# Second Five-Year Review Report
# Hudson River PCBs Superfund Site

## APPENDIX 2

## MASS REDUCTION EVALUATION

Prepared by:

Louis Berger US, Inc.

LimnoTech, Inc.

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**SECOND FIVE-YEAR REVIEW REPORT**
**HUDSON RIVER PCBs SUPERFUND SITE**

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# 1 BACKGROUND

The remedy selected for the Upper Hudson River PCBs Superfund Site required development of enforceable Performance Standards, with multiple interrelated objectives: to ensure that the clean-up would meet human health and environmental protection objectives, including reduction of Site risk and downstream transport of PCBs, and also to satisfy criteria for dredging productivity. An independent peer review panel reviewed Phase 1 performance relative to the Engineering Performance Standards (EPS) that governed that first year of dredging, and made recommendations that resulted in a revised 2010 Engineering Performance Standards (EPS) for Phase 2 (EPA, 2010a; EPA, 2010b). The 2010 Engineering Performance Standards presented performance standards for dredging residuals, resuspension and productivity that embodied specific requirements for Phase 2 dredging activities. An important component of the 2010 EPS was the accurate determination of the volume of sediment dredged and the mass of PCBs removed, and these two metrics provided a link among all three standards. The 2010 Productivity Standard specified the minimum volumes of sediment that were expected to be dredged during each year of Phase 2. The Resuspension Standard contained specific PCB load thresholds, as measured at the Waterford far-field station, limiting resuspension to a percentage of the mass of PCBs removed. Thus, accurate determination of the volume and mass of PCBs removed during Phase 2 was an important component of determining whether Phase 2 dredging activities were in overall compliance with the 2010 Productivity and Resuspension Standards. The Residuals Standard contained directives that affected the volume of sediment dredged (*e.g.*, limiting the number of dredging passes) and how dredged areas were to be closed out (*i.e.*, requiring cover with clean backfill material or an engineered cap), to limit post-dredge exposure and resuspension of residuals.

The Residuals Standard presented in the 2010 EPS was designed to detect and manage contaminated sediment that might remain after the initial dredging of a ‘Certification Unit’ (CU) and to confirm that the depth of contamination was accurately identified. The standard incorporated “lessons learned” from dredging that occurred in 2009 as part of Phase 1 dredging (EPA, 2010b). In particular, the peer review of Phase 1 dredging activities concluded that the full depth of PCB contamination in sediments dredged during Phase 1 was not accurately defined prior to commencement of Phase 1 dredging, resulting in PCB mass left behind. The incomplete characterization of the vertical extent of PCB contamination for the original dredging design became apparent during Phase 1 dredging in 2009, when as many as five dredging passes were required to remove PCB-contaminated sediment within a single CU. The recognition that existing core data were inadequate to properly delineate the vertical extent of PCB contamination was an important factor driving modifications incorporated in the Phase 2 Residuals Standard. As a result of the finding of the peer review panel, GE was instructed to conduct the Supplemental Engineering Data Collection (SEDC) program, which collected additional sediment cores in Phase 2 CUs prior to dredging in order to more accurately define the elevation of the bottom of contamination (General Electric 2011). Similarly, GE was required to dredge six inches below the design depth of contamination (DoC) elevation and collect sediment cores (hereinafter referred to as Residuals Cores) after each dredging pass to verify whether additional PCB-containing sediment remained below the design DoC elevation. Based on the PCB concentration of sediments below the dredged surface, the Residuals Standard provided specific directives on whether additional dredging passes would be required or whether the dredged area could be closed out with clean backfill or an engineered cap. The maximum area allowed to be capped was also outlined in the Residuals Standard using a nodal capping index. Additional details regarding the nodal capping index can be found in the 2010 EPS (EPA, 2010b). GE was also required to carry out bathymetric surveys after each dredging pass to confirm the volume of sediment dredged, confirm that the design DoC was reached in 95 percent of the dredging area, and to verify that the rate of removal of sediment volume was in compliance with the Productivity Standard.

The sediment and bathymetric data collected during implementation of Phase 2 Residuals provided a means to assess whether Phase 2 dredging was in compliance with the Residuals Standard; these data also allow verification of estimates of dredging volume and PCB mass present in the CUs as estimated in the 2002 ROD (EPA, 2002), as well as values reported by GE during Phase 2 dredging activities. Finally, these data can also facilitate estimates of the PCB mass that remains within the CUs now that Phase 2 dredging has been completed.

Volumes of sediment and mass of PCBs removed were estimated from predesign and post-dredged core data, as well as pre- and post-dredge bathymetry. Volume removed in each year of Phase 2 was found to be in compliance with the Productivity Standard. Total sediment volume and masses of Total PCB (TPCB[1]) and Tri+ PCB[2] removed in Phases 1 and 2 were found to be much greater than anticipated at the outset of the remedy, due to prior underestimates of depth of contamination that were corrected by coring that GE performed in 2010-2012 to support Phase 2 remedial design. The estimated masses of PCBs removed were also used to help assess compliance with the Resuspension Standard, which limited downstream transport to a percentage of dredged PCBs. Estimates of capped and backfill-covered areas demonstrate compliance with limits set in the Residuals Standard, and the estimated PCB mass left in place in capped or backfill-covered areas is small relative to the mass removed by dredging.

[1] 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.

[2] 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 PRODUCTIVITY AND RESIDUAL STANDARDS FOR PHASE 2 DREDGING

Full details of the Phase 2 EPS Productivity Standard can be found in the 2010 EPS (EPA, 2010b). Briefly, the Productivity Standard set goals for the volume of sediment to be dredged each year. While subordinate to the Residuals and Resuspension Standards, the Productivity Standard was implemented to monitor dredging progress and encourage a pace of work intended to control sediment resuspension from newly dredged surfaces. The 2010 Productivity Standard recognized that the estimates of anticipated total volume of sediments to be dredged were uncertain, and therefore set the yearly dredging productivity goal at 350,000 cubic yards/year based on actual productivity results from the Phase 1 dredging activities in 2009, as recommended by the peer review panel in 2010 (EPA, 2010a). The updated productivity goal of 350,000 cubic yards/year was above the original productivity goal of 319,000 cubic yards/year, as presented in the 2009 Phase 1 Performance Standards Compliance Plan (General Electric 2009).

As described above, the Residuals Standard provided specific directives and decision logic on whether additional dredging passes would be required to reduce sediment PCB concentration or whether the dredged area could be closed out by either covering the dredged surface with clean backfill or an engineered cap. Each dredging area was referred to as a certification unit (CU), and each CU was divided into nodal areas, based on the location of the Residuals Cores (the “nodes”) collected after each dredging pass. Residuals Cores encompassed sediment samples to 48 or 96 inches (depending on depth of contamination) or bedrock, whichever was encountered first. The cores were segmented into 6-inch lengths and a subset of the segments was analyzed for PCB Aroclors using Method 8082. Method 8082 was demonstrated to be equivalent to the sum of PCB congeners based on the results of performance evaluation samples, and Tri+ PCB (sum of detected PCBs in the tri-homologue and higher groups) concentrations were calculated from measurements of PCB Aroclors and a site-specific regression equation relating PCB Aroclor to Tri+ PCB (Appendix 5, Section 2.2.4).

Whether a nodal area needed to be redredged depended on the detected TPCB and Tri+ PCB concentrations in the Residuals Core samples from that node. With few exceptions, if a Residuals Core contained $\geq$ 6 mg/kg Tri+ PCB in any 6-inch segment below the surface core segment, or the surface core segment had a Tri+ PCB concentration $\geq$ 27 mg/kg, or any segment had a TPCB concentration > 500 mg/kg, the associated nodal area was required to be re-dredged. In addition, nodal areas that yielded Residuals Cores that did not meet the above criteria but caused the average surface concentration within the CU to be greater than 1 mg/kg Tri+ PCB were required to be either re-dredged or covered with an engineered cap, in order to achieve an average surface concentration within the CU of 1 mg/kg Tri+ PCB or less. The remaining nodal areas containing cores that did not meet the above criteria were deemed compliant and were covered with clean backfill material. If a nodal area was re-dredged, the associated node was re-occupied and a new Residuals Core collected, and the above steps were repeated in order to determine whether the nodal area was in compliance.

The total amount of capping was limited by additional provisions in the Residuals Standard, formulated with the intention that the mass of PCBs left in place within the CU be minimized such that 96-98 percent of PCB mass would be removed from the CU areas (EPA, 2002). Compliance with the Phase 2 Residuals Standard required that no more than 11 percent of the total dredged area be capped, and no more than 3 percent of the total area be capped with inventory present, as calculated using the nodal capping index. Inventory is defined as nodes containing sediment below the 6-inch surface core segment that contains Tri+ PCB concentrations equal to or greater than 6 mg/kg. The nodal capping index (NCI) was developed to facilitate timely tracking of the approximate extent of capping and backfilling within dredged areas on an area-weighted basis. The NCI acted as a surrogate for the exact extent of capping and backfilling. Briefly, each node was categorized according to sediment texture, location within the river bottom (*i.e.*, shoreline, bedrock, glacial clay) and whether the node was capped or backfilled. Based on this classification, the NCI calculated the total area capped within each CU, and formed the measurement basis for compliance with the capping criterion of the Residuals Standard.

Full details regarding the classification scheme and equations involved in the NCI are presented in the 2010 EPS (EPA, 2010b).

# 3 METHODS

## 3.1 Determination of Volume of Sediment Removed and Mass of PCBs in Sediment Removed

In order to calculate the sediment volume and PCB mass removed as a result of dredging activities during Phase 2, chemistry and bulk density data from the remedial design sediment sampling and analysis program (SSAP) (General Electric 2002), the SEDC program described above, and Phase 2 residuals cores were utilized, along with bathymetry data collected prior to and after each dredging pass. The methods employed are based on the equations and methodologies presented in the 2010 EPS. Briefly, differencing of bathymetric data collected after each dredging pass was used to calculate the total volume of sediment removed. In order to estimate the mass of PCBs removed, both the dry bulk density and PCB concentration within the dredge volume were determined using the following steps:

1) Because no dry bulk density data were available for the Residuals Cores collected during Phase 2, dry bulk density values measured on SSAP core segments were utilized. For each dredging pass, the subset of SSAP cores that fell within the dredging pass area were identified. The mean dry bulk density of this subset of SSAP cores was used as the dry bulk density value for the entire dredging pass volume. It is recognized that in certain instances, the depth of the dredge cut exceeded the depth of the SSAP cores that fell within the boundary of the dredging pass. However, the SSAP cores still provide the best available estimate of dry bulk density for the dredge volume and were included in the calculations presented here.
2) PCB concentrations (both TPCB and Tri+ PCB) were available for both the SSAP cores and the Residuals Cores. In the case of the first dredging pass, the SSAP core segments that fell within the dredging volume were used. For subsequent dredging passes, Residuals Core segments that fell within the dredging volume were used to calculate a PCB concentration. By differencing the bathymetry after each dredging pass, the depth of dredging at each Residuals Core can be obtained, and only the core segments that fell within the dredging depth interval were included in the mass

calculation, thereby avoiding including PCB mass that was outside the dredged volume and double counting PCB mass.

