Hudson River PCBs Superfund Site
Phase II Monitoring Report and Updates

Prepared by
Environmental Stewardship Concepts, LLC
For
Community Advisory Group Meeting
December 19, 2011

This report was prepared for Hudson River Sloop Clearwater (Clearwater) to summarize the information collected during the 2011 dredging of PCB contaminated sediments. Clearwater requested a summary and compilation of the information that ESC, LLC had monitored during the dredging process in 2011, including air and water quality information and habitat restoration. The other area of interest is the reduction of fish tissue PCB levels as a consequence of dredging and achieving the goal of fish that can be consumed safely by people or wildlife. The last topic remains under investigation because of the complexity of the relationship between sediment, water and fish tissue concentrations of PCBs.

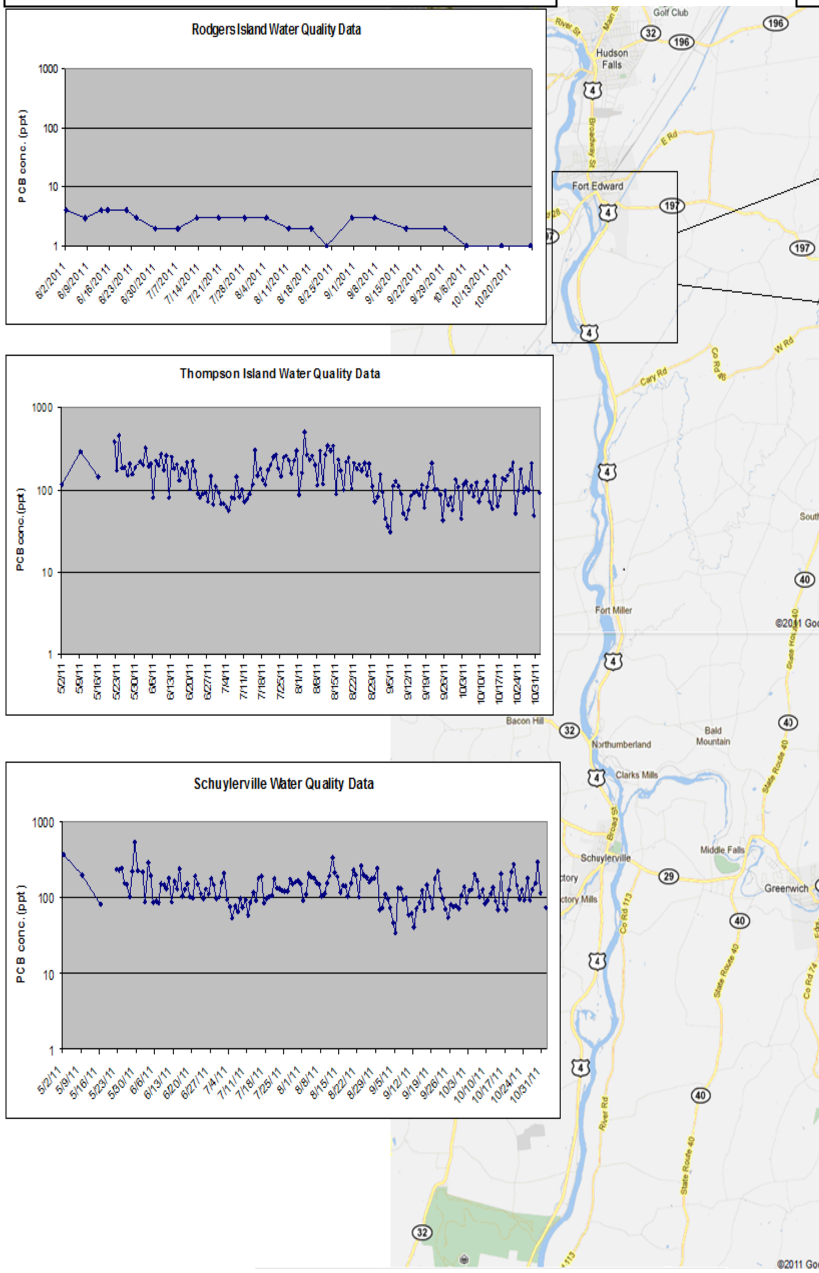
MONITORING

PCBs

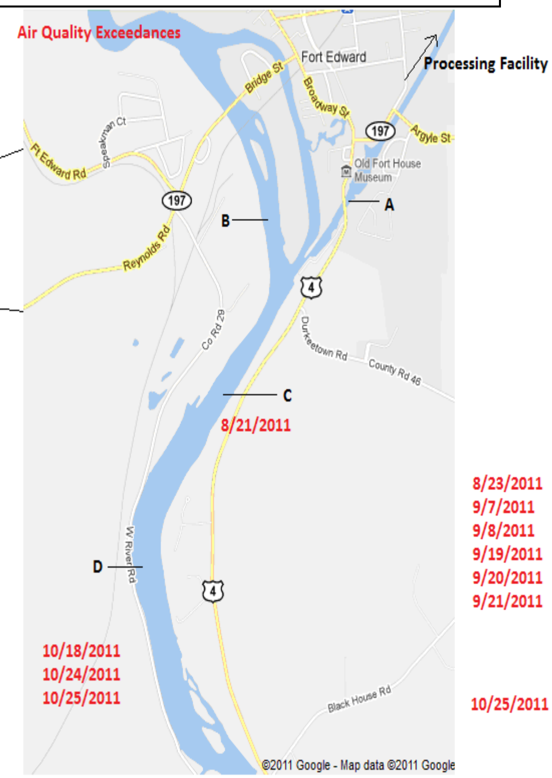
The second phase of dredging removed approximately 363,000 cubic yards of PCB-contaminated sediment during June 6 - November 8, 2011. Monitoring was conducted to analyze water quality, PCB load, air quality, odor, noise, lighting, and navigation. Monitoring data were collected daily from May-November. Weekly water quality monitoring for resuspension began on November 14, 2011 after dredging was completed and baseline levels of PCBs in the water were reached. Data were collected at Thompson Island, Schuylerville, and Waterford, while limited data are available for Rogers Island, Stillwater, Albany, and Poughkeepsie. Overall, PCB concentrations were under the control level of 500 ppt except for one exceedance that occurred at Waterford on May 21, 2011 with a concentration of 561 ppt (US EPA 2011, website).

PCB mass loads were monitored during dredging to ensure that PCB sediments traveling downstream did not exceed pre-established load limits. These load limits were established to limit the amount of PCBs that would be transported into the Lower Hudson, beyond the Waterford sampling station that is located the furthest downstream.

