UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
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NEW YORK, NY 10007-1866

145465

Date: SEP 28 2012

Re: Addendum to July 2012 Analysis of Alternatives Report – Grasse River Study Area

From: Doug Garbarini, Chief
New York Remediation Branch

To: File

Attached to this memorandum is the July 2012 Analysis of Alternatives Report (July 12 Alcoa AofA Report) for the Grasse River Study Area prepared by several contractors on behalf of Alcoa, Inc. (Alcoa). The United States Environmental Protection Agency (EPA) has previously informed Alcoa that, in lieu of requiring additional modifications to the July 12 Alcoa AofA Report, EPA would provide the additional comments and direction that follows in this memorandum to correct, clarify or supplement information provided in the July 12 Alcoa AofA Report. The attached July 12 Alcoa AofA Report, taken together with the memorandum, constitute the Final Analysis of Alternatives Report for the Grasse River (Alcoa Aggregation) Superfund Site.

1. Alcoa states it believes "that the assumptions used in the development of the Mohawk-specific PRG are overly conservative and result in an overstatement of potential risk to the Mohawk population..." (Section 3.2). EPA does not agree with this statement. The assumptions used in the development of the Mohawk-specific preliminary remediation goal (PRG) were based on a New York State Department of Health (NYSDOH) survey and are appropriate for the Mohawk population.

2. The July 12 Alcoa AofA Report lists the St. Regis Mohawk Tribal (SRMT) standard for sediment as a "to be considered" (TBC). At the time of the publication of the report in July 2012, EPA considered that standard to be a TBC. However, in September 2012, SRMT provided additional information to EPA regarding the reservation status of land along the banks of the Grasse River. In view of the information received, EPA is reevaluating its earlier determination regarding the status of the SRMT sediment standard.

   The United States maintains that Akwesasne, the Mohawk territory of the federally recognized SRMT, as described in the 1796 Treaty with the Seven Nations of Canada, 7 Stat. 55, includes land on both banks of the Grasse River, as well as land located along the St. Lawrence River downstream of the Site, together known as the "Indian Meadows." EPA notes, however, that the lands reserved by the 1796 Treaty are currently in dispute. *Canadian St. Regis Band of Mohawk Indians v. State of New York, et al.*, 5:82-cv-783 (N.D.N.Y.). Fishing, hunting, harvesting and spiritual ceremonies are

among the activities that have been historically and are now conducted by the SRMT in the lower Grasse River and the Indian Meadows. The lower Grasse River and the Indian Meadows are of significant cultural significance to the SRMT.

The SRMT has promulgated a 0.1 mg/kg cleanup standard for PCBs in sediments, which was approved by EPA under the Clean Water Act. Tribal Council Resolution No. 89-19 and Tribal Council Resolution No. 2007-72. EPA and the SRMT are currently discussing, on a government-to-government basis, whether the SRMT's sediment cleanup standard will be applied as a "relevant and appropriate" requirement for the cleanup. The SRMT cleanup standard is significantly lower than EPA's proposed action levels for sediment cleanup (i.e., $\geq$1 mg/kg PCB surface or SLWA concentration) in the Proposed Plan and may not be technically practicable to achieve. Because it is doubtful that the SRMT sediment standard can be achieved, and may therefore need to be waived due to technical impracticability if it is identified as an applicable or relevant and appropriate requirement (ARAR), EPA does not believe that the SRMT sediment standard would necessarily lead to a remedy that is different from the preferred remedy in the Proposed Plan.

EPA calculated the PRG of 0.01 mg/kg PCBs in fish tissue for protection of Mohawk health using a fish consumption rate for Mohawk subsistence anglers, which is higher than the average fish consumption rate of the non-Mohawk population.

3. Alcoa includes reference to the National Research Council's (NRC) 2001 *A Risk Management Strategy for PCB-Contaminated Sediments* and 2007 *Sediment Dredging at Superfund Megasites: Assessing the Effectiveness* in the Executive Summary and throughout the attached AofA Report document. Alcoa's referenced text reflects an emphasis on recommendations and case study lessons as they apply to dredging technology in the 2007 report. We note, however, that the NRC 2001 report also includes findings and recommendations applicable to cultural and societal risks that extend beyond the traditional human health and ecological risk assessments. The NRC's 2001 report included recommendations and options for managing risks posed by PCB-contaminated sediments. One of the NRC's recommendations is as follows:

> "Risk management of PCB contaminated sediment sites should comprehensively evaluate the broad range of risks posed by PCB contaminated sediments and associated remedial actions. These risks should include societal, cultural, and economic impacts as well as human health and ecological health." (Executive Summary pg. 5)

In the NRC 2001, a case-study provided of cultural impacts stated:

> "Cultural impacts can result when subsistence use of a resource is lost, affecting such traditions as sharing among the community or passing on indigenous knowledge to younger generations, as occurred among the Mohawk Community of Akwesasne on the St. Lawrence River." (Executive Summary pg. 8)

Societal impacts detailed in the NRC 2001 may include behavioral changes in breast-feeding patterns (pg. 177), or a community that perceives that the area in which it lives is unhealthy as a result of the contamination (pg. 106). Such concerns are relevant to members of the SRMT given the cultural, societal, and economic importance of the Grasse River resources to the SRMT, under the 1796 Treaty the above NRC 2001 recommendation is relevant.

All eleven of the NRC's findings apply to the Grasse River, and it should be noted that, in the NRC report, the Akwesasne Mohawk community served as a case-study of the cultural impacts from PCB-contaminated sediment (NRC 2001). The NRC 2001 recommends a risk management framework that considers this broader definition of risks, or effects on cultural traditions. The impacts of PCB contamination on Mohawk society and culture, such as impacts to Mohawk anglers, are important considerations for the evaluation of remedial alternatives for the Site and the selection of a remedy.

4. It is important to highlight the value of the Grasse River as an ecological resource, particularly the near shore area. The PCBs in the surface and subsurface sediment in the near shore areas are expected to present a greater direct and indirect exposure potential to affected fish and wildlife than the sediments in the main channel. The near shore sediments are expected to include a greater density of rooted vegetation, use by semi-aquatic species such as mink and wading birds, and a greater variety of habitat types. These uses are likely to result in greater penetration of the sediments by biological activity, a greater variety of species sensitivity, and an exposure potential to a greater number of species. Additionally, there is expected to be a greater impact from above-grade placement of capping materials resulting in significant or complete filling of the water column, preventing recovery of the affected habitats.

The Grasse River is a New York State Class B fresh surface water which means the best usages for the river are "primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival." (6 NYCRR § 701.7) The lower Grasse River is used for various recreational activities such as fishing, boating, and water sports. However, a fish consumption advisory issued initially in 1990 and updated annually by the New York State Department of Health (NYSDOH) currently indicates that no species of fish from the lower Grasse River (i.e., mouth of Grasse River to the Power Canal) should be eaten because of PCBs in the fish.

The Grasse River contains a diversity of habitats that supports a variety of species and is a corridor for species to travel between the "upper" river (upstream of Massena) and the St. Lawrence River. The State of New York has designated the Grasse River as a Significant Coastal Fish and Wildlife Habitat based on the significance of the habitats in the river in supporting cool and warm water fish populations including muskellunge, smallmouth bass, northern pike, walleye, bullhead, yellow perch, and lake sturgeon. Observations of both adult and juvenile muskellunge indicate that the Grasse River likely supports a spawning population of resident muskellunge and may serve as a spawning ground for fish residing in the St. Lawrence River. Multiple studies conducted by academic researchers have demonstrated the successful spawning, juvenile rearing, and

adult population of lake sturgeon, a New York State (NYS)-listed threatened species, in the Grasse River. Additional state and federally listed species have been documented in or around the Grasse River. Documented species include the NYS-listed endangered black tern; NYS-listed threatened species bald eagle, Blanding's turtle, common tern, eastern sand darter, mooneye, and upland sandpiper; and, NYS-listed species of special concern osprey and wood turtle. Indiana bats are both federally and NYS-listed endangered species known to exist in St. Lawrence County. Many regulated species (such as sport fish, waterfowl, mink, turtle, birds) are known to frequent the impacted areas. The ecological risk assessment has shown that PCB contamination poses a risk to many of the species at the Site, and that remediation is expected to reduce or eliminate those risks.

Unlike dredging in the main channel, dredging in the near shore would be more effective because the contaminated sediment can be fully captured by dredging as demonstrated by Remedial Options Pilot Study. Near shore areas that are dredged will be backfilled with clean material to grade to provide appropriate depth of sediment to allow for habitat re-establishment and species use.

5. The attached July 12 Alcoa AofA Report lacks sufficient information regarding habitat assessment, reconstruction, and monitoring. All active alternatives should include development of a habitat reconstruction plan. The objective of the habitat reconstruction plan will be to identify impacts to habitats and species from the remedy, identify habitat re-establishments goals, provide design specifications for habitat recovery, and provide the scope for monitoring of habitat recovery. The plan will be developed and implemented during design and remedy implementation, and will include the following components:

   A. Habitat assessment for affected species: A study will be conducted to assess the river for habitats that are present and use of the habitats by aquatic and semi-aquatic species. The study will include a survey for the presence of federal- and state-listed aquatic species and the habitats used by these species in the remedial area. Additionally, the study will document the habitat characteristics (including but not limited to temperature regime, substrate type, structure, plant species and density) of all areas affected by the remedy and identify any fish and wildlife concentration areas. Collected data will be used to determine the habitats affected by the remedy, any actions necessary to eliminate or minimize impacts to listed species, measures needed to protect existing habitats, and develop design specifications for the replacement and recovery of the all affected habitats following the remedy.

   B. Identification of habitat recovery material over capped areas and/or return to grade: Placement of clean substrate on top of the cap to allow for habitat re-establishment and species use, except where the material placed for the cap would be of sufficient quality and thickness to allow for omitting an additional habitat layer. The thickness of the habitat layer should be designed such that burrowing animals would not compromise the cap. The habitat recovery material will be

free of contaminants and will not require significant maintenance once habitat has been re-established. After placement of the habitat recovery material, the initial grade should be returned in near shore areas and main channel areas should be returned to a stable condition. The most appropriate substrate type will be determined based on the information collected during the habitat assessment and may vary depending on habitat re-establishment and species requirements or habitat reconstruction goals.

C. Design for restoration of vegetation: In areas disturbed by the remedy or implementation of the remedy, vegetation will be re-established through a mixture of appropriate active planting and seeding and passive measures to allow for healthy and diverse habitat. Vegetation placement will be determined during the design.

D. Monitoring habitat and biota recovery: A monitoring plan will assess the success of habitat re-construction materials, plantings, and recovery of biota. The monitoring plan will include baseline sampling and a plan to address corrective actions pertaining to habitat reconstruction, should they be necessary. Additionally, monitoring of PCBs in biota will be conducted to track the success of the remedy in reducing PCBs in the areas affected by the remedy. Monitoring will be specifically designed to track changes in PCB concentrations in aquatic and semi-aquatic species relevant to the Site.

6. The cost estimates for the alternatives evaluated in the AofA Report have been the subject of much discussion among the stakeholders during the review and revision of the AofA Report. The cost estimates for alternatives that are evaluated in detail in this type of feasibility study analysis are expected to have a level of accuracy range of +50 to -30 percent. EPA and New York State Department of Environmental Conservation (NYSDEC) disagreed with some line items of the cost estimates provided for the alternatives, believing that the costs listed for several of these line items were too high, particularly for the alternatives that included more significant amounts of dredging, and that these line items significantly impacted the overall estimate for those alternatives. Appendix C of the July 12 Alcoa AofA Report presents cost summaries for the base case and also presents a cost sensitivity analysis performed using recommended unit costs from EPA and NYSDEC. Appendix C contains greater detail of the uncertainties associated with the cost estimates for these alternatives. In addition, the cost of developing and implementing the habitat reconstruction plan identified above is not reflected in the cost estimates for the alternatives evaluated in the July 12 Alcoa AofA Report. A habitat reconstruction plan would be required for each of the nine active remedial alternatives evaluated in the Detailed Analysis of Alternatives.

7. EPA disagrees with Alcoa's suggestion in the July 12 Alcoa AofA Report that dredging is not an appropriate component of a Site remedy (e.g., "Alcoa believes that protection of human health and the environment for this site is achieved by the armored capping/capping component of the remedial alternatives (including in combined remedies)." (July 12 Alcoa AofA Report, Section 4.4.3). EPA believes that removal of

targeted sediment is a protective and permanent remedial approach in appropriate areas of the Site such as the near shore.

Attachment

Executive Summary

Analysis of Alternatives Report

Grasse River Study Area
Massena, New York

July 2012

Introduction

Working with the United States Environmental Protection Agency (USEPA), the New York State Department of Environmental Conservation (NYSDEC), the National Oceanic and Atmospheric Administration (NOAA), and the St. Regis Mohawk Tribe (SRMT) – collectively referred to as the Agencies – Alcoa Inc. (Alcoa) has developed a comprehensive understanding of the sources, nature, extent, and fate of polychlorinated biphenyls (PCBs) in the Grasse River Study Area near Massena, New York. This understanding is based on a detailed analysis of information gathered during site-specific investigations, modeling efforts, pilot studies, and removal actions undertaken at the site to help identify the most effective approach for protecting human health and the environment from potential risks associated with long-term exposure to PCBs present in the river. As stated by the National Research Council (NRC), "Basing remedial action objectives on the best scientific understanding of the mechanisms that lead to site-specific risk maximizes the likelihood that remedial actions will meet the objectives" (NRC, 2007 – p. 44). A fish consumption advisory is currently in effect for the lower Grasse River (all species – eat none from the river mouth upstream to the Power Canal) and for the Power Canal (smallmouth bass – eat up to one meal per month) due to elevated levels of PCBs in fish (New York State Department of Health [NYSDOH], 2012-2013). The overall goal of the remedial efforts is to reduce PCB levels in fish and other biota in the lower Grasse River.

This Analysis of Alternatives (AA) Report describes 10 potential remedial alternatives identified by Alcoa and the Agencies and evaluates these alternatives based on overall protectiveness, compliance with Applicable or Relevant and Appropriate Requirements (ARARs), long-term effectiveness and permanence, short-term effectiveness, implementability, and cost. This report was prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and USEPA guidance and reflects many years of interaction between Alcoa and the Agencies. In addition, the report reflects input received from the Grasse River Community Advisory Panel (CAP) as well as the broader community during a series of public meetings and information sessions conducted over the last decade.

The NRC (2007) used the Grasse River as one of three sediment site dredging case studies because of its history of comprehensive study and site-specific investigation, and the use of an approach that incorporates the conceptual framework supported by USEPA guidance. The approach used on the Grasse River for the development and evaluation of remedial alternatives conforms closely with NRC's final recommendations.

This Executive Summary presents an overview of the Grasse River Study Area, the key findings of the studies carried out since 1991, and the major conclusions from the development and evaluation of the 10 potential remedial alternatives. The key findings are:

- Source control actions coupled with in-river remedial actions and natural recovery processes have resulted in declines in fish tissue PCB concentrations of about 90 percent.

- The primary differences among the effectiveness of the alternatives are the projected rates at which PCB concentrations decline, short-term effectiveness, and cost.

- Natural recovery reduces fish tissue PCB concentrations at the lowest cost, albeit more slowly than alternatives with dredging and/or capping components. The rate of natural recovery could be impacted by periodic ice jam-related scour events; however, the 2003 ice jam only produced a measured increase in one of the three species in only one of the three monitoring reaches that are routinely monitored at the site, and this impact did not have any substantive effect on the recovery of site-wide fish tissue PCB levels.

- Effectiveness of the alternatives other than No Further Action and Monitored Natural Recovery (MNR) is driven by placement of a cap. When combined with large-scale capping, dredging has a negative influence on the achievement of PCB metrics.

- Dredging in the targeted areas removes mass from the river, but the volume of sediment removed from the river has little bearing on risk reduction. As stated by the NRC, "Remedies should be designed to meet long term risk reduction goals (as opposed to metrics not strictly related to risk, such as mass removal targets)" (NRC, 2007 – p. 8).

- Increases in Grasse River PCB fish tissue levels and PCB loading to the St. Lawrence River will be observed during dredging activities. The magnitude and duration of these impacts increase with the extent of the dredging program.

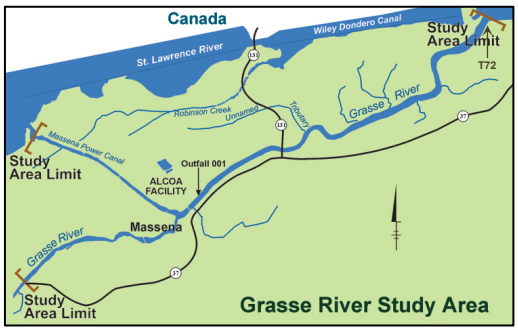
- A cap can achieve rapid risk reduction, be implemented with minimal short-term effects or overall impacts to the ecosystem, and is expected to remain stable in the Grasse River system.

- The capping-only alternative provides equivalent or better risk reduction (i.e., reduction in fish tissue PCB concentrations) to the combination alternatives at much lower cost.

- Protection against ice jam-induced scour will be provided by use of an armored cap or an ice control structure (ICS). The ICS has the disadvantage of potential risks to recreational users of the river (e.g., snowmobilers and boaters), and based on these public safety concerns this was not retained for detailed evaluation.

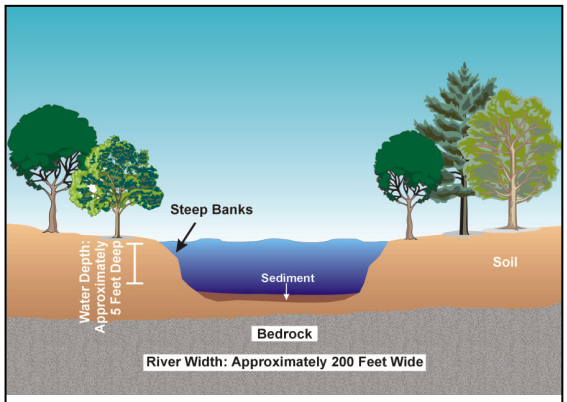
- The combination dredging and capping alternatives are expected to provide no benefit relative to the capping only alternative – as measured by predicted fish tissue PCB concentrations in 2036 – and add significant additional cost.

General Characteristics of the Study Area

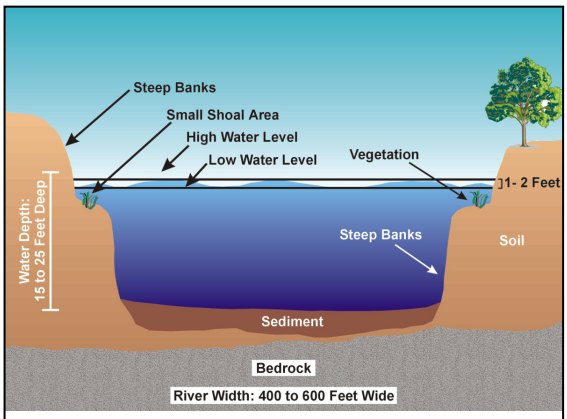


The Town of Massena, located along the northern border of New York State, has been the home of several major manufacturing operations for more than a century. Alcoa's 2,700-acre Massena-West facility, in operation since 1903, is located at the confluence of the Massena Power Canal and the Grasse River. Historic disposal of production waste by-products in on-site disposal areas – a practice that was common and widely accepted at the time – resulted in the release of PCBs and other compounds to the Grasse River. In 1985, the NYSDEC determined that select areas throughout the Alcoa facility posed a potential threat to the surrounding environment. In 1989, USEPA issued an Administrative Order (amended in 1995) directing Alcoa to investigate portions of the Grasse River to determine the nature and extent of impacts and develop and implement a plan to address potential human health and ecological risks. In 1991, Alcoa began implementation of land-based remedial activities at the facility.

The Grasse River Study Area (see map on page ES-2) encompasses 8.5 miles of the Grasse River, including the lower Grasse River, the background reach upstream of the confluence with the Power Canal, the Power Canal, and Robinson Creek. Upstream of the Power Canal, the river is about 5 feet deep with a cross-section of approximately 1,000 square feet. Below the confluence with the Power Canal, the river deepens to between 15 and 25 feet, and the cross-sectional area increases to approximately 9,000 square feet (see comparison cross-section figures below). This dramatic physical change is the result of dredging conducted in the lower



Typical Current Cross Section in the Background Reach, Upstream of the Lower River



Typical Current Lower Grasse River Cross Section

river in the early 1900s (approximately 1914 to 1918) to accommodate additional water flow from the newly constructed Power Canal. These changes included widening the channel on average 100 to 300 feet and deepening the channel by 14 feet or more throughout the lower river. Use of the Power Canal for power generation was terminated in the 1950s, coincident with the construction of new power-generating facilities on the St. Lawrence River. Terminating use of the Power Canal in conjunction with the construction of the St. Lawrence Seaway resulted in the river downstream of the Canal becoming a backwater of the St. Lawrence River and the functional equivalent of a reservoir. Normal water flow velocities are generally so low that they can be difficult or impossible to measure with conventional equipment – during low flows, it can take up to 21 days for water to travel from the Alcoa facility to the river's mouth, a distance of about 7 miles.

The bottom of the lower Grasse River is a mix of fine (silt/clay) and coarse (sand/gravel) sediment deposits. The fine sediment deposits, which can be as much as 6 to 8 feet thick, are found in areas in which sediment has accumulated since the Power Canal ceased operation in 1958. Near the bottom of these fine sediment deposits and just below the surface of the coarse sediment deposits are cobbles and boulders that overlay and intermix with a layer of dense glacial till and/or marine and lacustrine silts and clays. The cobbles and boulders are thought to be residual material left behind after the river was dredged to accommodate flow from the Power Canal (see photo to the right that shows rocks removed from river bottom in 2005). There are approximately 2.3 million cubic yards (cy) of sediments in the lower Grasse River covering about 400 acres; most of which are located in the fine sediment deposits. The top 3 inches of sediments have an average PCB concentration of 0.8 milligrams per kilogram (mg/kg; equivalent to 0.8 parts per million [ppm]) in the uppermost portion of the river (i.e., between the Power Canal and Alcoa Outfall 001), excluding a single elevated PCB measurement in the near shore sample at T3-NSS. Sediment (0-3 inches) PCB concentrations rise near Outfall 001 and exhibit considerable variability but no overall downstream trend for the next 3 miles (T4.5 to T36), averaging approximately 13 mg/kg. Sediment (0-3 inches) PCB concentrations in the remainder of the river (T36 to T72) average approximately 5 mg/kg.

Rocks and Debris Removed from River During 2005 ROPS

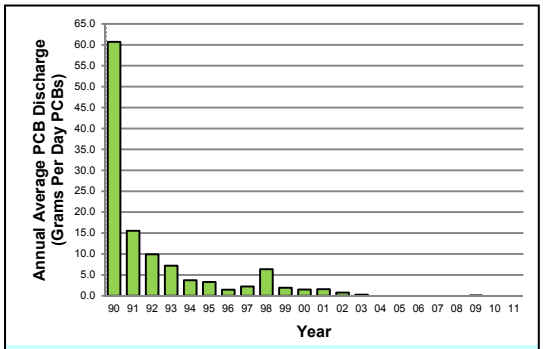
PCB concentrations in the main channel sediments are typically higher than those in near shore sediments. Within the main channel, sediment (0-3 inches) PCB concentrations in coarse sediment areas are typically higher than those in fine sediment areas (averaging 17 mg/kg and 8 mg/kg, respectively). The lower

concentrations in the fine sediment areas are attributed to higher rates of burial. The near shore areas generally have the lowest PCB concentrations, with about 60 percent of sediment (0-3 inches) samples containing PCB concentrations of 1 mg/kg or less. Overall, river-wide PCB concentrations in the top 3 inches of near shore sediments areas average about 5 mg/kg. (See Section 2.3 for more on the characterization of the Study Area.)

The Grasse River is covered with ice each winter, and ice jams sometimes occur in the upper portion of the Study Area (i.e., upstream of T16; see map on page ES-2) when ice from upstream breaks up, flows to the lower Grasse River, and builds up behind an intact ice cover. Extreme ice jams can cause scouring of river bottom sediments in the upper 1.8 miles of the lower river (i.e., between T1 and T19; see map on page ES-2). Ice jams severe enough to cause measurable scour have occurred about once every 10 years; at least four ice-related scour events have occurred over the past 40 to 50 years.

Source Control Actions

Between 1991 and 2001, Alcoa carried out an extensive series of remedial actions at the Massena facility that dramatically reduced PCB discharges to the lower Grasse River (see figure to the right) and the Unnamed Tributary – a critical first step for improving environmental quality in the lower Grasse River (see Section 1.1.2 and 2.2.2 for more details). These efforts to control external PCB sources are consistent with guidance in the NRC's A Risk Management Strategy for PCB-Contaminated Sediments (2001), USEPA's Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites (USEPA 11 Principles Memo; February 2002), and USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (December 2005), all of which support the control of ongoing sources as the first goal of remedial efforts directed at providing protection of human health and the environment. The source control actions at the Massena-West facility cost in excess of $250 million (MM).



Average Annual PCB Discharges from Outfall 001

Investigations in the Study Area

Alcoa has conducted intensive field and laboratory investigations in the Study Area, including the collection of more than 10,000 sediment, water column, and biota samples for PCB analysis. As a result of these investigations, which included the 1995 Non-Time-Critical Removal Action (NTCRA), 2001 Capping Pilot Study (CPS), 2005 Remedial Options Pilot Study (ROPS), and 2006 Activated Carbon Pilot Study (ACPS), Alcoa has gained a comprehensive understanding of the sources of PCBs to the river; the nature, extent and fate of PCBs in the system; and site-specific information on the efficacy of capping, dredging, and in situ amendments as means to reduce potential risks in the lower Grasse River. The combined cost to date of the site investigation studies, removal action, and pilot studies specific to the Grasse River is in excess of $65 MM.

Key Findings

The key findings of the studies, investigations, and actions completed at the Study Area and the results of the human health and ecological risk assessments (discussed below) form the basis of a conceptual site model that has guided development and evaluation of remedial alternatives. The findings, documented in the Comprehensive Characterization of the Lower Grasse River (Alcoa, April 2001), the Draft Addendum to the Comprehensive Characterization of the Lower Grasse River (Alcoa, April 2009), and other technical reports as summarized in Section 4.3, include:

- Plant discharges are currently an insignificant source of PCBs to the river.

- Source control actions already completed have had a major positive impact on the river. Since completion of these source controls, the river has been recovering rapidly. PCB levels in surface water and fish have declined by about 90 percent since the mid-1990s (Figure ES-1, attached).

- Long-term sedimentation and resultant burial of PCB-containing sediments are the principle means of natural recovery.

- The surface layer of sediments in the main channel of the river is the dominant source of PCBs found in surface water and fish. The steep side slopes (i.e., steeper than 3 horizontal to 1 vertical [3H:1V]) typically contain low levels of PCBs and represent a small fraction (about 5 percent) of the overall surface area of the river bottom. The shallow near shore area sediments (i.e., areas with water depths of less than 5 feet) also typically have low PCB concentrations (more than 60 percent of samples contain less than 1 mg/kg in the top 3 inches), indicating these areas are recovering naturally and are minor contributors to the PCBs observed in water and fish.

- The sediment source is widely dispersed; therefore, surface sediment PCB concentrations must be reduced over a relatively large portion of the river bottom through natural recovery processes and/or active remediation in order to further reduce PCB levels in fish.

- The vast majority of the PCB inventory in the river is buried under several feet of cleaner sediments in the fine sediment deposits. The coarse sediment deposits contain little to no recoverable PCB sediment inventory (i.e., sediments that can be successfully retrieved during sample collection activities – see also Section 2.3.1 of the main text for additional information).

- Buried sediments are expected to remain stable even during major open water high-flow events like the January 1998 storm, which was similar in magnitude to a 100-year flood. Monitoring data for fish and sediments collected prior to and following the 1998 high-flow event demonstrated that the event did not remobilize a substantive quantity of sediment-bound PCBs (see Figures ES-1 [fish data] and ES-2 [sediment data], attached).

- Buried sediments in the region upstream of T19 can be scoured during severe ice jams. The ice jam that occurred in 2003, which appears to be the most severe jam on record, caused scour in approximately 15 percent (or 15 acres) of this region (Figure ES-3a through 3c, attached). The greatest scour occurred in the CPS area (T15 to T17), where several feet of cap and sediment were eroded. Similar to the January 1998 storm, this event had no discernable long-term impact on PCB exposure; the long-term trends in water and fish PCB levels show no evidence of the 2003 ice jam-induced scour. Ice jams severe enough to cause sediment scour have occurred at a frequency of about once every 10 years based on the post-2003 ice jam investigation, which indicated that four ice scour events occurred over the past 40 to 50 years.

- Armored capping using designs conforming with USEPA and United States Army Corps of Engineers (USACE) guidance is an effective means by which to address ice jam-related sediment scour in the lower Grasse River for the reach of river that can be affected by these events.

- An ICS can address ice jam-related sediment scour in the lower Grasse River. As indicated above, a pier-type ICS was not retained due to public safety concerns.

- The Massena Electric Department (MED) Hydroelectric project was studied under a separate process under the oversight of the Federal Energy Regulatory Commission (FERC). USEPA informed the public and Alcoa that the MED project cannot be included as one of the process options for ice control until FERC approved the project. In 2010, MED decided to withdraw the proposed project.

- A clean cap can be placed over and isolate the PCB-containing sediments without remobilizing sediment PCBs to a measurable extent.

- Dredging can remove PCB mass from the river, but remobilizes PCBs even when proper and reasonable work practices and engineering controls (e.g., silt curtains) are employed.

- Dredging the fine sediment deposits in the main channel would leave behind a layer of residual PCB-containing sediments, largely because cobbles and boulders are interspersed with the fine sediment deposits, which impede the ability of a dredge to remove the targeted sediments. These residuals can contain high levels of PCBs because sediment concentrations in the main channel are highest near the bottom of the contaminated sediments to be dredged. Dredging residuals were up to 14 inches thick following main channel dredging conducted during the ROPS, and averaged 150 mg/kg PCBs. This residual layer will continue to affect PCB levels in the water column and biota unless dredging is combined with capping or ongoing natural recovery processes.

- Single-lift post-dredge capping (12 inches) reduces surface sediment PCB concentrations by about 95 percent. Greater reductions may be achieved if caps are applied in multiple lifts.

- Activated carbon can be added to the surface sediments without causing a significant PCB release and has been demonstrated through lab and pilot studies to significantly reduce PCB exposure and bioaccumulation in test organisms.

The water column and fish tissue trend monitoring data collected from the river since the mid-1990s illustrate the ability of ongoing natural recovery to reduce PCB levels in the river. This, coupled with the work conducted to evaluate long-term sediment stability in the system, support that MNR is an important component to the remedial approach for the river. The 1995 NTCRA, 2001 CPS, 2005 ROPS, and 2006 ACPS provide important site-specific data regarding the effectiveness of dredging, capping, and in situ amendments in the lower Grasse River. Brief descriptions of these programs and pilot studies, and their results are presented below.

- *Trend Monitoring Data*: Lipid-based PCB levels in smallmouth bass and brown bullhead from the lower river have declined by about 90 percent since the mid-1990s (see Figure ES-1, attached). Similarly, water column PCB levels have declined by more than 90 percent over this same time period. These declines are attributable to: 1) the downward trend in water column PCB concentrations resulting from the land-based remediation efforts (i.e., source control) performed at the Alcoa facility between 1990 and 2001 that significantly reduced PCB discharges to the river; and 2) natural recovery due to solids that continually enter the river from upstream and deposit on top of the PCB-containing sediments, reducing movement of PCBs to fish. This continual deposition, which occurs at an average rate of 0.2 to 0.7 centimeters per year (cm/yr), is the result of the oversized river channel created during the deepening of the lower Grasse River that occurred in the early 1900s, which has caused the lower river to serve as an efficient trap for solids that enter the system from upstream. The continual reductions in water column and fish tissue PCB concentrations that have been documented since the mid-1990s, coupled with the findings of the sediment stability evaluation (discussed below), support the inclusion of ongoing natural recovery as an important component to the remedial approach for the river.

- *Sediment Stability Evaluation:* Alcoa completed a number of field studies to investigate and document the stability of river sediments, including measurements of total suspended solids (TSS) and PCBs during high flows; sediment geochronology; sediment PCB concentration profiles with depth; comparison of bathymetric measurements at different points in time; trend monitoring of PCB levels in surface sediment, water, and fish; river velocity measurements; and sediment erodability measurements (see Section 2.4.2 for more information). In addition, the lower Grasse River has a large cross-sectional area and experiences low velocities due to the size of the river channel in relation to the volume of water that flows through it. During a 100-year flood event, peak velocities of about 2.5 to 4.5 feet per second (ft/s) are predicted for

the fine and coarse sediment areas, respectively. Peak velocities in the near shore areas are predicted to be about 2 to 2.5 ft/s.

These field studies, along with results of hydrodynamic and sediment transport modeling conducted for the site, indicate that even during extreme open water high-flow events, erosion impacts only the top few millimeters of the main channel sediment bed (see Section 2.4.2 and Figures ES-4A and ES-4B, attached). Further, natural sedimentation rates in fine sediment areas – a measure of how quickly sediments from upstream accumulate on the river bottom – exceed erosion rates during both normal and extreme (i.e., high-flow) circumstances. Coarse sediment areas have accumulated much less sediment than fine areas, but are stable with low rates of net sedimentation.

These findings are critical to the assessment of the potential effectiveness of natural recovery and capping as remedial options, and indicate that both the native sediments and a suitably designed and constructed cap will be stable and resistant to erosion, even during stresses equivalent to an open water 100-year flood. Erosion during a more extreme open water flood event (i.e., 1-in-500 year flood flow of 17,070 cubic feet per second [cfs]; Federal Emergency Management Agency [FEMA], May 1980) was estimated using the relationship between shear stress (which induces erosion) and flow rate (or velocity). Shear stress increases in proportion to the square of the velocity, and erosion increases in proportion to roughly the square of the shear stress. Thus, the 13 percent increase in velocity between a 100-year and 500-year flood translates to an approximate 28 percent increase in shear stress and an approximate 64 percent increase in erosion. Using the maximum erosion during a 100-year flood (i.e., conservatively estimated at about 0.9 cm), the maximum erosion during a 500-year flood is estimated to be between 1 and 1.5 cm. This estimate is conservative because the above calculation does not take account of water column solids/bed solids interactions that tend to reduce erosion.

Sediments may erode when a severe ice jam forms in the lower Grasse River. An exhaustive study conducted after the 2003 observation of sediment scour in the CPS area and documented in the Draft Addendum to the Comprehensive Characterization of the Lower Grasse River (Alcoa, April 2009) revealed that ice jam-induced scour has occurred at least four times in the last 40 to 50 years and can be expected about once a decade. These events occur only upstream of T19, when the ice in the lower Grasse River is particularly thick and ice breakup upstream of the lower Grasse River occurs in conjunction with an extreme high flow event. The 2003 event was particularly severe and scoured between 21,000 and 32,000 cy of sediment, primarily in the deeper channel areas of the river. Conversely, the accumulation of sediments in the near shore areas over past decades, coupled with available site-specific data and physical characteristics of the lower Grasse River, support that there has been no significant erosion of sediments from the near shore areas due to ice runs (Alcoa, December 2009a). While the 2003 event mobilized PCB-containing sediments from portions of the deeper channel, fish and water quality monitoring results revealed that the event did not have a long-term impact on PCB exposure levels in the river.

Evidence of sediment stability is also provided by the data from sediment cores collected for radio-dating and/or geochronology. Based on known historical fallout patterns, attributed to nuclear weapons testing during the 1950s and 1960s, peak Cesium 137 (^{137}Cs) levels mark the 1963 sediment layer (Pennington et al., 1973) and can be used to estimate deposition rates and indicate whether the sediment bed is prone to resuspension or mixing. Cores collected in 1997 for radio-dating generally exhibited the highest PCB concentrations at about 2 to 3 feet below the sediment-water interface (see Figure ES-5, attached; Alcoa, April 2001), and are located near the depth associated with the ^{137}Cs peak. The layers containing the maximum PCB concentration and the ^{137}Cs peak are both particularly distinct, which indicates that once deposited, the sediments have remained in place. These and other sediment cores collected from the river also lack the sharp discontinuities in the vertical profiles of PCBs and sediment properties that would be expected if layers were periodically eroded away and replaced by more recent material. Cores collected for geochronology as part of the investigations following the 2003 ice jam showed that, in the main channel upstream of T19, ongoing gradual deposition was occasionally interrupted by layers of coarse sediments that coincide in time with known or predicted ice jams. Downstream of T19, the layers of

coarse sediment did not exist, and the cores exhibited layering characteristic of long-term deposition. These data provide further support that fine sediments downstream of T19 are stable.

- *Non-Time-Critical Removal Action (NTCRA)*: The NTCRA, conducted between June and October 1995, targeted a 1-acre area of the lower Grasse River near Outfall 001 (see map on page ES-2) that contained the highest PCB concentrations in the Study Area. Mechanical equipment was used to remove approximately 400 cy of boulders and debris, and hydraulic dredging was used to remove approximately 2,600 in-situ cy of sediments. During dredging, the area was isolated from the rest of the river by a series of silt curtains (see photo to the right), and the boulders, debris, and dewatered sediments removed from the river were disposed in Alcoa's on-site Secure Landfill. Monitoring and sampling activities conducted before, during, and after the NTCRA indicated that approximately 7,800 pounds of PCBs were removed from the river. Average PCB concentrations in the top foot of the sediment bed were reduced by approximately 86 percent from 518 mg/kg (range of 12 to 1,708 mg/kg) to 75 mg/kg (range of 1.1 to 260 mg/kg). The dredging operation did, however, have negative short-term impacts on both the water column (see the water quality graph below, left panel) and biota, and elevated concentrations of PCBs remained in residual surface sediments. After multiple dredge passes, an average of 4 inches of sediment (maximum of 14 inches) remained at the end of the removal action, and higher PCB concentrations (relative to pre-dredging conditions) were observed at 30 percent of the sampling locations. An estimated 5 to 30 pounds of PCBs were resuspended during dredging and released downstream, leading to exceedances of PCB water quality criteria and increases in bioavailable PCBs. PCB concentrations in caged fish downstream of the NTCRA area before, during, and after the dredging activities are shown on Figure ES-6 (attached) and indicated a 50-fold increase adjacent to the dredged area and a 5-fold increase approximately 0.6 miles downstream during the removal action. Additionally, post-NTCRA results for spottail shiner samples collected in the vicinity of Outfall 001 indicated that PCB concentrations increased by as much as six-fold compared to prior years and remained elevated until they reached pre-NTCRA levels in approximately 3 years (see Figure ES-1, attached).

1995 NTCRA Program

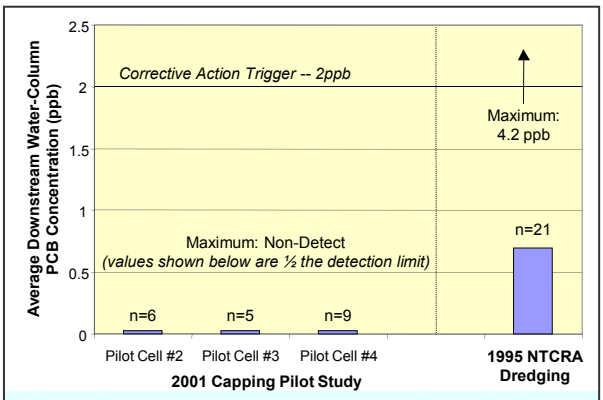
These findings are consistent with the NRC's conclusions (2001, 2007) and with USEPA guidance (2005) that mass removal cannot be presumed to reduce risk. This is particularly true at a site like the Grasse River, where the presence of boulders and the existence of hardpan and/or bedrock immediately under the impacted sediments can limit dredging effectiveness. (For additional information on the NTCRA activities, see Section 2.5.1.)

- *Capping Pilot Study (CPS)*: Alcoa designed and conducted the CPS to evaluate the potential effectiveness of covering PCB-containing sediments with a clean cap. During summer and fall 2001, Alcoa tested a variety of capping materials (e.g., sand/topsoil mixture, bentonite, AquaBlok™) and application methods (e.g., surface/subsurface clamshell, tremie pumping) in a 750-foot reach (covering approximately 7 acres) of the lower Grasse River approximately 1 mile downstream of Outfall 001. Sediment (0-3 inches) PCB concentrations in the CPS area prior to capping generally ranged from 3.0 to 11.5 mg/kg.

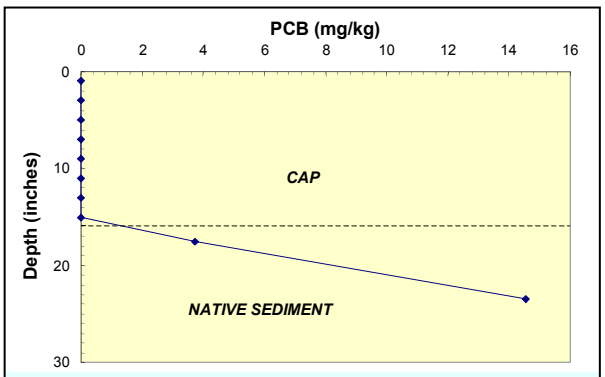
2001 Capping Pilot Study Program

Downstream impacts to the water column during the CPS were negligible (see the graph below, left, for a comparison of water quality data). PCB levels inside and adjacent to the capping cells during cap placement were generally near or below the detection limit (50 nanograms per liter [ng/L]), and PCBs were not detected at the downstream monitoring station. Corrective action trigger levels for PCBs, TSS, and turbidity were never reached during the project, and post-capping water quality monitoring showed no

residual effects. Sediment cores and samples of cap material collected after capping activities revealed that the cap materials were placed without significant entrainment of the underlying sediments into the cap (see the graph below, right, for typical core profile) and PCBs were typically not present in cap materials



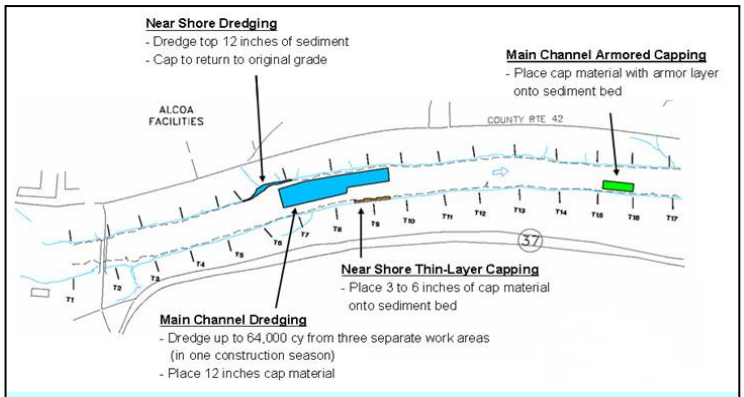
Downstream Water Quality Data



Vertical Profile of Total PCB for Sediment Core SED-2-04

at detectable levels (approximately 70 percent of the cores contained PCB concentrations below detectable limits throughout the entire cap). The targeted thickness of capping materials was achieved throughout the pilot area, with the exception of the steep side slopes, where only a few inches of material (compared to a target thickness of 1 foot) were successfully placed. Finally, data collected 2 to 3 weeks after the cap placement revealed active recolonization of the capped area by benthic organisms. (See Section 2.5.2 for more information.)

- *Remedial Options Pilot Study (ROPS)*: Alcoa undertook the ROPS in 2005 to develop a greater understanding of the effectiveness, implementability, and cost of remedial options for the lower Grasse River. The study involved main channel and near shore dredging followed by capping, near shore thin-layer capping, and armored capping as shown on the figure to the right. The operations and associated impact on water and sediment quality were extensively monitored.



ROPS Pilot Study Areas

The study revealed that dredging the main channel in the Grasse River is significantly hampered by the presence of cobbles and boulders, highly irregular bottom topography immediately beneath the soft sediments (Figure ES-7, attached), and the presence of peak PCB concentrations proximate to the interface between soft sediment deposits and underlying hard bottom materials, glacial till, and/or marine clay. Productivity was low, dredging equipment and the silt containment system were frequently damaged, and the foot or more of contaminated sediments that could not be removed contained surface PCB concentrations that averaged 150 mg/kg versus a pre-dredge surface concentration of about 4 mg/kg. About 3 percent of the PCB mass removed from the river bottom was released to the river and transported downstream, despite best efforts to minimize resuspension and capture resuspended solids within a silt containment system. The residual PCB-containing sediments were successfully capped; however, PCBs were entrained within the cap material and some surface contamination occurred, presumably due to sloughing of contaminated sediments from areas of high relief.

Excavation in the northern near shore area successfully removed the PCB inventory and reduced the average concentration in the top 3 inches of sediment by an order of magnitude (19 mg/kg to 1.9 mg/kg; 90 percent reduction). However, the amount of material removed was about double the volume that was

originally anticipated. The conditions encountered in this area differed from the ROPS main channel area, with significantly lower pre-dredge PCB concentrations and the absence of significant obstructions and hard bottom within the target cut depth of 1 foot.

Thin-layer capping was successfully demonstrated in the southern near shore area during the 2005 ROPS. Manual elevation measurements following material placement indicated an average cap thickness of about 0.4 feet. Four of six cores collected about 2 weeks after cap placement contained cap material (range of 0.2 to 0.3 ft). The two cores with no visible cap material were collected between the cap thickness measurement grid nodes in the central part of the cap area. Considering the cores with a visible cap, the average surficial sediment PCB concentration was 99 percent lower than the pre-capping average. Considering all cores, the reduction was 93 percent. Post-placement monitoring conducted in 2006, 2007, and 2010 verified that the near shore area cap was present and that PCBs in the top 2 inches of the cap remained relatively low (about 84 to 91 percent lower than pre-cap conditions). These data also revealed the need for potential construction improvements during cap placement, especially in areas characterized by steep side slopes. These construction improvements include modified placement procedures, consideration of the side slope steepness in the cap design, the use of a 6 inch target cap thickness, and more rigorous quality control procedures for establishing cap coverage and thickness. These considerations would be addressed during the remedial design phase (see Appendix E for additional details).

The armored cap was successfully placed over the fine sediments of the river and, with the exception of a single isolated area, has not settled since installation. (See Section 2.5.3 for more information.)

- *Activated Carbon Pilot Study (ACPS)*: The ACPS was conducted in summer and fall 2006 to evaluate the ability to deliver activated carbon to in-place sediments and assess the effectiveness of this approach in reducing the bioavailability of PCBs in river sediments and biota. Several laboratory and field studies have demonstrated that this technology is effective at sequestering PCBs in the activated carbon matrix, thereby reducing the bioavailability of the PCBs in the treated sediments. The ACPS consisted of the placement and mixing (either through mechanical or natural processes) of activated carbon into the biologically active portion of the river sediments in a 0.5-acre area of the lower river. The study included monitoring of the in-river operations and the impact on water quality during activated carbon application, and a 3-year post-application physiochemical and biological monitoring program.

2006 Activated Carbon Pilot Study

The ACPS demonstrated that activated carbon can be successfully applied to river sediments with minimal impact to water quality within the river. No measurable changes in water column PCBs were observed adjacent to or downstream of the pilot area, and only minor increases in TSS were measured. Post-construction monitoring revealed that the placed carbon is stable in the fine sediments and has significantly reduced PCB bioavailability. Batch equilibrium experiments show that aqueous phase PCB concentrations in surface sediments have been reduced by more than 95 percent at activated carbon concentrations of 2 percent or greater (Figure ES-8, attached). In-situ and ex-situ biological uptake studies show 80 to 90 percent reductions at activated carbon levels greater than 2 percent. (See Section 2.5.4 for additional details.)

Evaluation of Potential Risks

In 1993, the USEPA conducted a baseline risk assessment (BLRA; USEPA, April 1993) to evaluate potential risks associated with exposure to sediment, surface water, and biota in the Grasse River Study Area. The key finding of USEPA's work was the identification of PCBs as the primary driver of potential risks at the site.

Alcoa updated the human health portion of USEPA's assessment in 2002 in order to incorporate more recent site-specific data and assumptions, updated PCB exposure and toxicity factors, and current scientific and regulatory policy (RA Update; Alcoa, July 2002). The key conclusions from the RA Update follow.

- Consumption of PCB-containing fish from the lower Grasse River is the only exposure pathway with potential elevated risks and hazards for humans.
- Exposures to PCBs in sediment and surface water are generally associated with risks or hazards at or below the USEPA-established target risk level.

In addition, at the request of USEPA, Alcoa incorporated the revised exposure factors used in the RA Update to evaluate cancer risks and non-cancer hazards from non-PCB chemicals of concern (COCs) identified in the 1993 BLRA. These results support the conclusion from USEPA's (1993) BLRA that PCBs are the primary risk driver in the Grasse River.

USEPA needed to revisit the ecological portion of the 1993 BLRA to reflect current information, and therefore prepared the ecological risk analysis update (ERAU) in July 2010. The ERAU (USEPA, July 2010) concluded there is potential risk to piscivorous birds and mammals and insectivorous mammals. The potential risk to higher trophic-level organisms (i.e., birds and mink) were associated with the consumption of prey that bioaccumulate PCBs (i.e., fish and insects). As a result, USEPA developed ecological risk based sediment cleanup ranges for PCBs (SRC/SERAS, August 2010).

The risk assessment information summary is based on the findings of the BLRA, RA Update, and ERAU documents and includes the assumptions required by USEPA. Alcoa believes that a number of the assumptions used in calculating potential site risks are overly conservative and result in an overstatement of potential risk to the identified receptors. USEPA understands that there is uncertainty in the calculation of risk that may result in either an under or over estimate of risk. However, it should be noted that the exposure assumptions selected by USEPA are consistent with Agency policies, practices, and guidance and are representative of the Reasonable Maximum Exposed individual as well as the Central Tendency Individual. (See Section 3.2 for more on the risk assessments.)

Remedial Action Objectives

Remedial Action Objectives (RAOs) for protection of human health and the environment are the goals against which the remedial alternatives are evaluated. The final RAOs for the lower Grasse River were provided by USEPA, and are as follows (see Section 3.3 for more details on the RAOs):

1. Reduce the cancer risks and non-cancer health hazards for people eating fish from the Grasse River by reducing the concentration of PCBs in fish.

   The risk-based preliminary remediation goal (PRG) for the protection of human health is 0.05 mg/kg PCBs in fish fillet based on non-cancer hazard indices for the RME adult fish consumption rate of one half-pound meal per week (this level is protective of cancer risks as well). The risk-based PRG for the protection of Mohawk human health is 0.01 mg/kg PCBs in fish fillet based on non-cancer hazard indices for the adult tribal subsistence population with a consumption rate of 142 grams per day. Other target concentrations are 0.26 mg/kg PCBs in fish fillet, which is protective for cancer risks for the adult avid angler at a fish consumption rate of one half-pound meal per month and 0.36 mg/kg PCBs in fish fillet, which is protective of the central tendency (CT) or average angler, who consumes one half-pound meal every two months.

2. Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish.

   The risk-based PRG for the ecological exposure pathway is a range in whole-body fish (brown bullhead, spottail shiner) PCB concentrations of 0.22 to 0.44 mg/kg (wet weight) based on the lowest

observed adverse effect level (LOAEL) and the no observed adverse effect level (NOAEL) for consumption of fish by the mink. The ecological PRG is considered protective of all the ecological receptors evaluated because it was developed for the mink, the piscivorous mammal calculated to be a greatest risk from PCBs at the site. In addition, a range from 0.1 to 0.2 mg/kg (wet weight) PCBs in brown bullhead fillet was developed based on the NOAEL and LOAEL for consumption of fish by the mink.

3. Minimize the current and potential future bioavailability of PCBs in sediments.

   PCBs in sediments may become bioavailable by various mechanisms (e.g., pore water diffusion, bioturbation, biological activity, benthic food chains, ice jam event scour, etc). Minimizing the degree to which such mechanisms may make PCBs bioavailable (e.g., through removal and/or containment) will reduce PCB levels in biota and the associated risks to human health and the environment.

4. Protect the ecosystem of the lower Grasse River.

   The remedy will protect the ecosystem and replace and/or reconstruct habitat impacted by remedial activities in order to re-establish appropriate conditions for supporting the fish and wildlife of the river. The remedy will be monitored for ecosystem recovery through the measurement and analysis of appropriate physical, chemical, and biological parameters.

5. Minimize the long-term transport of PCBs from the lower Grasse River to the St. Lawrence River.

   PCBs that are transported downstream in the water column are available to biota, contributing to the risks from the site. Downstream transport also may move PCBs from contaminated areas to clean areas and from the lower Grasse River to the St. Lawrence River.

The work already performed at the site has resulted in significant progress toward the RAOs. Controlling PCB sources to the river has allowed natural recovery processes to reduce PCB concentrations in fish and the water column by about 90 percent. An important consideration in evaluating remedial alternatives includes the ability to accelerate the ongoing recovery of the river while not taking actions which can reverse the significant progress that has been made to date.

Development of Remedial Alternatives

In 2002, Alcoa submitted an AA Report to USEPA (Alcoa, June 2002). The evaluation of remedial alternatives presented in that report did not consider ice jam-induced scour, as this phenomenon was unknown prior to the ice jam event of 2003. This report incorporates the knowledge gained from the numerous ice-related studies, data collection and site-specific pilot studies conducted in the river subsequent to the 2003 ice event, and interactions with and specific directives from USEPA on the final list of alternatives. In this report, 10 potential alternatives are evaluated and carried forward for detailed analysis (see Section 5); these are summarized below. The figures referenced in the table below (which are included in the main body of the AA Report) show the areas of the river targeted for remedial action for each alternative. While in-situ activated carbon technology is not specifically identified in the list of remedial alternatives evaluated in the AA Report, results to date from the ACPS post-construction monitoring are very promising and support that activated carbon placement should be considered for integration into the site remedy during the remedial design phase.

Potential Remedial Alternatives for the Grasse River Study Area

Alternative 1 • No Further Action • No implementation period • No cost	***Alternative 2*** • MNR • No implementation period • Cost: $3.4 million

Alternative 3
(see Figure 4-2)
• T1-T72 Capping
  • Main channel
  T1-T21: Armor cap ≥ 1 mg/kg
  T21-T72: Cap ≥ 1 mg/kg
  • Near shore
  T1-T72: Near shore cap ≥ 1 mg/kg
• Implementation time: 3 years
• Cost: $114.1 million
	Alternative 4
	(see Figure 4-3)
	• T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping
	  • Main channel
	  T1-T21: Armor cap ≥ 1 mg/kg
	  T21-T72: Cap ≥ 1 mg/kg
	  • Near shore
	  T1-T21: Dredge/backfill to grade ≥ 1 mg/kg
	  T21-T72: Near shore cap ≥ 1 mg/kg
	• Implementation time: 3 years
	• Cost: $147.2 million

Alternative 5
(see Figure 4-4)
• T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping
  • Main channel
  T1-T21: Armor cap ≥ 1 mg/kg
  T21-T72: Cap ≥ 1 mg/kg
  • Near shore
  T1-T72: Dredge/backfill to grade ≥ 10 mg/kg and near shore cap ≥1 and <10 mg/kg
• Implementation time: 4 years
• Cost: $175.2 million
	Alternative 6
	(see Figure 4-5)
	• T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping
	  • Main channel
	  T1-T21: Armor cap ≥ 1 mg/kg
	  T21-T72: Cap ≥ 1 mg/kg
	  • Near shore
	  T1-T72: Dredge/backfill to grade ≥ 1 mg/kg
	• Implementation time: 4 years
	• Cost: $243.1million

Alternative 7
(see Figure 4-6)
• T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping
  • Main Channel
  ROPS WZ2 and 3 and T16.5 to T19.5: Dredge/armor cap
  T1-T21: Armor cap remaining undredged sediment ≥ 1 mg/kg
  T21-T72: Cap ≥ 1 mg/kg
  • Near shore
  T1-T72: Dredge/backfill to grade ≥ 1 mg/kg
• Implementation time: 5 years
• Cost: $351.6 million
	Alternative 8
	(see Figure 4-7)
	• T1-T21 Dredging/Capping, T21-T72 Capping
	  • Main channel
	  T1-T21: Dredge/armor cap ≥ 1 mg/kg
	  T21-T72: Cap ≥ 1 mg/kg
	  • Near shore
	  T1-T21: Dredge/backfill to grade ≥ 1 mg/kg
	  T21-T72: Near shore cap ≥ 1 mg/kg
	• Implementation time: 8 years
	• Cost: $388.0 million

Alternative 9
(see Figure 4-8)
• T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping
  • Main Channel
  ROPS WZ2 and 3 and T16.5 to T19.5: Dredge/armor cap
  T1-T21: Armor cap remaining undredged sediment ≥ 1 mg/kg
  T27 to T37 and T43 to T46: Dredge/cap
  T21-T72: Cap remaining undredged sediment ≥ 1 mg/kg
  • Near shore
  T1-T72: Dredge/backfilling to grade ≥ 1 mg/kg
• Implementation time: 7 years
• Cost: $588.5 million
	Alternative 10
	(see Figure 4-9)
	• T1-T72 Dredging/Capping
	  • Main channel
	  T1-T21: Dredge/armor cap ≥ 1 mg/kg
	  T21-T72: Dredge/cap ≥ 1 mg/kg
	  • Near shore
	  T1-T72: Dredge/backfill to grade ≥ 1 mg/kg
	• Implementation time: 18 years
	• Cost: $1.27 billion

Note:
1. All alternatives include ongoing site-wide natural recovery.

Evaluation of Remedial Alternatives

The 10 potential remedial alternatives were evaluated – both individually (Section 5) and comparatively (Section 6) – against seven of the nine decision-making criteria required by CERCLA and the NCP. The two modifying criteria, acceptance by the State (support agency) and the community, will be addressed by USEPA after compiling input received during the public comment period on the Proposed Plan.

The individual and comparative evaluations, along with results of site-specific modeling and data analyses performed since the early to mid-1990s, indicate that all 10 alternatives can be implemented and would provide some measure of overall protection of human health and the environment. What emerged as the key differences between the alternatives are the time until the RAOs are achieved (measured by long-term effectiveness and permanence), short-term effectiveness, and relative cost.

The effectiveness of the alternatives was evaluated using metrics for Grasse River fish tissue PCB concentrations and PCB loading to the St. Lawrence River. These included the predicted Grasse River fish tissue PCB concentration at the end of the model simulation period (i.e., 2036) and the percent reductions in PCB loading to the St. Lawrence River achieved by the year 2036. Based on the Remedial Action Objectives tied to PCB levels in fish tissue, projections were also made for the times to achieve fish tissue PCB concentrations of 0.36, 0.26, and 0.05 mg/kg. A final metric evaluated was the time to achieve a sediment (0-3 inches) PCB concentration of 1 mg/kg.

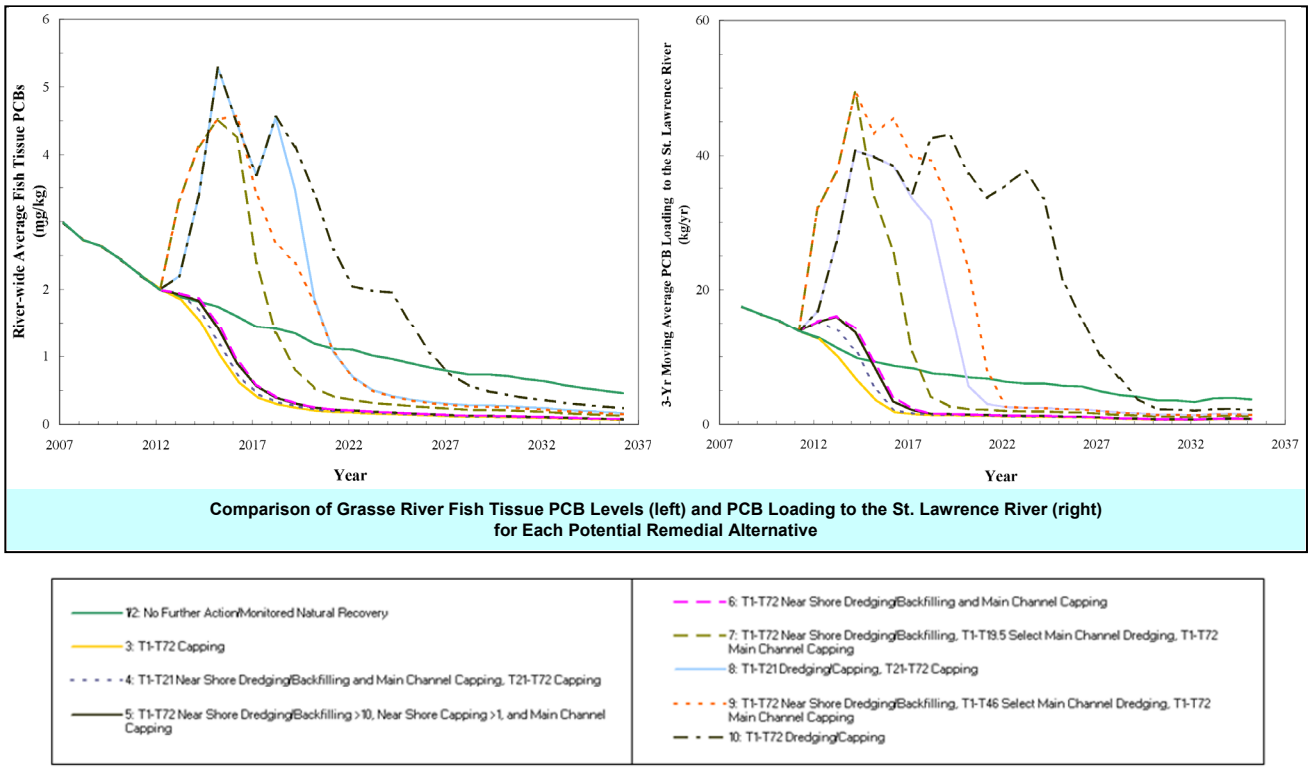
Long-Term Effectiveness and Permanence

Modeling was used to predict changes in PCB levels in water (including loading to the St. Lawrence River), sediment, and fish over the 30-year period from 2007 through 2036. For the model to simulate the remedial alternatives, a number of assumptions were made about implementation and effectiveness in reducing PCB levels in the river. While these are explained in detail in Appendix A, all key assumptions were based on site-specific data gathered during the 1995 NTCRA, 2001 CPS, and 2005 ROPS. For example, site-specific data demonstrated that 3 percent of the mass of PCBs dredged is released to the water column, and post-dredging PCB residual concentrations approximately equal the segment length-weighted average (SLWA) PCB concentration of the sediments removed. Conversely, the results of site-specific studies support that capping reduces surface sediment PCB concentrations by 95 percent.

