Second Five-Year Review Report
Hudson River PCBs Superfund Site

APPENDIX 8

DIFFERENCES BETWEEN ANTICIPATED AND IMPLEMENTED DREDGING OPERATIONS BASED ON THE FEASIBILITY STUDY AND 2002 RECORD OF DECISION ASSUMPTIONS AND FORECASTS

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HUDSON RIVER PCBs SUPERFUND SITE

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1 INTRODUCTION AND BACKGROUND

EPA developed the December 2000 Feasibility Study (FS, EPA 2000b), and the Revised Baseline Modeling Report (RMBR) (EPA 2000a) to support the Agency's reassessment of its 1984 interim No Action decision ([1984 ROD] EPA 1984) for polychlorinated biphenyls (PCBs) in the sediments of the Upper Hudson River. Potential remedial alternatives, including the selected remedy (REM-3/10/Select), were described and evaluated in the FS and in the 2002 Record of Decision ([ROD] EPA 2002). REM-3/10/Select consisted of removing contaminated sediments from certain areas of the Upper Hudson River and natural attenuation of PCBs that remained in the river after dredging. The selected remedy also included certain institutional controls, and a monitoring program to determine when Remedial Goals are reached, and assumed a separate upstream source control. The dredging component of REM-3/10/Select was implemented between 2009 and 2015, resulting in the removal of approximately 2.64 million cubic yards (CY) of contaminated sediments containing approximately 48,571 kg Tri+ PCB[1] (155,760 kg TPCBs[2]) from target areas within the Upper Hudson. Installation of initial habitat reconstruction measures took place between 2010 and 2016 after dredging and the placement of backfill and cap materials. Habitat reconstruction monitoring is on-going and will continue to be assessed and conducted under the operation, maintenance and monitoring (OM&M) phase of the project. Therefore, seeding and planting aspects of habitat reconstruction are not being evaluated as part of the EPA five-year review.

Several potential remedial alternatives were evaluated in the FS and ROD. This evaluation involved a set of linked models (discussed in detail in Appendices 1 and 3 of this five-year review) that projected the time required to meet project remedial goals over a 70-year

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[1] Tri + PCBs represents the sum of all measured PCB congeners with three or more chlorine atoms per molecule. PCBs are a group of chemicals consisting of 209 individual compounds known as congeners. The congeners can have from one to ten chlorine atoms per molecule, each with its own set of chemical properties.

[2] Total PCBs represents the sum of all measured PCB congeners. PCBs are a group of chemicals consisting of 209 individual compounds known as congeners. The congeners can have from one to ten chlorine atoms per molecule, each with its own set of chemical properties.

period. The linked models consisted of both hydrodynamic (for water flows and velocities in the Thompson Island Pool) and depth-of-scour (for suspended sediments) components, as well as the Hudson River Toxic Chemical Model (HUDTOX) and a mechanistic, process-based, time-varying representation of PCB bioaccumulation in fish (FISHRAND). Essentially, the hydrodynamic and depth-of-scour components were integrated and their output was used as input to HUDTOX to model the fate and transport of PCBs in the Upper Hudson River. The HUDTOX results were then used as input to FISHRAND to estimate Upper Hudson River fish PCB exposure concentrations for the 70-year (long-term) forecast period. Model mechanics and the linkages of these model components are described in detail in the RBMR (EPA 2000a) and the FS (EPA 2000b) and will not be repeated here. The model runs also included certain assumptions with regard to how the dredging would be implemented, including and upstream-to-downstream sequence of the dredging and the use of two sediment processing facilities, one at the northern end of the project area and one at the southern end. Long-term modeling assumptions and forecasts are discussed in detail in Appendix 1 (water column and sediment) and Appendix 3 (fish tissue concentrations) of this five-year review report. As described in Appendices 1 and 3, as well as in the RMBR, FS, and ROD, and in the text that follows, the linked models were not designed to evaluate short-term impacts from dredging operations.

The FS indicates that "modeling results do not consider the potential short-term adverse impacts of remedial actions" and specifically defines "short-term" as "to include the time from initiation of remedial activities, assumed to be in the year 2004, through the alternative-specific and river section-specific period for implementation, and a subsequent one- to two-year period for attenuation of residual impacts" (TAMS Consultants, Inc. 2000). In the RBMR (Section 2.5, *Mass Balance Model*), HUDTOX is described as "not developed to represent short-term behavior" because "PCB body burdens in fish are driven primarily by long-term average exposure concentrations, not short-term, event-scale exposures" (EPA 2000a.). Appendix D1 to the FS (*Use of Data Trends and Models in Evaluating Remedial Alternatives*, [EPA 2000b) further discusses that models are, by definition, simplifications of real-world conditions and that the HUDTOX-FISHRAND model specifically was calibrated at scales (reach to river section) larger than the local scales (certification unit, or CU) at which sediments are resuspended and biota take up PCBs from the sediment and water column. FS Appendix D1 also plainly states that model forecast interpretations must incorporate analyses of observed long-term data trends (EPA 2000b). One of the implications of the scales and purpose(s) for which these linked models were developed is that they were not designed to be effective at capturing short-term and localized impacts on water column and fish tissue concentrations resulting from implementation of the remedy. However, as will be discussed in Section 2.6, observations of fish tissue concentrations observed during dredging indicate that the Remedial Action Monitoring Program (RAMP) was capable of detecting these short-term and local (*e.g.*, during dredging and at scales smaller than reaches or river sections) increases.

The suite of linked models focused on residual impacts, risk assessment, and the time projected to attain target fish PCB concentrations at the river section scale (EPA 2002 [February 2002, Responsiveness Summary]). While the ROD evaluated potential remedies based on overall protectiveness, none of the potential remedial alternatives were forecast to achieve the remedial goal for protection of human health of 0.05 mg/kg PCBs in fish fillet within the 70-year forecast period. However, the projected time to attain PCB target levels in fish was significantly less for the potential active remediation alternatives (EPA 2002). For example, the target fish tissue concentrations (0.4 mg/kg and 0.2 mg/kg PCBs) were forecast in the ROD to be attained throughout the Upper Hudson within 5 years and 15 years of the completion of dredging, respectively, whereas the Monitored Natural Attenuation (MNA) alternative was projected to require at least 15 years to attain the 0.4 mg/kg target concentration (EPA 2002). In summary, the REM-3/10/Select alternative was chosen based on the need for active remediation in order to protect human health and the environment, and was deemed more cost effective than the more aggressive remedy REM-0/0/3, which was 24% more costly without substantially greater benefits in reducing ecological and human health risks.

Use of the models to forecast the impacts of active remediation posed greater challenges than forecasting MNA. As part of the RI/FS process, extensive data representative of MNA conditions were collected and used to calibrate the fate and transport and bioaccumulation models. With those calibrated models, only assumptions of future flows were needed to project MNA into the future. In contrast, dredging-period simulations required additional inputs to the models concerning dredging-related resuspension of solids and PCBs, including the character of the resuspended solids (percent coarse or fine), the proportion of those solids redeposited downstream of the dredging site, and the mass and character (fractions dissolved and adsorbed to solids) of PCBs released by dredging. Unlike MNA, there were no Site data to draw upon to develop those dredging period inputs, and assumptions were developed based on the limited experience available at the time from other contaminated sediment dredging sites and the state of science at the time with respect to resuspension from dredging operations. Provided with those engineering inputs, the ROD models simulated the resulting fate and transport of the resuspended and redeposited PCBs, and their exposure and uptake by fish. Dredging period simulations were inherently more uncertain than MNA forecasts by virtue of the need to develop resuspension and redeposition assumptions in the absence of site-specific experience and data.

In addition, during the design and implementation of the remedy, modifications were made to certain aspects of the dredging operations that were assumed in the models. Each individual modification by itself may not have constituted a major deviation from the model assumptions, and both the FS and the ROD anticipated that several key components of implementation would be decided in design (*e.g.*, sediment processing facility locations, working hours, and vessel traffic control). But together the modifications resulted in conditions during dredging that were not fully accounted for in the models.

It is not unusual for a large complex project such as the Hudson River remediation to encounter challenges that require changes to operational assumptions made in a record of decision, and to adjust the implementation in response to those challenges. This appendix describes how operational differences between assumptions in the FS and ROD and the project implementation likely resulted in short-term localized and transient impacts on water column and fish tissue PCB concentrations and PCB loading to the Lower Hudson River, which may confound efforts to directly compare observed data for PCB concentrations in fish to model forecasts for the dredging and immediate post-dredging periods. Because the dredging was only recently concluded in 2015, however, the post-dredging data are temporally limited and are not sufficient to fully evaluate the impacts of the short-term operational differences on the long-term predictions.

2 MODEL ASSUMPTIONS, FORECASTS, AND REMEDY IMPLEMENTION

Section 8 and Appendices E-1 and E-6 of the FS provide detailed discussions of the various remedial alternatives and their associated underlying modelling and forecasting assumptions (EPA 2000a). Sections 11 and 13 of the ROD further discuss these alternatives and approaches to dredging in the context of remedy selection (EPA 2002).

The following sections discuss differences between the assumptions in the ROD and actual implementation with regard to control of upstream sources, the duration and extent of dredging, sequencing of the dredging program, and other aspects of the dredging. Table A8-1 provides a comparison of the principal components of REM 3/10/Select as described in the FS, the ROD, and as implemented during Phase 1 and Phase 2 dredging (2009-2015). The headings in the text below reflect the "REM 3/10/Select Component" column of Table A8-1.

2.1 Upstream Source Control

The FS and the ROD both assumed that separate source control actions would be implemented in the vicinity of the GE Hudson Falls and Fort Edward plant sites in order to address the continuing release of PCBs from near those facilities to the Hudson. EPA's analyses of remedial alternatives in the FS and ROD assumed that significant reductions in loading to the river from the Hudson Falls and Fort Edward sources would occur once New York State's plans for remediation of these facilities were implemented. Actions implemented to date include remediation of Outfall 004 adjacent to the Fort Edward facility (NYSDEC 2002) and completion of a tunnel drain system to address discharge of PCBs via groundwater to the river from the vicinity of the GE Hudson Falls plant site (NYSDEC 2004). The FS and ROD assumes that source control would diminish the upstream water column Tri+ PCB load at Fort Edward (Rogers Island) from 0.16 kg/day to 0.0256 kg/day (equivalent to an average concentration of 2 ng/L) by January 1, 2005.

Recent project data indicate that current water column Tri+ PCB concentration measured at Fort Edward (Rogers Island) varies monthly but has approached 2 ng/L since 2010 and averaged less than 2.0 ng/L (actual levels averaged 0.085 ng/L Tri+ PCB and 1.3 ng/L TPCB[3]) during 2016. The significance of this is that the FS indicates that the rates at which long-term (over the 70-year forecast period) post-dredging water column and fish tissue forecasts would decline is dependent upon the magnitude of the upstream boundary load (EPA 2000a [Appendix D1]). Recent data indicate that the upstream source control assumptions used to support remedy selection have been met, even though upstream remedial work at the GE Hudson Falls facility is on-going as of the publication of this report. In combination with the dredging implemented to date, this reduction in upstream loadings due to source control is expected to facilitate reductions in PCB concentrations in water, sediment, and fish.

2.2 Dredging Commencement, Duration, and Extent

The remedy was implemented over a longer period, and with certain other operational changes, as compared to the implementation program assumed in the ROD. While these changes are not expected to affect the projected long-term outcome of the remedy, they have important implications for short-term impacts during and immediately following dredging. For example, overall, model projections for fish recovery assumed dredging would occur upstream to downstream, but this was not always the case during implementation. Also, certain developments during design delayed the start of dredging beyond the date envisioned either in the FS or in the ROD, which complicates any comparison of data showing PCBs in fish and water against the projections in the ROD.

As described in the FS, implementation of alternative REM-3/10/Select was anticipated to begin in 2004, require 5 years to complete, and would involve, to the extent practicable, dredging from upstream to downstream, starting at the head of River Section 1 (near Rogers Island) and proceeding consistently downriver through River Section 3. In addition, EPA

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[3] Total PCBs represents the sum of all measured PCB congeners. PCBs are a group of chemicals consisting of 209 individual compounds known as congeners. The congeners can have from one to ten chlorine atoms per molecule, each with its own set of chemical properties.

anticipated a one- to two-year period for attenuation of residual impacts (equilibration) (EPA 2000b). The actual equilibration period can vary based on post-dredging river conditions. The ROD did anticipate the need for some simultaneous dredging in multiple CUs, oriented upstream and downstream of each other, to accommodate unique operational considerations.

Remedial construction included dredging, backfill placement, capping (for compliance with the residuals performance standard), and habitat reconstruction. It was implemented in two phases (as envisioned in the ROD). In accordance with the ROD (and as specified in design), initial habitat reconstruction measures (including seeding and planting) were installed between 2010 and 2016 (an overlapping 7-year period). As a result, the construction of the selected remedy was executed in accordance with the conceptual approach articulated in the FS.

However, dredging took longer than originally anticipated to implement. As implemented, the dredging and backfill/capping components spanned 7 years (*i.e.*, 2009 through 2015), including the off-year 2010 for review of Phase 1 results and performance before resumption of dredging in 2011. Further, habitat reconstruction (which included intrusive work in the river, such as seeding and planting activities) was completed in 2016, the first year following completion of dredging and backfilling (*i.e.,* during the ROD-assumed year of equilibration). The longer remediation schedule resulted in PCBs being resuspended for a longer period of time than was assumed in the models. As anticipated in the FS, a post-dredge period of equilibration extending more than one year may be necessary, and if so, that equilibration period may still be underway. For these reasons, true post-dredging conditions (*i.e.*, post "short-term" as defined in the FS, and in the absence of any project activity other than monitoring) may not be realized until spring 2018 data collection, or later.

The spatial extent of dredging in River Sections 1 and 2 differed little from the assumptions presented in the FS and ROD. However, the spatial extent of dredging in River Section 3 was different from that described in the FS and ROD. Table A8-2 summarizes the Mass per Unit Area (MPA) criteria used to delineate target dredge areas in accordance with the

ROD and compares them to what was actually dredged during Phases 1 and 2. Targeted dredge areas in River Section 3 (which were defined based on the post-ROD Sediment Sampling and Analysis Program (SSAP)) were separated by greater distances than envisioned in the ROD, resulting in greater-than-anticipated vessel traffic during the last 2-3 years of dredging in River Section 3.

Other differences between anticipated and implemented dredging operations are the differences in pre- and post-dredging Tri+ PCB surface sediment concentrations and in the mass of PCBs removed through dredging by river section. Appendix 2 (Table A2-3) and Table A8-2 present the differences between ROD estimates of Tri+ PCB mass and volume of sediment planned to be removed versus actual removal. While the volume of sediment actually removed closely agrees with ROD removal expectations, the PCB mass removed by dredging (whether calculated as Tri+ or TPCBs) was 2.3 times the prospective ROD estimate.

2.3 Implementation Sequencing

The sequence of dredging also differed from the approach described in the FS and ROD. Overall, the FS and the ROD assumed a progressively upstream-to-downstream approach to implementation, while also allowing for simultaneous dredging in multiple nearby CUs where expedient to maintain productivity. Figure A8-1 compares an upstream- to downstream dredging program against the actual order in which all 100 CUs were dredged. This figure illustrates the extent to which implementation departed from the assumed strict upstream-to-downstream approach. Figure A8-2 indicates the volume of sediment dredged for each CU by year and also shows the locations of the CUs relative to RAMP fish monitoring stations and backfill/cap material barge loading areas. Together, these figures show the extent to which dredging was not implemented in a strictly upstream-to-downstream manner.

The sequence in which dredging was implemented was determined by post-ROD design adjustments and field responses to operational challenges. Specific examples where dredging was not implemented using a strict upstream-to-downstream approach:

- Phase 1 (in which CU17 and CU18 were dredged concurrently with CUs further upstream),
- Phase 2 dredging in River Section 2 (where the main river area in Reach 6 was dredged prior to the upstream Landlocked Area (Reach 7)). Within each reach, dredging was performed upstream-to-downstream, and
- Dredging upstream of CU01 (River Section 1), as well as near dams at CU60 (River Section 1) and CU95-96 (River Section 3).

Work upstream of CU01 was implemented in 2015 in response to a request from N.Y. State to address PCB levels in sediments adjacent to an originally delineated dredge area. In River Section 2, work in CUs 61-66 was delayed until 2014, and in River Section 3 work in CUs 95-96 was delayed until 2015 while designs and work plans were developed that adequately addressed:

- the transloading of dredged sediments out of the Landlocked Area (CUs 61-66),
- the transport of dredged material over water rather than over land by truck (CUs 61-66 and 95-96),
- near-dam safety during dredging and backfilling in CU60 and CUs95-96,
- seasonal restrictions on dredging activities due to the presence of federal- and state-listed species in River Section 3, and
- access to CU95 over shallow bedrock in low-water level years.

The implications of this sequencing are that while most of River Section 1 (upstream) was dredged in 3 years (2009, 2011, and 2012), significant dredging took place in the southern end of River Section 1 in 2013, and returned to River Section 1 in 2015 (northern end above CU1 and CU60 at the southern end). The lower part of River Section 2 (Reach 6, CU67-78) was dredged in 2013, followed by Reach 7 (CU61-66), which is upstream of Reach 6, which was dredged in 2014-2015 (see Figure A8-1). The CUs within those reaches were still dredged upstream to downstream. Figure A8-2 indicates the volume of sediment dredged by year (2009-2015) and also shows the river sections in which dredging took place each year. By 2015, dredging had taken place in River Section 1 over 5 separate construction seasons, and dredging occurred in both River Sections 2 and 3 over 3 separate construction seasons (2013, 2014, and 2015). Thus, implementation in River Section 1 took 1-2 years longer than the FS and ROD anticipated. In addition, work in River Sections 2 and 3—the areas closest to the Waterford water quality station and several downstream RAMP fish monitoring stations—took 3 of the 6 dredging years to complete, even though the target removal volume in these River Section 3 areas comprised only 41 percent of the project total.

