HUDSON RIVER PCBs REASSESSMENT RI/FS
PHASE 3 REPORT: FEASIBILITY STUDY

DECEMBER 2000

For

U.S. Environmental Protection Agency
Region 2
and
U.S. Army Corps of Engineers
Kansas City District

Book 4 of 6
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TAMS Consultants, Inc.

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BACKGROUND MATERIAL

A.1 Supporting Plates
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APPENDIX A

BACKGROUND MATERIAL

A.1 Supporting Plates

NOTES FOR ALL PLATES

1) Data Set Environment

Arc View GIS

2) Grid Coordinate System

STATE PLANE New York, in Feet, East New York (NY E), FIPZONE 3101.

3) Horizontal Datum Name

The coordinate system is based upon a network of geodetic control points referred to as the North American Datum of 1927 (NAD27).

4) Scale

All plates and appendices (except for Plate 1) are presented at a 1:15000 scale. Therefore, on 11" x 17" size plot, one inch equals 1250 ft. Plate 1 is presented at a 1: 190,080 scale map for an effective scale of one inch to 3 miles.

5) Base Map Data Source

Database for the Hudson River PCBs Reassessment RI/FS, Release 5, October 2000, TAMS Consultants and Environmental Protection Agency.

6) Bathymetry Specifications

Above Lock 5, contour lines (in feet) were provided in elevation (New York State Barge Canal Datum). The elevation for the water surface was calculated for each pool based on a flow of 3,090 cfs. The water depth was obtained by subtracting the river bottom elevation from the water surface elevation, then rounded to the closest 0.5 foot. For this reason, the water depth is indicated as "Approximate Water Depth" on plates.

Below Lock 5, the bathymetry information was digitized from the NOAA Digital Nautical Charts (Charts: 14786-17, 14786-15, 14786-14, 14786-13, 14786-12, 14786-11, 14786-10, 14786-9, 14786-8). Only 6 foot and 12 foot contour lines were available with no elevation information.

7) River Shoreline

The river shoreline presented on plates is based on a flow of 8,471 cfs. (Source: Hudson River Database Release 5, based on Normandeau Associates, Inc. 1977.)

8) Sediment Texture Coverage

The Side-Scan Sonar coverage (Side Scan Sonar survey conducted in 1992) was used from Fort Edward Dam to Lock 5. LTI sediment texture coverage based on a pole survey directed by GE (Conducted in 1991), was used from Lock 5 to Federal Dam.

9) Incomplete Set of Sheets

A full set includes 7 sheets covering the Hudson River from the Former Fort Edward Dam to Federal Dam. However, some plates and appendices in the report are incomplete sets because there are no data to be presented for one or a number of sheets. Data for 1998 Composite Samples and 1984 Samples are available for Thompson Island Pool only (Section 1), therefore only one sheet is presented for both plates and appendices. Data for 1977 were presented for the river from Thompson Island Dam to Federal Dam only and, the set of plate or appendix for 1977 data only has 6 sheets, starting at River Section 2.

Similarly, all plates presenting the Full-Section Remediation Target Boundary include only the first two sheets, since the extent of remediation for this scenario includes only River Section 1 and Section 2.

10) Thiessen Polygons

Plates 4-a and 4-b, as well as Appendex A-3 are respectively presenting the Mass/Area (g/m^2) and the Length Weighted Average using 1984 Thiessen Polygons. These represent polygons of influence where each polygon contains all the area that is closer to a given sample point than to any other sample points. The method is called polygonal declustering and often successfully corrects for irregular sample coverage. The method used the samples location as well as the sediment texture information from the side scan sonar classification.

All samples were assigned a texture (cohesive, non-cohesive) according to their sediment content. Thiessen polygons are first formed around cohesive sample points only and then around non-cohesive sample points only. Polygons formed are respectively clip to cohesive and non-cohesive areas of the sediment texture coverage from the side scan sonar classification, to insure that cohesive samples are applied only to cohesive area of the river and non-cohesive sample to non-cohesive areas. Each polygon was then assigned the value (e.g., Length Weighted Average, Mass per Unit Area) of the sample point that formed it.

11) MPA

In all plates an appendices, MPA stands for PCB <u>M</u>ass <u>p</u>er Unit <u>A</u>rea in g/m^2.

12) Alternatives

The specific alternatives are not numbered in this FS. Rather, they are identified by shorthand nomenclature which identifies the components of each alternative. The alternative identification system is described below.

The first set of characters describes the alternative category, of which there are four.
- NA designates "No Action"
- MNA designates "Monitored Natural Attenuation"
- CAP designates containment by capping in conjunction with dredging
- REM designates Removal (without capping)

For alternatives which include capping or removal (*i.e.*, CAP or REM) as a component, the extent of remediation (*i.e.*, remediation target areas) is specified by river section, as described above and the extent of remediation within each river section, listed sequentially from River Section 1 to River Section 3. The remediation designations are:

0	Full-section remediation or target areas with PCB mass per unit area (MPA) of 0 g/m^2; in other words, the remediation of all contaminated sediments within the river section
3	Expanded Hot Spot remediation or target areas with PCB MPA of 3 g/m^2 or greater
10	Hot Spot remediation or target areas with PCB MPA of 10 g/m^2 or greater
MNA	No target areas; monitored natural attenuation only in this section.

HUDSON RIVER PCBS REASSESSMENT FS

APPENDIX A

BACKGROUND MATERIAL

A.2 Hudson River Upstream Baseline

APPENDIX A.2
Hudson River Upstream Baseline

The upstream baseline for the Reassessment RI/FS is defined as the PCB conditions observed above the GE plant site at Hudson Falls, or the area upstream of the GE outfall just above Bakers Falls Dam at River Mile (RM) 196.1. The baseline is defined relative to the area of interest for this study. It is not equivalent to an uncontaminated background condition, as a number of sources of PCB load are present upstream of Bakers Falls. Concentrations in the environment and biota are, however, present at levels much lower than those seen below Bakers Falls.

PCB sources above Bakers Falls include a number of potential sources located between RM 196.1 and RM 210, including the South Glens Falls Dragstrip, GE-Moreau Site, West Glens Falls Containment Site, Moreau Landfill, and Niagara Mohawk Queensbury Site (USEPA, 1997). Of these, the most important to the river is likely the Niagara Mohawk Queensbury Site, which is identified by USEPA as being "near RM 210" and by NYSDEC as being at RM 208.2, located just above the Sherman Island Dam. This property is known to have elevated PCB concentrations, thought to be attributable to disposal of dielectric fluid from capacitors or cooling oil from transformers. NYSDEC reported elevated concentrations of PCBs on the riverbank (37,737 ppm maximum recorded) and on the adjacent river bottom (86.5 ppm). However, due to the presence of the Sherman Island Dam, high levels of contamination do not extend very far from this site and its effect on biota appears to be localized. A Record of Decision for Operable Unit 1 of the Queensbury site was issued by NYSDEC in March 1995, addressing surface and subsurface soil and shoreline sediments. Soils and sediments in excess of 1 ppm were removed, with remediation completed in fall of 1996. Investigations of Operable Unit 2, consisting of contaminated sediments within the river proper, are ongoing.

A closer approximation to background conditions (in which PCBs would still be present, due to regional atmospheric deposition), is found at and above the upstream end of the Sherman Island Pool, although some less significant, unidentified sources may be found in this reach as well. Data from biota, water, and sediment all confirm that PCB contamination is present above Bakers Falls; however, the concentrations are generally much less than are seen below Bakers Falls.

A.2.1 PCB Concentrations in Biota

Because environmental concentrations of PCBs above Bakers Falls are low, and often non-detect on packed-column GC analyses, some of the best evidence for baseline conditions comes from biota, which bioaccumulate PCBs. The primary source of information is NYSDEC fish monitoring. Other data are available from EPA Phase 2 sampling and NYSDOH macroinvertebrate studies.

NYSDEC Fish Sampling

NYSDEC has pursued extensive fish monitoring above RM 196.1, although not as extensive as downstream. The most recent release of the NYSDEC database (4/8/2000) contains 1,410 samples for the Hudson River above Bakers Falls, ranging from 1975 to 1999. (Note: 63 samples had PCB congener data for this part of the river, but were not contained in NYSDEC's organochlorine "Hudorg" database).

The NYSDEC fish samples have been analyzed using a variety of protocols, and primarily against Aroclor standards. As discussed in the RBMR (USEPA, 2000), the differing analytical methods can result in systematic biases in reported total PCB concentrations. Therefore, it is important to convert the NYSDEC Aroclor results to a consistent basis for comparison. Accordingly, the methods presented in the RBMR (Book 3, Chapter 4) were used to convert reported Aroclor quantitations to an estimate of Tri+ PCBs, consistent with the modeling effort. For 36 samples, congener results are reported and Tri+ PCB was calculated directly. Translation keys have not, however, been established for all the historical laboratories and protocols. Because these results cannot reliably be interpreted to a consistent basis they were eliminated from this summary. This leaves a total of 1,293 records dating from 1979 to 1999 or approximately 93% of the original data set.

Samples have also been collected at a large number of locations, although samples near the Queensbury site (RM 208.1–208.2) are most numerous. To aid summarization, the sampling locations were assigned into three groups. These are:

Group 1	RM 196.2 (Fenimore Bridge above Bakers Falls) to RM 200 (below feeder dam at Glens Falls).
Group 2	RM 201.1 (above Feeder Dam) to RM 205 (below Sherman Island Dam).
Group Q	RM 207 to RM 208.3, representing the area directly affected by the Niagra-Mohawk Queensbury site.
Group 3	RM 209 (Sherman Island Pool at Boat Launch above Queensbury Site) and upstream.

NYSDEC sampling results (converted to a consistent Tri+ PCB basis) are summarized below in Table A.2-1. While there are many samples, only a few species have long time series at a given location, and no species is well represented across all locational groups and years. Thus the evidence on temporal and spatial trends is somewhat limited. In general, however, concentrations appear to be higher in Groups 1 and 2, below Queensbury, while lower concentrations are seen upstream in Group 3. Highest reported concentrations are in the reach (Group Q) directly affected by Queensbury. In addition, concentrations appear to have been somewhat higher in the period from about 1984 to 1992 than in later years, perhaps reflecting remedial action at Queensbury. While fish in Group Q had clearly elevated PCB concentrations relative to other reaches in 1993, little difference is evident between Group Q and Group 2 in later years.

Table A.2-1

NYSDEC Fish Sampling Results for Hudson River above Bakers Falls, Converted to Consistent Basis as Tri+ PCBs

			Wet-weight Concentration (µg/kg)				Lipid-based Concentration (µg/kg-lipid)				
Species	**Location**	**Year**	**Mean**	**95% CL Upper**	**95% CL Lower**	**Median**	**Mean**	**95% CL Upper**	**95% CL Lower**	**Median**	**Count**
Brown Bullhead	1	1979	0.14	0.28	-0.01	0	21.95	40.29	3.61	0	20
		1995	0.16	0.16	0.16	0.16	7.9	7.9	7.9	7.9	1
	2	1990	0.06	0.06	0.06	0.06	3.46	3.46	3.46	3.46	1
		1991	0.03	0.04	0.02	0.03	3.7	5.14	2.26	2.98	12
		1992	0.19	0.23	0.15	0.17	12.55	16.06	9.03	11.66	12
		1993	0.31	0.36	0.26	0.3	14.24	24.95	3.54	9.31	18
		1997	0.29	0.4	0.17	0.13	7.91	10.08	5.74	8	20
		1998	0.14	0.17	0.11	0.13	6.51	8.31	4.71	5.49	18
	3	1986	0.67	0.84	0.51	0.61	64.4	94.55	34.24	35.51	21
		1987	0.17	0.41	-0.08	0	23.89	69.38	-21.59	0	14
		1992	0.05	0.06	0.03	0.05	2.25	3.16	1.34	2.44	3
		1998	0	0	0	0	0	0	0	0	1
Black Crappie	2	1991	0.02	0.04	0	0.02	6.12	12.28	-0.04	7.22	3
		1992	0.27	0.34	0.2	0.29	14.26	17.49	11.03	14.37	11
Carp	2	1992	2.58	6.98	-1.82	2.65	22.74	64.71	-19.24	17.49	4
		1993	3.36	25.21	-18.5	3.36	36.4	77.88	-5.08	36.4	2
		1998	1.33	1.71	0.95	1.41	17.5	25.51	9.48	15.34	16
	3	1995	0.42	1.03	-0.2	0.21	3.19	6.27	0.12	2.86	6
		1998	0.19	0.29	0.09	0.15	3.57	5.48	1.65	2.25	15
Creekchub	1	1997	1.51	1.51	1.51	1.51	42.39	42.39	42.39	42.39	1
Chain Pickerel	1	1995	0	0	0	0	0	0	0	0	1
	2	1991	0.01	0.02	0	0.01	3.75	3.75	3.75	3.75	2
		1992	0.03	0.08	-0.03	0	16.39	52.93	-20.14	0	6
		1993	0.12	0.12	0.12	0.12	18.85	18.85	18.85	18.85	1
Cyprinid	2	1993	0.13	0.25	0.02	0.11	10.40	17.07	3.74	10.41	3
	Q	1993	3.03	6.59	-0.54	2.09	180.71	414.46	-53.03	86.19	6
	3	1993	0.16	0.26	0.07	0.12	9.44	14.20	4.67	7.87	9
Fallfish	3	1992	0	0	0	0	0	0	0	0	4
Largemouth Bass	2	1991	0.02	0.13	-0.09	0.02	11.56	94.95	-71.82	11.56	2

			Wet-weight Concentration (µg/kg)				Lipid-based Concentration (µg/kg-lipid)				
Species	Location	Year	Mean	95% CL Upper	95% CL Lower	Median	Mean	95% CL Upper	95% CL Lower	Median	Count
		1992	0.19	0.27	0.12	0.15	40.67	54.66	26.68	31.91	12
		1993	0.30	1.05	-0.45	0.15	37.86	93.82	-18.09	28.18	3
		1997	0.14	0.23	0.06	0.16	16.31	20.26	12.37	15.84	3
		1998	0.06	0.1	0.02	0.07	4.66	7.85	1.46	4.38	9
	3	1998	0	0	0	0	0	0	0	0	2
Mirror Carp	3	1998	0.32	1.27	-0.63	0.13	13.55	58.37	-31.27	4.71	3
Northern Pike	2	1996	0	0	0	0	0	0	0	0	1
	Q	1997	0.14	0.44	-0.17	0.08	44.01	177.86	-89.84	15.17	3
		1998	0.05	0.17	-0.06	0.03	9.26	37.36	-18.84	0.65	4
	3	1996	0	0	0	0	0	0	0	0	3
		1997	0	0	0	0	0	0	0	0	1
Pumpkinseed	1	1995	0.11	0.21	0	0.09	10.44	19.18	1.7	12.79	5
	2	1979	0.32	0.39	0.25	0.28	10.17	12.67	7.67	8.96	17
		1980	0.59	0.65	0.53	0.58	15.16	16.74	13.57	14.33	24
		1981	0.35	0.39	0.32	0.33	9.97	11.36	8.58	8.66	26
		1982	0.16	0.24	0.08	0.13	5.23	7.56	2.91	4.69	34
		1983	0.36	0.39	0.32	0.32	11.25	12.41	10.08	9.83	50
		1984	0.59	0.79	0.38	0.39	15.56	21.07	10.04	9.44	25
		1985	0.22	0.29	0.16	0.16	6.4	8.25	4.55	4.9	21
		1986	0.31	0.42	0.19	0.51	13.17	18.25	8.1	19.74	24
		1987	0.14	0.16	0.13	0.14	3.85	4.23	3.47	3.79	13
		1988	0.27	0.54	0	0.14	6.67	11.4	1.95	4.39	23
		1989	0	0	0	0	0	0	0	0	15
		1990	0.23	1.19	-0.74	0.23	10.46	54.93	-34.02	10.46	2
		1991	0.02	0.02	0.01	0.02	4.34	5.4	3.28	4.27	12
		1992	0.13	0.21	0.06	0.1	12.73	19.2	6.25	14.16	11
		1993	0.17	0.23	0.11	0.14	4.66	13.43	1.82	4.66	25
		1994	0.06	0.09	0.02	0	1.53	2.45	0.6	0	29
		1995	0.08	0.14	0.02	0	2.4	4.1	0.7	0	29
		1996	0.04	0.06	0.02	0.07	1.38	2.04	0.71	1.92	18
		1997	0.2	0.31	0.1	0.23	6.47	9.95	3	6.86	18
		1998	0	0	0	0	0	0	0	0	11
	Q	1993	23.42	23.42	23.42	23.42	755.36	755.36	755.36	755.36	1
	3	1993	0.32	0.32	0.32	0.32	17.92	17.92	17.92	17.92	1
		1994	0	0	0	0	0	0	0	0	16

			Wet-weight Concentration (µg/kg)				Lipid-based Concentration (µg/kg-lipid)				
Species	**Location**	**Year**	**Mean**	**95% CL Upper**	**95% CL Lower**	**Median**	**Mean**	**95% CL Upper**	**95% CL Lower**	**Median**	**Count**
Rock Bass	1	1995	0.08	0.2	-0.04	0.05	23.96	73.45	-25.52	7.29	5
	2	1991	0.01	0.01	0	0.01	5.01	9.73	0.3	5.01	2
		1992	0.01	0.05	-0.03	0	2.01	10.65	-6.63	0	3
		1998	0	0	0	0	0	0	0	0	5
		1999	0.1	0.19	0	0	15.68	31.33	0.04	0	10
	Q	1995	0.49	1.02	-0.04	0	53.87	110.16	-2.42	0	21
		1996	0.08	0.26	-0.09	0	7.92	22.93	-7.1	0	5
		1997	0.02	0.06	-0.01	0	2.9	7.42	-1.62	0	10
		1998	0.09	0.19	-0.02	0	8.68	19.55	-2.19	0	10
		1999	0.10	0.19	0	0	15.68	31.33	0.04	0	10
	3	1996	0.03	0.06	-0.01	0	3.06	6.6	-0.49	0	14
		1997	0	0	0	0	0	0	0	0	12
		1998	0	0	0	0	0	0	0	0	8
		1999	0	0	0	0	0	0	0	0	10
Redbreast Sunfish	2	1993	0.26	0.48	0.04	0.25	14.50	43.70	-14.70	9.32	3
	3	1995	0.01	0.02	0	0	0.15	0.36	-0.07	0	20
		1996	0	0	0	0	0	0	0	0	2
Smallmouth Bass	1	1986	0.39	0.63	0.16	0.39	130.18	234.36	26	151.61	5
		1995	0.14	0.2	0.08	0.16	13.63	21.79	5.47	11.85	5
	2	1990	0.29	0.49	0.09	0.32	11.29	19.00	3.58	11.31	3
		1991	0.01	0.01	0.01	0.01	3.89	3.89	3.89	3.89	1
		1992	0.14	1.95	-1.67	0.14	28.46	390.02	-333.11	28.46	2
		1993	0.16	0.34	-0.02	0.17	105.01	355.22	-145.19	103.63	3
		1997	0.26	0.26	0.26	0.26	17.99	17.99	17.99	17.99	1
		1998	0.18	0.26	0.01	0.16	15.01	22.15	7.87	11.88	14
	Q	1993	3.47	7.15	-0.20	1.09	237.90	516.23	-40.42	55.48	8
		1995	0.17	0.27	0.07	0.14	11.45	18.23	4.67	8.62	15
		1996	0.18	0.47	-0.12	0.09	26.02	75.95	-23.92	11.03	4
		1997	0.11	0.30	0.00	0.17	32.85	58.70	7.00	22.78	14
		1998	0.11	0.22	0.00	0.05	10.54	20.78	0.30	3.08	9
		1999	0.24	0.46	0.03	0.12	15.54	32.26	-1.18	6.90	11
	3	1992	0.11	0.24	-0.03	0.02	21.91	40.73	3.10	2.85	14
		1993	0.10	0.11	0.09	0.10	8.97	23.01	-5.07	8.97	2
		1995	0.09	0.13	0.05	0.07	7.61	10.5	4.72	6.61	20
		1996	0	0	0	0	0	0	0	0	6

			Wet-weight Concentration (µg/kg)				Lipid-based Concentration (µg/kg-lipid)				
Species	**Location**	**Year**	**Mean**	**95% CL Upper**	**95% CL Lower**	**Median**	**Mean**	**95% CL Upper**	**95% CL Lower**	**Median**	**Count**
		1997	0.01	0.04	-0.01	0	2.10	6.94	-2.74	0	9
		1998	0.03	0.04	0.01	0	1.99	4.28	-0.31	0	26
		1999	0.02	0.06	-0.03	0	1.25	4.72	-2.22	0	5
Tessellated Darter	2	1993	0.18	0.38	-0.03	0.19	28.24	122.17	-65.70	6.60	3
Walleye	2	1991	0.03	0.08	-0.02	0.03	4.56	6.57	2.56	4.56	2
	Q	1996	0.12	0.12	0.12	0.12	13.53	13.53	13.53	13.53	1
		1997	0.03	0.03	0.03	0.03	12.98	12.98	12.98	12.98	1
		1998	0.18	0.30	0.05	0.12	18.79	26.81	10.78	18.88	11
	3	1996	0	0	0	0	0	0	0	0	3
		1997	0.04	0.05	0.03	0.04	10.63	21.95	-0.70	8.64	4
		1998	0.04	0.04	0.04	0.04	9.33	9.33	9.33	9.33	1
White Perch	Q	1995	0	0	0	0	0	0	0	0	1
White Sucker	1	1997	0.43	0.43	0.43	0.43	34.71	34.71	34.71	34.71	1
	3	1992	0	0	0	0	0	0	0	0	9
Yellow Bullhead	2	1998	0.12	0.56	-0.32	0.12	4.01	5.93	2.09	4.01	2
Yellow Perch	1	1995	0.05	0.14	-0.04	0	2.67	7.32	-1.97	0	5
	2	1991	0.04	0.04	0.03	0.03	6.19	7.36	5.03	5.81	12
		1992	0.26	0.43	0.08	0.16	23.54	35.51	11.56	15.36	11
		1993	0.23	0.29	0.16	0.22	15.38	18.90	11.67	14.17	19
		1997	0.12	0.18	0.07	0.08	7.49	11.91	3.06	4.52	20
		1998	0.04	0.07	0.01	0	2.16	3.56	0.75	0	25
	Q	1993	5.30	11.98	-1.37	1.27	127.51	282.26	-27.24	40.86	8
		1995	0.08	0.12	0.04	0.07	4.75	6.93	2.57	4.38	15
		1996	0.03	0.06	0	0	3.76	7.08	0.44	0	24
		1997	0.07	0.16	-0.03	0	9.52	24.40	-5.36	0	19
		1998	0.07	0.14	0	0	6.31	11.86	0.77	0	27
		1999	0.01	0.04	-0.01	0	1.61	5.07	-1.86	0	14
	3	1992	0.1	0.15	0.06	0.1	6.52	9.26	3.78	5.45	7
		1996	0	0	0	0	0	0	0	0	5
		1997	0	0	0	0	0	0	0	0	3
		1998	0.01	0.03	-0.01	0	1.56	5.57	-2.45	0	6
		1999	0	0	0	0	0	0	0	0	5

Notes: "95% CL" is the 95th percentile confidence limit on the mean value.

All results converted from NYSDEC reported amounts to estimate of Tri+ PCBs. Tri+ estimated as zero when all Aroclor quantitations are non-detect.

One of the best time series records for fish concentrations in the NYSDEC data is for pumpkinseed, which has been regularly sampled at RM 201.1 (above the Glens Falls feeder dam; in Group 2). Mean lipid-based concentrations by year are shown in FigureA.2-1. In all years, the mean concentrations at Glens Falls have been less than 20 mg/kg-lipid, which is an order of magnitude less than mean Tri+ concentrations observed in pumpkinseed in Thompson Island Pool, which ranged from 123 to 647 mg/kg-lipid between 1990 and 1997 (USEPA, 2000).

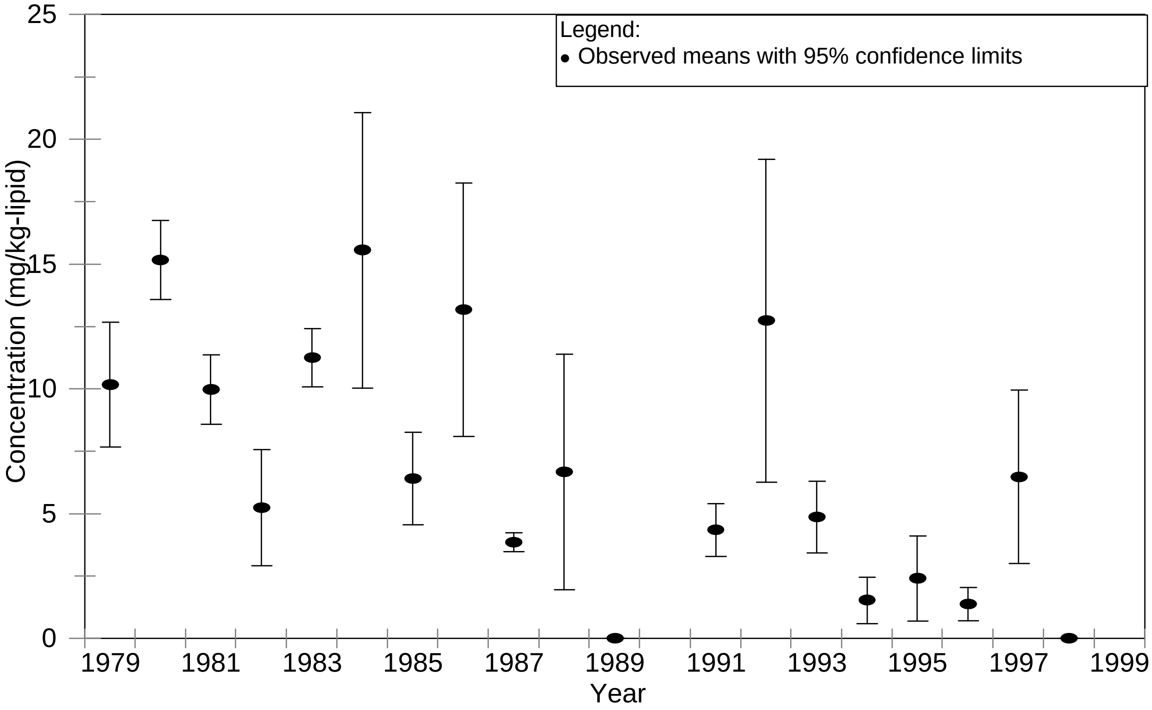

Figure A.2-1. Mean Lipid-Based Concentrations of Tri+ PCB in Pumpkinseed at RM 201.1

Some idea of the joint spatial and temporal trends in fish concentration may be gained by examining the results for rock bass and smallmouth bass in Groups 2 and 3. This is shown in Figure A.2-2 (Results from Group Q, adjacent to Queensbury, are much higher than either Group 2 or Group 3 in 1993. Note that the concentrations in Group 2, downstream of the Queensbury Site (closed symbols) are consistently higher than those in Group 3 (above Queensbury). For these species, there is no clear trend with time at either location. This indicates that the Queensbury Site has likely exerted some measurable effect downstream of the Sherman Island Dam.

