Louis Berger EPA Hudson River PCBs SUPERFUND SITE

Adaptive Management and Remedy Implementation:

Differences Between Anticipated and Operational Dredging on the Hudson River PCB Superfund Site

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Summary and Background

In the 2002 Record of Decision (ROD), USEPA (EPA) selected a dredging remedy from among several alternatives to address 2.65 million cubic yards of PCB-contaminated sediment in the Upper Hudson River. The selected remedy included removing contaminated sediments from areas exhibiting high levels of PCB inventory and surface concentration, followed by monitored natural attenuation (recovery). The selected remedy also included certain institutional controls, a monitoring program to determine when Remedial Objectives are reached, and separate upstream source control. Remedy selection involved the use of model forecasts based on reasoned assumptions regarding dredging implementation including the time needed to complete dredging, an upstream-to-downstream dredging sequence, and the use of two sediment processing facilities. Key differences between those assumptions and actual dredging operations influenced conditions in the river during implementation. Any individual modification by itself may not have constituted a major deviation from key modeling assumptions. However, the sum of these modifications resulted in conditions during dredging that were not fully accounted for in the modeled recovery trends. Table 1 summarizes differences between key remedy evaluation assumptions and actual dredging operations.

TABLE 1. REM 3/10/Select Remedial Alternative (The Selected Alternative) Components with Underlying Design Assumptions and Implementation Activities.

REM 3/10/Select Component	Anticipated for 2000 FS and 2002 ROD	Implemented for Phase 1 & Phase 2 Dredging (2009-2015)
Dredging Commencement and Duration	• 2004 (FS) or 2005 (ROD) start, • 5 or 6 year with 1 or 2 phase implementation, • 14 hour dredging days (6 days/week), • 1 year post-construction equilibration.	• Dredging 2009, and 2011-2015, • Phase 1 Peer Review in 2010, • 7 years (through 2015) total implementation, • 24 hour dredging days (6 days/week), • 8 years (2016) with initial habitat reconstruction, • 1-2 years post-construction equilibration.
Implementation Sequencing	Upstream to downstream (RS1 to RS3) with some simultaneous dredging during RS3 operations.	**2009, 2011-2012:** Generally upstream-to-downstream in RS1. **2013-2015:** Simultaneous dredging RS1, RS2, and RS3.
Dredging Infrastructure	• One upstream facility or 2 facilities (one upstream, one downstream), • In-river transport of dredged sediments and backfill materials.	• Single processing facility located upstream of target dredging areas, • In-river transport of dredged sediments and backfill materials, • Multiple backfill loading facilities.

References
Bridges, T., Fox, R., Fuglevand, P., Hartman, G., Magar, V., Schroeder, P., Thompson, T., 2010. Hudson River PCBs Site Peer Review of Phase 1 dredging, September 2010.

Discussion

As indicated in Table 1, implementation of the remedy and certain conditions in the field departed in several ways from the overall dredging approach and underlying dredging release assumptions outlined in the FS and ROD. For example, PCB flux to the water column from dredging was assumed to be derived from suspended sediment and estimated to settle within 10m of the dredge head. However, during implementation, PCB detections in the water column were at times dominated by the dissolved phase and the presence of oil sheens (Figure 1). The release and transport of dissolved PCBs, in addition to the modeled suspended load, had the potential to result in greater-than-anticipated short-term and localized increases in bioavailable PCBs. As prescribed by the ROD, dredging was conducted in two phases with an independent external peer review convened in 2010 after the completion of Phase 1 (2009).

The purpose of the peer review was to evaluate remedy implementation design and performance, and the configuration of the Engineering Performance Standards (EPS) for resuspension of dredged materials, PCB residuals, and production rates while maintaining protectiveness. In addition, EPA closely monitored dredging residuals and PCB load to the Lower Hudson River for the duration of dredging. In response to resuspension monitoring data, EPA directed the contractor to modify operations compared to original design cut depths.

