E-10	202	62,361	293	1.01591E-14	4.800E-02	2.632E+06	1	0.25	100	2.02167E-12
toluene*	6.25E+01	2.8E+01	1.02E-04	2.9E-03	92	62,361	293	1.44177E-08	7.800E-02	2.632E+06	1	0.25	100	4.66236E-06
xylene (sum: o-, m-, p-)	5.40E+02	7.7E+00	7.64E-04	5.9E-03	106	62,361	293	3.41346E-08	7.200E-02	2.632E+06	1	0.25	100	1.01892E-05
Inorganic														
none														

CANCER (c)	Ci (mg/kg)	pi mmHg	nfi LNAPL	ppi mmHg	MMI	R mmHg(cm ³)/(mol)Kj	T K	Clsg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
benzene*	6.25E+01	9.50E+01	1.20E-04	1.1E-02	78	62,361	293	4.87432E-08	8.700E-02	2.632E+06	1	0.25	100	1.75812E-05
Inorganic														
none														

*These substances were not detected. Thus, Ci for these substances was set to half the detection limit.

Ci is used to calculate the partial pressure (ppi) of each COC in the LNAPL phase. Area = 1/15 of an acre (1 acre = 4,046.873 m²) assumed aerial extent of LNAPL.

**Some values of pi and Di are estimated.

Assumption: Qi is constant, i.e., contaminant source is not depleted over time. Molecular mass of LNAPL is assumed = 150.

RP17

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	Qi mg/kg	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.75812E-05	4.2	1	1	1.33244E-06
ethylbenzene	4.48138E-06	4.2	1	1	3.39635E-07
fluorene	5.87465E-09	4.2	1	1	4.45228E-10
naphthalene	8.64771E-07	4.2	1	1	6.55393E-08
1-methylnaphthalene	1.34778E-07	4.2	1	1	1.02146E-08
2-methylnaphthalene	3.33576E-08	4.2	1	1	2.52811E-09
phenanthrene	5.75190E-12	4.2	1	1	4.35925E-13
phenol	1.34778E-07	4.2	1	1	1.02146E-08
2,4-dimethylphenol	1.01084E-08	4.2	1	1	7.66094E-10
pyrene	2.02167E-12	4.2	1	1	1.53219E-13
toluene	4.66236E-06	4.2	1	1	3.53351E-07
xylene (sum: o-, m-, p-)	1.01892E-05	4.2	1	1	7.72223E-07
Inorganic					
none					

CANCER (c)	Qi g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	1.75812E-05	4.2	1	1	1.33244E-06
Inorganic					
none					

*Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP17

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	Clad g/m ³	IRa m ³ /d	Fla m ³ /d	ABSF	CF mg/g	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucl d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	1.33244E-06	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	8.34406E-07	5.21504E-07
ethylbenzene	3.39635E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.12687E-07	1.32930E-07
fluorene	4.45228E-10	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.78812E-10	1.74258E-10
naphthalene	6.55393E-08	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	4.10422E-08	2.56514E-08
1-methylnaphthalene	1.02146E-08	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	6.39661E-09	3.99788E-09
2-methylnaphthalene	2.52811E-09	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	1.58316E-09	9.89475E-10
phenanthrene	4.35925E-13	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.72987E-13	1.70617E-13
phenol	1.02146E-08	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	6.39661E-09	3.99788E-09
2,4-dimethylphenol	7.66094E-10	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	4.79746E-10	2.99841E-10
pyrene	1.53219E-13	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	9.59491E-14	5.99682E-14
toluene	3.53351E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	2.21277E-07	1.38298E-07
xylene (sum: o-, m-, p-)	7.72223E-07	2.0E+01	0.1	1	1,000	8	5	25	9	70	9,125	3,285	4.83584E-07	3.02240E-07
Inorganic														
none														

CANCER (c)	Clad g/m ³	IRa m ³ /d	Fla m ³ /d	ABSF	CF mg/g	EFucl d/y	EFm d/y	EDucl y	EDm y	BM kg	ATc,ucl d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	1.33244E-06	2.0E+01	0.1	1	1,000	8	5	25	9	70	25,550	25,550	2.98002E-07	6.70505E-08
Inorganic														
none														

*EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFucl = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFm accounts for unforeseen onsite work.
EDm = 9 y (national median time at one residence, EPA 1989a).

Assumption: Industrial worker 10 to 100 m from site and 10X dispersion (Fla = 0.1).

RP17

RISK — Brickland Refinery, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	CI mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	6.25E+01	8.34406E-07	5.21504E-07	1.0E-03	8.34406E-04	5.21504E-04
ethylbenzene	2.10E+02	2.12687E-07	1.32930E-07	2.9E-01	7.33404E-07	4.58378E-07
fluorene	4.95E+02	2.78812E-10	1.74258E-10	4.0E-02	6.97031E-09	4.35844E-09
naphthalene	4.95E+02	4.10422E-08	2.56514E-08	4.0E-02	1.02606E-06	6.41285E-07
1-methylnaphthalene	2.00E+03	6.39661E-09	3.99788E-09	4.0E-02	1.59915E-07	9.99470E-08
2-methylnaphthalene	4.95E+02	1.58316E-09	9.89475E-10	4.0E-02	3.95790E-08	2.47369E-08
phenanthrene	1.30E+03	2.72987E-13	1.70617E-13	3.0E-02	9.09955E-12	5.68722E-12
phenol	4.95E+02	6.39661E-09	3.99788E-09	6.0E-01	1.06610E-08	6.66313E-09
2,4-dimethylphenol	4.95E+02	4.79746E-10	2.99841E-10	2.0E-02	2.39873E-08	1.49921E-08
pyrene	4.95E+02	9.59491E-14	5.99682E-14	3.0E-02	3.19830E-12	1.99894E-12
toluene	6.25E+01	2.21277E-07	1.38298E-07	1.0E-01	2.21277E-06	1.38298E-06
xylylene (sum: o-, m-, p-)	5.40E+02	4.83584E-07	3.02240E-07	2.0E-01	2.41792E-06	1.51120E-06
Inorganic						
none						
Hazard Index (HI) =				8.41037E-04	5.25648E-04	
HI (adult) =				8.41037E-04	5.25648E-04	

CANCER (c)	CI mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Potency Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucf	Cancer Risk mean
Organic						
benzene	6.25E+01	2.98002E-07	6.70505E-08	2.9E-02	8.64206E-09	1.94446E-09
Inorganic						
none						
Sum Cancer Risk =					8.64206E-09	1.94446E-09
Cancer Risk (adult) =					8.64206E-09	1.94446E-09

RP18

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Soil Dust*

adult

NONCANCER (nc)	Cs,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EFud d/y	EFm d/y	EDud y	EDm y	BM kg	ATnc,ud d	ATnc,m d	Intake Rate, ucl mg/(kg body mass)d	Intake Rate, mean mg/(kg body mass)d
Organic														
benzene	2.40E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	3.2434E-12	2.0289E-12
ethylbenzene	6.50E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	8.79217E-12	5.49511E-12
fluorene	5.10E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	6.89847E-12	4.31155E-12
naphthalene	7.90E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	1.06859E-11	6.87867E-12
1-methylnaphthalene	1.60E+02	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	2.16423E-11	1.35264E-11
2-methylnaphthalene	2.30E+00	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	3.11108E-13	1.94442E-13
phenanthrene														
phenol														
2,4-dimethylphenol	1.70E+00	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	2.29949E-13	1.43718E-13
pyrene	1.00E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	1.35264E-12	8.45401E-13
toluene	1.20E+02	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	1.62317E-11	1.01448E-11
xylene (sum: o-, m-, p-)														
Inorganic														
arsenic	2.20E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	2.97581E-12	1.85988E-12
barium	2.04E+02	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	2.75939E-11	1.72462E-11
cadmium	1.10E+00	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	1.48791E-13	9.29941E-14
chromium(III) = 677(chromium)	9.43E+00	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	1.27554E-12	7.97213E-13
chromium(VI) = 177(chromium)	1.57E+00	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	2.12365E-13	1.32728E-13
lead**	7.40E+01													
mercury	4.10E-01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	9,125	3,285	5.54583E-14	3.46614E-14
selenium	ND													
silver	ND													