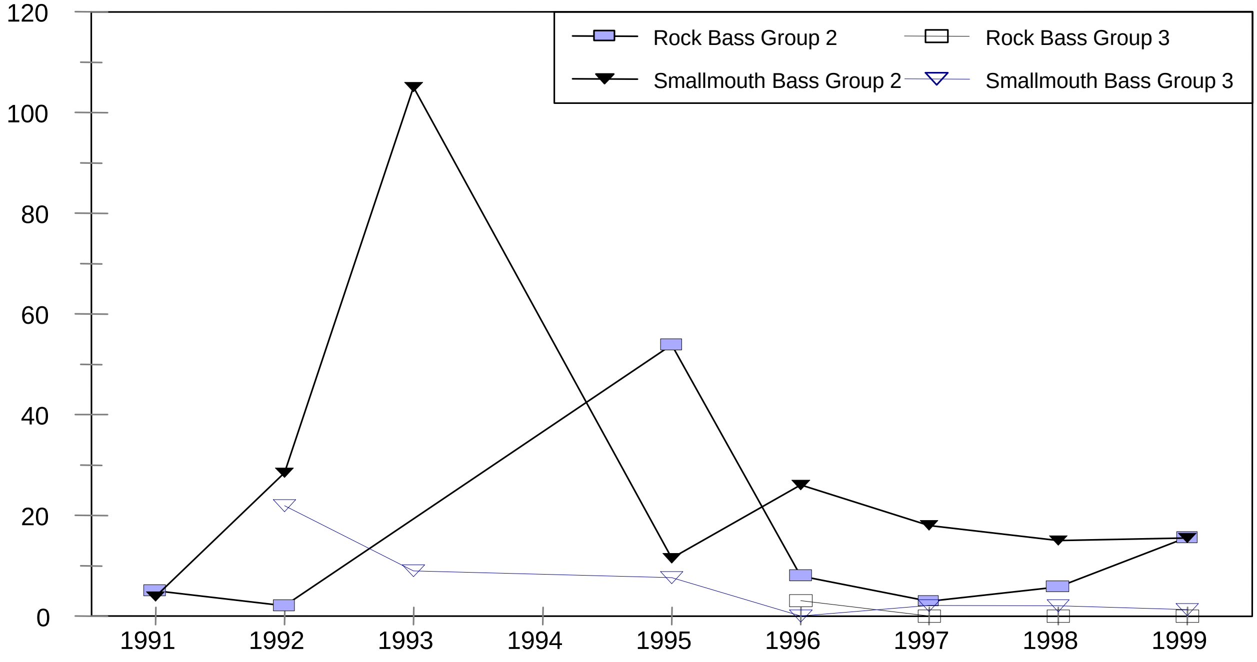

Figure A.2-2. Mean Lipid-Based Concentrations of Tri+ PCB in Rock Bass and Smallmouth Bass in Group 2 (RM 201-207) and Group 3 (RM 209+)

To provide a summary estimate of recent baseline conditions, averages for the 1991–1999 period are summarized in Table A.2-2, omitting samples immediately adjacent to Queensbury. In this table, Groups 1 and 2 are combined, representing all samples between Bakers Falls and Sherman Island Dam, below the Queensbury Site. Results for Group 3, above the Queensbury Site, are also presented. The summary clearly shows the impact of the sources at and downstream of Queensbury on concentrations in biota.

Table A.2-2. Summary of 1991–1999 NYSDEC Fish Results as Tri+ PCBs

	Groups 1 and 2 (RM 196.2–207)			Group 3 (RM 209 +)		
Species	**Mean (μg/kg)**	**Mean (μg/kg-lipid)**	**Count**	**Mean (μg/kg)**	**Mean (μg/kg-lipid)**	**Count**
Brown Bullhead	0.21	9.07	81	0.03	1.69	4
Black Crappie	0.21	12.51	14			0
Carp	1.74	20.17	22	0.26	3.46	21
Creekchub	1.51	42.39	1			0
Chain Pickerel	0.03	13.44	10			0
Cyprinid	0.13	10.40	3	0.16	9.44	9
Fallfish			0	0.0	0.0	4
Largemouth Bass	0.15	24.67	29	0.0	0.0	2
Mirror Carp			0	0.32	13.55	3
Northern Pike			0	0.0	0.0	4
Pumpkin-seed	0.09	5.59	158	0.02	1.05	17
Rock Bass	0.03	22.36	15	0.01	1.19	36
Redbreast Sunfish	0.26	14.50	3	0.01	0.14	22
Smallmouth Bass	0.16	25.85	26	0.05	6.75	82
Tessellated Darter	0.18	28.24	3			0
Walleye	0.03	4.56	2	0.03	6.48	8
White Sucker	0.43	34.71	1	0.0	0.0	9
Yellow Bass	0.12	4.01	2			0

	Groups 1 and 2 (RM 196.2–207)			Group 3 (RM 209 +)		
Species	**Mean (µg/kg)**	**Mean (µg/kg-lipid)**	**Count**	**Mean (µg/kg)**	**Mean (µg/kg-lipid)**	**Count**
Yellow Perch	0.12	9.14	92	0.03	2.11	26

Note: NYSDEC results converted to consistent basis as Tri+ PCBs. Tri+ estimated as zero when all individual Aroclor quantitations are reported as non-detect.

NYSDOH Macroinvertebrate Sampling

NYSDOH maintained an upstream macroinvertebrate sampling station at RM 197.6 (above Hudson Falls at Chase Bag Co.) from 1977 to 1985. Data include both multiplate and caddisfly larvae analyses, quantitated as Aroclor 1016 and 1254. Approximately 50 percent of the measurements were reported as non-detects, at a variety of detection limits ranging from 0.1 to 6.1 ppm depending on sample size. The average of detected values is 1.44 ppm for Aroclor 1016 and 2.4 ppm for Aroclor 1254.

EPA and NOAA Fish Samples

During August and September 1993, both EPA and NOAA collected fish samples at RM 203.3. The data were composites of multiple individuals of a given species. NOAA collected 17 composites, and EPA 11. Results are summarized in Table A.2-3, and show total PCB levels ranging from 0.019 to 0.73 mg/kg wet weight, essentially all of which is present as Tri+ PCB. Lipid-based concentrations range from 0.76 to 182 mg/kg, and generally appear to be consistent with NYSDEC monitoring in Group 2.

The homologue distribution of the USEPA and NOAA samples is generally consistent. Specifically, the pentachloro homologue fraction is usually the major fraction followed in decreasing order of importance hexachloro, tetrachloro and heptachloro, suggesting a single source. In a limited number of samples (6 of 28), the tetrachloro fraction is the largest. These homologue distributions are significantly higher in the more-chlorinated homologues as compared to locations downstream of GE. However, absolute concentrations are one-to-two orders-of-magnitude lower in the region above Bakers Falls.

The general consistency of the homologue patterns and the low values suggests a limited number of small sources, perhaps including atmospheric transport, as the origin of PCB contamination in this region. This will be contrasted with the water column results later in this subsection. Finally, as noted in Appendix K of the BERA (USEPA, 1999), the homologue patterns in fish are related to, but do not directly reflect the patterns at the point of exposure. Rather, the fish tend to preferentially retain the heavier homologues, suggesting that the PCB source(s) in the region represent homologue mixtures with less chlorinated congeners relative to the fish.

Table A.2-3. EPA and NOAA Fish Sampling Results at RM 203.3, August–September, 1993

EPA Samples																			
	Count	Mean	Mean	Pct	Total PCBs		Tri+		Mono	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca
Species		Len (mm)	Wgt (g)	Lipid	µg/kg	µg/kg-lipid	µg/kg	µg/kg/lip	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct	Pct
CYPD	10	50.0	1.1	1.8	152.0	8442.2	152.0	8442.2	0.00%	0.00%	9.85%	28.42%	31.23%	19.83%	9.20%	1.46%	0.00%	0.00%
YP	7	262.6	230.6	4.1	345.1	8416.1	345.1	8416.1	0.00%	0.00%	3.23%	17.81%	32.55%	29.54%	14.37%	2.27%	0.24%	0.00%
CYPD	10	43.3	0.8	0.8	60.0	7501.7	60.0	7501.7	0.00%	0.00%	0.81%	7.69%	34.64%	35.88%	18.35%	2.35%	0.28%	0.00%
YP	6	230.5	156.0	5.4	545.1	10094.3	545.1	10094.3	0.00%	0.00%	3.24%	15.34%	37.65%	28.04%	13.26%	2.48%	0.00%	0.00%
CYPD	10	45.3	0.7	1.4	65.7	4692.3	65.7	4692.3	0.00%	0.00%	2.01%	13.05%	32.46%	33.69%	16.63%	1.94%	0.23%	0.00%
YP	10	180.4	73.0	4.1	220.2	5370.7	220.2	5370.7	0.00%	0.00%	3.19%	15.91%	39.55%	27.78%	12.03%	1.47%	0.08%	0.00%
YP	11	155.6	45.1	2.7	156.2	5784.6	156.2	5784.6	0.00%	0.00%	3.13%	15.60%	36.74%	31.61%	11.36%	1.47%	0.09%	0.00%
YP	10	122.6	19.8	2.6	187.6	7215.7	185.2	7122.6	0.00%	1.29%	5.63%	22.27%	37.32%	23.94%	8.83%	0.73%	0.00%	0.00%
CYPD	10	62.0	1.9	2.4	18.2	756.7	18.2	756.7	0.00%	0.00%	1.53%	2.87%	29.07%	46.69%	17.21%	2.64%	0.00%	0.00%
CYPD	10	63.3	1.7	1.9	19.0	1000.1	19.0	1000.1	0.00%	0.00%	0.89%	2.01%	28.79%	48.84%	14.78%	4.68%	0.00%	0.00%
CYPD	10	66.0	1.9	2.2	117.1	5323.8	117.1	5323.8	0.00%	0.00%	11.55%	38.57%	28.84%	15.12%	4.85%	1.07%	0.00%	0.00%
NOAA Samples																		
LMB	15	61.0	43.0	0.4	84.2	22751.2	75.4	20389.5	9.21%	0.18%	8.74%	22.44%	22.76%	18.16%	11.21%	6.16%	0.16%	0.99%
PKSD	5	204.8	1636.0	1.0	731.6	71721.3	719.7	70558.5	0.00%	1.62%	4.06%	22.29%	60.52%	7.92%	2.77%	0.79%	0.03%	0.00%
RBRS	10	174.4	1020.0	0.6	161.7	26083.6	148.8	23997.5	7.92%	0.08%	5.20%	17.48%	23.81%	24.37%	15.64%	5.12%	0.38%	0.00%
SMB	4	46.0	5.0	1.6	48.7	2988.9	47.8	2933.7	0.00%	1.85%	15.28%	17.43%	21.46%	20.58%	16.70%	4.08%	2.63%	0.00%
TESS	3	52.0	4.0	3.1	158.5	5178.6	158.5	5178.6	0.00%	0.00%	4.67%	16.07%	25.47%	38.60%	11.38%	2.26%	1.56%	0.00%
LMB	11	79.8	70.0	0.7	134.4	19475.6	126.8	18370.1	5.36%	0.32%	13.58%	28.50%	22.42%	16.37%	9.38%	3.96%	0.10%	0.00%
PKSD	5	178.0	0.0	4.9	238.1	4820.8	238.0	4818.0	0.00%	0.06%	5.65%	18.05%	34.86%	28.25%	10.52%	2.51%	0.09%	0.00%
RBRS	7	122.3	242.0	4.0	232.6	5844.4	225.4	5663.6	2.93%	0.16%	10.58%	30.81%	25.60%	17.17%	8.93%	3.62%	0.21%	0.00%
SMB	6	55.8	13.0	0.2	140.7	87958.5	133.1	83177.3	0.58%	4.22%	16.20%	37.39%	21.99%	11.22%	5.79%	1.97%	0.00%	0.64%
TESS	20	29.4	4.0	1.4	58.6	4309.2	54.9	4037.8	3.67%	2.63%	12.48%	16.01%	19.53%	20.36%	19.05%	3.44%	2.83%	0.00%
LMB	8	91.4	82.0	1.0	610.1	59811.9	608.5	59658.9	0.12%	0.13%	1.64%	13.32%	54.63%	25.66%	3.58%	0.76%	0.15%	0.00%
PKSD	5	157.0	778.0	2.0	176.5	8781.9	175.6	8736.9	0.00%	0.51%	5.73%	16.95%	36.48%	28.46%	8.68%	3.08%	0.10%	0.00%
RBRS	10	96.6	160.0	3.8	334.7	8926.6	322.6	8602.7	3.53%	0.10%	4.96%	17.68%	36.64%	25.33%	8.89%	2.76%	0.11%	0.00%
SMB	5	83.0	33.0	0.1	200.4	182179.5	190.8	173445	0.36%	4.20%	22.48%	41.31%	18.05%	7.96%	3.98%	1.43%	0.00%	0.23%
TESS	1	55.0	2.0	0.4	142.7	40784.7	136.1	38893.3	0.00%	1.71%	16.75%	19.52%	17.50%	15.54%	10.19%	6.68%	9.18%	2.93%
PKSD	6	139.0	0.0	4.0	162.1	4011.9	161.9	4006.6	0.00%	0.13%	6.80%	19.45%	32.73%	25.81%	11.81%	3.16%	0.11%	0.00%
PKSD	16	126.2	648.0	3.3	140.5	4245.0	139.7	4219.7	0.00%	0.60%	8.97%	21.33%	28.71%	24.82%	12.20%	3.25%	0.12%	0.00%

A.2.2 PCB Concentrations in Water

Information on PCB concentrations in water upstream of Bakers Falls is available from three sources: USGS monitoring, EPA Phase 2 monitoring, and GE monitoring.

USGS Monitoring

USGS collected PCB samples at the Glens Falls station from 1977 to 1983, analyzing the results by packed column GC. A total of 45 samples are reported. Of these, all but two are reported as either 0 or non-detect at the 0.1 µg/L level. Samples collected on December 5, 1978 and September 28, 1980 report detectable PCBs at the detection limit of 0.1 µg/L.

EPA Phase 2 Monitoring

During the Phase 2 monitoring effort, EPA established two water column monitoring stations above Bakers Falls: Station 0001 at Glens Falls (RM 200.5) and Station 0002, at Fenimore Bridge (RM 197.2). Six transect samples were collected at each station, and five two-week flow-averaged samples were also collected at Station 0002. Total PCB concentrations observed were quite low, less than 4 ng/L in all samples, as shown in Figure A.2-3. Little difference is apparent between the two stations in the transect samples which included both locations, suggesting no significant gains in PCB load south of Glens Falls.

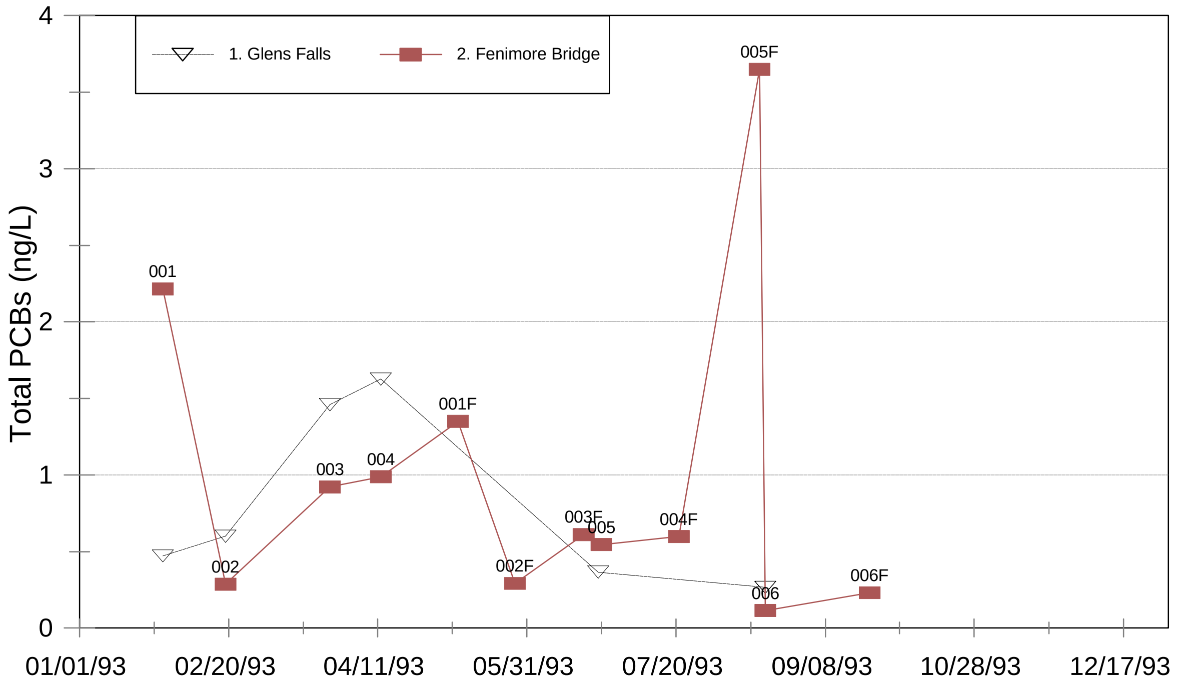

Figure A.2-3. U.S. EPA Phase 2 Water Column PCB Sampling Upstream of Bakers Falls

The dissolved fraction of PCBs in these samples ranged from 11 percent (Transect 1, Station 2) to 100 percent (Transect 6, Station 2). The homologue composition of the samples was also quite variable, as shown in Figures A.2-4 (Station 1) and A.2-5 (Station 2). For all samples except for Flow Averaged Event 5 at Station 2, Tri+ accounted for 94 percent or greater of the total PCBs. This is in marked contrast to conditions downstream, as Tri+ is only about 70 percent of the total PCB load at Thompson Island Dam. A number of the samples have large fractions of total PCBs in the penta- through heptachlorobiphenyl range, suggesting contamination by a highly-chlorinated mixture such as Aroclor 1260. The appearance of mono- and dichlorobiphenyls is sporadic, but appears to be most significant in the spring higher flow sampling events (003, 004, and 001F). Little mono- or dichlorobiphenyl is present in the summer transect samples (005 and 006), although flow-averaged sample 005F at Station 2 does have a large dichlorobiphenyl fraction. If it is assumed that the mono- and dichlorobiphenyls largely represent dechlorination by-products, this suggests that dechlorination within river sediments is not a significant load source above Bakers Falls, unlike the Thompson Island Pool, but that spring runoff may carry dechlorination products into the river from land-based sources.

Further exploration of the variation in homologue distribution reveals that much of the variation may be problematic. Specifically, individual homologue groups frequently consists of a single congener and not an Aroclor-like distribution as might be expected. This suggests that the variability may be due to trace contaminants other than PCBs which are misidentified analytically. By comparison, the fish results from the region yield a consistent pattern.

These results suggest that PCB water column concentrations above Bakers Falls are even lower than those measured by the USEPA in 1993. Concentrations in the water column are probably less than 1 ng/L in this region. As a result, direct measurement of concentration is a poor way to estimate PCB contributions. As documented by the fish results, it is likely that water column concentrations in the RM 197 to 209 region are one-to-two orders-of-magnitude lower than those found downstream in Remnant Deposits area and TI Pool.

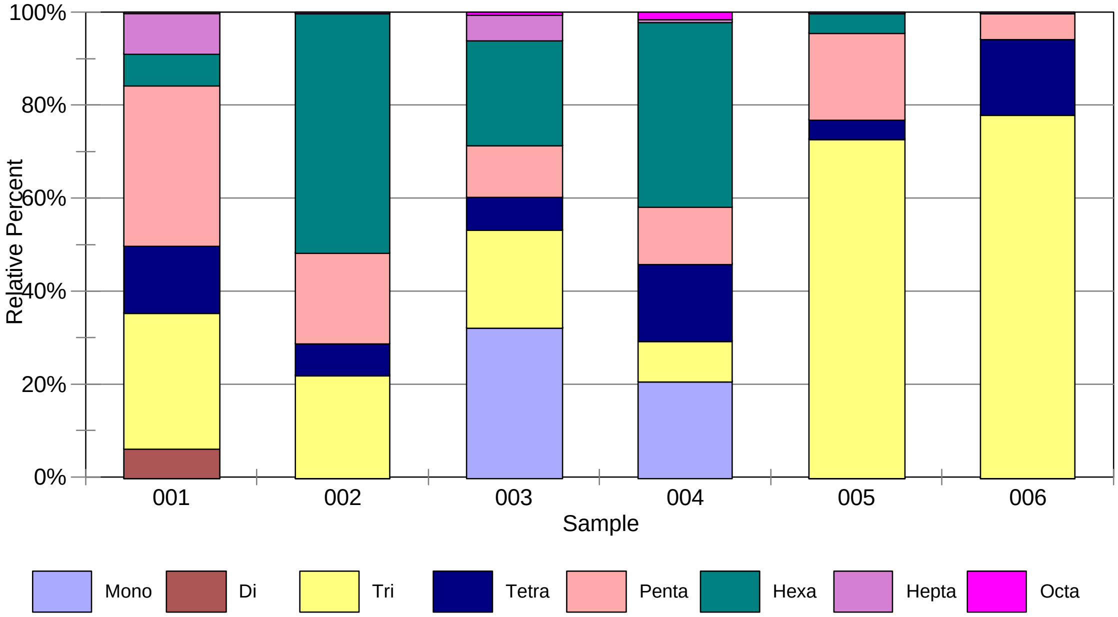

Figure A.2-4. Homologue Composition of Phase 2 Water Column Sampling at Glens Falls

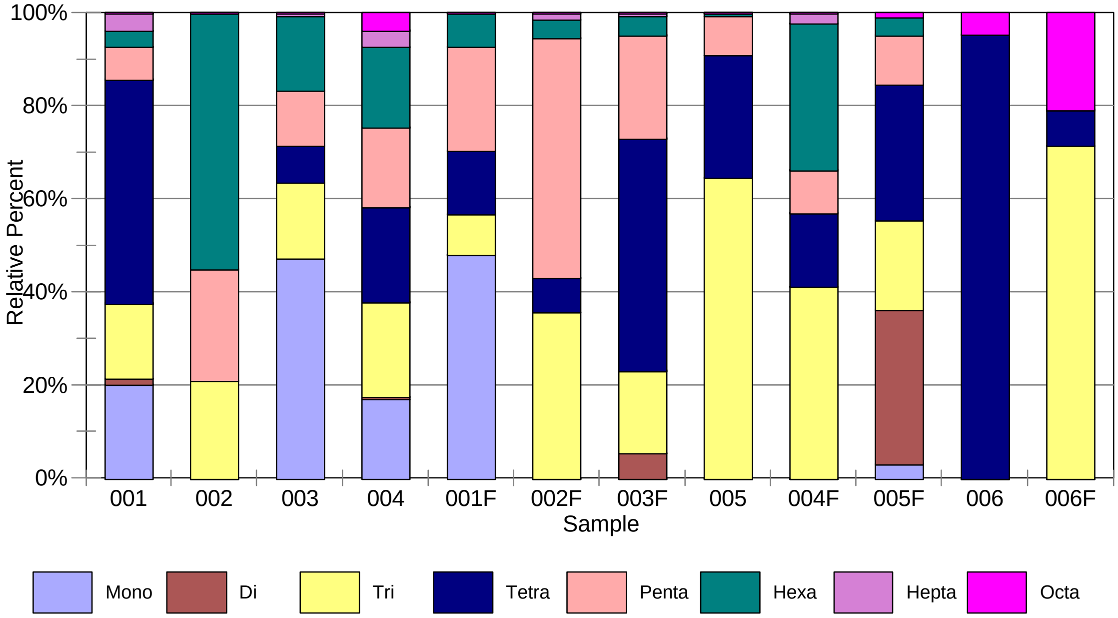

Figure A.2-5. Homologue Composition of Phase 2 Water Column Sampling at Fenimore Bridge

GE Monitoring

GE has pursued regular monitoring at Fenimore Bridge on an approximately two-week basis since 1991. These samples were analyzed by capillary column without filtration, and have a higher detection limit (11 ng/L) than the EPA samples. The April 3, 2000 release of the GE database contains 484 records at this station ("B.F. Br") from April 1, 1991 to March 8, 2000, as well as a number of miscellaneous samples from other nearby locations. Of the 484 observations, only 98 (20 percent) yielded detectable PCB concentrations at the 11 ng/L detection limit, consistent with the EPA Phase 2 results. The time series of GE observations (with non-detects at one-half of the detection limit) is shown in Figure A.6-6.

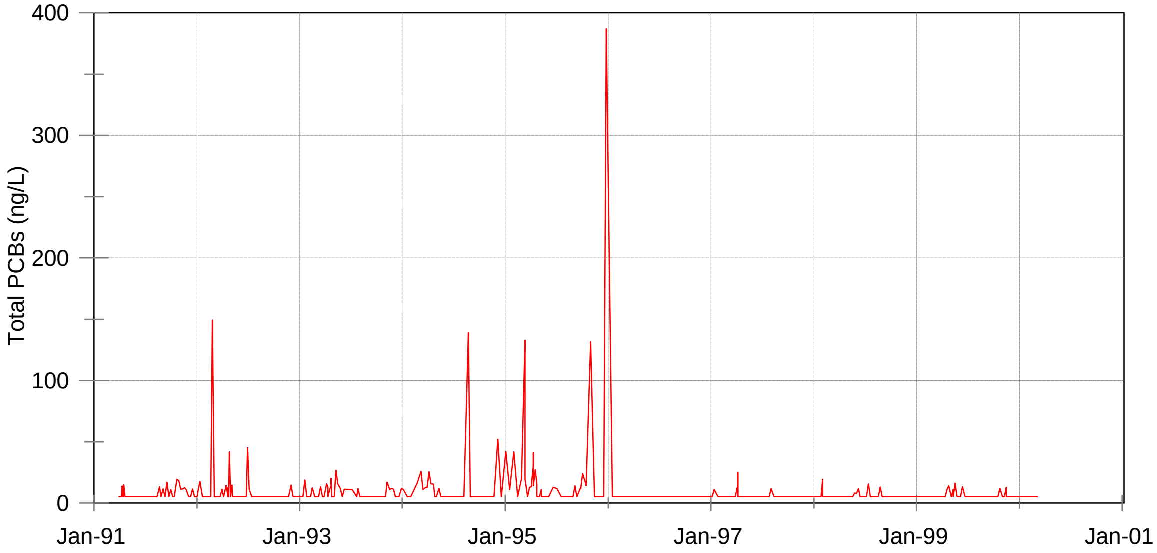

Figure A.2-6. GE Observations of Total PCBs at Fenimore Bridge

The majority of the GE observations are less than 20 ng/L; however, there are five individual observations greater than 100 ng/L, with a maximum recorded value of 387 ng/L on December 27, 1995. Because of the proximity of Fenimore Bridge to the GE Hudson Falls Plant, it is difficult to tell if these occasional spikes represent true upstream loads or localized input from the Hudson Falls area. None of these spikes have been observed since December of 1995; during the period from January 1996 through April 2000 the highest observed concentration is 25 ng/L. For this period, the average concentration (with non-detects set to one-half the detection limit) is 6.1 ng/L, while the average with non-detects set to zero is 0.98 ng/L.

Overall the GE samples with detectable concentrations, the homologue composition contains about equal proportions of tri-, tetra-, and pentachlorobiphenyls, with a significant proportion of hexachlorobiphenyls (Figure A.2-7). This homologue composition is shifted toward more chlorinated homologues compared to the PCBs observed at Rogers Island (see Figure 3-94 in the DEIR; USEPA, 1997), again suggesting the presence of contamination by Aroclor 1260 or 1254 upstream of Bakers Falls. The high concentration spikes observed at Fenimore Bridge tend to have 70 percent or more of their weight distributed in the tri- and tetrachlorobiphenyl range, which is more suggestive of Aroclor 1242 associated with the GE Hudson Falls facility.

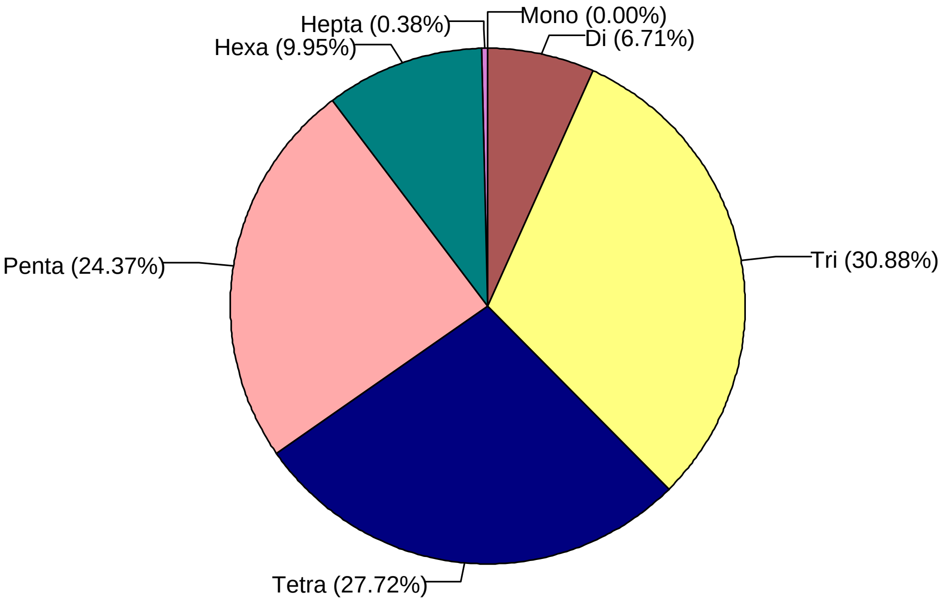

Figure A.2-7. Average PCB Homologue Composition by Weight Percent for GE Observations at Fenimore Bridge

Estimation of PCB load at Fenimore Bridge is difficult due to the large number of non-detects. Calculations made using flows at Fort Edward and estimating the concentration of non-detects at one-half of the detection limit (*e.g.*, 5.5 ng/L) yield an average load of total PCBs at Fenimore Bridge of about 0.16 kg/dy, or about 1/5 of the load seen at Rogers Island. The estimate was made using the same procedures as described in Section 3.3.4 of the DEIR (USEPA, 1997), but extended through September 1998. Much of this load, however, is estimated to be due to a few high-concentration spikes. The load at Fenimore Bridge based on the median of monthly load estimates is only 0.08 kg/dy.