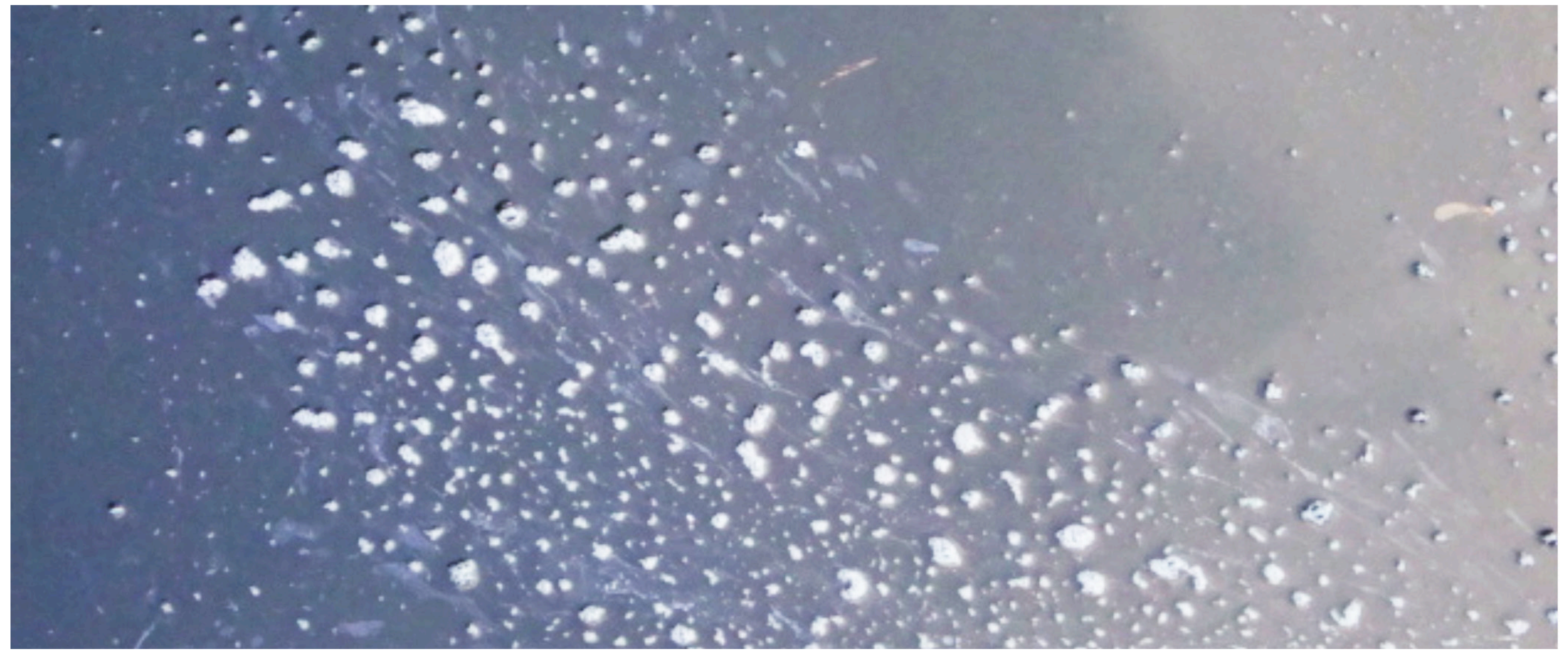

FIGURE 1. PCB Oil Sheen Observed On Water Surface During Phase 1 Dredging.

To address Peer Reviewers comments (Bridges et al., 2010), an index-based evaluation system was developed to facilitate rapid and efficient re-dredging and closure decisions to help minimize resuspension. Other departures from design with the potential to compound cumulative resuspension included the use of a single processing facility and dredging sequence changes made to increase safety while working upstream of dams.

TABLE 2. Project Lockages (passing through a lock) on Hudson River Champlain Canal During Dredging 2009-2016 as an Indicator of Increased Vessel Traffic Project-Wide and in the Final Two Years of Dredging.

Year	Lock C-7 RM 193.5 RS1	Lock C-6 RM 186 RS2	Lock C-5 RM 182.5 RS2/RS3	Lock C-4 RM 168 RS3	Lock C-3 RM 166 RS3	Lock C-2 RM 163.5 RS3	Lock C-1 RM 159.4 RS3	Total Project Lockages
2009	3,844	0	0	0	0	0	0	3,844
2010	521	0	0	0	0	0	0	521
2011	1,766	0	0	0	0	0	0	1,766
2012	3,036	0	0	0	0	0	0	3,036
2013	2,614	3,122	1,561	51	44	44	45	7,481
2014	2,598	2,160	4,636	1,830	1,270	682	592	13,768
2015	1,180	885	789	790	829	326	282	5,081
Totals	**15,559**	**6,167**	**6,986**	**2,671**	**2,143**	**1,052**	**919**	**35,497**

During Phase 1 (2009) and the first two years of Phase 2 (2011-2012), dredging took place only in RS1. Starting in 2013, dredging was conducted in RS2 and RS3, even as some dredging continued in RS1, clearly breaking with the "upstream to downstream" sequence anticipated by the ROD. In each dredging year, sediment was transported up-river and through Lock C-7 to a single processing facility in Fort Edward.

Table 2 indicates an increase in overall vessel traffic intensity starting in 2013 with over half of all lockages occurring in the last two years of dredging (2014-2015) as simultaneous dredging continued in all three River Sections. During this time dredging was conducted close to 2 dams (one in RS1 and another in RS3). These areas were also dredged out of the assumed "upstream to downstream" sequence following a comprehensive review, approval, and training process. This change in project vessel traffic patterns may have further contributed to the ROD-anticipated short-term increases in water column and fish tissue PCB concentrations observed during dredging. This contribution is potentially more influential than originally anticipated, as vessel activity intensified toward the end of dredging and the approaching ROD-anticipated post-dredging equilibration year. Figure 2 illustrates how fish tissue PCB concentrations reflected increases in exposure during dredging-related resuspension and departed from modeling assumptions. Data include the Baseline Monitoring Program (BMP; pre-dredging) and the Remedial Action Monitoring Program (RAMP, during dredging), as well as earlier data obtained by New York State.