CANCER (c)	Cs,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EFud d/y	EFm d/y	EDud y	EDm y	BM kg	ATc,ud d	ATc,m d	Intake Rate, ucl mg/(kg body mass)d	Intake Rate, mean mg/(kg body mass)d
Organic														
benzene	2.40E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	25,550	25,550	1.15941E-12	2.60867E-13
Inorganic														
arsenic	2.20E+01	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	25,550	25,550	1.06279E-12	2.39128E-13
cadmium	1.10E+00	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	25,550	25,550	5.31395E-14	1.19564E-14
chromium(VI) = 177(chromium)	1.57E+00	2.0E+01	0.1	1	2.2E-10	8	5	25	9	70	25,550	25,550	7.58446E-14	1.70650E-14

*A default PEF = 2.16E-10 kg/m³ is used; for onsite, no dispersion (dilution) is assumed (Fla = 1 is conservative).

EFm = 5 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and workers are assumed onsite for 15 d/y, 8 h/d.

EFud = 8 d/y (instead of the 250 d/y standard industrial default) because the site is not currently used and an additional 3 d/y to EFM accounts for unforeseen onsite work.

EDm = 9 y (national median time at one residence, EPA 1989a). Assumption: Resident 10 to 100 m from site and 10X dispersion (Fla = 0.1).

**Risk from exposure to lead is estimated using DTSC Lead Risk Assessment Spreadsheet (U.S. EPA Uptake-Biokinetic Model [UBM 1990, 1994, 0.99D]).

RP-18

RISK — Brickland Refinery, Sunland Park, New Mexico

CURRENT CONDITIONS (off site)

INDUSTRIAL

Inhalation of Soil Dust

adult

NONCANCER (nc)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic						
benzene	2.40E+01	3.24634E-12	2.02896E-12	1.0E-03	3.24634E-09	2.02896E-09
ethylbenzene	6.50E+01	8.79217E-12	5.49511E-12	2.9E-01	3.03178E-11	1.89486E-11
fluorene	5.10E+01	6.89847E-12	4.31155E-12	4.0E-02	1.72462E-10	1.07789E-10
naphthalene	7.90E+01	1.06859E-11	6.67867E-12	4.0E-02	2.67147E-10	1.66967E-10
1-methylnaphthalene	1.60E+02	2.16423E-11	1.35264E-11	4.0E-02	5.41057E-10	3.38160E-10
phenanthrene	2.30E+00	3.11108E-13	1.94442E-13	3.0E-02	1.03703E-11	6.48141E-12
phenol						
2,4-dimethylphenol	1.70E+00	2.29949E-13	1.43718E-13	3.0E-02	7.66497E-12	4.79061E-12
pyrene	1.00E+01	1.35264E-12	8.45401E-13	1.0E-01	1.35264E-11	8.45401E-12
toluene	1.20E+02	1.62317E-11	1.01448E-11	2.0E-01	8.11585E-11	5.07241E-11
xylylene (sum: o-, m-, p-)						
Inorganic						
arsenic	2.20E+01	2.97581E-12	1.85988E-12	3.0E-04	9.91937E-09	6.19961E-09
barium	2.04E+02	2.75939E-11	1.72462E-11	7.0E-02	3.94198E-10	2.46374E-10
cadmium	1.10E+00	1.48791E-13	9.29941E-14	5.0E-04	2.97581E-10	1.85988E-10
chromium(III) = 6/7[chromium]	9.43E+00	1.27554E-12	7.97213E-13	1.0E+00	1.27554E-12	7.97213E-13
chromium(VI) = 1/7[chromium]	1.57E+00	2.12365E-13	1.32728E-13	5.0E-03	4.24730E-11	2.65456E-11
lead	7.40E+01					
mercury	4.10E-01	5.54583E-14	3.46614E-14	3.0E-04	1.84861E-10	1.15538E-10
selenium	ND					
silver	ND					
Hazard Index (HI) =				1.52098E-08	1.52098E-08	9.50613E-09
HI (adult) =						9.50613E-09

CANCER (c)	Cis,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucI	Cancer Risk expected
Organic						
benzene	2.40E+01	1.15941E-12	2.60867E-13	2.9E-02	3.36228E-14	7.56513E-15
Inorganic						
arsenic	2.20E+01	1.06279E-12	2.39128E-13	1.5E+01	1.59419E-11	3.58692E-12
cadmium	1.10E+00	5.31395E-14	1.19564E-14	6.3E+00	3.34779E-13	7.53252E-14
chromium(VI) = 1/7[chromium]	1.57E+00	7.58446E-14	1.70650E-14	4.2E+01	3.18547E-12	7.16731E-13
Sum Cancer Risk =					1.94957E-11	4.38654E-12
Cancer Risk (adult) =					1.94957E-11	4.38654E-12

RP19

TIME REQUIRED FOR MASS OF SPECIFIC LNAPL CONTAMINANT TO REACH ZERO* — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (off site, future =+10 y)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

NONCANCER (nc)	Ci,t=0 mg/kg	A, LNAPL cm ²	h, LNAPL cm	V, LNAPL cm ³	d, LNAPL g/cm ³	M, LNAPL g	Mi,t=0 g	Qi,t=0 g/s	t, Mi=0 s	CF s/y	t, Mi=0 y
Organic											
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.03356E+04	6.757E-05	1.530E+08	3.156E+07	4.847E+00
ethylbenzene	2.10E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.47275E+04	8.612E-06	4.033E+09	3.156E+07	1.278E+02
fluorene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.18576E+04	2.258E-08	3.626E+12	3.156E+07	1.149E+05
naphthalene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.18576E+04	3.324E-06	2.463E+10	3.156E+07	7.805E+02
1-methylnaphthalene	2.00E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.30738E+05	2.590E-07	1.277E+12	3.156E+07	4.047E+04
2-methylnaphthalene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.18576E+04	1.282E-07	6.385E+11	3.156E+07	2.023E+04
phenanthrene	1.30E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	2.14980E+05	1.105E-11	1.945E+16	3.156E+07	6.163E+08
phenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.18576E+04	5.180E-07	1.580E+11	3.156E+07	5.008E+03
2,4-dimethylphenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.18576E+04	3.885E-08	2.107E+12	3.156E+07	6.677E+04
pyrene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.18576E+04	7.770E-12	1.054E+16	3.156E+07	3.338E+08
toluene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.03356E+04	1.792E-05	5.768E+08	3.156E+07	1.828E+01
xylene (mean: o-, m-, p-)	5.40E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.92992E+04	1.958E-05	4.561E+09	3.156E+07	1.445E+02
Inorganic											
none											

CANCER (c)	Ci,t=0 mg/kg	A, LNAPL cm ²	h, LNAPL cm	V, LNAPL cm ³	d, LNAPL g/cm ³	M, LNAPL g	Mi,t=0 g	Qi,t=0 g/s	t, Mi=0 s	CF s/y	t, Mi=0 y
Organic											
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.03356E+04	6.757E-05	1.530E+08	3.156E+07	4.847E+00
Inorganic											
none											

*Assumption: loss of LNAPL is by volatilization only. A more accurate estimate would require updating Ci,max and Qi (Qi,t=0 becoming Qi,t=t) over shorter time intervals, e.g., 1-month. Thus, the calculated t, Mi=0 for benzene is probably somewhat too small (the loss of benzene decreases its mole fraction-vapor pressure and therefore, its emission rate); however, the loss of benzene increases the loss rate for the other constituents. Assumption: density of LNAPL = 0.9 g/cm³. Qi is calculated using the RP3 equations.