A.2.3 PCB Concentrations in Sediment

Only limited sampling of sediment has taken place upstream of Bakers Falls. GE does not report sediment data from this reach. A few grab samples were collected by NYSDEC in 1976–78, and EPA obtained two cores in 1993 as part of the Phase 2 sampling, as well as five co-located surface sediment samples at one station during the ecological program.

1976–78 NYSDEC Sampling

As part of the 1976–78 NYSDEC sampling program, O'Brien & Gere collected four grab samples upstream of Bakers Falls, located at RM 199.4, 201.0, and two at 204.8. The latter three samples all show values of 1 ppm for Aroclors 1016, 1221, and 1254, but these are potentially intended to represent non-detects at this level (non-detect flags are not provided in the 1976–78 sediment data set). The sample at RM 199.4, collected on October 15, 1976, shows 0.02 ppm for Aroclors 1016 and 1221 and 0.05 ppm for Aroclor 1254.

EPA High Resolution Cores

EPA collected two high resolution cores upstream of Bakers Falls in late 1992: Core 27, located at RM 202.9 above the Feeder Canal in Glens Falls, and Core 28, located near Bakers Falls at RM 197.1. Core 28 was located in the narrow section between the primary GE discharge point and Bakers Falls Dam, and thus does not represent upstream baseline conditions. It also does not present a dateable cesium profile, and so is not discussed further here. Core 27, however, is believed to provide a useful historical record of PCB discharges at and above Glens Falls.

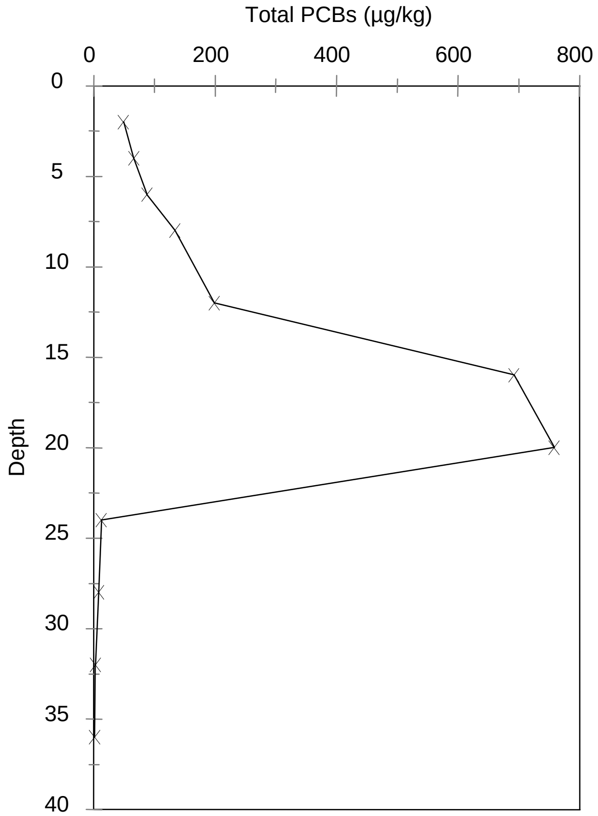

Figure A.2-8. Depth Profile of Total PCBs in Core 27, Collected at RM 202.9

The vertical distribution of total PCBs in Core 27 is shown in Figure A-2-8, showing a well defined maximum at a depth of 16–20 cm (the depths displayed in the figure are the bottom depths of the core sections). The maximum PCB concentration in this core is 758 µg/kg, which is far less than the PCB peaks in the high resolution cores in the upper Thompson Island Pool, which have peak concentrations on the order of 10^6 µg/kg, or 10,000 times higher than seen in Core 27. Concentration in the surface sediment layer (0–2 cm) was 48 µg/kg.

Based on cesium dating, the peak concentration in this core occurred at approximately 1954, while the inflection point at 8–12 cm depth corresponds with about 1971, spanning the period of maximum PCB release from the GE facilities and Fort Edward Dam removal. Prior to the ca. 1954 maximum, concentrations rapidly decline toward zero.

The next lower segment, dated approximately 1946, has a concentration of only 10 μg/kg. The bottom of the core, corresponding to approximately 1921, has no detectable PCBs.

Some interesting observations can be made on the basis of PCB homologue patterns in Core 27, which are displayed in Figure A.2-9. The top two layers (0–4 cm, corresponding to ca. 1985–1992) have total PCB concentrations well below 100 μg/kg and display a tri- through hexachlorobiphenyl pattern, suggesting ongoing input of low levels of a relatively unaltered, moderately chlorinated Aroclor. Mono- and dichlorobiphenyls are entirely absent from the first three layers. Indeed, mono- and dichlorobiphenyls are present at low levels, if at all, throughout the core profile, suggesting little active dechlorination at this site. This fits with the observation that the upstream baseline load generally has low levels of mono- and dichlorobiphenyl homologues.

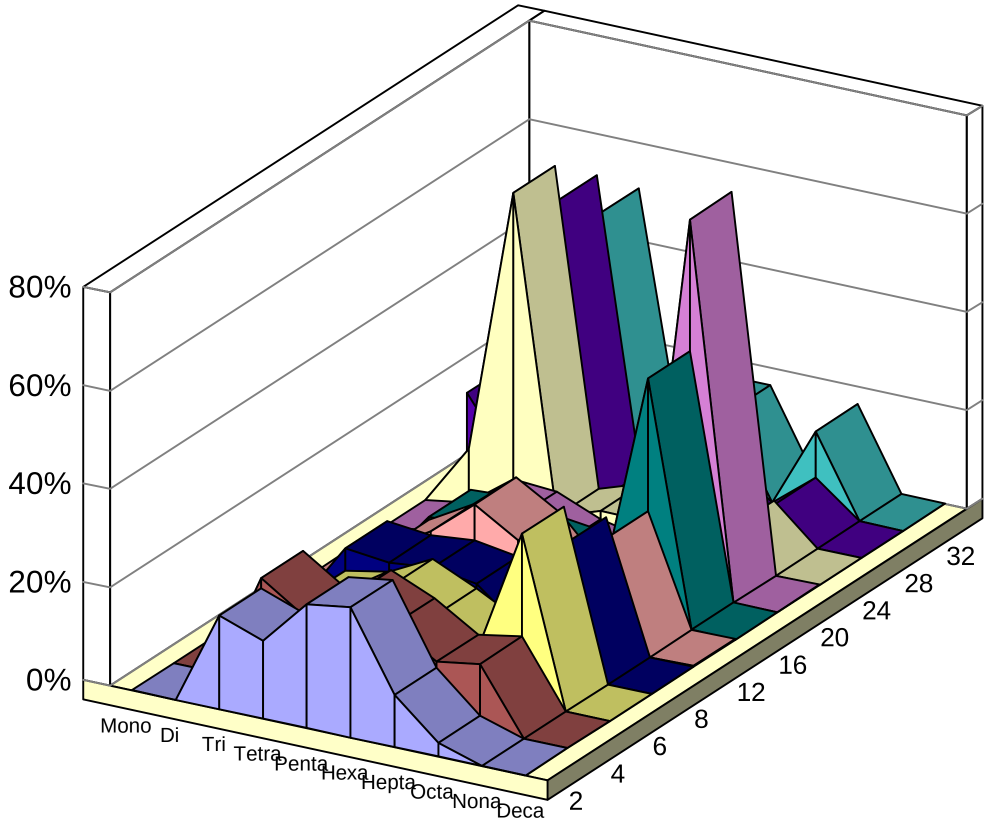

Figure A.2-9. Homologue Patterns in Core 27 Segments Expressed as Relative Percent
Note: Y-axis shows lower depth of core segments in cm.

The importance of higher chlorinated homologues increases with depth in Core 27. This is most readily shown by the octachlorobiphenyl fraction, which increases from 2.7 percent at the surface to 76.1 percent in the layer from 20–24 cm, corresponding to ca. 1946. This suggests releases of Aroclor 1260 upstream. Finally, in the lowest layers PCBs are present at very low concentrations and include a large trichlorobiphenyl fraction. These earlier layers may represent downward mixing and diffusion of more mobile congeners from the overlying layers.

EPA Ecological Sampling

EPA's Ecological Sampling Station 1 was located at RM 203.3. Five co-located surface sediment samples were collected on August 3, 1993. Total PCB concentrations in these five samples ranged from 23.1 to 112.6 ppb or µg/kg (dry weight), with an average of 66.9 µg/kg. These concentrations are consistent with the surface layer concentration in Core 27 at RM 202.9 (44 µg/kg). PCB congeners detected were about 24 percent each tetra-, penta-, and hexachlorobiphenyl homologues, with lesser amounts of hepta-, tri-, and octachlorobiphenyls, which is approximately consistent with the homologue distribution in the top section of Core 27. Mono- and dichlorobiphenyls were absent or nearly absent from the samples.

Summary of Baseline Conditions

Historical and recent data are available to assess the baseline conditions regarding PCB levels upstream of the GE facilities at Hudson Falls (*i.e.*, RM 197-209). These conditions are not considered background because of the presence of local PCB sources but they are still orders-of-magnitude below conditions found in the TI Pool and elsewhere.

Monitoring data on fish body burdens obtained by NYSDEC represent the most extensive record both temporally and spatially. The results show that for most recently available samples (1998-1999), fish body burdens were one to two orders-of-magnitude lower in this region relative to TI Pool and other locations downstream. Results for young-of-the-year pumpkinseed have the greatest temporal coverage and show a dramatic decline as a result of remedial efforts in the Queensbury area. As might be expected, fish body burdens increase from RM 209 to 197, attributable in part to contributions arising from the Niagra-Mohawk facility at Queensbury. Nonetheless, these levels are still dwarfed by the levels found downstream of the GE facilities. Simply put, fish body burdens upstream of the GE facilities are recorded in parts-per-billion while downstream of the GE facilities are recorded in parts-per-million.

Water column data are less extensive than fish data in this region, both temporally and spatially. USEPA data suggest mean concentrations of less than 2 ng/L and probably less than 1 ng/L. The more frequent but less sensitive GE data are largely non-detect at 11 ng/L although the results do show occasional spike concentrations which are quite high (387 ng/L maximum). It is most likely, however, that these values are the result of remedial activities at the Hudson Falls plant and Bakers Falls Dam. This is based on the observation that the homologue patterns of the spikes are very different from the normal patterns seen at the station. The pattern of the spike concentrations closely resembles the Aroclor mixtures released by GE. Additionally, the spike concentrations are principally found in the period 1995-1996 during which the Baker Falls Dam was undergoing replacement and essentially stop once the remedial and repair activities at the Bakers Falls Dam were completed in 1996. The otherwise irregular and low concentrations seen at Bakers Falls suggest that much of the PCB contamination is the result of other compounds in solution which interfere with the PCB measurements. A true local source generating 1 to 2 ng/L would have a more consistent homologue signal. A more consistent homologue signal can be seen in the fish data from the region.

Sediment samples represent the smallest data set and thus offer the least coverage over time and distance. However, a USEPA high resolution core was obtained from the region. It documents the occurrence of a very minor PCB source, generating less than a 1 mg/kg total PCB peak concentration in the core. This peak concentration can be compared to the 2,500 mg/kg peak concentration found in cores from the TI Pool. This comparison clearly documents the huge scale of the GE releases and inconsequential sources from the region above Bakers Falls.

In total, measurements of the three matrices confirm that the upstream loads and concentrations are minuscule compared to those released by GE. At a minimum, conditions downstream would have to improve by one to two orders-of-magnitude before the loads from upstream sources would become important.

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HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX A

BACKGROUND MATERIAL

A.3 Upstream Sources

APPENDIX A.3

PCB Sources to the Hudson River Originating Between Bakers Falls and Rogers Island

A.3.1 Overview

Several PCB sources exist above Rogers Island. An in-depth discussion of all known Hudson River PCB sources is given in chapter 2 of the DEIR (USEPA, 1997), but the primary sources are the General Electric (GE) plants at Hudson Falls and Fort Edward, the Fort Edward outfall and associated sediments, and the Remnant Deposits. The Remnant Deposits are fine beds of PCB-contaminated river sediment which were re-exposed as the result of the removal of the Fort Edward Dam in 1973. Remnant Deposits 2, 3, 4 and 5 were remediated using in-place containment methods as per USEPA's 1984 Record of Decision; however, the possible remediation of Remnant Deposit 1 has been left for this FS. This appendix presents the limited information for Remnant Deposit 1 in the context of the remedial strategies employed in this report and the possible need to remediate this area. In addition, the stability of Remnant Deposits 2, 3, 4 and 5 is assessed, because the most recent estimate of flow rate at 100-year flood conditions (as presented in the Response to Peer Review Comments on the RBMR [USEPA, 2000a]) is greater than previous estimates (*i.e.*, the estimates in the BMR; EPA, 1999) and is also higher than the design specification used by GE. The current state of the GE plants and the vicinity is discussed. The homologue patterns typically seen at Rogers Island are examined to determine the dominant source material as a basis to assess PCB sources from the region upstream of Rogers Island. Finally, the effect of the PCB sources on the estimated future background water column conditions is discussed.

A.3.2 General Electric - Hudson Falls Plant and Vicinity

NYSDEC has characterized the 25 acres in the vicinity of the GE Hudson Falls plant near RM 197 as a major source of PCBs to the Hudson River (NYSDEC, 1993a). According to the Reassessment Phase 1 Report (USEPA, 1991; Brown *et al.*, 1984), GE used PCBs for capacitor manufacturing at its Hudson Falls plant from 1952 to 1977.

In the late 1980s, wastewater generated on site, potentially containing PCBs, including process and sanitary wastewater as well as stormwater, was collected and stored on-site prior to transport to the treatment facility at the GE Fort Edward plant, resulting in the cessation of direct discharges to the Hudson River from the Hudson Falls plant (Dunn Geoscience, 1989). However, since that time, contamination has been found in soil and groundwater on site and on adjacent properties. This contamination represents a historical and current source of PCBs to the Hudson River above the remnant deposits. Evidence of this upstream source to the water column was found as early as 1983 by NYSDEC (Tofflemire, 1984).

An investigation conducted in 1989 found elevated concentrations of PCBs and volatile organic compounds (VOCs) in soil and groundwater at the site, including approximately 600 cubic yards of PCB-contaminated material near Buildings 1A/Tank Farm, 2, 3 and 4 as well as the railroad tracks (Dunn Geoscience, 1989). Historical operations at these buildings (including Building 4A) included storage, blending, and refining of dielectric fluids for the impregnation of capacitors (Dunn Geoscience, 1989). Contamination was also found in a bedrock air plenum below the Building 1 basement and is a likely source of groundwater contamination. Groundwater flow through fractures, joints and bedding planes in bedrock was determined to be in a northwest direction toward the Hudson River (Dunn Geoscience, 1989). Approximately 100 cubic yards of oily sludge were removed from the air plenum by GE for off-site incineration in 1989 (NYSDEC, 1993b).

Currently, a RI/FS is being performed under an Order on Consent with NYSDEC at the GE Hudson Falls site. The Hudson Falls facility is divided into three operable units, as defined below:

- Operable Unit 1 (OU1) includes contaminated soil areas below the former manufacturing buildings, extending from Sumpter Street to the railroad tracks, including the former railcar off-load area;

- Operable Units 2A and 2B (OU2A/B) include areas along the eastern shore of the Hudson River, extending from Fenimore Bridge, upstream of the pumphouse and the dam, downstream to the abandoned Bakers Falls hydroelectric facility on property currently owned by Niagara Mohawk Power Corporation (NiMo), including the abandoned Allen

Mills structure, the eastern raceway, and sediments/debris within the raceways, tunnels, and river; and

C Operable Units 2C and 2D (OU2C/D) include subsurface source areas below and adjacent to the plant, but does not include the Hudson River.

A Record of Decision was issued by NYSDEC for OU1 for excavation and off-site land disposal of approximately 3,000 cubic yards of surficial soil containing more than 10 ppm PCBs, with typical concentrations in the range of 500 ppm to 1,000 ppm and a maximum of 75,000 ppm (NYSDEC, 1993b).

Remedial investigation work for OU2A/B, including the eastern shore of the Hudson River and areas owned by the Niagara Mohawk Power Company, has been performed by O’Brien & Gere Engineers, Inc., under contract to GE. Releases from OU2A/B areas have the most significant and direct impact on conditions within the river. OU1 and OU2C/D areas are the likely sources of PCB contamination to OU2A/B and the Hudson River. The eastern raceway historically supplied Hudson River water from Bakers Falls to industries in this area, including the now-abandoned Allen Mills plant and Bakers Falls hydroelectric facility. Additional hydraulic structures were used for operations at Allen Mills, including the tailrace tunnel, lower raceway, turbine bays, drop shafts, and central tailrace (O'Brien & Gere, 1994a). The failure of gates along the western wall of the eastern raceway, sometime between 1990 and 1992, allowed flow to enter the Allen Mills hydraulic structures causing a mobilization of PCB-contaminated sediments and debris from the eastern raceway and tailrace tunnel (O'Brien & Gere, 1994a).

Hudson River water column sampling, conducted by GE as part of their ongoing Remnant Deposit Monitoring Program, showed elevated concentrations of PCBs in the river during this time period. These include a maximum value of 4,145 ng/L (4.1 µg/L) of total PCBs on September 18, 1991 at RM 194.3 (designated as RM 194.2 by GE due to differences in mapping references), near Fort Edward at Rogers Island (GE, 1994a). Based on this value, the in-river PCB load is estimated to be 33 kg/day (72 lb/day) at a flow of 3,230 cubic feet per second (cfs). This can be considered a non-scour period with total suspended solids (TSS) in the water column less than 5 mg/L. On this same date, with 17 ng/L PCBs at GE’s Fenimore Bridge sampling location (RM 197.1, designated as RM 197.0 by GE), upstream of

Bakers Falls and Hudson Falls OU2A/B, an estimate of the background in-river PCB load was 0.1 kg/day (0.3 lb/day), suggesting that almost the entire load of PCBs was derived from the area from Fenimore Bridge to Rogers Island, which encompasses the GE Hudson Falls and Fort Edward source areas and the Remnant Deposits.

Samples were not collected at GE's "Canoe Carry" station (RM 196.8), immediately downstream of OU2A/B on the western shore, during this period. Sampling at this station commenced in March 1992. The highest in-river concentration of PCBs at RM 196.8, from March 1992 through December 1993, was 721 ng/L on August 13, 1992 (GE, 1994a). At a flow of 3,310 cfs, the estimated in-river load at Canoe Carry on this date was 6 kg/day (13 lb/day), due almost entirely to the sources near Bakers Falls. Elevated concentrations of PCBs were persistent from June 1992 through October 1992, at both the Canoe Carry (maximum of 721 ng/L on August 13) and Rogers Island (maximum of 941 ng/L on September 23) stations, suggesting that a major portion of the in-river load at Rogers Island was derived from GE Hudson Falls OU2A/B. Elevated concentrations of PCBs in the water column persisted through mid-1993. Seepage at OU2A/B and water column samples in the Hudson River down to Rogers Island showed predominantly Aroclor 1242 (O'Brien & Gere, 1994a). The intermittent nature of the source is represented in the highly variable water column concentrations in the river during 1992 and 1993.

Possible source areas examined in the OU2A/B investigation include river sediments from Fenimore Bridge near the former GE Hudson Falls Outfall 002 to the eastern raceway below Bakers Falls dam; sediments/debris within the raceway and various Allen Mills hydraulic conduits; contaminant flow through fractured bedrock; and migration of contaminated material from historical pipe channels and conduits (O'Brien & Gere, 1994a). Dewatering of the eastern raceway and reconstruction of the intake gate structure in April 1993 by Adirondack Hydro Development Corporation (Adirondack Hydro) associated with rehabilitation of the Bakers Falls dam, western raceway, and Moreau Hydroelectric facility on the opposite side of the river, allowed for investigation and remedial activities in OU2A/B. Elevated concentrations of PCBs, volatile and semivolatile organic compounds, and metals were found in seepage, surface water, and sediment in OU2A/B areas. In addition, PCB-bearing oil-phase (non-aqueous phase liquid or "free product") samples were collected in groundwater and seepage in OU2C/D and OU2A/B locations.

Sediments above Bakers Falls dam near the GE Hudson Falls pumphouse were found to contain up to 22,000 ppm of PCBs. PCBs in the eastern raceway were detected at maximum concentrations of 390.5 mg/L in seepage water, 942,000 mg/L in seepage oil, and 33,400 ppm in shale fragments. Based on homologue distributions, PCBs in seepage water throughout OU2A/B areas have not been subject to environmental degradation processes and were characterized as unaltered Aroclor 1242 (O'Brien & Gere, 1994a). Sediments in the tailrace tunnel were found to contain up to 73,000 ppm PCBs. In addition, a direct discharge of water to the river from the tunnel contained concentrations of total PCBs ranging from 49.5 µg/L to 410 µg/L. Assuming a PCB concentration at the high end of this range (say 400 µg/L) and a flow of 20 cfs (the flow estimate for the lower tunnel contained in O'Brien & Gere, 1994a) would produce an estimated 20 kg/day (43 lb/day) external loading of PCBs to the river, which is at approximately the same order-of-magnitude as the 33 kg/day (72 lb/day) in-river loading estimated from river water column data.

General Electric conducted a three-phase Interim Remedial Measures (IRM) at the Hudson Falls OU2A/B site between 1993 and 1995, which included installation and operation of a temporary seepage collection system in the eastern raceway; removal and disposal of sediments/debris in the eastern raceway from the intake wall to the John Street combined sewer overflow (CSO) pipe, and from the tailrace tunnel; and design, installation, and operation of a long-term seepage collection system within OU2A/B (O'Brien & Gere, 1994a) which is ongoing. In addition, GE found and removed seven capacitors from the river immediately upstream of Bakers Falls dam (NYSDEC, 1993c). A reduction in PCB concentrations in the river in the second half of 1993 was evident following implementation of IRM tasks and the dewatering of the raceway. However, PCB concentrations greater than those upstream of Fenimore Bridge still existed in the river downstream of OU2A/B, suggesting a remaining source in the Bakers Falls area.

Potential sources remaining to be investigated include seepage above and below the dam, lower raceway sediments, and the eastern raceway south (downstream) of the John Street CSO pipe under the abandoned Bakers Falls hydroelectric facility (O'Brien & Gere, 1994a) as well as the bedding from the former GE outfall near the pumphouse or the CSO pipe at Bridge Street upstream of Bakers Falls (NYSDEC, 1994a). In June 1994, the pool between the wing dam and Bakers Falls dam was dewatered by NiMo by installing flashboards on the eastern side of Bakers Falls dam. This facilitated additional inspections and sampling by GE of seepage, including a visible oil product, from the western wall of the eastern raceway. During this period, GE collected approximately 30 gallons of PCB oil from seeps in the wing dam area and subsequently grouted the faults while the pool was dewatered.

In 1995, GE constructed a wastewater treatment plant at the Hudson Falls facility to manage stormwater and remedial wastewater. Wastewater is no longer transported from the Hudson Falls plant to the Fort Edward plant. Effluent from this new plant discharges to the Hudson River upstream of the Bakers Falls dam. The plant, on-line since December 1995, is permitted to treat up to 250 gpm. Daily discharge monitoring for the initial 28-day period indicated that PCB levels were below the 65 ng/L detection limit. Effluent is now monitored every six days to evaluate compliance.

In the summer of 1995, GE removed nearly 800 tons of PCB-contaminated sediments from the lower raceway (Ports, 1996). Additional recent work included construction of an inclined borehole through rock in a brecciated zone, approximately 300 feet in length, from the tailrace tunnel back up toward the plant. This allowed additional inspection and recovery of PCB product. Additional inclined or horizontal boreholes, approximately 20 to 30 feet in length, were installed to intercept and recover PCBs. Vertical wells were also installed to further define the full extent of contamination. According to NYSDEC, bedrock contamination does not extend beyond GE's property to the north and the extent of contamination off-site to the south and east has not been fully defined. Monitoring/recovery wells at the eastern property line of the Hudson Falls site have yielded abundant amounts of product (about one drum per week) (Farrar, 1996a). Extensive PCB contamination from the plant to the river in a westerly direction has reached the Hudson River. PCBs and VOCs were not detected in deep (below river level) bedrock wells installed on the opposite side of the river (right, west bank) near Adirondack Hydro property, suggesting that contamination does not extend to that side of the river at those locations.

Adirondack Hydro obtained approval from the Federal Energy Regulatory Commission (FERC) to bypass the Hudson River flows at Bakers Falls through their generating plant during low-flow conditions in the summer of 1996. During that time, GE and NYSDEC inspected and mapped the Falls to determine if there were any additional PCB seeps through the river bed and to evaluate the effectiveness of the 1994 grouting program. During this investigation, new seeps were noticed along the river bottom and it was determined that the earlier grouting was no longer effective. In a lower (plunge) pool which was not dewatered, a GE diver filmed additional seeps of PCB product below the water level. A collection system installed by GE in this area has recently recovered less than one liter of product per day beneath the water surface (Farrar, 1996b). Groundwater recovery wells in the area have captured approximately one liter of product per hour. Additional bedrock and overburden groundwater recovery wells will be installed by GE on-site in the near future to attempt a full-scale recovery of PCB product on GE property (Farrar, 1996b). However, as noted earlier, contamination has migrated off-site in an easterly direction and its extent has not been fully defined. USEPA will continue to monitor progress at the GE Hudson Falls site.

Dunn/GE completed an Interim Remedial Investigation for OU2C/D (Dunn, 1994a), including field reconnaissance surveys, fracture trace analyses, ground penetrating radar survey, pipe and conduit survey, and subsurface investigations (groundwater, soils/bedding, bedrock, and pipe sediments and water). Principal contaminants found in soil and groundwater include PCB Aroclor 1242, trichloroethene (TCE), and 1,2-dichloroethene (DCE). PCB concentrations in the soil samples ranged from not detected to 250,000 ppm. PCB concentrations in shallow and deep bedrock groundwater samples ranged from less than 1 µg/L (ppb) to approximately 1,950,000 µg/L (Dunn, 1994a). Isoconcentration contour maps for December 1993 show elevated concentrations of PCBs in bedrock, *i.e.*, greater than 100,000 µg/L, in shallow bedrock near Buildings 1, 1A/Tank Farm, 2, and near Sumpter Street, with orders-of-magnitude lower concentrations, *i.e.*, 1 to 10 µg/L, near the river in shallow bedrock. In contrast, elevated concentration of PCBs in bedrock (*i.e.*, greater than 1,000,000 µg/L) in deep bedrock were found closer to the river near GE's Buildings 7 and 7A and the abandoned Allen Mills. It should be noted that some of the reported groundwater PCB concentrations are several orders-of-magnitude greater than literature data for the solubility of PCBs in water, indicative of the presence of a pure PCB-bearing oil. Most reported Aroclor solubility values are in the 50 to 300 µg/L range (Montgomery and Welkom, 1990).

Potential contaminant pathways from the plant to the river were investigated, including sanitary and storm sewer lines and bedding, potable water and fire water lines and bedding, tunnel walls, building foundations, utility lines and bedding, and discharge piping and bedding. To date, GE, with NYSDEC approval, has undertaken numerous IRMs. IRMs completed or underway include: the removal of about 50 tons of PCBs from the Allen Mill area; grouting of PCB seeps identified in the River bottom; rerouting of the Sumpter Street sewer and excavation of old pipes that served as possible conduits of contaminated groundwater toward the river, removal and disposal of 8000 gallons of sludge and oil from beneath Building 1; stabilization of the river-wall of the old Allen Mill, and cleaning and RCRA-compliant refitting of the North and South storage basins. During 1995, GE installed a remedial wastewater treatment plant which discharged treated effluent to the Hudson River above the Bakers Falls dam. To date, stringent effluent criteria, set by NYSDEC, have been met (NYSDEC, 1999a).