PCB Water Quality Monitoring Results

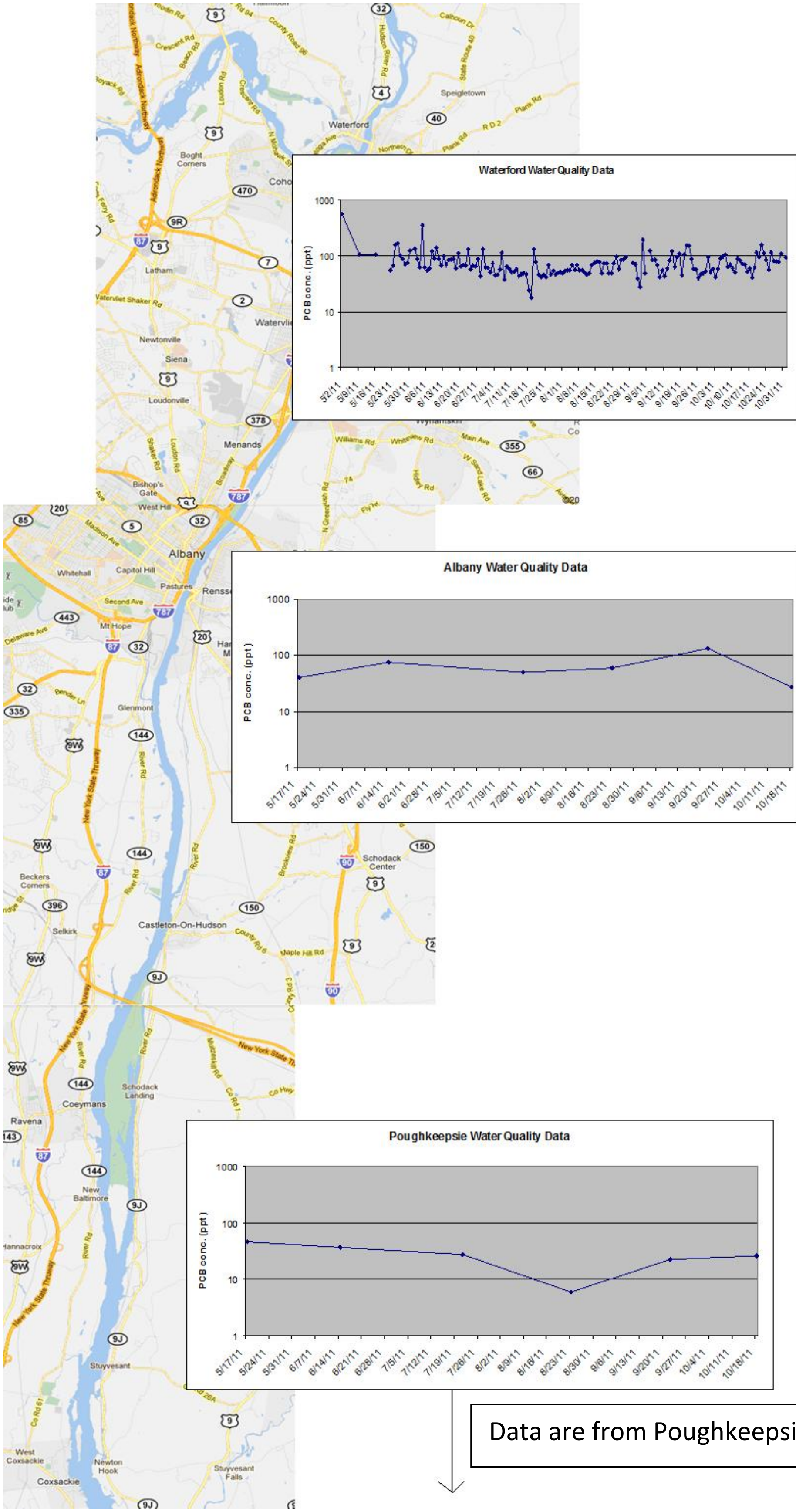


PCB Air Quality Monitoring Exceedances



PCB Monitoring Data Results

- Graphs show PCB concentrations in water (ppt) on a specific date at each monitoring station. >500 ppt = exceedance
- The 'Air Quality Exceedance' figure shows the date of a particular air quality exceedance (daily total PCBs above standard) and the river section to which it corresponds. All dates on the far right represent an exceedance in the processing facility area
- All data were collected from the EPA Hudson River Dredging Data Website: hudsondredgingdata.com



Data are from Poughkeepsie, further downstream

The established load limits are based on the Tri + PCB mass, which refers to the heavier PCBs, removed during the dredging season. At the far-field water monitoring stations, Thompson Island and Waterford, the load criteria are 2 percent and 1 percent, respectively. The dredging season ended in compliance with the load criteria at both monitoring stations (US EPA 2011, website).

Air Quality Monitoring

Air quality monitoring was conducted daily during river operations at stations near dredging sites and will continue at the Processing Facility until all sediment is transported off-site. The air quality performance standard concentration for residential areas is 0.11 $\mu g/m^3$ and 0.26 $\mu g/m^3$ for commercial/industrial areas. The concern levels are 80% of their respective standard for 24-hour PCB concentration averages, which equate to 0.08 $\mu g/m^3$ for residential areas and 0.21 $\mu g/m^3$ for commercial/industrial areas (Arcadis, 2011). Throughout the dredging period, a number of air quality standard exceedances were reported mainly in River Section D and at the Processing Facility (US EPA, 2011). The website reports, however, were vague because it was not made clear whether or not the PCB levels exceeded the industrial or residential standard. Additionally, the website did not indicate clearly if the "control" levels are equal to the "concern" levels referenced in the *Phase 2 Final Design Report* (Arcadis 2011, p. 19). ESC, LLC has been tracking the data and information regarding daily monitoring activities as well as reviewing *Daily Oversight Summary Reports*. Anytime an exceedance was reported for air quality or PCB load, ESC recorded the result and notified Clearwater. The ESC, LLC team analyzed the PCB load and air quality data by creating spatial and temporal graphs to determine any trends in exceedances of these characteristics. These figures are presented above and included in the PowerPoint presentation delivered to the CAG on December 8, 2011.