All 8 alternatives evaluated that include active remediation (Alternatives 3 through 10) are capable of achieving the RAOs and providing long-term protectiveness through site-wide natural recovery processes, benefits provided by completed external source control, and dredging/capping or capping only of PCB-containing sediment. All remedial alternatives are predicted to substantially reduce PCB levels in Grasse River fish and PCB loading to the St. Lawrence River over the 30-year projection period. By the year 2036, all alternatives are predicted to achieve a fish tissue PCB concentration below 0.46 mg/kg, with the lowest levels of about 0.07 mg/kg attained by the Alternatives 3 through 6 that emphasize capping as the primary remedial technology. Alternatives 7 through 10, which emphasize dredging technologies, are predicted to cause substantive increases in Grasse River fish PCB levels and PCB loading to the St. Lawrence River during remedy implementation consistent with what was observed during both the ROPS and NTCRA projects. These negative short-term impacts due to main channel dredging-related releases do not achieve greater reductions in long-term fish tissue levels attained by the alternatives that utilize capping as the primary remedial technology (Alternatives 3 through 6).

Implementation of those alternatives that include dredging would reduce the mass of PCBs in the lower Grasse River through permanent removal of this material. PCB mass removal does not necessarily equate to a reduction in risk (NRC, 2007).

The figures below show graphical representations of predicted reductions in Grasse River fish tissue PCB levels and PCB loading to the St. Lawrence River through 2036 associated with each alternative.



Comparison of Grasse River Fish Tissue PCB Levels (left) and PCB Loading to the St. Lawrence River (right) for Each Potential Remedial Alternative

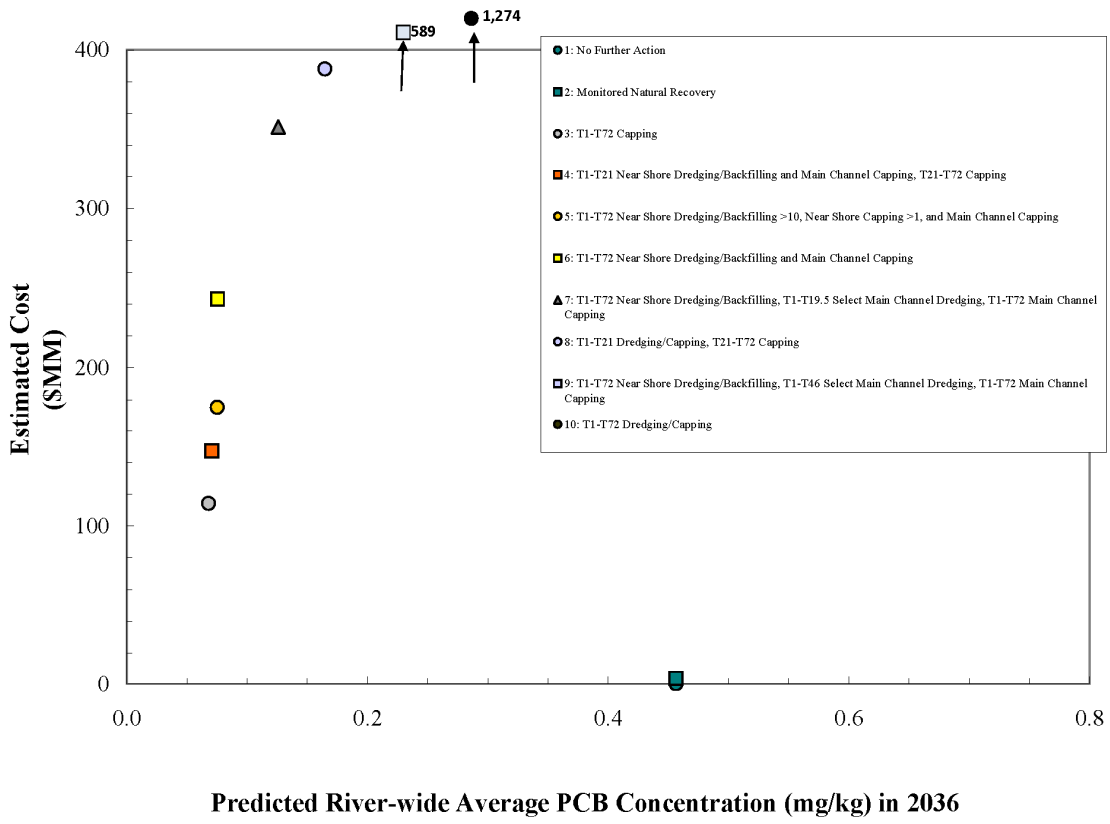
Short-Term Effectiveness

The short-term effectiveness criterion is used to assess the impacts and risks associated with implementation and construction of an alternative as well as near-term improvements achieved by the action. Implementation of either Alternative 1 or 2 – the No Further Action and MNR alternatives – will not lead to any short-term impacts or risks. For the alternative involving capping without dredging (Alternative 3), minimal negative short-term impacts are expected based on the experiences during the CPS and ROPS (see summary in the "Investigations" section). Alternatives incorporating dredging (Alternatives 4 through 10) will cause negative short-term impacts to the water column, potential for increased bioavailability of PCBs, and impacts to the ecosystem. The degree of these impacts would vary depending on the size of the area impacted by dredging. Due to the relatively long construction periods estimated for Alternatives 8 through 10 (7 to 18 years) and the large quantities of sediment targeted for removal (about 355,000 to 1,664,000 cy), short-term impacts resulting from implementation of these alternatives would be the most significant among the 10 alternatives.

For all alternatives (except No Further Action and MNR), reductions in both fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River are driven by the placement of a cap. The addition of dredging causes near-term degradation of water quality and increases in fish PCB levels in the Grasse River and PCB loading to the St. Lawrence River.

Time to Achieve Risk Reduction & Cost

The 10 remedial alternatives can be categorized into three general groupings based on the length of time necessary to achieve the PCB reduction metrics associated with the RAOs. These groupings are as follows (see Section 6.8): Alternatives 1 and 2 (no active remediation); Alternative 3 (capping) and Alternatives 4 through 6 (capping emphasis with some dredging); and Alternatives 7 through 10 (dredging emphasis with capping). All alternatives include ongoing site-wide natural recovery. As shown on the figure below, Alternatives 1 and 2 (no active remediation) are projected to achieve an average 2036 fish tissue PCB concentration of about 0.46 mg/kg at a cost of $0 to $3.4 MM. Alternative 3 (capping) is projected to achieve average 2036 fish tissue PCB concentration of about 0.07 mg/kg at a cost of about $114 MM. Alternatives 4 through 6 (capping emphasis with some dredging) are projected to achieve similar 2036 fish tissue PCB concentrations, as Alternative 3 but at costs that range between $147 MM to $243 MM.



Cost as a Function of Predicted Grasse River Fish Tissue PCB Levels in 2036

The higher costs for these alternatives are due to the inclusion of dredging components in addition to capping, which was determined to provide no additional benefit in terms of absolute reductions in predicted PCB levels in Grasse River fish and PCB loading to the St. Lawrence River – using assumptions that realistically portray the effectiveness of dredging and the benefit of capping. The dredging alternatives reduce the mass of PCBs potentially available for future remobilization, albeit at a greater cost. Alternatives 7 through 10, which consider larger-scale dredging components, are less protective in terms of fish tissue PCB concentrations and risk reduction relative to the alternatives that emphasize capping (i.e., Alternatives 3 through 6), have the highest short-term impacts of all the alternatives, and are the most costly of the alternatives considered. These alternatives are projected to achieve average 2036 fish tissue PCB concentration of between 0.13 and 0.24 mg/kg (Alternatives 7 through 10) – less protection in terms of fish tissue PCBs and risk reduction relative to the other alternatives – at costs that range between $352 MM and $1.27 billion (B). In all cases, dredging adds significant cost, but provides no additional benefit in terms of reducing fish PCB concentrations and associated potential risks.

Summary

Based on information gathered and assessed to date, reduction of surface sediment PCB levels over a large area of the lower Grasse River is necessary to achieve further significant reductions in PCB concentrations in fish and the water column. Currently available options for achieving these reductions include natural recovery, capping, and dredging, either alone or in combination. In-situ application of activated carbon has also been successfully demonstrated during the Grasse River ACPS to significantly reduce PCB exposure and bioaccumulation in test organisms.

The lessons learned during the NTCRA, CPS, and ROPS at this site, as well as those reported in the NRC study on dredging effectiveness (NRC, 2007) and elsewhere indicate that, while capping effectively reduces surface sediment PCB concentrations without significant environmental impacts, dredging releases PCBs and can result in residual PCB levels in surface sediment that are higher than current conditions. To account for the elevated PCB residuals in sediments after dredging, the alternatives that include dredging also include the placement of a cap over the dredged areas.

Although all the potential alternatives achieve the goals of reducing PCB levels in Grasse River fish and loading to the St. Lawrence River, Alcoa's evaluation of the results of site-specific modeling, data analyses, the comparative analysis, and experience gained during the NTCRA, CPS, and ROPS lead to the following conclusions:

- Source control actions, coupled with natural recovery processes, have resulted in declines in fish tissue PCB concentrations of about 90 percent.

- The primary differences among the effectiveness of the alternatives are the projected rates at which PCB concentrations decline, short-term effectiveness, and cost.

- Natural recovery reduces fish tissue PCB concentrations at the lowest cost, albeit more slowly than alternatives with dredging and/or capping components. The rate of natural recovery could be impacted by periodic ice jam-related scour events; however, the 2003 ice jam only produced a measured increase in one of the three species in only one of the three monitoring reaches that are routinely monitored at the site, and this impact did not have any substantive effect on the recovery of site-wide fish tissue PCB levels.

- Effectiveness of the alternatives (except No Further Action and MNR) is driven by placement of a cap. When combined with large-scale capping, dredging has a negative influence on the achievement of PCB metrics.

- Dredging in the targeted areas can remove mass from the river, but the volume of sediment removed from the river has little bearing on risk reduction. As stated by the NRC, "Remedies should be designed to meet long term risk reduction goals (as opposed to metrics not strictly related to risk, such as mass removal targets)" (NRC, 2007 – p. 8).

- Increases in Grasse River PCB fish tissue levels and PCB loading to the St. Lawrence River will be observed during dredging activities. The magnitude and duration of these impacts increase with the extent of the dredging program.

- A cap can achieve rapid risk reduction, can be implemented with minimal short-term effects or overall impacts to the ecosystem, and is expected to remain stable in the Grasse River system.

- The capping-only alternative (Alternative 3) provides equivalent or better risk reduction to the combination alternatives (Alternatives 4 through 10) at much lower cost.

- Protection against ice jam-induced scour will be provided by use of an armored cap (Alternatives 3 through 10).

- Alternatives 4 through 10 are expected to provide no benefit beyond that achieved by Alternative 3 – as measured by predicted fish tissue PCB concentrations in 2036 – and add significant cost ($33 MM to $1.159 B).

- Permanence is achieved through dredging/capping and/or capping for the lower Grasse River.

Alcoa is committed to pursuing an effective long-term remedy for the river, and will continue to work cooperatively with the Agencies to achieve this objective.

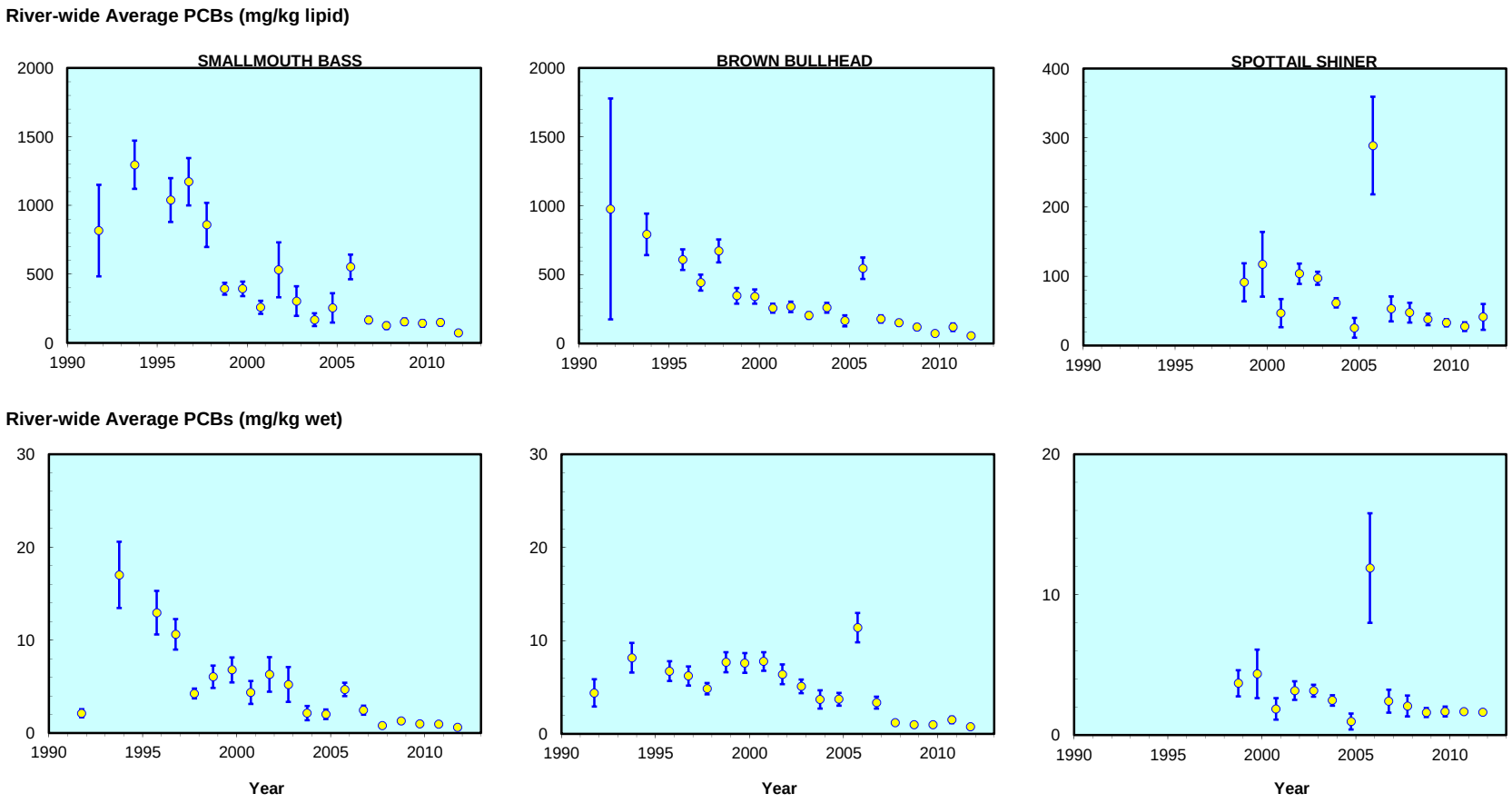
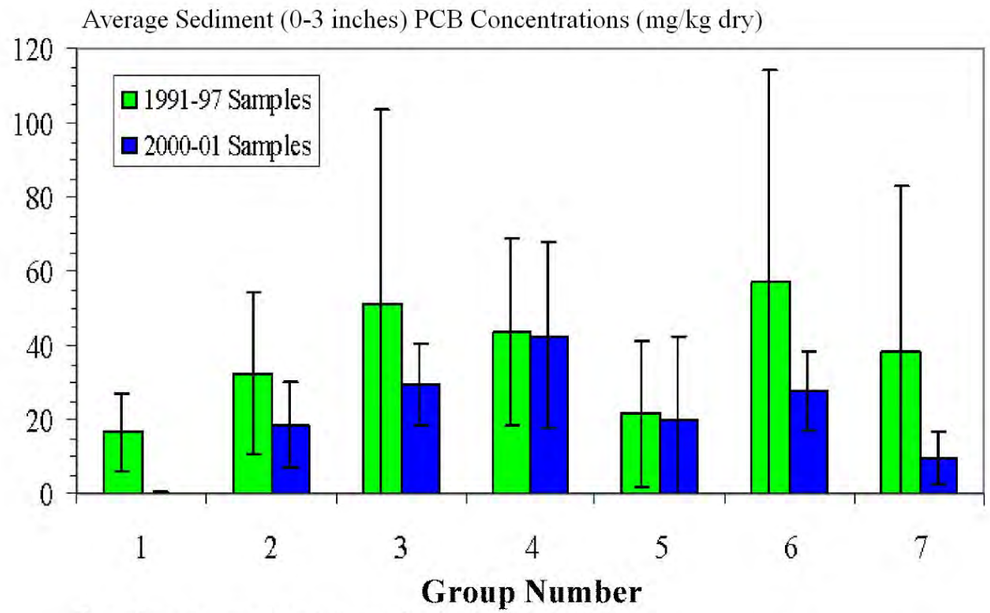
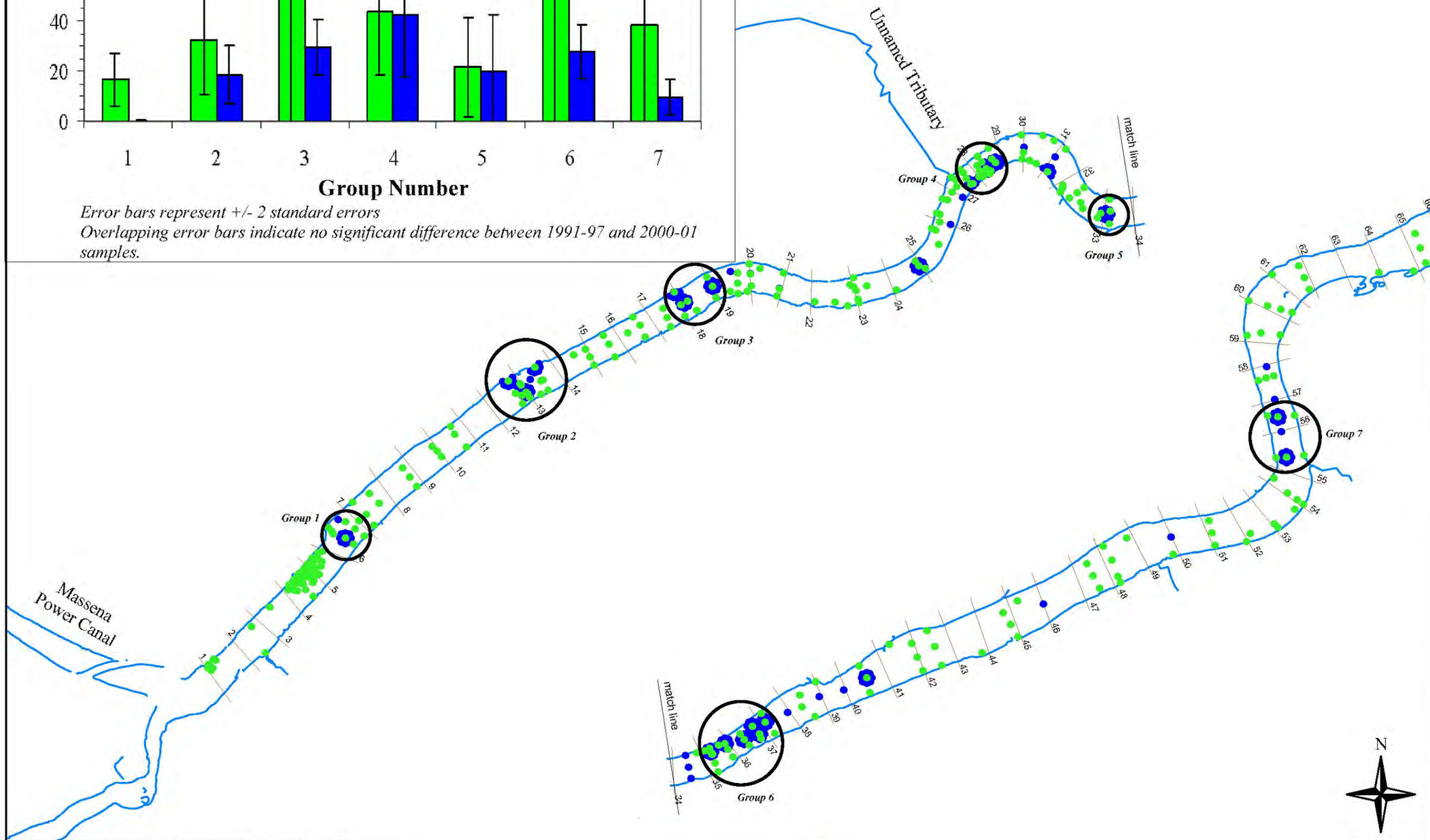


Figure ES-1. River-wide Average Aroclor-based PCB Levels in Smallmouth Bass, Brown Bullhead and Young-of-Year Spottail Shiner.

Values are arithmetic means +/- two standard errors of the mean computed from fall Trend Monitoring Survey Data.
Smallmouth bass and brown bullhead averages computed using fillet samples collected from the Upper, Middle and Lower Stretches.
Spottail shiner averages computed using whole-body composite samples collected from near Outfall 001, near the Unnamed Tributary and River Mouth locations.



Error bars represent +/- 2 standard errors
Overlapping error bars indicate no significant difference between 1991-97 and 2000-01 samples.



GRAPHIC SCALE

0.2 0 0.2 Miles

LEGEND

- 1991-97 Samples
- 2000-01 Samples
- Probing Transect

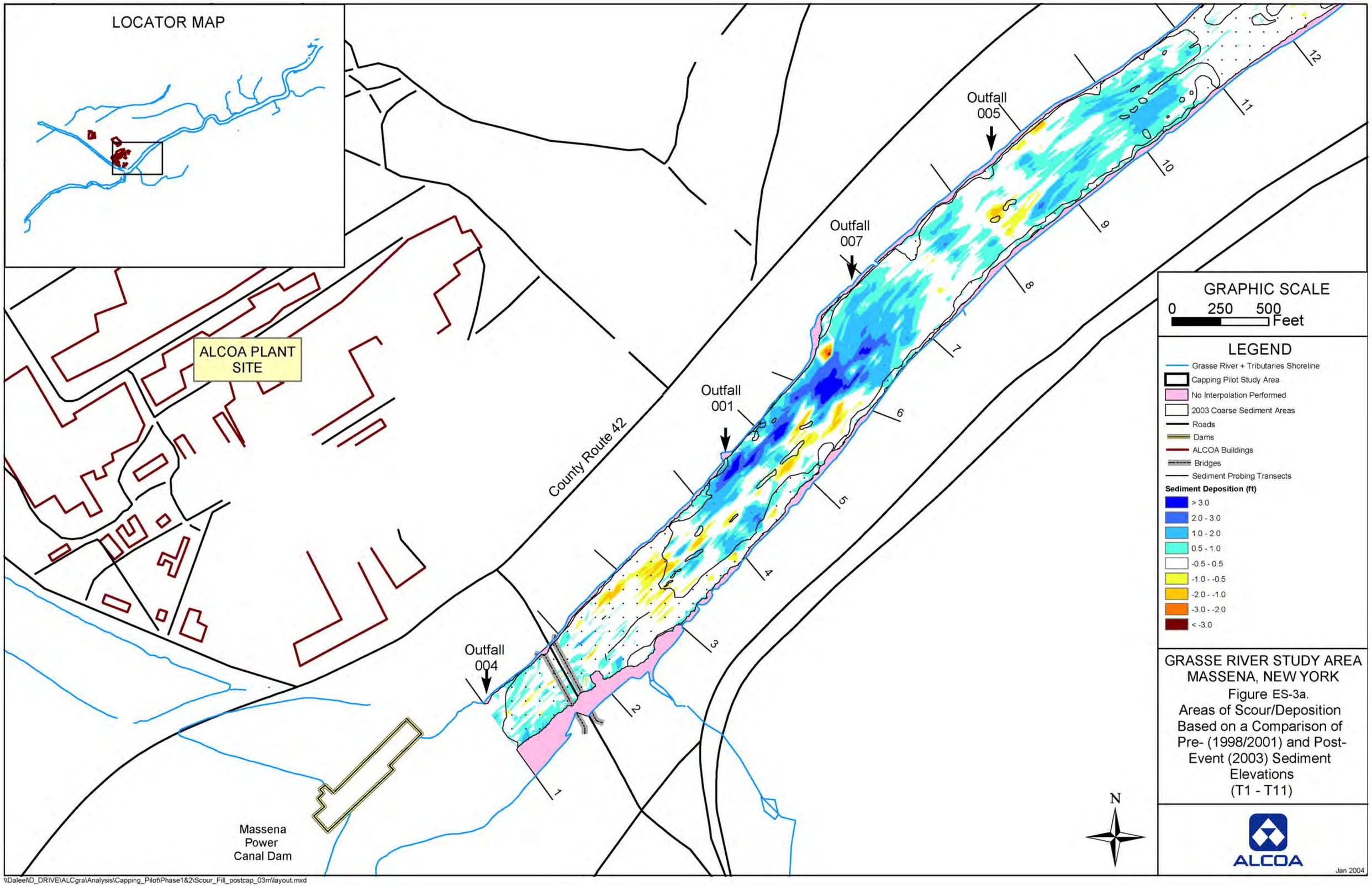
Lower Grasse River Study Area
Massena, New York

Figure ES-2.
Average PCB Concentrations in Surface Sediments Collected Prior to and After January 1998 High Flow

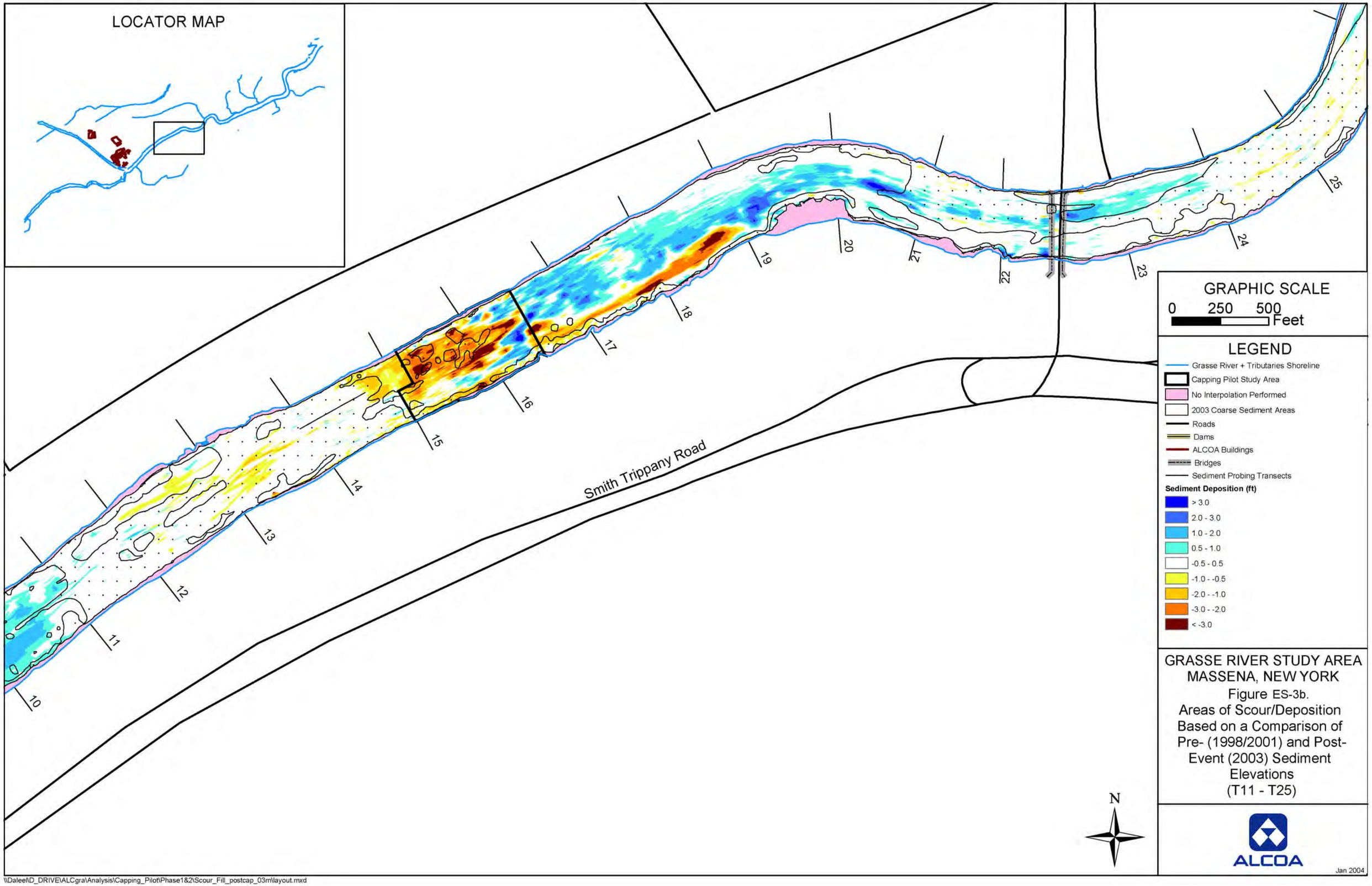
ALCOA

Jan 2002

\\emily\D_drive\ALCgra\documents\reports\AofA_202\main_report\sss_vs_preSSS_fig\sss_vs_preSSS_fig.apr

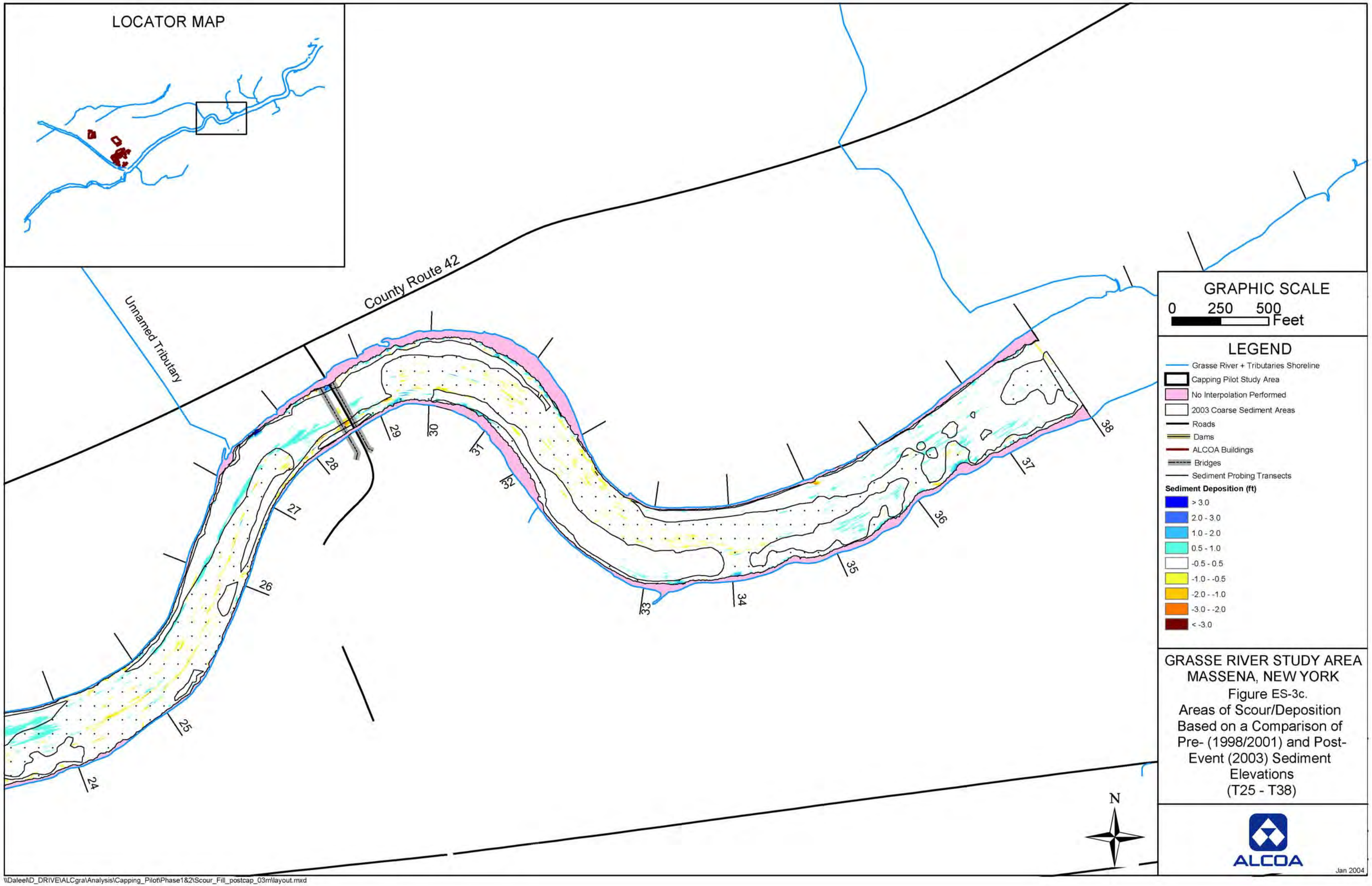


\\Dalee\D_DRIVE\ALCgra\Analysis\Capping_Pilot\Phase1&2\Scour_Fill_postcap_03m\layout.mxd



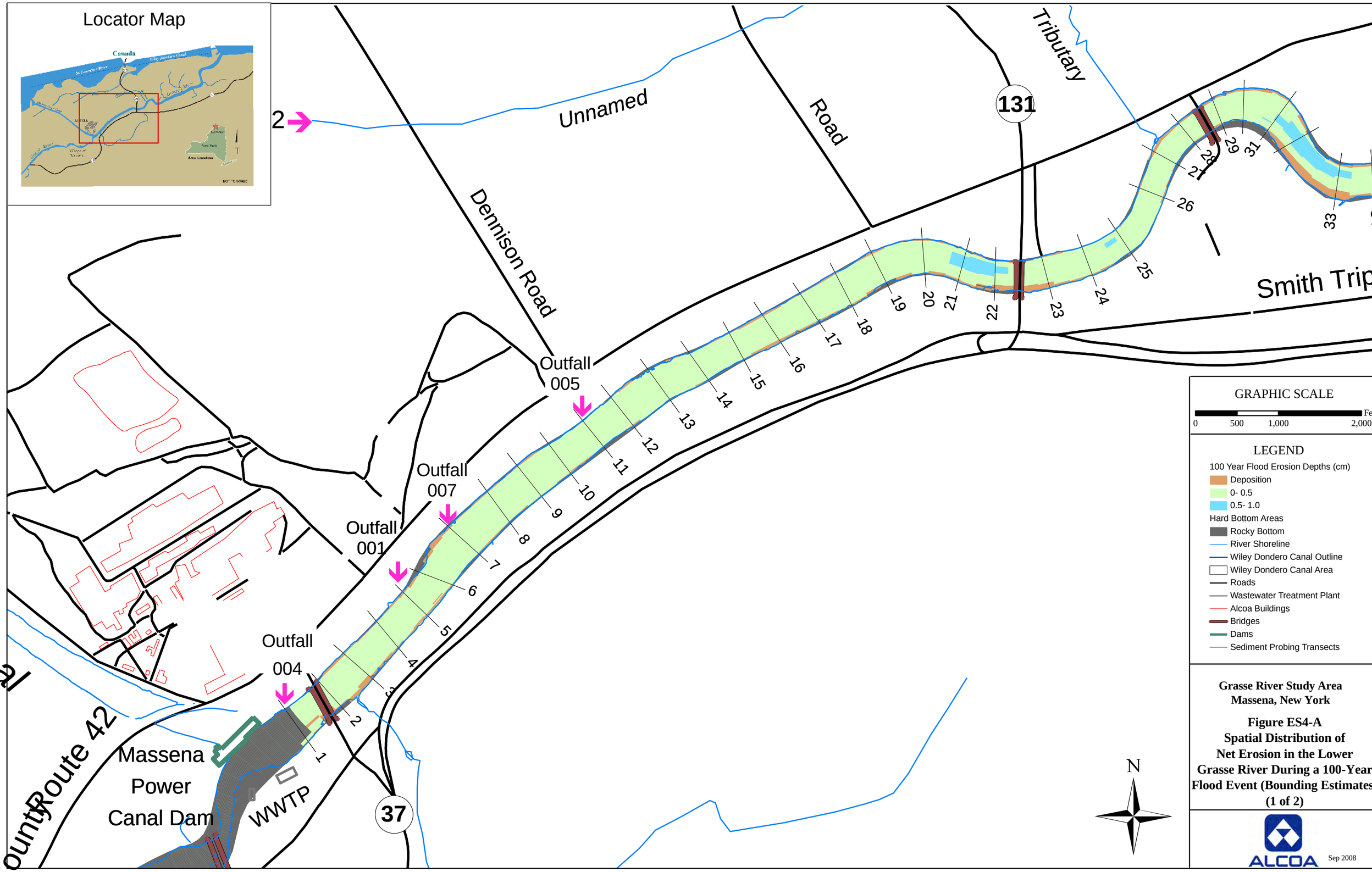
GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
Figure ES-3b.
Areas of Scour/Deposition Based on a Comparison of Pre- (1998/2001) and Post-Event (2003) Sediment Elevations
(T11 - T25)

\\Dalee\D_DRIVE\ALCgra\Analysis\Capping_Pilot\Phase1&2\Scour_Fill_postcap_03m\layout.mxd



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
Figure ES-3c.
Areas of Scour/Deposition Based on a Comparison of Pre- (1998/2001) and Post-Event (2003) Sediment Elevations
(T25 - T38)

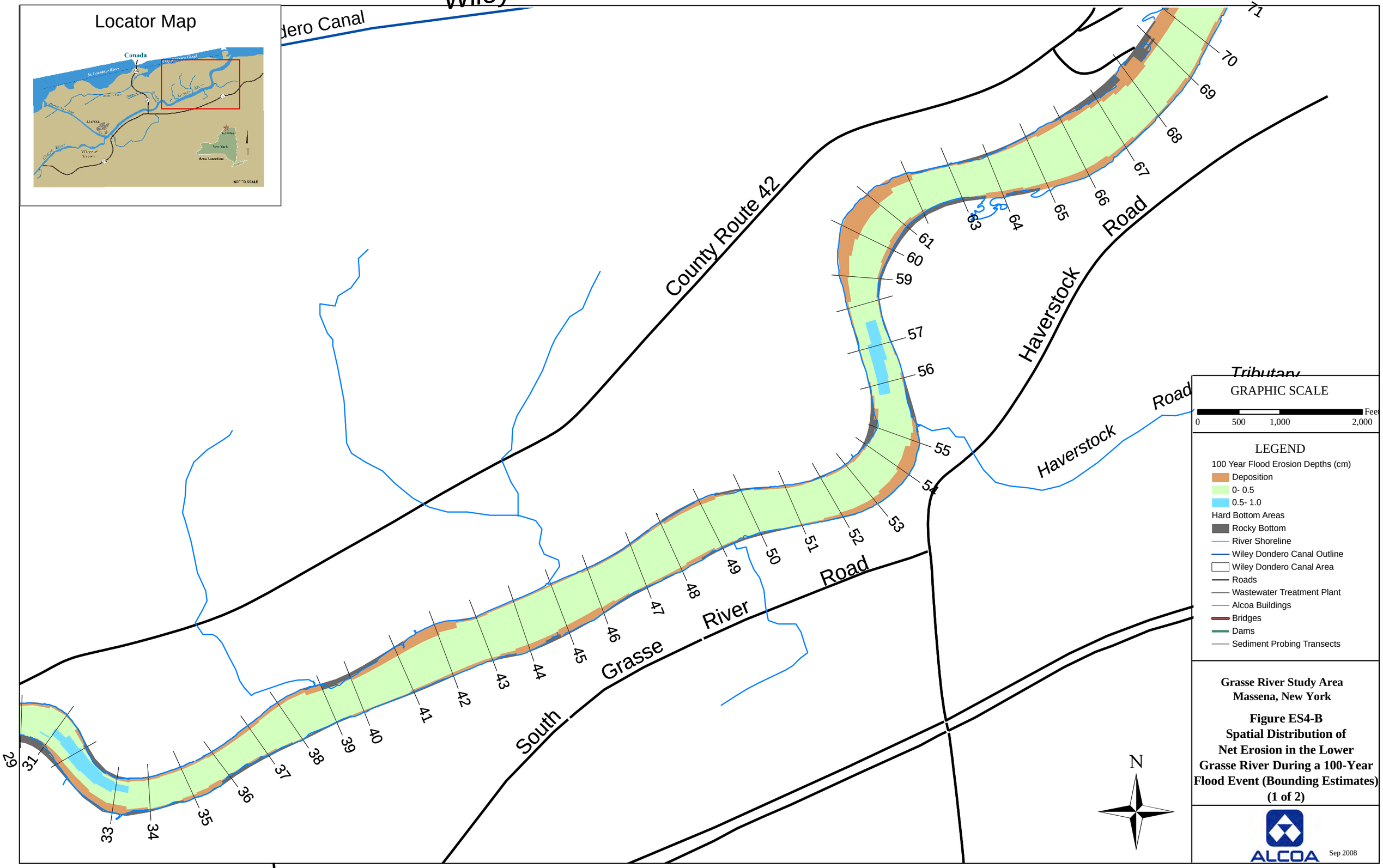
\\Dalee\D_DRIVE\ALCgra\Analysis\Capping_Pilot\Phase1&2\Scour_Fill_postcap_03m\layout.mxd



Grasse River Study Area
Massena, New York

Figure ES4-A
Spatial Distribution of Net Erosion in the Lower Grasse River During a 100-Year Flood Event (Bounding Estimates)
(1 of 2)

W/PMO-\\Peter\D_DRIVE\JOBS\ALCgra\Model\EFDC\Sedtran\Calibration\Longterm\seq-2\GIS_map\98_flood_shift_coh\ALCgra_Model_results_analysis0903.mxd



Grasse River Study Area
Massena, New York

Figure ES4-B
Spatial Distribution of Net Erosion in the Lower Grasse River During a 100-Year Flood Event (Bounding Estimates)
(1 of 2)

BW/PMO-\\Peter\D_DRIVE\JOBS\ALCgra\Model\EFDC\Sedtran\Calibration\Phase-2\GIS_map\98_flood_shift_coh\ALCgra_Model_results_analysis0903.mxd

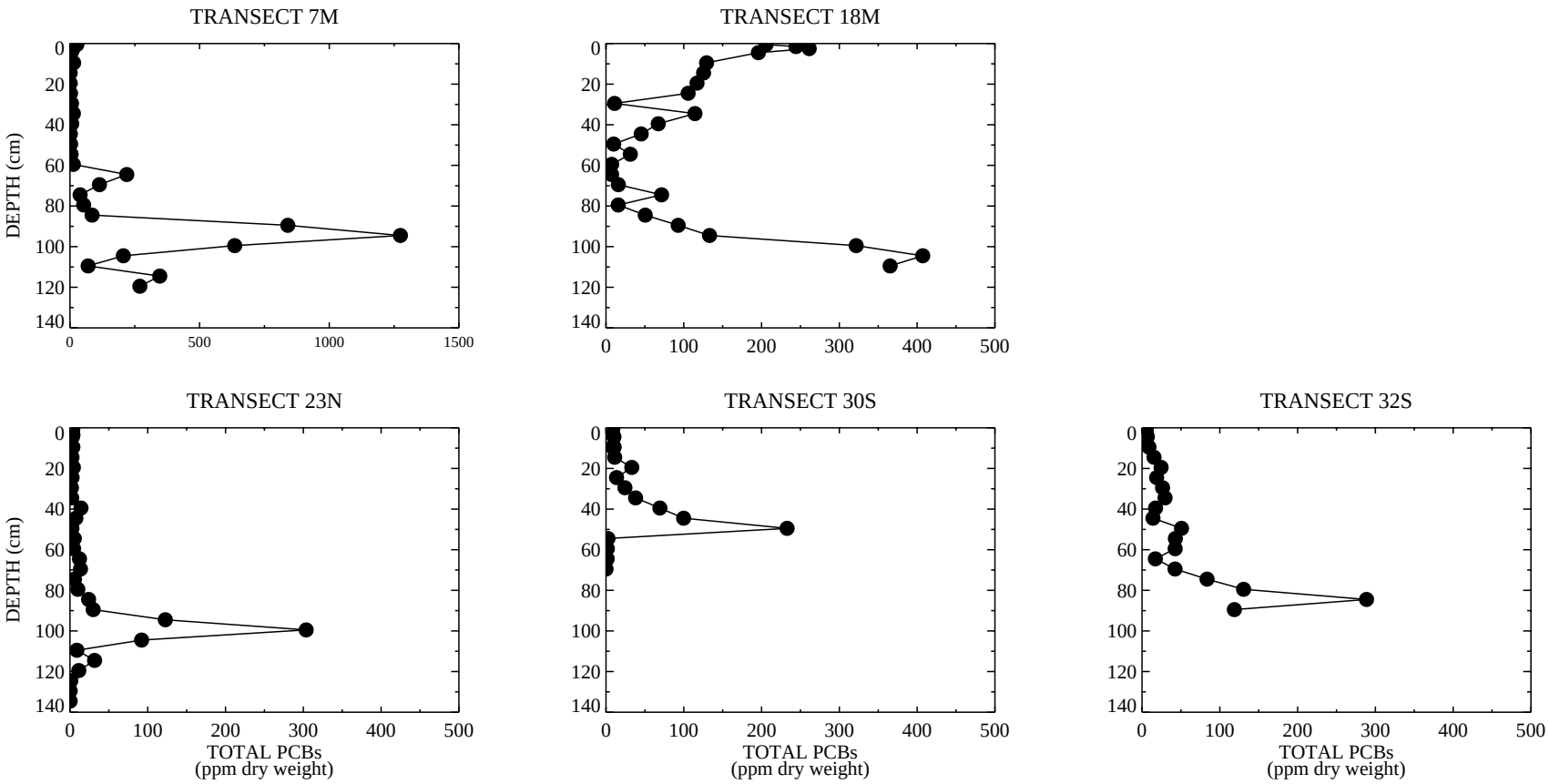


Figure ES-5. Vertical Distribution of Total PCB Levels in Sediment Cores Collected from the Lower Grasse River.

Data from 1997 SRS Sediment Core Sampling Program.

Data table: sediment_bz

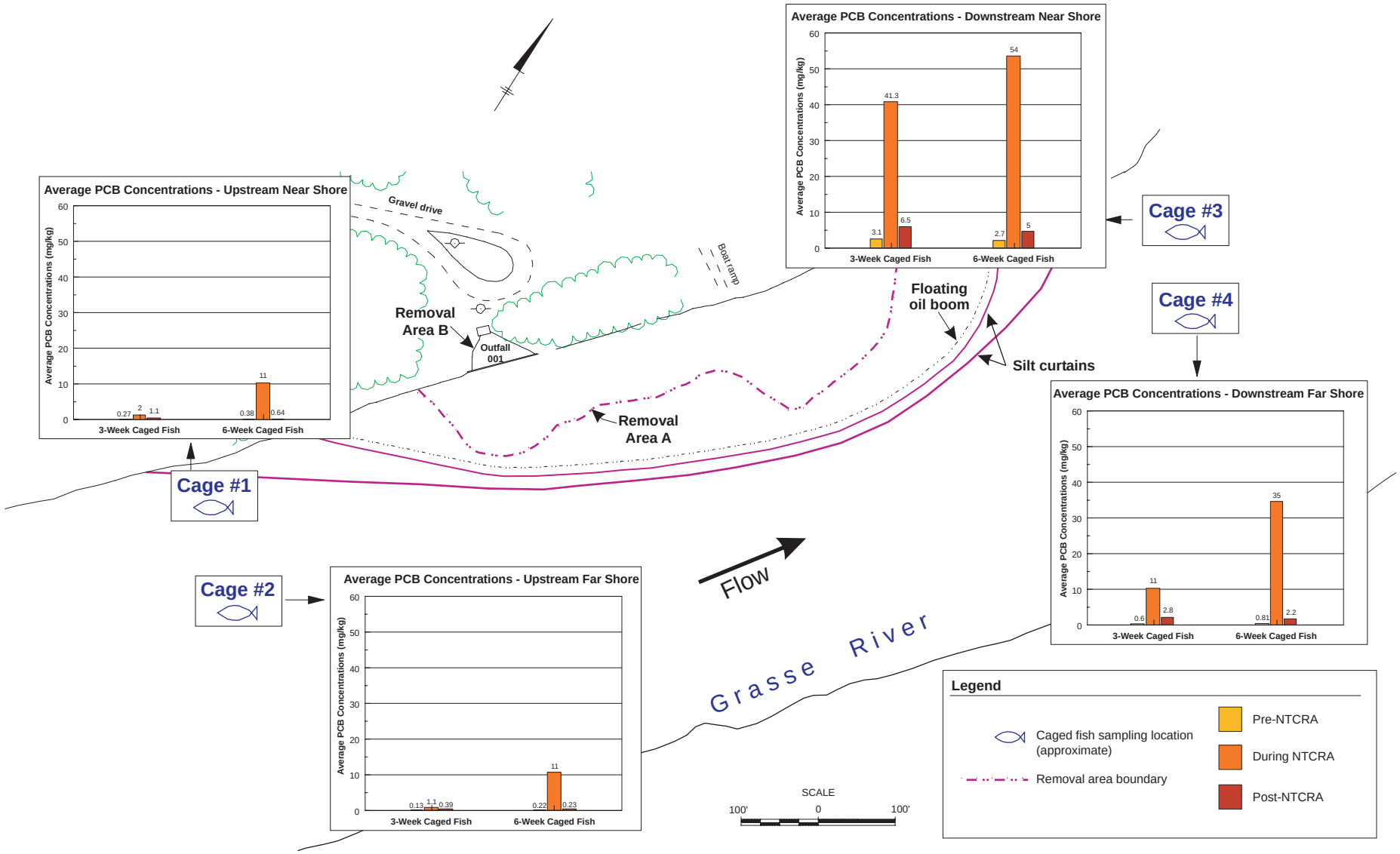


FIGURE ES-6. NTCRA Average PCB Concentrations at Caged Fish Locations

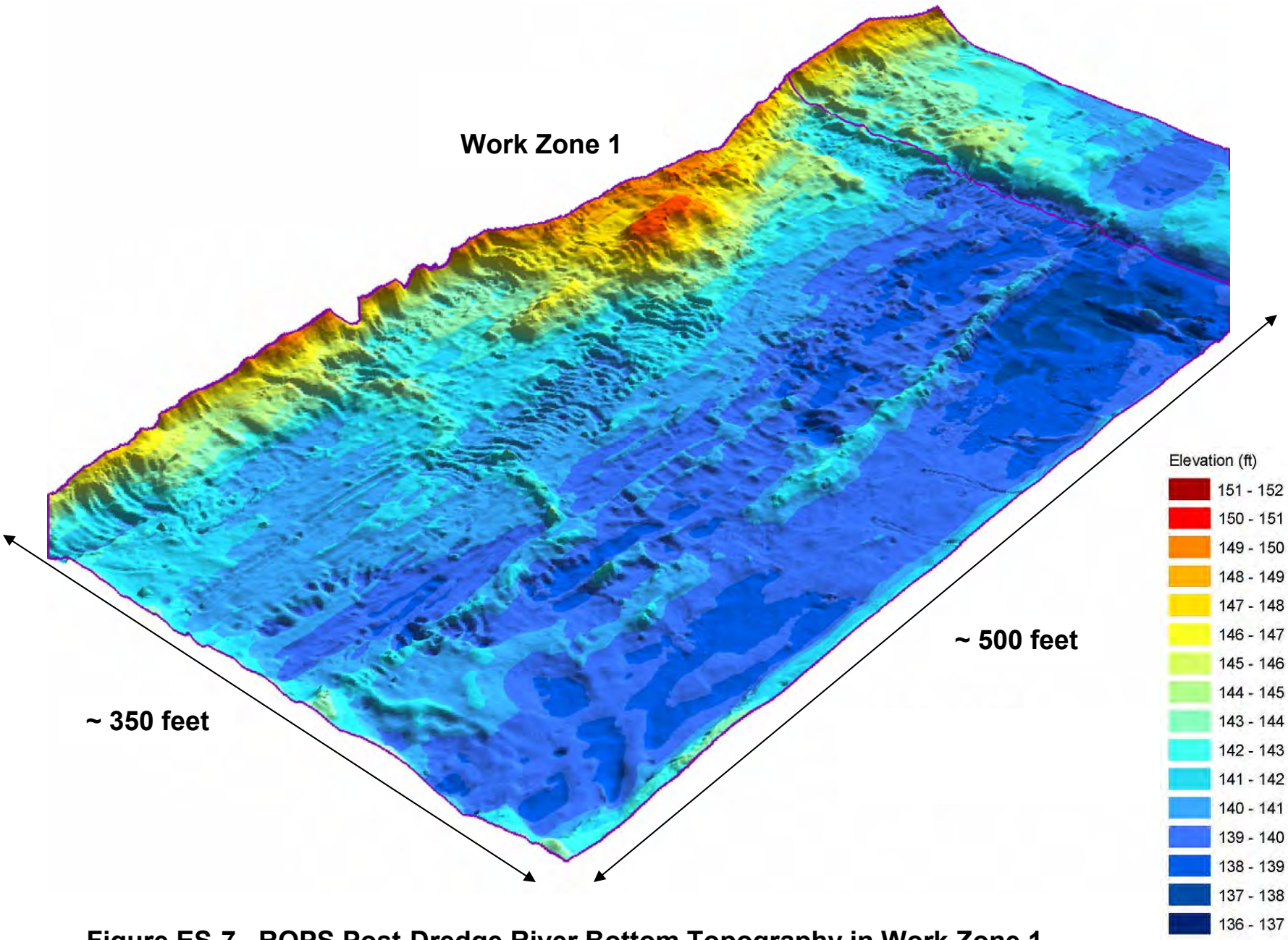


Figure ES-7. ROPS Post-Dredge River Bottom Topography in Work Zone 1.

Based on October 22, 2005 multibeam bathymetry data.

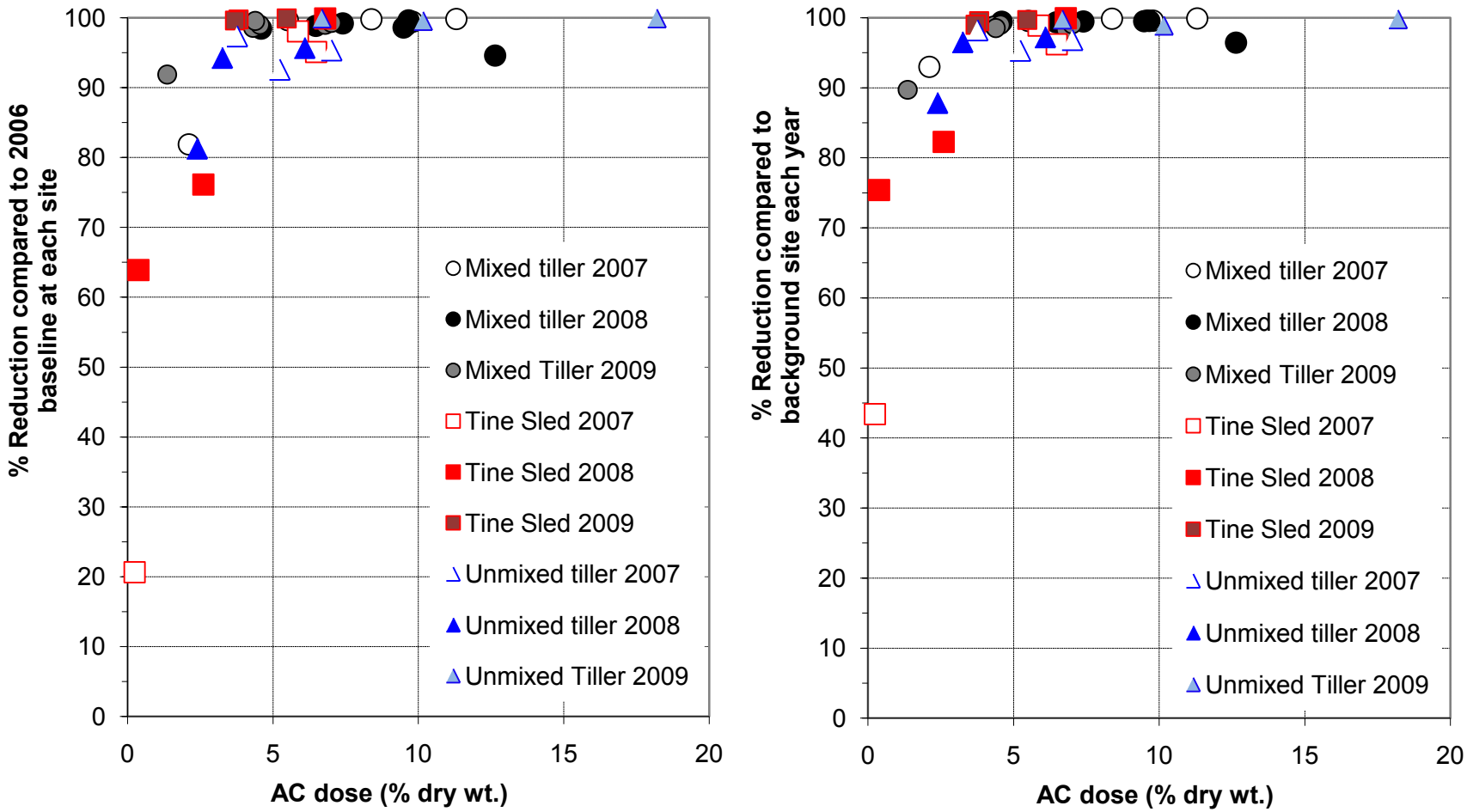


Figure ES-8. Percent reduction in aqueous equilibrium as a function of AC dose, calculated based on baseline measurements conducted at each site in 2006 before AC application (left) or based on measurements conducted at the background site each year (right).

Alcoa Inc.

Analysis of Alternatives Report

Grasse River Study Area
Massena, New York

July 2012

Acknowledgements

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- ARCADIS, Syracuse and Massena, New York;
- Dr. George Ashton;
- CDM Smith Inc., Cambridge, Massachusetts; and
- Exponent, Houston, Texas.

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Acronyms and Abbreviations

µg	micrograms
µg/L	micrograms per liter
^{137}Cs	cesium-137
^{210}Pb	lead-210
Alcoa	Alcoa Inc.
AA	Analysis of Alternatives
ACPS	Activated Carbon Pilot Study
ARAR	Applicable, Relevant, and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
B	billion (dollars)
BAF	bioaccumulation factor
BBL	Blasland, Bouck and Lee, Inc.
BC-C	black carbon-chemical pre-oxidation
BC-T	black carbon-thermal pre-combustion
BLRA	Baseline Risk Assessment
BZ 1	monochlorobiphenyl
BZ 19	2,2’,6-trichlorobiphenyl
BZ 4	2,2’-dichlorobiphenyl
CAP	Community Advisory Panel

CCLGR	Comprehensive Characterization of the Lower Grasse River
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeters
cm/d	centimeters per day
cm/yr	centimeters per year
COC	chemical of concern
CPS	Capping Pilot Study
CRQL	contract-required quantitation limit
CRREL	Cold Regions Research and Engineering Laboratory
CT	Central Tendency
CWA	Clean Water Act
cy	cubic yards
cy/day	cubic yards per day
cy/hr	cubic yards per hour
DoC	depth of contamination
ECL	Environmental Conservation Law
E&E	Ecology and Environment
EPC	exposure point concentration

ERAU	Ecological Risk Analysis Update
FEMA	Federal Emergency Management Agency
ft	feet
ft/s	feet per second
ft^2	square feet
ft^3/d-ft	cubic foot per day per linear foot of river
GAC	granular activated carbon
grams/day	grams per day
GM	General Motors
GPS	global positioning system
GRA	General Response Action
HASP	health and safety plan
HI	hazard index
HP	horsepower
HQ	hazard quotient
ICS	ice control structure
kg	kilograms
kg/yr	kilograms per year
L/d-m	liter per day per meter
L/m^2-d	liter per square meter per day

LOAEL	lowest observed adverse effect level
lb	pound
lbs/yr	pounds per year
MDL	method detection limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MGD	million gallons per day
MM	million (dollars)
MNR	monitored natural recovery
MSB	Main Street Bridge
MWWTP	Massena Waste Water Treatment Plant
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ng/L	nanograms per liter
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NRC	National Research Council
NTCRA	Non-Time-Critical Removal Action
NTU	nephelometric turbidity unit
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health

OSHA	Occupational Safety and Health Administration
OSI	Ocean Surveys, Inc.
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzodioxins
PCDF	polychlorinated dibenzofuran
pCi/g	picocuries per gram
ppm	parts per million
PRG	preliminary remediation goal
prop wash	propeller wash
RA Update	Human Health Risk Assessment Update
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDS	residual disturbed sediments
RMC	Reynolds Metals Company
RME	Reasonable Maximum Exposure
ROD	Record of Decision
ROPS	Remedial Options Pilot Study
RSI	River and Sediment Investigation
RTDF	Remedial Technologies Development Forum

SAV	submerged aquatic vegetation
SLRRP	St. Lawrence River Remediation Project
SLWA	segment length-weighted average
SPDES	State Pollution Discharge Elimination System
SPMD	semi-permeable membrane device
SRMT	St. Regis Mohawk Tribe
SRS	Supplemental Remedial Studies
SSS	Supplemental Sediment Sampling
T	1992 Sediment Probing Transect
TBC	to be considered
TEF	toxicity equivalency factor
TOC	total organic carbon
TRV	Toxicity Reference Value
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UCL	upper confidence limit
UI	untouched inventory
UMBC	University of Maryland Baltimore County
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture

USDOI	United States Department of the Interior
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
WC	water column transect
YOY	young-of-year

1. Introduction

In accordance with the United States Environmental Protection Agency's (USEPA's) Administrative Order (Index No. II Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] 90229) issued to Alcoa Inc. (Alcoa; previously known as the Aluminum Company of America) on September 28, 1989 and amended on May 24, 1995, this Analysis of Alternatives (AA) Report presents the development and evaluation of potential remedial alternatives for the Grasse River Study Area in Massena, New York (Figure 1-1). This report is based on the USEPA-approved 2002 AA Report (Alcoa, June 2002) and incorporates findings from the spring 2003 ice jam event and ice-related investigations (e.g., desktop and physical modeling, 2007 Ice Breaking Demonstration Project), 2005 Remedial Options Pilot Study (ROPS), 2006 Activated Carbon Pilot Study (ACPS), and other Grasse River-specific investigations conducted since 2002. It also considers regulatory guidance and related documents developed since 2002 specifically in support of the process for evaluating, selecting, and implementing remedial actions at contaminated sediment sites.