As noted above, the ROD anticipated some simultaneous dredging in multiple adjacent CUs. In addition, both the FS and ROD contemplated that revisions would likely be made to dredging plans after work commenced and monitoring data became available. The overall benefit of this approach was that the entire project could move forward while, for example, the alternative dredging approaches to CU60, the Landlocked Area, and CU95-96 were developed. This approach avoided delaying the overall project (and therefore the time period over which dredging-related resuspension occurred) while these areas were addressed. This approach reflected EPA's preference for an implementation schedule that would accomplish the targeted removal safely and as efficiently as compliance with the performance standards would allow.

Simultaneous dredging in multiple river sections, particularly during the later years of the project (2013-2015) resulted in the simultaneous transportation of dredged sediments and support vessel activity (including crew transportation, monitoring vessels, backfill barge movement, and maintenance vessel traffic) in all three river sections. Simultaneous dredging and in-river transport of dredged materials in all three river sections at this intensity was not envisioned by either the FS or the ROD. If the dredging had proceeded in a more consistently upstream-to-downstream direction, more water and fish monitoring locations (*i.e.*, at the scale of a river section) would have been located upstream of active dredging activities as dredging proceeded downstream, and recovery could have begun sooner at those stations. Implications for water column and fish tissue PCB concentrations resulting from this focus of project vessel traffic are discussed below.

2.4 Dredging Infrastructure, Floating Plant, and Vessel Traffic

The FS and ROD assumed that two facilities, one located at the upstream end of the Upper Hudson and another located at the downstream end of the project area, would be used to process dredged sediments (EPA 2000b; EPA 2002). Following a detailed facility siting process that occurred after the ROD was issued, however, EPA deemed a single upstream processing facility, located at the Energy Park/Longe/New York State Canal Corporation facility in Fort Edward, as suitable to process all of the sediments dredged at the Site. A single upstream processing facility was both feasible and appropriate because approximately 75 percent of the volume of sediment and 80 percent of the acreage targeted for removal were located upstream of CU78 in River Section 2 (and also north of Lock C5, located at the boundary of RS2 and RS3 at RM182.5). The Energy Park site is located in the Fort Edward Industrial Park in Fort Edward, on the west bank of the Champlain Canal between Locks 7 and 8, approximately 1.4 miles from the Hudson River. In addition to this sediment processing facility, several general support areas and barge loading facilities were established and operated during dredging. Table A8-3 summarizes on-river support facility locations and activities during implementation. This table indicates that most facilities were located in the northern half of the project area (above RM 179), were operated for multiple years, and also that multiple support facilities located in River Sections 2 and 3 were active in the last 3 years of dredging.

The floating plant and support vessels operating from these facilities were assumed to consist of mechanical dredges, using environmental dredging techniques with 4 CY buckets, working 14 hours per day at an average river flow of 3,000 cubic feet per second (cfs) and achieving approximately 50 percent working-hours efficiency (EPA 2000b, Appendix E-6). The FS acknowledged that the Upper Hudson is hydraulically complex and assumed water depths ranging from 2 to 23 feet, with current velocities between 0.05 and 1.5 ft/sec, and an average sediment removal thickness of approximately 2 to 5.5 ft in most areas (EPA 2000b, Appendix E-6). During dredging, multiple rigs using both 2 and 5 CY buckets were used, depending upon conditions at the point of dredging, while 8 large material barges were typically employed to place backfill and cap materials. In addition, approximately 18 to 22 tugs were used to move project barges. Table A8-4 compares the principal elements of the dredging portion of the remedy, as described in the FS and ROD, to the elements of the project as implemented. Dredge hours per day (24 implemented *vs*. 14 assumed), river flows routinely over 3,000 cfs (particularly in 2009, 2011, 2013, and 2014), the number of dredges working simultaneously, dredge bucket capacity (5 CY v 4 CY), and the volume and order of backfill placement all differed in implementation from FS assumptions. The numbers of barges and support vessels were not discussed in detail in the FS or the ROD, and both documents anticipated that aspects of dredging would be finalized in design (*i.e.*, as appropriate to address operational considerations).

As discussed above, the use of a single, upstream processing facility in conjunction with several dispersed downstream support facilities is different from the approach discussed in the FS and ROD. Use of floating plant and support vessels with a single upstream processing facility meant that as the project extended farther south, the distances travelled by barges and support vessels would increase from one dredging season to the next. Table A8-5 shows the number of lock passages (lockages) recorded each year by project vessels, along with the number of barges offloaded per day and the percent of project vessels supporting dredged sediment transport or placing backfill. These tables illustrate the extent to which long-distance travel (up and down the length of the Upper Hudson project area) took place in 2014 and 2015. In fact, 53 percent of all project lockages and 52 percent of all sediment barge miles were travelled during the final 2 years of dredging, when only 32 percent of targeted dredged sediments were removed (Table A8-6, See also Figure A8-2). During this period, many vessels regularly traversed the entire length of the Upper Hudson project area.

In addition, beginning in 2013, five of the project tugs involved in dredged-sediment transport were “liveaboard” or ocean-going “long-haul” tugs, employed specifically to ensure that transfers of dredge materials from the lower reaches of River Section 3 to the upstream processing facility (approx. 80 round trip miles involving 14 lockages) could be made safely over the full range of river flows assumed to be encountered over the length of the project area (General Electric2013). While these tugs were more capable and appropriate than smaller vessels for moving larger scows over longer distances, they had more powerful motors and deeper drafts (approximately 8-10 ft) than other project vessels and, in combination with other project vessel traffic, had the potential to impart short-term and local increases to resuspension. As a result, the use of long haul tugs to and from a single processing facility had the potential to result in increased resuspension throughout each river section. This, in combination with more total vessel traffic in the later years of dredging, likely resulted in short-term and localized water column PCB exposures and thus increased fish tissue PCB concentrations.

Table A8-6 shows the estimated sediment volume removed, along with the estimated barge miles travelled to the processing facility, and the fraction of cumulative barge miles required per year to move dredged sediments. This table indicates that while only 19 percent of the estimated total dredged sediment volume was removed, and only 30 percent of the backfill and cap materials were placed, in 2014-2015, 58 percent of the total sediment barge miles were required to deliver dredged sediments to processing and 53% of all project lockages took place during this time. Table A8-6 also indicates that peak support vessel (non-sediment barge) lock traffic was observed in 2014 and 2015. Because there were multiple backfill/capping material loading facilities along the project alignment, backfill barge traffic typically did not have to make multi-lock trips. Thus, the peak non-sediment barge lockages in 2014-2015 represent support vessel and not backfill barge traffic. This observation indicates that it was not just long-haul tug traffic miles that increased during 2013-2015, but total (cumulative) vessel traffic activity.

As part of the evaluation of Phase 1 dredging, conditions associated with water column PCB concentrations at the Thompson Island Dam (TID) monitoring station during 2009 were investigated (EPA 2010 [Appendix I-D]). This investigation demonstrated that water column PCB concentrations were correlated with the volume of sediment and mass of PCB removed, dredge bucket fill rates, and total vessel traffic. This study offered valuable insights into the impacts of implementation at the river section scale because during Phase 1 two CUs (CU17 and CU18) were dredged out of order. Because these southern-most Phase 1 CUs were located at RM189 (approximately 7 miles south of the processing facility) and near the southern (downstream) end of River Section 1, water column data collected at the TID station reflected dredging and vessel traffic from along that entire river section.

A positive correlation between vessel traffic and water column exposure concentration was identified in EPA's Phase 1 Evaluation Report. This correlation suggests that the longer trips and more intense vessel traffic in the last two years of implementation also would have caused short-term and localized increases in resuspension. These increases, in turn, had the potential to be reflected in both short-term water column increases and locally elevated fish tissue concentrations. Such short-term and temporary increases were anticipated in the FS (*see, e.g.*, section 8.5.2.5 and Appendix E-6 of the FS) although they were not modeled. Actual dredging activities were more-widely dispersed over the project area than originally envisioned, and attendant vessel traffic was especially heavy in the later years of dredging. This resulted in localized and transient but repeated annual increases in resuspension at monitoring locations that would otherwise have been experiencing relatively quiescent "post-dredging" conditions had implementation more consistently followed the assumptions in the FS and ROD.

2.5 Performance Standards Compliance

As noted above, section 8.5.2.5 and Appendix E-6 of the FS anticipated short-term and localized increases in PCBs from sediments to the water column, with subsequent downstream transport of suspended PCBs. Specifically, it was anticipated that near-field dredge plume PCB concentrations would reflect local PCB concentrations in dredged sediment, and that overall, releases would be minor and that downstream settling of both total suspended solids (TSS) and PCBs would be limited to 10-100 meters. The dredging plan outlined in the FS indicated that resuspension would be managed through operational practices, including control of sediment removal rates and use of enclosed dredge buckets and sediment barriers. Productivity assumptions included a 210-day dredging season (30 weeks) at six days of dredging per week (net 180 dredging days) and 12-14 hours actual dredging per day using 4 dredge platforms fitted with either 2 or 4 CY buckets operating in river flows of 3,000 cfs (EPA 2000b, Appendix E-1). Sediment-loss driven PCB resuspension rates of 0.3 percent were estimated for bucket-type dredging activities as fluxes at 10m from the dredge head (EPA 2000b, Appendix E-6). It was not anticipated that PCB release via the dissolved phase would result from dredging.

During implementation, dredging was conducted 24 hours per day, 6 days per week, and mean daily flows averaged more than 5,000 cfs during the 2009, 2011, 2013, and 2014 construction seasons. Results from Phase 1 dredging indicated that suspended solids concentrations were not a good predictor of PCB transport downstream of the dredging operations. Special studies showed that PCB detections were often dominated by the dissolved phase and the presence of oil sheens. 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. In conjunction with more hours per day dredged, increased total vessel traffic, and higher than assumed river flows, these factors presented the potential for higher than anticipated short-term exposures to fish.

The ROD anticipated that the remedy would be implemented over six years with 0.13 percent PCB loss due to resuspension and a one-year equilibration period following completion of dredging (EPA 2002, Section 11.1). Analyses in support of the ROD also indicated that there were not substantial differences in the times required to attain remedial goals for fish tissue concentrations between dredging approaches taking 5 or 6 years and assuming 0.13 percent or 2.5 percent resuspension losses. This schedule included the year to evaluate Phase 1 and was an estimate of time required for mobilization, operation, and demobilization of dredging-related activities. The ROD also anticipated that dredging equipment and methods would be selected based on their expected ability to meet performance standards (EPA 2002 Section 13.1) and that these expectations and the associated performance standards would be evaluated at the conclusion of Phase 1 dredging (EPA 2002, Section 11.5). As such, the ROD anticipated that revisions would likely be made to dredging activities as monitoring results became available.

During Phase 1 dredging, differences between the design depth of contamination and the actual depth of contamination resulted in more sediment removal than was anticipated in the design despite only 8 of 18 areas being dredged (EPA 2010). Typical Phase 1 sediment removal volumes were 1.6 times greater than design removal estimates (on a CU basis), and the resuspension standard (based on cumulative load) was exceeded at all downstream monitoring stations in 2009. During this time, some of the lowest project volume and mass removal totals were observed, and releases past Waterford exceeded 1 percent of the mass removed although the cumulative project criterion of 2,000 kg TPCBs transport to the Lower Hudson River was not exceeded.

In accordance with the ROD, an independent external peer review was conducted after Phase 1 to evaluate the Engineering Performance Standards (EPS) for resuspension of dredged materials, PCB residuals and production rates. Following an adaptive management approach, several proposed revisions to operations with resulting changes to performance standards occurred through the Phase 1 evaluations and were incorporated into Phase 2 designs and work plans. The assumed resuspension rate was adjusted to 1.0 percent (measured at Waterford) to better reflect actual conditions observed during dredging operations (EPA 2010), as compared to 0.3 percent presented in the FS for mechanical dredges and 0.13 percent for the selected remedy in the ROD. In addition, recommendations regarding the dredging productivity schedule, including a 350,000 CY per year target, were reflected in the Phase 2 EPS. These recommendations were adopted along with operational considerations designed to reduce the amount of time between the completion of dredging and the application of backfill/cap materials (EPA 2010; General Electric 2011). For the remainder of Phase 2, dredging efficiency continued to improve and instances of water column exceedances declined significantly for the remainder of implementation.

Multiple factors including sediment PCB concentrations, dredging technology, sediment type, and river flows can influence local- to river section - scale resuspension rates. Figure A8-3 summarizes the volume of sediment dredged by year and indicates the load at Waterford and percent release (compared to PCB mass removed) by year. Waterford is located immediately upstream of the transition between the Upper Hudson and the Lower Hudson River at the Federal Dam at Troy, NY. Load gain across the Federal Dam is an important monitoring parameter for the evaluation of predicted and observed water and sediment concentrations, predicted and observed fish tissue concentrations, and associated human health and ecological risk analyses. Figure A8-3 indicates that the highest percent releases of Tri+ PCBs were observed in 2009 and 2015. Figure A8-3 also indicates that the highest release percentages were not associated with the years of highest sediment or PCB mass removal (2012-2014). During Phase 2 dredging, releases past Waterford were generally lower than during Phase 1 despite yearly increases in the volume of sediment and PCB mass removed during 2011-2013. In 2013, however, when the largest volume of sediment was dredged, the percent of PCBs released was higher than in 2011, 2012, and 2014. The highest percent release occurred in 2015, when the volume and mass removed, and mass past Waterford, were the lowest during implementation. That percent release would be elevated in years of both relatively high and low volume and mass removal suggests other factors may influence resuspension and percent release. For 2015, this was potentially due to the closer proximity of the dredging to the Waterford station in later construction seasons (primarily 2015). Nonetheless, the Phase 2 cumulative load threshold of 2,000 kg PCBs past Waterford was not exceeded.

Productivity, vessel traffic, and resuspension data patterns suggest that the highest percent releases at Waterford were associated with Phase 1 dredging as well as the proximity of dredging to Waterford in 2015, the latter of which included high vessel traffic relatively near the Waterford monitoring station. The fact that the highest percentage release did not occur during the year of greatest volume and mass removed (2013), and that the cumulative load threshold for the project was not exceeded, are evidence of the effectiveness of the 2010 EPS modifications in controlling resuspension, notwithstanding that the operational differences discussed above likely caused increased resuspension.

2.6 Fish Tissue Monitoring During Dredging and ROD Modeling Expectation

Fish tissue PCB data collected during the Baseline Monitoring Program (BMP, 2004-2008), implementation (2009-2015), and in 2016 were used by EPA to assess short-term impacts to fish tissue PCB concentrations associated with implementation. Longer-term fish tissue trend analyses and comparisons to model output are presented in Appendix 3.

Figures A8-4.1 through A8-4.12 compare observed mean fish tissue concentrations (with 95 percent confidence interval, or CI) during implementation (2009-2015) and 2016 to the mean and 95 percent CI for data collected during the BMP. These graphs show that localized and short-term increases in fish tissue PCB concentrations were observed as dredging approached and progressed past individual fish monitoring stations. In general, fish tissue PCB levels were observed to recover to pre-dredging levels within one to three years after completion of dredging upstream of a monitoring station. These data are also presented in Table A8-7, which indicates the number of years required for:

- Observed fish tissue concentration ranges (observed mean ± 95% CI) to overlap baseline values (BMP mean ± 95% CI);
- Observed mean fish tissue concentrations to fall below the BMP mean; and,
- Observed mean fish tissue concentrations to fall below the lower confidence limit (LCL) of the BMP 95% CI.

As indicated in Table A8-7, fish tissue level CIs in River Section 1 generally took less than 3 years to overlap the BMP CI, and took between 1 and 4 years for observed mean tissue concentrations (expressed as mg/kg Lipid PCB, or LPCB) to fall below BMP means and LCLs. One exception to this pattern is at station TD1 (RM 194 and the most northern/upstream fish monitoring station), where fish tissue levels remained variable and elevated through 2015. Figures A8-4.1 (Black Bass at TD1) and A8-4.4 (Pumpkinseed at TD1) do not show a consistent increase in tissue concentrations after dredging (as is generally seen at other stations in this river section). However, this station is also proximal to the Moreau backfill-barge loading facility (RM 193) that operated until 2013, and in 2015 additional dredging was implemented upstream of CU1 (RM194), also very close to and upstream of this fish monitoring station. As a result of these activities, resuspension due to dredging and vessel traffic activities would have resulted in consistently elevated PCB levels in fish and obscured post-dredging recovery.

In River Section 2 (Reaches 7 and 6), observed fish tissue level CIs tended to overlap BMP CIs within 0-2 years, and the mean for most species took between 0 and 4 years to fall below the BMP means and LCLs at each station. For all but one species at one station (yellow perch at ND1), observed tissue concentrations decreased to below BMP levels within 1-4 years. As indicated in Figure A8-4.7, yellow perch at station ND1 peaked prior to dredging at that station and never rose above the BMP CI. Interestingly, and in general for River Section 2, peak tissue levels did not coincide with the year of dredging near the station for most species and stations.

River Section 2 encompasses 6 miles and was dredged in 2013 (Reach 6) and 2014 and 2015 (Reach 7), and was effectively dredged downstream to upstream (reach 6 dredged in 2013 and reach 7 dredged during 2014-2015). In addition, dredging in CU60, immediately upstream of CUs 61-66, took place in 2015. Reach 7 is also unique within the project area in that it does not have an active NYSCC navigation channel. As a result, while overall vessel traffic through Reach 7 may have been lower than other reaches, dredging occurred immediately upstream of this reach in 2015 and vessel barge traffic continued through Reach 6 from 2013 through 2015. This may have served to simultaneously keep fish tissue levels elevated throughout dredging activities, and may be confounding observation of post-dredging MNA responses in fish tissue levels.

