Draft

JD-1900 D3048

REMEDIAL INVESTIGATION REPORT FOR THE 3163 BUFFALO AVENUE SITE NIAGARA FALLS, NEW YORK

Volume II: Appendices A, B, C, D, E, and F

November 1990

Prepared for:

NEW YORK STATE DEPARTMENT
OF ENVIRONMENTAL CONSERVATION
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Albany, New York 12233

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International Specialists in the Environment

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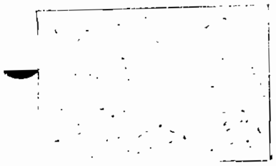
APPENDIX A

WELL LOGS

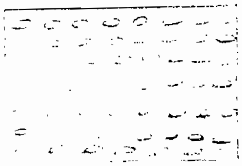
SUBSURFACE LOG EXPLANATION

Draft

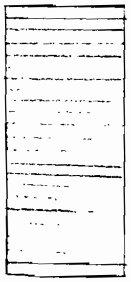


COARSE SILICA SAND PACK

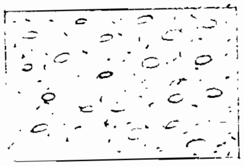
2" to 4" INTERNAL DIAMETER 304 STAINLESS STEEL CASING



LINEAR, PELLETIZED BENTONITE SEAL



STAINLESS STEEL WELL SCREEN: A ZONE AND B WELLS: 0.010 SLOT SIZE



5% BENTONITE GROUT

C, C-D, AND F ZONE WELLS HAVE A 6" BLACK IRON STEEL CASING WHICH EXTENDS TO 11.0' BELOW GROUND SURFACE

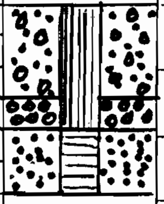
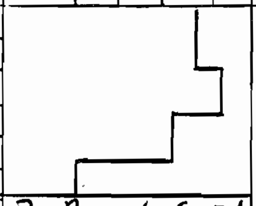
Draft

DATE
STARTED 11-3-89
FINISHED 11-3-89
SHEET 1 OF 1

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC1
SURFACE ELEVATION 569.56
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical JD 1030
LOCATION 3163 Buffalo Ave Niagara Falls, N.Y.

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
5 10	 2in. S.S w/ S.S Screen slot size 0.010in				 B.R. at 6.0'	0.0'-1.5' - Fill, large pebble to cobble, angular dolomite roadbed, in a matrix of dark brown to black, coarse sand to silt cinder rich, Minor roots and organics, minor assorted brick and cement Fragments and industrial debris 1.5'-2.0' - Fill, as above, decreasing matrix component 2.0'-3.4' - Fill, light brown to black, structureless, grain size pebble to clay saturated with volatile organics 5.0'-6.0' - Clay, tight, stiff, varegated dark gray to black, similar to Pleistocene lake bottom sediments	Samplin done wit Laskey Sampler 5 ft x 3in SAMPLERUN 0'-5.0' recovery 3.4' = 68% SAMLERUN 5.0'-6.0' Recovery 1.0' = 100%

640088

CLASSIFICATION/BY John Doerr

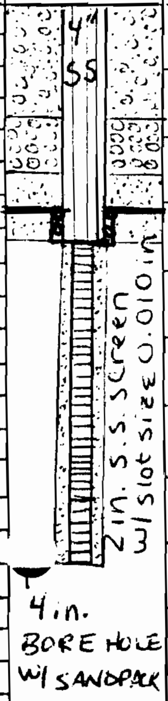
DATE
STARTED 11-7-89
FINISHED 11-13-89
SHEET 1 OF 2

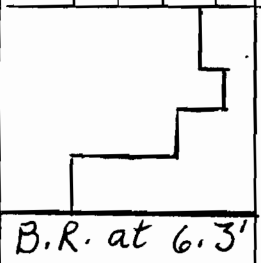
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

Draft
HOLE NUMBER SC1E
SURFACE ELEVATION 569.46
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical JD 1030
LOCATION 3163 Buffalo Ave Niagara Falls, N.Y.

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES





0.0'-1.5' - Fill, large pebble to cobble, angular dolomite roadbed, in a matrix of dark brown to black, coarse sand to silt cinder rich, Minor roots and organics, minor assorted brick and cement Fragments and industrial debris

1.5'-2.0' - Fill, as above, decreasing matrix component

2.0'-3.4' - Fill, light brown to black, structureless, grain size pebble to clay saturated with volatile organics

5.0'-6.3' - Clay, tight, stiff, var egated dark gray to black, similar to Pleistocene lake bottom sediments

6.3 - 17.15 - Dolomite, - B Aquifer, overall, Fine grained, micritic, medium gray to dark gray, minor cavities with calcite sphalerite fillings, dark gray when fresh

6.3'-9.3' - weathered zone, highly Fractured, shattered, composed of angular cobble to pebble size fragments, minor

Sampling done with Laskey Sampler 5 ft x 3in
SAMPLE RUN 1 0'-5.0' recovery 3.4' = 68%

SAMPLE RUN 2 5.0'-6.0' Recovery 1.3' = 100%

088

CLASSIFICATION/BY John Doerr

Draft

DATE STARTED 11-7-89 FINISHED 11-13-89 SHEET 2 OF 2	E + E DRILLING AND TESTING CO., INC. SUBSURFACE LOG	HOLE NUMBER SC1B SURFACE ELEVATION 569.46 GROUNDWATER DEPTH ( )

PROJECT Solvent Chemical
ND 1030

LOCATION 3163 Buffalo Ave
Niagara Falls N.Y.

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6, 6/12, 12/18, 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
						cavities ~1mm in size 9.3'-11.3' - Competent, Fresh Horizontal bedding plane fractures 11.3-13.1 Fracture zone, 60° dipping fractures, showing weathering along fractures, shattered by coring 13.1-17.15. Very competent otherwise as before open fractures noted at 9.8', 10.0', 15.4', 15.6', 15.7', 16.3', and 1	

640088

CLASSIFICATION/BY John Doerr

Draft

DATE
STARTED 11-13-89
FINISHED 11-14-89
SHEET 1 OF 1

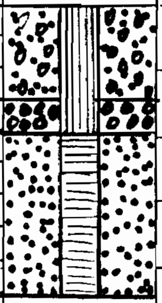
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

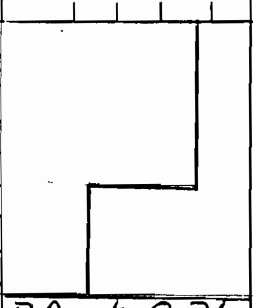
HOLE NUMBER SC2
SURFACE ELEVATION 569.5
GROUNDWATER DEPTH ( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls N.Y.

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
5 10	2 in. S.S. w/ S.S. screen slot size 0.010 in.				BR at 8.2'	0.0'-1.9'- Fill, angular pebble to cobble dolomite roadbed with ~ 50% dark brown to black matrix composed of coarse sand to silt size cinder. Minor organics, roots grass. Minor assorted industrial debris. Very soft slight oily sheen. 5.0'-6.6' - Sandy Clay, - possible Fill, moderate rounded pebbles, saturated 6.6'-8.0' Clay, red, plastic structureless, saturated 8.0'-8.2' Sandy Clay, Saturated, massive, gray	SAMPLE RU 0.0'-5.0' Recovery 1.9' = 38% SAMPLE RUN 5.0'-10.0' Recovery 3.2' = 64%





640088

CLASSIFICATION/BY John Doerr

DATE
STARTED 11-15-89
FINISHED 11-16-89
SHEET 1 OF

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

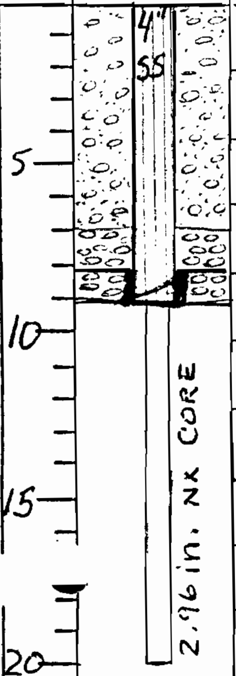
Draft
HOLE NUMBER C 2
SURFACE ELEVATION 569.3
GROUNDWATER DEPTH

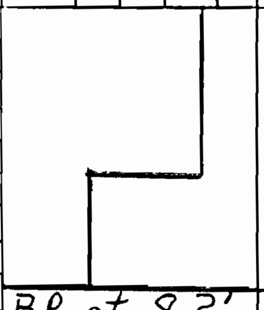
PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls N.Y.

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6, 6/12, 12/18, 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES

INFORMATION PERTAINING TO 0-8.2' FROM SC-2A




BR at 8.2'

0.0'-1.9'-Fill, angular pebble to cobble dolomite roadbed with ~ 50% dark brown to black matrix composed of coarse sand to silt size cinder. Minor organics, roots grass. Minor assorted industrial debris. Very soft slight oily sheen.

5.0'-6.6'-Sandy Clay, -possible Fill, moderate rounded pebbles, saturated

6.6'-8.0' Clay, red, plastic structureless, saturated

8.0'-8.2' Sandy Clay, Saturated, massive, gray

8.2-20.0- Lockport dolomite, B Zone, medium gray to dark gray, dark gray when fresh micritic, fine grained, minor small vugs

8.2'-10.2' Weathered Zone, highly fractured, numerous cobble sized fragments

10.2'-12.2'- Competent, massive occasional steeply dipping ~75°, Fine, Fractures

12.2'-13.4'- Finely bedded, open weathered bedding plane fractures

13.4'-15.0'- Competant, massive,

NOTES

SAMPLE RUN 0'-5.0'
Recover
1.9'=38

SAMPLE RUN 5.0'-10.0
Recover
3.2'=64%

SAMPLE RUN 10.0'-15.0
Recovery
10.0'=100

Core Run 1
9.8'-15.0'

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CLASSIFICATION/BY John Doerr

Draft

DATE
STARTED 11-15-89
FINISHED 11-16-89
SHEET 2 OF 2

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-21
SURFACE ELEVATION 569.39
GROUNDWATER DEPTH ________ (   )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
									15.0'-15.5' - Open bedding plane fractures, weathered vuggy 15.5'-16.8' - Highly Fractured, weathered zone. 16.8'-20.0' - competent, massive, minor bedding plane fractures	CORERUN2 15.0'-20.0

CLASSIFICATION/BY John Doerr

Draft

DATE
STARTED 11-22-89
FINISHED 11-22-89
SHEET 1 OF 1

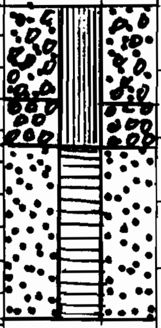
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC3
SURFACE ELEVATION 570.35
GROUNDWATER DEPTH ______ ( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls NY

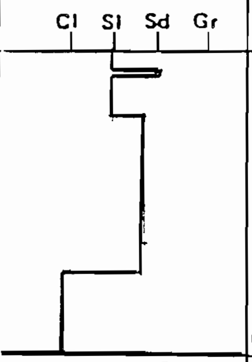
WELL DIAGRAM



2 in. S.S. w/ S.S. screen slot size 0.010 in

SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24
SS	1	13	25	12	16
SS	2	6	8	6	4
SS	3	4	5	6	8
SS	4	5	7	6	20
SS	5	11	18	14	40

PROFILE



B.R at 9.6'

FIELD IDENTIFICATION OF SOILS

0.0'-0.7 Silty Loam, dark brown to black, some organic debris, minor Fill
0.7'-0.8' Sand, tan, clean, minor Sandstone fragments
0.8'-1.2' Fill, brick debris in a matrix of silt and sand
2.0-3.4 - Fill, brick fragments mixed with silt and sand, moist to saturated
4.0'-5.0 - Silt and sand moist
5.0-6.0' Silty Clay - tan saturated
6.0-7.8' Silty Sand grading downward to tan to red highly plastic Clay, saturated
8.0-8.5' Clay, red, moist

NOTES

Samplin via Split spoon
SAMPLE RUN 1 0.0'-2.0' RECOVERY = 1.2' = 60
SAMPLE RUN 2.0'-4.0' Recovery 1.4' = 70%
SAMPLE RUN 4.0'-6.0' Recovery 2.0' = 100%
SAMPLE RUN 6.0'-8.0' Recovery 1.8' = 90%
SAMPLE RUN 8.0'-10.0' Recovery 0.5' = 25%

640088

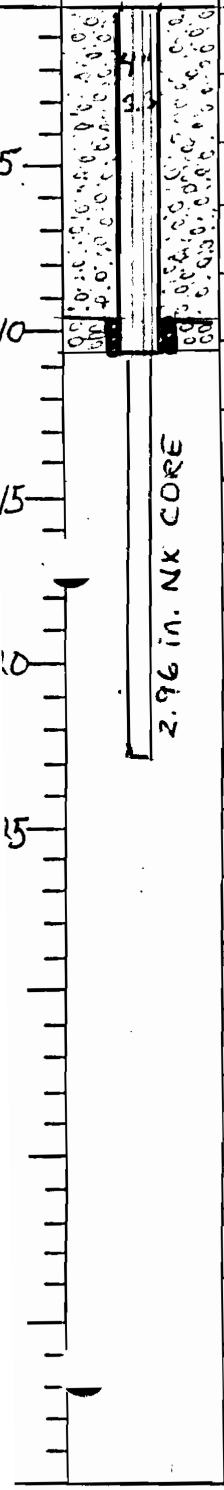
CLASSIFICATION/BY R. Meyers

DATE
STARTED 11-27-89
FINISHED 11-28-89
SHEET 1 OF 2

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

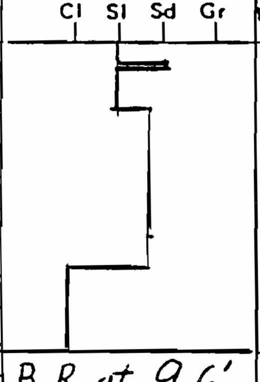
Draft
HOLE NUMBER SC3I
SURFACE ELEVATION 570.41
GROUNDWATER DEPTH 13.3

PROJECT Solvent Chemical JD 1030
LOCATION 3163 Buffalo Ave Niagara Falls NY



SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12
		12/18	18/24
SS	1	13	25
		12	16
	2	6	8
		6	4
	3	4	5
		6	8
	4	5	7
		6	20
	5	11	18
		14	40

PROFILE



B.R at 9.6'

FIELD IDENTIFICATION OF SOILS

INFORMATION PERTAINING TO 0-8.5' FROM SC-3A

0.0'-0.7 Silty Loam, dark brown to black, some organic debris, minor Fill

0.7'-0.8' Sand, tan, clean, minor Sandstone fragments

0.8'-1.2' Fill, brick debris in a matrix of silt and Sand

2.0-3.4- Fill, brick fragments mixed with silt and sand, moist to saturated

4.0'-5.0- Silt and sand moist

5.0-6.0' Silty Clay - tan saturated

6.0-7.8' Silty Sand grading downward to tan to red highly plastic Clay, saturated

8.0-8.5' Clay, red, moist

8.5-13.5' interbedded weathered dolomite and red clay

9.6'-20.0' Lockport dolomite B zone, medium gray to dark gray, micritic, fine grained, minor small vugs

13.0'-13.3'- High angle ~70° fracture with secondary mineralization

NOTES

Sampling via Split spoon

SAMPLE RUN 0.0'-2.0'
RECOVERY = 1.2' = 60%

SAMPLE RUN 2.0'-4.0'
Recovery 1.4' = 70%

SAMPLE RUN 4.0'-6.0'
Recovery 2.0' = 100%

SAMPLE RUN 6.0'-8.0'
Recovery 1.8' = 90%

SAMPLE RUN 8.0'-10.0'
Recovery 0.5' = 25%

CORE RUN 1: 11.2-16.2
Recovery 4.65' = 93%

10088

CLASSIFICATION/BY R. Watt

Draft

DATE
STARTED 11-27-89
FINISHED 11-28-89
SHEET 2 OF 2

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-3E
SURFACE ELEVATION 570.41
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12	BLOWS ON SAMPLER 12/18	BLOWS ON SAMPLER 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
									15.5'-18.0'- Heavily Fractured zone, horizontal, to sub-horizontal, some along stylolites 15.5'-15.9' Vuggy zone with secondary mineralization (calcite) 18.0'-19.4'- Competent, massive 19.4'-20.0' Heavily fractured No pieces >1" 20.0'-21.0'- Competent, massive 21.0'-21.2'- Bedding plane fracture, open, weathered	CORE RUN 2 16.2 -21.2' Recovery 4.3'=90%

640088

CLASSIFICATION/BY R. Watt

Draft

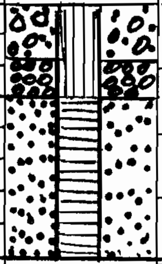
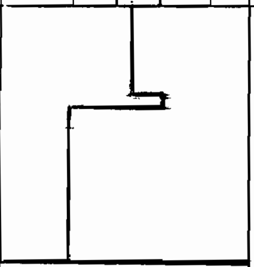
DATE
STARTED 12-1-89
FINISHED 12-1-89
SHEET 1 OF 1

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-4
SURFACE ELEVATION 568.6
GROUNDWATER DEPTH ______

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls N.Y.

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6, 6/12, 12/18, 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
5 10	 2in. s.s. w/ s.s. screen slot size 0.010 in.				 BR at 8.0'	0.0'-1.0' Fill, cobble to pebble size angular dolomite roadbed in a matrix of black silt and sand - moist 3.0'-3.5' - Fill, as above, with increasing gray clay component - saturated 3.5'-4.0' Clay, gray interbedded with sand, silt and gravel, grading into saturated highly plastic red clay	Sampling via Laskey Sampler SAMPLE RUN 1: 0'-3.0' RECOVERY: 33% SAMPLE RUN 2: 3.0'-8.0' RECOVERY = 20%

640088

CLASSIFICATION/BY K. Meyers

DATE
STARTED 11-30-89
FINISHED 12-1-89
SHEET 1 OF 1

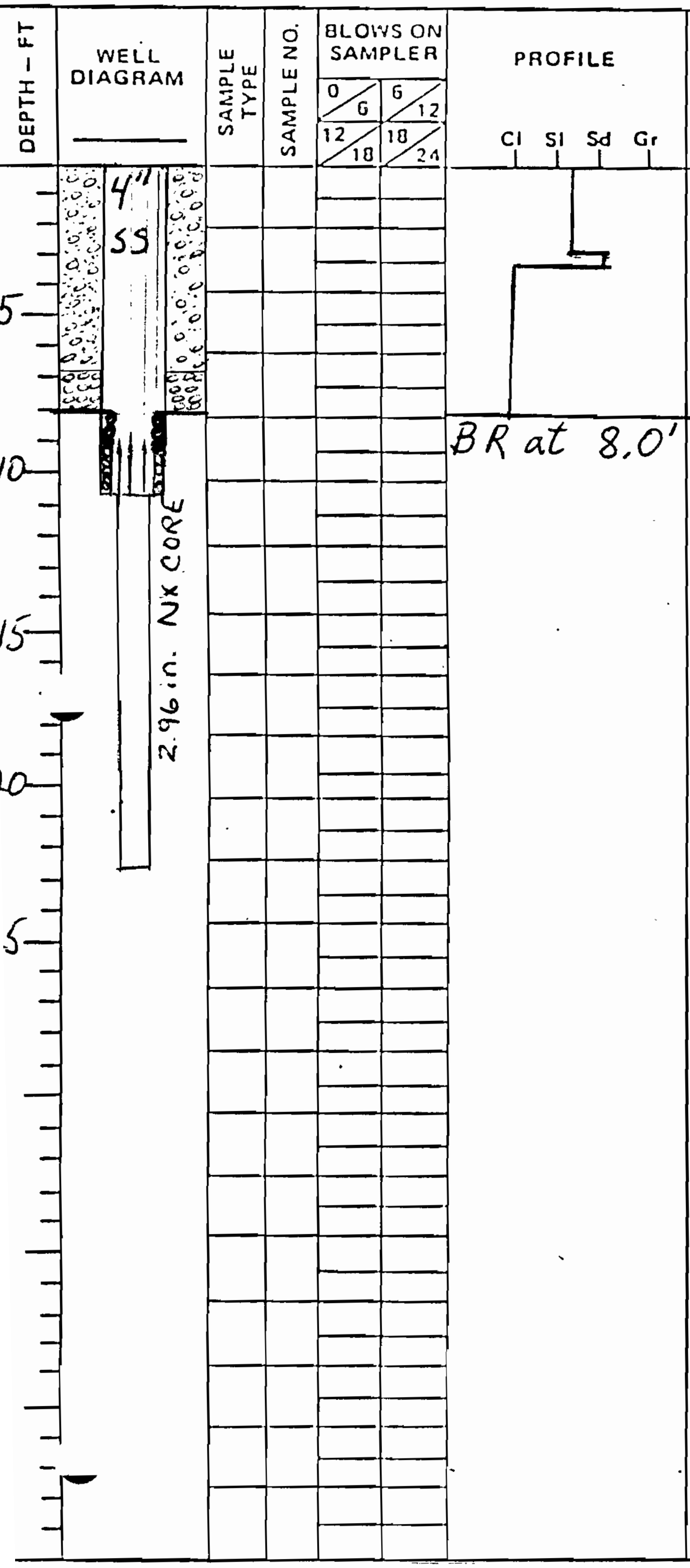
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

Draft

HOLE NUMBER SC-4E
SURFACE ELEVATION 568.78
GROUNDWATER DEPTH

PROJECT Solvent Chemical JD 1030

LOCATION 3163 Buffalo Ave Niagara Falls N.Y.



FIELD IDENTIFICATION OF SOILS

INFORMATION PERTAINING TO 0-4.0' FROM SC-4A.

0.0'-1.0' Fill, cobble to pebble size angular dolomite roadbed in a matrix of black silt and sand - moist

3.0'-3.5' - Fill, as above, with increasing gray clay component - saturated

3.5'-4.0' Clay, gray interbedded with sand, silt and gravel, grading into saturated highly plastic red clay

8.0'-22.5' Lockport dolomite medium gray to dark gray, dark gray when fresh, micritic, fine grained, minor vugs.

8.0'-11.0 - Weathered zone dolomite rubble

11.0'-11.6' - Competent, massive

11.6'-16.7' Core loss

16.7-17.2 - Competent, massive

17.2-17.7 - many horizontal (bedding plane) fractures

17.7'-22.5' - Competent, massive, minor vugs with secondary mineralization (calcite)

NOTES

Sampling via Laske Sampler'

SAMPLE RU 1: 0'-3.0' RECOVERY= 3.0' = 33%

SAMPLE RUN 2: 3.0'-8.0' RECOVERY= 20%

CORE RUN 1: 11.0'-22.5' Recover 9.0' = 90%

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CLASSIFICATION/BY R Meyers

Draft

DATE
STARTED 11-20-89
FINISHED 11-20-89
SHEET ____ OF ____

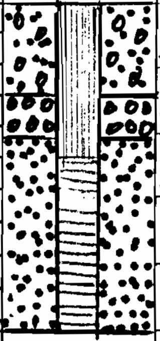
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5
SURFACE ELEVATION 570.5
GROUNDWATER DEPTH ________ ( )

PROJECT Solvent Chemical JD 1030

LOCATION 3163 Buffalo Ave Niagara Falls, N.Y.

WELL DIAGRAM



2in. s.s. w/ s.s. screen slot size 0.010 in.

DEPTH – FT	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24
	SS	1	7	10	5	10
	SS	2	8	7	6	9
5	SS	3	5	6	7	6
	SS	4	5	6	6	11
10	SS	5	7	7	9	18

PROFILE

BR at 12.5'

FIELD IDENTIFICATION OF SOILS

0.0'-0.4' Silty Loam, dark brown to black, minor organics, grass, roots

0.4'-0.7' Silty Clay, medium brown, plastic with yellow dark brown and black nodules glass and angular rock fragments

2.0'-2.5', Silty Clay, as above

2.5'-2.6' - Fill, gravel in black silty matrix;

4.0-4.3' Clay, mottled brown to black, plastic, saturated

6.0'-7.5 - Clay, yellow Brown to medium brown, finely laminated, yellow brown silt partings, occasional sub rounded pebbles, lacustrine/Fluvial origin

7.5-8.0' Clay, red, massive saturated, plastic

8.0-12.5' - Interbedded dolomite and clay, no sample

NOTES

Sampling via Split Spoon

SAMPLE RUN 1: 0.0'-2.0'
RECOVERY = 0.7' = 35%

SAMPLE RUN 2.0'-4.0'
Recovery 0.6' = 30%

SAMPLE RUN 3 4.0'-6.0'
Recovery 0.3' = 15%

SAMPLE RUN 4 6.0'-8.0'
Recovery 2.0' = 100%

SAMPLE RUN 5 8.0'-10.0'
Recovery 0' = 0%

640088

CLASSIFICATION/BY J. Doerr

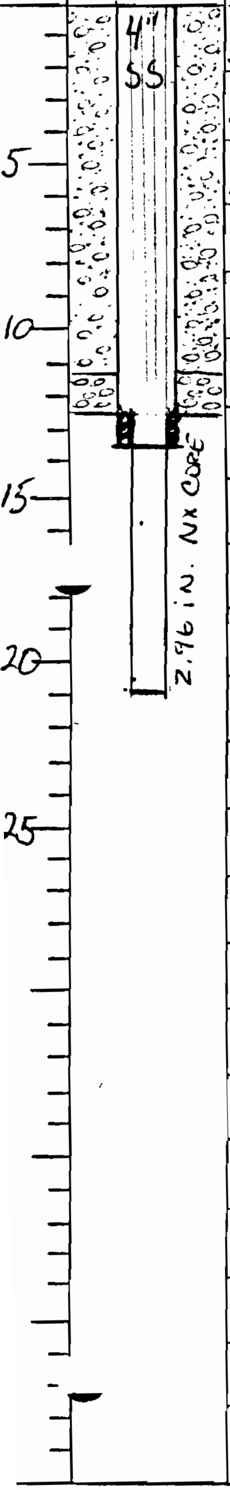
DATE
STARTED 11-20-89
FINISHED 11-21-89
SHEET 1 OF 2

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

Draft
HOLE NUMBER SC-5
SURFACE ELEVATION 570.6
GROUNDWATER DEPTH

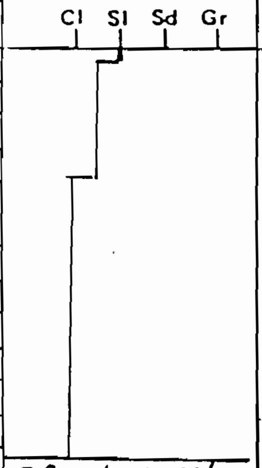
PROJECT Solvent Chemical JD 1030
LOCATION 3163 BuFFalo Ave Niagara Falls, N.Y.

DEPTH – FT
WELL DIAGRAM



SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12
		12/18	18/24
SS	1	7	10
		5	10
SS	2	8	7
		6	9
SS	3	5	6
		7	6
SS	4	5	6
		6	11
SS	5	7	7
		9	18

PROFILE



BR at 12.5'

FIELD IDENTIFICATION OF SOILS

INFORMATION PERTAINING TO 0-12.5' FROM SC-5A.

0.0'-0.4' Silty Loam, dark brown to black, minor organics, grass, roots

0.4'-0.7' Silty Clay, medium brown, plastic with yellow dark brown and black nodules glass and angular rock fragments

2.0'-2.5' Silty Clay, as above

2.5'-2.6' - Fill, gravel in black silty matrix.

4.0-4.3' Clay, mottled brown to black, plastic, saturated

6.0'-7.5' - Clay, yellow Brown to medium brown, Finely laminated, yellow brown silt partings, occasional sub rounded pebbles, lacustrine/Fluvial origin

7.5-8.0' Clay, red, massive saturated, plastic

8.0-12.5' - Interbedded dolomite and clay, no sample

12.5-21.0 - Lockport dolomite medium gray to dark gray, dark gray when fresh, micritic, Fine grained

NOTES

Sampling via Split Spoon

SAMPLE RUN 0.0'-2.0' RECOVERY = 0.7' = 35%

SAMPLE RUN 2.0'-4.0' Recovery 0.6' = 30%

SAMPLE RUN 4.0'-6.0' Recovery 0.3 = 15%

SAMPLE RUN 6.0'-8.0' Recovery 2.0' = 100%

SAMPLE RUN 8.0-10.0 Recovery 0' = 0%

10088

CLASSIFICATION/BY J. Doerr

A-15

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ecology and environment

Draft

DATE
STARTED 11-20-89
FINISHED 11-21-89
SHEET 2 OF 2

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5B
SURFACE ELEVATION 570.62
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6, 12/18	BLOWS ON SAMPLER 6/12, 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
							12.5'-14.1' - competent, massive, vuggy, increasing in size and number downward, size ranges from ~1mm to ~1cm 14.1'-14.4' Fracture zone, 14.4'-15.2' Heavily weathered zone, 3 bedding fractures 15.2'-19.4' - Heavily Fractured, weathered 19.4'-21.0' - competent massive	CORERUN 1: 12.5'-21.0'

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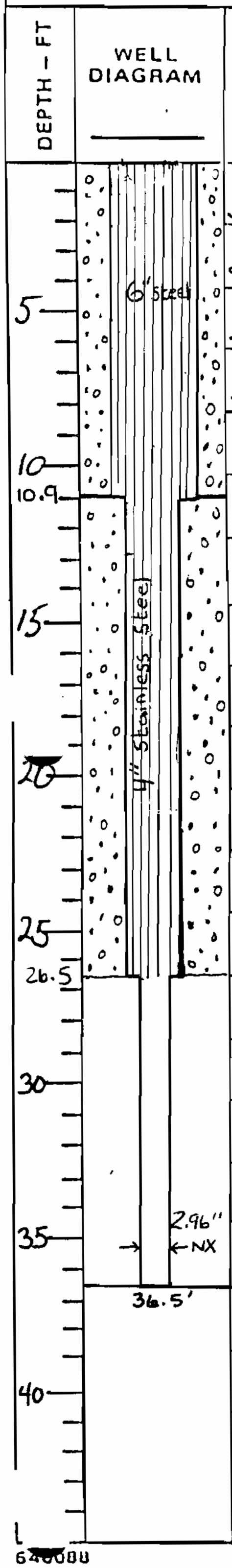
DATE
STARTED 11-5-89
FINISHED 12-8-89
SHEET 1 OF 3

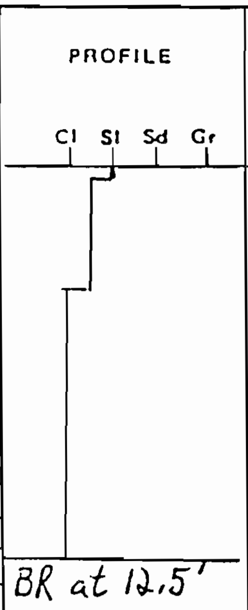
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5C Draft
SURFACE ELEVATION 570.62
GROUNDWATER DEPTH

PROJECT Solvent Chemical JD 1030
LOCATION 3163 Buffalo Ave Niagara Falls, N.Y.



SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12
		12/18	18/24
SS	1	7	10
		5	10
SS	2	8	7
		6	9
SS	3	5	6
		7	6
SS	4	5	6
		6	11
SS	5	7	7
		9	18



BR at 12.5'

FIELD IDENTIFICATION OF SOILS

INFORMATION PERTAINING TO 0-12.5' FROM SC-5A
INFORMATION PERTAINING TO 12.5-19' FROM SC-5B

0.0'-0.4' Silty Loam, dark brown to black, minor organics, grass, roots

0.4'-0.7' Silty Clay, medium brown, plastic with yellow dark brown and black nodules glass and angular rock fragments

2.0'-2.5' Silty Clay, as above

2.5'-2.6' - Fill, gravel in black silty matrix.

4.0-4.3' Clay, mottled brown to black, plastic, saturated

6.0'-7.5 - Clay, yellow brown to medium brown, finely laminated, yellow brown silt partings, occasional subrounded pebbles, lacustrine/fluvial origin.

7.5-8.0' Clay, red, massive saturated, plastic

8.0-12.5' - Interbedded dolomite and clay, no sample.

12.5-21.0 - Lockport dolomite medium gray to dark gray, dark gray when fresh, micritic, fine grained

NOTES

Sampling via Split Spoon

SAMPLE RUN 0.0'-2.0'
RECOVERY = 0.7' = 35%

SAMPLE RUN 2
2.0'-4.0'
Recovery 0.6' = 30%

SAMPLE RUN 3
4.0'-6.0'
Recovery 0.3' = 15%

SAMPLE RUN 4
6.0'-8.0'
Recovery 2.0' = 100%

SAMPLE RUN 5
8.0'-10.0'
Recovery 0' = 0%

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CLASSIFICATION/BY J Doerr

Draft

DATE
STARTED 11-5-89
FINISHED 12-8-89
SHEET 2 OF 3

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5
SURFACE ELEVATION 570.6
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical JD 1030
LOCATION 3163 Buffalo Ave Niagara Falls NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 12/18	BLOWS ON SAMPLER 6/12 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
							12.5'-14.1' - competent, massive, vuggy, increasing in size and number downward, size ranges from ~1mm to ~1cm 14.1'-14.4' Fracture zone, 14.4'-15.2' Heavily weathered zone, 3 bedding fractures 15.2'-19.0' - Heavily fractured, weathered	
							19.0'-19.85' - Highly fractured dolomite (rubble): mechanical fractures from drilling process. Fragments show large vugs up to 1" in width, partially filled with calcite. 19.85'-20.35' - Same dolomite but without vugs. Contains two bedding plane fractures	Core run Fro 19.0'-26.5' Recovery 7.2' = 96%
							20.35'-20.5' - Fracture zone.	Lost drill water return
							20.5'-23.25' - Competent dolostone with bedding plane fractures, some along stylolites, Contains few small vugs (2-5mm) partially filled with calcite. 23.25'-23.70' - Same dolomite with vertical stress fractures and secondary mineralization with calcite. 23.70'-24.0' - Highly fractured zone with small vugs and calcite. Believe fractured by core barrel movement. 24.0'-24.9' - Same dolomite with single vertical fracture showing secondary mineralization with calcite. Some large, up to ½", vugs filled with calcite and 2 bedding plane (horiz.) fractures @ stylolites. 24.9'-25.4' - Highly fractured zone with calcite.	

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CLASSIFICATION/BY J. Doerr / R. Meyers

Draft

DATE
STARTED 11-5-89
FINISHED 12-8-89
SHEET 3 OF 3

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5
SURFACE ELEVATION 570.6
GROUNDWATER DEPTH 17.62' BGS

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6, 6/12, 12/18, 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
						25.4'-26.5' Single piece of dolomite with 1 vug (½") filled with calcite 26.5'-34.5' Competent dolomite with few vugs and stress fractures filled with calcite containg the following fractures: 26.6' and 27.2' clean mechanical breaks along bedding planes. 27.85' Horizontal bedding plane fracture with stylolite. 28.0' 45° fracture with secondary calcite 28.3' Horizontal fracture with secondary calcite. 28.8' Horizontal fracture along bedding plane. 29.0' and 29.1' fractures along thick stylolites (horizontal) 29.65' Horizontal fracture at stylolite 30.65' and 31.0' same type fracture 31.35' and 31.9' same type of fracture but more open; ie, no mineralization. 32.4' to 32.5' Large open horizontal fracture with stylolite and secondary mineralization Area of water loss 32.7' Horizontal fracture with stylolite and secondary mineralization. 33.25' to 33.70' Area with 4 horizontal fractures with stylolites and secondary mineralization. 33.70' to 36.5' Dolostone is more competent with many more small vugs, but no stylolites. Secondary mineralization with calcite throughout. Also has 3 mechanical fractures at 33.95', 35.2', and 36.35'.	CORE RUN FRO 26.5'-36.5 Recovery 10' = 100% RQD = 81% Lost drill water return @ 32.75'

640088

CLASSIFICATION/BY R. Meyers

ATE
STARTED 12-12 -89
FINISHED 12-14-89
HEET 2 OF ~4

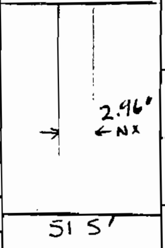
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER **Draft** 5C
SURFACE ELEVATION 571.38
GROUNDWATER DEPTH

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls NY

WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6, 12/18	6/12, 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES



12.5'-14.1' - competent, massive, vuggy, increasing in size and number downward, size ranges from ~1mm to ~1cm
14.1'-14.4' Fracture zone,
14.4'-15.2' Heavily weathered zone, 3 bedding fractures
15.2'-19.0' - Heavily Fractured, weathered
19.0'-19.85' - Highly Fractured dolomite (rubble): mechanical fractures from drilling process. Fragments show large vugs up to 1" in width, partially filled with calcite.
19.85'-20.35' - Same dolomite but without vugs. Contains two bedding plane fractures
20.35'-20.5' - Fracture zone.
20.5'-23.25' - Competent dolostone with bedding plane fractures, some along stylolites, Contains few small vugs (2-5mm) partially filled with calcite.
23.25'-23.70' - Same dolomite with vertical stress fractures and secondary mineralization with calcite.
23.70'-24.0' - Highly fractured zone with small vugs and calcite. Believe fractured by core barrel movement.
24.0'-24.9' - Same dolomite with single vertical fracture showing secondary mineralization with calcite. Some large, up to ½", vugs filled with calcite and 2 bedding plane (horiz.) fractures @ stylolites.
24.9'-25.4' - Highly Fractured zone with calcite.

Core run Fro
19.0'-26.5'
Recovery
7.2' = 96%

Lost drill water return

CLASSIFICATION/BY J Doerr / R. Meyers

DATE
STARTED 12-12-89
FINISHED 12-14-89
SHEET 3 OF 4

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

Draft
HOLE NUMBER SC-3CD
SURFACE ELEVATION 571.38
GROUNDWATER DEPTH

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 · 6/12 · 12/18 · 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
						25.4'-26.5' Single piece of dolomite with 1 vug (½") Filled with calcite	
						26.5'-34.5' Competent dolomite with Few vugs and stress Fractures Filled with calcite containg the Following Fractures:	Core Run From 26.5'-36.5' Recovery 10' = 100% RQD = 81%
						26.6' and 27.2' clean mechanical breaks along bedding planes.	
						27.85' Horizontal bedding plane Fracture with stylolite.	
						28.0' 45° Fracture with secondary calcite	Lost drill water return @ 32.75'
						28.3' Horizontal Fracture with secondary calcite.	
						28.8' Horizontal fracture along bedding plane.	
						29.0' and 29.1' Fractures along thick stylolites (horizontal)	
						29.65' Horizontal fracture at stylolite	
						30.65' and 31.0' Same type Fracture	
						31.35' and 31.9' Same type of Fracture but more open; ie, no mineralization.	
						32.4' to 32.5' Large open horizontal Fracture with stylolite and secondary mineralization Area of water loss	
						32.7' Horizontal Fracture with stylolite and secondary mineralization.	
						33.25' to 33.70' Area with 4 horizontal fractures with stylolites and secondary mineralization.	
						33.70' to 36.5' Dolostone is more competent with many more small vugs, but no stylolites. Secondary mineralization with calcite throughout. Also has 3 mechanical Fractures at 33.95', 35.2', and 36.35'.	

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Draft

DATE
STARTED 12-12-89
FINISHED 12-14-89
EET 4 OF 4

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5CI
SURFACE ELEVATION 571.38
GROUNDWATER DEPTH

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
						Dolomite with numerous vugs from 34.5' to 35.5' which are partially filled with calcite. 35.5' to 39.5' Dolomite is tighter with fewer, larger vugs completely filled with calcite. 34.5' to 39.5 The following fractures occur: 34.6', 34.75', 34.95', 35.15', 35.95', 36.25' and 36.55' which are bedding plane (horizontal) fractures. 36.7' to 36.8' Large open fracture with massive secondary calcite. 37.03', 37.90', 38.20' Tight, clean, horizontal bedding plane fractures 38.73' Horizontal fracture along Styiolite 38.73' to 39.5' Three clean, horizontal bedding plane fractures. 39.5' Horizontal fracture along stylolite.	Core Run from 34.5' to 39.5' Recovery 5.0' = 100% RQD = 54%
						Competent dolomite which is highly fractured. The vast majority of the fractures are tight, clean, mechanical breaks along bedding planes or stylolites with the following exceptions: 40.1' Small open fracture with styiolite 40.8' to 41.0' Fracture zone with secondary calcite 41.6' to 42.5' Highly fractured zone with secondary calcite. Contains four obviously water bearing fractures, all horizontal. 42.9' Horizontal fracture along vuggy zone.	Core run from 39.5' to 51.5' Recovery 12' = 100% RQD = 68% Area of water loss.

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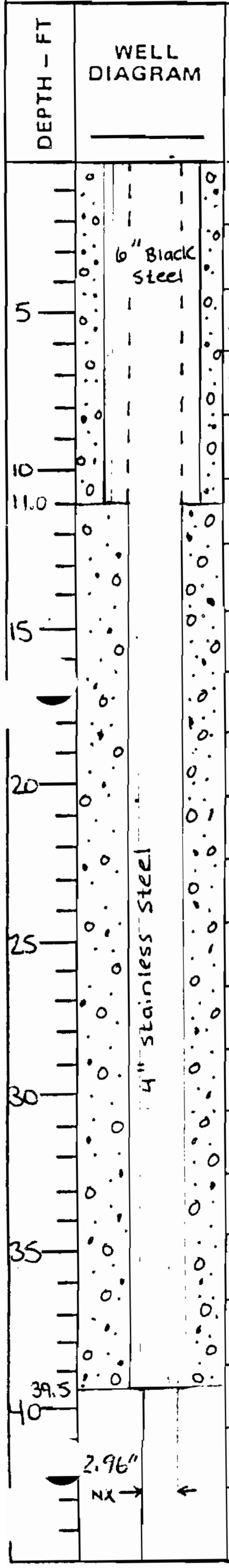
Draft

DATE
STARTED 12-12-89
FINISHED 12-14-89
SHEET 1 OF 4

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

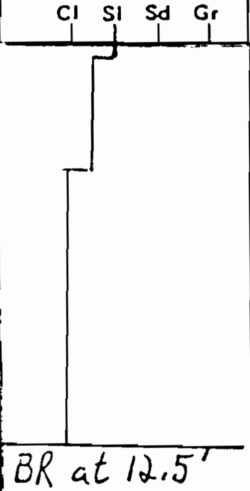
HOLE NUMBER SC-5C
SURFACE ELEVATION 571.3
GROUNDWATER DEPTH ( )

PROJECT Solvent Chemical JD 1030
LOCATION 3163 Buffalo Ave. Niagara Falls, NY



SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0–6	6–12
		12–18	18–24
SS	1	7	10
		5	10
SS	2	8	7
		6	9
SS	3	5	6
		7	6
SS	4	5	6
		6	11
SS	5	7	7
		9	18

PROFILE



FIELD IDENTIFICATION OF SOILS

INFORMATION PERTAINING TO 0-12.5' FROM SC-5A.
INFORMATION PERTAINING TO 12.5-19' FROM SC-5B
INFORMATION PERTAINING TO 19'-36.5' FROM SC-5C.

0.0'-0.4' Silty Loam, dark brown to black, minor organics, grass, roots

0.4'-0.7' Silty Clay, medium brown, plastic with yellow dark brown and black nodules glass and angular rock fragments

2.0'-2.5', Silty Clay, as above

2.5'-2.6' - Fill, gravel in black silty matrix.

4.0-4.3' Clay, mottled brown to black, plastic, saturated

6.0'-7.5' - Clay, yellow Brown to medium brown, finely laminated, yellow brown silt partings, occasional subrounded pebbles, lacustrine/Fluvial origin.

7.5-8.0' Clay, red, massive saturated, plastic

8.0-12.5' - Interbedded dolomite and clay, no sample.

12.5'-21.0' - Lockport dolomite medium gray to dark gray, dark gray when fresh, micritic, Fine grained

NOTES

Sampling via Split Spoon

SAMPLE RUN 0.0'-2.0' RECOVERY = 0.7' = 35%

SAMPLE RUN 2.0'-4.0' Recover 0.6' = 30%

SAMPLE RUN 4.0'-6.0' Recovery 0.3 = 15%

SAMPLE RUN 6.0'-8.0 Recover 2.0' = 100

SAMPLE RUN 8.0'-10.0' Recover 0' = 0%

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CLASSIFICATION/BY J. Doerr

Draft

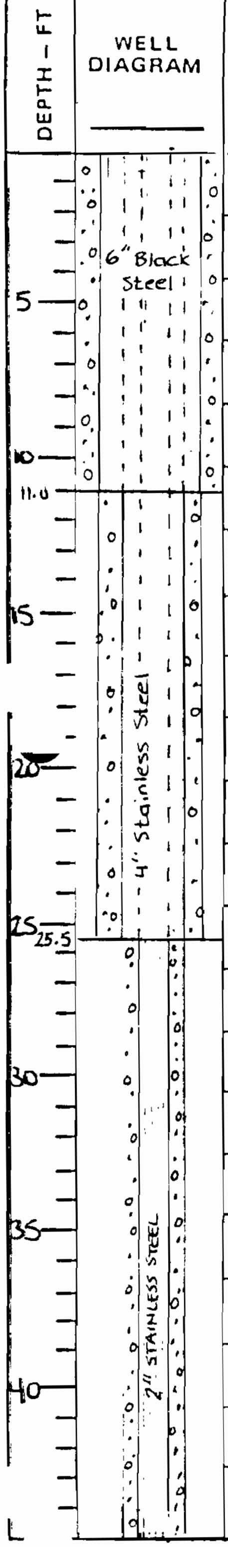
DATE
STARTED 1-2-90
FINISHED 1-3-90
SHEET 1 OF 6

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

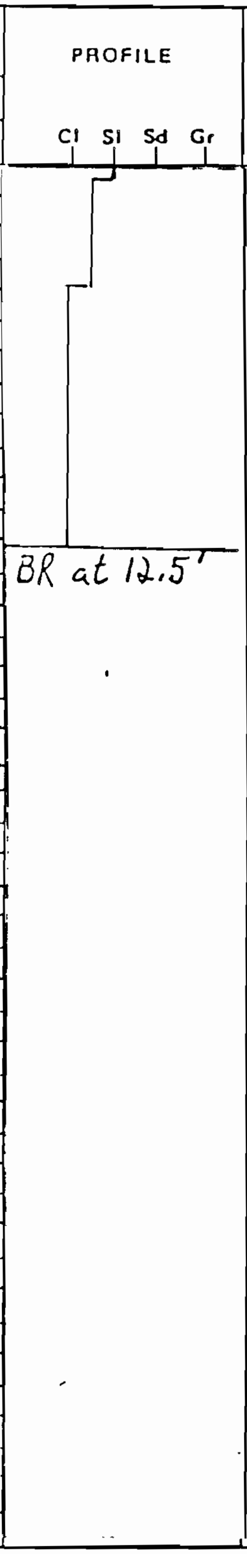
HOLE NUMBER SC-5F
SURFACE ELEVATION 570.64
GROUNDWATER DEPTH ( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY



SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	6/12
		12/18	18/24
SS	1	7	10
		5	10
SS	2	8	7
		6	9
SS	3	5	6
		7	6
SS	4	5	6
		6	11
SS	5	7	7
		9	18



BR at 12.5'

FIELD IDENTIFICATION OF SOILS
INFORMATION PERTAINING TO 0-12.5', FROM SC-5A
INFORMATION PERTAINING TO 12.5-19', FROM SC-5B
INFORMATION PERTAINING TO 19-36.5' FROM SC-5C
INFORMATION PERTAINING TO 36.5-49.5' FROM SC-5D.

0.0'-0.4' Silty Loam, dark brown to black, minor organics, grass, roots

0.4'-0.7' Silty Clay, medium brown, plastic with yellow dark brown and black nodules glass and angular rock fragments

2.0'-2.5' Silty Clay, as above

2.5'-2.6' - Fill, gravel in black silty matrix.

4.0-4.3' Clay, mottled brown to black, plastic, saturated

6.0'-7.5' - Clay, yellow brown to medium brown, finely laminated, yellow brown silt partings, occasional subrounded pebbles, lacustrine/fluvial origin

7.5-8.0' Clay, red, massive saturated, plastic

8.0-12.5' - Interbedded dolomite and clay, no sample.

12.5-21.0' - Lockport dolomite medium gray to dark gray, dark gray when fresh, micritic, fine grained

NOTES

Sampling via Split Spoon

SAMPLE RUN 1:
0.0 - 2.0
RECOVERY = 0.7' = 35%

SAMPLE RUN 2
2.0' - 4.0'
Recovery 0.6' = 30%

SAMPLE RUN 3
4.0' - 6.0'
Recovery 0.3' = 15%

SAMPLE RUN 4
6.0' - 8.0'
Recovery 2.0' = 100%

SAMPLE RUN 5
8.0' - 10.0'
Recovery 0' = 0%

CLASSIFICATION/BY J. Doerr

DATE
STARTED 1-2-90
FINISHED 1-3-90
SHEET 2 OF 6

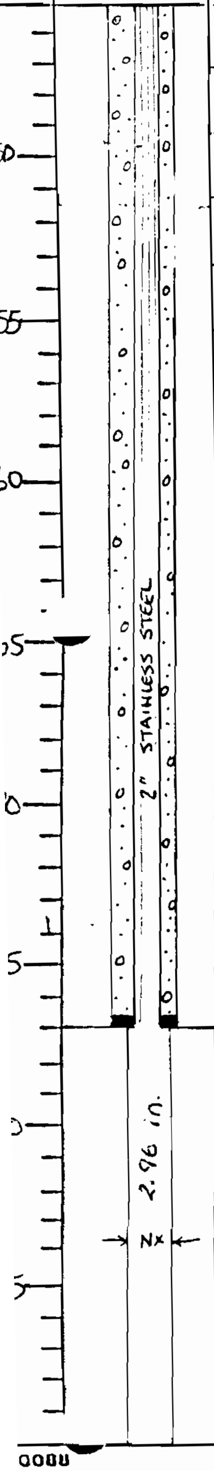
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5F **Draft**
SURFACE ELEVATION 570.64
GROUNDWATER DEPTH

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls NY

DEPTH – FT | WELL DIAGRAM | SAMPLE TYPE | SAMPLE NO. | BLOWS ON SAMPLER 0/6 6/12 12/18 18/24 | PROFILE Cl Si Sd Gr



FIELD IDENTIFICATION OF SOILS	NOTES
12.5'-14.1' - competent, massive, vuggy, increasing in size and number downward, size ranges from ~1mm to ~1cm	
14.1'-14.4' Fracture zone,	
14.4'-15.2' Heavily weathered zone, 3 bedding fractures	
15.2'-19.0' - Heavily Fractured, weathered	
19.0'-19.85' - Highly Fractured dolomite (rubble): mechanical fractures from drilling process. Fragments show large vugs up to 1" in width, partially filled with calcite.	Core run from 19.0'-26.5' Recovery 7.2' = 96%
19.85'-20.35' - Same dolomite but without vugs. Contains two bedding plane fractures	
20.35'-20.5' - Fracture zone.	Lost drill water return.
20.5'-23.25' - Competent dolostone with bedding plane fractures, some along stylolites, Contains few small vugs (2-5mm) partially filled with calcite.	
23.25'-23.70' - Same dolomite with vertical stress fractures and secondary mineralization with calcite.	
23.70'-24.0' - Highly fractured zone with small vugs and calcite. Believe fractured by core barrel movement.	
24.0'-24.9' - Same dolomite with single vertical fracture showing secondary mineralization with calcite. Some large, up to ½", vugs filled with calcite and 2 bedding plane (horiz.) fractures @ stylolites.	
24.9'-25.4' - Highly Fractured zone with calcite.	

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CLASSIFICATION BY J. Doerr / R. Meyers

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DATE
STARTED 1-2-90
FINISHED 1-3-90
SHEET 3 OF 6

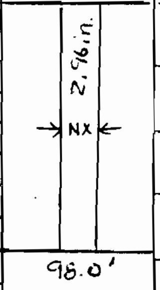
E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SG-5F
Draft
SURFACE ELEVATION 570.6
GROUNDWATER DEPTH

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6, 12/18	BLOWS ON SAMPLER 6/12, 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES



95

100

25.4'-26.5' Single piece of dolomite with 1 vug (½") filled with calcite

26.5'-34.5' Competent dolomite with few vugs and stress fractures filled with calcite containg the following fractures:

26.6' and 27.2' clean mechanical breaks along bedding planes.

27.85' Horizontal bedding plane fracture with stylolite.

28.0' 45° fracture with secondary calcite

28.3' Horizontal fracture with secondary calcite.

28.8' Horizontal fracture along bedding plane.

29.0' and 29.1' fractures along thick stylolites (horizontal)

29.65' Horizontal fracture at stylolite

30.65' and 31.0' Same type fracture

31.35' and 31.9' Same type of fracture but more open; ie, no mineralization.

32.4' to 32.5' Large open horizontal fracture with stylolite and secondary mineralization

Area of water loss

32.7' Horizontal fracture with stylolite and secondary mineralization.

33.25' to 33.70' Area with 4 horizontal fractures with stylolites and secondary mineralization.

33.70' to 36.5' Dolostone is more competent with many more small vugs, but no stylolites. Secondary mineralization with calcite throughout. Also has 3 mechanical fractures at 33.95', 35.2', and 36.35'.

Core Run Fro
26.5'-36.5
Recovery
10' = 100%
RQD = 81%

Lost drill water return @ 32.75'

640088

CLASSIFICATION/BY R. Meyers

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ecology and environment

ATE
STARTED 1-2-90
FINISHED 1-3-90
HEET 4 OF 6

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

Draft
HOLE NUMBER SC-5F
SURFACE ELEVATION 570.64
GROUNDWATER DEPTH

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY

DEPTH – F	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12	BLOWS ON SAMPLER 12/18	BLOWS ON SAMPLER 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
									Dolomite with numerous vugs from 34.5' to 35.5' which are partially filled with calcite. 35.5' to 39.5' Dolomite is tighter with fewer, larger vugs completely filled with calcite. 34.5' to 39.5 The following fractures occur: 34.6', 34.75', 34.95', 35.15', 35.95', 36.25' and 36.55' which are bedding plane (horizontal) fractures. 36.7' to 36.8' Large open fracture with massive secondary calcite. 37.03', 37.90', 38.20' Tight, clean, horizontal bedding plane fractures. 38.73' Horizontal fracture along stylolite 38.73' to 39.5' Three clean, horizontal bedding plane fractures. 39.5' Horizontal fracture along stylolite.	Core Run from 34.5' to 39.5' Recovery 5.0' = 100% RQD = 54%
									Competent dolomite which is highly fractured. The vast majority of the fractures are tight, clean, mechanical breaks along bedding planes or stylolites with the following exceptions: 40.1' Small open fracture with stylolite, 40.8' to 41.0' Fracture zone with secondary calcite 41.6' to 42.5' Highly fractured zone with secondary calcite. Contains four obviously water bearing fractures, all horizontal. 42.9' Horizontal fracture along vuggy zone.	Core run from 39.5' to 51.5' Recovery 12' = 100% RQD = 68% Area of water loss.

188

CLASSIFICATION/BY R. Meyers

Draft

DATE
STARTED 1-2-90
FINISHED 1-3-90
SHEET 5 OF 6

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC-5F
SURFACE ELEVATION 570.64
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical
JD1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	PROFILE Cl Si Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
						49.5' to 58.1' Highly Fractured dolostone with core segments ranging from 0.08' to 0.4'. The Fractures are horizontal bedding plane fractures with some secondary calcite. They are fairly tight with very few stylolites. The core has some small vugs (partially calcite filled) randomly spread out over the length of the core. In addition to the horizontal fractures, a single vertical Fracture is present from 55.85' to 56.25'.	Core Run from 49.5' to 58.1' Recovery 8.6' = 100% RQD = 17%
						58.1' to 64.3' The dolostone appears more weathered with more Solution Features such as vugs & stress Fractures Filled with calcite and gypsum. Most fractures in this zone are tight & horizontal with some secondary mineralization. Large open fractures are present at 61.0', 61.3', 61.9', 62.3', and 63.7'. 64.1' to 64.3' Area of calcite/gypsum 64.3' to 68.1' Dolostone is less weathered with very few vugs or solution features. The Fractures are horizontal and tighter than above and most are at stylolites. One open Fracture is at 65.85'	CORE RUN from 58.1' to 68.1' Recovery 10' = 100% RQD = 51%

640088

CLASSIFICATION/BY R Meyers

recycled paper

Draft

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

DATE
STARTED 1-2-90
FINISHED 1-3-90
SHEET 6 OF 6

HOLE NUMBER SC-5F
SURFACE ELEVATION 570.64
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave.
Niagara Falls, NY

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
						68.1' to 78.1' Lockport dolostone with comparitively few small vugs. Entire core is highly fractured with horizontal (bedding) fractures along stylolites and areas with secondary calcite/gypsum. Also a single vertical stress fracture from 73.8' to 74.1'.	CORE RUN from 68.1' to 78.1' Recovery 10' = 100% RQD = 15% slight oil odor.
						78.1' to 87.6' Same dolostone with few large (up to 2") open vugs and calcite/gypsum filled vugs. Core is highly fractured horizontally as above, with more open fractures at 78.6', 80.1', 82.25', 82.4', 82.7', 83.15', 84.9', and 86.6'.	CORE RUN From 78.1' to 87.6' Recovery 9.6' = 100% RQD = 25%
						87.6' to 98.0' Same dolostone with few large vugs filled with loose calcite crystals or massive calcite/gypsum. Core loss from 87.65' to 87.85'. The core is highly fractured from 87.6' to 94.5' with few tight bedding plane fractures from 94.5' to 98.0'. The fractures from 87.6' to 94.5' include numerous large open fractures with secondary mineralization (calcite/gypsum) and thick stylolites.	CORE RUN From 87.6' to 98.0' Recovery 10.2' = 98% RQD = 39%

640088

CLASSIFICATION/BY R. Meyers

Draft

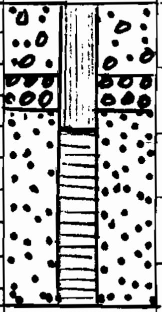
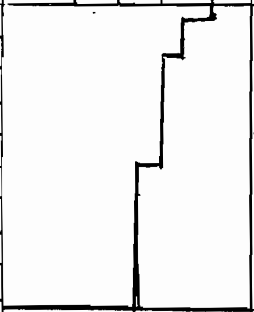
DATE
STARTED 11-28-89
FINISHED 11-28-89
SHEET 1 OF 1

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

HOLE NUMBER SC 6A
SURFACE ELEVATION 570.83
GROUNDWATER DEPTH
( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls N.Y.