Once the appropriate core segments were identified, the length of the segments (corrected for recovery), the PCB concentration (both TPCB and Tri+ PCB), and the dry bulk density were used to calculate a length-weighted PCB mass per unit volume (denoted as *m*) for each dredging pass using the following equation:

$$m_i = \frac{B_i \sum_{j=1}^{n_i} L_{ij} C_{ij}}{\sum_{j=1}^{n_i} L_{ij}} \qquad (1)$$

where $i$ is an individual core, $j$ is a core segment within core $i$, $n_i$ is the number of core segments within core $i$, $L_{ij}$ is the length of the core segment (corrected for recovery), $C_{ij}$ is the concentration (TPCB or Tri+ PCB) for the core segment, and $B_i$ is the bulk density of the core (note in the calculation presented here, all cores within the dredge volume are assumed to have the same dry bulk density).

The length of each core section is corrected for less than 100 percent core recovery by dividing the measured length by the fraction of sediment recovered. The core correction compensates for loss of recovery which results in under-sampling of some sediment strata during the core collection process. Once the PCB mass per unit volume (*m*) has been calculated for all cores located within the dredge volume, a length-weighted average mass per unit volume (*MPUV*) can be calculated as:

$$\overline{MPUV} = \frac{\sum_{i=1}^{n} L_i m_i}{\sum_{i=1}^{n} L_i} \qquad (2)$$

where *Li* represents total length of core segments within core *i* (corrected for recovery). The $\overline{MPUV}$ for each dredging pass is multiplied by the associated dredging pass volume (*V*) to determine the mass of PCBs (TPCB or Tri+ PCBs) dredged (*M*) per dredging pass, per CU, during Phase 2:

$$M = V \times \overline{MPUV} \qquad (3)$$

It should be noted that the above calculations of mass removed include the surface core segment (0-6”) of the residual cores. It may be expected that during dredging, some of the dredged sediment will escape the dredge bucket and resettle on the river bottom. As such, PCB mass in the surface core segment of the residual cores may represent a mixture of *in-situ* PCB contamination and PCB mass from overlying, dredged sediment. As it is not possible to determine with certainty the fraction of these two PCB sources in the surface core segment, the surface core segment was included in calculations and, therefore, the TPCB and Tri+ PCB mass removed values likely represent upper bounds on the mass removed.

Dredging activities conducted within CUs include dredging that targeting removal of PCB contaminated sediment, dredging for navigation purposes, and daylight dredging (dredging conducted to prevent collapse of dredge area walls during dredging and backfill activities). Outside of CUs, navigational dredging and access dredging (dredging for the purpose of allowing barge and boat traffic to reach dredge areas) was also performed. While mass and volume of dredging activities outside CUs were not included in the volume and mass estimates presented below, they do constitute additional removal of river sediment and PCB mass. Estimates of mass removed during navigational and access dredging is discussed in Section 4.1 and in Table A2-5.

### 3.2 Determination of Mass of PCBs in Sediment Remaining in Certification Units After Dredging

In order to estimate the mass of PCBs (both TPCB and Tri+ PCB) remaining within each CU after dredging activities were completed, similar methods and equations to those described above were utilized with slight modification, because the volume ($V$) in equation (3) is unknown. To estimate volume, we can express V as:

$$V = A \times \bar{L} \qquad (4)$$

where $\bar{L}$ represents the average length of core (corrected for recovery) within a particular CU and $A$ represents the area of the CU.

We can also re-express the $\overline{MPUV}$ as:

$$\overline{MPUV} = \frac{\sum_{i=1}^{n} L_i m_i}{\sum_{i=1}^{n} L_i} = \frac{\sum_{i=1}^{n} L_i m_i / n}{\sum_{i=1}^{n} L_i / n} = \frac{\overline{MPA}}{\bar{L}} \qquad (5)$$

where $\overline{MPA}$ is the average PCB (TPCB or Tri+ PCB) mass per area.

Combining equations (3), (4) and (5), the mass remaining after dredging (*M*) can be expressed as:

$$M = A \times \overline{MPA} \qquad (6)$$

Because the mass remaining after dredging is calculated for the entire CU, $B_i$ in equation (1) is calculated as the mean dry bulk density for all SSAP core segments collected within the CU. $C_{ij}$ and $L_{ij}$ were based on the Residuals Cores that were collected following the final dredging pass over the nodal areas of influence within the CU. In this way, $C_{ij}$ and $L_{ij}$ represent direct sampling of sediment that was left in place and subsequently covered with backfill or an engineered cap. The above calculations were carried out for each CU dredged in Phase 2.

### 3.3 Determination of Dredged Area Capped Using the Nodal Capping Index (NCI)

The post-dredging surfaces were first categorized as to their level of compliance with the Standard and then as to the areas of the river in which they fell. The level of compliance is defined by the categories below:

A. Inventory capped in place (*i.e.*, the node contained sediment below 6 inches containing Tri+ PCB concentrations equal to or greater than 6 mg/kg).
B. Elevated residuals capped (*i.e.*, the node caused the average surface concentration in the CU or sub-unit to exceed 1 mg/kg Tri+ PCB or had a surface concentration of 27 mg/kg Tri+ PCB or greater).

C. Compliant areas backfilled (*i.e.*, the node was part of a CU or sub-unit area whose average Tri+ PCB concentration was 1 mg/kg or less).

The following categories of river bottom areas were tracked as part of the standard. Note that the first three categories represent specific geographic settings, whereas the latter three represent river bottom types:

1) Structural offsets;
2) Cultural resource areas;
3) Shoreline areas;
4) Exposed bedrock areas;
5) Exposed glacial Lake Albany clay areas; and
6) River bottom not falling into any of the above categories, typically silt, sand, and gravel areas.

The extent of capping in a single CU for use in calculating the Nodal Capping Index is defined as follows:

$$A_{capped} = A_{CU} \times \left[ \frac{\Sigma\left(N_{field\ capped}\right)}{\Sigma\left(N_{field}\right) + \frac{1}{2}\Sigma\left(N_{shoreline}\right)} \right] \qquad (7)$$

where $A_{capped}$ is the area capped within the CU, as determined by the nodal capping index, $A_{CU}$ is the total area of the CU, $N_{field\ capped}$ is the number of nodes within the CU that were capped and in category 6 above and in compliance categories A or B, $N_{field}$ is the total number of nodes within the CU that are not specifically identified as boundary nodes (river bottom categories 1 and 2) or shoreline nodes, including all nodes from categories 4, 5 and 6, irrespective of their compliance category. Finally, $N_{shoreline}$ is the sum of nodes in the shoreline area of a CU; this includes all shoreline nodes irrespective of their compliance category.

Once $A_{capped}$ is determined for all CUs, the total percentage of area capped, based on the NCI, is calculated as:

$$Nodal\ Capping\ Index\ (NCI) = \frac{\sum A_{capped}}{\sum A_{CU}} \times 100 \qquad (8)$$

The NCI formed the measurement basis for compliance with the capping criteria of the Residuals Standard.

# 4 RESULTS AND DISCUSSION

## 4.1 Volume of Sediment Removed and Mass of PCBs in Sediment Removed

Results of EPA's calculation of volume of sediment removed and mass of PCBs in sediment removed on a CU-by-CU basis are presented in Tables A2-1a-b, and A2-2a-d. The results indicate that 2,374,000 cubic yards of sediment were removed from within CUs in the Upper Hudson River during Phase 2, which facilitated the removal of 135,700 kg of TPCB and 43,100 kg of Tri+ PCB. Using values of volume and mass of TPCB and Tri+ PCB removed during Phase 1 dredging (267,900 cubic yards, 20,020 kg and 5,460 kg for volume dredged, TPCB mass removed and Tri+ PCB mass removed, respectively) from the 2010 Phase 1 Evaluation Report (EPA, 2010b), the totals removed during both Phases 1 and 2 were 2,641,900 cubic yards of sediment, 155,800 kg of TPCB and 48,600 kg of Tri+ PCB. On a yearly basis (Tables A2-2a and A2-2b), 2012 had the highest total with respect to volume dredged, while 2015 had the lowest dredging total. Note that some CUs were dredged over 2 consecutive years. In these situations, in order to present annual values, CUs dredged over multiple years were included in the year in which the CU was first dredged. As a result of this grouping, annual values presented in Tables A2-2a and A2-2b may differ from the values presented in Annual Reports provided by GE during Phase 2 dredging activities. Total volume removed (summed over all Phase 2 years) calculated for this analysis was within 5 percent of values calculated by GE during Phase 2 activities, and TPCB and Tri+ PCB masses removed calculated for this analysis were within 6 percent of values calculated by GE during Phase 2 dredging activities. Estimates of volume dredged and PCB mass removed relies not only on accurate measurements of volume and area dredged, but also extrapolating the concentration of TPCB and Tri+ PCB measured in cores (*i.e.*, point estimates) to concentrations over relatively large areas and volumes (*i.e.*, areal and volume estimates). Further, bulk density was not directly measured on residual cores collected during dredging activities, and assumptions were required regarding estimation of the bulk density of sediments dredged. Therefore, differences between values calculated by GE and EPA are likely related to small differences in calculation of area and volume dredged on a CU by CU basis, estimates of MPUV and MPA using SSAP and residual core data on a CU by CU basis, and estimation of bulk density values for the residual cores where no bulk density was directly measured. EPA's and GE's values for volume of sediment and PCB mass removed should be considered as best estimates of the actual volume and mass removed given the data available, and the observation that both values agree well provides confidence that these values reflect the true volume and mass removed.