In River Section 3, responses were slightly faster than those observed in River Section 1 and River Section 2. Observed and BMP CIs overlapped within a year post-dredging and observed mean fish tissue levels fell below BMP means within two years. Within 1-3 years, all mean tissue levels fell below the BMP LCL. In summary, across most River Section 3 species and stations, fish tissue concentrations tended to peak in the year dredging was implemented or immediately downstream of a station in the following year. Within two years, observed CIs overlapped BMP CIs. On a mean basis, it has generally taken 2 years for the observed means to fall below BMP means, and from 1-4 years for observed mean tissue concentrations to fall below the BMP LCLs. River Section 3, like River Section 2, was dredged between 2013 and 2015 and fish tissue PCB concentrations may still be decreasing in the wake of dredging. As a result, it may be too early to discern true post-dredging fish tissue concentration trends for River Section 3.

As described earlier in this Appendix, the models developed for the FS (*e.g.*, HUDTOX and FISHRAND) were designed to evaluate long-term conditions and responses to remedial alternatives such as the selected remedy and MNA. The models were never designed to evaluate dredging and its short-term and localized impacts. As discussed in this appendix and in Appendixes 1 and 3, the FS and ROD anticipated short-term and localized increases in suspended PCB concentrations in the water column, and possibly in fish PCB body burdens, as a result of dredging activities. To minimize the effect of the dredging operation on the water column and fish, EPA developed standards to control resuspension and the transport of PCBs during the remediation. The Resuspension Standard's limits on PCB resuspension and load, coupled with the observation that EPS compliance data indicate that resuspended sediments settled close to the dredge areas, helped to limit the impacts to fish tissue concentrations during dredging.

The original engineering assumptions used as inputs to the dredging period simulations presented in the ROD (EPA 2002) anticipated a 0.13% release rate at the dredge head for the duration of dredging, assumed to commence in 2004 with completion by 2009. This engineering analysis in the ROD also assumed that PCB releases of 0.13 percent would be driven by solids, but observations during Phase 1 indicated that oil-based releases with subsequent dissolved phase transport was the primary mechanism. After Phase 1 the Resuspension Standard was set to a 1 percent loss rate at Waterford to minimize the load, maintain water column PCB concentrations below the drinking water standard, and reduce the transient impact in fish and overall impact in fish tissue concentrations. As part of the Feasibility Study, a set of model sensitivity runs were performed, including a run that included a 2.5% PCB release rate at the dredge head. None of the sensitivity analysis runs anticipated other conditions observed during dredging and discussed in this appendix, including the greater inventory of PCB estimated based on original depth of contamination estimates, increased dissolved phase release, and differences in implementation from model assumptions.

Short-term impacts to fish were generally not indicated in the model runs that included a 0.13% release rate, but short-term impacts were evident in the sensitivity runs that included the 2.5% release rate. See Appendix 3 for additional discussion of short-term impacts and subsequent recovery of fish from dredging-related resuspension.

Overall, increases associated with dredging at or proximal to monitoring stations, followed by declines in fish tissue levels in the wake of dredging, were consistently observed at RAMP fish monitoring stations. The amount of time it took fish tissue levels to return to, or drop to or below, pre-dredging levels varied across stations and even species within stations. Because it has been less than two years since dredging and backfill placement concluded and related vessel traffic has stopped, the project may still be within the ROD-anticipated period of equilibration, and it is too early to tell whether fish tissue concentrations are dropping in response to the absence of dredging (meaning recovering from the short-term and transient increases anticipated in the ROD and FS) or whether the observed fish tissue levels are fully reflecting the longer-term effects of project upstream source control and the benefits of contaminated sediment removal. The data and trends presented above suggest that Upper Hudson fish tissue PCB concentrations may still be reflecting the ROD-anticipated period of equilibration. The inherent variability in year-to-year measurements may require several years of post-post-dredging recovery from the short-term and transient impacts associated with implementation before a "post-dredging" MNA recovery trend can be identified and measured.

2.7 Comparison of Hudson River Fish Tissue Data Trends to Cumberland Bay (Wilcox Dock) Site

Post-dredging equilibration over several years has also been observed in other remedial sites. For example at Cumberland Bay (Lake Champlain, NY), fish tissue PCB levels were observed to require several years to recover in the wake of a removal action (NYSDEC 2012). Table A8-8 indicates the differences and similarities between the remedial action setting and implementation for Cumberland Bay (Wilcox Dock) Site and the Hudson River PCBs Superfund Site (River Section 1) location. Hudson River Section 1 was chosen to compare to Wilcox Dock because, of the three Hudson River Sections, it was the most consistently dredged upstream to downstream. In addition, the sites are similar in size, estimated mass of PCBs removed, the number of fish sampling stations for collection, and the number of fish collected at each station per year. Significant differences between the sites include the target volume of sediment removed, the dredging technology used, the range of fish species collected, fish sample preparation techniques, and the time over which the projects were implemented (Wilcox Dock over 2 years, Hudson River over 7). Figure A8-5.1 to 5.3 show the fish PCB tissue levels for rock bass and yellow perch for the source location (Wilcox Dock) and nearby "affected areas" from the time of dredging forward.

The Wilcox Dock remediation was implemented by NYSDEC in 1999 and 2000. The Hudson River PCBs Superfund Site was dredged in 2009 and 2011-2015. While limited pre-dredging data are available for the Wilcox Dock Site, Figures A8-5.1 and A8-5.2 indicate that for both fall-collected species (*i.e*., rock bass and yellow perch), several post-dredging years passed before fish tissue PCB levels began to stabilize. These figures also suggest similar post-dredging recovery rates for both species, and that rock bass tissue levels at the nearby affected areas also required at least three years to indicate a post-remediation reduction. While these data do not provide a controlled comparison in terms of implementation approaches, data collection, or lab processing/analytical approaches, they do suggest that some time is required for remedial sites to undergo equilibration before it is reasonable to expect to observe the ultimate post-dredge trend toward remedial goals and target PCB levels.

3 SUMMARY AND CONCLUSIONS

- Implementation of the remedy and certain conditions in the field departed in several ways from the underlying dredging release assumptions and the overall dredging approach outlined in the FS and ROD. Those departures and conditions may affect short-term impacts and the equilibration time required for fish tissue levels to reflect expected recovery rates. Specifically:
  - The FS assumed remedy implementation would begin within a year of issuing the ROD and the ROD assumed dredging would begin in 2005 and take five or six years to implement. Actual remediation required 7 years (8 years including habitat reconstructed after dredging) and was implemented in phases beginning in 2009, seven years after the ROD was issued and 4 years after dredging was assumed to begin. The longer remediation schedule resulted in PCBs being resuspended for a longer period of time than was assumed in the models.
  - Several operational aspects of implementation did not reflect underlying FS engineering assumptions, including:
    - PCB flux to the water column was assumed to consist of suspended sediment that was estimated to settle within 10m of the dredge head. Prior to dredging, dissolved PCBs were not expected to contribute significantly to overall PCB load. During implementation, PCB detections in the water column were often dominated by the dissolved phase and the presence of oil sheens. 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.
    - Dredging occurred 24-hours per day, as opposed to the 14-hour dredge days assumed in the FS, resulting in almost continuous periods of dredging-related resuspension.

    - Dredging occurred working in mean daily flows of over 5,000 cfs in 4 of the 6 dredging years (*vs*. approximately 3,000 cfs assumed in the ROD), and
    - The dredging sequence in River Sections 2 and 3 was arranged in response to operational safety and efficiency considerations, rather than upstream-to-downstream dredging. As a result, dredging occurred upstream of areas that were previously dredged, likely delaying the equilibration period for the downstream areas.
  - The use of a single processing facility at the upstream end of the Site resulted in more intensive project-related vessel traffic patterns along the entire project area for the two years immediately prior to the equilibration period described in the ROD. This change in barge transport and support vessel traffic intensity resulted in short-term increases in water column concentrations.
- Short-term and localized increases in fish tissue concentrations due to dredging were anticipated in the ROD and were observed at most of the RAMP fish monitoring stations between 2009 and 2015.
- Upstream source control measures at GE's Hudson Falls and Fort Edward facilities is substantially complete, although upstream control work is ongoing at GE's former Hudson Falls facility. Nevertheless, upstream boundary water column concentrations appear to have approached target levels projected in the ROD (2 ng/L Tri+ PCB) since 2010 and averaged less than 2 ng/L in 2016. In combination with the dredging implemented to date, this reduction in upstream loadings due to source control is expected to facilitate reductions in PCB concentrations in water, sediment, and fish.
- Not all PCB releases and fish tissue exposures that occurred during the dredging were reflected in the models. However, the Engineering Performance Standards and operational adjustments constrained these impacts (as reflected in load gain at Waterford remaining below the Resuspension Standard threshold, low project-wide resuspension exceedance rates, and observed fish tissue concentrations). Overall, such impacts, as anticipated by the FS and ROD, appear to have been short-term

and localized (*i.e.,* observed at spatial and temporal scales smaller than those underlying FS and ROD model forecasts).

- Because of differences between the timing and duration of implementation and the time frames assumed in the FS and ROD, direct comparisons of ROD calendar year forecasts may not be valid, and "apples-to-apples" comparisons of observed fish tissue concentrations to ROD forecasts using "years since dredging began" (*e.g.*, based on the presumed dredging start year) are confounded by the additional MNA that took place between the issuance of the ROD and implementation. Additionally, while short-term and localized increases in fish tissue PCB concentrations were anticipated in the FS and ROD, and were observed between 2009 and 2015, they were not reflected in the long-term fish tissue forecasts presented in the ROD. For these reasons direct comparisons of observed data to ROD forecasts are difficult to make.
- It is notable that dredging took place in all three river sections in 2015, the last year of dredging. As a result, the project area as a whole and within individual river sections is still at most 2 years "post-dredging." Since the ROD anticipated a year of equilibration, 2016 would fall within the post-dredging equilibration period, and the 2017 fish data represent the earliest possible post-dredge and post-equilibration year data.
- Because it has been less than two years since dredging and backfill placement concluded and related vessel traffic ended, and the project is possibly still within the anticipated period of equilibration, it is too early to tell whether fish tissue levels are recovering from the short-term and transient increases during dredging that were anticipated in the ROD and FS, or if the observed fish tissue levels are also reflecting the combined effects of project upstream source control and the benefits of remedy implementation (*i.e*., contaminated sediment removal).
- RAMP fish tissue data indicate that temporary and localized increases in fish tissue concentrations occurred as dredging approached the fish monitoring stations and also indicate that recovery from this perturbation can be seen at some stations, whereas recovery is still in progress at others. Data from the Cumberland Bay site

suggest that some post-dredging “time to recover” (*i.e.*, a multi-year post-dredging period of equilibration) would not be unique to the Hudson River PCBs Site.

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APPENDIX 8

Differences between Anticipated and Implemented Dredging Operations Based on the Feasibility Study and 2002 Record of Decision Assumptions and Forecasts

Tables and Figures

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Table A8-1. Comparison of principal components of REM 3/10/Select (EPA selected Remedy) as described in the FS, the 2002 ROD, and as implemented according to the Statements of Work (Attachment(s) to the consent decree) and EPA approved RAWP.

REM 3/10/Select Component	Anticipated for Feasibility Study (FS) and 2002 Record of Decision (ROD)	As Implemented During Phase 1 and Phase 2 Dredging (2009-2015)	Rationale for Operational Revision During Implementation
Upstream Source control(s)	Separate removal action at GE plants near Hudson Falls (including 1984 ROD Remnant Sites Capping and (then) on-going or pending NYSDEC actions). Upstream water column Tri+ PCB load at Fort Edward (Rogers Island) from 0.16 kg/day to 0.0256 kg/day.	No difference with respect to water column loading at Fort Edward and Remnant Sites capping. Other source control measures (Implemented or on-going by NYSDEC) include a tunnel drain system and contaminated soils removal at GE Hudson Falls plant site and at Outfall Fort Edward facility 004.	Upstream source control measures were defined by subsequent NYSDEC Records of Decision (RODs) and associated designs. Water quality objective (0.0256 kg/day, or equivalent target water column concentration of 2 ng/L (Tri+PCB) has been attained during 2016.
Dredging Commencement and Duration	2004 (FS) or 2005 (ROD) start date with 5 or 6 year 1 or 2-phase implementation with one year of post construction equilibration.	Dredging 2009-2015 with 2010 off for Phase 1 Peer Review (7 years to implement dredging, 8 years with initial habitat reconstruction in 2016) with one year of equilibration.	Time to design remedy, complete negotiations and construct processing facility. (7 years total: 2002-2009)
Dredging Extent	3 g/m^2 or greater PCBs from RS1, 10 g/m^2 in RS2, and selected sediments (Hot Spots 36, 37, part of Hot Spot 39; approx. 92 acres between approx. RMs 170-163.5) in RS3.	3 g/m^2 or greater PCBs from RS1, an MPA of 10 g/m^2 in RS2, and sediments with MPA of 10 g/m^2 within CU's 79-100 (approx. 96 acres between approx. RMs 182-155) in RS3	RS1 and RS2 were not significantly different from approaches anticipated in the FS or ROD.

REM 3/10/Select Component	Anticipated for Feasibility Study (FS) and 2002 Record of Decision (ROD)	As Implemented During Phase 1 and Phase 2 Dredging (2009-2015)	Rationale for Operational Revision During Implementation
Implementation Sequencing	Upstream to downstream RS1 to RS3 with some simultaneous dredging as operations moved into RS3	2009, 2011-2012: Generally upstream to downstream in RS1. 2013-2015: Simultaneous dredging RS1, RS2, and RS3.	CU's not dredged upstream to downstream in the interest of safety (CU's 60 and 95), overall project efficiency (CUs 60, 95, and 61-66), and logistical feasibility (CUs 17-18, and 61-66).
Dredging Infrastructure	One facility (upstream) or 2 facilities (one northern/upstream and one southern/ downstream) contemplated. Locations not specified. 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.	Use of single (upstream) processing facility determined to be efficient overall because approximately 75% of the targeted removal volume was located in the upstream half of the project area.
Dredging Equipment and Floating Plant	Mechanical environmental dredges with clamshell buckets (hydraulic also contemplated). Specifics left to design.	Mechanical-environmental dredges (barge mounted hydraulic excavator fitted with enclosed environmental buckets).	Not significantly different from approaches anticipated in the FS or ROD.
Performance Standards Compliance and Project Monitoring	Short and long-term monitoring (pre-, during, and post-construction) of dredging production, resuspension, backfilling, and community impacts (including sediment, water, and biota) to evaluate effectiveness and protection of human health and environment. Specifics to be detailed in design.	Not significantly different from approaches anticipated in the FS or ROD.	Not significantly different from approaches anticipated in the FS or ROD.

Table A8-2: (Adapted from FS Table 8-9 and 2002 ROD Table 13-1) Comparison of Targeted Acreage, Sediment, and Mass Removal for the FS, 2002 ROD, and Remedial Action (RA) Implementation by River Section.

River Section/Parameter	FS (Assumed) Contaminant Removal[5]	ROD (Estimated) Contaminant Removal	RA (Observed) Implementation Results [4]
River Section 1			
Area Remediated (Acres)	282	282	307.8
Volume Sediments Removed (CY)	1,561,400	1,561,400	1,424,550
PCB Mass Removed (kg, TPCB)	11,800	36,000[1]	90,075
PCB Mass Removed (kg, Tri+PCB)	--	11,100	27,261
River Section 2			
Area Remediated (Acres)	76	76	87.7
Volume Sediments Removed (CY)	580,100	580,100	536,476
PCB Mass Removed (kg, TPCB)	24,300	24,300	35,314
PCB Mass Removed (kg, Tri+PCB)	--	7,100	9,931
River Section 3 [2]			
Area Remediated (Acres)	135	135	96.1
Volume Sediments Removed (CY)	510,200	510,200	680,900
PCB Mass Removed (kg, TPCB)	9,500	9,500	30,371
PCB Mass Removed (kg, Tri+PCB)	--	3,500	11,379
Total for alternative			
Area Remediated (Acres)	493	493	491.6
Volume Sediments Removed (CY)	2,651,700	2,651,700	2,641,926
PCB Mass Removed (kg, TPCB)	45,600	69,800[3]	155,760
PCB Mass Removed (kg, Tri+PCB)	--	21,700	48,571

Notes:
1. Estimate reflects PCB mass removed from navigation channel dredging.
2. The FS/ROD remedial target criteria for River Section 1 sediment was 3 g/m^2 TPCB, for River Section 2 the remedial target criteria was 10g/m^2 TPCB, and for River Section 3 the remedial target criteria was for select removal sediment in Hotspots (HS) HS36, HS37 and HS39. For River Section 3, removal criteria were revised via 2004 Dispute Resolution to 10 g/m^2, resulting in actual RS3 targets delineated by CU's 79-100, and encompassing approximately 96 acres between RM182 and RM154.
3. Estimate rounded to 70,000 kg for 2002 ROD.
4. Based on volume and mass removed data presented in Appendix 2 of 2017 Five Year Review Report (Table A2-series) and CU Certification forms (acres).
5. FS Table 8-9 did not provide values for estimate of Tri+PCB mass removed.

Table A8-3. Major Dredged Material Processing Facilities, General Support Properties, and Barge Loading Areas by River Mile and River Section with Service Years (Sources: Project RAWP).