Elevated concentrations of PCBs, up to 44,000 ppm of Aroclor 1242, were found in sediments in a manhole connected to the Sumpter Street municipal sewer (Dunn, 1994b). The sewer, which is approximately 13 feet below the street surface and runs through contaminated material found below and adjacent to the plant buildings, historically discharged to the Village of Hudson Falls sewage treatment plant, which in turn discharged to the Hudson River just upstream of Fenimore Bridge, representing a potential historical pathway of PCBs to the river upstream of Bakers Falls. It has been documented that the Village of Hudson Falls treatment plant discharged approximately 1.1 kg PCBs/day (2.5 lb/day) in 1975 which was shown to be attributable to GE (Sofaer, 1976). In April 1994, the Sumpter Street sewer was bypassed by installing a new above-ground sewer at street level adjacent to the GE plant. This allowed municipal wastewater to bypass the contaminated area, prior to discharging to the existing Washington County Sewer District Pump Station near Bridge Street (Dunn, 1994c). Sampling and remedial activities are ongoing at OU2C/D, which remains a source area of PCB contamination to OU2A/B areas and the Hudson River. This source is mainly in the form of groundwater and DNAPL flow in the bedrock fractures, joints, or bedding planes, from the former capacitor manufacturing buildings to the eastern raceway and river.

Three pilot projects have been conducted to determine their effectiveness as remedial technologies. First is a system of six well clusters installed in and around the main building. Each cluster contains an overburden and shallow bedrock recovery well. Groundwater and PCB product (when encountered) pumped under various scenarios show this approach to be a viable and effective contaminant removal tool. Second, horizontal, angled and vertical wells were drilled into the bedrock from inside the tailrace tunnel. This, in turn, proved effective in draining product from the rock and provides hydraulic containment between the river and the site (NYSDEC, 1999a). Third, bedrock recovery wells have been installed along the plants western boundary with the river in an attempt to create a hydraulic barrier in the deeper sections of the bedrock.

In January 1997, GE submitted a Feasibility Study identifying and addressing possible alternatives to remediate the contaminants found and identified in OU2A and OU2B. Goals for the remedial program have been established through the remedy selection process stated in 6 NYCRR Part 375-1.10.

The overall remedial goal is to meet all Standards, Criteria, and Guidance (SCGs) and be protective of human health and the environment. At a minimum, the remedy selected should eliminate or mitigate all significant threats to the public health and to the environment presented by the hazardous waste disposed at the site through the proper application of scientific and engineering principles.

The goals selected for the GE Hudson Falls Plant site are:

C Eliminate, to the extent practicable, exceedances of applicable environmental quality standards related to releases of contaminants to the waters of the State, including the surface water standards and the groundwater standards.

Based upon the results of the RI/FS and the established remedy selection process the NYSDEC is proposing a suite of activities to address the contamination remaining at and in the vicinity of the GE Hudson Falls plant site, based in part upon a combination of alternatives. The estimated present worth cost to implement the remedy is $28,400,000. The cost to construct the remedy is estimated to be $19,096,000 and the average annual operation and maintenance cost is estimated at $606,000.

Elements of the selected remedy are:

1. Continued operation of the existing IRM groundwater, NAPL and seepage recovery systems, and completion of ongoing IRMs.

2. A remedial design program to verify the components of the conceptual design and provide the details necessary for the construction, operation, and maintenance, and monitoring of the remedial program. Any uncertainties identified during the RI/FS would be resolved.

3. Operation and maintenance of the groundwater containment and NAPL recovery systems to maximize hydraulic containment and NAPL recovery.

4. Demolition of the manufacturing buildings at the site after appropriate contaminant abatement, with proper off-site disposal of the demolition debris.

5. Excavation and on-site treatment of all soils at the site which contain contaminants above NYSDEC Division of Environmental Remediation criteria, with on-site placement of the treated soils.

6. Since the remedy results in untreated hazardous waste remaining at the site (in the bedrock beneath the site), a long term monitoring program would be instituted. This program would allow the effectiveness of the selected remedy to be monitored and would be a component of the operation and maintenance for the site. It would include groundwater and surface water monitoring and fish monitoring in the Hudson River.

7. Performance of remedial program effectiveness reviews every five years to determine if the remedy is still protective of human health and the environment, to determine if technology or other developments have allowed for enhancement of the remedy, and to determine if additional remedial actions should be implemented to enhance the effectiveness of the remedy.

A.3.3 General Electric Company - Fort Edward Plant and Vicinity

The GE Fort Edward plant site is listed in the Registry of Inactive Hazardous Waste Disposal Sites as a 10-acre "open dump" which poses a significant threat to the public health or environment (NYSDEC, 1993a). GE used PCBs at Fort Edward from 1946 to 1977 (USEPA, 1991). Contaminants found in soil and groundwater at the site include PCBs as well as VOCs, such as trichloroethene and tetrachloroethene. GE has implemented a NYSDEC-approved Remedial Plan at the site, including removal and disposal of contaminated soil and pumping and treatment of on-site and off-site groundwater. For management purposes the site has been divided into four operable units as follows:

C Operable Unit 1 (OU1) consists of off-site overburden contaminated groundwater. In accordance with a 1984 Order on Consent, GE established an off-site groundwater recovery system and conducts monitoring. GE will continue to provide operation and maintenance.

C Operable Unit 2 (OU2) consists of on-site contaminated soil and groundwater. The Remedial Investigation/Feasibility Study (RI/FS) conducted from 1984 to 1990 concluded that an expansion of the overburden groundwater recovery system was needed on-site; PCB recovery from the bedrock beneath the site was also needed and provided for thru the use of two recovery wells with off-site disposal of recovered product. PCB-contaminated soils from the railroad off-loading area were also removed and properly disposed off-site.

C Operable Unit 3 (OU3) consists of the main portion of the site, including the contaminated groundwater and soil beneath the facility.

C Operable Unit 4 (OU4) consists of contaminated soil along the riverbank adjacent to the former 004 outfall on the east shore of the Hudson River.

GE holds a New York State Pollutant Discharge Elimination System (SPDES) permit to discharge treated wastewater (process, sanitary, stormwater, cooling water, and pumped groundwater) to the Hudson River (NYSDEC, 1993d). The treatment system at Fort Edward includes activated sludge treatment, flow equalization, mixed-media filtration, groundwater air strippers, and carbon adsorption units. The SPDES permit requires sampling at various locations throughout the treatment system as well as at the outfall (Outfall 004) prior to discharging to the Hudson River immediately upstream of Remnant Deposit

3 and adjacent to the southernmost island of Remnant Deposit 1. Wastewater from GE's Hudson Falls plant, including wastewater associated with the cleanup described above, and leachate and groundwater pumped from the GE/Moreau NPL site and partially treated by air strippers, was transported by tanker truck to the treatment facility at Fort Edward.

The GE Fort Edward outfall pipe constructed in 1942 on the eastern (left) bank of the river immediately upstream of Remnant Deposit 3, was later buried by river sediments and weathered shale (Dames & Moore, 1994). The outfall was a 30-inch diameter corrugated metal pipe at the base of the steep cliff on the eastern shore above the current river level. The wastewater flow from the buried outfall was seeping through contaminated sediments and flowing down the riverbank prior to entering the Hudson River. NYSDEC, New York State Department of Health (NYSDOH), and GE collected soil and water samples from areas adjacent to the outfall in November 1993. Total PCB concentrations in the soil near the outfall ranged from 148 ppm to 5,571 ppm, predominantly consisting of Aroclor 1242 (Dames & Moore, 1994). A composite water sample from the flow discharge contained 14 µg/L PCBs. On March 14, 1994, NYSDEC issued an Order on Consent to GE to relocate the outfall pipe and to provide a more detailed investigation.

GE's Revised Investigative Work Plan and Interim Abatement Measure, submitted by Dames & Moore in February 1994 and included in the consent order, contains the abatement plan which calls for rerouting Outfall 004 from the existing manhole at the top of the cliff approximately 100 feet in elevation above the current river level and piping the wastewater directly to the river (subsurface discharge) approximately 20 to 30 feet downstream of the existing outfall. The new temporary 6-inch diameter flexible PVC outfall pipe was constructed on pipe skids down the face of the cliff, extending from the existing manhole to the river, thereby preventing the water from coming into direct contact with contaminated soils/sediments or bedding materials. The historical 30-inch diameter outfall pipe was cut and sealed at the top of the cliff near the existing manhole and the pipe sections downgradient, including the elbow, were removed by GE (Ports, 1994a). Additional work to be performed by GE and its consultants includes a review of historical soils and groundwater data; review of historical and current sewer lines and outfall locations to determine sources of PCBs found in the water and sediment near Outfall 004; additional soil sampling including borings and test pits; water sampling including a float survey; and a land topographic survey.

GE issued results of soil, sediment and seep/water samples collected in March and April 1994 to NYSDEC (GE, 1994b). PCB concentrations in two riverbank sediment samples collected approximately 150 feet and 300 feet downstream of Outfall 004 were less than 1 ppm. PCB concentrations in seeps at these locations were less than 0.1 µg/L. PCB concentrations in riverbank sediment and seep samples collected approximately 100 feet upstream of the outfall were 8.6 ppm and less than 0.05 µg/L, respectively. Samples collected along the line of the buried pipe showed elevated concentrations of PCBs, including 0.461 µg/L in standing water in the manhole at the top of the cliff, and PCB concentrations in three seep samples along the line of the pipe ranged from 5.9 to 19.8 µg/L. A sediment sample in this area contained 427 ppm PCBs. Assuming a flow of approximately 200 gpm or 0.5 cfs as an estimate for the seep discharge (Ports, 1994b) and a concentration of 20 µg/L (approximate high end of range), an estimate of the total PCB loading to the river from seepage is 0.02 kg/day (0.05 lb/day) or 9 kg/year (20 lb/year). Although minor, this represents an additional source of PCBs to the River above Rogers Island. The estimates above do not include potential PCB loading resulting from stream banks scour or erosion.

Results of soil and sediment samples collected in June 1994 in the outfall area, subsequent to installation of the temporary outfall pipe in April, were reviewed. Forty samples were collected at 19 locations on the cliff in an area adjacent to Outfall 004 extending approximately 300 feet upstream and downstream of the outfall at various elevations. PCB concentrations in samples collected upstream ranged from less than 1 ppm to 4,060 ppm at various depths. PCB concentrations detected in samples collected downstream of the outfall ranged from 1,760 ppm at a depth of 3 feet near the outfall to 31,800 ppm at the surface approximately 50 feet downstream. A sample collected approximately 300 feet downstream had a PCB concentration of 5,860 ppm in surficial soil/sediment up to a depth of 6 inches. PCB concentrations in samples collected along the line of the buried pipe ranged from 139 ppm approximately 20 feet upslope of the outfall, to 44,800 ppm approximately four feet downslope of the former outfall (GE, 1994c).

In view of the occurrence of elevated concentrations of PCBs in seep water adjacent to the outfall, a brief review of GE's water quality monitoring associated with the SPDES requirements was performed. Discharge limitations for various effluent parameters are included in the SPDES permit for GE's Fort Edward facility, including a daily maximum limitation of 0.44 µg/L for total PCBs (Aroclors 1016, 1242, 1221, and 1254; analyzed by USEPA Method 608) in treated effluent prior to discharging to the river. It should be noted that the final SPDES sampling point (identified as 004M) is at the top of the cliff in a sampling port inside the manhole, upgradient of the contaminated riverbank material, as described above. A record of the Discharge Monitoring Report (DMR) data for the facility from 1991 to April 1994 was obtained from NYSDEC's Bureau of Water Compliance Programs (NYSDEC, 1994b).

In general, permit holders submit DMRs to the state on a monthly basis. Discharge limitations in 1991 were on a mass basis and were 0.002 kg/day (0.0042 lb/day) for daily average loadings and 0.01 kg/day (0.022 lb/day) for daily maximum loadings. There were no reported exceedances from January through November 1991. Since December 1991, at which time the allowable daily maximum total PCB concentration was established as 0.44 µg/L, the data show nine exceedances in 29 months (through April 1994). From December 1991 through April 1994, the limitation was exceeded most recently in April 1994 (0.459 µg/L) and December 1993 (0.500 µg/L), with a maximum concentration of 1.068 µg/L in August 1992. It should be noted that the outfall (004M) is sampled for analysis of PCBs weekly, *i.e.*, once in seven days as a 24-hour composite, and the maximum of these values (usually at least four per month) is reported in the monthly DMR and not the individual weekly values. The mean of the 29 monthly maximums is 0.27 µg/L with a mean monthly maximum flow of 250,000 gpd (174 gpm or 0.4 cfs). Thus, an estimate of the mean PCB loading upgradient of the contaminated material for the 29-month period is about 2.6×10^{-4} kg/day (6×10^{-4} lb/day or about 2 lb/yr) with a monthly maximum of about 1.2×10^{-3} kg/day (2.6×10^{-3} lb/day) in August 1992. As discussed earlier, an estimate of the PCB loading from seeps along the face of the contaminated bank, downgradient of the SPDES monitoring point, is about 0.02 kg/day.

In addition, elevated concentrations of PCBs were found in wastewater at GE's Hudson Falls facility prior to construction of the on-site treatment plant at the Hudson Falls site. The wastewater sampling point at Hudson Falls (004D) potentially included the IRM wastewater, monitoring well water, air plenum sump discharge, and OU1 soil excavation dewatering fluids. The 004D outfall water was transported to the GE Fort Edward treatment facility prior to construction of the Hudson Falls treatment plant. PCB concentrations were reported in the DMR for outfall 004D from October 1993 to April 1994, with monthly maximum concentrations ranging from 0.3 µg/L in April 1994 to 550 µg/L and 770 µg/L in December and November 1993, respectively, with a mean monthly maximum of approximately 200 µg/L for the seven months. The potential effect of elevated concentrations in wastewater at GE Hudson Falls on the GE Fort Edward treatment facility is evident in the elevated concentrations at the outfall at Fort Edward in December 1993 and April 1994, suggesting a possible overload to the treatment system. No discharge was reported from the outfall (004E) from the GE/Moreau NPL site groundwater recovery project from December 1993 to April 1994.

The direct loading to the river is difficult to quantify since the sampling required by the SPDES permit is upgradient of the contaminated riverbank and the seeps represent a non-uniform distributed load. However, the magnitude of this Fort Edward source (not including potential scour or erosion of the contaminated riverbank soils/sediments) can be considered relatively minor compared to the GE Hudson Falls source.

The following OU3 and OU4 IRMs have been completed at the site:

C In 1985, two production wells were temporarily sealed to prevent migration of contaminants into the deep bedrock aquifer (OU3). These wells were permanently sealed in 1996.

C In 1994, a temporary diversion for the plant outfall was installed. The outfall originally flowed through contaminated soils of OU4. The permanent diversion was completed in 1996.

C In 1994, shoreline protection measures were installed to reduce the potential for scouring of the riverbank during high flow events in the Hudson River.

- In 1996, the PCB-contaminated former outfall pipeline and pipe bedding were removed from the OU4 area.

The RI for OU3 was conducted in two phases. The first phase was conducted between July 1995 and March 1996 and the second phase between April 1996 and January 1997. A report entitled “Fort Edward Remedial Investigation Report - January 20, 1997” has been prepared describing the field activities and findings of the RI in detail (as cited in NYSDEC, 1999b).

The site is contaminated with several types of compounds, including PCBs and volatile organic compounds (VOCs). As described in the RI report, numerous soil gas, soil and groundwater samples were collected at the site to characterize the nature and extent of contamination. Soil gas samples were collected and analyzed for VOCs. Elevated VOC concentrations were detected in the soil gas at portions of the site. Soil samples were collected from borings and soil piles and were found to contain VOCs, kerosene, and PCBs.

Groundwater samples were collected from 108 on-site monitoring wells, 22 off-site wells, and four off-site springs. VOCs and PCBs were detected in samples from shallow groundwater. Below some parts of the site, shallow groundwater is contaminated above Class GA groundwater standards or guidance values for numerous chemicals, including VOCs and PCBs. As with the on-site areas, off-site wells and springs were contaminated with chlorinated VOCs and PCBs. Shallow and intermediate bedrock groundwater had several low detections of VOCs. The deep bedrock wells were not contaminated above groundwater standards for VOCs or PCBs.

Based on the results of the RI/FS for the plant portion of the site, the NYSDEC in consultation with the New York State Department of Health (NYSDOH) has selected the collection of contaminated groundwater through an expanded recovery system and treatment at the facility’s treatment plant to remove contaminants and the installation and operation of an expanded DNAPL recovery system for Operable Unit 03 of the GE Fort Edward site. Treated groundwater would be discharged to the Hudson River through the existing permitted outfall. Separate phase oils will be collected and properly disposed in accordance with RCRA/TSCA regulations. This remedy is proposed to address the threat to human health and the environment created by the presence of VOCs and PCBs in groundwater above groundwater standards.

As described in the OU4 RI reports, soil, sediment and surface water samples were collected at this OU to characterize the nature and extent of contamination. Soil samples were collected from borings at selected locations and found to predominantly contain PCBs with some additional volatile and semivolatile organic compounds. The PCB-contaminated soils were found on and along the banks of the River. Almost 200 soil and sediment samples were collected from locations along and below the shoreline and below the surface of the Hudson River north and south of the former 004 discharge pipe. Soils immediately downstream from the former outfall contain very high concentrations of PCBs; concentrations diminish with distance from the outfall. A considerable volume of contaminated soil exists in the river along the eastern shoreline. Surface water sampling results from upstream and downstream of the 004 outfall area indicate that the site is an ongoing source of PCB to the Hudson River.

The NYSDEC, in consultation with NYSDOH, has selected removal and off-site disposal of all PCB-contaminated material from along the shoreline of the Hudson River in the vicinity of the former 004 outfall area.

A.3.4 Remnant Deposits

USEPA's 1984 Record of Decision called for in-place containment of Remnant Deposits 2, 3, 4 and 5, including capping and bank stabilization. The estimated annual scour of PCBs from the remnant deposits was approximately 3,900 kg/year (8,600 lb/year) in 1977 (Malcolm Pirnie, 1978). The bank stabilization with rip-rap was designed for a 100-year frequency flood of 41,400 cfs (Tomchuk, 2000). This design flow rate is less than the 47,000 cfs value used in the modeling effort (USEPA, 2000a), and is significantly less than the current estimated maximum 100-year flow rate of approximately 60,000 cfs. Due to changes in the management of the Hudson River, higher flows are now possible. The containment measures used to stabilize Remnant Deposits 2, 3, 4 and 5 should be re-examined in light of these higher flow rates.

Remnant Deposit 1, which is now three islands in the river adjacent to and slightly upstream of the GE Fort Edward outfall near RM 196.5, was not remediated.

As part of GE's baseline studies, four sediment samples collected in 1989 upstream of Remnant Deposit 1 and downstream of Bakers Falls; PCBs were detected at concentrations up to 3.54 ppm in these samples. Total PCB concentrations detected in samples collected at the southeast corner of the remnant island just upstream of the power line crossing ranged from less than 1 ppm to 99 ppm (Harza Engineering Co., 1990). Given these concentrations, areas within Remnant Deposit 1 would have mass per unit areas in excess of 3 g/m^2 and 10 g/m^2, meeting the criteria for consideration as target areas in the FS (see Section 3.5). Two surficial soil samples were collected by NYSDEC in August 1992 at Remnant Deposit 1. Total PCB concentrations in these samples were 1.6 ppm in a sample from a location in the center of the southernmost island and 12 ppm in a sample on the downstream face of the island (Ports, 1994c). Thus, in addition to the Hudson Falls source, contaminated soils/sediments in the remains of Remnant Deposit 1 may continue to be a scourable source of PCBs, via erosion, to the river upstream of the capped remnant deposits.

GE's sampling for the Post-Construction Remnant Deposit Monitoring Plan (PCRDMP) consisted of the collection of weekly water column samples at three locations, consisting of Fenimore Bridge (Route 27) above Bakers Falls near RM 197; Canoe Carry at RM 196.8 upstream of the remnant deposits and approximately 0.2 miles downstream of Bakers Falls dam; and Rogers Island Route 197 Bridge in Fort Edward near RM 194.3 (USEPA RM designation 194.2). Float surveys were also performed below Bakers Falls to monitor a mass of water as it traveled through the remnant deposits pool. Five locations were sampled in the center of the channel from Bakers Falls to Rogers Island, including RM 196.8, 196.4, 195.8, 195.3 and 194.7. PCB congener analyses (Method NEA-608) or PCB Aroclor analyses (EPA Method 8080) were conducted on these samples, with a method detection limit of 11 ng/L on a whole water basis, *i.e.*, the water samples were not field-filtered into dissolved and suspended matter (particulate) fractions (O'Brien & Gere, 1993). The Fenimore Bridge station was considered background with PCB concentrations in 1992 generally less than 11 ng/L and a maximum value of 44 ng/L in July 1992. Geometric mean concentrations at Canoe Carry and Rogers Island from March 1992 through December 1992 were 54 ng/L and 113 ng/L, respectively (O'Brien & Gere, 1993). Thus, either the PCB source from GE Hudson Falls was insufficiently mixed across the width of the river at the Canoe Carry sampling point, or a portion of the in-river load at Rogers Island was derived from an area below RM 196.8 rather than the Bakers Falls area.

According to GE, data from the 1992 PCRDMP showed that approximately 60 percent of the PCB mass in the water column at Rogers Island was detected upstream of the remnant deposits below Bakers Falls and the GE Hudson Falls sources. Elevated concentrations at Rogers Island resulted from "secondary remobilization of PCBs from the Bakers Falls source" which were stored in the remnant deposits pool with "contributions of PCBs from the remnant deposits being insignificant" (O'Brien & Gere, 1993). It was thus concluded that elevated concentrations of PCBs in the remnant deposits pool were primarily a result of an "unidentified upstream source(s) in the vicinity of Bakers Falls" (O'Brien & Gere, 1993) as described previously. The homologue and congener distributions of the in-river water column samples downstream of Bakers Falls to Rogers Island analyzed by GE showed predominantly Aroclor 1242, while the Hudson Falls source was characterized as unaltered Aroclor 1242. It was also shown by GE that elevated concentrations of PCBs did not correlate with high flow and high concentrations of total suspended solids (TSS) in the water column, suggesting that the PCB load occurred during non-scouring periods and was therefore not a result of scouring or erosion of the remnant deposits (O'Brien & Gere, 1993). The USEPA has not critically reviewed this conclusion at this time.

Mean total PCB concentrations at GE's Canoe Carry and Rogers Island sampling stations for the 1993 PCRDMP were 19 ng/L (standard deviation of 39 ng/L) and 38 ng/L (standard deviation of 169 ng/L), respectively, showing a reduction of in-river PCB concentrations compared to the 1992 PCRDMP, likely the result of remedial measures performed at Hudson Falls OU2A/B (O'Brien & Gere, 1994b). At a mean river flow of 6,275 cfs during GE's sampling period, these mean PCB concentrations translate into mean in-river loads of approximately 0.3 kg/day (0.6 lb/day) at Canoe Carry and 0.6 kg/day (1.3 lb/day) at Rogers Island. According to GE, PCB sources still persisted in the Bakers Falls area and were controlling water column concentrations in the remnant deposits pool, which remains as an unaltered Aroclor 1242 (O'Brien & Gere, 1994d).

GE also submitted the 1995 results for the PCRDMP to USEPA (GE, 1996). Samples were collected every week or every other week for a total of 33 sampling events in 1995. Total PCB concentrations ranged from not detected (less than 11 ng/L) to 381 ng/L (December 27, 1995) with a mean of about 32 ng/L (non-detected values, less than 11 ng/L, were taken as 5.5 ng/L) in samples from the Route 27 bridge above the Bakers Falls dam; less than 11 ng/L to 273 ng/L (June 7) with a mean of 32.5 ng/L at the Canoe Carry station below Bakers Falls; less than 11 ng/L to 362 ng/L (December 27) with a mean of 50 ng/L at the Rogers Island station; and from 14 ng/L to 237 ng/L (June 7) with a mean of 88 ng/L at the Thompson Island station. The summer 1995 data show an increase in PCB loading between the Rogers Island and Thompson Island Dam stations.

A.3.5 PCB Homologue Patterns at Rogers Island and RM 196.8 Near Bakers Falls

The PCB homologue pattern most often found at the GE Rogers Island water sampling station at the Route 197 bridge (RM 194.4) has an unaltered Aroclor 1242 pattern. This pattern is also seen at the RM 196.8 station below Bakers Falls. Figure A.3-1 shows the average homologue pattern for samples taken in 1997, 1998, and 1999 at RMs 194.4 and 197. The patterns match closely, with percent similarities (between the samples at RM 194.4 and RM 197) of 90 to 95 percent. This is evidence that the bulk of the PCB loading at Rogers Island comes from above RM 196.8. In addition, the patterns from 1998 and 1999 are similar to an unaltered Aroclor 1242 mixture. Thus, contamination from sediments altered by dechlorination are not evident in the water column these water column samples. While it is conceivable that scouring Remnant Deposit 1 could occur during high flow events, the expected altered water column pattern has not been found at the Rogers Island station, even during one-in-fifteen year flow events.

A.3.6 Upstream Boundary Condition

These sources contribute to the magnitude of the upstream boundary condition used in the modeling forecasts. The means of calculating this value, and the uncertainty surrounding this value (in particular, the affect of pulse loads), are discussed in section Appendix D (Risk Manager’s Toolbox).

A.3.7 Summary

The GE plants, Allen Mills and the Remnant Deposits have been and remain a source of PCBs to the water column, sediment and biota of Hudson River. Remediation of Allen Mills and efforts to control PCB releases to the Hudson River have reduced the PCB loading from the high levels observed during 1991-1993. At some point it may be necessary to re-examine the containment measures used to stabilize Remnant Deposits 2, 3 4, and 5 in light of recent flow rate estimates (USEPA, 2000a,b), which are higher than those upon which the design of the containment measures were based.

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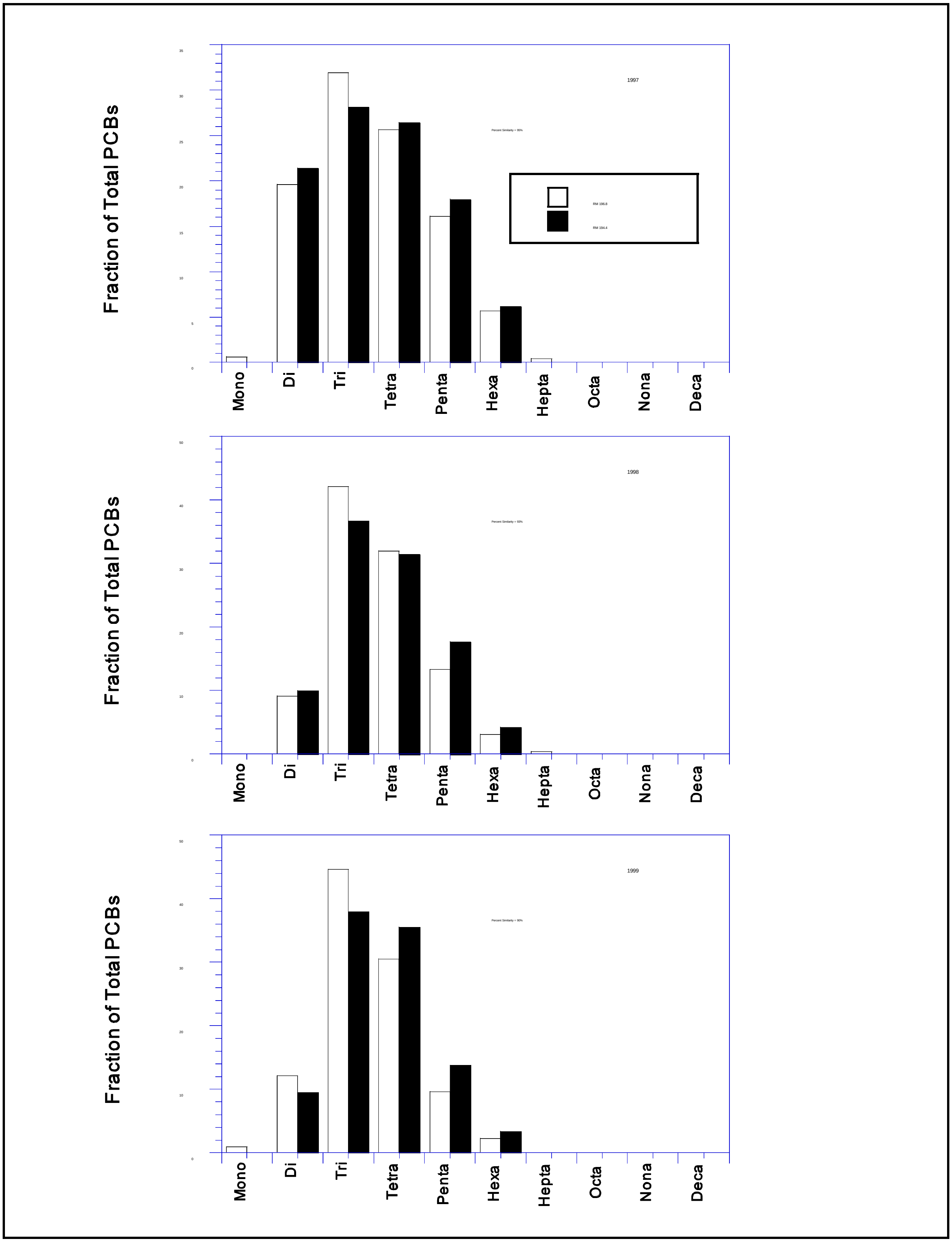

Figure A.3-1

Average Homologue Patterns at RM 196.8 and RM 194.4 (based on GE data)

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX A

BACKGROUND MATERIAL

A.4 Survey of Environmental Dredging Projects

Review of Remedial Projects
with
Significant Contaminated Sediment Removal Components

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Review of Remedial Projects with Significant Contaminated Sediment Removal Components

1.0 Objective

The objective of this report is to briefly summarize remedial work at various domestic and international remediation sites involving removal, handling, and disposal of contaminated sediments. In addition to describing the removal and materials handling technologies selected for those sites, an effort is also made herein to identify elements of each program that have relevance to potential sediment removal operations within the Upper Hudson.