Area = 1/15 of an acre (assumed) and height (h) of LNAPL = 2.29 ft (June 1995) = 2.29(12)(2.54) = 69.7992 cm.

**These substances were not detected. Thus, Ci for these substances was set to half the detection limit.

RP19

SOIL GAS EMISSION RATE (QI) AT ON SITE GROUND SURFACE FROM LNAPL CONTAMINANT* — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (off site, future =+10 y)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

NONCANCER (nc)	t, Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL mmHg	MMI mmHg	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	QI g/s
Organic															
benzene*	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	62,361	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
ethylbenzene	1.28E+02	2.10E+02	1.94E+02	9.5E+00	2.74E-04	2.6E-03	62,361	293	1.510E-08	6.6E-02	2.632E+06	1	0.25	100	4.13069E-06
fluorene*	1.15E+05	4.95E+02	4.95E+02	5.5E-03	4.47E-04	2.5E-06	62,361	293	2.235E-11	6.3E-02	2.632E+06	1	0.25	100	5.87414E-09
naphthalene*	7.80E+02	4.95E+02	4.89E+02	8.7E-01	5.73E-04	5.0E-04	62,361	293	3.490E-09	5.9E-02	2.632E+06	1	0.25	100	8.53691E-07
1-methylnaphthalene**	4.05E+04	2.00E+03	2.00E+03	4.5E-02	2.11E-03	9.5E-05	62,361	293	7.387E-10	4.4E-02	2.632E+06	1	0.25	100	1.34745E-07
2-methylnaphthalene**	2.02E+04	4.95E+02	4.95E+02	4.5E-02	5.23E-04	2.4E-05	62,361	293	1.828E-10	4.4E-02	2.632E+06	1	0.25	100	3.33411E-08
phenanthrene	6.16E+08	1.30E+03	1.30E+03	2.5E-06	1.10E-03	2.7E-09	62,361	293	2.668E-14	5.2E-02	2.632E+06	1	0.25	100	5.75190E-12
phenol* **	5.01E+03	4.95E+02	4.94E+02	1.0E-01	7.88E-04	7.9E-05	62,361	293	4.056E-10	8.0E-02	2.632E+06	1	0.25	100	1.34509E-07
2,4-dimethylphenol* **	6.68E+04	4.95E+02	4.95E+02	1.0E-02	6.09E-04	6.1E-06	62,361	293	4.063E-11	6.0E-02	2.632E+06	1	0.25	100	1.01069E-08
pyrene*	3.34E+08	4.95E+02	4.95E+02	2.5E-06	3.68E-04	9.2E-10	62,361	293	1.016E-14	4.8E-02	2.632E+06	1	0.25	100	2.02167E-12
toluene*	1.83E+01	6.25E+01	2.83E+01	2.8E+01	4.62E-05	1.3E-03	62,361	293	6.530E-09	7.8E-02	2.632E+06	1	0.25	100	2.11154E-06
xylene (sum: o-, m-, p-)	1.45E+02	5.40E+02	5.03E+02	7.7E+00	7.11E-04	5.5E-03	62,361	293	3.177E-08	7.2E-02	2.632E+06	1	0.25	100	9.48421E-06
Inorganic															
none															

CANCER (c)	t, Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL mmHg	MMI mmHg	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	QI g/s
benzene*	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	62,361	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
Inorganic															
none															

*These substances were not detected. Thus, Ci for these substances was set to half the detection limit. Ci is used to calculate the partial pressure (ppi) of each COC in the LNAPL phase. (Ci,t=10y) = (Ci,t=0)(1 - [10/(t,Mi=0)]). Benzene concentration estimated to reach zero in 10 years ((Ci,t=10y) = 0).

Area = 1/15 of an acre (1 acre = 4,046.873 m²) assumed aerial extent of LNAPL.

**Some values of pi and Di are estimated.

Assumption: Qi is constant, i.e., contaminant source is not depleted over time. Molecular mass (MM) of LNAPL is assumed = 150.

RP19

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (off site, future =+10 y)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

NONCANCER (nc)	Qi mg/kg	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
ethylbenzene	4.13069E-06	4.2	1	1	3.13057E-07
fluorene	5.87414E-09	4.2	1	1	4.45189E-10
naphthalene	8.53691E-07	4.2	1	1	6.46996E-08
1-methylnaphthalene	1.34745E-07	4.2	1	1	1.02121E-08
2-methylnaphthalene	3.33411E-08	4.2	1	1	2.52686E-09
phenanthrene	5.75190E-12	4.2	1	1	4.35925E-13
phenol	1.34509E-07	4.2	1	1	1.01942E-08
2,4-dimethylphenol	1.01069E-08	4.2	1	1	7.65979E-10
pyrene	2.02167E-12	4.2	1	1	1.53219E-13
toluene	2.11154E-06	4.2	1	1	1.60029E-07
xylene (sum: o-, m-, p-)	9.48421E-06	4.2	1	1	7.18790E-07
Inorganic					
none					

CANCER (c)	Qi,cd g/s	<v>.m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
Inorganic					
none					

*Mean wind speed (<v>.m) over El Paso = 4.2 m/s (API 1994).

RP19

RISK — Brickland Refinery, New Mexico

FUTURE I CONDITIONS (off site, future =+10 y)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

1 to 6 year old child

NONCANCER (nc)	C _i , t=0 mg/kg	C _i , t=10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	1.0E-03	0.00000E+00	0.00000E+00
ethylbenzene	2.10E+02	1.94E+02	4.00255E-06	4.00255E-06	2.9E-01	1.38019E-05	1.38019E-05
fluorene	4.95E+02	4.95E+02	5.69192E-09	5.69192E-09	4.0E-02	1.42298E-07	1.42298E-07
naphthalene	4.95E+02	4.89E+02	8.27209E-07	8.27209E-07	4.0E-02	2.06802E-05	2.06802E-05
1-methylnaphthalene	2.00E+03	2.00E+03	1.30565E-07	1.30565E-07	4.0E-02	3.26413E-06	3.26413E-06
2-methylnaphthalene	4.95E+02	4.95E+02	3.23069E-08	3.23069E-08	4.0E-02	8.07672E-07	8.07672E-07
phenanthrene	1.30E+03	1.30E+03	5.57348E-12	5.57348E-12	3.0E-02	1.85783E-10	1.85783E-10
phenol	4.95E+02	4.94E+02	1.30337E-07	1.30337E-07	6.0E-01	2.17228E-07	2.17228E-07
2,4-dimethylphenol	4.95E+02	4.95E+02	9.79334E-09	9.79334E-09	2.0E-02	4.89667E-07	4.89667E-07
pyrene	4.95E+02	4.95E+02	1.95896E-12	1.95896E-12	3.0E-02	6.52987E-11	6.52987E-11
toluene	6.25E+01	2.83E+01	2.04604E-06	2.04604E-06	1.0E-01	2.04604E-05	2.04604E-05
xylene (sum: o-, m-, p-)	5.40E+02	5.03E+02	9.19000E-06	9.19000E-06	2.0E-01	4.59500E-05	4.59500E-05
Inorganic							
none							
Hazard Index (HI) =						1.05814E-04	1.05814E-04

CANCER (c)	C _i , t=0 mg/kg	C _i , t=10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucf	Cancer Risk mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	2.9E-02	0.00000E+00	0.00000E+00
Inorganic							
none							
Sum Cancer Risk =						0.00000E+00	0.00000E+00

RP19

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (off site, future =+10 y)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant

7 to 30 year old "adult"

[illegible][illegible]