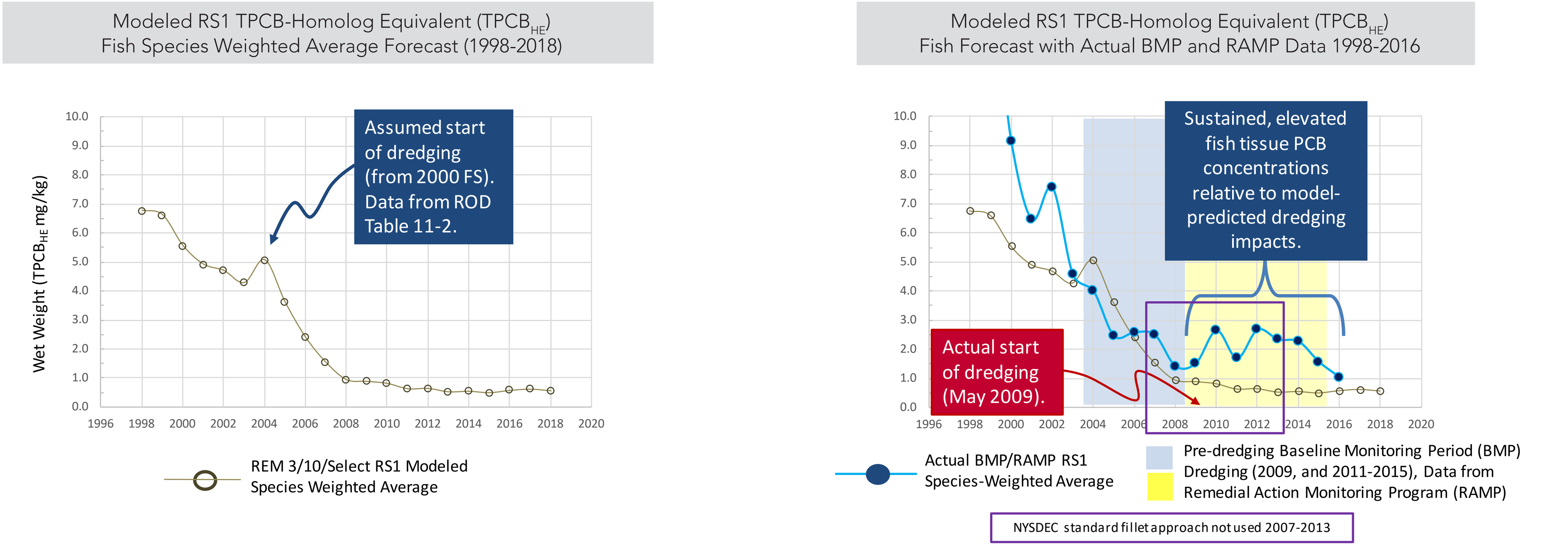

FIGURE 2. River Section 1 (RS1) Modeled (forecast) REM 3/10/Select Fish Tissue PCB Concentrations 1998-2018 (left panel) with RS1 Species Weighted TPCB-Homolog Equivalent (HE) Fish Tissue Concentrations (right panel). [computed from BMP and RAMP data collected 1998-2016].

The left panel of Figure 2 shows the fish species PCB weighted average model forecast curve for RS1, which suggested an initial increase due to dredging in the assumed first year of remediation (2004), followed by a rapid and steady decline in fish tissue levels. In contrast, real-time fish data (right panel, blue line with solid circles) demonstrate both the higher overall variability of actual fish data (relative to the model forecast) and the sustained effects of dredging and resuspension on fish tissue PCB levels throughout the dredging period. Figure 2 indicates that actual baseline variability was greater than the model-based estimate of the dredging impact) and that data from the RAMP period (2009-2015) remained elevated relative to model forecasts, both during dredging and after dredging was concluded in 2015.

Lessons Learned

Its not unusual for large and complex engineering projects to encounter challenges to operational assumptions made during planning. Engineering controls to reduce dissolved-phase PCBs, a longer than anticipated remediation schedule, non-sequential dredging activity, and more intense vessel traffic along the entire project area that was focused into the final two years of dredging all reflected necessary operational modifications. They also represent departures from key assumptions underlying model forecasts used for remedy selection, providing the potential for PCBs to be re-suspended over a longer period of time than was assumed in design, and adding to anticipated short-term impacts and the equilibration time required for fish tissue levels to attain interim project target concentrations. Despite all of these challenges, EPA notes that fish tissue levels have generally returned to pre-dredging levels, supporting EPA's original premise that dredging-related impacts would be short-lived. EPA anticipates that it will take as many as eight or more years of data to quantify the post-dredging trends in Upper Hudson River fish-tissue PCB concentrations with a reasonable degree of scientific certainty.