DEPTH – FT	WELL DIAGRAM	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	PROFILE Cl Sl Sd Gr	FIELD IDENTIFICATION OF SOILS	NOTES
5 10	 2 in. S.S. w/ SS. Screen slot size 0.010 in.				 BR at 9.6'	0.0'-0.7' Fill, gravel, medium to dark gray, 0.7'-1.7' Fill, medium sand to gravel, dark gray to black, moderate brick Fragments and industrial debris 1.7-2.5' Fill, silt to gravel, black, some industrial debris, moist 5.0-6.1 Sandy silt, black, Fine grained, some light gray to red clay, minor brick Fragments	Sampled via Laskey Sampler SAMPLE RUN 0.0'-5.0' RECOVERY = 2.5' = 50% SAMPLE RUN 2 5.0'-10.0' Recovery 1.1 = 24%

640088

CLASSIFICATION/BY R. Watt

DATE
STARTED 11-29-89
FINISHED 11-30-89
SHEET 1 OF 1

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

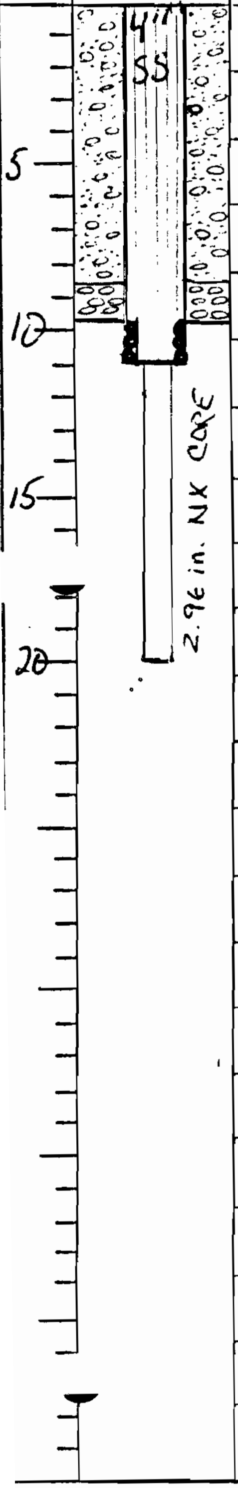
Draft

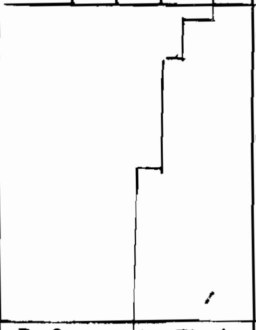
HOLE NUMBER SC 6
SURFACE ELEVATION 570.8
GROUNDWATER DEPTH ( )

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls N.Y.

DEPTH – FT | WELL DIAGRAM | SAMPLE TYPE | SAMPLE NO. | BLOWS ON SAMPLER 0/6, 6/12, 12/18, 18/24 | PROFILE (Cl, Sl, Sd, Gr) | FIELD IDENTIFICATION OF SOILS | NOTES





B.R. at 9.6

INFORMATION PERTAINING TO 0-6.1' FROM SC-6A.

0.0'-0.7' Fill, gravel, medium to dark gray,
0.7'-1.7' Fill, medium sand to gravel, dark gray to black, moderate brick Fragments and industrial debris
1.7-2.5' Fill, silt to gravel, black, Some industrial debris, moist

5.0-6.1 Sandy silt, black, Fine grained, some light gray to red clay, minor brick Fragments
9.6'-20.0'- Lockport dolomite medium gray to dark gray, dark gray when fresh, micritic, Fine grained minor vugs
9.6-12.0 - Weathered zone
12.0'-17.0'- Highly Fractured Some high angle (65°-75°) with 2nd degree calcitic mineralization
Some subhorizontal with thin mineralized stylolite 2nd degree mineralization
17.0'-19.5' - competent, massive
19.5'-20.0'- Highly Fractured vuggy

NOTES:

Sampled via Laskey Sampler
SAMPLE RUN
1: 0.0'-5.
RECOVERY =
2.5' = 50%

SAMPLE RUN 2
5.0'-10.0'
Recovery
1.1' = 24%

CORE RUN
10.0'-20.
Recover
8.7' = 87

40088

CLASSIFICATION/BY ecology and environment

DATE
STARTED 12-4-89
FINISHED 12-4-89
SHEET 1 OF 1

E + E DRILLING AND TESTING CO., INC.
SUBSURFACE LOG

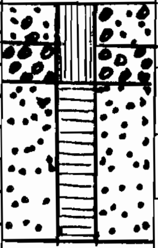
Draft
HOLE NUMBER SC 7A
SURFACE ELEVATION 569.15
GROUNDWATER DEPTH

PROJECT Solvent Chemical
JD 1030

LOCATION 3163 Buffalo Ave
Niagara Falls N.Y.

DEPTH – FT: 5, 10

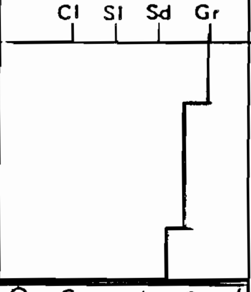
WELL DIAGRAM



2 in. s.s.
w/ s.s.
screen
slot size
0.010 in

SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0-6	6-12	12-18	18-24
SS	1	25	35	30	14
SS	2	4	6	6	6
SS	3	9	1	2	3
SS	4	25	35	42	50

PROFILE



B.R. at 7.5'

FIELD IDENTIFICATION OF SOILS

0.0'-0.5, Fill, angular, pebble cobble dolomite road bed with dark brown silty loam matrix

0.5-1.0'-Fill, as above, with concrete and brick fragments some industrial debris

2.0-3.2'-Fill, angular dolomite roadbed, black silty sand matrix.

4.0'-4.8'- Fill, as above, with some gray clay.

6.0-7.5, Fill, gravel, with sand silt matrix, black

NOTES

Sampled with Split Spoon.

SAMPLE RUN
0.0'-2.0'
RECOVERY = 1.0' = 50%

SAMPLE RUN 2
2.0'-4.0'
Recovery 1.2' = 60%

SAMPLE RUN 3
4.0'-6.0'
Recovery 0.8' = 40%

SAMPLE RUN 4
6.0'-8.0'
Recovery 1.5' = 75%

640088

CLASSIFICATION/BY R. Meyers

APPENDIX B

ANALYTICAL DATA

TABLE B-1

Page 1 of 21

DATA SUMMARY FORM: VOLATILES 1

Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

WATER SAMPLES
(ug/L) (PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	COMPOUND									
	Sample No.	MW-1A	MW-1B	MW-BL1	MW-TB1	MW-2B	MW-2A	MW-3A	MW-6A	
	Dilution Factor									
	Location	64993	64994	64995	64996	65191	65192	65193	65194	
10	Chloromethane									
10	Bromomethane									
10	***Vinyl Chloride**									
10	Chloroethane									
5	***Methylene Chloride**					13 J*	31 J*			
10	Acetone									
5	Carbon Disulfide									
5	***1,1-Dichloroethene**									
5	1,1-Dichloroethane									
5	***Total-1,2-Dichloroethene**					1400				
5	Chloroform									
5	***1,2-Dichloroethane**						54		11	
10	***2-Butanone**									
5	***1,1,1-Trichloroethane**									
5	***Carbon Tetrachloride**									
10	Vinyl Acetate									
5	Bromodichloromethane									

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

*

E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABL B-1

Page 2 of 21

DATA SUMMARY FORM: VOLATILES 1

Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L) (PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	MW-6B		MW-3B		MW-5B		MW-5BD		MW-4A		MW-4B		MW-4BD		MW-BL2			
	Dilution Factor																		
	Location	65195		65196		65392		65393		65394		65395		65396		65397			
CRQL	COMPOUND																		
10	Chloromethane																		
10	Bromomethane																		
10	*Vinyl_Chloride	2	J*	23	J*					800									
10	Chloroethane																		
5	*Methylene Chloride	1	J*																
10	Acetone																		
5	Carbon_Disulfide																		
5	*1,1-Dichloroethene																		
5	1,1-Dichloroethane	4	J*																
5	*Total-1,2-Dichloroethene	2	J*	160						2100									
5	Chloroform																		
5	*1,2-Dichloroethane																		
10	*2-Butanone																		
5	*1,1,1-Trichloroethane																		
5	*Carbon Tetrachloride																		
10	Vinyl_Acetate																		
5	Bromodichloromethane																		

CRDL = Contract Required Detection Limit

*Action Level Exists

SEE NARRATIVE FOR CODE DEFINITIONS

revised 12/88

* E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-1

Page 1 of 21

DATA SUMMARY FORM: V O L A T I L E S 1

Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L) (ppb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	MW-7A		MW-5A		MW-TB3		MW-TB4		MW-5C		MW-5CD		MW-TBS		MW-5F			
	Dilution Factor																		
	Location	65398		65399		65400		65401		65738		65739		65740		66069			
CRQL	**COMPOUND**																		
10	Chloromethane																		
10	Bromomethane																		
10	***Vinyl_Chloride**									74	J*					980			
10	Chloroethane																		
5	***Methylene_Chloride**																		
10	Acetone																		
5	Carbon_Disulfide																		
5	***1,1-Dichloroethene**																		
5	1,1-Dichloroethane																		
5	***Total-1,2-Dichloroethene**			110						820		630				2,400			
5	Chloroform																		
5	***1,2-Dichloroethane**																		
10	***2-Butanone**																		
5	***1,1,1-Trichloroethane**																		
5	***Carbon_Tetrachloride**																		
10	Vinyl_Acetate																		
5	Bromodichloromethane																		

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

revised 12/88

*E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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T 3LE B-1

Page 4 of 21

DATA SUMMARY FORM: VOLATILES 2

Site Name: 3163 BUFFALO AVENUE

Case #: ______ Sampling Date(s): ______

WATER SAMPLES
(ug/L) (PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	MW-1A		MW-1B		MW-BL1		MW-TB1		MW-2B		MW-2A		MW-3A		MW-6A			
	Dilution Factor																		
	Location	64993		64994		64995		64996		65191		65192		65193		65194			
CRQL	COMPOUND																		
5	***1,2-Dichloropropane**																		
5	Cis-1,3-Dichloropropene																		
5	Trichloroethene											60				3	J		
5	Dibromochloromethane																		
5	1,1,2-Trichloroethane																		
5	***Benzene**	540,000	E*	310,000	E*							100,000				4	J		
5	Trans-1,3-Dichloropropene																		
5	Bromoform																		
10	4-Methyl-2-pentanone											380							
10	2-Hexanone																		
5	***Tetrachloroethene**									87		510							
5	1,1,2,2-Tetrachloroethane																		
5	***Toluene**									58		960							
5	***Chlorobenzene**									43,000		180,000		800		110			
5	***Ethylbenzene**																		
5	***Styrene**																		
5	***Total Xylenes**																		

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

*
E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED
J = BELOW QUANTIFIABLE RANGE ; ESTIMATED

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TABLE B-1

DATA SUMMARY FORM: V O L A T I L E S 2

Page 5 of 21

Site Name: 3163 BUFFALO AVENUE

Case #: ________ Sampling Date(s): ________

WATER SAMPLES
(ug/L)(PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	Sample No.	MW-6B	MW-3B	MW-5B	MW-5BD	MW-4A	MW-4B	MW-4BD	MW-BL2	
	Dilution Factor									
	Location	65195	65196	65392	65393	65394	65395	65396	65397	
	COMPOUND									
5	***1,2-Dichloropropane**									
5	Cis-1,3-Dichloropropene									
5	Trichloroethene		27 J*							
5	Dibromochloromethane									
5	1,1,2-Trichloroethane									
5	***Benzene**	300		350	320	140				
5	Trans-1,3-Dichloropropene									
5	Bromoform									
10	4-Methyl-2-pentanone									
10	2-Hexanone									
5	***Tetrachloroethene**		45 J*							
5	1,1,2,2-Tetrachloroethane									
5	***Toluene**		95							
5	***Chlorobenzene**	1800	13,000	2100	1900	910			92	
5	***Ethylbenzene**		29 J*							
5	***Styrene**									
5	***Total Xylenes**		150							

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

revised 12/88

*
E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J - BELOW QUANTIFIABLE RANGE; ESTIMATED

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TA E B-1

DATA SUMMARY FORM: VOLATILES 2

Page 61 of 21

Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L) (PPb)

Case #: ________ Sampling Date(s): ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	Sample No.	MW-7A		MW-5A		MW-TB3		MW-TB4		MW-5C		MW-5CD		MW-TB5		MW-5F	
	Dilution Factor																
	Location	65398		65399		65400		65401		65738		65739		65740		66069	
CRQL	COMPOUND																
5	***1,2-Dichloropropane**																
5	Cis-1,3-Dichloropropene																
5	Trichloroethene			150						250							
5	Dibromochloromethane																
5	1,1,2-Trichloroethane																
5	***Benzene**	18,000	E*							920		1200					
5	Trans-1,3-Dichloropropene																
5	Bromoform																
10	4-Methyl-2-pentanone																
10	2-Hexanone																
5	***Tetrachloroethene**			820	E*					320							
5	1,1,2,2-Tetrachloroethane																
5	***Toluene**			1	J*							98	J*				
5	***Chlorobenzene**	39,000	E*							4300		7200		1	J*	58	J*
5	***Ethylbenzene**																
5	***Styrene**																
5	***Total Xylenes**																

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

* E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-1
DATA SUMMARY FORM: B N A S 1

Page 7 of 21

Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

WATER SAMPLES
(ug/L)(PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	Sample No.	MW-1A		MW-1B		MW-BLI		MW-TBI		MW-2B		MW-2A		MW-3A		MW-6A	
	Dilution Factor																
	Location	64993		64994		64995		64996		65191		65192		65193		65194	
CRQL	COMPOUND																
10	Phenol	1000		330								550					
10	bis(2-Chloroethyl)ether																
10	2-Chlorophenol	300		270													
10	***1,3-Dichlorobenzene**	2200		3900						20,000		4800		22	J*		
10	***1,4-Dichlorobenzene**	7400		12,000	E*					75,000		20,000	E*	39		7	J*
10	Benzyl Alcohol																
10	1,2-Dichlorobenzene	5800	E*	10,000	E*					120,000	E*	19,000	E*	430	E*	2	J*
10	2-Methylphenol																
10	bis(2-Chloroisopropyl)ether																
10	4-Methylphenol																
10	N-Nitroso-di-n-propylamine																
10	Hexachloroethane																
10	Nitrobenzene																
10	Isophorone																
10	2-Nitrophenol																
10	2,4-Dimethylphenol											65	J*				
50	Benzoic Acid																
10	bis(2-Chloroethoxy)methane																
10	2,4-Dichlorophenol	12	J*	20	J*												
10	1,2,4-Trichlorobenzene	1800		4900	E*					47,000		6300		18	J*		
10	Naphthalene	24	J*	25	J*							16	J				
10	4-Chloroaniline																

CRDL = Contract Required Detection Limit

*Action Level Exists

SEE NARRATIVE FOR CODE DEFINITIONS

*E - EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED

J - BELOW QUANTIFIABLE RANGE ; ESTIMATED

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TABLE B-1

DATA SUMMARY FORM: B N A S 1

Page 3 of 21

Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	MW-6B		MW-3B		MW-5B		MW-5BD		MW-4A		MW-4B		MW-4BD		MW-BL2		
	Dilution Factor																	
	Location	65195		65196		65392		65393		65394		65395		65396		65397		
CRQL	COMPOUND																	
10	Phenol					3	J*					8	J*					
10	bis(2-Chloroethyl)ether																	
10	2-Chlorophenol					6	J*	9	J*			14	J*					
10	***1,3-Dichlorobenzene**	65		1800		220		280		550		680		830	E*			
10	***1,4-Dichlorobenzene**	94		4900		450	E*	580		2700		2400	E*	2600	E*	9	J*	
10	Benzyl Alcohol																	
10	1,2-Dichlorobenzene	83		12,000	E*	950	E*	1300	E*	16,000	E*	3100	E*	3400	E*	31		
10	2-Methylphenol																	
10	bis(2-Chloroisopropyl)ether																	
10	4-Methylphenol																	
10	N-Nitroso-di-n-propylamine																	
10	Hexachloroethane																	
10	Nitrobenzene																	
10	Isophorone																	
10	2-Nitrophenol																	
10	2,4-Dimethylphenol																	
50	Benzoic Acid																	
10	bis(2-Chloroethoxy)methane																	
10	2,4-Dichlorophenol																	
10	1,2,4-Trichlorobenzene	120		4200		350		420		24000		620		680	E*	52		
10	Naphthalene																	
10	4-Chloroaniline																	

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

*E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED

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TABLE B-1

DATA SUMMARY FORM: B N A S 1

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

WATER SAMPLES
(ug/L)(PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	Sample No.	MW-7A		MW-5A		MW-TB3		MW-TB4		MW-5C		MW-5CD		MW-TB5		MW-5F		
	Dilution Factor																	
	Location	65398		65399		65400		65401		65738		65739		65740		66069		
CRQL	COMPOUND																	
10	Phenol	150	J*			NA		NA						NA				
10	bis(2-Chloroethyl)ether					↓		↓						↓				
10	2-Chlorophenol	52	J*															
10	***1,3-Dichlorobenzene**	2300		2	J*					750		810				4	J*	
10	***1,4-Dichlorobenzene**	21,000	E*	25						1900	E*	2100	E*			14		
10	Benzyl Alcohol																	
10	1,2-Dichlorobenzene	25,000		30						3900	E*	4700	E*			39		
10	2-Methylphenol																	
10	bis(2-Chloroisopropyl)ether																	
10	4-Methylphenol																	
10	N-Nitroso-di-n-propylamine																	
10	Hexachloroethane																	
10	Nitrobenzene																	
10	Isophorone																	
10	2-Nitrophenol																	
10	2,4-Dimethylphenol																	
50	Benzoic Acid																	
10	bis(2-Chloroethoxy)methane																	
10	2,4-Dichlorophenol	62	J*															
10	1,2,4-Trichlorobenzene	10,000	E*	11						2800	E*	1500				6	J*	
10	Naphthalene	38	J*															
10	4-Chloroaniline																	

CRDL = Contract Required Detection Limit

*Action Level Exists

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TABLE B-1

DATA SUMMARY FORM: B N A S 2

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

WATER SAMPLES
(ug/L) (PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	Sample No.	MW-1A	MW-1B	MW-BL1	MW-TB1	MW-2B	MW-2A	MW-3A	MW-6A	
	Dilution Factor									
	Location	64993	64994	64995	64996	65191	65192	65193	65194	
	COMPOUND									
10	Hexachlorobutadiene									
10	4-Chloro-3-methylphenol									
10	2-Methylnaphthalene	8 J*	26 J*				16 J*			
10	Hexachlorocyclopentadiene									
10	2,4,6-Trichlorophenol		13 J*							
50	2,4,5-Trichlorophenol									
10	2-Chloronaphthalene									
50	2-Nitroaniline									
10	Dimethylphthalate									
10	Acenaphthylene									
10	2,6-Dinitrotoluene									
50	3-Nitroaniline									
10	Acenaphthene		5 J*							
50	2,4-Dinitrophenol									
50	4-Nitrophenol									
10	Dibenzofuran		7 J*							
10	2,4-Dinitrotoluene									
10	Diethylphthalate									
10	4-Chlorophenyl-phenylether									
10	Fluorene		8 J*							
50	4-Nitroaniline									
50	4,6-Dinitro-2-methylphenol									

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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DATA SUMMARY FORM: B N A S 2

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Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L) (PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	Sample No. / Dilution Factor / Location / COMPOUND	MW-6B	MW-3B	MW-5B	MW-5BD	MW-4A	MW-4B	MW-4BD	MW-BL2	
	Dilution Factor									
	Location	65195	65196	65392	65393	65394	65395	65396	65397	
10	Hexachlorobutadiene									
10	4-Chloro-3-methylphenol									
10	2-Methylnaphthalene									
10	Hexachlorocyclopentadiene									
10	2,4,6-Trichlorophenol									
50	2,4,5-Trichlorophenol									
10	2-Chloronaphthalene									
50	2-Nitroaniline									
10	Dimethylphthalate									
10	Acenaphthylene									
10	2,6-Dinitrotoluene									
50	3-Nitroaniline									
10	Acenaphthene									
50	2,4-Dinitrophenol									
50	4-Nitrophenol									
10	Dibenzofuran									
10	2,4-Dinitrotoluene									
10	Diethylphthalate									
10	4-Chlorophenyl-phenylether									
10	Fluorene									
50	4-Nitroaniline									
50	4,6-Dinitro-2-methylphenol									

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

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TABLE B-1

DATA SUMMARY FORM: B N A S 2

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

WATER SAMPLES
(ug/L)(PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	COMPOUND								
	Sample No.	MW-7A	MW-5A	MW-TB3	MW-TB4	MW-5C	MW-5CD	MW-TB5	MW-5F
	Dilution Factor								
	Location	65398	65399	65400	65401	65738	65739	65740	66069
10	Hexachlorobutadiene								
10	4-Chloro-3-methylphenol								
10	2-Methylnaphthalene								
10	Hexachlorocyclopentadiene								
10	2,4,6-Trichlorophenol								
50	2,4,5-Trichlorophenol								
10	2-Chloronaphthalene								
50	2-Nitroaniline								
10	Dimethylphthalate								
10	Acenaphthylene								
10	2,6-Dinitrotoluene								
50	3-Nitroaniline								
10	Acenaphthene								
50	2,4-Dinitrophenol								
50	4-Nitrophenol								
10	Dibenzofuran								
10	2,4-Dinitrotoluene								
10	Diethylphthalate								
10	4-Chlorophenyl-phenylether								
10	Fluorene								
50	4-Nitroaniline								
50	4,6-Dinitro-2-methylphenol								

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

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DATA SUMMARY FORM: B N A S 3

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Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L) (PPb)

Case #: ________ **Sampling Date(s):** ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRDL	Sample No.	MW-1A	MW-1B	MW-BL1	MW-TB1	MW-2B	MW-2A	MW-3A	MW-6A	
	Dilution Factor									
	Location	64993	64994	64995	64996	65191	65192	65193	65194	
CRDL	COMPOUND									
10	N-Nitrosodiphenylamine									
10	4-Bromophenyl-phenylether									
10	***Hexachlorobenzene**		92 J*			160 J*	37 J*			
50	***Pentachlorophenol**									
10	Phenanthrene	24 J*	47 J*			77 J*	12 J*			
10	Anthracene	4 J*								
10	Di-n-butylphthalate									
10	Fluoranthene	15 J*	40 J*			56 J*	9 J*			
10	Pyrene	10 J*	26 J*			42 J*	7 J*			
10	Butylbenzylphthalate									
20	3,3-Dichlorobenzidine									
10	Benzo(a)anthracene									
10	Chrysene									
10	bis(2-Ethylhexyl)phthalate							11 J*	11 J*	
10	Di-n-octylphthalate									
10	Benzo(b)fluoranthene		18 J*							
10	Benzo(k)fluoranthene									
10	Benzo(a)pyrene		7 J*							
10	Indeno(1,2,3-cd)pyrene									
10	Dibenz(a,h)anthracene									
10	Benzo(g,h,i)perylene									

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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TABLE B-1
DATA SUMMARY FORM: B N A S 3

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Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(ppb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	MW-6B	MW-3B	MW-5B	MW-5BD	MW-4A	MW-4B	MW-4BD	MW-BL2	
	Dilution Factor									
	Location	65195	65196	65392	65393	65394	65395	65396	65397	
CRDL	**COMPOUND**									
10	N-Nitrosodiphenylamine									
10	4-Bromophenyl-phenylether									
10	***Hexachlorobenzene**									
50	***Pentachlorophenol**									
10	Phenanthrene									
10	Anthracene									
10	Di-n-butylphthalate									
10	Fluoranthene									
10	Pyrene									
10	Butylbenzylphthalate									
20	3,3-Dichlorobenzidine									
10	Benzo(a)anthracene									
10	Chrysene									
10	bis(2-Ethylhexyl)phthalate	6 J*								
10	Di-n-octylphthalate									
10	Benzo(b)fluoranthene									
10	Benzo(k)fluoranthene									
10	Benzo(a)pyrene									
10	Indeno(1,2,3-cd)pyrene									
10	Dibenz(a,h)anthracene									
10	Benzo(g,h,i)perylene									

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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DATA SUMMARY FORM: B N A S 3

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Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRDL	COMPOUND / Sample No.	MW-7A	MW-5A	MW-TB3	MW-TB4	MW-5C	MW-5CD	MW-TBS	MW-5F	
	Dilution Factor									
	Location	65398	65399	65400	65401	65738	65739	65740	66069	
10	N-Nitrosodiphenylamine									
10	4-Bromophenyl-phenylether									
10	***Hexachlorobenzene**									
50	***Pentachlorophenol**									
10	Phenanthrene	19 J'								
10	Anthracene									
10	Di-n-butylphthalate									
10	Fluoranthene									
10	Pyrene									
10	Butylbenzylphthalate									
20	3,3-Dichlorobenzidine									
10	Benzo(a)anthracene									
10	Chrysene									
10	bis(2-Ethylhexyl)phthalate								12	
10	Di-n-octylphthalate									
10	Benzo(b)fluoranthene									
10	Benzo(k)fluoranthene									
10	Benzo(a)pyrene									
10	Indeno(1,2,3-cd)pyrene									
10	Dibenz(a,h)anthracene									
10	Benzo(g,h,i)perylene									

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

* E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED
J' BELOW QUANTIFIABLE RANGE ; ESTIMATED

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DATA SUMMARY FORM: PESTICIDES AND PCBS

Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	COMPOUND																		
	Sample No.	MW-1A		MW-1B		MW-BL1		M-W-TB1		MW-2B		MW-2A		MW-3A		MW-6A			
	Dilution Factor																		
	Location	64993		64994		64995		64996		65191		65192		65193		65194			
0.05	alpha-BHC	.17		.27															
0.05	beta-BHC																		
0.05	delta-BHC	.034	J*																
0.05	***Gamma-BHC (Lindane)**																		
0.05	***Heptachlor**																		
0.05	Aldrin																		
0.05	Heptachlor Epoxide																		
0.05	Endosulfan I																		
0.10	Dieldrin																		
0.10	4,4'-DDE																		
0.10	***Endrin**																		
0.10	Endosulfan II																		
0.10	4,4'-DDD																		
0.10	Endosulfan Sulfate																		
0.10	4,4'-DDT																		
0.5	***Methoxychlor**																		
0.10	Endrin ketone																		
0.5	***Alpha-Chlordane**																		
0.5	***Gamma-Chlordane**																		
1.0	***Toxaphene**																		
0.5	***Aroclor-1016**																		
0.5	***Aroclor-1221**																		
0.5	***Aroclor-1232**																		
0.5	***Aroclor-1242**																		
0.5	***Aroclor-1248**																		
1.0	***Aroclor-1254**																		
1.0	***Aroclor-1260**																		

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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J = BELOW QUANTIFIABLE RANGE ; ESTIMATED

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DATA SUMMARY FORM: PESTICIDES AND PCBS

Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	MW-6B		MW-3B		MW-5B		MW-5BD		MW-4A		MW-4B		MW-4BD		MW-BL2		
	Dilution Factor																	
	Location	65195		65196		65392		65393		65394		65395		65396		65397		
CRQL	COMPOUND																	
0.05	alpha-BHC					.060		.070		.17	J	2.5		2.8				
0.05	beta-BHC							.050		.70		.86		84				
0.05	delta-BHC					.016	J*					.40	J*	1.0				
0.05	***Gamma-BHC (Lindane)**											.92		.42	J*			
0.05	***Heptachlor**																	
0.05	Aldrin																	
0.05	Heptachlor Epoxide																	
0.05	Endosulfan I																	
0.10	Dieldrin																	
0.10	4,4'-DDE																	
0.10	***Endrin**																	
0.10	Endosulfan II																	
0.10	4,4'-DDD																	
0.10	Endosulfan Sulfate																	
0.10	4,4'-DDT																	
0.5	***Methoxychlor**																	
0.10	Endrin ketone																	
0.5	***Alpha-Chlordane**																	
0.5	***Gamma-Chlordane**																	
1.0	***Toxaphene**																	
0.5	***Aroclor-1016**																	
0.5	***Aroclor-1221**																	
0.5	***Aroclor-1232**																	
0.5	***Aroclor-1242**																	
0.5	***Aroclor-1248**																	
1.0	***Aroclor-1254**																	
1.0	***Aroclor-1260**																	

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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J = BELOW QUANTIFIABLE RANGE; ESTIMATED

TABLE B-1

DATA SUMMARY FORM: PESTICIDES AND PCBS

Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(PPb)

Case #: ________ Sampling Date(s): ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	MW-7A		MW-5A		MW-TB3		MW-TB4		MW-5C		MW-5CD		MW-TBS		MW-5F	
	Dilution Factor																
	Location	65398		65399		65400		65401		65738		65739		65740		66069	
CRQL	COMPOUND																
0.05	alpha-BHC											.29				.023	J*
0.05	beta-BHC											.083					
0.05	delta-BHC																
0.05	***Gamma-BHC (Lindane)**											.073					
0.05	***Heptachlor**																
0.05	Aldrin																
0.05	Heptachlor Epoxide																
0.05	Endosulfan I																
0.10	Dieldrin																
0.10	4,4'-DDE																
0.10	***Endrin**																
0.10	Endosulfan II																
0.10	4,4'-DDD																
0.10	Endosulfan Sulfate																
0.10	4,4'-DDT																
0.5	***Methoxychlor**																
0.10	Endrin ketone																
0.5	***Alpha-Chlordane**																
0.5	***Gamma-Chlordane**																
1.0	***Toxaphene**																
0.5	***Aroclor-1016**																
0.5	***Aroclor-1221**																
0.5	***Aroclor-1232**																
0.5	***Aroclor-1242**																
0.5	***Aroclor-1248**																
1.0	***Aroclor-1254**																
1.0	***Aroclor-1260**																

CRDL = Contract Required Detection Limit

*Action Level Exists

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* E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-1

DATA SUMMARY FORM: INORGANICS

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Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(PPb)

Case #: ______ Sampling Date(s): ______

+Due to dilution, sample quantitation limit is affected
See dilution table for specifics.

CRDL	Sample No.	MW-1A	MW-1B	MW-BL1	MW-TBI	MW-2B	MW-2A	MW-3A	MW-6A	MW-6B
	Dilution Factor									
	Location	64993	64994	64995	64996	65191	65192	65193	65194	65195
CRDL	ANALYTE									
200	Aluminum	59600	3540		NA ↓		120,000	64,400	33700	5150
60	Antimony									
10	*Arsenic	26.5	11.8			14.5	38.0	16.5	15.9	9.4
200	Barium	821					8350	649	1280	
5	Beryllium									
5	*Cadmium	21.5	8.4				39.8	21.0	6.0	
5000	Calcium	699,000	588,000			348,000	1,070,000	840,000	75800	312000
10	*Chromium	863	51.1				323	242	123	21.1
50	Cobalt	653					131			
25	Copper	272	61.4				721	235	254	
100	Iron	186,000	20,000	108		1290	348,000	152,000	73,400	11,100
5	*Lead	904	63.2				885	322	477	53.9
5000	Magnesium	113,000	64,900			26,800	40,100	158,000	72,000	53,700
15	Manganese	3140	844			365	7130	4440	1780	393
0.2	Mercury	216	11.9				2.9	5.4		.29
40	*Nickel	1280					419	178	115	
5000	Potassium	18,200	14,800			11,600	40,200	9320	31,800	10,000
5	Selenium									
10	Silver									
5000	Sodium	160,000	23,300			166,000	136,000	15,900	31,400	253,000
10	Thallium									
50	Vanadium	87.1					353	133	71.9	
20	Zinc	1610	3230	85.8		74.3	3580	2320	882	391
10	*Cyanide	24.2	84.0			298	256	11.0	34.0	-180

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

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DATA SUMMARY FORM: INORGANICS

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Site Name: 3163 BUFFALO AVENUE

WATER SAMPLES
(ug/L)(PPb)

Case #: ________ Sampling Date(s): ________

+Due to dilution, sample quantitation limit is affected
See dilution table for specifics.

CRDL	Sample No.	MW-3B	MW-5B	MW-5BD	MW-4A	MW-4B	MW-4BD	MW-BL2	MW-7A	MW-5A	
	Dilution Factor										
	Location	65196	65392	65393	65394	65395	65396	65397	65398	65399	
CRDL	ANALYTE										
200	Aluminum	471	9770	9160	74200	5620	5230		59300	12600	
60	Antimony										
10	***Arsenic**	14.8	12.5	11.0	18.5				69.7	13.2	
200	Barium	97.7			734				1400	1500	
5	Beryllium										
5	***Cadmium**		10.5	10.7	37.0				46.2	39.6	
5000	Calcium	249,000	1,090,000	940,000	1,360,000	400,000	353,000		496,000	1,290,000	
10	***Chromium**	46.4	38.2	63.7	128	38.5	54.5		252	260	
50	Cobalt	13.0			62.1				60.9	112	
25	Copper		40.1	28.2	229		17.1		861.	531	
100	Iron	7640	27,500	27,800	151,000	10100	9990		280,000	292,000	
5	***Lead**	14.7	524	485	481	51.0	52.0		3430	424	
5000	Magnesium	22,600	435,000	302,000	283000	45300	46,200		135,000	245,000	
15	Manganese	363	2530	2170	7270	472	490		4030	7230	
0.2	Mercury	.24			.92				3.7	2.1	
40	***Nickel**			37.1	182	230			271	339	
5000	Potassium	16,000	14100	12900	13,100	11700	12,600		164,000	11000	
5	Selenium										
10	Silver										
5000	Sodium	235,000	121,000	109,000	67500	113000	127,000		159,000	21700	
10	Thallium										
50	Vanadium				155	367	10.0		164	255	
20	Zinc	408	1490	1420	5170	30.0			8690	2320	
10	***Cyanide**	1890		21.0			10.0		30.0		

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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TABLE B-1

DATA SUMMARY FORM: INORGANICS

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

WATER SAMPLES
(ug/L) (PPb)

+Due to dilution, sample quantitation limit is affecte
See dilution table for specifics.

CRDL	ANALYTE										
	Sample No.	MW-TB3	MW-TB4	MW-5C	MW-5CD	MW TB5	MW-5F				
	Dilution Factor										
	Location	65400	65401	65738	65739	65740	66069				
		NA	NA			NA					
200	Aluminum	↓	↓	2240	982	↓	1680				
60	Antimony										
10	***Arsenic**			35.5							
200	Barium										
5	Beryllium										
5	***Cadmium**										
5000	Calcium			121,000	630,000		563000				
10	***Chromium**			33.5	24.3		88.0				
50	Cobalt										
25	Copper										
100	Iron			7290	3730		2650				
5	***Lead**			67.0	86.0		21.9				
5000	Magnesium			30,700	144,000		88100				
15	Manganese			218	584		93.2				
0.2	Mercury			.43							
40	***Nickel**										
5000	Potassium			11800	11200		10200				
5	Selenium										
10	Silver										
5000	Sodium			1380000	255000		196000				
10	Thallium										
50	Vanadium										
20	Zinc			486	400		177				
10	***Cyanide**			2540	825						

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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DATA SUMMARY FORM: VOLATILES 1

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-1B2		SB-1BC				SB-2A2		SB-2AC		SB-5B2		SB-5BC		DU-5BC			
	Dilution Factor																		
	% Moisture																		
	Location	56049		56050				57225		57308		58105		58106		58107			
CRQL	**COMPOUND**																		
10	Chloromethane																		
10	Bromomethane																		
10	Vinyl Chloride																		
10	Chloroethane																		
5	Methylene Chloride																		
10	Acetone																		
5	Carbon Disulfide																		
5	1,1-Dichloroethene																		
5	1,1-Dichloroethane																		
5	Total-1,2-Dichloroethene																		
5	Chloroform																		
5	1,2-Dichloroethane																		
10	2-Butanone																		
5	1,1,1-Trichloroethane																		
5	Carbon Tetrachloride																		
10	Vinyl Acetate																		
5	Bromodichloromethane																		

CRDL = Contract Required Detection Limit

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TABLE 3-2

DATA SUMMARY FORM: VOLATILES 1

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture/100)

	Sample No.	SB-3A2		SB-3AC		SB-6A2		SB-6AC		SB-4AC		SB-7A2		SB-7AC		SB-4A2			
	Dilution Factor																		
	% Moisture																		
	Location	58161		58162		58250		58251		58517		58563		58564		61038			
CRQL	**COMPOUND**																		
10	Chloromethane																		
10	Bromomethane																		
10	Vinyl Chloride																		
10	Chloroethane																		
5	Methylene Chloride																		
10	Acetone																		
5	Carbon Disulfide																		
5	1,1-Dichloroethene																		
5	1,1-Dichloroethane																		
5	Total-1,2-Dichloroethene																		
5	Chloroform																		
5	1,2-Dichloroethane																		
10	2-Butanone																		
5	1,1,1-Trichloroethane																		
5	Carbon Tetrachloride																		
10	Vinyl Acetate																		
5	Bromodichloromethane																		

CRDL = Contract Required Detection Limit

SEE NARRATIVE FOR CODE DEFINITIONS

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DATA SUMMARY FORM: VOLATILES 1

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SE-01	SB-E	SB-D	SB-C	SB-A	SB-B	SB-J	SB-JD	
	Dilution Factor									
	% Moisture									
	Location	61318	68845	69002	69003	69004	69005	69006	69006	
CRQL	**COMPOUND**									
10	Chloromethane									
10	Bromomethane									
10	Vinyl Chloride									
10	Chloroethane									
5	Methylene Chloride									
10	Acetone	200								
5	Carbon Disulfide		220,000							
5	1,1-Dichloroethene									
5	1,1-Dichloroethane									
5	Total-1,2-Dichloroethene									
5	Chloroform									
5	1,2-Dichloroethane									
10	2-Butanone									
5	1,1,1-Trichloroethane									
5	Carbon Tetrachloride									
10	Vinyl Acetate									
5	Bromodichloromethane									

CRDL = Contract Required Detection Limit

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DATA SUMMARY FORM: VOLATILES 1

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-I	SB-F	SB-H	SB-G	SE-2				
	Dilution Factor									
	% Moisture									
	Location	69181	69183	69184	69185	67818				
CRQL	COMPOUND									
10	Chloromethane									
10	Bromomethane									
10	Vinyl Chloride									
10	Chloroethane									
5	Methylene Chloride									
10	Acetone									
5	Carbon Disulfide	96,000	780,000	290,000	2,200,000					
5	1,1-Dichloroethene									
5	1,1-Dichloroethane									
5	Total-1,2-Dichloroethene									
5	Chloroform									
5	1,2-Dichloroethane									
10	2-Butanone									
5	1,1,1-Trichloroethane									
5	Carbon Tetrachloride									
10	Vinyl Acetate									
5	Bromodichloromethane									

CRDL = Contract Required Detection Limit

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DATA SUMMARY FORM: VOLATILES 2

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ________ **Sampling Date(s):** ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

CRQL	COMPOUND									
	Sample No.	SB-1B2	SB-1BC		SB-2A2	SB-2AC	SB-5B2	SB-5BC	DU-5BC	
	Dilution Factor									
	% Moisture									
	Location	56049	56050		57225	57308	58105	58106	58107	
5	1,2-Dichloropropane									
5	Cis-1,3-Dichloropropene									
5	Trichloroethene							260 J*		
5	Dibromochloromethane									
5	1,1,2-Trichloroethane									
5	Benzene	68,000	120,000		5600	50,000				
5	Trans-1,3-Dichloropropene									
5	Bromoform									
10	4-Methyl-2-pentanone									
10	2-Hexanone									
5	Tetrachloroethene									
5	1,1,2,2-Tetrachloroethane									
5	Toluene						280 J*	290 J*		
5	Chlorobenzene	430,000 E*	280,000		90,000	490,000	280 J*			
5	Ethylbenzene									
5	Styrene									
5	Total Xylenes									

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

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*
E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-2

DATA SUMMARY FORM: VOLATILES 2

Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

SOIL SAMPLES
(ug/Kg) (PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

CRQL	Sample No.	SB-3A2	SB-3AC	SB-6A2	SB-6AC	SB-4AC	SB-7A2	SB-7AC	SB-4A2
	Dilution Factor								
	% Moisture								
	Location	58161	58162	58250	58251	58517	58563	58564	61038
CRQL	COMPOUND								
5	1,2-Dichloropropane								
5	Cis-1,3-Dichloropropene								
5	Trichloroethene								
5	Dibromochloromethane								
5	1,1,2-Trichloroethane								5 J*
5	Benzene						5300	11,000	
5	Trans-1,3-Dichloropropene								
5	Bromoform								
10	4-Methyl-2-pentanone								
10	2-Hexanone								
5	Tetrachloroethene								
5	1,1,2,2-Tetrachloroethane								
5	Toluene								
5	Chlorobenzene				560 J*		150,000	490,000	45
5	Ethylbenzene								
5	Styrene								
5	Total Xylenes			1100 J*	210 J*				4 J*

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

*
E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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DATA SUMMARY FORM: VOLATILES 2

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SE-01		SB-E		SB-D		SB-C		SB-A		SB-B		SB-J		SB-JD		
	Dilution Factor																	
	% Moisture																	
	Location	61318		68845		69002		69003		69004		69005		69006		69007		
CRQL	**COMPOUND**																	
5	1,2-Dichloropropane																	
5	Cis-1,3-Dichloropropene																	
5	Trichloroethene																	
5	Dibromochloromethane																	
5	1,1,2-Trichloroethane																	
5	Benzene	4400	E*	36,000	J*			940										
5	Trans-1,3-Dichloropropene																	
5	Bromoform																	
10	4-Methyl-2-pentanone																	
10	2-Hexanone																	
5	Tetrachloroethene																	
5	1,1,2,2-Tetrachloroethane																	
5	Toluene																	
5	Chlorobenzene	25,000		1500000		56000	J*					75000	J*	34000	J*	100,000	J*	
5	Ethylbenzene																	
5	Styrene																	
5	Total Xylenes																	

CRQL = Contract Required Quantitation Limit

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*
E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED
J = BELOW QUANTIFIABLE RANGE ; ESTIMATED

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TABLE B-2

DATA SUMMARY FORM: VOLATILES 2

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ____ **Sampling Date(s):** ____

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-I	SB-F	SB-H	SB-G	SE-2				
	Dilution Factor									
	% Moisture									
	Location	69181	69183	69184	69185	69818				
CRQL	**COMPOUND**									
5	1,2-Dichloropropane									
5	Cis-1,3-Dichloropropene									
5	Trichloroethene									
5	Dibromochloromethane									
5	1,1,2-Trichloroethane									
5	Benzene									
5	Trans-1,3-Dichloropropene									
5	Bromoform									
10	4-Methyl-2-pentanone									
10	2-Hexanone									
5	Tetrachloroethene									
5	1,1,2,2-Tetrachloroethane									
5	Toluene									
5	Chlorobenzene		19,000 J	24000 J						
5	Ethylbenzene									
5	Styrene									
5	Total Xylenes									

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

*
E=EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J BELOW QUANTIFIABLE RANGE; ESTIMATED

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DATA SUMMARY FORM: B N A S 1

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-1B2	SB-1BC		SB-2A2	SB-2AC	SB-5B2	SB-5BC	DU-5BC	
	Dilution Factor									
	% Moisture									
	Location	56049	56050		57225	57308	58105	58106	58107	
CRQL	**COMPOUND**									
330	Phenol	6100	2200 J*			360 J*				
330	bis(2-Chloroethyl)ether									
330	2-Chlorophenol	850 J*				290 J*				
330	1,3-Dichlorobenzene	110,000	39,000		7,700	15,000				
330	1,4-Dichlorobenzene	310,000 E*	150,000		24,000	65,000		51 J*		
330	Benzyl Alcohol									
330	1,2-Dichlorobenzene	250,000 E*	98,000		16,000	61,000				
330	2-Methylphenol									
330	bis(2-Chloroisopropyl)ether									
330	4-Methylphenol									
330	N-Nitroso-di-n-propylamine									
330	Hexachloroethane									
330	Nitrobenzene									
330	Isophorone							100 J*		
330	2-Nitrophenol									
330	2,4-Dimethylphenol									
1600	Benzoic Acid									
330	bis(2-Chloroethoxy)methane									
330	2,4-Dichlorophenol									
330	1,2,4-Trichlorobenzene	160,000	72000		27,000	52,000 E*				
330	Naphthalene	2600			420 J*					
330	4-Chloroaniline									

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

* E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED
J = BELOW QUANTIFIABLE RANGE ; ESTIMATED

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DATA SUMMARY FORM: B N A S 1

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-3A2		SB-3AC		SB-6A2		SB-6AC		SB-4AC		SB-7A2		SB-7AC		SB-4A2	
	Dilution Factor																
	% Moisture																
	Location	58161		58162		58250		58251		58517		58563		58564		61038	
CRQL	**COMPOUND**																
330	Phenol			210	J*	180	J*	190	J*								
330	bis(2-Chloroethyl)ether																
330	2-Chlorophenol																
330	1,3-Dichlorobenzene			60	J*	740	J*	180	J*	600	J*	73000		36,000	J*	2500	J*
330	1,4-Dichlorobenzene			160	J*	770	J*	200	J*	2700	J*	850,000		500,000		6200	
330	Benzyl Alcohol																
330	1,2-Dichlorobenzene	120	J*	1200		440	J*	110	J*	32,000		1,500,000		650,000		1600	J*
330	2-Methylphenol																
330	bis(2-Chloroisopropyl)ether																
330	4-Methylphenol			75	J*	62	J*										
330	N-Nitroso-di-n-propylamine																
330	Hexachloroethane																
330	Nitrobenzene																
330	Isophorone	3100															
330	2-Nitrophenol																
330	2,4-Dimethylphenol			64	J*												
1600	Benzoic Acid																
330	bis(2-Chloroethoxy)methane																
330	2,4-Dichlorophenol																
330	1,2,4-Trichlorobenzene			200	J*	1700		480	J*	340,000		2,100,000		730,000		51,000	
330	Naphthalene					510	J*	100	J*	920	J*	930	J*				
330	4-Chloroaniline																

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

* E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-2
DATA SUMMARY FORM: B N A S 1

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

CRQL	Sample No.	SE-01		SB-E		SB-D		SB-C		SB-A		SB-B		SB-J		SB-JD	
	Dilution Factor																
	% Moisture																
	Location	68845		68845		69002		69003		69004		69005		69006		69007	
CRQL	COMPOUND																
330	Phenol																
330	bis(2-Chloroethyl)ether																
330	2-Chlorophenol																
330	1,3-Dichlorobenzene			170,000				2200		46,000	J*	41,000	J*	160,000		140,000	J*
330	1,4-Dichlorobenzene	470,000		1,900,000				9400		97,000		79,000		940,000		930,000	
330	Benzyl Alcohol																
330	1,2-Dichlorobenzene	840,000		2,200,000				9400		360,000		300,000		2,000,000		200,000	
330	2-Methylphenol							640									
330	bis(2-Chloroisopropyl)ether																
330	4-Methylphenol							920									
330	N-Nitroso-di-n-propylamine																
330	Hexachloroethane																
330	Nitrobenzene																
330	Isophorone																
330	2-Nitrophenol																
330	2,4-Dimethylphenol							640									
1600	Benzoic Acid																
330	bis(2-Chloroethoxy)methane																
330	2,4-Dichlorophenol																
330	1,2,4-Trichlorobenzene	2,700,000		2,300,000				4200		340,000		470,000		2,100,000		1,900,000	
330	Naphthalene							170	J*								
330	4-Chloroaniline																

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

* E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-2
DATA SUMMARY RM: B N A S 1

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/

	Sample No.	SB-I		SB-F		SB-H		SB-G		SE-2				
	Dilution Factor													
	% Moisture													
	Location	69181		69183		69184		69185		69818				
CRQL	COMPOUND													
330	Phenol													
330	bis(2-Chloroethyl)ether													
330	2-Chlorophenol													
330	1,3-Dichlorobenzene	1700	J*	240,000		54,000	J*	79,000		15,000				
330	1,4-Dichlorobenzene	140,000		910,000		330,000		290,000		39,000				
330	Benzyl Alcohol													
330	1,2-Dichlorobenzene	270,000		2,400,000	E*	640,000		380,000		52,000				
330	2-Methylphenol													
330	bis(2-Chloroisopropyl)ether													
330	4-Methylphenol													
330	N-Nitroso-di-n-propylamine													
330	Hexachloroethane													
330	Nitrobenzene													
330	Isophorone													
330	2-Nitrophenol													
330	2,4-Dimethylphenol													
1600	Benzoic Acid													
330	bis(2-Chloroethoxy)methane													
330	2,4-Dichlorophenol													
330	1,2,4-Trichlorobenzene	1,900,000		2,800,000	E*	4,300,000	E*	1,100,000	E*	12000				
330	Naphthalene									840	J*			
330	4-Chloroaniline													

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITION

* E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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DATA SUMMARY FORM: B N A S **2**

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES (ug/Kg)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

CRQL	Sample No.	SB-1B2	SB-1BC		SB-2A2	SB-2AC	SB-5B2	SB-5BC	DU-5BC	
	Dilution Factor									
	% Moisture									
	Location	56049	56050		57225	57308	58105	58106	58107	
CRQL	COMPOUND									
330	Hexachlorobutadiene	99 J*			350 J*					
330	4-Chloro-3-methylphenol									
330	2-Methylnaphthalene	2300			400 J*	430 J*				
330	Hexachlorocyclopentadiene									
330	2,4,6-Trichlorophenol									
1600	2,4,5-Trichlorophenol									
330	2-Chloronaphthalene									
1600	2-Nitroaniline									
330	Dimethylphthalate									
330	Acenaphthylene	71 J*			83 J*					
330	2,6-Dinitrotoluene									
1600	3-Nitroaniline									
330	Acenaphthene				580 J*	85 J*		85 J*		
1600	2,4-Dinitrophenol	2300								
1600	4-Nitrophenol									
330	Dibenzofuran	2100			550 J*	99 J*				
330	2,4-Dinitrotoluene									
330	Diethylphthalate									
330	4-Chlorophenyl-phenylether									
330	Fluorene	2600			770 J*	100 J*		91 J*		
1600	4-Nitroaniline									
1600	4,6-Dinitro-2-methylphenol									

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

E = EXCEEDS QUANTITIABLE RANGE ; ESTIMATED

J = BELOW QUANTITIABLE RANGE ; ESTIMATED

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DATA SUMMARY FORM: B N A S 2

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ Sampling Date(s): ______

SOIL SAMPLES
(ug/Kg)(PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

CRQL	Sample No.	SB-3A2	SB-3AC	SB-6A2	SB-6AC	SB-4AC	SB-7A2	SB-7AC	SB-4A2	
	Dilution Factor									
	% Moisture									
	Location	58161	58162	58250	58251	58517	58563	58564	61038	
CRQL	COMPOUND									
330	Hexachlorobutadiene									
330	4-Chloro-3-methylphenol									
330	2-Methylnaphthalene			180 J*						
330	Hexachlorocyclopentadiene									
330	2,4,6-Trichlorophenol									
1600	2,4,5-Trichlorophenol									
330	2-Chloronaphthalene									
1600	2-Nitroaniline									
330	Dimethylphthalate									
330	Acenaphthylene			44 J*						
330	2,6-Dinitrotoluene									
1600	3-Nitroaniline									
330	Acenaphthene			340 J	49 J*	1100 J*				
1600	2,4-Dinitrophenol									
1600	4-Nitrophenol									
330	Dibenzofuran			320 J*	56 J*	220 J*				
330	2,4-Dinitrotoluene									
330	Diethylphthalate	490 J*	460 J*	85 J*	54 J	690 J*				
330	4-Chlorophenyl-phenylether									
330	Fluorene			510 J*		410 J*				
1600	4-Nitroaniline									
1600	4,6-Dinitro-2-methylphenol									

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

* E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED

J - BELOW QUANTIFIABLE RANGE ; ESTIMATED

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TABLE R-2
DATA SUMMARY RM: B N A S 2

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ________ Sampling Date(s): ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/1

CRQL	Sample No.	SE-01		SB-E		SB-D		SB-C		SB-A		SB-B		SB-J		SB-JD	
	Dilution Factor																
	% Moisture																
	Location	61318		68845		69002		69003		69004		69005		69006		69007	
CRQL	COMPOUND																
330	Hexachlorobutadiene																
330	4-Chloro-3 methylphenol																
330	2-Methylnaphthalene	3000															
330	Hexachlorocyclopentadiene																
330	2,4,6-Trichlorophenol																
1600	2,4,5-Trichlorophenol																
330	2-Chloronaphthalene																
1600	2-Nitroaniline																
330	Dimethylphthalate																
330	Acenaphthylene																
330	2,6-Dinitrotoluene																
1600	3-Nitroaniline																
330	Acenaphthene	270	J*					80	J*								
1600	2,4-Dinitrophenol																
1600	4-Nitrophenol																
330	Dibenzofuran	140	J*					75	J*								
330	2,4-Dinitrotoluene																
330	Diethylphthalate							190	J*								
330	4-Chlorophenyl-phenylether																
330	Fluorene	140	J*					54	J*								
1600	4-Nitroaniline																
1600	4,6-Dinitro-2-methylphenol																

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITION

* E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED
B = BELOW QUANTIFIABLE RANGE ; ESTIMATED

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TABLE B-2
DATA SUMMARY FORM: B N A S 2

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ____ **Sampling Date(s):** ____

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-I		SB-F		SB-H		SB-G		SE -2									
	Dilution Factor																		
	% Moisture																		
	Location	69181		69183		69184		69185		69818									
CRQL	**COMPOUND**																		
330	Hexachlorobutadiene																		
330	4-Chloro-3-methylphenol																		
330	2-Methylnaphthalene									160	J*								
330	Hexachlorocyclopentadiene																		
330	2,4,6-Trichlorophenol																		
1600	2,4,5-Trichlorophenol																		
330	2-Chloronaphthalene																		
1600	2-Nitroaniline																		
330	Dimethylphthalate																		
330	Acenaphthylene																		
330	2,6-Dinitrotoluene																		
1600	3-Nitroaniline																		
330	Acenaphthene									370	J*								
1600	2,4-Dinitrophenol																		
1600	4-Nitrophenol																		
330	Dibenzofuran																		
330	2,4-Dinitrotoluene																		
330	Diethylphthalate									60	J*								
330	4-Chlorophenyl-phenylether																		
330	Fluorene									350	J*								
1600	4-Nitroaniline																		
1600	4,6-Dinitro-2-methylphenol																		

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

* E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-2

DATA SUMMARY FORM: B N A S 3

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-1B2	SB-1BC		SB-2A2	SB-2AC	SB-5B2	SB-5BC	DU-5BC	
	Dilution Factor									
	% Moisture									
	Location	56049	56050		57225	57308	58105	58106	58107	
CRQL	COMPOUND									
330	N-Nitrosodiphenylamine									
330	4-Bromophenyl-phenylether									
330	Hexachlorobenzene	1600			1900 J*	1300 J*				
1600	Pentachlorophenol									
330	Phenanthrene	19000	2400 J*		4600	670 J*		540 J*	77 J*	
330	Anthracene	4700	590 J*		1500 J*	140 J*		91 J*		
330	Di-n-butylphthalate									
330	Fluoranthene	17000	2200 J*		5400	760 J*		600 J*	110 J*	
330	Pyrene	12,000	2000 J*		5000	650 J*		240 J*	100 J*	
330	Butylbenzylphthalate									
1600	3,3-Dichlorobenzidine									
330	Benzo(a)anthracene	7700			3000 J*	320 J*			73 J*	
330	Chrysene	8500			2800 J*	350 J*		770 J*	88 J*	
330	bis(2-Ethylhexyl)phthalate									
330	Di-n-octylphthalate									
330	Benzo(b)fluoranthene	9280	2000 J*		5500	610 J*		33,000 E*	120 J*	
330	Benzo(k)fluoranthene									
330	Benzo(a)pyrene	5100			3200 J*	320 J*		13,000	73 J*	
330	Indeno(1,2,3-cd)pyrene	3200			1900 J*	230 J*		7,000	59 J*	
330	Dibenz(a,h)anthracene	1300			580 J*			5300		
330	Benzo(g,h,i)perylene	2900			2000 J*	240 J*		8200	69 J*	

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

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*E - EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
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TABLE B-2

DATA SUMMARY FORM: B N A S 3

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ________ **Sampling Date(s):** ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-3A2	SB-3AC	SB-6A2	SB-6AC	SB-4AC	SB-7A2	SB-7AC	SB-4A2	
	Dilution Factor									
	% Moisture									
	Location	58161	58162	58251	58251	58517	58563	58564	61038	
CRQL	**COMPOUND**									
330	N-Nitrosodiphenylamine									
330	4-Bromophenyl-phenylether									
330	Hexachlorobenzene			170 J*	48 J*					
1600	Pentachlorophenol									
330	Phenanthrene	130 J*	160 J*	3300	430 J*	4800	660 J*			
330	Anthracene			1000	93 J*	1200 J				
330	Di-n-butylphthalate				70 J*					
330	Fluoranthene	110 J*	180 J*	4100	710 J*	9400	730 J*			
330	Pyrene		160 J*	4300	280 J*	7600				
330	Butylbenzylphthalate									
1600	3,3-Dichlorobenzidine									
330	Benzo(a)anthracene	250 J*		2600	450 J*	3900				
330	Chrysene	290 J*	350 J		580 J*	5000				
330	bis(2-Ethylhexyl)phthalate									
330	Di-n-octylphthalate									
330	Benzo(b)fluoranthene	370 J*	6100	3800	14,000 E*	6000				
330	Benzo(k)fluoranthene									
330	Benzo(a)pyrene	190 J*	3600	2200	6300	2600 J*	1200 J*			
330	Indeno(1,2,3-cd)pyrene	65 J*	2000	1500	2900	1700 J*				
330	Dibenz(a,h)anthracene	180 J*	3500	420 J*	2300	480 J*				
330	Benzo(g,h,i)perylene	140 J*	3800	1500	5200	1500 J	1700 J*			