Facility	River Section / Certification Unit	River Mile	Years in Service
Sediment Processing Facility	Not located in a RS	197	2009-2015
Moreau Barge Loading Area	RS1 / CU09	193.9	2009-2013
Rt 4 Support Facility	RS1 / CU29	192	2009-2015
Isthmus Transloading Area[1]	RS2 / CU62	188	2014-2015
Fort Miller Barge Loading Area	RS2 / CU66	186.4	2013-2015
Saratoga Barge Loading Area	RS2 / CU78	182.7	2013-2015
Rennsalear Barge Loading Area	RS3 / CU95	164.4	2013-2015

Notes:
1. Used to transfer dredged sediments out of Reach 7 (the landlocked area) into dredge barges on the Champlain Canal for transport to the dredged sediment processing facility.

Table A8-4: Summary of REM-3/10/Select (Mechanical Removal) engineering parameters from the FS and 2002 ROD compared to removal, transportation, and backfill placement quantities observed during implementation.

ORIGINAL ESTIMATES (adapted from FS TABLES 8-9 and 8-10A and 2002 ROD Table 13-1)				IMPLEMENTATION ESTIMATES
Removal	Sediment targeted for removal	RS1 (CY)	1,561,400	1,440,150
		RS2 (CY)	580,100	536,476
		RS3 (CY)	510,200	680,900
		Total Volume (CY)	**2,651,700**	**2,641,926 [1]**
Transportation	Sediment Removal	Number of Dredges	4	4-5 [2]
		Total Dredging Hours	48,600	43,592 [1]
		Est Dredging Season (days)	**210**	**206 (Avg 2009-2015)[1]**
	In-River Transport of Dredged Sediments	Barge Loads to SF/Day	4	Not Implemented
		Barge Loads to NF/Day	8-9	5.3 [2]
		Total Project Lockages [3]	**Not Est.**	**35,497 [3]**
	Land-based Transportation	Rail Cars From SF/Day	29	Not Est.
		Rail Cars From NF/Day	16	24 [1]
Reconstruction	Backfill Quantities	Sand	327,000	Not estimated
		Gravel	327,000	Not estimated
		Silty Material	197,000	Not estimated
		Total Volume (CY)	**851,000**	**1,362,266 [4]**
	Shoreline Stabilization	Hydroseeding	17	Not Est
		Vegetative Mattress	47	Not Est.
		Veg. Mattress & Revetment	27	Not Est.
		Total (LF)	**91,000**	**71,280 [5]**
	Habitat Reconstruction Planting Areas	Shallow vegetation	22	Not Est
		Emergent vegetation	22	Not Est.
		Shallow Planting	55	Not Est.
		Total Planting Areas (Acres)	**99**	**69.3 [6]**
	SAV & RFW Habitat Reconstruction Acres		**Not Est.**	**124.9**

Notes:

1. Based on GE Annual Report data (2009-2015) includes access dredging.
2. Based on annual Remedial Action Work Plans (RAWP) and GE Annual Report data 2009-2015. Estimate derived as sum of total barges unloaded per year (4,898) divided by the total number of days dredging took place per year (925).
3. Not estimated for FS or ROD. Lockage is defined as trip through a NYSCC Champlain Canal Lock. Estimate based on GE lockages reported annually to NYSCC (2009-2015).
4. Based on difference in bathy surfaces recorded post dredging (mudline) and post-backfill placement.
5. Estimates of planted habitat reconstruction acres and linear feet (LF) of shoreline established are based on CU Certification Form 3 data (2010-2016).
6. Due to use of planting with natural recolonization a total of 124.9 acres of submerged aquatic vegetation (SAV) and riverine fringing wetland (RFW) were established during habitat reconstruction and are monitored annually.

Table A8-5. GE reported project-related lockages (a vessel passing through a lock) for Champlain Canal locks C-1 through C-7 during implementation (2009-2015). Lockage data represent GE (annually) reported lockages to NYSCC.

Year	**Lock C-1** RM 159.4 RS3	**Lock C-2** RM 163.5 RS3	**Lock C-3** RM 166 RS3	**Lock C-4** RM 168 RS3	**Lock C-5** RM 182.5 RS2/RS3[1]	**Lock C-6** RM 186 RS2	**Lock C-7** RM 193.5 RS1	Total Project Lockages	Dredged Sediment Barge Offloads [2]	Sediment Barge Offloads / Day
2009	0	0	0	0	0	0	3,844	3,844	638	3.9
2010	0	0	0	0	0	0	521	521	0	0
2011	0	0	0	0	0	0	1,766	1,766	669	4.8
2012	0	0	0	0	0	0	3,036	3,036	1,270	7.6
2013	45	44	44	51	1,561	3,122	2,614	7,481	1,124	6.7
2014	592	682	1,270	1,830	4,636	2,160	2,598	13,768	869	5.4
2015	282	326	829	790	789	885	1,180	5,081	327	2.7
Totals	***919***	***1,052***	***2,143***	***2,671***	***6,986***	***6,167***	***15,559***	***35,497***	***4,897***	***5.2 (Avg)***

Notes:

1. NYSCC Lock 5 is located at the downstream end of RS2 and represents the transition from RS2 to RS3.
2. Reported as dredge barge offloads at processing facility (Source: GE Annual Reports)

Table A8-6: Estimated volume of sediment dredged, dredge scow offloads, and miles travelled by dredged sediment scows over RA period 2009-2015 with estimated support vessel lockages and backfill/cap material placed per year.

Year	Est Volume Sediment Removed (CY)	# of Sediment Scow Offloads (per year)	Est Total Sediment Barge Miles Travelled	Est % Dredged Sediment Barge Miles Travelled	% Lockages not by Sediment Barges[1]	Est Volume Backfill & Cap Placed (CY)
2009	267,900	638	2,710	2.9%	83.4%	112,023
2010	0	0	0	0	0	0
2011	351,728	670	3,080	3.3%	62.1%	202,154
2012	604,273	1,270	9,800	10.6%	58.2%	288,154
2013	648,208	1,124	24,000	24.9%	85.0%	345,777
2014	565,941	869	38,100	41.1%	93.7%	269,948
2015	203,877	327	14,900	17.2%	93.6%	144,210
Totals	***2,641,926***	***4,898***	***92,590***	***100.0%***	***86.2%(avg)***	***1,362,266***

<u>Notes:</u>
[1] Fraction of lockages that are not Processing Facility bound-barges expressed as the percent of vessel traffic supporting removal and transportation of in-river dredged sediment or backfill/cap placement transportation each year.

Table A8-7. Years to return to A) within baseline range, B) at or below BMP mean, and C) at or below BMP LCL based on year of dredging at Station. *Note some stations dredged in multiple and non-consecutive years.

RS1 Station (STN)	Species	Figure	Time (yrs) since STN Dredged	Time (yrs) Observed CI Overlaps BMP CI	Time (yrs) where observed mean was at or below BMP mean	Time (yrs) where observed mean was at or below BMP LCL	Notes
TD1	Black bass	A8-4.1	1	1-3	4	>4	Barge loading area 2009-2013, additional dredging 2015
TD2	Black bass	A8-4.1	5	0-1	2	3	Station adjacent to TIP navigation channel 2009-2015
TD3	Black bass	A8-4.1	4	2	3	>4	Station adjacent to TIP navigation channel 2009-2015
TD4	Black bass	A8-4.1	4	0-1	2	2	Station adjacent to TIP navigation channel 2009-2015
TD5	Black bass	A8-4.1	2	0-1	2	2	Station dredged 2012-2014
Species Station Range			***1-5***	***0-3***	***2-4***	***2-4+***	
TD1	Br Bullhead	A8-4.2	1	0-1	2	4	Barge loading area 2009-2013, additional dredging 2015
TD2	Br Bullhead	A8-4.2	5	0-1	4	4	Station adjacent to TIP navigation channel 2009-2015
TD3	Br Bullhead	A8-4.2	4	0-1	1-3	1-3	Station adjacent to TIP navigation channel 2009-2015
TD4	Br Bullhead	A8-4.2	4	0-1	2	3	Station adjacent to TIP navigation channel 2009-2015
TD5	Br Bullhead	A8-4.2	3	0-1	2	2	Station dredged 2012-2014
Species Station Range			***1-5***	***0-1***	***1-4***	***1-4***	
TD1	Yellow Perch	A8-4.3	1	0-1	4	4	Barge loading area 2009-2013, additional dredging 2015
TD2	Yellow Perch	A8-4.3	4	0-2	1-2	1-2	Station adjacent to TIP navigation channel 2009-2015
TD3	Yellow Perch	A8-4.3	4	1	1	1	Station adjacent to TIP navigation channel 2009-2015
TD4	Yellow Perch	A8-4.3	4	2	2	2	Station adjacent to TIP navigation channel 2009-2015
TD5	Yellow Perch	A8-4.3	3	1	1	1	Station dredged 2012-2014
Species Station Range			***1-4***	***0-2***	***1-4***	***1-4***	
Range of Species in RS1 Spp Weighted Avg			***1-5***	***0-3***	***1-4***	***1-4+***	
TD1	Pumpkinseed	A8-4.4	1	1	1	1	Barge loading area 2009-2013, additional dredging 2015
TD2	Pumpkinseed	A8-4.4	5	1	3	3	Station adjacent to TIP navigation channel 2009-2015
TD3	Pumpkinseed	A8-4.4	4	2	2	2	Station adjacent to TIP navigation channel 2009-2015
TD4	Pumpkinseed	A8-4.4	4	0-1	1	2	Station adjacent to TIP navigation channel 2009-2015
TD5	Pumpkinseed	A8-4.4	4	1	1	1	Station dredged 2012; barge traffic 2009-2015
Species Station Range			***1-5***	***0-2***	***1-3***	***1-3***	
Range of ALL Study Species in RS1			***1-5***	***0-3***	***1-4***	***1-4+***	

Table A8-7 (Cont'd)

RS2 Station (STN)	Species	Figure	Time (yrs) since STN Dredged	Time (yrs) Observed CI Overlaps BMP CI	Time (yrs) where observed mean was at or below BMP mean	Time (yrs) where observed mean was at or below BMP LCL	Notes
ND1	Black bass	A8-4.5	2	1	2	2	Station dredged 2014; barge transloading 2014-15
ND2	Black bass	A8-4.5	1	0-1	>1	>1	Station dredged 2014-2015
ND3	Black bass	A8-4.5	3	0-1	3	3	Station dredged 2013; barge traffic 2013-2015
ND5	Black bass	A8-4.5	3	0-1	2	3	Station dredged 2013; barge traffic 2013-2015
Species Station Range			***1-3***	***0-1***	***>1-3***	***>1-3***	
ND1	Br Bullhead	A8-4.6	2	0-1	2	2	Station dredged 2014; barge transloading 2014-15
ND2	Br Bullhead	A8-4.6	1	0-1	1	1	Station dredged 2014-2015
ND3	Br Bullhead	A8-4.6	3	0-1	1	2	Station dredged 2013; barge traffic 2013-2015
ND5	Br Bullhead	A8-4.6	3	0-1	3	3	Station dredged 2013; barge traffic 2013-2015
Species Station Range			***1-3***	***0-1***	***1-3***	***1-3***	
ND1	Yellow Perch	A8-4.7	2	0-1	0-1	0-1	Station dredged 2014; barge transloading 2014-15
ND2	Yellow Perch	A8-4.7	1	0-1	0-1	2	Station dredged 2014-2015
ND3	Yellow Perch	A8-4.7	3	1	3	4	Station dredged 2013; barge traffic 2013-2015
ND5	Yellow Perch	A8-4.7	3	2	2	3	Station dredged 2013; barge traffic 2013-2015
Species Station Range			***1-3***	***0-2***	***0-3***	***0-4***	
Range of Species in RS2 Spp Weighted Avg			***1-3***	***0-2***	***0-3***	***0-4***	
ND1	Pumpkinseed	A8-4.8	2	0-1	2	2	Station dredged 2014; barge transloading 2014-15
ND2	Pumpkinseed	A8-4.8	1	0-1	1	>1	Station dredged 2014-2015
ND3	Pumpkinseed	A8-4.8	3	1	2	2	Station dredged 2013; barge traffic 2013-2015
ND5	Pumpkinseed	A8-4.8	3	1	1	1	Station dredged 2013; barge traffic 2013-2015
Species Station Range			***1-3***	***0-1***	***1-2***	***1-2***	
Range of ALL Study Species in RS2			***1-3***	***0-2***	***0-3***	***0-4***	

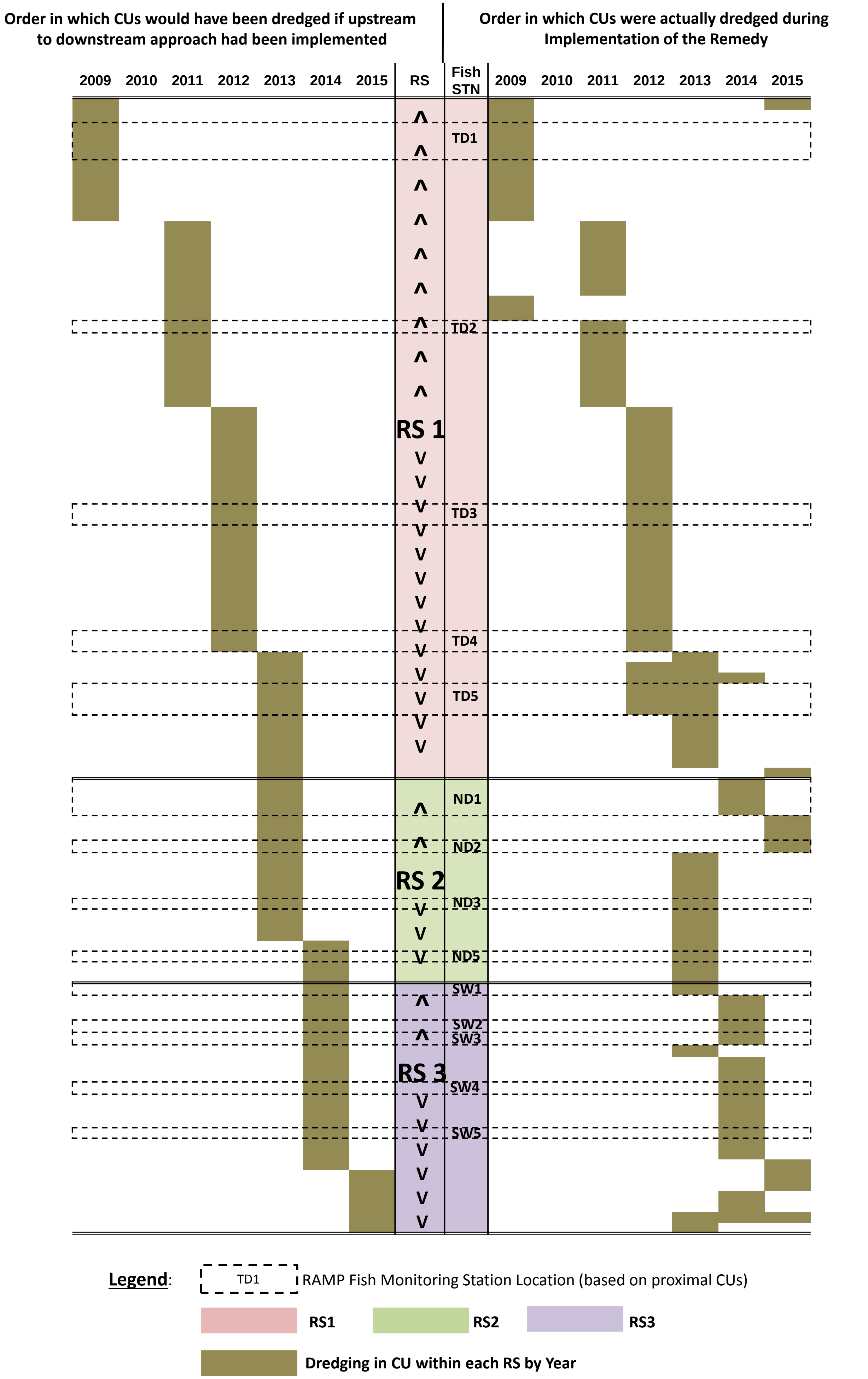
Table A8-7 (Cont'd)