A comparison of the volume and mass of sediment removed during each dredging pass of Phase 2 indicates that 75 percent of the total PCB mass and 80 percent of the total sediment volume were removed during the first dredging pass. Based on the Residuals Cores collected after the first pass, 88 out of the 91 CUs dredged in Phase 2 required a second pass. 24 percent of the total PCB mass and 19 percent of the total sediment volume were removed during the second pass. 20 CUs required a third pass, with 1 percent of the total PCB mass and 1 percent of the total volume of sediment removed during the third pass. On an individual CU basis, the first dredging pass removed between 23 and 100 percent of the total PCBs dredged within a respective CU, while the second dredging pass removed between 2 and 73 percent of total PCB mass within a CU and the third dredging pass removed between 0 and 10 percent of total PCB mass within a CU. Further, we identified three CUs (CU-16, CU-26, and CU-97) that had more PCB mass removed during the second pass than during the first pass.

Compared to the 2010 Productivity Standard's target volumes, Phase 2 dredging years 2011 through 2014 met or exceeded the volume of sediment to be dredged. For the years 2012 to 2014, dredging volumes were approximately 100, 155, 180, and 175 percent, respectively, of the stated goal of 350,000 cubic yards each year. In 2015, only 237,000 cubic yards of sediment were dredged, which represented the volume in CUs remaining to be dredged in the final year.

To put these results into context, the actual volume of sediment and mass of PCBs dredged in Phases 1 and 2 were compared with the estimated volume of sediment and mass of PCBs to be removed, as presented in the 2002 ROD and the 2007 Phase 2 Dredge Area Delineation (DAD) Report (2002, EPA; General Electric 2007). Table A2-3 presents estimates of the mass of TPCB and Tri+ PCB to be removed from the Upper Hudson River during Phase 1 and 2 dredging activities. Using values calculated in this report, along with values presented in the Phase 1 Evaluation Report (EPA, 2010c), the actual dredged volume was within 1 percent of the estimated 2,650,000 cubic yards presented in the 2002 ROD, and 47 percent more than the 1,800,000 cubic yards estimated in the 2007 DAD Report. With regard to the TPCB mass removed, actual TPCB mass removed was 123 percent more than the 69,800 kg estimated in the 2002 ROD and 38 percent more than the 113,100 kg estimated in the 2007 DAD report. While the 2007 Phase 2 DAD Report did not estimate a specific amount of Tri+ PCBs to be removed, the actual amount of Tri+ PCBs removed was 123 percent more than the 21,700 kg estimated in the 2002 ROD.

It should be noted that dredge volumes and mass presented above include dredging required to maintain a navigable channel within the dredging areas. Data provided by GE (Table A2-5) indicate that approximately 444,000 cubic yards were dredged inside CUs and 7,300 cubic yards were dredged outside CUs specifically for navigation channel access. Dredging resulted in the removal of 18,900 kg of TPCB and 6,400 kg of Tri+ PCB mass from the navigation channel within certification units. Further, additional dredging took place in the Upper Hudson River that was not included in the above volume and mass estimates. In particular, access dredging was conducted to allow access for barges and other dredge-related ship traffic to reach CUs, and daylight dredging was conducted where dredging depths were such that additional dredging was required within and along the border of CUs to prevent the collapse of dredge walls prior to the placement of clean backfill or cap material. While exact values for the volume and mass removed as a result of access and daylight dredging were not tracked during Phase 2 dredging, GE estimates that approximately 4,000 cubic yards of sediment were removed for these purposes, and represents additional volume and PCB mass removed beyond the values calculated above.

It follows from this analysis that the estimates in the 2002 ROD and 2007 Phase 2 DAD Report of the *in-situ* mass of PCB-contaminated sediments in the Upper Hudson River were underestimates. The mass removed values for both TPCB and Tri+ PCB calculated by EPA were within 6 percent of the values calculated by GE during Phase 2 dredging.

While some differences between EPA's and GE's estimates are expected, both values exceeded mass removal objectives laid out in the 2002 ROD. Similarly, the close agreement between EPA's and GE's estimates for volume of sediment and PCB mass removed (less than 6 percent difference) indicate that GE correctly implemented the metrics for determining compliance with the Phase 2 Productivity and Residuals Standards.

## 4.2 Proportion of Phase 2 Dredged Area Covered by Engineering Cap and Percentage of Dredged Area Capped with Inventory present

The total area within each CU covered by an engineered cap was determined using the NCI and compared with the actual area capped, based on analysis of EPA-approved capping design plans for each CU. The total area closed out with engineered caps using the NCI was 34 acres, and the total area closed out with engineered caps that contained undredged inventory (*i.e.*, the node contained sediment below 6 inches containing Tri+ PCB concentrations equal to or greater than 6 mg/kg) was 2.2 acres.

When compared with the compliance thresholds for percentage of dredge area capped and area capped with undredged inventory, the NCI-calculated area capped (which is the area used for determination of compliance) was 7.7 percent of the total area dredged in Phase 2 (442 acres), and the NCI-calculated area capped with inventory was 0.5 percent of the total area dredged in Phase 2. Both of these areas were below the compliance thresholds set out in the Residuals Standard (*i.e.*, 11 and 3 percent for total area capped and area capped with inventory, respectively). As noted in Section 2, the NCI acted as a surrogate for the exact extent of capping and backfilling. An important factor in the decision to use the NCI as a measure of dredged area capped was the need to expeditiously determine compliance with capping limitations in the Residuals Standard while active dredging was taking place to avoid delaying the closure of dredged areas and potentially increasing the amount of sediment resuspension. Additionally, in requiring the capped areas to extend out to surrounding compliant nodes, the approach was inherently conservative in capping the full extent of non-compliant sediment.

## 4.3 Mass of PCBs in Sediment Remaining in Certification Units After Dredging

Tables A2-4a and A2-4b present the mass of PCBs (both TPCB and Tri+ PCB) remaining in sediments within CU boundaries subsequently covered by engineered caps. Based on the data from the Residuals Cores, 3,900 kg of TPCB and 1,100 kg of Tri+ PCB remaining after dredging were subsequently covered by clean backfill or an engineered cap during the Phase 2 dredging years. This represents 2.9 and 2.7 percent of the TPCB and Tri+ PCB removed during Phase 2, respectively, which is within the Residuals Standard goal of removal of 96 to 98 percent of PCBs within the dredged areas.

Thus, the calculation of PCB mass remaining within the CUs indicates that the dredging activities were carried out in a manner that not only met the Productivity and Residuals Standards for Phase 2, but also removed 135,700 kg of TPCB mass within the targeted dredge areas, which equated to removal of approximately 97 percent of all PCB mass within the dredged areas.

## 4.4 Amount of TPCB Mass Removed from the Upper Hudson River

The 2002 ROD presented estimates of the percentage of total PCB mass that would be removed at the conclusion of dredging activities (EPA, 2002, Table 363334). Using sediment data from 1984, 1991 and 1994, the 2002 ROD estimated that 65 percent of TPCB mass would be removed from the Upper Hudson River. At the River Section scale, the 2002 ROD estimated that 80 percent, 86 percent, and 26 percent of TPCB mass will be removed from River Section 1, 2 and 3, respectively. In order to assess whether dredging activities met these estimates, the mass of TPCB outside CUs were estimated for each River Section using SSAP and SEDC cores collected outside dredge areas between 2004 and 2012, and combined with mass dredged inside CUs to estimate the total inventory of TPCBs in each river section. For River Sections 1 and 2, the framework presented in Section 3.2 was used to estimate the mass of TPCB outside CU areas and areas delineated as bedrock. In River Section 3, a strong bias existed in the location of SSAP and SEDC cores. For example, in River Section 3, gravel areas comprised 36 percent of the total un-dredged area (the largest sediment texture class present in un-dredged areas in River Section 3); however, only 3 percent of cores were collected in gravel areas. Recognizing this sampling bias, the estimate of TPCB mass outside CUs in River Section 3 was stratified based on side-scan sonar-derived sediment texture class collected by GE in 2002 and 2003 (General Electric 2003a, 2003b), such that the TPCB mass in each sediment texture class was calculated using the approach in Section 3.2, and then summed to get a total TPCB mass for River Section 3. It was noted that approximately 20 percent of the un-dredged area in River Section 3 was not classified with a side-scan sonar-derived sediment texture class. A review of cores from the unclassified areas, as well as a review of the location of the unclassified areas within River Section 3, indicate they were predominately comprised of gravel and bedrock substrate. Thus, two methods were used to estimate the TPCB mass in River Section 3: 1) assuming all unclassified areas were gravel, and the MPA for gravel areas in River Section 3 was applied to the unclassified area, and 2) assuming all unclassified areas were bedrock and the unclassified areas were excluded from the calculation. The first method represents an upper bound on the mass of TPCBs in River Section 3, while the second method represents a lower bound.

Tables A2-6a and A2-6b present the result of this analysis using both methods described above. The results indicate that 98 percent of TPCB mass was removed from River Section 1, 78 percent of TPCB mass was removed from River Section 2, and either 39 percent or 41 percent of TPCB mass was removed from River Section 3 (using methods 1 and 2 described above, respectively). Overall, the total TPCB mass removed in all three River Sections was 72 percent or 73 percent, using either method 1 or 2 described above, respectively. These results compare favorably with the estimates of percent of TPCB mass removed presented in the 2002 ROD. In River Section 1, ROD estimates were exceeded by 18 percent and in River section 3 ROD estimates were exceeded by 11 percent. Only in River Section 2 was the actual percentage removed (77 percent) below the ROD estimate (86 percent). Across all River Section in the Upper Hudson River, the total TPCB mass removed in the Upper Hudson River exceeded ROD estimates by 7 to 8 percent, depending on the method used. Further, more recent estimates of mass removed in River Section 1, as presented in the 2007 Phase 2 DAD (General Electric 2007) (98 percent of TPCB mass removed), agrees well with the our estimate, providing additional confidence in our values for River Section 1 (the 2007 Phase 2 DAD did not attempt to estimate total TPCB mass inventory in River Sections 2 and 3).