The information presented in this AA Report was prepared in accordance with CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final (USEPA, October 1988).

1.1 Overview

In this report, the lower Grasse River is defined as the reach of river between the Massena Power Canal (Power Canal) and the St. Lawrence River as shown on Figure 1-1. Due to polychlorinated biphenyl (PCB) levels in the fish, a fish consumption advisory (eat none) is currently in effect for this stretch of river (New York State Department of Health [NYSDOH], 2012-2013). There is also a fish consumption advisory in effect for the Power Canal (smallmouth bass – eat up to one meal per month; NYSDOH, 2012-2013).

The results of the updated human health risk assessment for the site (Alcoa, July 2002) show that long-term consumption of fish from the lower Grasse River is the only human health risk exposure pathway of potential concern associated with the PCBs present in the lower river (see Section 3.2). Similarly, model calculations from the updated ecological risk assessment for the site indicate that the greatest risk is to the piscivorous mammal community (i.e., consumption of fish by mink) (SRC/SERAS, August 2010). In this context, the primary objective for the remedial alternatives that are presented in this AA Report is to address potential site risks by reducing PCB levels in fish.

The list of alternatives evaluated in this AA Report reflects significant interactions among Alcoa and USEPA, the New York State Department of Environmental Conservation (NYSDEC), NYSDOH, National Oceanic and Atmospheric Administration (NOAA), and the St. Regis Mohawk Tribe (SRMT) – collectively referred to as the Agencies. Information and input gathered during discussions with the Agencies as well as extensive interactions with the community have been incorporated throughout this document, as appropriate. In addition, the development and evaluation of the potential alternatives is based on the results of the following site-specific studies:

- Site-specific investigation programs as documented in the final Comprehensive Characterization of the Lower Grasse River (CCLGR) Report (Alcoa, April 2001), Draft Addendum to the CCLGR Report (Draft CCLGR Addendum; Alcoa, April 2009), and Draft Near Shore Sampling Program Report (Alcoa, March 2011);

- Grasse River pilot and demonstration studies of remedial technologies including the 1995 Non-Time-Critical Removal Action (NTCRA; Blasland, Bouck & Lee, Inc. [BBL], December 1995), 2001 Capping Pilot Study (CPS; Alcoa, April 2002a), 2005 ROPS (Alcoa, May 2006), 2006 ACPS (Alcoa, November 2007), and 2007 Ice Breaking Demonstration Project (Alcoa, June 2007b);

- Human Health Risk Assessment Update (Alcoa, July 2002), Ecological Risk Assessment Update (USEPA, July 2010), and Risk Based Sediment Clean Up Ranges for the Lower Grasse River Study Area (SRC/SERAS, August 2010); and

- Study of ice jams in the lower Grasse River and options to mitigate the impact of such jams on PCB release from buried sediments including the evaluation of a stand-alone pier-type ice control structure (ICS) at river transect T6.75 and the evaluation of armored capping during the ROPS.

The Grasse River Study Area is unique, and the task of developing and evaluating potential remedial alternatives is complex. Specific examples of site complexities include the history of river channel modifications associated with the historic operation of the Power Canal, the nature of river bottom conditions, stratification of portions of the river during the summer months due to the entry of colder water from the St. Lawrence River, the periodic formation of ice jams in a portion of the lower river, and the occurrence of pressure waves resulting from operations of the lock system at the mouth of the river. Each of these items is discussed in further detail in the following sections.

Also considered in the development of this AA Report were a number of documents that have direct relevance in both the evaluation of remedial options and the decision-making framework for complex sediment sites. These documents include the following:

- A Risk Management Strategy for PCB-Contaminated Sediments (National Research Council [NRC], 2001), which supports the use of a site-specific risk management framework for decision-making at contaminated sediment sites;

- Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites (USEPA 11 Risk Management Principles Memo; USEPA, February 2002), which provides guidance for scientifically sound and nationally consistent risk management decisions at contaminated sediment sites;

- Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005), which provides technical and policy guidance for making risk management decisions for contaminated sediment sites;

- Sediment Dredging at Superfund Megasites: Assessing the Effectiveness (NRC, 2007), which presents a study on the effectiveness of dredging as a remedial option; and

- The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk (Bridges et al., February 2008), which evaluated these four issues as they relate to environmental dredging.

The sections that follow briefly describe the Grasse River Study Area, Alcoa Massena-West Plant history (including source control activities), and the extensive river investigations carried out to develop a thorough understanding of both the site and available remedial options for reducing PCB levels in fish in the lower Grasse River.

1.1.1 Grasse River Study Area

The Grasse River Study Area (or Study Area) is located along the northern boundary of New York State in the Town and Village of Massena, and encompasses approximately 8.5 miles of the Grasse River, including the lower Grasse River and the background reach located upstream of the Power Canal confluence (see Figure 1-1). The Alcoa Massena-West Plant is located on the north shore of the lower Grasse River near Massena. Two other large manufacturing facilities, the Alcoa Massena-East Plant (formerly Reynolds Metals Company [RMC]) and the former General Motors Corporation (GM) site, are located approximately 7 miles northeast of Massena, adjacent to the St. Lawrence River.

The Study Area extends from just downstream of the Route 37 Bridge in Massena to the St. Lawrence River confluence and includes the Power Canal and Robinson Creek (which discharges to the St. Lawrence River). The Power Canal, constructed between 1898 and 1903, connects the Massena Intake Dam on the St. Lawrence River to the former Power Dam at the Power Canal/Grasse River confluence. The Power Dam was the original source of hydroelectric power for the Alcoa Massena-West facility. The lower Grasse River was deepened between about 1914 and 1918 from the Power Dam to the confluence with the St. Lawrence River in support of increasing the generating capacity of the Power Canal. Use of the Power Canal for power generation was terminated in the 1950s, coincident with the construction of new power-generating facilities on the St. Lawrence River.

Deepening of the lower Grasse River to accommodate the Power Canal flow significantly altered the physical and ecological characteristics of the lower river. The cross section of the river currently increases dramatically downstream of the Power Canal, from approximately 5,000 square feet (ft^2) near Outfall 001 (see Figure 1-1) to approximately 9,000 ft^2 at the mouth. From the Power Canal to the confluence with the St. Lawrence River, the river banks are steep; the river bottom is underlain by bedrock, hard till, and/or marine clays; and there are minimal floodplains.

To better understand the river bottom, sediment probing, and mapping (i.e., side-scan sonar and sub-bottom profiling) were conducted throughout the Study Area. These studies revealed that some areas of the river bottom include boulders, cobbles, and rock outcrops (see Alcoa, April 2001; Alcoa, April 2009; Ocean Surveys, Inc. [OSI] reports from 1998 through 2003). A better understanding of the bottom conditions was obtained from the 2005 ROPS (Alcoa, May 2006), which indicated that rock debris and outcrops may be

common features masked by sediments that have accumulated on the river bottom in the upper portion of the river.

The hydrograph for the lower Grasse River is the result of runoff from the watershed and other upstream water inputs, and is not dependent on the water surface elevation in the St. Lawrence River. The St. Lawrence River is, however, a hydraulic control point that significantly influences both the water depth and flow of the lower Grasse River, forming a backwater that extends upstream of the Power Canal. As a result, the lower Grasse River is the functional equivalent of a reservoir and water elevation changes in the St. Lawrence River can alter flow velocities in the Grasse River because of these backwater effects.

The flow velocity in the lower Grasse River under typical summer flow conditions is generally so low that it can be difficult or impossible to measure with conventional velocity meters. When flows are low, especially during the summer months, the colder water from the St. Lawrence River migrates upstream along the bottom of the lower Grasse River, leading to periods of stratification. In addition, water surface elevations fluctuate daily (approximately 1 foot) as a result of water releases from the Robert Moses - Robert Saunders Power Dam on the St. Lawrence Seaway to meet electrical demand. Pressure waves in the Grasse River also occur as a result of water releases from the Snell Lock (located just upstream of the Grasse River/St. Lawrence River confluence) during ship passage through the St. Lawrence Seaway. The release of water from the Snell Lock causes a temporary increase in water elevation in the St. Lawrence River system, inducing a wave that propagates up the Grasse River. In addition to the temporary increase in the water levels, the wave causes transient upstream and downstream currents as it passes through the system.

The middle of the river channel throughout much of the Study Area is fairly deep (15 to 25 feet). As a result, areas capable of supporting aquatic vegetation are primarily associated with the near shore zones within about 25 feet of either river bank.

The extent of the 100- and 500-year floodplain beyond the river banks adjacent to the lower Grasse River is minimal, with little, if any, difference between the two limits (Figure 1-2). Additionally, the vast majority of land areas adjacent to the Power Canal and Robinson Creek have been designated as areas of minimal flooding (Federal Emergency Management Agency [FEMA], June 1986). Wetland areas contiguous to the Study Area as defined by the National Wetlands Inventory (United States Department of the Interior [USDOI], May 1981) are also depicted on Figure 1-2.

Ice jams can occur in the reach of the river between sediment probing Transect (T) 1 and T16 (Alcoa, April 2009). These jams sometimes cause sediment scour, which has been documented as far downstream as T19 (see Figure 1-3 for transect markers). As a result, the portion of the river from T1 to T19 is considered subject to ice jam-related scour (additional discussion is provided in Section 2). Ice jam events that are severe enough to cause significant sediment scour occur, on average, approximately once every 10 years. This estimated frequency is based on the post-2003 ice jam investigation that identified four ice scour events over the past 40 to 50 years (Alcoa, April 2009).

Detailed discussions of the Study Area's hydrology and hydraulics, floodplains, wetlands, river use, and fish habitat are provided in Section 3.1 of the CCLGR Report (Alcoa, April 2001) and the Draft CCLGR Addendum (Alcoa, April 2009).

1.1.2 Alcoa Massena-West Plant History and Source Control

The 2,700-acre Alcoa Massena-West Plant has been in operation since 1903. The facility is located adjacent to the lower Grasse River and the Power Canal, and consists of three major production areas including a fabricating plant, ingot and extrusion plant, and smelting plant (Areas I, II, and III on Figure 1-4). Production processes have historically generated various waste by-products (e.g., waste oil, solvents, caustics, and acids), which were disposed in on-site lagoons and landfills; a practice that, at the time, was common and generally accepted.

As a result of these disposal practices, in 1985 the NYSDEC determined that select areas throughout the facility posed a potential threat to the surrounding environment. Extensive land-based investigations and remediation efforts were initiated at the plant in 1991 to mitigate off-site migration of chemical constituents, especially to the lower Grasse River. This effort was conducted in accordance with two Records of Decision (RODs) issued by NYSDEC in 1991 and 1992 (later amended in 1994) for fourteen areas of contamination on and adjacent to the facility. During the course of the remediation 4 additional areas were added to the upland program. This program was completed in 2001 and included the following components:

- Remediation of 18 separate disposal areas, including 37 acres of landfills and 100 acres of lagoons;
- Construction of a Secure Landfill (completed and capped) to dispose of excavated material;
- Construction and use of three new stormwater/wastewater impoundments providing for additional management of stormwater runoff from the Alcoa facility;
- Remediation of the Unnamed Tributary, which discharges to the lower Grasse River, with 6,100 linear feet of pipeline cleaned and sliplined;
- Remediation of 3.7 miles of unpaved plant roads through excavation and placement of an asphalt cap to allow for continued use;
- Cleaning of underground utilities that are part of the stormwater/wastewater collection system;
- Reduction of significant storm-related bypasses of PCB-containing wastewaters at Outfall 004 by directing the flow to a storage/settling lagoon prior to entering the activated carbon treatment plant;
- Redirection of Outfall 005 effluent to an expanded sand filtration and activated carbon unit at the Outfall 004 location for treatment of PCB-containing stormwaters; and

- Wetlands mitigation including replacement of approximately 100 acres of wetlands converted to upland areas during remediation with newly created wetlands in an equivalent-sized area off site and within the non-industrialized land west of the Alcoa Massena-East Plant.

These remedial efforts and source control actions, in conjunction with upgrades of the wastewater treatment facilities at the Massena-West Plant, have dramatically reduced PCB discharges from the facility to the lower Grasse River and the Unnamed Tributary, which is a critical first step in any sediment remediation effort (USEPA, April 1998; NRC, 2001; USEPA, February 2002). Figure 1-5 illustrates the reduction in discharge of PCBs to the Grasse River through Outfall 001 (see Figure 1-4 for outfall locations) as a result of these activities. As discussed in Section 2, these source control activities, coupled with ongoing natural sedimentation processes in the river (i.e., natural recovery), have resulted in significant declines in PCB concentrations in fish in the lower Grasse River.

Further details are discussed in Section 2.2.2 of this document and Section 3 of the CCLGR (Alcoa, April 2001).

1.1.3 Site-Specific Investigations and Activities

Since the issuance of USEPA's Administrative Order in 1989, Alcoa has conducted numerous investigations throughout the Study Area, which collectively have contributed to the development of a comprehensive understanding of the nature and extent of PCBs in the Grasse River system. In addition, Alcoa has performed several demonstration and pilot projects designed to evaluate the efficacy of a variety of remedial technologies including main channel capping, near shore area capping, armored capping, dredging, and in-situ activated carbon treatment for management of PCB-containing sediments in the lower Grasse River. These in-depth field investigations and activities generated site-specific information that is directly relevant to the evaluation of remedial options for reducing PCB levels in fish as described in Sections 5 and 6.

The timing and primary objectives of these investigations and activities are summarized below. Section 2 of this AA Report, the CCLGR Report (Alcoa, April 2001) and the Draft CCLGR Addendum (Alcoa, April 2009) provide additional detailed discussions including findings and conclusions.

- River and Sediment Investigation (RSI) Program – Phase I (Summer and Fall 1991): Sediment, water column, and biota (fish, frog, and crayfish) samples were collected from throughout the Study Area to quantify the presence of PCBs and other chemical constituents (Ecology & Environment, Inc. [E&E], Inc., October 1992).

- Sediment Probing Program (November 1992): Sediment probing was carried out in the lower Grasse River from the confluence of the Power Canal to the St. Lawrence River to better define the quantity and location of river bottom sediments (Alcoa, April 2001). Results were considered in the development and analysis of potential remedial alternatives, and this data set was subsequently supplemented by more recent river bottom characterization activities as described below.

- RSI Program – Phase II (July 1993 through May 1994): Sediment, water column, fish, and benthic macroinvertebrate samples were collected throughout the Study Area to further characterize the area, support sediment transport modeling, and refine estimates of the volume of PCB-containing sediments (BBL, December 1994).

- NTCRA (July through September 1995): Analysis of the RSI Program data revealed elevated levels of PCBs in an area of sediment adjacent to Alcoa's Outfall 001 (see Figure 1-3). Alcoa removed, dewatered, and disposed approximately 2,600 cubic yards (cy) of PCB-containing sediment, along with 400 cy of boulders/debris, and gained site-specific information on the implementation and effectiveness of dredging (BBL, December 1995).

- Supplemental Remedial Studies (SRS) Program (initiated 1995, ongoing): Water column and fish sampling have been conducted annually with sediment and semi-permeable membrane devices (SPMDs) sampling also conducted during certain years to support an understanding of PCB fate and transport processes in the river. Surveys include assessing PCB levels and other parameters (including water temperature, suspended solids, and organic carbon content). This information is critical for the development of a supportable conceptual site model that can be used in the identification and evaluation of potential remedial alternatives for reducing PCB levels in fish and other biota (Alcoa, April 2001; Alcoa, April 2002b; Alcoa, April 2009).

- Supplemental Sediment Probing (1996, May 2001): Sediment probing was conducted to gain a better understanding of sediment and river bottom conditions, characterize side slopes, and better define sediment volumes at specific locations within the lower river (Alcoa, April 2001; Alcoa, July 2001). Probing data were subsequently supplemented by more recent river bottom characterization activities as described below.

- Supplemental Sediment Sampling (SSS; 2000 through 2001): Sediment samples were collected from approximately 300 locations and analyzed to refine the understanding of PCB distribution in sediment within the Study Area (Alcoa, April 2001; Alcoa, April 2002b).

- CPS (summer through fall 2001): Capping materials were placed over a 750-foot stretch (approximately 7 acres) of the lower Grasse River (see Figure 1-3) to evaluate several different cap designs and placement techniques and gather site-specific data on the feasibility and efficacy of main channel capping (Alcoa, April 2002a). Long-term monitoring activities were conducted in 2002 (Alcoa, September 2003) and 2003 (Alcoa, April 2009) to assess various aspects of the in-place performance of the main channel cap.

- 2003/2004 River Ice Evaluation (spring 2003 through January 2004): In response to the identification of significant changes to the CPS area during the spring 2003 monitoring, sediment probing and sampling, remote sensing, underwater video, tree scar surveys, river bank sampling, and sediment stratigraphy analysis were conducted to evaluate and identify the mechanism(s) responsible for scour evidenced within the CPS area (later learned to be an ice jam scour event), the location and frequency of these events, and to evaluate potential downstream impacts (Alcoa, April 2009).

- Bathymetric Surveys (April 2003 to October 2005): High-resolution bathymetric surveys were collected to assess the configuration of the river bottom (see Appendix A).

- ROPS (April through December 2005): Alcoa conducted removal and capping activities (see Figure 1-3) to obtain site-specific information pertaining to potential remedial alternatives. Post-ROPS monitoring was conducted in 2006 (Alcoa, June 2007a) and 2007 (Alcoa, September 2008) to assess the conditions of the caps. The ROPS included the following components.
  - Main channel: Removal of approximately 24,400 cy of sediment and debris followed by placement of a 1-foot sand/topsoil cap
  - Northern near shore: Removal of approximately 1,600 cy of sediment and debris followed by capping with sand/topsoil to restore the original bottom elevation
  - Southern near shore: Placement of a 3- to 6-inch sand/topsoil cap over a 0.5-acre area
  - Main channel (downstream): Placement of an armored cap consisting of sand/topsoil, gravel, and armor stone over a 1-acre area

- River Ice Monitoring (2004 to present): Annual monitoring is conducted to document ice formation and breakup on the Grasse River. Activities include tracking climatological conditions, measuring river stage, visually observing ice formation and extent, predicting and measuring ice thickness, documenting conditions with photographs and video, and visually observing ice breakup (Alcoa, July 2006; Alcoa, June 2007a; Alcoa, September 2008; and Alcoa, June 2009a).

- ICS Evaluation (2005 to 2009): Computer-based and large-scale physical and flume models have been used to evaluate potential ICS locations and the technical feasibility of an ICS for the lower Grasse River (Alcoa, October 2009).

- Phases 1 and 2 Sediment Sampling Program (May 2006 and September/October 2007): Sediment cores were collected from approximately 200 locations to estimate the depth and volume of PCB-containing sediments in various reaches of the river and better understand the nature of the material below the contaminated sediment layer (Alcoa, June 2007a; Alcoa, September 2008).

- ACPS (September and October 2006): Alcoa conducted a field demonstration of in-situ activated carbon treatment in an approximate 0.5-acre main channel area (see Figure 1-3) using different application techniques and mixing methods to evaluate the effectiveness of applying and mixing activated carbon in sediments of the lower Grasse River. Implementation of the Grasse River ACPS is summarized in the Construction Documentation Report (Alcoa, November 2007). Additional post-ACPS monitoring was conducted in 2007, 2008, and 2009 to continue evaluating the effectiveness of the application/mixing process, erosion potential of treated sediments (2007 and 2008 only), benthic community recolonization of the study area, and reduction in PCB bioaccumulation in benthic organisms. Results of the 2007 and 2008 post-ACPS monitoring are presented in a combined summary report (Alcoa, February 2010), and the results from the 2009 monitoring are presented in a subsequent report (Alcoa, November 2010a). Additional testing on the effect of sediment amendments on native rooted vegetation was conducted in 2011 (Alcoa, November 2011).

- Ice Breaking Demonstration Project (March 2007): Alcoa completed an Ice Breaking Demonstration Project over an approximate 7-mile reach of the lower Grasse River (i.e., from approximately the Grasse River mouth to T6; see Figure 1-3) to evaluate the effectiveness of mechanical ice breaking as an interim measure to minimize the potential for ice jam-related sediment scour (Alcoa, June 2007b).

- Near Shore Sampling Program (August to September 2010): Alcoa performed a series of investigations to better characterize the near shore areas of the lower Grasse River. Activities included sediment characterization, geotechnical investigations, observations of shoreline and bank conditions, habitat characteristics assessment, assessment of the ROPS northern and southern near shore areas characteristics, and sediment PCB sampling, (Alcoa, March 2011).

As a result of these pilot and demonstration projects, approximately 15 acres of river bottom have been capped (i.e., main channel cap, near shore area cap, armored cap) or treated with activated carbon, and approximately 29,000 cy of PCB-containing sediment and approximately 15,200 pounds (lbs) of PCBs have been removed. Section 2.5 presents additional details on the site-specific actions (i.e., NTCRA, CPS, ROPS, ACPS, and Ice Breaking Demonstration Project).

1.2 Community Relations

Alcoa, working in coordination with USEPA, has initiated and maintained a community relations program to provide opportunities for community involvement in the Grasse River project. The goal of Alcoa's community relations program is to keep the local community informed regarding the status of site work, provide opportunities for community members to ask questions about current and future activities, and offer a feedback mechanism for interested parties to provide input related to the project. To achieve this goal, Alcoa has implemented a number of different community relations efforts.

Starting in the 1990s, Alcoa worked with local business owners and the public, held open house meetings, and jointly ran several public meetings with USEPA to provide periodic community updates on major activities related to the project in an effort to keep interested parties informed.

In 2001, Alcoa, in coordination with USEPA, initiated a community involvement program to communicate project status to people who live in and around Massena. As part of this program, Alcoa formed a Community Advisory Panel (CAP) in April 2001 to provide a formal forum through which the community can express its interests and concerns regarding the Grasse River project. A third-party facilitator helped to create the group by selecting a representative cross-section of community members including representatives from local government, local business, public education, healthcare, labor, and the SRMT. This group meets regularly during periods of project activity/progress to promote information exchange with the community about the project.

Other activities conducted to date include multiple public meetings held by Alcoa and USEPA to specifically discuss the CPS, ROPS, ACPS, and Ice Breaking Demonstration Project. These public meetings and availability sessions have been held at the St. Lawrence Centre Mall, Massena Public Library, Massena Town Hall, and the SRMT Administration Building in Akwesasne. In addition, Alcoa has developed several

community mailers and fact sheets for widespread distribution to the surrounding community. The table below lists meetings and availability sessions conducted as part of Alcoa's community relations efforts.

Table 1-1: Listing of CAP Meetings and Public Availability Sessions

CAP Meetings	Public Availability Sessions
2001	
April 18, May 24, June 14, July 9, August 15, October 11 and 23, December 6	July 9
2002	
February 5, April 9, May 8 June 5, October 1, November 20	February 4-6
2003	
February 12, May 27, June 24, September 30	--
2004	
March 3, May 12, September 29	June 2-3
2005	
February 23, July 20, November 9	April 11-12
2006	
March 18, September 27	March 29
2007	
January 30, March 14, April 9	January 30, March 21-April 6 (focus groups)
2008	
April 23	--
2009	
May 13	
2011	
August 4	
2012	
April 16	
June 20	

Alcoa also generated and maintains a project website designed to provide the public with information about the Grasse River project (www.thegrasseriver.com). The website provides a general overview of the project and details on the land-based remediation; environmental studies; risk assessment; development of remedial options; current project status; community involvement; and links to reports, presentations, and other useful resources to allow for greater understanding of the project.

Additional activities will be planned in the future with USEPA to provide the public with continued opportunities to be involved in the project and comment on the evaluation of the potential remedial alternatives.

1.3 Report Organization

The remainder of this AA Report is organized into six sections. Overall characterization of the lower Grasse River system is presented in Section 2, while Section 3 discusses site Remedial Action Objectives (RAOs) and General Response Actions (GRAs). Section 4 presents an evaluation/screening of various potential remedial technologies and development of potential remedial alternatives. The detailed and comparative analyses of alternatives are included in Sections 5 and 6, respectively. Section 7 presents a list of source materials cited in the text.

2. Characterization of the Lower River

2.1 Introduction

In order to identify remedial alternatives that can address potential risks associated with the presence of PCBs in the lower Grasse River, the nature and extent of PCBs and the PCB fate and transport processes in the river must be understood. Since the early to mid-1990s, Alcoa has performed numerous field and laboratory studies (see Section 1.1.3) and developed predictive numerical models to understand PCB sources to the system, important processes affecting PCB fate and transport in the river, and the relationships between PCBs in the water column and sediment to those found in fish that inhabit the lower river. The interpretation of the information gathered during these studies serves as the foundation for the conceptual model for the river, and from this, provides an opportunity to comparatively assess the effectiveness of various approaches for reducing PCB levels in fish in the river. This approach is consistent with the recommendations of the NRC report on management of PCB-contaminated sediments (NRC, 2001) and USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005).

The studies are summarized in Table 2-1 and include the following.

- Collection of more than 5,000 sediment samples to determine the nature and extent of PCB-containing sediment, and analysis of the trends in sediment PCB levels that represent the current source of PCBs to the water column and biota.

- Collection of more than 2,000 water column samples to determine the spatial and temporal trends in PCB levels and support identification of the significant sources of PCBs found in the water column.

- Collection of more than 3,000 fish samples over a period of 17 years to determine the spatial and temporal trends in PCB levels and support identification of the pathways by which PCBs move from sediment and water to fish.

- Monitoring of external PCB sources (i.e., outfalls) during dry and wet weather conditions to quantify the magnitude of PCB discharges to the river.

- Monitoring of river flow and velocity to understand transport processes and the shear forces applied to the river sediments during high-flow events.

- Mapping of the river bottom using side-scan sonar and manual probing to determine the type and quantity of sediments.

- Measurement of the erosion potential of the river sediments using both sediment shaker and SedFlume devices to support assessment of the erosion that would occur under high-flow conditions.

- Review of the historic record of ice jams, hindcasting of ice jam potential, survey of ice-related scarring on trees along the river shoreline, analysis of sediment stratigraphy to look for event-based changes, and numerical modeling of ice jam formation and breakup to support an understanding of the frequency, magnitude, and location of past ice scour events in the river.

- Numerical and physical modeling to evaluate engineered options for controlling the formation and breakup of ice jams on the lower Grasse River.

- Laboratory study of PCB partitioning within Grasse River sediments and PCB migration from sediments to support quantification of the PCB flux from river sediments to the water column.

- Laboratory study of the dechlorination and degradation of PCBs within Grasse River sediments to understand the potential for natural degradation of PCBs.

- Measurement of groundwater flow to the river and studies of water movement and stratification using a dye tracer and various chemical tracers to determine the importance of both groundwater in PCB migration from sediments, and river stratification in the movement of PCBs within the water column.

- Development of a hydrodynamic model to estimate river velocity and water depth under various flow conditions and evaluate the shear forces to which river sediments would be subjected during high-flow events.

- Development of a sediment transport model to estimate where and at what rate sediments would accumulate on the river bottom, as well as how much erosion would occur during high-flow events.

- Development of PCB fate and bioaccumulation models to understand the relationships between PCB concentrations in water and sediment to those in fish and provide a means to predict the short- and long-term effectiveness of various remedial approaches.

- Development of dynamic river ice and turbulence models to understand flow conditions during the formation and breakup of ice jams, determine the forces imposed on the river sediments underneath the toe of an ice jam in support of armor cap design, evaluate the ability of various ICS designs to retain ice under a range of ice thickness and river flow conditions, and assess the backwater effects associated with the retention of ice at an ICS.

- Implementation and monitoring of the NTCRA to remove sediments from an area with elevated PCB concentrations and to support an understanding of the effectiveness of dredging as a remedial option.

- Laboratory studies of the effectiveness of capping of sediments as a remedial option.

- Implementation and intense monitoring of the CPS, a site-specific field program designed to develop an understanding of the feasibility and construction impacts associated with the use of main channel capping as a remedial option.

- Implementation and extensive monitoring of the ROPS to develop site-specific information pertaining to dredging, post-dredge capping, near shore area capping, and armored capping.

- Implementation and monitoring of the ACPS to evaluate the ability to deliver activated carbon to the river sediments, and the effectiveness of this technology in reducing the availability of sediment PCBs to the overlying water column and benthic community.

- Implementation of an Ice Breaking Demonstration Project to evaluate the feasibility of mechanical ice breaking as an interim option to mitigate ice jam-related sediment scour.

- Investigation of near shore areas to update the conceptual site model and further understand conditions in these areas of the river. Work included sampling to determine the nature and extent of PCB-containing sediment, geotechnical evaluation, elevation measurements, and visual characterization of the shoreline, banks, and habitats.

Consistent with USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005), throughout the various river studies listed above, Alcoa engaged national experts in various fields to assist in the design, implementation, and/or review of the data. These experts either participated directly in the studies or acted in a peer review capacity to promote the proper scoping and interpretation of results. Experts engaged in the Grasse River project are listed below.

<u>Capping Peer Review Panel</u>

This panel reviewed the pre-engineering and laboratory cap design studies conducted in advance of the 2001 CPS. Members included:

- Mr. Steven Liikala, Wilder Construction, Inc.;

- Dr. Louis Thibodeaux, Louisiana State University;

- Dr. Danny Reible, Louisiana State University (currently at the University of Texas at Austin);

- Dr. Gerald Matisoff, Case Western Reserve University;

- Dr. Wilbert Lick, University of California at Santa Barbara; and

- Dr. Robert Werner, State University of New York College of Environmental Science and Forestry.

The field capping studies were also reviewed by members of the USEPA-sponsored Remedial Technologies Development Forum (RTDF).

Ice Expert Team

This team assisted in the design, implementation, and interpretation of the river ice investigation, and the design and evaluation of engineered ICSs as a means of managing ice formation and breakup on the Grasse River. This team includes:

- Dr. George D. Ashton, P.E., former Chief, Research and Engineering Directorate, United States Army Corps (USACE) Cold Regions Research and Engineering Laboratory (CRREL);
- Mr. Guenther E. Frankenstein, P.E., former Director, Ice Engineering Facility, USACE CRREL;
- Mr. Andrew M. Tuthill, Research Hydraulic Engineer, USACE CRREL;
- Dr. Hung Tao Shen, Professor of Civil and Environmental Engineering, Clarkson University;
- Dr. Rudy L. Slingerland, Professor of Geosciences, Penn State University; and
- Dr. Philip L.F. Liu, Professor of Civil and Environmental Engineering, Cornell University.

Activated Carbon Expert Team

This team provided technical support for the applicability and use of activated carbon in the Grasse River including assisting in the design, implementation, and data interpretation for the 2006 ACPS.

- Dr. Upal Ghosh, Assistant Professor and Graduate Program Director, Department of Civil and Environmental Engineering, University of Maryland Baltimore County (UMBC); and
- Dr. Richard G. Luthy, Professor and Chair, Department of Civil and Environmental Engineering, Stanford University.

The results of the river studies are summarized below. More detailed information can be found in the CCLGR Report (Alcoa, April 2001), Draft CCLGR Addendum (Alcoa, April 2009), NTCRA Documentation Report (BBL, December 1995), CPS Documentation Report (Alcoa, April 2002a), Draft ROPS Documentation Report (Alcoa, May 2006), Lower Grasse River Ice Breaking Demonstration Project Draft Documentation Report (Alcoa, June 2007b), Grasse River ACPS Construction Documentation Report (Alcoa, November 2007), Grasse River T6.75 ICS Basis of Design Report (Alcoa, October 2009), Draft Near Shore Program Report (Alcoa, March 2010), and annual Data Summary Reports (Alcoa, April 2005; June 2006; June 2007a; September 2008; June 2009a; July 2010; July 2011).

2.2 Ongoing PCB Sources

Potential sources of PCBs evaluated as part of the river studies program include: 1) the Grasse River upstream of the confluence with the Power Canal (Section 2.2.1); 2) the discharge through the dam at the terminus of the Power Canal (Section 2.2.1); 3) plant discharges (Section 2.2.2); and 4) the Unnamed Tributary (Section 2.2.2).

2.2.1 Upstream Sources

Since the mid-1990s, nearly 170 water column samples have been collected upstream of the lower Grasse River at the Main Street Bridge and water column transect (WC) 001 (Figure 2-1). PCB concentrations were low, averaging about 1.9 nanograms per liter (ng/L). Recent data collected at the Main Street Bridge (WC-MSB) between 2006 and 2011 indicate a lower average PCB concentration of about 0.2 ng/L (range from non-detect to 3 ng/L). These recent levels are similar to PCB levels measured in remote, un-impacted streams and precipitation in the eastern U.S. during the late 1990s and 2000s (0.4 to 0.5 ng/L; VanRy et al., 2002; 0.3 ng/L, USEPA, March 2004; 0.1 to 0.4 ng/L, Glaser et al., November 2006; 0.1 to 0.4 ng/L, Interstate Commission on the Potomac River Basin, January 2007). Low PCB levels were also measured in SPMDs deployed at the upstream location (averaging 0.12 micrograms [µg] compared to 32.8 µg downstream at WC007). Sediment samples collected in the upstream Grasse River between the Route 37 Bridge and WC001 during RSI Phase I activities all yielded PCB results below the contract required quantitation limit (CRQL) (CRQL = 0.08 milligrams per kilogram [mg/kg] or parts per million [ppm]). PCB results from sediment samples collected during RSI Phase I activities between WC001 (upstream of the Main Street Bridge) and the Power Canal were also below the CRQL, except for two samples (1.2 mg/kg, 0- to 3-inch; 0.38 mg/kg, 12- to 24-inch) (Alcoa, April 2001).

The Power Canal releases a small flow of water to the Grasse River just upstream of the Alcoa facility (BBL, December 1994). The PCB concentrations of that water are low, as indicated by water column, SPMD, and surface sediment samples. For example, total PCB levels in water samples collected from the Power Canal in June 1995 averaged 7.9 ng/L. In 1999, all concentrations from water samples collected from the Massena Intake Dam on the St. Lawrence Seaway (WC002) were below the 20 ng/L detection limit, except for one sample collected in September that contained 87 ng/L. PCB levels measured in SPMDs deployed in the Power Canal in 1995 also were low (about 0.50 µg). Sediment samples collected from the top 3 inches of the Power Canal during RSI Phase I activities contained relatively low PCB levels, averaging less than 1 mg/kg. PCB concentrations measured during this survey ranged from non-detect to 2 mg/kg, except for two samples that contained slightly higher PCB concentrations (5.4 mg/kg and 5.9 mg/kg).

PCB source concentrations within the lower Grasse River are significantly higher than those from the upstream sources, as evidenced by comparisons of PCB levels measured in paired SPMDs deployed immediately upstream of the facility but downstream of the confluence with the Power Canal (WC004), and at a transect 1 mile downstream of Outfall 001 (WC007) (during several surveys conducted from June 1995 to October 1997). On average, the PCB mass in the upstream SPMD was about 20-fold lower than in the downstream SPMD, except for samples collected in June 1995 and 1997, where upstream results were 5- to

10-fold lower. Stratification is sometimes observed at WC007 during the summer months and may have affected PCB levels in these samples.

2.2.2 Plant Outfalls and Tributaries

The facility presently has five permitted outfalls that discharge stormwater and treated wastewater, three discharging to the lower Grasse River (001, 004, and 007), one discharging to the Power Canal (003), and one discharging to Robinson Creek (008). Two other outfalls, 002 and 005, function as emergency bypasses during storms that exceed design levels. The locations of these outfalls are shown on Figure 1-4. The extensive external source control efforts implemented at the Alcoa facility between 1991 and 2001 (in accordance with NYSDEC's 1991 and 1992 RODs; RODs amended in 1994) have dramatically reduced PCB discharges to the lower Grasse River. PCB discharges from Outfall 001, which is the main plant outfall, declined from about 60 grams per day (grams/day) in 1990 to about 2.2 grams/day in 1997 (see Figure 1-5). In 1998, PCB discharges from Outfall 001 increased to about 6.4 grams/day, likely due to sewer cleaning activities undertaken in fall 1998, as well as the lowering of the detection limit for reporting PCBs by the Alcoa Massena Operations ChemLab[1]. PCB discharges from Outfall 001 declined from about 1.9 grams/day in 1999 to 0.8 grams/day in 2003. Since 2004, PCB levels measured in the Outfall 001 discharge have been below detectable limits, except for one low level detection (0.08 micrograms per liter [µg/L]) in 2009. In comparison, the PCB model for the site predicts an average daily PCB flux from the river sediments in 2009 to be about 45 grams/day.

State Pollution Discharge Elimination System (SPDES) monitoring data collected for Outfalls 003 (discharging to the Power Canal) and 007 indicate a negligible (less than 0.1 percent) contribution of PCB mass discharges to the lower Grasse River, with only occasional detections of PCBs in these outfalls (see Appendix A for additional details).

PCB discharges from the former Outfall 002 entered the Unnamed Tributary, an 8,000-foot long channel that primarily conveys surface water collected from the northern portion of the Alcoa facility directly to the lower Grasse River (see Figure 1-1). Prior to removal of the Outfall 002 discharge to the Unnamed Tributary in 1998, this tributary contributed about 0.5 million gallons per day (MGD) to the Grasse River. An average flow of about 0.33 MGD was estimated during four storms in June through August 1997.

Based on data from the storm sampling in 1997, the storm-related discharges of PCBs from the Unnamed Tributary to the lower Grasse River were calculated to range from 0.01 to 0.06 kilograms per year (kg/yr) (average about 0.03 kg/yr). In addition, the PCB composition in these samples is much different than that observed in the river. Samples collected from the Unnamed Tributary during these storm events contained higher levels of hexa- and hepta-chlorobiphenyls (i.e., PCB molecules containing six and seven chlorine atoms, respectively) relative to those observed in the river (Figure 2-2) (Alcoa, April 2001).

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[1] The Alcoa Massena Operations ChemLab detection limits for PCB Method 608 were reduced in October 1998. The method detection limit was lowered from 0.175 µg/L for Aroclors 1242, 1248, and 1254 and 0.125 µg/L for Aroclor 1260, to 0.065 µg/L for each individual Aroclor.

Alcoa completed a major remedial action on the Unnamed Tributary in 1998. This effort included the removal of a significant amount of sediments containing PCBs, as well as the rerouting of all Outfall 002 discharges (except for flows greater than the 50-year, 24-hour storm) to a surface impoundment. In turn, these waters are pumped to a second impoundment before being discharged to the river through Outfall 001. PCB levels in water samples collected from the Unnamed Tributary in August and October 2000 were low (non-detect to 1.2 ng/L). PCB concentrations in sediment samples collected during the same period ranged from non-detect to 1.4 mg/kg (Alcoa, April 2001).

The Massena Waste Water Treatment Plant (MWWTP) discharges about 2.7 MGD of treated sewage (secondary/activated sludge) to the river, with a permitted 30-day average discharge allowance of up to 4.8 MGD (Siddon, February 2001). No data from direct monitoring of the discharge are available, but data from a sample (June 1995) taken in the discharge plume's zone of initial dilution showed only 8.9 ng/L total PCBs, a value consistent with values obtained at the same time from nearby WC004 (14.0 ng/L) and from WC001 (3.9 ng/L). PCB data from SPMDs located within the discharge plume's zone of initial dilution also have been low (1.5 µg) (Alcoa, April 2001).

Four other small tributaries enter the lower Grasse River within the Study Area including the Haverstock Road Tributary (the others are unnamed). No data are available for these small tributaries; however, there is no reason to believe these tributaries contribute PCBs to the lower Grasse River based on their locations and drainage areas.

2.3 PCBs in the Lower River

2.3.1 River Sediments

Side scan sonar surveys were conducted in the lower Grasse River to characterize and delineate the nature of sediment deposits throughout the river. Based on information collected during these surveys, river sediments were classified as either coarse (Type I) or fine (Type II). Within the two classifications, sediment type is fairly uniform, but the thickness of the sediment varies based on channel width and depth and the channel bed type. These classifications are defined as follows (OSI, August 2003):

- Coarse sediments (Type I) – these areas represent irregular portions of the river bed that are principally represented by rock outcrops and/or assemblages of boulders/cobbles which may be overlain by a thin veneer of sediments composed of silts and sand/gravel generally less than 6 inches thick; and

- Fine sediments (Type II) – these areas represent flat/smooth portions of the river bed that are principally composed of sediment deposits of silt, clay, sand, and gravel that are generally thicker than 6 inches.

The delineation of the fine and coarse sediment areas is shown on Figures 2-3 through 2-11, along with sediment PCB data collected during sampling activities between 2000 and 2010. Information obtained during these sampling efforts, along with historic probing information, are consistent with the sediment classifications defined above; the coarse sediment areas typically have little to no sediment (i.e., less than 6 inches of sediment and are difficult to sample), while the fine sediment areas typically contain several feet of

recoverable sediment (i.e., sediments that can be successfully retrieved from the river during sample collection activities; Alcoa, June 2007a; Alcoa, September 2008). Cobbles and boulders are commonly found in the sediment deposits.

The river sediments are typically underlain by a hard bottom comprised of bedrock, glacial till, or marine sediments (Alcoa, April 2009). A thin veneer of sand and gravel overlies bedrock upstream of T5. From approximately T5 to T21, the channel is cut into a poorly sorted sand-rich glacial till and its own alluvium. Downstream of T21, the channel flows through a sequence of marine and lacustrine silts and clays. Gravel has been observed in cores collected in the T35, T37, and T46 area and could have resulted from historic gravel deposits along the river. The source of this gravel is not conclusively known, and additional data would be collected during remedial design if deemed necessary to support the design of the selected remedial action.

Several studies have been conducted to characterize the PCB levels in the sediment deposits throughout the river (see Section 1.1.3). Results of these PCB sediment sampling surveys are shown on Figures 2-3 through 2-19, and are detailed below.

For the ice scour-prone reach of the river (i.e., T1 to T19; see Figure 1-3 for transect markers), sediment samples collected between 2003 and 2010 were used to characterize current sediment PCB concentrations. Sediment data collected in this reach of the river prior to 2003 were not included because: 1) the 2003 ice jam event affected sediments in this reach of the river; and 2) an extensive sediment characterization effort was conducted between 2003 and 2010 to establish a current representation of sediment conditions in this reach of the river. For the reach of the river not subject to ice jam-related scour (i.e., T19 to T72), data collected since 2000 were used to characterize sediment PCB concentrations. Data collected prior to 2000 were not used to characterize “current” sediment PCB concentrations in recognition of the age of the pre-2000 data, changes in sediment PCB concentrations in some portions of this reach over time (due to ongoing natural recovery processes), and the extensive sediment characterization efforts conducted in this reach of the river since 2000. Sediment cores collected prior to 2000 were used to supplement components of the conceptual site model, but they were not used to define “current” conditions nor were they used in the development of remedial alternatives for the site.

Since the late 1990s, “surface sediments” or the bioavailable layer were defined as those found in the top 3 inches of the sediment column. This definition was based on numerous lines of evidence, including physical, chemical, and biological data collected from the site, and served as the basis for the sediment sampling program designs employed at the site, analyses aimed at understanding PCB fate mechanisms at work in the river, and prior evaluations of remedial alternatives for the site (e.g., Alcoa, April 2001; Alcoa, June 2002; Alcoa, April 2009). The site-specific information that supports this definition was provided to USEPA in the memorandum entitled Defining Surface Sediments in the Lower Grasse River (Alcoa, June 2009b).

Subsequent to the June 2009 submittal, USEPA issued a directive, for the purposes of updating this AA Report, to define “surface sediments” as those found in the top 6 inches of sediment in the main channel and top 12 inches of sediment in near shore areas (USEPA, October 2009). Alcoa does not agree with these

definitions of surface sediments and believes they are inconsistent with the site data and both Agency (USEPA, April 1998) and NRC (2001) documents on management of contaminated sediment sites.

This change has also resulted in a significant reduction in the available sediment data; roughly 50 percent of the post-2000 sediment samples for the main channel and near shore areas surface grab samples (i.e., collected from the top 3 inches of sediment), which were collected in accordance with what was understood to be the definition of surface sediments until USEPA issued its letter in October 2009. This change had a more dramatic effect on the sampling density in near shore areas, as most of the sampling conducted after 2000 was focused on the top 3 inches of the sediments in these areas. The Near Shore Sampling Program undertaken in 2010, however, provided significant additional data regarding PCB distribution in the near shore areas. As a result, Alcoa collected over 180 sediment cores from the near shore areas in 2010 to fill the gap that resulted from this change in definition (Figures 2-12 through 2-19) (Alcoa, March 2011).

In response to the directive from USEPA the definitions of surface sediments as stated in its determination letter (USEPA, October 2009) have been incorporated for the purpose of identifying target areas for remediation in the alternatives discussed in this report. To maintain consistency with the current understanding of sediment PCB distributions and PCB fate mechanisms at work in the river, the discussion that follows focuses primarily on sediment PCB levels measured within the top 3 inches of the sediment column.

<u>PCBs within the Top 3 Inches of the Sediment Column</u>

PCB concentrations in the top 3 inches of the sediment column are highly variable and range over several orders of magnitude, even for closely spaced samples (Figure 2-20). Considering all river areas (main channel, side slopes and near shore) and both sediment types (fine and coarse), the river-wide average is about 8 mg/kg (area-weighted average using Thiessen polygon analysis). Further, concentrations in the uppermost portion of the lower river (i.e., upstream of Outfall 001, T1 to T4) are low, averaging about 0.8 mg/kg (excluding a single elevated PCB measurement in the near shore sample at T3-NSS). Sediment (0-3 inches) PCB concentrations rise near Outfall 001 and exhibit considerable variability but no overall downstream trend for the next 3 miles (about T4.5 to T36), averaging approximately 13 mg/kg. Sediment (0-3 inches) PCB concentrations in the remainder of the river (T36 to T72) average approximately 5 mg/kg.

PCB concentrations in the top 3 inches of the sediments are typically higher in the main channel than in near shore areas (Figure 2-21). Within the main channel, concentrations in the coarse sediment areas are typically higher than those in fine sediment areas (averaging 17 mg/kg and 8 mg/kg, respectively). The lower concentrations in the fine sediment areas are attributed to higher rates of burial in these areas.

The near shore areas generally have the lowest PCB concentrations, with about 60 percent of the 0- to 3-inch sediment samples containing PCB concentrations of 1 mg/kg or less. Overall, river-wide PCB concentrations in the top 3 inches of near shore sediments areas average about 5 mg/kg.

The significant variability in sediment PCB concentrations and lack of identifiable “hot spots” indicate that the sediments act as a diffuse and widespread source of PCBs to the water column. The increases observed in

the water column PCB data collected downstream of the Alcoa facility are consistent with patterns expected from such a diffuse source. This pattern is exemplified by the results of the June 2000 float survey (Figure 2-22) which indicate that, although areas of elevated sediment PCB concentrations may have local effects, these areas are not the predominant source of the PCBs in the water column (Alcoa, April 2001).

PCBs in Buried Sediments

Sediment core data collected from the main channel of the river indicate that maximum PCB concentrations tend to be located at depth in the river sediments. In the sediment cores collected in 1991, peak PCB levels are, on average, found about 1 to 3 feet below the sediment-water interface (Alcoa, April 2001). Twelve high-resolution sediment cores were collected from the lower Grasse River in 1997 and analyzed for cesium-137 (^{137}Cs). Of the 12 high-resolution cores, five contained distinct ^{137}Cs peaks at depth; samples from these five cores were then analyzed for PCBs. The peak PCB concentration in Core 30S (collected in the southern portion of the channel near T30) was measured about 1.6 feet (50 centimeters [cm]) below the sediment-water interface; peak PCB levels in the other four cores occurred between 2.8 to 3.5 feet (85 to 105 cm) below the sediment-water interface (Figure 2-23) (Alcoa, April 2001).

PCB levels in main channel sediment cores collected in 2000 and 2001 generally increase with sediment depth, with maximum concentrations occurring approximately 2 to 3 feet below the sediment-water interface (Alcoa, April 2001). Similarly, cores collected from the main channel between 2003 and 2007 exhibit maximum PCB concentrations approximately 1 to 4 feet below the sediment-water interface (Alcoa, April 2005; June 2007a; September 2008; April 2009). PCB concentrations observed in dated fine-resolution cores tend to peak at depths near the ^{137}Cs peak, corresponding to the early 1960s time frame. These data are consistent with the conceptual site model of historic PCB discharges accumulating in the deeper sediments and being gradually covered by cleaner sediments as on-site sources of PCBs to the river were controlled.

For those cores collected in the near shore areas in 2010, peak sediment PCB concentrations above 1 mg/kg generally occurred within the top 1.0 to 1.5 feet of sediments, with approximately 90 percent of the peak PCB concentrations above 1 mg/kg occurring in this depth stratum. In only a few instances were peak PCB concentrations observed at depths greater than 18 inches. The shallower depths of the PCB concentration peaks in the near shore are not unexpected given the sediment deposits in these areas are typically thinner than those found in the deeper main channel areas of the river.

Buried sediments can act as a PCB source to the water column and fish if there are mechanisms capable of moving these sediments (or the PCBs in them) to the surface sediments or to the water column. These mechanisms include molecular diffusion, groundwater movement through the sediments to the river, sediment resuspension during high-flow events, ice-related scour, bioturbation, and propeller wash (prop wash). The significance of each of these potential transport mechanisms is evaluated in Section 2.4.

2.3.2 Water Column

The water column has been monitored for PCBs at several transects (see Figure 2-1) over an extended period of time. PCB levels in the lower Grasse River exhibit a distinct seasonal pattern; highest levels typically occur during the summer months, and lowest levels occur in the late fall (note that no data are collected during winter due to ice formation in the river). Superimposed on this seasonal pattern is an overall decline over the period of record. These patterns are partially due to seasonal and year-to-year variations in river flow. However, the same patterns occur for PCB mass flux (i.e., the product of PCB concentration and river flow), indicating that PCB sources to the river vary seasonally and have declined over time (Alcoa, April 2001).

At WC007, average summertime PCB concentrations declined from about 115 ng/L in 1996 to about 20 ng/L in 2007 (83 percent reduction; Figure 2-24, top panel). At WC007A/WC131[2], PCB levels declined from about 200 ng/L in 1996 to about 8 ng/L in 2011 (96 percent reduction; Figure 2-24, middle panel). Finally, PCB levels measured at WC011 have declined from about 130 ng/L in 1997 to about 12 ng/L in 2011 (91 percent reduction; Figure 2-24, bottom panel).

PCB concentrations increased at all locations in 2005. These increases resulted from PCB releases during the dredging component of the ROPS (Alcoa, May 2006). The increases did not persist, as water column PCB concentrations measured throughout the river in 2006 were similar to those observed prior to the ROPS.

2.3.3 Resident Fish

Resident fish have been collected from various stretches (Figure 2-25) within the Grasse River since the early to mid-1990s. Sample collection is conducted in the fall each year to capture changes in exposure experienced during the active feeding season.

Over this period of record, average wet tissue PCB concentrations in smallmouth bass have declined from 12 to 20 mg/kg in 1993 to about 0.4 to 0.9 mg/kg in 2011 (Figure 2-26). Between 1993 and 2004, a general, though variable, decline in average PCB levels is observed, with 2004 concentrations averaging 1.5 to 3 mg/kg. River-wide effects of the 2001 CPS and 2003 ice jam event are not evident in the fish tissue PCB concentration data. In 2005, a temporary increase to 4 to 5 mg/kg is observed; this increase is a consequence of the PCBs released to the river during the 2005 ROPS dredging-related activities (Alcoa, May 2006). The 2005 fish sampling event was performed August 29 to September 21, 2005, and all ROPS dredging activities were completed October 21, 2005. Between 2006 and 2011, average PCB levels declined to levels similar to or lower than those observed prior to the 2005 ROPS. Average lipid-normalized PCB concentrations (expressed as mg/kg lipid) in smallmouth bass exhibit patterns similar to those of the wet tissue concentrations (Figure 2-26); average lipid-normalized PCB levels decline between 1993 and

[2] Transect WC007A was sampled between 1996 and 1999. Between 2000 and 2007, water column samples were collected from Transect WC131, which is located about 500 feet upstream of Transect WC007A.

2004, temporarily increase in 2005 due to the ROPS-related PCB releases, and decline to pre-ROPS levels between 2006 and 2009. Overall, lipid-based PCB concentrations in smallmouth bass from the lower river have declined by more than 90 percent since the mid-1990s. Average PCB concentrations in smallmouth bass in 2011 are the lowest on record (at all locations).

Average wet tissue PCB concentrations in brown bullhead have also declined over this period. Between 1993 and 2004, average wet tissue PCB concentrations dropped by about a factor of two, from about 7 to 9 mg/kg to 3 to 4 mg/kg (Figure 2-27). Similar to the smallmouth bass, PCB levels in brown bullhead increased in 2005 as a result of the 2005 ROPS dredging-related PCB releases, before declining to pre-ROPS levels starting in 2006. By 2011, PCB levels in brown bullhead average about 0.6 to 1.0 mg/kg. Lipid-normalized PCBs in brown bullhead exhibit a continual decline between 1993 and 2009. Interruptions to this decline are evident in 2003 (PCB levels in brown bullhead from the Upper Stretch increased in response to the 2003 ice jam event) and 2005 (PCB levels in brown bullhead collected from all river stretches increase in response to the 2005 ROPS dredging-related PCB releases) (Figure 2-27). Overall, lipid-based PCB concentrations in brown bullhead from the lower river have declined by more than 90 percent since the mid-1990s. Average PCB concentrations in brown bullhead in 2011 are the lowest on record (at all locations).

PCB levels in young-of-year (YOY) spottail shiner from near Outfall 001 and near the Unnamed Tributary declined from about 4 to 6 mg/kg in 1998-1999 to about 1.3 to 2.7 mg/kg in 2011. This decline is comparable to that observed in the water column over this same period. At the mouth of the river, YOY spottail shiner PCB levels declined from about 2 mg/kg in 1998 to about 0.9 mg/kg in 2011 (Figure 2-28). Similar to the smallmouth bass and brown bullhead, increases in PCB levels in YOY spottail shiner collected throughout the river in 2005 were observed. Similar trends are exhibited in the lipid-normalized PCB concentrations (Figure 2-28). Overall, lipid-based PCB concentrations in spottail shiner from the lower river have declined by about 55 to 60 percent since the late-1990s.

Lipid content in the resident fish has varied over time (see Appendix A for additional details) and may account for some of the variability observed in the long-term wet weight PCB concentration trends discussed above. However, the declines in lipid-normalized PCB concentration trends discussed above account for these year-to-year variations in lipid content and indicate the observed declines are the result of the reduction in PCB exposure in the river that is attributable to reductions in PCB loading provided by the on-site source control activities, as well as ongoing deposition of clean sediments from upriver.

2.4 Phenomena Affecting PCB Fate

2.4.1 Mass Transfer from Surface Sediment Pore Water

Pore water PCBs can be transported to the water column via several physical and biological mechanisms. The net result of these mechanisms is a seasonal variation characterized by maximum flux in the summer and minimum flux in the winter. This flux has been identified as the dominant source of water column PCBs, as evidenced by the similarity of the PCB composition in the water column and sediment pore water (Alcoa, April 2001), the observed increase in downstream water column PCB concentrations during the float survey

and routine monitoring studies, results of the ongoing sources studies that indicate the other identified potential sources are not significant, and the consistency with sediment data. Taken together, these findings support the conclusion that PCBs in pore water are a widespread and diffuse source of PCBs to the water column.

Representing the flux from sediment pore water as a simple mass transfer phenomenon, mass transfer rates necessary to account for the PCB accumulation in the water column range from 1 to 3 centimeters per day (cm/d) in winter to about 20 cm/d in summer. These lower winter values are consistent with mass transfer rates of 2 to 3 cm/d observed in laboratory column flux studies from Grasse River sediments (Nadal, 1998), where bioturbation was not evident.

2.4.2 Resuspension

Ice-Related Resuspension

The March 2003 ice jam event demonstrated that ice jam-related scour is a mechanism that can mobilize and re-distribute buried sediments and PCBs in the upper reach of the lower Grasse River (Alcoa, April 2009). An extensive investigation was conducted subsequent to the March 2003 event to characterize the event, understand the magnitude and frequency of ice jam events that have occurred historically, and determine the relevance of ice-related sediment scour to future remedial options for the river. This investigation included several field and desktop studies as listed below.

- Review of photographic documentation of the 2002-2003 winter ice formation and breakup periods.
- Review of hydrometeorological conditions during the 2002-2003 winter.
- Geophysical surveys of the river bottom.
- River-wide collection of sediment samples for physical and chemical characterization.
- Collection of river bank soils for PCB analysis.
- Routine monitoring of PCBs in the water column and resident fish.
- Manual sediment probing.
- Numerical DynaRICE modeling of the 2003 ice scour event and the turbulence generated underneath the toe of the 2003 ice jam.
- Underwater videography.
- Review of historic information pertaining to the occurrence of past ice jams in the river, including interviews with local residents.

- Hindcasting analysis of river flows and ice thicknesses for past winters.
- Surveys of ice-related scarring on trees along the shoreline in the upper (i.e., upstream of Massena) and lower (i.e., downstream of Massena) portions of the river.
- Stratigraphic analysis of sediment cores from select areas of the river.
- Collection of high-resolution sediment cores for physical and chemical characterization.
- Numerical DynaRICE modeling of ice jam formation and breakup in various reaches of the lower river.

Based on the information obtained during the investigation, it was established that, in late March 2003, the coincidence of warm air temperatures and a rapid increase in flow caused a mechanical breakup of the ice cover on the Grasse River upstream of Massena. This breakup led to an ice run that delivered a large volume of floating ice pieces to the lower Grasse River, where it encountered an intact ice cover. The thick, intact ice cover on the lower river temporarily arrested the ice run, forming two small jams before the ice run traveled further downstream and formed a thick ice jam over the 2001 CPS area; a generalized cross-section of an ice jam is presented on Figure 2-29. The thick jam created a blockage that restricted the flow in the river, resulting in a backwater upstream of the toe of the jam. This backwater, coupled with the reduced cross-section for flow under the jam and the extreme roughness of the underside of the jam, produced high velocities and turbulence that scoured both the cap material and some underlying sediments in the CPS area and immediate vicinity.

In addition to ice jam related sediment scour, other potential sediment transport mechanisms can occur under ice (Ettema and Daly, 2004). These mechanisms include the transport of sediment by ice (i.e., sediment embedded in ice), and bed load and suspended load transport under ice cover. Sediment transport by ice is not believed to be a significant transport mechanism at the site. Bed load transport under an ice cover is also not believed to be a significant transport process given the cohesive nature of the Grasse River sediments.

Review of historic records, local citizen interviews, and physical evidence collected during the investigation that followed the March 2003 event indicate that ice jams occur infrequently on the lower Grasse River, with only six known ice jams documented during approximately the past 40 years. A hindcasting analysis using historic river flow and climatological records suggests that there may have been 5 additional years during this period where conditions were favorable for ice jamming, but no physical evidence or observations corroborate that ice jams actually occurred. Ice jams severe enough to cause sediment scour, such as the 2003 ice event, occur even less frequently. Geochronology of the river sediments indicates that events severe enough to cause sediment scour occur at a frequency of about one per decade; at least four ice-related scour events have occurred over the past 40 to 50 years. The stratigraphic analysis results are consistent with dates of known ice jams determined through the dating of ice-related tree scars (Alcoa, April 2009).

Information obtained during this investigation indicates that severe ice jam events can cause sediment scour of main channel sediments in the upper 1.8 miles of the lower Grasse River (from about T1 to T19; see Figure 1-3 for transect markers) (Alcoa, April 2009). The principal evidence includes the following:

- Surveys of tree scars indicate ice jams are limited to the upper 1.5 miles of the lower Grasse River (to about T16; Figure 2-30). No evidence of ice jam-related scarring was observed downstream of T16. Tree scars were noted downstream of T16, but these scars were observed at a height of about 1 to 2 feet above low mean water level, which indicates they are the result of normal sheet ice floes and not ice jams (Alcoa, April 2009).

- Comparison of bathymetry data collected before and after the 2003 event indicates that ice-related sediment scour occurred in select portions of the river bottom in the upper 1.8 miles of the river (i.e., between T1 and T19) (Figures 2-31 through 2-33). A maximum scour depth of approximately 5 feet was noted in the immediate vicinity of the ice jam toe. Deposition occurred in other portions of this reach and downstream to about T28. The ice-related sediment scour and associated deposition were primarily limited to the main channel of the river, and did not have any adverse impacts on overall PCB levels in the river, although some localized effects were observed (Alcoa, April 2009).