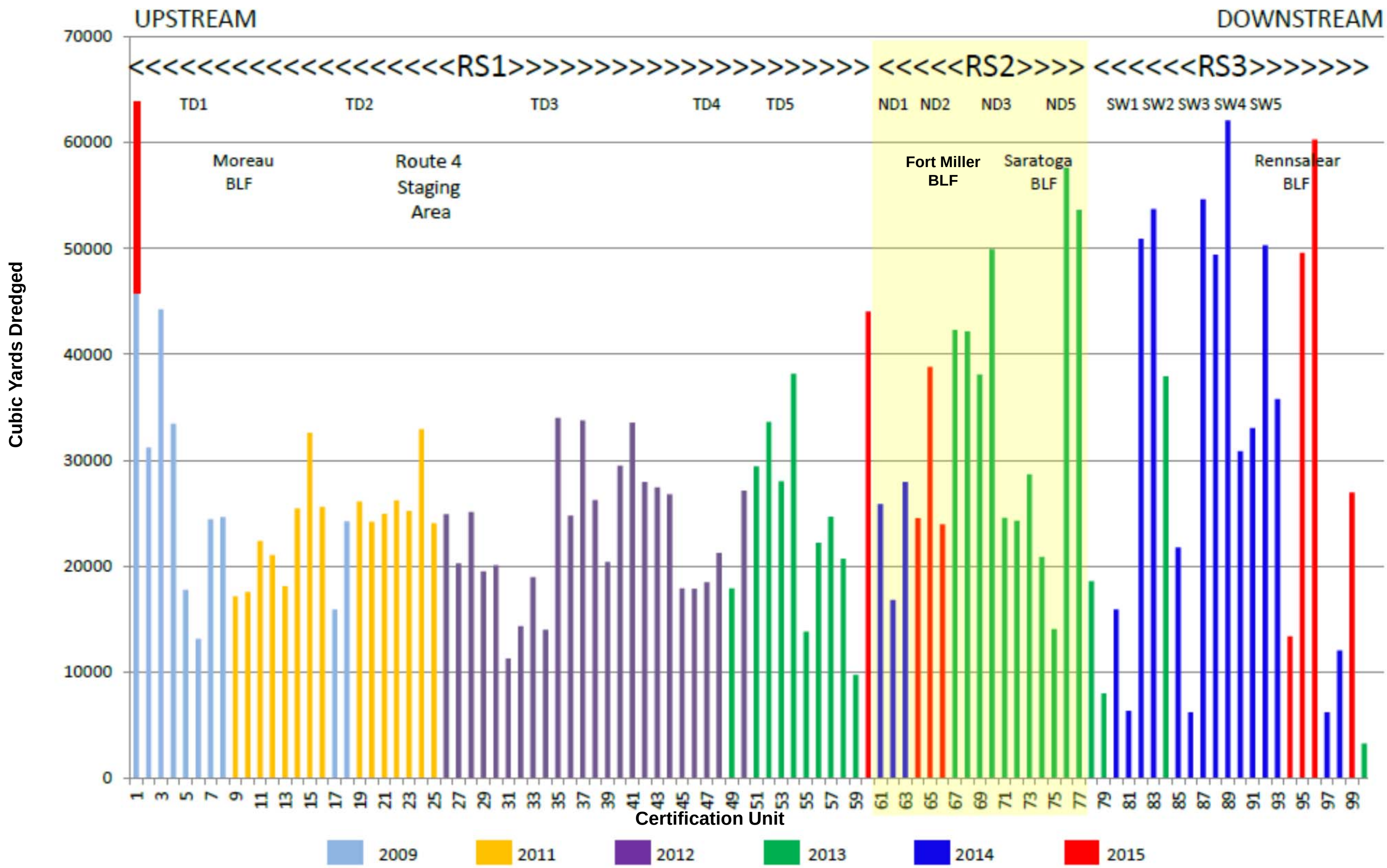
RS3 Station (STN)	Species	Figure	Time (yrs) since STN Dredged	Time (yrs) Observed CI Overlaps BMP CI	Time (yrs) where observed mean was at or below BMP mean	Time (yrs) where observed mean was at or below BMP LCL	Notes
SW1	Black bass	A8-4.9	3	0-1	2	>3	Station located downstream of Lock 5, barge traffic
SW2	Black bass	A8-4.9	2	0-1	2	>2	Dredged 2014, barge traffic 2013-2015
SW3	Black bass	A8-4.9	2	1	1	2	Station dredged 2014; barge traffic 2014-2015
SW4	Black bass	A8-4.9	2	1	2	>2	Station dredged 2014; barge traffic 2014-2015
SW5	Black bass	A8-4.9	2	0-1	2	>2	Station dredged 2014; barge traffic 2014-2015
Species Station Range			***2-3***	***0-1***	***1-2***	***2-3+***	
SW1	Br Bullhead	A8-4.10	3	0-1	1-2	3	Station located downstream of Lock 5, barge traffic
SW2	Br Bullhead	A8-4.10	2	0-1	2	>2	Dredged 2014, barge traffic 2013-2015
SW3	Br Bullhead	A8-4.10	2	1	1	>2	Station dredged 2014; barge traffic 2014-2015
SW4	Br Bullhead	A8-4.10	2	0-1	0	2	Station dredged 2014; barge traffic 2014-2015
SW5	Br Bullhead	A8-4.10	2	0-1	0	1	Station dredged 2014; barge traffic 2014-2015
Species Station Range			***2-3***	***0-1***	***0-2***	***1-3***	
SW1	Yellow Perch	A8-4.11	3	0-1	2	2	Station located downstream of Lock 5, barge traffic
SW2	Yellow Perch	A8-4.11	2	0-1	2	>2	Dredged 2014, barge traffic 2013-2015
SW3	Yellow Perch	A8-4.11	2	1	1	2	Station dredged 2014; barge traffic 2014-2015
SW4	Yellow Perch	A8-4.11	2	0-1	1	2	Station dredged 2014; barge traffic 2014-2015
SW5	Yellow Perch	A8-4.11	2	0-1	2	>2	Station dredged 2014; barge traffic 2014-2015
Species Station Range			***2-3***	***0-1***	***1-2***	***2-2+***	
Range of Species in RS3 Spp Weighted Avg			***2-3***	***0-1***	***0-2***	***1-3+***	
SW1	Pumpkinseed	A8-4.12	3	0-1	1	2	Station located downstream of Lock 5, barge traffic
SW2	Pumpkinseed	A8-4.12	2	0-1	1	2	Dredged 2014, barge traffic 2013-2015
SW3	Pumpkinseed	A8-4.12	2	0-1	0-1	1	Station dredged 2014; barge traffic 2014-2015
SW4	Pumpkinseed	A8-4.12	2	0-1	1	2	Station dredged 2014; barge traffic 2014-2015
SW5	Pumpkinseed	A8-4.12	2	1	1	>2	Station dredged 2014; barge traffic 2014-2015
Species Station Range			***2-3***	***0-1***	***0-1***	***1-2+***	
Range of ALL Study Species in RS3			***2-3***	***0-1***	***0-2***	***1-3+***	

Table A8-8. Comparison of USEPA Hudson River BMP/RAMP and NYSDEC Cumberland Bay (Plattsburgh, NY) Remedial Sites Fish Collection and Monitoring Programs (Based on Hudson RS1 sampling approach).

Component	Cumberland Bay	Hudson River (RS1)
Target Contaminant(s)	PCBs (Ar 1242)	PCBs (multiple Aroclors)
Area (sq miles)	3.6	0.83*
Target Sed Volume (CY)	230,000	Approx 1.4 million
Dredge Approach	Hydraulic Dredging	Mechanical with hydraulic buckets
Est Mass PCB removed (lbs)	20,000	16,800
Time of Implement (Yrs)	2 (actual dredging) (1999-2000)	6 (actual dredging), 7 total (2009-2015)
Primary Target Fish Species	Rock Bass, Yellow Perch.	Largemouth bass, brown bullhead, yellow perch, pumpkinseed/forage fish spp.
# Sampling Stations	4 total in “affected area” 9 total in Long Term Monitoring (LTM) area	5 (RS1); 17 total in project area
Samples/Yr	Variable (target was up to 20 per spp). Actual collections ranged between 10 (Spring) and 20 (Fall)	30 fish per species per RS (5/station) (30 total individual PKSD and 10 total composite forage fish samples in the fall)
Sampling Years	1994, 1997, and 1999-2009	2004-2008 (BMP) 2009-2015 (RAMP)
Fish Processing Approach	Fall collected spp: 1999-2009 WH 2010-2011 Std Fillet (additional fish) Spring collected fish: 1994 & 1997: “many of the YP were prepared as std fillets.” 1999-2006: “for YP and RB the head and viscera were removed from many of the samples.”	Fall Collected spp: 2003-2015 WH individual PKSD, WH-composited forage fish Spring Collected Spp: 2004-2006 and 2014-2016 NYSDEC standard fillet 2007-2013 non-NYSDEC standard fillet approach (fillets included belly flap but did not include rib cage material).
Target analytes	TPCB; Lipids	TPCB; Lipids
PCB analysis method	8280 (PCDD/F congeners--not PCB Aroclors) with congeners (1668) 2007 & 2010.	8082 (PCB Aroclors) with 5% of samples also run as congeners (1668) every other year
Lipids analysis method	Gravimetric	Gravimetric

Figure A8-1: FS and ROD Envisioned "Upstream to Downstream" Dredging Approach Compared to Phase 1 and Phase 2 Dredging Implementation by year and River Section (RS).

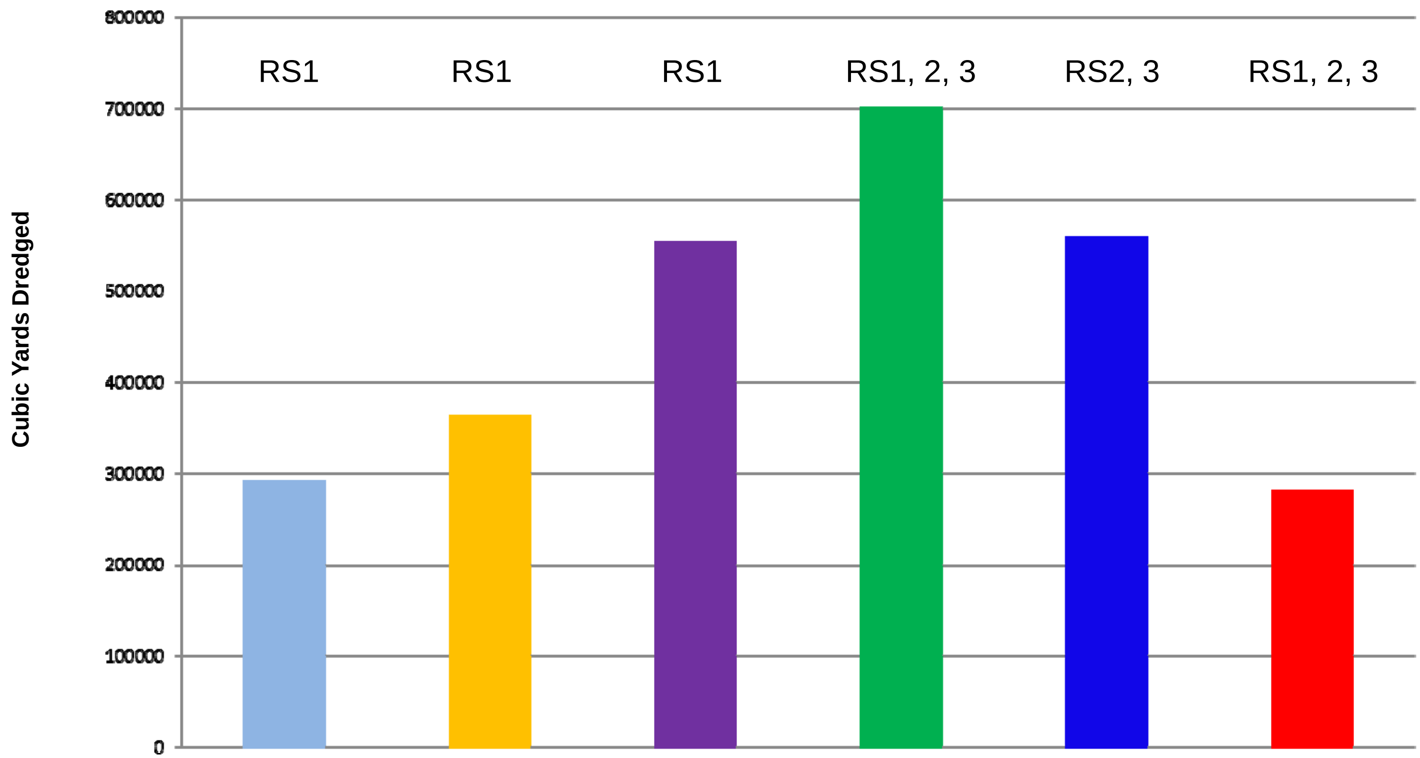




Estimated Volume Dredged (CY) for Each CU by Dredge Year Showing River Section (RS), RAMP Fish Collection Stations and Barge Loading Facility Locations

Figure A8-2

May 2017



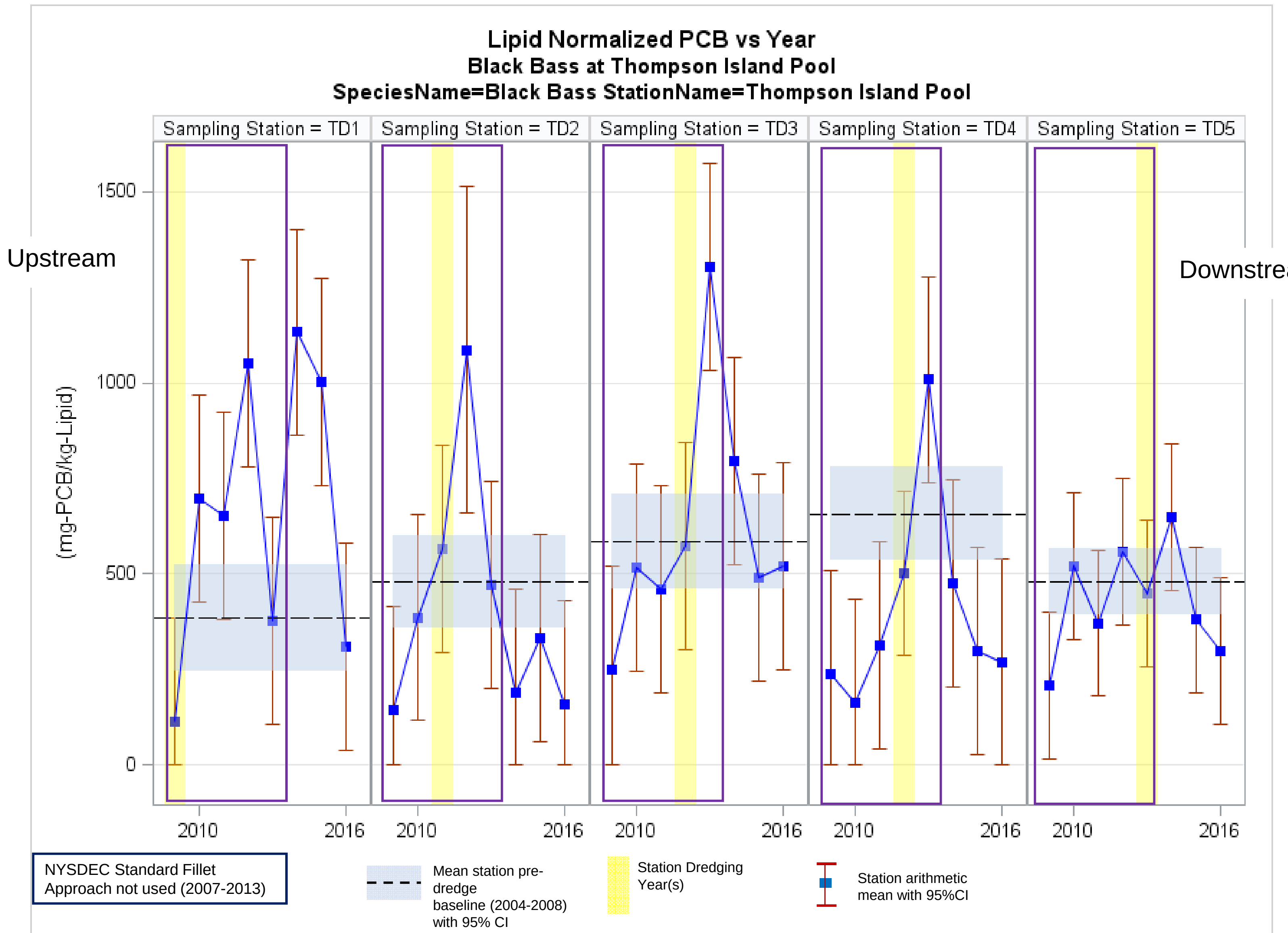
Year	2009	2011	2012	2013	2014	2015
Volume Dredged (CY)	292,369	363,335	555,034	701,948	559,484	281,526
% of Total Volume Dredged (09-15)	11%	13%	20%	25%	20%	10%
Area Dredged (Ac)	48.2	75.1	122.9	119.7	84.8	39.7
Est Mass Removed (kg Tri+ PCB)	5,350	9,070	10,080	9,275	8,915	2,991
Est Net Load Past Waterford (kg Tri+ PCB)^	71.3	96.8	36.9	112.7	40.1	32.4
Percent Release	1.3	0.33	0.3	1.07	0.45	1.49

^ Louis Berger Tri+PCB Net Load (above baseline) Past Waterford (kg) by daily net load 2011-2015. GE data based on 7 day running average for 2009. Percent Release data is from the Waterford monitoring station.