In terms of actual mass removed and mass remaining outside CUs, subsequent to the 2002 ROD, SSAP and SEDC core collection programs along with results from Phase 1 dredging in 2009 indicated that substantially more mass was present in the Upper Hudson River than originally anticipated. A comparison of 2002 ROD estimates of TPCB mass removed and mass outside CUs with the estimates of actual mass removed and mass outside CUs presented in this appendix indicates that the actual mass removed (155,800 kg) was 123 percent more than 69,800 kg estimated in the 2002 ROD (*i.e.*, the actual dredged mass was 2.23 times the 2002 ROD estimate), while the mass outside dredged area (60,500 or 56,400 kg using method 1 and 2 respectively) was only 61 or 50 percent more than the 37,500 kg of TPCB mass outside dredged areas as estimated in the 2002 ROD. The observation of a larger increase in mass inside dredged areas compared to outside dredged areas relative to 2002 ROD estimates is consistent with the observation that the highest concentrations of PCBs were found primarily in fine-grained sediment and areas with high organic content (including wood debris) that were specifically targeted for removal during dredging. The areas outside the dredged areas generally were observed to be more coarse-grained in nature. Therefore, the observation of a larger increase in mass inside dredged areas compared to outside dredged areas is not unexpected and indicates that dredging activities successfully targeted areas with the largest inventory of PCBs.

Overall, this analysis was carried out in order to assess the success of dredging activities relative to estimates set forth in 2002 ROD, and indicates that mass of PCBs removed exceeded estimates from the 2002 ROD and the largest increases in TPCB mass relative to 2002 ROD estimates was largely confined to the dredged areas. While our confidence in estimates of TPCB mass outside dredged areas is higher for River Sections 1 and 2 compared with River Section 3, there is no evidence to support the concept that because of the significant increase in mass within the CUs targeted for removal, there must be a significant mass left outside of the CUs. The fact that dredging removed twice the anticipated mass is unrelated to the observation of higher than anticipated surface concentrations. The higher than anticipated surface concentrations is related to shallower core results outside of targeted dredge areas. The concept regarding twice the anticipated mass removed is related primarily to PCBs found deeper in debris areas dredged.

### 4.5 Summary

The primary objective of these analyses was to determine whether Phase 2 dredging activities were in compliance with the Productivity and Residuals Standards presented in the Phase 2 EPS. The results indicate that dredging activities were in compliance with the Productivity Standards throughout Phase 2. Volumes dredged between 2011 and 2014 ranged from 100 to 175 percent of the stated annual Productivity Standard goal (350,000 cubic yards). In 2015, the last year of Phase 2 dredging, the remaining areas to be dredged contained less than the Productivity Standard goal of 350,000 cubic yards, and therefore, the total volume removed (237,000 cubic yards) was necessarily below the Productivity Standard. The total volume dredged calculated by EPA is within 5 percent of the values GE reported during Phase 2 dredging, providing confidence that the removal targets laid out in the Productivity Standards were achieved and Phase 2 dredging remained in compliance with the Productivity Standards throughout Phase 2.

Estimates of total mass removed during both Phase 1 and Phase 2 (154,600 kg of TPCB and 48,200 kg of Tri+ PCB) exceeded estimated amounts as reported in both the 2002 ROD and the 2007 Phase 2 DAD Report (General Electric 2007). This occurred because those earlier estimates were based on cores that did not fully characterize the vertical extent of contamination. Based on “lessons learned” from Phase 1 dredging, additional sediment sampling programs were carried out prior to Phase 2 dredging and revised standards were implemented for Phase 2.

Collection of additional cores in 2010 to better characterize the depth of contamination within the CUs, along with requiring GE to dredge six inches deeper than the identified depth of contamination, minimized the number of dredging passes required within each CU while still removing greater than 96 percent of PCB mass within the dredged areas. Additionally, the observation that approximately 25 percent of the total PCB mass was removed during the second dredging pass highlights the effectiveness of the Phase 2 Residual Cores in targeting additional inventory for removal. Phase 2 dredging successfully removed approximately 130,000 kg of PCB while conducting a maximum of three dredging passes in a given area, reducing the amount of dredging-related resuspension of sediment. The mass removed values for both TPCB and Tri+ PCB calculated by EPA were within 6 percent of the values calculated by GE during Phase 2 dredging. While some differences between EPA's and GE's estimates are expected, both values exceeded mass removal objectives laid out in the 2002 ROD.

# 5 CONCLUSIONS

Volumes of sediment and mass of PCBs removed were estimated from predesign and post-dredging core data, as well as pre- and post-dredge bathymetry. Volumes removed in each year of Phase 2 were found to be in compliance with the Productivity Standard. Total sediment volume and masses of TPCB and Tri+ PCB removed in Phases 1 and 2 were found to be much greater than anticipated at the outset of the remedy, due to prior underestimates of depth of contamination which were remedied by coring conducted in 2010 to 2012 to support Phase 2 remedial design. The estimated mass of PCBs removed annually was used to help assess compliance with the Resuspension Standard, which limited downstream transport to a percentage of dredged PCBs. Estimates of PCB mass removed and areas capped and backfill demonstrate compliance with limits set in the Residuals Standard, and the estimated PCB mass left in place in capped and sand-covered areas (3,900 kg of TPCB and 1,100 kg of Tri+ PCB) is small relative to the mass removed by dredging (134,600 kg of TPCB and 42,800 kg of Tri+ PCB).

Important objectives of the evaluation discussed here were to confirm that: (1) the expectations of PCB removal during dredging, as presented in the 2002 ROD, were achieved; (2) Phase 2 dredging activities were in compliance with the Productivity and Residuals Standards; and (3) GE correctly implemented the metrics (*e.g.*, calculation of PCB mass removed and the NCI used to determine compliance with the Engineering Performance Standards during Phase 2. Based on EPA's calculations presented in this appendix, the amount of PCBs removed during Phase 1 and Phase 2 exceeded expectations in the 2002 ROD by more than 2-fold. Targeting of surface sediment PCB concentrations, in combination with removal of PCB mass and natural recovery, served to reduce Tri+ PCB concentrations in surface sediments to an extent consistent with the changes anticipated by modeling results presented in the 2002 ROD (Appendix 4, Table A4-5). Similarly, the close agreement between EPA's and GE's estimates for volume of sediment and PCB mass removed (less than 6 percent difference) indicate that GE correctly implemented the metrics for determining compliance with the Phase 2 Productivity and Residuals Standards.

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# Second Five-Year Review Report
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## APPENDIX 2

## MASS REDUCTION EVALUATION

### Tables

Prepared by:

Louis Berger US, Inc.

LimnoTech, Inc.

May 2017

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## APPENDIX 2
## MASS REDUCTION EVALUATION

**Tables**


Prepared by:

Louis Berger US, Inc.

LimnoTech, Inc.


May 2017

## Table A2-1a. Volume of Sediment Removed from Certification Units in Phase 2 by Certification Unit

| CU | Year Dredged | Pass 1 (cy) | Pass 2 (cy) | Pass 3 (cy) | Total (cy) |
|---|---|---|---|---|---|
| CU01a | 2015 | 9,645 | | | 9,645 |
| CU09 | 2011 | 7,982 | 6,751 | | 14,734 |
| CU10 | 2011 | 12,892 | 3,998 | | 16,891 |
| CU11 | 2011 | 15,121 | 5,929 | | 21,050 |
| CU12 | 2011 | 14,956 | 5,249 | | 20,205 |
| CU13 | 2011 | 14,196 | 2,463 | | 16,659 |
| CU14 | 2011 | 21,932 | 3,057 | | 24,989 |
| CU15 | 2011 | 22,747 | 9,275 | 299 | 32,322 |
| CU16 | 2011 | 17,790 | 6,450 | 767 | 25,007 |
| CU19 | 2011 | 20,004 | 4,884 | | 24,888 |
| CU20 | 2011 | 18,984 | 4,569 | 441 | 23,994 |
| CU21 | 2011 | 18,225 | 5,752 | 359 | 24,336 |
| CU22 | 2011 | 19,306 | 5,881 | 679 | 25,866 |
| CU23 | 2011 | 19,513 | 4,487 | 633 | 24,633 |
| CU24 | 2011 | 30,427 | 2,003 | | 32,429 |
| CU25 | 2011 | 19,955 | 3,771 | | 23,726 |
| CU26 | 2012 | 16,654 | 7,168 | 647 | 24,469 |
| CU27 | 2012 | 14,641 | 4,956 | 212 | 19,809 |
| CU28 | 2012 | 18,218 | 6,400 | | 24,618 |
| CU29 | 2012 | 15,521 | 3,534 | | 19,055 |
| CU30 | 2012 | 16,425 | 3,032 | | 19,457 |
| CU31 | 2012 | 11,088 | | | 11,088 |
| CU32 | 2012 | 12,793 | 1,306 | | 14,098 |
| CU33 | 2012 | 16,409 | 2,251 | | 18,660 |
| CU34 | 2012 | 11,772 | 1,631 | | 13,403 |
| CU35 | 2012 | 23,182 | 10,368 | | 33,551 |
| CU36 | 2012 | 21,201 | 2,890 | | 24,092 |
| CU37 | 2012 | 26,194 | 6,784 | | 32,978 |
| CU38 | 2012 | 21,411 | 4,591 | | 26,002 |
| CU39 | 2012 | 19,280 | 797 | | 20,077 |
| CU40 | 2012 | 21,933 | 6,078 | 343 | 28,353 |
| CU41 | 2012 | 27,013 | 5,013 | | 32,026 |
| CU42 | 2012 | 22,892 | 4,542 | | 27,434 |
| CU43 | 2012 | 21,113 | 4,495 | 1,045 | 26,653 |
| CU44 | 2012 | 18,615 | 6,747 | 598 | 25,960 |
| CU45 | 2012 | 13,958 | 3,373 | 192 | 17,523 |
| CU46 | 2012 | 15,199 | 2,259 | | 17,457 |
| CU47 | 2012 | 14,657 | 3,287 | | 17,944 |
| CU48 | 2012 | 16,125 | 4,233 | | 20,357 |
| CU49 | 2013 | 13,279 | 4,051 | | 17,330 |
| CU50 | 2012 | 22,205 | 4,907 | | 27,112 |
| CU51 | 2012/2013 | 27,413 | 1,982 | | 29,395 |
| CU52 | 2012/2014 | 32,086 | 1,083 | | 33,169 |
| CU53 | 2012/2015 | 26,440 | 2,093 | | 28,533 |
| CU54 | 2013 | 36,005 | 2,156 | | 38,161 |
| CU55 | 2013 | 10,579 | 2,482 | | 13,061 |