- Stratigraphic analysis of sediment cores collected from the ice scour prone reach of the river (i.e., T1 to T19) show signs of multiple scour/deposition events (Figures 2-34 and 2-35). In contrast, stratigraphic analysis of sediment cores collected downstream of T19 show no evidence of past ice jam-related scour events (Figures 2-35 and 2-36). The vertical distribution of physical and chemical measurements in sediment cores collected throughout the river is consistent with the observations from the stratigraphic analysis (Alcoa, April 2009).

- Numerical modeling suggests that the occurrence of hypothetical ice jams of similar magnitude to that of the 2003 event would not cause significant scour in the lower river downstream of the known limits of ice jam scour impacts.

Ice-related erosion is not expected to be a significant mechanism for remobilization of near shore sediments in the T1 to T19 stretch of the river. This is based on the following (Alcoa, December 2009a):

- The near shore areas convey only a small portion of the overall river flow and, thus, experience low flow velocities even during elevated open water flows.

- Near shore sediment cores typically do not show signs of past disturbance by ice (i.e., most cores exhibit uniform distributions of physical and chemical properties with depth) (Alcoa, April 2009; Alcoa, March 2011).

- During ice runs, near shore ice typically remains in place longer than that in the main channel, which serves to protect the banks/shoreline from damage.

- During ice jamming, the lateral forces of the ice accumulation push against the banks rather than scraping them, and near bank ice becomes plastered against the banks (Beltaos, 1995; Beltaos, 2008).

Resuspension under Non-Ice Conditions

The lower Grasse River was deepened in the early 1900s to accommodate water flow from the Power Canal. After flows from the Power Canal ceased in the 1950s, velocities in the river decreased significantly, and the river has functioned as an efficient trap for sediment transported from upstream. During a dye study conducted in the lower Grasse River (July/August 1997), when river flows were at common summertime lows (95 to 105 cubic feet per second [cfs]), the average water velocities, based on dye concentration measurements, were estimated to be on the order of 0.02 feet per second (ft/s). At these low flows, the travel time between the Power Canal and the river's mouth is close to 21 days. During extreme flow conditions, flow velocities are still fairly low. A hydrodynamic model developed for the lower Grasse River predicted maximum flow velocities during a storm flow of 15,600 cfs (similar in magnitude to a 100-year flood event) in the river to be about 2.5 to 4.5 ft/s in the main channel and about 2.0 to 2.5 ft/s in the near shore areas (Appendix A).

As discussed in Section 1.1.1, the lower Grasse River is the functional equivalent of a reservoir under typical flow conditions due to the oversized river channel and the St. Lawrence River serving as a downstream hydraulic control point. In order to evaluate sediment stability under high-flow, non-ice conditions, a weight of evidence approach was employed to understand the stability of the Grasse River sediments. This approach consisted of several field and desktop studies including:

- Examination of physical characteristics of the river;
- Erodability studies of native sediments;
- River velocity measurements;
- Numerical modeling of routine and elevated flow conditions;
- Trend monitoring of PCB levels in sediment, water, and fish;
- Comparison of bathymetric measurements collected at various points in time;
- Total suspended solids (TSS) and PCB concentration measurements during high flows;
- Sediment geochronology; and
- Sediment PCB composition.

The results of the field studies demonstrate that resuspension in the river under non-ice conditions is insufficient to materially impact PCB fate (Alcoa, April 2001; Alcoa, April 2009). The principal evidence includes the following:

- Current velocities in the river are low, even during elevated river flows. Peak velocities of about 1 ft/s were measured in the main channel of the river during an approximate 6,000 cfs spring flood in May 2002 (Alcoa, September 2003).

- The PCB concentrations in the water column, sediments, and fish did not show any measurable effects from the extreme high-flow event (estimated to approximate 100-year return period) that occurred in January 1998. A comparison of pre- and post-1998 sediment (from top 3 inches) and fish concentrations indicates that sediments remained stable during this event and that scour did not result in the remobilization of deeper higher concentration sediments (Figure 2-37).

- Comparison of sediment surface elevations measured downstream of T24 before and after the 2003 ice jam showed no signs of significant scour or deposition (see Figures 2-32 and 2-33) (Alcoa, April 2009).

- TSS concentrations remain relatively low (about 20 milligrams per liter [mg/L]) during high flows.

- Particulate PCB concentrations were very low (0.5 to 1 mg/kg) during high flows (Figure 2-38).

- PCB composition in the water column was similar during low flow and high flow (Figure 2-39) and differed from the composition of the PCBs in the top 3 inches of the sediment (Figure 2-40). It more closely matched the composition estimated to exist in the pore waters of the sediment (Figure 2-41). Note that direct measurements of pore water PCB concentrations do not exist; therefore, pore water PCB concentrations were estimated through laboratory studies using sediments collected from the lower Grasse River. Two studies were performed: (1) batch aqueous extraction studies to evaluate the equilibrium concentration and composition of PCB homologs in sediment pore water; and (2) column flux studies to evaluate diffusive release of these PCBs under quiescent conditions (details are provided in Nadal, 1998). Results of these studies are summarized in the CCLGR (Alcoa, April 2001).

- Geochronology based on ^{137}Cs and lead-210 (^{210}Pb) indicated that disturbance of deposited sediments was atypical (i.e., most profiles were consistent with continual deposition having sharp, well-defined ^{137}Cs peaks; Figure 2-42).

- Sediment cores collected from the river, including those from the near shore areas of the river, exhibit relatively uniform distributions of physical and chemical properties, indicating that these sediments have not been subject of significant disturbance (Alcoa, December 2009a; Alcoa, April 2009; Alcoa, March 2011).

These field observations are supported by modeling performed at the site. The site hydrodynamic model predicts peak velocities of about 2.5 to 4.5 ft/s and 2.0 to 2.5 ft/s in the main channel and near shore areas, respectively, during a 100-year flood event (Appendix A). Predicted scour depths calculated by the

sediment transport model are also consistent with the site data. The in-situ resuspension potential (i.e., eroded sediment mass per unit area) of lower Grasse River cohesive sediments was measured during sediment shaker studies and laboratory-scale flume (SedFlume) testing conducted between 1998 and 2000.

Using these data, upper-bound erosion potential functions were developed and, coupled with bounding estimates of several other key model parameters, used in the hydrodynamic and sediment transport models to provide conservative estimates of sediment scour in the lower Grasse River during a 100-year flood event. These upper-bound estimates were selected such that reasonable maximum estimates of sediment erosion and reasonable minimum estimates of natural recovery were used. Multiple simulations were performed with several sets of bounding parameters so that a conservative estimate of sediment scour during an extreme flood event could be attained.

Results indicate that, for a variety of bounding parameter values, the extent of sediment scour during an extreme flood did not change appreciably. On average, about 0.1 cm of net erosion is predicted to occur during a 100-year flood. The maximum erosion predicted during the 100-year flood was about 0.9 cm (see Appendix A). Erosion during a more extreme flood event (i.e., 1-in-500 year flood flow of 17,070 cfs; FEMA, May 1980) was estimated using the relationships between shear stress (which induces erosion) and flow rate (or velocity), and the potential effects of a 500-year flood were also estimated. Shear stress increases in proportion to the square of the velocity, and erosion increases in proportion to roughly the square of the shear stress. Thus, a 13 percent increase in velocity translates to an approximate 28 percent increase in shear stress and an approximate 64 percent increase in erosion. This represents an upper-bound estimate of erosion in that it assumes clean water scour (i.e., ignores water column solids/bed solids interactions). Using the maximum erosion during a 100-year flood (i.e., conservatively estimated at about 0.9 cm), the maximum estimated erosion during a 500-year flood is expected to be between 1 and 1.5 cm. Thus, even under extreme flow conditions, little sediment resuspension is expected within the river (Alcoa, April 2001).

2.4.3 Deposition and Burial

Deposition is the process in which solids in the water column settle onto and remain on the river bottom. Continual deposition over long time periods results in the buildup of cleaner solids on top of the PCB-containing sediments, essentially moving the PCB-containing sediments deeper in the sediment column over time; this process is termed burial.

<u>Historic Sedimentation Rates</u>

Historic sediment deposition rates in the lower Grasse River were examined through the analysis of finely sliced sediment samples from high-resolution cores collected from the main channel in 1997 and 2003, and near shore sediments in 2004. For the cores collected in 1997, ^{137}Cs levels were used to estimate long-term average deposition rates. These data indicate that long-term average deposition rates of 2 to 3 centimeters per year (cm/yr) have occurred historically in the river, except for Core 30S, where a lower deposition rate of 1.2 cm/yr was estimated (see Figure 2-42). The lower deposition rate estimated for Core 30S is likely due to higher velocities that are experienced in this portion of the river relative to the other areas, which would serve to reduce the amount of solids that can settle onto the river bottom at this location. Cesium peaks

were not evident in seven of the 12 cores analyzed. However, ^{137}Cs levels in these cores are relatively constant with depth (1 to 2 picoCuries/gram [pCi/g] dry) at levels similar to those observed in the post-1970 sections of sediment cores with distinct cesium peaks, suggesting that only post-1970 sediments were collected. If this is the case, deposition rates for these cores are greater than the 2 to 3 cm/yr estimated for the cores with ^{137}Cs peaks.

For the cores collected in 2003, peak organic carbon-normalized PCB concentrations were used to estimate long-term average sedimentation rates. For this analysis, the peak organic carbon-normalized PCB concentration in each core was assumed to represent 1963, based on the fact that the high-resolution cores collected in 1997 showed that peak PCB concentrations and peak ^{137}Cs levels were found at similar depths (Alcoa, April 2001). Long-term average sedimentation rates of 0.2 to 0.4 cm/yr were estimated for coarse sediment areas. In the fine sediment areas, the highest sedimentation rate of 3.4 cm/yr was observed in the area where deposition was known to have occurred during the 2003 ice event. Further downstream, average sedimentation rates were lower (0.6 to 1.3 cm/yr) (Alcoa, April 2009).

Similar to the 2003 sediment cores, peak organic carbon-normalized PCB concentrations in near shore sediment cores collected in 2004 and 2010 were used to estimate long-term average sedimentation rates for the near shore areas. In the near shore area near T10, an average sedimentation rate of 1.0 cm/yr was determined. Average sedimentation rates in near shore areas located further downstream were lower; between T29 and T38, long-term average sedimentation rates of less than 0.1 cm/yr to 0.7 cm/yr were estimated (Alcoa, March 2011), while those determined from cores collected between T48 and T67 ranged from 0.2 to 0.5 cm/yr (Alcoa, April 2009).

Contemporary Sedimentation Rates

Contemporary sedimentation rates were estimated in three ways: 1) one-dimensional modeling of ^{210}Pb profiles in the surface sediments; 2) evaluation of solids loading entering the river from upstream; and 3) evaluation of bathymetric changes in the river before and after the 2003 ice scour event.

Modeling of ^{210}Pb profiles in sediments of three high-resolution cores (Cores 7M, 13M, and 18M) indicate that contemporary sedimentation rates may be as low as 0.2 cm/yr, a rate much lower than those discerned from the ^{137}Cs profiles (Alcoa, April 2001).

For the solids loading analysis, river flow and TSS measurements collected from the Main Street Bridge in Massena were used to develop a functional relationship between solids loading and river flow (i.e., a solids rating curve). This rating curve and the river hydrograph were used to estimate solids loading to the river for the years 1997 through 2006. The hydrodynamic and sediment transport models developed for the site predict that this loading would result in an average deposition rate of about 0.2 cm/yr in the fine sediment deposits. This rate may underestimate the true rate because the suspended solids measurements upon which the rating curve is based may under-represent solids transport for two reasons: 1) they do not account for the coarser solids (i.e., sands) that are known to enter the river from upstream and deposit in the upper reach of the lower river (as evidenced by the high sand content in sediment cores collected from this

reach); and 2) they do not fully characterize the uniquely high solids transport from upstream areas that appears to occur in association with ice runs.

Comparison of the pre- and post-2003 ice event bathymetry (see Figures 2-31 through 2-33) indicates a net accumulation of approximately 43,200 cy of material over a period of 2 to 5 years. This volume equates to average sedimentation rates of 2.3 cm/yr (T1 to T14) and 0.7 cm/yr (T14 to T38)[3] (Alcoa, April 2009).

Based on the above analyses, the weight of evidence suggests that current sedimentation rates in the main channel are on the order of 0.2 to 0.7 cm/yr, which are more consistent with those discerned from the 2003 main channel PCB core data and lower than those determined from the ^{137}Cs data. Crop rotation and other soil conservation practices within the Grasse River watershed have significantly increased since the mid-1980s and may be responsible for the apparent reduction in solids loading to the river since the 1960s and 1970s (Howard, April 1998).

2.4.4 Bioturbation

Numerous benthic community assessments have been performed within the lower Grasse River to determine the abundance and composition of organisms that dwell in the river sediments. Results of these assessments indicate that chironomids and oligochaetes are the predominant organisms present in the river sediments, comprising 85 to 100 percent of the organisms collected during these studies (Alcoa, June 2009b).

Review of published literature reveals that most studies on the effects of these organisms on sediment bed mixing have been conducted in lake sediments, which indicate that chironomids and oligochaetes generally burrow to depths of 8 to 10 cm (Matisoff and Wang, July 2000; McCall and Tevesz, July 1982; Ford, 1962). However, several studies suggest that most of the population of benthic organisms is found closer to the surface than the maximum depth of occurrence (Milbrink, 1973; Ford, 1962; Matisoff and Wang, July 2000; Krezoski et al., 1978; Charbonneau and Hare, 1998). These studies are consistent with other information from the site, as well as USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, which states "population density has a tremendous effect on whether organisms present at the site may have a significant effect on the mixing zone depth" and "typically the population of benthic organisms is greatest in the top few centimeters of sediment" (USEPA, December 2005 – p. 2-30). Consistent with this finding, USEPA's Contaminated Sediment Management Strategy supports the use of the top 5 cm in defining surface sediments (USEPA, April 1998). Individual organisms can be found at deeper depths; however, the fact that individuals can reach depths deeper than the bulk of the community is not evidence that substantive vertical mixing occurs to these depths or that these individuals provide a significant pathway for PCB transfer up the food chain. Based on the above information, biological mixing to a depth of about 5 cm would be expected in the lower Grasse River. Biological mixing is greater in summer months than winter months, which is why higher PCB flux rates are observed in the summer.

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[3] Sedimentation rates were determined separately for these two stretches of river due to the time frame upon which the bathymetry changes were based (1998 to 2003 for T1 to T14; 2001 and 2003 for T14 to T38).

The vertical profiles of ^{210}Pb levels in sediments of three of the 12 high-resolution cores collected in 1997 were examined to assess the extent of biological mixing in the lower Grasse River sediments. In all three cores, ^{210}Pb levels ranged from about 1.6 to 2.6 pCi/g dry weight at the surface and declined exponentially to values of about 0.5 pCi/g dry weight at 30 cm below the sediment-water interface (Figure 2-43). ^{210}Pb levels are expected to be relatively constant throughout the active depth of mixing and to decline exponentially below this depth.

The existence of large gradients in ^{210}Pb levels within the top few centimeters of each core suggests that little bioturbation is occurring in sediments of the lower Grasse River. The depth and intensity of biological mixing in the sediments of these three cores were determined through the calibration of a one-dimensional transport model. Results of this modeling analysis indicate that limited mixing (both depth and intensity) is required to reproduce the ^{210}Pb profiles observed in the three cores (Alcoa, April 2001). The ^{210}Pb data are consistent with other information for the site, and suggest that any significant bioturbation in lower Grasse River sediments is restricted to the upper few centimeters (Alcoa, April 2001; Alcoa June 2009b).

2.4.5 Groundwater Movement through the Sediments to the River

Groundwater could enter the lower Grasse River in several ways: 1) through the banks (i.e., local groundwater discharge); 2) in a preferential, highly localized manner from the fractured bedrock that exists at the river bottom in the upper end of the Study Area); and/or 3) in a diffuse manner through the soft sediments and underlying till that cover most of the river bottom downstream of Outfall 001.

Although the piezometric heads in monitoring wells along the river are higher than the elevation of the river, discharge through the banks is likely to be limited by the low hydraulic conductivity of the underlying soils (mostly clay and till). Also, any such discharge is not expected to be significant because of the limited amount of PCB-containing sediments found on the steep banks. Discharge from fractured bedrock, which exists at the river bottom in the upper end of the Study also is not believed to be an important pathway because: 1) there are minimal to no PCB-containing sediments in much of the area where bedrock is located near or at the bottom of the river; and 2) only a small sediment surface area would be involved where PCB-containing sediments did exist. Thus, the largest effect of any groundwater discharges potentially would be from diffuse flow through the soft sediments on the bottom of the river (Alcoa, April 2001).

To determine the diffuse discharge through underlying till, an initial order of magnitude estimate of the groundwater flux to the river was calculated based on hydrogeological studies performed for the Alcoa facility. The calibrated, numeric, three-dimensional, finite element model DYNFLOW was used to estimate discharge (flux per unit length of river) through the overburden and shallow bedrock from the plant (north) side of the river in the region between the Power Canal and the confluence with the St. Lawrence River. Flow through deep bedrock was not modeled. Discharges to the river from the south side were assumed to be the same as from the north side. The resulting estimate for total groundwater flux (from the north and south sides) was approximately 1 cubic foot per day per linear foot of river (1 ft^3/d-ft), which is approximately equal to 100 liters per day per meter (L/d-m). If distributed over the river bottom, the areal flow rate is about 1 liter per square meter per day (L/m^2-d). The equivalent Darcy velocity is 0.1 cm/d, more than an order of

magnitude lower than the estimated diffusive mass transfer velocity from sediments needed to reproduce the PCB levels observed in the water column (Alcoa, April 2001).

In addition to the modeling, groundwater seepage rates were measured at three sediment probing transects with soft sediment bottoms (T6, T13, and T28) in the lower Grasse River during two surveys; one in fall 1998 and one in spring/summer 1999. A third set of measurements was obtained from several locations within and adjacent to the CPS area between April and November 2002 as part of the CPS post-implementation monitoring. Overall area-wide average fluxes of -0.004 L/m^2-d (the negative sign implying flow from the river into the sediments), +0.014 L/m^2-d and +0.045 cm/d were measured for the 1998, 1999, and 2002 surveys, respectively (Alcoa, April 2001; Alcoa, September 2003). The lowest and highest individual seepage velocities (ignoring porosity effects) for the three surveys were as follows: -0.023 cm/d and +0.025 cm/d for 1998; -0.062 cm/d and +0.041 cm/d for 1999; and -0.011 cm/d and +0.059 cm/d for 2002 (Alcoa, April 2001; Alcoa, September 2003).

There are seasonal variations in the groundwater elevations at the Massena site, and also likely seasonal head differences between water beneath and within the river. Monitoring wells on the Massena site typically show changes of groundwater elevations of less than two feet for the valley wells and 5 to 10 feet for ridge wells. These variations are a small fraction of the total head difference of about 50 feet for wells just north of the North Grasse River Road to 100 feet for wells near the south side of the Secure Landfill. Therefore, seasonal variations in groundwater elevation likely result in head differences of no more than 10 percent of the seasonally-averaged head. This suggests that there should not be significant seasonal variations in the amount of groundwater discharging to the lower Grasse River unless other factors (i.e., flows and heads associated with the St. Lawrence River) are involved (Alcoa, April 2001).

The evidence from the multiple and fundamentally different characterization approaches supports a conclusion that there is no significant amount of groundwater being discharged in a broad, diffuse pattern through the soft sediments present in areas downstream of Outfall 001. However, the available data do not exclude the possibility of some locally significant groundwater discharges through the banks of the Grasse River or through bedrock fractures where bedrock lies at or near the river bottom (Alcoa, April 2001) and the data support that discharge of PCBs from the upland areas through groundwater to the Grasse River is not a concern. All impacted groundwater around the upland sites continue to be actively monitored.

2.4.6 Propeller Wash

The turbulence and water motion caused by boat propellers, known as propeller wash (or prop wash), can cause resuspension of sediments, particularly in shallow waters. The USACE has developed methods to calculate the velocity on the river bottom caused by boat propellers (Palermo et al., September 1998). These methods were used to determine the bottom velocities caused by two boat sizes: 1) a 16-foot long, 8-foot wide boat with a 50-horsepower (HP) engine and 12-inch propeller; and 2) a 20-foot long, 8-foot wide boat with a 250 HP engine and 18-inch propeller. The USACE equations were used in conjunction with those from other studies to compute the resuspension that would be caused by these boats when operated at top speed or when accelerating from a stationary position. Operations in deep water caused negligible resuspension. Top-speed travel in water less than 5 feet deep (an inadvisable, and likely rare, practice) was

estimated to resuspend sediments from the top 0.03 and 0.16 cm of sediment for the smaller and larger boats, respectively. Full-throttle acceleration from a stationary position in 5 feet of water would resuspend 0.35 cm of sediment over a length of about 250 feet of river bottom.

The modest depths of resuspension are the result of the short time (on the order of a few seconds) the sediment bed is subjected to the high velocities. The resuspension depths are sufficient, however, to generate a visible sediment plume. For example, the full-throttle acceleration would cause a TSS concentration of 1,600 mg/L in the wake behind the boat. The details of the prop wash calculations are presented in Appendix B. In addition, placement of boat anchors is expected to have potential localized impacts due to the relatively small surface area potentially affected by this activity.

2.4.7 Dechlorination and Degradation

Analysis of the PCB congener data from the high-resolution cores provides several indications that there are bacteria present in the lower Grasse River sediments that are capable of dechlorinating PCBs. For example, reductions in the total number of chlorines per biphenyl molecule are observed in the high-resolution core data (Figure 2-44). In addition, there are strong relationships between dechlorination end-products BZ 4 (2,2'-dichlorobiphenyl) and BZ 19 (2,2',6-trichlorobiphenyl) and the total number of chlorines, suggesting the production of these congeners during the dechlorination process. The lack of accumulation of BZ 1 (monochlorobiphenyl) in sediments containing PCBs dominated by BZ 4 and BZ 19 suggests the existence of some mechanism for the destruction of BZ 1 (Alcoa, April 2001).

Additional evidence of microbial degradation is seen in the ratios of biphenyl to total PCBs measured in sediment samples; the ratios are 1 to 3 orders of magnitude greater than those observed in pure Aroclors 1242 and 1248 (0.02 and 0.03 percent, respectively). Microcosm experiments using lower Grasse River sediments spiked with dichloro-orthonated PCB congeners suggest the potential for PCB destruction under anaerobic conditions. In these experiments, a 25 percent reduction in congener mass was observed. In addition, small amounts of biphenyl (equaling 2.7 percent of the spiked congeners) were produced (Alcoa, April 2001).

Although the laboratory studies indicate the potential for these processes to contribute to the long-term fate of PCBs in the lower Grasse River, it does not appear that dechlorination and biodegradation of PCBs are currently important near-term processes in the river. Long-term in-river studies would be required to collect the necessary information to understand to what extent biodegradation may be an important consideration in the evaluation of the long-term fate of PCBs in the lower Grasse River (Alcoa, April 2001).

2.5 Site-Specific Actions

PCB levels measured in the water column and resident fish of the river over the past 17 years have dramatically declined since the mid- to late 1990s. These declines are due to two factors: 1) a downward trend in water column PCB concentrations that resulted from the land-based remediation efforts performed on Alcoa plant site property between 1990 and 2001 that significantly reduced the PCB discharges to the river; and 2) natural recovery due to "clean" solids that continually enter the river from upstream and deposit

on top of the PCB-containing sediments, reducing the movement of PCBs to the water column and fish. This deposition of clean solids onto the lower river sediment bed is expected to continue to reduce PCB levels in water and fish into the future.

In addition to the land-based remediation that was performed between 1990 and 2001, Alcoa also conducted several site-specific actions in the river to obtain information regarding technologies that could help accelerate the observed recovery in water and fish tissue monitoring data. The NRC report entitled Sediment Dredging at Superfund Megasites: Assessing the Effectiveness supports the use of pilot studies indicating that "complicating site conditions and operational limitations can also be identified through pilot studies to verify the performance of the selected technology under site-specific conditions" (NRC, 2007 – p. 181). USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites also indicates that, in evaluating removal activities, "project managers should make realistic, site-specific predictions of residual contamination based on pilot studies or data from comparable sites" (USEPA, December 2005 – p. iv). The site-specific actions conducted within the Grasse River include the 1995 NTCRA, 2001 CPS, 2005 ROPS, 2006 ACPS, and 2007 Ice Breaking Demonstration Project.

As described herein, these projects and related monitoring have provided site-specific knowledge regarding the efficacy of dredging, various capping approaches, in-situ activated carbon technology, and monitored natural recovery that have been used to inform the development and evaluation of alternatives for the Study Area. As a result of these projects, approximately 15 acres of river bottom have been addressed through capping or activated carbon treatment and approximately 29,000 cy of sediment containing 15,200 lbs of PCBs have been removed.

Additional details for all pilot and/or demonstration projects conducted within the lower Grasse River are provided in Sections 2.5.1 through 2.5.7.

2.5.1 Non-Time-Critical Removal Action

The NTCRA was conducted in 1995 (with USACE oversight) to address a targeted 3,500 in-situ cy of PCB-containing sediment located adjacent to Alcoa's Outfall 001. In cooperation with USEPA, NYSDEC, and USACE, Alcoa designed the NTCRA to remove the most upstream location of sediments containing the highest levels of PCBs in the lower Grasse River while obtaining Study Area-specific data (e.g., dredging capability and effectiveness). A summary of the NTCRA and associated results is presented below. Additional information can be found in the draft NTCRA Documentation Report (BBL, December 1995).

2.5.1.1 NTCRA Construction (Removal and Water Treatment) Activities

From July 1995 through September 1995, Alcoa conducted the removal, dewatering, and disposal of approximately 2,600 in-situ cy of sediments along with 400 cy of boulders/debris from a 1-acre area adjacent to Outfall 001 (see Figure 1-3). Removal of boulders/debris was accomplished using mechanical excavation equipment. Removal of sediment from the majority of the area was accomplished using a horizontal auger dredge, while sediment removal in an area immediate to the outfall was conducted using manual (i.e., hand-held) hydraulic dredging techniques. During sediment removal activities, the targeted area was isolated

using a triple-layer silt containment system, with the secondary curtain lowered to the river bottom to limit PCB and TSS transport. All boulders and dewatered sediments were disposed in Alcoa's on-site Secure Landfill.

As dredging operations progressed throughout the NTCRA area, a number of implementation issues were identified. Most notably, the uneven/rocky nature and unique characteristics of the river bottom, including the presence of hardpan, prevented the removal of all sediment. After all practicable efforts were taken, an average of 4 inches (up to 14 inches) of sediment remained where the horizontal auger dredge was used, and approximately 6 inches of sediment remained within the area immediately adjacent to the outfall where the hand-held dredging was conducted.

Water treatment operations took place throughout the entire sediment removal process. During the water treatment operations, more than 11.6 million gallons of filtrate were processed. Grab samples of the treatment plant effluent were collected daily and analyzed for total PCBs. In 93 percent of the samples collected, PCB Aroclor concentrations were not detected above the method detection limit (MDL) of 0.065 μg/L. With one exception, the discharge criteria agreed upon by the Agencies (0.3 μg/L) were met.

2.5.1.2 NTCRA Environmental Monitoring Results

Along with the removal and disposal operations described above, Alcoa implemented the NTCRA Environmental Monitoring Plan (BBL, May 1995) to document the operations and assist in the evaluation of the various aspects of the dredging and dewatering activities. The NTCRA Environmental Monitoring Plan provided for the collection of water column, sediment, air, and biota samples (along with operational data) before, during, and after the NTCRA.

Water column monitoring data indicated that the containment system was effective in containing a majority of the suspended sediment; however, based on local TSS monitoring, some solids did escape the system (estimated at 0.2 percent of the total removal volume). Water column data also indicated the release of PCBs outside of the containment system (estimated at 5 to 30 lbs). PCB levels in water column samples collected 6 weeks after removal of the silt curtain system were consistent with pre-NTCRA levels.

Post-NTCRA (1995) sediment sampling indicated that the average PCB concentration in the top foot of sediment was reduced approximately 86 percent from 518 mg/kg to 75 mg/kg. If only 0- to 3-inch core sections are considered, the average PCB concentration was reduced approximately 57 percent from 176 mg/kg to 75 mg/kg (ranging from 1.1 to 260 mg/kg). Thirty percent of the locations sampled exhibited an increase in PCB concentration within the top foot from pre- to post-conditions. Eight grab samples collected from the top 3 inches of sediment from the NTCRA area in 1997 (approximately 2 years after dredging) as part of the SRS Program yielded PCB (Aroclor) concentrations ranging from 4.52 to 3,480 mg/kg, with an arithmetic average of 452 mg/kg.

PCBs were not detected in any air samples collected during the NTCRA.

Biota monitoring (both caged fish and resident fish sampling) indicated the release of PCBs from the containment system that surrounded the NTCRA area. Specifically, caged fathead minnows deployed during and shortly after the removal action exhibited much higher PCB concentrations than those deployed shortly before the NTCRA. Similarly, post-NTCRA spottail shiner samples collected in the vicinity of the NTCRA area exhibited PCB concentrations as much as six times higher than shiner collected in previous years. By 1998, the spottail shiner collected in this vicinity exhibited concentrations apparently lower than previous pre-NTCRA levels. On-going source control activities also likely contributed to observed declines in fish tissue concentrations.

2.5.2 Capping Pilot Study

Alcoa implemented the CPS in summer and fall 2001 to obtain site-specific data to evaluate the feasibility and construction-related impacts of placing clean capping material over the native sediments. The study involved the placement of capping materials over a 750-foot stretch of main channel sediments (covering approximately 7 acres) about 1 mile downstream of Outfall 001 between sediment probing Transects T15 and T16.5 (see Figure 1-3) using the cap designs and placement techniques discussed below. Additional details regarding the CPS are presented in the Documentation Report, Grasse River Capping Pilot Study (Alcoa, April 2002a). Alcoa continued to monitor the main channel cap in 2002 (Alcoa, September 2003) and 2003 as discussed further below.

2.5.2.1 Capping Pre-Engineering Design Studies

In 1998, Alcoa initiated a series of pre-design studies to evaluate the potential of a subaqueous cap to reduce concentrations of PCBs in surface sediment. The pre-design studies consisted of field, laboratory, and modeling efforts. Details of the studies, approaches, and results are presented in the Lower Grasse River Capping Pre-Engineering Design Studies Report (Alcoa, March 2001). These pre-design studies included PCB transport modeling, ^{210}Pb modeling, hydrodynamic and sediment transport modeling, molecular diffusive transport evaluation, capping material adsorption study, cap settling study, cap consolidation study, cap stability tests, groundwater seepage study, sediment-water interface photography, ecological survey, sediment bed elevation measurement study, geophysical survey, cohesive properties test, literature search and consultation with experts, and potential cap material testing.

2.5.2.2 CPS Design

Alcoa consulted several resources to guide the development of a conceptual cap design including the USEPA (Palermo et al., September 1998) and USACE Guidance for Subaqueous Material Capping (USACE, June 1998). In addition, the Capping Pilot Study Work Plan (Alcoa, July 2001) was provided to the USEPA-sponsored RTDF for comment.

The CPS was designed to achieve several objectives through the placement and monitoring of three different cap material types using both surface and subsurface placement techniques. The 7-acre site was divided into four cells and two phases. The first phase was designed to screen capping material and

application methods and was conducted in Test Cell #1, which was further sub-divided into five subcells. The second phase was conducted in Pilot Cells #2 through 4, and was designed to evaluate the material/application combinations considered most promising based on the first phase of work under operating conditions approximating full-scale application. Cap materials included, either alone or in combination, a 1:1 sand/topsoil mix, granulated bentonite, and AquaBlok™ (i.e., a commercial, clay-gravel composite), while application methods included surface and subsurface placement of dry material via mechanical clamshell bucket, and subsurface placement of slurried material via tremie pumping application. The sand and topsoil mix was designed to have the approximate characteristics of the native main channel sediments. The intent of this formulation was to provide adsorptive capacity for the aqueous phase PCBs that might diffuse into the cap while also providing a favorable substrate for recolonization of benthic organisms (Alcoa, July 2001).

The pilot study objectives included evaluation of the following:

- Cap placement techniques;
- Cap coverage effectiveness (including the ability to cap steep side slopes and the extent of particle size gradation of cap material during placement);
- Extent of potential mixing of underlying sediment in cap materials during placement;
- Degree and effects of resuspension during placement;
- Water column effects during placement;
- Cost; and
- Recolonization of the cap by benthic organisms.

2.5.2.3 CPS Monitoring Results

An extensive monitoring program was implemented during the study to collect the information needed to evaluate each of the pilot study objectives. The monitoring program included bathymetric survey, cap thickness measurements, water quality monitoring, sediment core collection, and benthic invertebrate sampling. Conclusions regarding each of these objectives are provided below.

<u>Cap Placement Techniques</u>

- Placement of dry, bulk capping material by clamshell was demonstrated to be more effective, cost efficient, and successful at achieving environmental objectives than was placement of slurried cap material using a tremie pumping system. Pneumatic broadcasting of granular bentonite was briefly

piloted and determined an unsuccessful means of material placement. Both clamshell and tremie application techniques were able to reliably meet cap thickness targets.

Cap Materials

- The 1:1 sand/topsoil mixture was identified as the best material of those tested during the CPS considering the combination of logistics, production rates, cap coverage, and unit costs. In addition, the sand/topsoil mix provides a reasonably natural sediment bed conducive to the re-establishment of benthic organisms.

- The total organic carbon (TOC) content of the in-place cap was variable (non-detect to 1.78 percent; average 0.71 percent), but sufficient to significantly attenuate PCB migration through the cap.

Cap Coverage Effectiveness

- Average cap thickness met (or exceeded) the target thickness (1 or 2 feet) for all cells using clamshell placement with the sand/topsoil mix.

- The uniformity of cap thickness varied from cell to cell. For the pilot cells, where the application could be considered most representative of a full-scale project, the standard deviation of the cap thickness measurements, expressed as a percentage of the average thickness, averaged 27 percent.

  Target cap thickness was not achieved on the steep side slopes (30 to 50 percent grade), indicating that the side slopes of the river in the area of the CPS generally can support a cap no more than a few inches thick. The best coverage on the side slopes was achieved in Pilot Cells #2 and 4, where 2 to 12 inches of material remained in place after application. No PCBs were detected in this material.

- Vertical profiles of TOC and grain size in the caps indicated no significant loss of fine-grained material or separation by grain size.

Entrainment of PCBs into Cap Materials

- None of the application techniques resulted in significant PCB entrainment into the cap. PCB levels in cap materials were typically near or below detection limits (commonly 0.06 mg/kg).

- For the pilot cells, PCBs were non-detect in 95 percent (153 of 161) of the cap material samples analyzed from 24 cores. When detected, PCBs were at concentrations less than 1 mg/kg (except one sample at 1.51 mg/kg), and were almost exclusively seen at the interval just above the native main channel sediments. Sixteen (67 percent) of the cores contained PCB concentrations that were below detectable limits throughout the entire cap. Of the remaining eight cores, five (21 percent) contained PCB concentrations that were below detectable limits except for the bottom 2 to 4 inches of the cap. In these instances, the detectable PCBs at the bottom of the cap were 10 to 200 times lower than the PCB

concentrations being capped. The remaining three cores either contained no cap material (two cores from the side slope areas) or contained a low level PCB detection in the middle of the cap layer.

Water Quality Impacts

- Water quality impacts from PCBs were negligible at downstream monitoring stations, as well as inside and adjacent to the Test Cell.

- While TSS and turbidity levels were elevated inside the cell undergoing capping, downstream levels were not significantly elevated by the capping. Where elevated levels of TSS and turbidity were seen, it was primarily due to placement of clean material.

- At the downstream monitoring station, the corrective action trigger levels for PCBs (2 μg/L), TSS (25 mg/L over background), and turbidity (25 Nephelometric Turbidity Units [NTU] over background) were never reached during the project.

- Water quality monitoring results obtained during the centerline wedge capping – performed without the use of silt curtains – were comparable to the results obtained with silt curtains in place.

- Post-capping water quality monitoring in October/November 2001 showed no residual effects of the main channel capping (i.e., non-detect levels of PCBs and TSS and turbidity levels consistent with baseline conditions).

Recolonization by Benthic Community

- Data collected 2 to 3 weeks after completion of the study indicate the presence of 17 different benthic species within the capped area compared to 39 species identified during the pre-capping assessment.

2.5.2.4 2002/2003 Post-CPS Monitoring Results

Monitoring continued in 2002 to evaluate various aspects of the in-place performance of the main channel cap the year following installation. Monitoring included cap thickness measurements, cap observation, cap material shaker study, near-bed sediment transport monitoring, sediment core collection, groundwater seepage monitoring, and benthic invertebrate sampling. A summary of the results of the 2002 monitoring activities is presented below, and details on the monitoring program are provided in the 2002 Capping Pilot Study Monitoring Program Summary Report (Alcoa, September 2003).

- The main channel cap remained intact with the total average cap thickness maintained.

- The erosive properties of the in-place main channel cap were found to be similar to those of the native lower river sediments.

- There was no evidence of significant PCB migration into and through the main channel cap, with the vast majority of samples collected from the cap containing no detectable PCBs.

- Groundwater advection through the main channel cap was not an important PCB transport mechanism.

- A relatively abundant and diverse assemblage of macroinvertebrate organisms had successfully recolonized the in-place main channel cap within 1 year of placement.

Monitoring activities for the CPS area continued in April 2003, beginning with cap thickness measurements. Results of these initial cap thickness measurements indicated that significant changes in bed elevation (i.e., scour and deposition) occurred within the CPS area between the conclusion of the 2002 monitoring activities and the initiation of the 2003 monitoring work. As a result of these observations, an extensive follow-up investigation was performed in 2003 to understand the cause of changes in the CPS area, the mechanisms involved, and the overall impacts of the event on the distribution of PCBs in the river. This investigation and results are summarized in Section 2.4.2, with additional information presented in the Draft CCLGR Addendum (Alcoa, April 2009). In summary, results of the investigation indicated that an ice run that occurred in the upper portion of the river contributed to the formation of several ice jams in the lower river, including a jam directly over the CPS area. The occurrence of ice jams in the lower Grasse River was not known prior to the 2003 event, and the capping materials used in the CPS were not designed to withstand ice jam-related scour forces.

The 2003 ice jam revealed that, despite the extensive studies undertaken to date, several outstanding technical issues relevant to the development and evaluation of remedial options for the river need to be studied and addressed prior to remedy selection. To gather additional information to address these issues, Alcoa and USEPA agreed to perform the ROPS in 2005 (Section 2.5.3).

2.5.3 Remedial Options Pilot Study

The ROPS was performed between April and December 2005 to provide information pertaining to potential remedial alternatives for addressing contaminated sediments in the lower Grasse River. The ROPS was conducted by Alcoa with oversight from the Agencies (USEPA served as the lead Agency). Three primary objectives were developed for the ROPS.

- Evaluate remedial options to reduce potential risks associated with exposure to buried PCBs that could be mobilized by a future ice jam-related sediment scour event in the lower Grasse River.

- Develop information to address outstanding issues regarding remedy effectiveness, remedy implementation, and the conceptual site model that impact the analysis of remedial alternatives.

- Make progress in the lower Grasse River to support final remedy development, evaluation, selection, and implementation.

In consideration of these objectives, four major construction components of the ROPS were designed to be completed in one construction season in select portions of the main channel and near shore areas within the lower Grasse River between T7 and T16 (see Figure 1-3). A monitoring component common to all activities was also part of the pilot study. The ROPS construction components included the following activities.

- Dredging all soft sediments, to the extent possible, in the main channel and adjacent northern side slope area in the vicinity of T7 with cap placement over dredged areas.
- Dredging 1 ft of soft sediment in the northern near shore area (i.e., areas with less than 5 ft of water) between T6 and T7 with cap placement over dredged areas.
- Placement of a 3- to 6-inch cap in the southern near shore area between T8.5 and T9.5.
- Placement of an armored cap in the main channel between T15 and T16.

Installation of a pier-type ICS was also proposed as a ROPS component, with an area upstream of the Route 37 Bridge initially identified as the preferred location for construction of such a structure based on physical characteristics along the river. However, in response to community concerns raised with respect to the originally proposed location (which was several miles upstream of the Study Area), Alcoa and USEPA agreed to evaluate alternative locations for an ICS and review alternative interim ice control measures (see Section 2.5.5).

A summary of the construction and monitoring activities associated with each component is presented below. Additional information can be found in the Draft ROPS Documentation Report (Alcoa, May 2006).

2.5.3.1 ROPS Construction Components

Mobilization activities in the project area began in April 2005 and included establishing four distinct work areas (i.e., project personnel area, materials processing pad, river operations area, and Secure Landfill Cell 3). To mitigate movement of resuspended sediment and PCBs outside the various work zones, a silt curtain containment system was installed for each targeted dredging and/or capping area. The curtains enclosed the northern near shore and main channel dredging/capping areas. Additional silt curtains were installed in an “L” configuration downstream of the armored cap area and the southern near shore area cap.

The curtains required full-time maintenance throughout the ROPS due to the pressure wave phenomenon in the Grasse River associated with the release of water from the Snell Lock at the mouth of the river and from several extreme flow events that occurred during the study. The curtain system was modified (i.e., installing gates, air curtains, new higher strength curtains, and supplemental anchors); however, even with these additional measures, the curtains were severely damaged after a number of high-flow events and intense local storms as well as from the impacts of the pressure wave from lock operations on the St. Lawrence Seaway, resulting in dredging shutdowns and delays.

Main Channel Dredging

The main channel was initially divided into three separate work zones (Work Zones 1, 2, and 3). In general, debris removal preceded sediment removal and was carried out continuously during the main channel work. Dredging was initially performed using a horizontal auger hydraulic dredge. During the main channel dredging efforts, down time occurred due to frequent equipment maintenance and repairs caused by site bottom conditions, limitations imposed by the dredge slurry processing system, and weather-related delays.

After dredging the top layer of sediment, a variety of issues complicated removal of the remaining materials, and far less sediment was removed than originally anticipated. The underlying river bottom was determined to be irregular and uneven, and dredge operators frequently encountered hard bottom, rocks, or interbedded debris which resulted in equipment damage and delays. In addition, sampling efforts conducted to track the progress of the removal work indicated that significant deposits of PCB-containing sediments remained in many areas after repeated dredging attempts. These problems were compounded by the fact that, as sediment removal became more difficult, the dredged material contained less sediment and more water, and that excess water had to be separated from the sediments and treated. Results of daily water column sampling showed periodic exceedances of the PCB water quality action level, which necessitated modifications to the type of equipment employed and operation of the debris removal process. Collectively, all of these issues impacted removal efforts and significantly reduced dredging productivity.

The initial plan was modified in various ways in an effort to address these complications and maintain progress toward the project goals. These included:

- Sediment sampling was conducted using vibracoring methods in an effort to more accurately characterize the depth of remaining PCB-containing sediments.
- Multibeam bathymetry surveys of the work area were conducted to provide a better understanding of the bottom conditions encountered and to gauge progress on sediment removal efforts.
- Divers were deployed to collect video footage of select topographic features (typically boulders, rocks, and rock formations) observed on the multibeam survey.
- Orientation of the dredge relative to river flow, and its forward speed and auger rotation rate, were varied in an effort to improve capture of the remaining sediments.
- Numerous dredging passes were conducted in an attempt to remove residual PCB-containing sediments.
- Debris removal equipment and associated operating practices were modified in an effort to address periodic exceedances of the water quality action level for PCBs.
- Alternative dredging equipment was tested toward the end of the study.

- Geotubes were employed in an effort to relieve capacity constraints in the sediment dewatering system (components of dewatering system listed below).

In late August, the results of the investigative efforts and the difficulties encountered in removing sediment led Alcoa, in coordination with USEPA, to reassess what could be completed in the remaining construction season. Specifically, Alcoa proposed to concentrate remaining removal activities in Work Zone 1 and the first 75 feet of Work Zone 2 (termed expanded Work Zone 1), which represented approximately one third of the main channel area included in the original plan. This area was targeted in an effort to learn as much as possible about the issues impacting removal of the remaining sediments and to complete removal to the extent possible before the end of the construction season.

In early October, Alcoa tested a mechanical clamshell dredge and a swinging ladder cutterhead hydraulic dredge. The cutterhead dredge worked for 10 days in specific areas within Work Zone 1, most of which had already been subject to multiple dredging passes by the horizontal auger. Sampling conducted after the completion of the work and measurements of the volume of sediment removed indicated that the cutterhead dredge did not significantly improve dredging removal efficiency. The mechanical dredge was used for 3 days in discrete sections of the work area; no significant improvements in dredge removal efficiency were noted. Although limited conclusions can be drawn from this effort due to the short duration of the work, the site bottom conditions encountered are expected to negatively impact the effectiveness of any currently available environmental dredging technology.

Despite numerous attempts to improve efficiency and productivity, at the end of the season, significant amounts of PCB-containing sediment remained in some portions of expanded Work Zone 1. During the initial dredging passes, sediments were removed at a rate of about 38 cubic yards per hour (cy/hr), but as efforts turned to removing remaining sediments and negotiating the rockier, more irregular areas, dredging productivity dropped by nearly half, to about 20 cy/hr, and then further declined in the final 2 weeks.

Comparison of pre- and post-dredging multibeam bathymetry indicated that approximately 24,400 cy (20,600 cy in Work Zone 1 and 3,800 cy in Work Zone 2) of the 49,500 cy of sediments originally targeted in these work zones had been removed (total targeted removal volume for the main channel, including Work Zones 1, 2, and 3, was approximately 64,000 cy). Approximately 84 percent of the PCB mass targeted was removed from Work Zone 1. Residual sediments were, on average, 16 inches thick with an average surface PCB concentration of 150 mg/kg compared to the pre-dredging baseline surface concentration of approximately 4 mg/kg. The entire area of the main channel that was subject to dredging and/or debris removal was capped prior to the conclusion of construction activities to isolate remaining PCBs.

Overall, a total of 1,156 upstream/downstream and 244 cross-channel dredge passes were conducted in Work Zone 1, which corresponds to more than 100 dredge passes in each 25-ft by 25-ft subunit within the work zone (complete coverage of each subunit required roughly four dredge passes when accounting for overlap).

Northern Near Shore Removal

In the northern near shore area, conventional mechanical excavation equipment (i.e., a long stick excavator) mounted on a barge was used to remove debris and targeted sediments to a minimum depth of 1 foot. The 1-foot-thick layer of sediment targeted for removal was successfully dredged, although much more material was removed than originally anticipated (1,600 cy versus the initial estimate of 800 cy). No significant operational issues were encountered with the exception of survey control issues, resulting in the area needing to be revisited twice following the initial removal effort to achieve the target depth of removal. The average post-dredging PCB concentration in the top 3 inches of sediment was an order of magnitude lower than pre-ROPS conditions (1.9 mg/kg compared to 19 mg/kg).

Sediment Dewatering, Processing, and Disposal at Alcoa's Secure Landfill

Large objects within the hydraulically dredged materials (debris, stones, wood, etc.) were segregated using screens, and the remaining materials were dewatered. The sediment dewatering system operated 24 hours per day and included shaker screens, hydrocyclones, agitated pump tank and feed mix tanks, polymer treatment, and filter presses. Water removed from the sediments was captured, treated, and tested before being discharged to the river. Dewatered material was disposed in Alcoa's on-site Secure Landfill. No exceedances of the effluent criteria for PCBs occurred at any time during the study.

Several times during the ROPS, dredging in the main channel was delayed because of insufficient capacity in the dewatering system. The primary constraint was the rate at which fine sediments were processed through the filter press operation. Several adjustments were made to increase the percent fines in the dredge slurry; however, negligible increases were attained. In response to this issue, Geotubes were utilized to evaluate the efficiency of this alternate dewatering approach. A polymer was added to the sediment before it was pumped into the Geotubes to improve the dewatering characteristics of the slurry.

At the completion of the project, the filled Geotubes were allowed to dewater, then were cut open, the contents stabilized, and the dewatered sediments removed and disposed at Alcoa's on-site Secure Landfill. All the water that drained out of the Geotubes was captured and treated before being discharged back to the lower Grasse River. Although valuable information on the use of Geotubes was collected and operational dredging time was increased, the addition of the Geotubes ultimately did not significantly impact dredging productivity rates, and the Geotubes materials also required the addition of a stabilizing agent prior to being transported to the Secure Landfill due to the high water content of the solids.

Main Channel Post-Dredge Capping

Dredged areas (i.e., main channel and northern near shore) were capped via clamshell with a single lift of a clean mixture of sand and topsoil to limit the potential for exposure to remaining PCB-impacted sediments. Approximately 1 foot of a sand and topsoil mixture was placed in the main channel, and an adequate volume of this mixture was placed in the northern near shore area to restore the riverbed to the pre-ROPS elevation/grade. All capping materials were placed using a mechanical clamshell.

In the main channel area, approximately 13,100 cy of sand and topsoil were placed across expanded Work Zone 1. Samples of the main channel cap surface (i.e., top 2 inches) analyzed for PCBs showed an average concentration of 7.4 mg/kg, which represents a 95 percent reduction relative to post-dredging conditions (139 mg/kg).

The average post-capping concentration of 7.4 mg/kg at the cap surface (i.e., top 2 inches) reflected an increase from average sediment PCB levels in the top 3 inches of sediments from Work Zones 1 and 2 prior to dredging (approximately 4 mg/kg). Placement of the cap materials in a single lift, which was successfully performed during the CPS over areas of the river that had not been dredged, was potentially a factor in the post-capping PCB levels observed.

Grid-based elevation measurements were taken during cap placement to monitor achievement of the target cap material thickness of 1 foot (with an allowable over-placement of 6 inches). A multibeam bathymetric survey conducted at the conclusion of all site construction activities indicated that there was significant variability in the final cap thickness, which ranged from 0.5 to 2.5 feet with an average of 1.5 feet in the main channel capping area.

Northern Near Shore Post-Removal Capping

Approximately 1,700 cy of sand and topsoil were placed in a single lift via clamshell as part of the capping effort in the northern near shore area, and the final cap thickness ranged from 0 to 2.2 feet with an average of 1 foot across the area. Post-placement samples of the cap analyzed for PCBs showed an average concentration of 0.24 mg/kg in the top 2 inches, which represents an 87 percent reduction relative to post-dredging conditions (1.9 mg/kg) and a 99 percent reduction compared to baseline conditions (19 mg/kg). In addition, there was relatively little mixing of the underlying sediments and cap materials, and the mixing that did occur appeared to be limited to the bottom 2 to 4 inches of the cap.

Southern Near Shore Area Thin-Layer Capping

A 3- to 6-inch sand/topsoil cap (approximately 300 cy) was placed in a single lift via clamshell in the southern near shore area over top of the existing sediments to evaluate implementation of thin-layer capping in a near shore area that had not been dredged. Cap thickness estimates from manual elevation measurements indicate an average cap thickness of about 0.4 feet (range of 0.3 to 0.5 feet), which was within the target cap thickness of 0.3 to 0.5 feet (3.6 to 6.0 inches). Four of the six post-placement cores contained cap material (range of 0.2 to 0.3 ft); two others did not contain any cap material. These two cores were collected between the cap thickness measurement grid nodes measured immediately following construction. The lower cap thicknesses or lack of cap material observed in the post-placement cores is likely attributable to the constructability/quality control procedures employed during the capping process and the limited areal extent of the localized placement of additional cap material in response to measurements at each grid node (Alcoa, May 2006). Review of the data also indicates that steepness of the near shore areas may impact cap placement in these areas. While these data identify areas where improvements in characterizing the target cap areas and placement/measurement procedures during construction could ensure more uniform cap coverage and longer-term stability of the in-place cap, they do not constitute failure

of capping in the near shore areas of the river. Improvements in placing and verifying cap thickness during construction and consideration of site-specific conditions (e.g., bottom slope) in the design would be necessary to achieve consistency and more uniform cap thickness across the entire cap area.

PCB levels measured at the cap surface (i.e., top 2 inches) post-placement were near or below the detection limit in five of the six cores collected from this region. One core contained a PCB concentration of 3.34 mg/kg at the cap surface; however, this sample appeared to consist of native sediment and not cap material. The average PCB concentration in the top 2 inches of the placed cap was 99 percent lower than the pre-ROPS value (0.06 mg/kg compared to 8.3 mg/kg), considering the four cores that contained cap material. Considering all six of the post-placement cores, an average PCB concentration in the top 2 inches of the cap was about 0.60 mg/kg. This value is about 93 percent lower than the pre-ROPS value of 8.3 mg/kg.

Surface sediment PCB concentrations were reduced by 93 to 99 percent immediately after cap placement, depending on the post-placement cores used for the estimation of post-cap conditions. Note that these reductions are consistent with the 95 percent reduction used to simulate cap effectiveness for the site (see Appendix E for additional details).

Main Channel Armored Capping

An armored cap was placed via clamshell on native (undredged) sediments in an approximate 1-acre area downstream of the main ROPS work area. There were two different configurations of the armored cap, which was designed specifically to resist the faster water flows and scour forces associated with ice jams. In the upstream half of the area, the cap consisted of a layer of sand and topsoil, a filter layer of small gravel, and then an armor layer of large stones. The downstream half cap consisted of two different filter layers of small gravel and a top layer of large armor stones.

Approximately 3,800 cy of materials were placed as part of the main channel armored cap. Grid-based elevation measurements were taken following each lift during armored cap construction to monitor achievement of the target cap material thickness of 2.1 feet in the upstream half of the cap area and 1.7 feet in the downstream half of the cap area (with an allowable over-placement of 12 inches). Comparison of pre- and post-armored capping multibeam bathymetric surveys indicated that, on average, final cap thickness in the upstream portion (which included the sand/topsoil base layer) was 1.9 feet and 1.3 feet in the downstream area.

Based on these multibeam bathymetry comparisons, only about 35% of the upstream portion of the armored cap area contained a cap thickness that met or exceeded the minimum 2.1 feet requirement, while only about 23% of the downstream portion of the armored cap area contained a cap thickness that met or exceeded the 1.7 feet minimum requirement. Several factors likely contributed to this: 1) local adjustments to the cap (in the event cap thickness at a particular grid node was not within the prescribed tolerance limits) were limited in areal extent; 2) measurement error associated with the manual elevation measurement technique; and 3) consolidation of the in-place cap material and/or native sediment. Improvements in placement and measurement techniques would be implemented for future armored cap placement activities

(Alcoa, May 2006). Post-placement PCB levels were not measured in the armored cap area due to logistical considerations associated with sampling the materials used for the armor and base layers.

2.5.3.2 ROPS Environmental Monitoring Results

An intensive baseline, during-construction, and post-construction monitoring program was developed for the ROPS. The environmental monitoring results are summarized below (additional monitoring results associated with construction are described in Section 2.5.3.1).

- More than 800 water samples were collected for PCB and solids analysis. While action levels for turbidity and TSS were never exceeded during the project, PCB action levels were exceeded on 8 of 128 days of in-river activities. Water monitoring data also revealed that approximately 225 lbs (102 kilograms [kg]) of PCBs (approximately 3 percent of the total PCB mass removed during the ROPS) were released and transported downstream, primarily during debris and sediment removal activities, with the majority of the water column PCB releases occurring in soluble form. At the downstream transect, dissolved PCBs comprised 69 to 89 percent of the total PCBs. TSS and turbidity action levels were never exceeded, although releases of solids were higher during cap placement than during dredging.

- More than 100 air samples were collected for analysis of PCBs, particulate matter, and other compounds. There were no exceedances of the action levels for PCBs or other compounds. Some elevated levels of particulate matter were measured, but further assessment revealed the exceedances were not related to the ROPS.

- A total of 144 fish samples were collected for PCB analysis throughout the lower Grasse River in association with the SRS Program (collection occurred in August and September 2005). PCB levels in the species sampled – smallmouth bass, brown bullhead, and YOY spottail shiner – increased relative to previous years as a result of resuspension-derived PCB releases associated with the dredging and debris removal operations. PCB levels in the YOY spottail shiner near the river mouth were the highest ever recorded. Subsequent annual fish monitoring results indicated that PCB levels in fish declined to levels approximating pre-dredge concentrations by the fall of 2006.

- Monitoring was also carried out to gauge impacts associated with odor, noise, and lighting impacts on the community. All results were below established corrective action levels.

2.5.3.3 ROPS Findings and Conclusions

As summarized below, the ROPS was successful for a variety of reasons despite the numerous difficulties encountered during the work.

- Significant information was developed regarding the uniqueness and complexity of the site conditions as they relate to the implementability and effectiveness of remedial options.

- A significant quantity of PCB-containing sediments was removed from an area of the river that is prone to ice jam-related scour. Residual PCBs were isolated under caps, and a wealth of new site-specific monitoring data was collected.

- A wide variety of response actions were undertaken in an effort to both understand and address new project-related issues as they were identified. Included were efforts to maintain the silt curtains, develop a better understanding of site bottom conditions, increase dredging productivity while continuing to remove remaining PCB-containing sediments in the work area, and optimize the sediment dewatering process.

- Dredging involves tradeoffs that impact the development of remedial options, including:
  - Dredging productivity and resuspension control;
  - Dredging productivity and level of effort necessary to address residual PCBs;
  - Cost and effort to maintain a complex containment system and its effectiveness in preventing (or minimizing) downstream releases of PCBs;
  - Environmental benefits and impacts of dredging, particularly related to residual PCB levels in sediments and observed PCB levels in fish; and
  - Maintaining a safe work environment while balancing the project goals, efficiency, schedule, and cost.

- A variety of cap configurations can be placed successfully in different areas of the river. There is room for improvement with respect to achieving consistency in the targeted cap thickness across the entire cap area.

2.5.3.4 Post-ROPS Monitoring Results

Post-ROPS monitoring conducted in 2006 and 2007 included sediment core collection, multibeam bathymetry (2006 only), cap observation, and ecological monitoring (macroinvertebrate sampling and habitat characterization). Additional monitoring was also performed in the northern and southern near shore areas as part of the 2010 Near Shore Sampling Program. Results from these post-ROPS monitoring events are presented in the 2006 Data Summary Report (Alcoa, June 2007a), 2007 Data Summary Report (Alcoa, September 2008), and Near Shore Sampling Program Report (Alcoa, March 2011). A summary is also presented below.

PCBs measured in the top 2 inches of the 2006 sediment cores from each of the study areas were, on average, higher than those from 2005. The 2007 average PCB levels in these sediments were all lower than those measured in 2006 (except in the northern and southern near shore areas), and also lower than 2005 levels in the main channel. Surface PCB concentrations measured in the northern near shore and southern near shore areas in 2010 were higher than those measured in prior years. This increase in surface PCB concentrations is due, in part, to recontamination of the caps (i.e., deposition of material in the cap surface). Average concentrations by area over the monitoring period are summarized below.

Table 2-2: ROPS Areas Average Sediment PCB Concentration (2005, 2006, 2007, and 2010)

ROPS Area	Average Sediment (0- to 2-inch) PCB Concentration (mg/kg)			
	2005	2006	2007	2010
Work Zone 1	8.9	35.0	3.3	N/A
Work Zone 2	3.3	5.4	2.5	N/A
Northern Near Shore	0.24	0.64	0.96	1.2
Southern Near Shore	0.62	1.1	1.3	2.0

Several cores from Work Zone 1 and the northern near shore area contained an observable amount of material (i.e., dark gray/brown organic materials) that settled on the cap surface in 2006 and 2007.

As indicated above, both the northern and southern near shore area samples collected post-cap placement (i.e., 2006 to 2010) show evidence of surface recontamination from adjoining (un-remediated) areas. The higher PCB concentrations in the southern near shore cap area in 2006 and 2007 (relative to 2005 post-cap conditions) also generally coincide with cap material thicknesses that are less than the 0.3 ft target thickness, and tend to be concentrated in the central portion of the capped area. This central section of the southern near shore area contains steep side slopes that may only be able to support a few inches of cap material. These factors likely explain the reduced cap thickness and higher PCB levels observed in this area in 2006 and 2007. The southern near shore cap areas immediately upstream and downstream of this affected area exhibit intact caps and contain PCB concentrations (top 2 inches of cap material) that range from non-detect to about 0.40 mg/kg (95 to 99 percent lower than pre-cap conditions). See Appendix E for additional details regarding the southern near shore.

- A comparison of main channel sediment bed elevations between 2005 and 2006 indicates that measurable change did not occur throughout most of the area; two exceptions are noted. Deposition occurred in the upstream and southern portions of Work Zone 1 (consistent with sediment core observations), and changes were noted in a few isolated areas along the southern edge of the work areas, which is attributable to removal of silt curtains and anchors which were in place during the 2005 survey. Cap thickness measurements (based on sediment cores) were similar to (or slightly higher than) those obtained immediately after main channel cap placement in 2005.

- Ecological monitoring studies in 2006 and 2007 generally indicate that recolonization is occurring in the northern and southern near shore areas by a benthic community similar to the one present prior to implementation of construction activities. Results of the aquatic habitat surveys also show that conditions are relatively similar to pre-construction conditions. Some differences were noted between the pre-ROPS and 2006 post-ROPS sampling, particularly in the northern near shore area (i.e., increase in oligochaetes and decrease in vegetative cover). Fewer differences were noted between the pre-ROPS and 2007 post-ROPS benthic sampling and the aquatic habitats were comparable; however, the vegetative cover in the northern near shore area still appeared to be recovering.