Estimated Volume of Sediment Dredged (CY) by Year

Figure A8-3

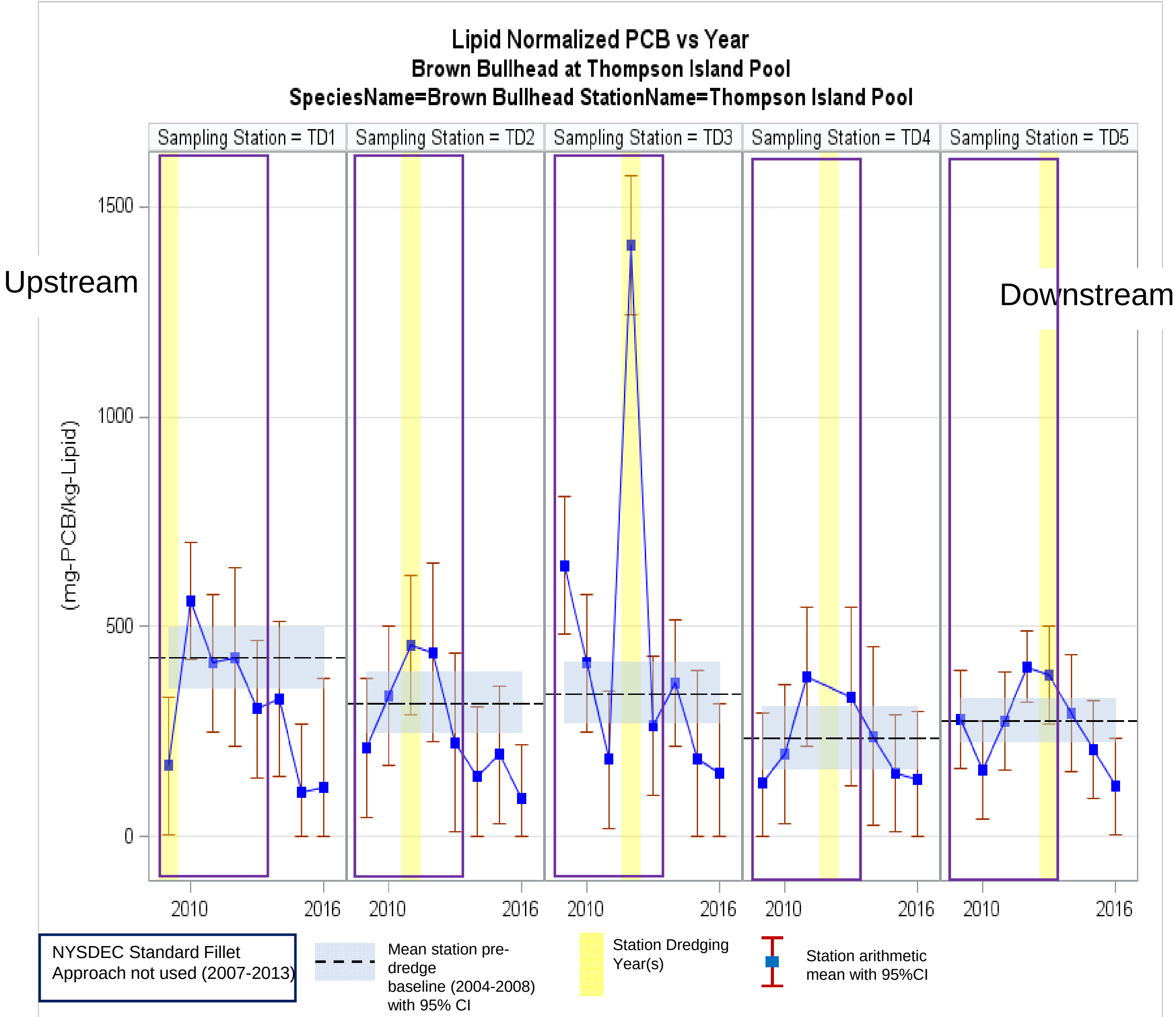
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.1

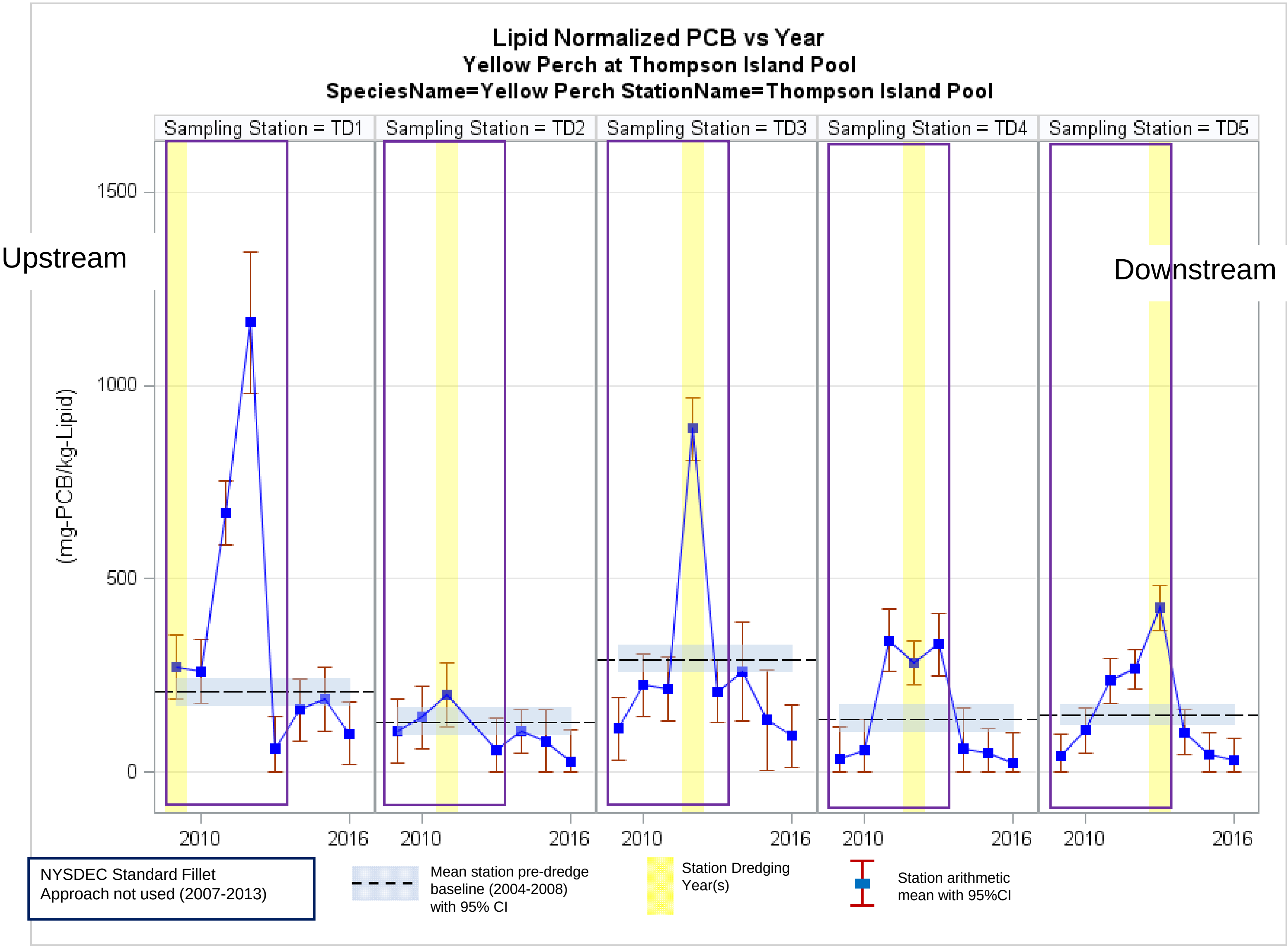
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.2

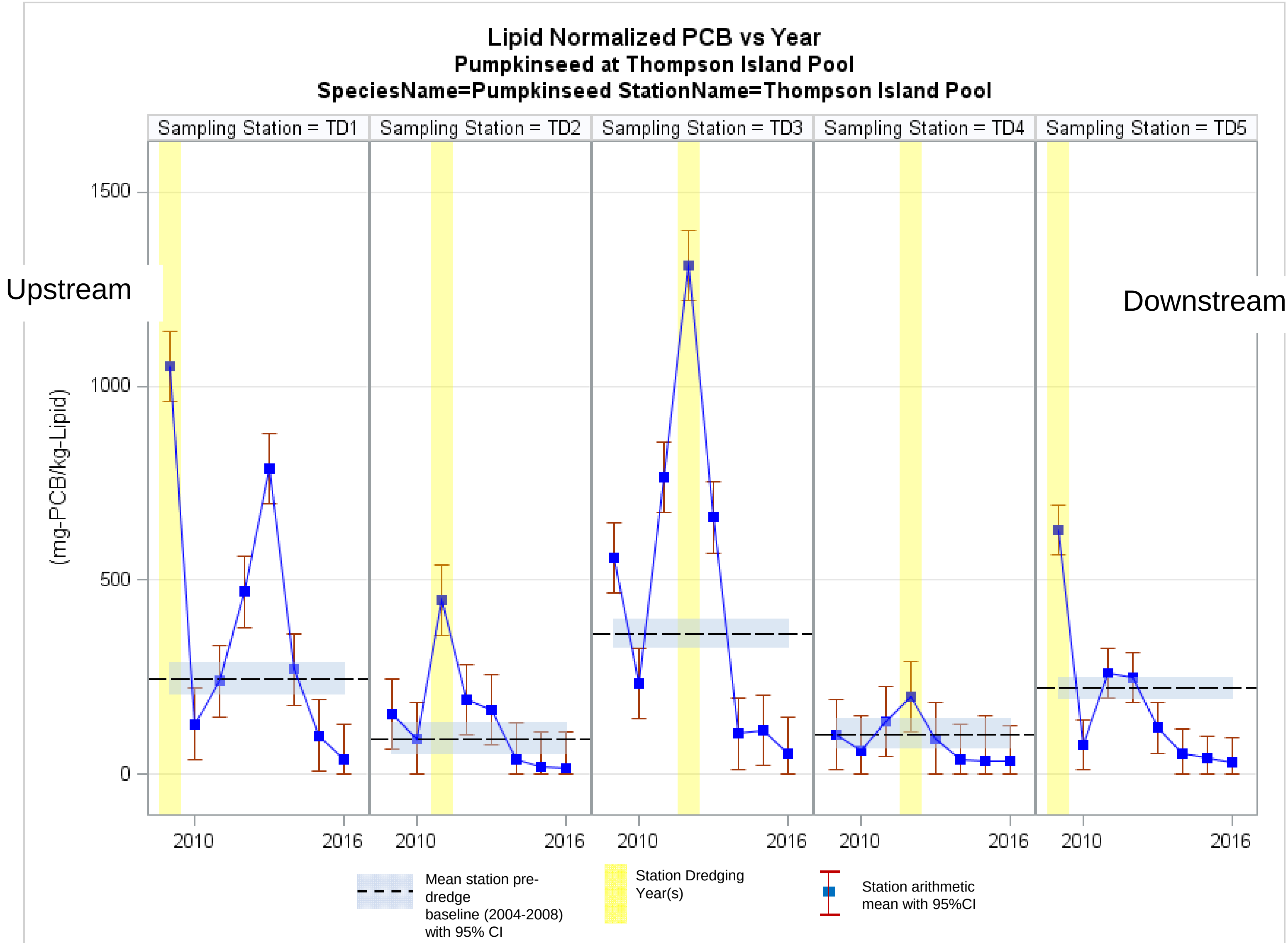
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.3

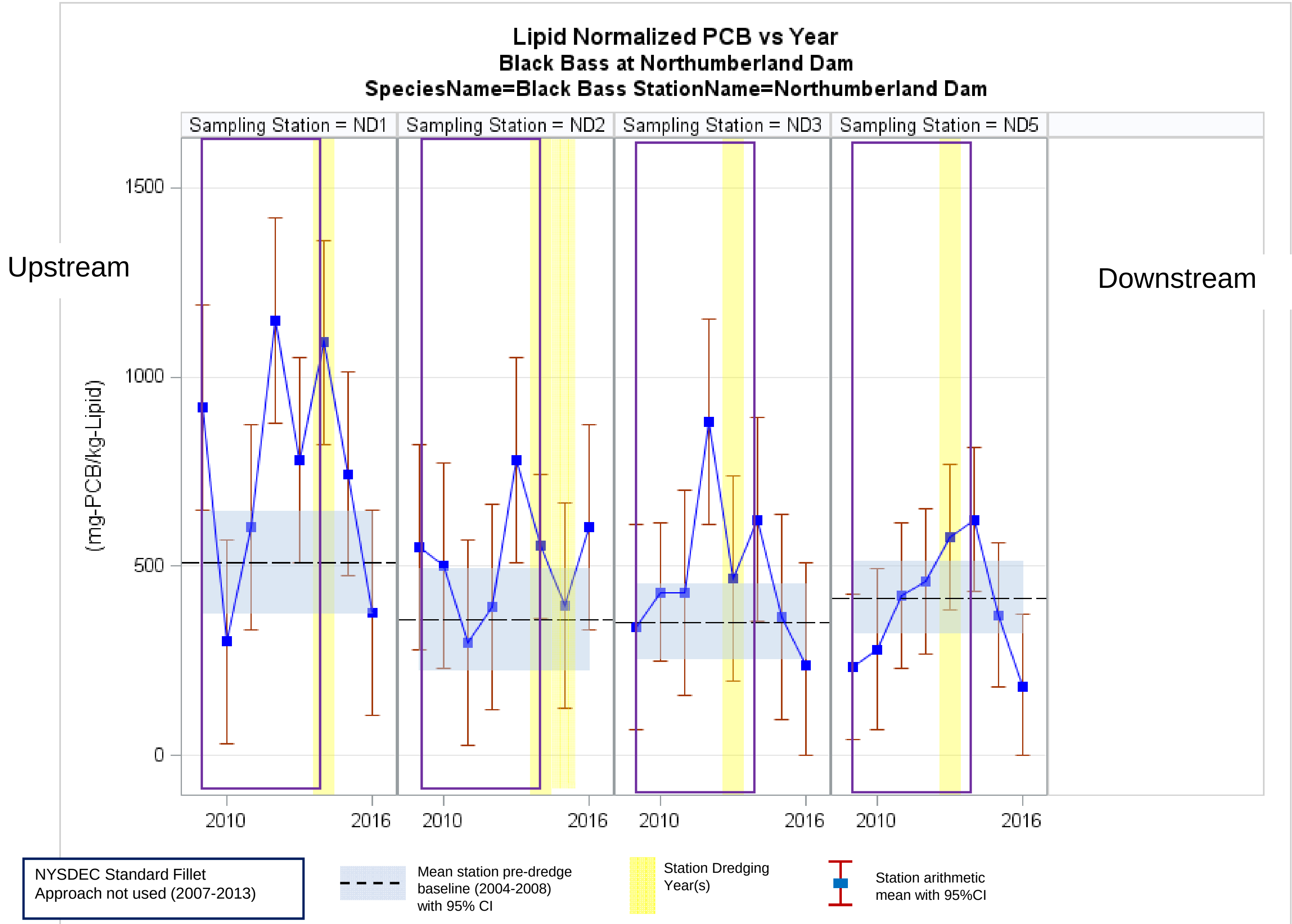
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.4

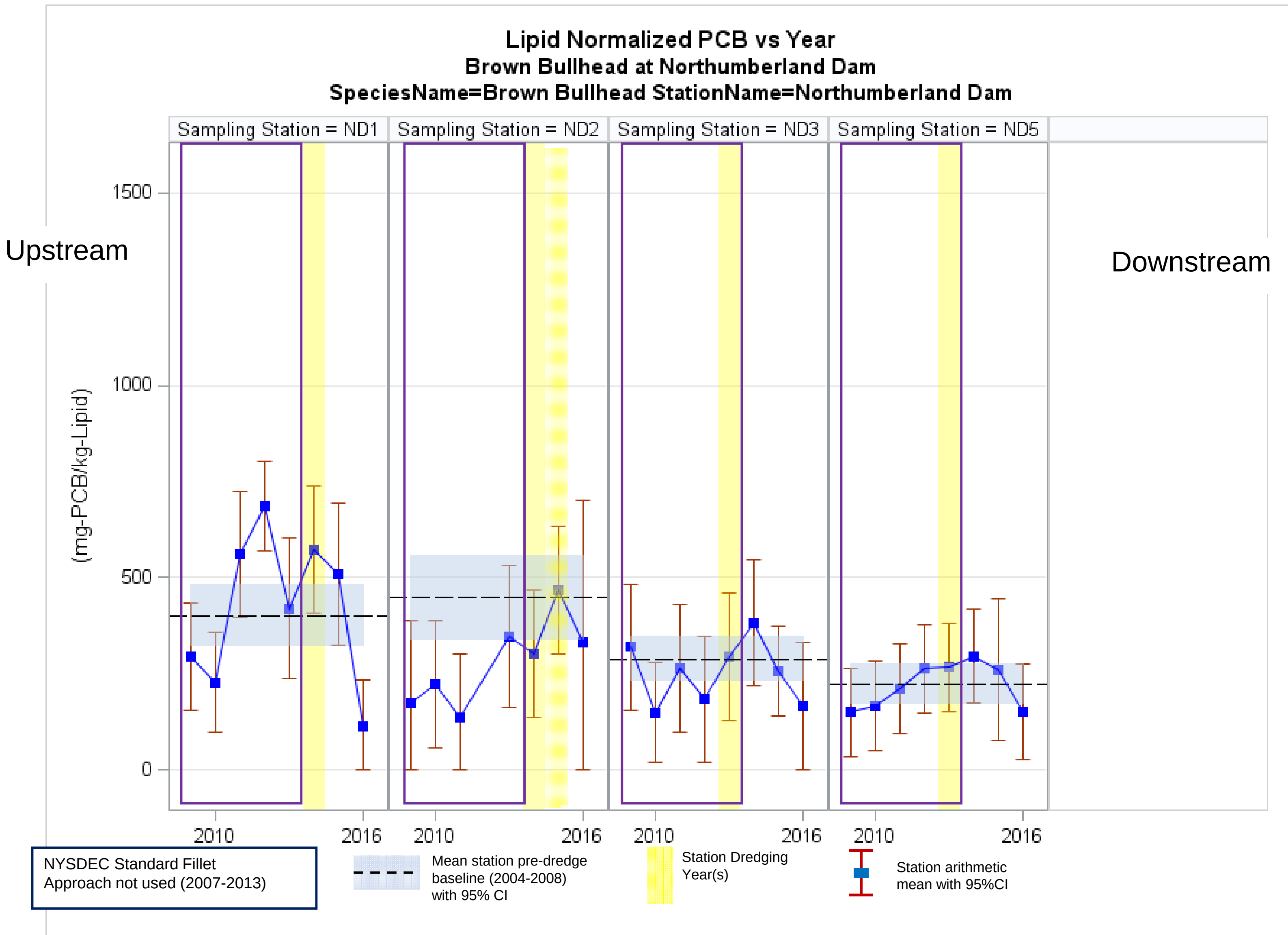
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.5