2.0 Resources

The following organizations and information sources were researched to locate relevant information for the sites described in this document. The site survey program described herein was initiated by reviewing a database prepared by the General Electric Corporation (GE). Upon completion of that review, the research effort was extended to numerous other information sources so as to obtain more current data and, as well, data on sites not covered by GE.

Agencies/Organizations/Sources

USEPA Regional Offices
International Association of Dredging Companies (IADC)
Western Dredging Association (WEDA)
Central Dredging Association (CEDA)
Michigan Department of Environmental Quality
Wisconsin Department of Natural Resources
Great Lakes National Program Office
Fox River Group
International Joint Commission -US and Canada Great Lakes 2000 Cleanup Fund
Environment Canada
Ontario Ministry of the Environment
Dredging Contractors
Ontario Center for Environmental Technology Advancement
Technical Journals

Libraries and Databases

USEPA CERCLA Database
USACE Dredging Projects Database

GE Database
New York Public Library: Science, Industry and Business Library branch
    ASFA Part 3: Aquatic Pollution and Environmental Quality abstract database
    Environmental Engineering Abstracts database
    Environmental Sciences and Pollution Management
    Water Resources Abstracts
    Applied Science and Technology Index
    Carleton University and Ottawa University Libraries (Ottawa, Canada)

3.0 Findings for Domestic Sites

Table 1 provides a list of the domestic remedial projects selected for review in this report. Also shown on the table are several of the principal characteristics of each project with a focus on the dredging and materials handling component of the remedial work. In addition, for reference purposes, matters such as construction phase monitoring and water treatment technologies are also detailed.

A brief evaluation of the projects considered herein follows. The evaluation is based on information obtained from the previously identified databases, phone conversations with USEPA regional staff, and discussions with contractors and equipment vendors. As already stated, the information provided for each project is focused on aspects of the work that would have particular relevance to active remedies for the Upper Hudson.

Bayou Bonfouca, Louisiana. This was the site of a creosote works that operated from 1892 to 1970. The principal contaminants of concern were polynuclear aromatic hydrocarbons (PAHs) and the contaminated media were soils, sediments, and groundwater. Included within the final remedial strategy was the dredging of approximately 170,000 cubic yards of contaminated sediment and treatment of that material by incineration. Information provided by USEPA suggests that dredging represented less than 20% of the total cost of remediation (see Table 1 for costs).

Of particular importance is the fact that the sediment removal work was accomplished using a specially configured bucket excavator mounted on a barge. Computer controlled dredging sensors allowed a 3" dredge tolerance. In addition, since the contaminated sediments were relatively fine grained, multiple containment barriers (turbidity curtains) were employed to reduce migration of sediments.

Black River, Ohio - The Black River discharges into Lake Erie between Cleveland and Sandusky. US Steel operated a coking facility within the lower drainage basin that was considered to be a major source of sediment PAH and metal contamination. Ultimately, US Steel removed and landfilled 60,000 cubic yards of sediment at a cost of approximately $5 million.

From discussions with USEPA Region 5 it was determined that the work was largely accomplished using mechanical dredges outfitted with water tight clamshell buckets. Apparently, the major difficulty encountered during the work was movement of contaminated sediments to shoreside processing facilities. Alternative materials handling methods were tried including rolling containers off barges using a ramp leading to shore. Ultimately it was decided to unload barges using a shore based bucket unloader. The material handling difficulties at this site demonstrate the importance of establishing efficient material handling procedures.

Another facet of the Black River project worth noting is that fishery impacts increased immediately after dredging but then dramatically diminished as the full benefits of remediation took effect. During a phone conversation with staff of USEPA Region 5 they expressed the view that the sediment removal project is considered a success because the incidence of liver tumors in brown bullhead continues to be low.

Cherry Farm/River Road, New York - These two adjoining sites lie along the Niagara River shoreline, south of Grand Island Bridge. The sites were used for disposal of waste from steel manufacturing and then operated as an industrial landfill (flyash, bottom ash, foundry sand, slag, sludge, boiler cleaning waste, and miscellaneous debris). The targeted contaminants in river sediments were PAHs, though samples showed elevated levels of metals and PCBs as well.

The remedial program consisted of removing approximately 50,000 cubic yards of contaminated river sediment by means of a hydraulic cutter head dredge (the original specifications would have permitted either mechanical or hydraulic dredging). The sediments were pumped as slurry for several thousand feet to an on-site settling pond for final disposal. The contract documents specified a definitive cut line to which contaminated sediment removal was to occur. The acceptability of the work was to be determined by, among other means, a post-dredging bathymetric survey. A 120’ x 60’ area was capped instead of being dredged due to the steep slope of the sediments.

Commencement Bay, Washington - Sitcum Waterway, Hylebos Waterway, and Thea Foss Waterway are three sites in Project Area 4 of this site. Sitcum Waterway, contaminated with metals and PAHs, required dredging of 838,000 cubic yards of contaminated sediment from the Sitcum and Blair Waterways in 1994. These sediments were used to fill a nearby waterway, creating container storage space for the Port. The more highly contaminated sediment from the Sitcum Waterway was placed below the groundwater table and capped with the cleaner sediment from the Blair Waterway. Because the sediment was below groundwater, it was theorized that the contaminants would remain bound to the sediment matrix. This eliminated costs associated with installing liners and barriers. The dredging plan included staggered dredge cuts due to the variable sediment contamination pattern. This reduced the volume of material dredged.

The Hylebos Waterway, contaminated with PCBs, metals, and PAHs, contains about 940,000 cubic yards of contaminated sediment. Remediation is anticipated to begin in 2001. The remedial alternative chosen by USEPA includes dredging with a Toyo Pump (increases solids and reduces turbidity), slurry aeration (sediment treatment technology), and disposal into slips and an upland disposal facility. An interesting aspect of this project is USEPA’s decision to raise cleanup levels based on potential post-dredging natural attenuation.

Thea Foss Waterway and Wheeler Osgood Waterway contain sediments contaminated with PAHs, organics, and metals. Current recommendations are for dredging 620,000 cubic yards and capping 400,000 cubic yards of sediment. The dredged sediment would be placed in the St. Paul Waterway and an upland disposal facility. A final cleanup remedy selection is expected this year (2000).

Ford Outfall, River Raisin, Michigan - The remedial work at this location consisted of removing about 30,000 cubic yards of PCB contaminated sediments. The bulk of the dredging was accomplished using a Cable Arm bucket dredge. This bucket has been specifically designed to minimize resuspension of sediments by means of overlapping side plates and other features. After reaching shore, the dredged material was stabilized by adding about 15% cement. The stabilized sediment was stored in dedicated cells onsite. The sediments reached a strength of 25 psi after 1-2 days of curing. A number of problems were encountered at the site requiring the contractor to redredge several times in order to achieve final clean up goals. While many of the features of this project are relevant to the Upper Hudson, it appears that the targeted sediments were uniformly soft materials rendering use of the Cable Arm dredge particularly effective. Where some debris was encountered, a conventional bucket was employed to remove that debris.

Fox River, Wisconsin, Deposit N Demonstration - Deposit N is one of 34 PCB hotspots identified along the Fox River. It is a three-acre deposit and is situated in waters that are about 8 feet deep. The average PCB level of Deposit N is about 45 ppm and the sediments here are about 2 feet thick. The object of the demonstration project was to, among other matters, validate dredging using hydraulic equipment. During the late 1998 work period (work was halted by severe weather conditions), about 4,200 cubic yards of sediment were removed containing approximately 100 pounds of PCBs. Work resumed in August of 1999 on Deposit N and dredging of a second area, Deposit O, was initiated. The total amount removed from Deposit N was 7,160 cubic yards and from Deposit O was 1,030 cubic yards.

Bench scale tests were performed to establish dewatering system design. The target sediment water content corresponded to a minimum compressive strength of 0.4 tons/ft^2. The dewatering processing train produced a filter cake of 45% solids. The sediment ranged from a sandy/silt (containing higher PCB concentrations) mix to mostly sand (containing lower PCB concentrations). The sediment was dredged with a Morray Ultra dredge and pumped ¼ mile to shore. Silt curtains and 80 mil HDPE barriers fastened to the river bottom were used to control turbidity.

Relevant aspects of the Fox River situation include the project's positive experience with hydraulic dredging. In addition, the slurry processing train used is likely to have general applicability wherever hydraulic dredging is being considered.

Fox River SMU 56/57 – Dredging of another PCB-contaminated area in the Fox River was begun in 1999 and continued through 2000. About 80,000 cubic yards of contaminated sediment were targeted for removal by a hydraulic dredging system (horizontal auger). A woven geotextile perimeter silt curtain was used to control turbidity. The sediment slurry generated by the dredge was discharged into a series of holding tanks and then processed by means of flocculation, settling, and mechanical (filter press) dewatering. The dewatered filter cake contained about 55% solids and was carted to a state landfill (average PCB levels less than 100 ppm). The slurry processing train has proven to be a constraint on achieving desired productivity rates. To improve the situation, additional filter presses were added to the slurry processing system.

The turbidity barrier used on this project functioned well under typical river velocity conditions ranging between 2 and 3 feet per second; however the barrier system experienced some damage during a storm event when velocities approached 4.5 feet per second. Prior to dredging an area, a trackhoe has been employed to scavenge debris; this unit also loosened the sediment to be dredged. Over one recent period, dredging productivity averaged about 750 cubic yards per day (August through October, 2000) though productivity was exceeding 1,000 cubic yards per day as work progressed into October, 2000.

For those sites where the proposed remedial technology is hydraulic dredging, the Fox River experience demonstrates the importance of establishing a technically sound design basis for the sediment slurry processing system.

GM Central Foundry, Massena, New York - The goal of this project was removal of an 11-acre PCB area adjacent to the GM aluminum casting facility in Massena, NY. Approximately 13,800 cubic yards of sediment (auger dredge) and rock (backhoe) were removed. The work was accomplished within a sheet pile system when the designed double silt curtain containment system was found to be ineffective due to highly variable current speeds and variable current direction . Shoreline areas (less than 5') were isolated with a port-a-dam and dry excavated. Dredged sediment was dewatered and the resulting filtercake was stockpiled on-site for later off-site disposal.

While over 99% of the contaminated sediment mass was removed from the St. Lawrence River at the GM site, the clean up goal of 1 ppm PCBs was not met in all areas despite re-dredging efforts. A hot spot remaining in an area where the highest pre-dredging concentrations of PCBs were found (> 500 ppm), was isolated with a multi-layer engineered cap. The inability to reach the clean up goal in this area is attributed to the presence of a hard till layer underneath a thin layer of residual sediments.

Grasse River (Hot Spot), New York - This demonstration project involved removal of about 3,000 cubic yards of sediment and boulders that were contaminated with PCBs as a result of the operation of an ALCOA facility. The cost of the project was approximately $1,670 per cubic yard. Sediments were removed by means of an auger dredge. The presence of boulders significantly interfered with and reduced the efficiency of removal operations. A backhoe was used to remove boulders and some sediment was also removed by means of a diver assisted vacuum system. Resuspension controls included silt curtains, a sheetpile wall, and oil booms. Dewatered sediment was treated with lime and disposed in an onsite landfill.

Aspects of the Grasse River Project of interest include the fact that this was a demonstration project to determine the viability of the selected removal and materials handling systems. In addition, the river conditions encountered at this location include the presence of boulders, rock outcrops and a stepped river bottom. Alternatives for more extensive remediation of the Grasse River are under consideration. The PRP has expressed a preference for a remedy that involves capping by particle broadcasting instead of removal.

Housatonic River, Massachusetts – Cleanup on this river is divided in three segments: the first ½ mile adjacent to the GE facility (ongoing; hotspot cleanup is complete); the next 1½ miles downstream to the confluence; and the rest of the river downstream of the confluence. In 1997, GE excavated and disposed of 5,000 cubic yards of heavily contaminated sediment (1,534 ppm average PCB) from a 550' section of river and 170' of riverbank (the hotspot area). Sheetpile was used to divert the flow and standard excavating equipment was used to excavate in the "dry." Sediments were gravity-dewatered on a pad.

In October 1999, remediation of the second phase of the first ½ mile cleanup began. Sheetpile was driven in the middle of the river channel, diverting half of the river flow. Removal is being conducted in the "dry" using conventional equipment after dewatering. Targeted sediments range to a depth of 2.5 feet. Contamination deeper than that will be capped with a silty sand sorptive layer and then covered by an armoring layer. Cleanup is expected to be complete in May 2001. Two more extensive removal actions are planned for the next 1-1/2 miles of the river. Of interest here is the dry removal strategy and the sectioning of the project into a number of individual stages.

LTV Steel, Indiana - The LTV site is located along the south shore of Lake Michigan. LTV discharged waste oils and heavy metals; PCBs were also found in nearby Lake Michigan sediments. USEPA determined that since the contaminated sediments did not pose a current health or ecological problem, it would be appropriate to specify a sediment removal elevation or depth as opposed to specifying removal requirements established by risk analyses.

Originally it had been planned to conduct removal operations by diver assisted vacuum systems in order to minimize sediment resuspension (to protect plant intake water quality). Production rates with the diver assisted systems proved very low; the next approach was to use a suction dredge which tended to clog with debris. Finally, a cutterhead/suction unit was installed and the work was able to proceed largely uninterrupted by debris. Silt curtains and floating booms were used to control turbidity.

There are several relevant aspects of the LTV project. These include the fact that the USEPA specified a cut limit for the removal work since health and ecological risks were not considered significant. Also, the success with the cutter head could be relevant to other contaminated sediment sites.

Manistique River, Michigan - The Manistique River, located in Michigan’s Upper Peninsula, flows generally south into Lake Michigan at the town of Manistique. The area of concern is the last 1.7 miles of river from a dam to Manistique Harbor. USEPA’s original strategy was to cap the PCB-contaminated sediments. However, based on the results of a small-scale demonstration project (1995), the Agency changed from capping to dredging. The Agency was of the view that 13,000 to 14,000 pounds of PCBs could be removed, leaving behind between 140 and 700 pounds of contaminant. USEPA also determined that sediment resuspension could be adequately controlled by means of silt barriers. Residual sediments with PCB levels greater than 10 ppm would be capped with sand. It was expected that the river would eventually be fully restored as a result of the removal.

During 1995 about 10,000 cubic yards of material were dredged from the North Bay area. Most of the material went to a non-TSCA landfill but about 3% was shipped by rail to TSCA facility in Utah. A cofferdam and silt barriers were installed to contain suspended sediments during dredging. USEPA and the PRPs worked closely and successfully to accomplish the project.

In May 1997, an agreement was reached to remove about 120,000 cubic yards (18,000 pounds of PCB) of sediment from the river. The project was expected to take about 5 years and the PRPs would be absolved from further responsibility. The PRPs would pay a cost equivalent to that for capping the sediments. PCB concentrations were estimated to be in the range of hundreds of parts per million with the highest concentration being 2,510 ppm. About 105 pounds of PCB were estimated to be discharged to Lake Michigan each year and greater loss was expected to occur during severe storms. Sport fish were being impacted by PCB contamination.

The recommendation to dredge was controversial with the PRPs and the local community. USEPA was recommending, in part, that the dredged material be disposed in a local landfill. The opposition was partly based on concern over sediment resuspension during dredging. Opponents recommended capping. However, once USEPA conducted their 1995 dredging demonstration successfully, the community and PRPs supported the dredging alterative. One factor that influenced the support was USEPA’s use of diver assisted dredging techniques for removal. In addition, by separating the dredged material into a large volume non-TSCA fraction and a small volume TSCA fraction, the disposal issue was largely resolved. Thus USEPA proposed a total dredging remedy for which the PRPs agreed to pay $6.4 million. USEPA anticipated completing the Manistique project in 2000.

The 1995 dredging was accomplished by dive teams using vacuum removal methods. In addition, a small auger dredge supplemented the work of the dive teams. Further work (post 1995) was accomplished by means of a hydraulic cutterhead which was ultimately fitted with twin suction pumps. It has been reported that 62,000 cubic yards of bottom materials were removed in 1997 and 31,000 cubic yards in 1998 and that between 28% to 47% of dewatered materials (post 1995) were disposed in a TSCA landfill. Based on phone conversations with USEPA regional staff, it was determined that the hydraulic dredge discharged to a hopper barge which then proceeded to a pump out station.

Several aspects of the Manistique situation are potentially relevant to other sites. USEPA conducted a demonstration project that gained acceptance for large-scale removal of contaminated sediments. In addition, the combination of dredging and water transport technologies (hydraulic dredge discharging to hopper barge) selected for Manistique is an interesting though infrequently used concept. Finally, the use of hydrocyclones to separate dredged materials into cleaner and more contaminated fractions can reduce overall project costs by increasing management options and thereby decreasing disposal costs.

New Bedford Harbor, MA (Hot Spots) - This port city, about 55 miles south of Boston, experienced industrial discharges of PCBs. USEPA originally divided the site into three units with the first unit comprised of those locations on the west side of the Acushnet River estuary where PCB levels in sediments exceeded 4,000 ppm (hot spots). With assistance from the Corps of Engineers, a pilot project was conducted to establish the preferred dredging technology for sediment removal (technologies were cutterhead, horizontal auger, and match box dredges). The cutterhead dredge, constrained by site specific operating procedures to limit sediment resuspension, was selected as the preferred technology.

Hot spot sediments were originally to be incinerated. However, community and congressional opposition led USEPA to store the sediments in a shoreline confined disposal facility until a permanent disposal solution could be found. In December 1999, USEPA announced that the dredged material removed from the hot spots would be stabilized and shipped by truck to a remote off-site landfill (14,000 cubic yards).

On October 1, 1998, the USEPA announced its decision for the rest of the New Bedford site. The decision calls for dredging approximately 500,000 cubic yards of sediment. In New Bedford's upper harbor, sediments above 10 ppm PCB will be removed while in its lower harbor sediments above 50 ppm PCB will be removed. In addition, certain popular though contaminated shoreline areas will also undergo soil/sediment removal. All dredged material will be discharged into one of four shoreline confined disposal facilities for final disposal. Entrained water will be decanted, treated and discharged back to the harbor. A cap, possibly of navigational dredged material, will be placed over the contaminated sediments and the confined disposal facilities (44 acres) will ultimately support recreational activity.

The design is complete for one of the CDF cells which will probably be built during Spring 2001. Dredging is expected to commence in 2002. A pilot project was conducted in August 2000 wherein a European technology, the horizontal profiling bucket fitted to a hydraulic excavator, was tested. The bucket was designed to be fully enclosing and could take a wide, shallow cut of sediment. The excavator and bucket position was established by an onboard digital geographic positioning system coupled to additional electronic components that enabled relatively precise control and monitoring of system operation. A somewhat unique aspect of this demonstration was that while removal was by mechanical methods, the sediments were re-slurried and pumped a short distance to shoreside ponds or cells. The objective was to avoid handling the large quantity of water that would be generated by hydraulic dredging operations.

As already suggested, several aspects of the New Bedford situation are of interest. Among these is the recent demonstration of the horizontal profiler which, in concept, will allow productive mechanical dredging to occur even where relatively shallow cuts are being taken. Additionally, the novel approach of coupling mechanical removal operations with slurry transport may have some application to other remedial work. Finally, USEPA's decision not to incinerate sediments but rather stabilize and ship them to an remote off-site disposal facility may be of relevance to the Upper Hudson site.

Ottawa River, Ohio – The Unnamed Tributary was historically an oxbow in the main channel of the Ottawa River that has since been re-channelized. PCB concentrations in Unnamed Tributary sediment were reported as high as 74,000 ppm. The Tributary was isolated with a sheetpile cofferdam and excavated in the dry. The soft silty sediments were stored on a staging pad for gravity dewatering and then combined with 8-10% Pozzament for transport to offsite landfills.

The City of Toledo is conducting 9 sediment capping demonstration project on a 2.5 acre portion of the Ottawa River. The river has elevated levels of PCBs, PAHs and various metals in the project area. Three sediment caps of different design were installed along a 2.5 acre section of the River. The principal component of each design is AquaBlok^{TM}, a composite aggregate comprised of a solid dense core surrounded by a clay mineral-based (bentonite-rich) coating fixed to the core with polymers. The material hydrates and forms a cohesive, low-permeability, erosion-resistant barrier. Various installation techniques were also demonstrated in this project: using a barge-based telescoping conveyor; using a helicopter; and from shore using a dragline. Post-capping survey data indicated that good spatial coverage was achieved. A benthic invertebrate organism study was conducted last summer and this summer to determine if organisms colonized the encapsulated areas. Depending on the results of this study, this procedure could be applicable to other riverine projects using capping as part or all of their remediation.

Outboard Marine, Waukegan, Illinois - This site is on the west shore of Lake Michigan. A marine products manufacturer discharged PCB-laden hydraulic fluids into the harbor. There were an estimated 700,000 pounds of PCB on-site and 300,000 pounds in Waukegan Harbor. Navigational dredging within the Harbor had been severely hampered by the presence of highly contaminated sediments. USEPA's 1989 ROD called for isolation from the general harbor of the most contaminated Outboard Marine slip (Slip No. 3) and removing and treating those sediments with PCBs in excess of 500 ppm. Less contaminated harbor sediments were to be dredged and placed into the isolated Slip No. 3 containment structure, which would ultimately be capped.

About 27,000 cubic yards of sediment were removed from the harbor by means of a hydraulic dredge. Bottom-anchored silt curtains were used to control resuspension. Approximately 23,000 cubic yards of sediments were removed from the isolated slip and processed by thermal desorption. Harbor sediments were then placed into the isolated slip after it had been partially dredged and capped with clean sand. USEPA's target for the harbor cleanup was removal, containment, and treatment of contaminated sediments down to 50 ppm PCB. This target was derived from a site-specific modeling analysis which showed that below a 50 ppm residual sediment level, little additional PCBs would be discharged to the Lake. USEPA estimates that about 900 kg of PCBs remained in harbor sediments after the cleanup. Since these residual sediments are potentially resuspended by navigational activity, a further effort is underway to resolve the problem.

The contract documents for the harbor dredging specified that removal be accomplished to a stated elevation or to a designated soil type. This approach was expected to achieve the less than 50 ppm target. It is also reported that harbor bottom samples taken in 1996 showed PCB levels less than the targeted level of 50 ppm but also indicate the presence of heavy metals which were not considered in the ROD. Of potential relevance to the Upper Hudson situation is that the project's contract documents specified detailed removal requirements in terms of elevations and residual soil type. In addition, functioning of the hydraulic dredge appeared satisfactory.

Additional dredging funded by the City of Waukegan and the Army Corps of Engineers is planned for 2002. The goal is to remove PCB contamination and restore adequate navigation depths for commercial shipping.

Reynolds Metals Company, New York – Sediments in the St. Lawrence River adjacent to the Reynolds facility have been contaminated with PCBs, aluminum, furans and PAHs due to discharges from four permitted outfalls. EPA's plan of action consists of dredging approximately 77,600 cubic yards of contaminated sediment. Sediment with PCB levels below 50 ppm will be disposed onsite: sediment with PCB levels between 50 and 500 ppm will be shipped offsite for disposal in an approved landfill. Sediment with PCB levels above 500 ppm will be sent to an offsite facility for treatment.

In the Final Dredging Program Work Plan (February 2000), the removal equipment chosen is the Cable Arm Environmental Bucket, a closed bucket clamshell. This removes sediment at high solids content in precise increments while minimizing resuspension. A cantilevered steel sheet pile system will be used to enclose the dredging area; then an internal silt curtain will separate a non-contaminated area from the actual work zone. Dewatering will be by gravity drainage with solidification as needed. Water treatment will be conducted onsite with discharge to the St. Lawrence River.

Saginaw River/Bay, Michigan - The Saginaw River/Bay is one of the 43 Great Lakes Areas of Concern. Dredging of 345,000 cubic yards of PCB-contaminated sediment from 5 hot spots in the lower Saginaw River began the week of April, 2000. The goal is removal of about 90% of the PCBs in the river and bay and is expected to be completed in November 2000. 160,000 cubic yards has been dredged so far. A Cable Arm bucket is being used to minimize turbidity. A convention clamshell is utilized when wood debris is encountered. Turbidity monitoring and air monitoring are being conducted; to date no particular problems have been reported. The removed sediment is transported by barge to an approved disposal facility with no further treatment.

Sheboygan River/Harbor, Wisconsin - About 14 miles of the Sheboygan River sediments became contaminated when soils, used to construct a flood protection dike, eroded. The soils had been contaminated with PCBs by historical industrial activities. After conducting a RI/FS, the PRP proposed and implemented a pilot program to remove certain sediment deposits (4,000 cubic yards) closest to their facility and to armor additional nearby deposits. The removal was accomplished using a sealed clamshell and a backhoe. The armoring consisted of placing a geotextile fabric over the deposit, covering this with one foot of gravel, and then placing a second geotextile over the gravel. The top fabric was anchored with gabions and then covered with rip-rap.

In-river testing was conducted both before and after the pilot remedial work. Results of the program were inconclusive with some parameters improving somewhat (sediment loads) and others showing little observable trend (fish levels). Approximately four years after remedial work was completed observations were also made of the physical condition of the armoring systems. Armoring along the banks appeared stable. Armoring systems within the river experienced loss of rip-rap and gravel in some cases. It was concluded by Wisconsin Department of Natural Resources that the condition of in-river armoring systems was difficult to ascertain and that their overall performance and longevity raised numerous questions.

USEPA issued its FS for the overall river PCB contamination problem in 1998. A record of decision was signed on May 12, 2000, which calls for the removal of about 21,000 cubic yards of sediment from the Upper River and 53,000 cubic yards from the Inner Harbor. The Agency, using health and ecological risk methods, determined that the selected alternative should remove sufficient river sediment to provide a residual sediment PCB level of 1 ppm after 30 years. A dredging technology has not yet been selected for removal of river sediments. However, USEPA anticipates using a clamshell dredge for removal work and then stabilizing the sediments before they are hauled to final disposal.

An aspect of the Sheboygan situation of relevance is the effort by the PRP to armor in-river sediments. Wisconsin DNR has expressed reservations over the effectiveness of the pilot program and has requested considerably more information before they would give further consideration to this technology. Observed damage to the armoring system and continued water column PCB levels were factors in WDNR’s negative assessment.

United Heckathorn, San Francisco Bay - This site supported a number of different chemical operations that discharged residuals to nearby Lauritzen Canal, which is within Richmond Harbor adjacent to the Bay. Sediments in the canal were found to have elevated levels of DDT and dieldrin, among other contaminants. In 1990 USEPA issued an order requiring immediate removal of 2,500 cubic yards of contaminated soil; in 1994 USEPA recommended dredging of the Canal’s contaminated marine sediments.