- Visual observation of the cap areas was achieved through underwater video documentation in 2006 and 2007. The cap surface in Work Zones 1 and 2 appeared relatively smooth with some mounding. No clear transition was observed between areas not affected by ROPS activities and capped areas or between Work Zones 1 and 2. Video obtained in the armored cap area showed the presence of armor stone materials with finer-grained material on top of or in between the armor stone. In the areas observed, video footage indicated that the armored cap coverage appeared to be adequate (i.e., armor stone appeared throughout the area without large breaks or gaps). Note that video was also obtained in the armored cap area in 2009, and there was continued evidence of deposition of finer-grained material over/within the armor stone (Figure 2-45).

Additional monitoring was performed in the ROPS northern and southern near shore areas as part of the 2010 Near Shore Sampling Program. Monitoring included sediment core collection, bed elevation surveying, and a qualitative habitat assessment. The sediment core data collected yielded results that are consistent with prior post-construction sampling events. In both the northern and southern near shore areas, estimated cap thicknesses in 2010 were similar to those measured during earlier post-ROPS monitoring events. Overall, PCB concentrations in the surface (0 to 2 inches) of the caps in both areas have remained low, but some core locations have exhibited increases since 2005 that are attributable to deposition of recent sediments onto the capped area, as discussed above. Examination of core locations where a lack of cap material and/or high PCB concentrations were noted indicated that steep bottom slopes, and in one instance, a focused surface water discharge could explain a number of these observations. Monitoring also indicated that aquatic vegetation and habitat have re-established in both areas since 2005, although re-establishment took longer for the northern near shore area where dredging was conducted prior to capping. Additional details on the monitoring efforts and results are presented in the Draft Near Shore Sampling Program Report (Alcoa, March 2011).

2.5.4 Activated Carbon Pilot Study

The ACPS was initiated in September 2006 to evaluate the effectiveness of activated carbon as a means to sequester sediment PCBs and reduce PCB flux from sediments and uptake by biota. Recent laboratory and field studies conducted by Stanford University, UMBC, and others have demonstrated that mixing activated carbon into surface sediments successfully sequesters PCBs, and is effective at reducing PCB bioaccumulation in benthic organisms and reducing release of bioavailable PCBs into the water column.

The overall objective of the ACPS was to evaluate if the bioavailability of PCBs within lower Grasse River sediments can be reduced at the field scale through the placement and mixing (by mechanical or natural processes) of activated carbon into native sediments. Other ACPS objectives included the following:

- Evaluate the ability to deliver activated carbon into in-place sediments and determine the extent to which PCBs and sediments are released to the river during application;

- Measure the change in PCB bioavailability to deposit-feeding benthic organisms that results from activated carbon amendment;

- Evaluate changes in PCB desorption kinetics and equilibrium partitioning from sediments that result from activated carbon amendment;

- Evaluate potential impacts to the benthic community structure associated with the addition of activated carbon to the sediments; and

- Evaluate whether the erosion potential of the sediments is altered by activated carbon amendment.

In support of these objectives, Alcoa, with oversight from the Agencies, implemented a pilot demonstration project. The project began with laboratory studies and land-based equipment testing, continued with field-scale testing of alternative placement methods, and culminated in a field demonstration of the most promising activated carbon application and mixing methods to a 0.5-acre pilot area within the lower Grasse River (see Figure 1-3). Additional information can be found in the ACPS Documentation Report (Alcoa, November 2007).

2.5.4.1 ACPS Field Demonstration

Based on the results of initial laboratory studies that evaluated bioavailability reductions achieved at different activated carbon doses, a target application concentration of 2.5 percent activated carbon (dry-weight basis) in the top 6 inches of sediment after treatment was used in the Grasse River field demonstration. Three application techniques were implemented within the pilot study area as follows.

- A 7-foot by 12-foot enclosed device that first applied (sprayed) activated carbon onto the sediment surface, and then mixed the material into near-surface sediments using a roto-tiller type mechanical mixing unit (tiller).

- A 7-foot by 10-foot tine sled device (tine sled) that included direct injection of activated carbon into near-surface sediments.

- Application of activated carbon to the sediment surface using the tiller, but with the mixing devices removed. Monitoring of this “unmixed” treatment area allowed for an evaluation of the rate and extent of incorporation of the surficial layer of placed activated carbon into near-surface sediments over time through natural processes (e.g., bioturbation).

The 0.5-acre pilot area was divided into four separate test plots to evaluate the different application techniques and mixing methods. These plots included the Initial Testing Area (tiller with and without mixing and tine sled), Mixed Tiller Treatment Area (tiller with mixing), Tine Sled Mixed Treatment Area (tine sled), and Unmixed Tiller Treatment Area (tiller without mixing). A single L-shaped curtain was installed adjacent to and downstream of the test plots.

2.5.4.2 ACPS Monitoring Results

Baseline, during-construction, and post-construction monitoring was conducted to evaluate potential impacts to the surrounding environment due to activated carbon placement (water column and noise monitoring) and to assess the amount of carbon placed (sediment sampling).

Water Column and Noise Monitoring

Project action levels for PCBs were not exceeded adjacent to or downstream of the ACPS area during activated carbon application; all levels were below the detection limit (0.065 μg/L). Turbidity levels during the performance of the project activities never approached the action level of 25 NTUs above background. Water quality monitoring performed immediately adjacent to the ACPS area indicated that only a small increase in turbidity occurred during activated carbon application and/or mixing using the tine sled and tiller equipment. Levels measured downstream of the ACPS area were only slightly higher than those measured upstream, with average turbidity and TSS increases of roughly 0.2 NTU and 0.8 mg/L, respectively. The water column monitoring data indicate that construction activities did not have a significant impact on water quality in the river, suggesting that the use of silt curtains to contain suspended solids and/or activated carbon is not necessary for future applications of activated carbon using the tine sled or tiller equipment.

All noise levels measured throughout the course of the construction activities were comparable with baseline monitoring values.

Sediment Cores

Sediment cores (five-point composite and single cores) were collected immediately following the fall 2006 application of activated carbon, and samples were submitted for quick turnaround laboratory analyses to verify achievement of the target dose of activated carbon. While variability in baseline concentrations and analytical recovery procedures resulted in uncertainties associated with interpretation of individual TOC and black carbon-thermal pre-combustion (BC-T) measurements, respectively, a weight of evidence approach that used multiple comparisons was employed to inform real-time field decisions relative to the activated carbon application. Following completion of field activities, UMBC refined and improved a black carbon-chemical pre-oxidation (BC-C) method, resulting in a more accurate and precise procedure to confirm activated carbon concentrations in Grasse River sediments, relative to TOC and BC-T methods. Subsequently, archived baseline and post-application sediment samples were analyzed by UMBC, using the confirmatory BC-C method, to determine with greater confidence the activated carbon dose achieved by the various application techniques.

The results of the TOC and BC-T measurements available during construction (i.e., weight of evidence approach or “three method average delta” metric) indicate that the overall dose of activated carbon added to the treatment areas achieved or exceeded the target dose of 2.5 percent using both the tiller (with and without mixing) and tine sled devices. The achievement of the target activated carbon dose of 2.5 percent was confirmed following implementation using the BC-C method. The overall average activated carbon dose achieved in the top 3 inches of sediments throughout all treatment areas ranged from 3.2 to 5.3

percent for the five-point composite samples. BC-C testing of single cores also confirmed that the target activated carbon dose of 2.5 percent was achieved with the overall average activated carbon dose measured in sediments (top 3 inches) throughout all treatment areas ranging from 2.5 to 4.5 percent.

The tiller without mixing successfully applied activated carbon to the sediment surface, as measured in samples from the 0- to 3-inch sediment layer. Both the tiller with mixing and tine sled successfully mixed activated carbon into the 0- to 3-inch sediment layer, with some samples also showing slight increases in activated carbon levels in the 3- to 6-inch sediment layer. Compared with the tine sled, application of activated carbon using the tiller (with or without mixing) resulted in greater small-scale spatial variability based on evaluation of the TOC measurements.

Activated carbon applied to the Grasse River sediments was observed, through underwater video coverage, to be stable on the river bottom under ambient hydrodynamic conditions in the river, including during a pressure wave event caused by the opening of the Snell Lock.

2.5.4.3 Post-ACPS Monitoring

The results of the 2006 ACPS monitoring were used to evaluate the ability to successfully apply activated carbon to the sediments and the impacts of this application on river water quality. Project objectives focused on the effectiveness of the activated carbon treatment in reducing PCB bioavailability in benthic organisms, the evaluation of potential changes to the benthic community, and the evaluation of potential changes to the erosion potential of sediments were further evaluated in a detailed 3-year post-implementation physicochemical and biological monitoring program (i.e., 2007 through 2009). This program was designed to evaluate the longer-term effectiveness of the activated carbon treatment.

Monitoring performed in 2007 and 2008 included in-situ and ex-situ PCB biological uptake studies, sediment sampling, erosion potential testing (via shaker studies), macroinvertebrate community studies, and in-situ passive samplers. A summary of results from the 2007 and 2008 monitoring activities are summarized below. Additional information can be found in the ACPS 2007 and 2008 Monitoring Results Summary Reports (Alcoa, November 2008; Alcoa, February 2010).

- Measurements of activated carbon levels in the treated sediments (i.e., BC-C analysis and microscopy results) support that the applied carbon remained in place approximately 2 years following placement.

- Activated carbon levels measured in the sediments in 2007 and 2008 were consistent with expected levels considering mass balance calculations based on the 2006 application rates.

- The vast majority of sediment samples collected for biological uptake testing yielded activated carbon concentrations at or above the target dosage.

- PCB accumulation in the test organisms (wet weight basis) exposed to the mixed (tiller) treatment area was reduced in excess of 80 percent for the in-situ tests and in excess of 90 percent for the ex-situ tests (Table 2-3).

- Batch equilibrium testing to evaluate the effect of activated carbon on PCB partitioning between the sediment and water phases in 2007 and 2008 showed reductions in the range of 93 to 99 percent for 10 of the 12 treated samples from the mixed and unmixed treatment areas (Table 2-3).

- Three trends were observed in the results from the in-situ passive samplers: 1) there was a decline in ambient PCB levels from 2006 to 2008; 2) aqueous PCB concentration at the sediment surface in the Mixed Tiller Area decreased by 90 percent (similar to reductions observed from biological testing); and 3) similar freely dissolved aqueous PCB concentrations were observed at all test areas (Figure 2-46).

- Results of ecological monitoring activities show a benthic community adapted to fine-grained sediments pre- and post-carbon application. Benthic habitat measures were similar comparing the treatment areas and upstream background locations within each sampling year, with the exception of the Unmixed Tiller Treatment Area in 2008, which showed a low metric score in almost every category. The reason for this is unknown, and additional sampling was conducted in 2009 to help determine if these trends persist. Differences between the 2006 pre-carbon and 2007 and 2008 post-carbon application data (primarily grain size and benthic order/metric results) appear to be more related to temporal differences than to activated carbon application; changes in the treatment areas were reflected in similar changes in the upstream background locations.

- Erosion potential testing indicated that the erosion potential of treated sediments is higher than pre-treatment sediments, but is within the range of historic data for native sediments.

- Sediment core testing for PCBs showed consistency among the 2006, 2007, and 2008 samples, with PCB concentrations generally increasing with depth.

- PCB desorption rate and extent from the sediment samples were reduced after application of carbon to sediments in the field.

Additional monitoring was also performed in 2009 to address specific questions raised from the 2007 and 2008 results. The 2009 monitoring included in-situ PCB uptake studies, sediment sampling, macroinvertebrate community studies, and laboratory studies on the effects of activated carbon on plant growth. A summary of results from the 2009 monitoring activities are summarized below, and additional information can be found in the ACPS Summary of 2006 to 2009 Monitoring Results (Alcoa, November 2010a).

- PCB concentrations in surface sediment decreased from 2006 to 2009, with a larger decrease noted for those sediments treated with activated carbon.

- Activated carbon remains in place in the treated sediments, with no evidence of downstream migration. The 2008 and 2009 results indicate that activated carbon appears slightly deeper in the sediment profile than observed in 2006 post-construction and 2007 sampling. This trend is likely due to recent sedimentation on top of the treated sediments since 2006.

- The average percent reduction observed through in-situ bioaccumulation testing is 92 percent, and 93 to 95 percent though ex-situ bioaccumulation testing (Table 2-3).

- Results from the in-situ passive samplers showed a reduced aqueous PCB concentration at the sediment water interface where the sediments have been treated with activated carbon (Figure 2-46).

- No major changes to benthic community were observed as a result of activated carbon amendment.

- Activated carbon did not impact submerged aquatic vegetation survival, although it may result in slower growth rates.

Additional submerged aquatic vegetation testing was conducted in the laboratory to help understand if the slower growth rates observed in 2009 were due to sediment dilution or any specific property of the activated carbon. Testing evaluated other types of carbon and an inert and physically similar amendment. The laboratory results indicate that plants continue to grow in sediment amended with activated carbon, but at a reduced rate after fresh amendment at a dose of 5 percent or higher by mass. Physical dilution of sediment with an inert material (perlite) appeared to have a similar effect on plant growth suggesting that the primary mechanism of impacts may be related to volume dilution of sediment. Further testing has been proposed through a small-scale field study to establish the expected impacts of activated carbon addition on plant growth for a full-scale application of the technology. Additional details on the testing, results, and proposed study are provided in Evaluation of the Effect of Sediment Amendments on the Survival and Growth of Native Rooted Vegetation from the Lower Grasse River, Laboratory Phase 2 (Alcoa, November 2011).

2.5.5 T6.75 Ice Control Structure Evaluation

The ice jam-related scour event that occurred in the lower Grasse River in 2003 prompted an assessment of ice control options as part of the evaluation of long-term remedial options to manage PCB-containing sediments in the lower Grasse River. In response to the 2003 ice scour event, Alcoa retained several nationally recognized experts in river ice engineering and initiated a series of studies to investigate options for controlling ice on the Grasse River (see Section 2.1). Several structural and non-structural alternatives were evaluated, and a pier-type ICS at river transect T6.75 was identified as a potentially viable long-term option to prevent the formation of ice jams capable of causing sediment scour on the lower Grasse River (Alcoa, October 2009).

Early stages of the ice control assessment focused on the identification of candidate areas along the Grasse River where conditions were favorable for the construction of a pier-type ICS. As discussed in Section 2.5.3, a location in the upper Grasse River, approximately 0.6 miles upstream of the Route 37 Bridge in the Town of Louisville, was identified as a suitable location for construction of an ICS but was not pursued due to

community concerns regarding the construction of the ICS at this location. The site selection process then focused on candidate areas within the lower Grasse River. Results of this evaluation led to the selection of the T6.75 location in the lower river.

Based on ICS designs employed at other rivers, a conceptual design for the T6.75 ICS was developed. An L-shaped configuration consisting of 24 transverse and 26 longitudinal piers was selected to take advantage of the natural widening of the river that would serve as the flow relief channel for the ICS (Figures 2-47 and 2-48). The transverse and longitudinal piers were spaced appropriately to provide ice retention while enhancing debris passage and allowing small boat traffic through the structure. Elevations of the piers were set based on maximum water heights measured during the physical model testing. Additional details regarding the T6.75 ICS design are provided in the Grasse River T6.75 ICS Basis of Design Report (Alcoa, October 2009).

Although initial numerical modeling provided confidence that this design would be effective at retaining ice, physical and numerical modeling studies were conducted to verify the performance of this ICS design and answer other technical issues associated with an ICS at this location. An overview of each study is provided below.

Physical Model Study

A physical model study was conducted by USACE CRREL at their refrigerated research facility in Hanover, New Hampshire to refine the ICS design and evaluate its performance under a wide range of ice and hydraulic conditions. The physical modeling study consisted of two components: 1) a 1:15 scale Flume Model to evaluate the local ice holding capacity and ice accumulation stability in the vicinity of the piers; and 2) a 1:30 scale River Model to assess the overall reliability of the ICS design. Specific design factors, such as ice forces on the piers, under-ice velocities in the vicinity of the ICS, and potential ICS failure modes, were also assessed. Several combinations of river flow, ice volume, ice strength, and initial conditions (i.e., open water vs. broken ice sheets) were tested during the physical model study. Results of the physical model tests are discussed in Section 2.5.5.2.

Numerical Model Study

Numerical modeling was conducted by Clarkson University to provide additional information pertaining to the ICS performance and to investigate potential impacts of the ICS on backwater levels upstream of the T6.75 ICS location. For this study, the dynamic river ice model (i.e., DynaRICE) developed by Clarkson University (Shen et al., 2000), the same modeling framework used during the river ice investigation that was conducted following the 2003 ice jam event (Alcoa, April 2009), was applied to evaluate the stability of ice accumulations behind ICSs at various locations on the Grasse River including the proposed location at T6.75. Results of the numerical DynaRICE modeling simulations for the T6.75 ICS are discussed in Section 2.5.5.2. The model simulations were also used to support the design of the physical model study.

2.5.5.1 Design Conditions

The 2003 ice event was used as the design event for the physical and numerical modeling studies. In addition, six combinations of ice supply and river flow representing a 100-year return interval (i.e., event that has 1 percent chance of occurring in any given year) were used to evaluate the ICS performance under extreme, low-frequency event conditions (Alcoa, October 2009). These scenarios were considered conservative because: 1) the hydrograph for the 2003 event, which was used as the basis for the 100-year hydrographs, is atypical of most other jam events that occurred or may have occurred historically on the river; and 2) scaling the atypical 2003 hydrograph results in numerically modeled peak flows that are considerably higher than the breakup discharges estimated to have occurred during historic events (Alcoa, October 2009). Additional conservatism was also built into the modeling analyses. For example, the numerical model did not consider overbank flow onto the floodplains, thereby resulting in more severe backwater effects than would be expected had floodplains been included in the modeling domain. Further, the use of the 2003 ice supply as the basis for scaling ice supply volumes for the sensitivity cases was deemed conservative because the 2003 ice supply includes ice present on the river downstream of the proposed T6.75 ICS location. In the physical model, conservative assumptions regarding ice strength and the absence of ice upstream of the ICS prior to the ice breakup run were tested.

2.5.5.2 Design Evaluation Results

The two primary performance criteria considered during the physical and numerical model testing included overall ice retention capability and backwater levels upstream of the ICS. Other factors, such as ice forces on the piers, under-ice velocities in the vicinity of the ICS, and potential ICS failure modes, were also examined. A summary of the Grasse River ICS performance evaluation is provided below. Additional details pertaining to these studies are provided in the Grasse River T6.75 ICS Basis of Design Report (Alcoa, October 2009).

<u>Ice Retention</u>

Results of the physical River Model testing indicate that the T6.75 ICS design can reliably retain ice under a range of ice and hydraulic conditions more severe than the design 2003 ice jam event (Alcoa, October 2009). In the physical River Model, the ICS performed acceptably at discharges as high as 11,714 cfs with the more conservative open water initial condition upstream of the piers (Alcoa, October 2009). The physically modeled discharge of 11,714 cfs is considered conservative because it is higher than any of the historic breakup discharges identified in the hindcasting analysis over the 81-year period of record (Alcoa, April 2009). The open water condition upstream of the piers is considered conservative because all observations regarding ice breakup in the Grasse River indicate that the breakup of ice in the upper river precedes breakup of the lower river, and that the breakup run from the upper river must fracture the intact ice cover that exists in the 0.75-mile reach of the lower river upstream of T6.75 before it could form a jam at the structure.

The physical River Model results indicated that some ice passage would occur under certain conditions, but that the ice passed represented a small fraction (less than 5 percent) of the solid ice volume entering

from upstream (Alcoa, October 2009). Numerical DynaRICE model simulations assuming conservative ice release volumes indicated that, in the event an intact ice cover exists on the river downstream of the T6.75 ICS, the release of ice through the ICS piers would not result in the formation of significant ice jams downstream (Alcoa, October 2009). Other physical model tests indicated that factors such as test duration, larger ice volumes, and flow surges did not materially impact the performance of the T6.75 ICS. Physical model tests also showed that a single pier can be removed to facilitate boat passage without compromising the effectiveness of the ICS.

Results of the numerical DynaRICE modeling were generally consistent with the physical River Model testing. The numerical DynaRICE model showed thick and/or grounded ice upstream of the ICS and the diversion of river flow into the flow relief channel and towards the southern portion of the channel, both of which agreed with observations made during the physical River Model testing. In addition, the numerical DynaRICE model predicted maximum velocities that were within the range of velocities measured during the physical River Model testing (Alcoa, October 2009).

Backwater Levels Upstream of the ICS

Due to its larger domain, more realistic ice supply, and dynamic hydrograph, the numerical DynaRICE model is considered the more appropriate tool for predicting upstream water surface elevation profiles caused by ice accumulations at the ICS (Alcoa, October 2009). Given this, numerical DynaRICE model simulations were conducted to evaluate the backwater effects upstream of the T6.75 ICS under a wide range of river flow and ice supply conditions. Maximum water surface elevation profiles upstream of the ICS were relatively similar across the range of modeled flow and ice conditions. Comparison of the maximum water surface elevation profiles to the available 1-in-100 year open water high-flow water elevations estimated from a FEMA flood insurance study for the Village of Massena indicated the potential for backwater impacts on properties along the river in an approximate 1.2-mile stretch of river extending from the T6.75 ICS upstream to approximately 1,500 feet upstream of the Railroad Bridge. This comparison indicates that flowage easements would be required for properties situated along this stretch of river, much of which is currently owned by Alcoa and/or the Village of Massena. Maximum projected backwater levels upstream of the Railroad Bridge are lower than those predicted under natural open water flood conditions and, thus, flowage easements would not be required.

Additional details regarding the T6.75 ICS design are provided in the Grasse River T6.75 ICS Basis of Design Report (Alcoa, October 2009).

2.5.6 Ice Breaking Demonstration Project

Alcoa conducted a USEPA-directed Ice Breaking Demonstration Project in March 2007 to evaluate the effectiveness of mechanical ice breaking as an interim measure for mitigating future ice jam-related sediment scour in the lower Grasse River. The project involved breaking the intact ice cover in an approximate 7-mile reach of the lower Grasse River from the mouth to approximately T6 (see Figure 1-3). Additional information can be found in the Ice Breaking Demonstration Project Documentation Report (Alcoa, June 2007b).

In response to the findings from the 2003 ice jam event, USEPA and Alcoa evaluated both interim and long-term measures to prevent future ice jam events (Alcoa, October 2005). An interim (and potentially longer-term) pier-type ICS was originally proposed to be a component of the 2005 ROPS (Section 2.5.3); however, as discussed previously, this was not pursued due to community concerns associated with the planned location of the ICS, which was several miles upstream of the lower Grasse River in the Town of Louisville. Mechanical ice breaking in the lower river was subsequently identified as the only potentially feasible non-structural interim measure.

The project was implemented to evaluate the feasibility of ice breaking as an interim measure for mitigating ice jam scour in the lower Grasse River and to develop site-specific information to support an understanding of the impact of site conditions (e.g., ice thickness, weather, river flow) on the schedule, production rate, and associated cost of the ice breaking operation. Another key objective included evaluation of the community notification measures to minimize potential safety issues associated with winter recreational use of the river once ice breaking activities were initiated.

Safety of the community and personnel involved with ice breaking and monitoring activities, along with protection of the surrounding environment, were critical considerations during the planning and implementation stages of the project, as ice breaking would be performed prior to natural ice out from the river, during a time when the river would normally be used for recreational purposes (e.g., snowmobiling, ice fishing). In addition, it was recognized that, during conduct of the project, portions of the lower river would contain both broken and unbroken ice. As such, it was essential that the community be informed that the lower river was not safe for recreational use. Alcoa, working in conjunction with USEPA, developed and implemented an extensive community notification program and developed emergency planning and response procedures to inform and protect the community.

2.5.6.1 Ice Breaking Activities

Ice breaking was performed in an approximate 7-mile reach of the lower Grasse River with two excavators operating from a barge that was moved by a shallow-draft tug. Two crews worked in alternating 12-hour shifts, 24 hours per day to complete the project. Progress made during each shift was dependent on many conditions including ice thickness, river flows, air temperature, wind speed, and river course. These conditions impacted the ability to clear ice from the channel once it was broken, and backtracking was required during several shifts to clear and widen channels that had become clogged with ice pieces or where ice had reformed. No work was conducted during one day shift due to extremely cold temperatures. Equipment failures also resulted in some delays, but down time associated with this work was limited. The original schedule for the work was 3 days, and the actual time to implement the work was 5 days.

2.5.6.2 Ice Breaking Monitoring Activities

Monitoring conducted during the course of ice breaking activities included measurement of ice thickness, tracking of ice breaking progress, turbidity monitoring, noise monitoring, warning sign/banner observation, and photographic documentation. In addition, the captain and crew of the ice breaking operation, along

with shore-side support personnel, monitored for the presence of individuals on the ice in the vicinity of the work. These activities were conducted to inform site management on progress of the work, identify the impact that site conditions have on ice breaking effectiveness, and to maintain measures implemented to protect the community.

2.5.6.3 Ice Breaking Findings and Conclusions

The ice breaking operation was successfully completed in the lower Grasse River, with an approximate 7-mile channel opened from the confluence with the St. Lawrence Seaway to just downstream of the Alcoa Bridge. Observations and data collected during the project provided useful information regarding implementation-related issues, impacts of site conditions on effectiveness and efficiency, and on the effectiveness of community notification efforts.

Observations conducted during the study and follow-up interviews with community members after the study supported a conclusion that the relative risk to community and worker safety associated with ice breaking is greater than the relative risk of a future ice jam event. Information developed during the project showed that, despite the significant level of effort employed in community notification, recreational users continued to access the river following the initiation of the ice breaking activities. In addition, the convergence of inherently unpredictable conditions which must occur for the work to be successful in avoiding a future ice jam event (i.e., timing, river flow, wind direction, and air temperature) impact both: 1) the ability to successfully complete the ice breaking construction activities; and 2) the natural ice breakup of the river as it relates to the potential in any given year for a significant ice jam to occur in the lower Grasse River.

2.5.7 Summary of Efforts Associated with Site-Specific Actions

Alcoa has invested significant resources in developing high-quality, site-specific information directly related to the effectiveness, implementability, and cost of remedial alternatives for the lower Grasse River. This work was conducted to support informed decision making based on a realistic assessment of expected outcomes in terms of the degree of risk reduction achieved and the associated costs for each of the potential remedial options. To date, the cost of these site-specific studies exceeds $65 million (MM), of which more than 50 percent was spent directly on or in support of dredging-related activities associated with the NTCRA and ROPS.

In addition to these expenditures, Alcoa has expended more than $250 MM in the remediation of land-based disposal areas and wastewater treatment system upgrades in support of controlling sources of PCBs to the lower Grasse River. Over the course of these activities, which date back to the mid-1990s, PCB levels in fish and the water column have declined by about 90 percent in response to the combined effects of source control activities and ongoing recovery processes in the lower Grasse River (see Figures 1-5, 2-24, and 2-26 through 2-28).

3. Development of Remedial Action Objectives and General Response Actions

3.1 Introduction

This section presents the Remedial Action Objectives (RAOs) for the Study Area, provides a list of the Applicable, Relevant, and Appropriate Requirements (ARARs) and items "to be considered" (TBCs), and identifies the General Response Actions (GRAs) for use in the development of remedial alternatives.

RAOs are site-specific goals developed based on identified concerns related to potential human health and ecological risks, and form the basis for comparing the effectiveness of various potential remedial alternatives. The findings of the human health and ecological risk assessments are the basis for developing RAOs and identifying GRAs. Baseline risk assessment information is summarized in Section 3.2. A list of the RAOs is presented in Section 3.3.

ARARs are federal, state, and tribal standards, requirements, criteria, or limitations that apply to the Study Area, and must be considered in the development and evaluation of the specific remedial actions. Compliance with ARARs is one of the nine criteria considered under CERCLA in the evaluation of potential remedial alternatives (Sections 5 and 6). ARARs are further described in Section 3.4, and a list of potential ARARs (as developed in coordination with USEPA and updated considering new guidance documents and requirements) for the Study Area is provided in Tables 3-1 through 3-3.

GRAs represent general categories of the types of remedial actions that may be considered to achieve the RAOs and comply with ARARs. The GRAs for the site are presented in Section 3.5.

3.2 Risk Assessment

USEPA prepared the Baseline Risk Assessment (BLRA) in April 1993. Since that time, Alcoa has prepared an update to the human health portion of the BLRA (RA Update; Alcoa, July 2002) and, at USEPA's request, Alcoa incorporated the revised exposure factors used in the RA Update to evaluate cancer risks and non-cancer hazards from non-PCB chemicals of concern (COCs) identified in the 1993 BLRA (see Appendix G). USEPA prepared the ecological risk analysis update (ERAU) in July 2010 as an update to the ecological portion of the BLRA. Summaries of human health and ecological risks based on these updates are provided in Sections 3.2.1 and 3.2.2, respectively. These updates were both specific to potential risks in the lower Grasse River, and did not address potential risks associated with the Power Canal and Robinson Creek. Potential risks for these two areas from the USEPA BLRA (April 1993) are also summarized in the sections below.

The risk assessment information summary presented in this document is based on the findings of the BLRA, RA Update, and ERAU documents and includes the assumptions required by USEPA. The exposure assumptions selected by USEPA for the BLRA are consistent with Agency policies, practices, and guidance and are representative of the Reasonable Maximum Exposed individual as well as the Central Tendency Individual. USEPA understands that there is uncertainty in the calculation of risk that may result in either an

under or over estimate of risk. As discussed in the RA Update (Alcoa, July 2002) and comments submitted by Alcoa on the ERAU, Alcoa believes that a number of the assumptions used in calculating potential site risks are overly conservative and result in an overstatement of potential risk to the identified receptors.

3.2.1 Human Health Risk Assessment Update (RA Update)

In July 2002, Alcoa updated the human health portion of the USEPA Baseline Risk Assessment (BLRA) (April 1993) with input from the Agencies using a more complete PCB data set and updated PCB toxicity information and exposure factors (Alcoa, July 2002). Numerous additional data collection efforts were performed between the preparation of the 1993 BLRA (which was based only on RSI Phase I data) and Alcoa's RA update (i.e., data collected from 1994 through 2001). Specifically, these efforts include annual monitoring of fish fillet PCB concentrations in smallmouth bass and brown bullhead, as well as sediment and water column data collected in association with the RSI Phase II (BBL, December 1994), NTCRA (BBL, December 1995), and the SRS Program (1996 through 2001) (Alcoa, April 2001). Trends in fish, sediment, and water column data collected after completion of the RA Update (2002 through 2011) are summarized in Section 3.2.1.1. The RA Update was specific to PCBs because PCBs were identified in the USEPA BLRA (April 1993) as the primary risk driver for the site. As such, samples collected since the 1991/1992 RSI Phase I investigations generally have been analyzed only for PCBs.

The RA Update also incorporated PCB exposure and toxicity factors that reflected more recent scientific and regulatory policy and specific conditions at the Study Area. The exposure factors included Agency-default and Agency-recommended values, and site-specific values. The exposure pathways evaluated in the RA Update included ingestion of fish by local and Mohawk anglers[4], incidental ingestion of and dermal contact with sediment by recreational users and Mohawk anglers, and incidental ingestion of and dermal contact with surface water by recreational users. however, this has since been revised to reference Mohawk anglers.] As noted in the RA Update (Alcoa, July 2002), Alcoa did not agree with some of the exposure assumptions used in the analysis but agreed to complete the assessment in the interest of moving the project forward.

In addition, at the request of USEPA, Alcoa incorporated the revised exposure factors used in the RA Update to evaluate cancer risks and non-cancer hazards from non-PCB COCs identified in the 1993 BLRA; this assessment is described in Section 3.2.1.4. USEPA's request was based on the need to update the exposure factors and toxicity information to reflect the current information.

Potential risks associated with the Power Canal and Robinson Creek were not addressed in the RA Update. The human health risk information for these two areas from the USEPA BLRA (April 1993) is summarized in Sections 3.2.1.2 and 3.2.1.3.

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[4] The RA Update originally included references to SRMT anglers; these references are intended to indicate Mohawk anglers.

3.2.1.1 Lower Grasse River

The RA Update presents the evaluation of potential risks associated with consumption of fish from the lower Grasse River using 1997 to 2000 fish fillet PCB data. For exposure assessment purposes, fish data were grouped by river reach. Specifically, analytical data were combined for Reaches 1 and 2 (Background Stretch), and Reaches 4 through 8 (Upper, Middle, and Lower Stretches) to assess risks to local anglers (Figure 3-1). Consistent with the USEPA BLRA (April 1993), it was assumed that Mohawk anglers fished only in Reaches 7 and 8 (Lower Stretch) and, as such, only PCB data for the Lower Stretch were used to evaluate Mohawk angler exposure. Because there are no site-specific data to indicate that Mohawk anglers fish in Reaches 4 through 6, there may be uncertainties associated with this assumption that impact the estimate of potential risks to Mohawk anglers via fish ingestion. Similar to the approach taken by USEPA (1993), fish fillet PCB data for two species (smallmouth bass and brown bullhead) were used to evaluate potential human health risk.

The RA Update evaluated potential risks associated with direct exposure of Mohawk anglers and recreational users to sediment using data from the Aroclor-based sediment samples collected in 1997, 2000, and 2001. These sediment samples were collected from the 0- to 3-inch depth interval and are most appropriate for evaluating exposure to sediments. These sediment data were combined for Reaches 4 through 8 to evaluate recreational exposure, and Reaches 7 and 8 to evaluate Mohawk angler exposure.

The RA Update also evaluated potential risks associated with exposure to river water during recreational use. The exposure scenario was evaluated using water column (congener-specific) data collected during the summer months (end of May through early September) in Reaches 4 through 8 from 1996 through 2000. This congener data set was used because, at the time the RA Update was prepared, it was more representative of current conditions than data collected prior to 1996. The water column PCB Aroclor data collected prior to 1996 resulted in mostly non-detectable concentrations. Since 1996, Alcoa has analyzed water column samples for PCBs on a congener-specific basis to obtain lower detection limits. The 1996 to 2000 congener-specific data were used to derive total PCB concentrations, which then were used to assess potential risk on a total PCB basis. As discussed below, water column concentrations have continued to decline since the RA Update was prepared in 2002.

Both Reasonable Maximum Exposure (RME) and Central Tendency (CT) exposure scenarios were evaluated for the three potential exposure pathways: fish consumption; sediment contact; and contact with water via recreational use. The RME scenarios were intended to represent the highest exposure that could reasonably be expected to occur. RME exposure factors were chosen in consultation with USEPA. The CT exposure factors were selected to represent a more typical exposure (generally 50 percent of the RME values). Both scenarios include a significant degree of conservatism, as discussed in the uncertainty section below.

Summary of Potential Carcinogenic and Non-Carcinogenic Risks for the Lower Grasse River

The results of the RA Update indicate that consumption of fish containing PCBs is the most significant exposure pathway at the Study Area. For example, calculated CT cancer risks associated with fish consumption by Mohawk anglers (7×10^{-4}) exceeded USEPA's target risk range of 1×10^{-4} to 1×10^{-6}. The RME cancer risks associated with fish consumption from Reaches 4 through 8 by local anglers (3×10^{-3}) and from Reaches 7 and 8 by Mohawk anglers (2×10^{-2}) also exceeded USEPA's target risk range. The calculated CT and RME cancer risks associated with exposure to sediment and surface water by Mohawk anglers and recreational users were all within or below USEPA's acceptable risk range.

For non-carcinogenic health hazards, the CT hazard indices (HIs) associated with local and Mohawk anglers consumption of fish from Reaches 4 through 8 and Reaches 7 and 8, respectively, were greater than 1.0 (9.9 and 67, respectively). An HI greater than 1.0 indicates that overall potential exposure to chemicals of interest may present concern for non-cancer health effects. For the RME scenario, the HIs associated with consumption of fish by local anglers from Reaches 4 through 8 and by Mohawk anglers from Reaches 7 and 8 were 160 and 614, respectively. For Mohawk anglers and recreational users, the HIs associated with incidental ingestion and dermal contact with sediment were near or below 1.0, as were the HIs for incidental ingestion and dermal contact with surface water by recreational users. HI values below 1.0 indicate that non-cancer health effects are not expected.

In summary, the RA Update results indicate that the greatest concern for potential human health effects is associated with fish consumption from the lower Grasse River.

Uncertainties in the RA Update

The RME exposure variables used in the RA Update generally were based on conservative Agency-default or Agency-recommended values, and as such, actual exposures and estimated risks are unlikely to be higher and may, in fact, be lower than suggested in the RA Update. The CT exposure scenarios are "average" exposure scenarios generally more typical of actual exposures. However, CTs also included conservative assumptions, and as such, actual exposures may be lower than those presented in the CT risk evaluation. Uncertainties are described in the RA Update and briefly summarized below.

Fish

USEPA recommended that the RA Update use a fish ingestion rate of 142 grams/day for the RME scenario. There are, however, more recent Mohawk-specific data that suggest lower fish consumption rates. For example, Fitzgerald et al. (1999) indicate that the frequency of fish ingestion by Mohawk men is approximately two meals per month (women were found to consume less fish). The variability in reported fish consumption rates from different studies indicates uncertainty in this value that would affect the risk assessment calculations.

Additionally, in conjunction with the 95th percentile ingestion rates, the RME fish consumption scenario assumed that 100 percent of the fish consumed by anglers come from the Grasse River (i.e., anglers consume fish at a relatively high rate and that all the fish they consume are taken from the Grasse River). These conservative assumptions do not consider that fish also may be caught and consumed from other nearby lakes and rivers and/or purchased from commercial sources. Combining the 95th percentile fish ingestion rate and assuming that the Grasse River is the sole source of the fish ingested likely results in an overestimation of PCB exposure resulting from Grasse River fish ingestion.

In addition, the RA Update assumed (based on USEPA's assumptions in the 1993 BLRA) that Mohawk anglers fish in Reaches 7 and 8 only. Because there are no site-specific data to indicate that Mohawk anglers fish in Reaches 4 through 6, there may be uncertainties associated with this assumption that impact the estimate of potential risks to Mohawk anglers via fish ingestion.

Sediment

The sediment PCB data set used in the RA Update included all sediment PCB data (0 to 3 inches) collected in 1997, 2000, and 2001 from the lower Grasse River. Both near shore and mid-channel sediment samples are included in the data set.

Additional data were collected subsequent to the completion of and acceptance by USEPA of the 2002 Update, including a focused investigation in 2010 of the near shore areas of the river (areas with water depth less than 5 feet). The assessment of potential risks and hazards to recreational users was re-evaluated using the most recent information on near shore river sediments – data that more closely represent current environmental conditions of sediments that would most likely be contacted during recreational activities. A comparison of the near shore data indicate that the 2010 PCB levels in the top 3 inches of sediments of the near shore areas of the river (97.5% upper confidence limit [UCL] = 12.4 mg/kg) were more than four-fold lower than the PCBs levels used in the 2002 Update (95% UCL = 51.4 mg/kg). The 2002 RA Update reported no cancer risks exceeding EPA's target risk level and all non-cancer hazards at or below EPA's target level of 1. Given that these more recent concentrations are more than four times lower, contacting near shore river sediments, including accidental ingestion of these sediments, does not represent an increased risk to any age group. Supporting calculations are provided in Appendix G.

<u>Trends in Data Collected After Completion of the RA Update</u>

Data collection efforts continued from 2002 through 2011 for resident fish, water column, and sediment as part of the various programs outlined in Section 1.1.3 (e.g., SRS Program, Phases 1 and 2 Sediment Sampling Program, 2010 Near Shore Sampling Program). Overall, this monitoring indicates that PCB levels have declined river-wide since the RA Update was completed in 2002. Trends over the 2002 to 2011 period are summarized below. Longer-term trends (mid-1990s to present) are discussed in Section 2.3.

Resident fish PCB concentrations have declined by about 65 percent since 2002. Considering data through 2011, average lipid-based PCBs in smallmouth bass in the Lower Stretch declined by about 93 percent.

Smallmouth bass collected from the Upper Stretch and brown bullhead collected from the Middle and Lower Stretches exhibited declines in average lipid-based PCB concentrations of about 70 to 80 percent. Smallmouth bass collected from the Middle Stretch and brown bullhead collected from the Upper Stretch exhibited declines in average lipid-based PCB concentrations of about 41 and 59 percent, respectively. PCB levels in smallmouth bass and brown bullhead measured in 2011 are the lowest on records (at all locations). Spottail shiner samples collected from near the Unnamed Tributary and River mouth in 2011 contained the lowest PCB levels on record for these locations (species lipid-based PCB levels declined by 73 to 81 percent), while those from near Outfall 001 declined by 62 percent through 2010. In 2011, PCB concentrations in spottail shiner collected near Outfall 001 increased to levels that are similar to those observed in 2006 and 2007. It is important to note that PCB levels in all sampled species were temporarily elevated in 2005 as a result of the release of PCBs during the 2005 ROPS dredging activities conducted within the Upper Stretch of the river; 2006 results showed a return to near pre-ROPS levels.

Water column PCB levels have also declined since 2002. For example, summertime PCB flux at the Route 131 Bridge declined over this period from about 30 to 50 grams/day in 2002-2003 to about 14 grams/day in 2011. Similar to the resident fish, a temporary rise in PCB concentration was observed in 2005 as a result of PCB releases during the ROPS dredging activities (Section 2.3).

River-wide sediment (top 3 inches) PCB concentrations in 2002 averaged about 11 mg/kg. The current average river-wide sediment (top 3 inches) PCB concentration is slightly lower (about 8 mg/kg).

3.2.1.2 Power Canal

As mentioned previously, the RA Update did not address the Power Canal; therefore, human health risk information from the USEPA BLRA (April 1993) is summarized here. For the Power Canal (designated as Reach 3; see Figure 3-1), the USEPA BLRA (April 1993) reported a potential human health cancer risk associated with fish consumption by local anglers exceeding 1×10^{-3}, but concluded that there was no risk associated with exposure to either sediment or surface water of the Power Canal due to lack of access (i.e., nearly vertical banks). If the updated assumptions used in the RA Update were applied to the Power Canal, the CT cancer risk for fish consumption for local anglers (7×10^{-6}) would fall within USEPA's target risk range, and the RME exposure would be 7×10^{-4}. A fish consumption advisory (eat no more than one meal per month for smallmouth bass) is currently in effect for the Power Canal (NYSDOH, 2012-2013).

Fish monitoring was initially conducted in the Power Canal as part of the 1991 RSI Phase I biota sampling event. Additional fish monitoring was performed in the Power Canal from 2002 through 2011 to assess PCB levels and verify historic RSI Phase I data. Data for adult smallmouth bass from these collection events are summarized in the following table.

Table 3-4: Total PCB Concentrations in Smallmouth Bass (1991 and 2002 through 2011; mg/kg wet weight) [(1)]

Year	Average	Maximum
1991	0.5	1.9
2002	0.8	1.5
2003	Adequate fish could not be located for collection/analysis	
2004	0.6	1.7
2005	0.6	1.6
2006	0.3	0.7
2007	0.1	0.3
2008	0.2	0.7
2009	0.1	0.3
2010	0.2	0.4
2011	0.1	0.4

[(1)] Arithmetic mean PCB concentration in fillet samples.

The fish tissue PCB levels presented in the table above indicate that levels are within the range of the historic levels used in the USEPA BLRA (April 1993) through 2005, with lower PCB levels observed from most recent sampling events (i.e., between 2006 and 2011). Supporting calculations are provided in Appendix G. In view of these data and the BLRA conclusion of lack of access due to steep banks, at USEPA's direction, the Power Canal is not being addressed in this AA Report.

3.2.1.3 Robinson Creek

As discussed above, the RA Update did not address Robinson Creek; therefore, human health risk information from the USEPA BLRA (April 1993) is summarized here. For Robinson Creek (see Figure 3-1), USEPA (April 1993) estimated an overall cancer risk of 6×10^{-6} for dermal contact and incidental ingestion of PCB-containing sediment in Robinson Creek, which is within USEPA's target range of 1×10^{-4} to 1×10^{-6} for incremental cancer risk. With respect to non-carcinogenic hazards, USEPA estimated an HI of 1.0 for a "child recreational user" due to dermal contact with aluminum in surface water.

Because the potential carcinogenic risk is in USEPA's range of acceptable risk and no HI values were above 1.0 for non-carcinogenic risks, Robinson Creek will not be addressed in the potential remedial alternatives for the Study Area.

3.2.1.4 Recalculating Risk and Hazards for Non-PCB Chemicals of Concern

USEPA requested that Alcoa recalculate risks and hazards associated with non-PCB chemicals of concern in the Study Area that were identified in USEPA's (1993) BLRA. The risks and hazards were revised based on changes in the toxicity factors (reference doses and cancer slope factors) that were identified by USEPA and conveyed to Alcoa via e-mail on June 3, 2009. In addition, the risk and hazard calculations were revised to include updates in exposure factors from the RA Update (Alcoa, July 2002). Following additional

discussions with USEPA, Alcoa revised the risk evaluation based on USEPA's comments and direction. The final Recalculating Risk and Hazards for Non-PCB Chemicals of Concern is provided in Appendix G.

Using the site characterization data contained in USEPA's (1993) BLRA and incorporating the toxicity and exposure factors from the RA Update resulted in revised individual hazard quotients (HQs) and non-PCB cumulative HIs of less than unity (1). Risks and hazards for recreational receptors exposed to both surface water and sediments are within USEPA's target risk range (e.g., less than 1 and equal to or less than 1 in 10,000 or 1E-04).

Similarly, cancer risks to local anglers from non-PCB COCs (i.e., polychlorinated dibenzodioxins [PCDDs] and polychlorinated dibenzofurans [PCDFs]) were recalculated using the updated exposure factors. Risks to a local angler in Reaches 4 through 8 were calculated using fish PCDD and PCDF congener data collected during the RSI – Phases I and II (E&E, October 1992 and BBL, December 1994, respectively). Congener data from 10 fish were converted to dioxin equivalent concentrations using the 2005 World Health Organization's Toxicity Equivalency Factors (TEFs) (Van den Berg et al., 2006), and the average dioxin equivalent concentration from these 10 fish was used as the exposure point concentration (EPC) for Reaches 4 through 8. Resulting cancer risk from the PCDD and PCDF congeners using the cancer slope factor for TCDD requested by EPA (EPA, 1985) was within USEPA's target risk range (1E-04 to 1E-06).

It is important to note that in both the Phase I and Phase II Investigations, 2,3,7,8-TCDD was not detected in water or sediment near or downstream of the facility, and this congener was detected in only one of the 14 fish samples (4 fish had no detectable congeners). As such, the 1992 report concluded that "the occurrence of 2,3,7,8-TCDD is considered to be the result of sources other than the ALCOA outfalls and is considered an anomaly in the Grasse River" (E&E, October 1992). These results support the conclusion from USEPA's (1993) BLRA that PCBs are the primary risk driver in the Grasse River.

3.2.1.5 Mohawk-Specific Preliminary Remedial Goal for Human Health

USEPA developed a risk-based preliminary remedial goal for the protection of Mohawk human health of 0.01 mg/kg PCBs in fish fillet based on non-cancer hazard indices for the adult tribal subsistence population with a consumption rate of 142 grams/day. The calculations and historical background regarding the consumption rate is provided in the Historical Background on Grasse River Risk Assessment (USEPA, November 2011).

Alcoa provided comments to USEPA expressing concerns regarding the inputs used to develop the Mohawk risk calculation. These concerns included the methodology used to develop the fish consumption rate and the fraction ingested from the Grasse River. Based on these concerns, Alcoa believes that the assumptions used in the development of the Mohawk-specific preliminary remediation goal (PRG) are overly conservative and result in an overstatement of potential risk to the Mohawk population. These comments were included in Alcoa's responses to USEPA's comments on the Draft AA Report (Alcoa, December 2011). USEPA selected the survey conducted by the NYSDOH as representative of the Mohawk of Akwesasne population's consumption rates and not just one component of the population (i.e., adult males). The NYSDOH

document that serves as the basis for the fish ingestion rate was extensively review by NYSDOH scientists, was made available for public review, and the final document includes a response to comments.

3.2.2 Ecological Risk Assessment

USEPA needed to revisit the ecological portion of the 1993 BLRA to reflect the current information and therefore prepared the ecological risk analysis update (ERAU) in July 2010. USEPA initially updated the BLRA in February 2010 and, after receiving technical input from Alcoa and other stakeholders, finalized the document in July 2010. Alcoa provided comments to USEPA expressing a concern that a number of the assumptions adopted in the analysis are overly conservative and data used in the assessment do not represent current environmental conditions at the site (Alcoa, November 2010b). Based on these considerations, Alcoa believes that the analysis provides an overestimate of potential ecological risk associated with the Grasse River site.

Conclusions from the 2010 ERAU are provided below. For purposes of the updated risk analysis, current data were defined as data collected from 2003 to 2008 in the upper portion of the Study Area (T1 to T19) and data collected from 2000 to 2008 in the lower portion of the Study Area (T20 to T72). These definitions of current conditions were discussed on a conference call held on May 28, 2009. Additional details are provided in the final ERAU (USEPA, July 2010).

- Sediment: Available information indicates potential risks to aquatic organisms from exposure to the maximum concentrations of Aroclor 1016, 1221, 1232, 1242, 1248, 1254, and 1260, total PCBs, and dioxin-like PCB congeners.

- Surface water: Available information indicates potential risk to aquatic organisms from exposure to the maximum measured concentrations of total PCBs and dioxin-like PCB congeners.

- Fish tissue: Available information indicates a potential for adverse ecological effects from exposure to total PCBs and dioxin-like PCB congeners.

- Food chain models: There is model-calculated potential risk to piscivorous birds and mammals from dietary exposure to Aroclor 1232, 1248, 1254, and 1260, and total PCBs; and to insectivorous mammals from dietary exposure to Aroclor 1248 and 1260 and total PCBs.

Since completion of the ERAU, additional data collection efforts have been completed for water, fish, and sediment. The trends in data collection are summarized in Section 3.2.1.1, and monitoring results indicates that PCB levels continue to decline river-wide.

Potential risks associated with the Power Canal and Robinson Creek were not addressed in the ERAU. The ecological risk information for these two areas from the USEPA BLRA (April 1993) is summarized in Sections 3.2.2.2 and 3.2.2.3.

3.2.2.1 Power Canal

An assessment of ecological risks associated with the Power Canal was included in the USEPA BLRA (April 1993). A listing of the conclusions from the BLRA is provided below.

- Surface water comparisons were only based on one sample; therefore, definitive conclusions could not be made. "In general, however, surface water quality within the Massena Power Canal does not appear to be impaired" (USEPA, April 1993; pg. 6-7).

- "Mean concentrations of total PCBs, PAHs, and cadmium detected within the Power Canal sediments may result in adverse impacts to sensitive biota within this habitat. Severe effects are not anticipated from the level of contamination evidence within the Power Canal" (USEPA, April 1993; pg. 6-8).

- Considering whole-body smallmouth bass PCB concentrations, "fish utilizing these aquatic environments may experience chronic reproductive effects from PCB exposure (based on reported effects for rainbow trout" (USEPA, April 1993; pg. 6-8).

- "Estimated exposure doses for two receptor birds, least bittern (a New York Species of Special Concern) and belted kingfisher approach recommended dietary limits for birds foraging within the Power Canal" (USEPA, April 1993; pg. 6-8).

- "Estimated whole-body fish PCB levels within the Power Canal and particularly the lower Grasse River exceed both mink protection criteria and levels at which mink reproductive impairment has been documented in controlled studies" (USEPA, April 1993; pg. 6-9).

3.2.2.2 Robinson Creek

Ecological risks specific to Robinson Creek (see Figure 3-1) were assessed as part of USEPA's BLRA (April 1993). The conclusions of the assessment for Robinson Creek are listed below.

- "Although detected concentrations of aluminum and lead were above chronic AWQC [ambient water quality criteria] within Robinson Creek, these metals were not detected in filtered surface water samples. Therefore, aluminum and lead may not be present in a bioavailable form to aquatic biota inhabiting Robinson Creek" (USEPA, April 1993; pg. 6-7).

- "Concentrations of total PCBs and several PAHs within sediments of Robinson Creek and the Unnamed Tributary may result in impacts to sensitive benthic invertebrates. Detected cyanide may also impact biota within the sediments of Robinson Creek. Severe impacts to these habitats are not anticipated although there is considerable uncertainty associated with cyanide concentrations within Robinson Creek" (USEPA, April 1993; pg. 6-8).

3.2.2.3 Risk Based Sediment Clean Up Ranges

USEPA developed ecological risk based sediment cleanup ranges for PCBs (SRC/SERAS, August 2010). As summarized in Section 3.2.2.1, results from the food chain exposure models indicate potential risk to piscivorous birds and mammals, and insectivorous mammals. "PCB concentrations in fish are a result of exposure of fish to PCBs in water and surface sediment, and dietary exposure to PCBs through aquatic or benthic food webs" (SRC/SERAS, August 2010). Therefore, site-specific bioaccumulation factors (BAFs) were developed to estimate the risk-based cleanup ranges for fish.

In the ERAU, fish exposure was assumed to be through ingestion of contaminated prey obtained from the Grasse River. The estimated risk-based cleanup ranges are a function of the ERAU food chain models, Toxicity Reference Values (TRVs), life history parameters, and exposure and risk assessment assumptions. "The risk based clean up ranges were calculated using representative exposure parameters, the mean PCB concentrations measured in sediment, and mean and maximum measured PCB concentrations in spottail shiners and brown bullheads in the upper (between transects T1 and T19) and lower (between transects T20 and T72) portion of the Lower Grasse River study area. In general, model calculations suggested that the greatest risk was to the piscivorous mammal community" (SRC/SERAS, August 2010); clean up goals are based on consumption of fish by the mink. The critical findings reported by USEPA are listed below.

- "Lowest observed adverse effect level (LOAEL) and no observed adverse effect level (NOAEL) cleanup goals were calculated to identify a range of sediment PCB concentrations below which adverse effects on wildlife receptors would not be expected."

- "LOAEL-based clean up goals calculated using mean spottail shiner PCB concentrations ranged from 2.58 to 5.05 mg/kg for mink consuming shiners captured between transects T1 to T19, while clean up goals ranging from 1.22 to 6.46 mg/kg were calculated for mink consuming fish captured between transects T20 and T72 (Tables 4 and 5)."

- "NOAEL-based cleanup goals ranging from 1.29 to 2.52 mg/kg and 0.61 to 3.23 mg/kg were calculated for the upper and lower portion of the Lower Grasse River study area, respectively [based upon mean spottail shiner PCB concentrations]" (SRC/SERAS, August 2010).

In addition, SRC/SERAS provided sediment cleanup goals using brown bullhead fillet data; however, since ecological receptors consume the entire fish, Alcoa views these data as highly uncertain for calculating risks or sediment clean up concentrations.

Since surface sediments are the primary source of PCBs to biota within the Grasse River, "it was assumed that the remediation of sediment would ultimately reduce contaminant loading to the ecological receptors within the Grasse River" (SRC/SERAS, August 2010).

3.2.3 Summary and Conclusions

The RA Update concludes that consumption of fish from the lower Grasse River is the most significant human health risk pathway at the site. Specifically, the greatest potential risks to human health are associated with consumption of PCB-containing fish from Reaches 4 through 8 by local anglers and consumption of fish from Reaches 7 and 8 by Mohawk anglers. Risks associated with PCBs from direct exposure to sediment and surface water are much lower, and exposures from these pathways are generally associated with risks or HIs at or below USEPA's range of acceptable risk. Risks and hazards for non-PCB chemicals of concern for surface water and sediments are within USEPA's target risk range. Similarly, non-PCBs risks and hazards for local anglers result in no exceedances of the upper end of the target risk range.

The ERAU (USEPA, July 2010) concludes there is potential risk to piscivorous birds and mammals and insectivorous mammals. The potential risk to higher trophic-level organisms (i.e., birds and mink) were associated with the consumption of prey that bioaccumulate PCBs (i.e., fish and insects).

As discussed in the uncertainty sections above, it is believed that the use of conservative exposure assumptions in both the human health and ecological risk assessments may overestimate the actual risk to the potential receptors. Also, the continued decline in PCB concentrations observed in lower Grasse River fish, sediments, and surface water since the RA Update and ERAU were completed (based on data collected through 2001 and 2008, respectively) indicates that current potential risks to human and wildlife receptors are lower than those estimated within these risk assessment documents.

3.3 Remedial Action Objectives

As stated in USEPA guidance (USEPA, October 1988), RAOs are developed as medium-specific goals or objectives for the protection of human health and the environment. RAOs for the Grasse River Study Area are based on the RA Update, applicable rules and regulations, discussions with and input from the Agencies, and other Study Area-specific goals. The final Study Area RAOs were provided by USEPA via email (USEPA, March 2012), and are presented below.

1. Reduce the cancer risks and non-cancer health hazards for people eating fish from the Grasse River by reducing the concentration of PCBs in fish.

   The risk-based preliminary remediation goal (PRG) for the protection of human health is 0.05 mg/kg PCBs in fish fillet based on non-cancer hazard indices for the RME adult fish consumption rate of one half-pound meal per week (this level is protective of cancer risks as well). The risk-based PRG for the protection of Mohawk human health is 0.01 mg/kg PCBs in fish fillet based on non-cancer hazard indices for the adult tribal subsistence population with a consumption rate of 142 grams per day. Other target concentrations are 0.26 mg/kg PCBs in fish fillet, which is protective for cancer risks for the adult avid angler at a fish consumption rate of one half-pound meal per month and 0.36 mg/kg PCBs in fish fillet, which is protective of the CT or average angler, who consumes one half-pound meal every two months.

2. Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish.

   The risk-based PRG for the ecological exposure pathway is a range in whole-body fish (brown bullhead, spottail shiner) PCB concentrations of 0.22 to 0.44 mg/kg (wet weight) based on the LOAEL and the NOAEL for consumption of fish by the mink. The ecological PRG is considered protective of all the ecological receptors evaluated because it was developed for the mink, the piscivorous mammal calculated to be a greatest risk from PCBs at the site. In addition, a range from 0.1 to 0.2 mg/kg (wet weight) PCBs in brown bullhead fillet was developed based on the NOAEL and LOAEL for consumption of fish by the mink.

3. Minimize the current and potential future bioavailability of PCBs in sediments.

   PCBs in sediments may become bioavailable by various mechanisms (e.g., pore water diffusion, bioturbation, biological activity, benthic food chains, ice jam event scour, etc). Minimizing the degree to which such mechanisms may make PCBs bioavailable (e.g., through removal and/or containment) will reduce PCB levels in biota and the associated risks to human health and the environment.

4. Protect the ecosystem of the lower Grasse River.

   The remedy will protect the ecosystem and replace and/or reconstruct habitat impacted by remedial activities in order to re-establish appropriate conditions for supporting the fish and wildlife of the river. The remedy will be monitored for ecosystem recovery through the measurement and analysis of appropriate physical, chemical, and biological parameters.

5. Minimize the long-term transport of PCBs from the lower Grasse River to the St. Lawrence River.

   PCBs that are transported downstream in the water column are available to biota, contributing to the risks from the site. Downstream transport also may move PCBs from contaminated areas to clean areas and from the lower Grasse River to the St. Lawrence River.

As discussed in Section 3.2, human ingestion of lower Grasse River fish is the PCB exposure pathway of greatest concern within the Study Area for human health. Similarly, ecological risks are also driven by consumption of fish exposed to PCBs. Reducing PCB levels in fish will address these concerns as well as potential risks associated with other exposure pathways.

Alcoa completed an extensive external source control program in 2001 that has reduced direct discharges of PCBs to the lower Grasse River to insignificant levels (see Section 1.1.2 for additional details). The only remaining substantive PCB source to the river is the widespread diffusive flux from the sediments. This source is being reduced by natural recovery processes in the river, as evidenced by the downward trends observed in PCB levels in fish tissue and the water column over the last 15 years. Significant efforts have also been undertaken since the discovery of ice jam-related sediment scour in 2003 to identify both short-

term and long-term management options to prevent remobilization of buried PCBs in the section of the river that is affected by this phenomenon.

Remedial alternatives included in this report were evaluated with respect to projected effectiveness in accelerating the reductions in PCB levels in lower Grasse River fish and PCB loading to the St. Lawrence River. For alternatives involving active remediation, data regarding potential impacts to the river ecosystem were collected during the post-monitoring programs conducted for the pilot study projects. For example (as described in Sections 2.5.3.2 and 2.5.3.4), monitoring during the ROPS included benthic community and aquatic habitat studies for the northern and southern near shore areas.

3.4 Identification of ARARs and TBCs

According to USEPA guidance (USEPA, October 1988), remedial actions must comply with ARARs of federal, state, and tribal standards, requirements, criteria, or limitations. In addition, if a state is authorized to implement a program in lieu of a federal agency, state laws arising out of that program constitute the ARAR instead of the federal authorizing legislation. State ARARs take precedence if they are more stringent than the associated federal requirements (USEPA, October 1988). In addition to ARARs, guidance materials that have not been promulgated or regulatory standards that are not applicable or relevant may be considered; these are referred to as TBCs. While TBCs may be considered along with ARARs, they are not legally binding and do not have the status of ARARs.

The ARARs and TBCs identified for the Study Area are categorized into three types: 1) chemical-specific; 2) action-specific; and 3) location-specific. The chemical-specific ARARs establish the acceptable amounts or concentrations of a chemical that may be found in, or discharged to, the ambient environment. Action-specific ARARs are technology- or activity-based performance or design requirements associated with the potential remedial activities being considered for the Study Area. Location-specific ARARs establish requirements that protect environmentally sensitive areas and other areas of special interest. Occasionally, circumstances may justify a waiver of an ARAR. USEPA guidance (October 1988) identifies six such cases:

- The remedial action selected is only a part of a total remedial action (i.e., it is an interim remedy) and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.

- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.

- For §104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

A complete list of potential ARARs and TBCs identified for the Study Area is presented in Tables 3-1 through 3-3. Note that the ARARs and TBCs identified for the Study Area were developed in coordination with USEPA during preparation of the USEPA-approved 2002 AA Report (Alcoa, June 2002), and have been updated to include guidance and related documents on the remediation of contaminated sediments, that were released subsequent to the 2002 AA Report, requirements or considerations pertaining to ice management measures, and recently received input from USEPA on ARARs/TBCs. The application of the ARARs in the evaluation of the potential remedial alternatives is discussed further in Sections 5 and 6.