RP19

RISK — Brickland Refinery, New Mexico

FUTURE I CONDITIONS (off site, future =+10 y)

RESIDENTIAL

Inhalation of Volatile Organics from LNAPL Contaminant
7 to 30 year old "adult"

NONCANCER (nc)	C _i , max, t=0 mg/kg	C _i , max, t=10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	1.0E-03	0.00000E+00	0.00000E+00
ethylbenzene	2.10E+02	1.94E+02	8.57690E-07	8.57690E-07	2.9E-01	2.95755E-06	2.95755E-06
fluorene	4.95E+02	4.95E+02	1.21970E-09	1.21970E-09	4.0E-02	3.04924E-08	3.04924E-08
naphthalene	4.95E+02	4.89E+02	1.77259E-07	1.77259E-07	4.0E-02	4.43148E-06	4.43148E-06
1-methylnaphthalene	2.00E+03	2.00E+03	2.79782E-08	2.79782E-08	4.0E-02	6.99456E-07	6.99456E-07
2-methylnaphthalene	4.95E+02	4.95E+02	6.92291E-09	6.92291E-09	4.0E-02	1.73073E-07	1.73073E-07
phenanthrene	1.30E+03	1.30E+03	1.19432E-12	1.19432E-12	3.0E-02	3.98105E-11	3.98105E-11
phenol	4.95E+02	4.94E+02	2.79293E-08	2.79293E-08	6.0E-01	4.65488E-08	4.65488E-08
2,4-dimethylphenol	4.95E+02	4.95E+02	2.09857E-09	2.09857E-09	2.0E-02	1.04929E-07	1.04929E-07
pyrene	4.95E+02	4.95E+02	4.19777E-13	4.19777E-13	3.0E-02	1.39926E-11	1.39926E-11
toluene	6.25E+01	2.83E+01	4.38436E-07	4.38436E-07	1.0E-01	4.38436E-06	4.38436E-06
xylene (sum: o-, m-, p-)	5.40E+02	5.03E+02	1.96929E-06	1.96929E-06	2.0E-01	9.84643E-06	9.84643E-06
Inorganic							
none							
Hazard Index (HI) =						2.26744E-05	2.26744E-05
HI (child + adult) =						1.28488E-04	1.28488E-04

CANCER (c)	C _i , max, t=0 mg/kg	C _i , max, t=10y mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Potency Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucf	Cancer Risk mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	2.9E-02	0.00000E+00	0.00000E+00
Inorganic							
none							
Sum Cancer Risk =						0.00000E+00	0.00000E+00
Cancer Risk (child + adult) =						0.00000E+00	0.00000E+00

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico

FUTURE I CONDITIONS (off site, future = +10 y)

RESIDENTIAL

Inhalation of Soil Dust*

1 to 6 year old child

NONCANCER (nc)	Cis,max mg/kg	Cis,t=10y,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EF d/y	EDm y	EDud y	BM kg	ATcm d	Intake Rate, ucl mg/(kg body mass)d	Intake Rate, mean mg/(kg body mass)d
Organic													
benzene	2.40E+01	4.80E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	1.32559E-11	1.32559E-11
ethylbenzene	6.50E+01	1.30E+01	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	3.59014E-11	3.59014E-11
fluorene													
naphthalene	5.10E+01	5.10E+01	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	1.40844E-10	1.40844E-10
1-methylnaphthalene	7.90E+01	7.90E+01	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	2.18170E-10	2.18170E-10
2-methylnaphthalene	1.80E+02	1.80E+02	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	4.41863E-10	4.41863E-10
phenanthrene	2.30E+00	2.30E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	6.35178E-12	6.35178E-12
phenol													
2,4-dimethylphenol													
pyrene	1.70E+00	1.70E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	4.69479E-12	4.69479E-12
toluene	1.00E+01	2.00E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	5.52329E-12	5.52329E-12
xylene (mean: o-, m-, p-)	1.20E+02	2.40E+01	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	6.62795E-11	6.62795E-11
Inorganic													
arsenic	2.20E+01	2.20E+01	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	6.07562E-11	6.07562E-11
barium	2.04E+02	2.04E+02	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	5.63375E-10	5.63375E-10
cadmium	1.10E+00	1.10E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	3.03781E-12	3.03781E-12
chromium(III) = 6/7[chromium]	9.43E+00	9.43E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	2.60423E-11	2.60423E-11
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	4.33578E-12	4.33578E-12
lead**	7.40E+01	7.40E+01											
mercury	4.10E-01	4.10E-01	2.0E+01	0.01	1	2.2E-10	350	6	2	15	730	1.13227E-12	1.13227E-12
selenium	ND	ND											
silver	ND	ND											

CANCER (c)	Cis,max mg/kg	Cis,t=10y,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EF d/y	EDm y	EDud y	BM kg	ATcm d	Intake Rate, ucl mg/(kg body mass)d	Intake Rate, mean mg/(kg body mass)d
Organic													
benzene	2.40E+01	4.80E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	25,550	1.13622E-12	3.78740E-13
Inorganic													
arsenic	2.20E+01	2.20E+01	2.0E+01	0.01	1	2.2E-10	350	6	2	15	25,550	5.20767E-12	1.73589E-12
cadmium	1.10E+00	1.10E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	25,550	2.60384E-13	8.67945E-14
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	2.0E+01	0.01	1	2.2E-10	350	6	2	15	25,550	3.71638E-13	1.23879E-13

*Future I simulates conditions of the site in the next 10 years assuming no human remedial action. Default PEF = 2.16E-10 kg/m³. Assumption: 10X dispersion to building roof air intake (Fla = 0.1).

Assumption: Based on Thibodeaux time-varying model for volatile emissions (1982), concentration of BTEX after 10 years (Cis,t=10y) is 1/5 the original concentration (Cis,t=0). (Daugherty, 1991)

Assumption: Resident 10 to 100 m from site and 10X dispersion and a 10X attenuation for constituent entering residence (Fla = 0.01, Sheet 1 and Sheet 3).

**Risk from exposure to lead is estimated using DTSC Lead Risk Assessment Spreadsheet (U.S. EPA Uptake-Biokinetic Model [UBM 1990, 1994, 0.99D]).

RP20

RISK — Brickland Refinery, Sunland Park, New Mexico

FUTURE CONDITIONS (off site, future = +10 y)

RESIDENTIAL

Inhalation of Soil Dust

1 to 6 year old child

NONCANCER (nc)	Cis,max mg/kg	Cis,1=10y,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	2.40E+01	4.80E+00	1.32559E-11	1.32559E-11	1.0E-03	1.32559E-08	1.32559E-08
ethylbenzene	6.50E+01	1.30E+01	3.59014E-11	3.59014E-11	2.9E-01	1.23798E-10	1.23798E-10
fluorene	5.10E+01	5.10E+01	1.40844E-10	1.40844E-10	4.0E-02	3.52110E-09	3.52110E-09
naphthalene	7.90E+01	7.90E+01	2.18170E-10	2.18170E-10	4.0E-02	5.45425E-09	5.45425E-09
1-methylnaphthalene	1.60E+02	1.60E+02	4.41863E-10	4.41863E-10	4.0E-02	1.10466E-08	1.10466E-08
2-methylnaphthalene	2.30E+00	2.30E+00	6.35178E-12	6.35178E-12	3.0E-02	2.11726E-10	2.11726E-10
phenanthrene							
phenol							
2,4-dimethylphenol							
pyrene	1.70E+00	1.70E+00	4.69479E-12	4.69479E-12	3.0E-02	1.56493E-10	1.56493E-10
toluene	1.00E+01	2.00E+00	5.52329E-12	5.52329E-12	1.0E-01	5.52329E-11	5.52329E-11
xylene (mean: o-, m-, p-)	1.20E+02	2.40E+01	6.62795E-11	6.62795E-11	2.0E-01	3.31397E-10	3.31397E-10
Inorganic							
arsenic	2.20E+01	2.20E+01	6.07562E-11	6.07562E-11	3.0E-04	2.02521E-07	2.02521E-07
barium	2.04E+02	2.04E+02	5.63375E-10	5.63375E-10	7.0E-02	8.04822E-09	8.04822E-09
cadmium	1.10E+00	1.10E+00	3.03781E-12	3.03781E-12	5.0E-04	6.07562E-09	6.07562E-09
chromium(III) = 6/7[chromium]	9.43E+00	9.43E+00	2.60423E-11	2.60423E-11	3.0E-04	8.68077E-08	8.68077E-08
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	4.33578E-12	4.33578E-12	5.0E-03	8.67156E-10	8.67156E-10
lead	7.40E+01	7.40E+01	1.13227E-12	1.13227E-12	1.0E-04	1.13227E-08	1.13227E-08
mercury	4.10E-01	4.10E-01					
selenium	ND	ND					
silver	ND	ND					
Hazard Index (HI) =						3.49798E-07	3.49798E-07