Canal dredging was accomplished using an enclosed bucket (smoothed edge clamshell) to minimize resuspension. Silt curtains were deployed at the ends of the canal to contain material that may have become waterborne. Ultimately the marine sediments were shipped to remote landfills in Arizona and Utah. Problems encountered during remedial work included debris fouling of sediment processing facilities, inefficient rail operations and public opposition to the Arizona landfill site. Several of these matters may be relevant to an Upper Hudson remedy.

Willow Run Creek, Michigan - This site consists of a series of lagoons and ponds that stored PCB-contaminated sludges from various industrial facilities. The cleanup plan consisted of isolating the lagoons from the nearby stream, dewatering the lagoons and then stabilizing the sludges. The stabilized sludge was excavated and disposed at a nearby landfill. Ultimately, over 300,000 cubic yards of sludge/sediment was removed at a cost exceeding $50 million. Isolation of the lagoons was accomplished with thousands of feet of sheet pile and excavation of stabilized material was by means of a pontoon/tracked excavator.

Several aspects of this project may be of interest. The concept of in-situ stabilization appears unique to the Willow Run site. However, the approach may have some applicability to deposits that lay in back bays and secondary channels. In addition, use of sheet piling to isolate a work area may be a viable strategy for particular contaminated sites.

4.0 Findings for International Sites

It was determined from the database research and phone conversations with Environment Canada's regional representatives that a number of environmentally oriented Canadian dredging projects have occurred in the Great Lakes Basin. Environment Canada's Remediation Technologies Program has produced both pilot and full-scale dredging projects that have had their environmental performance fully evaluated. Summaries of several Canadian and European projects are presented below and in Table 2.

Welland River, Ontario

The Welland River Reef remediation project was selected for funding under Environment Canada's Great Lakes 2000 Cleanup Fund. It was a full-scale demonstration intended to show that contaminated sediments could be removed from a riverine environment, using innovative dredging techniques, without contaminating downstream areas. The full-scale program (1995) was preceded by a pilot scale effort (1991) to demonstrate the viability of dredging and treatment technologies.

The project consisted of removing two contaminated sediment deposits (about 11,000 cubic yards) that had accumulated in the Welland River near two sewer outfalls. An Amphibex dredge (a combination mechanical/hydraulic suction machine) removed about 75 percent of the material and a long-reach backhoe (land-based) accomplished the remainder of the work. The contaminated deposits consisted of industrial mill scale (granular metallic particles) and solvent extractable contaminants (oil and grease). The width of the river varied from 40 to 60 yards and depths were relatively shallow.

The Amphibex dredge was fitted with a pump bucket on its backhoe-style arm. Configured in this manner, the dredge was able to remove both river sediments and floodplain materials, which consisted of root mass and stalks from aquatic vegetation. The machine's backhoe feature enabled removal of larger debris. The unit's overall production rate was estimated at about 27 cubic yards per hour (productivity greater on fine-grained materials than on coarse materials). Dredging was accomplished within a geotextile curtain to control the movement of resuspended materials. Use of the curtain was considered to be particularly necessary when fine-grained materials were being handled. The Amphibex equipment experienced some difficulty in maintaining the planned removal rate due to debris and the high specific gravity of mill scale. The long-reach backhoe was used to improve overall project productivity.

This project demonstrates the use of an amphibious excavator in a riverine environment. One factor leading to selection of the excavator was its ability to access the Welland River by walking into the river using its spuds, backhoe bucket, and stabilizers. This feature has applicability to areas where contaminated sediments have deposited in shallow shoreline areas or secondary channels. The relatively low productivity of the unit may pose a problem in some instances.

Northern Wood Preservers, Thunder Bay Harbor, Ontario

This site is situated along the Thunder Bay waterfront adjacent to Lake Superior and is the location of a plant that produces, among other items, creosoted wood products. The facility is situated on a solid core pier extending about 300 meters into the harbor. The harbor bottom in the immediate pier vicinity was contaminated with PAHs, dioxins, furans, and other industrial chemicals. Environment Canada developed a plan that consisted of, among other matters, removing acutely toxic sediments and enclosing the pier so as to limit further leaching of contaminants into the harbor.

In the process of developing a remedial strategy Environment Canada reviewed various dredging technologies including the Mudcat horizontal auger, Cable Arm bucket, Pneuma dredge and the Amphibex excavator. The agency yards concluded that either the Cable Arm or Amphibex system would be preferred for this site. Based on information currently available it appears that the Cable Arm was actually selected for sediment removal because it avoids the need to handle and process the dredged material in slurry form.

The same factors that came into play at this site may at other contaminated sediment sites. Sediment removal by hydraulic methods will involve handling a slurry containing somewhere between 10% and 20% solids. Considerable processing would be needed before the slurried sediments can be finally disposed. On the other hand, use of mechanical methods to remove sediments will involve setting up one or more transfer facility operations.

Collingwood Harbor, Georgian Bay, Ontario

This site is situated at the south end of Georgian Bay, which is an embayment of Lake Huron. Historic ship building and repair activities resulted in some sediments within the harbor having high levels of metals, PCBs and other constituents. The maximum depth of the harbor is 21 ft. Environment Canada selected this site for demonstration of the Pneuma Pump technology.

During the demonstration project about 2000 cubic yards of sediments were removed from a shipyard slip. Ship repair debris within the slip caused numerous and lengthy down times for the Pneuma system. After the slip demonstration project, the Pneuma dredge was used on a larger scale cleanup of the harbor (11,000 cubic yards in 1993) and also supplied borrow material for construction of a landfill cap. Apparently, Environment Canada views the Pneuma system as having operated successfully under the conditions present in Collingwood Harbor.

Hamilton Harbor, Toronto Harbor, Pickering NGS, Ontario

Demonstration of the Cable Arm clamshell bucket occurred at Hamilton and Toronto Harbors under the Environment Canada Remedial Technologies Program. Dredging at the Pickering Nuclear Generating Station (NGS) was a commercial application of the technology. The demonstration began in 1991 at Hamilton and commercial application occurred in 1993.

The first Hamilton Harbor demonstration had the goal of demonstrating both the Cable Arm system and obtaining about 10 cubic yards of contaminated sediment for use in a treatability study. The bucket used here was open and sediment spillage was observed from the bucket top. The concept of an enclosed bucket was, in part, derived from this demonstration.

For the next demonstration at Toronto Harbor, Cable Arm enclosed their bucket and also incorporated vents and rubber seals to improve performance. About 275 cubic yards of contaminated sediment were removed during this demonstration with approximately 49% solids content. A production rate of 17 cycles per hour was attained in about 27 feet of water.

Based on this demonstration, further modifications were made to the bucket. These modifications included additional seals, use of inner side plates, and epoxy coating of the bucket. The changes were demonstrated in a second Hamilton Harbor demonstration which involved removal of about 170 cubic yards of contaminated sediment. Based on results of the second Hamilton program, the Cable Arm system was selected for dredging at the Pickering complex. Based on the Canadian demonstration projects, it appears that considerable effort has gone into designing features into the Cable Arm bucket that reduce sediment resuspension during removal operations. In addition, effort has been made to increase dredging productivity when this system is used. Based on the Canadian evaluation, the Cable Arm system has been selected for removal work at several US remedial sites.

Severn Sound, Georgian Bay, Ontario

Severn Sound is composed of a group of bays in the southeastern portion of Georgian Bay on Lake Huron. In 1993 an unusual meteorological condition exposed a portion of the Bay’s shoreline showing a large accumulation of debris from wood products manufacturing including logs, slabs and sawdust. In 1994 a cleanup program was implemented that resulted in removal of about 4400 cubic yards of wood wastes. Approximately 90 percent of the work was accomplished using a grapple with the remainder of the material removed by a Visor Grab dredge.

The Visor Grab unit operated for about 14 hours with a production rate of about 30 cubic yards per hour. Debris not removed by the grapple routinely prevented the Visor bucket from fully sealing. However, it was observed that little of the fine material resuspended during removal operations migrated outside the confined work area (enclosed by silt curtain). Environment Canada concluded that the Visor unit has the potential to remediate contaminated sites if some minor modifications were made to the equipment.

Lake Jarnsjon, Sweden

The Eman River in southeastern Sweden is about 140 miles long and has a mean average discharge at the Baltic Sea of about 900 cubic feet per second. Approximately 400 kg of PCBs accumulated in Lake Jarnsjon (area of about 60 acres with typical depths of 4 to 6 feet) as a result of paper manufacturing in the Eman watershed. The continuing discharge of PCBs from lake sediments was expected to cause ecological problems in the river until at least the year 2060. The contaminated sediments were described as soft organic sediments (partly decomposed fibers) with a mineral silty content.

Two factors controlled the selection of sediment removal technology: required low resuspension of sediments during dredging and low water content to reduce slurry volume. Dredging was carried out using a suction dredge with a specially designed auger head. An unusual feature of the auger is that it was designed to oscillate from right to left in front of the dredge. Also, in order to reduce resuspension, a cap of steel plates was installed over the auger head. The dredge was equipped with a positioning system that provided a vertical accuracy of 10 cm and a horizontal accuracy of 5 cm. This equipment functioned best when soft sediments were being removed. A mechanical dredge was used when denser materials were encountered. Ultimately, about 170,000 cubic yards of material were removed containing about 394 kg of PCB.

Prior to sediment removal it was estimated that by using a hydraulic dredge a spillage rate of 1 percent or less could be achieved. In order to further control the spread of resuspended sediments, removal of the most-contaminated material was planned to occur within a geotextile screen. Also, dredging was halted during the most ecologically sensitive time of the year. In general, PCB concentrations recorded in the river during dredging were considered to be no higher than those recorded prior to remediation. However, higher suspended sediment loads were observed leaving the lake when mechanical dredging occurred outside the protective screen.

One of the important factors related to this project is the extensive modeling that occurred prior to initiating the work (mathematical and physical modeling). In addition, great effort was expended monitoring the river and lake (PCBs, TSS, flows, temperature, etc.,) during the removal program so that a full evaluation of the program’s success could be made.

Port of Hamburg, Germany

This German port is situated near the mouth of the Elbe River, which is approximately 700 miles long. In order to maintain port operations about 2 million cubic yards of sediment must be dredged each year. Due to the highly industrialized nature of the Elbe watershed, harbor sediments exhibit high levels of contaminants, particularly heavy metals. Historically, disposal of dredged material had been in polders but as the contamination problem began to be understood, an alternative dredged material management strategy was adopted by the Port.

The basis of the strategy developed for Hamburg is that contaminants are fixed to fine grained sediments and, therefore, the coarse grained fraction (sand) can be regarded as clean. As a result, sand can be usefully separated from the silty fraction and the silt disposed in a confined disposal facility. In order to implement this strategy a processing facility was built ($80 million) and began operation in 1993. This facility screens out coarse fragments and debris and then separates the sand fraction from the dredge material by means of hydro-cyclones and classifiers. Silts are thickened and then dewatered by means of belt and filter presses. Ultimately, the incoming dredged material is separated into approximately equal fractions sand and silt by weight.

The viability of handling sediments found in Hamburg Harbor (and also in Rotterdam and Amsterdam, Netherlands) depends on several factors. It would be necessary for the contaminants to be principally bound to fine grained materials. In addition, it would also be necessary to find that in the process of removing the fine grained sediments a substantial fraction of coarse grain material would also be removed. The coarse fraction could then be separated and handled as a relatively clean by-product.

Ketelmeer, Netherlands

This is a large-scale Dutch remedial project occurring in an embayment of Ijsselmeer at a point where the River Ijssel discharges into a lake. The River Ijssel is essentially a component of the Rhine River delta that encompasses much of Holland. Sediments here, laden with metal and organic contaminants, were creating significant ecological and public concern. The strategy executed involved the removal of the contaminated sediments and placement into a secure impoundment in the center of the lake.

The removal work was conducted by means of large backhoes with onboard computer positioning systems directing the actual dredging. The project was vast in scale and involved as many as ten dredging machines operating simultaneously to both create the storage impoundment (actually an island with an enclosing berm or dike) and remove contaminated sediments from the lake bottom. At the impoundment, dredged material was moved by a conveyor system from barges to the permanent storage area.

There are several aspects of the Ketelmeer project of importance. The scale of remedial work here is substantial. The use of backhoes may have applicability to a wide range of sediment types. Obtaining information on the perormance of these machines (particulalrly in terms of sediment resuspension rates and precision of removal operations) would be of considerable value for remedial work in general. The use of conveyors to move silty dredged material from barges to the impoundment island appears to be a novel technique for handling fresh sediments. Finally, given the large number of dredges and materials handling techniques being employed at this site, there is every reason to believe that much useful information could be obtained for application to remedial work in the US.

Hudson River PCB Reassessment Feasibility Study

Domestic Remedial Projects Using Sediment Removal Technologies

Summary Charateristics - Table 1

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control/Barrier during Dredging	Dredging Cost/ Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
Bayou Bonfouca									
PAHs (creosote)	Remove sediments > 1,300 ppm PAHs	* 15 months (9 hrs/day, 5 d/wk) * 169,000 cy	* Mechanical dredge with 5.2 cy bucket. * Fitted with sensors & controls to achieve 3-inch dredging tolerance.	* 5 layers of silt curtains, 2 near the dredge and 3 in succession away from the dredge. * 5,000 feet of sheetpiling for bank support	* $ 21.1 milion, $125/cy dredging *$115 million total	* Air - Continuous real time air monitoring in work zone. * Water - No water monitoring done in river during dredging. * Post dredging: removed targeted sediment to predetermined depths.	* Transfer from dredge to barge-mounted slurry processing unit (SPU); pumped via an 18-inch pipeline from SPU to a 2.5-acre onsite retention pond * Dewatered and incinerated	* 500 gpm WWTP. Water to a clarifier then through bioreactor/GAC * 171 million gallons	* Rocks, debris, logs prevent bucket closure. * Oil slick on water during dredging.
Black River									
Metals; PAHs	Remove sediments to natural till layer	* 5.5 months * 60,000 cy	* Cutter head and clamshell. * Operations switched between mechanical and hydraulic systems.	None	* Cost for dredging not available. * Total cost $ 5 million.	* Air - No monitoring. * Water - Samples obtained from upstream and downstream sampling points prior to dredging and for two weeks after dredging. * Post dredging: soundings were used to evaluate dredging results	* Dredges discharged into rolloff boxes either on barges or on shore. * Permanent disposal into a project-specific landfill located about one river mile from work area.	* Dedicated wastewater treatment facility at landfill; treated water discharged to the river. * Volume not available	* Project delayed pending identifying disposal site. * Changed dredges to meet site conditions.
Cherry Farm									
* PCBs - on-site sediments. * PAHs and metals-Niagara River sediments.	<20 ppm or <50 ppm PAH depending on dredging depth	* 6 months, 12 hrs/day, 6 days/wk * 50,000 cy	Cutterhead dredge was chosen because sediment was too consolidated for clamshell dredging.	Silt curtains were placed along weed beds to minimize impact of dredging on the beds.	$ 2.2 million $ 50/cy total (except for disposal)	* Air - Periodically near onsite disposal pond during placement of sediments. * Water - Real time turbidity monitors were located downstream of dredging operations. * Post dredging: sediment removal completed to predetermined removal elevations.	* Sediment pumped via 5,000 ft pipeline from dredge to on-site 2-acre disposal pond. * Pond Capped	* No water treatment; polymer addition and gravity settling.	* Sediments were more consolidated than originally anticipated and required replacement of the original cutting head.
Commencement Bay, Hylebos Waterway									
PCBs, PAHs, metals	* 450 ppb PCB after cleanup * 300 ppb PCB after year 10	* Work has not commenced	* small removal action area going to use Toyo pump (smaller slurry ratios) for loose/non-debris material in combination with a mechanical dredge for consolidated/debris areas	not available	not available	not available	not available	not availalble	not available

Hudson River PCB Reassessment Feasibility Study

Domestic Remedial Projects Using Sediment Removal Technologies

Summary Charateristics - Table 1

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control/Barrier during Dredging	Dredging Cost/ Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
Commencement Bay - Sitcum Waterway									
Metals, PAHs	* Two feet below contaminated sediments, or * To navigational depth.	* 11 months, 6 days/week, 24 hrs/day. * 2.83 million cy, including 2.4 million cy from Blair and 0.425 million cy from Sitcum Waterway.	* Various hydraulic and mechanical dredges. * Size dictated by work area (open water versus interpier zone). * Hydraulic dredging principally selected because of sandy sediments.	* Not used at dredge site.	* dredge and place: $2-5 per cy. * dredge at/under piers: $25 per cy.	* Air - none. * Water - DO, turbidity, and temperature monitored 3 times per day at work and disposal areas. Results did not exceed compliance levels. Elevated zinc levels were measured but did not halt dredging.	* Sediments disposed in subaqueous containment by filling existing canal. * Canal bermed and sediments discharged to cell either hydraulically or from scow. * Clean sediments used as cap. * Site of future marine terminal facilitiy.	* Overflow from containment cell to waterway.	Dredging tidally influenced. Thus, two-foot overdredging allowance.
Ford Outfall									
PCBs	10 ppm PCBs or sediment removal down to native clay.	* Approx. 51 days over 3 months for dredging (8 hours per day, 5 days per week). * 28,500 cy	* 4 cy and 6 cy Cable Arm bucket; supplemented by conventional clamshell for debris. * Clamshell bucket was chosen to minimize resuspension and water volume to be treated.	3,000 l.f. of silt curtain including an outer curtain and an inner curtain around the dredging area.	$10 million (total) $62 per cy - water-side costs	* Air - Performed (no details). * Water - Water column monitoring for PCBs during first week of dredging. Action levels not exceeded. * Post-dredging: At completion of redredging, 3 of 7 sub-areas exhibited somewhat greater than 10 ppm PCBs.	* Dredge dumped contaminated sediments into a three-compartment scow. * Wet sediments unloaded from barge, truck hauled to processing site, stabilized, and disposed.	* Inclined plate clarifier, bag filters, activated carbon, and sand filters. * 1,041,000 gallons	* Redredging required due to suspended sediment settling and disturbance to silt curtain and bottom conditions by passing freighter.
Fox River - (Deposit N/O)									
Mainly PCBs (1242); metals (mercury) to a lesser extent.	Remove sediments to an underlying hard-pan base	* Nov-Dec 1998 *Aug-Oct 1999 *Oct-Nov 1999 7,160 cy from Deposit N 1,030 cy from Deposit O	* Hydraulic dredging - Eight-inch diameter hydraulic dredge with a swinging ladder configuration. * Dredge selection was based on controlling sediment resuspension.	*Turbidity barriers - 80 mil HDPE - fastened to the bottom and connected to the shoreline around perimeter of deposit *2 deflection barriers of 80 mil HDPE and a silt curtain	*$4.3 million, $525/cy (total cost)	* Air - particulate standard met. * Water - 6 turbidity meters in the river generating hourly data. * Post dredging: 97 pounds removed; 16 of 19 post-dredging samples exhibited PCB concentrations greater than 2 ppm. * Caged fish data showed no elevated PCB levels.	* Dredged material pumped to on-shore processing; shaker screen and hydrocyclones remove +200 sieve material; sediment slurry to filter presses. * 4,812 tons to landfill (<50 ppm PCBs);1,658 tons to Wayne Disposal Facility (>50 ppm PCB).	* Filtrate from presses to bag filters, sand filters and carbon absorbers. Effluent limit 1.2 ppb PCB * 300,000 to 600,000 gpd	Contractor was not able to achieve full dredging capacity due to insufficient sediment dewatering capacity.
Fox River - (SMU 56/57)									
Mainly PCBs (1242), metals (mercury); PAHs to a lesser extent.	<1 ppm PCBs or <10 ppm with 6" sand cover	* Aug-Dec 1999 30,000 cy *Fall 2000 (69 days) 50,000 cy	*Hydraulic (cutterhead then auger) dredging	Woven geotextile perimeteer silt curtain	$9M (1999 total cost)	* Air - PCBs at 25 stations *Water- Monitoring upstream and downstream before and during dredging for TSS, TOC, DOC and turbidity	Sediments are piped to settling basin, receive polymer addition, filter press and trucked to offsite waste disposal facilities	Sand, cloth and carbon filters (total volume unknown)	* Lower solids content than anticipated led to underbidding by Contractor (1999) *Dredging passes contained some furrows and final dredging elevations not always achieved (1999)

Hudson River PCB Reassessment Feasibility Study

Domestic Remedial Projects Using Sediment Removal Technologies

Summary Charateristics - Table 1

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control/Barrier during Dredging	Dredging Cost/ Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
GM Central Foundry (Massena)									
PCBs	Remove >85% of contaminated sediment; test to determine if < 1 ppm PCBs residual achieved.	* 6 months for dredging, 2 shifts per day, 5 days per week. * 13,800 cy; * (10,200 cy to be remediated)	* Hydraulic (auger) dredging. * Sediments and rock removed using a barge-mounted backhoe.	* Sheetpile isolated removal area from river. * Internal silt curtains isolate areas >500 ppm PCBs. * Shoreline sediments excavated "in-the-dry" using Portadam and backhoe.	* Cost of dredging unavailable. * $7 million (ongoing)	* Air - Particulates/NIOSH 5503 (PCBs); periodically elevated PCB levels. * Water - Monitoring for turbidity, TSS, and PCBs. * Post dredging: cleanup level of 1 ppm PCBs not achieved in some areas. * Data appear to indicate a general downward trend in spottail shiner PCB concentrations.	* Boulders/debris loaded into unlined 20 cy rolloff on barge. * Sediments pumped to onshore processing facilities.	* Residual water treated via mixed-media filters, cartridge filters, granular activated carbon; discharged to river. * 43 million gallons.	* Rocks requiring removal in advance of dredging. * Initial contractor attempted silt curtains; sheet piling proved successful.
Grasse River, Project 1									
PCBs	Pilot study to gain information regarding remedial dredging, and remove high PCB concentrations from the major hot spot.	* 3.5 months. * 2,600 (in situ) sediment and 400 cy rocks.	* Hydraulic (auger) dredge. * Backhoe for boulder and debris removal. * Some diver-assisted vacuum dredging.	Three silt curtains (outer, inner secondary, and one for nearshore zone).	$1,620/cy $4.87 million	* Air - No detectable PCBs * Water - TSS and/or PCBs; PCBs detected above the acute Federal AWQC of 2 µg/L. * Post dredging: removed average 2 feet of sediment from one-acre hot spot; 75 ppm residual PCB in sediment.	* Sediment slurry pumped to onshore processing facilities. Lime added to slurry then sent to filter presses. Dewatered filter cake transported to nearby TSCA landfill. * 2,819 tons of dewatered filter cake, sand, and shaker screen rejects disposed; 400 tons of rocks/boulders landfilled.	* Two 300 gpm treatment trains (sand filters, dual-bag filters, and liquid phase GAC). * Approximately 11.7 million gallons	* Hardpan bottom inhibited removal of sediment (i.e., could not over-excavate). * Increase in downstream caged fish PCB levels and dissolved PCBs. * Naturally stepped bottom awkward for auger operations.
LTV Steel									
PAHs (oils)	Target was removal of sediments down to either the underlying slag fill or natural "hard pan".	* Three years (5 months per year) * 109,000 cy	* Initially used diver-assisted vacuum dredging; poor productivity. * Switched to suction dredge to minimize sediment resuspension; installed cutter head to complete work.	* Steel shroud for dredge head fabricated but not needed. * With cutter operating at low speed, no increase in suspended sediment levels as compared to suction system.	* Not available. * $12 million (total project)	* Air - None. * Water - Turbidity continuously monitored with limit of 10 NTUs above background. The average turbidity recorded directly downstream of the dredge was 4.2 NTUs and ranged from 2 to 10 NTUs. * Post dredging: Depth target achieved.	* Sediment slurry pumped about a mile for processing. * Sediments clarifier thickened; then belt presses; cake transported off-site to landfill. * 79,925 tons of dewatered solids to landfill. * 26,320 gallons of oil recovered from sediments.	* Water from dewatering and from thickener overflow to clarifiers and sand-filters and discharged. * Not available	* Low dive team production, compounded by the presence of debris, rocks, and plastic refuse. * Operational constraints imposed by operating industrial facility. * Difficulties imposed by winter weather also caused delays.
Housatonic River									
PCBs (1254/1260)	Comply with CERCLA Order and abate Agency-asserted imminent hazard	8.5 months 7,000 cy	Dry excavation	Sheet pile cofferdam	$4.5 million; $750/cy	*Air- 1997 continuous upwind and downwind PCBs and particulates *Water - 1997 continuous upstream and downstream PCBs, TSS, and turbidity	Gravity dewater in stockpile	*Sedimentation, filtration, caisson adsorption *16.3 million gal.	*Dewatering *Removal depth limited to structural capacity of sheetpiling *Presence of NAPL

Hudson River PCB Reassessment Feasibility Study

Domestic Remedial Projects Using Sediment Removal Technologies

Summary Charateristics - Table 1

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control / Barrier during Dredging	Dredging Cost / Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
Manistique River / Harbor									
PCBs (1248)	Removal of all material over 10 ppm PCB.	* 3 months-1995; 6 mos.-1996&97; 5 months-1998. * As per EPA, 10,000 cy (1995); 15,000 cy (1996); 62,000 cy (1997); 31,000 cy (1998). 25,050 cy (1999)	* hydraulic dredge w/ twin suction pumps and modified head, some diver assisted dredging * Vortex suction pump prevents jamming and clogging blades by debris.	Silt curtains and floating booms. Also, cofferdam installed.	$200-300/cy (including treatment) 1999 - $411/cy	* Air - Limited monitoring during first year. * Water - Turbidity and PCB monitoring. PCB levels 100-200 ppt in river during dredging. * Post dredging: December 1997, 10 sediment samples collected from dredged areas show mean of 18.1 ppm and a median of 7.2 ppm PCB.	* In 1997 pumped from dredge to barges and barged to a pump station; about 617 barge loads (1200 cy barges). Material was pumped from barges to treatment site about 1 mile distant.	* Dual media filter/activated carbon. * 16 million gal. (1995);35.2 million gal. (1996);122.1 million gal. (1997);120.6 million gal. (1998); 204.5 million gal. (1999)	Wood and wood debris in targeted dredging areas. In 1997, dredge production rate exceeded land based handling and water treatment capacity, limiting dredging to 1 - 2 hours per day. Weather-related shutdowns of dredging activity due to disruption of barge spuds.
New Bedford Harbor - Project 1 (Hot Spots)									
PCBs (1016, 1242, 1254); metals	Removal to <4,000 ppm PCBs and storage in CDF, pending treatment.	* 16.5 months, 4-6 hr/day * 14,000 cy	* Hydraulic dredging - Hot spots dredged using Ellicott 370 12-inch cutterhead * Cutterhead selected via pilot program.	* Use of silt curtains abandoned due to their continuous disturbance of the bottom. * High suction rate, low auger rotation emphasized to control resuspension.	$1.74 million; $124 per cy	* Air - Air Monitoring for PCBs. * Water - Resuspension Monitoring. * Post dredging: Achieved the less than 4,000 ppm PCBs target based on limited sampling.	* Sediments pumped to nearshore CDF. * Storage in CDF for several years. * Final dispoal in off-site landfill.	* Water treatment - settling, flocculation, sand filter, micro (fiber) filters, UV/oxidation. * 160 million gallons treated.	* Dredging limited to 4-6 hour high tide, daytime window. * Four to six hours of dredging would "max-out" WWTP for 24 hours. * Volatilization caused some exceedance of PCB-in-air limit. Operations modified. * Silt curtains removed because of disturbance of harbor bottom.
Outboard Marine									
PCBs (1242 and 1248)	Remove >500 ppm PCBs from slip; prepare slip as containment; remove >50 ppm PCBs from Harbor and deposit in slip.	* Three years total. * 50,000 cy from about 10 acres of Upper Harbor, Slip #3, and onshore ditch and lagoon areas.	* Hydraulic cutter head for Harbor and slip. * Flocculent sediment viewed as easier to move to disposal area with hydraulic dredge than mechanical.	* Silt curtain installed at Upper Harbor. * Cutoff wall installed at Slip #3 to isolate it from Harbor. * After dredging, coagulant added to harbor to aid in the settling.	Bid at $30 - 40 per cy; reportedly achieved or bettered this rate.	* Air - Personnel and perimeter air sampling. Below action limits. * Water- Turbidity recorded daily during dredging at depths of 10' and 20'. Below the action limit. * Post dredging: Completed to designated soil type. Results verified by depth sounder and samples. EPA sediment samples ranged from 3 to 9 ppm PCBs.	* Sediments pumped to containment cells via dredge discharge line. * Polymer added through dredge discharge line to enhance settlement.	* Water treatment with sand filtration and GAC. * 95 million gallons treated water discharged overboard.	* Silt curtain failures due to wind and currents. * Material deposited into Slip #3 required 3 years to settle. * Upper Harbor dredging prohibited during boating season; accomplished during winter months.