3.5 General Response Actions

To support the development of potential remedial alternatives used to achieve the RAOs provided in Section 3.3, a number of GRAs were identified. GRAs typically are media-specific technology types that may be used to satisfy one or more of the RAOs. For the Study Area, the GRAs are grouped into seven broad categories:

1. No Further Action: No further remedial activities would be performed within the Study Area beyond the 1995 NTCRA, 2001 CPS, 2005 ROPS, 2006 ACPS, and on-site external source control measures completed by Alcoa in 2001. Evaluation of the no further action approach is required as part of the CERCLA process.

2. Monitoring: A monitoring program would be developed to track future trends in fish and other media as appropriate. Water column and resident fish monitoring are currently ongoing at the site.

3. Institutional Controls: Includes access/deed restrictions and fish consumption advisories as appropriate to reduce contact with PCB-containing media within the Study Area. A fish consumption advisory is currently in effect for the lower Grasse River (from the river mouth upstream to the Power Canal) and a less restrictive consumption advisory for the Power Canal due to PCBs (NYSDOH, 2012-2013).

4. Source Control/Natural Recovery: Includes measures to reduce direct PCB sources to the River, as appropriate. The Principles for Managing Contaminated Sediment Risks as Hazardous Waste Sites guidance document (USEPA, February 2002) indicates that the source of significant contamination to sediments under investigation should be identified and controlled as early in the risk management process as possible. The on-site external source control measures at the Alcoa facility were completed in 2001. Source control also may include activities within the river to address PCB sources within the

system (i.e., diffusive flux from surface sediment). Natural recovery processes include ongoing in-river sedimentation and biodegradation.

5. In-Place Containment: Includes capping to isolate PCBs contained in the river from the water column and biota.

6. Treatment: Includes both in-situ and ex-situ treatment (e.g., activated carbon application, biodegradation, immobilization, and/or other potentially appropriate treatment technologies) to reduce levels and/or movement of PCBs.

7. Sediment Removal and Subsequent Management: Includes removal of sediment via dredging or excavation followed by subsequent management, such as dewatering and landfill disposal.

8. Ice Management: Includes use of structural (e.g., ice booms, dams, weirs, pier-type structures) or non-structural means (e.g., thermal or chemical melting, ice breaking) to control ice jamming in the river and mitigate the potential for ice jam-related scour and exposure to currently isolated PCB-containing sediments. Armored capping is an additional ice management alternative that is covered under the category of in-place containment.

These GRAs are discussed in greater detail in Section 4.2 (Identification of Representative Process Options).

4. Technology Screening and Alternative Development

4.1 Introduction

This section identifies and screens remedial technologies and process options that will be used to develop remedial alternatives for the lower Grasse River, and then uses these technologies/process options to assemble the list of remedial alternatives. The evaluation of technologies potentially applicable to remediation was carried out in two steps (USEPA, October 1988). In Step 1, a wide array of possible remedial technologies was evaluated based on their technical implementability at the Study Area. Technologies that have not been demonstrated in practice to be effective in addressing the site-specific issues, or that could not be implemented at the Study Area due to site-specific conditions, were eliminated from further consideration at this point. In Step 2, the remaining remedial technologies were evaluated based on overall effectiveness, implementability, and relative cost (USEPA, October 1988). Site-specific findings from the investigation efforts (as presented in Section 2) were considered in relation to each remedial technology retained in this second step. The technologies were then assembled into the potential remedial alternatives that are analyzed in detail in Sections 5 and 6.

4.1.1 Step 1 – Identification and Screening of Potential Remedial Technologies

Based on the Study Area-specific GRAs identified in Section 3.5, potential technology types and process options associated with each GRA were compiled. "Technology types" are general categories of technologies, while "process options" refer to specific processes within each technology type (USEPA, October 1988). For example, dredging is a technology type under the more general sediment removal GRA, and mechanical dredging is a process option under dredging.

As noted above, in this initial step, technology types and process options were evaluated only on the basis of technical implementability at the Study Area. Technical implementability is a general, non-detailed evaluation of whether a technology type or process option is implementable with respect to specific Study Area conditions, whether implementation is feasible, and whether the technology has been developed for full-scale use. This analysis was based on general knowledge and experience at the Study Area, site-specific pilot studies, experience gained from other PCB sediment sites, and information available in the literature. This initial screening step reduced the number of potential remedial technologies that were subjected to a more rigorous evaluation in Step 2.

Table 4-1 summarizes the identification and screening of potential remedial technologies/process options that could reasonably be applied at the Study Area. The first two columns of the table identify GRAs with several broad technology types and associated process options. This table also provides a brief description of each process option, along with comments on technical implementability (as defined above). Process options retained for further evaluation in Step 2 (see Section 4.1.2) are shaded.

4.1.2 Step 2 – Evaluation of Remedial Technologies and Selection of Representative Process Options

Those process options retained in Table 4-1 (i.e., those that are shaded) were further evaluated based on the expanded criteria of overall effectiveness (including ability to meet RAOs), implementability (technical and administrative), and relative cost. The various process options within a particular technology group were evaluated against other processes in the same technology type. As a result, where appropriate, one process option from each technology type was retained for the development of potential remedial alternatives. Selection of a representative process option is not intended to eliminate other retained process options in a technology type from possible use; it is simply intended to streamline the development of potential remedial alternatives. A process option(s) not selected as representative still could be considered during remedial design if its technology type was part of the selected remedial alternative. The screening criteria used in this evaluation are described below.

Criterion 1: Effectiveness

The potential effectiveness of each process option was evaluated relative to the following: 1) whether RAOs can be achieved; 2) potential effects to human health and the environment during the construction and implementation phase; and 3) its reliability with respect to the chemical constituents and conditions at the Study Area (USEPA, October 1988). General knowledge of other relevant sites and previous experiences at the Grasse River Study Area (i.e., 1995 NTCRA, 2001 CPS, 2005 ROPS, 2006 ACPS, and 2007 Ice Breaking Demonstration Project) were also used in this evaluation.

Criterion 2: Implementability

Both the technical and administrative feasibility of implementing each process option were evaluated (USEPA, October 1988). Because technical implementability was the focus of the initial screening step, this evaluation concentrated on the institutional aspects of implementability, including the ability to obtain necessary approvals, availability of any storage/disposal services needed, and availability of necessary equipment and personnel. According to 40 CFR 300.400, "no federal, state, or local permits are required for on-site response actions conducted pursuant to CERCLA sections 104, 106, 120, 121, or 122." The term "on-site" refers to the Study Area, "and all suitable areas in very close proximity . . . necessary for implementation of the response action."

Criterion 3: Cost

Relative costs (i.e., high, low, or moderate) were identified so that process options within each remedial technology type could be compared. This relative evaluation was conducted because detailed cost comparisons cannot be made among different remedial technologies or GRAs at this point in the feasibility study process. In addition, it should be noted that, while certain remedial technology types (e.g., sediment dewatering) can only be used in combination with other technology types to form a complete remedial alternative or are dependent on the amount of constituent-containing media being addressed, others (e.g., no further action, institutional controls) may stand alone.

Table 4-2 presents Step 2 of the screening process (i.e., evaluation of criteria 1 through 3 noted above) with respect to the GRAs retained after Step 1. Section 4.2 below provides a description of the selected representative process option(s) for each technology type. Development of potential Study Area-specific remedial alternatives is presented in Sections 4.3 and 4.4.

4.2 Identification of Representative Process Options

Based on the two-step evaluation and technology screening process, a representative process option(s) for each GRA/technology type was retained for incorporation into potential Study Area-specific remedial alternatives for further analysis. The basis of selection for each representative process option within each GRA/technology type is described below and is further justified in Table 4-2. Retained representative process options for each technology type are summarized in Table 4-3.

A. No Further Action

No Further Action was retained as a representative process option during the initial screening step, as required by the NCP. Although this process option does not include any form of active remediation, it will be retained and used as a baseline against which other alternatives may be evaluated. As discussed previously, a number of remedial actions already have taken place in support of improving conditions in the river including the on-site external source control activities discussed in Section 1.1.2 and the 1995 NTCRA, 2001 CPS, 2005 ROPS, 2006 ACPS, and 2007 Ice Breaking Demonstration Project summarized in Section 2.5. Ongoing site-wide natural recovery processes drive the effectiveness of this process option.

B. Monitoring

Site-wide monitoring was retained as a representative process option under this GRA. Monitoring activities, which would provide a mechanism to track natural recovery processes and any active remedial measures, are currently being conducted at the Study Area as part of the SRS Program (1995 through 2011). An appropriately detailed monitoring plan would be developed during the remedial design phase.

C. Institutional Controls

For this GRA, fish consumption advisories were retained as a representative process option. It is anticipated that fish consumption advisories (maintained by NYSDOH) currently in place at the Study Area would be revisited and modified as appropriate based on monitoring results. Access restrictions were also considered as a process option under this GRA, but were not carried forward due to potential implementation difficulties.

D. Source Control/Natural Recovery

Source control has been retained as a representative process option. The extensive external source reduction described in Section 1.1.2 will expedite the achievement of the RAOs by addressing the release of known sources to the river and allowing natural recovery processes that are currently ongoing in the river, such as sedimentation from upstream areas and biologically mediated dechlorination processes in the

sediments, to continue. As these natural processes are ongoing in the river, they are retained as representative process options as well.

E. In-Place Containment

Capping has been retained as the technology type under in-place containment. The representative process options retained under the capping technology type include main channel capping, armored capping, and near shore capping.

Capping

Main Channel Cap – Main channel capping was retained as a representative process option. This technology was demonstrated during the 2001 CPS (Section 2.5.2; Alcoa, April 2002a) and the 2005 ROPS (Section 2.5.3; Alcoa, May 2006) in the lower Grasse River, and has been used at a number of other sites across the country.

Armored Cap – Armored capping was also retained as a representative process option within the capping technology type. It is envisioned that armored capping would be used in main channel areas where the added stability of an armored layer is required to protect against erosive forces in ice scour prone areas. As with the main channel cap retained above, based on USEPA (Palermo et al., September 1998) and USACE (June 1998) guidance, technical research and full-scale application of armored capping as a remedial action at other sites, armored capping is a viable technology for use at the Grasse River Study Area. Further, implementation of this technology was successfully demonstrated in the main channel of the lower Grasse River during the 2005 ROPS (Section 2.5.3).

Near Shore Cap – Near shore capping was retained as a representative process option. This technology follows the same principles as main channel capping, but employs a cap of reduced thickness to address concerns associated with altering the bathymetry in the near shore areas. As stated in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, application of a near shore cap "normally accelerates natural recovery by adding a layer of clean sediment over contaminated sediment" (USEPA, December 2005 – p. 4-11). This was successfully demonstrated in the southern near shore area during the 2005 ROPS; however, it should also be noted that improvements in placing and verifying cap thickness during construction and considering the impact of site conditions such as bottom slopes in the final design would be necessary to both provide more uniform cap coverage and ensure longer-term stability of the in-place cap. PCB levels measured at the cap surface (i.e., top 2 inches) immediately after placement showed that capping reduced surface PCB concentrations by 93 to 99 percent. Cap samples collected in 2006, 2007, and 2010 showed evidence of surface recontamination from adjoining (un-remediated) areas. The higher PCB concentrations in the cap area in 2006 and 2007 also generally coincide with cap material thickness that were less than the 0.3 ft target thickness, and tended to be concentrated in the central portion of the capped area. This central portion of the capped area contains steep side slopes that may only be able to support a few inches of cap material. These factors likely contribute to the reduced cap thickness and higher PCB levels observed in this area in 2006 and 2007. Experience from several other large-scale sites such as the Ketchikan Pulp Site (Alaska) and the Wyckoff/Eagle Harbor Superfund Site (Washington),

indicates that near shore caps can be successfully placed with uniform thickness using a variety of methods (Merritt et al., May 2009).

Inclusion of these process options under the capping technology widens the array of alternatives to be evaluated consistent with USEPA guidance (October 1988), which suggests the evaluation of one or more containment alternatives that prevent potential exposure and reduce mobility.

Any cap (e.g., main channel cap, armored cap, or near shore cap) placed within the lower Grasse River would be designed in accordance with USEPA, USACE, and other applicable guidance documents (United States Department of Agriculture [USDA], July 1989; USACE, July 1991; Maynord and Oswalt, 1993; vanRijn, 1993; Maynord, August 1995; Hoffmans and Verheij, May 1997; USACE, June 1998; USEPA, September 1998; Palermo, March 2000; and United States Department of Transportation [USDOT], March 2001). These documents provide technical guidance for using subaqueous, in-situ capping as a remediation technique for affected sediments, and include detailed guidance on site and sediment characterization, cap design, equipment and placement techniques, and monitoring and management considerations. As stated in Palermo et al. (September 1998) and further supported in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (December 2005), "capping can remedy adverse effects (e.g., bioaccumulation by benthic organisms and fish) of sediments containing chemical constituents through three primary functions:

1. Physical isolation of the affected sediment from the benthic environment.

2. Physical isolation of the affected sediment, preventing resuspension and transport to other sites.

3. Reduction of the flux of dissolved constituents into the water column."

In preparation for the 2001 CPS, Alcoa conducted a series of pre-design studies to assess the efficacy of main channel capping in the lower Grasse River as a means for reducing PCB flux from the sediment to the overlying water column. The results of these studies are presented in the Lower Grasse River Capping Pre-Engineering Design Studies Report (Alcoa, March 2001), and support the technical basis for cap design considerations. Further, application of a main channel cap, armored cap, and near shore cap was pilot tested during the CPS (Alcoa, April 2002a) and ROPS (Alcoa, May 2006). Knowledge gathered from these studies will also provide site-specific information that would be used during cap design.

F. Sediment Treatment

Sediment treatment technology types include both in-situ and ex-situ techniques. As noted in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, "for the majority of sediment removed from Superfund sites, treatment is not conducted prior to disposal, generally because sediment sites often have widespread low-level contamination, which the NCP acknowledges is more difficult to treat" (USEPA, December 2005 – p. 6-29). As such, only application of activated carbon was retained under the in-situ treatment technologies, as the other identified process options are considered not feasible, have not been tested at full scale, or are not cost effective. In-situ activated carbon application was demonstrated

during the 2006 ACPS (Section 2.5.4; Alcoa, November 2006) and consists of the addition of activated carbon to the upper layer of sediment using specially designed equipment. Results from the ACPS indicated that activated carbon was successfully placed at targeted concentrations, and longer-term monitoring has demonstrated success in reducing the PCB flux (see Section 2.5.4).

While in-situ activated carbon technology is not specifically identified in the list of remedial alternatives presented later in this section, the results to date from the ACPS post-construction monitoring (i.e., in-situ and ex-situ PCB biological uptake studies, sediment sampling, erosion potential testing, macroinvertebrate community studies, and in-situ passive sampling) clearly support that this technology warrants consideration for adoption into the overall site remediation strategy during the remedial design phase.

A number of ex-situ treatment technologies were retained based on preliminary screening efforts, and can be grouped into three technology types: immobilization; extraction; and destruction. Because these three technology types are largely considered ex-situ processes, it is likely that each would be used in conjunction with other technology types (i.e., removal, dewatering, disposal, and residuals management) to achieve the RAOs. Considering the need for disposal of sediment for the alternatives that include removal, treatment to address free water in removed sediment may become necessary to meet landfill requirements. Based on prior experience on the Grasse River and other sediment sites, stabilization/solidification will be retained as a representative process option under treatment. Stabilization/solidification was performed on sediments removed during the NTCRA and ROPS prior to disposal (BBL, December 1995 and Alcoa, May 2006, respectively).

G. Sediment Removal

Both hydraulic and mechanical dredging were retained as representative process options for sediment removal. These processes were used during the NTCRA and ROPS removal activities (BBL, December 1995 and Alcoa, May 2006, respectively).

Hydraulically dredged material can be transported via piping directly to a staging/processing area. Booster pumps may be required to transport the materials as the distance and elevation increases between the dredge and processing areas. However, a greater volume of water must be removed from the slurry and discharged and/or treated (USEPA, December 2005). The solids content of hydraulically dredged slurries normally averages less than 10 percent by weight, but it can vary considerably with the specific gravity, grain size and distribution of the sediment, and depth and thickness of the dredge cut. In general, hydraulic dredges cannot operate in rough water or remove large debris, and they may become clogged with weeds, wood, rocks, and other materials.

Mechanical dredges have been used extensively and are widely available. These dredges remove sediment at about the same water content as the in-situ material, thereby minimizing the amount of water removed (USEPA, December 2005). They can also operate in areas with limited space, and are highly maneuverable. The dredges are also able to remove large debris. Mechanically dredged sediment can be transported by barge or piped short distances. Mechanical dredges, however, have the potential for spillage during dredging and unloading (EPRI and Northeast Utilities, September 1999). The water contained within

the bucket during removal activities must be managed or, if allowed to leak out "generally leads to higher contaminant losses during dredging" (USEPA, December 2005 – p. 6-10).

Both hydraulic and mechanical dredging were retained as viable process options, as each possesses attributes applicable to specific characteristics of the lower Grasse River. The actual dredging option to be used in implementation of a dredging alternative would be selected during remedial design, and would depend on the specific project objectives and associated constraints for the dredging operation and downstream support processing steps, as the interrelationship between these operations must be considered in this evaluation. For purposes of evaluation in this AA Report, hydraulic dredging has been carried forward as the representative sediment removal process option for the main channel, with mechanical equipment for removal of rocks and other debris, and mechanical dredging has been carried forward as the representative sediment removal process option for the near shore areas.

H. Sediment Dewatering

Plate and frame filter press, belt filter press, solid-bowl evaporator, hydrocyclone, and gravity thickener or settling basin were all retained as potential dewatering process options. Plate and frame filter press (recessed chamber) was selected as the representative process option because it was implemented during NTCRA and ROPS activities. However, the final decision regarding the most appropriate method will be made during the design phase if dewatering is necessary to support a remedial alternative that involves sediment removal.

I. Sediment Disposal

Disposal in an on-site landfill was selected as the representative process option for on-site disposal. Alcoa's on-site Secure Landfill meets Toxic Substance Control Act (TSCA) and Resource Conservation and Recovery Act (RCRA) requirements and can accept materials containing PCBs at concentrations higher than 50 mg/kg. Sediments removed during the NTCRA and ROPS were disposed in Alcoa's on-site Secure Landfill.

The current on-site landfill configuration has a remaining permitted capacity to accommodate approximately 60,000 cy of in-situ sediment. Additional capacity of the secure landfill could be provided and would require additional regulatory approval and permitting beyond what has already been done, the scope and extent of which would depend on the volume determined to be required. Incrementally increasing the landfill capacity to 100,000 cy can be done within the footprint of the existing Cell 3. Expansions beyond 100,000 cy would require more extensive regulatory approvals and additional studies and time to complete with no certainty in final outcome of this process. Therefore, it was assumed for the purposes of this AA Report that sediment volumes up to 100,000 cy would be disposed on-site and any additional landfill volumes would be disposed off-site.

J. Water Treatment

For the purposes of this document, filtration and granular activated carbon (GAC) were retained as the representative process options for water treatment. GAC was used during both the NTCRA and ROPS for water treatment (BBL, December 1995; Alcoa, May 2006).

K. Ice Management

A pier-type ICS was initially considered as a representative process option for ice management based on the results of physical and numerical model testing indicating that a pier-type ICS at T6.75 in the lower river can effectively retain ice. However, due to public safety concerns associated with the construction of piers in the river, this will not be retained for evaluation in this document. Therefore, for the purposes of this document, no options for controlling the formation of ice jams in the lower Grasse River are included. It should be noted that armored capping has been retained as a representative process option for ice management under the category of in-place containment (see Section E). The specific documents that present the overall ice evaluation and management options are included in the Administrative Record (e.g., Alcoa, October 2005; Alcoa, June 2007b; Alcoa, October 2009; Alcoa, April 2009).

4.3 Key Elements of the Conceptual Site Model and Site-Specific Pilot Studies Influencing Assembly of Remedial Action Alternatives

In order to develop an array of potential remedial alternatives for the Study Area that will achieve the RAOs and comply with the ARARs and TBCs, it is necessary to consider the key findings of the studies, investigations, and actions completed at the site to date. Understanding the past and current sources of PCBs to the river, trends in PCB levels in various media; the influence of natural recovery processes; and the lessons learned during the NTCRA, CPS, ROPS, ACPS, and Ice Breaking Demonstration Project provide information to support the identification and evaluation of remedial alternatives. The models and the array of data analyses and interpretations that underlie the conceptual site model for the Grasse River are documented in the CCLGR Report (Alcoa, April 2001), Draft CCLGR Addendum (Alcoa, April 2009), NTCRA Documentation Report (BBL, December 1995), CPS Documentation Report (Alcoa, April 2002a), Draft ROPS Documentation Report (Alcoa, May 2006), Grasse River ACPS Construction Documentation Report (Alcoa, November 2007), and Grasse River T6.75 ICS Basis of Design Report (Alcoa, October 2009). The major findings pertinent to the development of the potential remedial alternatives are presented below.

4.3.1 PCB Sources

1. **Plant discharges are currently an insignificant PCB source**. PCB discharges from the Alcoa facility may have provided a significant historic PCB load to the river, but recent effluent data indicate that PCB loading has dramatically declined in response to the extensive on-site remediation efforts and wastewater treatment system upgrades. PCB loading from the plant has declined from about 60 grams/day (50 pounds per year [lbs/yr]) in 1990 to non-detect levels in 2011. Currently, the plant discharges represent an inconsequential contribution to the PCB loading to the water column observed in the river.

2. **The Grasse River upstream of the Study Area and the tributaries within the Study Area are insignificant PCB sources**. The contribution of PCBs to the lower Grasse River from upriver appears to be due to atmospheric deposition of PCBs in the watershed. This upstream source is negligible in comparison to other sources in the river. Depending on future trends, this source could increase in importance as other sources are reduced or eliminated. The Power Canal is an insignificant source because of its negligible flow and low PCB concentrations. The Unnamed Tributary may have been an important source of PCBs to the river historically, but remediation efforts have virtually eliminated PCB discharges associated with the Unnamed Tributary (Alcoa, April 2001).

3. **Surface sediments are the dominant source of the PCBs found in water and fish**. PCB-containing sediments have been identified in the lower 7 miles of the Grasse River in the reach extending from the Power Canal to the mouth. The sediment (top 3 inches) PCB concentrations in the lower Grasse River average about 8 mg/kg. In the uppermost reach of the river (i.e., upstream of Outfall 001 [T1 to T4.5]), sediment (top 3 inches) PCB concentrations are low, averaging about 0.8 mg/kg (excluding a single elevated PCB measurement from the near shore core at T3-NSS). Sediment (0-3 inches) PCB concentrations rise near Outfall 001 and exhibit considerable variability but no overall downstream trend for the next 3 miles (i.e., T4.5 to T36), averaging approximately 13 mg/kg. Sediment (0-3 inches) PCB concentrations in the lowermost portion of the river (T36 to T72) average approximately 5 mg/kg. Sediment (top 3 inches) PCB concentrations in the main channel are typically higher than those in the near shore areas (17 mg/kg and 8 mg/kg for main channel coarse and fine sediment areas, respectively, vs. 5 mg/kg in the near shore areas). Analysis of water column, SPMD, and sediment data, along with laboratory tests on Grasse River sediments and information on current PCB sources to the river, indicate that surface sediments are currently the principal PCB source to the water column.

4. **Severe ice jams are infrequent, but can mobilize and re-distribute main channel sediments and PCBs in the upper 1.8 miles of the river.** Comparisons of pre- and post-2003 event sediment elevations indicate that ice-related sediment scour during the 2003 event occurred in select portions of the main channel river bottom between T1 and T19; no signs of significant scour were observed downstream of T19. The primary mechanism for this ice-related scour was the increase in water velocity and turbulence underneath the toe of the ice jam. Tree scars, vertical profiles of physical and chemical properties in high-resolution sediment cores, and geochronology of river sediments provide a weight of evidence that ice jam-related scour is limited to the upper reach of the river. An evaluation of available data regarding ice-related impacts to the near shore areas in the T1-T19 reach of the river indicated that ice-related sediment scour was not a significant concern in these areas (Alcoa, December 2009a). The geochronology of river sediments also indicates that ice jams severe enough to cause sediment scour occur at a frequency of about one per decade; at least four ice-related scour events have occurred over the past 40 to 50 years.

5. **Buried sediments are isolated and sequestered under non-ice conditions**. Extensive studies and modeling of the lower Grasse River system indicate that PCBs present in the deeper sediments are sequestered under non-ice conditions and not at risk of being moved into surface sediments or the water column under open water conditions. This conclusion is supported by studies summarized in Section 2.4.2. These studies show that high-flow events are not expected to affect deeper sediments.

The absence of an adverse effect is attributed to the relatively low velocities that exist even under extreme events. Maximum velocities during a 100-year flood are 2.5 to 4.5 ft/s in the main channel and about 2.0 to 2.5 ft/s in the near shore areas. Data from other sites and site-specific data show that velocities of this magnitude disturb only the upper few millimeters of sediment.

Hydrodynamic and sediment transport models were developed for the lower Grasse River using bounding estimates of several model parameters so that a conservative estimate of sediment scour during a 100-year flood could be attained. The models predict that, on average, about 0.1 cm of erosion occurs during a 100-year flood. The maximum erosion predicted during the 100-year flood was about 0.9 cm (see Appendix A), while maximum erosion during a 500-year flood is estimated to be between 1 and 1.5 cm. Consistent with the modeling data, the results of sediment sampling conducted before and after the major flow event in January 1998, which approximated a flood with a 100-year recurrence interval, do not show evidence of any significant remobilization of buried PCBs due to sediment scour.

The effects of prop wash were evaluated following guidance developed by the USACE. Using conservative assumptions about motor size and boat operations in shallow water, the calculations indicate that prop wash could have minor impacts in very shallow water and over relatively small areas, but overall would not disturb deeper sediments (see Section 2.4.6).

6. **The sediment source is widely dispersed, and effective remediation must reduce the surface sediment PCB concentrations over a relatively large portion of the river bottom.** The relatively widespread distribution of sediment PCBs in the lower Grasse River suggests that the PCB sediment source is diffuse, and widespread diffusive flux from the sediments is the primary PCB source to the water column. Sediment PCB concentrations vary greatly over short distances in the river. While there are localized regions of elevated surface PCB concentrations in some areas, results of PCB fate modeling and analysis of the water column data indicate that PCB fluxes from areas of higher concentration are not the predominant source of PCBs in the water column, although these areas may have local effects.

4.3.2 PCB Trends

1. **Source control actions already taken have significantly reduced PCB levels in the river.** Lipid-based PCB levels in smallmouth bass and brown bullhead from the lower river have declined by about 90 percent since the mid-1990s. Similarly, water column PCB levels have declined by more than 90 percent over this same time period. These declines are attributable to two factors: 1) a downward trend in water column PCB concentrations resulting from the land-based remediation efforts performed at the Alcoa plant site between 1990 and 2001 that significantly reduced PCB discharges to the river; and 2) natural recovery due to solids that continually enter the river from upstream and deposit on top of the PCB-containing sediments, reducing movement of PCBs to fish.

   The observed decline in PCBs continued through a 100-year high flow event that occurred in January 1998, construction activities associated with the 2001 CPS, and the severe ice jam event that occurred in 2003 (some local impacts were observed). Sediment removal performed as part of the 2005 ROPS

caused increases in both water column and fish tissue PCB levels, but these only resulted in the short-term interruption of the decline observed prior to 2004. PCB levels measured between 2006 and 2011 were similar to those measured in the few years prior to 2005.

4.3.3 Natural Recovery Mechanisms

1. **Deposition and burial are the principal means of natural recovery.** Deposition, at an average rate of 0.2 to 0.7 cm/yr, occurs because the lower Grasse River is functionally equivalent to a reservoir. River velocity decreases significantly as water reaches the site, providing conditions conducive to the settling of solids. The velocity decreases because the channel depth, and consequently the river cross-section, increases dramatically. The greater depth is the result of the river deepening that occurred in the early 1900s to accommodate water diverted from the St. Lawrence River to generate electrical power (a practice that ceased in the 1950s).

2. **PCB dechlorination and degradation may contribute to natural recovery**. A combination of sediment core data analyses and laboratory experimentation provide many indications that dechlorination and biodegradation of PCBs are occurring in sediments of the lower Grasse River. These studies also document that both aerobic and anaerobic PCB-degrading organisms are present in Grasse River sediments. The laboratory studies indicate the potential for these processes to contribute to the long-term fate of PCBs in the lower Grasse River. Long-term in-river studies would be required to collect the necessary information to understand the extent to which biodegradation may be an important consideration in the evaluation of the long-term fate of PCBs in the lower Grasse River.

4.3.4 Efficacy of Capping

1. **A clean cap can be placed over and isolate the PCB-containing sediments.** The CPS showed that capping material released from a clamshell bucket above or below the water surface covers the river bottom and entrains little or no underlying PCB-containing sediments into the cap. Overall, capping of the native river sediments reduced PCB concentrations in the top 3 inches of the sediment column by about 92 to 97 percent. The placement of cap material over post-dredge residuals during the ROPS yielded similar reductions in sediment PCB concentration (about 95 percent), but greater mixing of the post-dredge residuals and the placed cap material was observed.

2. **Capping of native sediments does not remobilize sediment PCBs to a measurable extent**. During the CPS, average PCB levels measured inside and adjacent to the area being capped generally were near or below the detection limit and within the range of water column samples historically collected from a station near the capped area. All PCB concentrations measured at a station downstream of the capped area were below the detection limit. Results obtained from the CPS are expected to be translatable to other portions of the river, given that surface sediment PCB levels in other portions of the river are, on average, comparable to those observed in the pilot area prior to capping (see Section 4.3.1).

In contrast, the capping of post-dredge residuals during the ROPS did result in the release of PCBs downstream. This is believed to be due to the physical nature (i.e., low density) of the post-dredge residuals being capped relative to the native sediments.

3. **The steep side slopes of the river in the area of the CPS generally can support a cap no more than a few inches thick**. Target cap thickness was not consistently achieved on the side slopes of the river during the pilot study. For the pilot cells, 2 to 12 inches of material remained in place after application. No PCBs were detected in the cap material. The need for and feasibility of capping these areas would be assessed during the design phase.

4.3.5 Efficacy of Dredging

1. **Dredging can remove PCB mass from the river.** The ROPS activities removed about 75 percent (24,400 cy) of the targeted sediments and about 84 percent of the PCB mass present in the targeted sediments in Work Zone 1. The targeted sediments in this context are defined as the entire depth of sediment present within the ROPS Work Zone 1 footprint based on both pre-dredge and during construction investigations (pre-dredge probing estimates underestimated the actual depth of contamination at many locations). Similar results were obtained during the NTCRA activities; about 84 percent (2,600 cy) of the targeted sediments and greater than 90 percent of the PCB mass in the targeted sediments were removed.

2. **Dredging can leave post-dredging residual PCB contamination**. The ROPS activities in the main channel were unable to remove all of the targeted sediments and left, on average, about 16 inches of residual sediments (consisting of both untouched inventory and generated residuals) on the river bottom with an average residual PCB surface concentration of 150 mg/kg. Twenty-eight sediment cores were collected from the ROPS Work Zone 1 after completion of the dredging operations. Of these post-dredge cores, 15 contained residual disturbed sediments (RDS) on top of untouched inventory (UI), while the remaining 13 cores contained only UI. For the 15 cores that contained both RDS and UI, the RDS layer averaged 6 inches and the UI layer averaged 10 inches. The 13 post-dredge cores that contained only UI had an average depth of PCB-containing sediment of 17 inches. This post-dredge residual PCB concentration is significantly higher than the pre-dredging average 0- to 3-inch PCB concentration of 4 mg/kg. Similar results were obtained during the NTCRA; post-dredge residuals were, on average, 4 inches thick and contained an average concentration of about 75 mg/kg.

   The inability to remove all of the targeted sediments during these studies can be attributed, in part, to the presence of an uneven hard bottom upon which the PCB-containing sediments sit and the presence of cobbles and boulders on top of this hard bottom. These features prevented over-dredging into clean sediment, limited access to sediments in depressions or under cobbles and boulders, and prevented uniform contact between the dredge head and the hard bottom. The inability to remove these deeper sediments, which typically contain higher PCB concentrations, also limited dredge effectiveness by leaving behind post-dredge residuals with elevated PCB concentrations. The presence of clean underlying soft material could theoretically improve residual PCB levels; however, conditions such as these are typically only present in portions of the downstream half of the river. Underwater surveys

conducted by OSI identified rocky areas in other portions of the lower Grasse River, which could pose difficulties similar to those encountered during the NTCRA and ROPS activities.

The ROPS activities in the northern near shore area were successful in removing PCB inventory and leaving relatively low residual PCB concentrations (surface concentration was reduced 90 percent). The conditions encountered in this area were much different from the main channel with significantly lower pre-dredge PCB concentrations and the absence of significant obstructions and hard bottom conditions within the target cut depth of 1 foot (Alcoa, May 2006).

3. **Dredging can remobilize PCBs that are in buried sediments**. Water column sampling conducted during the ROPS indicated that approximately 3 percent of the PCB mass removed during sediment removal activities was released downstream. These releases resulted in PCB levels downstream of the work area above the corrective action level of 2 µg/L on 8 of the 128 days of in-river activities. PCB levels as high as 9.2 µg/L were measured in the water column immediately outside of the silt containment system during the sediment removal activities. Maximum PCB levels of 3.2 µg/L and 4.4 µg/L were measured at the locations approximately 2,000 feet (WCT14) and 6,200 feet (WC131), respectively, downstream of the work area during the sediment removal activities. The results of the ROPS water column monitoring indicate that water column releases associated with dredging would constrain dredging production rates in order to maintain compliance with water quality criteria.

4.3.6 Efficacy of Ice Control Options

1. **A stand-alone, pier-type ICS at T6.75 can effectively retain ice and control ice jams in the lower Grasse River.** Extensive numerical and physical model testing of the T6.75 ICS design showed that the structure can retain most of the ice delivered to it for the 2003 design event and a range of river discharges and ice supply volumes with recurrence intervals of 1 in 100 years (Alcoa, October 2009). Some ice passage between the piers was observed during the physical model study, but the ice passed represented a small fraction (i.e., less than 5 percent) of the solid ice volume entering from upstream. Numerical model simulations show that the release of ice through the ICS piers would not result in the formation of significant jams downstream.

   Numerical modeling predicted that maximum water surface elevations would exceed the 1-in-100 year open water flood elevations estimated by FEMA in the approximate 1.2-mile stretch of river upstream of the T6.75 ICS. Further upstream, maximum projected water surface elevations during these ice-related conditions are lower than those predicted under natural open water flood conditions.

   Although results of physical and numerical model testing indicating that a pier-type ICS at T6.75 can effectively retain ice, this technology has not been retained due to public safety concerns associated with the construction of piers in the river.

2. **An armored cap that is designed to withstand ice jam-related forces can be constructed in the lower Grasse River.** Ice dynamics and turbulence underneath the 2003 ice jam were modeled to support the design of an armored cap for the lower Grasse River. This cap design was successfully constructed in the lower Grasse River during the ROPS.

4.4 Basis for Development of Potential Remedial Alternatives

The rationale used to develop the list of potential remedial alternatives builds on the conceptual site model, prior AA Report (Alcoa, June 2002), results of additional data collection and pilot studies performed in the lower Grasse River since submission of that report in June 2002, and interactions with and specific directives from USEPA on the final list of alternatives. It should be noted that, while in-situ activated carbon treatment is not currently included in the list of remedial options, this option warrants consideration for integration into the remedy as appropriate during remedial design (see Section 4.2).

4.4.1 Selection of Removal and Armored Capping Target Areas

Components of the updated conceptual site model that are pertinent to the development of removal and armored capping components for the lower Grasse River sediments are provided below. Additional sampling and/or surveying will be performed during the pre-remedial design phase to refine the limits of remedial actions and better characterize the deposits requiring remediation (e.g., Type I and II areas).

- Under current conditions, PCBs in buried sediments in the main channel area upstream of T19 are potentially vulnerable to ice-related scour.

- PCBs in buried sediments downstream of T19 are currently stable and effectively sequestered under any reasonable future condition.

- Dredging is not considered for the coarse sediment deposits (i.e., Type I sediments) because the low PCB inventory in these deposits would not affect projected natural recovery rates, even if PCBs in these deposits were to be released to the river by erosion during an ice jam.

- Capping considers both fine (i.e., Type II) and coarse sediment deposits. The velocities in the fine and coarse sediment areas downstream of the ice scour prone reach were estimated to confirm that the current cap design is expected to be stable given the relatively low velocities the placed caps would experience even under high flow events (see also Section 2.3.1). The table below summarizes the peak (vertically averaged) velocities predicted by the site hydrodynamic model during the January 1998 high flow event, which approximates a 100-yr open water flow event.

Table 4-4: Peak Velocities (ft/s) Between T21 and T72 for 100-yr Open Water Flow Condition

River Reach	Main Channel		Near Shore Areas
	Coarse Sediment Area	Fine Sediment Area	
Vertically-averaged	3.0	2.4	2.0
12 inches above bed	2.2	1.9	1.7
6 inches above bed	2.0	1.7	1.5

- Vertical-averaged velocities produced by the model are typically higher than those found closer to the bed and, thus, over-estimate the velocities that are encountered at the bed surface. The vertical velocity distribution in a non-stratified river can be represented by the log-law, as presented below.

- The "expected" volumes presented for the sediment areas targeted for removal are based on the preliminary site sampling and investigations conducted to date (representing the "neatline") and also include a multiplier to account for engineering and construction considerations. Neatline volumes were generated for the removal areas by assuming removal down to the depth of contamination (DoC) (i.e., the depth at which sediment PCB concentrations reach and remain below 1 mg/kg), or for cores without a DoC, down to the maximum of the sediment probing and core penetration depths. Thus, because not all sediment cores recovered sediments below the DoC, the sediment volumes presented for the alternatives in this report are uncertain. These neatline volumes were then adjusted to account for constructability considerations (e.g., stable side slopes, over-dredge allowances, and provisions for additional volume from future sampling/remedy implementation). An adjustment multiplier of 1.1 has been used for main channel removal areas in T1 to T34 and T49 to T59, and a multiplier of 1.5 has been used for main channel removal areas in T34 to T49 and T59 to T72 and near shore areas between T1 and T72 (see Section 4.5).

- The surface sediment PCB concentration is the appropriate metric for targeting capping actions at those locations where sediments are not currently vulnerable to ice jam-induced scour (downstream of T19).

- The segment length-weighted average (SLWA) PCB concentration is an appropriate metric for targeting dredging and/or armored capping actions at locations where sediments are vulnerable to ice jam-induced scour because it provides a representative measure of the amount of PCBs present in sediment deposits that could potentially be released to the river by erosion during an ice jam. This metric was also used for the near shore areas in the T1 to T19 reach of the river in consideration of the divergent views that exist regarding the stability of sediments in this area. For this evaluation, SLWA concentrations are calculated over the interval from the surface of the sediments to the DoC or, when a DoC is not observed, to the depth of recovered sediments (see Figure 4-1).

- Remedial alternatives that include dredging within the ice scour-vulnerable reach of the river would require placement of a post-dredging armored cap to contain anticipated post-dredge residual PCB-containing sediments and protect these residuals from future ice scour events.

Note the results of the river ice investigation identified the main channel area in the T1 to T19 reach of river as potentially vulnerable to ice jam-induced scour (Alcoa, April 2009). For the purposes of remedy development, however, T21 has been used to define the downstream extent of this reach. This was done to recognize the fact that the contiguous fine sediment deposit in this portion of the river extends beyond T19 down to T21, and that any remedy developed to address this deposit would consider the entire deposit and not just the portion that is susceptible to ice jam-induced scour.

4.4.2 Surface Sediment Concentration Metric – Alternatives Including Capping

For the main channel sections of the lower Grasse River that are not vulnerable to ice jam-induced scour by virtue of being downstream of T21, a maximum PCB concentration criteria of 1 mg/kg was used to identify areas for main channel capping as directed by USEPA. This criterion is applied to the top 6 inches of the sediment column in the main channel areas as directed by USEPA (October 2009). Surface sediment PCB concentration is the appropriate metric for targeting capping actions because these concentrations determine exposure to benthic organisms within the biologically active layer and PCB flux from sediments to the water column. Capping of these sediments would immediately interdict a large portion of the current PCB flux to the water column.

For the near shore areas of the lower Grasse River, a maximum sediment PCB concentration threshold of 1 was used to identify near shore capping areas, and these thresholds were applied to the top 12 inches of the sediment column as directed by USEPA (October 2009).

Removal volumes for alternatives that include dredging in the near shore areas assume, as requested by the Agencies, that dredging would be conducted to the DoC. This is different from the approach taken during the 2005 ROPS near shore dredging, where a sediment depth of 12 inches was targeted for removal prior to capping back to original grade.

4.4.3 Metrics for Ice Scour Prone River Reaches - Alternatives with Armored Capping Alone or Dredging Followed by Armored Capping

A dual SLWA/maximum surface sediment PCB concentration criterion is used to develop remedial alternatives in which an ice scour-prone reach of the river is addressed either by armored capping alone or dredging followed by armored capping. The SLWA metric is a measure of the amount of PCBs within the depth of sediment column potentially vulnerable to resuspension during an ice scour event. The maximum surface sediment criterion is included at the direction of USEPA (USEPA, October 2009).

For alternatives involving armored capping alone or dredging followed by armored capping within river sections that are currently vulnerable to ice jam-induced scour, a SLWA/maximum surface sediment PCB concentration of 1 mg/kg is used to define areas to receive an armored cap based on direction by USEPA.

As discussed in Section 4.4.2, for alternatives involving capping alone or dredging followed by capping in river areas that are not vulnerable to ice jam-induced scour, only the maximum surface sediment PCB concentration metric is used.

Alcoa believes that protection of human health and the environment for this site is achieved by the armored capping/capping component of the remedial alternatives (including in combined remedies).

4.5 Assembly of Potential Remedial Alternatives

Potential remedial alternatives were developed based on Agency input, the conceptual site model, experience obtained through the conduct of several site-specific pilot studies, and the GRAs/technology types and associated representative process options retained after the two-step screening process. Each remedial alternative was designed to include the necessary number of representative process options so that the potential remedial alternative describes the complete scope of the remedial action that would be undertaken. In addition, the alternatives were developed to be consistent with the May 24, 1995 Amendment to the Administrative Order, which requires that this AA Report shall include analysis of dredging and an alternative(s) combining dredging with in-situ containment.

A total of 10 potential alternatives were developed based on discussions with the Agencies between December 2008 and March 2012. Consistent with USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, most of these alternatives include a combination of remedial options.

As discussed in Section 1.1, Alcoa has completed an extensive land-based remediation effort and has performed several in-river pilot and demonstration studies aimed at evaluating potential remedial alternatives for the lower Grasse River. As a result of these activities, approximately 29,000 cy of PCB-containing sediment have been removed from the river, and approximately 15 acres of river bottom have been capped (i.e., main channel cap, near shore cap, armored cap) or treated with activated carbon. The land-based remediation efforts and ongoing natural recovery processes (e.g., naturally occurring sedimentation) have dramatically reduced PCB levels in the river water and fish. A fundamental consideration in the evaluation of the alternatives presented below is which approach is best suited to accelerate the already observed decline in PCBs in the river in the most timely and cost-effective manner while limiting impacts to the community and the ecosystem of the lower Grasse River.

The 10 potential remedial alternatives to be evaluated are listed below. As indicated in Table 4-5, each alternative consists of combinations of remedial actions, PCB metrics, and PCB concentration thresholds that vary by river area and river stretch. Therefore, in an attempt to simplify the presentation and discussion of the alternatives, a naming convention that captures the major elements of each alternative and the varying PCB concentration thresholds for different river stretches was developed. In general, the naming convention is structured as follows: Stretch1 Action 1, Stretch 2 Action 2 Near Shore PCB Threshold/Main Channel PCB Threshold, where:

- Stretch = river stretch in which the Action is to be conducted (e.g., T1-T21)
- Action = remedial action to be conducted (e.g., Dredging/Capping)
- Near Shore PCB Threshold = PCB concentration threshold used to identify target near shore areas for the Action within the Stretch

- Main Channel PCB Threshold = PCB concentration threshold used to identify target main channel sediments for the Action within the Stretch

For example, Alternative 4 – T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping consists of the following components:

- Dredging near shore sediments with placement of backfill between T1 and T21 with PCB concentrations greater than or equal to 1 mg/kg;

- Placement of armor caps over main channel sediments between T1 and T21 with PCB concentrations greater than or equal to 1 mg/kg; and

- Placement of caps over near shore and main channel sediments between T21 and T72 with PCB concentrations greater than or equal to 1 mg/kg.

The names of each of the alternatives and summary of the total dredge volumes (both neatline and expected, including volume increase factors) and capping areas are listed below in Table 4-5. Table 4-6 provides a detailed description of each alternative that includes the sediment volumes targeted for removal (for dredging/capping components) and acreages targeted for capping (for dredging/capping and capping only components). Detailed descriptions of the alternatives are also provided in Sections 4.5.1 through 4.5.10. Maps depicting the areas targeted for remediation are provided on Figures 4-2 through 4-9. The detailed evaluation of these alternatives is provided in Section 5.

Table 4-5: Summary of Grasse River Alternative Descriptions, Dredge Volumes, and Capping Areas

Alternative No.	Abbreviated Alternative Description	Neatline Dredge Volume (in-situ CY)	Expected Dredge Volume (in-situ CY)	Neatline Acres Capped (acres)
1	No Further Action	0	0	0
2	Monitored Natural Recovery (MNR)	0	0	0
3	T1-T72 Capping	0	0	325
4	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping	17,200	25,900	325
5	T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping	30,800	46,100	325
6	T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping	72,400	108,700	325
7	T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping	208,300	258,300	325

Alternative No.	Abbreviated Alternative Description	Neatline Dredge Volume (in-situ CY)	Expected Dredge Volume (in-situ CY)	Neatline Acres Capped (acres)
8	T1-T21 Dredging/Capping, T21-T72 Capping	316,500	355,100	325
9	T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping	476,700	633,200	325
10	T1-T72 Dredging/Capping	1,225,700	1,663,500	325

4.5.1 Alternative 1: No Further Action

Alternative 1 would consider the results of prior source control actions, sediment remediation and pilot studies actions (i.e., NTCRA, CPS, ROPS, and ACPS; see Section 2.5), and extensive monitoring performed between 1991 and 2011 within the lower Grasse River. Naturally occurring sedimentation and microbially mediated dechlorination and degradation of PCBs – collectively referred to as natural recovery processes – would be relied upon to further reduce risk in the lower Grasse River over time.

Alternative 1 does not include any future monitoring beyond 2010. Fish tissue concentrations would continue to be reduced via natural processes, and existing fish consumption advisories in the lower Grasse River would be continued. This alternative will be carried forward for comparative purposes only.

4.5.2 Alternative 2: Monitored Natural Recovery

For Alternative 2, no further active remediation would be undertaken in the Study Area beyond the extensive source controls and pilot study actions previously completed by Alcoa. Naturally occurring sedimentation and microbially mediated dechlorination and degradation of PCBs – collectively referred to as natural recovery processes – would be relied upon to further reduce risk in the lower Grasse River over time.

A 30-year monitoring program would be developed and implemented in coordination with USEPA. Components to the program are assumed to include periodic monitoring of the water column and fish in the lower Grasse River. The monitoring program would be reviewed, at a minimum, every 5 years to assess whether modifications were warranted. A 30-year duration is used for cost estimating purposes consistent with the USEPA and USACE (2000) guidance. It is anticipated that fish consumption advisories would remain in place until NYSDOH determines the advisories are no longer needed.

4.5.3 Alternative 3: T1-T72 Capping

Figure 4-2 depicts the areas targeted for remedial action for Alternative 3. Alternative 3 combines the following components:

- Placement of an armored cap (25 inches) over sediments in the main channel between T1 and T21 with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (59 acres);

- Placement of a main channel cap (12 inches) over sediments between T21 and T72 with maximum sediment (0-6 inches) PCB concentrations greater than or equal to 1 mg/kg (225 acres);

- Placement of a near shore cap (6 inches) over sediments in the near shore areas between T1 and T21 with SLWA or maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (10 acres);

- Placement of a near shore cap (6 inches) over sediments in the near shore areas between T21 and T72 with maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (31 acres); and

- Ongoing site-wide natural recovery.

Armored Capping

A 25-inch thick armored cap would be placed over the areas requiring active remediation in the main channel between T1 and T21 (59 acres). This cap would consist of a sand/topsoil (50:50) mix and gravel/cobbles, as was used during the ROPS (Alcoa, May 2006). Construction of the armored cap in the manner described herein is also a component of Alternatives 4 through 10, and to minimize redundancy, this discussion will be referenced in the subsequent alternative descriptions.

Main Channel Capping

A 12-inch thick main channel cap would be placed between T21 and T72 (225 acres). This cap would consist of a sand/topsoil (50:50) mix, as was used during the CPS and ROPS (Alcoa, April 2002a; Alcoa, May 2006). Construction of the armored cap in the manner described herein is also a component of Alternatives 4 through 10, and to minimize redundancy, this discussion will be referenced in the subsequent alternative descriptions.

Near Shore Capping

A near shore cap (6 inches thick) would be placed over approximately 41 acres in the near shore areas of the river requiring active remediation between T1 and T72 (10 acres between T1 and T21, and 31 acres between T21 and T72). This cap would consist of a sand/topsoil (50:50) mix, as was used during the ROPS (Alcoa, May 2006). The near shore cap would provide the same physical and/or chemical isolation functions as the main channel cap, but would be designed to concurrently minimize near shore bathymetry impacts in response to concerns identified by the Agency stakeholder group in prior discussions. Construction of the

near shore cap in the manner described herein is also a component of Alternatives 4 through 8, and to minimize redundancy, this discussion will be referenced in the subsequent alternative descriptions.

Institutional Controls

Following completion of remedial actions, contaminated sediments that are contained beneath the armored caps and main channel caps would be subject to long-term institutional controls and monitoring. Existing regulatory authorities have created a comprehensive regulatory and permitting framework that governs the types of intrusive activities, such as placement/removal of structures in navigable waters that could affect the integrity of the placed caps. Additionally, the locations of the caps would be indicated on all appropriate local governmental units' mapping systems. The existing fish consumption advisory would remain in effect until the NYSDOH determined that the advisory could be modified or removed.

As part of the CERCLA 5-year review, USEPA would require periodic review of the status and effectiveness of the institutional controls implemented at the site. Institutional controls described herein are also a component of all other alternatives with the exception of Alternatives 1 and 2; to minimize redundancy this discussion will be referenced in subsequent alternative descriptions.

Monitoring

Environmental monitoring would be performed during all in-river capping work and in the long term, as briefly summarized below.

Monitoring During Capping: Water column sampling would be performed during capping operations.

Long-Term Monitoring: Following completion of capping activities, a long-term monitoring program similar to that described for Alternative 2, with the additional provisions described below, would be conducted. The actual long-term monitoring program will be determined in coordination with USEPA. It is assumed that the program would include provisions for cap maintenance, observation after extreme ice/flood events, and bathymetry surveys. The monitoring program would be reviewed at a minimum, every 5 years to assess whether modifications were warranted. A 30-year duration is used for cost estimating purposes consistent with the USEPA and USACE (2000) guidance.

Monitoring of caps in the manner described herein is also a component of all alternatives with the exception of Alternatives 1 and 2. To minimize redundancy, this discussion will be referenced in subsequent alternative descriptions as appropriate.

4.5.4 Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping

The areas targeted for remedial action under Alternative 4 are shown on Figure 4-3. Alternative 4 combines the following components:

- Placement of an armored cap (25 inches) over main channel sediments between T1 and T21 with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (59 acres);

- Placement of a main channel cap (12 inches) between T21 and T72 with maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (225 acres);

- Dredge near shore sediments with subsequent placement of backfill to restore grade between T1 and T21 with SLWA or maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (about 26,000 in-situ cy, 10 acres);

- Placement of a near shore cap (6 inches) over sediments in the near shore areas between T21 and T72 with maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (31 acres); and

- Ongoing site-wide natural recovery.

Dredging

Approximately 26,000 in-situ cy of soft sediment material (in an area covering approximately 10 acres) would be removed from the near shore areas between T1 and T21.

Consistent with the ROPS, dredged sediments were assumed to be mechanically dewatered and the effluent water treated. Actual dewatering and water treatment equipment to be used would be determined in the design phase. Dewatered sediment would be disposed in Alcoa's on-site Secure Landfill, which can be expanded within the current footprint to an approximate capacity of 100,000 cy. It should be noted, however, that for alternatives involving larger removal volumes (e.g., Alternatives 6 through 10), multiple landfill facilities would be required given the total anticipated volume of dredging. For these larger alternatives, dewatering materials would be disposed of at Alcoa's on-site Secure Landfill and also would be transported to an off-site approved landfill(s). Alcoa's on-site Secure Landfill is permitted to accept materials with PCB concentrations in excess of 50 mg/kg, and as such, segregation would not be required for the dredged materials disposed on site.

Capping would be sequenced to occur upstream of dredging operations, and would be performed subsequent to dredging actions beginning the first construction year.

Armored Capping

A 25-inch-thick armored cap would be placed over the areas requiring active remediation in the main channel between T1 and T21 (59 acres) to protect these sediments from potential future ice scour events. Additional details of the armor cap are discussed for Alternative 3 (see Section 4.5.3).

Main Channel Capping

A 12-inch thick main channel cap would be placed over the areas requiring active remediation (225 acres) between T21 and T72 (see Section 4.5.3 for additional details).

Near Shore Backfilling/Capping

After removal of approximately 26,000 in-situ cy of soft sediment in the near shore areas between T1 and T21, a sand/topsoil materials would be placed over approximately 10 acres to return the post-dredge surface to original grade. A 6-inch thick near shore cap would also be placed in the near shore areas of the river over the areas requiring active remediation between T21 and T72 (31 acres). Additional details for near shore capping are provided in Section 4.5.3.

Institutional Controls

Institutional controls would be implemented as described in Section 4.5.3 for Alternative 3.

Monitoring

Environmental monitoring would be performed during all in-river work and in the long term. During construction activities related to capping and long-term monitoring would be similar to that described for Alternative 3 (Section 4.5.3). Details of long-term monitoring during construction activities related to dredging are provided below.

Monitoring During Dredging: During dredging operations, water column sampling and air monitoring would be performed to verify protection of water and air quality. In addition, the discharge from the water treatment operations would be monitored to ensure that the treated water meets applicable discharge standards.

Monitoring of dredging-related activities in the manner described herein is also a component of all of alternatives with the exception of Alternatives 1, 2, and 3. To minimize redundancy, this discussion will be referenced in subsequent alternative descriptions as appropriate.

4.5.5 Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping

Figure 4-4 depicts the areas targeted for remedial actions for Alternative 5. Alternative 5 combines the following components:

- Placement of an armored cap (25 inches) over sediments in the main channel between T1 and T21 with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (59 acres);

- Placement of a main channel cap (12 inches) over sediments between T21 and T72 with maximum sediment (0-6 inches) PCB concentrations greater than or equal to 1 mg/kg (225 acres);

- Dredge near shore sediments with subsequent placement of backfill to restore grade with SLWA or maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 10 mg/kg (about 18,000 cy, 6 acres) and placement of a near shore cap (6 inches) over sediments in the near shore areas with SLWA or maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 and less than 10 mg/kg (4 acres) between T1 and T21;

- Dredge near shore sediments with subsequent placement of backfill to restore grade with maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 10 mg/kg (about 28,000 cy, 7 acres) and placement of a near shore cap (6 inches) over sediments in the near shore areas with maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 and less than 10 mg/kg (24 acres) between T21 and T72; and

- Ongoing site-wide natural recovery.

Dredging

Approximately 18,000 in-situ cy of soft sediment material (in an area covering approximately 6 acres) would be removed from the near shore areas between T1 and T21 and an additional 28,000 in-situ cy of soft sediment material (in an area covering approximately 7 acres) would be removed from the near shore areas between T21 and T72. Additional details on the dredging-related assumptions are provided above for Alternative 4 (see Section 4.5.4).

Armored Capping

A 25-inch thick armored cap would be placed over the areas requiring active remediation in the main channel between T1 and T21 (59 acres). Additional details of the armor cap are discussed for Alternative 3 (see Section 4.5.3).

Main Channel Capping

A 12-inch thick main channel cap would be placed over the areas requiring active remediation between T21 and T72 (225 acres; see Section 4.5.3 for additional details).

Near Shore Backfilling/Capping

After removal of approximately 46,000 cy of near shore sediments between T1 and T72 covering approximately 13 acres, backfill would be placed on the post-dredge surface to return the elevation to pre-dredge grades. In addition, a 6-inch thick near shore cap would be placed over approximately 28 acres of the remaining near shore areas of the river between T1 and T72 that require active remediation and is not otherwise addressed by the dredging and backfilling to grade component (see Section 4.5.3 for additional details on near shore capping).

Institutional Controls

Institutional controls, as they pertain to capping, would be implemented as described in Alternative 3 (see Section 4.5.3).

Monitoring

During construction activities related to capping and long-term monitoring would be similar to that described for Alternative 3 (Section 4.5.3). Details of long-term monitoring during construction activities related to dredging during construction activities related to dredging are provided in Section 4.5.4.

4.5.6 Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping

The areas targeted for remedial action under Alternative 6 are shown on Figure 4-5. Alternative 6 combines the following components:

- Placement of an armored cap (25 inches) over main channel sediments between T1 and T21 with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (59 acres);
- Placement of a main channel cap (12 inches) between T21 and T72 with maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (225 acres);
- Dredge near shore sediments with subsequent placement of backfill to restore grade between T1 and T21 (about 26,000 in-situ cy, 10 acres) with SLWA or maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg ;
- Dredge near shore sediments with subsequent placement of backfill to restore grade (about 83,000 cy, 31 acres) between T21 and T72 with maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg; and
- Ongoing site-wide natural recovery.

Dredging

Approximately 26,000 in-situ cy of soft sediment material (in an area covering approximately 10 acres) would be removed from the near shore areas between T1 and T21. An additional 83,000 in-situ cy of soft sediment material (in an area covering approximately 31 acres) would be removed from the near shore areas between T21 and T72. Additional details related to dredging are provided above under Alternative 4 (see Section 4.5.4).

Armored Capping

A 25-inch-thick armored cap would be placed over the areas requiring active remediation in the main channel between T1 and T21 (59 acres) to protect these sediments from potential future ice scour events. Additional details of the armor cap are discussed under Alternative 3 (see Section 4.5.3).

Main Channel Capping

A 12-inch thick main channel cap would be placed over the areas requiring active remediation (225 acres) between T21 and T72 (see Section 4.5.3).

Near Shore Backfilling

After removal of approximately 109,000 in-situ cy of soft sediment in the near shore areas between T1 and T72, backfill would be placed over approximately 41 acres to return the post-dredge surface to original grade (see Section 4.5.4 for additional details).

Institutional Controls

Institutional controls would be implemented as described in Section 4.5.3 for Alternative 3.

Monitoring

During construction activities related to capping and long-term monitoring would be similar to that described for Alternative 3 (Section 4.5.3). Details of long-term monitoring during construction activities related to dredging are provided in Section 4.5.4.

4.5.7 Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping

The areas targeted for remedial action under Alternative 7 are shown on Figure 4-6. Alternative 7 combines the following components:

- Dredge main channel sediments from Work Zones 2 and 3 from the ROPS and T16.5 to T19.5 (about 150,000 in-situ cy, 19 acres);
- Placement of an armored cap (25 inches) over dredged main channel sediments from Work Zones 2 and 3 from the ROPS and T16.5 to T19.5 (about 19 acres);
- Placement of an armored cap (25 inches) over remaining undredged sediments in the main channel between T1 and T21 with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (about 40 acres);

- Placement of a main channel cap (12 inches) over remaining undredged sediments in the main channel between T21 and T72 with maximum sediment (0-6 inches) PCB concentrations greater than or equal to 1 mg/kg (about 225 acres);

- Dredge near shore sediments and subsequent placement of backfill to restore grade between T1 and T21 in areas with a SLWA or maximum sediment (0 to 12 inches) PCB concentration greater than or equal to 1 mg/kg (about 26,000 cy, 10 acres);

- Dredge near shore sediments and subsequent placement of backfill to restore grade between T21 and T72 in areas with a maximum sediment (0 to 12 inches) PCB concentration greater than or equal to 1 mg/kg (about 83,000 in-situ cy, 31 acres); and

- Ongoing site-wide natural recovery.

Dredging

Approximately 109,000 in-situ cy of soft sediment material (in an area covering approximately 41 acres) would be removed from the near shore between T1 and T72 and approximately 150,000 in-situ cy of soft sediment material (in an area covering approximately 19 acres) would be removed from the main channel areas between T1 and T21. Additional details on the dredging-related assumptions are provided above for Alternative 4 (see Section 4.5.4).

Armored Capping

A 25-inch thick armored cap would be placed over the areas requiring active remediation in the main channel between T1 and T21 (59 acres, 19 acres over dredged areas). Additional details of the armor cap are discussed for Alternative 3 (see Section 4.5.3).

Main Channel Capping

A 12-inch thick main channel cap would be placed over the areas requiring active remediation between T21 and T72 (225 acres; see Section 4.5.3 for additional details).

Near Shore Backfilling

After removal of approximately 109,000 cy of near shore sediments between T1 and T72, backfill would be placed on the post-dredge surface covering approximately 41 acres to return the elevation to pre-dredge grades (see Section 4.5.4 for additional details).

Institutional Controls

Institutional controls would be implemented as described in Sections 4.5.3 for Alternative 3.