CANCER (c)	Cis,max mg/kg	Cis,1=10y,max mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/kg body mass)/d	Cancer Risk ud	Cancer Risk expected
Organic							
benzene	2.40E+01	4.80E+00	1.13622E-12	3.78740E-13	2.9E-02	3.29504E-14	1.09835E-14
Inorganic							
arsenic	2.20E+01	2.20E+01	5.20767E-12	1.73589E-12	1.5E+01	7.81151E-11	2.60384E-11
cadmium	1.10E+00	1.10E+00	2.60384E-13	8.67945E-14	6.3E+00	1.64042E-12	5.46805E-13
chromium(VI) = 1/7[chromium]	1.57E+00	1.57E+00	3.71638E-13	1.23879E-13	4.2E+01	1.56088E-11	5.20294E-12
Sum Cancer Risk =						9.53972E-11	3.17991E-11

RP20

EXPOSURE — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (off site, future = +10 y)

RESIDENTIAL

Inhalation of Soil Dust

7 to 30 year old "adult"

NONCANCER (nc)	Cis,max mg/kg	Cis,t=10y,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EFud d/y	EDud y	EDm y	BM kg	ATnc,ud d	ATnc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	2.40E+01	4.80E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	2.84055E-12	2.84055E-12
ethylbenzene	6.50E+01	1.30E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	7.69315E-12	7.69315E-12
fluorene	5.10E+01	5.10E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	3.01808E-11	3.01808E-11
naphthalene	7.90E+01	7.90E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	4.67507E-11	4.67507E-11
1-methylnaphthalene	1.60E+02	1.60E+02	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	9.46849E-11	9.46849E-11
2-methylnaphthalene	2.30E+00	2.30E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.36110E-12	1.36110E-12
phenanthrene														
phenol														
2,4-dimethylphenol														
pyrene	1.70E+00	1.70E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.00603E-12	1.00603E-12
toluene	1.00E+01	2.00E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.18356E-12	1.18356E-12
xylene (sum: o-, m-, p-)	1.20E+02	2.40E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.42027E-11	1.42027E-11
Inorganic														
arsenic	2.20E+01	2.20E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.30192E-11	1.30192E-11
barium	2.04E+02	2.04E+02	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	1.20723E-10	1.20723E-10
cadmium	1.10E+00	1.10E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	6.50959E-13	6.50959E-13
chromium(III) = 67[chromium]	9.43E+00	9.43E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	5.58049E-12	5.58049E-12
chromium(VI) = 17[chromium]	1.57E+00	1.57E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	9.29098E-13	9.29098E-13
lead**	7.40E+01	7.40E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555	2.42630E-13	2.42630E-13
mercury	4.10E-01	4.10E-01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	8,760	2,555		
selenium	ND	ND												
silver	ND	ND												

CANCER (c)	Cis,max mg/kg	Cis,t=10y,max mg/kg	IRa m ³ /d	Fla	ABSF	PEF kg/m ³	EFud d/y	EDud y	EDm y	BM kg	ATc,ud d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic														
benzene	2.40E+01	4.80E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	9.73902E-13	2.84055E-13
Inorganic														
arsenic	2.20E+01	2.20E+01	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	4.46372E-12	1.30192E-12
cadmium	1.10E+00	1.10E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	2.23186E-13	6.50959E-14
chromium(VI) = 17[chromium]	1.57E+00	1.57E+00	2.0E+01	0.01	1	2.2E-10	350	24	7	70	25,550	25,550	3.18547E-13	9.29098E-14

RP21

TIME REQUIRED FOR MASS OF SPECIFIC LNAPL CONTAMINANT TO REACH ZERO* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (off site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

NONCANCER (ng)	C _{i,t=0} mg/kg	A _i LNAPL cm ²	h _i LNAPL cm	V _i LNAPL cm ³	d _i LNAPL g/cm ³	M _{i,t=0} g	Q _{i,t=0} g/s	t _i M _i =0 s	CF s/y	t _i M _i =0 y
Organic										
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	6.757E-05	1.530E+08	3.156E+07	4.847E+00
ethylbenzene	2.10E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	8.612E-06	4.033E+09	3.156E+07	1.278E+02
fluorene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	2.258E-08	3.626E+12	3.156E+07	1.149E+05
naphthalene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.324E-06	2.463E+10	3.156E+07	7.805E+02
1-methylnaphthalene**	2.00E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	2.590E-07	1.277E+12	3.156E+07	4.047E+04
2-methylnaphthalene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.282E-07	6.385E+11	3.156E+07	2.023E+04
phenanthrene	1.30E+03	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.105E-11	1.945E+16	3.156E+07	6.163E+08
phenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	5.180E-07	1.580E+11	3.156E+07	5.008E+03
2,4-dimethylphenol**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	3.885E-08	2.107E+12	3.156E+07	6.677E+04
pyrene**	4.95E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	7.770E-12	1.054E+16	3.156E+07	3.338E+08
toluene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.792E-05	5.768E+08	3.156E+07	1.828E+01
xylene (mean: o-, m-, p-)	5.40E+02	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	1.958E-05	4.561E+09	3.156E+07	1.445E+02
Inorganic										
none										

CANCER (g)	C _{i,t=0} mg/kg	A _i LNAPL cm ²	h _i LNAPL cm	V _i LNAPL cm ³	d _i LNAPL g/cm ³	M _{i,t=0} g	Q _{i,t=0} g/s	t _i M _i =0 s	CF s/y	t _i M _i =0 y
Organic										
benzene**	6.25E+01	2.63E+06	6.98E+01	1.84E+08	9.00E-01	1.65E+08	6.757E-05	1.530E+08	3.156E+07	4.847E+00
Inorganic										
none										

*Assumption: loss of LNAPL is by volatilization only. A more accurate estimate would require updating C_i max and Q_i (Q_{i,t=0} becoming Q_{i,t=t}) over shorter time intervals, e.g., 1-month. Thus, the calculated t_iM_i=0 for benzene is probably somewhat too small (the loss of benzene decreases its mole fraction-vapor pressure and therefore, its emission rate); however, the loss of benzene increases the loss rate for the other constituents. Assumption: density of LNAPL = 0.9 g/cm³. Q_i is calculated using the RP3 equations. Area = 1/15 of an acre (assumed) and height (h) of LNAPL = 2.29 ft (June 1995) = 2.29(12)(2.54) = 69.7992 cm.