Odor Monitoring

Odor monitoring was conducted daily during dredging operations. The control level for odor monitoring was reached when the presence of uncomfortable odors was noted by the remedial action team or by the public. The exceedance level for odor monitoring is the exceedance of the hydrogen sulfide standard (0.01 ppm) or frequent, recurrent odor complaints related to project activities. Data showed typical operations (no presence of uncomfortable odor) for odor, with no exceedances. The Hudson River Dredging website indicated, in error, that odor reached the control level on November 4, 2011. The error has been corrected on the website to indicate that there have been no odor exceedances (US EPA, 2011).

Noise, Light, and Navigation Monitoring
There were no reported exceedances of noise standards (from 65-80 decibels), light levels (0.2 to 1 footcandle, where 0.1 is light produced by a 60-watt bulb), or navigation impacts during dredging operations (US EPA, 2011). Light was monitored because operations continued after dark.

DAILY OVERSIGHT SUMMARIES

Daily Oversight Summary Reports described dredging, process facility, and rail yard operations throughout the dredging season. The reports also covered water quality, sediment sampling/processing and survey activities, quality of life performance standards monitoring, weather conditions, and miscellaneous comments and/or safety notes. Dredging occurred in Certification Units (CUs) 11, 12, 14 - 16, 19 - 25 and backfill and/or capping was conducted in CUs 9 - 16, 19 - 25.

DREDGING OPERATIONS UPDATE

Overall, the dredging proceeded as planned with some occasional minor setbacks, due to extreme weather conditions (Hurricane Irene, lightning, etc.), and/or repairs needed on the equipment (leaks in dredging equipment). Best management practices (BMPs) were deployed in areas of high PCB concentrations as needed. BMPs were deployed in CU16 on August 31, Sept. 19, and Sept. 26 as sheen was noticed due to PCBs in dredge material. Similarly, BMPs were deployed in CU22, CU23, CU24, and CU25 on Sept. 27, Oct. 12, Oct. 24 – 25, and Oct. 22, respectively (US EPA/USACE/LBG 2011).

HABITAT CONSTRUCTION

The Phase 2 habitat construction activities outlined in the *Remedial Action Work Plan* have not yet been finalized but will include: planting riverine fringing wetland vegetation and submerged aquatic and floating vegetation, repairing and planting on shoreline areas above the 119 foot elevation if disturbed during dredging, monitoring plantings, and replanting the following year (Parsons, 2011). As noted by the Trustees from NOAA and the Fish and Wildlife Service, this plan does pose some potential issues. For instance, the backfill material is unsuitable for native plant growth and backfilling will not return all areas to their original depths. In addition, only about 1/3 of the dredged area will be replanted. Capping and stabilization may cause the river bottom and shoreline to harden and the habitat construction may increase the possibility for erosion of the river banks. It seems as if the habitat conditions in the river prior to dredging were not taken into account when preparing a habitat construction plan. For example, some riverine and fringing wetland areas are being seeded with annual seeds where a perennial seed would be preferable. Also, grass or herbaceous mixes are being planted in areas where trees and shrubs would be preferable. Finally, no woody debris will be placed in the river to mimic pre-dredge conditions (NOAA and USFWS 2011, poster at SETAC annual meeting Boston, MA).

Phase 1 habitat construction measures are currently underway. According to Daily Oversight Summary Reports, near-shore areas in CU19 were stabilized with coir fabric and seeded with river fringing wetlands (RFW) vegetation on October 13 – 15.

MUSSELS

Because of freshwater mussels' importance as a keystone species in the Hudson River ecosystem, the NOAA and the USFWS have expressed concern over the destruction of mussel beds during the dredging process (NOAA and USFWS 2011, poster). As described in the *Phase 2 Final Design Report*, the Phase 2 habitat construction plan does not include any action to harvest mussels prior to dredging or reseeding mussel beds after dredging is complete (Arcadis 2011 p. 86-87). Mussels are an integral part of the Upper Hudson River ecosystem as mussel beds provide other aquatic species with habitat, food, and clean water (USFWS 2010, website). Certain mussel species' larvae depend on symbiotic relationships with certain fish species (NHDES 2005, p. 1). Damaging and drastically altering mussels' habitats will most likely affect these crucial relationships and affect endemic mussel populations and distribution. Additionally, inadequate mussel habitat construction may promote the colonization of invasive mussel species, such as the zebra mussel (Brosnan and Foley 2011, letter).