Monitoring

During construction activities related to capping and long-term monitoring would be similar to that described for Alternative 3 (Section 4.5.3). Details of long-term monitoring during construction activities related to dredging are provided in Section 4.5.4.

4.5.8 Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping

Figure 4-7 presents the river areas targeted for remediation under Alternative 8. Alternative 8 combines the following components:

- Dredge main channel areas and subsequent placement of an armored cap (25 inches) between T1 and T21 with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (about 329,000 in-situ cy, 59 acres);
- Placement of a cap (12 inches) over sediments in the main channel between T21 and T72 with maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (225 acres);
- Dredge near shore sediments and subsequent placement of backfill to restore grade between T1 and T21 with SLWA or maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (about 26,000 in-situ cy, 10 acres);
- Placement of a near shore cap (6 inches) over sediments in the near shore areas between T21 and T72 with maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (31 acres); and
- Ongoing site-wide natural recovery.

Dredging

Approximately 329,000 in-situ cy of soft sediment material (in an area covering approximately 59 acres) would be removed from the main channel between T1 and T21. In addition to the main channel dredging, approximately 26,000 in-situ cy of sediment (in an area covering approximately 10 acres) would be removed from the near shore areas between T1 and T21. Additional details related to dredging are provided above for Alternative 4 (see Section 4.5.4).

Armored Capping

Following the removal of approximately 329,000 cy of sediment from the main channel between T1 and T21, a 25-inch-thick armored cap (59 acres) would be placed over the post-dredge surface to address any remaining residual PCB concentrations and protect the post-dredge surface from future ice scour events. Additional details regarding armored cap placement are provided above for Alternative 3 (see Section 4.5.3).

Main Channel Capping

A 12-inch thick main channel cap would be placed over the areas requiring active remediation between T21 and T72, covering approximately 225 acres (see Section 4.5.3 for additional details).

Near Shore Backfilling/Capping

After removal of approximately 26,000 cy of near shore sediments between T1 and T21, backfill would be placed on the post-dredge surface to return the elevation to pre-dredge grades. A 6-inch thick near shore cap (31 acres) would be placed over the near shore areas of the river between T21 and T72 that require active remediation (see Section 4.5.3 for additional details on near shore capping, and Section 4.5.4 for additional details on near shore backfilling).

Institutional Controls

Institutional controls would be implemented as described in Alternative 3 (see Section 4.5.3).

Monitoring

During construction activities related to capping and long-term monitoring would be similar to that described for Alternative 3 (Section 4.5.3). Details of long-term monitoring during construction activities related to dredging are provided in Section 4.5.4.

4.5.9 Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping

The areas targeted for remedial action under Alternative 9 is shown on Figure 4-8. Alternative 9 combines the following components:

- Dredge main channel sediments from Work Zones 2 and 3 from the ROPS and T16.5 to T19.5 , T27 to T37, and T43 to T46 (about 525,000 in-situ cy, 76 acres);
- Placement of an armored cap (25 inches) over dredged main channel sediments from Work Zones 2 and 3 from the ROPS, T16.5 to T19.5, T27 to T37, and T43 to T46 (about 76 acres);
- Placement of an armored cap (25 inches) over remaining undredged sediments in the main channel between T1 and T21 with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (about 40 acres);
- Placement of a main channel cap (12 inches) over remaining undredged sediments in the main channel between T21 and T72 with maximum sediment (0-6 inches) PCB concentrations greater than or equal to 1 mg/kg (about 168 acres total);

- Dredge near shore sediments and subsequent placement of backfill to restore grade between T1 and T21 in areas with a SLWA or maximum sediment (0 to 12 inches) PCB concentration greater than or equal to 1 mg/kg (about 26,000 cy, 10 acres);

- Dredge near shore sediments and subsequent placement of backfill to restore grade between T21 and T72 in areas with a maximum sediment (0 to 12 inches) PCB concentration greater than or equal to 1 mg/kg (about 83,000 in-situ cy, 31 acres); and

- Ongoing site-wide natural recovery.

Dredging

Approximately 109,000 in-situ cy of soft sediment material (in an area covering approximately 41 acres) would be removed from the near shore between T1 and T72 and approximately 525,000 in-situ cy of soft sediment material (in an area covering approximately 76 acres) would be removed from the main channel areas between T1 and T72. Additional details on the dredging-related assumptions are provided above for Alternative 4 (see Section 4.5.4).

Armored Capping

A 25-inch thick armored cap would be placed over the areas requiring active remediation in the main channel between T1 and T21 (59 acres, 19 acres over dredged areas). Additional details of the armor cap are discussed for Alternative 3 (see Section 4.5.3).

Main Channel Capping

A 12-inch thick main channel cap would be placed over the areas requiring active remediation between T21 and T72 (225 acres, 57 acres over dredged areas; see Section 4.5.3 for additional details).

Near Shore Backfilling

After removal of approximately 109,000 cy of near shore sediments between T1 and T72, backfill would be placed on the post-dredge surface covering approximately 41 acres to return the elevation to pre-dredge grades (see Section 4.5.4).

Institutional Controls

Institutional controls would be implemented as described in Sections 4.5.3 for Alternative 3.

Monitoring

During construction activities related to capping and long-term monitoring would be similar to that described for Alternative 3 (Section 4.5.3). Details of long-term monitoring during construction activities related to dredging are provided in Section 4.5.4.

4.5.10 Alternative 10: T1-T72 Dredging/Capping

Figure 4-9 depicts the areas targeted for remedial actions for Alternative 10. Alternative 10 includes the following components:

- Dredge main channel sediments and subsequent placement of an armored cap (25 inches) between T1 and T21 in areas with SLWA or maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (about 329,000 in-situ cy, 59 acres);
- Dredge main channel sediments and subsequent placement of a cap (12 inches) between T21 and T72 in areas with maximum sediment (0 to 6 inches) PCB concentrations greater than or equal to 1 mg/kg (about 1,226,000 in-situ cy, 225 acres);
- Dredge near shore sediments and subsequent placement of backfill to restore grade between T1 and T21 in areas with SLWA or maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (about 26,000 in-situ cy, 10 acres);
- Dredge near shore sediments and subsequent placement of backfill to restore grade between T21 and T72 in areas with maximum sediment (0 to 12 inches) PCB concentrations greater than or equal to 1 mg/kg (about 83,000 in-situ cy, 31 acres); and
- Ongoing site-wide natural recovery.

Dredging

Approximately 1,664,000 in-situ cy of soft sediment would be targeted for removal from the main channel and near shore areas under Alternative 10. Given this volume, multiple landfill facilities would be required for this alternative. Additional details on the dredging-related assumptions are provided above under Alternative 4 (see Section 4.5.4).

Armored Capping

After the removal of sediment from the main channel, a 25-inch armored cap would be placed on the post-dredge surface between T1 and T21 (approximately 59 acres; see Section 4.5.3 for additional details).

Main Channel Capping

A 12-inch thick main channel cap would be placed on the post-dredge surface between T21 and T72 (approximately 225 acres) to address residual PCB concentrations (see Section 4.5.3).

Near Shore Backfilling

After the removal of the targeted soft sediment material in the near shore areas between T1 and T72, backfill would be placed on the post-dredge surface to return the sediment surface to its pre-dredge elevation (e.g., "cap to original grade"). Approximately 109,000 cy of capping material would be placed over 41 acres of near shore area to return the post-dredge surface to original grade (see Section 4.5.4 for additional details).

Institutional Controls

Institutional controls would be implemented as described in Sections 4.5.3 for Alternative 3.

Monitoring

During construction activities related to capping and long-term monitoring would be similar to that described for Alternative 3 (Section 4.5.3). During construction activities related to dredging are provided in Section 4.5.4.

5. Detailed Analysis of Alternatives

This section presents the detailed analysis of the alternatives that were assembled from the retained technologies and process options and described in Section 4.5. The CERCLA evaluation criteria used for this analysis are summarized in Section 5.1. Key technology components and process options (i.e., MNR, dredging, and capping) that are common to the alternatives are evaluated with respect to the CERCLA evaluation criteria in Section 5.2. A detailed analysis of each individual alternative is presented in Section 5.3. The results of this detailed analysis are used to perform the comparative analysis of the alternatives presented in Section 6. Throughout these sections, the 10 remedial alternatives identified in Section 4.5 are referenced by number (1 through 10) and the shorthand names listed in Table 4-6.

The detailed analysis of alternatives relies on a significant body of site-specific data and analyses, site-specific modeling, and site-specific remedial activities (e.g., NTCRA, CPS, ROPS, and ACPS) conducted since the mid 1990s. The findings and conclusions from these efforts are summarized in Section 2 and Appendix A, the CCLGR (Alcoa, April 2001), the Draft CCLGR Addendum (Alcoa, April 2009), and various construction documentation reports associated with various site-specific activities (BBL, December 1995; Alcoa, April 2002a; Alcoa, May 2006; Alcoa, June 2007b; Alcoa, November 2007).

While representative process options are identified in the alternatives, it should be recognized that these may be modified during the design and implementation phases of the selected alternative due to engineering considerations, localized site conditions, and/or new information. For example, as summarized in Section 2.5.4, activated carbon could in some areas replace or supplement, as appropriate, the capping technologies described in the alternatives.

As described in detail in Appendix A, projected changes in water column, sediment, and fish tissue PCB concentrations used in this analysis were derived from model simulations of the period from 2007 to 2036 for each remedial alternative. For purposes of evaluation, the effectiveness of each remedial alternative was assessed using the following metrics:

- Time needed to achieve particular river-wide average fish tissue PCB concentrations specified by USEPA (i.e., 0.36 mg/kg, 0.26 mg/kg, and 0.05 mg/kg);
- River-wide fish Grasse River tissue PCB concentrations at the end of the simulation in 2036; and
- Time needed to achieve 85 percent reduction in PCB loading to the St. Lawrence River.

These metrics were selected to provide meaningful short- and long-term points of comparison among alternatives over the 30 years simulated by the model, consistent with the approach used in the USEPA-approved 2002 AA Report (Alcoa, June 2002). The 0.36, 0.26, and 0.05 mg/kg targets were identified by USEPA as interim and long-term goals for PCB levels in fish. The 85 percent loading reduction to the St. Lawrence River metric was used to provide a longer-term average rate of decline in the water column PCBs associated with active remediation in the river, and was calculated based on an average baseline PCB load

of about 14 kg/yr predicted between 2010 and 2012 (2012 assumed to be the last year before the start of remedial activities for the modeling evaluation). Three-year average PCB loadings were used to dampen year-to-year variations associated with fluctuations in river flows used in the synthetic hydrograph for the model projections. The evaluation of alternatives also considered the estimated dates at which predicted river-wide average sediment (0-3 inch) PCB concentrations reach 1 mg/kg.

5.1 CERCLA Evaluation Criteria

Nine evaluation criteria (two threshold, five balancing, and two modifying criteria) were established to address the overall requirements of CERCLA and the NCP (USEPA, October 1988). Application of these criteria to the range of potential remedial technologies/process options and site-wide alternatives is presented in Sections 5.2 and 5.3, respectively. These evaluations support the comparative analysis presented in Section 6, which in turn supports identification of the most appropriate remedial action for the Grasse River Study Area. The nine evaluation criteria are summarized below.

Threshold Criteria

- **Overall Protection of Human Health and the Environment**: Addresses the overall ability of an alternative to eliminate, reduce, or control potential exposures to PCBs in both the short and long term.

- **Compliance with ARARs**: Assesses whether the alternative attains the identified chemical-specific, action-specific, and location-specific ARARs (see Section 3.4).

Balancing Criteria

- **Long-term Effectiveness and Permanence**: Evaluates the alternative for the long-term effectiveness and permanence it provides. Factors considered under this criterion include the magnitude of residual risk remaining after implementation, along with the adequacy and reliability of control measures (e.g., containment systems and institutional controls). The potential for each alternative to achieve the RAOs established in Section 3.3 are assessed in the comparative analysis of this criterion contained in Section 6. Site RAOs include the following:

  1. Reduce the cancer risks and non-cancer health hazards for people eating fish from the Grasse River by reducing the concentration of PCBs in fish.
  2. Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish.
  3. Minimize the current and potential future bioavailability of PCBs in sediments.
  4. Protect the ecosystem of the lower Grasse River.
  5. Minimize the long-term transport of PCBs from the lower Grasse River to the St. Lawrence River.

- **Reduction of Toxicity, Mobility, or Volume through Treatment**: Addresses the degree to which an alternative reduces the toxicity, mobility, or volume of chemical constituents through treatment, including how treatment addresses the principle threats posed by the site.

- **Short-term Effectiveness**: Assesses effects and risks to human health and the environment related to construction and implementation of each alternative. Considerations include short-term impacts on workers and the community during the remedial action, potential environmental effects of the remedial action, effectiveness of mitigation measures, and the time until protection is achieved through consideration of near-term improvements resulting from remedy implementation.

- **Implementability**: Evaluates the ease or difficulty of implementing the alternative by considering technical feasibility, administrative feasibility, and availability of services and materials required for implementation.

- **Cost**: Evaluates present-worth (present day dollars) direct and indirect capital, operating, and maintenance costs of implementing an alternative.

Modifying Criteria

- **State (Support Agency) Acceptance**: Assesses the technical and administration issues the supporting agencies may have regarding the alternatives.

- **Community Acceptance**: Assesses issues and concerns interested persons in the community may have about the potential remedial alternative.

Note that the modifying criteria (State [Support Agency] Acceptance and Community Acceptance]) will be evaluated by USEPA after compilation of public comments and input received on the Proposed Remedial Action Plan for the site.

To avoid repetition, Section 5.2 presents an analysis of common elements of remedial technologies and process options (i.e., MNR, dredging, and capping) with respect to the CERCLA evaluation criteria. Evaluation of the common elements is then incorporated by reference in the subsequent detailed analyses of each alternative (Section 5.3).

5.2 Evaluation of Common Elements of Remedial Alternatives

Elements common to several of the remedial alternatives include MNR, dredging/removal, and in-situ capping. These common elements are evaluated in this section against each of the CERCLA evaluation criteria with the exception of cost and the modifying criteria (State [Support Agency] Acceptance and Community Acceptance]). This evaluation relies heavily on site-specific data and pilot studies. Note that the activated carbon technology is not included in this evaluation as discussed in Section 4.2.

As discussed in Section 1.1.3, since USEPA's Administrative Order was issued in 1989, source control actions by Alcoa have effectively eliminated PCB discharges to the Grasse River. In conjunction with these efforts, a long-term monitoring program was established to track trends in fish, water, and surface sediment concentrations since the mid-1990s (see Figures 2-24 and 2-26 to 2-28), and this database has provided

important information with regard to the potential for natural recovery to serve as a component of the final remedial approach. Alcoa, in coordination with USEPA, also undertook a series of pilot-scale projects that evaluated the efficacy of dredging and capping for the site-specific conditions in the river, and has conducted a similar pilot-scale evaluation of in-situ PCB sequestration by activated carbon. These studies provide the site-specific data necessary to evaluate the potential effectiveness of a range of remedial alternatives at the site.

As discussed in Section 1.1.2, between 1991 and 2001, Alcoa carried out remedial actions at the Massena facility that dramatically reduced PCB discharges to the lower Grasse River. For example, PCB discharges from Outfall 001, which totaled approximately 22 kg/yr (60 grams/day) in 1990, were reduced to non-detectable levels by 2003 (see Figure 1-5). This early focus on source control is consistent with guidance documents developed by the NRC (2001*;* 2007) and USEPA (February 2002; December 2005; July 2008), which recommend that the first goal of any sediment remediation effort should be to control ongoing sources. The total cost of Alcoa's land-side remediation efforts, including source control work associated with the Grasse River, was more than $250 MM (1991 to 2001 dollars).

Monitoring data show that the source control and in-river remediation efforts have allowed natural recovery processes in the river to dramatically reduce PCB levels in the water column and fish (see Figures 2-24 and 2-26 to 2-28). This recovery is the result of deposition of lower concentration solids that continually enter the river from upstream and deposit on top of the PCB-containing sediments, progressively limiting the movement of PCBs into the overlying water column and fish tissue.

Between July and September 1995, Alcoa completed the NTCRA, which included removal of approximately 2,600 cy of sediments containing the highest PCB concentrations (ranging from non-detect to 11,000 mg/kg) in the lower Grasse River (Section 2.5.1; BBL, December 1995). The NTCRA provided initial information on the implementation and effectiveness of dredging within an area adjacent to Outfall 001 (Alcoa, April 2009). The NTCRA was completed at a cost of approximately $5 MM (1995 dollars).

In summer and fall 2001, Alcoa implemented the CPS over approximately 7 acres of the lower Grasse River to evaluate the feasibility and construction requirements of placing clean capping material over the native sediments (Section 2.5.2; Alcoa, April 2002a). The CPS was completed at a cost of approximately $3 MM (2001 dollars).

Between April and December 2005, Alcoa completed the ROPS, which included removal of approximately 26,000 cy of sediments downstream of Outfall 001 with the highest remaining PCB concentrations (ranging from non-detect to 3,700 mg/kg) (Section 2.5.3; Alcoa, May 2006). In addition, the ROPS included post-dredge capping of approximately 4.1 acres in the main channel and 0.5 acres in the near shore areas, armored capping of approximately 1 acre in the main channel sediments, and thin-layer capping of approximately 0.5 acres in the near shore areas. The ROPS provided detailed information on the implementation and effectiveness of dredging followed by capping and armored capping in the reach of the river that is potentially vulnerable to ice jam-induced scour, as well as near shore excavation followed by

capping and thin-layer capping in the near shore. The ROPS was completed at a cost of approximately $28 MM (2005 dollars).

In September 2006, Alcoa initiated a field study in a 0.5-acre area of the lower river to evaluate the effectiveness of activated carbon as a means to sequester PCBs and reduce PCB flux from sediments and uptake by biota (Section 2.5.4; Alcoa, November 2007). Construction was completed in October 2006, and the activated carbon application area was monitored over a 3-year period (2007-2009). Costs through 2009 for the ACPS have exceeded $2.5 MM (2006 dollars).

The NTCRA, CPS, ROPS, ACPS, and source control activities have generated considerable site-specific information that is relevant to the evaluation of MNR, near shore capping, armored capping, ice control, dredging, and in-situ activated carbon treatment for management of PCB-containing sediments. The results of this work form the basis for the detailed alternative analysis presented in the sections below.

5.2.1 Overall Protection of Human Health and the Environment

This criterion addresses the overall ability to eliminate, reduce, or control potential exposures to PCBs in both the short and long term. An evaluation of the site-specific application of MNR, dredging/removal, and in-situ capping in consideration of this criterion follows.

5.2.1.1 Monitored Natural Recovery

Natural sedimentation in the Study Area ranges from 0.2 to 0.7 cm/yr and provides a source of clean material that progressively covers sediments and reduces surface sediment concentrations and associated PCB risks over time, as described in Section 4.3.2. Periodic ice jam-related scour events can remobilize PCBs in the river section vulnerable to this phenomenon, which could affect the rate of recovery of the system. Since the early to mid-1990s, average fish tissue PCB concentrations in smallmouth bass and brown bullhead have declined by more than 90 percent as a result of prior source control actions and natural recovery processes (see Figures 2-26 and 2-27 and Section 4.3.2). Significant declines have also occurred in YOY spottail shiner, though monitoring of these species did not begin until the late 1990s (Figure 2-28).

Notable events that occurred during this monitoring program included a high open water flow event approximating a 100-year storm in 1998 and a major ice jam-related sediment scour event in 2003 – both of which did not adversely impact the recovery of river-wide fish tissue PCBs, and implementation of the ROPS dredging in 2005, which resulted in PCB releases to the water column and temporary increases in fish tissue PCBs. Throughout this time frame, the fish data provide evidence of the role of natural processes in reducing risk at the site, consistent with MNR guidance (USEPA, December 2005; Magar et al., May 2009). As presented in Appendix A, detailed modeling was performed to evaluate reductions in fish tissue PCBs (and thus risk) attributable to ongoing recovery processes. Consistent with direction from USEPA, the model was developed and calibrated to provide a conservative estimate of future natural recovery rates (see Appendix A).

As discussed in the CCLGR Report (Alcoa, April 2001), a combination of sediment core data analyses and laboratory experiments revealed that dechlorination and biodegradation are occurring in sediments of the lower Grasse River. These studies also documented that both aerobic and anaerobic PCB-degrading organisms are present in Grasse River sediments. Although the laboratory studies indicate the potential for these processes to contribute to the long-term fate of PCBs in the lower Grasse River, dechlorination and biodegradation of PCBs are currently proceeding at relatively slow rates. These rates are generally insufficient to constitute important near-term recovery processes in the river. Nevertheless, these processes contribute to the long-term protectiveness of MNR.

5.2.1.2 Dredging/Removal

While alternatives including removal would reduce the volume of PCB-containing sediments in the river, elevated post-dredging PCB residuals are expected, resulting in post-dredge surface sediment concentrations that are greater than current (baseline) conditions. This expectation is based on the results of the ROPS, and is also consistent with the findings of the NRC report on dredging effectiveness for the site conditions encountered on the lower Grasse River. Specifically, the NRC noted, "Dredging effectiveness is limited by resuspension and release of contaminants during dredging and the generation and exposure of residual contamination by dredging" (NRC, 2007 – p. 163) and "Dredging *alone* is unlikely to be effective in meeting short-term and long-term goals if a site has one or more unfavorable conditions" (NRC, 2007 – p. 5). USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites likewise notes that "the level of uncertainty associated with estimating residual contamination [after dredging] can be high at some sites," and that "[a]nother limitation [of dredging] may include the potential for contaminant losses during dredging through resuspension" (USEPA, December 2005 – p. iv-v).

Previous sediment dredging in the T5 to T8 reach (i.e., 1995 NTCRA and 2005 ROPS) targeted relatively high PCB concentration sediment deposits, and these actions caused short-term increases in fish tissue concentrations from dredging-related resuspension, water column releases, and elevated PCB residual concentrations in surface sediment. Similar dredging-related residuals and corresponding increases in fish tissue concentrations have also been documented at other sediment cleanup sites (Patmont and Palermo, January 2007; Bridges et al., February 2008).

The dredging difficulties experienced during the NTCRA and ROPS are also anticipated in other areas of the river. Main channel dredging would have limited effectiveness as a means to provide overall protection of human health and the environment because of the following site-specific conditions:

- Rocks/cobbles or other debris on the river bottom which increases resuspension and residuals generation;
- Bedrock and/or hardpan in some areas under the soft sediments which precludes over-dredging into clean material;

- In general, the highest sediment PCB concentrations are located in the soft sediments immediately overlying hard bottom, resulting in relatively high post-dredge residual concentrations due to the inability of the dredge equipment to remove all sediment above the hard bottom surface;
- Significant small-scale spatial variability in the DoC in the sediment column leading to uncertainty in the extent of contaminated sediments;
- Dredging-induced mixing of PCB-containing sediment with underlying or surrounding sediment;
- Limitations and inconsistencies of removal efficacy in this setting; and
- Resuspension and settlement of sediment resulting from the factors listed above.

The above conditions limit the ability to achieve low post-dredging residual PCB concentrations. ROPS post-dredging surface sediment PCB concentrations in the main channel dredging area were significantly higher than pre-dredging levels (i.e., post-dredge average of 150 mg/kg versus the pre-dredge concentration of 4.1 mg/kg; Alcoa, May 2006). Impacts to the water column are also expected to occur as observed during both the 1995 NTCRA and 2005 ROPS dredging; the corrective action trigger of 2 µg/L was exceeded during removal operations during both studies (BBL, December 1995; Alcoa, May 2006). Additionally, PCB concentrations in fish were observed to increase during the NTCRA (see Figure ES-4) and ROPS main channel dredging activities (see Figures 2-26 to 2-28).

The inability to remove all sediments from the target area and higher PCB levels that typically exist at depth in this system would act as continuing sources of PCBs to the water column and fish if not controlled via post-dredge capping. For this reason, dredged areas would be covered with either an armored cap (in the ice scour-prone river section – T1 to T21) or main channel cap (T21 to T72), as discussed below. Reasonable and practical means would be undertaken to reduce impacts associated with the implementation of dredging. However, extensive measures undertaken during the ROPS in an effort to attenuate these impacts (Alcoa, May 2006) were largely unsuccessful.

Relative to main channel dredging, the northern near shore removal action achieved lower surface sediment PCB concentrations (i.e., post-dredge average of 1.9 mg/kg versus the pre-dredge concentration of 19 mg/kg; Alcoa, May 2006). Due to the presence of woody debris and the difficult access characteristics of the area, removal was conducted using an open bucket mechanical excavator on a spud barge. The site conditions encountered in this area during implementation were much different from those in the main channel area, with significantly lower pre-dredge PCB concentrations and the absence of hard bottom conditions within the target cut depth (1 ft). Numerous re-dredging attempts in an effort to consistently achieve the target cut depth resulted in nearly a 100 percent increase over the targeted dredge volume. The ability of dredging to reduce surface sediment PCB concentrations in other near shore areas of the lower Grasse River would depend on location-specific conditions including PCB concentration levels, PCB concentration profiles with depth, and the extent to which difficult bottom conditions and debris are present in these areas.

5.2.1.3 In-Situ Capping

Placement of caps would provide for protection of human health and the environment by reducing PCB levels on the sediment surface and reducing PCB flux to the water column, which in turn would reduce PCB levels in fish and other biota. Caps included in the remedial alternatives for this AA Report would be designed in accordance with USEPA and USACE guidance to provide long-term chemical isolation and ensure the stability, integrity, and protectiveness of the caps under the range of potential erosional forces. The preliminary cap designs for armored caps, main channel caps, and near shore caps at the site were determined through an evaluation of site-specific information so that the cap would meet the following objectives:

- Physical isolation of PCBs in the sediment from the benthic environment;
- Erosion protection (i.e., to mitigate resuspension and transport of sediments to downstream areas) to maintain cap stability against forces resulting from open water river flows, ice jam-related flows, and propeller wash from recreational boats; and
- Chemical isolation (i.e., reduce the flux of dissolved PCBs to the water column).

In accordance with USEPA (Palermo et al., September 1998) and USACE (USACE, June 1998) design guidance, the total thickness of a protective cap was specified as the sum of the thicknesses required to achieve each of the design objectives listed above. An additional factor of safety beyond the USEPA and USACE design requirements was also incorporated into the preliminary cap designs (see Appendices A and D) to ensure their protectiveness.

Caps to be placed in the main channel within the ice scour prone reach of the river (T1-T21) would be armored to protect against ice-related forces generated during severe ice jam events. Caps or post-dredge backfill to be placed in the near shore and caps to be placed downstream of T21 would not be armored based on studies conducted following the 2003 ice jam event that show PCBs in buried sediments downstream of T21 are stable and effectively sequestered (i.e., the downstream reaches are not susceptible to ice jam-related scour (Alcoa, April 2009; Alcoa, December 2009)[5]; and studies supporting that during non-ice conditions shear stress throughout in the river is insufficient to materially impact PCB fate (see Section 2.4.2 and Alcoa, April 2001). Additional discussion of cap stability and long-term effectiveness considerations are provided in Section 5.2.3.3.

Caps have also been used to address dredging residuals as was done during the ROPS and at other environmental dredging sites (Patmont and Palermo, January 2007; Bridges et al., February 2008). Results

[5] As discussed in Section 4.4.1, the results of the river ice investigation identified the T1 to T19 reach of river as potentially vulnerable to ice jam-induced scour (Alcoa, April 2009). For the purposes of remedy development, however, T21 has been used to define the downstream extent of this reach. This was done to recognize the fact that the contiguous fine sediment deposit in this portion of the river extends beyond T19 down to T21, and that any remedy developed to address this deposit would consider the entire deposit and not just the portion that is susceptible to ice jam-induced scour.

of the ROPS post-dredge cap monitoring indicate significantly more entrainment of PCBs into the cap matrix relative to capping over un-dredged sediments and higher rates of PCB resuspension than is observed in capping over un-dredged sediments. Both of these findings are attributable to the low density residual layer that remains on the sediment surface after dredging as well as sloughing of material from nearby un-dredged areas.

5.2.2 Compliance with ARARs

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, respectively. Potential chemical-specific ARARs include the following federal and state water quality criteria for PCBs (Table 3-1):

- Clean Water Act ambient water quality criteria (CWA-AWQC) for navigable waters (0.001 µg/L) and aquatic life (criterion continuous concentration [chronic]; 0.014 µg/L); and

- New York State Surface Water Quality Standard for PCBs for human health ($1x10^{-6}$ µg/L) or wildlife (1.2×10^{-4} µg/L).

The detailed evaluation of alternatives presented in Section 5.3 and the comparative evaluation of alternatives presented in Section 6 discuss 25-year projections of the river-wide average water column PCB levels from the Study Area-specific modeling (Appendix A). Based on these results, technical impracticability waivers would be required for some of the chemical-specific ARARs (see Sections 5.3 and 6). Section 3.4 of this AA Report lists the six cases where an ARAR may be waived.

Measures would also be taken under all alternatives as necessary to comply with location-specific ARARs (Table 3-3) including substantive requirements of the Coastal Zone Management Act, Endangered Species Act, and National Historic and Historical Preservation Act. It is anticipated that none of the remedial alternatives listed in Table 4-6 would invoke wetlands permit requirements, as activities would not be conducted in areas with identified wetlands. Based on analyses conducted in support of the ROPS (Alcoa, May 2006), placement of near shore and main channel caps under any of the alternatives listed in Table 4-6 would not be expected to adversely affect areas outside the existing floodplains, even during a significant high-flow event (i.e., a 100-year flood) as described in Appendix F.

Action-specific ARARs (Table 3-2) are specific to the remedial technology being implemented and are discussed for each remedial technology below.

5.2.2.1 Natural Recovery

Because natural recovery would not include any active remediation, no action-specific ARARs (Table 3-2) would apply.

5.2.2.2 Dredging/Removal

For the dredging/removal portion of the alternatives, compliance with action-specific ARARs would be achieved through the following activities:

- Treatment and discharge of water collected during removal operations considering the applicable ARARs (i.e., CWA, Rivers and Harbors Act, New York SPDES, Surface Water Regulations);
- Disposal of removed materials in a landfill permitted to hold dredged material that contains PCBs in excess of 50 mg/kg in accordance with applicable ARARs (i.e., Solid Waste Disposal Act, TSCA, USDOT Placarding and Handling, and New York State Environmental Conservation Laws [ECLs]); and
- Dust control procedures considering applicable ARARs (i.e., Clean Air Act and Air Pollution Control Law).

5.2.2.3 In-Situ Capping/Backfilling

The capping and backfilling components of the remedial alternatives listed in Table 4-6 are anticipated to meet all potential federal and state action-specific ARARs (Table 3-2), including the CWA, Rivers and Harbors Act (Section 10), and Use and Protection of Waters.

5.2.3 Long-term Effectiveness and Permanence

This criterion evaluates the remedial technologies/process options relative to long-term effectiveness and permanence. Factors considered under this criterion are discussed in Section 5.1. A technology-specific evaluation of the site-specific application of MNR, dredging/removal, and in-situ capping in consideration of this criterion follows.

5.2.3.1 Monitored Natural Recovery

Natural recovery processes would cause long-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River. Data pertaining to the long-term effectiveness and permanence of source control and natural recovery processes have been developed through an extensive long-term monitoring program which includes more than 15 years of monitoring at the site. The data demonstrate that source control actions at the Alcoa plant site have been effective in controlling PCB sources to the lower Grasse River, and have documented the steady long-term downward trends in water column and fish PCB concentrations occurring as a result of natural recovery processes (see Figures 2-24 and 2-26 to 2-28, respectively). These natural recovery processes are expected to continue over the long term.

Because PCB-containing sediment would remain in the river for alternatives that include natural recovery, the potential for sediment erosion is relevant in the evaluation of long-term effectiveness and permanence. As summarized in Section 4.3.1, erosion under non-ice conditions is not a significant mechanism for moving

PCBs from buried sediments to the bioavailable surface sediments and the water column, based on erodability studies, comparisons of bathymetric measurements collected at various points over time, examination of sediment geochronology, and collection of TSS and PCB data during several high-flow events. Hydrodynamic modeling has also shown that river velocities remain too low to cause significant erosion even when extreme river flows or storm events occur (see Appendix A). These findings are consistent with monitoring results obtained prior to and after a high-flow event in 1998, which approximated a 100-year flood, and indicated that there were no discernable long-term impacts on PCB levels in sediment, water, or fish tissue PCB concentrations resulting from this high flow event (see Figure 2-37).

The conclusion of limited erosion during high flow events is also supported by sediment transport modeling which indicates that most of the river bottom is aggrading. The sediment transport model predicts that, on average, about 0.1 cm of erosion could occur during a 100-year flood. The maximum erosion predicted during the 100-year flood was about 0.9 cm (see Appendix A). Erosion during a more extreme flood event (i.e., 1-in-500 year flood flow of 17,070 cfs; FEMA, May 1980) was also estimated using the relationships between shear stress (which induces erosion) and flow rate (or velocity). Shear stress increases in proportion to the square of the velocity, and erosion increases in proportion to roughly the square of the shear stress. Thus, a 13 percent increase in velocity translates to an approximate 28 percent increase in shear stress and an approximate 64 percent increase in erosion. This represents an upper-bound estimate of erosion in that it assumes clean water scour (i.e., ignores water column solids/bed solids interactions). Using the maximum erosion during a 100-year flood (i.e., conservatively estimated at about 0.9 cm), the maximum estimated erosion during a 500-year flood is expected to be between 1 and 1.5 cm.

Severe ice jam events, such as the one that occurred in 2003, have the potential to remobilize buried sediments and PCBs in the upper 1.8 miles of the lower Grasse River (from about T1 to T19; see Figure 1-3 for transect markers) (Alcoa, April 2009). These events, however, are localized, and site data do not indicate that such events substantively disrupt river-wide natural recovery. Similar to the 1998 open water high flow event discussed above, no significant changes in water column, sediment, and fish tissue PCB concentrations were observed as a result of the 2003 ice jam event (Alcoa, April 2009). The relative impact of these events on long-term effectiveness could increase as further reductions in PCB levels in fish are observed through ongoing natural recovery processes.

5.2.3.2 Dredging/Removal

During ROPS main channel dredging activities, post-dredge surface sediment PCB concentrations approximately equal to the SLWA of the dredged sediments remained at the post-dredge surface at the completion of the main channel dredging (and re-dredging) activities, resulting in a post-dredge surface concentration approximately 40 times higher than pre-dredge conditions (see Section 2.5.3.1; Alcoa, May 2006). Similar dredging residuals have been observed during other environmental dredging projects, particularly when rocks/cobbles or other debris are present on the river bottom, which increases resuspension and residuals generation (Patmont and Palermo, January 2007). These considerations are

built into the remedial alternatives included in this AA Report, where all dredging alternatives include post-dredge capping and/or backfill[6] as necessary. The long-term effectiveness and permanence of alternatives that include dredging followed by capping is driven by the post-dredge capping component as it is the ability of the caps to provide long-term containment of the post-dredging residuals that controls potential future exposures to human health and the environment.

Sediments removed as part of each alternative would be disposed of at Alcoa's on-site Secure Landfill and/or selected off-site landfill(s). These disposal facilities would provide effective long-term management of the dredged materials, controlling potential future exposure to human and environmental receptors to within acceptable levels.

5.2.3.3 In-Situ Capping

As discussed in Section 5.2.1.3, caps included in the remedial alternatives for this AA Report were based on preliminary designs developed for the lower Grasse River that follow USEPA and USACE guidance. Caps designed and constructed in accordance with this guidance provide long-term chemical isolation and stability (USEPA, December 2005).

Different cap designs have been developed to address the range of potential erosional forces anticipated within different areas of the lower Grasse River. Under current conditions, PCBs in buried sediments in the main channel upstream of T21 are potentially vulnerable to ice jam-related scour, while PCBs in buried sediments in the near shore areas and in the main channel downstream of T21 are currently stable and effectively sequestered (i.e., the downstream reaches are not susceptible to ice jam-related scour) (Alcoa, April 2009). Therefore, armored caps capable of withstanding ice jam-related scour such as the event that occurred in 2003 have been designed for main channel sediments in the upper reach (T1 to T21) of the river and caps without an armoring component have been designed for the near shore areas and main channel sediments in the downstream reach (T21 to T72).

Propeller wash and potential scour from recreational boats (see Section 2.4.6 and Appendix B) were also evaluated. The results of these analyses support that these mechanisms would not impact the long-term stability of the caps. Placement of anchors on the caps is also expected to have minimal impact, primarily due to the relatively small surface area potentially affected by this activity.

Preliminary designs of protective armored caps (T1 to T21), main channel caps (T21 to T72), and near shore caps (T1 to T72) are presented below. Caps similar to the armored cap, main channel cap, and near shore cap designs summarized above were successfully placed in the lower Grasse River during the 2005 ROPS (Alcoa, May 2006) and in the nearby St. Lawrence River during the 2009 St. Lawrence River Remediation Project (SLRRP).

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[6] The term backfill is used in this AA Report to describe clean materials placed after dredging (primarily in the near shore) to restore bathymetry to pre-dredge conditions, but not for containment of residual contamination.

Armored Cap Design (T1-T21)

The chemical isolation layer thickness for the armored caps (for main channel sediments in ice scour-prone areas: T1 to T21) was developed in accordance with USEPA (Palermo et al., September 1998) and USACE (USACE, June 1998) design guidance. The preliminary design thickness for the chemical isolation component of the armored cap is 6 inches. Although laboratory studies have demonstrated that very thin layers (0.04 to 0.3 inches) of clean sediment can effectively reduce chemical flux from sediments to the overlying water column (Talbert et al., 2001), a conservative thickness of 6 inches was selected for the preliminary isolation layer design based on the results of one-dimensional transport modeling. Results of the evaluation, which included the effects of biological mixing, indicate that a 6-inch isolation layer of sand/topsoil would reduce the long-term (i.e., steady-state) diffusive PCB flux from the underlying sediments to the overlying water column by 97 to 99.5 percent (see Appendix D).

The preliminary armor stone design to protect against location specific erosional forces was developed using available guidance from several sources, including: USACE (July 1991); USDA (July 1989); USEPA (September 1998); Maynord and Oswalt (1993); Palermo et al. (June 1998; September 1998); and Palermo (March 2000). A factor of safety was incorporated into this preliminary design, as described in the Armored Cap Basis of Design Memorandum (Alcoa, September 2004). The surface armor specification for the upstream (T1 to T21) caps consists of gravels and cobbles (a gradation of 3- to 10-inch diameter materials). A graded filter layer was developed following the Terzaghi-Vicksburg criteria (January 1943) to separate the chemical isolation layer from the armoring layer to provide sufficient geotechnical filtering (e.g., preventing the potential migration of sand/topsoil from the chemical isolation layer through the overlying armor stone).

Based on the cap design evaluation presented above, the armored cap would have a total thickness of 25 inches, comprised of 6 inches of a sand/topsoil (50:50 mix) chemical isolation layer overlain by 6 inches of a gravel filter layer, and covered with 13 inches of 3- to 10-inch-diameter gravel/cobbles (Alcoa, September 2004). It is important to note that this preliminary cap design was based on conservative assumptions applied to each individual cap component. When considered together, this conservative design approach provides redundant protective components to the overall cap design. Cap specifications may be refined as appropriate during final design, consistent with USEPA and USACE design guidance.

Main Channel Cap Design (T21-T72)

Consistent with the armored cap design summarized above, a conservative isolation layer thickness of 6 inches of sand/topsoil was also selected for the main channel cap. Similarly, the preliminary design for the overlying erosion layer of the main channel cap consisted of 5 inches of sand/topsoil, consistent with USEPA and USACE design guidance for erosional forces downstream of T21 (e.g., flood flows, propeller wash, etc). A 5-inch-thick layer would also ensure that benthic invertebrates are physically separated from the underlying isolation layer. Specifically, the 5-inch physical isolation component of the cap was based on an assumed 4-inch (or 10 cm) bioturbation depth and a 1-inch consolidation depth. Although the site data and available literature support the finding that biological mixing in the Grasse River sediments is limited to the top few centimeters, as discussed in Section 2.4.4, Alcoa followed the USEPA cap design guidance

(Palermo et al., 1998) and selected a conservative value of 4 inches for the purposes of the Grasse River cap design. This conservative depth of 4 inches is consistent with the results of site-specific ^{210}Pb profiles and bioturbation observed at other similar sites. Consolidation testing performed as part of the pre-engineering design studies (Alcoa, March 2001) also confirmed the protectiveness of the main channel cap design.

For the purpose of preliminary cap designs for this AA Report, the total main channel cap thickness was calculated as the sum of the erosion/physical isolation component (5 inches) plus the chemical isolation component (6 inches), and rounded up to 12 inches of placed sand/topsoil. One-dimensional transport modeling (Appendix D) indicates that PCBs would not break through a 12-inch sand/topsoil cap, assuming net sedimentation would continue, albeit at a reduced rate. Under the conservative assumption of no sedimentation into the future, a 12-inch sand/topsoil cap would reduce the current diffusive PCB flux to the overlying water column by about 98 percent (Appendix D). Cap specifications may be refined as appropriate during final design, consistent with USEPA and USACE design guidance.

Near Shore Cap Design (T1-T72)

Based on concerns expressed by NYSDEC regarding the potential impact of bathymetric changes in the near shore areas on habitat, efforts were undertaken to identify a means by which to isolate PCB-containing sediments in these areas from fish and other ecological receptors while minimizing impacts to bathymetry. Other potential benefits associated with a near shore cap design included providing the best opportunity for submerged aquatic vegetation (SAV) in these areas to rapidly re-establish following remedial action and the avoidance of shoreline stability issues.

Near shore areas within the lower Grasse River contain lower sediment PCB concentrations than the main channel, with about 60 percent of sediment samples collected in the top 3 inches of the near shore areas having PCB concentrations below 1 mg/kg. Much of the near shore area is also characterized by relatively thin deposits (typically 1 foot or less) of sediments. Due to these low concentrations and limited extent, the near shore area is expected to be significantly less of a contributor to PCB levels in fish (Alcoa, May 2004; Alcoa, December 2009a).

One-dimensional transport modeling performed for the preliminary cap design indicated that a 6-inch sand/topsoil cap would reduce the current diffusive PCB flux to the overlying water column by approximately 99 percent assuming that current rates of net sedimentation continue (Appendix D). Under the conservative assumption of no sedimentation into the future, a 6-inch sand/topsoil cap would reduce the current diffusive PCB flux to the overlying water column by about 97 percent (Appendix D). Since the near shore areas are subjected to relatively low velocities and shear stresses compared with those in the main channel, there is no need for a separate armor layer beyond the sand/topsoil chemical isolation layer. Based on these analyses, a 6-inch thick layer of sand/topsoil placed in the near shore area would optimize long-term effectiveness and permanence, while concurrently minimizing bathymetry impacts and preserving existing habitat and SAV to the maximum extent practicable. Cap specifications may be refined as appropriate during final design, consistent with USEPA and USACE design guidance.

Accumulation of sediment in the near shore areas in the lower Grasse River over past decades, coupled with site-specific sediment core profile data collected from this area and an understanding of the physical characteristics of the lower Grasse River, support the conclusion that near shore sediments are stable (Alcoa, December 2009a). In addition, the 2005 ROPS demonstrated that capping in the near shore can be successfully implemented in the river (Alcoa, May 2006). Post-ROPS data collected in 2006, 2007, and 2010 indicated, despite some of the challenges posed by the area selected for near shore capping in 2005, the cap remained in place and was effective at sequestering underlying PCB-containing sediments throughout much of the capped area (Appendix E). These data also indicated the need for additional construction improvements relative to those used during the ROPS, including modified placement procedures such as the use of alternative placement equipment, consideration for multi-lift placement, the use of a 6 inch target cap thickness, and more rigorous quality control procedures for establishing cap coverage and thickness. These considerations, in addition to the potential design-related modifications described above, would be addressed during the remedial design phase (see Appendix E).

For alternatives that include dredging of the near shore areas, the thickness of the post-dredge backfill would depend on the depth of the excavation. It is assumed these areas would be returned to the original bathymetry following dredging, as was done in the 2005 ROPS, subject to appropriate refinements during final design.

Other General Cap Design Considerations

Based on the extensive site-specific data collection and pilot study efforts directed towards evaluation of cap stability, coupled with the results of the hydrodynamic and sediment transport modeling, the armored cap, main channel cap, and near shore cap are all expected to be stable over the long term and would protect underlying contaminated sediments from erosion under future conditions, including extreme open water flows and ice jam events (Alcoa, December 2009a).

Long-term monitoring and maintenance of the caps is included as an element of all capping alternatives to ensure their long-term effectiveness and permanence, consistent with USEPA and USACE guidance. Proper design and installation would reduce future maintenance requirements. In the event that damage to the caps occurs, affected areas would be identified during post-construction monitoring and subsequently addressed.

5.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the degree to which an alternative reduces the toxicity, mobility, or volume of chemical constituents through treatment, including how treatment addresses the principle threats posed by the site. Reduction in toxicity, mobility, or volume through treatment would not occur for any of the alternatives evaluated in this AA Report because none of the alternatives include a treatment component. However, natural recovery process and engineering controls associated with active remediation are expected to reduce the volume and mobility of the PCBs, as described below.

5.2.4.1 Monitored Natural Recovery

The reduction in total volume of the PCBs currently in the river would be limited to that which would occur through microbial degradation, as described in Section 4.3.3. Reduction in mobility and toxicity is expected to naturally occur through sedimentation, microbially mediated dechlorination, and degradation of PCBs within the sediments of the river, all of which can reduce the long-term quantity and concentration of PCBs available for biological exposure as evidenced by the reduction in fish tissue concentrations observed to date.

5.2.4.2 Dredging/Removal

Some alternatives include removal of sediment from the river via dredging, which would reduce the volume of the PCB-containing sediment in the lower Grasse River. However, based on experience during the NTCRA and ROPS, as well as experiences from a large number of other environmental dredging projects (Bridges et al., February 2008), increases in mobility would occur during the dredging period that cannot be effectively mitigated.

Over the longer term, mobility of the dredged PCBs would be reduced via disposal in Alcoa's on-site Secure Landfill and selected off-site landfill(s). Stabilization/ solidification of removed sediments would further reduce PCB mobility.

5.2.4.3 In-Situ Capping/Backfilling

Implementation of capping or backfilling does not include treatment that would reduce the toxicity or volume of PCBs. However, although not a treatment, placement of capping materials would reduce the mobility of PCBs through isolation of PCBs in the native sediments.

5.2.5 Short-term Effectiveness

This criterion assesses effects and risks to human health and the environment related to construction and implementation of each alternative, as described in Section 5.1.

Short-term impacts common to all of the alternatives except Alternatives 1 and 2 include temporary disruption of upland areas along the river to construct access points; possible disruption of, or inconvenience to recreational boating traffic in the river; and potential transportation accidents (both on water and upland). To the extent practicable, measures would be taken to minimize disruption to boating traffic and the potential for transportation accidents (including barge accidents in the river and truck accidents associated with transport of PCB-containing dredged sediment to the landfill and transport of clean capping material to the staging area). It is expected that necessary access and staging areas would be constructed on Alcoa property to the extent possible, thereby minimizing potential effects to the community.

Appropriate health and safety practices (Occupational Safety and Health Administration [OSHA] 29 CFR 1910.129) would be followed through implementation of a project-specific health and safety plan (HASP). The results of monitoring during previous Grasse River studies indicate that remediation workers and the community were not exposed to PCB levels that present unacceptable health risks during construction.

Additional short-term impacts associated with each remedial technology/process option are described below.

5.2.5.1 Monitored Natural Recovery

There are no short-term effects associated with MNR.

5.2.5.2 Dredging/Removal

As discussed in Section 5.2.3.2, dredging activities during the NTCRA and ROPS resulted in PCBs being released to the water column and residual PCBs remained in the post-dredge surface sediments (BBL, December 1995; Alcoa, May 2006). As discussed in Section 4.3.5, water column sampling conducted during the ROPS indicated that approximately 3 percent of the PCB mass removed during sediment removal activities was released downstream, resulting in significant short term increases in water and fish tissue PCB concentrations (see Figures 2-24 and 2-26 to 2-28, respectively). These releases resulted in PCB levels downstream of the work area that sometimes exceeded the 2 µg/L corrective action level used previously on Grasse River projects. During the ROPS, water column releases associated with dredging constrained dredging production rates.

Silt curtains were installed around the areas targeted for dredging during the ROPS (Section 2.5.3). The results of the ROPS program raised questions regarding the effectiveness of a silt curtain system to control PCB resuspension in this setting. Site conditions (short-term pressure waves and flow increases) routinely damaged the silt curtains during the ROPS. Silt curtains have been retained in this AA Report for alternatives that include dredging for costing purposes. However, this assumption would be revisited during remedy implementation if dredging is selected as a component of the final remedy[7].

In areas of the river targeted for dredging, the fish habitat and benthic community would be significantly altered and/or eliminated in the short term. However, placement of post-dredge caps or backfill in the dredged areas is expected to result in habitat recolonization within several years (see below and also RAO #4).

[7] For the purposes of cost estimating for this AA Report, silt curtains have been included as a contingency in the event that monitoring during implementation indicates they are warranted.

5.2.5.3 In-Situ Capping/Backfilling

Short-term impacts associated with cap or backfill placement would include possible effects on water quality (primarily turbidity and surface foam from the capping or backfill materials themselves). The placement of cap or backfill materials could also potentially result in resuspension of PCB-containing materials during and immediately following remedial activities; however, results of both the CPS and ROPS (as described in Sections 2.5.2 and 2.5.3, respectively) indicated that resuspension of PCB-containing material and adverse effects on the water column were minimal. Appropriate construction means and methods would be utilized to minimize the potential for mixing with and/or suspension of bottom sediments.

Corrective action levels for PCBs, TSS, and turbidity were not exceeded as a result of cap placement during the CPS and ROPS. Monitoring data collected during the ROPS indicated that silt curtains had little effect in controlling downstream water quality impacts (see Section 5.2.5.2). Ineffective silt curtain applications have also been noted at other sediment cleanup sites with characteristics similar to the lower Grasse River and, in these situations, their use is not recommended (USEPA, December 2005). Silt curtains have been retained in this AA Report as an element of alternatives including capping for costing purposes. However, consistent with the discussion in Section 5.2.5.2, this assumption would be revisited during remedy implementation if capping is selected as a component of the final remedy. If determined to be necessary during remedial design or construction, TSS and surface foam impacts potentially associated with placement of clean capping materials could be controlled through best management practices.

The sand/topsoil material to be used to cap or backfill non-ice scour prone areas would supplement ongoing sediment deposition of similar sand and silt-sized materials at the site, providing suitable substrate for the benthic invertebrate community (i.e., the mixture largely mimics existing site sediments). Post-capping benthic monitoring collected after placement of sand/topsoil caps during the CPS revealed that successful benthic recolonization occurred rapidly (within weeks to months) following completion of construction (Alcoa, April 2002a). Similarly, recolonization was documented during post-ROPS near shore ecological monitoring. However, slower recolonization rates were noted in the northern near shore area that was excavated and then capped, compared to the southern near shore area where a 3- to 6-inch cap was placed without prior excavation (Alcoa, September 2008).

Placement of armored caps may temporarily affect biota due to changes in substrate type (i.e., from a substrate dominated by homogenous fines [sands and silts] to a more complex substrate, dominated by larger, coarser material [gravels and cobbles]). Biota in the vicinity of the armored cap would likely mirror changes in increased habitat complexity by displaying greater diversity and abundance; however, these changes are anticipated to be transient, as natural deposition is expected to begin to fill in the armored cap over time, returning the area to a substrate and biota community that is more typical of pre-cap conditions. Some anticipated temporary changes to biota due to placement of the armored cap are listed below (from Merritt and Cummins, 1996; Smith, 1985; and Krebs, 1994):

- The armored cap would provide more surface area and greater attachment points for benthic macroinvertebrates such as mayflies, caddisflies, and crayfish;

- The interstitial spaces of the armored cap would provide cover for small fish such as minnows, darters, and YOY fish;
- The armored cap would attract fish that feed on invertebrates, and larger fish that feed on invertebrates and/or small fish (e.g., rock bass and smallmouth bass); and
- The armored cap would provide a substrate for fish that spawn on gravel and rocks, such as lake sturgeon, walleye, and smallmouth bass.

As part of the post-ROPS monitoring conducted in 2006 and 2007 (Alcoa, June 2007a; Alcoa, September 2008), underwater video coverage was obtained in the armored cap area to visually document the physical condition of the cap and recent sedimentation. Results of the video observation in both 2006 and 2007 revealed that finer-grained sediment had deposited within the interstices and on the surface of the armor stone materials. Further video monitoring of the armored cap area in 2009 was consistent with the 2006 and 2007 observations. While the thickness or overall prevalence of these finer-grained materials could not be precisely characterized from the video, the coverage obtained indicated sediment deposition over the entire area observed (see Figure 2-45). Natural sedimentation processes are expected to continue to promote recolonization of benthic organisms on the surface of the armored cap (see RAO #4).

5.2.6 Implementability

This criterion evaluates the ease or difficulty of implementing the remedial technology/process option by considering technical feasibility, administrative feasibility, and availability of services and materials required for implementation.

Implementation of any of the alternatives except Alternatives 1 and 2 would require an appropriate upland staging area. The size and number of staging areas would be dependent on the type and extent of remediation included in the various alternatives. It is expected that necessary access and staging areas to support these alternatives would be constructed on property owned or leased by Alcoa, thereby facilitating implementation. Additional implementability considerations associated with each remedial technology/process option are described below.

5.2.6.1 Monitored Natural Recovery

There are no implementability issues associated with MNR because it does not require any site construction activities.

5.2.6.2 Dredging/Removal

Based on efforts conducted during the NTCRA and ROPS, dredging/removal in the lower Grasse River is both administratively and technically implementable, although there are some limitations. Dredging of sediment from the lower Grasse River could be accomplished using construction equipment available from a

number of marine contractors. Necessary equipment, personnel, and services are expected to be available in sufficient supply to implement the dredging components of the remedial alternatives and as demonstrated through the NTCRA and ROPS removal operations, dredging and dewatering of sediment can be executed at the Study Area. However, as documented during the NTCRA and ROPS activities and discussed in Section 2.5.3, site-specific conditions would affect the implementability and practicability of removing sediment from targeted areas. Alcoa's on-site Secure Landfill and/or an approved off-site landfill(s) would be utilized to permanently contain dredged sediment.

Based on the NTCRA and ROPS pilot project experiences, for the purposes of this AA Report, a single hydraulic dredge was assumed to be used for main channel dredging from T1 to T21 and the rate of sediment dredging (400 cubic yards per day [cy/day]) was assumed to be limited by water quality constraints (assuming a 3 percent PCB mass release to the water column during dredging; see Appendix A and discussion below). Dredging in the main channel from T21 to T72 was assumed to be performed using a larger hydraulic dredge or multiple smaller hydraulic dredges (with a total removal rate of 800 cy/day), with similar water quality limitations based on the PCBs present within specific deposits. Removal in the near shore areas would be performed using at least two mechanical dredges operating concurrently (dredge production rates in the near shore area [assumed at 400 cy/day total] are limited by access and operational constraints more so than by water quality limitations). In addition, dredging in the main channel and near shore areas would be conducted concurrently. Boulder and/or debris removal via mechanical equipment would occur in advance of, or during, hydraulic dredging activities as necessary to remove boulders and/or debris. The specific dredging equipment to be used would be determined in the design phase. All removal activities would proceed from upstream to downstream to minimize the risk of recontamination.

As discussed in Section 4.4.1, the initial estimates of dredge volumes for the sediment areas targeted for removal are based on the preliminary site sampling and investigations conducted to date, and represent what can be referred to as the "neatline" volumes. These neatline volumes were adjusted to account for constructability considerations (e.g., stable side slopes, efficient dredge lane widths, overdredge allowances). Section 4.5 presents a summary of the adjusted, or "expected", dredge volumes for each of the alternatives involving dredging that are evaluated in this AA Report.

For purposes of this evaluation, it was assumed that dredged sediment would undergo a similar dewatering process to that used during the ROPS (see Section 2.5.3). Dredged material likely would be pumped to the upland staging area on Alcoa's property and dewatered using mechanical filter presses. The effluent would then be treated on site through a system of bag filters, sand filters, and carbon filters, and the treated water discharged back to the lower Grasse River. Actual dewatering and water treatment equipment to be used would be determined in the design phase.

5.2.6.3 In-Situ Capping/Backfilling

Based on efforts conducted during the CPS and ROPS, placement of caps and backfill in the lower Grasse River is both administratively and technically implementable. In addition, the CPS and ROPS confirmed the implementability of operations such as onshore preparation of the cap materials and transportation of the

cap materials from the staging area to the placement area. Necessary personnel for the various tasks (i.e., crane and loader operators, Global Positioning System [GPS] engineer, and monitoring crew) are readily available. The ROPS demonstrated that an armored cap can be successfully placed in the main channel of the river; specific cap placement methods to achieve target cap thickness for these alternatives would be determined during the design phase.

For the purpose of this AA Report, armored caps with the same general specifications as those successfully placed during the ROPS would be installed in the main channel between T1 and T21 as a component of certain alternatives (Table 4-6). For these alternatives, the armored cap would include 6 inches of a sand/topsoil (50:50 mix) base layer overlain by 6 inches of a gravel filter layer and 13 inches of 3- to 10-inch-diameter gravel/cobbles (i.e., 25 inches total). Similarly, consistent with the CPS and ROPS (Alcoa, April 2002; May 2006) caps without armoring (both near shore and main channel) would consist of a sand/topsoil (50:50 mix).

Based on recent capping project experiences (i.e., CPS, ROPS, and SLRRP) and a preliminary review of local borrow pits, it is likely that suitable materials for all of the different cap specifications can be obtained from local sources. In the CPS, ROPS, and SLRRP, the caps were all successfully placed using a mechanical clamshell bucket or other mechanical means. For the armored caps, the base, filter, and gravel/cobble armor materials were placed in sequential lifts. Cap and backfill materials would be placed with a controlled release above the existing river bottom, with real-time GPS surveying to promote placement accuracy. Actual placement techniques for the construction of in-situ caps and backfill would be determined during the design phase of the project.

Detailed evaluation of the post-ROPS near shore cap monitoring data also identified the need for careful quality control during placement to ensure adequate cap coverage and to minimize mixing with underlying native sediments (see Appendix E). These data also suggest that location-specific designs may be needed in certain near shore areas (e.g., steep slopes or other localized physical conditions) to ensure the protectiveness of the near shore caps. Such detailed analyses would be performed during remedial design. Recent advances in cap placement techniques have improved the uniformity of placement of cap layers, achieving thickness tolerances of 3 inches or less, while concurrently minimizing mixing of cap materials into underlying sediments.

Placement of the armored cap in the main channel between T1 and T21 is estimated to occur at an average rate of approximately 900 to 1,200 cy/day based on similar cap placement activities during the CPS, ROPS, and SLRRP and dependent on whether concurrent dredging activities are planned in the same reach as capping. Placement of the 12-inch main channel caps are estimated to occur at an average rate of approximately 1,440 cy/day in the main channel between T21 and T72. Similarly, placement of the 6-inch near shore caps are estimated to occur at an average rate of approximately 800 cy/day in the near shore area between T1 and T21 and between 450 and 600 cy/day between T21 and T72, depending on whether concurrent dredging activities are planned in the same reach as capping. In general, the placement rates for T21 to T72 are lower than those for T1 to T21 because of the increased distance to transport cap materials from the anticipated shore-side staging area to the capping sites. Capping would be performed concurrently

in the main channel and near shore areas using two capping platforms in the main channel and two platforms in the near shore (potentially concurrently along both sides of the river).

5.3 Individual Detailed Analysis of Alternatives

This section presents a detailed analysis of the 10 remedial alternatives described in Section 4.5. To avoid repetition, this section makes reference where appropriate to the analysis of common elements of remedial technologies and process options (i.e., MNR, dredging, and capping) presented in Section 5.2.

A detailed presentation of the cost estimates for each alternative is provided in Appendix C. In addition, Appendix C presents a sensitivity analysis of costs based on variable unit costs for particular components of the remedy, as requested by USEPA. The unit costs recommended by USEPA and incorporated into the cost sensitivity analysis are summarized as follows:

- $70 per cy for sediment dewatering (Alcoa's base case estimate is $100 per cy)
- On-site disposal for all sediment (Alcoa's base case estimate includes on-site disposal up to 100,000 cy)
- Multiplier for routine engineering design of 11 percent of the total construction cost (Alcoa's base case estimate includes 15 percent)

5.3.1 Alternatives 1and 2: No Further Action and Monitored Natural Recovery (MNR)

Alternatives 1 and 2 – No Further Action and MNR include:

- No further action (baseline condition)
- A 30-year monitoring program including periodic monitoring of the water column and fish in the lower Grasse River (2 only)

5.3.1.1 Overall Protection of Human Health and the Environment (Alternatives 1 and 2: No Further Action and MNR)

The Superfund program requires that the "no action" alternative be considered as a baseline for comparison with the other alternatives. The no further action remedial alternative (Alternative 1) does not include any future physical remedial measures that address sediment contamination at the site.

Because Alternative 1 would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Alternative 2 would include monitoring associated with the five year reviews.

Alternatives 1 and 2 would result in continuing declines of PCB concentrations in Grasse River fish tissue and PCB loadings to the St. Lawrence River, reducing risks associated with exposure to PCBs, as described in Section 5.2.1.1. However, periodic ice jam-related scour events could result in the remobilization of PCBs that may affect the rate of recovery of the system. Based on the 30 year modeling projections, fish tissue would not be reduced to levels necessary to meet RAO #1 to protect human health (see Section 5.3.1.3). Under Alternative 2, the current fish consumption advisories would be maintained. Although the fish

consumption advisories alone would not provide for complete protection of human health, they are important institutional controls that will be maintained until monitoring data indicate they are no longer necessary and NYSDOH modifies the fish consumption advisory.