**These substances were not detected. Thus, C_i for these substances was set to half the detection limit.

RP21

SOIL GAS EMISSION RATE (Qi) AT ON SITE GROUND SURFACE FROM LNAPL CONTAMINANT* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (off site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

NONCANCER (nc)	t, Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL (t = 10 y)	MMi mmHg	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
Organic															
benzene	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	62,361	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
ethylbenzene	1.28E+02	2.10E+02	1.94E+02	9.5E+00	2.74E-04	2.6E-03	62,361	293	1.510E-08	6.6E-02	2.632E+06	1	0.25	100	4.13069E-06
fluorene	1.15E+05	4.95E+02	4.95E+02	5.5E-03	4.47E-04	2.5E-06	62,361	293	2.235E-11	6.3E-02	2.632E+06	1	0.25	100	5.87414E-09
naphthalene	7.80E+02	4.95E+02	4.89E+02	8.7E-01	5.73E-04	5.0E-04	62,361	293	3.490E-09	5.9E-02	2.632E+06	1	0.25	100	8.53691E-07
1-methylnaphthalene**	4.05E+04	2.00E+03	2.00E+03	4.5E-02	2.11E-03	9.5E-05	62,361	293	7.387E-10	4.4E-02	2.632E+06	1	0.25	100	1.34745E-07
2-methylnaphthalene**	2.02E+04	4.95E+02	4.95E+02	4.5E-02	5.23E-04	2.4E-05	62,361	293	1.828E-10	4.4E-02	2.632E+06	1	0.25	100	3.33411E-08
phenanthrene	6.16E+08	1.30E+03	1.30E+03	2.5E-06	1.10E-03	2.7E-09	62,361	293	2.668E-14	5.2E-02	2.632E+06	1	0.25	100	5.75190E-12
phenol**	5.01E+03	4.95E+02	4.94E+02	1.0E-01	7.88E-04	7.9E-05	62,361	293	4.056E-10	8.0E-02	2.632E+06	1	0.25	100	1.34509E-07
2,4-dimethylphenol**	6.68E+04	4.95E+02	4.95E+02	1.0E-02	6.09E-04	6.1E-06	62,361	293	4.063E-11	6.0E-02	2.632E+06	1	0.25	100	1.01069E-08
pyrene	3.34E+08	4.95E+02	4.95E+02	2.5E-06	3.68E-04	9.2E-10	62,361	293	1.016E-14	4.8E-02	2.632E+06	1	0.25	100	2.02167E-12
toluene	1.83E+01	6.25E+01	2.83E+01	2.8E+01	4.62E-05	1.3E-03	62,361	293	6.530E-09	7.8E-02	2.632E+06	1	0.25	100	2.11154E-06
xylene (sum: o-, m-, p-)	1.45E+02	5.40E+02	5.03E+02	7.7E+00	7.11E-04	5.5E-03	62,361	293	3.177E-08	7.2E-02	2.632E+06	1	0.25	100	9.48421E-06
Inorganic															
none															

CANCER (c)	t, Mi=0 y	Ci,t=0 mg/kg	Ci,t=10y mg/kg	pi mmHg	nfi, LNAPL (t = 10 y)	MMi mmHg	R mmHg(cm ³)/(mol)K	T K	Cisg g/cm ³	Di cm ² /s	A cm ²	nfi	P	di cm	Qi g/s
benzene	4.85E+00	6.25E+01	0.00E+00	9.5E+01	0.00E+00	0.0E+00	62,361	293	0.000E+00	8.7E-02	2.632E+06	1	0.25	100	0.00000E+00
Inorganic															
none															

*These substances were not detected. Thus, Ci for these substances was set to half the detection limit. Ci is used to calculate the partial pressure (ppi) of each COC in the LNAPL phase. (Ci,t=10y) = (Ci,t=0)(1 - [10(t,Mi=0)]). Benzene concentration estimated to reach zero in 10 years ((Ci,t=10y) = 0).

Area = 1/15 of an acre (1 acre = 4,046.873 m²) assumed aerial extent of LNAPL.

**Some values of pi and Di are estimated.

Assumption: Qi is constant, i.e., contaminant source is not depleted over time. Molecular mass (MM) of LNAPL is assumed = 150.

RP21

AIRBORNE CONCENTRATION (Ciad) OF SOIL GAS AT ON SITE RECEPTOR — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (off site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

NONCANCER (nc)	Qi mg/kg	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
ethylbenzene	4.13069E-06	4.2	1	1	3.13057E-07
fluorene	5.87414E-09	4.2	1	1	4.45189E-10
naphthalene	8.53691E-07	4.2	1	1	6.46996E-08
1-methylnaphthalene	1.34745E-07	4.2	1	1	1.02121E-08
2-methylnaphthalene	3.33411E-08	4.2	1	1	2.52686E-09
phenanthrene	5.75190E-12	4.2	1	1	4.35925E-13
phenol	1.34509E-07	4.2	1	1	1.01942E-08
2,4-dimethylphenol	1.01069E-08	4.2	1	1	7.65979E-10
pyrene	2.02167E-12	4.2	1	1	1.53219E-13
toluene	2.11154E-06	4.2	1	1	1.60029E-07
xylene (sum: o-, m-, p-)	9.48421E-06	4.2	1	1	7.18790E-07
Inorganic					
none					

CANCER (c)	Qi,ud g/s	<v>,m* m/s	sigma-x m	sigma-z m	Ciad g/m ³
Organic					
benzene	0.00000E+00	4.2	1	1	0.00000E+00
Inorganic					
none					

*Mean wind speed (<v>,m) over El Paso = 4.2 m/s (API 1994).

RP21

EXPOSURE* — Brickland Refinery, Sunland Park, New Mexico

FUTURE / CONDITIONS (off site, future = +10 y)

INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant

adult

NONCANCER (nc)	Clad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EF d/y	EDm y	EDucl y	BM kg	ATnc,ucf d	ATnc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic													
benzene	0.00000E+00	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	0.00000E+00	0.00000E+00
ethylbenzene	3.13057E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	6.12636E-06	6.12636E-06
fluorene	4.45189E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	8.71212E-09	8.71212E-09
naphthalene	6.46996E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.26614E-06	1.26614E-06
1-methylnaphthalene	1.02121E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.99845E-07	1.99845E-07
2-methylnaphthalene	2.52686E-09	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	4.94493E-08	4.94493E-08
phenanthrene	4.35925E-13	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	8.53083E-12	8.53083E-12
phenol	1.01942E-08	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.99495E-07	1.99495E-07
2,4-dimethylphenol	7.65979E-10	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.49898E-08	1.49898E-08
pyrene	1.53219E-13	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	2.99841E-12	2.99841E-12
toluene	1.60029E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	3.13169E-06	3.13169E-06
xylene (sum: o-, m-, p-)	7.18790E-07	2.0E+01	0.1	1	1,000	250	25	9	70	9,125	3,285	1.40663E-05	1.40663E-05
Inorganic													
none													

CANCER (c)	Clad g/m ³	IRa m ³ /d	Fla	ABSF	CF	EF d/y	EDm y	EDucl y	BM kg	ATc,ucf d	ATc,m d	Intake Rate, ucl mg/[(kg body mass)d]	Intake Rate, mean mg/[(kg body mass)d]
Organic													
benzene	0.00000E+00	2.0E+01	0.1	1	1,000	250	25	9	70	25,550	25,550	0.00000E+00	0.00000E+00
Inorganic													
none													

*Assumption: Resident 10 to 100 m from site and 10X dispersion (Fla = 0.1).