| CU | Year Dredged | Pass 1 (cy) | Pass 2 (cy) | Pass 3 (cy) | Total (cy) |
|---|---|---|---|---|---|
| CU56 | 2013 | 16,208 | 4,988 | | 21,197 |
| CU57 | 2013 | 16,685 | 6,395 | | 23,080 |
| CU58 | 2013 | 18,728 | 1,321 | | 20,049 |
| CU59 | 2013 | 9,788 | | | 9,788 |
| CU60 | 2015 | 18,214 | 1,125 | | 19,339 |
| CU61 | 2014 | 20,812 | 2,935 | 763 | 24,509 |
| CU62 | 2014 | 14,398 | 1,467 | | 15,865 |
| CU63 | 2014 | 24,130 | 1,753 | | 25,883 |
| CU64 | 2014/2015 | 17,727 | 4,812 | | 22,539 |
| CU65 | 2015 | 19,897 | 3,437 | | 23,334 |
| CU66 | 2015 | 21,625 | 1,730 | | 23,355 |
| CU67 | 2013 | 32,387 | 6,267 | 459 | 39,113 |
| CU68 | 2013 | 27,726 | 9,800 | 2,669 | 40,195 |
| CU69 | 2013 | 28,245 | 6,810 | | 35,055 |
| CU70 | 2013 | 34,894 | 14,165 | 440 | 49,499 |
| CU71 | 2013 | 20,037 | 4,317 | | 24,354 |
| CU72 | 2013 | 17,140 | 6,244 | | 23,384 |
| CU73 | 2013 | 24,260 | 4,748 | 492 | 29,500 |
| CU74 | 2013 | 14,859 | 5,352 | | 20,211 |
| CU75 | 2013 | 10,727 | 2,508 | | 13,236 |
| CU76 | 2013 | 34,795 | 19,652 | 1,633 | 56,080 |
| CU77 | 2013 | 39,955 | 9,851 | 2,377 | 52,183 |
| CU78 | 2013 | 15,453 | 2,552 | 178 | 18,182 |
| CU79 | 2013 | 6,055 | 1,611 | | 7,666 |
| CU80 | 2014 | 13,375 | 1,947 | | 15,322 |
| CU81 | 2014 | 4,752 | 1,006 | | 5,758 |
| CU82 | 2014 | 38,995 | 7,161 | | 46,155 |
| CU83 | 2013/2014 | 43,995 | 9,398 | | 53,393 |
| CU84 | 2013 | 34,981 | 14,076 | | 49,057 |
| CU85 | 2014 | 15,169 | 5,701 | | 20,870 |
| CU86 | 2014 | 5,492 | 537 | | 6,028 |
| CU87 | 2014 | 39,716 | 10,200 | | 49,916 |
| CU88 | 2014 | 31,545 | 15,908 | | 47,453 |
| CU89 | 2014 | 41,851 | 18,982 | | 60,834 |
| CU90 | 2014 | 23,327 | 5,803 | | 29,130 |
| CU91 | 2014 | 25,245 | 4,364 | | 29,609 |
| CU92 | 2014 | 37,813 | 10,214 | | 48,027 |
| CU93 | 2014 | 28,526 | 6,263 | | 34,789 |
| CU94 | 2015 | 9,793 | 2,044 | | 11,836 |
| CU95 | 2015 | 37,976 | 5,194 | | 43,170 |
| CU96 | 2015 | 47,838 | 7,360 | | 55,198 |
| CU97 | 2014 | 4,998 | 1,240 | | 6,238 |
| CU98 | 2014 | 8,919 | 2,652 | | 11,570 |
| CU99 | 2014 | 28,424 | 18,021 | | 46,445 |
| CU100 | 2013 | 1,436 | 999 | | 2,434 |
| **Totals** | | **1,896,884** | **461,917** | **15,226** | **2,374,026** |

## Table A2-1b. Volume of Sediment Removed from Certification Units in Phase 1 and Phase 2 by Year

| Year Dredged | Pass 1 (cy) | Pass 2 (cy) | Pass 3 (cy) | Pass 4 (cy) | Pass 5 (cy) | Total (cy) | GE calculated Dredge Volume (cy) | 2010 EPS Productivity Standard (cy) |
|---|---|---|---|---|---|---|---|---|
| 2009 | 130,200 | 78,800 | 35,900 | 17,000 | 5,700 | 267,900 | 286,354 | N/A |
| Phase 1 total | 130,200 | 78,800 | 35,900 | 17,000 | 5,700 | 267,900 | 286,354 | |
| 2011 | 274,029 | 74,520 | 3,178 | | | 351,728 | 363,332 | 350,000 |
| 2012 | 438,498 | 100,641 | 3,037 | | | 542,176 | 663,265 | 350,000 |
| 2013 | 491,636 | 132,326 | 8,248 | | | 632,210 | 628,057 | 350,000 |
| 2014 | 483,566 | 126,635 | 763 | | | 610,963 | 582,917 | 350,000 |
| 2015 | 209,155 | 27,794 | 0 | | | 236,949 | 230,399 | 350,000 |
| Phase 2 total | 1,896,884 | 461,917 | 15,226 | | | 2,374,026 | 2,467,970 | 1,750,000 |
| **Phase 1 + 2 Total** | **2,027,084** | **540,717** | **51,126** | **17,000** | **5,700** | **2,641,926** | **2,754,324** | |

NOTE: Some CUs were dredged in multiple years, however for EPA calculation of dredge volumes by year, CUs were grouped by the initial year a CU was dredged, so values may not match up with GE values.

## Table A2-2a. Mass of TPCB Removed from Certification Units in Phase 2

| CU | Year Dredged | Pass 1 (kg) | Pass 2 (kg) | Pass 3 (kg) | Total (kg) |
|---|---|---|---|---|---|
| CU01a | 2015 | 23 | | | 23 |
| CU09 | 2011 | 276 | 244 | | 520 |
| CU10 | 2011 | 350 | 124 | | 474 |
| CU11 | 2011 | 680 | 410 | | 1,090 |
| CU12 | 2011 | 586 | 476 | | 1,062 |
| CU13 | 2011 | 597 | 118 | | 716 |
| CU14 | 2011 | 1,266 | 346 | | 1,612 |
| CU15 | 2011 | 2,583 | 1,294 | 2 | 3,878 |
| CU16 | 2011 | 1,404 | 4,088 | 210 | 5,703 |
| CU19 | 2011 | 1,263 | 153 | | 1,416 |
| CU20 | 2011 | 843 | 146 | 23 | 1,012 |
| CU21 | 2011 | 553 | 200 | 18 | 771 |
| CU22 | 2011 | 982 | 204 | 18 | 1,204 |
| CU23 | 2011 | 935 | 369 | 43 | 1,347 |
| CU24 | 2011 | 2,328 | 133 | | 2,461 |
| CU25 | 2011 | 1,587 | 310 | | 1,897 |
| CU26 | 2012 | 1,222 | 1,564 | 56 | 2,842 |
| CU27 | 2012 | 1,253 | 560 | 1 | 1,814 |
| CU28 | 2012 | 1,427 | 333 | | 1,760 |
| CU29 | 2012 | 806 | 301 | | 1,107 |
| CU30 | 2012 | 1,144 | 146 | | 1,289 |
| CU31 | 2012 | 241 | | | 241 |
| CU32 | 2012 | 231 | 209 | | 440 |
| CU33 | 2012 | 395 | 72 | | 467 |
| CU34 | 2012 | 435 | 94 | | 529 |
| CU35 | 2012 | 2,886 | 1,115 | | 4,001 |
| CU36 | 2012 | 1,680 | 119 | | 1,800 |
| CU37 | 2012 | 1,450 | 175 | | 1,626 |
| CU38 | 2012 | 1,097 | 479 | | 1,575 |
| CU39 | 2012 | 1,346 | 71 | | 1,417 |
| CU40 | 2012 | 1,283 | 946 | 259 | 2,488 |
| CU41 | 2012 | 1,288 | 611 | | 1,898 |
| CU42 | 2012 | 1,111 | 641 | | 1,752 |
| CU43 | 2012 | 1,714 | 360 | 102 | 2,177 |
| CU44 | 2012 | 1,380 | 610 | 13 | 2,003 |
| CU45 | 2012 | 780 | 217 | 1 | 998 |
| CU46 | 2012 | 1,400 | 391 | | 1,791 |
| CU47 | 2012 | 583 | 81 | | 664 |
| CU48 | 2012 | 755 | 544 | | 1,298 |
| CU49 | 2013 | 644 | 141 | | 785 |
| CU50 | 2012 | 630 | 147 | | 778 |
| CU51 | 2012/2013 | 364 | 19 | | 383 |
| CU52 | 2012/2014 | 322 | 23 | | 345 |
| CU53 | 2012/2015 | 243 | 14 | | 257 |
| CU54 | 2013 | 1,260 | 31 | | 1,291 |

| CU | Year Dredged | Pass 1 (kg) | Pass 2 (kg) | Pass 3 (kg) | Total (kg) |
|---|---|---|---|---|---|
| CU55 | 2013 | 423 | 68 | | 491 |
| CU56 | 2013 | 1,345 | 742 | | 2,087 |
| CU57 | 2013 | 474 | 146 | | 620 |
| CU58 | 2013 | 663 | 30 | | 693 |
| CU59 | 2013 | 398 | | | 398 |
| CU60 | 2015 | 747 | 18 | | 765 |
| CU61 | 2014 | 2,384 | 389 | 140 | 2,913 |
| CU62 | 2014 | 982 | 118 | | 1,099 |
| CU63 | 2014 | 1,024 | 68 | | 1,092 |
| CU64 | 2014/2015 | 1,266 | 935 | | 2,201 |
| CU65 | 2015 | 1,646 | 902 | | 2,548 |
| CU66 | 2015 | 1,148 | 34 | | 1,182 |
| CU67 | 2013 | 3,243 | 190 | 34 | 3,467 |
| CU68 | 2013 | 3,378 | 367 | 28 | 3,772 |
| CU69 | 2013 | 2,609 | 273 | | 2,882 |
| CU70 | 2013 | 2,574 | 478 | 92 | 3,145 |
| CU71 | 2013 | 1,333 | 215 | | 1,549 |
| CU72 | 2013 | 858 | 400 | | 1,258 |
| CU73 | 2013 | 1,394 | 246 | 21 | 1,660 |
| CU74 | 2013 | 965 | 216 | | 1,181 |
| CU75 | 2013 | 728 | 117 | | 845 |
| CU76 | 2013 | 1,610 | 817 | 14 | 2,441 |
| CU77 | 2013 | 1,364 | 618 | 95 | 2,077 |
| CU78 | 2013 | 431 | 42 | 1.0 | 475 |
| CU79 | 2013 | 315 | 64 | | 378 |
| CU80 | 2014 | 663 | 33 | | 697 |
| CU81 | 2014 | 146 | 11 | | 157 |
| CU82 | 2014 | 1,548 | 538 | | 2,087 |
| CU83 | 2013/2014 | 2,209 | 313 | | 2,522 |
| CU84 | 2013 | 1,772 | 865 | | 2,636 |
| CU85 | 2014 | 613 | 216 | | 829 |
| CU86 | 2014 | 227 | 11 | | 238 |
| CU87 | 2014 | 1,702 | 411 | | 2,114 |
| CU88 | 2014 | 1,732 | 674 | | 2,406 |
| CU89 | 2014 | 2,553 | 1,185 | | 3,738 |
| CU90 | 2014 | 927 | 235 | | 1,162 |
| CU91 | 2014 | 1,023 | 169 | | 1,192 |
| CU92 | 2014 | 1,553 | 392 | | 1,945 |
| CU93 | 2014 | 2,403 | 421 | | 2,824 |
| CU94 | 2015 | 251 | 46 | | 298 |
| CU95 | 2015 | 1,076 | 124 | | 1,201 |
| CU96 | 2015 | 1,315 | 351 | | 1,666 |
| CU97 | 2014 | 194 | 79 | | 273 |
| CU98 | 2014 | 179 | 79 | | 258 |
| CU99 | 2014 | 888 | 370 | | 1,258 |
| CU100 | 2013 | 14 | 6 | | 20 |
| **Totals** | | **101,919** | **32,653** | **1,171** | **135,743** |