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

*E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED

J BELOW QUANTIFIABLE RANGE; ESTIMATED

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DATA SUMMARY FORM: B N A S 3

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg) (PPb)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

CRQL	Sample No.	SE-01	SB-E	SB-D	SB-C	SB-A	SB-B	SB-J	SB-JD	
	Dilution Factor									
	% Moisture									
	Location	61318	68845	69002	69003	69004	69005	69006	69007	
CRQL	COMPOUND									
330	N-Nitrosodiphenylamine									
330	4-Bromophenyl-phenylether									
330	Hexachlorobenzene									
1600	Pentachlorophenol									
330	Phenanthrene	730 J*			840	1400 J*	3200 J*			
330	Anthracene				100 J*					
330	Di-n-butylphthalate									
330	Fluoranthene				860	1400 J*	2700 J*			
330	Pyrene	1100 J*			1300		3200 J*			
330	Butylbenzylphthalate									
1600	3,3-Dichlorobenzidine									
330	Benzo(a)anthracene				560					
330	Chrysene				870					
330	bis(2-Ethylhexyl)phthalate									
330	Di-n-octylphthalate									
330	Benzo(b)fluoranthene	1300 J*			1700					
330	Benzo(k)fluoranthene									
330	Benzo(a)pyrene	590 J*			650					
330	Indeno(1,2,3-cd)pyrene	570 J*			1000					
330	Dibenz(a,h)anthracene				290 J*					
330	Benzo(g,h,i)perylene	470 J*			1100					

CRQL = Contract Required Quantitation Limit

SEE NARRATIVE FOR CODE DEFINITIONS

*E = EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
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TABLE B-2

DATA SUMMARY RM: B N A S 3

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)

CRQL	Sample No.	SB-I	SB-F	SB-H	SB-G	SE-2			
	Dilution Factor								
	% Moisture								
	Location	69181	69183	69184	69185	69818			
	COMPOUND								
330	N-Nitrosodiphenylamine					86 J*			
330	4-Bromophenyl phenylether								
330	Hexachlorobenzene			12,000 J*		1500 J*			
1600	Pentachlorophenol								
330	Phenanthrene					2100 J*			
330	Anthracene					430 J*			
330	Di-n-butylphthalate								
330	Fluoranthene					2400 J*			
330	Pyrene					2000 J*			
330	Butylbenzylphthalate								
1600	3,3 Dichlorobenzidine								
330	Benzo(a)anthracene								
330	Chrysene					1300 J*			
330	bis(2-Ethylhexyl)phthalate								
330	Di-n-octylphthalate					220 J*			
330	Benzo(b)fluoranthene					2500 J*			
330	Benzo(k)fluoranthene								
330	Benzo(a)pyrene					1200 J*			
330	Indeno(1,2,3-cd)pyrene					1100 J*			
330	Dibenz(a,h)anthracene					290			
330	Benzo(g,h,i)perylene					990			

CRQL = Contract Required Quantitation Limit

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* E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED

J = BELOW QUANTIFIABLE RANGE ; ESTIMATED

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DATA SUMMARY FORM: PESTICIDES AND PCBS

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg) (PPb)

Case #: ________ Sampling Date(s): ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-1B2	SB-1BC		SB-2A2	SB-2AC	SB-5B2	SB-5BC	DU-5BC	
	Dilution Factor									
	% Moisture									
	Location	56049	56050		57225	57308	58105	58106	58107	
CRQL	COMPOUND									
8	alpha-BHC								7.8 J	
8	beta-BHC									
8	delta-BHC									
8	Gamma-BHC (Lindane)									
8	Heptachlor									
8	Aldrin									
8	Heptachlor Epoxide									
8	Endosulfan I									
16	Dieldrin									
16	4,4'-DDE									
16	Endrin									
16	Endosulfan II									
16	4,4'-DDD									
16	Endosulfan Sulfate									
16	4,4'-DDT									
80	Methoxychlor									
16	Endrin ketone									
80	Alpha-Chlordane									
80	Gamma-Chlordane									
160	Toxaphene									
80	Aroclor-1016									
80	Aroclor-1221									
80	Aroclor-1232									
80	Aroclor-1242									
80	Aroclor-1248									
160	Aroclor-1254									
160	Aroclor-1260									

CRQL = Contract Required Quantitation Limit

*E = EXCEEDS QUANTIFIABLE RANGE ; ESTIMATED

J = BELOW QUANTIFIABLE RANGE ; ESTIMATED

SEE NARRATIVE FOR CODE DEFINITIONS

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TABLE B-2
DATA SUMMARY FORM: PESTICIDES AND PCBS

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ________ Sampling Date(s): ________

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

CRQL	Sample No.	SB-3A2	SB-3AC	SB-6A2	SB-6AC	SB-4AC	SB-7A2	SB-7AC	SB-4A2	
	Dilution Factor									
	% Moisture									
	Location	58161	58162	58250	58251	58517	58563	58564	61038	
	COMPOUND									
8	alpha-BHC					74 J*				
8	beta-BHC					300				
8	delta-BHC									
8	Gamma-BHC (Lindane)					40 J*				
8	Heptachlor									
8	Aldrin									
8	Heptachlor Epoxide									
8	Endosulfan I									
16	Dieldrin			1600 J*	480 J*					
16	4,4'-DDE									
16	Endrin									
16	Endosulfan II									
16	4,4'-DDD									
16	Endosulfan Sulfate									
16	4,4'-DDT									
80	Methoxychlor									
16	Endrin ketone									
80	Alpha-Chlordane									
80	Gamma-Chlordane									
160	Toxaphene									
80	Aroclor-1016									
80	Aroclor-1221									
80	Aroclor-1232									
80	Aroclor-1242									
80	Aroclor-1248									
160	Aroclor-1254									
160	Aroclor-1260									

CRQL = Contract Required Quantitation Limit

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*E = EXCEEDS QUANTITATIVE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE; ESTIMATED

TABLE B-2

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DATA SUMMARY FORM: PESTICIDES AND PCBS

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(ug/Kg)(PPb)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SE-01		SB-E		SB-D		SB-C		SB-A		SB-B		SB-J		SB-JD			
	Dilution Factor																		
	% Moisture																		
	Location	61318		68845		69002		69003		69004		69005		69006		69007			
CRQL	COMPOUND																		
8	alpha-BHC																		
8	beta-BHC																		
8	delta-BHC																		
8	Gamma-BHC (Lindane)																		
8	Heptachlor																		
8	Aldrin																		
8	Heptachlor Epoxide																		
8	Endosulfan I																		
16	Dieldrin																		
16	4,4'-DDE																		
16	Endrin																		
16	Endosulfan II																		
16	4,4'-DDD																		
16	Endosulfan Sulfate																		
16	4,4'-DDT																		
80	Methoxychlor																		
16	Endrin ketone																		
80	Alpha-Chlordane																		
80	Gamma-Chlordane																		
160	Toxaphene																		
80	Aroclor-1016																		
80	Aroclor-1221																		
80	Aroclor-1232																		
80	Aroclor-1242																		
80	Aroclor-1248																		
160	Aroclor-1254																		
160	Aroclor-1260			451	J*														

CRQL = Contract Required Quantitation Limit

*E - EXCEEDS QUANTIFIABLE RANGE; ESTIMATED
J - BELOW QUANTIFIABLE RANGE; ESTIMATED

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TABLE B-2

DATA SUMMARY FORM: PESTICIDES AND PCBS

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ Sampling Date(s): ______

SOIL SAMPLES
(ug/Kg)(PPb)

To calculate sample quantitation limit:
(CRQL * Dilution Factor) / ((100 - % moisture)/100)

	Sample No.	SB-I		SB-F		SB-H		SB-G		SE-2									
	Dilution Factor																		
	% Moisture																		
	Location	69181		69183		69184		69185		69818									
IQL	COMPOUND																		
8	alpha-BHC																		
8	beta-BHC																		
8	delta-BHC																		
8	Gamma-BHC (Lindane)																		
8	Heptachlor																		
8	Aldrin																		
8	Heptachlor Epoxide																		
8	Endosulfan I																		
16	Dieldrin																		
16	4,4'-DDE																		
16	Endrin																		
16	Endosulfan II																		
16	4,4'-DDD																		
16	Endosulfan Sulfate																		
16	4,4'-DDT																		
80	Methoxychlor																		
16	Endrin ketone																		
80	Alpha-Chlordane																		
80	Gamma-Chlordane																		
160	Toxaphene																		
80	Aroclor-1016																		
80	Aroclor-1221																		
80	Aroclor-1232																		
80	Aroclor-1242																		
80	Aroclor-1248																		
160	Aroclor-1254																		
160	Aroclor-1260																		

CRQL = Contract Required Quantitation Limit

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TABLE B-2

DATA SUMMARY FORM: INORGANICS

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(mg/Kg)(PPm)

Case #: ______ Sampling Date(s): ______

+Due to dilution, sample quantitation limit is affected.
See dilution table for specifics.

	Sample No.	SB-1B2	SB-1BC		SB-2A2	SB-2AC	SB.-5B2	SB-5BC	DU-5BC	SB-3A2	
	Dilution Factor										
	% Solids										
	Location	56049	56050		57225	57308	58105	58106	58107	58161	
CRDL	ANALYTE										
40	Aluminum	19900	6750		10,000	6310	8290	7180	9910	3320	
12	Antimony										
2	Arsenic	5.3	4.8		23.6	13.3	4.4	3.8	4.6	3.1	
40	Barium	326	188		10,200	6340	97.1	84.7	150	59.7	
1	Beryllium					.48					
1	Cadmium	3.6	4.2		5.6	2.9	1.4	1.7	2.0		
1000	Calcium	68,700	52,200		70,800	46,600	16,400	74,300	30,700	6730	
2	Chromium	112	277		37.2	28.7	14.8	14	25.1	21.5	
10	Cobalt	29.9			12.9						
5	Copper	60.9	142		1870	162	19.4	28.4	24.6	23.1	
20	Iron	34,600	38,800		18300	14,400	13,400	17,600	16300	7690	
1	***Lead**	547	3,180		634	225	51.2	60.9	82.9	125	
1000	Magnesium	5260	18,000		13800	17400	4520	10,600	7740	1290	
3	Manganese	651	406		364	309	410	395	577	95	
0.2	Mercury	443	111		4.4	15.5	.68	.52		.92	
8	Nickel	435	210		98.3	55.9	14.8		18.1		
1000	Potassium										
1	Selenium										
2	Silver										
1000	Sodium	5260			1420						
2	Thallium										
10	Vanadium	30.1	13.7		33.4	17.3	13.9	18.5	19.5		
4	Zinc	769	394		1140	488	129	93.6	225	362	
2	Cyanide				82.1	25.5			4.8		

CRDL = Contract Required Detection Limit

*Action Level Exists

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DATA SUMMARY FORM: INORGANICS

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Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(mg/Kg) (ppm)

Case #: ________ Sampling Date(s): ________

+Due to dilution, sample quantitation limit is affected.
See dilution table for specifics.

CRDL	Sample No.	SB-3AC	SB-6A2	SB-6AC	SB-4AC	SB-7A2	SB-7AC	SB-4A2	SE-01	SB-D	
	Dilution Factor										
	% Solids										
	Location	58162	58250	58251	58517	58563	58564	61038	61318	69002	
CRDL	ANALYTE										
40	Aluminum	4810	8480	5110	7180	2080	4960	9440	8230	30100	
12	Antimony										
2	Arsenic	3.0	6.6	6.3	3.5	4.9	3.7	2.5	23.4	13.6	
40	Barium	81.4	1940	2200	111	513	104	96.7	21100	623	
1	Beryllium				.47						
1	Cadmium	1.9	11.8	4.5	2.9	14.7	3.2	1.8	38.6	12.7	
1000	Calcium	24700	93,800	55900	107,000	34,200	25300	53700	35700	61100	
2	Chromium	30.0	44.8	30.6	12.6	71.9	186	14.2	92.3	49.0	
10	Cobalt								28.5		
5	Copper	31.9	643	333	28.7	643	116	29.8	8860	339	
20	Iron	12,900	21,500	15,100	12500	120,000	20200	14100	51800	31200	
1	*Lead	185	621	386	38.0	1080	286	24.2	18700	1360	
1000	Magnesium	7540	11,300	13800	33400		1690	11800	18200	10400	
3	Manganese	285	307	248	565	713	266	244	654	629	
0.2	Mercury	2.9	.44	38.6	1.1	.26	.36	6.4	5.8	23.3	
8	Nickel		79.4	36.2	11.7	36.6	13.7	13.7	242	37.2	
1000	Potassium									4590	
1	Selenium								6.2		
2	Silver								5.4		
1000	Sodium										
2	Thallium		.52	.49							
10	Vanadium	12.1	26.6	15.9	15.9	42.7	13.9	19.4	54.9	53.3	
4	Zinc	267	1690	1070	613	1990	952	486	34700	7900	
2	Cyanide		19.4	3.5				3.9			

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

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TABLE B-2
DATA SUMMARY FORM: I N O R G A N I C S

Page 27 of 28

Site Name: 3163 BUFFALO AVENUE

SOIL SAMPLES
(mg/Kg)(ppm)

Case #: ______ Sampling Date(s): ______

+Due to dilution, sample quantitation limit is affected.
See dilution table for specifics.

CRDL	Sample No.	SB-C	SB-A	SB-B	SB-J	SB-JD	SB-I	SB-F	SB-H	SB-G
	Dilution Factor									
	% Solids									
	Location	69003	69004	69005	69006	69007	69181	69183	69184	69185
CRDL	ANALYTE									
40	Aluminum	8930	9500	21500	7140	10700	9970	16300	8980	13100
12	Antimony								75.3	
2	Arsenic	26.8	13.1	104	14.8	20.8	14.7	13.9	39.1	19.4
40	Barium	31.5	5230	19200	370	545	848	869	428	958
1	Beryllium									
1	Cadmium	14.4	17.2	8.7	3.7	7.3	55.0	21.0	74.8	12.6
1000	Calcium	23,800	80500	184000	49600	37,300	48700	79600	23400	143000
2	Chromium	33.6	91.8	1530	182	356	81.4	54.6	80.4	200
10	Cobalt		18.4	61.6						
5	Copper	285	1020	352	248	516	877	518	8180	468
20	Iron	34,600	94100	56300	20,000	26,400	46200	35500	69900	45600
1	***Lead**	1110	1920	752	1180	2790	7240	779	31600	1520
1000	Magnesium	5130	21400	49600	16600	13,600	17300	25400	11,700	69700
3	Manganese	376	770	1480	298	305	591	1080	495	903
0.2	Mercury	19.2	23.4	22.5	2.9	5.7	2.0	1.4	3.9	1.6
8	Nickel	27.4	108	128	31.3	40.7	41.4	42.9	54.4	46.7
1000	Potassium			4900			1070	1560		
1	Selenium								13.4	
2	Silver								16.4	
1000	Sodium									
2	Thallium									
10	Vanadium	33.7	34.5	47.6	22.7	32.1	24.3	38.0	87.4	32.6
4	Zinc	5890	10200	1820	4110	12100	26500	18200	56,900	7600
2	Cyanide		5.6	1.8	3.2	6.1	1.5			

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

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TABLE B-2
DATA SUMMARY FORM: INORGANICS

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ Sampling Date(s): ______

SOIL SAMPLES
(mg/Kg)(ppm)

+Due to dilution, sample quantitation limit is affected.
See dilution table for specifics.

CRDL	ANALYTE										
	Sample No.	SE-2	SB-E								
	Dilution Factor										
	% Solids										
	Location	69818	68845								
40	Aluminum	8870	9060								
12	Antimony										
2	Arsenic	5.1	18.7								
40	Barium	873	191								
1	Beryllium										
1	Cadmium	10.4	4.0								
1000	Calcium	70600	45800								
2	Chromium	42.8	24.1								
10	Cobalt										
5	Copper	488	644								
20	Iron	18900	24500								
1	***Lead**	1370	627								
1000	Magnesium	24100	18700								
3	Manganese	603	401								
0.2	Mercury	1.2	3.6								
8	Nickel	22.8	20.3								
1000	Potassium		1460								
1	Selenium										
2	Silver	3.9									
1000	Sodium										
2	Thallium										
10	Vanadium	21.1	27.5								
4	Zinc	8000	1530								
2	Cyanide										

CRDL = Contract Required Detection Limit

*Action Level Exists

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Page 1 of 7

DATA SUMMARY FORM: VOLATILES 1

Site Name: 3163 BUFFALO AVENUE

NAPL SAMPLES
(ug/L)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	COMPOUND										
	Sample No.	SB-1B NA		MW-2B							
	Dilution Factor										
	Location	56354		69384							
10	Chloromethane										
10	Bromomethane										
10	***Vinyl Chloride**										
10	Chloroethane										
5	***Methylene Chloride**										
10	Acetone										
5	Carbon Disulfide			1100000							
5	***1,1-Dichloroethene**										
5	1,1-Dichloroethane										
5	***Total-1,2-Dichloroethene**			31000	J*						
5	Chloroform										
5	***1,2-Dichloroethane**										
10	***2-Butanone**										
5	***1,1,1-Trichloroethane**										
5	***Carbon Tetrachloride**										
10	Vinyl Acetate										
5	Bromodichloromethane										

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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* E = EXCEEDS QUANTIFIABLE RANGE, ESTIMATED

J = BELOW QUANTIFIABLE RANGE, ESTIMATED

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TAB E B-3

Page 2 of 7

DATA SUMMARY FORM: VOLATILES 2

Site Name: 3163 BUFFALO AVENUE

NAPL SAMPLES
(ug/L)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	SB-1B-NA		MW-2B								
	Dilution Factor											
	Location	56354		69384								
CRQL	COMPOUND											
5	***1,2-Dichloropropane**											
5	Cis-1,3-Dichloropropene											
5	Trichloroethene											
5	Dibromochloromethane											
5	1,1,2-Trichloroethane											
5	***Benzene**	160 000		120,0000								
5	Trans-1,3-Dichloropropene											
5	Bromoform											
10	4-Methyl-2-pentanone											
10	2-Hexanone											
5	***Tetrachloroethene**			210,000								
5	1,1,2,2-Tetrachloroethane											
5	***Toluene**			67,000								
5	***Chlorobenzene**	290,000		11,000,000								
5	***Ethylbenzene**			16,000	J*							
5	***Styrene**											
5	***Total Xylenes**			36000	J*							

CRDL = Contract Required Detection Limit

*Action Level Exists

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* E = EXCEEDS QUANTIFIABLE RANGE, ESTIMATED

J = BELOW QUANTIFIABLE RANGE, ESTIMATED

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TABLE B-3

DATA SUMMARY FORM: B N A S 1

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Site Name: 3163 BUFFALO AVENUE

NAPL SAMPLES
(ug/L)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

CRQL	COMPOUND												
	Sample No.	SB-1B-NA		MW-2B									
	Dilution Factor												
	Location	56354		69384									
10	Phenol	2900											
10	bis(2-Chloroethyl)ether												
10	2-Chlorophenol	470	J*										
10	***1,3-Dichlorobenzene**	11,000		45,200									
10	***1,4-Dichlorobenzene**	37,000	E*	188000									
10	Benzyl Alcohol												
10	1,2-Dichlorobenzene	28,000		287,000									
10	2-Methylphenol												
10	bis(2-Chloroisopropyl)ether												
10	4-Methylphenol												
10	N-Nitroso-di-n-propylamine												
10	Hexachloroethane												
10	Nitrobenzene												
10	Isophorone												
10	2-Nitrophenol												
10	2,4-Dimethylphenol												
50	Benzoic Acid												
10	bis(2-Chloroethoxy)methane												
10	2,4-Dichlorophenol												
10	1,2,4-Trichlorobenzene	14000		123,000									
10	Naphthalene	83	J*										
10	4-Chloroaniline												

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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* E = EXCEEDS QUANTIFIABLE RANGE, ESTIMATED

J: BELOW QUANTIFIABLE RANGE, ESTIMATED

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TABLE B-3

DATA SUMMARY FORM: B N A S 2

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Site Name: 3163 BUFFALO AVENUE

NAPL SAMPLES
(ug/L)

Case #: ______ **Sampling Date(s):** ______

To calculate sample quantitation limit: (CRQL * Dilution Factor)

	Sample No.	SB-1B-NA		MW-2B															
	Dilution Factor																		
	Location	56354		69384															
CRQL	**COMPOUND**																		
10	Hexachlorobutadiene	72	J*																
10	4-Chloro-3-methylphenol																		
10	2-Methylnaphthalene																		
10	Hexachlorocyclopentadiene																		
10	2,4,6-Trichlorophenol																		
50	2,4,5-Trichlorophenol																		
10	2-Chloronaphthalene																		
50	2-Nitroaniline																		
10	Dimethylphthalate																		
10	Acenaphthylene																		
10	2,6-Dinitrotoluene																		
50	3-Nitroaniline																		
10	Acenaphthene																		
50	2,4-Dinitrophenol																		
50	4-Nitrophenol																		
10	Dibenzofuran																		
10	2,4-Dinitrotoluene																		
10	Diethylphthalate																		
10	4-Chlorophenyl-phenylether																		
10	Fluorene																		
50	4-Nitroaniline																		
50	4,6-Dinitro-2-methylphenol																		

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

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* E = EXCEEDS QUANTIFIABLE RANGE, ESTIMATED

J = BELOW QUANTIFIABLE RANGE, ESTIMATED

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TABLE B-3

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DATA SUMMARY FORM: B N A S 3

Site Name: 3163 BUFFALO AVENUE

NAPL SAMPLES
(ug/L)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	SB-1B-NA		MW-2B															
	Dilution Factor																		
	Location	56354		69384															
CRDL	**COMPOUND**																		
10	N-Nitrosodiphenylamine																		
10	4-Bromophenyl-phenylether																		
10	***Hexachlorobenzene**																		
50	***Pentachlorophenol**																		
10	Phenanthrene	90	J*																
10	Anthracene																		
10	Di-n-butylphthalate																		
10	Fluoranthene	94	J*																
10	Pyrene	76	J*																
10	Butylbenzylphthalate																		
20	3,3-Dichlorobenzidine																		
10	Benzo(a)anthracene																		
10	Chrysene																		
10	bis(2-Ethylhexyl)phthalate																		
10	Di-n-octylphthalate																		
10	Benzo(b)fluoranthene	76	J*																
10	Benzo(k)fluoranthene																		
10	Benzo(a)pyrene																		
10	Indeno(1,2,3-cd)pyrene																		
10	Dibenz(a,h)anthracene																		
10	Benzo(g,h,i)perylene																		

CRDL = Contract Required Detection Limit ***Action Level Exists** **SEE NARRATIVE FOR CODE DEFINITIONS**

* E EXCEEDS QUANTIFIABLE RANGE, ESTIMATED
J: BELOW QUANTIFIABLE RANGE, ESTIMATED

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TABLE B-3

Page 6 of 7

DATA SUMMARY FORM: PESTICIDES AND PCBS

Site Name: 3163 BUFFALO AVENUE

NAPL SAMPLES
(ug/L)

Case #: ______ Sampling Date(s): ______

To calculate sample quantitation limit:
(CRQL * Dilution Factor)

	Sample No.	SB-1B-NA	MW-2B							
	Dilution Factor									
CRQL	Location COMPOUND	Not run for Pesticides NR	Not run for Pesticides NR							
0.05	alpha-BHC	↓	↓							
0.05	beta-BHC									
0.05	delta-BHC									
0.05	***Gamma-BHC (Lindane)**									
0.05	***Heptachlor**									
0.05	Aldrin									
0.05	Heptachlor Epoxide									
0.05	Endosulfan I									
0.10	Dieldrin									
0.10	4,4'-DDE									
0.10	***Endrin**									
0.10	Endosulfan II									
0.10	4,4'-DDD									
0.10	Endosulfan Sulfate									
0.10	4,4'-DDT									
0.5	***Methoxychlor**									
0.10	Endrin ketone									
0.5	***Alpha-Chlordane**									
0.5	***Gamma-Chlordane**									
1.0	***Toxaphene**									
0.5	***Aroclor-1016**									
0.5	***Aroclor-1221**									
0.5	***Aroclor-1232**									
0.5	***Aroclor-1242**									
0.5	***Aroclor-1248**									
1.0	***Aroclor-1254**									
1.0	***Aroclor-1260**									

CRDL = Contract Required Detection Limit

*Action Level Exists

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* E = EXCEEDS QUANTFIABLE RANGE; ESTIMATED
J = BELOW QUANTIFIABLE RANGE, ESTIMATED

TABLE B-3

DATA SUMMARY FORM: INORGANICS

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Site Name: 3163 BUFFALO AVENUE

Case #: ______ **Sampling Date(s):** ______

NAPL SAMPLES
(ug/L)

+Due to dilution, sample quantitation limit is affected
See dilution table for specifics.

	Sample No.	SB-1B-NA	MW-2B								
	Dilution Factor										
	Location	Not run for Metals	Not run for metals								
CRDL	ANALYTE	NR ↓	NR ↓								
200	Aluminum										
60	Antimony										
10	***Arsenic**										
200	Barium										
5	Beryllium										
5	***Cadmium**										
5000	Calcium										
10	***Chromium**										
50	Cobalt										
25	Copper										
100	Iron										
5	***Lead**										
5000	Magnesium										
15	Manganese										
0.2	Mercury										
40	***Nickel**										
5000	Potassium										
5	Selenium										
10	Silver										
5000	Sodium										
10	Thallium										
50	Vanadium										
20	Zinc										
10	***Cyanide**										

CRDL = Contract Required Detection Limit *Action Level Exists SEE NARRATIVE FOR CODE DEFINITIONS

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Table B-4
Tentatively Identified Compounds (TIC's)
Soil Samples

Compound	R.I. Value (min)	SB-4A2 61038	SB-E 68845	SB-D 69002	SB-C 69003	SB-A 69004	SB-B 69005	SB-J 69006	SB-JD 69007	SB-I 69181	SB-F 69183	SB-H 69184	SB-G 69185
Volatiles:													
Benzene, trichloro isomer	28.98 - 29.57	1700J											2,500000
Benzene, trimethyl	22.79	4.8 J											
SEMIVOLATILES:													
Anthracene, methyl					240 J								
Benzene, Bromochloro	11.22 - 11.34		65,000J										
Benzene, Tetrachloro, isomer	13.96 -				240 J								
Benzene, Tetrachloro, isomer	15.13 - 15.34				240J			73,000J			160,000	340,000J	
Benzine, Tetrachloro, isomer	15.96 16.19		29,000J		690J			110,000J	73,000J		280,000	730,000J	24,000 J
Benzene, trichloro, is	12.98 - 13.22		270,000J	83,000J	830 J	49,000J	82,000J	350,000J	320,000J		320,000J	1,400,000J	130,000 J
Benzene, trichloro ethyl	16.59												
Benzene 1,2,4 trichloro 3 methyl	15.29												
Benzenamine, trichloro, is.	16.49				1700J								
1,3 Isobenzo- furandione	15.44												
2,3,4,5,6 Penta- cloroethyibe	22.09 - 22.14												
Phenol 2-[4-hydroxyphenyl]	25.06												

Tentatively Identified compounds
(TIC's)
Soil Samples

ompound	RI (min)	SB 1B2 56049	SB 1BC 56050	SB 2A2 57235	SB 2AC 57308	SB 5B2 58105	SB 5BC 58106	DU-5BC 58107	SB 3A2 58161	SB 3AC 58162	SB 6A2 58250	SB 6AC 58251	SB 4AC 58511	SB 7A2 58503	SB 7AC 58504
Volatiles															
enzene, tetrachloro isomer	28.96	4800 J													
enzene, trichloro isomer	28.98 - 29.57														
enzene, trimethyl	22.79														
Semivolatiles															
nthracene, methyl															
enzene, Bromochloro	11.22 - 11.34													4800 J	
enzene, chloro methyl - isomer	8.42	2400 J													
enzene, chloro methyl isomer	8.59	1600 J													
benzene, dichloromethyl	12.32	2500 J													
enzene, tetrachloro isomer	13.96														
enzene, tetra chloro isomer	15.13 - 15.34													55,000 J	34,000 J
enzene, tetra chloro isomer	15.96 - 16.19													85,000 J	36,000 J
enzene, trichloro isomer	12.98 - 13.22												230 J	40,000 J	36,000 J
enzene, trichloro ethyl	16.59										610 J				
enzene, 1,2,4 trichloro 3 methyl	15.29										390 J				
enzenamine trichloro	16.49														
3 benzene furandione	15.44											770 J			
,3,4,5,6 Penta-chloro ethylbe	22.69 - 22.14										2500 J	930 J			
henols															
-(4 Hydroxyphenyl]	25.06														
naphthalene, tetrachloro (total of all isomers)	23.84 - 24.94										5530 J				
naphthalene, trichloro isomer											2700 J	410 J			

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Table B-4

Tentatively Identified Compounds (TIC's)

Water Samples

Compound	RF value (min)	GW-1A 64993	GW-1B 64994	GW-2B 65191	GW-2A 65192	GW-3A 6519	GW-6A 65194	GW-6B 65195	GW-3B 65196	GW-5B 65392	GW-5B D 65393	GW-4A 65394	GW-4B 65395	GW-4B D 65396
VOLATILES:														
Bromochloro Benzene is.	27.15													
Bromochloro Benzene is	28.05													
Tetrahydro thiophene	16.50							8.0J						170J
SEMIVOLATILES:														
Chloromethyl Benzene, is	8.95		33J			120J								
Chloromethyl Benzene, is	9.10		23J			80J								
Pentachlorobenzene	20.18		74J											
Tetrachloro benzene, is.	16.93-16.96	83J	500J	1800J	380J									
Tetrachloro benzene, is	17.78-17.82	92J	520J	2500J	430J									
Trichloro binzene, is	13.40							40J						
Trichloro benzene, is.	14.73-14.80	510J	1400J	9800J	1100J				760J	83J	76J	380J	110J	110J
Chlorophenol isomer	14.58-14.59	160J	73J		200J									
Chlorotoluene isomer	21.64-				380J									
Chlorotoluene isomer	21.81				270J									
Dimethyl Cresol Isomer	17.41	180J												
L-alpha terpinol	14.39				100J									
Tetrahydro thiophene	4.87-16.46			1400J							35J		1100J	
Tribromo phenol-isomer	25.64													
1-oxide tetrahydro thiophene														

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Table B-4
Tentatively Identified Compounds (TIC:)
Water Samples

Compound	RT value (min)	GW-7A 65398	GW-5A 65399	GW-5C 65738	GW-5C D 65739	GW-5F
Bromochloro benzene is.	27.15-	70 J				
Bromochloro benzene is.	28.05	100 J				
Tetrahydro thiophene	15.96- 16.50			350 J	650 J	
SEMIVOLATILES:						
Chloromethyl Benzene, is.	8.95					
Chloromethyl Benzene, is	9.10					
Pentachloro benzene	20.18					
Tetrachloro Benzene, is.	16.93- 16.96	220 J				
Tetrachloro Benzene, is	17.78- 17.82	340 J		100 J		
Trichloro benzene, is	13.40					
Trichloro benzene, is.	14.73- 14.80	2300 J		710 J	410 J	
Chlorophenol isomer	14.58- 14.59					
hlorotoluene isomer	2165					
hlorotoluene isomer	2181					
Dimethyl cresol, isomer	17.41					
alpha terpineol	14.39					
Tetrahydro thiophene	4.87- 16.46			880 J	2600 J	
ribromo phenol isom.	2564		15 J			
1-oxide tetrahydro thiophene	12.99			330 J		

Table B-4
Tentatively Identified Compounds
Sediment Samples

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c[illegible]npound	RT Value (min)	SE-1 61318	SE-2	SE-1 DL 61318 DL
OLATILES:				
enzene, chloromethyl		960J		
SEMIVOLATILES:				
enzene, pentachloro	19.23 - 19.48	39,000J		92,000 J
enzene, dichloro methyl	12.22	10,000 J		
enzene, etrachloro isomer	15.88 - 16.32	170000J	2000 J	1,000,000J
enzene, trachloro isomer	16.71 - 17.18	33,000J	3400J	1,200,000J
enzene, trachloro, isomer	17.40	10,000J		
Benzene, ichloro isomer	13.70 - 14.20	110,000J	4000 J	880,000J
enzene, trichloro hloromethyl isomer	18.67	33,000		
e zene, trichloro n[illegible]omethyl isomer	19.20	17,000		
enzene, ichloromethyl is.	15.45 - 15.67	36000J		92000J
Benzene, ichloromethyl is.	15.90	39,000J		
1, 1 Biphenyl dichloro	20.93	8500 J		
1, 1 Biphenyl dichloro	22.12	6900J		
Biphenyl trichloro	24.47	4900J		
3, 4, 5, 6 Pentachloro toluene	21.81	9,200J		

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #: 9000.352	**RE:** JD-1030
SAMPLE DATE: 02/06/90	**PO#:**
DATE RECEIVED: 02/06/90	**SAMPLED BY:** E & E INC.
SAMPLE TYPE: Water	**DELIVERED BY:** E & E INC.

E & E Lab # 90:	64993	64994	64995
Customer #:	BA-GW-1A	BA-GW-1B	BA-GW-BL-1

Results in: MG/L

Total Organic Carbon	400	340	<1.0
Total Organic Halogens	349	240	<1.0

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #:	9000.366	**RE:**	JD-1030
SAMPLE DATE:	02/07/90	**PO#:**	
DATE RECEIVED:	02/07/90	**SAMPLED BY:**	E & E INC.
SAMPLE TYPE:	Water	**DELIVERED BY:**	E & E INC.

E & E Lab # 90:	65191	65192	65193
Customer #:	BA-GW-2B	BA-GW-2A	BA-GW-3A

Results in: MG/L

Total Organic Carbon	4.0	180	78
Total Organic Halogens	350	230	0.7

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #: 9000.384

SAMPLE DATE: 02/08/90

DATE RECEIVED: 02/08/90

SAMPLE TYPE: Water

RE: JD-1030

PO#:

SAMPLED BY: E & E INC.

DELIVERED BY: E & E INC.

E & E Lab # 90:	65395	65396	65397
Customer #:	BA-GW-4B	BA-GW-4B DUP	BA-GW-BL2

Results in: MG/L

Total Organic Carbon	29	50	<1.0
Total Organic Halogens	240	580	0.023

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #:	9000.384	RE:	JD-1030
SAMPLE DATE:	02/08/90	PO#:	
DATE RECEIVED:	02/08/90	SAMPLED BY:	E & E INC.
SAMPLE TYPE:	Water	DELIVERED BY:	E & E INC.

E & E Lab # 90:	65392	65393	65394
Customer #:	BA-GW-5B	BA-GW-5B DUP	BA-GW-4A
Results in: MG/L			
Total Organic Carbon	42	110	140
Total Organic Halogens	170	120	1400

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #:	9000.384	**RE:**	JD-1030
SAMPLE DATE:	02/08/90	**PO#:**	
DATE RECEIVED:	02/08/90	**SAMPLED BY:**	E & E INC.
SAMPLE TYPE:	Water	**DELIVERED BY:**	E & E INC.

E & E Lab # 90:	65398	65399
Customer #:	BA-GW-7A	BA-GW-5A
Results in: MG/L		
Total Organic Carbon	280	360
Total Organic Halogens	1,800	1,500

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #:	9000.402	RE:	JD-1030
SAMPLE DATE:	02/09/90	PO#:	
DATE RECEIVED:	02/09/90	SAMPLED BY:	E & E INC.
SAMPLE TYPE:	Water	DELIVERED BY:	E & E INC.

E & E Lab # 90:	65738	65739
Customer #:	BA-GW-5C	BA-GW-5C-D
	Results in: MG/L	
Total Organic Carbon	70	30
Total Organic Halogens	2,100	1,300

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #:	9000.425	**RE:**	JD-1030
SAMPLE DATE:	02/13/90	**PO#:**	
DATE RECEIVED:	02/13/90	**SAMPLED BY:**	E & E INC.
SAMPLE TYPE:	Water	**DELIVERED BY:**	E & E INC.

E & E Lab # 90:	66069
Customer #:	BA-GW- 5F

Results in: MG/L

Total Organic Carbon	36
Total Organic Halogens	1,100

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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LABORATORY REPORT

FOR

SOLVENT CHEMICAL - 3163 BUFFALO AVENUE

JOB #:	9000.366	**RE:**	JD-1030
SAMPLE DATE:	02/07/90	**PO#:**	
DATE RECEIVED:	02/07/90	**SAMPLED BY:**	E & E INC.
SAMPLE TYPE:	Water	**DELIVERED BY:**	E & E INC.

E & E Lab # 90:	65194	65195	65196
Customer #:	BA-GW-6A	BA-GW-6B	BA-GW-3B
Results in: MG/L			
Total Organic Carbon	17	50	42
Total Organic Halogens	0.3	0.74	320

Analytical References: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, U.S.EPA, 1986.

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Table B-1

COMPARISON OF TOTAL ORGANICS TO TOTAL ORGANIC HALOGENS

Monitoring Well	TOX (μg/l)	Total Organics (μg/l)	TOX/ Total Organics*
1A	349,000	559,622	.624
2A	230,000	335,667	.685
3A	700	1,520	.460
4A	1,400,000	47,581	29.4
5A	1,500,000	1,164	1,288.
6A	300	148	2.03
7A	1,800,000	118,651	15.2
1B	240,000	344,357	.697
2B	350,000	322,393	1.09
3B	320,000	37,189	8.60
4B	240,000	8,037	29.86
4B (Dup)	580,000	7,878	73.62
5B	170,000	4,542	37.42
5B (Dup)	120,000	4,920	24.39
6B	740	2,525	.293
5C	2,100,000	18,404	114.
5CD	1,300,000	21,898	59.37
5F	1,100,000	3,513	313.

[IL]JD1900:D3048/4085/34

*Total organics: total detected TCL compounds plus detected TICs.

APPENDIX C

SLUG TEST DATA

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Table C-1

SLUG TESTING SUMMARY TABLE
3163 BUFFALO AVENUE
TESTING DATES: MARCH 16, 1990 - MARCH 21, 1990

Well	Aq. Type	Screen (ft)	Water Level (ft)	Bouwer-Rice Method Hydr. Cond. (gal/day/ft^2)	Bouwer-Rice Method Transmissivity (gal/day/ft^2)
Shallow Wells					
MW1A	Unconfined	4.0 - 6.0	5.16	1.4	2.81
MW2A	Unconfined	4.0 - 8.2	7.06	1.6	8.05
MW3A	Unconfined	4.5 - 8.5	6.12	1.2	7.12
MW4A	Unconfined	4.0 - 8.0	4.2	0.4	1.97
MW5A	Unconfined	6.0 - 12.5	7.87	2.5	18.96
MW6A	Unconfined	4.0 - 9.6	5.93	1.26	7.08
MW7A	Unconfined	3.5 - 7.5	4.49	18.63	93.17
Intermediate Wells					
MW1B	Unconfined	6.3 - 17.15	11.57	38.45	221.9
MW2B	Unconfined	8.2 - 20.0	9.24	3.75	45.02
MW3B	Unconfined	9.6 - 21.2	16.05	0.8	9.34
MW4B	Unconfined	8.0 - 22.5	10.62	-- NOT ENOUGH DATA --	
MW5B	Unconfined	12.5 - 21.0	18.04	1.04	8.82
MW6B	Unconfined	9.6 - 20.0	9.6	8.72	90.69
Deep Wells					
MW5C	Unconfined	26.5 - 36.5	19.32	19.17	191.72
MW5CD	Unconfined	39.5 - 51.5	23.83	24.77	297.24
MW5F	Unconfined	77.0 - 98.0	17.92	11.31	237.51

02[IL]JD1900:D3048/1262/22

Average Transmissivities:

Shallow Wells:	19.88 gpd/ft (heavily weighted by T value for SC7A)
Intermediate Wells:	75.15 gpd/ft (heavily weighted by T value for SC1B)
Deep Wells:	242.16 gpd/ft

```
                         DATA SET: SOLVEX

        CLIENT: SOLVENT CHEMICAL                              DATE: 3/13/90
      LOCATION: BUFFALO AVE.                              WELL NO.: SC1A
        COUNTY: ERIE                                   WELL DEPTH:     6.00 ft
       PROJECT: Bail-down Test                        WATER TABLE:    5.160 ft
       AQUIFER: Unknown                                 THICKNESS:     2.00 ft
 INTAKE RADIUS:   0.667 ft                         CASING RADIUS:    0.167 ft
    SCREEN TOP:   4.000 ft                           SCREEN BASE:     6.00 ft
  INITIAL HEAD:   0.680 ft                          TRANS. RATIO:  1.0000

                               MODEL PARAMETERS:

    TRANSMISSIVITY:          .000261 square ft/min

      CONDUCTIVITY:          .000130  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

    No.          TIME             Head, H (ft)
                 (mins)             DATA

      1      1.000E-04             0.730
      2        0.100               0.700
      3        0.700               0.680
      4        0.800               0.650
      5        0.950               0.640
      6        1.15                0.620
      7        1.60                0.600
      8        1.75                0.590
      9        2.10                0.560
     10        2.80                0.530
     11        3.10                0.500
     12        3.80                0.480
     13        4.10                0.460
     14        4.80                0.430
     15        5.10                0.410
     16        5.80                0.400
     17        6.10                0.380
     18        6.80                0.350
     19        7.10                0.340
     20        7.80                0.330
     21        8.10                0.260
     22        8.80                0.290
     23        9.10                0.280
```

```
No.         TIME            Head, H (ft)
           (mins)              DATA

 24         9.80               0.270
 25        11.80               0.200

 CURRENT RESOLUTION MATRIIX NOT AVAILABLE
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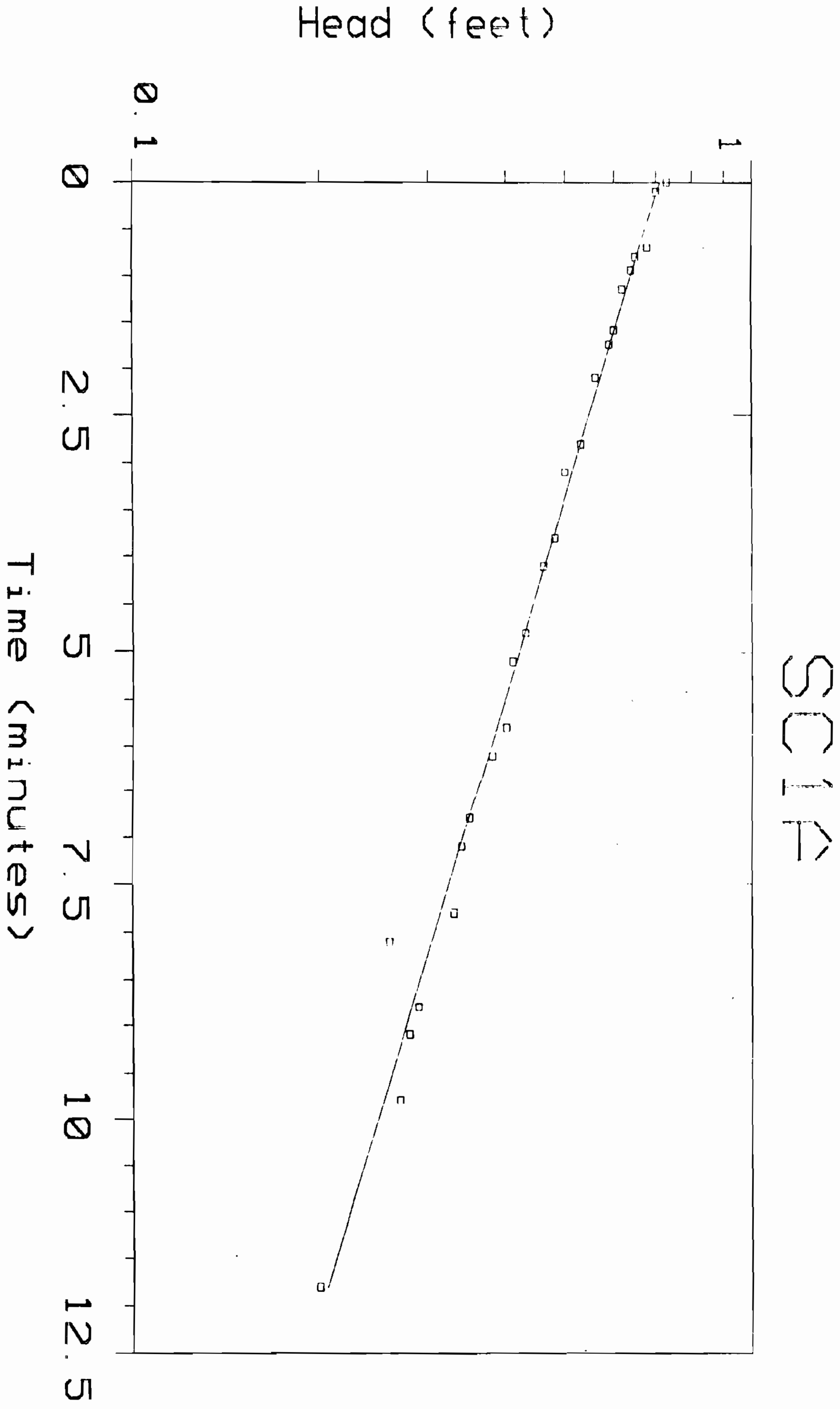
Head (feet)
0.1
1
SC1A
0
2.5
5
7.5
10
12.5
Time (minutes)

```
-----------------------     SC1B     ---------------------- PAGE 1



                  DATA SET: SC1B

      CLIENT: SOLVENT CHEMICAL                         DATE: 3/11/90
    LOCATION: BUFFALO AVE.                         WELL NO.: SC1B
      COUNTY: ERIE                               WELL DEPTH:    17.50 ft
     PROJECT: Slug test                         WATER·TABLE:   11.570 ft
     AQUIFER: Unknown                             THICKNESS:     5.76 ft
INTAKE RADIUS:   0.667 ft                    CASING RADIUS:    0.167 ft
   SCREEN TOP:   6.000 ft                       SCREEN BASE:    17.50 ft
 INITIAL HEAD:   6.760 ft                      TRANS. RATIO:   1.0000

                          MODEL PARAMETERS:

   TRANSMISSIVITY:         .0206 square ft/min

     CONDUCTIVITY:        .00357  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

   No.         TIME              Head, H (ft)            DIFFERENCE
              (mins)         DATA       SYNTHETIC         (percent)

     1      1.000E-04        6.76          6.73             0.332
     2        0.250          5.03          4.35            13.47
     3        0.500          3.34          2.81            15.84
     4        0.750          1.38          1.81           -31.55
     5        1.00           0.940         1.17           -24.73
     6        1.25           0.810         0.757            6.51
     7        1.50           0.430         0.489          -13.73
     8        1.75           0.400         0.315           21.03

    CURRENT RESOLUTION MATRIIX NOT AVAILABLE
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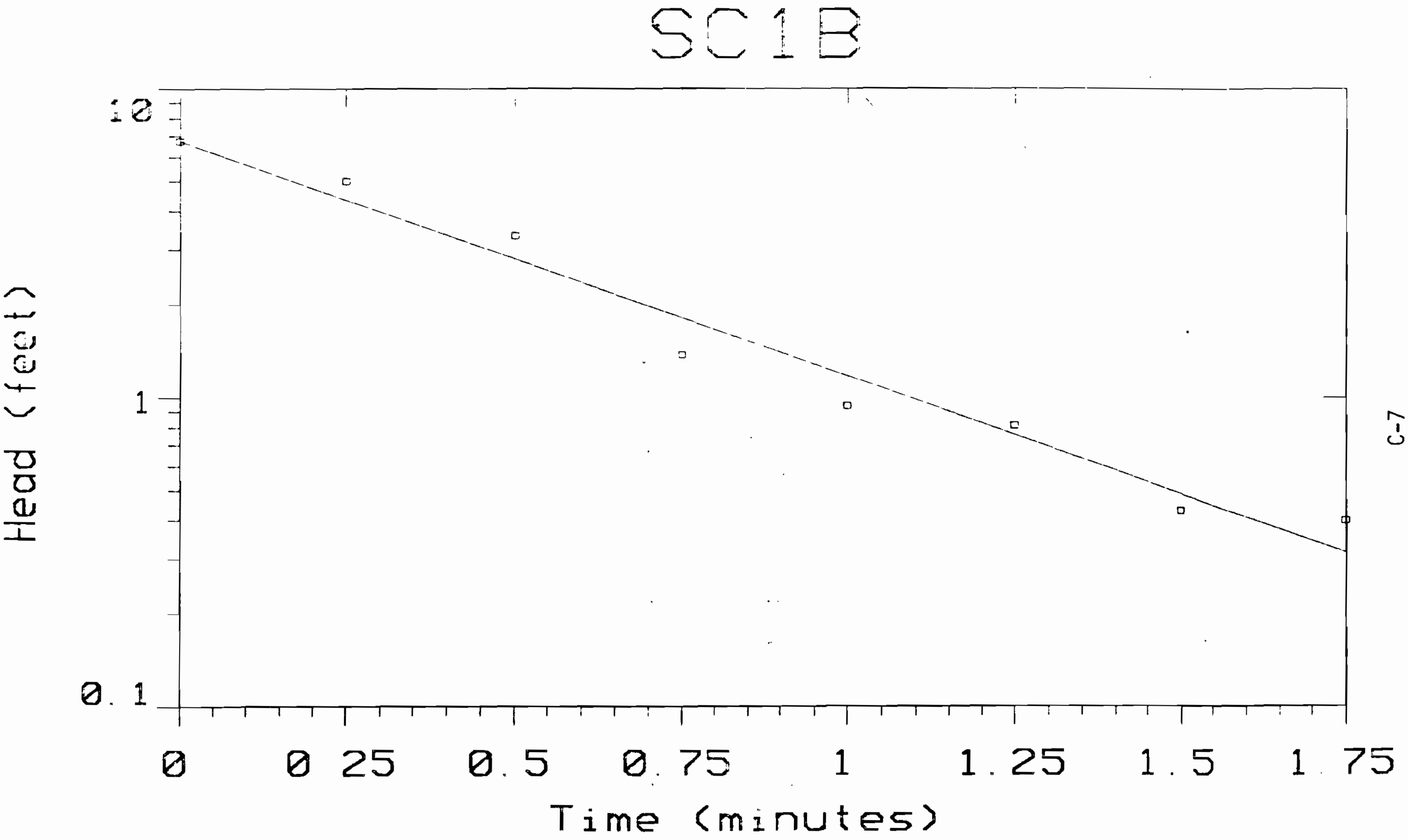

DATA SET: SC2A

CLIENT: SOLVENT CHEMICAL
DATE: 3/16/90
LOCATION: BUFFALO AVE.
WELL NO.: SC2A
COUNTY: ERIE
WELL DEPTH. 8.20 ft
PROJECT: Slug Test
WATER TABLE: 7.060 ft
AQUIFER: Unknown
THICKNESS: 5.20 ft
INTAKE RADIUS: 0.667 ft
CASING RADIUS: 0.167 ft
SCREEN TOP: 4.000 ft
SCREEN BASE: 9.20 ft
INITIAL HEAD: 1.450 ft
TRANS. RATIO: 1.0000

MODEL PARAMETERS:

TRANSMISSIVITY: .000748 square ft/min

CONDUCTIVITY: .000149 ft/min

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	1.000E-04	1.32		
2	0.200	1.28		
3	0.280	1.24		
4	0.410	1.21		
5	0.580	1.19		
6	0.700	1.14		
7	0.920	1.10		
8	1.20	1.06		
9	1.35	1.03		
10	1.53	1.00		
11	1.77	0.980		
12	2.07	0.930		
13	2.35	0.900		
14	2.85	0.810		
15	3.35	0.740		
16	3.85	0.680		
17	4.35	0.630		
18	4.85	0.580		
19	5.35	0.550		
20	5.85	0.530		
21	6.35	0.510		
22	6.85	0.480		
23	7.35	0.460	0.482	-4.96

```
No.        TIME              Head, H (ft)               DIFFERENCE
           (mins)         DATA        SYNTHETIC          (percent)

 24         7.85          0.450         0.462            -2.83
 25         8.35          0.440         0.443            -0.795
 26         8.85          0.420         0.425            -1.20
 27         9.35          0.410         0.407             0.643
 28         9.85          0.390         0.390            -0.101
 29        10.35          0.370         0.374            -1.12
 30        10.85          0.360         0.358             0.396
 31        11.35          0.350         0.343             1.81
 32        11.85          0.340         0.329             3.13
 33        12.35          0.330         0.315             4.35
 34        14.35          0.290         0.266             8.18
 35        16.35          0.220         0.224            -2.10
 36        18.35          0.190         0.189             0.259
 37        20.35          0.150         0.159            -5.88
 38        22.35          0.110
 39        24.35          0.0900
 40        26.35          0.0700
 41        28.35          0.0400
 42        30.35          0.0200

 CURRENT RESOLUTION MATRIIX NOT AVAILABLE
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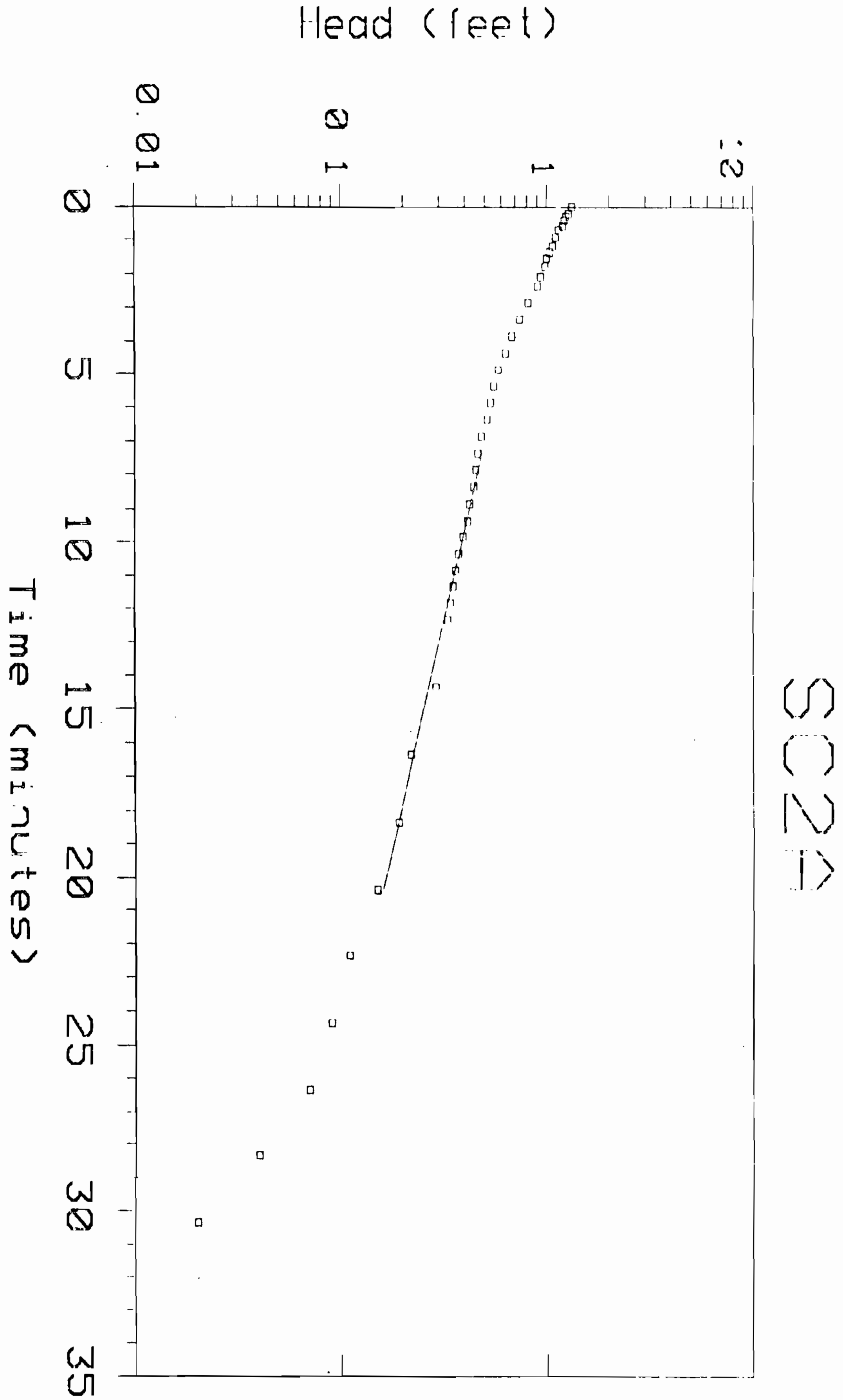
Head (feet)
0.01
0.1
1
2
0
5
10
15
20
25
30
35
Time (minutes)
SC2A

```
---------------------      SC2B      --------------------- PAGE 1



                    DATA SET: SC2B

       CLIENT: SOLVENT CHEMICAL                          DATE: 3/16/90
     LOCATION: BUFFALO AVE.                          WELL NO.: SC2B
       COUNTY: ERIE                                WELL DEPTH:   22.00 ft
      PROJECT: Bail-down Test                     WATER TABLE:    9.240 ft
      AQUIFER: Unknown                              THICKNESS:   12.00 ft
INTAKE RADIUS:    0.667 ft                     CASING RADIUS:    0.167 ft
   SCREEN TOP:    8.200 ft                       SCREEN BASE:   20.00 ft
 INITIAL HEAD:    0.430 ft                       TRANS. RATIO:  1.0000

                          MODEL PARAMETERS:

    TRANSMISSIVITY:          .00418 square ft/min

      CONDUCTIVITY:         .000348  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

    No.          TIME              Head, H (ft)            DIFFERENCE
                (mins)         DATA        SYNTHETIC        (percent)