RP21

RISK — Brickland Refinery, New Mexico

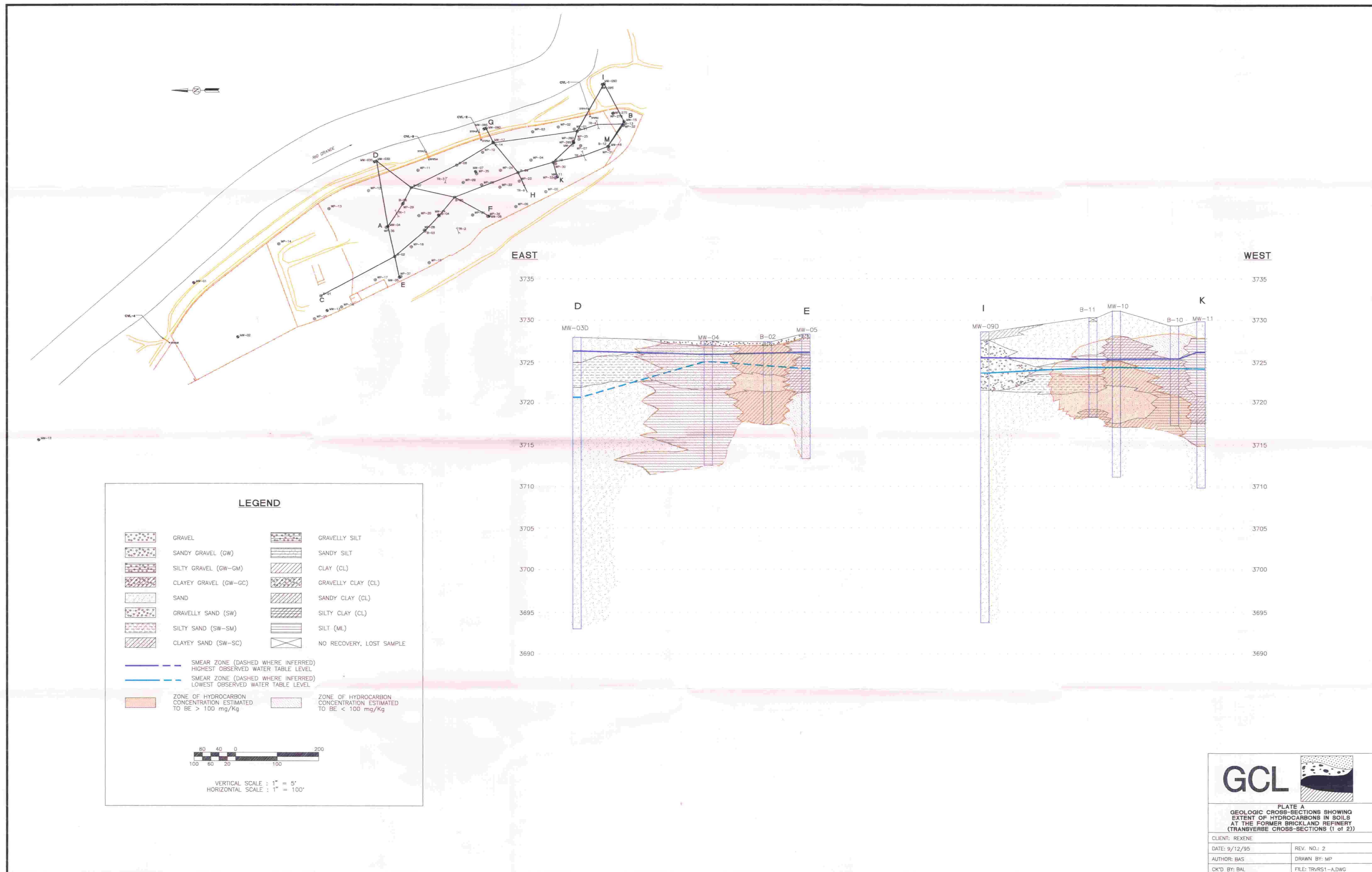
FUTURE / CONDITIONS (off site, future = +10 y)