## Table A2-2b. Mass of Tri+PCB Removed from Certification Units in Phase 2

| CU | Year Dredged | Pass 1 (kg) | Pass 2 (kg) | Pass 3 (kg) | Total (kg) |
|---|---|---|---|---|---|
| CU01a | 2015 | 18 | | | 18 |
| CU09 | 2011 | 119 | 82 | | 200 |
| CU10 | 2011 | 172 | 45 | | 217 |
| CU11 | 2011 | 292 | 142 | | 435 |
| CU12 | 2011 | 285 | 124 | | 409 |
| CU13 | 2011 | 230 | 35 | | 265 |
| CU14 | 2011 | 418 | 101 | | 519 |
| CU15 | 2011 | 722 | 351 | 1 | 1,074 |
| CU16 | 2011 | 519 | 1,185 | 56 | 1,760 |
| CU19 | 2011 | 358 | 47 | | 406 |
| CU20 | 2011 | 300 | 65 | 10 | 376 |
| CU21 | 2011 | 248 | 82 | 10 | 340 |
| CU22 | 2011 | 326 | 94 | 8 | 428 |
| CU23 | 2011 | 312 | 148 | 17 | 476 |
| CU24 | 2011 | 831 | 53 | | 884 |
| CU25 | 2011 | 541 | 133 | | 674 |
| CU26 | 2012 | 470 | 443 | 22 | 935 |
| CU27 | 2012 | 415 | 160 | 0.4 | 576 |
| CU28 | 2012 | 675 | 124 | | 799 |
| CU29 | 2012 | 284 | 81 | | 365 |
| CU30 | 2012 | 309 | 38 | | 347 |
| CU31 | 2012 | 97 | | | 97 |
| CU32 | 2012 | 111 | 55 | | 166 |
| CU33 | 2012 | 173 | 30 | | 203 |
| CU34 | 2012 | 170 | 26 | | 196 |
| CU35 | 2012 | 627 | 248 | | 875 |
| CU36 | 2012 | 427 | 30 | | 457 |
| CU37 | 2012 | 419 | 46 | | 465 |
| CU38 | 2012 | 262 | 106 | | 367 |
| CU39 | 2012 | 326 | 15 | | 341 |
| CU40 | 2012 | 404 | 228 | 54 | 686 |
| CU41 | 2012 | 471 | 255 | | 726 |
| CU42 | 2012 | 457 | 220 | | 676 |
| CU43 | 2012 | 552 | 104 | 36 | 692 |
| CU44 | 2012 | 376 | 151 | 6 | 532 |
| CU45 | 2012 | 216 | 58 | 0 | 274 |
| CU46 | 2012 | 336 | 82 | | 418 |
| CU47 | 2012 | 173 | 22 | | 195 |
| CU48 | 2012 | 220 | 115 | | 335 |
| CU49 | 2013 | 279 | 35 | | 314 |
| CU50 | 2012 | 151 | 38 | | 189 |
| CU51 | 2012/2013 | 127 | 5 | | 131 |
| CU52 | 2012/2014 | 129 | 7 | | 135 |
| CU53 | 2012/2015 | 102 | 6 | | 107 |
| CU54 | 2013 | 349 | 7 | | 356 |

| CU | Year Dredged | Pass 1 (kg) | Pass 2 (kg) | Pass 3 (kg) | Total (kg) |
|---|---|---|---|---|---|
| CU55 | 2013 | 129 | 17 | | 146 |
| CU56 | 2013 | 354 | 204 | | 558 |
| CU57 | 2013 | 135 | 41 | | 176 |
| CU58 | 2013 | 188 | 8 | | 196 |
| CU59 | 2013 | 85 | | | 85 |
| CU60 | 2015 | 198 | 5 | | 203 |
| CU61 | 2014 | 596 | 82 | 31 | 709 |
| CU62 | 2014 | 212 | 24 | | 236 |
| CU63 | 2014 | 381 | 19 | | 400 |
| CU64 | 2014/2015 | 261 | 173 | | 434 |
| CU65 | 2015 | 459 | 222 | | 681 |
| CU66 | 2015 | 750 | 14 | | 764 |
| CU67 | 2013 | 930 | 51 | 8 | 989 |
| CU68 | 2013 | 905 | 114 | 7 | 1,026 |
| CU69 | 2013 | 639 | 70 | | 708 |
| CU70 | 2013 | 698 | 142 | 23 | 862 |
| CU71 | 2013 | 368 | 59 | | 426 |
| CU72 | 2013 | 214 | 94 | | 308 |
| CU73 | 2013 | 371 | 67 | 5 | 443 |
| CU74 | 2013 | 244 | 52 | | 297 |
| CU75 | 2013 | 209 | 30 | | 240 |
| CU76 | 2013 | 453 | 212 | 4 | 669 |
| CU77 | 2013 | 534 | 175 | 28 | 737 |
| CU78 | 2013 | 177 | 15 | 0.5 | 192 |
| CU79 | 2013 | 89 | 18 | | 107 |
| CU80 | 2014 | 224 | 10 | | 234 |
| CU81 | 2014 | 60 | 4 | | 65 |
| CU82 | 2014 | 532 | 178 | | 710 |
| CU83 | 2013/2014 | 773 | 123 | | 896 |
| CU84 | 2013 | 551 | 278 | | 829 |
| CU85 | 2014 | 220 | 75 | | 295 |
| CU86 | 2014 | 73 | 5 | | 77 |
| CU87 | 2014 | 611 | 149 | | 761 |
| CU88 | 2014 | 731 | 302 | | 1,033 |
| CU89 | 2014 | 823 | 357 | | 1,180 |
| CU90 | 2014 | 349 | 74 | | 423 |
| CU91 | 2014 | 354 | 71 | | 425 |
| CU92 | 2014 | 539 | 124 | | 663 |
| CU93 | 2014 | 801 | 126 | | 927 |
| CU94 | 2015 | 131 | 21 | | 152 |
| CU95 | 2015 | 502 | 52 | | 554 |
| CU96 | 2015 | 714 | 156 | | 870 |
| CU97 | 2014 | 112 | 42 | | 154 |
| CU98 | 2014 | 160 | 63 | | 224 |
| CU99 | 2014 | 442 | 147 | | 589 |
| CU100 | 2013 | 16 | 4 | | 20 |
| **Totals** | | **33,093** | **9,691** | **326** | **43,110** |

## Table A2-2c. Mass of TPCB in Sediment Removed from Certification Units in Phase 1 and 2 by Year

| Year Dredged | Pass 1 (kg) | Pass 2 (kg) | Pass 3 (kg) | Pass 4 (kg) | Pass 5 (kg) | Total (kg) | GE calculated mass removed (kg) |
|---|---|---|---|---|---|---|---|
| 2009 | 11,523 | 6,597 | 1,366 | 381 | 150 | 20,017 | 16,320 |
| Phase 1 total | 11,523 | 6,597 | 1,366 | 381 | 150 | 20,017 | 16,320 |
| 2011 | 16,233 | 8,616 | 314 | | | 25,163 | 27,200 |
| 2012 | 26,539 | 9,786 | 432 | | | 36,757 | 33,370 |
| 2013 | 28,159 | 6,090 | 285 | | | 34,534 | 32,460 |
| 2014 | 23,272 | 5,736 | 140 | | | 29,147 | 26,570 |
| 2015 | 7,715 | 2,425 | 0 | | | 10,140 | 8,185 |
| Phase 2 total | 101,919 | 32,653 | 1,171 | | | 135,743 | 127,785 |
| Phase 1 + 2 Total | 113,442 | 39,250 | 2,537 | 381 | 150 | 155,760 | 144,105 |

NOTE: Some CUs were dredged in multiple years; however, for EPA calculation of dredge volumes by year, CUs were grouped by the initial year a CU was dredged, so values may not match up with GE values.

## Table A2-2d. Mass of Tri+PCB in Sediment Removed from Certification Units in Phase 1 and 2 by Year

| Year Dredged | Pass 1 (kg) | Pass 2 (kg) | Pass 3 (kg) | Pass 4 (kg) | Pass 5 (kg) | Total (kg) | GE calculated mass removed (kg) |
|---|---|---|---|---|---|---|---|
| 2009 | 3,036 | 1,798 | 413 | 150 | 64 | 5,461 | N/A |
| Phase 1 total | 3,036 | 1,798 | 413 | 150 | 64 | 5,461 | N/A |
| 2011 | 5,673 | 2,689 | 102 | | | 8,463 | 9,070 |
| 2012 | 8,120 | 2,673 | 119 | | | 10,912 | 10,080 |
| 2013 | 8,044 | 1,699 | 75 | | | 9,818 | 9,275 |
| 2014 | 8,123 | 1,982 | 31 | | | 10,135 | 8,915 |
| 2015 | 3,134 | 648 | 0 | | | 3,782 | 2,991 |
| Phase 2 total | 33,093 | 9,691 | 326 | | | 43,110 | 40,331 |
| Phase 1 + 2 Total | 36,129 | 11,489 | 739 | 150 | 64 | 48,571 | 40,331 |

NOTE: Some CUs were dredged in multiple years; however, for EPA calculation of dredge volumes by year, CUs were grouped by the initial year a CU was dredged, so values may not match up with GE values.