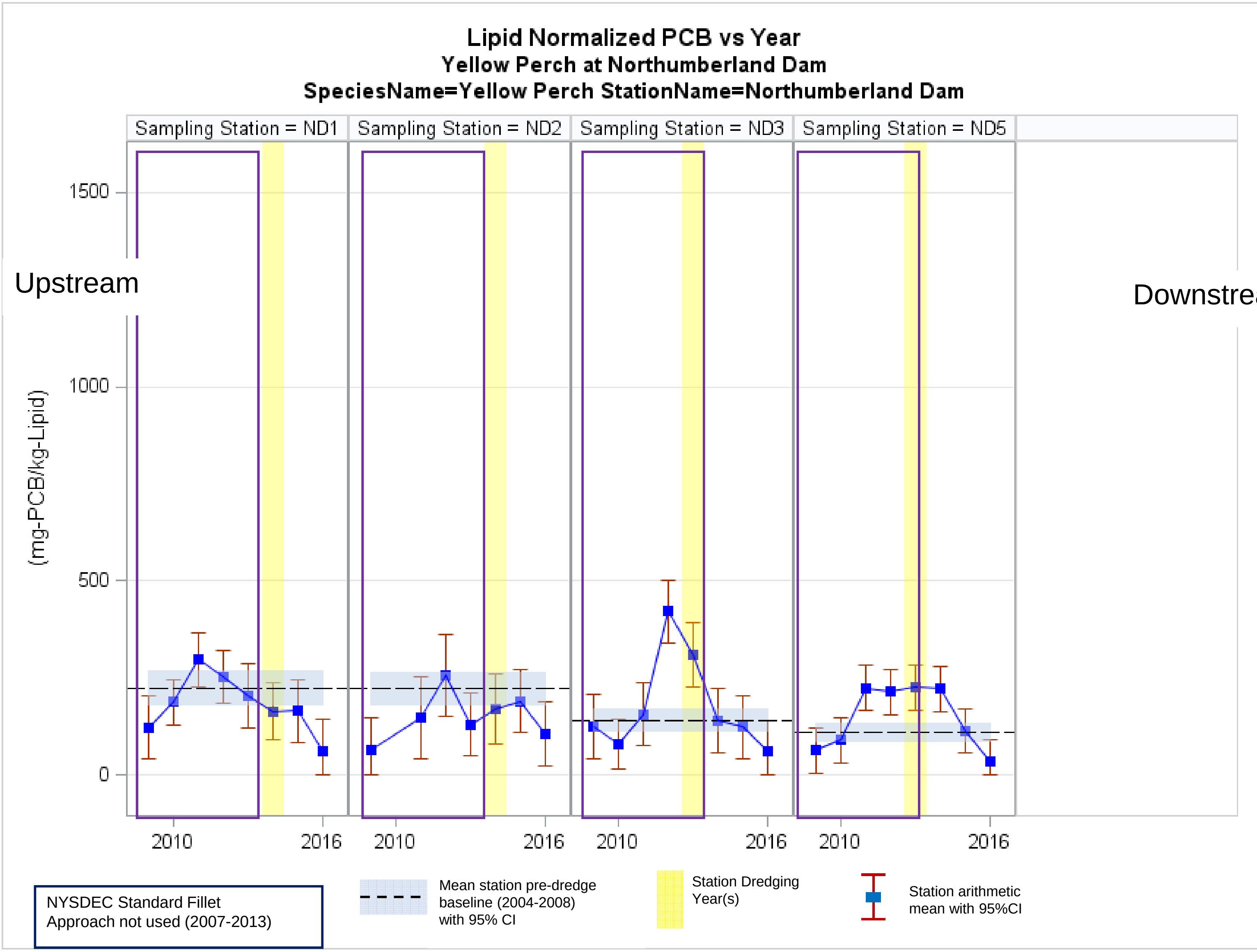
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.6

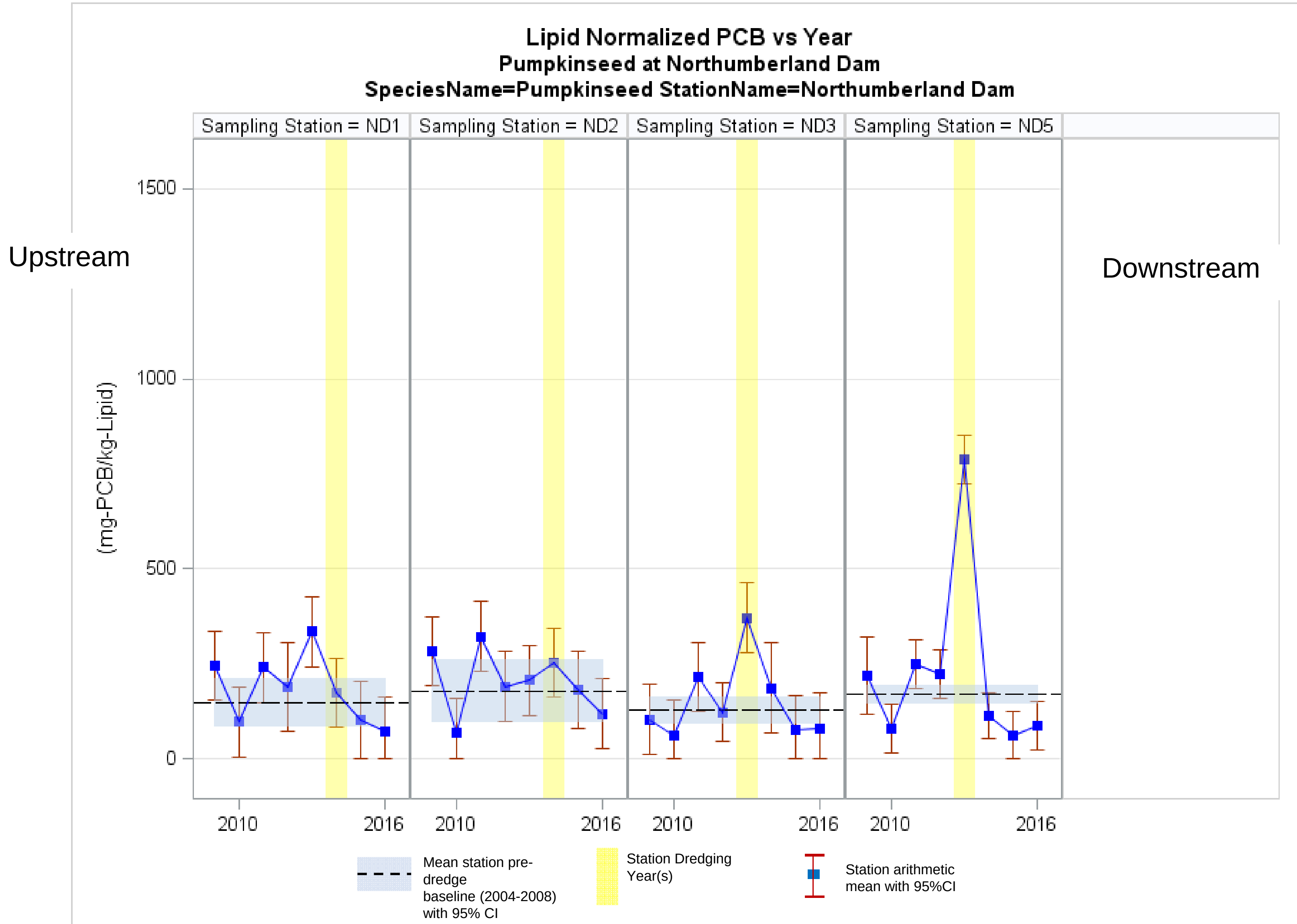
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.7

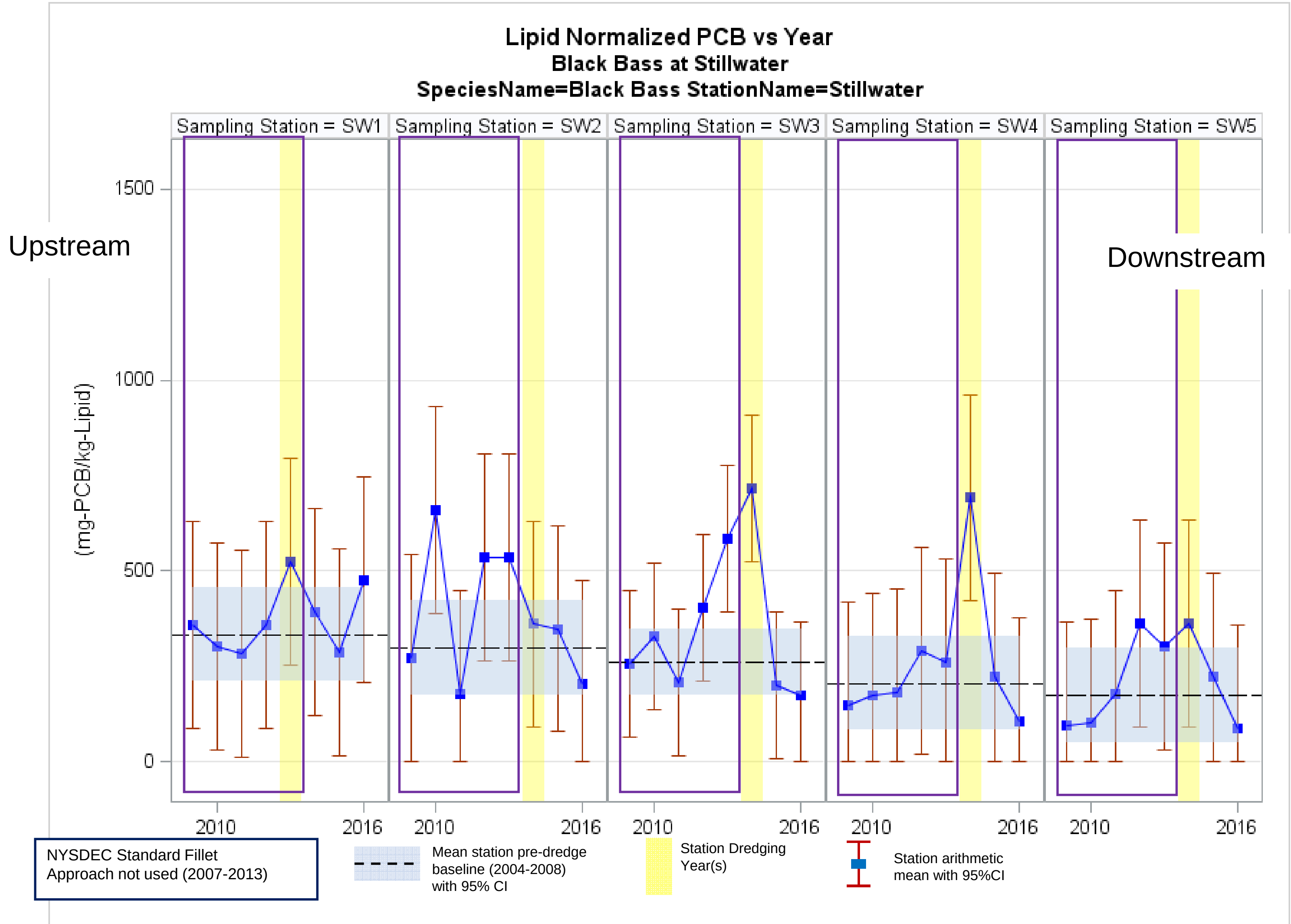
May 2017



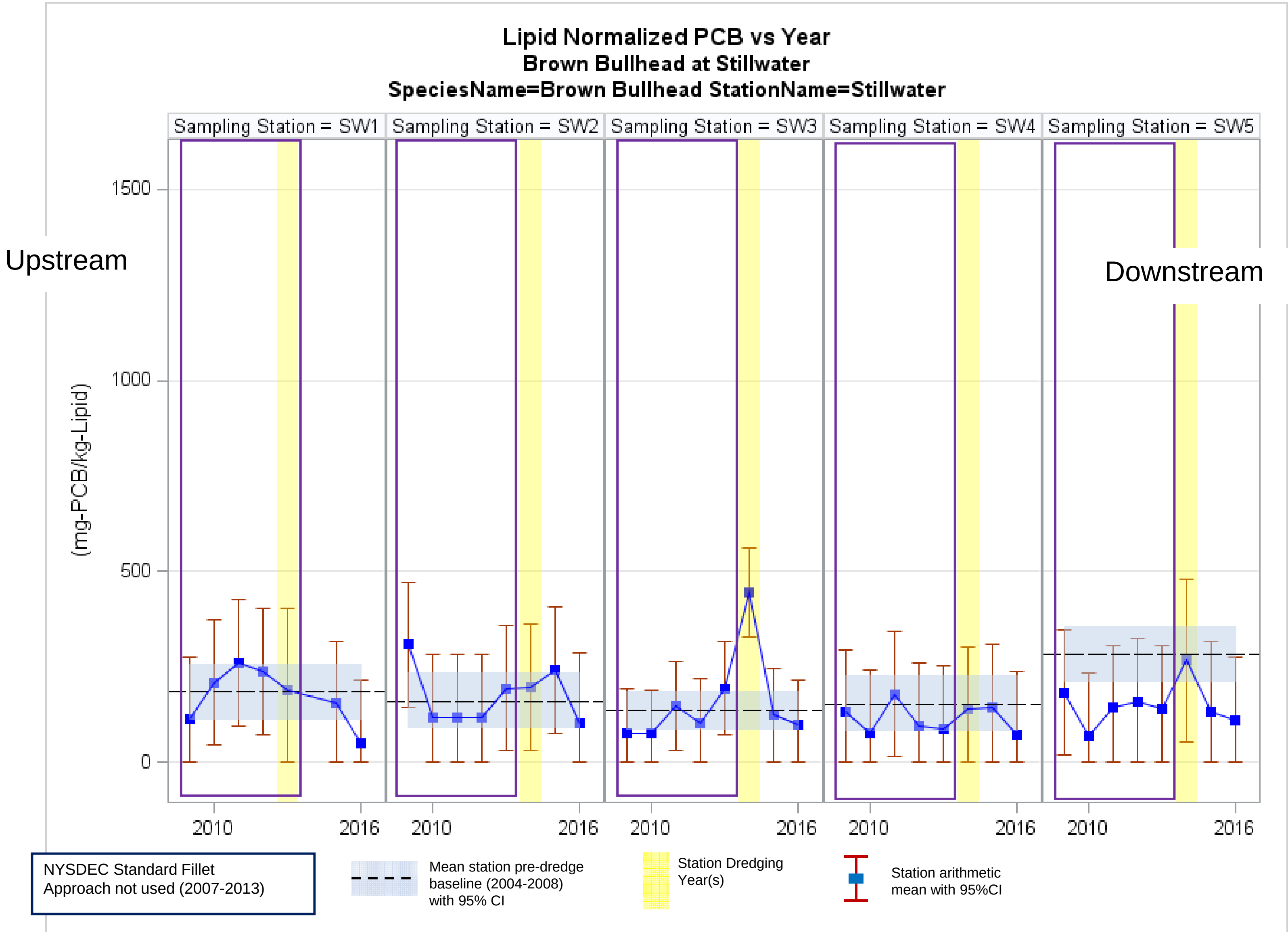
Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.8

May 2017



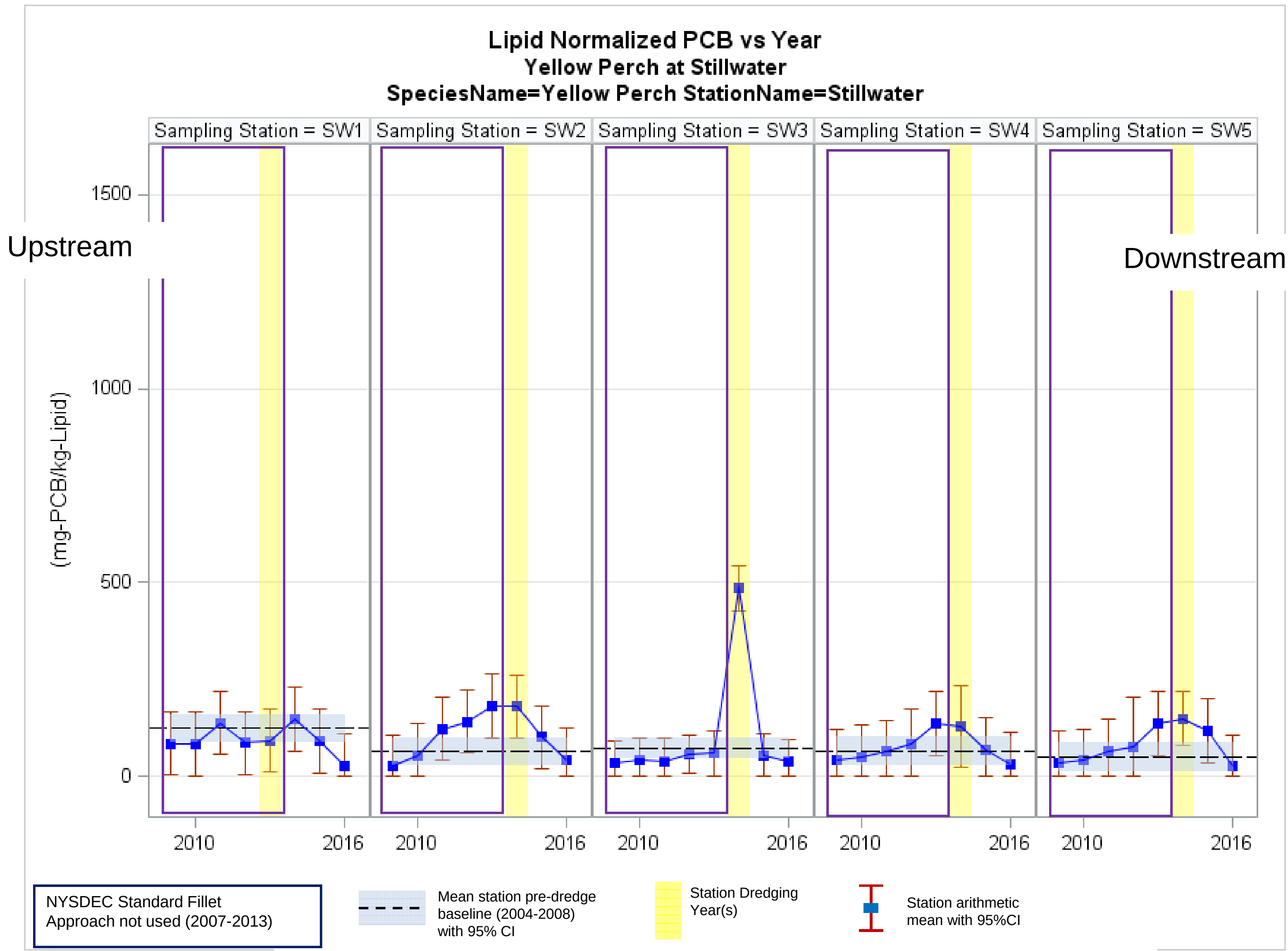
	Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016	Figure A8-4.9
		May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.10