Hudson River PCB Reassessment Feasibility Study

Domestic Remedial Projects Using Sediment Removal Technologies

Summary Charateristics - Table 1

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control/Barrier during Dredging	Dredging Cost/ Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
Ottawa River									
PCBs	Predetermined depth	5 months 9,692 cy (8039 cy sediment, 1653 cy wetlands soil)	Dry excavation with conventional earth moving equipment	Steel sheeting and earthen berm	$ 5 million, about $516/cy	*Air - none *Water - sewer discharge for PCBs, TTO, total metals, pH, BTEX, and TPH	Gravity dewatered on pad and then solidified with 8-10% Pozzament for transport to TSCA and non-TSCA landfills	*About 1 million gal. *Oil/water separator to coagulant addition to soil skimmer to mixer to inclined plate clarifier to bag, sand and activated media filters	
Reynolds Metals									
PCBs, PAHs, TCDFs	Removal of 77,600 cy of contaminated sediment with >1 ppm PCBs	Project to start in 2001	Mechanical (closed bucket clamshell) dredging	Cantilevered sheet pile system			Gravity drainage with solidification as needed		*Boulders, cobbles
Saginaw River									
PCBs, DDT, TCDD, TCDF, PAHs, heavy metals	Removal of 90% of PCBs	*6 months (ongoing) *160,00 cy of 345,000 cy	Mechanical (closed bucket clamshell) dredging	Silt curtains		*Air - yes *Water - turbidity	Removed sediment in placed in confined disposal facility without treatment	None	*Wood pieces require the switch to conventional dredge
Sheboygan River/Harbor (Pilot Study)									
PCBs throughout; metals and PAHs lower river and harbor.	No stated cleanup goals in Pilot Study. Final remedial program calls for 1ppm PCB residual after 30 yrs.	* November 1989 - November 1991. * 4,000 cy removed; 1,200 square yards capped. * Final remediation under review.	* Mechanical dredging with sealed clamshell and backhoe as necessary. * Mechanical dredging to avoid handling large slurry flows.	Double-layer silt curtains (geomembrane lined with a geotextile) anchored to the river bottom.	Approximately $450/cy (includes actual dredging and install/remove silt curtains).	* Air - None. * Water - pre-, during (daily)- and post-removal for TSS/turbidity; weekly total and dissolved PCBs. * Post dredging: pre- and post-dredging sediment samples to monitor dredging and the need for additional dredge passes or subsequent capping/armoring. Pre-, during-, and post-construction water and caged/resident fish sampling.	* Removed sediment placed in sealed, gasketed boxes and transported to PRP facility for final disposition. *Five areas capped without any prior sediment removal. *Four other areas were capped following pilot dredging activities due to elevated levels of PCBs remaining.	* Construction water and runoff from materials storage treated (flocculation/sedimentation, multimedia filter, GAC) with final discharge to Sheboygan River.	*Shallow water limited barge movement. *Excessive haul distances/times due to access issues. *Low production rates and high costs during winter work.

Hudson River PCB Reassessment Feasibility Study

Domestic Remedial Projects Using Sediment Removal Technologies

Summary Charateristics - Table 1

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control / Barrier during Dredging	Dredging Cost / Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
United Heckathorn									
DDT; dieldrin (and DDE)	Removal to a DDT target level of 590 ppb, to meet human health risk needs and surface water criteria.	* 7 months (typically 24 hours per day, six days per week) * 108,000 cy	* Mechanical dredging; wet excavation -12 cy Cable Arm bucket; 7 cy conventional clamshell bucket (in areas of obstructions) * Mechanical dredging was used because less processing water is produced (not enough space for water treatment).	*Cable arm bucket limited turbidity. * Silt curtains also employed.	* Not available. * $10 million (total project)	* Air - none * Water - turbidity both inside and outside silt curtain * Post dredging - Verification of depth target. EPA analyzed verification cores for DDT and dieldrin. *Year one lipid-corrected DDT concentrations in mussels lower than pre-dredging concentrations.	* Dredge to scow to dewatering cell. * Each load of sediment raked before stabilizing reagent added. * Rail transport to two commercial landfills.	* Onsite treatment system (no details). * Discharge back to harbor. * 2.8 million gallons.	* Extensive debris. * Silt curtain damage. * Logistical delays with rail cars. * Disposal site load refusals, and public controversy regarding disposal.
Willow Run Creek									
PCBs	Remove sludges in Sludge Lagoon (1 ppm PCBs) and remove sediments and soils in ponds (1 ppm PCBs).	* 32 months to implement removal. * 450,000 cy of solidified sediments (disposed volume).	* Sheetpile to isolate pond areas; excavator mounted on a pontoon/tracked buggy; on-site mixing plant for stabilization reagent used in-situ; temporary wastewater treatment tanks. * Avoid downstream contamination of Bellville Lake.	Sheet pile wall to avoid discharge of resuspended materials.	* N/A * $80 million (total cost including landfill constr.)	* Air - unknown * Water - turbidity monitoring showed no problems. * Post dredging: Verification samples taken from each cell to determine if target levels achieved. Target level for sediments was 1 ppm. Removal efforts were repeated as necessary until the target levels were met.	* In-situ dewatering and solidification of sediments, then transported to dedicated landfill. * Water treated at temporary WWT facility.	* Temporary WWT facilities to support work at two Ponds. Waste water from dedicated TSCA landfill treated at local POTW. * Not available.	* Obstructions delayed the installation of sheetpile. * Silt like sediments difficult to stabilize. * Odors at landfill apparently originated from solidification agent. * PCB air levels exceeded EPA and State action levels. * Stabilization agents in slurry form not effective; dry reagent mix caused fugitive dust problem.

Hudson River PCB Reassessment Feasibility Study

International Remedial Projects Using Sediment Removal Technologies

Summary Characteristics - Table 2

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control/Barrier during Dredging	Dredging Cost/ Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
Welland River, Ontario									
* Mill scale particulate * Solvent extractable contaminants (Oil, Grease)	Residual metals below specified criteria	* 9,833 m^3 of reef materials (7,613 from Amphibex and 2,220 from backhoe) * Fall 1995: 6 wks, 12 hr/day	* Amphibex * Demonstrate the Amphibex technology for a full-scale removal	Silt curtain	* Dredging and slurry transport: C$20/cu.m. * Project cost: C$426,700 *	* Air: None * Water: Turbidity, TSS (Fluctuated with weather) < 40 NTU	* Temporary storage basins on-site; dewatering facility; trucks to landfill * Some material recycled within Atlas Steel Co. plant; Municipal landfill	* 9,000 m^3 * Atlas's North Filtration Plant; Welland WWTP	* Man-made debris removed by long-reach excavator. * Dense material slowed dredging. * Dificulty with slurry volumes.
Thunder Bay, Ontario									
* PAHs * Northern Wood Preservers.	* Remove acutely toxic sediment to 26 ppm PAH * Isolate other contaminant sources.	* 1,500 m^3 * Oct.20 to Nov. 1, 1997	Cable Arm environmental bucket to minimize resuspension	Polyethylene silt curtain	* Dredging cost: unknown * Project cost: C$22 million	* Air: unknown * Water:Turbidity with electronic sensors. * Post dredging: unknown	* Dredged material stored for treatment. * Isolation barrier constructed around pier. * Rockfill containment berm for rest of area.	* not available * Volume unknown	Ice conditions delayed dredging for a season
Collingwood Harbour, Georgian Bay, Ontario									
Heavy metals	* Remove sediment that failed biological assessment criteria.	* 1993: dredging for 3 wks * 10,000 m^3	* Pneuma Pump mounted on barge. * Demonstrate removal of very fine floc.	Silt curtain	* Dredging cost: unknown * Project cost: C$1.2 million	* Air: none * Water: TSS: 25 mg/L max. allowable never exceeded. * Post dredging: Contaminants removed.	* Pumped 1.2 km to CDF * Underwater CDF with riprap construction, geotextile, liner system	N/A	N/A
Hamilton Harbour, Lake Ontario									
PAHs	Demonstrate Cable Arm dredging system.	* Duration: N/A * 8 m^3	* Cable Arm environmental bucket * Basis: Pilot test	N/A	N/A	Air: unknown Water: turbidity Post dredging: unknown	N/A	N/A	* Spillage from top opening of bucket created visible sediment plume.
Toronto Harbour, Lake Ontario									
* Moderate levels of heavy metals * No organics	Demonstrate efficiency of cable arm bucket.	* 250 m^3, 49% solids * 17 cycles/hr in 8m of water	* Closed Top - Cable Arm environmental bucket. * Basis: pilot test	Closed off slip area	N/A	Air: unknown Water: turbidity Post dredging: unknown	N/A	N/A	* Implement further modifications to Cable Arm bucket.

Hudson River PCB Reassessment Feasibility Study

International Remedial Projects Using Sediment Removal Technologies

Summary Characteristics - Table 2

Contaminant	Dredging Goal	Dredging Duration and Volume	Dredging Method and Basis	Sediment Resuspension Control/Barrier during Dredging	Dredging Cost/ Project Cost	Monitoring During and After Dredging	Material Handling and Disposal	Water Treatment and Volume	Site-Specific Difficulties
Hamilton Harbour, Lake Ontario									
PAHs	Perform "surgical dredging"	* 24 cycles/hr * 150 m^3, 44-48% solids	* Modified Cable Arm environmental bucket.	N/A	N/A	Air: unknown Water: turbidity Post dredging: unknown	N/A	N/A	N/A
Severn Sound, Georgian Bay, Ontario									
Wood debris	Demonstration of Visor Grab technology	* 14 hour dredging. * 375 m^3 removed by Visor; 40% solids content	* Grapple for wood debris; * Visor grab for fines.	Silt curtain	N/A	Air: unknown Water: turbidity Post dredging: unknown	N/A	N/A	* Debris hindered Visor Grab operation of closing lid
Lake Jarnsjon, Sweden									
PCBs	Remove 400 kg of PCB.	170,000 cubic yards	* Customized suction auger dredger. * Basis: minimize resuspension and slurry water content.	Geotextile screen	N/A	Air: unknown Water: Chemical analysis for PCBs in sediment; dredged area and upstream/downstream sampling in water column.	* Sediments pumped to processing facility. * Sediments disposed in near site landfill.	* Flocculation, flotation, sedimentation. * volume unknown	* Auger productivity reduced in dense sediments.
8897									
* Heavy metals	* Maintain depth required for navigation.	* As necessary for navigational purposes. * Approximately 2 million cubic yards per year.	* Mechanical dredges.	N/A	* Processing facility $80 M investment. * $8 M O&M/yr.	N/A	* Sediments barged to hydraulic off-loading facility. * Sediments separated into coarse and fine fractions for disposal purposes.	* Transport water recycled to reduce consumption.	N/A
Ketelmeer, Netherlands									
* Heavy metals. * Organics	N/A	Duration: several years	Mechanical dredges	N/A	N/A	N/A	Disposal in a CDF situated within Ketelmeer.	No treatment was observed	N/A

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX A

BACKGROUND MATERIAL

A.5 Preliminary Human Health and Ecological Risk-BasedConcentrations (RBCs)

MENZIE ⬢ CURA & ASSOCIATES, INC.
Environmental Consultants
One Courthouse Lane, Suite Two Chelmsford, Massachusetts 01824-1794 (978) 453-4300 Fax (978) 970-2791

Date: October 15, 2000
To: Hudson River Team
From: Katherine von Stackelberg
Re: Ecological Preliminary Remediation Goals

This memorandum describes the method used to calculate target levels in fish based on exposure parameters developed for three ecological receptors: otter, mink, and eagle. The otter and the eagle both consume large, whole fish, represented by the largemouth bass. The mink consumes a smaller, forage fish, represented by pumpkinseed or spottail shiner. The target levels are expressed on a wet weight basis and represent a concentration in the whole fish, rather than the fillet. Target levels are provided for total PCBs as well as for the toxicity equivalents (TEQ) for the 11 dioxin-like congeners.

The following equation is used to estimate the target levels:

$$\text{Target Level} = TQ * TRV * \left(\frac{IR * Frac}{BW} \right)^{-1}$$

where:

Target Level = Target level in fish (mg/kg)
TQ = Target toxicity quotient (1)
TRV = Toxicity reference value (mg/kg-day)
IR = Ingestion rate (kg/day)
Frac = Fraction of fish in the diet
BW = Body weight (kg)

This equation is used with the exposure parameters and toxicity reference values provided in the Revised Baseline Ecological Risk Assessment (USEPA, 2000). For the dioxin-like congeners, an additional unitless fraction is added to the numerator of the equation representing the fraction of total PCB represented by the dioxin-like congeners. The TRVs for the TEQ congeners were developed based on the toxicity of dioxin, as described in the Revised Baseline Ecological Risk Assessment (USEPA, 2000)[1].

Table 1 provides the target levels in fish. Target levels are provided for otter, mink, and eagle dietary doses and additionally, based on egg concentrations for the eagle. The bottom of the table shows the TRVs that were used in the calculations.

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[1] US Environmental Protection Agency (USEPA). 2000. Further Site Characterization and Analysis, Volume 2E – Revised Baseline Ecological Risk Assessment Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and US Army Corps of Engineers, Kansas City District. Prepared by TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc.

TARGET FISH LEVELS FOR HUDSON RIVER BASED ON ECOLOGICAL RECEPTORS -- DRAFT

	Target Fish Concentration (mg/Kg)			
Species	Dietary Dose		Egg Concentration	Egg Concentration
	NOAEL	LOAEL	NOAEL	LOAEL
Otter (TEQ)	0.015	0.4		
Mink (TEQ)	0.034	1.0		
Eagle (TEQ)	0.04	0.4	0.03	0.7
Otter	0.03	0.3		
Mink	0.07	0.7		
Eagle	14	56	0.1	0.3

Notes:

NOAEL - No Observed Adverse Effect Level

LOAEL - Lowest Observed Adverse Effect Level

Dietary dose: target fish levels back calculated from a toxicity quotient of 1 for the listed receptors based on consumption of piscivorous fish.

Egg concentration: target fish levels back calculated from a toxicity quotient of 1 for the listed receptors based on egg predicted egg concentration (using a biomagnification factor of 28 from fish concentration).

TRVs:	NOAEL	LOAEL	NOAEL TEQ	LOAEL TEQ
Mink	0.004	0.04	0.00000008	0.00000224
Otter	0.004	0.04	0.00000008	0.00000224
Eagle	1.8	7.1	0.0000014	0.000014
Eagle Egg	5.5	8.7	0.00021	0.005

All TRVs in mg/kg-day except eagle egg (mg/kg wet weight)

Gradient
CORPORATION

November 7, 2000

Writer's Direct Line
(617) 234-2337
dmerrill@gradcorp.com

Mr. Bruce Fidler
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

Re: Hudson River PCBs Reassessment RI/FS
USACE KC District Contract#: DACW41-D-98-9002
Development of Preliminary Target Contaminant Concentration Ranges

Dear Bruce:

Enclosed is our evaluation of human health risk-based target concentrations of PCBs in fish for the Upper Hudson River. The RBCs for fish consumption were calculated for PCBs and dioxin-like PCBs. While the calculation of these RBCs is in many respects straightforward, there are a number of challenging issues that lie ahead in terms of translating these RBCs into remedial action objectives for sediments or other media. For example:

- The RBCs represent a target average, or upper bound average, concentration in fish. The declining concentrations in fish over time should be factored into the RAO determination. Furthermore, the time-frame of the averaging differs for non-cancer and cancer RBCs.
- In the RBC calculations it is assumed that 100% of the fish intake is from the Hudson, which is a site-specific consideration given the extensive size of the site.
- Different fish species accumulate PCBs to differing degrees, a fact that could perhaps be included using a weighted species percent to the RBCs in a manner analogous to the risk calculations.
- As noted in our scope of work letter, because the RBCs represent a target average, it is "allowable" to have concentration values above the RBC so long as the average concentration in fish meets the average. We have developed techniques that address this issue when the concentration data (in this case PCB concentration in fish) are lognormal.

There are no doubt other issues that should be considered as the RBCs are used in the RAO setting process. If you have any questions, please give me or Tracey Slayton a call.

Yours truly,

GRADIENT CORPORATION

David E. Merrill

David E. Merrill
Principal Scientist

enclosure

cc: Tracey Slayton

8708676/FSTask/RAO
RBC_MEM.DOC

Hudson River PCBs Reassessment RI/FS
Development of Preliminary Human Health Based
Target Contaminant Concentration Ranges in Fish

Gradient calculated a risk-based concentration in fish ($\mathrm{RBC_F}$) corresponding to a range of target risk (ranging from 10^{-6} to 10^{-4}), and a non-cancer Hazard Index of 1.0.

Calculating the RBCs is a straightforward exercise of solving the intake and risk equations in the Risk Assessment for the concentration that equates to a specified target cancer risk (TR) in the case of carcinogenic risk, or a specified target Hazard Index (HI) for non-carcinogenic health impacts. The equations for these calculations are given below.

Risk-Based Concentration -- Cancer

$$\mathrm{RBC_{F\_C}} = \mathrm{TR} \times \left\{ \mathrm{CSF} \times \frac{\mathrm{IR} \times (1 - \mathrm{LOSS}) \times \mathrm{FS} \times \mathrm{EF} \times \mathrm{ED} \times \mathrm{CF}}{\mathrm{BW} \times \mathrm{AT}} \right\}^{-1}$$

Risk-Based Concentration -- Non-Cancer

$$\mathrm{RBC_{F\_NC}} = \mathrm{HI} \times \mathrm{RfD} \times \left\{ \frac{\mathrm{IR} \times (1 - \mathrm{LOSS}) \times \mathrm{FS} \times \mathrm{EF} \times \mathrm{ED} \times \mathrm{CF}}{\mathrm{BW} \times \mathrm{AT}} \right\}^{-1}$$

where:

$\mathrm{RBC_{F\_C}}$ = Cancer risk-based concentration of PCBs in fish (mg/kg)
$\mathrm{RBC_{F\_NC}}$ = Non-cancer risk-based concentration of PCBs in fish (mg/kg)
TR = Target risk, *e.g.*, 10^{-6} (unitless)
HI = Target non-cancer hazard index (unitless)
CSF = Cancer slope factor $(\mathrm{mg/kg\text{-}day})^{-1}$
RfD = Non-cancer reference dose (mg/kg-day)
IR = Annualized fish ingestion rate (g/day)
LOSS = Cooking loss (g/g)
FS = Fraction from source (unitless fraction)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion Factor (10^{-3} kg/g)
BW = Body weight (kg)
AT = Averaging time (days)

The RBC calculation adopted the exposure factors that were used in our Phase 2 Risk Assessment, using both the central tendency and reasonable maximum exposure (RME) factors. Table 1 summarizes the exposure factors and corresponding RBC_F values for PCBs in fish.

Overall, the RBC values for PCB risk levels range from 0.044 to 0.44 mg/kg for non-cancer effects, and 0.002 to 13 mg/kg for cancer effects as summarized below.

Target Risk or Non-Cancer Hazard Index	**Central Tendency**	**Reasonable Maximum Exposure (RME)**
$TR = 10^{-4}$	$RBC_{F\_C} = 13$	$RBC_{F\_C} = 0.2$
$TR = 10^{-5}$	$RBC_{F\_C} = 1.3$	$RBC_{F\_C} = 0.02$
$TR = 10^{-6}$	$RBC_{F\_C} = 0.13$	$RBC_{F\_C} = 0.002$
HI = 1.0	$RBC_{F\_NC} = 0.44$	$RBC_{F\_NC} = 0.044$

RBCs for Dioxin-Like PCB Congeners

As discussed in the Phase 2 Baseline Human Heath Risk Assessment for the Upper Hudson River (HHRA), certain PCB congeners exhibit dioxin-like toxicity. As was the case in the HHRA, only a plausible upper bound cancer slope factor is available for dioxins, therefore, RBC values for high-end exposure cancer effects from dioxin-like PCB congeners were calculated. In order to account for the toxicity of dioxin-like PCB congeners, a congener-weighted CSF was calculated. The congener weighted slope factor ($CSF_{weighted}$) is equal to the upper bound CSF for 2,3,7,8-TCDD (150,000 per mg/kg-d) and multiplied that by the sum of the product of each congener TEF and the ratio of each congener over total PCBs:

$$CSF_{weighted} = \sum_i TEF_i \times \frac{C_i}{Total\ PCB}$$

where

TEF_i = dioxin toxicity equivalency factor for the i^{th} congener

C_i = average concentration of i^{th} congener in fish

The congener TEF values, and the average congener PCB concentration values are those tabulated in Table 5-36 of the HHRA. The congener weighted CSF is 2.7 $(mg/kg\text{-}d)^{-1}$. Table 2 (attached) summarizes the exposure factors and corresponding RBC_F values for PCBs in fish for dioxin-like PCB risk levels.

Overall, the RBC values for PCBs for dioxin-like PCB risk levels range from 0.14 to 0.0014 mg/kg for cancer effects as summarized below. The RBCs below represent the concentration of Total PCBs at the associated target cancer risk levels, where the cancer risk is attributable to the dioxin-like component of the Total PCBs. These RBCs are calculated with the presumption that the relative concentrations of dioxin-like PCB congeners remain at the average relative concentrations summarized in Table 5-36 of the HHRA.

Target Dioxin-Like Cancer Risk	**Central Tendency**	**Reasonable Maximum Exposure (RME)**
$TR = 10^{-4}$	NA	$RBC_{F\_C} = 0.14$
$TR = 10^{-5}$	NA	$RBC_{F\_C} = 0.014$
$TR = 10^{-6}$	NA	$RBC_{F\_C} = 0.0014$

References

U.S. Environmental Protection Agency (USEPA). 1999. Phase 2 Report, Further Site Characterization and Analysis: Volume 2F – Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA and U.S. Army Corps of Engineers. USEPA, Region II, New York, New York. August.

TABLE 1

CALCULATION OF RISK-BASED CONCENTRATIONS OF PCBS IN FISH -- UPPER HUDSON RIVER

HUDSON RIVER PCBs REASSESSMENT RI/FS

Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference
RfD	Reference Dose	mg/kg-d	2.00E-05	Oral RfD for Aroclor 1254, see text.	2.00E-05	Oral RfD for Aroclor 1254, see text.
CSF	Cancer Slope Factor	$(mg/kg\text{-}d)^{-1}$	2	Upper-bound CSF for exposures to PCBs via fish ingestion, see text.	1	Central estimate CSF for exposures to PCBs via fish ingestion, see text.
IR_{fish}	Ingestion Rate of Fish	grams/day	31.9	90th percentile value, based on 1991 NY Angler survey.	4.0	50th percentile value, based on 1991 NY Angler survey.
Loss	Cooking Loss	g/g	0	Assumes 100% PCBs remains in fish.	0.2	Assumes 20% PCBs in fish is lost through cooking.
FS	Fraction from Source	unitless	1	Assumes 100% fish ingested is from Upper Hudson.	1	Assumes 100% fish ingested is from Upper Hudson.
EF	Exposure Frequency	days/year	365	Fish ingestion rate already averaged over one year.	365	Fish ingestion rate already averaged over one year.
ED-C	Exposure Duration (Cancer)	years	40	95th percentile value, based on 1991 NY Angler and 1990 US Census data.	12	50th percentile value, based on 1991 NY Angler and 1990 US Census data.
ED-NC	Exposure Duration (Non-cancer)	years	7	see text	12	50th percentile value, based on 1991 NY Angler and 1990 US Census data.
CF	Conversion Factor	kg/g	1.00E-03	--	1.00E-03	--
BW	Body Weight	kg	70	Mean adult body weight, males and females (USEPA, 1989b).	70	Mean adult body weight, males and females (USEPA, 1989b).
AT-C	Averaging Time (Cancer)	days	25,550	70-year lifetime exposure x 365 d/yr (USEPA, 1989b).	25,550	70-year lifetime exposure x 365 d/yr (USEPA, 1989b).
AT-NC	Averaging Time (Noncancer)	days	2,555	ED (years) x 365 days/year.	4,380	ED (years) x 365 days/year.
RBC_f-NC	Risk-based Concentration of PCBs in Fish (Non-cancer), HI=1	mg/kg wet weight	0.044	RBC_f-NC = (HI x RfD x BW x AT-NC)/(IR x (1 - Loss) X FS x EF x ED-NC x CF)	0.44	RBC_f-NC = (HI x RfD x BW x AT-NC)/(IR x (1 - Loss) X FS x EF x ED-NC x CF)
RBC_f-C-10^{-4}	Risk-based Concentration of PCBs in Fish (Cancer), Risk = 10^{-4}	mg/kg wet weight	0.2	RBC_f-C = (Risk x BW x AT-C)/(CSF x IR x (1 - Loss) X FS x EF x ED-C x CF)	12.8	RBC_f-C = (Risk x BW x AT-C)/(CSF x IR x (1 - Loss) X FS x EF x ED-C x CF)
RBC_f-C-10^{-5}	Risk-based Concentration of PCBs in Fish (Cancer), Risk = 10^{-5}	mg/kg wet weight	0.02	RBC_f-C = (Risk x BW x AT-C)/(CSF x IR x (1 - Loss) X FS x EF x ED-C x CF)	1.28	RBC_f-C = (Risk x BW x AT-C)/(CSF x IR x (1 - Loss) X FS x EF x ED-C x CF)
RBC_f-C-10^{-6}	Risk-based Concentration of PCBs in Fish (Cancer), Risk = 10^{-6}	mg/kg wet weight	0.002	RBC_f-C = (Risk x BW x AT-C)/(CSF x IR x (1 - Loss) X FS x EF x ED-C x CF)	0.128	RBC_f-C = (Risk x BW x AT-C)/(CSF x IR x (1 - Loss) X FS x EF x ED-C x CF)

TABLE 2

CALCULATION OF RISK-BASED CONCENTRATIONS OF DIOXIN-LIKE PCBS IN FISH -- UPPER HUDSON RIVER

HUDSON RIVER PCBs REASSESSMENT RI/FS

Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference
CSF	Cancer Slope Factor	$(mg/kg\text{-}d)^{-1}$	2.7	Congener-weighted CSF**.
IR_{fish}	Ingestion Rate of Fish	grams/day	31.9	90th percentile value, based on 1991 NY Angler survey.
Loss	Cooking Loss	g/g	0	Assumes 100% PCBs remains in fish.
FS	Fraction from Source	unitless	1	Assumes 100% fish ingested is from Upper Hudson.
EF	Exposure Frequency	days/year	365	Fish ingestion rate already averaged over one year.
ED	Exposure Duration	years	40	95th percentile value, based on 1991 NY Angler and 1990 US Census data.
CF	Conversion Factor	kg/g	1.00E-03	--
BW	Body Weight	kg	70	Mean adult body weight, males and females (USEPA, 1989b).
AT	Averaging Time	days	25,550	70-year lifetime exposure x 365 d/yr (USEPA, 1989b).
$RBC_f\text{-}10^{-4}$	Risk-based Concentration of Dioxin-like PCBs in Fish, Risk = 10^{-4}	mg/kg wet weight	0.14	RBC_f = (Risk x BW x AT)/(CSF x IR x (1 - Loss) X FS x EF x ED x CF)
$RBC_f\text{-}10^{-5}$	Risk-based Concentration of Dioxin-like PCBs in Fish, Risk = 10^{-5}	mg/kg wet weight	0.014	RBC_f = (Risk x BW x AT)/(CSF x IR x (1 - Loss) X FS x EF x ED x CF)
$RBC_f\text{-}10^{-6}$	Risk-based Concentration of Dioxin-like PCBs in Fish, Risk = 10^{-6}	mg/kg wet weight	0.0014	RBC_f = (Risk x BW x AT)/(CSF x IR x (1 - Loss) X FS x EF x ED x CF)

Note:

For dioxin, only a plausible upper bound slope factor is available; therefore, a central tendency estimate was not calculated.

** Congener-weighted CSF is the product of the Dioxin CSF (150,000 per mg/kg-d) and the sum of the product of each congener TEF and the congener over total PCB Ratio. See Table 5-36 in HHRA report.