     1       1.000E-04         0.970          0.202           79.10
     2         0.250           0.200
     3         0.500           0.180
     4         0.750           0.160
     5         1.00            0.160
     6         1.25            0.150
     7         1.50            0.140
     8         1.75            0.140
     9         2.00            0.140
    10         2.50            0.130
    11         3.00            0.130
    12         3.50            0.120
    13         4.00            0.120
    14         4.50            0.120
    15         5.00            0.110
    16         5.50            0.100
    17         6.00            0.100
    18         6.50            0.0900
    19         7.00            0.0900
    20         7.50            0.0900
    21         8.00            0.0900
    22         8.50            0.0800
    23         9.00            0.0800
```

```
--------------------       SC02        -------------------   PAGE 2



No.        TIME              Head, H (ft)          DIFFERENCE
          (mins)          DATA        SYNTHETIC     (percent)

 24        9.50          0.0700
 25       10.00          0.0700
 26       10.50          0.0700
 27       11.00          0.0600
 28       11.50          0.0600
 29       12.00          0.0500
 30       14.00          0.0500
 31       16.00          0.0400

 CURRENT RESOLUTION MATRIIX NOT AVAILABLE
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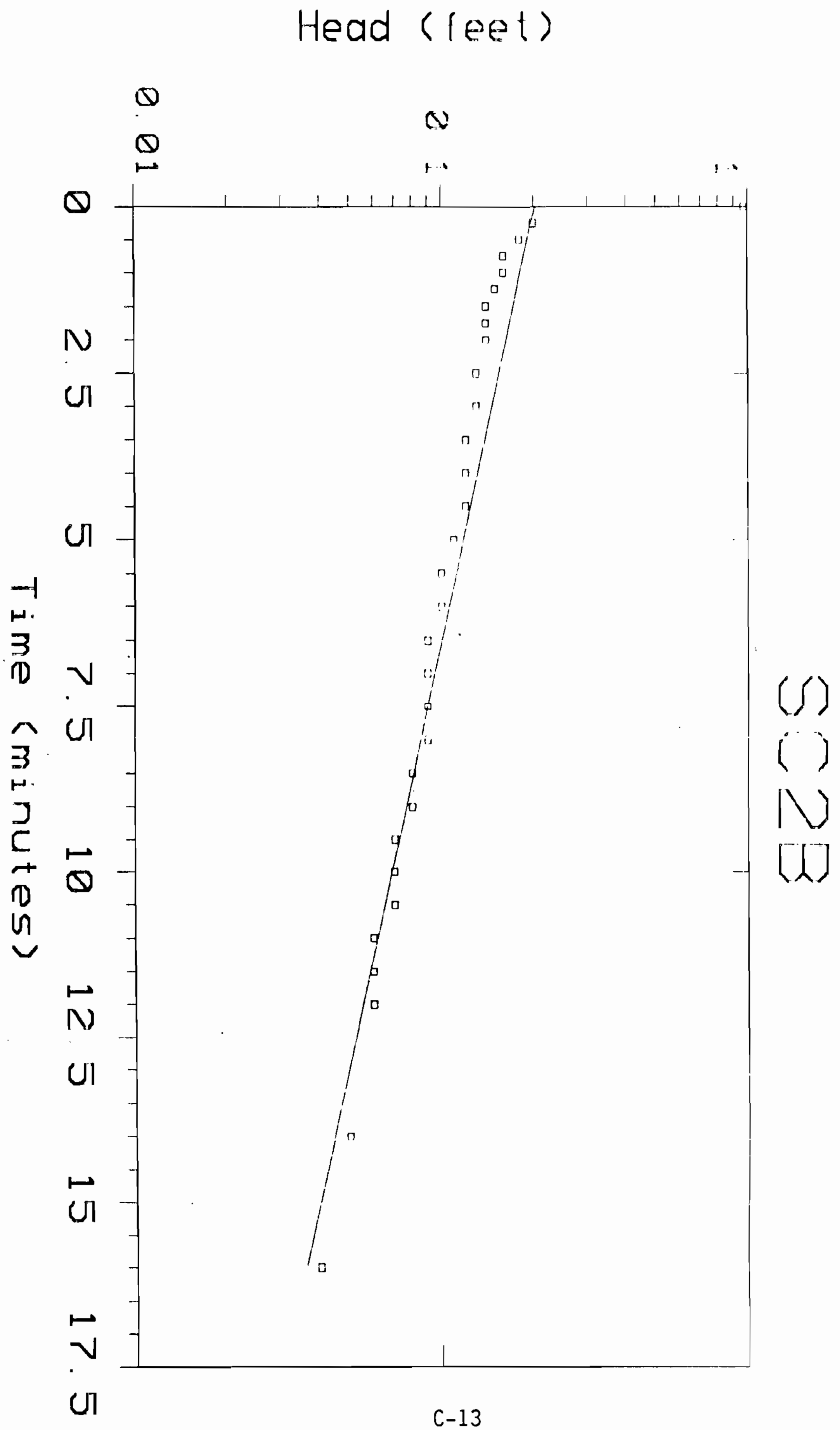
Head (feet)
0.01
0.1
1
0
2.5
5
7.5
10
12.5
15
17.5
Time (minutes)
SC2B

```
                    DATA SET: SC3A

      CLIENT: SOLVENT CHEMICAL                          DATE: 3/19/90
    LOCATION: BUFFALO AVE.                          WELL NO.: SC3A
      COUNTY: ERIE                                WELL DEPTH:     9.60 ft
     PROJECT: Bail-down Test                     WATER TABLE:    6.120 ft
     AQUIFER: Unknown                              THICKNESS:     6.00 ft
INTAKE RADIUS:   0.667 ft                     CASING RADIUS:    0.167 ft
  SCREEN TOP:    4.500 ft                       SCREEN BASE:     9.60 ft
INITIAL HEAD:    2.780 ft                      TRANS. RATIO:   1.0022

                         MODEL PARAMETERS:

   TRANSMISSIVITY:        .000661 square ft/min

     CONDUCTIVITY:        .000110  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

   No.        TIME              Head, H (ft)            DIFFERENCE
             (mins)           DATA        SYNTHETIC      (percent)

     1     1.000E-04          2.78
     2       0.250            0.290
     3       0.500            0.760
     4       0.750            0.900
     5       1.00             0.960
     6       1.25             1.06
     7       1.50             1.14
     8       1.75             1.19
     9       2.00             1.25
    10       2.50             1.36
    11       3.00             1.51
    12       3.50             1.90
    13       4.00             2.12
    14       4.50             2.27
    15       5.00             2.38
    16       5.50             2.45
    17       6.00             2.52
    18       6.50             2.56
    19       7.00             2.59
    20       7.50             2.63
    21       8.00             2.66
    22       8.50             2.67
```

CURRENT RESOLUTION MATRIIX NOT AVAILABLE

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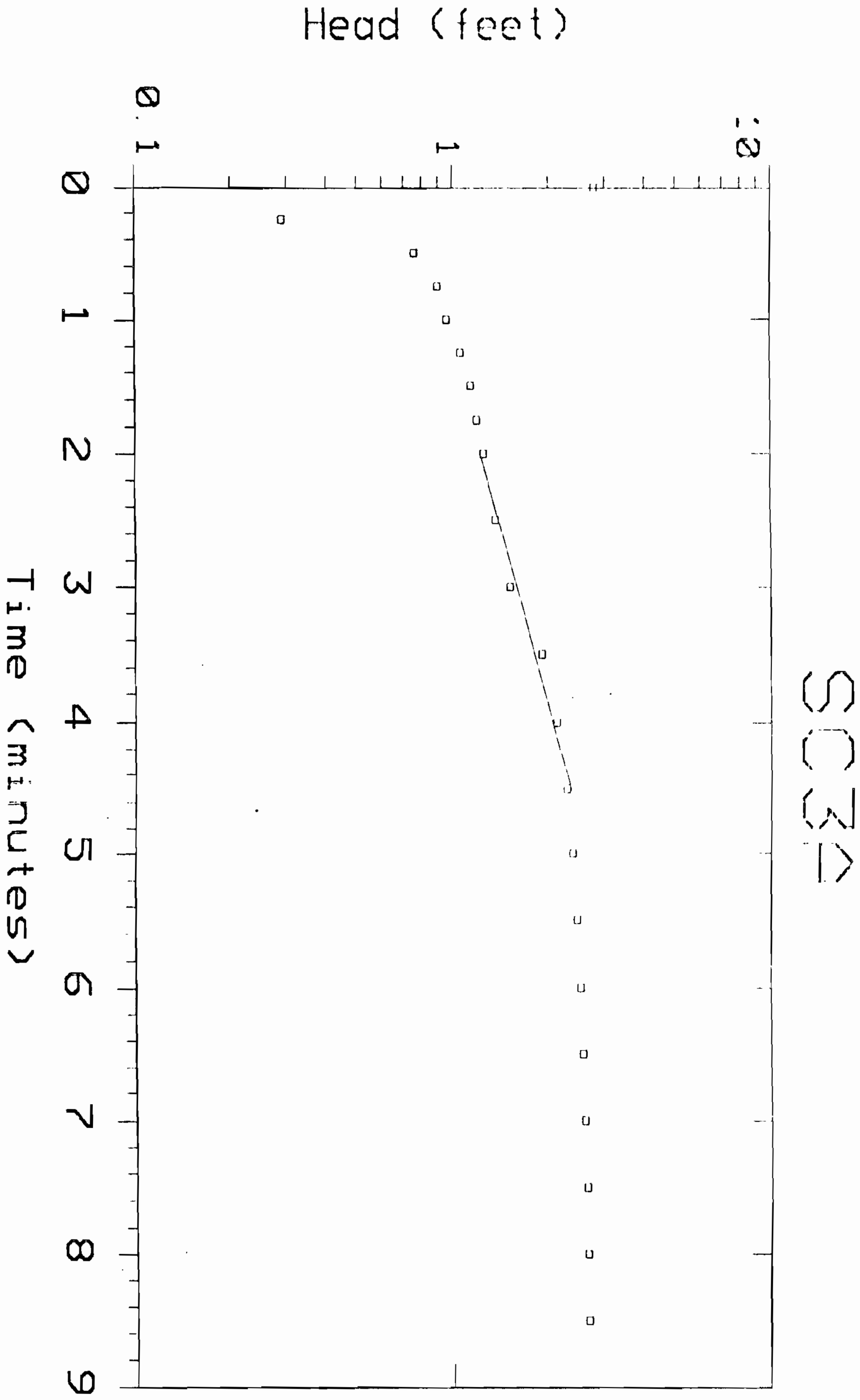

```
--------------------          SC3B          -------------------- PAGE 1



                         DATA SET: SC3B

      CLIENT: SOLVENT CHEMICAL                          DATE: 3/20/90
    LOCATION: BUFFALO AVE.                          WELL NO.: SC3B
      COUNTY: ERIE                                WELL DEPTH:   21.20 ft
     PROJECT: Bail-down Test                     WATER TABLE:   [illegible] ft
     AQUIFER: Unknown                              THICKNESS:   11.60 ft
INTAKE RADIUS:   0.667 ft                     CASING RADIUS:   0.167 ft
   SCREEN TOP:   9.600 ft                        SCREEN BASE:   21.20 ft
 INITIAL HEAD:   0.300 ft                       TRANS. RATIO:  1.0000

                            MODEL PARAMETERS:

    TRANSMISSIVITY:        .000867 square ft/min

      CONDUCTIVITY:        7.47E-5  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

    No.        TIME              Head, H (ft)             DIFFERENCE
              (mins)         DATA        SYNTHETIC         (percent)

      1      1.000E-04       0.300
      2        0.250         0.140
      3        0.500         0.170
      4        0.750         0.200
      5        1.00          0.210
      6        1.25          0.220
      7        1.50          0.230
      8        1.75          0.240
      9        2.00          0.240
     10        2.50          0.240
     11        3.00          0.240
     12        3.50          0.240
     13        4.00          0.240
     14        4.50          0.240
     15        5.00          0.240

     CURRENT RESOLUTION MATRIIX NOT AVAILABLE
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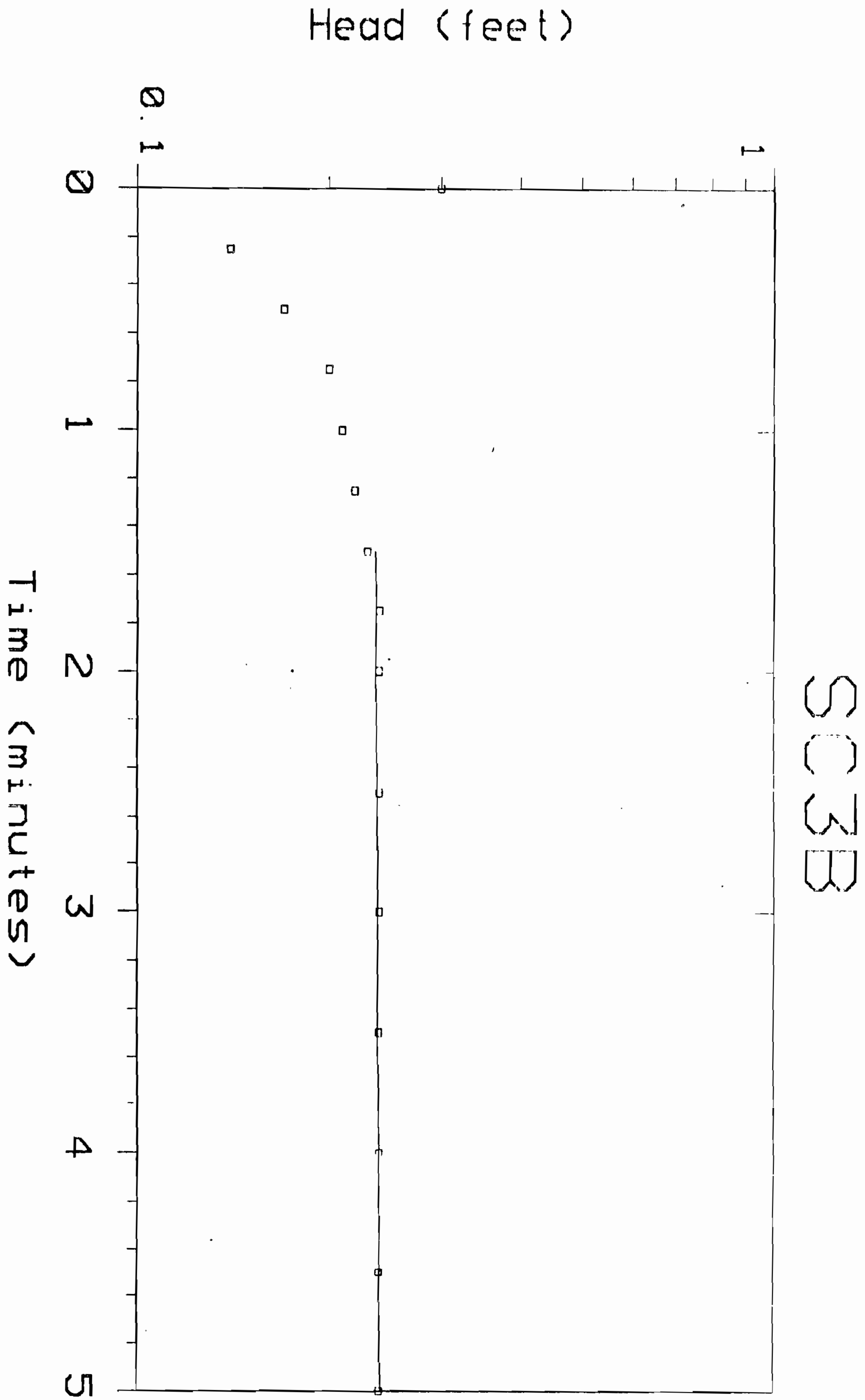


```
--------------------          SC4A          --------------------  PAGE 1




                    DATA SET: SC4A

      CLIENT: SOLVENT CHEMICAL                         DATE: 3/19/90
    LOCATION: BUFFALO AVE.                         WELL NO.: SC4A
      COUNTY: ERIE                               WELL DEPTH:     9.00 ft
     PROJECT: Bail-down Test                    WATER TABLE:    4.200 ft
     AQUIFER: Unknown                             THICKNESS:     5.00 ft
INTAKE RADIUS:   0.667 ft                     CASING RADIUS:    0.167 ft
   SCREEN TOP:   3.000 ft                       SCREEN BASE:     9.00 ft
 INITIAL HEAD:   3.230 ft                      TRANS. RATIO:   1.0000

                          MODEL PARAMETERS:

   TRANSMISSIVITY:        .000183 square ft/min

     CONDUCTIVITY:        3.67E-5  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

   No.        TIME              Head, H (ft)              DIFFERENCE
             (mins)          DATA        SYNTHETIC         (percent)

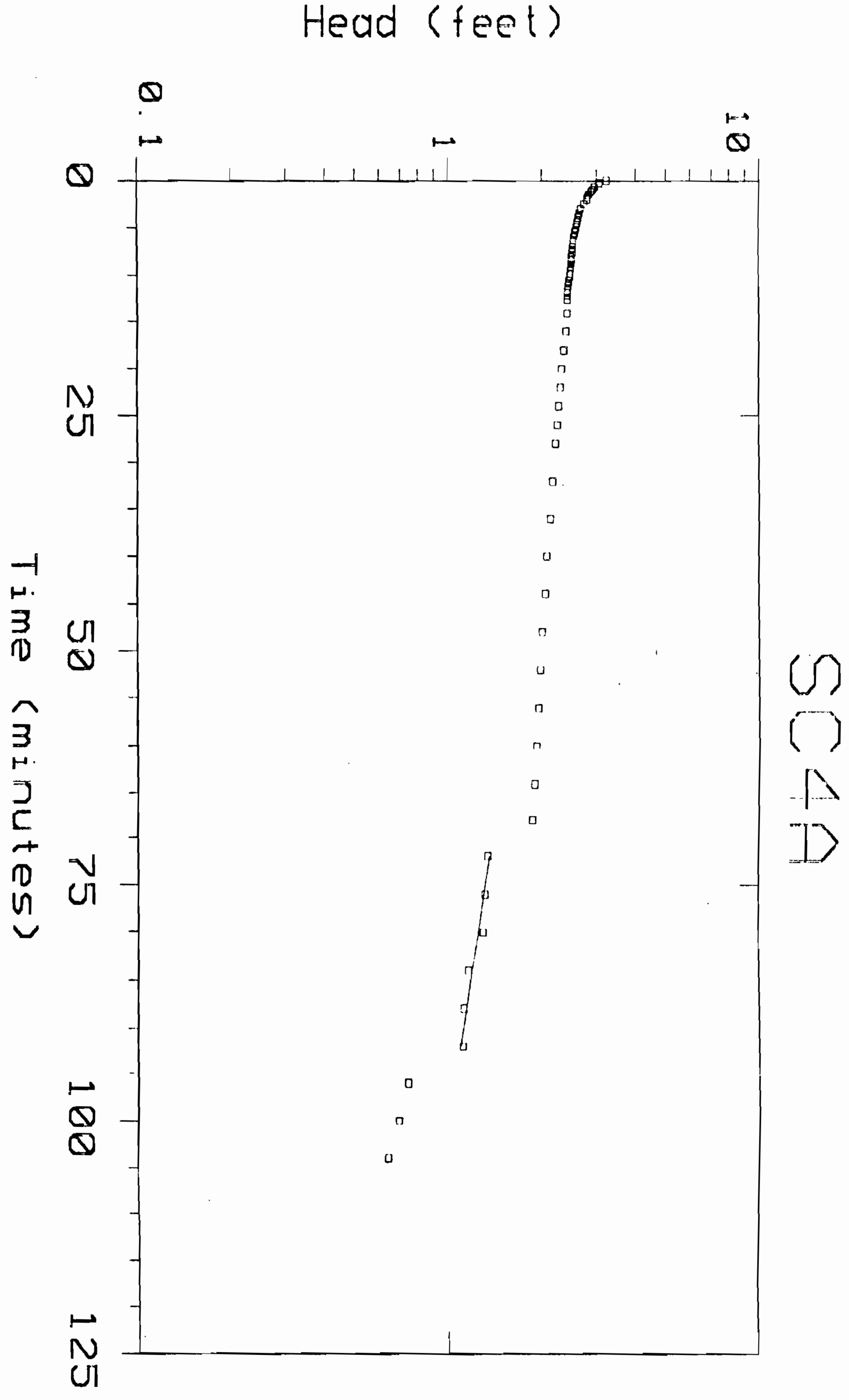
     1     1.000E-04         3.23
     2       0.250           3.06
     3       0.500           3.06
     4       0.750           2.96
     5       1.00            2.91
     6       1.25            2.88
     7       1.50            2.84
     8       1.75            2.81
     9       2.00            2.80
    10       2.50            2.74
    11       3.00            2.68
    12       3.50            2.65
    13       4.00            2.63
    14       4.50            2.61
    15       5.00            2.59
    16       5.50            2.57
    17       6.00            2.55
    18       6.50            2.54
    19       7.00            2.53
    20       7.50            2.52
    21       8.00            2.50
    22       8.50            2.50
    23       9.00            2.49
```

```
--------------------          SC4A          -------------------- PAGE 2


No.          TIME               Head, H (ft)              DIFFERENCE
            (mins)          DATA        SYNTHETIC         (percent)

 24          9.50           2.48
 25         10.00           2.47
 26         10.50           2.45
 27         11.00           2.44
 28         11.50           2.43
 29         12.00           2.42
 30         12.50           2.42
 31         14.00           2.41
 32         16.00           2.39
 33         18.00           2.36
 34         20.00           2.32
 35         22.00           2.30
 36         24.00           2.28
 37         26.00           2.25
 38         28.00           2.22
 39         32.00           2.17
 40         36.00           2.13
 41         40.00           2.08
 42         44.00           2.05
 43         48.00           2.01
 44         52.00           1.98
 45         56.00           1.95
 46         60.00           1.92
 47         64.00           1.89
 48         68.00           1.86
 49         72.00           1.34
 50         76.00           1.31
 51         80.00           1.29
 52         84.00           1.16
 53         88.00           1.12
 54         92.00           1.11
 55         96.00           0.740
 56        100.0            0.690
 57        104.0            0.640

 CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```


SC4A
Head (feet)
0.1
1
10
Time (minutes)
0
25
50
75
100
125

```
                        DATA SET: SC4B

      CLIENT: SOLVENT CHEMICAL                         DATE: 3/13/90
    LOCATION: BUFFALO AVE.                         WELL NO.: SC4B
      COUNTY: ERIE                               WELL DEPTH:   22.50 ft
     PROJECT: Bail-down Test                    WATER TABLE:  10.620 ft
     AQUIFER: Unknown                             THICKNESS:   14.50 ft
INTAKE RADIUS:   0.667 ft                    CASING RADIUS:   0.167 ft
  SCREEN TOP:    9.000 ft                      SCREEN BASE:   22.50 ft
INITIAL HEAD:    0.020 ft                     TRANS. RATIO:  1.0000

                              MODEL PARAMETERS:

    TRANSMISSIVITY:    UNKNOWN

      CONDUCTIVITY:       -1.00E-9   ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

    No.        TIME               Head, H (ft)               DIFFERENCE
              (mins)          DATA        SYNTHETIC           (percent)

     1      1.000E-04        0.0200         0.0200            4.357E-05
     2        0.500          0.0200
     3        0.750          0.0200

     CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```

Draft

DATA SET: SC5A

CLIENT:	SOLVENT CHEMICAL	DATE:	3/16/90
LOCATION:	BUFFALO AVE.	WELL NO.:	SC5A
COUNTY:	ERIE	WELL DEPTH:	12.50 ft
PROJECT:	Bail-down Test	WATER TABLE:	7.870 ft
AQUIFER:	Unknown	THICKNESS:	7.50 ft
INTAKE RADIUS:	0.667 ft	CASING RADIUS:	0.167 ft
SCREEN TOP:	5.000 ft	SCREEN BASE:	12.50 ft
INITIAL HEAD:	2.890 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

TRANSMISSIVITY: .00176 square ft/min

CONDUCTIVITY: .000235 ft/min

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	1.000E-04	2.89		
2	0.250	2.54		
3	0.500	2.26		
4	0.750	2.15		
5	1.00	1.56		
6	1.25	1.97		
7	1.50	1.89		
8	1.75	1.81		
9	2.00	1.73		
10	2.50	1.61		
11	3.00	1.54		
12	3.50	1.42		
13	4.00	1.33		
14	4.50	1.26		
15	5.00	1.15		
16	5.50	1.12		
17	6.00	1.03		
18	6.50	0.950		
19	7.00	0.890		
20	7.50	0.860		
21	8.00	0.790		
22	8.50	0.770		
23	9.00	0.740		

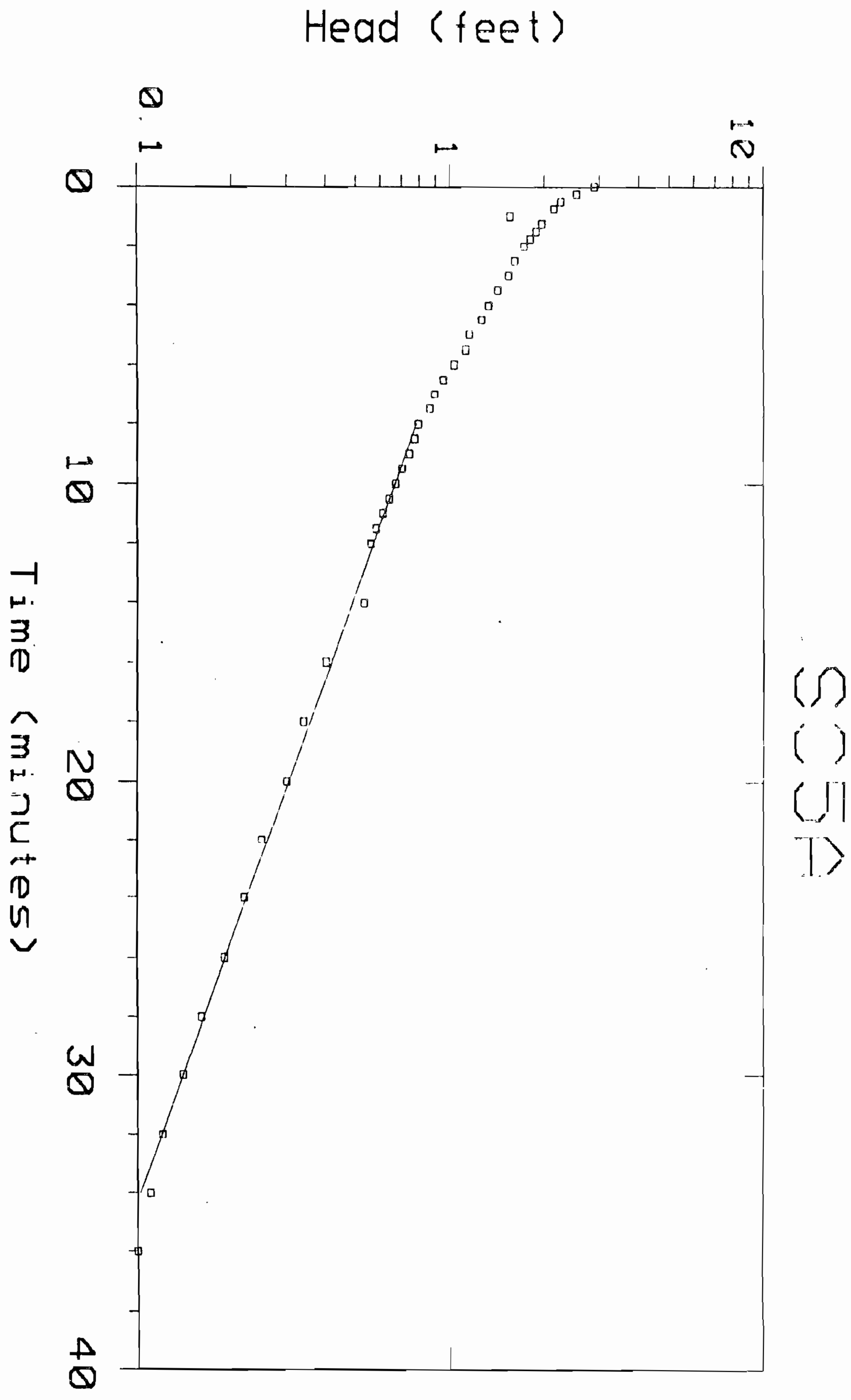
```
--------------------     SC5A      -------------------- PAGE 2


No.        TIME              Head, H (ft)          DIFFERENCE
           (mins)         DATA        SYNTHETIC      (percent)

 24         9.50          0.700
 25        10.00          0.670
 26        10.50          0.640
 27        11.00          0.610
 28        11.50          0.580
 29        12.00          0.560
 30        14.00          0.530
 31        16.00          0.400
 32        18.00          0.340
 33        20.00          0.300
 34        22.00          0.250
 35        24.00          0.220
 36        26.00          0.190
 37        28.00          0.160
 38        30.00          0.140
 39        32.00          0.120
 40        34.00          0.110
 41        36.00          0.100

 CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```

Draft



```
                    DATA SET: SC5B

      CLIENT: SOLVENT CHEMICAL                        DATE: 3/29/90
    LOCATION: BUFFALO AVE.                        WELL NO.: SC5B
      COUNTY: ERIE                              WELL DEPTH:  21.[illegible] ft
     PROJECT: Slug Test                        WATER TABLE:  18.040 ft
     AQUIFER: Unknown                            THICKNESS:   8.50 ft
INTAKE RADIUS:   0.667 ft                    CASING RADIUS:   0.167 ft
  SCREEN TOP:  12.500 ft                       SCREEN BASE:  21.70 ft
INITIAL HEAD:   0.620 ft                      TRANS. RATIO:  1.0000

                          MODEL PARAMETERS:

    TRANSMISSIVITY:        .000819 square ft/min

      CONDUCTIVITY:        9.63E-5  ft/min

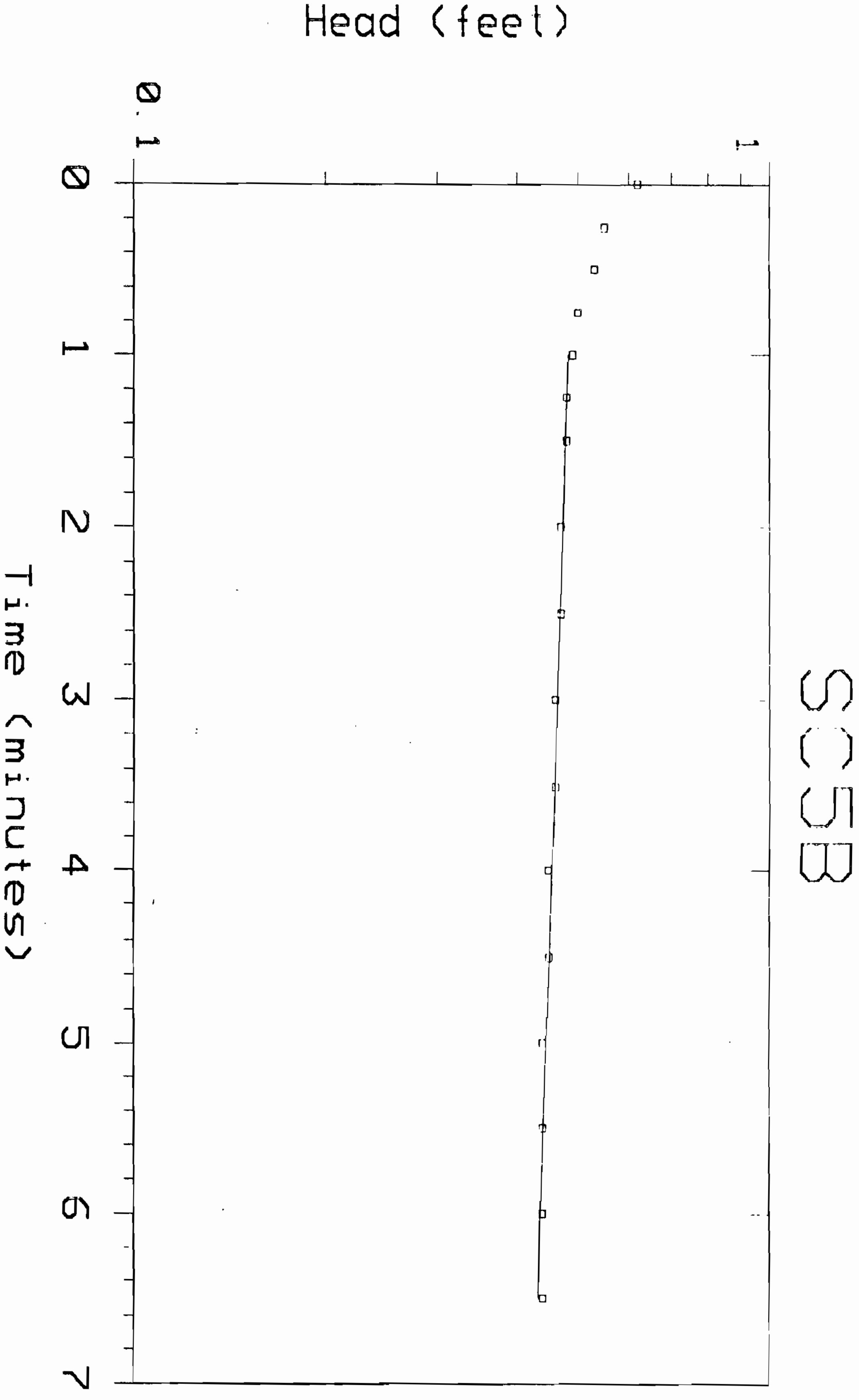
MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

    No.        TIME            Head, H (ft)              DIFFERENCE
               (mins)       DATA        SYNTHETIC         (percent)

      1     1.000E-04       0.620
      2        0.250        0.550
      3        0.500        0.530
      4        0.750        0.500
      5        1.00         0.490
      6        1.25         0.480
      7        1.50         0.480
      8        2.00         0.470
      9        2.50         0.470
     10        3.00         0.460
     11        3.50         0.460
     12        4.00         0.450
     13        4.50         0.450
     14        5.00         0.440
     15        5.50         0.440
     16        6.00         0.440
     17        6.50         0.440

    CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```

Draft



DATA SET: SC5C

CLIENT:	SOLVENT CHEMICAL	DATE:	3/16/90
LOCATION:	BUFFALO AVE.	WELL NO.:	SC5C
COUNTY:	ERIE	WELL DEPTH:	36.50 ft
PROJECT:	Slug test	WATER TABLE:	19.320 ft
AQUIFER:	Unknown	THICKNESS:	10.00 ft
INTAKE RADIUS:	0.667 ft	CASING RADIUS:	0.167 ft
SCREEN TOP:	26.500 ft	SCREEN BASE:	35.50 ft
INITIAL HEAD:	1.140 ft	TRANS. RATIO:	1.0000

MODEL PARAMETERS:

TRANSMISSIVITY: .0178 square ft/min

CONDUCTIVITY: .00178 ft/min

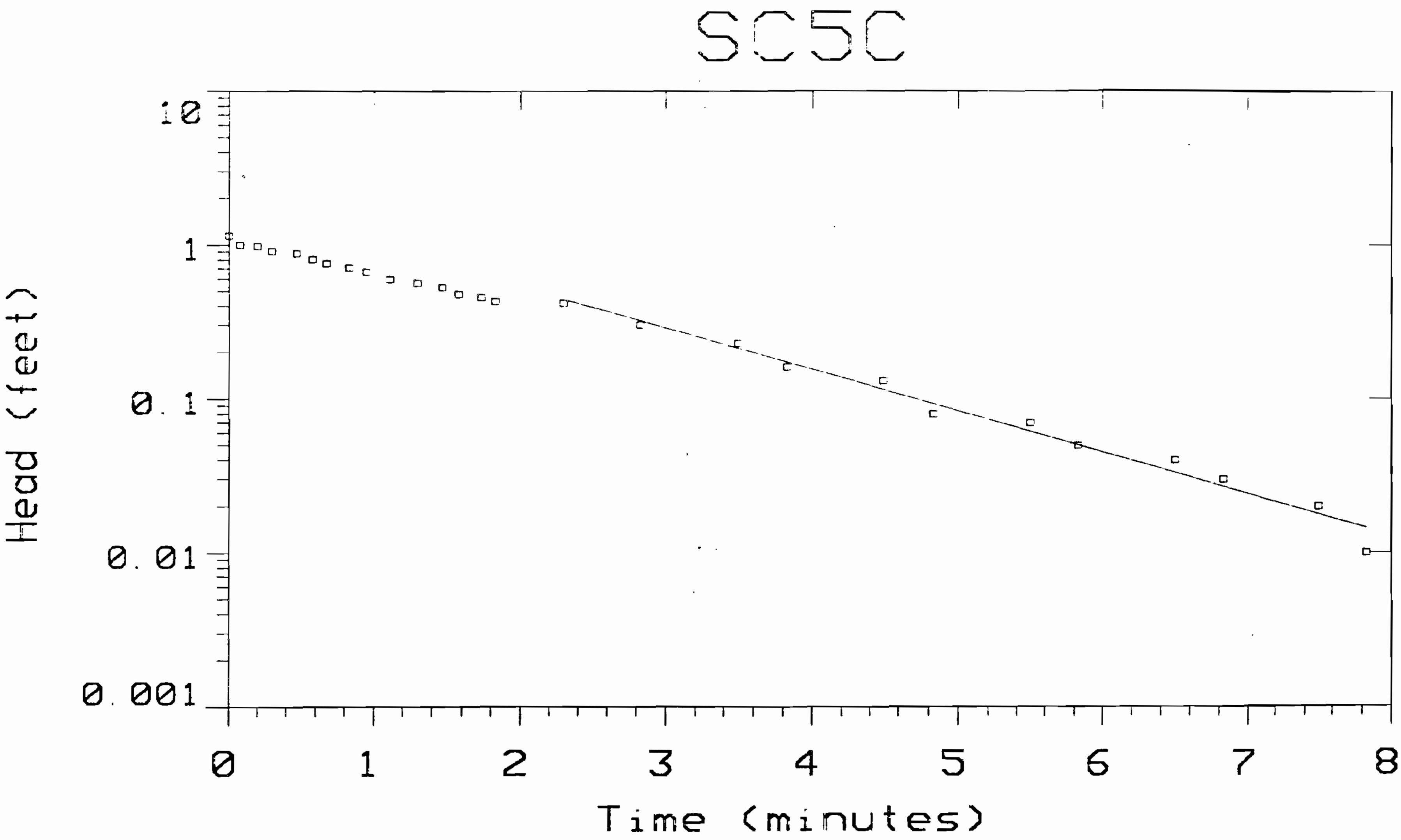
MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice

No.	TIME (mins)	Head, H (ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	1.000E-04	1.14		
2	0.0800	1.00		
3	0.200	0.980		
4	0.300	0.910		
5	0.470	0.880		
6	0.580	0.810		
7	0.670	0.760		
8	0.830	0.710		
9	0.950	0.670		
10	1.11	0.600		
11	1.30	0.570		
12	1.47	0.530		
13	1.58	0.480		
14	1.73	0.460		
15	1.83	0.430		
16	2.30	0.420	0.446	-6.24
17	2.83	0.300	0.321	-7.15
18	3.50	0.230	0.212	7.68
19	3.83	0.160	0.173	-8.19
20	4.50	0.130	0.114	12.03
21	4.83	0.0800	0.0932	-16.52
22	5.50	0.0700	0.0615	12.02
23	5.83	0.0500	0.0502	-0.406

```
No.        TIME              Head, H (ft)            DIFFERENCE
           (mins)         DATA         SYNTHETIC      (percent)

 24        6.50           0.0400        0.0331          17.04
 25        6.83           0.0300        0.0270           9.93
 26        7.50           0.0200        0.0178          10.[illegible]
 27        7.83           0.0100        0.0145         -45.59

 CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```


SC5C
Head (feet)
10
1
0.1
0.01
0.001
0
1
2
3
4
5
6
7
8
Time (minutes)

Draft

```
---------------------        SC5CD         -------------------- PAGE 1



                          DATA SET: SC5CD

       CLIENT: SOLVENT CHEMICAL                          DATE: 3/20/90
     LOCATION: BUFFALO AVE.                          WELL NO.: SC5CD
       COUNTY: ERIE                                WELL DEPTH:   42.90 ft
      PROJECT: Slug test                          WATER TABLE:  23.830 ft
      AQUIFER: Unknown                              THICKNESS:   30.40 ft
INTAKE RADIUS:   0.667 ft                      CASING RADIUS:   0.167 ft
   SCREEN TOP:  12.500 ft                        SCREEN BASE:   42.90 ft
 INITIAL HEAD:   8.180 ft                       TRANS. RATIO:  1.0000

                                MODEL PARAMETERS:

    TRANSMISSIVITY:         .0701 square ft/min

      CONDUCTIVITY:        .00230  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

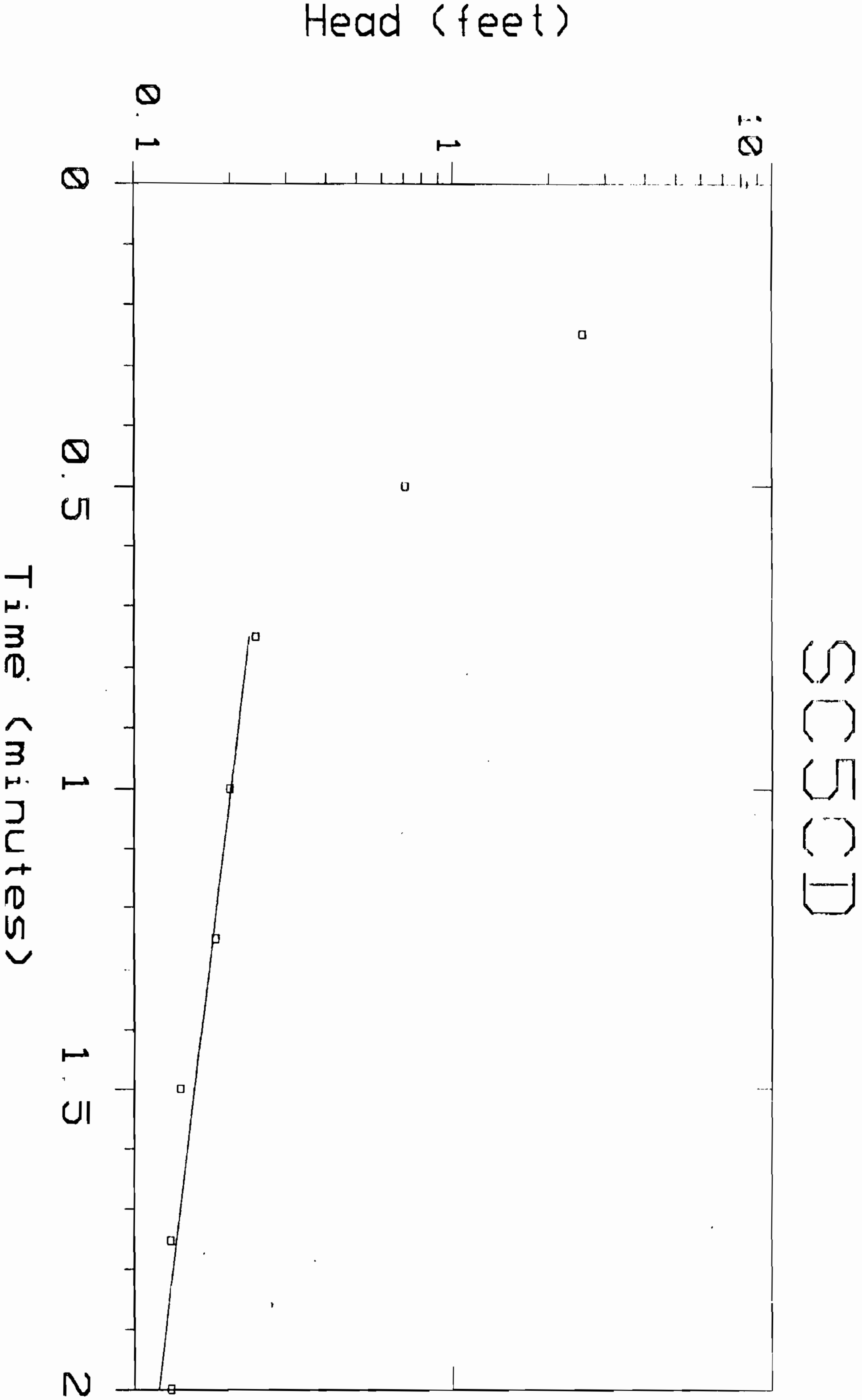
    No.        TIME               Head, H (ft)          DIFFERENCE
              (mins)          DATA        SYNTHETIC      (percent)

     1      1.000E-04         8.18
     2        0.250           2.55
     3        0.500           0.710
     4        0.750           0.240        0.229           4.23
     5        1.00            0.200        0.201          -0.735
     6        1.25            0.180        0.176           1.88
     7        1.50            0.140        0.154         -10.58
     8        1.75            0.130        0.135          -4.39
     9        2.00            0.130        0.118           8.48

    CURRENT RESOLUTION MATRIIX NOT AVAILABLE




               *          Ecology & Environment          *
```


SC5CD
Head (feet)
0.1
1
10
Time (minutes)
0
0.5
1
1.5
2

```
                         DATA SET: SC5F

      CLIENT: SOLVENT CHEMICAL                         DATE: 3/20/96
    LOCATION: BUFFALO AVE.                         WELL NO.: SC5F
      COUNTY: ERIE                               WELL DEPTH:   98.00 ft
     PROJECT: Slug test                         WATER TABLE:  17.920 ft
     AQUIFER: Unknown                             THICKNESS:   55.50 ft
INTAKE RADIUS:   0.667 ft                    CASING RADIUS:   0.167 ft
   SCREEN TOP:  12.500 ft                      SCREEN BASE:   98.00 ft
 INITIAL HEAD:   1.670 ft                     TRANS. RATIO:  1.0000

                              MODEL PARAMETERS:

   TRANSMISSIVITY:            .0902 square ft/min

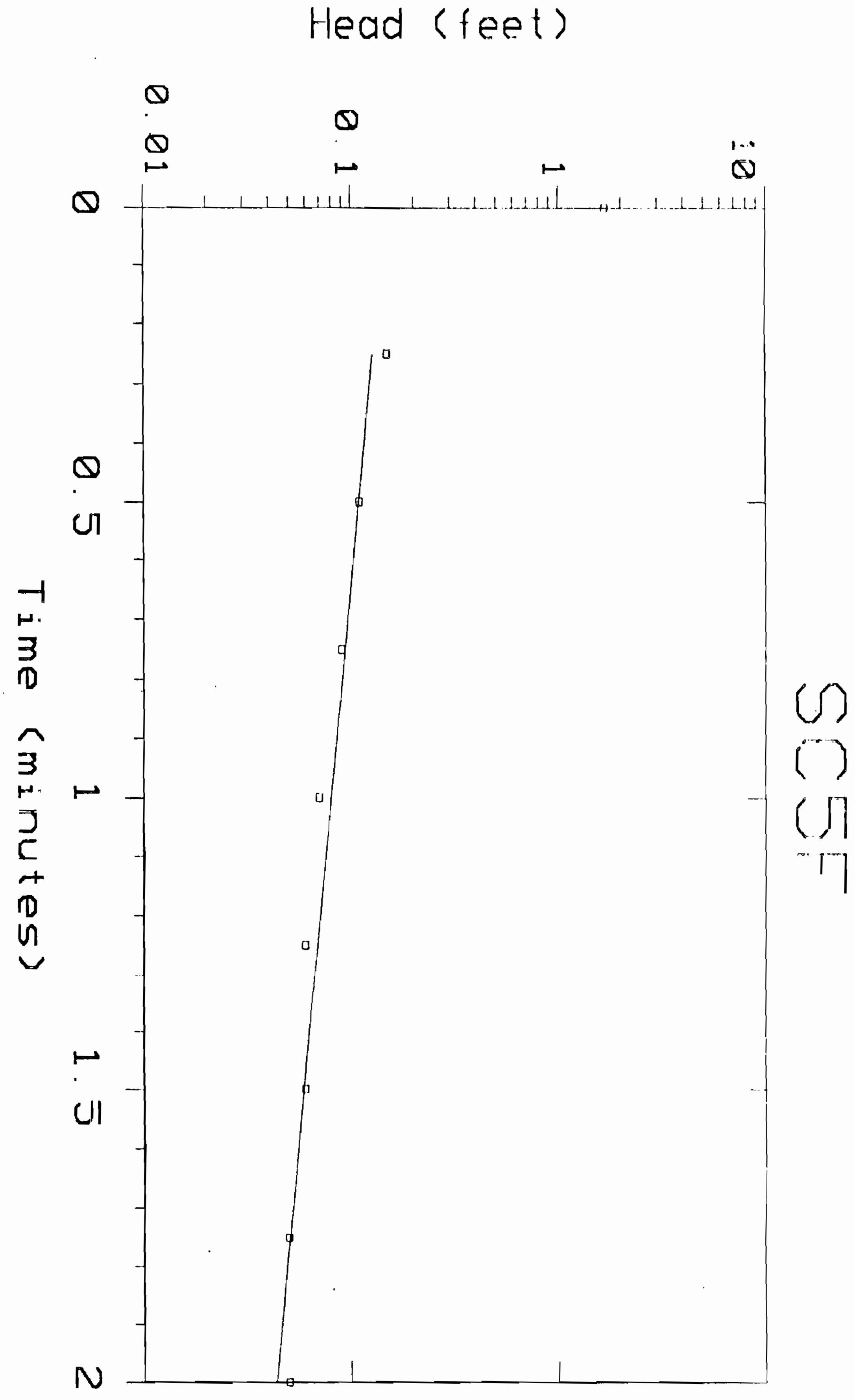
     CONDUCTIVITY:           .00105  ft/min

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

   No.        TIME             Head, H (ft)            DIFFERENCE
             (mins)        DATA        SYNTHETIC        (percent)

    1      1.000E-04       1.67
    2        0.250         0.150         0.127            14.77
    3        0.500         0.110         0.109             0.445
    4        0.750         0.0900        0.0938           -4.22
    5        1.00          0.0700        0.0803          -14.78
    6        1.25          0.0600        0.0688          -14.71
    7        1.50          0.0600        0.0589            1.73
    8        1.75          0.0500        0.0505           -1.00
    9        2.00          0.0500        0.0432           13.43

    CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```


SCSF
Head (feet)
0.01
0.1
1
10
0
0.5
1
1.5
2
Time (minutes)

Draft

```
--------------------     SC6A     -------------------- PAGE 1



                     DATA SET: SC6A

      CLIENT: SOLVENT CHEMICAL                    DATE: 3/19/90
    LOCATION: BUFFALO AVE.                     WELL NO.: SC6A
      COUNTY: ERIE                           WELL DEPTH:    9.60 ft
     PROJECT: Slug test                     WATER TABLE:   5.930 ft
     AQUIFER: Unknown                         THICKNESS:    5.60 ft
INTAKE RADIUS:   0.667 ft                CASING RADIUS:   0.167 ft
   SCREEN TOP:   4.000 ft                  SCREEN BASE:    9.60 ft
 INITIAL HEAD:   3.110 ft                 TRANS. RATIO:  1.0000

                         MODEL PARAMETERS:

   TRANSMISSIVITY:       .000657 square ft/min

     CONDUCTIVITY:       .000117  ft/min

MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

   No.         TIME                Head, H (ft)           DIFFERENCE
              (mins)           DATA        SYNTHETIC       (percent)

     1      1.000E-04          3.11
     2        0.250            3.03
     3        0.500            2.94
     4        0.750            2.88
     5        1.00             2.85
     6        1.25             2.81
     7        1.50             2.78
     8        1.75             2.76
     9        2.00             2.73
    10        2.50             2.69
    11        3.00             2.65
    12        3.50             2.59
    13        4.00             2.55
    14        4.50             2.52
    15        5.00             2.49
    16        5.50             2.46
    17        6.00             2.42
    18        6.50             2.39
    19        7.00             2.36
    20        7.50             2.33
    21        8.00             2.28
    22        8.50             2.25
    23        9.00             2.22

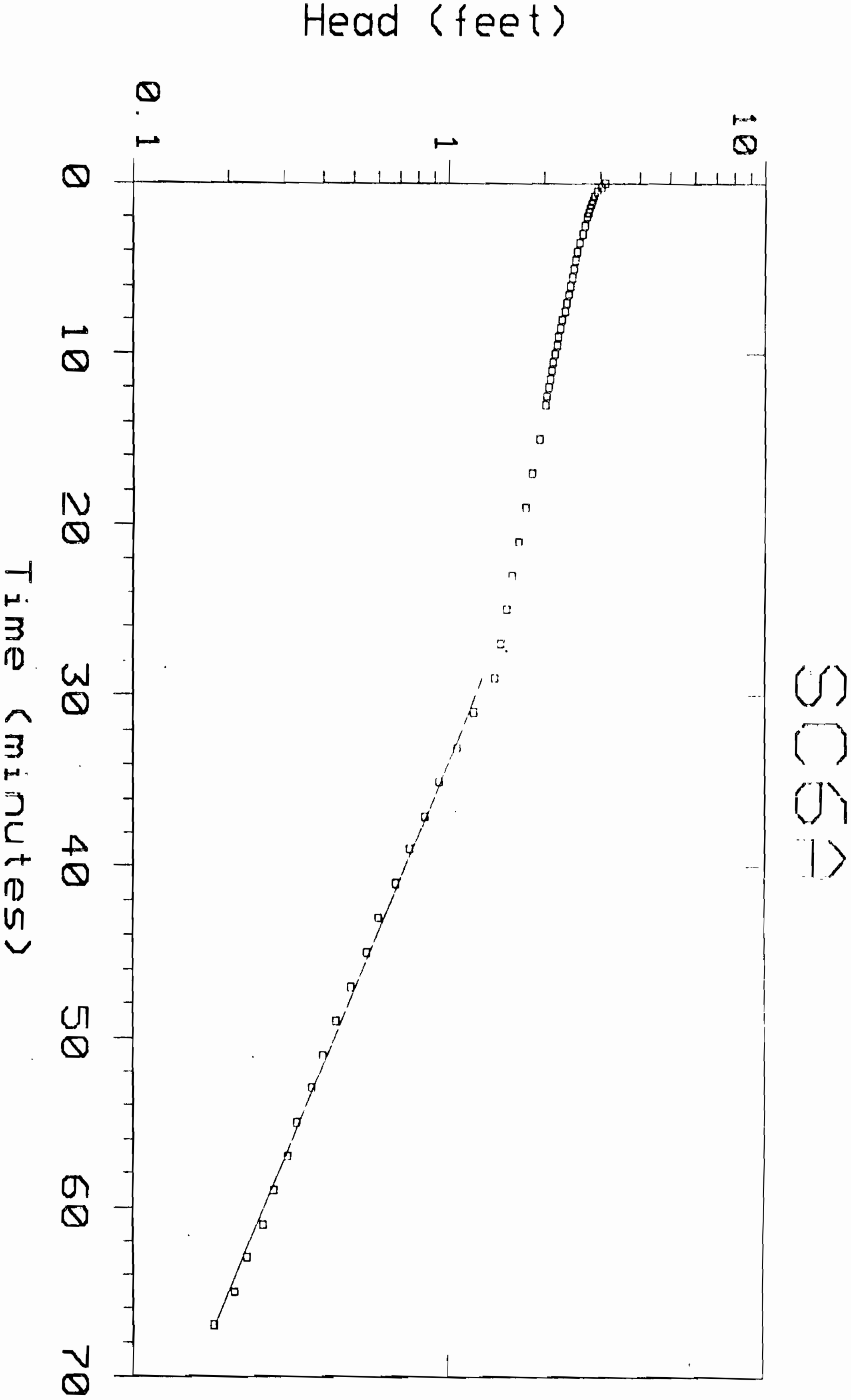
                 *         Ecology & Environment          *
```

```
No.          TIME                 Head. H (ft)              DIFFERENCE
             (mins)             DATA       SYNTHETIC         (percent)

 24           9.50              2.20
 25          10.00              2.17
 26          10.50              2.13
 27          11.00              2.12
 28          11.50              2.09
 29          12.00              2.07
 30          12.50              2.04
 31          13.00              2.02
 32          15.00              1.94
 33          17.00              1.83
 34          19.00              1.75
 35          21.00              1.66
 36          23.00              1.58
 37          25.00              1.52
 38          27.00              1.46
 39          29.00              1.40
 40          31.00              1.20
 41          33.00              1.06
 42          35.00              0.930
 43          37.00              0.840
 44          39.00              0.750
 45          41.00              0.680
 46          43.00              0.600
 47          45.00              0.550
 48          47.00              0.490
 49          49.00              0.440
 50          51.00              0.400
 51          53.00              0.370
 52          55.00              0.330
 53          57.00              0.310
 54          59.00              0.280
 55          61.00              0.260
 56          63.00              0.230
 57          65.00              0.210
 58          67.00              0.180

 CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```

Draft



```
 ---------------------       SC6B        --------------------- PAGE 1



                         DATA SET: SC6B

      CLIENT: SOLVENT CHEMICAL                        DATE: 2/20/90
    LOCATION: BUFFALO AVE.                        WELL NO.: SC6B
      COUNTY: ERIE                              WELL DEPTH:   20.00 ft
     PROJECT: Slug test                        WATER TABLE:   9.600 ft
     AQUIFER: Unknown                            THICKNESS:   11.40 ft
INTAKE RADIUS:   0.667 ft                   CASING RADIUS:   0.167 ft
   SCREEN TOP:   9.600 ft                     SCREEN BASE:   11.22 ft
 INITIAL HEAD:   0.690 ft                     TRANS. RATIO:  1.0000

                          MODEL PARAMETERS:

    TRANSMISSIVITY:          .00842 square ft/min

      CONDUCTIVITY:         .000810  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

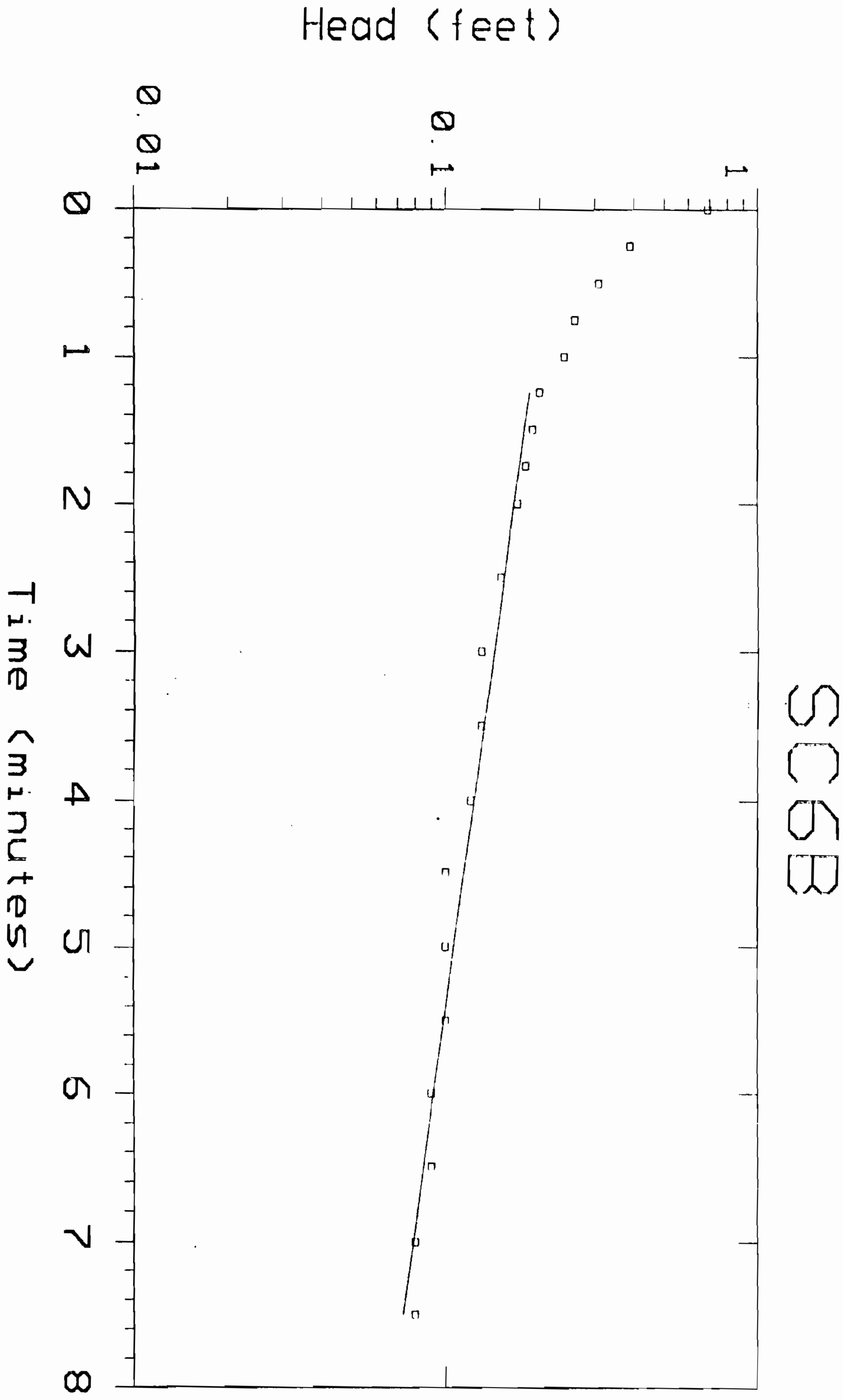
    No.        TIME                Head, H (ft)             DIFFERENCE
              (mins)            DATA        SYNTHETIC        (percent)

      1      1.000E-04          0.690
      2        0.250            0.390
      3        0.500            0.310
      4        0.750            0.260
      5        1.00             0.240
      6        1.25             0.200
      7        1.50             0.190
      8        1.75             0.180
      9        2.00             0.170
     10        2.50             0.150
     11        3.00             0.130
     12        3.50             0.130
     13        4.00             0.120
     14        4.50             0.100
     15        5.00             0.100
     16        5.50             0.100
     17        6.00             0.0900
     18        6.50             0.0900
     19        7.00             0.0800
     20        7.50             0.0800

     CURRENT RESOLUTION MATRIIX NOT AVAILABLE



              *          Ecology & Environment          *
```


SC6B
Head (feet)
0.01
0.1
1
Time (minutes)
0
1
2
3
4
5
6
7
8

```
                         DATA SET: SC7A

       CLIENT: SOLVENT CHEMICAL                              DATE: 3/19/90
     LOCATION: BUFFALO AVE.                               WELL NO   SC7A
       COUNTY: ERIE                                     WELL DEPTH:     7.50 ft
      PROJECT: Slug test                               WATER TABLE:    4.430 ft
      AQUIFER: Unknown                                   THICKNESS:     5.00 ft
INTAKE RADIUS:   0.667 ft                           CASING RADIUS:    0.167 ft
   SCREEN TOP:   2.500 ft                             SCREEN BASE:     7.50 ft
 INITIAL HEAD:   2.900 ft                             TRANS. RATIO:  1.0000

                              MODEL PARAMETERS:

    TRANSMISSIVITY:          .00865 square ft/min

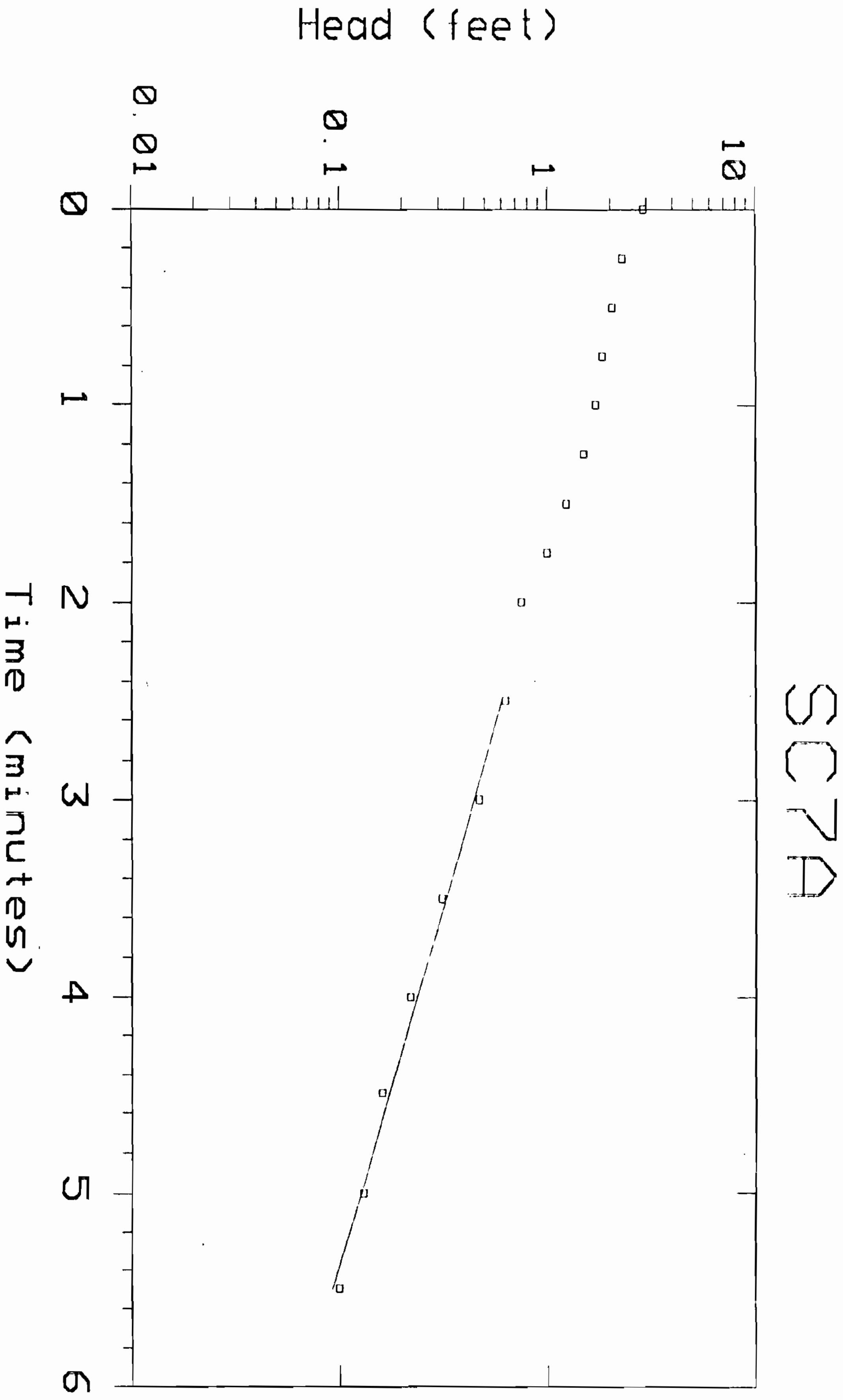
      CONDUCTIVITY:          .00173  ft/min

 MODEL TYPE: UNCONFINED PARTIALLY PENETRATED AQUIFER (Bouwer & Rice)

    No.        TIME              Head, H (ft)             DIFFERENCE
              (mins)          DATA        SYNTHETIC        (percent)

     1      1.000E-04         2.90
     2        0.250           2.29
     3        0.500           2.05
     4        0.750           1.84
     5        1.00            1.70
     6        1.25            1.49
     7        1.50            1.23
     8        1.75            0.990
     9        2.00            0.750
    10        2.50            0.630
    11        3.00            0.470
    12        3.50            0.310
    13        4.00            0.220
    14        4.50            0.160
    15        5.00            0.130
    16        5.50            0.100

     CURRENT RESOLUTION MATRIIX NOT AVAILABLE
```


SC7A
Head (feet)
0.01
0.1
1
10
Time (minutes)
0
1
2
3
4
5
6

APPENDIX D

LOADING DATA

Draft

3163 BUFFALO AVENUE LOADING DATA
A-ZONE (BEST CASE)

Contaminant	Western Boundary*		Northern Boundary**	
	February (#/D)	May (#/D)	February (#/D)	May (#/D)
Vinyl chloride	--	--	2.34×10^{-5}	2.6×10^{-5}
Total-1,2-dichloroethene	--	--	8.65×10^{-5}	9.58×10^{-5}
1,2-Dichloroethane	--	--	--	--
Trichloroethene	--	--	3.4×10^{-5}	3.8×10^{-5}
Benzene	0.0742	0.083	4.1×10^{-6}	4.55×10^{-6}
Tetrachloroethene	--	--	1.84×10^{-4}	2.04×10^{-4}
Chlorobenzene	0.042	0.046	2.7×10^{-5}	3×10^{-5}
1,3-Dichlorobenzene	2.69×10^{-3}	2.98×10^{-3}	1.65×10^{-5}	1.79×10^{-4}
1,4-Dichlorobenzene	0.023	0.026	8.46×10^{-5}	8.86×10^{-4}
1,2-Dichlorobenzene	0.027	0.03	4.76×10^{-4}	5.28×10^{-4}
1,2,4-Trichlorobenzene	0.0109	0.0121	7.06×10^{-4}	7.84×10^{-4}
Arsenic	7.73×10^{-5}	8.59×10^{-5}	3.49×10^{-6}	3.88×10^{-6}
Barium	1.58×10^{-3}	1.76×10^{-3}	3.51×10^{-4}	3.96×10^{-4}
Cadmium	5.17×10^{-5}	5.75×10^{-5}	9.94×10^{-6}	1.11×10^{-5}
Chromium	2.79×10^{-4}	3.1×10^{-4}	6.18×10^{-5}	6.82×10^{-5}
Lead	3.79×10^{-3}	4.18×10^{-3}	1.09×10^{-4}	1.22×10^{-4}
Manganese	4.64×10^{-3}	5.16×10^{-3}	1.83×10^{-3}	2.04×10^{-3}
Zinc	9.47×10^{-3}	0.0105	5.24×10^{-4}	5.82×10^{-4}
Cyanide	3.46×10^{-4}	3.84×10^{-5}	1.51×10^{-4}	1.68×10^{-4}

[IL]JD1900:D3048/1229/23

*Western wells = SC1A, SC7A
**Northern wells = SC5A, SC4A

3163 BUFFALO AVENUE LOADING DATA
A-ZONE (WORST CASE)

	Western Boundary*		Northern Boundary**	
Contaminant	February (#/D)	May (#/D)	February (#/D)	May (#/D)
Vinyl chloride	--	--	4.06×10^{-5}	4.5×10^{-5}
Total-1,2-dichloroethene	--	--	1.56×10^{-4}	1.23×10^{-3}
1,2-Dichloroethane	--	--	--	--
Trichloroethene	--	--	6.6×10^{-5}	7.4×10^{-5}
Benzene	0.0783	0.0874	7.11×10^{-6}	7.88×10^{-6}
Tetrachloroethene	--	--	3.57×10^{-4}	3.96×10^{-4}
Chlorobenzene	0.0506	0.0557	4.7×10^{-5}	5×10^{-5}
1,3-Dichlorobenzene	3.21×10^{-3}	0.028	2.89×10^{-5}	3.1×10^{-4}
1,4-Dichlorobenzene	0.028	0.0387	1.48×10^{-4}	1.97×10^{-4}
1,2-Dichlorobenzene	0.0331	0.037	8.26×10^{-4}	9.17×10^{-4}
1,2,4-Trichlorobenzene	0.0132	0.0146	1.22×10^{-3}	1.36×10^{-3}
Arsenic	9.31×10^{-5}	1.03×10^{-4}	6.65×10^{-6}	7.67×10^{-6}
Barium	1.9×10^{-3}	2.11×10^{-3}	6.88×10^{-4}	3.1×10^{-4}
Cadmium	6.22×10^{-5}	6.72×10^{-4}	1.74×10^{-4}	3.16×10^{-4}
Chromium	3.36×10^{-4}	3.7×10^{-4}	1.2×10^{-4}	1.31×10^{-4}
Lead	4.54×10^{-3}	5.04×10^{-3}	2.08×10^{-4}	2.33×10^{-4}
Manganese	5.55×10^{-3}	6.18×10^{-3}	3.51×10^{-3}	3.9×10^{-3}
Zinc	0.115	0.0127	1×10^{-3}	1.13×10^{-3}
Cyanide	4.14×10^{-4}	4.58×10^{-4}	2.62×10^{-4}	2.91×10^{-4}

[IL]JD1900:D3048/1229/23

*Western wells = SC1A, SC7A
**Northern wells = SC5A, SC4A

3163 BUFFALO AVENUE LOADING DATA
A-ZONE

Loading Totals	Western Boundary*		Northern Boundary**	
	February (#/D)	May (#/D)	February (#/D)	May (#/D)
VOLATILE ORGANICS				
Best case	0.1162	0.129	3.59×10^{-4}	3.98×10^{-4}
Worst case	0.1289	0.1431	6.74×10^{-4}	1.87×10^{-3}
SEMI-VOLATILE ORGANICS				
Best case	0.0636	0.0711	1.28×10^{-3}	2.37×10^{-3}
Worst case	0.0775	0.1183	2.22×10^{-3}	2.78×10^{-3}
METALS				
Best case	0.02	0.022	3.04×10^{-3}	3.39×10^{-3}
Worst case	0.128	0.0276	5.97×10^{-3}	6.32×10^{-3}
TOTAL LOADING				
Best case	0.1998	0.2221	4.68×10^{-3}	6.16×10^{-3}
Worst case	0.3344	0.289	8.86×10^{-3}	0.011

[IL]JD1900:D3048/1229/23

*Western wells = SC1A, SC7A
**Northern wells = SC5A, SC4A

3163 BUFFALO AVENUE LOADING DATA
B-ZONE (BEST CASE)

Contaminant	Western Boundary*		Northern Boundary**	
	February (#/D)	May (#/D)	February (#/D)	May (#/D)
Vinyl chloride	—	—	—	—
Total-1,2-dichloroethene	—	—	—	—
1,2-Dichloroethane	—	—	—	—
Trichloroethene	—	—	—	—
Benzene	8.97	12.5	2.6×10^{-4}	3.6×10^{-4}
Tetrachloroethene	—	—	—	—
Chlorobenzene	—	—	1.56×10^{-3}	2.18×10^{-3}
1,3-Dichlorobenzene	0.113	0.158	0.0304	0.0425
1,4-Dichlorobenzene	0.347	0.485	0.1068	0.1494
1,2-Dichlorobenzene	0.289	0.404	0.1382	0.1933
1,2,4-Trichlorobenzene	0.142	0.199	0.2776	0.0388
Arsenic	3.4×10^{-4}	4.76×10^{-4}	9.29×10^{-6}	1.3×10^{-5}
Barium	—	—	—	—
Cadmium	2.43×10^{-4}	3.4×10^{-4}	7.8×10^{-6}	1.09×10^{-5}
Chromium	1.47×10^{-3}	2.06×10^{-3}	1.73×10^{-3}	2.4×10^{-3}
Lead	3.86×10^{-3}	5.4×10^{-3}	2.65×10^{-3}	3.7×10^{-3}
Manganese	0.024	0.034	0.228	0.032
Zinc	0.093	0.13	2.43×10^{-3}	3.4×10^{-3}
Cyanide	2.43×10^{-3}	3.4×10^{-3}	—	—

[IL]JD1900:D3048/1229/23

*Western wells = SC1B
**Northern wells = SC4B, SC5B

3163 BUFFALO AVENUE LOADING DATA
B-ZONE (WORST CASE)

Contaminant	Western Boundary* February (#/D)	Western Boundary* May (#/D)	Northern Boundary** February (#/D)	Northern Boundary** May (#/D)
Vinyl chloride	--	--	--	--
Total-1,2-dichloroethene	--	--	--	--
1,2-Dichloroethane	--	--	--	--
Trichloroethene	--	--	--	--
Benzene	8.97	12.5	1.21×10^{-3}	1.69×10^{-3}
Tetrachloroethene	--	--	--	--
Chlorobenzene	--	--	7.28×10^{-3}	0.0102
1,3-Dichlorobenzene	0.113	0.158	0.031	0.0433
1,4-Dichlorobenzene	0.347	0.485	0.1081	0.1512
1,2-Dichlorobenzene	0.289	0.404	0.1408	0.1969
1,2,4-Trichlorobenzene	0.142	0.199	0.0287	0.0401
Arsenic	3.4×10^{-4}	4.76×10^{-4}	4.33×10^{-5}	6.06×10^{-5}
Barium	--	--	--	--
Cadmium	2.43×10^{-4}	3.4×10^{-4}	3.64×10^{-5}	5.09×10^{-5}
Chromium	1.47×10^{-3}	2.06×10^{-3}	1.823×10^{-3}	2.55×10^{-3}
Lead	3.86×10^{-3}	5.4×10^{-3}	4.07×10^{-3}	5.69×10^{-3}
Manganese	0.024	0.034	0.0294	0.0414
Zinc	0.093	0.13	6.46×10^{-3}	9.03×10^{-3}
Cyanide	2.43×10^{-3}	3.4×10^{-3}	--	--

[IL]JD1900:D3048/1229/23

*Western wells = SC1B (same values as best case)
**Northern wells = SC4B, SC5B

3163 BUFFALO AVENUE LOADING DATA
B-ZONE

Loading Totals	Western Boundary*		Northern Boundary**	
	February (#/D)	May (#/D)	February (#/D)	May (#/D)
VOLATILE ORGANICS				
Best case	8.97	12.5	1.82×10^{-3}	2.54×10^{-3}
Worst case	8.97	12.5	8.49×10^{-3}	0.0119
SEMI-VOLATILE ORGANICS				
Best case	0.891	1.246	0.553	0.424
Worst case	0.891	1.246	0.3086	0.4315
METALS				
Best case	0.125	0.176	0.235	0.0415
Worst case	0.125	0.176	0.0418	0.0588
TOTAL LOADING				
Best case	10.0	13.92	0.79	0.468
Worst case	10.0	13.92	0.3589	0.5022

[IL]JD1900:D3048/1229/23

*Western wells = SC1B
**Northern wells = SC4B, SC5B

3163 BUFFALO AVENUE LOADING DATA

Contaminant	Zone*	Best Case (#/D)	Worst Case (#/D)	Month W.L. Taken
Vinyl chloride	C	1.13×10^{-5}	1.18×10^{-5}	March
Total-1,2-dichloroethene	C	0.013	0.0136	March
1,2-Dichloroethane	C	--	--	March
Trichloroethenene	C	3.97×10^{-3}	4.5×10^{-3}	March
Benzene	C	0.147	0.153	March
Tetrachloroethene	C	5.09×10^{-3}	5.33×10^{-3}	March
Chlorobenzene	C	0.0684	0.072	March
1,3-Dichlorobenzene	C	0.1192	0.124	March
1,4-Dichlorobenzene	C	0.0302	0.032	March
1,2-Dichlorobenzene	C	0.062	0.065	March
1,2,4-Trichlorobenzene	C	0.0446	0.047	March
Arsenic	C	5.64×10^{-4}	5.9×10^{-4}	March
Barium	C	--	--	March
Cadmium	C	--	--	March
Chromium	C	5.3×10^{-4}	5.58×10^{-4}	March
Lead	C	1.07×10^{-3}	1.12×10^{-3}	March
Manganese	C	3.46×10^{-3}	3.63×10^{-3}	March
Zinc	C	7.73×10^{-3}	8.09×10^{-3}	March
Cyanide	C	0.04	0.042	March

[IL]JD1900:D3048/1229/23

*C Zone = well SC5C; C-D Zone = well SC5C-D; F Zone = well SC5F; all are northern boundary wells.

3163 BUFFALO AVENUE LOADING DATA

Contaminant	Zone*	Best Case (#/D)	Worst Case (#/D)	Month W.L. Taken
Vinyl chloride	C-D	--	--	May
Total-1,2-dichloroethene	C-D	0.0154	0.0346	May
1,2-Dichloroethane	C-D	--	--	May
Trichloroethenene	C-D	--	--	May
Benzene	C-D	0.0295	0.067	May
Tetrachloroethene	C-D	--	--	May
Chlorobenzene	C-D	0.175	0.395	May
1,3-Dichlorobenzene	C-D	0.0195	0.044	May
1,4-Dichlorobenzene	C-D	0.051	0.115	May
1,2-Dichlorobenzene	C-D	0.115	0.258	May
1,2,4-Trichlorobenzene	C-D	0.0364	0.082	May
Arsenic	C-D	--	--	May
Barium	C-D	--	--	May
Cadmium	C-D	--	--	May
Chromium	C-D	5.91×10^{-4}	1.33×10^{-3}	May
Lead	C-D	2.09×10^{-3}	4.7×10^{-3}	May
Manganese	C-D	0.014	0.032	May
Zinc	C-D	9.77×10^{-3}	0.022	May
Cyanide	C-D	0.02	0.045	May

[IL]JD1900:D3048/1229/23

*C Zone = well SC5C; C-D Zone = well SC5C-D; F Zone = well SC5F; all are northern boundary wells.

3163 BUFFALO AVENUE LOADING DATA

Contaminant	Zone*	Best Case (#/D)	Worst Case (#/D)	Month W.L. Taken
Vinyl chloride	F	0.646	3.42	May
Total-1,2-dichloroethene	F	0.158	0.836	May
1,2-Dichloroethane	F	--	--	May
Trichloroethenene	F	--	--	May
Benzene	F	--	--	May
Tetrachloroethene	F	--	--	May
Chlorobenzene	F	--	--	May
1,3-Dichlorobenzene	F	--	--	May
1,4-Dichlorobenzene	F	9.06×10^{-4}	4.8×10^{-3}	May
1,2-Dichlorobenzene	F	2.57×10^{-3}	0.0136	May
1,2,4-Trichlorobenzene	F	--	--	May
Arsenic	F	--	--	May
Barium	F	--	--	May
Cadmium	F	--	--	May
Chromium	F	0.578	3.06	May
Lead	F	1.43×10^{-3}	7.57×10^{-3}	May
Manganese	F	6.04×10^{-3}	0.032	May
Zinc	F	0.117	0.062	May
Cyanide	F	--	--	May

[IL]JD1900:D3048/1229/23

*C Zone = well SC5C; C-D Zone = well SC5C-D; F Zone = well SC5F; all are northern boundary wells.

3163 BUFFALO AVENUE LOADING DATA

Loading Totals	C Zone	C-D Zone	F Zone
VOLATILE ORGANICS			
Best case	0.2375	0.2199	0.804
Worst case	0.2484	0.4966	4.256
SEMI-VOLATILE ORGANICS			
Best case	0.256	0.2219	3.476×10^{-3}
Worst case	0.268	0.499	0.0184
METALS			
Best case	0.0533	0.0446	0.7024
Worst case	0.056	0.105	3.16
TOTAL LOADING			
Best case	0.5468	0.4864	1.51
Worst case	0.5724	1.1	7.43

[IL]JD1900:D3048/1229/23

3163 BUFFALO AVENUE LOADING DATA

(values given in lb/day)
(all worst case)

	Western Boundary*	Northern Boundary**
A ZONE		
PESTICIDE		
α BHC	1.9×10^{-5}	9.5×10^{-6}
β BHC	--	3.9×10^{-5}
∂ BHC	3.9×10^{-6}	--
γ BHC	--	--
B ZONE		
PESTICIDE		
α BHC	0.011	0.155
β BHC	--	--
∂ BHC	--	7.75×10^{-5}
γ BHC	--	--
C ZONE		
PESTICIDE		
α BHC	--	--
β BHC	--	--
∂ BHC	--	--
γ BHC	--	--

[IL]JD1900:D3048/1229/23

*Western wells = SC1A; SC1B.
**Northern wells = SC4A; SC4B; SC5B; SC5C; SC5C; SC-5C-D; SC5F.

3163 BUFFALO AVENUE LOADING DATA

(values given in lb/day)
(all worst case)

C-D ZONE	Well SC-D
PESTICIDE	
α BHC	0.016
β BHC	4.55×10^{-3}
∂ BHC	--
γ BHC	4×10^{-3}
F ZONE	Well 5F
PESTICIDE	
α BHC	8×10^{-3}
β BHC	--
∂ BHC	--
γ BHC	--

[IL]JD1900:D3048/1229/23

APPENDIX E

TOXILOGICAL PROFILES

ARSENIC

Arsenic is a naturally occurring element usually found combined with one or more other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is referred to as inorganic arsenic, while oxygen combined with carbon and hydrogen is referred to as organic arsenic. The organic forms are usually less toxic than the inorganic forms (ATSDR 1989). Arsenic is widely distributed in the environment from natural sources, but higher concentrations have been found associated with the following situations: waste chemical disposal sites, smelting of copper and other metals, fossil fuel combustion, and pesticide use. Average 24-hour ambient air arsenic levels in the United States (U.S.), based on National Air Sampling Network data, ranged from 2.6 ng/m^3 to 10.9 ng/m^3 (Akland 1983). The natural arsenic content of soils varies between 0.1 and 80 ppm, with an average of 5 to 6 ppm (Walsh and Keenly 1975). Over 90% of all surface water contains 10 µg/L arsenic or less. The average concentration of arsenic in U.S. drinking water supplies is about 2 µg/L (Greathouse and Craun 1978).

Environmental Chemistry and Fate

Arsenic may be released to the atmosphere as a gas or vapor, or adsorbed to particulate matter and transported to other media by dry or wet deposition (ATSDR 1989). Trivalent arsenic may undergo oxidation in the air; therefore, atmospheric arsenic is usually a mixture of the trivalent and pentavalent forms. Most airborne arsenic is usually adsorbed on small-diameter particulate matter. Photolysis is not considered to be an important fate process for arsenic.

Arsenic in surface water can undergo a complex pattern of transformations: oxidation-reduction, ligand exchange, biotransformation, precipitation, and adsorption (EPA 1978). As a consequence of these reactions, arsenic is extremely mobile in aquatic systems, and riverborne arsenic is capable of being transported great distances. Factors most strongly influencing the rates of these reactions include: Eh, pH, metal sulfide and sulfide ion concentrations, iron concentration, presence of phosphorus minerals, temperature, salinity, and distribution and composition of biota (EPA 1979).

Sorption onto clays, iron oxides, manganese compounds, and organic matter is an important fate mechanism in surface water, with sediment serving as a reservoir for most of the arsenic entering surface water. Sediment-bound trivalent and pentavalent arsenic, methylated by aerobic and anaerobic microorganisms, may be released back into the water column.

Soluble forms of arsenic adsorb to soil and travel with the soil matter. Shifts in oxidation state may occur in either direction, depending on the particular characteristics of the soil and groundwater. Volatilization of methylated arsenicals from groundwater is possible.

Arsenic in soil is predominantly found in an insoluble, adsorbed form. Clay with high anion-exchange capacity strongly adsorbs pentavalent arsenic. Other important adsorption processes include complexation and chelation by organic material, iron, or calcium. Leaching of arsenic is usually important in the top 30 centimeters of soil, but may also be important at greater depth in sandy soils. Arsenate predominates in aerobic soils; arsenite is the predominant form in slightly reduced soils; and arsine, methylated arsenicals and elemental arsenic predominate in very reduced conditions (e.g., swamps and bogs)(ATSDR 1987).

As noted above, microorganisms may reduce and methylate arsenicals in water and soil, resulting in volatilization and emission to the air. The volatilization rate is heavily dependent on whether the soil is oxygenated or anaerobic, the pH, and the microbe types and concentrations in soils.

In aquatic systems, bioconcentration of arsenic primarily occurs in algae and lower invertebrates, but biomagnification does not appear to be significant (EPA 1979).

Plants may accumulate arsenic via root uptake, with uptake being dependent on the species, soil arsenic concentration, and soil characteristics.

Toxicokinetics

Exposure to arsenic compounds may occur orally and through inhalation. Little is known about the dermal absorption route. Inorganic arsenic compounds are generally well absorbed, widely distributed and promptly excreted. The rates of these processes depend on the chemical and physical form, particularly the water solubility, of the arsenic compound. Exposure of animal species to either trivalent or pentavalent arsenic leads to the initial accumulation of arsenic in liver, kidney, lung, spleen, aorta, skin, hair, and upper gastrointestinal tract (EPA 1984a). These tissues are cleared rapidly except for skin and hair, where the sulfhydryl groups of keratin may promote tight arsenic (III) binding (ATSDR 1989).

Metabolism of arsenic occurs predominantly in the liver by methylation. The major metabolite is dimethylarsinic acid, which is excreted in the urine.

Noncarcinogenic Effects

At high doses, arsenic compounds have been shown to produce acute and chronic toxic effects, including irreversible systemic damage. The trivalent compounds are the most toxic and tend to accumulate in the body. Animal studies have shown that chronic arsenic exposure may cause body weight changes, decreased blood hemoglobin, liver damage, and kidney damage.

There is evidence that arsenic is an essential element enhancing growth and development in certain animal species, and it has been suggested that arsenic may be an essential element for humans (NAS 1980). Whether or not arsenic is an essential element is the subject of continuing research.

Teratogenic effects of arsenic compounds at relatively high exposure levels have been demonstrated in a number of animal species (ATSDR 1989). Generally, these effects have been observed following parenteral (injection) administration; whereas, administration at lower doses by the more relevant oral route has not resulted in any significant reproductive or developmental effects.

Mutagenicity and Carcinogenicity

Arsenic has been shown to be mutagenic in several assay systems and to induce chromosomal aberrations *in vivo* and *in vitro*. Animal carcinogenicity studies have reported conflicting results. Several studies have reported an increased incidence of bronchogenic carcinomas in rats exposed intratracheally to an arsenic-containing pesticide. Reasons for inconsistent carcinogenicity findings in animals may include inappropriate selection of an animal model, and use of flawed study designs. In humans, epidemiologic studies and case reports have documented that arsenic is associated with tumors of the skin, lungs, genital organs, and visual organs (EPA 1987, ATSDR 1989).

EPA has classified arsenic in Group A, a human carcinogen, based on extensive evidence of human carcinogenicity through inhalation and ingestion exposure (EPA 1990a,b).

Quantitative Indices of Toxicity

Quantitative indices of toxicity for arsenic are presented in Table 1.

Using the absolute-risk linear model, EPA derived the upper-bound 95% confidence limit slope factor (SF) based on human exposure data. The upper-bound estimate for the inhalation route is 50.0 $(mg/kg/day)^{-1}$.

Standards and Criteria

Standards and criteria relevant to arsenic are listed in Table 2. The current MCL for arsenic under the National Interim Drinking Water Regulations is 50 ug/L. The NAS Drinking Water Committee has analyzed the toxicology of arsenic (NAS 1983a). Based upon this evaluation, NAS recommended the retention of the MCL, pending resolution of the question whether arsenic is an essential element in the human diet.

Consistent with the NAS recommendations, EPA has proposed that the MCL remain at the current MCL of 50 ug/L. In its determination, EPA stated that the MCL was below concentrations at which noncarcinogenic toxicity had been demonstrated and was within the concentration range which might be, based on further investigation, essential for humans (EPA 1985, 1987).

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Table 1A

NONCARCINOGENIC INDICES OF TOXICITY FOR ARSENIC

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	1×10^{-3}
Subchronic RfD (RfDs) mg/kg/day	1×10^{-3}
Confidence Level	NS
Critical Effect	keratosis; hyperpigmentation; cancer
Test Species for Critical Effect	Human
RfD Basis	Inhalation
RfD Source	HEAST - EPA 1990b
Uncertainty Factor	
- Chronic RfD	1
- Subchronic RfD	1

NS = Not specified.

Table 1B

CARCINOGENIC TOXICITY INDICES FOR ARSENIC

Oral Route	
Slope Factor (SF) (mg/kg-day)$^{-1}$	NA
Weight of Evidence Classification	A
Type of Cancer	Skin
Test Species	Human populations
SF Basis	Water
SF Source	IRIS - EPA 1990a
Inhalation Route	
Slope Factor (mg/kg-day)$^{-1}$	50.0
Weight of Evidence Classification	A
Type of Cancer	Respiratory tract
Test Species	Human populations
SF Basis	Occupational air
SF Source	IRIS - EPA 1990a

Table 2

STANDARDS AND CRITERIA FOR ARSENIC

Standard or Criterion	Value	Reference
<u>Drinking Water</u>		
U.S. Primary Drinking Water Standards		
MCL (a)	0.05 mg/L	EPA 1990a
MCLG (b)	0.05 mg/L	EPA 1990a
<u>Surface Water</u>		
U.S. EPA Ambient Water Quality Criteria		
Ingesting Water and Organisms	2.2×10^{-6} mg/L	EPA 1990a
Ingesting Organisms Only	1.75×10^{-5} mg/L	EPA 1990a
<u>Occupational Air Concentrations</u>		
OSHA PEL TWA	$10\ \mu g/m^3$	OSHA 1989
ACGIH TWA	$0.2\ mg/m^3$	ACGIH 1989

(a) Maximum contaminant level
(b) Maximum contaminant level goal

BARIUM

Barium (Ba) is a naturally occurring silvery-white metal used industrially commercially in the form of Ba compounds, primarily as barite ($BaSO_4$). Barite is used extensively as a weighting agent in oil and gas drilling fluids. Other major uses for barite are in the production of barium chemicals and in the glass, paint, and rubber industries. Barium concentrations have been monitored in various environmental media. In soils, barium concentrations range from 100 to 3,000 mg/kg, the median being about 500 ppm (Adriano 1986). Concentrations of barium in drinking water supplies generally range from <0.6 µg/L to approximately 10 µg/L.

Environmental Chemistry and Fate

In soils, barium is not expected to be very mobile because it forms water-insoluble salts and because it does not form soluble complexes with humic and fulvic materials (EPA 1985a). Under acidic conditions, however, some of the water-insoluble barium compounds may become more soluble and partitioning to groundwater may occur.

In aquatic media, barium is likely to be present as suspended particulate matter or sediments. In the absence of any other possible removal mechanism, the residence time of barium in aquatic systems would be several hundred years (EPA 1985a).

Noncarcinogenic Effects

Acute exposure to barium in animals and humans results in a variety of cardiac, gastrointestinal, and neuromuscular effects (EPA 1985a).

The role of barium in the development of hypertension in experimental animals and humans is open to question. In deriving an oral reference dose (RfD), EPA identified a no-observed-adverse-effect level (NOAEL) reported in a study by Perry et al. (1983), in which mice chronically received 5.1×10^{-1} mg/kg/day of barium (EPA 1990b). EPA applied an uncertainty factor to the NOAEL to derive an oral RfD of 5.0×10^{-2} mg/kg/day (EPA 1990b). EPA has also derived an inhalation RfD of 1.4×10^{-4} mg/kg/day by application of an uncertainty factor of 1,000 to a subchronic no-observed-effect-level (NOEL) of 0.14 mg/kg/day identified in a study in rats (EPA 1990b).

Reproduction and Development

No adequate mammalian studies on the potential reproductive or developmental effects of barium have been identified (EPA 1987).

Mutagenicity and Carcinogenicity

No adequate studies on the mutagenicity and carcinogenicity of barium have been identified (EPA 1987). Based on the absence of data, EPA has placed barium in carcinogenicity category D, not classified (EPA 1987).

Quantitative Indices of Toxicity

Quantitative indices of toxicity for barium are presented in Table 1.

Based upon the studies by Perry et al. (1983), EPA has derived an oral reference dose (RfD) and RfDs of 5 x 10-2 mg/kg/day. An inhalation RfD was calculated from the experiments by Tamsenko et al. (1977). The RfD is 1 x 10^{-4} mg/kg/day for chronic and 1 x 10^{-3} mg/kg/day subchronic.

Standards and Criteria

Standards and criteria relevant to barium are listed in Table 2.

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Table 1

INDICES OF TOXICITY FOR BARIUM

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	5×10^{-2}
Subchronic RfD (RfDs) mg/kg/day	5×10^{-2}
Confidence Level	Medium
Critical Effect	Fetotoxicity; increased blood pressure
Test Species for Critical Effect	Rat
RfD Basis	Drinking water
RfD Source	HEAST, IRIS (EPA 1990a,b)
Uncertainty Factor	
- Chronic RFD	100
- Subchronic RFD	100
Inhalation Route	
Chronic RfD, mg/kg/day	1×10^{-4}
Subchronic RfDs, mg/kg/day	1×10^{-3}
Confidence Level	Medium
Critical Effect	Fetotoxicity; increased blood pressure
Test Species for Critical Effect	Rat
RfD Basis	Drinking water
RfD Source	HEAST, EPA 1990b
Uncertainty Factor	
- Chronic RfD	1,000
- Subchronic RfD	100

Table 2

STANDARDS AND CRITERIA FOR BARIUM

Standard or Criterion	Value	Reference
Drinking Water		
National Primary Drinking Water Regulations		
MCL (a)	1.0 mg/L (5.0 mg/L proposed)	EPA 1989
MCLG (proposed) (b)	1.5 mg/L	EPA 1989
Occupational Exposure Limits (Air)		
Barium-Soluble Compounds as Ba		
OSHA PEL TWA	0.5 mg/m^3	OSHA 1989
ACGIH TWA	0.5 mg/m^3	ACGIH 1989

a MCL = Maximum contaminant level.
b MCLG = Maximum contaminant level goal.

BENZENE

Benzene has a long history of industrial use. Most notably, benzene has found extensive use as a solvent and as a starting material for the synthesis of other chemicals. Currently, benzene is used as an octane enhancing additive to gasoline to replace alkyl lead compounds. Benzene has been detected in drinking water, food, and air. Based upon federal drinking water surveys, concentrations of benzene in approximately 1.3% of all groundwater systems are estimated to exceed 0.5 µg/L. The highest level reported in groundwater was 80 µg/L. Benzene has been reported in urban and suburban air at levels less than 30 $\mu g/m^3$ (10 ppb). Benzene also has been reported in indoor air at levels higher than in outdoor air.

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of benzene (CAS No. 71-43-2) are summarized below (Howard 1989; MacKay and Shiu 1981):

Chemical Formula	C_6H_6
Molecular Weight	78.1 g/mole
Physical State at 20°C	Liquid
Water Solubility	1.79 E+03 mg/L (25°C)
Liquid Density at 20°C	.88 g/ml
Vapor Pressure	95.2 mm Hg (25°C)
Henry's Law Constant	5.43×10^{-3} $atm \cdot m^3/mole$
Octanol-Water Partition Coefficient (Log K_{ow})	2.13
Organic Carbon Partition Coefficient (K_{oc})	83 ml/g
Bioconcentration Factor (BCF)	5.2

Benzene has a high water solubility and vapor pressure. As a consequence of these two properties, benzene can be characterized as a highly mobile chemical. For benzene released to air, some rainwater washout is anticipated. After deposition in water or soil, volatilization is expected to return some portion back to the atmosphere. Based upon benzene's high Henry's Law Constant, volatilization following release to water will result in substantial loss to the atmosphere.

Benzene's half-life in surface water has been estimated to range from 1 to 6 days, depending on the water temperature, depth, turbulence, and air movement over the water surface. Its half-life in air has been estimated to be 6 days or longer, with the major degradation mechanism being photooxidation.

Due to its high water solubility and high vapor pressure, transport to sediments is not expected to be a major surface-water fate process.

Benzene released to soil can be transported to air via volatilization, to surface water via runoff, and to groundwater via leaching. The first two pathways predominate in surficial soil, whereas the third pathway predominates at lower soil depths.

Benzene, like other low-molecular-weight organics, is subject to biooxidation in subsurface soil and groundwater. No estimates of the half-life in these media were found. Frequently, the availability of other nutrients such as nitrogen, phosphorus, sulfur, trace minerals, and oxygen is a rate-limiting factor in this process.

According to criteria developed by Kenaga (1980), benzene, with a K_{oc} of 83, would be considered mobile in soils. Other factors which influence soil mobility include soil type, amount of rainfall, depth to groundwater, and extent of degradation (ATSDR 1989).

Benzene is rapidly degraded in the atmosphere via reaction with the hydroxy radical. In soils and water, biodegradation is also an important process. In contrast to water, the biodegradation process in soil has not been well characterized. In this medium benzene metabolism proceeds through the formation of cis-dihydrodiols and with further oxidation, to catechols which are substrates for ring fission (Gibson, 1988; Hopper, 1978).

Toxicokinetics

Benzene is readily absorbed via inhalation and ingestion, but poorly absorbed through skin (NIOSH 1974). If benzene behaves like other low-molecular-weight organics, it will be absorbed almost completely via ingestion. However, in humans, only about 50% of an inhaled dose is absorbed (Nomiyama and Nomiyama 1974a, b). Benzene is highly lipid soluble and distributes preferentially to adipose tissue, bone marrow, and the liver (EPA 1983).

Metabolism occurs via oxidation to phenol, followed by conjugation, preferentially with sulfate, but also to glucuronic acid. The metabolites are excreted in the urine (EPA 1985a). Elimination of benzene from the body is biphasic. The initial rapid phase is due to exhalation of unchanged benzene, with a half-life of about 5 hours, while the remainder is excreted much more slowly as metabolites in the urine (Nomiyama and Nomiyama 1974a, b).

Noncarcinogenic Effects

The main effects of brief exposure to high levels of benzene are drowsiness, dizziness, and headaches. These symptoms should disappear after exposure stops.

The best-known and longest-recognized toxic effect of benzene in humans is depression of bone marrow function. Benzene-exposed individuals have been found to display anemia, leucopenia, and/or thrombocytopenia (Kalf 1987; EPA 1987; ATSDR 1989). When simultaneous depression of all three cell types (pancytopenia) is accompanied by bone marrow necrosis, the syndrome is called aplastic anemia.

Benzene and its metabolites localize in the bone marrow, and it is widely agreed that the metabolites are primarily responsible for various hematotoxic effects.

The potential mechanisms for the development of pancytopenia in humans include the destruction of bone marrow cells, the impairment of the differentiation of these cells, or the destruction of more mature hematopoietic cell precursers and circulating cells (Goldstein 1977).

This conclusion is based upon studies which demonstrate that chemicals which alter benzene metabolism also alter benzene toxicity. For example, coadministration of agents such as toluene and phenobarbitol alleviate benzene toxicity, while agents such as ethanol increase benzene toxicity.

Specific benzene metabolites for which hematotoxic effects have been demonstrated experimentally include: benzene oxide, hydroquinone, phenol, catechol and trans, trans-mucondialdehyde.

Carcinogenicity and Mutagenicity

Excess leukemia mortality, particularly acute myelogenous and monocytic leukemia, has been demonstrated among humans occupationally exposed to benzene (see for example, Aksoy 1985; Rinsky et al. 1981; Ott et al. 1981). According to its weight-of-evidence carcinogenicity criteria, EPA has classified benzene in Category A, "human carcinogen," based on sufficient evidence from epidemiological studies on man (EPA 1987). In addition to this definitive human evidence, several long-term bioassays have demonstrated increased incidences of tumors and leukemia following administration in animals.

Benzene has been tested extensively for genotoxic properties. Benzene was not mutagenic in several bacterial and yeast systems. Equivocal results have been reported for clastogenic results *in vitro*; several investigators have reported positive results in mouse micronucleus assays, as well as chromosomal observations in rabbits. Many investigators have reported significant increases in chromosomal aberrations in symptomatic and asymptomatic workers with either a current or past history of exposure to benzene (ATSDR 1989).

Quantitative Indices of Toxicity

Table 1 summarizes the quantitative indices of toxicity for benzene.

Both carcinogenic and noncarcinogenic quantitative indices of toxicity have been derived for benzene. EPA has derived a slope factor (SF) for benzene from epidemiologic data from studies of workers occupationally exposed to benzene (Rinsky et al. 1981; Ott et al. 1978). The SF of 0.029 $(mg/kg/day)^{-1}$ adopted by the EPA is an average value derived from the application of several mathematical carcinogenesis models (EPA 1990a, b).

EPA has derived an oral acceptable daily intake of 0.0007 mg/kg/day (EPA 1987) using data from Wolf et al. (1956) and leukopenia as the severest noncarcinogenic toxicological end point of concern.

Standard and Criteria

Standards and criteria applicable to benzene are summarized in Table 2.

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Table 1B

INDICES OF TOXICITY FOR BENZENE

Oral Route	
Slope Factor (SF) $(mg/kg\text{-}day)^{-1}$	2.9×10^{-2}
Weight of Evidence Classification	A
Type of Cancer	Leukemia
Test Species	Human
SF Basis	Occupational
SF Source	IRIS - EPA 1990a
Inhalation Route	
Slope Factor $(mg/kg\text{-}day)^{-1}$	2.9×10^{-2}
Weight of Evidence Classification	A
Type of Cancer	Leukemia
Test Species	Human
SF Basis	Occupational
SF Source	HEAST; EPA 1985a, 1987a

Table 2

STANDARDS AND CRITERIA FOR BENZENE

Standard or Criterion	Value	Reference
Slope Factor (SF)	2.9×10^{-2}(mg/kg/day)$^{-1}$	EPA 1990a
Drinking Water		
National Primary Drinking Water Regulations		
MCL (a)	0.005 mg/L	EPA 1990a
MCLG (b)	0	EPA 1990a
Surface Water		
EPA Ambient Water Quality Criteria		
Drinking Water Only	0*	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	3.0 mg/m^3 (1.0 ppm)	OSHA 1989
OSHA STEL	15 mg/m^3 (5 ppm)	OSHA 1989
ACGIH TLV TWA	30 mg/m^3 (10 ppm)	ACGIH 1989

*Recommended concentration in drinking water is 0; concentration of 0.67 µg/L corresponds to the 10^{-6} lifetime cancer risk value.

a MCL = Maximum contaminant level.
b MCLG = Maximum contaminant level goal.

CADMIUM

Cadmium is a naturally occurring mineral distributed in trace amounts in the earth's crust. Many of the lead and zinc ores contain small amounts of cadmium and cadmium is produced as a by-product of lead and zinc smelting. The principal uses of cadmium are in the fabrication of alloys and solders, metal plating, as pigments, as stabilizers in plastic materials and in batteries.

Background concentrations of cadmium in surface waters are usually less than 1 µg/L. Surface waters contain more than 2 µg/L of cadmium have probably been contaminated by discharges of industrial wastes or by leaching from areas of landfill or from soils to which sewage sludge has been added (WHO 1984). Drinking water normally contains 1 µg/L or less of cadmium. Higher levels of cadmium (up to 5 µg/L in tap water may be associated with plated plumbing fittings, silver-based solders, and galvanized iron piping materials (CEC 1978). Cadmium has been detected in ambient air at concentrations less than 0.001 µg/m^3 in rural areas to 0.5 µg/m^3 in urban and industrialized areas (WHO 1984). Most food stuffs contain trace amounts of cadmium (less than 0.1 mg/kg wet weight). Typical dietary intakes range from 15 to 60 µg of cadmium per day.

Environmental Chemistry and Fate

The primary sources of atmospheric cadmium are combustion of coal and petroleum products. Cadmium from these sources is primarily adsorbed on small, highly respirable particles, which can be transported over large distances and transferred to other environmental compartments via wet and dry deposition. Cadmium adsorbed to small particulates is more persistent in the atmosphere than that adsorbed to larger particulates. Photochemical reactions are apparently not involved in the environmental fate of cadmium (ATSDR 1989).

Relative to other metals, cadmium is mobile in surface water. In natural waters, cadmium exists as a hydrated ion, metal-inorganic complexes with carbonate, hydroxyl, chlorine or sulfate anions; or as metal-organic complexes with humic acids (ATSDR 1989).

Because it exists only as the divalent cation, aqueous cadmium is not strongly influenced by the redox potential of water. However, under reducing conditions forming sulfide, cadmium will precipitate in sediments as cadmium sulfide. The concentration of aqueous cadmium is usually inversely related to the pH value and the amount of organic material present (ATSDR 1989). Humic acid substances account for most of the organic complexes, with solubility dependent on the nature of the humic substance. Sorption by clays and iron oxides is important in reducing aquatic cadmium concentrations.

Cadmium concentrations are typically low in groundwater due to several factors. These factors include sorption by mineral matter and clay, binding to humic substances, precipitation as cadmium sulfide in the presence of sulfide, and precipitation as cadmium carbonate at high pHs.

In soil, cadmium may occur as free cadmium compounds or as the divalent ion dissolved in soil moisture. As a consequence of cation exchange, cadmium may be bound to soil minerals or organic constituents. The aerobic nature of topsoils tends to reduce the amount of cadmium bound to sulfide. High soil acidity favors release of the divalent cadmium cation and facilitates uptake by plants.

Cadmium is not reduced or methylated by microorganisms. However, the biological production of sulfide results in cadmium precipitation. Cadmium is strongly accumulated by all organisms, with typical concentrations in freshwater and marine organisms being hundreds to thousands of times higher than in water. Bioaccumulation of cadmium is strongly correlated with soil cation-exchange capacity (CEC), increasing with decreasing CEC. Bioconcentration in aquatic life is greatest for bottom feeders (e.g., mollusks and crustaceans), followed by fish and aquatic plants (ATSDR 1989). Bioaccumulation due to the use of cadmium-containing fertilizers on food crops has been noted in beef and poultry.

Toxicokinetics

Cadmium ingested in food and water is poorly absorbed from the gastrointestinal tract with absorption efficiencies ranging from 1 to 6% depending on the chemical form and dose level of the cadmium and on the age, sex, and gastrointestinal contents of the receptor organism. Absorption of cadmium via the inhalation route depends on the size of the particles carrying the cadmium and how deeply they penetrate into the lungs. No information on inhalation absorption was found for humans. However, values from 30 to 60% have been reported for animals.

Once absorbed, cadmium distributes to most tissues but it is preferentially accumulated in the kidneys and liver. Excretion is primarily via the urine and is very slow with a half-life in humans estimated to range from 17 to 38 years. The long half-life leads to a marked tendency for cadmium to accumulate in exposed organisms. Cadmium accumulation in the renal cortex leads to the characteristic renal injury that is the most common toxicological consequence of chronic exposure.

Noncarcinogenic Effects

Acute and chronic exposure to cadmium in animals and humans results in renal dysfunction, hypertension, anemia, and altered liver microsomal activity. The kidneys are considered to be the critical target organ in humans chronically exposed to cadmium by ingestion. The early clinical signs of renal injury include proteinuria, glucosuria, and aminoaciduria.

To calculate a drinking water equivalent level (DWEL), USEPA used renal dysfunction as an endpoint, and the most widely accepted estimate for the critical (threshold) concentration of cadmium in the renal cortex--200 µg/g. Using a 4.5% absorption of the daily dose and 0.01% excretion in the total body burden per day, USEPA calculated an lowest observed adverse effect level (LOAEL) of 352 µg/day for renal effects in humans. Incorporating an uncertainty factor of 10, USEPA has developed a reference intake of 35 µg/day. Adjusting the intake for consumption of 2 liters of water per day, USEPA has derived a DWEL of 18 µg/L (EPA 1989).

Embryotoxic and teratogenic effects have been demonstrated in many mammalian species following parenteral administration of high doses of cadmium. In contrast, there is little evidence of these effects at lower doses by either of the more relevant inhalation or oral exposure routes (USEPA 1981; USPHS 1987).

Carcinogenicity and Mutagenicity

Cadmium chloride aerosol administered by inhalation for 18 months produced lung tumors in rats. In contrast, all cancer bioassays in which cadmium has been administered orally have been negative. Recent epidemiological studies indicated that workers chronically exposed to cadmium are at risk of elevated lung cancer mortality. According to its weight-of-evidence carcinogenicity criteria, USEPA has classified cadmium in Group B1 (probable human carcinogen) for inhalation based on the epidemiological data (USEPA 1986).

While the Agency has concluded that cadmium is a carcinogen by the inhalation route, USEPA has classified cadmium in Group D, inadequate evidence for carcinogenicity for the oral route of exposure, because of the negative results reported for cancer bioassays in which cadmium was administered orally (USEPA 1989). Consistent with this categorization, USEPA has proposed that the maximum contaminant level (MCL) for cadmium be set based upon noncarcinogenic toxicological endpoints (EPA 1989).

Quantitative Indices of Toxicity

Quantitative indices of toxicity for cadmium are presented in Table 1.

EPA has derived a reference dose (RfD) based upon the assumption that absorption of cadmium is 2.5% for food and 5% for water. Thus the toxicokinetic model predicts a NOAEL of .005 and .01 µg/kg/day for water and food respectively. With a UF value equal to 10, an RfD of .005 µg/kg/day for cadmium in water and an RfD of .001 µg/kg/day for cadmium in food was established.

Standards and Criteria

Standards and criteria applicable to cadmium are summarized in Table 2.

The current MCL for cadmium, under the National Interim Primary Drinking Water Regulations, is 10 µg/L. This level was designed to prevent renal dysfunction, and was based on a critical value of cadmium in the kidney cortex of 200 µg/g, and assumptions on gastrointestinal absorption, excretion of the absorbed dose, daily excretion of the total body burden, and daily dietary cadmium intakes. The World Health Organization (WHO) guideline for drinking water is 5 µg/L. This value was based on a value for provisional tolerable weekly cadmium intake, assuming that 25% of the total cadmium intake was attributable to drinking water. USEPA has proposed a maximum contaminant level goal (MCLG) of 5 µg/L based upon the WHO guidelines and the National Academy of Science (NAS) recommendations (USEPA 1989).

The WHO's provisional tolerable weekly intake criteria of 0.0067 to 0.0083 mg/kg/week is used to evaluate dietary intake of cadmium by the Food and Drug Administration (FDA). Standards for cadmium concentrations in food are not currently available and cadmium in food surveys are not routinely conducted by Federal regulatory agencies. The FDA's contaminants team is proposing to develop criteria for evaluating inorganic contaminants in shellfish (FDA 1989).

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Table 1A

NONCARCINOGENIC INDICES OF TOXICITY FOR CADMIUM

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	
- Food	1×10^{-3}
- Water	5×10^{-4}
Subchronic RfD mg/kg/day	ND
Confidence Level	High
Critical Effect	Significant proteinurea
Test Species for Critical Effect	Human - renal cortex tissue
RfD Basis	Food and Water
RfD Source	IRIS - EPA 1990a
Uncertainty Factor	
- Chronic RfD	10
- Subchronic RfD	ND
Modifying Factor	
- Chronic RfD	1
- Subchronic RfD	ND

ND = Not determined.

Table 1B

INDICES OF TOXICITY FOR CADMIUM

Inhalation Route	
Slope Factor $(mg/kg\text{-}day)^{-1}$	6.1
Weight of Evidence Classification	B1
Type of Cancer	Respiratory tract
Test Species	Human
SF Basis	Occupational
SF Source	HEAST - EPA 1990b

Table 2

STANDARDS AND CRITERIA
For Cadmium

Standard or Criterion	Value	Reference
<u>Drinking Water</u>		
National Primary Drinking Water Regulations	0.005 mg/L (p)	EPA 1989
Maximum Contaminant Level	0.010 mg/L	EPA 1989
Proposed Revised MCL	0.005 mg/L	EPA 1989
Maximum Contaminant Level Goal	0.005 mg/L (p)	EPA 1989
<u>Surface Water</u>		
EPA Ambient Water Quality Criteria		
Water Consumption Only	0.010 mg/L	EPA 1990a
<u>Occupational Air Concentrations</u>		
OSHA PEL TWA: Dust	0.2 mg/m^3 (f)	OSHA 1989
Fumes	0.1 mg/m^3 (f)	OSHA 1989
All forms	0.001/0.005 mg/m^3 (p)	OSHA 1989
ACGIH TWA	0.05 mg/m^3	ACGIH 1989

(f) = final standard
(p) = proposed standard

CHLOROBENZENE

Chlorobenzene is used as a chemical manufacturing intermediate and as a heat transfer medium. Industrial uses of chlorobenzene include in metal cleaning operations and as an organic solvent. Releases of chlorobenzene to the environment have occurred near industrial areas. The EPA reports that a maximum of 0.1% of groundwater sources of drinking water contain chlorobenzene levels between 0.5 and 5 μg/L. Chlorobenzene has been identified as a contaminant in air at very low levels (less than 1 ppb) in urban and suburban areas.