To protect the sensitive and integral freshwater mussel species, measures, which may include harvesting mussels before dredging and transplanting them to reconstructed mussel beds or reseeding reconstructed mussel beds, would promote a more complete post-dredging habitat restoration.

The White Sulphur Springs National Fish Hatchery's Aquatic Resources Recovery Center (ARRC) in West Virginia (part of the Northeast Region U.S. Fish and Wildlife Service) has supplied mussels and assisted in mussel habitat recovery at various sites, including sites in the Ohio River and James River (USFWS 2010, website). ARRC propagates and raises over 30 freshwater mussel species, and states its mission to "work with partners to recover and maintain mussels, fish and other aquatic resources at self-sustaining levels for the benefit of the American Public" (USFWS 2009, p. 1). Working with ARRC during

Phase 2 habitat construction might be a feasible option, assuming that the center can provide endemic mussel species, which may include *Anodonta implicate, Lampsilis cariosa,* and *Ligumia nasuta* (NatureServe 2010, website). A field survey documenting location and mussel species within the Phase 2 area or similar areas would provide valuable information on species appropriate for reintroduction (Brosnan and Foley 2011, letter).

PCB LEVELS IN FISH

The ultimate goal of the Hudson River PCB remediation is reduction of fish tissue PCB concentrations to levels that pose little risk to wildlife and permit human fish consumption. The processes of fish uptake and accumulation of PCBs is dependent, in part, on sediment PCB concentrations for a variety of reasons. Thus, the PCBs that remain in the river following dredging will have an important impact on fish tissue PCB levels. Sediment and fish tissue monitoring provide data that allow an assessment of progress toward the goal of reducing PCBs in fish tissues to a “safe” level. NOAA and US FWS are concerned that the post dredge PCB sediment levels will remain above the predicted values. This topic remains under investigation by ESC, LLC, and is a topic of discussion between Clearwater and EPA concerning the TAG contract and resources. The following material presents information on how fish tissue PCB levels are modeled and predicted. From a scientific standpoint, ESC considers an important question to be how the remaining PCBs in the sediment affect the fish tissue PCB concentrations.

MODELS

Purpose

The Hudson River PCBs Superfund Site, Phase 2 remediation goals and cleanup actions rely on various model outputs. The *Volume 2D - Revised Baseline Modeling Report*, which provides information for the *PCB Reassessment RI/FS*, describes the fate and transport and bioaccumulation models. Outputs from bioaccumulation models, which include a **Bivariate BAF Analysis**, an **Empirical Probabilistic Food Chain Model**, and a time-varying, mechanistic model called **FISHRAND**, were used to develop a framework that relates PCB concentrations in sediment and water to fish body burden PCB concentrations (TAMs 2000a, p. 8). The human health risk assessment, presented as *Volume 2F* of the *RI/FS*, considers these model outputs and provides information that is quantitatively incorporated into cleanup alternatives in the form of preliminary remediation goals (PRGs). To satisfy remedial action objectives (RAOs), as stated in the *Hudson River PCBs Reassessment RI/FS,* preliminary remediation goals were established and are as follows (TAMs 2000a, p. 3-4):

- 0.05 mg/kg PCBs in fish fillet to be protective of human health, considering a consumption rate of one fish meal per week for adults
- 0.2 mg/kg PCBs in fish fillet to be protective of human health, considering a consumption rate of one meal per month
- 0.4 mg/kg PCBs in fish fillet to be protective of human health, considering a consumption rate of one meal every two months
- 0.3 to 0.03 mg/kg PCBs in whole fish bodies, correspondingly 0.12 to 0.012 mg/kg in fish fillets to be protective of ecological health, considering to the ecological exposure pathway