## Table A2-3. Combined Phase 1 and Phase 2 PCB Mass and Volume Removal Estimated and Actual Values

| Category | Source | Tri+ PCB Mass (kg) | Total PCB Mass (kg) | Total Area (acres) | Volume (cy) |
|---|---|---|---|---|---|
| Dredge Removal Estimates | 2002 ROD Resp. Summ. (Table 363334-1 and 424851-1) | 21,700 | 69,800 | 493 | 2,650,000 |
| | 2007 DAD report (Table 6-1) | N/A[1] | 113,100 | 491 | 1,800,000 |
| Actual Dredge Removal | 2010 Phase 1 EPA Evaluation Report *and* Phase 2 Data | 48,571 | 155,760 | 490 | 2,641,926 |

[1]: The 2007 DAD report did not report a Tri+PCB mass.

## Table A2-4a. Capped Inventory of TPCB in sediment remaining in Certification Units after Phase 2 dredging

| CU | Year Dredged | Inventory (kg) |
|---|---|---|
| CU01a | 2015 | |
| CU09 | 2011 | 42 |
| CU10 | 2011 | 5 |
| CU11 | 2011 | 82 |
| CU12 | 2011 | 25 |
| CU13 | 2011 | 26 |
| CU14 | 2011 | 47 |
| CU15 | 2011 | 29 |
| CU16 | 2011 | 9 |
| CU19 | 2011 | 67 |
| CU20 | 2011 | 0 |
| CU21 | 2011 | 45 |
| CU22 | 2011 | 19 |
| CU23 | 2011 | 0 |
| CU24 | 2011 | 15 |
| CU25 | 2011 | 22 |
| CU26 | 2012 | 249 |
| CU27 | 2012 | 24 |
| CU28 | 2012 | 58 |
| CU29 | 2012 | 50 |
| CU30 | 2012 | 17 |
| CU31 | 2012 | 0 |
| CU32 | 2012 | 42 |
| CU33 | 2012 | 0 |
| CU34 | 2012 | 0 |
| CU35 | 2012 | 110 |
| CU36 | 2012 | 106 |
| CU37 | 2012 | 73 |
| CU38 | 2012 | 0 |
| CU39 | 2012 | 22 |
| CU40 | 2012 | 709 |
| CU41 | 2012 | 95 |
| CU42 | 2012 | 189 |
| CU43 | 2012 | 163 |
| CU44 | 2012 | 56 |
| CU45 | 2012 | 43 |
| CU46 | 2012 | 42 |
| CU47 | 2012 | 16 |
| CU48 | 2012 | 0 |
| CU49 | 2013 | 11 |
| CU50 | 2012 | 14 |
| CU51 | 2012/2013 | 29 |
| CU52 | 2012/2014 | 0 |
| CU53 | 2012/2015 | 17 |
| CU54 | 2013 | 0 |

| CU | Year Dredged | Inventory (kg) |
|---|---|---|
| CU55 | 2013 | 4 |
| CU56 | 2013 | 17 |
| CU57 | 2013 | 10 |
| CU58 | 2013 | 0 |
| CU59 | 2013 | 0 |
| CU60 | 2015 | 12 |
| CU61 | 2014 | 147 |
| CU62 | 2014 | 4 |
| CU63 | 2014 | 31 |
| CU64 | 2014/2015 | 10 |
| CU65 | 2015 | 13 |
| CU66 | 2015 | 5 |
| CU67 | 2013 | 30 |
| CU68 | 2013 | 20 |
| CU69 | 2013 | 29 |
| CU70 | 2013 | 89 |
| CU71 | 2013 | 13 |
| CU72 | 2013 | 101 |
| CU73 | 2013 | 46 |
| CU74 | 2013 | 59 |
| CU75 | 2013 | 12 |
| CU76 | 2013 | 49 |
| CU77 | 2013 | 45 |
| CU78 | 2013 | 6 |
| CU79 | 2013 | 2 |
| CU80 | 2014 | 0 |
| CU81 | 2014 | 0 |
| CU82 | 2014 | 48 |
| CU83 | 2013/2014 | 56 |
| CU84 | 2013 | 37 |
| CU85 | 2014 | 18 |
| CU86 | 2014 | 0 |
| CU87 | 2014 | 51 |
| CU88 | 2014 | 113 |
| CU89 | 2014 | 94 |
| CU90 | 2014 | 26 |
| CU91 | 2014 | 18 |
| CU92 | 2014 | 42 |
| CU93 | 2014 | 19 |
| CU94 | 2015 | 4 |
| CU95 | 2015 | 22 |
| CU96 | 2015 | 35 |
| CU97 | 2014 | 17 |
| CU98 | 2014 | 0 |
| CU99 | 2014 | 12 |
| CU100 | 2013 | 0 |
| **Totals** | | **3,935** |

## Table A2-4b. Capped Inventory of Tri+PCB in sediment remaining in Certification Units after Phase 2 dredging

| CU | Year Dredged | Inventory (kg) |
|---|---|---|
| CU01a | 2015 | |
| CU09 | 2011 | 15 |
| CU10 | 2011 | 3 |
| CU11 | 2011 | 27 |
| CU12 | 2011 | 11 |
| CU13 | 2011 | 9 |
| CU14 | 2011 | 15 |
| CU15 | 2011 | 11 |
| CU16 | 2011 | 3 |
| CU19 | 2011 | 16 |
| CU20 | 2011 | 0 |
| CU21 | 2011 | 21 |
| CU22 | 2011 | 4 |
| CU23 | 2011 | 26 |
| CU24 | 2011 | 3 |
| CU25 | 2011 | 5 |
| CU26 | 2012 | 70 |
| CU27 | 2012 | 5 |
| CU28 | 2012 | 18 |
| CU29 | 2012 | 18 |
| CU30 | 2012 | 7 |
| CU31 | 2012 | 0 |
| CU32 | 2012 | 12 |
| CU33 | 2012 | 0 |
| CU34 | 2012 | 0 |
| CU35 | 2012 | 28 |
| CU36 | 2012 | 24 |
| CU37 | 2012 | 16 |
| CU38 | 2012 | 0 |
| CU39 | 2012 | 5 |
| CU40 | 2012 | 151 |
| CU41 | 2012 | 21 |
| CU42 | 2012 | 60 |
| CU43 | 2012 | 38 |
| CU44 | 2012 | 13 |
| CU45 | 2012 | 10 |
| CU46 | 2012 | 9 |
| CU47 | 2012 | 4 |
| CU48 | 2012 | 0 |
| CU49 | 2013 | 2 |
| CU50 | 2012 | 4 |
| CU51 | 2012/2013 | 10 |
| CU52 | 2012/2014 | 0 |
| CU53 | 2012/2015 | 6 |
| CU54 | 2013 | 0 |

| CU | Year Dredged | Inventory (kg) |
|---|---|---|
| CU55 | 2013 | 1 |
| CU56 | 2013 | 7 |
| CU57 | 2013 | 3 |
| CU58 | 2013 | 0 |
| CU59 | 2013 | 0 |
| CU60 | 2015 | 4 |
| CU61 | 2014 | 37 |
| CU62 | 2014 | 1 |
| CU63 | 2014 | 9 |
| CU64 | 2014/2015 | 2 |
| CU65 | 2015 | 5 |
| CU66 | 2015 | 2 |
| CU67 | 2013 | 11 |
| CU68 | 2013 | 5 |
| CU69 | 2013 | 8 |
| CU70 | 2013 | 27 |
| CU71 | 2013 | 4 |
| CU72 | 2013 | 23 |
| CU73 | 2013 | 16 |
| CU74 | 2013 | 13 |
| CU75 | 2013 | 4 |
| CU76 | 2013 | 16 |
| CU77 | 2013 | 14 |
| CU78 | 2013 | 4 |
| CU79 | 2013 | 1 |
| CU80 | 2014 | 0 |
| CU81 | 2014 | 0 |
| CU82 | 2014 | 16 |
| CU83 | 2013/2014 | 18 |
| CU84 | 2013 | 12 |
| CU85 | 2014 | 8 |
| CU86 | 2014 | 0 |
| CU87 | 2014 | 17 |
| CU88 | 2014 | 52 |
| CU89 | 2014 | 29 |
| CU90 | 2014 | 9 |
| CU91 | 2014 | 6 |
| CU92 | 2014 | 15 |
| CU93 | 2014 | 5 |
| CU94 | 2015 | 2 |
| CU95 | 2015 | 9 |
| CU96 | 2015 | 18 |
| CU97 | 2014 | 9 |
| CU98 | 2014 | 0 |
| CU99 | 2014 | 5 |
| CU100 | 2013 | 0 |
| **Totals** | | **1,143** |