Environmental Transport and Fate

The relevant physical and chemical properties and environmental fate of chlorobenzene (CAS No. 108-90-7) are summarized below (EPA 1986a):

Molecular Formula	C_6H_5Cl
Molecular Weight	113 g/mole
Physical State at 20°C	Liquid
Water Solubility	466 mg/L (25°C)
Density	1.10 g/ml
Vapor Pressure	11.7 mm Hg (25°C)
Henry's Law Constant	3.7×10^{-3} atm·m^3/mole (20°C)
Octanol-Water Partition Coefficient (Log K_{ow})	2.84
Organic Carbon Partition Coefficient (K_{oc})	330 mL/g
Bioconcentration Factor (BCF)	10

Chlorobenzene's moderate water solubility, vapor pressure, and Henry's Law Constant indicate that volatilization is probably a major loss mechanism of chlorobenzene from surface water and surficial soils. A half-life range of 0.5 to 9 hours has been estimated for surface waters, depending on water temperature, depth, turbulence, and air movement across the water surface. A half-life in air has been estimated to be 3.5 days (EPA 1986).

Chlorobenzene's moderate water solubility, vapor pressure, K_{oc}, and log K_{ow} values suggest that this compound will have a low to moderate mobility in the subsurface. Biodegradation of chlorobenzene in the subsurface is possible; however, limited data suggest that it is a slow process for this compound. Accordingly, chlorobenzene is estimated to have a soil half-life of several months.

Chlorobenzene has a moderate BCF and reportedly bioaccumulates in fish, aquatic invertebrates, and algae.

Toxicokinetics

No specific data were found in the available literature on the absorption of chlorobenzene. However, based on the physical properties of the compound and extrapolation from related compounds, chlorobenzene would be expected to be nearly completely absorbed via the oral route and about 60% absorbed via inhalation (Astrand 1975; Dallas et al. 1983). In rats, chlorobenzene absorbed by inhalation was preferentially found in the adipose tissue, liver, and kidneys (Sullivan et al. 1983). Metabolism occurs via oxidation to p-chlorophenol, p-chlorolatechol, and p-chlorophenyl-mercapturic acid (Williams et al. 1975). At lower doses, chlorobenzene is excreted mainly as metabolites, including conjugation products, in the urine. However, as these pathways become saturated at higher doses, excretion of unchanged chlorobenzene in exhaled air increases (Sullivan et al. 1983).

Noncarcinogenic Effects

Data on toxic effects in humans is sparse and is derived from incidents of accidental poisoning or occupational exposure in which the dose or even the causative agent may be unclear. Adverse effects reported include CNS depression, eye and respiratory irritation, and decreased blood cell counts.

In animals (mainly rats), increases in liver/body weight and kidney/body weight ratios, decreased body weight gains, and histopathological lesions in the liver, kidney, and lymphoid tissue have been reported (Monsanto 1980; Knapp et al. 1971; Hazelton 1967b; NTP 1985; Battelle 1978).

No data were found in the available literature on the reproductive effects of chlorobenzene.

Two studies in rats and rabbits in which pregnant females were exposed to chlorobenzene during the major organ-forming period failed to produce any evidence of teratogenicity, although some maternal toxicity (increased liver/body weight ratios) was noted at higher doses (John et al. 1984; Hayes et al. 1982).

Chlorobenzene has been shown to be mutagenic in some experimental systems, but not in others (EPA 1987).

Carcinogenicity and Mutagenicity

Chlorobenzene was tested in the NTP bioassay program (NTP 1985). The results indicated a borderline significant increase in liver tumors in high-dose male rats. No increased tumor incidence in female rats or male or female mice was detected. According to its weight-of-evidence carcinogenicity criteria, EPA has placed chlorobenzene in Category D, "not classified."

Standards and Criteria

Standards and criteria applicable to chlorobenzene are listed in Table 1.

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Table 1

STANDARDS AND CRITERIA FOR CHLOROBENZENE

Standard or Criterion	Value	Reference
Reference Dose		
Oral	3×10^{-2} (mg/kg/day)	EPA 1990
Inhalation	5×10^{-3} (mg/kg/day)	EPA 1990
Surface Water		
EPA Ambient Water Quality Criteria		
Water Ingestion Only	488 µg/L	EPA 1986
Freshwater Acute Aquatic Toxicity	488 µg/L	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	350 mg/m^3 (75 ppm)	OSHA 1989
ACGIH TWA	350 mg/m^3 (75 ppm)	ACGIH 1989

CHROMIUM

Chromium is a naturally occurring element that is used mainly for making steel and other alloys. Chromium compounds are also used in refractory brick for the metallurgical industry and in the chemical industry for metal finishing, manufacture of pigments, leather tanning, wood treatment, and water treatment. Larger amounts of chromium are emitted into the environment from the mining of ores containing chromium and the use of chromium compounds in industrial processes than from natural processes. The atmospheric chromium concentration in the United States is typically less than 0.01 $\mu g/m^3$ in rural areas and 0.01 to 0.03 $\mu g/m^3$ in urban areas (Fishbein 1984). The concentration of chromium in United States river waters usually ranges between 1 and 30 µg/L. Chromium concentrations in soils are reported to range from 5 to 1,500 mg/kg (Carey 1982).

Environmental Chemistry and Fate

The dominant chromium species in water and sediment are hexavalent chromium, or Cr(VI), and trivalent chromium, or Cr(III), both of which will partition between water and sediment. The principal chromium species which will enter into chromium equilibrium in natural water is $Cr(OH)_3$. In soil, Cr(III) is the dominant species. Cr(VI) is soluble in water, existing in solution as a complex anion. Cr(III) may be soluble as an organic complex (Towill et al. 1978), depending on the availability of suitable complexing agents. Cr(VI) is reduced readily by organic matter to Cr(III), while Cr(III) may be oxidized slowly to Cr(VI) in ambient water (EPA 1985a). Cr(III) is likely to be precipitated as insoluble $Cr(OH)_3$ and deposited in sediment. In the pH range of natural water (5.0 to 9.0) and in the presence of chlorides, Cr(III) compounds are likely to precipitate as $Cr(OH)_3$. Higher pH levels are likely to increase $Cr(OH)_3$ formation. Most of the Cr(III) present in surface water is present as particulate matter in sediment.

Most chromium is present in soil in a mineral state, either adsorbed or precipitated (EPA 1985a). Organic matter present in soil is likely to reduce any soluble chromate to insoluble chromium trioxide (Cr_2O_3). The most common form of chromium in soil is Cr(III) as Cr_2O_3-nH_2O (EPA 1985a).

Chromium may be deposited in surface water and sediment by surface runoff, atmospheric deposition of chromium-containing particulate matter, and emissions from specific chromium sources (Versar 1979). Cr(VI), due to its solubility, is likely to be transported by water. Cr(III) may also be transported by water as suspended particulate matter or as bedload sediment.

Flooding of soils and the resulting anaerobic decomposition of plant matter may increase dissolution of Cr_2O_3-nH_2O in soil (Towill et al. 1978). Chromium is also transported from soil by runoff and may be transported to the atmosphere by aerosol formation (John et al. 1973).

No data were found to indicate that photolysis, volatilization, or sorption are important factors in the environmental fate and transport of chromium (EPA 1985a).

Toxicokinetics

Absorption of chromium and chromium compounds is associated with the inhalation, oral, and dermal routes of exposure. Orally administered chromium in humans resulted in approximately 0.4% of the ^{51}Cr (from $^{51}CrCl_3$) and approximately 10.6% of the ^{51}Cr (from Na_2CrO_4) being absorbed (Donaldson and Barreras 1966). Dermal absorption of chromium is dependent on the chemical species, as well as on physical factors.

Chromium may be distributed throughout the body, with the highest concentrations found in the kidneys, lymph nodes, lungs, spleen, liver, and blood.

Chromium is metabolized by reduction of Cr(VI) to Cr(III) (ATSDR 1987). In vitro studies have shown that Cr(VI) is readily reduced to Cr(III) by gastric juices or glutathione (GSH) (Kitagawa et al. 1982; Levis et al. 1978).

Excretion of chromium occurs in multiple stages: a rapid phase representing clearance from the blood, and at least two slower phases representing clearance from tissues. Urinary excretion is the primary route of elimination (Cavalleri and Minoia 1985; Mertz et al. 1965).

Noncarcinogenic Effects

Following inhalation, Cr(VI) is a respiratory tract irritant. Nasal irritation and slight transient effects on pulmonary function occur at the lowest-observed-adverse-effect level (LOAEL). Ulceration and perforation of the nasal passages have been observed at concentrations of 20 to 46 µg/m^3 (ATSDR 1989). In vitro studies of chromium-induced toxicity following inhalation have indicated that the immune system may be affected. Depression of some indices of the immune system were reported at the higher concentrations, and stimulation was reported at lower concentrations. Hypersensitivity reactions have been reported in humans following inhalation exposure to chromium compounds (Glaser 1985; ATSDR 1989; Moller 1986).

Occupational exposure to chromium compounds by inhalation have resulted in changes in the kidney and liver. Reports of kidney damage, but not liver damage, following oral and dermal exposure to Cr(VI) compounds have been cited (ATSDR 1989).

Carcinogenicity and Mutagenicity

Based on positive animal studies and positive epidemiological studies demonstrating excess cancer mortality in humans among Cr(VI)-exposed workers, and according to its weight-of-evidence carcinogenicity criteria, EPA has placed Cr(VI) in Category A, "human carcinogen" (EPA 1985a). However, since chromium has not been shown to be carcinogenic by the oral route, EPA has concluded that chromium in drinking water should be regulated based upon noncarcinogenic chronic toxicity data (EPA 1985a, b).

Cr(VI) has demonstrated consistently positive mutagenic activity in a number of bacterial systems. Both Cr(III) and Cr(VI) have been shown to interact with DNA in bacterial assays. Cr(VI) has inhibited DNA synthesis and increased unscheduled DNA synthesis in mammalian cells in culture. Both valences have been demonstrated to produce clastogenic effects in mammalian cells. Increased frequencies of chromosomal aberrations have also been observed in occupationally exposed workers.

Quantitative Indices of Toxicity

Table 1 summarizes the quantitative indices of toxicity for chromium (III) and chromium (VI).

There are two chromium valences of principal concern in soil and drinking water: Cr(III) and Cr(VI). Cr(VI) is much more toxic than

Cr(III) and has been shown to produce liver and kidney damage, internal hemorrhages, and respiratory disorders. EPA has developed an adjusted acceptable daily intake (AADI) for total chromium based upon the effects of Cr(VI) for the following reasons (EPA 1985a):

- The two valences are in dynamic equilibrium in aqueous media;
- An AADI based upon Cr(VI), the more toxic of the two valences, will be more conservative (health-protective); and
- Reduction of Cr(VI) to Cr(III) in the stomach following oral intake is incomplete and, relative to Cr(III), there is greater Cr(VI) absorption and tissue accumulation.

EPA derived the provisional AADI for total chromium based on a no-observed-adverse-effect level (NOAEL) reported in a study in which rats were exposed to Cr(VI) in drinking water for one year. Based on a NOAEL of 2.41 mg/kg/day, an uncertainty factor of 500, and standard intake and physiological assumptions, EPA derived an oral reference dose (RfD) of 5.0×10^{-3} mg/kg/day (EPA 1987, 1990a,b).

Standards and Criteria

Standards and criteria applicable to chromium are summarized in Table 2.

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Table 1A

INDICES OF TOXICITY FOR CHROMIUM (III)

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	1.0
Subchronic RfD (RfDs) mg/kg/day	10
Confidence Level	Low
Critical Effect	Hepatotoxicity
Test Species for Critical Effect	Rat
RfD Basis	Diet
RfD Source	IRIS - EPA 1990a
Uncertainty Factor	
- Chronic RfD	100
- Subchronic RfD	100
Modifying Factor	
- Chronic RfD	10
- Subchronic RfD	NS

Table 1B

INDICES OF TOXICITY FOR CHROMIUM (VI)

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	5×10^{-3}
Subchronic RfD (RfDs) mg/kg/day	2×10^{-2}
Confidence Level	Low
Critical Effect	Cancer - not defined
Test Species for Critical Effect	Rat
RfD Basis	Water
RfD Source	IRIS - EPA 1990a
Uncertainty Factor	
- Chronic RfD	500
- Subchronic RfD	100
Modifying Factor	
- Chronic RfD	1
- Subchronic RfD	NS

Table 1C

CARCINOGENIC INDICES OF TOXICITY FOR CHROMIUM (VI)

Inhalation Route	
Slope Factor $(mg/kg\text{-}day)^{-1}$	41.0
Weight of Evidence Classification	A
Type of Cancer	Lung
Test Species	Rat
SF Basis	Occupational Air
SF Source	IRIS

Table 2

STANDARDS AND CRITERIA FOR CHROMIUM

Standard or Criterion	Value	Reference
Drinking Water		
National Primary Drinking Water Regulations		
MCL (a) present	0.05 mg/L	EPA 1989a
proposed	0.1 mg/L	EPA 1989a
MCLG (b) proposed	0.1 mg/L	EPA 1989a
Surface Water		
EPA Ambient Water Quality Criteria		
Water and Fish Consumption		
Cr(III)	179 mg/L	ATSDR 1989
Cr(VI)	50 µg/L	ATSDR 1989
Occupational Air Concentrations		
OSHA PEL TWA		
Chromates	0.1 mg/m^3 (ceiling)	OSHA 1989
ACGIH TLV TWA		
Chromium Metal	0.5 mg/m^3	ACGIH 1989
Cr(II) and Cr(III)	0.5 mg/m^3	ACGIH 1989
Water-Soluble Cr(VI) Compounds	0.05 mg/m^3	ACGIH 1989
Certain Water-Insoluble Cr(VI) Compounds	0.05 mg/m^3	ACGIH 1989
Chromite Ore Processing	0.05 mg/m^3	ACGIH 1989

a MCL = Maximum contaminant level.

CYANIDE

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate for three representative cyanides (Clement Associates, Inc. 1985) are summarized below.

	Hydrogen Cyanide	Potassium Cyanide	Sodium Cyanide
CAS #	74-90-8	151-50-8	143-33-9
Chemical Formula	HCN	KCN	NaCN
Molecular Weight (g/mole)	27	65	49
Physical State at 20°C	Liquid		
Water Solubility	1.0×10^6	5.0×10^5	8.2×10^5
Density at 20°C	.70	--	--
Vapor Pressure	6.2×10^2	--	--
Henry's Law Constant	1.2×10^{-4}	--	--
Log K_{ow}	-2.5×10^{-1}	--	--
K_{oc}	0.66	-0.44	--
Bioconcentration Factor	0	0	0

Cyanides (CNs) are naturally occurring substances found in a number of foods and plants and are produced by certain bacteria, fungi, and algae. Minute amounts of cyanocobalamin (vitamin B-12) are a human dietary requirement (ATSDR 1989).

Cyanides have industrial uses as intermediates in a variety of processes. Widespread use contributes to the numerous sources from which cyanide is released to the environment.

Hydrogen cyanide (HCN) gas and soluble cyanide salts are the most mobile forms of cyanide in the environment (EPA 1984). Residence times in soil and water are variable and are influenced by such factors as pH, wind speed and cyanide concentration (Callahan et al. 1979).

A pH less than 9.2 is considered more condusive to environmental transport. Volatilization is considered a major fate process from surface water and surficial soils. Half-life estimates for atmospheric residence have been reported at approximately 334 days (Fritz et al. 1982). The long residence time results in widespread distribution before removal by wet and dry deposition.

A number of common plants may bioaccumulate large quantities of cyanogenic glycoside. Hydrolyzation may occur upon ingestion, forming free HCN, resulting in toxicity.

In aquatic environments, hydrogen cyanide is not expected to undergo direct photolysis, to chemically hydrolyze, to adsorb significantly to suspended sediments, or to bioaccumulate significantly in aquatic organisms (Callahan et al. 1979). Biodegradation will occur unless cyanide concentrations are at levels toxic to microorganisms. High concentrations of cyanides in subsurface soils (i.e., landfills, spills) may leach into groundwater (EPA 1984).

Toxicokinetics

Cyanides are readily absorbed via the inhalation, oral, and dermal routes of exposure. Inhalation of HCN is reportedly the most rapid route of entry resulting in the most rapid onset of toxic effects (ATSDR 1989).

Following absorption, cyanide is distributed throughout the body. Detoxification and excretion occur through the formation of thiocyanate, which is excreted in the urine. Small amounts of cyanide are also released through the lungs (ATSDR 1989).

Cyanide exerts its acute toxic effects through interference with the electron transport chain, preventing the utilization of oxygen by cells (ATSDR 1989).

Noncarcinogenic Effects

Cyanide is acutely lethal at high concentrations (Dudley et al. 1942). Inhalation of 270 ppm HCN (300 mg/m^3) results in nearly immediate death, whereas inhalation of 135 ppm (150 mg/m^3) is fatal after 30 minutes of exposure. The human oral and dermal LD_{50}s have been estimated to be 1.52 mg/kg (EPA 1987) and 100 mg/kg (Reiders 1971), respectively. Symptoms of acute exposure to HCN include tachycardia accompanied by palpitation, vertigo, buzzing in the ears, headache, epigastric burning, vomiting, general weakness, tremor, sensory obtusion, dyspnea, and loss of consciousness (Carmelo 1955). The severity and rapidity of the onset of effects depends on the route, dose, and duration of exposure and the CN compound administered.

Neurotoxicity is the major target organ effect in cyanide poisoning. The nervous system is sensitive to cyanide toxicity partly because of its high metabolic oxygen demands. Symptoms of chronic exposure to CN in humans and laboratory animals include enlargement of the thyroid gland (Vanderlaan and Bissel 1946). The enlarged thyroid is thought to result from an iodine imbalance caused by thiocyanate, cyanide's principal metabolite.

Evidence of possible developmental effects following inhalation exposure to concentrations of CN below fetotoxic doses is not conclusive.

Carcinogenicity and Mutagenicity

Cyanides have not been associated with carcinogenic effects in animals or humans. Mutagenicity studies have been negative or only slightly positive (ATSDR 1989).

Quantitative Indices of Toxicity

The reference dose (RFD) for cyanide was based upon a dietary rat study by Howard and Hanzel (1955). This study provided the highest NOAEL, 10.8 mg/kg/day, and was chosen for the derivation of an RfD for Cyanide of 1.5 mg/day or .02 mg/kg/day. Quantitative indices of toxicity are summarized in Table 1.

Standards and Criteria

Standards and criteria relevant to the cyanides are listed in Table 2.

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Table 1

INDICES OF TOXICITY
FOR CYANIDE

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	2×10^{-2}
Subchronic RfD (RfDs) mg/kg/day	2×10^{-2}
Confidence Level	Medium
Critical Effect	Myelin degeneration, weight loss, thyroid effects
Test Species for Critical Effect	Rat
RfD Basis	DIET
RfD Source	IRIS - EPA 1990a
Uncertainty Factor	
- Chronic RfD	100
- Subchronic RfD	100
Modifying Factor	
- Chronic RfD	5
- Subchronic RfD	5

Table 2

STANDARDS AND CRITERIA
For Cyanide

Standard or Criterion	Value	Reference
Drinking Water		
Lifetime drinking water health advisory	0.154 mg/L	EPA 1987
Surface Water		
EPA Ambient Water Quality Criteria Aquatic Organisms and Drinking Water	200 ug/L	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	5 mg/m^3	OSHA 1989
ACGIH	5 mg/m^3	ACGIH 1989

1,2- and 1,3-DICHLOROBENZENES

Industrial uses of 1,2-dichlorobenzene (1,2-DCB) and 1,3-dichlorobenzene (1,3-DCB) include use as intermediates in chemical manufacturing, in metal polishing agents, and in industrial odor control. Environmental releases have resulted in the detection of 1,2 DCB and 1,3-DCB in various media. Surface water concentrations of 0.13 to 0.4 ppb have been reported.

Environmental Transport and Fate

The relevant physical and chemical properties and environmental fate of 1,2-DCB (CAS No. 95-50-1) and 1,3-DCB (CAS No. 541-73-1) are presented below (Howard 1989; MacKay and Shiu 1981):

	1,2-DCB	1,3-DCB
Chemical Formula	$C_6H_4Cl_2$	$C_6H_4Cl_2$
Molecular Weight (g/mole)	147.0	147.0
Physical State at 20°C	Liquid	Liquid
Water Solubility (mg/L at 25°C)	156	111
Density at 20°C	1-3	1-3
Vapor Pressure (mm Hg at 25°C)	1.47	2.35
Henry's Law Constant (atm·m^3/mole)	1.20×10^{-3}	1.8×10^{-3}
Octanol-Water Partition Coefficient (Log K_{ow})	3.38	3.6
Organic Carbon Partition Coefficient (K_{oc})	1,700	1,700
Bioconcentration Factor (BCF)	5	5

The log K_{ow}s, high K_{oc}s, and low vapor pressures indicate that adsorption to soils is the major fate process of DCB isomers in soils. Adsorption to sediments will dominate the transport and fate of isomers discharged into aquatic media. Both isomers are heavier than water, causing DCB to sink in standing water.

The log K_{ow}s suggest that DCB isomers will bioaccumulate. Biodegradation is not likely to be a significant degradation pathway for DCB isomers, based upon data which indicate that chlorobenzene is resistant to biodegradation and that resistance increases with increasing chlorination of the benzene ring (ATSDR 1989). Very little information is available on the meta-isomer (1,3-DCB). Therefore, unless otherwise noted, the properties of this isomer will be assumed to be identical to those of the ortho-isomer (1,2-DCB).

Toxicokinetics

The DCB isomers exhibit low water solubilities and high lipid solubilities (Neely _et al_. 1974). The absorption characteristics are assumed to be similar to those of benzene and the low-molecular-weight chlorinated aliphatics. As such, approximately 100% of an orally administered dose of DCB is absorbed, while approximately 30% of any DCB isomer inhaled over a period of one to several hours is absorbed and retained (Astrand 1975). In laboratory animals, following absorption, DCBs are primarily distributed to adipose tissue, and subsequently to the liver and kidneys (EPA 1985). Metabolism proceeds by oxidation of the parent compound, forming principally phenols and catechols. Further metabolism to form conjugates of glucoronic or sulfuric acids occurs as the major elimination pathway. Hawkins _et al_. (1980) studied the kinetics of excretion of ^{14}C-p-DCB in rats. Most of the ^{14}C activity (91 to 97%) was eliminated in the urine within 5 days after cessation of exposure, while small amounts were found in the feces and expired air. About 50 to 60% was excreted in the bile during the first 2 days, suggesting reabsorption in the enterohepatic circulation.

Noncarcinogenic Effects

The principal toxic effects of 1,2-DCB in humans and other animals following acute and longer-term exposures include central nervous system (CNS) depression, blood dyscrasias, and lung, kidney, and liver damage. Similar data are not available for 1,3-DCB. However, EPA has determined that short-term assessments developed for 1,2-DCB should apply to 1,3-DCB (EPA 1985a, b).

Carcinogenicity and Mutagenicity

The few studies available on the carcinogenic potential of DCBs have been negative or insufficient to clearly classify any DCB isomer as carcinogenic. Preliminary results of a National Toxicology Program (NTP) stomach tube (gavage) bioassay indicate that 1,2-DCB was not carcinogenic under the conditions of the experiment. Pending receipt of the final NTP report for 1,2-DCB, and according to its weight-of-evidence carcinogenicity criteria, EPA has placed 1,2-DCB in Group D, "not classified" (EPA 1987d).

In general, DCBs have shown little or no mutagenic activity in a range of bacterial systems. However, several studies with mold and plant cultures treated with DCBs have reported mutations and chromosomal alterations (EPA 1987d).

Quantitative Indices of Toxicity

EPA is in the process of establishing an enforceable MCL for 1,2-DCB, but not for 1,3-DCB. As a first step in the process, EPA has issued a proposed MCLG for 1,2-DCB based upon a no-observed-adverse-effect level (NOAEL) reported in a subchronic gavage study in mice and rats. Based upon a NOAEL of 125 mg/kg/day and an uncertainty factor of 100, EPA has derived a proposed MCLG for 1,2-DCB of 0.6 mg/L (EPA 1985b).

In the absence of sufficient data, EPA has not developed, and is not in the process of developing, a drinking water standard for 1,3-DCB.

Standards and Criteria

Standards and criteria applicable to 1,2-DCB are presented in Table 1, and those applicable to 1,3-DCB are presented in Table 2.

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Table 1

STANDARDS AND CRITERIA FOR 1,2-DICHLOROBENZENE

Standard or Criterion	Value	Reference
Reference Dose		
Oral	9×10^{-2} mg/kg/day	EPA 1990a
Inhalation	4×10^{-2} mg/kg/day	EPA 1990a
Drinking Water		
U.S. Primary Drinking Water Standards		
MCL (proposed)	0.6 mg/L	EPA 1989
MCLG (proposed)	0.6 mg/L	EPA 1989
Surface Water		
EPA Ambient Water Quality Criteria		
Adjusted for Drinking Water Only	470 µg/L	EPA 1986
Aquatic Organisms and Drinking Water	400 µg/L	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	300 mg/m^3 (50 ppm) (Ceiling)	OSHA 1989
ACGIH TWA	300 mg/m^3 (50 ppm) (Ceiling)	ACGIH 1989

Table 2

STANDARDS AND CRITERIA FOR 1,3-DICHLOROBENZENE

Standard or Criterion	Value	Reference
EPA Ambient Water Quality Criteria		
Ingestion of Aquatic Organisms and Water	400 µg/L	EPA 1986

1,4-DICHLOROBENZENE (p-DCB)

p-DCB is commonly used as an insecticide, and as a component of deodorant blocks used in restrooms. It is estimated that 70 million pounds of p-DCB are used each year in the manufacture of these two types of products. It is also used in the manufacture of certain resins; smaller amounts are used in the pharmaceutical industry and as a general insecticide in farm operations.

Home use of products containing p-DCB can result in release of large amounts to the indoor air, resulting in indoor air concentrations which are much higher than outdoor concentrations. A survey of select chemicals in indoor air, undertaken by the EPA Total Exposure Assessment Methodology (TEAM) Study (Wallace et al. 1986), reported mean personal air concentrations of 5.5 to 18 µg/m^3. By contrast, outdoor mean concentrations ranged from 0.53 to 4.2 µg/m^3. The TEAM Study by Wallace et al (1986) reported on the combined occurrence of m- and p-DCB in drinking water in selected cities in New Jersey, North Carolina, and North Dakota. These DCB's were detected in $\geq$3% of the drinking water samples, with the reported concentration ranging from <1 µg/L to 100 µg/L.

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of p-DCB (CAS No. 106-16-7) are presented below (Howard 1989; MacKay and Shiu 1981):

Chemical Formula	$C_6H_4Cl_2$
Molecular Weight (g/mole)	147.0
Physical State at 20°C	Liquid
Water Solubility (mg/L at 25° C)	80
Density at 20°C	1.3
Vapor Pressure (mmHg at 25° C)	1.8
Henry's Law Constant (atm-m^3/mole)	2.89×10^{-3}
Log K_{ow}	3.6
K_{oc}	1,700
BCF	1.31

Little is known about the environmental fate of p-DCB. The high log octanol/water partition coefficient suggests that adsorption to organic matter in sediments and soil is probably an important environmental fate process. Atmospheric transport of p-DCB occurs following volatilization. The estimated half-life for evaporation of p-DCB from surface waters is 9 hours or less (ATSDR 1989). The residence time for p-DCB in the atmosphere is estimated at more than 38 days. p-DCB appears to be fairly resistant to biodegradation and persistent in the environment. Bioaccumulation is estimated to be an important fate process. Sorption, bioaccumulation, and volatilization with subsequent atmospheric oxidation are likely to be competing processes, in which the dominant fate is determined by local environmental conditions (ATSDR 1989).

Toxicokinetics

The dichlorobenzenes exhibit a low water solubility and are highly lipid soluble (Neely et al. 1974; EPA 1985). This property enables p-DCB to cross most of the barrier membranes, including those in skin, brain, and placenta. Quantitative absorption studies are not available and it is assumed that p-DCB possesses similar absorption characteristics to benzene and the lower molecular weight chlorinated aliphatics. As such, it is expected to be 100% absorbed when administered orally and about 30% absorbed via inhalation when exposure persists from 1 to 3 hours.

Laboratory animal experiments show that p-DCB absorbed following oral or inhalation exposure is distributed mainly to adipose tissue, with some distribution to the liver and kidney, and minor amounts to other organs. Absorbed p-DCB is metabolized mainly by oxidation to dichlorophenol, conjugated with glucoronic or sulfonic acid, and rapidly eliminated, mainly in the urine (ATSDR 1989).

Noncarcinogenic Effects

The major target organs of p-DCB are the CNS, liver, and kidneys. The adverse effects on these tissues are reported in most of the available literature (ATSDR 1989).

CNS effects have been reported following inhalation of relatively high doses. Acute poisoning is characterized by signs of disturbance of the CNS, including hyperexcitability, restlessness, and muscle spasms or tremors. The most frequent cause of death is respiratory depression (EPA 1987a).

Liver effects have been reported in animal studies following short-term, intermediate, and chronic exposure by the oral and inhalation routes. Findings typically include liver degeneration or necrosis, sometimes coincident with porphyria. Effects on liver enzymes have also been reported. In case studies in humans, cirrhoses and subacute or acute yellow atrophy of the liver have been diagnosed following inhalation exposure (EPA 1987; ATSDR 1987).

Adverse renal effects have generally been observed in the same subchronic and chronic studies in which hepatotoxicity has occurred. Reported effects ranged in severity from increased kidney weights to degeneration, mineralization, and hyperplasia of renal tissue (ATSDR 1987).

Carcinogenicity and Mutagenicity

No human data are available regarding the carcinogenicity of p-DCB. Positive studies for carcinogenicity have been obtained using animal models following oral administration, but not following long-term inhalation exposure. In the NTP (1987) 2-year carcinogenesis bioassay of p-DCB, there was clear evidence of carcinogenicity in male rats and in mice of both sexes.

The p-DCB was not mutagenic in microbial or mammalian systems (ATSDR 1989; Anderson 1976). The positive results in carcinogenicity testing of p-DCB combined with negative results in mutagenicity testing suggest that p-DCB may act as a tumor promoter rather than as an initiator in the carcinogenic process. Further studies are needed (ATSDR 1989).

Quantitative Indices of Toxicity

EPA has categorized p-DCB in group B-2: probable human carcinogen. EPA has derived an oral carcinogenic potency factor of 2.4×10^{-2} $(mg/kg/day)^{-1}$ based on an analysis of the NTP (1986) carcinogenicity data. A reference dose of 1×10^{-2} mg/kg/day has been calculated for p-DCB (EPA 1990b).

Standards and Criteria

Standards and criteria relevant to 1,4-dichlorobenzene are listed in Table 1.

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Table 1

STANDARDS AND CRITERIA
For
1,4-Dichlorobenzene

Standard or Criterion	Value	Reference
Reference Dose		
Inhalation	1×10^{-2} mg/kg/day	EPA 1990b
Carcinogenic Potency Factor		
Oral	2.4×10^{-2} (mg/kg/day)-1	EPA 1990b
Drinking Water		
U.S. Primary Drinking Water Standards		
MCL	0.075 mg/L	EPA 1987b
MCLG	0.075 mg/L (0p)	EPA 1987b
Surface Water		
U.S. EPA Ambient Water Quality Criteria		
Aquatic Organisms and Water Consumption	0.4 mg/L	EPA 1986
Adjusted for Water Consumption Only	0.47 mg/L	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	450 mg/m^3 (75 ppm)	OSHA 1989
ACGIH TWA	450 mg/m^3 (75 ppm)	ACGIH 1989

MCL: Maximum Contaminant Level
MCLG: Maximum Contaminant Level Goal
P: Proposed

1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE OR EDC)

EDC is a clear, volatile, and flammable synthetic organic liquid that is not found naturally in the environment. EDC is used primarily to make vinyl chloride and other solvents that remove grease, glue, and dirt. EDC is widely used and has been detected in ambient urban and rural air, and in indoor air samples of residences located near hazardous waste disposal sites. It has also been identified in surface water, groundwater, and drinking water. The average background concentration of EDC in ambient air at mid-latitudes has been reported to be 40 ppt (168 ng/m^3). In urban areas concentrations ranged from 0.1 to 1.5 ppb (Singh et al. 1982). Concentrations of EDC in domestic surface waters used as drinking water sources have been reported to range from trace amounts to 4.8 µg/L (Brown et al. 1984). Concentrations in domestic groundwater supplies used for drinking water have been reported at concentrations up to 400 µg/L (Brown et al. 1984). No information was found on the concentrations of EDC in soil. It is expected that the lack of available soil monitoring data is due at least in part to rapid partitioning of EDC released from soils into ambient air and water.

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of 1,2-dichloroethane (CAS No. 107-06-2) are summarized below (Howard 1989; McKay and Shiu 1981):

Chemical Formula	$C_2H_4Cl_2$
Physical State at 20°C	Liquid
Molecular Weight	99.0 g/mole
Density at 20°C	1.25
Water Solubility	8.52×10^3 mg/L (25° C)
Vapor Pressure	78.7 mmHg (25° C)
Henry's Law Constant	1.1×10^{-4} atm-m^3/mole (25°C)
Octanol-Water Partition Coefficient (Log K_{ow})	1.48
Organic Carbon Partition	

Coefficient (K_{oc})	14 ml/g
Bioconcentration Factor (BCF)	1.2

Based on its high water solubility, high vapor pressure, and high Henry's Law Constant, volatilization would be expected to be the predominant removal mechanism for EDC from surface water and surficial soils. Its half-life in surface water has been estimated to range from 1 to 6 days, and its half-life in air has been estimated to be as short as 1.3 days due to photooxidation.

This compound is quite mobile in the subsurface. Its high vapor pressure, high vapor density, and high water solubility make vapor phase transport of this compound through the unsaturated zone quite likely. Its low octanol/water and organic carbon distribution coefficients indicate that it is only weakly adsorbed to soil particles and consequently only slightly retarded in its movement in groundwater.

Based on its low BCF, EDC is not expected to accumulate significantly in aquatic organisms.

Toxicokinetics

EDC is absorbed by humans and laboratory animals following inhalation, ingestion, and dermal exposure. Reitz *et al*. (1980, 1982) found that ^{14}C-EDC in corn oil given orally to rats (150 mg/kg) was completely absorbed by virtue of a complete recovery of radioactivity in exhaled air, urine, and carcass. Absorption following inhalation and dermal application were also significant routes of EDC entry into the body (EPA 1985).

Distribution studies have been conducted *in vivo* in rats. Forty-eight hours after a single oral dose, the highest EDC concentrations occurred in the liver and kidneys. EDC was also found in the forestomach, stomach, and spleen (Reitz *et al*. 1980).

Yllner (1971) reported on excretory pathways of EDC in mice following intraperitoniel injection. Eleven to 46% of the dose was excreted unchanged via the lungs, 5 to 13% of the dose was metabolized to carbon dioxide and water, and 50 to 73% of the dose was excreted as urinary metabolites.

Noncarcinogenic Effects

EDC exhibits a moderate level of acute toxicity, as evidenced by median lethal doses of 489, 680, and 860 mg/kg for the mouse, rat, and rabbit, respectively (NIOSH 1983).

At relatively high doses, EDC produces central nervous system (CNS) depression as well as damage to the liver, kidneys, and adrenals. Symptoms of CNS depression typically include headache, dizziness, nausea, and general weakness. Effects on the liver include necrosis and epithelial cell damage, and effects on the kidneys include degeneration of the proximal tubule (EPA 1987).

In a multi-generation study in which male and female mice received doses of EDC in drinking water ranging from 0 to 50 mg/kg/day for 25 weeks, no reproductive or developmental effects were observed (Lane et al. 1982).

Carcinogenicity and Mutagenicity

In an NCI-sponsored bioassay, EDC administered by stomach tube (gavage) was shown to produce statistically significant increased tumor incidences in both $B_6C_3F_1$ mice and Osborne-Mendel rats (NCI 1978).

Male mice received EDC doses of 97 or 195 mg/kg/day and female mice 149 or 299 mg/kg/day for 78 weeks. Male and female rats received 47 or 95 mg/kg/day for 78 weeks.

Statistically significant increased tumor incidences of alveolar/bronchiolar adenomas were reported in both sexes of mice (NCI 1978). In addition, statistically significant increases in mammary adenocarcinomas and endometrial polyps or sarcomas were reported in female mice only (NCI 1978). Statistically increased incidence of squamous cell carcinomas of the forestomach and circulatory system hemangiosarcomas and mammary gland adenocarcinomas were reported in male and female rats, respectively (NCI 1978).

EDC has been shown to induce gene mutations in bacteria, plants, Drosophilia melanogaster, and cultured Chinese hamster ovary cells (EPA 1985). In addition, EDC has been reported to cause meiotic chromosomal disjunction in Drosophilia. Based upon these data and weight-of-evidence criteria, EPA has determined that EDC is a mutagen that may have the potential for causing adverse effects in humans (EPA 1985).

Based upon the above data, EPA has categorized EDC in group B_2, "probable human carcinogen," according to its carcinogenicity guidelines (EPA 1987).

Quantitative Indices of Toxicity

Due to insufficient data, EPA has not derived a reference dose for noncarcinogenic effects (EPA 1987, 1990a,b).

In a National Cancer Institute (NCI) report, EDC has been shown to elicit statistically significant increased tumor incidences in $B_6C_3F_1$ mice and Osborne-Mendel rats (NCI 1978). Based on these data, EPA has categorized EDC in group B_2, "probable human carcinogen" (EPA 1987). Applying the linearized multistage model to the hemangiosarcoma incidence data in male rats, EPA has derived a 95% upper-bound estimate of the oral slope factor (SF) of 9.1×10^{-2} $(mg/kg/day)^{-1}$ (EPA 1990a). The inhalation SF is 9.1×10^{-2} $(mg/kg/day)^{-1}$ (EPA 1990a). Quantitative indices of toxicity are summarized in Table 1.

Toxicity to Wildlife and Domestic Animals

EDC is one of the least toxic of the chlorinated ethanes to aquatic life. Acute toxicity has been reported in both fresh- and saltwater species, at concentrations greater than 118 mg/L, and chronic toxicity was observed at 20 mg/L (EPA 1984).

Standards and Criteria

Standards and criteria relevant to 1,2-Dichloroethane are listed in Table 2.

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Table 1

INDICES OF TOXICITY
For 1,2-Dichloroethane

Oral Route	
Slope Factor (SF) $(mg/kg\text{-}day)^{-1}$	9.1×10^{-2}
Weight of Evidence Classification	B2
Type of Cancer	Hemangiosarcoma
Test Species	Rat - National Cancer Institute Sponsored Bioassay
SF Basis	Gavage
SF Source	IRIS - EPA 1990a
Inhalation Route	
Slope Factor $(mg/kg\text{-}day)^{-1}$	9.1×10^{-2}
Weight of Evidence Classification	B2
Type of Cancer	Hemangiosarcoma
Test Species	Rat
SF Basis	Oral exposure
SF Source	IRIS, EPA 1990a

Table 2

STANDARDS AND CRITERIA
For 1,2-Dichloroethane

Standard or Criterion	Value	Reference
Drinking Water		
National Primary Drinking Water Regulations		
MCL (a)	0.005 mg/L	EPA 1987
MCLG (b)	0	EPA 1987
Surface Water		
EPA Ambient Water Quality Criteria		
Aquatic Organisms and Drinking Water	0 (0.94 ug/L)*	EPA, 1990a
Occupational Air Concentrations		
OSHA PEL TWA	4 mg/m^3	OSHA 1989
OSHA STEL	8 mg/m^3	OSHA 1989
ACGIH TLV TWA	40 mg/m^3 (10 ppm)	ACGIH 1989

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* The concentration given in parentheses for potential carcinogens corresponds to a risk of 10^{-6}.

a MCL = Maximum contaminant level
b MCLG = Maximum contaminant level goal

CIS-1,2-DICHLOROETHENE (cis-1,2-DCE)

The dichloroethylenes are synthetic organic chemicals with no known natural sources. Cis-1,2-DEC's major use is as a captive intermediate in the manufacture of other chlorinated organic chemicals. Environmentally, cis-1,2-DCE can also occur as the degradation product of trichloroethylene and tetrachloroethylene.

Monitoring studies have been undertaken to determine the concentration of cis-1,2-DCE in various media. Results indicate that cis-1,2-DCE is a relatively rare contaminant of groundwater. It was reported that the 1,2-dichloroethylenes have been usually found to co-occur with trichloroethylene.

Environmental Chemistry and Fate

The relevant physical and chemical properties (EPA 1986) and environmental fate of cis-1,2-DCE (CAS #540-59-0) are summarized below (Howard 1989; MacKay and Shiu 1981):

Chemical Formula	$C_2Cl_2H_2$
Molecular Weight	97.0 g/mole
Physical state at 20°C	Liquid
Water Solubility	3.500 mg/L (25°C)
Density	
Vapor Pressure	2.00×10^{2} mmHg (25°C)
Henry's Law Constant	7.58×10^{-3} atm-m^3/mol (25°C)
Octanol-Water Partition Coefficient (Log K_{ow})	1.86
Organic Carbon Partition Coefficient (K_{oc})	49 ml/g
Bioconcentration Factor (BCF)	1.6

The relatively high vapor pressure and high water solubility of cis-1,2-DCE indicate that its predominant loss mechanism from surface water and surface soils is likely to be volatilization. The half-life in surface water has been estimated to range from 1 to 6 days, depending on temperature, water turbulence, and air movement across the water surface. The evaporative loss from surface soils is expected to be in the same range as the surface water half-life. The half-life of cis-1,2-DCE in air has been estimated to be less than 2 days (EPA 1987). Cis-1,2-DCE has been identified as a biodegradation product of trichloroethene and tetrachloroethene in groundwater.

Toxicokinetics

Cis-1,2-DCE is a neutral, low-molecular weight, lipid soluble material which would be expected to be readily absorbed following exposure by any route (e.g., oral, inhalation, dermal) (EPA 1984). Distribution and elimination patterns for cis-1,2-DCE are predicted to be similar to 1,1-dichloroethene (1,1-DCE). As such, the highest concentrations are expected to be found in the liver and kidneys (McKenna et al. 1978). Elimination is expected to occur rapidly, with most of a single dose being excreted in the urine within 24 to 72 hours after exposure (Jaeger et al. 1977).

Noncarcinogenic Effects

At high concentrations, the dichloroethylenes, like other chlorinated ethylenes, possess anesthetic properties. In fact, cis-1,2-DCE was used as an anesthetic agent, with some success prior to introduction of newer anesthetic gases (Irish 1963). In laboratory studies, the cis/trans DCE isomer mixture was reported to have an LC_{50} of 770 mg/kg for rats (NIOSH 1978). No information was found in the available literature on the effects of long-term exposures to cis-1,2-DCE (EPA 1987).

Carcinogenicity and Mutagenicity

No information was found in the literature on the carcinogenic potential of cis-1,2-DCE. Several studies have failed to detect any mutagenic activity on the part of cis-1,2-DCE, with or without microsomal activation (EPA 1987). Cis-1,2-DCE has been placed in EPA's weight-of-evidence of carcinogenicity category Group D: not classified. This category is for agents with inadequate evidence of carcinogenicity.

Quantitative Indices of Toxicity and Standards and Criteria

Standards and criteria relevant to cis-1,2-DCE are listed in Table 1.

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TABLE 1

STANDARDS AND CRITERIA FOR CIS-1,2-DICHLOROETHENE

Standard or Criterion	Value	Reference
Reference Dose		
Acceptable Daily Intake	0.01 mg/kg/day	EPA 1987
Drinking Water		
National Primary Drinking Water Regulations		
MCLG (Proposed)	0.07 mg/L	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	790 mg/m^3 (200 ppm)	OSHA 1989
ACGIH TLV TWA	790 mg/m^3	ACGIH 1989

HEXACHLOROCYCLOHEXANE (HCH)

HCH is a synthetic chemical that exists in eight chemical forms called isomers. These isomers may be identified as alpha-, beta-, delta-, and gamma-HCH. Gamma-HCH, commonly called Lindane, has been used as an insecticide and as a human pharmaceutical for the treatment of lice and scabies.

Technical-grade HCH, a mixture of several isomers, typically contains approximately 40% Lindane as well as the alpha-, beta-, delta-, and gamma-forms of HCH. Technical-grade HCH does not occur as a natural product and is no longer available in the U.S. for insecticide use. Also, Lindane has not been produced in the U.S. since 1977. Lindane is available in emulsifiable and flowable concentrates, soluble concentrates/liquids, wetable powders, dusts, ready-to-use liquids, pressurized liquids and impregnated materials, oil base and aerosol sprays, granules, and as a smoke generator (Berg 1988; EPA 1985a). Gamma-HCH is also sold separately or in combination with fungicides, fertilizers, other insecticides, or wood preservatives (Hayes 1982).

Environmental Chemistry and Fate

Physical and chemical properties relevant to the environmental fate and transport of HCH are summarized below (ATSDR 1989):

Property	α-HCH	β-HCH	γ-HCH	δ-HCH
CAS#	391-84-6	319-85-7	58-98-9	319-86-8
Chemical Formula	$C_6H_6Cl_6$	C_6H_6Cl6	$C_6H_6Cl_6$	C_6H_6Cl6
Molecular Weight	290.85	290.85	290.85	290.85
Physical State @ 20°C	monoclonic prism	crystalline solid	crystalline solid; monoclonic prism	fine plates
Water solubility	69.5 ppm	5 ppm	17 ppm	10 ppm
Vapor pressure @ 20°C (mmHg)	.02	.005	$4x10^{-6}$	.02

Henry's Law Constant @ 25°C (ATM-m^3/mol)	6.0×10^{-6}	4.5×10^{-7}	8.0×10^{-6}	2.1×10^{-7}
Organic Carbon Partition Coefficient [Koc(ml/g)]	3,800	3,800	1,080	6,600
Octanol/Water Partition Coefficient [Log Kow]	3.81	3.78	3.61	4.14
Bioconcentration Factor (BCF) (L/kg)	130	130	130	130

HCH is a white solid with some tendency to volatilize into the air. The vapor is colorless and almost odorless (ATSDR 1989).

Lindane and α-, β-, and δ-HCH can be found in the air as a vapor or attached to small particles such as soil and dust.

Transport Processes

Gamma-HCH present in soil can lead to groundwater, sorbed to soil particles, or volatilize into the atmosphere. Based upon its moderate K_{oc} value and a water solubility of 17 ppm (Hollified 1979), gamma-HCH is expected to leach slowly to groundwater. Gamma-HCH that has sorbed to the soil can be released to the atmosphere by wind erosion of surface soil particles. It is believed that windblown dust contributes substantially to the occurrence and long distance transport of pesticides in the atmosphere (ATSDR 1989). This is supported by monitoring studies performed by Stanley et al. (1971) which found that many pesticides are present in the atmosphere attached to particulates. Dust entrainment can lead to the transport of the pesticides from agricultural areas to the urban areas. Gamma-HCH can also enter the atmosphere via volatilization from treated agricultural soils and plant foliage (Lewis and Lee 1976). The widespread global distribution of HCH isomers is indicative of persistence of gamma-HCH in the air (ATSDR 1989).

Degradation Process

Gamma-HCH can be present in the air as vapor or sorbed to particulate matter. Photodegradation and other degradation processes are not prominent in the removal of gamma-HCH from the air as compared to wash-out with precipitation or dry deposition. However, gamma-HCH undergoes photodegradation to form two isomers of tetrachlorohexene and pentachlorohexane in propanol solution when irradiated with ultraviolet light from a low pressure mercury lamp (Hamada et al. 1981). Similar transformations of gamma-HCH and other isomers are though to occur to some extent in the atmosphere. Biodegradation is believed to be the significant degradative process for gamma-HCH in aquatic systems. Zoetemann et al. (1980) estimated river, lake, and groundwater half-lives for gamma-HCH from degradation data in these bodies to be 3-30 days, and >300 days, respectively. Gamma-HCH in soil and sediment is degraded primarily by biotransformation. Numerous studies-conclude that gamma-HCH is transformed to tetrachlorohexene, tri-, tetra-, and pentachlorinated benzenes, penta-, and tetra-cyclohexanes, other isomers of HCH, and other related chemicals (Callahan et al. 1979).

Environmental Concentrations

Air. Air monitoring during the years 1970-1972 in 10 states across the U.S. reported a mean gamma-HCH concentration in ambient air of 0.9 ng/m^3 for all years and all states combined (Kutz et al. 1976). Gamma-HCH was detected in 67.7% of all 2,479 samples, with a maximum concentration of 11.7 ng/m^3 reported (ATSDR 1989). A mean alpha-HCH concentration in ambient air of 1.2 ng/m^3 was also reported in positive samples (Kutz et al. 1976). Atlas and Giam (1981) measured the concentration of organic pollutants, including gamma-HCH, in the atmosphere and precipitation in the remote marine atmosphere. A total of 17 atmospheric samples and 16 rain samples were analyzed and yielded mean gamma-HCH concentrations of 0.015 ng/m^3 and 0.51 ng/l, respectively. A global distribution and atmospheric transport of chlorinated hydrocarbons study performed by Tanabe et al. (1982) confirmed the widespread distribution of HCH isomers. HCH residues were detected in all 79 air and water samples collected. The range of concentrations were 1.1 to 2.0 ng/m^3 in air and 3.1 to 7.3 ng/l in water.

Water. Surface water concentrations of gamma-HCH have been measured in many areas across the U.S. Much of the available monitoring studies were conducted in the early to mid-1970s. A recent study in 1980-1981 was performed at the Niagara River near its entry into Lake Ontario. This study showed gamma-HCH detected in 99% of all samples at a mean concentration of 2.1 parts per trillion (ppt) (Kuntz and Warry 1983). Gamma-HCH has been detected in groundwater at a median concentration of 16 ppt in Chesterfield County, South Carolina and 163 ppt in Hampton, South Carolina (Sandhu et al. 1978). Gamma-HCH has also been detected in drinking water from Cincinnati, Ohio (Keith et al. 1976), Hampton, South Carolina (Sandhu et al. 1978), and Oahu, Hawaii (Bevenue et al. 1972) at mean concentrations of 0.01 ppt, 10 ppt, and 0.2 ppt, respectively. In addition, rain and snow water in Portland, Oregon in 1982, gamma-HCH was detected at mean concentrations of 0.45 to 11 ppt (Pankow et al. 1984).

Soil. The United States Soils Monitoring Program showed that gamma-HCH was not detected in cropland soils or crops in 37 states during the summer and fall of 1971 (Carey et al. 1978). The minimum detection levels were 0.002 to 0.03 ppm. Gamma-HCH concentrations in the surface soils of five western Alabama counties were less than 0.1 ppm (Albright et al. 1974). Most of the sediment monitoring data for gamma-HCH are derived from the Great Lakes. The average concentration for the Niagara River was 2 ppb (Kuntz and Warry 1983), the Lake Ontario sediments contained 2.4 ppb (Oliver and Charlton 1984) and Lake Michigan sediments contained less than 2.5 ppt to 0.15 ppt (Schacht et al. 1974).

Human Exposure and Body Burdens

The most probable route of non-medicinal human exposure to gamma-HCH is ingestion of food or water containing the pesticide. The average daily dietary intake has been estimated to be 4 μg/kg/day (Duggan et al. 1983). Gamma-HCH can travel through the food chain. Human exposures can result from the ingestion of plants, animals, animal products, milk, and water containing pesticide (ATSDR 1989). The National Human Adipose Tissue Survey (NHATS) in 1982 showed that beta-HCH detected in 87% of 46 composite samples at <19-570 µg/g concentrations (Stanley 1986). These concentrations were detected most often in post-mortem samples collected from southern U.S. citizens.

Human body burdens of HCH may be influenced by factors such as age, dietary habits, and residence. Saxena et al. (1981a) found that non-vegetarian women between the ages of 26 and 34 who live in a rural area tend to show higher body levels of gamma-HCH than other women. The higher levels of gamma-HCH in women at an older child-bearing age suggest that a longer life span may cause a greater accumulation of pesticide in the body (ATSDR 1989). In addition, studies indicate that gamma-HCH is also present in human milk at an average level of 0.006 ppm in Alberta, Canada (Currie et al. 1979). Takahaski et al. (1981) demonstrated that of 50 breast milk donors in Oahu, Hawaii, 82% of the samples showed HCH at a mean level of 81 ppb as extractable lipid with a range of 0-480 ppb.

Toxicokinetics

Absorption of HCH following oral exposure have lead to many accidental poisonings in humans (Berry et al. 1987; Nantel et al. 1977; Harris et al. 1969; Khare et al. 1977; Munk and Nantel 1977; Powell 1980; Starr and Clifford 1972). Information concerning the rate of absorption from the gastrointestinal tract (G.I. tract) is inferred from studies conducted in mice and rats.

Gamma-HCH is readily absorbed from the G.I. tract (Aldaya et al. 1981; Turner and Shanks 1980) and then absorbed from the intestine into the blood. Turner and Shanks (1980) showed that only a small amount of gamma-HCH actually entered the lymphatic system from the intestine. The rapid absorption and excretion of gamma-HCH may be attributed to its unusually high solubility in water.

Evidence exists that humans absorb gamma-HCH vapor or dusts via inhalation. Occupational studies have shown adverse health effects, including hematological abnormalities and neurological effects, as a result of worker exposure to gamma-HCH in workplace air (Brassow et al. 1981; Czelgledi-Janko and Arar 1970; Kashyap 1986; Samuels and Milby

1971). However, no specific studies have quantified the rate or extent of absorption of the HCH isomers following inhalation exposure.

The ready absorption of gamma-HCH through human skin has been demonstrated in several studies that examined the usage of antiscabies lotion (Feldmann and Maibach 1974; Grinsburg et al. 1977; Lange et al. 1981). The maximum levels of gamma-HCH reached in scabies patient were greater than those reported for normal volunteers. Studies involving topical application of gamma-HCH to the forearm indicated that at least 9% of an applied dose is readily absorbed and that maximum absorption occurs 2-3 days after application (Feldmann and Maibach 1974).

Distribution

HCH residues are quite lipophilic and are distributed throughout the body tissues in proportion to their lipid content. The overall distribution of gamma-HCH is greatest in fat followed by brain, kidney, muscle, lungs, heart, spleen, liver, and blood (Srinivasan and Radhakrishnamurty 1983b).

Metabolism

Gamma-HCH appears to be rapidly transformed by hepatic enzymes to its primary metabolites, chlorophenols, and chlorobenzenes (Chadwick et al. 1978a; Chadwick and Freal 1972a; Engst et al. 1979; Kujawa et al. 1977). Other urinary metabolites identified include other trichlorophenols, dichlorophenols, tetrachlorophenols, and dihydroxy-chlorobenzenes. Following occupational exposure, pentachlorophenol has also been identified as a urinary metabolite in humans (Engst et al. 1979). In vitro studies have established that an epoxide forms during the metabolism of pentachlorocyclohexane, a primary metabolite formed by dehydrogenation of gamma-HCH, which may be responsible for the mutagenic and carcinogenic effects of gamma-HCH (Fitzloff and Pan 1984).

Excretion

The major route of excretion of HCH in humans appears to be in the urine, but some excretion also occurs via breast milk and semen (ATSDR 1989). Very little HCH is eliminated in the exhaled air (Ahdaya et al. 1981; Chadwick et al. 1985) and in the feces (Chadwick et al. 1985).

Noncarcinogenic Effects

The major noncarcinogenic effects of HCH appear to involve the nervous system, the liver, the blood, and reproduction and development of offspring.

Neurological Effects

In humans, the nervous system appears to be one of the primary target systems for HCH toxicity. Most of the information is from case reports of acute gamma-HCH poisoning. Seizures and convulsions have been observed in individuals who have accidentally or intentionally ingested gamma-HCH as insecticide pellets, liquid scabicide, or contaminated food (Davies et al. 1983; Harris et al. 1969; Munk and Nantel 1977; Nantel et al. 1977; Powell 1980; Starr and Clifford 1972). These symptoms were observed in rats following a single intragastric administration of approximately 60-150 mg/kg (Tilson et al. 1987; Tusell et al. 1987).

Paresthesia of the face and extremities, headache, and vertigo have been reported in a group of 45 workers occupationally exposed to technical-grade HCH for prolonged periods of time (Kashyap 1986). Abnormal EEG patterns have been reported in 16 of 37 workers following exposure to gamma-HCH for 0.5 to 2 years in a fertilizer plant (Czegledi-Janko and Arar 1970). However, exposure concentrations were not reported; these EEG changes were found to correlate with blood levels of gamma-HCH.

Hepatic Effects

In humans, technical-grade HCH exposure caused significant increases in the blood levels of the enzymes lactate dehydrogenase, leucine aminopeptidase, and gamma-glutamyl transpeptidase in 19 individuals in a HCH formulating plant (Kashyap 1986). Experimentally, gamma-HCH was reported to increase liver microsomal activity in Osborne-Mendel rats exposed to 6.2 and 13.3 µg/kg/day and in CF1 and B6C3F1 strain mice exposed to 16.1 and 34.6 µg/kg/day in the diet for 3 days (Oesch et al. 1982). Similar effects were also shown in experiments with alpha-HCH (a mixture of the alpha, beta, gamma and delta-HCH isomers, was reported to cause fatty degeneration and necrosis of the liver in rats exposed to 2.5 μg/kg/day for 33-61 weeks (Fitzhugh et al. 1950); these effects were more apparent at 40 μg/kg/day. Technical-grade HCH was also reported to cause liver cancer in mice following exposure to 65 μg/kg/day in the diet for 2-8 months (Thakore et al. 1981; Karnick et al. 1981) and exposure to 0.3-13 μg/kg/day for 32-80 weeks (Kashyap et al. 1979; Munir et al. 1983).

Immunological Effects

A significant increase (approximately 18%) in the level of immunoglobulin M (IgM) was noted in 19 workers occupationally exposed to technical-grade HCH during pesticide formulation (Kashyap 1986).

Some evidence of possible immunotoxic effects of gamma-HCH is available form animal studies. Immunosuppression was reported in rats exposed by garage to 6.25 and 25 μg of gamma-HCH/kg/day for five weeks (Dewan et al. 1980) and in rabbits exposed by capsule five times each week to 1.5, 6 and 12 μg/kg/day for 5-6 weeks (Desi et al. 1978).