Birvariate BAF Analysis

The *Bivariate BAF Analysis* describes the statistical relationship between PCB concentrations in fish tissue and PCB concentrations in sediment and water. The analysis requires historical fish, sediment, and water-column data, and is a summarizing tool rather than a predicting tool (TAMS 2000a, p. 8). Two independent variables (sediment PCB concentrations and water-column PCB concentrations) are considered in a bivariate analysis, and the analysis output may be used in more complex food web models (TAMS 2000a, p.15). The model is straightforward, simply relating the independent factors (sediment and/or water PCB concentrations) to the dependent factor (fish PCB concentrations), and operates under several limitations. The model does not account for biological processes underlying the statistical relationships (TAMs 2000a, p. 9). The BAF analysis is operated under the assumption that biota is in a steady-state with water and sediment concentrations and that temporal change only occurs annually (TAMs 2000a, p. 10). Additionally, data on the organic carbon fraction in suspended solids is not available to support "theoretically optimal" BAF analysis (TAMs 2000a, p.17). Congener-specific data for all media from the Upper Hudson is limited as well, as data is only available from the 1990s, there are only a small number of samples for any given fish species, and the data do not offer a time-series perspective on the relationship between PCB levels in fish and PCB levels in sediment and water (TAMs 2000a, p. 15).

Empirical Probabilistic Food Chain Model

The *Empirical Probabilistic Food Chain Model* is more complex and relies on information concerning species-specific fish feeding behaviors. The model provides a framework for biologically-based food chain and environmental exposure relationships. Rather than providing a single estimated fish tissue PCB concentration for a specific sediment PCB concentration, this model provides a distribution of fish tissue concentrations, which takes variability and uncertainty of data into account (TAMS 2000a, p. 17). The model requires extensive knowledge on a number of biological factors, such as food web structure and species-specific ecology, and uses modeled sediment and water PCB concentrations rather than measured concentrations (TAMS 2000a, p. 20). This model operates under several limitations. The model is based on limited data including those data on fish species' trophic level, feeding preferences and lipid content, and it assumes that fish are in a quasi steady-state with the environment. Additionally, the distribution of PCB concentrations is affected by variable factors that are not well-documented in the Hudson (TAMS 2000a, p. 18).

FISHRAND

Various PCB uptake parameters are considered in the *FISHRAND* model. FISHRAND describes the change in PCB concentrations in aquatic animals over time, by taking into account such species-specific factors as uptake rates, growth rates, metabolic rates, excretion rates, etc. Results produced from complex equations describing these factors supply the model input parameters (TAMS 2000a, p. 24). This model, however, does not explicitly consider benthic feeding strategies nor does it account for in-depth contaminant and fish body interaction processes. Since the input values correspond to averages over time, space, and species, they are not easily related to experimental measurements. Also, the relative difference between observed and predicted FISHRAND data is significant, from 25-40% (TAMS 2000a, Table 6-2).

Upper Hudson River Toxic Chemical Model (HUDTOX)

The *Upper Hudson River Toxic Chemical Model (HUDTOX)* describes the fate and transport of PCBs in the Upper Hudson River, from Fort Edward to Troy, New York. Output from this model supplies the sediment and water PCB concentrations for the Empirical Probabilistic Food Chain Model and the FISHRAND model (TAMS 2000a, p. 32).

Summary Limitations

When using a model to predict any sort of results, there are inherent limitations and uncertainties related to the output. As expected, there are general limitations associated with the bioaccumulations models. Sediment and water concentration estimations, provided by the HUDTOX model and used as input variables in the Food Chain model and FISHRAND, do not account for every mechanism contributing to transport processes. Also uptake processes are simplified in the bioaccumulation models, and fish feeding preferences are highly uncertain. The Bivariate BAF Analysis and the Food Web Model cannot be reliably used as predictive tools, but can be more effectively used as tools to extrapolate beyond observed data (TAMS 2000a, p. 91).

Additionally, all parameters have some uncertainty associated with them, even measured data (TAMS 2000a, p. 93).

Data

The Bivariate BAF Analysis relied on fish tissue data that were collected yearly, beginning in 1977 and ending in 1997 between river miles 142 and 193. Between 26 and 310 fish samples were collected each year, but sampling efforts for some species were more comprehensive than others. During sampling efforts, as little as two fish samples were collected for some species (TAMS 2000a, Table 4-5). Not raw data, but rather estimates of water and sediment PCB concentrations from HUDTOX output were used in Food Chain and FISHRAND models (TAMS 2000a, p. 69, 99).