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX B

VOLUME COMPUTATION

Appendix B

Volume Computation for Sediment Removal

To compute the volume to be remediated, target areas for sediment remediation were first delineated. The basic methods and assumptions for delineating areas for sediment remediation were as follows:

- Target areas were defined as areas that have sediment sample(s) with PCB levels greater than a minimum target area criterion. These minimum target area criteria were defined on the basis of mass of PCBs per unit area [g/m^2] or PCB concentration in the "surface" sediment (mg/kg). (Here "surface" simply refers to the sediment sample collected at the sediment-water interface regardless of sediment depth represented.) Some judgment was used in determining whether to include or exclude certain areas. For example, if an area includes only one sampling point greater than the target PCB level with surrounding samples with lower PCB levels, then the area would not be included as a target area. On the other hand, if a sampling point with less than the target PCB level is found in an area with surrounding elevated PCB detections, the area would be included as a target area.

- Target areas in the Thompson Island Pool were delineated by primarily using 1984 NYSDEC results interpretted via a polygonal declustering analysis (Thiessen polygons) in conjunction with the 1992 USEPA side-scan sonar survey results (see USEPA, 1999-LRC Responsiveness Summary for a discussion of this application). PCB data from 1977 (including the NYSDEC hot spot delineations), 1991 (GE), 1994 (USEPA), and 1998-99 (GE) were used to check and confirm the delineated areas to the extent possible.

- Target areas between TI Dam and Lock 5 were delineated by primarily using the 1992 side-scan sonar results and the 1994 USEPA low resolution coring results. 1977 NYSDEC data were used to supplement the 1994 USEPA data in areas not sampled in 1994. PCB data from 1991 (GE) and 1998-99 (GE) were used to check and confirm the delineated areas to the extent possible.

- Target areas below Lock 5 were delineated by primarily using 1977 NYSDEC PCB data and the 1994 USEPA PCB data. PCB data from 1991 (GE) and the GE sediment texture survey were used to support the delineated areas in a limited fashion.

- Sediments in target areas located along shorelines were considered to extend to the shoreline as defined in the USEPA Hudson River Database (USEPA, 2000), corresponding to a river flow of 8,470 cfs.

- Sediments in target areas located in or along rocky areas (as defined by side scan sonar) were excluded from the calculation based on an assumed non-dredgeable area extending a 20-foot distance from the perimeter of the rocky area delineation.

After the target areas were delineated, an estimate was made of the depth of contamination. The basic assumptions and methods for estimating the depth of contamination were as follows:

- The depth of contamination was estimated using the 1977 and 1984 NYSDEC cores, 1994 low resolution sampling by USEPA, and 1998-99 GE coring data. For purposes of the analysis, the depth (in sample cores) at which contamination fell below 1 mg/kg was used to define the depth of contamination. One mg/kg PCBs was selected rather nondetect levels because of the estimated higher detections assoicated with the NYSDEC data. The 1 mg/kg threshold essentially converts all the data sets to the same basis.

- Some modification was made to the various data sets where the sample cores were considered "incomplete" and a depth of contamination could not be directly estimated. An "incomplete" core is one with PCB concentration greater than 1 mg/kg at the bottom of the core and no cesium-137 data were available or the cesium-137 data did not provide an alternate basis for assessment. To estimate the additional material to be removed at the bottom of an incomplete core, existing complete cores were examined and grouped based on maximum PCB concentration and distance from the point of maximum concentration to the bottom of core. This analysis showed that where the maximum concentration in a core is less than 100 ppm, the distance between the depth of the maximum PCB concentration and the bottom of the core is generally less than 1 foot; where the maximum concentration is greater 100 ppm, this distance is generally more than 1 foot. Therefore, to calculate the depth of contamination in incomplete cores, where the concentration at the bottom ranged from 1-100 ppm, 1 foot was added to core length to define the depth of contamination. For cores where the PCB concentration was greater than 100 ppm, 1.5 feet were added to the core. Also, for cores that exhibited contamination depths of less than 1 foot, it was assumed that 1 foot of material would be removed (1 foot was the minimum dredge cut).

Using the estimated depth of contamination, the limit of removal was estimated using the following assumptions and methods:

- The next step in the computational process was to develop a composite map,of the Upper Hudson sediments that displayed the depth of contamination at each sample location. That composite map included data from complete cores and from incomplete cores that had been modified as described above. Also illustrated on the map were the boundaries of target areas (*Hot Spot*, Expanded *Hot Spot*, and full-section) that had been established as described above. With this information illustrated it was possible to estimate the depth to which dredging would be needed to remove the targeted contaminated sediments.

- The process was initiated by setting a minimum area within which the depth of removal would not be varied. This was done to simulate a reasonably-sized working zone for dredging equipment (at least 50,000 square feet though typically substantially larger work areas were defined). Within this area, a single removal depth was specified based on the deepest core (*i.e.,* greatest depth of contamination) observed for the area. Where the depth of contamination for an entire area was defined as less than foot, a one foot removal depth was selected to reflect a minimum cut attainable by dredging equipment. In addition, in expanded *hot spot* areas, a minimum cut depth of 2 feet was assumed; and in *hot spot* areas, a minimum cut depth of 2.5 feet was assumed, to provide a conservative estimate of volume removed in the more highly contaminated zones where multiple dredging passes may be required to remove all contaminants.

- With the above guidelines in-mind, it was possible to assign removal depths to target areas based on the distribution of data points illustrated on the composite map. In the more contaminated target areas associated with the *Hot Spot* and Expanded *Hot Spot* remediation scenarios, the depth of contamination data were generally clustered so as to permit selection of removal depths representative of relatively large areas (greater than 50,000 square feet). In some instances, a single data point called for substantially greater removal than other nearby data would require. In that case, a minimum practical working area (50,000 square feet) was defined around that location, setting the surrounding areas at shallower removal depths as defined by the associated data points. This procedure was applied consistently throughout the Upper Hudson for each remediation scenario. Ultimately several maps were generated of the Upper Hudson River displaying these results. These maps are included as Plates 13 through 15 - Removal Areas and Depths. Individual maps have been prepared to illustrate depths of dredging for full-section removal, Expanded *Hot Spot* removal and *Hot Spot* removal scenarios.

The target areas classified by depth of removal were digitized and entered into a GIS system for purposes of automating the computation of the actual volumes of sediment that would be removed under various target removal scenarios. The methods used in GIS are described below.

- The automated method employed a GIS system running on ArcView 3.2, with Spatial Analyst and 3D extensions.

- Each area with a different depth of removal was designated as a separate polygon in ArcView. For each new polygon created in ArcView, a unique identifier was assigned using the x,y coordinates from the northwestern corner of the polygon. The new coverage was joined with the sediment texture data (cohesive and non-cohesive sediment classifications) and river bathymetry (0-6, 6-12 and >12 ft of water depth).

- The GIS system calculates sediment volumes based on the current elevation of the river bottom (the sediment-water interface as defined by the bathymetry, representing the upper surface), the removal depth (defined by the depth assigned to each target area, representing the lower surface) and the horizontal limits of each target area (representing the sides of the removal volume). These three surface defined the volume of sediment for removal for each target area, which was then calculated by the GIS system. The determination of the lower surface (*i.e.,* the removal depth) involved several steps described below.

- To create a surface from the removal depth coverage, a “staircase” elevation map was created to represent sediment removal to an elevation. For this purpose a surface was generated between the bathymetric contour lines (river bottom) by assigning the removal depth to the deeper contour line for each polygon. Thus a two foot removal between bathymetric contours of 10 and 11 feet of water depth would define the removal surface at 13 ft (11+2). Thus each target area with its single removal depth was “sliced” via its intersection with the bathymetric contours to create a removal surface which resembles a staircase, expressed in terms of water depth. Because the absolute height of water in the river relative to sea level can also be estimated from the NYS Department of Canals data, these surfaces (*i.e.*, the river bottom and the removal depth) can be expressed either in terms of bathymetry or, more accurately, in terms of absolute elevation. Most calculations were done on the basis of absolute elevation since, in fact, the sediment removal volumes are independent of the depth of water in the river.

- In the calculations, features such as island were excluded.The resolution of the surfaces was defined at a 1 sqft horizontal grid for the volume calculation above Lock 5 where bathymetric data were extensive. Some areas were not covered by the bathymetric data however, including the river portion above Rogers Island, the portion west of Griffin Island, and a small portion of the river near the dams. For the areas with no bathymetry information, the volume was computed using the depth of contamination multiplied by the surface area of the target area. Below Lock 5, the bathymetry information was digitized from the NOAA Digital Nautical Charts (Charts: 14786-17, 14786-15, 14786-14, 14786-13, 14786-12, 14786-11, 14786-10, 14786-9, 14786-8). However, since only the 6 ft. and 12 ft. contours were available and then without the associated absolute water elevation information, the resolution of the volume calculation was greatly limited. However, the likely sediment removal volumes in this region (Section 3) are quite small relative to Sections 1 and 2 so this limitation does not represent a large source of error for the engineering calculations.

Results of the computational effort are displayed in Table B-1. The table provides estimates of targeted sediment volumes by river section and, within each section, by water depth for each remediation scenario.

TABLE B-1: TARGETED SEDIMENT VOLUMES

River Section	Volume Removed by Water Depth (Cubic Yards)											
	Full-Section				Expanded *Hot Spot* Remediation				*Hot Spot* Remediation			
	0-6'	6-12'	>12'	Total	0-6'	6-12'	>12'	Total	0-6'	6-12'	>12'	Total
1	897,130	735,833	531,994	2,164,956	699,851	525,302	291,273	1,516,426	539,206	308,884	116,763	964,854
2	503,459	402,844	325,572	1,231,875	389,452	188,783	144,477	722,712	298,702	148,686	90,771	538,159
3	-	-	-	-	468,813	78,144	24,120	571,076	224,184	-	-	224,184
Total	1,400,589	1,138,676	857,566	3,396,831	1,558,115	792,228	459,870	2,810,214	1,062,092	457,570	207,534	1,727,196

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX C

VENDOR AND TECHNOLOGY CONTACT INFORMATION

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Beneficial Use	Consolidating Technologies (CTI)	Beneficial Use	Will von Hacht 610-278-9678
Beneficial Use	Mine Reclamation	Pennsylvania Mine Reclamation Project	Paul Linanne 717-783-2267
Bioremediation	Environmental Catalyst Company	Catalytic Air Oxidation	MK Carter 408-356-6693
Bioremediation	Advanced Solutions for Environmental Treatment (ASET)	X-19	Mel Bernstein 650-494-0182
Bioremediation	Intech One Eighty	White Rot Fungus	Dr. Aust D. Steven 801-753-2111
Bioremediation/ Soil Washing	BioGenesis Enterprises Inc.	Soil and Sediment Washing Process	414-571-2468 or Charles Wilde 703-913-9700
Bioremediation/Soil Washing	Institute of Gas Technology	PCB-REM	Dr. J. Robert Paterek 847-768-0720
Bioremediation	Institute of Gas Technology	Fluid Extraction - Biological Degradation (FEBD)	Dr. Robert Paterek 847-768-0720
Bioremediation	Bio-Genesis Technologies	Aerobic Biotreatment System (ABS)	Paul Coukoulis 602-990-0709
Bioremediation	MBI International	Anaerobic PCB Dechlorinating Consortia	Dr. Muru R. Natarajan 517-336-4636
Bioremediation	Interstate Remediation Services	Bio-Integration	Don Parris 941-952-5825
Bioremediation	Arctech, Inc.	Bioremediation Solid-Phase	Daman Walia 703-222-0280
Bioremediation	ETUS, Inc. Enhanced Bioremediation	Enhanced Bioremediation Technology	Richard Gion 407-321-7910
Bioremediation	Eco-Tec, Inc.	EnviroMech Gold Biocatalytic Degradation	425-201-6848
Bioremediation	B&S Research, Inc.	B&S Achieve-B&S Industrial	Mr. H. W Lashmett 218-984-3757

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Bioremediation	Bogart Environmental Services, Inc.	Bevrox Biotreatment - Liquid-solid contact (LSC) digestion process	Jim League 615-754-2847
Capping	Aquablok	Capping	John Hull, Joe Jersak 419-385-
Cement Stabilization of PCBs	Blue Circle Cement	Stabilizing sediments for Rail transport	Dan Gorke 518-756-5088
Cement Stabilization of PCBs	Pozzolan Cement	Stabilizing sediments for Rail transport	Leo Palmateer 518-756-5089
Cement Stabilization of PCBs	St. Lawrence Cement Company	Stabilizing sediments for Rail transport	518-943-4040
Chemical Dechlorination	Xetex Corporation	XeChlor Process	Dr. Remey Hennet 212-332-3333
Chemical Dechlorination	SDTX Technologies, Inc.	KPEG	Not available (Company no longer in business)
Chemical Dechlorination	Eco-Logic	Gas Phase Chemical Reduction Process	Elizabeth Kummling 519-856-9591
Chemical Dechlorination	Commodore Environmental Services	Solvated Electron Technology (SET)	James Deaugelis 212-308-5800
Chemical Dechlorination AND Solidification/ Stabilization	Funderburk and Associates	Dechlorination and Immobilization	Ray Funderburk 800-723-8847 or 713-934-4500
Chemical Dechlorination	Galson Remediation Corp.	APEG PLUS	Colleen Ward 518-453-6444
Chemical Dechlorination	National Risk Management Research Laboratory	Base Catalyzed Decomposition	Steven Detwiler 610-431-9100
Containment	IWT/Cargo Guard	Silt Curtains	Pete Daly 732-295-5556
Dewatering	Warman Group (Weir Slurry Group)	Hydrocyclone	Debbie Switzer 608-221-5837
Dewatering	FSE Minerals - Technequip	Hydrocyclone	Campbell McClure 416-749-3991
Dewatering	ALRick Press Company	Hydrocyclone/Belt Filter Press	518-762-4969

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Dewatering	Phoenix Process Equipment	Belt Filter Press	502-499-6198
Dewatering	Jager Process- G.P. Jager & Associates, Inc.	Belt Filter Press	Robert Fenton 201-986-1994
Dewatering	JWI -US Filter (owned by Vivendi)	Belt Filter Press	616-772-9011
Disposal	Waste Management Model City Facility	Landfill- TSCA	Pat Ludwig 716-754-8231
Disposal	Chemical Waste Management of the Northwest (Arlington, OR)	Landfill- TSCA	503-454-2643
Disposal	Chemical Waste Management Kettleman City, CA	Landfill- TSCA	Edward Vasquez 209-386-9711
Disposal	Chemical Waste Management Emmelle, AL	Landfill- TSCA	Polly Goodwin 205-652-9721
Disposal	Wayne Disposal Facility	Landfill- TSCA	Lisa Gregery 716-681-9003
Disposal	Waste Control Specialists, LLC	Landfill- TSCA	Sam Seed or Robert Kaizer 888-789-2783
Disposal	US Ecology Inc.	Landfill- TSCA	Tracy Smith or Kevin Whittmer 775-553-2203
Disposal	Safety -Kleen Lone Facility	Landfill- TSCA	Vicky Sbhwerdtfeger 580-697-3500
Disposal	Safety-Kleen Grassy Mountain Facility	Landfill- TSCA	Adam Garzier 801-323-8963
Disposal	Envirosafe Services Inc. Of Idaho	Landfill- TSCA	Mike Spomer 800-274-1516
Disposal	ECDC Environmental	Landfill- Non-TSCA	William W. Gay 914-381-8570
Disposal	Horizon Environment	Landfill- Non-TSCA	Eric Paquin 450-430-8778
Disposal	Al Turi Landfill	Landfill-Non-TSCA	914-294-5630
Disposal	BFI Waste Systems of North America Inc. Niagara Falls Landfill (formerly CECOS)	Landfill-Non-TSCA	Ron Ball 716-614-3383
Disposal	Colonie Landfill	Landfill- Non-TSCA	518-783-2827

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Disposal	Deleware County Sanitary Landfill	Landfill- Non-TSCA	Bruno Bruni 607-865-5805
Disposal	Franklin County Regional Landfill	Landfill- Non-TSCA	Julie Rushford or George Eades 518-483-8270
Disposal	Fresh Kills Landfill	Landfill- Non-TSCA	Greg Anderson 212-442-9078
Disposal	Fulton County Landfill	Landfill- Non-TSCA	518-736-5501
Disposal	Greater Albany Landfill	Landfill- Non-TSCA	Joe Pibbalhaus 518-869-3651
Disposal	Clinton County Landfill: New England Waste Services (formerly Schuyler Falls Landfill)	Landfill- Non-TSCA	Julie Liberty or Craig Squire 518-563-5514
Disposal	Sullivan County Landfill	Landfill- Non-TSCA	914-794-4466
Disposal	CINTEC	Landfill- Non-TSCA	Tony Lemme 514-368-4861
Disposal	Enfoui-Bec (Becancour)	Landfill- Non-TSCA	Stephanie Lemay 819-233-2443
Extraction	Envirogen, Inc.	SoPE (Solid Organic Phase Extraction)	Ronald Unterman 609-936-9300
Extraction	Syracuse University	Supercritical Fluid Extraction (SFE)	Lawrence Tavlarides 315-443-1883
Extraction	Terra-Kleen Response Group, Inc	Solvent Extraction Treatment System	Alan Cash 619-558-8762
Extraction	National Research Council of Canada	Solvent Extraction Soil Remediation (SESR)	Abdul Majid 613-993-2017
Extraction	Commodore Environmental Services	Solvated Electron Technology	James Deangelis 212-308-5800
Extraction	Institute of Gas Technology	SELPHOX	Michael Mensinger 847-768-0602
Extraction	Metcalf & Eddy, Inc	ORG-X	Neville Chung 781-246-5200
Extraction	Environmental Treatment and Technologies Corporation	Methanol Extraction Process	RIMS unable contact vendor

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Extraction	Arctech, Inc.	Light Activated Reduction of Chemicals (LARC)	Daman Walia 703-222-0280
Extraction	Enviro-Sciences (formerly ART International)	L.E.E.P. (Low Energy Extraction Process)	Information not available
Extraction	Institute of Gas Technology	Fluid Extraction - Biological Degradation (FEBD)	Dr. Robert Paterek 847-768-0720
Extraction	S.S. Papadopulos & Associates, Inc.	Detergent Extraction of NAPLS (DNAPLS)	James Lolcama 301-718-8908
Extraction	American Biotherm Company, LLC	Biotherm Process	Information not available
Extraction	Resources Conservation Company	B.E.S.T. Process	Bill Heins 425-828-2400
In river Transport	S.C. Loveland Co., Inc. Marine Transportation	Barge dredged material in river - Hopper Barges	609-935-8100
In river Transport	Hughes Marine Firms	Barge dredged material in river - Hopper Barges	Bill Hughes 732-225-1212
In river Transport	Shugart	Transport dredge in river - Spud Barges	803-581-5191
Incineration	Bennett Environment - RECUPER SOLS	Thermal Oxidation Unit	Rob Griffith 604-681-8828
Incineration	IT Corporation	Thermal Destruction Unit	Gregory McCartney 419-425-6003
Incineration	Roy F. Weston, Inc	Transportable Incineration System	Christopher Young 610-701-3182
Incineration	Safety-Kleen (Aragonite) Inc.	Off-site incineration facility	801-323-8100
Incineration	Onyx Environmental Services	Off-site incineration facility	Jeff Campbell 409-736-4160
Incineration	Safety-Kleen (Deer Park) Inc.	Off-site incineration facility	713-930-2300
Incineration	Safety-Kleen (Coffeyville) Inc.	Off-site incineration facility	316-251-4459

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Incineration	Retech, Inc.	Plasma Arc Centrifugal Treatment (PACT) System	Ron Womack 707-462-6522
Incineration	Smith Technology Corp.	Pyrokiln Thermal Encapsulation	Bernice Bloomquist 214-770-1800
Incineration	Shirco Infrared Systems Inc.	Electric Infrared Incineration	Company Bankrupt
Incineration	Pedco, Inc.	Rotary Cascading Bed Incineration	RIMS unable contact vendor
Incineration	IT Corporation	Hybrid Thermal Treatment System (HTTS)	William Bosack 412-858-3950
Incineration	Institute Gas and Technology	AGGCOM	Michael Mensinger 847-768-0602
Incineration	General Atomics Circulating Bed Combustor	CBC	Dan Jensen 619-455-4158
Incineration	Combustion Process Manufacturing Corporation	CPMC Process	Richard Dick 713-499-2930
Incineration	CINTEC Environment	Circulating Fluidized Bed Combustor	Philippe Guerin 514-364-6860
Incineration	Battelle Memorial Institute	UNIDEMP	Rajv Kohli 614-424-6424
Incineration	B&W Services, Inc.	Cyclone Furnace Vitrification	George Dudich 804-522-5217
Removal	Caterpillar, Inc.	Dredge	732-885-5555
Removal	Cable Arm	Dredge	Ray Bergeron 734-676-6108
Removal	Young Corporation	Dredge	Ron Szpak 800-321-9090
Removal	HAM Dredging	Dredge	Hahns VanderWAL 403-253-1702
Removal	Hawco	Dredge	
Removal	IHC Dredge Technology Corporation	Dredge	973-696-1559
Removal	Boskslis Dredging of the Netherlands	Dredge	Bart Propper 504-587-8702

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Removal	Bean-Stuyvesant	Dredge	Ancil Taylor 504-587-8701
Soil Washing	Linatex, Inc.	Soil/Sediment Washing	Peter Hall 615-452-5500 or 615-230-2235
Soil Washing	Kinit Enterprises	Trozone Soil Remediation System	RIMS unable contact vendor
Soil Washing	GHEA Associates	Soil Washing Technology	RIMS unable contact vendor April'99
Soil Washing	ARCADIS Geraghty & Miller, Inc.	Soil Washing	Information not available
Soil Washing	Environmental Remediation International (EnRem)	Soil Remediation System (SRS)	Richard Gutensohn 775-786-6886
Soil Washing	Westinghouse Remediation	Soil Washing	404-298-7101
Soil Washing	Metcalf and Eddy	Hydro-Sep Soil Washing Process	Neville Chung 781-246-5200
Solidification/ Stabilization	Soliditech, Inc.	Solidification Stabilization	Technology no longer active
Solidification/ Stabilization	Geo-Con, Inc.	Solidification Stabilization	Ken Andromalas 412-856-7700
Solidification/ Stabilization	Chemfix Technologies	Chemical Fixation/ Stabilization	Information not available
Solidification/ Stabilization	CBA Environmental Services	MITU	Bruce Bruso 717-682-8742
Solidification/ Stabilization	Millgard Environmental Corporation (Hayward Baker)	MecTool	George Burke 800-456-6548
Solidification/ Stabilization	STC Remediation	Solidification Stabilization / Chemical Fixation	Scott Larson 602-948-7100
Thermal Desorption	Advanced Soil Technologies	AST Thermal Desorption System	Kirk Shellum 612-486-7000
Thermal Desorption	Recycling Sciences International, Inc.	DAVES Process Desorption Vapor Extraction System	William Meenan 312-663-4242
Thermal Desorption	Dura Therm, Inc.	Dura Therm Desorption Technology	Barry Hogan 281-339-1352

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Thermal Desorption	CMI Corporation	Enviro-Tech Thermal Desorption	405-787-6020
Thermal Desorption	Eco-Logic	Gas Phase Chemical Reduction Process	Elizabeth Kummling 519-856-9591
Thermal Desorption	Midwest Soil Remediation, Inc.	Gem 1000	Bruce Penn 847-742-4331
Thermal Desorption	Seaview Thermal Systems	High Temperature Thermal Distillation	Not known
Thermal Desorption	Midwest Soil Remediation, Inc.	High Capacity Indirect Thermal Desorption Unit	Bruce Penn 847-742-4331
Thermal Desorption	Hrubetz Environmental Services, Inc.	HRUBOUT Process	Michael Hrubetz 214-363-7833
Thermal Desorption	Maxymillian Technologies	Indirect System	Hilary Hinds 617-557-6077
Thermal Desorption	McLaren/Hart Environmental Engineering Corp.	IRV-100, IRV-150, and IRHV-2000 Thermal Desorption System	Ron Hill 704-587-0003
Thermal Desorption	Midwest Soil Remediation, Inc.	Low Temp. Thermal Desorption (CM180-120) and (CMI ET-650)	Bruce Penn 847-742-4331
Thermal Desorption	Environmental Soil Management	Low Temp. Thermal Desorption	518-747-5500
Thermal Desorption	Carson Environmental	Low Temperature Oxidation	Carson Late 310-478-0792
Thermal Desorption	On-site Thermal Services Division of Soil Restoration and Recycling, L.L.C.	Low Temperature Thermal Desorption Plant (LTTDP)	Bill Boren 520-574-0123
Thermal Desorption	Smith Technologies Corporation	Low Temp. Thermal Aeration System (LTTA)	Joe Hutton 303-790-1747
Thermal Desorption	ASTEC/SPI Division	Low Temperature Thermal Desorption System (LTTDS)	Not available
Thermal Desorption	Contamination Technologies, Inc.	Low Temperature Thermal Desorber	RIMS unable contact vendor

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Thermal Desorption	Carlo Environmental Technologies, Inc.	Medium Temperature Thermal Desorption	Darwin Loyer 810-465-6232
Thermal Desorption	Covenant Environmental Technologies	Mobile Retort Unit	Rick P. Newman 901-278-2134
Thermal Desorption	Eagle Environmental Technologies, Ltd.	Plasma Technique	Jerry Wilmo 775-348-7448
Thermal Desorption	Purgo, Inc.	Portable Anaerobic Thermal Desorption Unit	Gay Turner 804-550-7448
Thermal Desorption	Separation and Recovery Systems, Inc.	SAREX process	Christopher Hebble 949-261-8860
Thermal Desorption	ConTeck Environmental Services, Inc.	Soil Roaster	Chris Krege 612-441-4965
Thermal Desorption	Smith Technology Corporation	Soil Tech ATP	214-651-8516
Thermal Desorption	ARCADIS Geraghty and Miller, Inc.	STRATEX	Michael Mann 813-264-3506
Thermal Desorption	Advanced Environmental Services, Inc.	System 64MT Low Temperature Thermal Desorption	Tad Copper 319-377-6357
Thermal Desorption	Philip Environmental Services Corporation	Thermal Recycling System	NA
Thermal Desorption	ETTS EcoTechniek Thermal Treatment	Thermal Desorption	Not available
Thermal Desorption	SCC Environmental	Thermal Phase Separation Unit	Paul Antle 709-726-0506
Thermal Desorption	IT Corporation	Thermal Desorption	Edward Alperin 423-690-3211
Thermal Desorption	Westinghouse Remediation Services	Thermal Desorption	404-298-7101 or 800-752-3303
Thermal Desorption	Caswan Environmental Services, Ltd.	Thermal Distillation and Recovery Process	RIMS unable contact vendor
Thermal Desorption	Maxymillian Technologies, Inc.	Thermal Desorption Unit	Hilary Hinds 617-557-6077
Thermal Desorption	ETG Environmental Inc.	Thermo-O-Detox Medium Temperature Thermal Desorption	610-431-9140

TECHNOLOGY/VENDOR CONTACT INFORMATION

Treatment Classification	Vendor Name	Process Name	Vendor Contact
Thermal Desorption	ThermoRetec, Thermatek Thermal Desorption	Remediation Technologies, Inc.	Mark McCabe 978-371-1422
Thermal Desorption	Thermotech Systems Corporation	Two-stage Tandem Soil Remediation Unit (TDU)	Mark Howard 407-290-6000
Thermal Desorption	Rust Federal Services, Inc.	VAC*TRAX	John Westcott 864-281-0906
Thermal Desorption	Waste Management Inc.	XTRAX	606-329-1848
Thermal Destruction /Beneficial Use	Geo-Safe Corporation (A.K.A. GeoMelt)	In situ Vitrification	509-375-0710
Thermal Destruction /Beneficial Use	JCI/Upcycle	Manufacture of Lightweight Aggregate	Jay Derman 518-463-0905 Henry Schlieper 908-665-0940
Thermal Destruction /Beneficial Use	Westinghouse Science and Technology Center	Plasma Arc Vitrification	Shyam Dighe 724-722-5276
Thermal Destruction /Beneficial Use	Institute of Gas and Technology ENDESCO Services Inc.	Cement Lock- Technology	Michael Mernsteinger 847-768-062
Thermal Desorption	Ariel Industries, Inc.	Ariel SST Low Temperature Thermal Desorber	Timothy Boyd 706-277-7070
Transportation	Canadien Pacific Railroad	Transport from Transfer Station by RR	Edward Fitzgerald 518-383-7218
Transportation	CSX Railroad	Transport from Transfer Station by RR	
Wastewater Treatment	NYSDEC	GE WW Treatment at Hudson Falls	Bill Ports NYSDEC