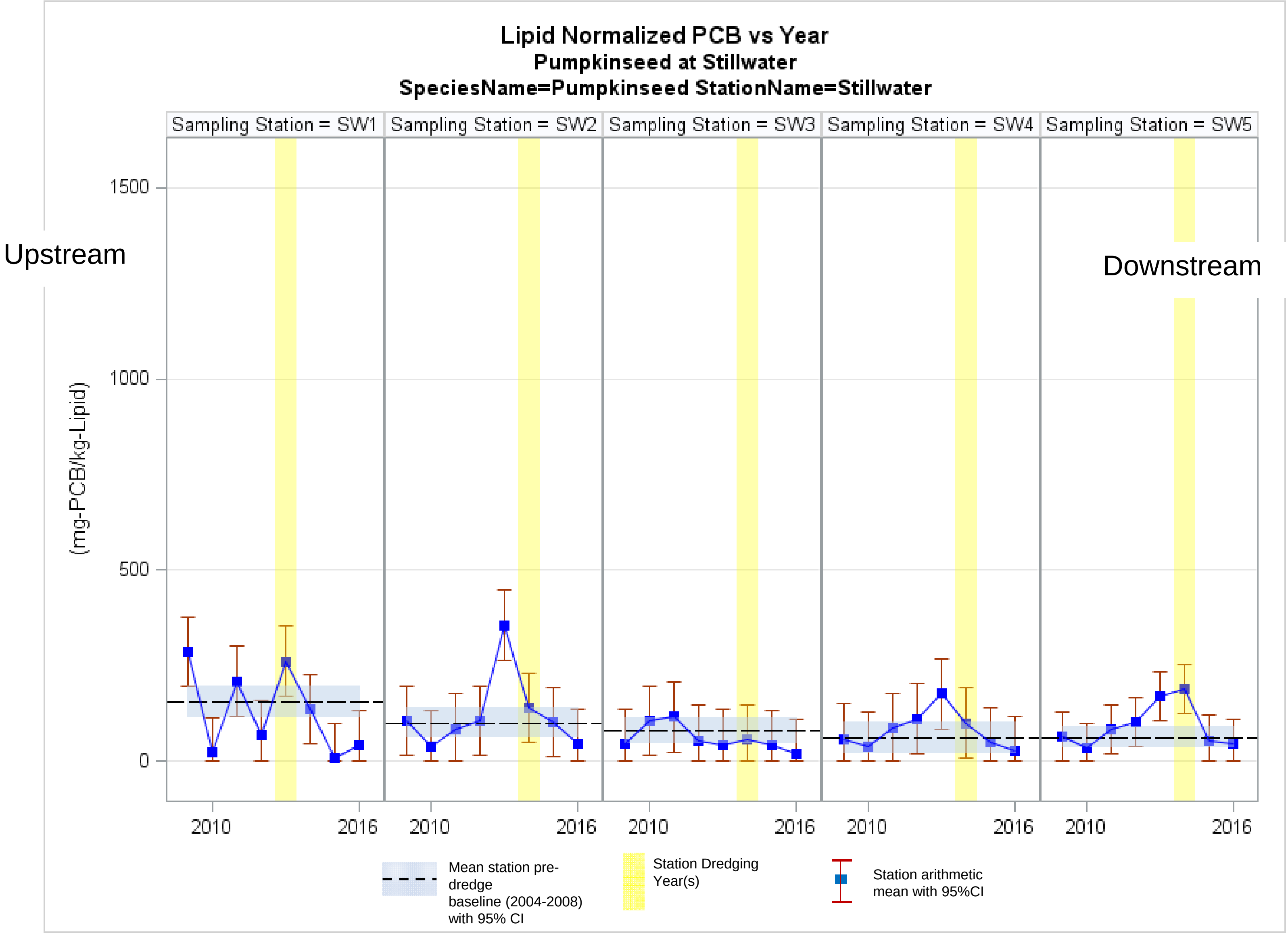
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.11

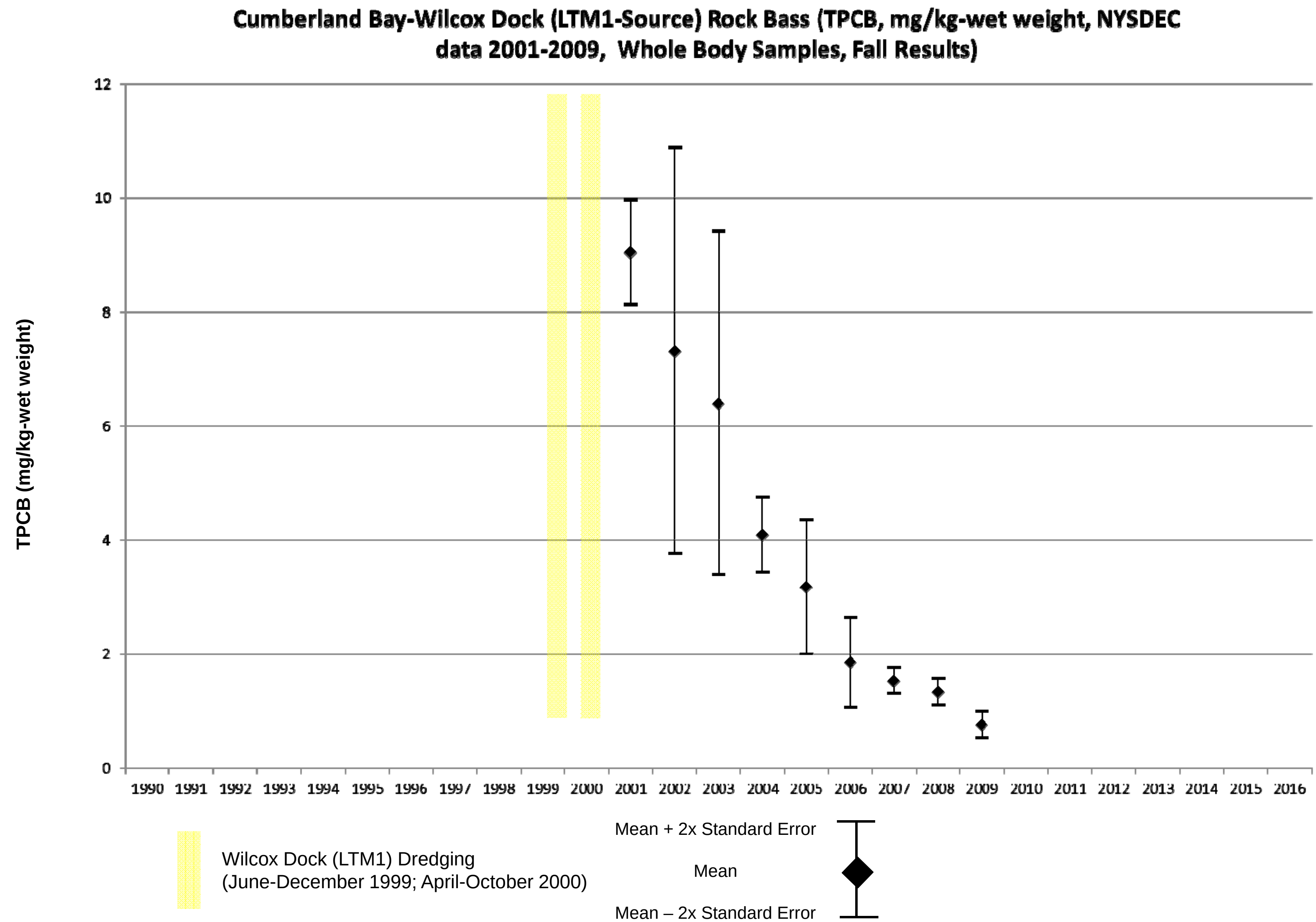
May 2017



Lipid Normalized PCB vs Year - RAMP Species Weighted Average Fish Tissue Concentrations Relative to Baseline 2009-2016

Figure A8-4.12

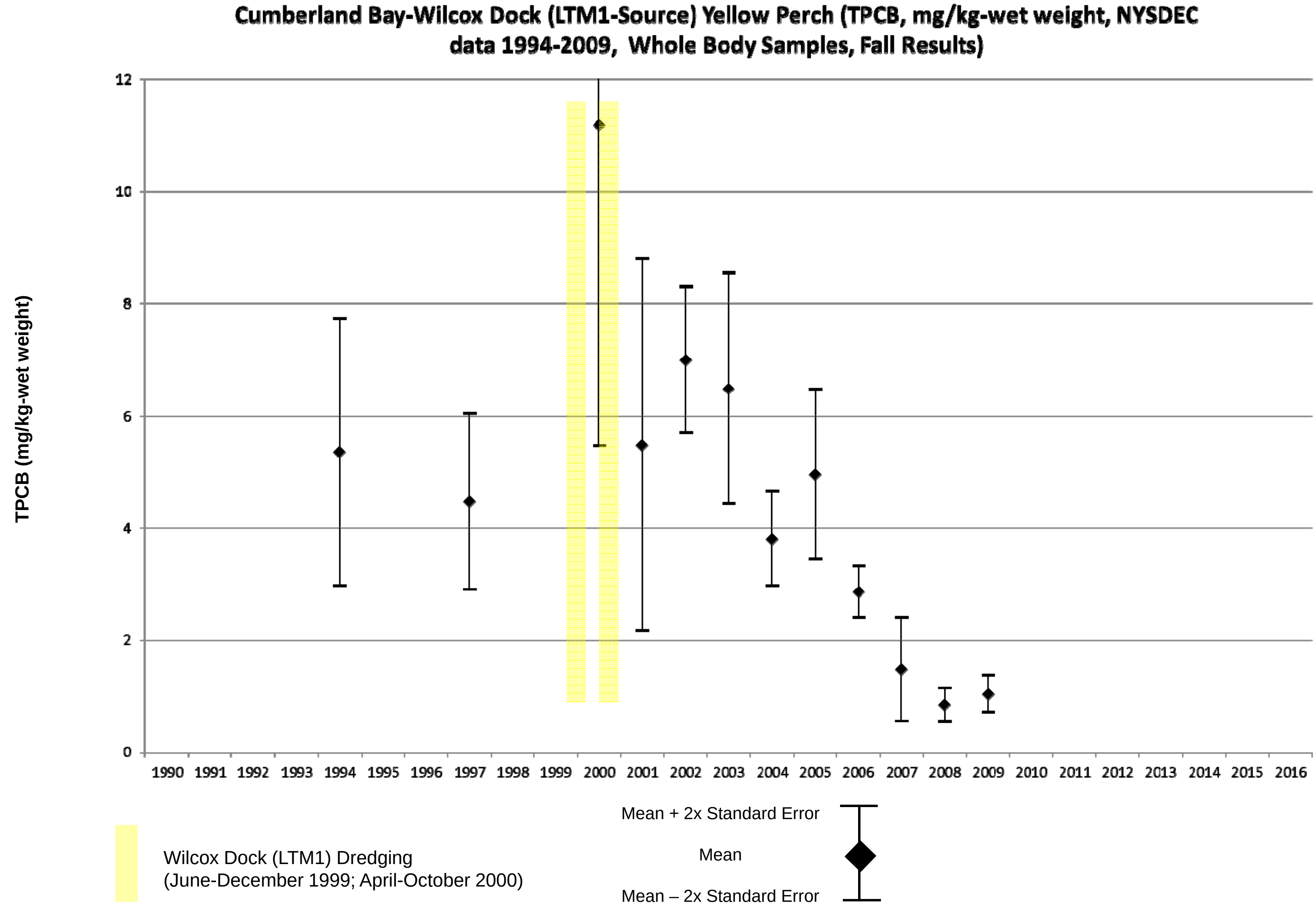
May 2017



Cumberland Bay (Lake Champlain, NY) Post-Remediation Fish Tissue PCB Concentration Trends

Figure A8-5.1

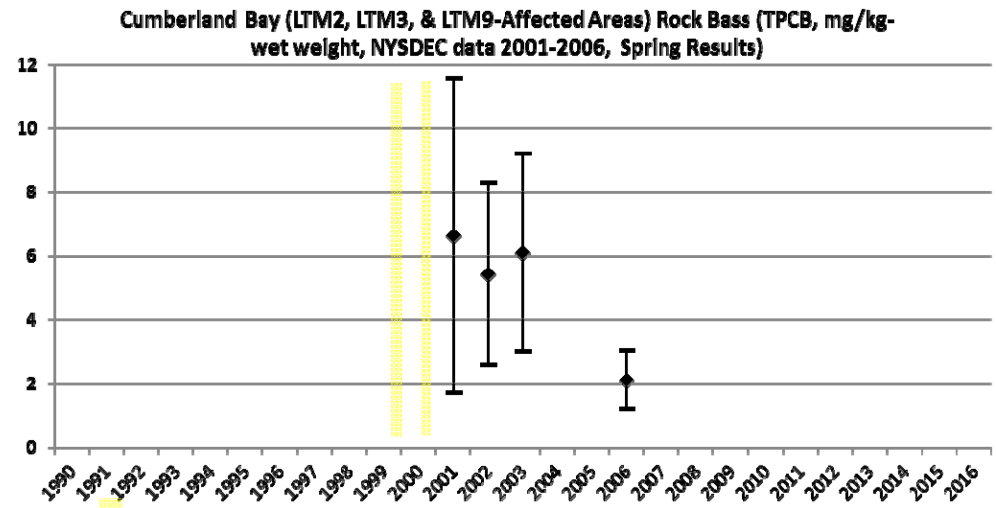
May 2017



Cumberland Bay (Lake Champlain, NY) Post-Remediation Fish Tissue PCB Concentration Trends

Figure A8-5.2

May 2017

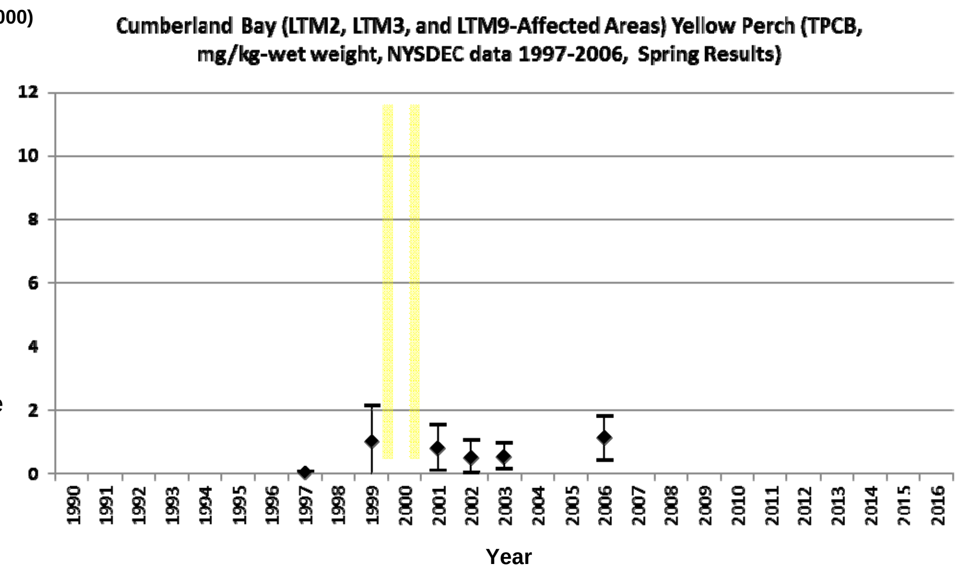


Rock Bass:
Spring data are not as consistent over time as Fall data but Spring Rock Bass tissue levels are consistent with Fall tissue levels for the years in which both seasons were collected (2001-2003 and 2006).

Dredging (June-December 1999; April-October 2000)

Mean + 2x Standard Error
Mean
Mean – 2x Standard Error

Yellow Perch:
Spring data are not as consistent over time as Fall data and Spring YP tissue levels are consistently lower with than Fall tissue levels for the years in which both seasons were collected (1997, 2001-2003 and 2006). Note that spring is YP spawning season and LTM1 is a major YP spawning area. Thus it's possible that the fish collected at these stations may have included fish from other parts of the lake.



Cumberland Bay (Lake Champlain NY) Post-Remediation Fish Tissue PCB Concentration Trends

Figure A8-5.3

May 2017