## Table A2-5. Summary of Navigation Channel Volumes and PCB Mass Removed

| Reach | Certification Unit | Area of CU w/in Channel (Acres) | %Area of CU w/in Channel | Volume Removed from Channel[1] (cy) | % CU Volume Removed in Channel | Average Depth of Cut in Channel (feet) | Tri+ PCB Mass Removed from Channel[4] (kg) | Total PCB Mass Removed from Channel (kg) |
|---|---|---|---|---|---|---|---|---|
| 8 | 1[2] | 2.72 | 80.1 | 47,142 | 87% | 9.55 | N/A | 380 |
| | 1A[3] | --- | --- | 7,392 | --- | 2.12 | 10 | 20 |
| | 2 | 1.12 | 22.1 | 8,631 | 28% | 4.78 | N/A | 660 |
| | 3 | 0.88 | 18.0 | 10,171 | 23% | 7.18 | N/A | 1,330 |
| | 4 | 1.15 | 25.5 | 8,846 | 26% | 4.77 | N/A | 640 |
| | 11 | 0.00 | 0.04 | 2 | 0% | 0.73 | 0 | 0 |
| | 12 | 2.01 | 40.6 | 8,447 | 40% | 2.61 | 120 | 280 |
| | 13 | 3.62 | 74.5 | 11,569 | 64% | 1.98 | 180 | 540 |
| | 14 | 2.03 | 40.7 | 5,855 | 23% | 1.78 | 90 | 240 |
| | 15 | 2.34 | 47.9 | 8,826 | 27% | 2.34 | 270 | 750 |
| | 16 | 2.64 | 47.9 | 7,187 | 28% | 1.69 | 160 | 440 |
| | 17 | 0.52 | 10.5 | 919 | 6% | 1.09 | N/A | 10 |
| | 19 | 1.71 | 34.4 | 8,496 | 33% | 3.07 | 160 | 310 |
| | 20 | 1.73 | 34.2 | 12,211 | 50% | 4.37 | 240 | 510 |
| | 21 | 2.16 | 43.4 | 13,585 | 54% | 3.89 | 210 | 390 |
| | 22 | 1.75 | 34.9 | 12,622 | 48% | 4.46 | 250 | 490 |
| | 23 | 1.48 | 29.5 | 10,351 | 41% | 4.34 | 220 | 460 |
| | 24 | 1.45 | 28.9 | 13,856 | 42% | 5.90 | 460 | 920 |
| | 25 | 1.08 | 21.4 | 6,714 | 28% | 3.86 | 170 | 360 |
| | 26 | 1.63 | 38.4 | 15,748 | 63% | 6.00 | 500 | 1,330 |
| | 27 | 2.00 | 47.8 | 14,935 | 74% | 4.63 | 430 | 1,220 |
| | 28 | 1.49 | 31.5 | 8,873 | 35% | 3.70 | 230 | 570 |
| | 29 | 1.29 | 26.1 | 4,168 | 21% | 2.00 | 40 | 90 |
| | 30 | 1.49 | 30.1 | 4,931 | 25% | 2.05 | 50 | 130 |
| | 31 | 1.26 | 26.1 | 3,372 | 30% | 1.66 | 30 | 70 |
| | 32 | 1.10 | 22.3 | 3,482 | 24% | 1.96 | 40 | 90 |
| | 33 | 1.67 | 30.4 | 7,538 | 40% | 2.80 | 100 | 230 |
| | 34 | 2.14 | 53.9 | 7,675 | 55% | 2.22 | 90 | 180 |
| | 37 | 2.50 | 37.4 | 6,339 | 19% | 1.57 | 80 | 190 |
| | 38 | 0.86 | 15.4 | 1,889 | 7% | 1.36 | 30 | 110 |
| | 39 | 0.93 | 16.6 | 2,685 | 13% | 1.80 | 50 | 120 |
| | 40 | 1.86 | 33.5 | 9,915 | 34% | 3.31 | 160 | 390 |
| | 41 | 2.38 | 42.4 | 14,321 | 43% | 3.73 | 220 | 490 |
| | 42 | 2.07 | 39.0 | 14,873 | 53% | 4.44 | 220 | 580 |
| | 43 | 2.33 | 43.0 | 12,271 | 45% | 3.26 | 200 | 530 |
| | 44 | 1.80 | 36.1 | 10,369 | 39% | 3.57 | 170 | 370 |
| | 45 | 1.56 | 31.4 | 4,168 | 23% | 1.65 | 50 | 110 |
| | 46 | 0.75 | 14.5 | 1,548 | 9% | 1.28 | 20 | 80 |
| | 47 | 0.88 | 22.3 | 2,434 | 13% | 1.71 | 30 | 50 |
| | 48 | 2.20 | 39.9 | 5,969 | 28% | 1.68 | 70 | 170 |
| | 49 | 2.65 | 40.9 | 6,573 | 37% | 1.54 | 70 | 150 |
| | 55 | 2.44 | 47.4 | 6,057 | 44% | 1.53 | 60 | 110 |
| | 56 | 1.99 | 34.2 | 4,066 | 18% | 1.27 | 30 | 80 |
| | 57 | 1.70 | 31.2 | 4,024 | 16% | 1.47 | 30 | 90 |
| | 58 | 1.97 | 32.8 | 6,810 | 33% | 2.14 | 70 | 280 |

| Reach | Certification Unit | Area of CU w/in Channel (Acres) | %Area of CU w/in Channel | Volume Removed from Channel[1] (cy) | % CU Volume Removed in Channel | Average Depth of Cut in Channel (feet) | Tri+ PCB Mass Removed from Channel[4] (kg) | Total PCB Mass Removed from Channel (kg) |
|---|---|---|---|---|---|---|---|---|
| 6 | 67 | 0.89 | 16.0 | 8,345 | 20% | 5.82 | 200 | 700 |
| | 68 | 1.18 | 22.5 | 9,971 | 24% | 5.22 | 180 | 560 |
| | 69 | 0.14 | 2.6 | 562 | 1% | 2.51 | 10 | 40 |
| | 70 | 0.04 | 0.8 | 393 | 1% | 5.92 | 0 | 10 |
| | 71 | 0.00 | 0.1 | 12 | 0% | 2.78 | 0 | 0 |
| | 73 | 0.02 | 0.4 | 74 | 0% | 1.98 | 0 | 0 |
| | 74 | 0.21 | 4.5 | 579 | 3% | 1.67 | 10 | 20 |
| | 75 | 0.07 | 2.1 | 324 | 2% | 3.04 | 10 | 20 |
| | 77 | 1.36 | 32.7 | 19,260 | 36% | 8.75 | 200 | 460 |
| | 78 | 0.88 | 33.0 | 6,954 | 37% | 4.91 | 60 | 160 |
| 5 | 80 | 0.16 | 6.2 | 492 | 3% | 1.93 | 10 | 20 |
| | 82 | 0.00 | 0.02 | 4 | 0% | 2.29 | 0 | 0 |
| | 83 | 0.55 | 8.4 | 4,151 | 7% | 4.64 | 90 | 210 |
| | 88 | 0.84 | 13.8 | 4,347 | 9% | 3.19 | 60 | 130 |
| | 91 | 0.30 | 5.6 | 486 | 1% | 1.00 | 0 | 10 |
| 4 | 92 | 0.01 | 0.2 | 74 | 0% | 3.76 | 1 | 5 |
| 3 | 96 | 0.08 | 1.1 | 303 | 1% | 2.21 | 3 | 5 |
| **Total Inside CU** | | **82.1** | **16.7** | **444,186** | **16%** | **3.2** | **6,444 (excludes Phase 1 CUs)** | **18,890** |
| Outside CU[6] | | --- | --- | 7,286 | --- | --- | --- | --- |

Notes

Table compiled by and GE and provided to EPA.

1. Navigation channel removal volumes based on CU-wide volumes obtained from Parsons. For internal use only.

2. Combines 2009 and 2015 dredging within CU-1. Volume removed from within CU-1 (within the channel) by year: 2009 = 42,525 cy; 2015 = 4,617 cy

3. Data represent 2015 dredging outside the CU-1 boundary.

4. Tri+ PCB mass was not calculated for Phase 1 areas.

5. Water depths based on the design shoreline elevation (reach specific) and the final post-dredge/post-cap/backfill surveys. Phase 1 areas based on 2009 surveys.

6. Areas outside the CUs (excluding 1A) based on bathymetry survey extents to account for dredge-to-daylight areas; not representative of the navigation channel as a whole. Survey extents vary between the post-dredge and post-cap/backfill surveys.

CU - certification unit

CY - cubic yards; kg - kilograms; ft - feet

## Table A2-6a. Estimate of mass of TPCB in sediment outside dredged areas in Upper Hudson River (Method 1)

| River Section | Sediment type[1] | Total area (acres) | Dredged area (acres) | Total non-dredge area (acres)[2] | Non-dredged area with sediment texture class (acres) | Number of SSAP/SEDC cores used to calculate mass outside CUs | Average mass per unit Area (MPA) (g/m2)[3] | Mass dredged (kg)[4] | Mass outside CUs (kg) | Total PCB mass in River Section (kg) | Percent PCB mass removed (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | All | 553 | 307 | 220 | N/A | 1020 | 2.27 | 90055 | 2016 | 92071 | 97.8 |
| 2 | All | 474 | 85 | 307 | N/A | 872 | 8.27 | 35313 | 10269 | 45582 | 77.5 |
| 3 | Silt | | | | 343 | 2040 | 11.27 | | 15653 | | |
| 3 | Transitional | | | | 266 | 300 | 8.87 | | 9564 | | |
| 3 | Silt and Sand | 3082 | 99 | 2512 | 700 | 334 | 4.42 | 30371 | 12523 | 78578 | 38.7 |
| 3 | Gravel | | | | 729 | 69 | 2.15 | | 6344 | | |
| 3 | Unclassified | | | | 474 | N/A | 2.15 | | 4122 | | |
| | | | | | | | Total: | 155739 | 60491 | 216230 | 72.0 |

[1]: River Section 1 and 2 were not stratified by sediment texture class; River Section 3 was stratified by sediment texture class.

[2]: CU areas and bedrock substrate removed from all River Sections.

[3]: Unclassified areas in River Section 3 were assumed to be gravel and assigned the MPA for gravel areas (Method 1). See text for additional details on methodology.

[4]: The mass dredged in River Section 1 includes both Phase 1 and Phase 2 Dredging.

## Table A2-6b. Estimate of mass of TPCB in sediment outside dredged areas in Upper Hudson River (Method 2)

| River Section | Sediment type[1] | Total area (acres) | Dredged area (acres) | Total non-dredge area (acres)[2] | Non-dredged area with sediment texture class (acres) | Number of SSAP/SEDC cores used to calculate mass outside CUs | Average mass per unit Area (MPA) (g/m2)[3] | Mass dredged (kg)[4] | Mass outside CUs (kg) | Total PCB mass in River Section (kg) | Percent PCB mass removed (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | All | 553 | 307 | 220 | N/A | 1020 | 2.27 | 90055 | 2016 | 92071 | 97.8 |
| 2 | All | 474 | 85 | 307 | N/A | 872 | 8.27 | 35313 | 10269 | 45582 | 77.5 |
| 3 | Silt | | | | 343 | 2040 | 11.27 | | 15653 | | |
| 3 | Transitional | | | | 266 | 300 | 8.87 | | 9564 | | |
| 3 | Silt and Sand | 3082 | 99 | 2512 | 700 | 334 | 4.42 | 30371 | 12523 | 74455 | 40.8 |
| 3 | Gravel | | | | 729 | 69 | 2.15 | | 6344 | | |
| 3 | Unclassified | | | | 474 | N/A | 0.00 | | 0 | | |
| | | | | | | | Total: | 155739 | 56369 | 212108 | 73.4 |

[1]: River Section 1 and 2 were not stratified by sediment texture class; River Section 3 was stratified by sediment texture class.

[2]: CU areas and bedrock substrate removed from all River Sections.

[3]: Unclassified areas in RS3 were assumed to be bedrock and excluded from calculations (Method 2). See text for additional details on methodology.

[4]: The mass dredged in River Section 1 includes both Phase 1 and Phase 2 Dredging.