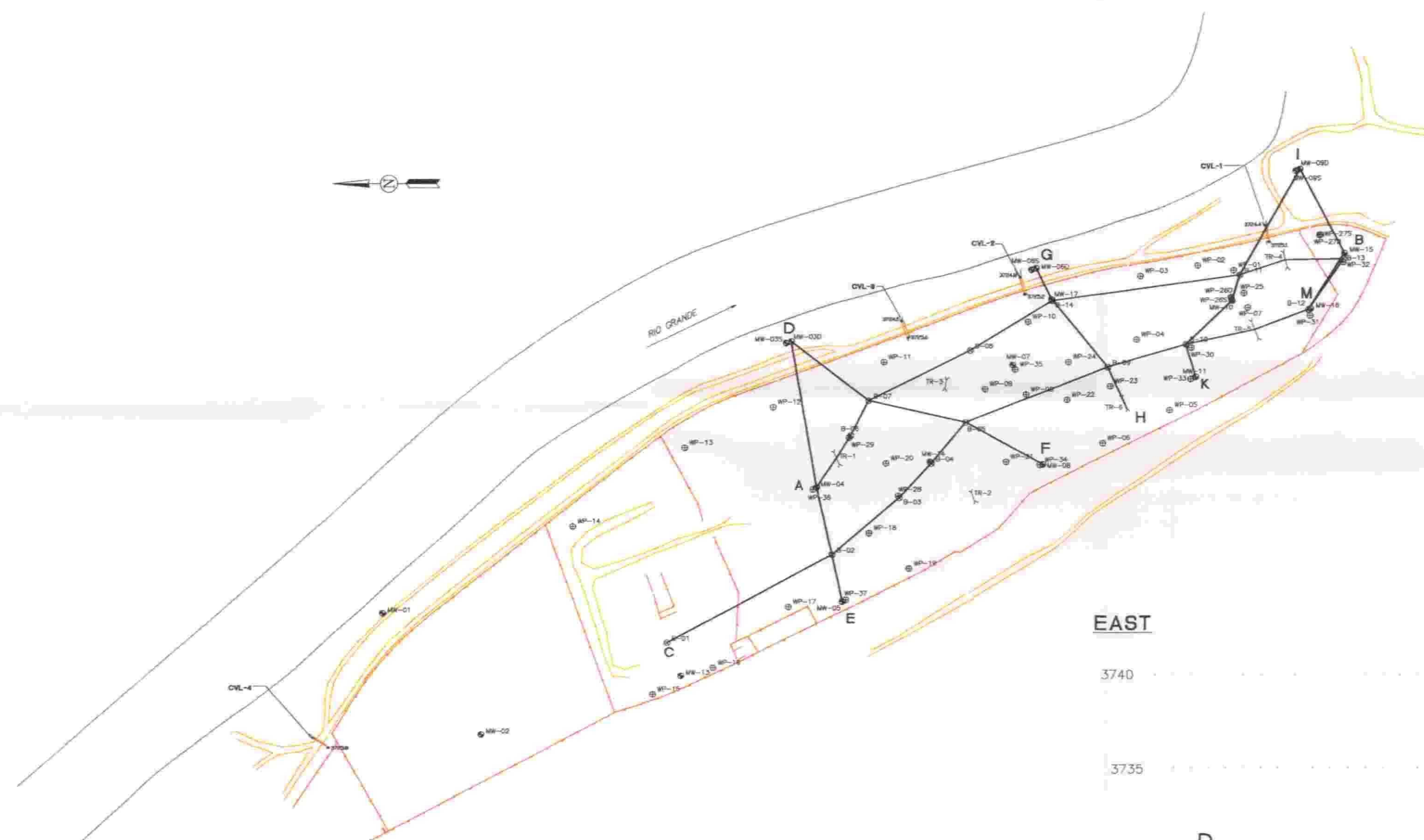
INDUSTRIAL

Inhalation of Volatile Organics from LNAPL Contaminant
adult

NONCANCER (nc)	C _i (=0) mg/kg	C _i (=10y) mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Reference Dose, RfD mg/(kg body mass)/d	Hazard Quotient (HQ), ucl	Hazard Quotient (HQ), mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	1.0E-03	0.00000E+00	0.00000E+00
ethylbenzene	2.10E+02	1.94E+02	6.12636E-06	6.12636E-06	2.9E-01	2.11254E-05	2.11254E-05
fluorene	4.95E+02	4.95E+02	8.71212E-09	8.71212E-09	4.0E-02	2.17803E-07	2.17803E-07
naphthalene	4.95E+02	4.89E+02	1.26614E-06	1.26614E-06	4.0E-02	3.16534E-05	3.16534E-05
1-methylnaphthalene	2.00E+03	2.00E+03	1.99845E-07	1.99845E-07	4.0E-02	4.99612E-06	4.99612E-06
2-methylnaphthalene	4.95E+02	4.95E+02	4.94493E-08	4.94493E-08	4.0E-02	1.23623E-06	1.23623E-06
phenanthrene	1.30E+03	1.30E+03	8.53083E-12	8.53083E-12	3.0E-02	2.84361E-10	2.84361E-10
phenol	4.95E+02	4.94E+02	1.99495E-07	1.99495E-07	6.0E-01	3.32491E-07	3.32491E-07
2,4-dimethylphenol	4.95E+02	4.95E+02	1.49898E-08	1.49898E-08	2.0E-02	7.49490E-07	7.49490E-07
pyrene	4.95E+02	4.95E+02	2.99841E-12	2.99841E-12	3.0E-02	9.99470E-11	9.99470E-11
toluene	6.25E+01	2.83E+01	3.13169E-06	3.13169E-06	1.0E-01	3.13169E-05	3.13169E-05
xylene (sum: o-, m-, p-)	5.40E+02	5.03E+02	1.40663E-05	1.40663E-05	2.0E-01	7.03317E-05	7.03317E-05
Inorganic							
none							
Hazard Index (HI) =					1.61960E-04	1.61960E-04	1.61960E-04
HI (adult) =					1.61960E-04	1.61960E-04	1.61960E-04

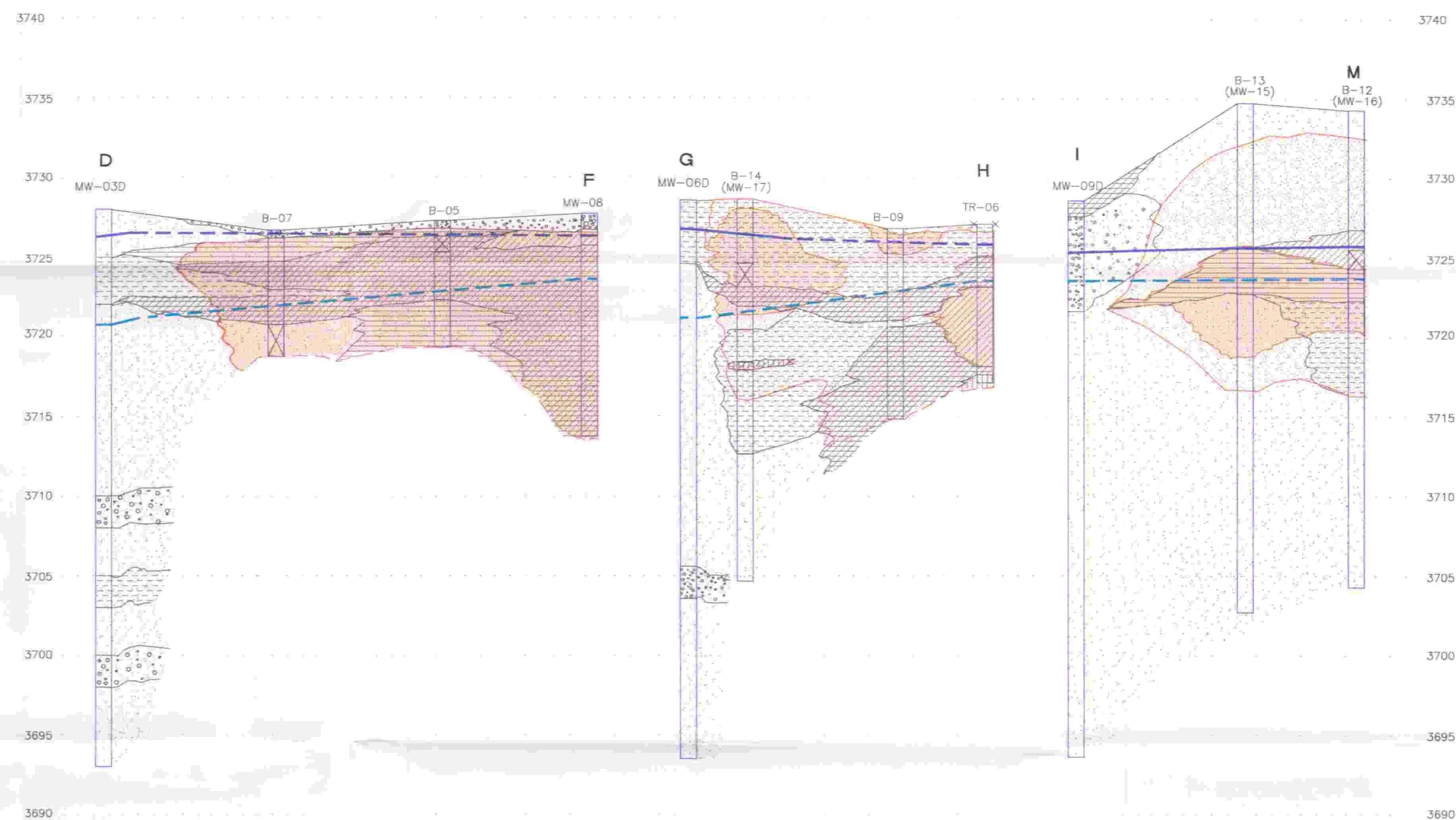
CANCER (c)	C _i (=0) mg/kg	C _i (=10y) mg/kg	Intake Rate, ucl mg/(kg body mass)/d	Intake Rate, mean mg/(kg body mass)/d	Cancer Slope Factor 1/(mg/(kg body mass)/d)	Cancer Risk ucl	Cancer Risk mean
Organic							
benzene	6.25E+01	0.00E+00	0.00000E+00	0.00000E+00	2.9E-02	0.00000E+00	0.00000E+00
Inorganic							
none							
Sum Cancer Risk =					0.00000E+00	0.00000E+00	0.00000E+00
Cancer Risk (adult) =					0.00000E+00	0.00000E+00	0.00000E+00





EAST

WEST



LEGEND

	GRAVEL		GRAVELLY SILT
	SANDY GRAVEL (GW)		SANDY SILT
	SILTY GRAVEL (GW-GM)		CLAY (CL)
	CLAYEY GRAVEL (GW-GC)		GRAVELLY CLAY (CL)
	SAND		SANDY CLAY (CL)
	GRAVELLY SAND (SW)		SILTY CLAY (CL)
	SILTY SAND (SW-SM)		SILT (ML)
	CLAYEY SAND (SW-SC)		NO RECOVERY, LOST SAMPLE

--- SMEAR ZONE (DASHED WHERE INFERRED)
 --- HIGHEST OBSERVED WATER TABLE LEVEL
 --- SMEAR ZONE (DASHED WHERE INFERRED)
 --- LOWEST OBSERVED WATER TABLE LEVEL

ZONE OF HYDROCARBON CONCENTRATION ESTIMATED TO BE > 100 mg/Kg
 ZONE OF HYDROCARBON CONCENTRATION ESTIMATED TO BE < 100 mg/Kg



VERTICAL SCALE : 1" = 5'
 HORIZONTAL SCALE : 1" = 100'



PLATE B
 GEOLOGIC CROSS-SECTIONS SHOWING
 EXTENT OF HYDROCARBONS IN SOILS
 AT THE FORMER BRICKLAND REFINERY
 (TRANSVERSE CROSS-SECTIONS (2 of 2))

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