CONCLUSIONS

PCB concentrations in fish were estimated as part of the process to develop the proposed remedial alternatives presented in the *Hudson River PCBs Reassessment RI/FS* (TAMS 2000b). Fish bioaccumulation and fate and transport (HUDTOX) modeling results were used to assess if these remedial alternatives will likely reduce PCB levels in fish populations to levels meeting human and ecological risk criteria (PRGs) (TAMs 2000b, p. ES-10).

The table below includes projected fish tissue concentrations for years 2020 and 2046, under the scenarios of both monitored natural attenuation (no active remedial effort) and the selected remedy as listed in the 2002 *Record of Decision* for the Hudson River PCBs Site (US EPA 2002). Projections of PCB concentrations consider both sediment resuspension and fish uptake rates and mechanisms. The table provides the predicted percent improvement by remediation as related to decreasing PCB concentrations in fish, according to modeling results. The information is provided in Table 9.1-1 in the *Phase 1 Evaluation Report* and in Table 799-1 in the *Responsiveness Summary* (Anchor QEA 2010; TAMS 2002). These projections rely on modeling results produced during the *Phase 1 Evaluation*, conducted by Anchor QEA, LLC for General Electric Company.

PCB Concentrations in Fish Based on Bioaccumulation Models

Year	River Section	Fish PCB Concentration (mg/kg-wet weight)		Percent Improvement by Remediation
		MNA	ROD Remedy	
2020	1	0.289	0.179	38
	2	0.124	0.083	33
	3	0.109	0.079	28
2046	1	0.143	0.120	16
	2	0.073	0.062	15
	3	0.064	0.057	11

MNA = Monitored Natural Attenuation
ROD Remedy = Selected alternative remedy as listed in the 2002 Record of Decision

Based on modeling results and Phase 1 post-dredging data, Anchor QEA's *Phase 1 Evaluation Report* states that the EPA modeling effort used to establish the load standard for Phase 1 operations needs to be reassessed to take post dredge data into account (Anchor QEA 2010, p. ES-4). The report cited that the Upper Hudson fish sampled in the immediate dredging area after Phase 1 dredging showed a 500% increase in PCB concentrations, relating the increase to sediment resuspension caused by dredging (Anchor QEA 2010, p. ES-4).

In another analysis of PCB concentrations in fish samples (wet weight and lipid adjusted values), however, the New York Department of Environmental Conservation determined that increases in PCB concentrations related to dredging activities occurred in localized areas, rather than throughout the Superfund Site. The highest PCB concentration increases in fish were detected in the Thompson Island area, which had "average wet weight and lipid adjusted PCB levels that [during dredging activities] increased about 150% over the average of the [PCB concentrations in] fish from the previous five years" (Richter et al 2010, p. 9). During dredging activities, PCB levels were elevated in the Northumberland-Miller Section by about 50% over baseline monitoring levels, calculated from fish samples collected between 2004 and 2009 (Richter et al 2010, p. 9). The report states that there were no significant increases in PCB concentrations in fish in the Albany or Stillwater sections (Richter et al 2010, p. 8). These findings do not support the 500% increase in PCB concentrations that is referenced in Anchor QEA's *Phase 1 Evaluation Report*.

In the *Hudson River PCBs Site Peer Review of Phase 1 Dredging*, the Peer Review Panel, like Anchor QEA, agrees that the numerical PCB load criteria need to be re-evaluated for both the Upper and Lower Hudson (Bridges et al 2009, Table 3). The Panel, however, believes that data collected during the 2009 dredging season and the HUDTOX and FISHRAND models are insufficient to determine appropriate numerical PCB loads (Bridges et al 2009, Table 3). The Peer Review report states that the HUDTOX and FISHRAND models "are outdated and inadequate" and neither GE nor EPA have collected a sufficient amount of fish tissue data to "accurately project MNR and post-dredge fish recovery rates" (Bridges et al 2009, p. 19). Additionally, sediment data collected in 2007-2008 suggest that EPA and GE models "underestimated future PCB concentrations under natural recovery scenarios" (Field et al 2009, poster).

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