Hematological Effects

Hematological effects have been reported in humans following acute or long-term inhalation exposure to gamma-HCH. Hypochronic anemia was discovered in a 2.5-year-old boy who was exposed to gamma-HCH in a home due to operation of an HCH vaporizer. Air concentrations measured in the basement and living room of the house were 2.4 to 5.5 μg/m^3 (Morgan et al. 1980). Other abnormalities have been reported as result of chronic human occupational exposure including instances of leukopenia, leukocytosis, granulocytopenia, granulocytosis, eosinophilia, monocytosis, and thrombocytopenia (Brassow et al. 1981; Jedlicka et al. 1958; Samuels and Milby 1971). Aplastic anemia and bone marrow hyperplasia have been reported in a woman as a result of excessive dermal expose to gamma-HCH when bathing her dog in a 2% solution once a week for years (Woodliff et al. 1966). In addition, reduced hemoglobin and hematocrit values and near complete absence of red blood cell precursors in bone marrow were reported in a 2-year-old boy exposed to a dog that was dipped regularly in mange containing 12% gamma-HCH (Vodopick 1975).

Standards and Guidelines

Standards and guidelines pertinent to HCH are summarized in Table 1.

Reproductive and Developmental Effects

Statistically significant increases in levels of serum luteinizing hormone (LH) were reported in a group of 54 men after occupational exposure to gamma-HCH for approximately 8 years in a Lindane-producing factory (Tomczak et al. 1981). Ovarian and uterine weight increases and atrophy were also associated with exposure to HCH. A 13-week exposure study to 0.5 µg beta-HCH/kg/day in rats fed 12.5 µg/kg/day displayed these effects (Van Velsen et al. 1986). Exposure to 12.5 µg-HCH/kg/day resulted in severed effects in male rats including degeneration of somniferous tubules and disruption of spermatogenesis (Van Velsen et al. 1986).

Gamma-HCH has not been reported to cause developmental effects in animals.

Genotoxic Effects

No increase in the frequency of chromosome aberrations was observed in humans exposed to HCH primarily by inhalation in a pesticide production factory following an exposure of 8 hours/day for at least 6 months (Kiraly et al. 1979). No other studies were located pertaining to genotoxicity of HCH to humans (ATSDR 1989). In animals, ingestion of tech-grade HCH was reported to induce dominant lethal mutations in mice (Lakkad et al. 1982). In rats, exposure to alpha-HCH was reported to result in mitotic disturbances including an increased mitotic rate and frequency of polyploid hepatic cells (Hitachi et al. 1975).

Carcinogenic Effects

No studies were located regarding the carcinogenicity in humans following exposure to gamma-, alpha-, beta-, delta-isomers of HCH, or technical-grade HCH by any route. Alpha-, beta-, gamma-, and technical-grade HCH have been found to be carcinogenic in rats and/or mice following long-term exposure (Hanada 1973; Ito et al. 1973, 1975, 1976;

Kashyap _et_ _al_. 1979; Munir _et_ _al_. 1983; NCI 1977; Thakore _et_ _al_. 1981; Thorpe and Walker 1973; Tsukada _et_ _al_. 1979; Wolff _et_ _al_. 1987). Hepatocellular carcinoma is the most frequently reported tumor type, although in many studies the liver was the only organ under investigation (ATSDR 1989). The available animal data suggest that liver cancer may be of potential concern to individuals exposed to HCH for prolonged periods of time.

Table 1

STANDARDS AND CRITERIA FOR HCH

Standard or Criterion	Value	Reference
Reference Dose		
Oral	$3x10^{-4}$ mg/kg/day	EPA 1990
Carcinogenicity Potency Factor	$(mg/kg/day)^{-1}$	
Inhalation	α-HCH 6.3	EPA 1990
	β-HCH 1.8	
	technical-HCH 1.8	
Drinking Water		
National Primary Drinking Water Regulations		
Maximum Contaminant Level (MCL) [Lindane]	.004 mg/L	EPA 1975 (40 CFR 141)
MCL (proposed) [Lindane]	.0002 mg/L	EPA 1985c
Food		
EPA Tolerances	Range:	
	.01 ppm 7.0 ppm (pecans) 1 or 3 ppm (fruits and vegetables)	EPA 1974 (40 CFR 180.133)
Ambient Water (Aquatic Organisms) [Lindane]		
Fresh Water: Acute	2.0 µg/L	EPA 1986
Chronic (24 hr. avg.)	0.8 µg/L	
Marine: Acute	16 µg/L	
Chronic (24 hr. avg.)	--	

Table 1 (Cont.)

Standard or Criterion	Value	Reference
Ambient Air		
No Ambient air quality criteria established		
Occupational Air Concentrations [Lindane]		
ACGIH TLV TWA (a)	.5 mg/m^3 (skin)	ACGIH 1986
OSHA PEL TWA (b)	.5 mg/m^3 (skin)	OSHA 1989
NIOSH REL TWA (c)	.5 mg/m^3	NIOSH 1985
NIOSH IDLH (d)	1,000 mg/m^3	NIOSH 1985

02[IL]JD1900:D3048/1251

a: American Conference of Governmental Industrial Hygienists, Threshold Limit Value, Time Weighed Average.

b: Occupational Safety and Health Administration, Permissible Exposure Limit, Time Weighted Average.

c: National Institute for Occupational Safety and Health, Recommended Exposure Limit, Time Weighted Average.

d: National Institute for Occupational Safety and Health, Immediately Dangerous to Life or Health Level.

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LEAD

Lead (Pb) is a naturally occurring metal which is used in such processes as the manufacture of storage batteries and production of ammunition, and in miscellaneous metal products (e.g., sheet lead, solder, and pipes) and various chemicals, including gasoline additives. Lead has been monitored in the ambient air, surface waters, ground waters, and soils. Levels of lead in ambient air range from 7.5×10^{-5} $\mu g/m^3$ in remote areas to more than 10 $\mu g/m^3$ near stationary sources such as smelters. Levels of lead in surface waters throughout the United States typically range between 5 and 30 µg/L, although levels as high as 890 µg/L have been monitored (EPA 1986a). The lead content of soil ranges from 10 to 30 µg/gm in soils originating from crustal rock to 10,000 µg/g in soils adjacent to roadways (EPA 1986a).

Environmental Chemistry and Fate

Lead and its inorganic compounds exist in the atmosphere mainly as particulates that can be removed from the atmosphere by either wet or dry deposition. Particle size and atmospheric turbulence are the primary factors determining the half life of particulate lead in the atmosphere. Lead also readily undergoes photolysis in the atmosphere.

The movement of lead in aquatic environments is influenced by lead speciation. In water with high concentrations of dissolved organics, complexation is an important mechanism for retaining lead in solution. In waters without substantial dissolved organics, lead can become adsorbed to suspended particulates and eventually settle out.

Sorption processes exert dominant effects on the distribution of lead in aquatic and terrestrial environments. Adsorption to inorganic solids, organic materials, hydrous iron, and manganese oxides controls the mobility of lead in soils and sediments.

The dominant sorption mechanisms are dependent on geological setting, pH, Eh, availability of ligands and chemical composition. Additional factors operative in sediments include dissolved and particulate ion concentrations and salinity. The solubilities of lead carbonate, sulfate, and sulfide are low. Over most of the pH range, lead carbonate and lead sulfate control solubility. Lead is strongly complexed to organic materials present in aquatic systems and soil. Lead in soils is not easily taken up by plants, so the availability of lead to terrestrial organisms by this route appears to be limited (EPA 1982).

Bioaccumulation of lead has been demonstrated for a variety of organisms, with bioconcentration factors typically ranging from 42 to 1,700 (EPA 1986).

Toxicokinetics

The rate and degree of absorption of chemicals are largely related to their solubility in body tissues and fluids. Each lead compound has unique solubility characteristics, resulting in compound-specific differences in absorption.

Prior to absorption of airborne lead by the lungs, some fraction of inhaled lead must be deposited in the respiratory tract. The rate of deposition of airborne particulate lead in adults ranges from 30 to 50% and is modified by such factors as particle size and deposition rate (EPA 1986). Relatively little is known about deposition of airborne lead in children. Once deposited in the lower respiratory tract, lead is almost completely absorbed (EPA 1986). Particulate lead deposited in the upper respiratory tract is cleared from the tract by ciliary action but may then be swallowed.

The primary site of lead absorption in children is the gastrointestinal tract (Hammond 1982). For dietary lead, absorption is approximately 50% in children and 5 to 15% in adults (Goyer 1986). The physical and chemical properties of the ingested lead and a number of dietary factors such as nutritional status and the composition of the diet affect the extent and rate of gastrointestinal absorption of lead.

Dermal absorption of inorganic lead compounds is much less significant than absorption due to inhalation or oral exposure (Goyer 1986).

The distribution of lead in the body is initially dependent on the rate of delivery by the bloodstream to various organs and tissues. However, lead may subsequently redistribute based upon its relative affinity with various tissues. In humans, roughly 95% of the total body burden of lead is found in the bones (ATSDR 1989).

In humans, any dietary lead not absorbed by the gastrointestinal tract is eliminated in the feces. Airborne lead that has been swallowed and not absorbed is also eliminated in the feces. Absorbed lead is excreted either by the kidneys or into the gastrointestinal tract via the bile (ATSDR 1989).

Noncarcinogenic Effects

When toxicological information is considered in assessing the noncarcinogenic effects of substances, the data are evaluated in order to identify an exposure level below which no adverse effects are observed. Historically, the observed threshold, or no-effect level, for lead-induced toxic effects has continued to decline as increasingly sophisticated experimental and clinical measures are employed to detect the more subtle effects. These include alterations in physiological functions at blood lead (PbB) levels below the currently accepted maximum safe level for exposure to children, the segment of the population currently regarded to be at highest risk of lead-induced effects (EPA 1985a, ATSDR 1989).

The most serious effects associated with markedly elevated PbB levels are severe neurotoxic effects that include irreversible brain damage. For most adults, such damage does not occur until PbB levels exceed 100 to 120 micrograms per deciliter (µg/dl). At these PbB levels, severe gastrointestinal symptoms and effects on several other organ systems are often found (Kehoe et al. 1961a). Precise thresholds for occurrence of overt neurological and gastrointestinal signs and symptoms of lead exposure in cases of subencephalopathic lead intoxication have yet to be established, but such effects have been observed in chronic occupationally exposed adults at PbB levels as low as 40 to 50 µg/dl (ATSDR 1988).

Toward the lower range of PbB levels associated with overt lead intoxication, less severe but important signs of impairment in normal physiological functioning in several organ systems are evident among apparently asymptomatic lead-exposed adults (EPA 1985c). These include:

- Slowed nerve conduction velocities, indicative of peripheral nerve dysfunction (at PbB levels as low as 30 to 40 µg/dl) (Seppalainen et al. 1975);
- Altered testicular function (at PbB levels of 40 to 50 µg/dl) (Lancranjan et al. 1975); and
- Reduced hemoglobin production (at approximately 50 µg/dl)

(Zielhuis 1975).

EPA has concluded that all of the above effects point toward a generalized impairment of normal physiological functioning of several different organ systems at adult PbB levels exceeding 30 to 40 µg/dl. Evidence of impaired heme synthesis in blood occurs at even lower levels.

The second National Health and Nutrition Examination Survey (NHANES-II) examined a representative sample of the U.S. population and found that PbB levels were related to ambient environmental exposures. A clinically relevant relationship between blood lead and blood pressure was seen. Younger men (aged 24 to 55 years) with diastolic high blood pressure had significantly higher blood lead levels than those with normal pressures (Harlan et al. 1985). Additional analyses of the same data by Pirkle et al. (1985) found a statistically significant correlation between PbB levels and diastolic blood pressure in white males, ages 40 to 50, with no threshold apparent in the range of 6 to 30 µg/dl. Of particular concern is the finding of a 2 mm Hg increase in diastolic pressure per incremental PbB level increase of 0.5 µg/dl. Possible increases in the risk of more severe medical events (stroke, heart attack, death) associated with lead-induced increases in blood pressure are also estimated in one of the recently published studies (EPA 1986).

Children represent a sensitive subpopulation with regard to lead toxicity. As with adults, lead affects many different organ systems and biochemical/physiological processes across a wide range of exposure levels. Effective PbB levels for producing encephalopathy or death in children are lower than in adults, starting at approximately 80 to 100 µg/dl. Permanent mental retardation and other marked neurological deficits are among lasting neurological sequelae typically seen in cases of nonfatal childhood lead encephalopathy. Other overt neurological signs and symptoms of subencephalopathic lead intoxication, such as peripheral neuropathies (functional and/or pathological changes in the peripheral nervous system), have been detected in some children at PbB levels as low as 40 to 60 µg/dl. Chronic kidney disease is most evident at PbB levels above 100 µg/dl. Moreover, colic and other overt gastrointestinal symptoms occur in children, at PbB levels as low as 60 µg/dl. Frank anemia is also evident at 70 µg/dl, representing an extreme manifestation of reduced hemoglobin synthesis at PbB levels as low as 40 µg/dl. All these effects are widely accepted as adverse health effects, and are reflective of the widespread marked impact of lead on the normal physiological functioning of many different organ systems (EPA 1984d, 1985c, ATSDR 1989).

Other studies demonstrate additional important health effects occurring in children non-overtly intoxicated with lead at similar or lower PbB levels than those indicated above. Among the most important and controversial of these electrophysiological and neuropsychological effects are indications of peripheral nerve dysfunction, evidenced by slowed nerve conduction velocities (NCV) found in children with PbB levels lower than 30 µg/dl (Otto _et_ _al_. 1981, 1985). EPA has concluded that while none of these studies on central nervous system (CNS) effects can be regarded individually as conclusively proving significant cognitive (IQ) or behavioral effects occurring below 30 µg/dl, they clearly indicate likely associations between neuropsychologic deficits at PbB levels as low as 30 to 50 µg/dl. The magnitude of average observed IQ deficits is approximately 5 points at mean PbB levels of 50 to 70 µg/dl and about 4 points at mean levels of 30 to 50 µg/dl (EPA 1985b). In testimony given to the Subcommittee on Health and the Environment (COEC 1988), Dr. Herbert Needleman reported findings that children with elevated lead levels in shed baby teeth had lower IQ scores, poorer auditory and language functioning scores, and difficulties with attention. Infants with blood levels greater than 10 µg/dl had IQ scores 4-7 points below those with blood lead levels below 3 µg/dl.

Many different impacts (representing potentially impaired functioning and depleted reserve capacities of many different tissues and organs) have been noted at PbB levels below 30 µg/dl.

At PbB levels around 10 to 15 µg/dl, initial signs of detectable heme synthesis impairment occur in many different organ systems, indications of increasing degrees of pyrimidine metabolism interference, signs of altered nervous system activity, and interference in vitamin-D metabolism. EPA has stated that on the basis of these data, these effects might be viewed as sufficiently adverse to warrant avoidance as PbB levels exceed 10 to 15 µg/dl (EPA 1988c).

Reproduction and Development

There is a paucity of exposure data on which to evaluate the effects of lead on reproduction and development in humans. Early studies of pregnant women exposed to high levels of lead indicated toxic, but not teratogenic, effects on the fetus. One recently reported study hints at birth anomalies which may be associated with exposure to low lead levels (mean cord blood level of 15 µg/dl) among women in the general population. However, the significance of these studies has been questioned because of the absence of reported statistically significant associations between cord blood levels and specific types of minor anomalies or any major anomalies. Evidence from recent studies indicates that the length of gestation is reduced as prenatal lead exposure increases, even at PbB levels below 15 µg/dl (McMichael et al. 1986; Dietrich et al. 1986, 1987). Based on risk estimates of McMichael et al. (1986), the risk of preterm delivery increases by at least fourfold as either cord blood or maternal blood lead level at delivery increases from ≤ 8 to >14 µg/dl.

A review of the literature regarding neurobehavioral effects of prenatal lead exposure suggests that neurobehavioral deficits are associated with prenatal internal exposure levels, at maternal or cord blood lead concentrations, of ≈10 to 15 µg/dl (ATSDR 1988; 1987; EPA 1986a) and possibly even lower. There are no reliable data pointing to adverse effects in human offspring following lead exposure to fathers (ATSDR 1989). However, the contribution of adversely affected sperm is not ruled out.

EPA has concluded that the current collective human data, regarding lead's effects on reproduction and *in utero* development, are insufficient for accurate estimation of exposure-effect or no-effect levels (EPA 1985b). In the absence of sufficient data, it has been suggested that it would be prudent to avoid lead exposures resulting in PbB levels exceeding 25 to 30 µg/dl to pregnant women and women of child-bearing age in general. This conclusion was based on the known equilibration between maternal and fetal blood lead concentrations and growing evidence of deleterious effects in young children as PbB levels approach 25 to 30 µg/dl. Industrial lead exposure of men, in which PbB levels of 40 to 50 µg/dl are seen, also appears to result in altered testicular function (EPA 1985b).

Carcinogenicity and Mutagenicity

Several studies have reported renal tumors in Wistar rats following ingestion of high doses of a lead salt (lead acetate) (Azar 1973). Lead subacetate (another lead salt) produced benign tumors (renal carcinomas or adenomas) in Swiss mice and in several strains of rats, but not in golden hamsters. Gliomas (CNS tumors) were also observed in many of these studies (Azar 1973; Zawirska and Medras 1972; ATSDR 1989).

There have been a number of epidemiological studies which have assessed the mortality of lead-exposed workers. In some of the studies, no excess cancer mortality was observed. In one study, nonstatistically significant excess cancer mortality of the respiratory system and cancer of the digestive organs and peritoneum was reported, which on evaluation by other statistical techniques by another investigator was reported to achieve statistical significance. Another study has reported increased mortality from renal cancer among a group of lead smelting workers. However, this excess mortality, based on only six cases, did not achieve statistical significance. On review of all of these studies, EPA concluded that the absence of good lead exposure documentation made it difficult to assess the contribution of lead to the observed results.

The International Agency for Research on Cancer (IARC) has classified lead in Group 3, inadequate evidence for carcinogenicity in humans, sufficient evidence for carcinogenicity in animals (for some salts). EPA has classified lead in category B_2 (sufficient evidence in animals, insufficient evidence in humans) according to EPA's Guidelines for Carcinogen Risk Assessment (EPA 1985b, 1986b). However, the agency noted that the doses inducing kidney tumors in positive rat studies were beyond the human lethal dose, and several epidemiological studies have not shown an association between lead exposure and elevated cancer in occupationally exposed workers. Nevertheless, EPA has recently proposed to set a maximum contaminant level goal (MCLG) for lead in drinking water based on both carcinogenic and noncarcinogenic endpoints (EPA 1988).

Lead is a cellular poison. Consequently, short-term mutagenicity assays result in significant cellular toxicity prior to expression of mutagenicity.

Quantitative Indices of Toxicity

EPA derived an oral reference dose of 1.4 x 10^{-3} mg/kg/day for lead based on its determination that a PbB concentration of 15 μg/dl represents a level of concern for the most sensitive human subpopulation--infants (EPA 1985).

The current EPA drinking water maximum contaminant level (MCL) for lead of 50 μg/L was designed to limit PbB levels in 99.5% of the population to below 30 μg/dl.

EPA has recently proposed (EPA 1988) a new MCL for lead of 0.005 mg/L for finished drinking water entering a distribution system, supplemented by requirements for additional corrosion control or educational measures if either the average lead concentration in the mornings first draw of water at the tap exceeds 0.010 mg/L or if 5% of the samples exceed 0.020 mg/L. These primary drinking water standards were proposed with the intent of achieving a large reduction in the number of people with blood lead levels above the range of concern of 10 to 15 μg/dl and above 25 μg/dl, the level at which the Centers for Disease Control (CDC) recommends medical intervention.

Standards and Criteria

Standards and criteria applicable to lead are summarized in Table 1.

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Table 1

STANDARDS AND CRITERIA FOR LEAD

Standard or Criterion	Value	Reference
Reference Dose (Withdrawn, but not replaced)		
Oral	1.4×10^{-3} (mg/kg/day)	EPA 1986b
Inhalation	4.3×10^{-4} (mg/kg/day)	EPA 1986b
Drinking Water		
National Primary Drinking Water Regulations		
MCL (a)	50(5p) µg/L	EPA 1988
MCLG (b)	0.02 mg/L (p)	EPA 1988
Surface Water		
EPA Ambient Water Quality Criteria		
Aquatic Organisms and Drinking Water	50 µg/L	EPA 1990a
Drinking Water only	50 µg/L	EPA 1986
Occupational Air Concentrations		
Lead inorganic dusts and fumes		
OSHA PEL TWA	0.05 mg/m^3	OSHA 1989
ACGIH TLV TWA	0.15 mg/m^3	ACGIH 1989

p proposed (53 Federal Register 31517-31578)
a MCL = Maximum contaminant level.
b MCLG = Maximum contaminant level goal.

MANGANESE

Manganese is a naturally occurring element, and is an essential element for both animals and man. Background concentrations vary depending on geological and other influences. Freshwater may contain from 1 to 2,000 µg/L, and higher concentrations have been detected in waters impacted by industrial discharges. Ambient air concentration for nonindustrialized and industrialized areas of 0.05 $\mu g/m^3$ and 0.3 $\mu g/m^3$ have been reported (WHO 1984).

The manganese content of food varies considerably. Low concentrations are found in dairy products (0.0 to 1.9 mg/kg), meats (0.0 to 0.8 mg/kg), and fish (0.0 to 0.1 mg/kg). Higher concentrations have been found in grains and cereals (1.2 to 30.8 mg/kg), nuts (0.4 to 35.1 mg/kg), and vegetables (0.2 to 12.7 mg/kg). Tea leaves contained the highest concentration, and a cup of tea can contain from 1.4 to 3.6 mg (WHO 1984).

Environmental Transport and Fate

Manganese (elemental CAS #7439-96-5) can exist in the oxidation states from -3 to +7. Its inorganic chemistry is dominated by compounds in the +2, +4, and +7 states (USEPA 1984). The principle sources of manganese in the atmosphere are natural including dust, volcanic emissions, and forest fires. Anthropogenic sources of manganese include industrial emissions and combustion of fossil fuels (Lantzy and MacKenzie 1979). Manganese in the atmosphere is generally present in particulate form (USEPA 1982). The atmospheric residence time is estimated at 7 days (Cupitt 1980) with removal occurring by wet or dry deposition.

In aquatic systems, the fate of manganese is influenced by chemical and microbiological reactions. In most natural systems manganese is expected to be predominantly adsorbed to sediments and suspended particulates, in the form of MnO_2 and/or Mn_3O_4. Although manganese may undergo chemical speciation due to chemical and microbiological reactions, the residence time of aquatic manganese may be a few hundred years (USEPA 1984).

In the soil, manganese speciation may occur through chemical and microbiological interactions. Soil pH and the oxidation-reduction potential will influence speciation. It has been suggested that in water-logged acidic soils, manganese passes freely into solution and may leach to groundwater (USEPA 1982).

Toxicokinetics

Manganese is an essential element and is a co-factor for a number of enzymatic reactions particularly those involved in phosphorylation and cholesterol and fatty acid synthesis. Absorption of manganese from the gastrointestinal tract is controlled by homeostatic mechanisms. Extent of absorption is dependent upon availability, concentration in the diet, interactions with other metals or other dietary constituents, and age (USEPA 1982). Limited quantitative data indicate that under normal conditions gastrointestinal absorption of manganese is low, averaging approximately 3% of the ingested manganese. It is expected to be absorbed as Mn^{2+} (EPA 1984; Mena et al. 1969). Following inhalation exposure, manganese absorption into the bloodstream occurs only if particles are sufficiently small to be able to reach the alveoli (WHO 1980). Larger particles are removed by mucociliary clearance.

Absorption through the skin is not expected to occur to any great extent (Rodier 1955).

Manganese is reportedly distributed in the plasma by a transferrin type of B-globulin (WHO 1981). Absorbed manganese is concentrated in the liver and may form complexes with bile components (WHO 1981). Elimination is almost exclusively through the feces.

Noncarcinogenic Effects

In humans, manganese dusts and compounds have relatively low oral and dermal toxicity, but may cause a variety of toxic effects after inhalation exposure (WHO 1981). One of two common syndromes associated with inhalation exposure (manganism) involves the central nervous system (CNS). Chronic manganese exposure may result in a psychiatric disorder with characteristic symptoms including irritability, difficulty in walking, and speech disturbances. If the condition persists, a Parkinson-like syndrome may develop (Mena et al. 1967).

The second condition associated with acute manganese inhalation exposure (generally due to manganese dioxide in mining or manufacturing) is manganese pneumonitis. Men working in industrial plants with high concentrations of manganese dust show an incidence of respiratory disease 30 times greater than normal (Goyer 1986).

Carcinogenicity

There is no epidemiological information relating manganese exposure to cancer occurrence in humans. Results of studies with divalent manganese are suggestive of carcinogenic activity in laboratory animals (USEPA 1984). More information is needed before a more definitive conclusion can be made about the carcinogenicity of manganese and its compounds (USEPA 1984; EPA 1982; Goyer 1986). Therefore, it is classified by USEPA in category D - not classifiable as to carcinogenicity.

Quantitative Indices of Toxicity

The quantitative indices of toxicity for manganese are summarized in Table 1.

EPA has derived an inhalation reference dose (RfD) of 3 x 10^{-4} mg/kg/day based upon studies conducted by Saric _et_ _al_. (1977). Oral reference doses were calculated from experiments performed by Laskey _et_ _al_. (1982); the RfD chronic is 2 x 10^{-1} mg/kg/day and the subchronic, RfD is 5 x 10^{-1} mg/kg/day.

Standards and Criteria

Relevant standards and criteria for manganese are summarized in Table 2.

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Table 1

INDICES OF TOXICITY FOR MANGANESE

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	2×10^{-1}
Subchronic RfD (RfDs) mg/kg/day	5×10^{-1}
Confidence Level	NS
Critical Effect	CNS; reproductive
Test Species for Critical Effect	Rat
RfD Basis	Drinking water
RfD Source	IRIS - EPA 1990a [AND/OR] HEAST - EPA 1990b
Uncertainty Factor	
- Chronic RfD	100
- Subchronic RfD	100
Inhalation Route	
Chronic Reference Dose (RfD) mg/kg/day	3×10^{-4}
Subchronic RfD (RfDs) mg/kg/day	3×10^{-4}
Confidence Level	NS
Critical Effect	CNS
Test Species for Critical Effect	Human
RfD Basis	Occupational air
RfD Source	IRIS - EPA 1990a [AND/OR] HEAST - EPA 1990b
Uncertainty Factor	
- Chronic RfD	100
- Subchronic RfD	100

NS = Not specified.

Table 2

STANDARDS AND CRITERIA
For Manganese

Standard or Criterion	Value	Reference
Surface Water		
USEPA Ambient Water Quality Criteria		
Ingestion of Fish and Water	50 mg/L	USEPA 1986
Occupation Exposure Limits (Air)		
OSHA PEL TWA:		
Dusts	5.0 mg/m^3 (ceiling)	OSHA 1989
Fumes	1.0 mg/m^3	OSHA 1989
ACGIH TWA:		
Dusts	5.0 mg/m^3	ACGIH 1989
Fumes	1.0 mg/m^3	ACGIH 1989

TETRACHLOROETHENE (PERCHLOROETHYLENE)

Tetrachloroethene, also known as perchloroethylene (PCE), is a synthetic organic chemical with no natural resources. It is used in industry in a variety of processes, as a solvent for many organic substances, as a cleaning agent, as a metal degreaser, as an intermediate in the synthesis of certain fluorocarbons, and in the textile industry. It is not consumed during its various uses and may be released to the environment. Air monitoring data for the United States has demonstrated mean PCE concentrations of 160 ppt in rural and remote areas, 790 ppt in urban and suburban areas, and 1,300 ppt in areas near emission sources (ATSDR 1988). PCE has been detected in many drinking water sources, with median concentrations of 0.3 and 3.0 µg/L in surface and groundwaters, respectively (ATSDR 1988).

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental transport and fate of PCE (CAS No. 127-18-4) are summarized below (Howard 1989; Clement Associates, Inc. 1985; MacKay and Shiu 1981):

Chemical Formula	C_2Cl_4
Molecular Weight	165.8 g/mole
Physical State at 20°C	Liquid
Water Solubility	1,500 mg/L (25°C)
Density at 20°C	1.63 g/ml
Vapor Pressure	18.5 mm Hg (25°C)
Henry's Law Constant	2.3 E-04 (25 °C)
Octanol-Water Partition Coefficient (Log K_{ow})	2.88
Organic Carbon Partition Coefficient (K_{oc})	364 mL/g
Bioconcentration Factor (BCF)	31

PCE's moderate water solubility, vapor pressure, and Henry's Law stant indicate that volatilization is the major loss mechanism from face soil and surface water. The half-life in surface water has been imated to range from 1 to 30 days. Its moderate K_{oc} and moderate water solubility indicate that transport from unsaturated zone soils to groundwater via rain infiltration is an important pathway. In soils and groundwater, PCE is biodegraded in a series of monodechlorinations to trichloroethene, cis- and trans-1,2-dichloroethylene, vinylidene chloride (1,1-dichloroethene), and vinyl chloride (chloroethene). PCE's half-life in the subsurface has been estimated to range from as little as 2 days to about 9 months (Smith and Dragun 1984). Once PCE reaches the groundwater, its moderate K_{oc} indicates that transport may be moderately retarded by high organic carbon sediments. Finally, PCE is subject to low bioconcentration in aquatic species.

Toxicokinetics

PCE is absorbed completely by rats following oral exposure (Schumann et al. 1980). However, only 25% absorption occurred in human volunteers following a 4-hour inhalation exposure. Animal studies indicate that once in the bloodstream, PCE concentrates in adipose tissue and the brain (Monster 1979). Metabolism occurs via oxidation, possibly through an epoxide intermediate, to trichloroethanol and trichloroacetic acid (Ikeda 1977). PCE is eliminated unchanged via the lungs, with an estimated half-life of 65 to 70 hours; its metabolites are eliminated via the urine with a half-life of 144 hours (Ikeda and Imamura 1973).

Noncarcinogenic Effects

In animals, the most characteristic effect following acute high-level exposure to PCE is on the central nervous system (CNS). At increasing concentrations, CNS depression, dizziness, unconsciousness, respiratory and cardiac arrest, and finally death occur (EPA 1985; ATSDR 1989). Short-term, subchronic, high-level exposure effects are manifested principally as damage to the liver and kidney. Liver damage progresses from congestion and cloudy swelling to fatty degeneration and cell death. Kidney damage progresses from increased organ rate, cloudy swelling of the tubular cell walls, sloughing of cells, and cell death. Longer-term exposure in animals results principally in the liver and kidney damage described above. In humans, like animals, the principal effects consequent to high short-term or chronic exposure are CNS and liver and kidney dysfunction.

Mild reproductive toxicity was exhibited by $B_6C_3F_1$ mice and Sprague-Dawley rats following inhalation exposure to PCE for 7 hours per day from days 6 to 15 of gestation, the period of highest susceptibility to teratogenic effects (Schwetz et al. 1975). Pregnant rats exposed to 300 ppm (2,000 mg/m^3) had mild reductions in body weight and twice the number of resorptions per implantation compared to controls, while mice exhibited a significant increase in liver weight and decreased fetal weight compared to controls (Schwetz et al. 1975). Following prenatal exposure, significant subcutaneous edema, delayed skull hardening, and presence of split sternebrae were observed in mouse pups. Differences in neurotransmitter levels and some alterations in behavioral tests were noted in offspring of rats exposed to 900 ppm (3,600 mg/m^3), but not in those exposed to 100 ppm (400 mg/m^3). As the more significant findings occurred at concentrations which may have been maternally toxic, the relevance of these findings to reproductive risks at lower nonmaternally toxic concentrations (e.g., 100 ppm) can be questioned.

Carcinogenicity and Mutagenicity

The National Cancer Institute (NCI) concluded that commercially used PCE-containing stabilizers acted as a liver carcinogen in $B_6C_3F_1$ mice administered 386 to 1,072 mg/kg by stomach tube (gavage) for 78 weeks (NCI 1977, as cited in EPA 1987). Because of high mortality rates, NCI made no conclusion as to carcinogenicity of PCE in Osborne-Mendel rats (NCI 1976, as cited in EPA 1987).

In a National Toxicity Program (NTP) inhalation bioassay (NTP 1985, as cited in EPA 1987), $B_6C_3F_1$ mice and Osborne-Mendel rats were exposed to PCE in concentrations of 0, 200 (1,340 mg/m^3), and 400 ppm (2,680 mg/m^3), and 0, 100 (680 mg/m^3), and 200 ppm (1,360 mg/m^3), respectively. PCE induced hepatocellular carcinomas in both sexes of mice. Male rats exhibited a significantly increased incidence of mononuclear cell leukemia and an increased incidence of combined kidney tubular adenomas and carcinomas. Classification of PCE as a carcinogen in rats is controversial. EPA's Science Advisory Board (SAB) has questioned the relevance of mononuclear leukemia to man (a resistant species to this type of leukemia) and the validity of combining the adenomas and carcinomas to achieve statistical significance (EPA 1987).

Based upon these data, and according to its weight-of-evidence carcinogenicity criteria, EPA has placed PCE in Category B2, "probable human carcinogen" (EPA 1987). However, EPA's SAB has recommended classifying PCE in Category C, "possible human carcinogen" (EPA 1987).

PCE has been evaluated for its ability to cause gene mutation, chromosomal aberrations, unscheduled DNA synthesis, and mitotic recombination. In general, these responses have been weak and were observed at high concentrations that were cytotoxic (EPA 1985). Additionally, no dose-dependent relationships were demonstrated in these studies (EPA 1985).

Quantitative Indices of Toxicity

Quantitative indices of toxicity for tetrachloroethene are presented in Table 1. Using the linearized multistage carcinogenesis model, EPA derived the upper-bound 95% confidence limit slope factor (SF) based on animal data. The upper-bound estimate for the oral route is 5.1×10^{-2} $(mg/kg/day)^{-1}$; the corresponding estimate for the inhalation route is 3.3×10^{-3} $(mg/kg/day)^{-1}$ (EPA 1990a).

EPA has derived a reference dose (RfD) based upon a study (Buben and O'Flaherty 1985) in which Swiss-Cox mice received PCE in corn oil by gavage at doses ranging from 0 to 2,000 mg/kg/day 5 days per week for 6 weeks (EPA 1987). Based upon findings of slight increases in liver weight, EPA defined 20 mg/kg/day as a no-observed-adverse-effect level (NOAEL). Based upon findings of significantly increased liver weights, EPA defined 100 mg/kg/day as a lowest-observed-adverse-effect level (LOAEL) (EPA 1990a). Using the NOAEL of 20 mg/kg/day scaled to correspond to average daily doses over a 6-week period and dividing by an uncertainty factor of 1,000, EPA derived an RfD of 1×10^{-2} mg/kg/day (EPA 1990b).

PCE is the most acutely toxic to aquatic life of the chloroethylenes but is only moderately toxic relative to other types of compounds. The trout was reportedly the most sensitive to PCE exposure with an LC_{50} value of 4,800 µg/L. The EPA (1984) reported the lowest values known to cause toxicity in aquatic organisms; however, the aquatic species tested was not specified. Freshwater species toxicity values of 5,280 and 840 µg/L were reported for acute and chronic exposure, respectively.

Standards and Criteria

Standards and criteria applicable to PCE are summarized in Table 2.

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Table 1

INDICES OF TOXICITY
FOR TETRACHLOROETHENE

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	1×10^{-2}
Subchronic RfD (RfDs) mg/kg/day	1×10^{-1}
Confidence Level	Medium
Critical Effect	Hepatotoxicity - mice Weight gain - rats
Test Species for Critical Effect	mice/rat
RfD Basis	Oral
RfD Source	IRIS - EPA 1990a
Uncertainty Factor	
- Chronic RfD	1000
- Subchronic RfD	100
Modifying Factor	
- Chronic RfD	1
- Subchronic RfD	NS

NS = Not specified.

Table 2

Standards and Criteria for Tetrachloroethene

Standard or Criterion	Value	Reference
Drinking Water		
National Primary Drinking Water Regulations		
Proposed MCL (a)	0.005 mg/L	EPA 1990a,b
Proposed MCLG (b)	0	EPA 1990a,b
Surface Water		
EPA Ambient Water Quality Criteria		
Aquatic Organisms and Drinking Water	0*	EPA 1986
Drinking Water Only	0	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	670 mg/m^3 (100 ppm)	OSHA 1989
ACGIH TWA	335 mg/m^3 (50ppm)	ACGIH 1989

*Potential carcinogens have a criterion value of 0. A concentration of 0.8 µg/L corresponds to a risk of 10^{-6}, as presented in water quality criteria documents.

a MCL = Maximum contaminant level.
b MCLG = Maximum contaminant level goal.

POLYCYCLIC AROMATIC HYDROCARBONS

Introduction

Polycyclic aromatic hydrocarbons (PAHs) contain only carbon and hydrogen and consist of two or more fused benzene rings in linear, angular or cluster arrangements. PAHs are formed wherever natural or synthetic chemicals are exposed to high temperature; they may also be synthesized by some plants and bacteria.

The following sections address specific aspects of PAH-related information useful in evaluating potential human health and environmental risks of PAHs.

Sources and Concentrations of PAHs in the Environment

As discussed above, there are both natural (e.g., forest fires and synthesis by plants and microorganisms, etc.) and anthropogenic sources of PAHs. Currently, primary anthropogenic sources accounting for greater than 90% of total air emissions are fossil fuel combustion, by electrical power plants, refuse burning, and agricultural burning (NAS 1972). PAHs are also emitted from automobiles, buses, and trucks and are typically localized along highways. Those emitted by power plants or jet engine exhausts may be spread over long distances.

Many of the current combustion processes and certain industrial processes (e.g., coke production and petroleum refining) have led to the widespread presence of PAHs in ambient air. The concentrations of PAHs in air vary greatly depending on the relation to sources. Sawicki et al. (1965) examined benzo(a)pyrene (BaP) concentrations in air for 131 urban and suburban areas in the United States. In urban areas concentrations ranged from 0.1 to 61 ng/m^3. In nonurban areas concentrations ranged from 0.01 to 1.9 ng/m^3. Gordon (1976) reported the geometric mean of the sum of 15 PAH airborne concentrations to be 10.9 ng/m^3, only 4.2% of which was due to BaP.

Typical concentrations with no known sources of BaP in soils of the world range from 100 to 1,000 µg/kg (Edwards 1983). Where quantified, total PAH concentrations were reported to be 10 times the value of BaP alone (Edwards 1983). Measured concentrations ranged from 0.4 µg/kg in protected remote areas to 650,000 µg/kg in highly polluted areas

(Edwards 1983).

PAHs in surface waters originate from fallout of particulate matter, absorption of atmospheric gases, and polluted water (IARC 1983). Except near major sources, concentrations of PAHs in water are typically on the order of 0.0003 µg/L. A survey of PAH concentrations found in water is given in Table 1.

Environmental Transport and Fate

Relevant physical and chemical properties of selected PAHs are summarized in Table 2. In general, most priority pollutant PAHs can be characterized as having low vapor pressure, low water solubility, low Henry's Law constants, high octanol-water partition coefficients (log Kow) and high organic carbon partition coefficients (Kocs). High Kocs indicate that most PAHs are strongly sorbed to organic matter in the soils. Combined with low water solubilities, rates of transport of most PAHs from the unsaturated zone via infiltration to the saturated zone will be extremely low. Low vapor pressures, low Henry's Law constants and low Koc, indicate that most PAHs will not readily volatilize from surface water nor from surface soils.

The exceptions to this generalization are acenaphthene, fluorene, fluoranthene, fluorene, naphthalene and pyrene with solubilities greater than 100 µg/L. Although these compounds have relatively high Kocs (10^3 or greater) relative to other PAHs, their high solubility indicates that they are relatively mobile and may be observed in groundwater.

Typically, although they are regarded as persistent in the environment, PAHs are degradable by soil microorganisms. Degradation rates and degree of degradation are influenced by environmental factors, microbial flora and physicochemical properties of the PAHs themselves. Important environmental factors include temperature, pH, oxygen status, populations present, and the relative proportions of bacteria, fungi, and actinomycetes (Sims and Overcash 1983). Physico-chemical properties include chemical structure, concentration, and lipophilicity.

Human Exposure Levels

Because of the ubiquitous presence of PAHs in the environment, it is important to evaluate baseline, non-site-related human exposures. For the purpose of this discussion, PAH exposure data have been divided into four categories consistent with the breakdown of available data: benzo(a)pyrene, naphthalene, the anthracene group, and the acenaphthene group.

BaP has been the most studied PAH. Table 3 presents typical dietary consumption, BaP concentrations in food, and estimated BaP daily intakes (USEPA 1982). As the table displays, BaP is found in numerous dietary items including charcoaled beef, oil, fruits, grains, and vegetables corresponding to an estimated 0.05 μg/day intake in the diet.

Table 4 presents an estimated distribution of the U.S. population exposed to ranges of BaP concentrations in ambient air (USEPA 1982). The table indicates that nearly half the U.S. population is exposed to concentrations less than 1 ng/m^3 and nearly 99.5% of the population is exposed to less than 5 ng/m^3. Using a breathing rate of 0.875 m^3/day, assuming 24-hour exposure and 100% absorption, daily intakes of 20 ng/day and 100 ng/day were predicted for those exposed to the respective BaP concentrations.

Cigarette smoke is a major source of PAH exposure. Tables 5 and 6 show that, with the exception of acenaphthene and fluorene for which data were not available, the priority pollutant PAHs are found in significant concentrations in mainstream cigarette smoke. Assuming 25 cigarettes smoked per day, mean intake estimates range from 0.05 μg/day for benzo(g,h,i)perylene to 38 μg/day for naphthalene, with an intake of 1 μg/day for BaP. Although the data are far less extensive, side-stream smoke and concentration in smoke-polluted rooms represent significant sources of PAH intake for the nonsmoker and smoker alike.

Table 7 summarizes the typical human intakes of BaP, naphthalene, the anthracene group and the acenaphthalene group of PAHs (USEPA 1982; IARC 1983). In descending order of intake, naphthalene was followed by individual members of the anthracene group, benzo(a)pyrene, and individual members of the acenaphthene group. Not counting exposure to side-stream smoke or exposures in the "other" category, intakes for naphthalene were 41.2 and 3.2 μg/day for smokers and nonsmokers. Values for individual members of the anthracene group were 7 and 1 µg/day, respectively. Intakes of benzo(a)pyrene were 2.1 and 1.1 µg/day, respectively.

Toxicology of PAHs

Noncarcinogenic Effects

Very little attention has been paid to noncarcinogenic effects of PAHs. It is known, however, that rapidly proliferating tissues (e.g., bone marrow, lymphoid organs, testes, etc.) appear to be the preferred targets for PAH-induced cytotoxicity.

Acute and chronic exposure to various PAHs classified as carcinogens has resulted in destruction of specific hematopoietic and lymphoid elements, ovotoxicity, anti-spermatogenic effects, adrenal necrosis and changes in the intestinal and respiratory epithelia. This tissue damage occurs at doses expected to induce carcinomas and malignancy risks predominate in evaluating PAH toxicity. For PAHs classified as noncarcinogenic, very little is known about toxic responses or mechanisms.

Carcinogenicity and Mutagenicity

EPA has issued final carcinogenicity risk assessment guidelines (51 FR 33992-34012, September 24, 1986). These guidelines established weight-of-evidence criteria for evaluating and categorizing chemicals as to their potential carcinogenicity. According to this categorization scheme, five of the 15 priority pollutant PAHs have been placed in category B_2 (probable human carcinogens) sufficient evidence in animals, inadequate data for humans. A sixth (indeno (1,2,3-cd) perylene) has been placed in category C, possible human carcinogen based on limited evidence of carcinogenicity in animals in the absence of human data (EPA 1986A). Table 8 contains EPAs most current categorization of priority pollutant PAHs (EPA 1986). Following its risk assessment guidelines, EPA typically performs quantitative risk assessments for groups A or B, and in some cases, depending on the quality of the data, for group C. In order to be reasonably conservative (health-protective), estimated potencies will be used for all six PAHs categorized as B_2 or C carcinogens.

To date, EPA has estimated a carcinogenicity slope factor (SF) for carcinogenic PAHs using data for a single PAH, benzo(a)pyrene (BaP). This limited effort does not take into account the clearly documented differences in quantitative dose-response relationships for the other PAHs. Thorslund et al. (1986) have evaluated the relative potency estimates for the other five carcinogenic PAHs to BaP. Using a series of sophisticated statistical procedures, these authors have derived estimated relative potencies for the five other "carcinogenic" PAHs relative to BaP. For the potency estimation, the authors used only bioassays from individual laboratories in which BaP and other PAHs were tested in common. Table 9 summarizes the results of the procedures.

Standards and Criteria

Relevant standards and criteria for PAHs are summarized in Table 10.

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Table 1

CONCENTRATIONS OF 15 PRIORITY POLLUTANTS POLYCYCLIC AROMATIC HYDROCARBONS IN WATER

Compound	Concentration Range (ng/l)			
	Surface Water	Tap Water	Rainfall	Groundwater
Acenaphthene	N.D.	N.D.	N.D.	N.D.
Anthracene	1,000	1.1-59.7	N.D.	N.D.
Benzo(a)anthracene	1.9-30.6	0.4-10.7	3.2-12.3	0-1.3
Benzo(b)fluoranthene	0-320	0.6-45	4.4-840	0.5-9.0
Benzo(b)fluoranthene	0-400	0.9-8.0	1.6-450	0.2-3.5
Benzo(g,h,i)perylene	1.0-11.2	N.D.	N.D.	N.D.
Benzo(a)pyrene	0-13,000	0-1,000	10-1,000	0.1-6
Chrysene	7.6-62.0	N.D.	N.D.	N.D.
Dibenzo(a,h)anthracene	N.D.	N.D.	N.D.	N.D.
Fluoranthene	4.7-1,200	7.2-132.6	5.6-1,460	3.5-100
Fluorene	300	4-16	N.D.	N.D.
Indeno(1,2,3-cd)pyrene	0-350	0.3-75	0-1,020	0.2-5
Naphthalene	N.D.	N.D.	N.D.	N.D.
Phenanthrene	0-1,300	24-90	N.D.	N.D.
Pyrene	2.0-530	N.D.	5.8-27.8	1.6-2.5

Source: Commission of European Communities (1979) as cited in IARC (1983).

Draft

Table 2

PHYSICAL AND CHEMICAL PROPERTIES OF SELECTED PAHs

Compound	Molecular Weight (g/mole)	Cas No.	Vapor Pressure (mmHg) at 20°C	Source	Water Solubility (mg/l)	Source	Henry's Law Constant	Source	Log Kow	Source	Koc (ml/g)	Source
Acenaphthene	154.2	83-32-9	1.55×10^{-3}	A	3.42	A	9.2×10^{-5}	A	3.98	A	4.6×10^{3}	A
Acenaphthylene	154.2	208-96-8	2.90×10^{-2}	A	3.93	A	1.45×10^{-3}	A	3.72	A	2.5×10^{3}	A
Anthracene	178.2	120-12-7	1.70 (25°C) $\times 10^{-5}$	A	4.5×10^{-2}	A	8.6×10^{-5}	A	4.45	A	1.4×10^{4}	A
Benzo(a)anthracene	228.3	56-55-3	2.2×10^{-8}	B	1.2×10^{-3}	B	1.0×10^{-6}	B	5.61	A	2.0×10^{5}	A
Benzo(b)fluoranthene	252.3	205-99-2	5.0×10^{-7}	A	1.4×10^{-2}	A	1.22×10^{-5}	A	6.06	A	5.5×10^{5}	A
Benzo(k)fluoranthene	252.3	207-08-9	5.1×10^{-7}	A	4.3×10^{-3}	A	5.0×10^{-7}	A	6.06	A	5.5×10^{5}	A
Benzo(g,h,i)perylene	276.3	191-24-2	1.0 (25°C) $\times 10^{-10}$	A	7.0×10^{-3}	A	5.34×10^{-8}	A	6.51	A	1.6×10^{6}	A
Benzo(a)pyrene	252.3	50-32-8	5.6×10^{-9}	A	3.8×10^{-3}	A	4.9×10^{-7}	A	6.06	A	5.5×10^{6}	A
Chrysene	228.3	218-01-9	6.3×10^{-9}	A	1.8×10^{-3}	B	1.05×10^{-6}	A	5.61	A	2.0×10^{5}	A
Dibenzo(a,h)-anthracene	278.4	53-70-3	1.1×10^{-10}	A	5.0×10^{-4}	B	7.33×10^{-8}	A	6.83	A	3.3×10^{6}	A
Fluoranthene	202.3	206-44-0	5.0 (25°C) $\times 10^{-6}$	A	2.6×10^{-1}	A	6.46×10^{-6}	A	4.90	A	3.8×10^{4}	A
Fluorene	166.2	86-73-7	7.1×10^{-4}	A	1.83	B	6.42×10^{-5}	A	4.18	A	7.3×10^{3}	A
Indeno(1,2,3-cd)-perylene	276.3	193-39-5	1.0×10^{-10}	A	5.3×10^{-4}	A	6.95×10^{-8}	A	6.51	A	1.6×10^{6}	A
2-Methylnaphthalene	142.2	91-57-6	ND		ND		ND		ND		ND	
Naphthalene	128.2	91-20-3	$8.7 \text{ X } 10^{-2}$	A	$3.17 \text{ X } 10^{1}$	A	$4.6 \text{ X } 10^{-4}$	A	3.37		$9.3 \text{ X } 10^{2}$	A
Phenanthrene	178.2	85-01-3	9.6 (25°C) $\times 10^{-4}$	A	1.3	A	2.26×10^{-4}	A	4.46	A	1.44×10^{4}	A
Pyrene	202	129-00-3	2.5 (25°C) $\times 10^{-6}$	A	1.47×10^{-1}	B	5.04×10^{-6}	A	4.88	A	3.8×10^{4}	A

Key: ND = No Data

Sources:
A: Mabey, W. et al, 1982, Aquatic Fate Process Data for Organic Priority Pollutants (EPA 440/4-81-014).
B: ATSDR, 1990, Toxicological Profile for Polycyclic Aromatic Hydrocarbons. Draft for Public Comment.

Table 3

LEVELS OF BENZO(A)PYRENE IN FOODS AND ESTIMATED HUMAN INTAKES

Food	Consumption (g/day)		Benzo(a)pyrene Contamination (ug/kg)		Intake (ug/day)	
	Typical	Maximum	Typical	Maximum	Typical	Maximum
Charcoal broiled beef	--	--	--	--	--	--
Hamburger	10	ND	ND	2.6	ND	0.03
Steak	3	86	5	50	0.02	4.3
Smoked Pork**	1	27	2	55	0.002	1.5
Smoked Sausage***	1.5	30	ND	4	0.006	0.12
Smoked Fish?	0.1	14	1	37	0.0001	0.5
Oil	18	ND	1	8	0.02	0.14
Fruits	205	ND	0.02	6	0.004	1.2
Grains	256	ND	ND	0.3	ND	0.008
Vegetables - Total	248	ND	0.01	0.1	0.002	0.2
- Leafy	40	ND	ND	7.5	NA	0.3
				Total	0.05	

Source: USEPA 1982.

Key:

ND = No data available.
* = Consumption of beef - 86 g/day, 15% charcoal broiled - 80% hamburger, 20% steak. Worst case maximum 86 g consumption of charcoal-broiled steak.
** = Consumption of pork - 27 g/day, 5% smoked. Worst case maximum, 27 g/day smoked.
*** = Consumption of sausage - 30 g/day, 5% smoked. Worst case maximum, 30 g/day smoked.
? = Consumption of fish - 14 g/day, 1% smoked. Worst case maximum 14 g/day smoked.

Table 4

ESTIMATED DISTRIBUTION OF THE SIZE OF THE U.S. POPULATION EXPOSED TO RANGES OF BENZO(a)PYRENE (BaP) IN AMBIENT AIR*

	BaP Concentration (ng/m^3)				
	<0.5	0.5 - 1.0	1.0 - 5.0	>5.0	Total
Population (1,000's) Exposed	73,294	26,731	102,132	1,059	203,216
Percentage	36.1	13.2	50.3	0.5	100.1**

*Monitoring data were not available for areas representing 50% of the population. Upper 95% confidence limits of natural average concentrations were used to assign exposures to these populations. The levels were as follows:

Urban standard metropolitan statistical area (SMSA):	1.3 ng/m^3
Urban non-SMSA:	1.4 ng/m^3
Rural:	0.23 ng/m^3

**Does not sum to 100% due to independent rounding.

Table 5

DAILY INTAKE FROM CIGARETTE SMOKE FOR 15 PRIORITY POLLUTANT PAHs*

Compound	Concentration Range (ug/100 Cigarettes)	Intake Range 1,2 (ug/day)	1 Mean Intake (ug/day)
Acenaphthene	ND	ND	
Anthracene	2.3 - 23.5	0.6 - 5.9	3.3
Benzo (a) anthracene	0.4 - 7.6	0.1 - 1.9	1.0
Benzo (b) fluoranthene	0.3 - 2.2	0.1 - 0.6	0.4
Benzo (k) fluoranthene	0.6 - 1.2	0.2 - 0.3	0.3
Benzo (g,h,i) perylene	0.1 - 0.4	0.03 - 0.1	0.05
Benzo (a) pyrene	0.5 - 7.8	0.1 - 2.0	1.0
Chrysene	0.6 - 9.6	0.2 - 2.4	1.3
Dibenzo (a,h) anthracene	0.4	0.1	0.1
Fluoranthene	1 - 27.2	0.03 - 6.8	3.4
Fluorene	present	ND	ND
Indeno (1,2,3k-cd) pyrene	present	ND	ND
Naphthalene	300**	75	38
Phenanthrene	8.5 - 62.4	2.1 - 15.6	8.8
Pyrene	5-27	1.3 - 6.8	4.1

Key:

ND = No data.
*Unless otherwise footnoted, value from Table 1 (IARC 1983).
**USEPA 1982.
1Assuming 10% absorption and 25 cigarettes smoked per day.
2Rounded to the nearest tenth.

Table 6

CONCENTRATION OF THE 15 PRIORITY POLYCYCLIC AROMATIC HYDROCARBONS IN CIGARETTE SMOKE*

Compound	Cigarette Side Stream Smoke (ug/100 cigarettes)	Cigarette Smoke-Polluted Rooms (ng/m^3)
Acenaphthene	ND	ND
Anthracene	ND	ND
Benzo (a) anthracene	ND	ND
Benzo (b) fluoranthene	ND	ND
Benzo (k) fluoranthene	ND	ND
Benzo (g,h,i) perylene	9.8	5.9 - 17
Benzo (a) pyrene	2.5 - 19.9	2.8 - 760
Chrysene	ND	ND
Dibenzo (a,h) anthracene	ND	ND
Fluoranthene	126	99
Fluorene	ND	ND
Indeno (1,2,3-cd) pyrene	ND	ND
Naphthalene	ND	830**
Phenanthrene	ND	ND
Pyrene	34 - 101	2-66

Key:

ND = No data.
*Unless otherwise footnoted, value from Table 1 (IARC 1983).
**USEPA 1982.

ESTIMATED DAILY IN[illegible]S PRIORITY POLLUTANT POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) (ug/day)[a]

Route of Exposure	Benzo(a)pyrene	Naphthalene	Individual PAHs in the Anthracene Group[c]	Individual PAHs in the Acenaphthalene Group[d]
Typical Diet	0.005	0.4[f]	1[i]	<0.05
Drinking Water	0.0006	2.8	1[i]	<0.005
Ambient Air	--	0.001-0.007[g]	1[i]	0.002-6.4[j]
Urban	0.02-2	N.D.	1[i]	--
Suburban	0.002-0.2	N.D.	1[i]	--
Smoking[b]	1.0	38[k]	3.3-8.8[l]	0.05-1.3[l]
Sidestream Smoke	--[e]	145[h]	--	--
Charcoal Meats[e]	N.D.	N.D.[e]	--	N.D.[e]
Other		140 (mothballs)	21 (fluoranthene)	--
Total				
Smoker[m]	2.1	41.2	7	0.9
Nonsmoker[m]	1.1	3.2	1	0.2

Key:

N.D. = No data found.

[a] Unless otherwise footnoted, all data except smoking taken from USEPA 1982. Smoking data taken from IARC (1983).

[b] Consistent with estimates in USEPA 1982, smokers are assumed to smoke an average of 25 cigarettes per day. USEPA (1982) reported that roughly 25% to 30% of smokers consume more cigarettes than this average. Consequently, those smokers would be subject to higher exposure.

[c] Compounds in the anthracene group are anthracene, acenaphthene, fluoranthene, fluorene, phenanthrene, and pyrene.

[d] Compounds in the acenaphthylene group are acenaphthylene, benzo(a)anthracene, chrysene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene.

[e] Unless otherwise specified, intakes for charcoaled meats included in estimated intakes for a typical diet.

[f] Estimate for naphthalene based upon fish consumption only. No data were found for other foods.

[g] Urban/rural breakdown not available. Data applies to all ambient air other than a nearby source.

[h] Maximum concentration for a 2-hour exposure in a smoke-filled room, using a concentration in air of 83 ug/m^3 (USEPA 1982) and assuming a respiratory flow of 0.875 m^3/hr.

[i] Total for dietary, ambient air, and drinking water exposure. Exposure to fluorene could be as high as 21 ug/day.

[j] Levels of benzo(g,h,i)perylene are somewhat higher (USEPA 1982).

[k] Benzo(a)anthracene identified in cigarette smoke (USEPA 1982).

[l] Data taken from Table 5.

[m] Totals calculated using mean of ranges. For acenaphthalene group, categories with less than notations, the mean of 0 and the upper limit are used in calculating totals. No sidestream smoke exposures are included in nonsmoking totals.

Table 8

EPA CARCINOGENICITY CATEGORIZATION FOR ORAL AND INHALATION ROUTES OF EXPOSURE FOR THE 15 PRIORITY POLLUTANTS POLYCYCLIC AROMATIC HYDROCARBONS*

Compound	EPA Carcinogenicity Classifications* Inhalation	 Oral
Acenaphthene	D	D
Anthracene	D	D
Benzo (a) anthracene	B2	B2
Benzo (b) fluoranthene	B2	B2
Benzo (k) fluoranthene	D	D
Benzo (g,h,i) perylene	D	D
Benzo (a) pyrene	B2	B2
Chrysene	B2	B2
Dibenzo (a,h) anthracene	B2	B2
Fluoranthene	D	D
Fluorene	D	D
Indeno (1,2,3-cd) pyrene	C	C
Naphthalene	D**	D**
Phenanthrene	D	D
Pyrene	D	D

*Unless otherwise footnoted, classification taken from USEPA (1986a).
**Classification from USEPA (1984).

Table 9

RELATIVE POTENCY ESTIMATES AND SLOPE FACTORS (SFS) DERIVED FOR POLYCYCLIC AROMATIC HYDROCARBONS CATEGORIZED IN GROUP A, B, OR C ACCORDING TO EPA'S WEIGHT-OF-EVIDENCE CRITERIA

Compound	Relative Potency Estimates	Oral* SFs	Inhalation* SFs
Benzo(a)pyrene	1	11.5	6.1
Benzo(a)anthracene	0.145	1.7	0.89
Benzo(b)fluoranthene	0.140	1.6	0.85
Chrysene	0.0044	0.05	0.026
Dibenzo(a,h)anthracene	2.82	32.4	17.2
Indeno(1,2,3-cd)perylene	0.232	2.7	1.4

*SFs derived by obtaining the product of the relative potency estimates and the EPA SF for benzo(a)pyrene.

Source: Thorslund *et al*. (1986).

Table 10

RELEVANT STANDARDS AND CRITERIA FOR POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

Standard or Criterion	Value	Reference
Slope Factors (SFs)		
Inhalation**	6.11 $(mg/kg/day)^{-1}$	USEPA 1986b
Oral**	11.5 $(mg/kg/day)^{-1}$	
Water Quality Criteria for Drinking Water	2.8 ng/L	USEPA 1986c
Occupational Exposure Limit		
OSHA (PEL)	0.2 mg/m^3*	OSHA 1989

*As coal tar pitch volatiles.
**For benzo(a)pyrene.

TRICHLOROETHENE (TCE)

Trichloroethene (TCE) is a widely used industrial solvent, particularly in metal degreasing, which consumes the large majority of its production. Other miscellaneous applications include use in dry cleaning, as a low temperature heat exchange fluid, and in textile processing.

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of TCE (CAS No. 79-01-6) are summarized below (Howard 1989: MacKay and Shiu 1981):

Chemical Formula	C_2HCl_3
Molecular Weight	131.5 g/mole
Physical state at 20°C	Liquid
Water Solubility	1,100 mg/L (25°C)
Density at 20°C	1.46 g/ml
Vapor Pressure	57.9 mm Hg (25°C)
Henry's Law Constant	1.2E-03 $atm \cdot m^3/mole$
Octanol-Water Partition Coefficient(Log K_{ow})	2.38
Organic Carbon Partition Coefficient (K_{oc})	126 mL/g
Bioconcentration Factor (BCF)	10.6

TCE's high vapor pressure and Henry's Law Constant indicate that volatilization will be the predominant removal mechanism for this compound from surface water and surficial soil. Its half-life in surface water has been estimated to range from 1 to 90 days, depending on water temperature, depth, turbulence, and movement of air across the water surface. In air, its half-life has been estimated to be 4 days or more, with its major degradation mechanism being photooxidation.

TCE's high water solubility and low to moderate log K_{ow} and K_{oc} indicate that TCE will be moderately to highly mobile in the subsurface. Since TCE is denser than water as a liquid and denser than air as a vapor, it has a marked tendency to sink through the unsaturated and saturated zones. TCE is biodegraded in the subsurface by reductive dehalogenation to dichloroethenes and vinyl chloride. Its half-life in groundwater has been estimated to range from minimal at low concentrations to 4 to 9 months at higher concentrations (Smith and Dragun 1984).

TCE is moderately bioconcentrated in aquatic organisms.

Toxicokinetics

TCE was absorbed almost completely (97%) following oral administration in rats (Dekant et al. 1984). No information was found on absorption following inhalation exposure; however, only 25% of an inhalation dose of tetrachloroethene was absorbed by human volunteers. TCE distributes throughout the body, but the highest levels are found in the adipose tissues, kidney, lung, adrenals, vas deferens, epididymis, brain, and liver. TCE is metabolized oxidatively to trichloroethylene oxide, trichloroacetaldehyde, trichloroacetic acid, monochloroacetic acid, trichloroethanol, and trichloroethanol glucuronide (EPA 1985b). TCE is eliminated from the body by exhalation of the original compound and urinary excretion of the metabolites (EPA 1987b).

Noncarcinogenic Effects

TCE elicits a low level of acute toxicity, as reflected by the median lethal dose (LD_{50}) of 4,920 mg/kg in rats, 3,200 mg/kg in mice, and 2,800 mg/kg in dogs. At near-lethal doses, mild changes in biochemical indices of liver function have been reported. Following short-duration inhalation exposure to high airborne concentrations, central nervous system (CNS) effects predominate. Chronic exposure of laboratory animals to TCE vapor has resulted in mild kidney and liver damage.

TCE exhibits no embryotoxic or teratogenic toxicity below maternally toxic levels (EPA 1985). Illustrative of this finding is the absence of significant results in a study by Schwetz et al. (1975) of the effects on offspring of mice and rats exposed to 300 ppm TCE (1,614 mg/m^3) for 7 hours/day during the period of highest susceptibility to teratogenic effects (during days 6 to 15 of gestation).

Carcinogenicity and Mutagenicity

There has been a series of animal bioassays evaluating the carcinogenicity of TCE following ingestion. The first of these studies showed a dose-related increased incidence of hepatocellular carcinomas in

$B_6C_3F_1$ mice receiving technical-grade TCE by stomach tube (gavage) (NCI 1976). Osborne-Mendel rats, exposed according to the same protocols as the $B_6C_3F_1$ mice, showed no increases in tumors (NCI 1976). The finding of an increased incidence of hepatocellular carcinomas was confirmed in subsequent gavage studies, in which $B_6C_3F_1$ mice received purified TCE (NTP 1982, 1986). Also in these studies, an increased incidence of kidney adenocarcinomas was reported in a high-dose group of male Fischer 344 rats (NTP 1982, 1986). Maltoni et al. (1986) reported an increased incidence of leukemia in male Sprague-Dawley rats receiving TCE by gavage.

Other oral studies tend to confirm the results or show deficiencies which limit their usefulness (EPA 1987a). A number of inhalation studies have also been performed. Of these, Maltoni et al. (1986) show a statistically significant increased incidence of hepatomas in male Swiss mice and male and female $B_6C_3F_1$ mice, as well as hepatomas and lung tumors in $B_6C_3F_1$ mice. Male Sprague-Dawley rats exposed under similar experimental protocols showed a statistically increased incidence in kidney tumors and Leydig cell tumors, as well as an increased incidence of leukemia (Maltoni et al. 1986). In another inhalation study, female Han:NMRI mice (but not Han:Wist rats) and Syrian hamsters exposed to TCE by inhalation showed an increased incidence of lymphomas (Henschler et al. 1980). However, viruses and/or immunosuppression may have enhanced susceptibility (Henschler et al. 1980; EPA 1987a). Fukuda et al. (1983) reported an increased incidence of lung tumors in ICR mice, but not in Sprague-Dawley rats, and Bell et al. (1978) reported an increased incidence of hepatocellular carcinomas in $B_6C_3F_1$ mice, but not in Charles River rats exposed by inhalation to TCE.

There have been three cohort studies of TCE-exposed workers (Shindell and Ulrich 1985; Axelson et al. 1978; Tola et al. 1980), one malignant lymphoma case-control study (Hardell et al. 1981), and two surveys of liver cancer cases for TCE exposure (Paddle 1985; Novotna et al. 1978). EPA has concluded that these studies suffered from one or more deficiencies that diminish their usefulness and/or diminish their sensitivity to detect a human carcinogenic response: small sample size, absence of analyses by tumor site, problems with exposure definition, and problems with duration of exposure (EPA 1987a). Consequently, EPA has judged the epidemiologic data to be inadequate for evaluating the carcinogenic potential of TCE (EPA 1987a).

Based upon the positive animal data and the absence of adequate human data, and according to its weight-of-evidence carcinogenicity criteria, EPA has placed TCE in Category B2, "probable human carcinogen," for both the oral and inhalation routes of exposure (EPA 1987a; 1990a).

Commercial TCE containing stabilizers (e.g., dioxane, etc.) has been reported to be weakly mutagenic in a variety of in vitro and in vivo assays representing a wide evolutionary range of organisms (EPA 1987a). Based on these data, EPA has concluded that commercial TCE may have the potential to cause weak or borderline increases above the spontaneous level of mutagenic effects in exposed human tissues (EPA 1987a).

Quantitative Indices of Toxicity

Based on the results of the NTP study (1983), EPA has derived slope factors for the oral and inhalation routes of exposure. The upper-bound estimate for the oral route, based upon the gavage data, is 1.1 x 10^{-2} $(mg/kg/day)^{-1}$ (EPA 1985; 1990a). The corresponding estimate for the inhalation data is 1.3 x 10^{-3} (EPA 1990a). Quantitative indices of toxicity are summarized in Table 1.

Standards and Criteria

Standards and criteria applicable to TCE are summarized in Table 2.

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Table 1

INDICES OF TOXICITY FOR TRICHLOROETHENE

Oral Route	
Slope Factor (SF) $(mg/kg\text{-}day)^{-1}$	1.1×10^{-2}
Weight of Evidence Classification	B2
Type of Cancer	Hepatocellular Carcinoma Malignant lymphoma
Test Species	Mice
SF Basis	Oral, inhalation
SF Source	IRIS - EPA 1990a
Inhalation Route	
Slope Factor $(mg/kg\text{-}day)^{-1}$	1.3×10^{-2}
Weight of Evidence Classification	B2
Type of Cancer	Hepatocellular
Test Species	Mice
SF Basis	Oral exposure
SF Source	IRIS

TABLE 2

STANDARDS AND CRITERIA FOR TRICHLOROETHENE

Standard or Criterion	Value	Reference
Drinking Water		
National Primary Drinking Water Regulations		
MCL (a)	0.005 mg/L	EPA 1987
MCLG (b)	0	EPA 1987
Surface Water		
EPA Ambient Water Quality Criteria		
Aquatic Organisms and Drinking Water	0 (2.7 µg/L)*	EPA 1986
Adjusted for Drinking Water Only	0 (2.8 µg/L)*	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	270 mg/m^3 (50 ppm)	OSHA 1989
OSHA STEL	1,080 mg/m^3 (200 ppm)	OSHA 1989
ACGIH TLV TWA	270 mg/m^3 (50 ppm)	ACGIH 1989

* The concentration value given in parentheses corresponds to a risk of 10^{-6}.

a MCL = Maximum contaminant level.
b MCLG = Maximum contaminant level goal.

1,2,4-TRICHLOROBENZENE

1,2,4-Trichlorobenzene (TCB) is the most widely used as a dye carrier in the textile industry. The pesticide industry consumes approximately 28% of produced TCB, in the manufacture of pesticides. In addition, 18% of TCB production is used in dielectric liquids and transformer oils. Miscellaneous uses include degreasing agents, septic tank and drain cleaner formulations, wood preservation, and abrasive formulations used in the manufacture of grinding wheels (EPA 1980).

Environmental Chemistry and Fate

The relevant physical chemical properties and environmental fate of TCB (CAS No. 120-82-1) are summarized below (Howard 1989; Weast 1983; MacKay and Shiu 1981; Mabey et al. 1982; U.S. Air Force 1989).

Molecular Formula	$C_6H_3CL_3$
Molecular Weight	181.5
Physical State at 20°C	Liquid
Water Solubility (mg/L at 25°C)	4.88 E+01
Liquid Density (g/ml)	1.45
Vapor Pressure (mmHg at 25°C)	2.9E-01
Henry's Law Constant (atm-m^3/mole)	4.33E-03
Octanol-Water Partition Coefficient (Log K_{ow})	4.02
Organic Carbon Partition Coefficient (K_{oc})	9,200
Bioconcentration Factor (BCF)	630

The Log K_{ow}s, moderate K_{oc}, and low vapor pressure, indicate that absorption to soils and leaching to groundwater will copredominate for TCB in soils. Similarly, absorption to sediments and solvation will copredominate in groundwater and surface water. TCB has a higher density than water, causing TCB to sink in aqueous media.

The Log K_{ow} suggests that TCB will bioaccumulate. 1,2,4-TCB is not expected to be rapidly biodegraded in the environment. In most soil-groundwater systems, the concentration of microorganisms capable of biodegrading 1,2,4-TCB is expected to be low and drop off sharply with increasing depth.

Toxicokinetics

In male rats and female rats at least 89% and 99% of 10 mg of radiolabelled TCB was absorbed from the gastrointestinal tract (Lingg et al. 1982). Kociba et al. (1981) has shown that TCB is absorbed in the respiratory tract following inhalation by rats, rabbits, and beagle dogs. Unfortunately, the latter study was not designed to provide quantitative absorption rate data.

Noncarcinogenic Toxicity

Several animal studies have been reported on the subchronic toxicity of 1,2,4-TCB. 1,2,4-TCB inhalation studies of 1.5 to 6 months duration in rats, rabbits, dogs, and monkeys showed no major irreversible toxic effects, but reported transient histological changes and increased liver weight (Kociba et al. 1981; Carlson and Tardiff 1976). Increased uroporphyrins were also reported (Kociba et al. 1981; Watanabe et al. 1978).

Reproduction and Development

A multigenerational study conducted indicated no adverse reproductive effects in rats receiving 400 mg/L of 1,2,4-TCB in drinking water (Robinson et al. 1981). Two studies indicated no teratogenic effects in rats ingesting 300 mg/kg/day 1,2,4-TCB (Ruddick et al. 1983) but reduced embryonic development was observed at a maternally toxic dose of 360 mg/kg (Kitchin et al. 1983).

Carcinogenicty and Mutagenicity

Neither oral nor inhalation carcinogenicity bioassays could be located in the available literature. No oral or human carcinogenicity data could be located in the available literature.

Negative results were obtained in a Salmonella typhimurium reverse mutation assay in five strains without rat liver S-9 metabolic activation (Schoeny et al. 1979; Lawelor et al. 1979). However, this test system is insensitive to chlorinated compounds (Rinkus and Legator 1980).

According to its weight-of-evidence carcinogenicity guidelines, EPA has categorized 1,2,4-TCB in Group D - not classified (EPA 1990b).

Quantitative Indices of Toxicity

Table 1 summarizes the quantitative indices of toxicity for 1,2,4-TCB.

Standards and Criteria

Standards and criteria applicable to 1,2,4-TCB are summarized in Table 2.

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Table 1A

INDICES OF TOXICITY FOR 1,2,4-TRICHLOROBENZENE

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	2.0E-02
Subchronic RfD (RfDs) mg/kg/day	2.0E-01
Confidence Level	NS
Critical Effect	Increased liver-to-body weight ratio
Test Species for Critical Effect	--
RfD Basis	Gavage
RfD Source	HEAST - EPA 1990b
Uncertainty Factor	
- Chronic RfD	1000
- Subchronic RfD	100
Inhalation Route	
Chronic Reference Dose (RfD) mg/kg/day	3.0E-03
Subchronic RfD (RfDs) mg/kg/day	3.0E-02
Confidence Level	NS
Critical Effect	Increased uroporphyrin
Test Species for Critical Effect	--
RfD Basis	Inhalation
RfD Source	HEAST - EPA 1990b
Uncertainty Factor	
- Chronic RfD	1000
- Subchronic RfD	100

NS = Not specified.

Table 1B

INDICES OF TOXICITY
FOR 1,2,4-TRICHLOROBENZENE

Oral Route	
Slope Factor (SF) $(mg/kg\text{-}day)^{-1}$	None
Weight of Evidence Classification	D
Type of Cancer	NA
Test Species	NA
SF Basis	NA
SF Source	IRIS - EPA 1990a
Inhalation Route	
Slope Factor $(mg/kg\text{-}day)^{-1}$	None
Weight of Evidence Classification	D
Type of Cancer	NA
Test Species	NA
SF Basis	NA
SF Source	NA

NA = Not applicable

Table 2

Standards and Criteria for 1,2,4-Trichlorobenzene

Standard or Criterion	Value	Reference
Drinking Water		
National Primary Drinking Water Regulations		
Proposed MCL (a)	None	EPA 1990a
Proposed MCLG (b)	None	EPA 1990a
Surface Water		
EPA Ambient Water Quality Criteria		
Aquatic Organisms and Drinking Water	None	EPA 1990
Drinking Water Only	None	EPA 1990
Occupational Air Concentrations		
OSHA PEL Ceiling	40 mg/m^3 (5 ppm)	OSHA 1989
ACGIH TWA	40 mg/m^3 (5 ppm)	ACGIH 1989

*Potential carcinogens have a criterion value of 0. A concentration of 0.8 µg/L corresponds to a risk of 10^{-6}, as presented in water quality criteria documents.

a MCL = Maximum contaminant level.
b MCLG = Maximum contaminant level goal.

TRANS-1,2-DICHLOROETHENE (t-1,2-DCE)

Trans-1,2-dichloroethene (t-1,2-DCE) is widely used in industry. Applications include use as a solvent for fats, phenols, and camphor, as a refrigerant, as an additive to dye and lacquer solutions, as a low-temperature solvent for heat sensitive substances, and in rubber manufacturing, organic synthesis, and medicine. T-1,2-DCE is a synthetic chemical with no known natural sources. Monitoring studies have found that t-1,2-DCE is a relatively rare contaminant in groundwater, but levels as high as 40 µg/L have been reported. The majority of detected concentrations were below 0.5 µg/L (EPA 1985).

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of t-1,2-DCE (CAS No. 156-60-5) are summarized below (Howard 1989; MacKay and Shiu 1981)):

Chemical Formula	$C_2H_2Cl_2$
Molecular Weight	97 g/mole
Physical State at 20°C	Liquid
Water Solubility	6,300 mg/L (25°C)
Density at 20°C	1.26
Vapor Pressure	340 mm Hg (25°C)
Henry's Law Constant	6.5×10^{-3} atm·m^3/mole (25°C)
Octanol-Water Partition Coefficient (Log K_{ow})	0.48
Organic Carbon Partition Coefficient (K_{oc})	59 mL/g
Bioconcentration Factor (BCF)	1.6

The relatively high vapor pressure of t-1,2-DCE indicates that its predominant loss mechanism from surface water and surface soils is likely to be volatilization. Its half-life in surface water has been estimated to range from 1 to 6 days, depending on temperature, water turbulence, and air movement across the water surface. No half-life estimate in soils was found; however, evaporative loss from surface soils would probably have a half-life in the same range as the surface water half-life. The half-life of t-1,2-DCE in air has been estimated to be <2 days.

Bulk t-1,2-DCE is denser than water, and t-1,2-DCE vapors are denser than air. Therefore, the compound has a tendency to sink through surface and groundwater when present as a bulk liquid and through the unsaturated zone as a vapor.

The low K_{oc} value indicates that t-1,2-DCE is only poorly adsorbed by soil particles and therefore only slightly retarded in its movement through the subsurface. In subsurface soils and groundwater, biologically mediated reductive dehalogenation to vinyl chloride is probably the primary fate (Smith and Dragun 1984). However, no half-life estimate has been found.

Toxicokinetics

T-1,2-DCE is a low-molecular-weight, lipid-soluble material which should be readily absorbed by any route of exposure (oral, inhalation, dermal) (EPA 1984). No specific information on the distribution, metabolism, and excretion of t-1,2-DCE was found; however, if it behaves like the cis-isomer, rat studies indicate that it will concentrate in the liver and kidneys, undergo metabolism by liver microsomal enzymes, and most of a single dose will be excreted in the urine in a few days (EPA 1987).

Noncarcinogenic Effects

At high concentrations over short-term periods, t-1,2-DCE, like other chlorinated ethylenes, possesses anesthetic properties. An oral median lethal dose (LD_{50}) of 1,300 ppb for rats has been reported (Freundt et al. 1977). After prolonged exposure, severe pneumonic infiltration, changes in blood chemistry and cell counts, and liver degeneration with lipid accumulation have been observed (Freundt et al. 1977). No information on reproductive or developmental effects was found in the available literature.

Carcinogenic Effects

No information was found in the literature on the carcinogenic potential of t-1,2-DCE. Several studies have failed to detect any mutagenic activity, with or without microsomal activation (EPA 1987).

Quantitative Indices of Toxicity

No lifetime toxicity data were available for t-1,2-DCE. The oral reference dose (RfD) was derived based on data from a 90-day feeding study in which 1,2-DCE was administered to mice in drinking water (Barnes et al. 1985). Using a no-observed-adverse-effect level (NOAEL) of 0.1 mg/kg, EPA derived an oral RfD of 0.02 mg/kg/day (EPA 1990a). EPA has not derived an inhalation RfD for t-1,2-DCE.

The EPA confidence in the database is rated low because of the lack of chronic studies and the lack of data on reproductive and developmental toxicity. Quantitative indices of toxicity are summarized in Table 1.

Standards and Criteria

Standards and criteria applicable to t-1,2-DCE are listed in Table 2.

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Table 1

INDICES OF TOXICITY
FOR TRANS-1,2-DICHLOROETHENE

Oral Route	
Chronic Reference Dose (RfD) mg/kg/day	0.02
Subchronic RfD mg/kg/day	0.2
Confidence Level	Low
Critical Effect	Increased serum alkaline phosphatase
Test Species for Critical Effect	Mice
RfD Basis	Drinking water
RfD Source	IRIS
Uncertainty Factor	
- Chronic RfD	1,000
- Subchronic RfD	100
Modifying Factor	
- Chronic RfD	1
- Subchronic RfD	1

NS = Not specified.

Table 2

STANDARDS AND CRITERIA FOR TRANS-1,2-DICHLOROETHENE

Standard or Criterion	Value	Reference
Drinking Water		
National Primary Drinking Water Regulations		
Proposed MCL (a)	0.1 mg/L	EPA 1989
Proposed MCLG (b)	0.1 mg/L	EPA 1989
Surface Water		
EPA Ambient Water Quality Criteria	Insufficient data to develop	EPA 1986
Occupational Air Concentrations		
OSHA PEL TWA	790 mg/m^3 (200 ppm)	OSHA 1989
ACGIH TLV TWA	790 mg/m^3	ACGIH 1989

a MCL = Maximum contaminant level.
b MCLG = Maximum contaminant level goal.

VINYL CHLORIDE

Vinyl chloride and polyvinyl chloride (PVC) are used as raw materials in the plastics, rubber, paper, glass, and automotive industries. In addition, vinyl chloride and PVC are used in the manufacture of electrical wire insulation and cables, piping, industrial and household equipment, medical supplies, food packaging materials, and building and construction materials. Man-made sources are responsible for all of the vinyl chloride found in the environment. Air in rural/remote and urban/suburban areas of the United States (U.S.) typically contain no detectable amounts of vinyl chloride (Stephens et al. 1986). In areas near polyvinyl chloride and vinyl chloride manufacturers, the concentration of vinyl chloride in air typically ranges from trace levels to 105 $\mu g/m^3$ (ATSDR 1989).

Vinyl chloride has been identified in some surface, ground and drinking waters in the U.S. In a 1982 EPA groundwater supply survey, vinyl chloride was identified in less than 1% of groundwater supplies. The maximum concentration detected was 8.4 µg/L (Westrick et al. 1984).

Environmental Transport and Fate

The relevant physical and chemical properties and environmental fate of vinyl chloride (CAS No. 75-01-4) are summarized below (Howard 1989; McKay and Shiu 1981).

Chemical Formula	CH_2CHCl
Molecular Weight	63 g/mole
Physical State at 20°C	gas
Water Solubility	2,760 mg/L (25° C)
Vapor Density	2.15
Vapor Pressure	2,660 mm Hg (25° C)
Henry's Law Constant	6.9E-01 $atm \cdot m^3$/mole (°C)
Octanol-water Partition Coefficient (Log Kow)	1.38
Organic Carbon Partition Coefficient (Koc)	57
Bioconcentration Factor (BCF)	0.91

Vinyl chloride has a high water solubility and vapor pressure. As a consequence of these two properties, vinyl chloride can be characterized as a highly mobile chemical. For vinyl chloride released to air, some rainwater washout is anticipated. After deposition in water or soil, volatilization is expected to return some portion back to the atmosphere. Based on vinyl chloride's high Henry's Law Constant, following release to water, volatilization will result in substantial loss to the atmosphere. Vinyl chloride's half-life in a typical pond, river, and lake has been estimated, to be 43.3, 8.7, and 34.7 hours, respectively (EPA 1985). In waters containing photosensitizers, such as humic materials, photodegradation may be fairly rapid (ATSDR 1989). The half-life for vinyl chloride in air, based on reaction with photochemically generated hydroxyl radicals, has been estimated to range from 1.5 to 1.8 days (EPA 1985).

Due to its high water solubility, high vapor pressure and moderate Koc, adsorption to sediments is not expected to be a major surface water fate process.

Vinyl chloride released to soil can be transported to air via volatilization, to surface water via runoff and groundwater via leaching. The first two pathways predominate in surficial soil, whereas the latter predominates at lower soil depths (EPA 1985).

According to criteria developed by Kenaga (1980), vinyl chloride with a Koc of 57, would be considered to be mobile in soil.

Based on data in aquatic media, chemical reaction of vinyl chloride in soil does not appear to be a significant fate process, and it appears that vinyl chloride in soil would be resistant to biodegradation under aerobic conditions (ATSDR 1989). In soils, vinyl chloride is a biodegradation product of trans-1,2-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethane.

Toxicokinetics

Vinyl chloride is readily absorbed via inhalation and ingestion, but poorly absorbed through intact skin (ATSDR 1989). Vinyl chloride metabolism occurs primarily in the liver, with toxicity apparently attributable to enzymatic conversion to reactive polar intermediates. Three alternative metabolic pathways have been postulated for vinyl chloride following oral or inhalation exposure (Hefner 1975b). At low concentrations, sequential oxidation to 2-chloroethanol, 2-chloroacetaldehyde and 2-chloroacetic acid involving alcohol dehydrogenase appears to predominate. When this dehydrogenase becomes saturated, 2-chloroethanol may be oxidized by catalase in the presence of hydrogen peroxide. The third pathway involves oxidation of vinyl chloride by a mixed function oxidase to form 2-chloroethylene oxide which spontaneously rearranges to 2-chloroacetaldehyde.

At low oral doses (less than 1 ug/kg) of vinyl chloride the metabolites are excreted primarily in the urine, whereas, at high oral doses (greater than 100 ug/kg), most of the chemical is expired as vinyl chloride (EPA 1985).

Noncarcinogenic Effects

Studies on humans working in vinyl chloride plants suggest that noncarcinogenic systemic effects may occur above an airborne concentration of 50 ppm. At levels upwards to and exceeding 1000 ppm, workers reported dizziness, headaches and/or euphoria. Long-term exposure at these levels have resulted in numerous pulmonary, gastrointestinal, cardiovascular and central nervous system effects. Data are insufficient to characterize effects at low air concentration.

Reproduction and Developmental Effects

Infante _et al_. (1976a,b) reported an association between human exposure to vinyl chloride and birth defects and fetal loss, but this association was contradicted by Edmonds _et al_. (1975) and Hatch _et al_. (1981). Inhalation exposure of rats and rabbits to vinyl chloride concentrations as high as 2,500 ppm (6,500 mg/m^3) on days 6 to 15 (rats) and 6 to 18 (rabbits) of gestation, and mice to vinyl chloride levels as high as 500 ppm (2,300 mg/m^3) on days 6 to 15 of gestation, did not induce teratogenic effects but did increase skeletal variants in the high dosed group of mice (John _et al_. 1977). A developmental effects study with vinyl chloride in rats exposed by inhalation to 600 or 6,000 ppm (2,160 or 21,160 mg/m^3) 4 hours daily on days 9 through 21 of gestation was negative for teratogenicity and inconclusive for fetotoxicity (Radike _et al_. 1977).

Carcinogenicity and Mutagenicity

Elevated angiosarcoma mortality among workers occupationally exposed to vinyl chloride have unequivocally shown vinyl chloride to be a human carcinogen. EPA has placed vinyl chloride according to its carcinogenicity weight-of-evidence criteria in category A, "human carcinogen" (EPA 1990a). In addition to definitive human evidence, several long-term bioassays have demonstrated increased incidence of tumors in mice, rats, and hamsters.

Studies of vinyl chloride effects in occupationally exposed workers showed increases in the number of chromosome aberrations in peripheral lymphocytes particularly at exposure concentrations above the current 1 ppm Occupational Safety and Health Administration Standard. Numerous *in vitro* assays have shown vinyl chloride metabolites, but not the parent compound, to be mutagenic.

Quantitative Indices of Toxicity

EPA has derived an estimated oral slope factor (SF) of 2.3 $(mg/kg/day)^{-1}$ (EPA 1987, EPA 1990a) based upon the incidence of lung and liver tumors in male and female rats exposed dietarily to vinyl chloride for a lifetime (Feron *et al*. 1981). EPA has also derived an inhalation SF (EPA 1990a) of 2.95×10^{-1} $(mg/kg/day)^{-1}$ based upon the incidence of liver angiosarcomas in male and female rats exposed for up to 1 year to concentrations of up to 30,000 ppm (Maltoni *et al*. 1980). EPA has not derived a noncarcinogenic reference dose for either oral or inhalation exposure to vinyl chloride (EPA 1990a,b). Table 1 summarizes the quantitative indices of toxicity for vinyl chloride.

Standards and Criteria

Standards and criteria applicable to vinyl chloride are listed in Table 2.

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Table 1

INDICES OF TOXICITY FOR VINYL CHLORIDE

Oral Route	
Slope Factor (SF) $(mg/kg\text{-}day)^{-1}$	2.3
Weight of Evidence Classification	A
Type of Cancer	Lung
Test Species	Rat
SF Basis	Diet
SF Source	HEAST - EPA 1989b
Inhalation Route	
Slope Factor $(mg/kg\text{-}day)^{-1}$	2.95×10^{-1}
Weight of Evidence Classification	A
Type of Cancer	Liver
Test Species	Rat
SF Basis	1 year inhalation study
SF Source	HEAST; EPA 1989b

TABLE 2

STANDARDS AND CRITERIA FOR VINYL CHLORIDE

Standard or Criterion	Value	Reference
U.S. Primary Drinking Water Standards		
MCL	0.002 mg/L	EPA 1990a
MCLG	0	EPA 1990a
Surface Water		
EPA Ambient Water Quality Criteria		
Human Health	0.002 mg/L (1 X 10^{-6} risk)	EPA 1986b
Occupational Air Concentrations		
OSH PEL TWA	2 mg/m^3 (1 ppm)	OSHA 1989
ACGIH TLV TWA	10 mg/m^3 (5 ppm)	ACGIH 1989

MCL: Maximum Contaminant Level.
MCLG: Maximum Contaminant Level Goal.

ZINC CAS No.: 7440-66-6

Zinc is a naturally occurring element usually found in the form of zinc sulfide ores. Smelting or electrolytic processing are the two most common methods for extracting zinc from the ore. Zinc is commonly used as a protective coating of other metals and in alloys such as bronze and brass. Zinc is also used in organic chemical extractions and reductions.

Zinc may be released to the atmosphere as dust and fumes from zinc production facilities, lead smelters, brass works, automobile emissions, fuel combustion, incineration, and soil erosion (ATSDR 1988). Zinc concentrations in the ambient air in urban areas have been found to range from 0.1 to 1.7 ug/m^3. Near smelting operations, concentrations as high as 15.7 ug/m^3 were reported (ATSDR 1988).

Urban runoff, mine drainage, and municipal and industrial effluents are concentrated sources of zinc released to water. The maximum, minimum, and average concentrations in 1,577 raw surface waters in the United States were 1.183, 0.002, and 0.064 mg/L, respectively. There was a 76.5% frequency of detection. The maximum, minimum, and average concentrations in 380 finished waters in the United States were 2.01, 0.003, and 0.08 mg/L, respectively (NRC 1977). Higher mean concentrations of zinc in finished water may be due to water treatment and/or transport through pipe systems.

Data pertaining to ambient concentrations of zinc in soil are limited. Zinc is generally found in soils at concentrations between 10 mg/kg and 300 mg/kg with a mean of approximately 50 mg/kg (USEPA 1980). The major source of zinc for the general population is food (EPA 1987). Meat products contain relatively high concentrations (6 mg/kg in potatoes and 8 mg/kg in grains). An average zinc intake in man is on the order of 0.14 to 0.21 mg/kg/day (NRC 1977).

ENVIRONMENTAL CHEMISTRY AND FATE

Zinc is a metal belonging to Group IIB of the periodic table. Its natural valence states are 0 and 2+. Zinc forms a variety of inorganic compounds and a number of compounds with organic ligands. The element is amphoteric and forms both acidic and basic salts.

In the atmosphere zinc is expected to be present as dust and fumes from zinc production facilities, lead smelts, brass works, vehicular emissions, fuel combustion, incineration, and soil erosion. Atmosphere is found preferentially in the smaller diameter particles (<3 um in aerodynamic diameter). Smaller particles have longer atmospheric residence times than larger particles; however, no estimate of the atmospheric half-life is available.

Zinc introduced into the aquatic environment is partitioned into sediments through sorption onto hydrous iron and manganese oxides, clay minerals and organic material; a small part may be partitioned into the aquatic phase through speciation into soluble zinc compounds. Sorption of zinc is probably the dominant fate of zinc in the aquatic environment.

Information regarding the fate of zinc in soil is inadequate. However, zinc is likely to be strongly sorbed onto soil. Soil conditions not amenable for the sorption of zinc may lead to the leaching of zinc. The tendency of zinc to be sorbed is affected by the pH and salinity of soils. Decrease of pH (<7) and increase of soil salinity favors desorption (U.S. EPA, 1980).

The bioconcentration factors (BCFs) for zinc in aquatic organisms have been determined by several investigators (U.S. EPA, 1980). BCFs for zinc in edible portions of aquatic organisms have been found to vary from 43 in soft-shell clam, _Mya arenaria_, to 16,700 in oyster, _Crassostrea virginica_ (U.S. EPA, 1980).

Toxicokinetics

Zinc is an essential element and its uptake from the gastrointestinal tract depends in part on the zinc status of the organism. Zinc levels in the body are rigidly controlled by a homeostatic mechanism. Zinc is absorbed and excreted from the gastrointestinal tract. Apparent absorption ranges from 20% to 80% with a mean of about 50%. Many dietary factors, including protein, phytate, and fiber content, seem to influence zinc absorption. In one study in which human volunteers ingested zinc added to bread during baking, zinc absorption was reported to range from 12% to 39%, with an average of 25%.

No quantitative studies of zinc absorption via inhalation were found. However, increased serum and plasma zinc levels have been observed following inhalation of zinc oxide fumes. An indeterminant amount of this absorption may have resulted from ingestion of zinc bearing particles following ciliary clearance from the respiratory tract.

Noncarcinogenic Effects

Zinc is an essential trace element in human and animal nutrition. In the body it is found in high concentrations in male reproductive organs, pancreatic islets, muscle, kidney, liver, and bone. It is essential for the activity of some enzymes (U.S. EPA, 1980). The human recommended daily allowance (RDA) of zinc for adults is 15 mg (NAS, 1980). Zinc appears to be toxic only at levels at least an order of magnitude greater than the recommended daily allowance (RDA); toxicity appears to result from an overload of the homeostatic mechanism for absorption and excretion of zinc.

Acute toxicity resulting from the ingestion of food stored in galvanized containers has produced symptoms including severe diarrhea, abdominal cramping, nausea, and vomiting.

There are a variety of reports in the literature concerning subchronic exposure to zinc, including both experimental toxicological and therapeutic studies. Most commonly no adverse effects of zinc were noted. Subchronic occupational exposure in humans has resulted almost exclusively from inhalation of zinc fumes or dusts and has been associated with a condition called "metal fume fever." This condition has also been associated with chronic exposure and is characterized by flu-like symptoms including throat irritation, body aches, weakness, fatigue, and general malaise followed by fever and chills. The syndrome commonly runs its course in 24 to 48 hours. "Immunity" to the syndrome quickly develops among workers, but it is also quickly lost on cessation of exposure so that the syndrome most commonly re-occurs after several days away from work.

No teratogenic effects were observed in one experimental study in rats. However, reduced copper concentrations in the liver and other organs of the fetuses were found. There are a small number (3) of case reports of premature deliveries, including one stillborn fetus, in pregnant women who took zinc dietary supplements during the third trimester. Zinc supplementation in animals has resulted in increased fetal resorption. Zinc supplementation for pregnant women has been recommended, but because of the known interaction between zinc and copper, excessive zinc supplementation for prolonged times could have an adverse effect on the fetus. It is also well-documented that zinc deficiency during pregnancy may have an adverse effect on the fetus (NRC, 1978).

No reports of teratogenicity or fetotoxicity in man or animals associated with inhalation of zinc or its compounds have been found in the available literature.

Carcinogenicity and Mutagenicity

No pertinent reports associating zinc with cancer in humans were found in the available literature, nor were any reports of bioassays of zinc or its compounds available. Accordingly, zinc and its compounds have been placed in EPA's carcinogenicity weight-of-evidence category D - Not classified.

No data were found concerning mutagenicity of zinc or its compounds.

Quantitative Indices of Toxicity

Table 1 summarizes the quantitative indices of toxicity for zinc.

EPA has derived an oral reference dose (RfD) of 2×10^{-1} mg/kg/day based upon studies presented by Pories et al. (1967) and Prasad et al. (1975).

STANDARDS AND CRITERIA

Table 2 summarizes relevant standards and criteria for zinc.

Standards for zinc in food are not currently available and zinc in food surveys are not routinely conducted by US regulatory agencies. The Food and Drug Administration's (FDA's) contaminants team are proposing to develop criteria for evaluating inorganic contaminants in shellfish (FDA 1989).

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Table 1

INDICES OF TOXICITY
FOR ZINC

Oral Route	
Chronic Reference Dose (RfD)	2×10^{-1}
Subchronic RfD (RfDs)	2×10^{-1}
Confidence Level	NS
Critical Effect	Anemia
Test Species for Critical Effect	Human
RfD Basis	Therapeutic dosage
RfD Source	HEAST
Uncertainty Factor	
- Chronic RfD	10
- Subchronic RfD	10

Table 2

STANDARDS AND CRITERIA FOR ZINC

Standard or Criterion	Value	Reference
<u>Drinking Water</u>		
National Secondary Drinking Water Regulations		
SMCL (a)	5 mg/L	EPA 1989
<u>Surface Water</u>		
EPA Ambient Water Quality Criteria		
Water Ingestion	5 mg/L	ATSDR 1988
<u>Occupational Air Concentrations</u>		
OSHA PEL TWA		
· Zinc chloride fume	1 mg/m^3	OSHA 1989
· Zinc oxide fume	5 mg/m^3	OSHA 1989
· Zinc oxide dust	10 mg/m^3	OSHA 1989
ACGIH TWA		
· Zinc chloride fume	0.01 mg/m^3	ACGIH 1989
· Zinc chromates	0.01 mg/m^3	ACGIH 1989
· Zinc oxide fume	5 mg/m^3	ACGIH 1989
· Zinc oxide dust	10 mg/m^3	ACGIH 1989

(a) SMCL is a secondary contaminant level based on aesthetics rather than adverse health effects.

CARBON DISULFIDE

Carbon disulfide (CS_2, also known as carbon bisulfide and dithiocarbonic anhydride) is a colorless, highly flammable, and highly volatile liquid used to manufacture rayon, cellophane and carbon tetrachloride. Applications developed during the 19th century still prevail in the manufacture of flotation agents, herbicides, insecticides, ammonium thiocyanate, sodium thiocyanate, xanthogenates, electric vacuum tubes, etc. Carbon disulfide can be utilized as a direct reactant, a chemical intermediate, and as a solvent (Timmerman 1978). As a solvent, it is used by industry for phosphorus, sulfur, selenium, bromine, iodine, fats, resins, and rubber (CMR 1983; Berg 1981; Windholz 1983).

Carbon disulfide exists in the atmosphere at concentrations typically around 0.02 ppb (Brimblecombe 1986). Carbon disulfide is emitted from a wide variety of man-made and natural sources (Hoshika et al. 1975; Graedel 1978; Beard and Guenzi 1983; Aneja et al., 1982; Steudler and Peterson 1984; Farwell et al. 1979; Adams et al. 1979; Lovelock 1974). The major anthropogenic source of carbon disulfide emissions are viscose rayon manufacturing sites (U.S. Environmental Protection Agency [EPA] 1980); however, the largest global sources are natural (Khalil and Rasmussen 1984). Based on average atmospheric concentrations in rural and urban areas of the United States (Brodzinsky and Singh 1982), the average daily intakes of carbon disulfide by inhalation in these areas are 0.0026 and 0.0041 mg, respectively.

ENVIRONMENTAL CHEMISTRY AND FATE

Physical and chemical properties relevant to the environmental fate and transport of carbon disulfide (CAS#: 75-15-0) are summarized below.

Property	Value	Source
Chemical formula:	CS_2	
Molecular weight:	76.13	
Water solubility (at 20°C):	2,940 mg/l	Windholz 1983
Log K_{ow} (calculated):	2.16	Leo et al. 1971
K_{oc} (calculated):	54	EPA 1986a

Density (at 20/4°C):	1.2632	Windholz 1983
Vapor pressure (at 20°C):	297 mmHg	Timmerman 1978
Henry's Law Constant:	1.23×10^{-2} atm · m^3/mol	EPA 1986b
Bioconcentration Factor (BCF):	≤ 26	EPA 1986a

TRANSPORT

Carbon disulfide's high vapor pressure and Henry's Law Constant indicates that it will rapidly evaporate from surface waters and soils. Its relatively high water solubility and low K_{oc} indicate that it will be highly mobile in the subsurface. Its low BCF indicates that it will not accumulate significantly in aquatic organisms.

FATE

Carbon disulfide appears to be stable in aqueous media and soil under environmentally relevant conditions. It does not undergo hydrolysis, oxidation, or photolysis under these conditions (EPA 1986a). Since carbon disulfide has been used as a soil fumigant because of its toxicity to bacteria, it is unlikely to undergo significant biodegradation in soil or water (EPA 1986a).

In the atmosphere, carbon disulfide appears to be susceptible to oxidation by hydroxide radicals, atomic oxygen, and ozone. The half-life of carbon disulfide in these processes has been estimated to range from three to 150 days. Khalil and Rasmussen (1984) estimated the overall lifetime of atmospheric carbon disulfide to be about 13 days.

ENVIRONMENTAL CONCENTRATIONS

Air

Khalil and Rasmussen (1984) estimated emissions of carbon disulfide to the atmosphere in the northern hemisphere as follows:

Source	Metric tons/year
oceans	300,000
soils	640,000
marshes	50,000
volcanoes	10,000
chemical industries	260,000
sulfur recovery	70,000

Brodzinsky and Singh (1982) measured carbon disulfide at 61 rural/remote and 88 urban/suburban sites in the United States; the average concentrations found were 41 and 65 parts per trillion (ppt), respectively. Using these concentrations and assuming an average adult breathing rate of $20 m^3$/day, the average daily exposure to carbon disulfide in the U.S. would be 0.0026 and 0.0041 mg in rural and urban areas, respectively (EPA 1986a).

Air concentrations of carbon disulfide of 16 to 40 mg/m^3 have been reported at viscose rayon plants (Westburg et al. 1984; Cicollelm and Vincent 1984).

Water

Carbon disulfide has been identified, but not quantified in drinking waters of Miami, Florida, Cincinnati, Ohio (EPA 1975), and New Orleans, Louisiana (EPA 1974), and in sewage treatment plant effluents. It has also been found in Lake Ontario at levels ranging from a trace to 3.9 ppm as well as in the Niagara River waters at levels of 0 to 25 ppb (Kaiser et al. 1983). Lovelock (1974) reported levels of carbon disulfide in the open Atlantic Ocean, in mud at the sea bottom, in the Atlantic Ocean off Ireland and in stagnant bay waters of 0.52, 29.5, 0.78, and 5.4 ng/l, respectively. Lovelock speculates that anaerobic conditions on the sea floor are the source of the carbon disulfide.

Human Exposure

Carbon disulfide has been detected in waters, ambient air, grains that were fumigated with this compound, and the mother's milk of rayon factory employees. Women from Bayonne, New Jersey, Jersey City, New Jersey, Bridgeville, Pennsylvania and Baton Rouge, Louisiana were identified as having carbon disulfide in their breast milk. Seventeen rayon factory employees who were breast-feeding were found to have concentrations of 6.8 to 12.3 µg/100 ml. Contamination of milk was still detected before and after work hours, and even after 23 to 57 days away from the job (Cai and Bao 1981).

PHARMACOKINETICS

Absorption

In humans, carbon disulfide is absorbed substantially from the lungs. Herrman et al. (1982) reported that volunteers exposed to 6 to 108 mg carbon disulfide/m^3 for 30 minutes retained an average of 52.4% of the inhaled chemical in the lungs (retention was 48.7% during the last 5 minutes of exposure). It has been reported that retention of carbon disulfide is approximately 70 to 80% initially and then declines to a steady state of 15 to 45% within 1 to 2 hours (Beauchamp et al. 1983; World Health Organization (WHO) 1981).

Distribution

Studies on rats and mice indicate that carbon disulfide and its metabolites are distributed rapidly to body fat and highly perfused tissues (McKenna and DiStefano 1977; Bergman et al. 1984). Carbon disulfide is eliminated more rapidly from the tissues than are its metabolites, but neither appears to bioaccumulate in any tissue (McKenna and DiStefano 1977). Danielsson et al. (1984) also showed that carbon disulfide and its metabolites can cross the placenta throughout gestation, with metabolites accumulating in the bone, liver and neuroepithelium of the fetus.

Metabolism

Studies on animals and humans suggest that carbon disulfide is metabolized by reaction with amino acids or reduced glutathione to form thiocarbamates or conjugated glutathione, and by reactions catalyzed by cytochrome P450 to form reactive sulfur. Reactive sulfur may further react to form thiourea, carbonyl sulfide, or monothiocarbamate (McKenna and DiStefano 1977; Van Doorn et al. 1981; Soucek and Madlo 1953; Chengelis and Neal 1980, 1981; Bond and DeMatteis 1969; Freundt and Dreher 1969; Hunter and Neal 1975; Freundt and Kuttner 1969; Freundt et al. 1976; Mack et al. 1974; DeMatteis and Seawright 1973; Dalvi et al. 1974, 1975; Dalvi and Neal 1978; DeMatteis 1974; Zatignani and Neal 1975).

Excretion

In humans, 10-30% of absorbed carbon disulfide is excreted unchanged in expired air (Soucek 1957; McKee et al., 1943; Demus 1964) and <1% is excreted unchanged in urine (Soucek 1957; Soucek and Pavelkova 1953; McKee et al. 1943). The remaining carbon disulfide is excreted primarily as metabolites in the urine (Beauchamp et al. 1983). Urinary excretion appears to be proportional to the exposure concentration.

TOXICITY

Carcinogenic Effects

Exposure to carbon disulfide has not been proven to be carcinogenic. It has been reported, however, that there is an association between lymphocytic leukemia and multiple solvent exposure (Checkoway et al. 1984; Wilcosky et al. 1984). The cases of 11 hourly male workers from the U.S. rubber industry whose deaths were attributed to lymphocytic leukemia were studied and compared with exposure records from the plants. It was found that of the 24 solvents to which workers were exposed, carbon disulfide and carbon tetrachloride were strongly associated with leukemia (McMichael et al. 1976).

Mutagenicity

Mutagenicity studies with carbon disulfide have yielded primarily negative results. Genotoxicity has been reported in foreign literature, but omission of experimental details precludes interpretation of these studies (Beauchamp et al. 1983).

Teratogenicity

Administration of carbon disulfide to CD rats and New Zealand white rabbits by gavage resulted in adverse maternal and developmental effects including decreased average fetal body weight, maternal toxicity (abnormal posture, rigidity, or paralysis of hind limbs, ataxia, lethargy, and rough or erect coat), a significant dose-related reduction in maternal weight gain and elevated liver weights (Jones-Price et al. 1984a,b). Salnikova and Chirkova (1974) observed "slight embryotoxicity" in rats exposed to 4.2 ppm throughout gestation; however, failure to report daily exposures makes these results difficult to interpret. In these studies, congenital malformations such as hydrocephalus, club foot, and tail deformation were observed in the F_1 generation at 100 and 200 mg/m^3. The incidence and severity of these malformations increased in the F_2 generation. It is suggested that carbon disulfide interferes with hormonal regulation of prenatal development, which may result in permanent alteration of the xenobiotic metabolizing function of the body and impaired future ability to detoxify carbon disulfide (EPA 1986).

Other Reproductive Effects

Based on studies in rats and human occupational exposure, it has been suggested that inhaled carbon disulfide may reduce male reproductive performance (reduced sperm count) (Zenick et al. 1984a,b; Tepe and Zenick 1984; Cirla et al. 1978; Lancrajan et al. 1969; Lancrajan 1972).

In a study in which "mongrel" rats were administered distilled CS_2 dissolved in peanut oil intraperitoneally, rats treated with 25 mg/kg of CS_2 every second day for 60 days had thickened vascular walls in the testis and a reduced number of spermatozoa in the tubular lumen. In rats dosed with 25 mg/kg CS_2 (120 days, every other day), advanced regressive lesions were found in all parts of the testis (Gondzik 1971).

NONCARCINOGENIC EFFECTS

Studies show that repeated ingestion of CS_2 causes neurologic and hematologic damage. Occupational exposure to inhaled carbon disulfide is associated with cardiovascular, neurological, immunological, and ocular disorders (Beauchamp et al. 1983).

Neurological Effects

Case reports from occupational exposures suggest that carbon disulfide at concentrations of 144 to 321 ppm may cause psychosis, polyneuritis (absent or weakened Achilles or patellar reflexes), tremors, weakness of limbs, myopathy, and vertigo (Vigliani 1954). Epidemiological studies have also linked exposure to psychological disorders (Hanninen 1971; Tuttle *et al*. 1976).

Cardiovascular Effects

Occupational exposure to carbon disulfide at concentrations of 10 to 161 ppm has been associated with an increased risk of mortality from coronary heart disease (National Institute of Occupational Safety and Health [NIOSH] 1978).

Opthalmological Effects

A majority of occupational exposure reports indicate ocular damage due to carbon disulfide exposure, but the exact nature of the damage is widely disputed (EPA 1986).

STANDARDS AND CRITERIA

Standards and criteria relevant to carbon disulfide are listed in Table 1.

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Table 1

STANDARDS AND CRITERIA FOR CARBON DISULFIDE

Standard or Criterion	Value	Reference
Reference Dose		
Oral	0.1 mg/kg/day	EPA 1990a,b
Inhalation	0.01 mg/kg/day	EPA 1990a,b
Drinking Water		
National Primary Drinking Water Regulations		
MCL(a)	Not established	
MCLG(b)	Not established	
DWEL(c)	0.7 mg/L	Calculated from reference dose
Surface Water		
EPA Ambient Water Quality Criteria	None established	
Occupational Air Concentrations		
OSHA PEL TWA	12 mg/m^3 (Skin)	OSHA 1989
OSHA PEL STEL	36 mg/m^3	OSHA 1989
ACGIH TLV TWA	31 mg/m^3 (Skin)	ACGIH 1990
NIOSH REL TWA	3 mg/m^3 (Skin)	ACGIH 1990
NIOSH REL STEL	30 mg/m^3	ACGIH 1990

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Key:

(a) MCL = Maximum Contaminant Level
(b) MCLG = Maximum Contaminant Level Goal
(c) DWEL = Drinking Water Equivalent Level

APPENDIX F

CONTAMINANT MIGRATION ESTIMATION METHODS

This appendix briefly describes the models, assumptions, and input data used to estimate chemical concentrations in surface water or ambient air to which workers or recreational fishermen may be exposed.

River Dispersion and Volatilization Loss Model

The model for mixing and dilution in a river described in Thomann and Mueller (1987) was applied to estimate exposure concentrations in the Niagara River, as well as the volatilization loss to the ambient air for volatile chemicals.

The discharge from the Falls Street tunnel into the lower Niagara River was modeled as a point source to the river. The contaminants assumed to be entering the river at this point source are the groundwater contaminants detected in the vicinity of the site, which are assumed to be captured by the Falls Street tunnel and to flow without degradation through the length of the tunnel.

Two downstream locations were chosen as points where river concentrations were modeled: the Whirlpool (for fishermen exposure), and the mouth of the Niagara River at Lake Ontario (for residential drinking water exposure).

The inorganics were modeled as conservative (non-decaying) dissolved pollutants. At any downstream location, the in-stream concentration is given by:

$$s = \frac{W}{Q}$$

where

s = concentration (assuming complete mixing) in mg/L

W = total mass loading rate of a given inorganic (metal or cyanide), in mg/day

Q = river flow in L/day

In applying this model, the annual average diverted Niagara River flow of 100,000 cfs, or 2.45×10^{11} L/day, was used for Q. (The actual average annual flow of the river is 200,000 cfs. However, up to 100,000 cfs is diverted around the Niagara Falls area for public and industrial use. Thus, the flow model uses 100,000 cfs because of the diversion.) The mass loadings W were calculated as described elsewhere.

The river concentrations of organic compounds due to the point discharge from the tunnel were modeled using the model for nonconservative pollutants from a point source:

$$S_1 = S_{10}\, e^{-K_{11}\, X_1/U_1}$$

where

S_1 = concentration of non conservative pollutant due to point source, mg/L

S_{10} = maximum concentration in river immediately after complete mixing with point discharge, mg/L

K_{11} = volatilization rate, day^{-1}

X_1 = distance downstream from the point discharge, feet

U_1 = average river velocity, in feet/day

where

$$S_{10} = \frac{W_1}{Q_1}$$

where

W_1 = pollutant mass loading from point source, in mg/day

Q_1 = average river flow in reach just downstream from point source, in L/day. ($Q_1 = Q$)

The average river velocity was calculated as follows:

$$U_1 = \frac{Q}{A}$$

where

$$A = B \cdot H$$

where

A = average river channel effective cross-sectional area, ft^2

B = average river channel width, ft

H = average river channel depth, ft

The volatilization rate K_{11} was calculated using the chemicals' Henry's Law constants and the estimated stream reaeration coefficient (see Thomann and Mueller, pp. 532-536).

Table F-1 summarizes the site-specific input parameter values assumed in applying the river dispersion model.

Volatilization rates of organic compounds from the river surface were calculated at the assumed exposure locations, and were then used as vapor source strengths as inputs to appropriate air dispersion models in order to ultimately calculate ambient air exposure concentrations of vapors for nearby fishermen or workers. The total river volatilization rate was calculated as follows (see Thomann and Mueller, p. 532):

$$Q = kl \cdot A_s \cdot f_d \cdot C_T$$

where

Q = total mass loss rate from river due to volatilization, mg/s

k_1 = volatilization rate in m/s

A_s = river/air interface surface area over which volatilization occurs, m^2

f_d = fraction of contaminant dissolved in water column, assumed to be 1.0

C_T = total concentration of contaminant in water column, mg/m^3

In the above equation,

$$k_1 = K \cdot H \cdot \frac{1 \text{ day}}{86{,}400\text{s}}$$

where

K = volatilization rate in day^{-1}

$= K_{11}$ above

H = average river depth, in m

Also, C_T is calculated as S_1, using the point source model above. The river surface area A_s over which volatilization occurs was taken to be the area of an appropriate section of the river at each exposure location.

Table F-1

SUMMARY OF SITE-SPECIFIC INPUTS USED IN THE RIVER DISPERSION AND VOLATILIZATION MODEL

Symbol	Parameter	Units	Value	Source
Q	Average river flow	L/day	2.45E+11	Annual average flow for Niagara River is 100,000 cfs
B	Average river width	ft	400	At Whirlpool; Estimated from site map
H	Average river depth	ft	16.7	Report on Niagara River
A	Average river cross-sectional area	ft^2	6,680	Calculated as B·H
U_1	Average river velocity	ft/day	2.59E+06	Site-specific estimate of 30 ft/s near the Whirlpool
Point Source Model				
W_1	Mass loading	mg/day	--	Calculated based on groundwater concentrations
x_1	Distance downstream from point	ft	13,800	Estimated distance from Falls Treet tunnel outfall to Whirlpool
K_{11}	Volatilization rate for point source	day^{-1}	--	Calculated from Henry's Law constant and river re-aeration coefficient (see Thomann and Mueller 1987, p. 532); chemical-specific value

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Source: Ecology and Environment, Inc. 1990.

Near Field Air Dispersion: "Box Model"

For scenarios where the receptor is at the source or very close to the source, within approximately 100 meters downwind, the near field "box model" of GRI (1988) Section 1.2.2 was applied. This model is as follows:

$$C_a = Q/(H_b\ W_b \cdot U_m)$$

where

C_a = On-site air concentration (mg/m^3)

Q = Compound source strength or emission rate from earth or water surface (mg/s)

H_b = Height of box at downwind edge (m) (depends on downwind distance x to receptor)

W_b = Crosswind width of box = crosswind dimension of land or water area (m) emitting volatile organic vapors

U_m = Average wind speed throughout box (m/s)

$= 0.22\ U_{10}\ \ln\ (2.5\ H_b)$

where

U_{10} = Wind speed at 10 m elevation (m/s)

In applying the above model, Q was calculated as the mass flux from volatilization from the river surface, as described previously.

Table F-2 summarizes the site-specific input parameter values assumed in applying this model.

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Table F-2

SUMMARY OF SITE-SPECIFIC INPUTS USED IN THE "BOX" MODEL FOR NEAR FIELD AIR DISPERSION

Symbol	Parameter	Units	Value	Source
A_c	Area of contamination	m^2	59,830	Area of section of Niagara River just upstream of Falls Street tunnel outfall, contributing to worker exposures: 1,400′ x 460′
H_b	Height of box	m	6.1	GRI (1988), Exhibit 1.2.2-2
x	Downwind distance to receptor from upwind edge of source	m	100	For nearby receptors (workers)
W_b	Crosswind width of box	m	140.2	One-half the width of the Niagara River near Prospect Poinnt (460 ft.)
U_{10}	Wind speed at 10m height	m/s	5.5	Annual average for Buffalo, N.Y.

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Source: Ecology and Environment, Inc., 1990.

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