5.3.1.2 Compliance with ARARs (Alternatives 1 and 2: No Further Action and MNR)

Based on Study Area-specific modeling (Appendix A), river-wide average water column PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs (14 ng/L) by approximately 2011. This projection is consistent with summertime PCB levels measured in the river in 2011, which averaged 8 ng/L and 13 ng/L at WC131 and WC011, respectively. The projections indicate that the CWA-AWQC for navigable waters and New York State PCB standard for the protection of human health or wildlife would not be met within the projection period due to site background PCB loading conditions accounted for in the model projections. As such, technical impracticability waivers may be required for these ARARs.

The applicable action-specific ARARs that relate to sampling activities under Alternative 2, as presented in Table 3-2, would be achieved during implementation. Any monitoring activities conducted under this alternative would be performed in compliance with the substantive requirements of applicable regulatory requirements.

Because Alternatives 1 and 2 would not include any active remediation, no action-specific or location-specific ARARs (Tables 3-2 and 3-3, respectively) would apply.

5.3.1.3 Long-term Effectiveness and Permanence (Alternatives 1 and 2: No Further Action and MNR)

Long-term reductions in Grasse River fish tissue PCB levels and PCB loading to the St. Lawrence River would continue under the No Further Action and MNR alternatives because historic PCB sources to the river have previously been controlled, and ongoing natural recovery processes would continue to reduce exposures over time, as described in Section 5.2.3.1.

Site-specific modeling was performed to predict the time necessary to achieve various percent reductions in river-wide average PCB concentrations in Grasse River fish and PCB loading to the St. Lawrence River as a result of alternative implementation (see Appendix A for details). Fate and transport model predictions of Alternatives 1 and 2 are illustrated on Figure 5-1 and summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [1]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
1 / 2	>2036	>2036	>2036	0.46	>2035	>2036

[1] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

The on-site remedial activities completed in 2001 (see Section 2.2.2) significantly reduced PCB inputs to the lower Grasse River and achieved effective source control. As a result, the remaining primary source of PCBs to the water column, fish, and benthic organisms is the widespread diffusive flux of PCB from surface sediments. Periodic remobilization of sediments and PCBs could occur in areas of river that are vulnerable to ice jam-related scour, as discussed in Section 5.2.3.1.

In summary, under Alternative 1 – No Further Action and Alternative 2 – MNR, remobilization and downstream transport of PCBs in parts of the upper river may occur (historically approximately once a decade) due to ice jam-related scour events, potentially affecting the rate of fish tissue recovery and permanence of this alternative. However, monitoring of the 2003 event, along with modeling of other potential ice jam events, indicate that such events are unlikely to substantively affect the long-term effectiveness of the alternative.

5.3.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternatives 1 and 2: No Further Action and MNR)

These alternatives do not include active treatment of the PCB-containing sediment in the lower Grasse River and therefore, there is no reduction of toxicity, mobility, and volume through treatment. Reduction of PCBs is expected to naturally occur via natural biodegradation and burial processes as described in Sections 4.3.3 and 5.2.4.1.

5.3.1.5 Short-term Effectiveness (Alternatives 1 and 2: No Further Action and MNR)

There are no short-term effects associated with the implementation of these alternatives. Risks to workers engaged in monitoring activities under Alternative 2 would be managed through the implementation of a HASP that meets the requirements of OSHA 29 CFR 1910.129.

5.3.1.6 Implementability (Alternatives 1 and 2: No Further Action and MNR)

Alternative 1 does not involve active remediation or monitoring; therefore, there are no implementability issues. There are no administrative or technical feasibility issues associated with the implementation of the monitoring included in Alternative 2.

5.3.1.7 Cost (Alternatives 1 and 2: No Further Action and MNR)

There are no future costs associated with Alternative 1 – No Further Action beyond that which has already been expended at the site.

The estimated present worth of the future monitoring program planned for Alternative 2 is approximately $3.4 MM. The present worth analysis for this alternative was performed assuming that the long-term monitoring program would include annual water column and fish tissue sampling in the lower Grasse River for a period of 30 years. A future discount rate of 7 percent was used for the present worth calculation as specified by USEPA guidance (USEPA, July 2000). The total estimated cost is provided in present day dollars. Details of this cost estimate are provided in Appendix C.

5.3.2 Alternative 3: T1-T72 Capping

Alternative 3 – T1-T72 Capping includes:

- Armored cap main channel sediments (T1-T21) greater than or equal to 1 mg/kg
- Cap main channel (T21-T72) greater than or equal to 1 mg/kg
- Near shore cap (T1-T72) greater than or equal to 1 mg/kg

Figure 4-2 depicts the areas targeted for remedial actions for Alternative 3. Table 4-6 provides a summary of the remedial components.

5.3.2.1 Overall Protection of Human Health and the Environment (Alternative 3: T1-T72 Capping)

Alternative 3 provides overall protection of human health and the environment through completed source control actions, the isolation of PCB-containing sediments that are potentially vulnerable to ice-related scour (T1 to T21) by placing a 25-inch thick armored cap over the existing sediment surface, capping of main channel sediments between T21 and T72, capping of near shore sediments between T1 and T72, and ongoing natural recovery processes. Specifically, Alternative 3 includes placement of 41 acres of near shore cap (T1-T72), 59 acres of main channel armored cap (T1-T21), and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored to prevent remobilization of PCBs that are currently buried in the sediment column in the reach of the river vulnerable to ice jam-related scour. These actions would address the sources of PCBs to fish and other biota including the diffusive flux of PCBs from surface sediments to the water column.

5.3.2.2 Compliance with ARARs (Alternative 3: T1-T72 Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and compliance with these ARARs is discussed in Section 5.2.2 for the MNR and capping components of this alternative. Based on Study Area-specific modeling (Appendix A), PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2011 for Alternative 3. This projection is consistent with summertime PCB levels measured in the river in 2011, which averaged 8 ng/L and 13 ng/L at WC131 and WC011, respectively. River-wide average water column PCB levels are predicted to meet the CWA-AWQC for navigable waters by 2026 for Alternative 3. However, the New York State PCB standard for the protection of human health or wildlife would not be met within the projection

period for this alternative due to site background PCB loading conditions accounted for in the model projections. As such, a technical impracticability waiver may be required for this ARAR.

Alternative 3 is anticipated to comply with action-specific and location-specific ARARs (Tables 3-2 and 3-3, respectively), as discussed in more detail in Section 5.2.2.

5.3.2.3 Long-term Effectiveness and Permanence (Alternative 3: T1-T72 Capping)

As discussed in Section 5.2.3.1, the protectiveness of Alternative 3 is driven by reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and capping. The long-term effectiveness and permanence of monitored natural recovery and capping for these alternatives has been extensively evaluated and is discussed in detail in Sections 5.2.3.1 and 5.2.3.3, respectively.

Results of the numerical modeling for Alternative 3 are illustrated on Figure 5-2, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [1]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
3	2018	2019	>2036	0.07	2016	2015

[1] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2012.

Alternative 3 provides long-term effectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River through placement of the three types of caps, continued natural recovery processes, institutional controls to maintain the integrity of the caps, and long-term monitoring and maintenance. Based on site-specific data, design considerations, and long-term modeling results described in this AA Report, the benefits provided by the caps are expected to be permanent. Proper design and installation would reduce/eliminate the frequency and extent of necessary maintenance. In the event that damage to the caps occurs, affected areas would be identified during monitoring and subsequently addressed.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Therefore, Alternative 3 would include monitoring associated with the five year reviews.

5.3.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 3: T1-T72 Capping)

As discussed in Section 5.2.4, Alternative 3 does not include a treatment component. Therefore, reduction in toxicity, mobility, or volume would not occur through treatment, but would occur through natural processes. However, in addition to the reductions in mobility and toxicity through natural recovery, placement of capping materials would reduce the mobility of PCBs through isolation of PCBs in the areas where caps have been placed, as described in Section 5.2.4.3.

5.3.2.5 Short-term Effectiveness (Alternative 3: T1-T72 Capping)

The short-term effects of capping would last for approximately 3 construction seasons under Alternative 3. These short-term effects could include potential water quality impacts (primarily turbidity and surface foam from the capping materials themselves), and potential impacts to the benthic and fish communities, as described in Section 5.2.5.3. Results of the site specific pilot studies incorporating capping indicate that minimal water quality impacts are expected and that rapid recolonization of benthic habitat would occur following cap placement. No dredging related PCB releases would occur with this alternative.

There would also be impacts to the surrounding community over the 3-year period for construction activities for Alternative 3 as described in Section 5.2.3.2 (e.g., disruption of recreational traffic on river, potential for transportation accidents). For example, truck traffic would dramatically increase over the current conditions due to the need to transport cap materials to the river over the construction period. If 20-cy capacity trucks were used to transport the materials from the river, approximately 890,000 miles of truck travel would be required to deliver the needed clean capping materials for Alternative 3. Given the large volume of capping materials, alternate means of delivery (e.g. barges, rail cars) would be evaluated during the detailed design.

Implementation of this alternative would provide significant near-term improvements, as evidenced by predicted reductions in PCB concentrations in Grasse River fish and PCB loading to the St. Lawrence River (see Figure 5-3).

5.3.2.6 Implementability (Alternative 3: T1-T72 Capping)

Installation of all caps under Alternative 3 is expected to extend over approximately 3 construction seasons. Implementability issues for this alternative, including technical and administrative feasibility, are discussed in Section 5.2.6. Each of the capping components included in this alternative has been successfully implemented with a few exceptions during the CPS, ROPS, and SLRRP as described in Section 5.2.6.3.

5.3.2.7 Cost (Alternative 3: T1-T72 Capping)

The estimated present worth of Alternative 3 is approximately $114 MM. This estimate is based on the anticipated construction period (3 years) for the placement of caps followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all capital cost

expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

5.3.3 Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping

Alternative 4 – T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping includes:

- Armored cap main channel sediments (T1-T21) greater than or equal to 1 mg/kg
- Cap main channel (T21-T72) greater than or equal to 1 mg/kg
- Dredge/backfill to grade near shore greater than or equal to 1 mg/kg
- Near shore cap (T21-T72) greater than or equal to 1 mg/kg

Figure 4-3 depicts the areas targeted for remedial action for Alternative 4. Table 4-6 provides a summary of the remedial components.

5.3.3.1 Overall Protection of Human Health and the Environment (Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping)

Alternative 4 provides overall protection of human health and the environment by reducing PCB concentrations in the surface sediments, which in turn would reduce the levels of PCBs in fish and other biota. This is accomplished through the source control actions already completed by Alcoa, the ongoing natural recovery processes in the lower Grasse River (see Section 5.2.1.1), and through the placement of caps to accelerate the ongoing recovery process. Specifically, Alternative 4 includes placement of 31 acres of near shore cap (T1-T72), 59 acres of main channel armored cap (T1-T21), and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored where necessary to prevent remobilization of PCBs that are currently buried in the sediment column in the reach of the river vulnerable to ice jam-related scour.

Alternative 4 includes removal of approximately 26,000 cy of PCB-containing sediment from the near shore areas between T1 and T21 (10 acres) and backfilling to grade.

The ability of near shore dredging to reduce surface sediment PCB concentrations would depend on location-specific conditions as discussed in Section 5.2.1.2. The debris anticipated in the near shore area would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during dredging.

5.3.3.2 Compliance with ARARs (Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and general compliance considerations for these ARARs are discussed in Section 5.2.2. PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2014. Based on Study Area-specific modeling (Appendix A), the CWA-AWQC for navigable waters is projected to be achieved by 2031 for Alternative 4. The New York State PCB standard for the protection of human

health and wildlife would not be met within the projection period for this alternative due to site background PCB loading conditions accounted for in the model projections. As such, a technical impracticability waiver may be required for this ARAR.

As discussed in Section 5.2.2, dredging and capping under Alternative 4 are anticipated to meet all potential federal and state action-specific ARARs (Table 3-2) and location-specific ARARs (Table 3-3).

5.3.3.3 Long-term Effectiveness and Permanence (Alternative4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping)

As discussed in Section 5.2.3.1, long-term effectiveness and permanence under Alternative 4 would be achieved by dredging of near shore sediments between T1-T21 and reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and main channel capping. The long-term effectiveness and permanence of capping are dependent on the physical stability of the cap and the ability of the cap to mitigate movement of PCBs from the underlying sediments into the water column over the long term. Each of these issues was evaluated in detail as discussed in Section 5.2.3.3. Approximately 960 lbs of PCBs would be permanently removed from the near shore areas under Alternative 4.

Following implementation of the dredging elements of Alternative 4 (and associated short-term releases and risks), longer-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River would occur as a result of Alcoa's completed source control actions, placement of the backfill and caps associated with this alternative, and ongoing natural recovery processes. Surface sediment PCB concentrations between T1 and T72 are expected to be further reduced after placement of the caps through natural recovery processes. Armored capping is expected to provide protection against periodic ice jam-related scour and remobilization of PCBs for the main channel sediments between T1 and T21 as described in Section 5.2.3.3.

Results of the numerical modeling for Alternative 4 are illustrated on Figures 5-3, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [(1)]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
4	2018	2019	>2036	0.07	2016	2016

[(1)] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

Alternative 4 would provide long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River through dredging of the near shore sediment from T1-T21,

continued natural recovery processes, placement of the backfill and caps, institutional controls to maintain integrity of the cap, and long-term monitoring and maintenance (as necessary). Monitoring would provide a means for identification and subsequent repairs if necessary. Alcoa's on-site Secure Landfill would provide adequate control and effective long-term management of all dredged sediment materials and would maintain any potential exposure to human and environmental receptors within acceptable levels.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Therefore, Alternative 4 would include monitoring associated with the five year reviews.

5.3.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping)

Consistent with all other alternatives considered herein, a reduction in toxicity, mobility, or volume through treatment would not occur because Alternative 4 does not include a treatment component. Removal of approximately 26,000 in-situ cy of sediment from the river via dredging under this alternative would reduce the volume of the PCB-containing sediment in the lower Grasse River. Based on experience during the NTCRA and ROPS, there may be an increase in PCB mobility during the dredging in the near shore between T1 and T21 for Alternative 4.

A detailed discussion of reduction of toxicity, mobility, or volume related to the dredging, capping, and MNR components of this alternative are provided in Section 5.2.4.

In addition to the reductions in toxicity, mobility, and volume through natural process (described in Section 5.2.4.1), placement of capping materials and ongoing natural recovery processes would further reduce the mobility of PCBs through isolation of PCBs in the native sediments in areas where caps have been placed and where natural sedimentation occurs.

5.3.3.5 Short-term Effectiveness (Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping)

The short-term effects of implementation of Alternative 4 would extend over approximately 3 years. These short-term impacts, and measures to be taken to minimize these effects to the extent practicable, are described in Section 5.2.5. Alternative 4 includes dredging and therefore would have short-term impacts, including disruption of existing benthic habitat, removal of SAV, and the potential for shoreline destabilization associated with removal of sediments from these areas of the river.

Results of the numerical modeling for Alternative 4 are illustrated on Figure 5-3. The short-term risk associated with Alternative 4, is illustrated by the period of predicted increases in fish tissue concentrations.

Approximately 26,000 in-situ cy of sediment would be removed over 10 acres of the near shore under Alternative 4, resulting in an anticipated 30 lbs of PCBs being transported downstream. Measures will be taken to minimize the downstream transport of PCBs-containing sediment during dredging.

Similar to that described in Section 5.3.2.5, there would also be impacts to the surrounding community over the 3-year period for construction activities for Alternative 4. For example, truck traffic would dramatically increase over the current conditions due to the need to transport cap/backfill materials to the river over the construction period. Truck traffic due to material removed from the river would have minimal impact to the surrounding community as travel on public roads during transport is minimal. If 20-cy capacity trucks were used to transport the materials to and from the river, approximately 2,000 miles of truck travel would be required to carry removed potentially contaminated materials to the on-site landfill. This traffic would primarily be limited to Alcoa's property and County Route 42 between Route 131 and Alcoa Road. An additional approximately 920,000 miles of truck travel would also be required to deliver the needed clean capping materials for Alternative 4 and transport would occur beyond Alcoa's property and County Route 42. Given the large volume of materials to be transported, alternate means of transport (e.g., barge or rail) would be evaluated during the detailed design.

5.3.3.6 Implementability (Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping)

Implementability issues for this alternative, including technical and administrative feasibility, are discus in Section 5.2.6.

Based on the anticipated production rates presented in Section 5.2.6, the duration of Alternative 4 is expected to extend over approximately 3 construction seasons. Alcoa's on-site Secure Landfill would be utilized to permanently contain all of the sediment dredged under Alternative 4.As discussed in Section 5.2.6, necessary personnel and services are likely to be available for the 3-year project duration to implement Alternative 4.

5.3.3.7 Cost (Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping)

The estimated present worth cost of Alternative 4 is approximately $147 MM. This estimate is based on the anticipated construction period (3 years) for dredging and placement of backfill and caps followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all capital cost expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

5.3.4 Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping

Figure 4-4 depicts the areas targeted for remedial action for Alternative 5. Table 4-6 provides a summary of the remedial components.

5.3.4.1 Overall Protection of Human Health and the Environment (Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping)

Alternative 5– T1-T72 Near Shore Dredging/Backfilling 10/1 and Main Channel Capping includes:

- Armored cap main channel sediments (T1-T21) greater than or equal to 1 mg/kg
- Cap main channel (T21-T72) greater than or equal to 1 mg/kg
- Dredge/backfill to grade near shore (T1-T72) greater than or equal to 10 mg/kg
- Near shore cap (T1-T72) greater than or equal to1 mg/kg

Alternative 5 would provide overall protection of human health and the environment by reducing PCB concentrations in the surface sediments, which in turn would reduce the levels of PCBs in fish and other biota. This is accomplished through the source control actions already completed by Alcoa, the ongoing natural recovery processes in the lower Grasse River (see Section 5.2.1.1), and through the placement of caps to accelerate the ongoing recovery process. Specifically, Alternative 5 includes placement of 28 acres of near shore cap (T1-T72), 59 acres of main channel armored cap (T1-T21), and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored to prevent remobilization of PCBs that are currently buried in the sediment column in the reach of the river vulnerable to ice jam-related scour.

Alternative 5 includes removal of approximately 46,000 cy of PCB-containing sediment from the near shore areas between T1 and T72 (13 acres) and backfilling to grade. The ability of near shore dredging to reduce surface sediment PCB concentrations would depend on location-specific conditions as discussed in Sections 5.2.1.2 and 5.3.3.1. The debris anticipated in the near shore area would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during dredging.

5.3.4.2 Compliance with ARARs (Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and general compliance considerations for these ARARs are discussed in Section 5.2.2. PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2015. Based on Study Area-specific modeling (Appendix A), the CWA-AWQC for navigable waters is projected to be achieved by 2031 for Alternative 5. The New York State PCB standard for the protection of human health and wildlife would not be met within the projection period for this alternative due to site background PCB loading conditions accounted for in the model projections. As such, a technical impracticability waiver may be required for this ARAR.

As discussed in Section 5.2.2, dredging and capping under Alternative 5 are anticipated to meet all potential federal and state action-specific ARARs (Table 3-2) and location-specific ARARs (Table 3-3).

5.3.4.3 Long-term Effectiveness and Permanence (Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping)

As discussed in Section 5.2.3, long-term effectiveness and permanence under Alternative 5 would be achieved by dredging near shore sediments greater than 10 mg/kg between T1 and T72 and reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and main channel capping. The long-term effectiveness and permanence of capping are dependent on the physical stability of the cap and the ability of the cap to mitigate movement of PCBs from the underlying sediments into the water column over the long term. Each of these issues was evaluated in detail as discussed in Section 5.2.3.3. Approximately 1,800 lbs of PCBs would be permanently removed from the near shore areas under Alternative 5.Following implementation of the dredging elements of Alternative 5 (and associated short-term releases and risks), longer-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River would occur as a result of Alcoa's completed source control actions, placement of the backfill and caps associated with this alternative, and ongoing natural recovery processes. Surface sediment concentrations are expected to be further reduced after the placement of caps through natural recovery processes. Armored capping is expected to provide protection against periodic ice jam-related scour and remobilization of PCBs for the main channel sediments between T1 and T21 as described in Section 5.2.3.3.

Results of the numerical modeling for Alternative 5 are illustrated on Figure 5-4, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [1]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
5	2019	2020	>2036	0.08	2017	2016

[1] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

Alternative 5 would provide long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River through dredging of the near shore sediment from T1-T21 which are equal to or greater than 10 ppm, continued natural recovery processes, placement of the backfill and caps, institutional controls to maintain integrity of the caps, and long-term monitoring and maintenance (as necessary). Monitoring would provide a means for identification and subsequent repairs if necessary. Alcoa's on-site Secure Landfill would provide adequate control and effective long-term management of all dredged sediment materials and would maintain any potential exposure to human and environmental receptors within acceptable levels.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Therefore, Alternative 5 would include monitoring associated with the five year reviews.

5.3.4.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping)

Consistent with all other alternatives considered herein, a reduction in toxicity, mobility, or volume through treatment would not occur because Alternative 5 does not include a treatment component. Removal of approximately 46,000 in-situ cy of sediment from the river via dredging under this alternative would reduce the potential of future mobility and volume of the PCB-containing sediment in the lower Grasse River. Based on experience during the NTCRA and ROPS, there may be an increase in PCB mobility during the dredging of the near shore area between T1 and T72 for Alternative 5.

A detailed discussion of reduction of toxicity, mobility, or volume related to the dredging, capping, and MNR components of this alternative are provided in Section 5.2.4.

5.3.4.5 Short-term Effectiveness (Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping)

The short-term effects of implementation of Alternative 5 would extend over approximately 4 years. These short-term impacts, and measures to be taken to minimize these effects to the extent practicable, are described in Section 5.2.5. Alternative 5 includes dredging and therefore would have short-term impacts, including disruption of existing benthic habitat, removal of SAV, and the potential for shoreline destabilization associated with removal of sediments from these areas of the river.

Results of the numerical modeling for Alternative 5 are illustrated on Figure 5-4. The short-term risk associated with this alternative is illustrated by the period of predicted increases in fish tissue concentrations.

Approximately 46,000 in-situ cy of sediment would be removed over 13 acres of the near shore under Alternative 5, resulting in an anticipated 55 lbs of PCBs being transported downstream. Measures will be taken to minimize the downstream transport of PCB-containing sediment during dredging.

Similar to that described in Section 5.3.3.5, approximately 4,000 miles of truck travel would be required to carry removed potentially contaminated materials to the on-site landfill, which is anticipated to be limited to Alcoa's property and County Route 42 between Kinnie Road and east of Alcoa Road. An additional approximately 940,000 miles of truck travel on public roads will be necessary to deliver the needed clean capping materials for Alternative 5. Given the large volume of materials to be transported, alternate means of transport would be evaluated during the detailed design.

5.3.4.6 Implementability (Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping)

Implementability issues for these alternatives, including technical and administrative feasibility, are discussed in Section 5.2.6.

Based on the anticipated production rates presented in Section 5.2.6, the duration of Alternative 5 is expected to extend over approximately 4 construction seasons. Alcoa's on-site Secure Landfill would be utilized to permanently contain all of the sediment dredged under Alternative 5. As discussed in Section 5.2.6, necessary personnel, services and equipment are likely to be available for the 4-year project duration to implement Alternative 5.

5.3.4.7 Cost (Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping)

The estimated present worth cost of Alternative 5 is approximately $175 MM. This estimate is based on the anticipated construction period (4 years) for dredging and placement of backfill and caps followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all capital cost expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

5.3.5 Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping

Alternative 6– T1-T72 Near Shore Dredging/Backfill and Main Channel Capping includes:

- Armored cap main channel sediments (T1-T21) greater than or equal to 1 mg/kg
- Cap main channel (T21-T72) greater than or equal to 1 mg/kg
- Dredge/backfill to grade near shore (T1-T72) greater than or equal to 1 mg/kg

Figure 4-5 depicts the areas targeted for remedial action for Alternative 6. Table 4-6 provides a summary of the remedial components.

5.3.5.1 Overall Protection of Human Health and the Environment (Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping)

Alternative 6 would provide overall protection of human health and the environment by reducing PCB concentrations in the surface sediments, which in turn would reduce the levels of PCBs in fish and other biota. This is accomplished through the source control actions already completed by Alcoa, the ongoing natural recovery processes in the lower Grasse River (see Section 5.2.1.1), and through the placement of caps to accelerate the ongoing recovery process. Specifically, Alternative 6 includes placement of 59 acres of main channel armored cap (T1-T21) and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored to prevent remobilization of PCBs that are currently buried in the sediment column in the reach of the river vulnerable to ice jam-related scour.

Alternative 6 includes the removal of approximately 109,000 cy of PCB-containing sediment from the near shore areas between T1 and T72 (41 acres) and backfilling to grade. The ability of near shore dredging to reduce surface sediment PCB concentrations would depend on location-specific conditions as discussed in Sections 5.2.1.2 and 5.3.3.1. The debris anticipated in the near shore area would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during dredging.

5.3.5.2 Compliance with ARARs (Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and general compliance considerations for these ARARs are discussed in Section 5.2.2. PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2016. Based on Study Area-specific modeling (Appendix A), the CWA-AWQC for navigable waters is projected to be achieved by 2031 for Alternative 6. The New York State PCB standard for the protection of human health and wildlife would not be met within the projection period for this alternative due to site background PCB loading conditions accounted for in the model projections. As such, a technical impracticability waiver may be required for this ARAR.

As discussed in Section 5.2.2, dredging and capping under Alternative 6 are anticipated to meet all potential federal and state action-specific ARARs (Table 3-2) and location-specific ARARs (Table 3-3).

5.3.5.3 Long-term Effectiveness and Permanence (Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping)

As discussed in Section 5.2.3.1, long-term effectiveness and permanence under Alternative 6 would be achieved by dredging near shore sediments between T1 and T72 and reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and main channel capping. The long-term effectiveness and permanence of capping are dependent on the physical stability of the cap and the ability of the cap to mitigate movement of PCBs from the underlying sediments into the water column over the long term. Each of these issues was evaluated in detail as discussed in Section 5.2.3.3. Approximately 2,100 lbs of PCBs would be permanently removed from the near shore areas under Alternative 6.

Following implementation of the dredging elements of Alternative 6, longer-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River would occur as a result of Alcoa's completed source control actions, placement of the backfill and caps associated with this alternative, and ongoing natural recovery processes. Surface sediment concentrations are expected to be further reduced after the placement of caps through natural recovery processes. Armored capping is expected to provide protection against periodic ice jam-related scour and remobilization of PCBs for the main channel sediments between T1 and T21 as described in Section 5.2.3.3.

Results of the numerical modeling for Alternative 6 are illustrated on Figure 5-5, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [1]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
6	2019	2020	>2036	0.08	2018	2016

[1] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

Alternative 6 would provide long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River through dredging of near shore sediment between T1 and T72, continued natural recovery processes, placement of the backfill and caps, institutional controls to maintain integrity of the caps, and long-term monitoring and maintenance (as necessary). Monitoring would provide a means for identification and subsequent repairs if necessary. Alcoa's on-site Secure Landfill would provide adequate control and effective long-term management of all dredged sediment materials and would maintain any potential exposure to human and environmental receptors within acceptable levels.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Therefore, Alternative 6 would include monitoring associated with the five year reviews.

5.3.5.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping)

Consistent with all other alternatives considered herein, a reduction in toxicity, mobility, or volume through treatment would not occur because Alternative 6 does not include a treatment component. Removal of approximately 109,000 in-situ cy of sediment from the river via dredging under this alternative would reduce the potential of future mobility and volume of the PCB-containing sediment in the lower Grasse River. Based on experience during the NTCRA and ROPS, there may be an increase in PCB mobility during the dredging of the near shore area between T1 and T72 for Alternative 6.

A detailed discussion of reduction of toxicity, mobility, or volume related to the dredging, capping, and MNR components of this alternative are provided in Section 5.2.4.

5.3.5.5 Short-term Effectiveness (Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping)

The short-term effects of implementation of Alternative 6 would extend over approximately 4 years. These short-term impacts, and measures to be taken to minimize these effects to the extent practicable, are described in Section 5.2.5. Alternative 6 includes dredging and therefore would have short-term impacts,

including disruption of existing benthic habitat, removal of SAV, and the potential for shoreline destabilization associated with removal of sediments from these areas of the river.

Results of the numerical modeling for Alternative 6 are illustrated on Figure 5-5. The short-term risk associated with this alternative, is illustrated by the period of predicted increases in fish tissue concentrations.

Approximately 109,000 in-situ cy of sediment would be removed over 41 acres of the near shore under Alternative 6, resulting in an anticipated 60 lbs of PCBs being transported downstream. Measures will be taken to minimize the downstream transport of PCBs contaminated sediment during dredging.

Similar to that described in Section 5.3.3.5, approximately 9,000 miles of truck travel would be required to transport dredged sediment to the on-site landfill, which is anticipated to be limited to Alcoa's property and County Route 42 between Kinnie Road and east of Alcoa Road. Approximately 245,000 miles of truck travel on public roads would be required to transport potentially contaminated materials to an off-site landfill, along with approximately 1 million miles of truck travel on public roads to deliver the needed clean backfill and capping materials for Alternative 6. Given the large volume of materials to be transported, alternate means of transport (e.g., barge or rail) would be evaluated during the detailed design.

5.3.5.6 Implementability (Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping)

Implementability issues for this alternative, including technical and administrative feasibility, are discussed in Section 5.2.6.

Based on the anticipated production rates presented in Section 5.2.6 the estimated project duration is 4 years for Alternative 6. Dredging is estimated to extend over 4 construction seasons (depending on sequencing with capping operations in the same areas) with the dredging production rate limited by site conditions.

Alcoa's on-site Secure Landfill would be utilized to permanently contain most of the sediment dredged under Alternative 6, but some sediment would require off-site disposal at an approved landfill(s).

As discussed in Section 5.2.6, necessary personnel, services and equipment are likely to be available for the 4-year project duration to implement Alternative 6.

5.3.5.7 Cost (Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping)

The estimated present worth cost of Alternative 6 is approximately $243 MM. This estimate is based on the anticipated construction period (4 years) for dredging and placement of backfill and caps followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all

capital cost expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

5.3.6 Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping

Alternative 7 – T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping includes:

- Dredge/armor cap select main channel areas (T1-T19.5)
- Armor cap main channel (T1-T21) greater than or equal to 1 mg/kg
- Cap main channel (T21-T72) greater than or equal to1mg/kg
- Dredge/backfill to grade near shore (T1-T72) greater than or equal to 1 mg/kg

Figure 4-6 depicts the areas targeted for remedial actions for Alternative 7. Table 4-6 provides a summary of the remedial components.

5.3.6.1 Overall Protection of Human Health and the Environment (Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Alternative 7 provides overall protection of human health and the environment by reducing PCB concentrations in the surface sediments, which in turn would reduce the levels of PCBs in fish and other biota. This is accomplished through the source control actions already completed by Alcoa, the ongoing natural recovery processes in the lower Grasse River (see Section 5.2.1.1), and through the placement of caps to accelerate the ongoing recovery process. Specifically, Alternative 7 includes placement of 59 acres of main channel armored cap (T1-T21) and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored to prevent remobilization of residual PCB concentrations which are equal to or greater than 1 ppm that are currently buried in the sediment column in the reach of the river vulnerable to ice jam-related scour.

Alternative 7 includes the removal of approximately 109,000 cy of PCB-containing sediment from the near shore areas between T1 and T72 (41 acres) and backfilling to grade. The ability of near shore dredging to reduce surface sediment PCB concentrations would depend on location-specific conditions as discussed in Sections 5.2.1.2 and 5.3.3.1. The debris anticipated in the near shore area would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during near shore dredging.

The limitations and uncertainties associated with dredging approximately 150,000 cy of PCB-containing sediments over 19 acres in the main channel (T1-T19.5) under Alternative 7 would be anticipated to be similar to that experienced during the NTCRA and ROPS. PCB residuals would still be expected to remain after dredging based on the results of the ROPS, as described in Section 5.2.1.2, with the magnitude of the residuals and resuspension influenced by the amount of debris and hard bottom conditions encountered in these areas (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during main channel dredging, but the potential for residuals and other impacts exists. Based on these considerations, post-dredge residual management and risk reduction as it relates to overall protection of human health and the environment would be accomplished through the placement of the post-dredge caps.

5.3.6.2 Compliance with ARARs (Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and general compliance considerations for these ARARs are discussed in Section 5.2.2. Water column PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2017 for Alternative 7. The CWA-AWQC for navigable waters (0.001 µg/L) and the New York State standard for the protection of human health or wildlife would not be met within the projection period due to releases during dredging and site background PCB loading conditions accounted for in model projections. Technical impracticability waivers may be required for these ARARs under Alternative 7.

It is expected that all action-specific and location-specific ARARs (Tables 3-2 and 3-3) would be achieved for Alternative 7, as discussed in Section 5.2.2.

5.3.6.3 Long-term Effectiveness and Permanence (Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping)

As discussed in Section 5.2.3.1, long-term effectiveness and permanence under Alternative 7 would be achieved by near shore dredging between T1 and T72 and select main channel dredging between T1 and T19.5 in the area susceptible to remobilization due to periodic ice jam- related scour and reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and capping. The long-term effectiveness and permanence of capping are dependent on the physical stability of the cap and the ability of the cap to mitigate movement of PCBs from the underlying sediments into the water column over the long term. Each of these issues was evaluated in detail as discussed in Section 5.2.3.3.

The dredging component of Alternative 7 would target the permanent removal of approximately 258,000 in-situ cy of PCB sediments containing an estimated 15,000 lbs of PCBs from the lower Grasse River. As discussed in Section 5.2.3.2, during ROPS dredging activities, PCBs were released to the water column and a residual PCB mass remained in the post-dredge surface sediments (Alcoa, May 2006). A similar condition would be anticipated during implementation of this alternative. Alcoa's on-site Secure Landfill and approved off-site landfill(s) would provide adequate control and effective long-term management of all dredged sediment materials and would maintain any potential exposure to human and environmental receptors within acceptable levels.

The limitations and uncertainties associated with the removal of PCB-containing sediments experienced during the NTCRA and ROPS (see Sections 5.2.1.2 and 5.2.3.2) would also be anticipated to occur during dredging of approximately 150,000 cy from the main channel during implementation of Alternative 7. As discussed previously, the anticipated amount of debris in these areas would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008).

Following implementation of the dredging elements of Alternative 7, longer-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River would occur as a result of Alcoa's completed source control actions, placement of the backfill and caps associated with this alternative, and ongoing natural recovery processes. Surface sediment concentrations are expected to be further reduced after the placement of caps through natural recovery processes. Armored capping is expected to provide protection against periodic ice jam-related scour and remobilization of PCBs for the main channel sediments between T1 and T21 as described in Section 5.2.3.3.

Fate and transport model predictions for Alternative 7 are illustrated on Figure 5-6, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [1]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
7	2022	2026	>2036	0.13	2022	2018

[1] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

Alternative 7 provides long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River through sediment removal and subsequent placement of the backfill and caps, continued natural recovery processes, institutional controls to maintain the integrity of the caps, and long-term monitoring and maintenance. Further, based on site-specific studies and modeling, the caps would address each of the potential fate and transport processes in the lower Grasse River, which could remobilize PCBs in the future. Monitoring would provide a means for identification and subsequent repair of damage to the cap.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Therefore, Alternative 7 would include monitoring associated with the five year reviews.

5.3.6.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Consistent with all other alternatives considered herein, a reduction in toxicity, mobility, or volume through treatment would not occur because Alternative 7 does not include a treatment component. Removal of approximately 258,000 in-situ cy of sediment from the river via dredging under this alternative would reduce the potential of future mobility and volume of the PCB-containing sediment in the lower Grasse River. Based on experience during the NTCRA and ROPS, there may be an increase in PCB mobility during the dredging of the near shore area between T1 and T72 for Alternative 7, similar to those described in Section 5.3.3.4.

A detailed discussion of reduction of toxicity, mobility, or volume related to the dredging, capping, and MNR components of this alternative are provided in Section 5.2.4.

5.3.6.5 Short-term Effectiveness (Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping)

The short-term effects of implementation of Alternative 7 would extend over approximately 5 years. These short-term impacts, and measures to be taken to minimize these effects to the extent practicable, are described in Section 5.2.5. Alternative 7 includes dredging and therefore would have short-term impacts, including disruption of existing benthic habitat, removal of SAV, and the potential for shoreline destabilization associated with removal of sediments from these areas of the river.

Results of the numerical modeling for Alternative 7 are illustrated on Figure 5-6. The short-term risk associated with this alternative is illustrated by the period of predicted increases in fish tissue concentrations.

Approximately 258,000 in-situ cy of sediment would be removed over 60 acres of the near shore and main channel under Alternative 7, resulting in an anticipated 440 lbs of PCBs being transported downstream. Measures will be taken to minimize the downstream transport of PCB-containing sediment during dredging.

Approximately 9,000 miles of truck travel would be required to transport dredged sediment to the on-site landfill, which is anticipated to be limited to Alcoa's property and County Route 42 between Kinnie Road and east of Alcoa Road. Approximately 4.5 million miles of truck travel would be required on public roads to carry removed potentially contaminated materials to the off-site landfill, along with approximately 1 million miles of truck travel on public roads to deliver the needed clean capping materials for Alternative 7. Given the large volume of materials to be transported, alternate means of transport would be evaluated during the detailed design.

5.3.6.6 Implementability (Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Implementability issues for this alternative, including technical and administrative feasibility, are discussed in Section 5.2.6. As documented during the NTCRA and ROPS activities and discussed previously, site-specific conditions affect the practicability of removing sediment from the main channel targeted areas.

The estimated project duration for Alternative 7 is 5 years. Alcoa's on-site Secure Landfill would be utilized to permanently contain approximately 100,000 of the dredged sediment, with the remainder (approximately 158,000 cy) of sediment requiring off-site disposal at an approved landfill(s). As discussed in Section 5.2.6, necessary personnel, services, and equipment are likely to be available for the 5-year project duration to implement Alternative 7.

5.3.6.7 Cost (Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping)

The estimated present worth of Alternative 7 is approximately $352 million. This costs is based on the anticipated construction period for dredging and backfill and cap placement (5 years), followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all capital cost expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

5.3.7 Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping

Alternative 8 – T1-T21 Dredging/Capping, T21-T72 Capping includes:

- Dredge and armored cap main channel sediments (T1-T21) greater than or equal to 1 mg/kg
- Cap main channel (T21-T72) greater than or equal to 1 mg/kg
- Dredge/backfill to grade near shore (T1-T21) greater than or equal to 1 mg/kg
- Near shore cap (T21-T72) greater than or equal to 1mg/kg

Figure 4-7 presents the river areas targeted for remediation under Alternative 8. Table 4-6 provides a summary of the remedial components.

5.3.7.1 Overall Protection of Human Health and the Environment (Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping)

Alternative 8 provides overall protection of human health and the environment by reducing PCB concentrations in the surface sediments, which in turn would reduce the levels of PCBs in fish and other biota. This is accomplished through the source control actions already completed by Alcoa, the ongoing natural recovery processes in the lower Grasse River (see Section 5.2.1.1), and through the placement of caps to accelerate the ongoing recovery process. Specifically, Alternative 8 includes placement of 31 acres of near shore cap (T21-T72), 59 acres of main channel armored cap (T1-T21), and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored to prevent remobilization of residual PCB concentrations which are equal to or greater than 1 ppm that are currently buried in the sediment column in the reach of the river which is vulnerable to ice jam-related scour.

Alternative 8 includes the removal of approximately 26,000 cy of PCB-containing sediment from the near shore areas between T1 and T72 (10 acres) and backfilling to grade. The ability of near shore dredging to reduce surface sediment PCB concentrations would depend on location-specific conditions as discussed in Sections 5.2.1.2 and 5.3.3.1. The debris anticipated in the near shore area would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during near shore dredging.

The limitations and uncertainties associated with dredging approximately 329,000 cy of PCB-containing sediments in the main channel over 59 acres (T1-T21) are consistent with the other main channel dredging alternatives as discussed in Section 5.2.1.2 and 5.3.6.1. Reasonable and practical means would be undertaken to reduce concerns associated with the implementation of main channel dredging, but the potential for residuals and other impacts exists. Based on these considerations, post-dredge residual

management and risk reduction as it relates to overall protection of human health and the environment would be accomplished through the placement of the post-dredge caps.

5.3.7.2 Compliance with ARARs (Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and compliance with these ARARs is discussed in Section 5.2.2 for the MNR, removal, and capping components of these alternatives. Based on Study Area-specific modeling (Appendix A), PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2020. The CWA-AWQC for navigable waters (0.001 µg/L) and the New York State PCB standard for the protection of human health or wildlife would not be met within the projection period for this alternative due to releases during dredging and site background PCB loading conditions accounted for in the model projections. As such, a technical impracticability waiver may be required for these ARARs.

Alternative 8 is anticipated to meet all potential action-specific and location-specific ARARs (Tables 3-2 and 3-3, respectively), as discussed in detail in Section 5.2.2.

5.3.7.3 Long-term Effectiveness and Permanence (Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping)

As discussed in Section 5.2.3.1, long-term effectiveness and permanence under Alternative 8 would be achieved by near shore dredging between T1 and T21 and main channel dredging between T1 and T21 in the area susceptible to remobilization due to periodic ice jam- related scour and by reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and main channel capping. The long-term effectiveness and permanence of capping are dependent on the physical stability of the cap and the ability of the cap to mitigate movement of PCBs from the underlying sediments into the water column over the long term. Each of these issues was evaluated in detail as discussed in Section 5.2.3.3.

The dredging component of Alternative 8 would target the permanent removal of approximately 355,000 in-situ cy of sediments containing an estimated 19,000 lbs of PCBs from the lower Grasse River. Due to the limitations with regard to main channel dredging effectiveness, not all of the PCB-containing sediments would be removed from the targeted areas as described in Section 5.2.3.2. A similar condition would be anticipated during implementation of this alternative. Therefore, caps are planned to control post-dredge residuals.

Limitations and uncertainties associated with dredging approximately 329,000 cy of the main channel under Alternative 8 are consistent with the other main channel dredging alternatives as discussed in Section 5.3.6.3.

Following implementation of the dredging elements of Alternative 8, longer-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River would occur as a result of Alcoa's completed source control actions, placement of the backfill and caps associated with this alternative, and ongoing

natural recovery processes. Surface sediment concentrations are expected to be further reduced after the placement of caps through natural recovery processes. Armored capping is expected to provide protection against periodic ice jam-related scour and remobilization of PCBs for the main channel sediments between T1 and T21 as described in Section 5.2.3.3.

Results of the numerical modeling for Alternative 8 are illustrated on Figures 5-7, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [1]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
8	2025	2031	>2036	0.16	2027	2021

[1] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

Alternative 8 provides long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River through sediment removal and subsequent placement of the caps, continued natural recovery processes, institutional controls to maintain the integrity of the caps, and long-term monitoring and maintenance. Further, based on site-specific studies and modeling, the caps would address each of the potential fate and transport processes in the lower Grasse River, which could remobilize PCBs in the future. Monitoring would provide a means for identification and subsequent repairs if necessary.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Therefore, Alternative 8 would include monitoring associated with the five year reviews.

5.3.7.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping)

Consistent with all other alternatives considered herein, a reduction in toxicity, mobility, or volume through treatment would not occur because Alternative 8 does not include a treatment component. Removal of approximately 355,000 in-situ cy of sediment from the river via dredging under this alternative would reduce the potential of future mobility and volume of the PCB-containing sediment in the lower Grasse River. Based on experience during the NTCRA and ROPS, there may be an increase in PCB mobility during the dredging of the near shore and main channel for Alternative 8, similar to those described in Section 5.3.3.4.

Detailed discussions of reduction of toxicity, mobility, or volume related to the dredging, capping, and natural recovery components of this alternative are provided in Section 5.2.4.

5.3.7.5 Short-term Effectiveness (Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping)

The short-term effects of implementation of Alternative 8 would extend over approximately 8 years. These short-term impacts, and measures to be taken to minimize these effects to the extent practicable, are described in Section 5.2.5. Alternative 8 includes dredging and therefore would have short-term impacts, including disruption of existing benthic habitat, removal of SAV, and the potential for shoreline destabilization associated with removal of sediments from these areas of the river.

Results of the numerical modeling for Alternative 8 are illustrated on Figure 5-7. The short-term risk associated with this alternative is illustrated by the period of predicted increases in fish tissue concentrations.

Approximately 355,000 in-situ cy of sediment would be removed over 59 acres of the near shore and main channel under Alternative 8, resulting in an anticipated 580 lbs of PCBs being transported downstream. Measures will be taken to minimize the downstream transport of PCB-containing sediment during dredging.

Approximately 9,000 miles of truck travel would be required to transport dredged sediment to the on-site landfill, which is anticipated to be limited to Alcoa's property and County Route 42 between Kinnie Road and east of Alcoa Road. Approximately 7.2 million miles of truck travel would be required on public roads to carry removed potentially contaminated materials to the off-site landfill, along with approximately 920,000 miles of truck travel on public roads to deliver the needed clean capping materials for Alternative 8. Given the large volume of materials to be transported, alternate means of transport would be evaluated during the detailed design.

5.3.7.6 Implementability (Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping)

Implementability issues for these alternatives, including technical and administrative feasibility, are discussed in Section 5.2.6. As documented during the NTCRA and ROPS activities, site conditions, including the presence of debris and underlying hardpan, are expected to affect the practicability of removing sediment from the targeted main channel areas under Alternative 8.

Based on the anticipated production rates presented in Section 5.2.6, it is estimated that Alternative 8 would take approximately 8 construction seasons to complete. Alcoa's on-site Secure Landfill would be utilized to permanently contain a portion of the sediment dredged under Alternative 8, with the majority of sediment requiring off-site disposal at an approved landfill(s).

As discussed in Section 5.2.6, necessary personnel and services are likely to be available for the 8-year project duration to implement Alternative 8. However, prediction of local equipment availability for such long duration projects is uncertain.

5.3.7.7 Cost (Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping)

The estimated present worth of Alternative 8 is approximately $388 MM. This is based on an 8-year construction period for this alternative, followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all capital cost expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

5.3.8 Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping

Figure 4-8 depicts the areas targeted for remedial actions for Alternative 9. Table 4-6 provides a summary of the remedial components.

Alternative 9 – T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping includes:

- Dredge/armor cap select main channel areas (T1-T19.5)
- Armor cap main channel (T1-T21) greater than or equal to 1 mg/kg
- Dredge/cap select main channel areas (T27-T46)
- Cap main channel (T21-T72) greater than or equal to 1 mg/kg
- Dredge/backfill to grade near shore (T1-T21) greater than or equal to 1 mg/kg
- Dredge/backfill to grade near shore (T21-T72) greater than or equal to 1 mg/kg

5.3.8.1 Overall Protection of Human Health and the Environment (Alternative 9: T1-T72 Near Shore Dredging/Capping, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Alternative 9 provides overall protection of human health and the environment by reducing PCB concentrations in the surface sediments, which in turn would reduce the levels of PCBs in fish and other biota. This is accomplished through the source control actions already completed by Alcoa, the ongoing natural recovery processes in the lower Grasse River (see Section 5.2.1.1), and through the placement of caps to accelerate the ongoing recovery process. Alternative 9 includes placement of 59 acres of main channel armored cap (T1-T21) and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored to prevent remobilization of residual PCB concentrations which are equal to or greater than 1 ppm that are currently buried in the sediment column in the reach of the river vulnerable to ice jam-related scour.

Alternative 9 includes the removal of approximately 109,000 cy of PCB-containing sediment from the near shore areas between T1 and T72 (41 acres) and backfilling to grade. The ability of near shore dredging to reduce surface sediment PCB concentrations would depend on location-specific conditions as discussed in Sections 5.2.1.2 and 5.3.3.1. The debris anticipated in the near shore area would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during near shore dredging.

The limitations and uncertainties associated with dredging approximately 525,000 cy of PCB-containing sediments in the main channel over 76 acres (T1-T21) are consistent with the other main channel dredging alternatives as discussed in Section 5.2.1.2 and 5.3.6.1. Reasonable and practical means would be undertaken to reduce concerns associated with the implementation of main channel dredging, these the

potential for residuals and other impacts exists. Post-dredge residual management and risk reduction as it relates to overall protection of human health and the environment would be accomplished through the placement of post-dredge caps.

5.3.8.2 Compliance with ARARs (Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and general compliance considerations for these ARARs are discussed in Section 5.2.2. Water column PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2021 for Alternative 9. The CWA-AWQC for navigable waters (0.001 µg/L) and the New York State standard for the protection of human health or wildlife would not be met within the projection period due to releases during dredging and site background PCB loading conditions accounted for in model projections. Technical impracticability waivers may be required for these ARARs under Alternative 9.

It is expected that all action-specific and location-specific ARARs (Tables 3-2 and 3-3) would be achieved for Alternative 9, as discussed in Section 5.2.2.

5.3.8.3 Long-term Effectiveness and Permanence (Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping)

As discussed in Section 5.2.3.1, long-term effectiveness and permanence under Alternative 9 would be achieved by near shore dredging between T1 and T72 and select main channel dredging between T1 and T46 (including the area susceptible to remobilization due to periodic ice jam- related scour) and by reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and capping. The long-term effectiveness and permanence of capping are dependent on the physical stability of the cap and the ability of the cap to mitigate movement of PCBs from the underlying sediments into the water column over the long term. Each of these issues was evaluated in detail as discussed in Section 5.2.3.3.

The dredging component of Alternative 9 would target the permanent removal of approximately 633,000 in-situ cy of sediments containing an estimated 28,000 lbs of PCBs from the lower Grasse River. As discussed in Section 5.2.3.2, during ROPS dredging activities, PCBs were released to the water column and a residual PCB mass remained in the post-dredge surface sediments (Alcoa, May 2006). A similar condition would be anticipated during implementation of this alternative. Limitations and uncertainties associated with dredging approximately 525,000 cy of the main channel under Alternative 9 are consistent with the other main channel dredging alternatives as discussed in Section 5.3.6.3.

Following implementation of the dredging elements of Alternative 9, longer-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River would occur as a result of Alcoa's completed source control actions, placement of the backfill and caps associated with this alternative, and ongoing natural recovery processes. Surface sediment concentrations are expected to be further reduced after the

placement of caps through natural recovery processes. Armored capping is expected to provide protection against periodic ice jam-related scour and remobilization of PCBs for the main channel sediments between T1 and T21 as described in Section 5.2.3.3.

Fate and transport model predictions for Alternative 9 are illustrated on Figure 5-8, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River [1]	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
9	2025	2029	>2036	0.15	2027	2021

[1] Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

Based on site-specific studies and modeling, the caps would address each of the potential fate and transport processes in the lower Grasse River, which could remobilize PCBs in the future. Institutional controls would be put in place to maintain integrity of the cap, and long-term monitoring and maintenance would be performed for identification and subsequent repair of damage to the cap.

Because this alternative would result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Therefore, Alternative 9 would include monitoring associated with the five year reviews.

5.3.8.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Consistent with all other alternatives considered herein, a reduction in toxicity, mobility, or volume through treatment would not occur because Alternative 9 does not include a treatment component. Removal of approximately 633,000 in-situ cy of sediment from the river via dredging under this alternative would reduce the potential of future mobility and volume of the PCB-containing sediment in the lower Grasse River. Based on experience during the NTCRA and ROPS, there may be an increase in PCB mobility during the dredging of Alternative 9, similar to those described in Section 5.3.3.4.

Detailed discussions of reduction of toxicity, mobility, or volume related to the dredging, capping, and natural recovery components of these alternatives are provided in Section 5.2.4.

5.3.8.5 Short-term Effectiveness (Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping)

The short-term effects of implementation of Alternative 9 would extend over approximately 7 years. These short-term impacts, and measures to be taken to minimize these effects to the extent practicable, are described in Section 5.2.5. Alternative 9 includes dredging and therefore would have short-term impacts, including disruption of existing benthic habitat, removal of SAV, and the potential for shoreline destabilization associated with removal of sediments from these areas of the river.

Results of the numerical modeling for Alternative 9 are illustrated on Figure 5-8. The short-term risk associated with this alternative is illustrated by the period of predicted increases in fish tissue concentrations.

Approximately 633,000 in-situ cy of sediment would be removed over 117 acres of the near shore and main channel under Alternative 9, resulting in an anticipated 840 lbs of PCBs being transported downstream. Measures will be taken to minimize the downstream transport of PCB-containing sediment during dredging.

Approximately 9,000 miles of truck travel would be required to transport dredged sediment to the on-site landfill, which is anticipated to be limited to Alcoa's property and County Route 42 between Kinnie Road and east of Alcoa Road. Approximately 15 million miles of truck travel would be required on public roads to carry removed potentially contaminated materials to an off-site landfill, along with approximately 1 million miles of truck travel on public roads to deliver the needed clean capping materials for Alternative 9. Given the large volume of materials to be transported, alternate means of transport would be evaluated during the detailed design.

5.3.8.6 Implementability (Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping)

Implementability issues for this alternative, including technical and administrative feasibility, are discussed in Section 5.2.6. As documented during the NTCRA and ROPS activities and discussed previously, site-specific conditions affect the practicability of removing sediment from the targeted main channel areas.

Based on the anticipated production rates, in-water construction under Alternative 9 would be spread over approximately 7 construction seasons. Alcoa's on-site Secure Landfill would be utilized to permanently contain a portion of the sediment dredged under Alternative 9, with the majority of sediment requiring off-site disposal at an approved landfill(s).

As discussed in Section 5.2.6, necessary personnel and services are likely to be available for the 7-year project duration to implement Alternative 9. However, prediction of local equipment availability for such long duration projects is uncertain.

5.3.8.7 Cost (Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping)

The estimated present worth of Alternative 9 is approximately $589 million. This costs is based on the anticipated construction period for dredging and cap placement (7 years), followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all capital cost expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

5.3.9 Alternative 10: T1-T72 Dredging/Capping

Alternative 10 – T1-T72 Dredging/Capping includes:

- Dredge/armor cap main channel (T1-T21) greater than or equal to 1 mg/kg
- Dredge/cap main channel (T21-T72) greater than or equal to 1 mg/kg
- Dredge/backfill to grade near shore (T1-T72) greater than or equal to1 mg/kg

Figure 4-9 depicts the areas targeted for remedial actions for Alternative 10. Table 4-6 provides a summary of the remedial components.

5.3.9.1 Overall Protection of Human Health and the Environment (Alternative 10: T1-T72 Dredging/Capping)

Alternative 10 provides overall protection of human health and the environment by reducing PCB concentrations in the surface sediments, which in turn would reduce the levels of PCBs in fish and other biota. This is accomplished through the source control actions already completed by Alcoa, the ongoing natural recovery processes in the lower Grasse River (see Section 5.2.1.1), and through the placement of caps to accelerate the ongoing recovery process. Alternative 10 includes placement of 59 acres of main channel armored cap (T1-T21) and 225 acres of 12-inch main channel cap downstream of T21. The main channel cap from T1-T21 would be armored to prevent remobilization of residual PCB concentrations which are equal to or greater than 1 ppm that are currently buried in the sediment column in the reach of the river vulnerable to ice jam-related scour.

Alternative 10 includes the removal of approximately 109,000 cy of PCB-containing sediment from the near shore areas between T1 and T72 (41 acres) and backfilling to grade. The ability of near shore dredging to reduce surface sediment PCB concentrations would depend on location-specific conditions as discussed in Sections 5.2.1.2 and 5.3.3.1. The debris anticipated in the near shore area would increase resuspension and residuals generation (Patmont and Palermo, January 2007; Bridges et al., February 2008). Reasonable and practical means would be undertaken to minimize impacts during near shore dredging.

The limitations and uncertainties associated with dredging approximately 1,555,000 cy of PCB-containing sediments in the main channel over 284 acres (T1-T21) are consistent with the other main channel dredging alternatives as discussed in Section 5.2.1.2 and 5.3.6.1. Reasonable and practical means would be undertaken to reduce concerns associated with the implementation of main channel dredging, but the potential for residuals and other impacts exists. Post-dredge residual management and risk reduction as it

relates to overall protection of human health and the environment would be accomplished through the placement of the post-dredge caps.

5.3.9.2 Compliance with ARARs (Alternative 10: T1-T72 Dredging/Capping)

Potential chemical-specific, action-specific, and location-specific ARARs are presented in Tables 3-1 through 3-3, and general compliance considerations for these ARARs are discussed in Section 5.2.2. Water column PCB levels are predicted to meet the CWA aquatic life criterion for chronic exposure to PCBs by approximately 2026 for Alternative 10. The CWA-AWQC for navigable waters (0.001 µg/L) and the New York State standard for the protection of human health or wildlife would not be met within the projection period due to releases during dredging and site background PCB loading conditions accounted for in the model projections. Technical impracticability waivers may be required for these ARARs under Alternative 10.

It is expected that all action-specific and location-specific ARARs (Tables 3-2 and 3-3) would be achieved for Alternative 10, as discussed in Section 5.2.2.

5.3.9.3 Long-term Effectiveness and Permanence (Alternative 10: T1-T72 Dredging/Capping)

As discussed in Section 5.2.3.1, long-term effectiveness and permanence under Alternative 10 would be achieved by dredging of T1-T72 near shore and main channel including the area susceptible to remobilization due to periodic ice jam- related scour and by reductions in surface sediment PCB concentrations attributed to source control, ongoing natural recovery processes, and capping. The long-term effectiveness and permanence of capping are dependent on the physical stability of the cap and the ability of the cap to mitigate movement of PCBs from the underlying sediments into the water column over the long term. Each of these issues was evaluated in detail as discussed in Section 5.2.3.3.

Limitations and uncertainties associated with dredging of the main channel under Alternative 10 are consistent with the other main channel dredging alternatives as discussed in Section 5.3.6.3.

Following implementation of the dredging elements of Alternative 10, longer-term reductions in Grasse River fish PCB levels and PCB loading to the St. Lawrence River would occur as a result of Alcoa's completed source control actions, placement of the backfill and caps associated with this alternative, and ongoing natural recovery processes. Surface sediment concentrations are expected to be further reduced after the placement of caps through natural recovery processes. Armored capping is expected to provide protection against periodic ice jam-related scour and remobilization of PCBs for the main channel sediments between T1 and T21 as described in Section 5.2.3.3. .

Fate and transport model predictions for Alternative 10 are illustrated on Figure 5-9, and are summarized in the table below.

Alternative	River-wide Average Fish Tissue PCB Levels				Average PCB Loading to St. Lawrence River (1)	River-wide Average Sediment (0-3") PCB Levels
	Estimated Dates to Reach			PCB Levels in 2036 (mg/kg)	Estimated Dates to Reach	
	0.36 mg/kg	0.26 mg/kg	0.05 mg/kg		85% Reduction	1 mg/kg
10	2032	2035	>2036	0.24	>2035	2028

Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.

The dredging component of Alternative 10 would target the permanent removal of approximately 1,664,000 in-situ cy of sediments containing an estimated 42,000 lb of PCBs from the lower Grasse River. As discussed in Section 5.2.3.2, during ROPS dredging activities, PCBs were released to the water column and a residual PCB mass remained in the post-dredge surface sediments (Alcoa, May 2006). A similar condition would be anticipated during implementation of this alternative.

Based on site-specific studies and modeling, the caps would address each of the potential fate and transport processes in the lower Grasse River, which could remobilize PCBs in the future. Institutional controls would be put in place to maintain integrity of the cap, and long-term monitoring and maintenance would provide a means for identification and subsequent repairs if necessary.

Even though the intention of Alternative 10 is to remove all PCB-containing sediments equal to greater than 1 ppm, it is anticipated that the main channel dredging will leave residual sediment concentration greater than 1 ppm. Because this alternative would most likely result in contaminants remaining above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed every five years, at a minimum. Alternative 10 would include monitoring associated with the five year reviews.

5.3.9.4 Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 10: T1-T72 Dredging/Capping)

Consistent with all other alternatives considered herein, a reduction in toxicity, mobility, or volume through treatment would not occur because Alternative 10 does not include a treatment component. Removal of approximately 1,664,000 in-situ cy of sediment from the river via dredging under this alternative would reduce the potential of future mobility and volume of the PCB-containing sediment in the lower Grasse River. Based on experience during the NTCRA and ROPS, there may be an increase in PCB mobility during the dredging of Alternative 10, similar to those described in Section 5.3.3.4.

Detailed discussions of reduction of toxicity, mobility, or volume related to the dredging, capping, and natural recovery components of these alternatives are provided in Section 5.2.4.

5.3.9.5 Short-term Effectiveness (Alternative 10: T1-T72 Dredging/Capping)

The short-term effects of implementation of Alternative 10 would extend over approximately 18 years. These short-term impacts, and measures to be taken to minimize these effects to the extent practicable, are described in Section 5.2.5. Alternative 10 includes dredging and therefore would have short-term impacts, including disruption of existing benthic habitat, removal of SAV, and the potential for shoreline destabilization associated with removal of sediments from these areas of the river.

Results of the numerical modeling for Alternative 10 are illustrated on Figure 5-9. The short-term risk associated with this alternative is illustrated by the period of predicted increases in fish tissue concentrations.

Approximately 1,664,000 in-situ cy of sediment would be removed over 246 acres of the near shore and main channel under Alternative 10, resulting in an anticipated 1,270 lbs of PCBs being transported downstream. Measures will be taken to minimize the downstream transport of PCB-containing sediment during dredging.

Similar to that described in Section 5.3.3.5, approximately 9,000 miles of truck travel would be required to transport dredged sediment to the on-site landfill, which is anticipated to be limited to Alcoa's property and County Route 42 between Kinnie Road and east of Alcoa Road. Approximately 44 million miles of truck travel would be required on public roads to carry removed potentially contaminated materials to an off-site landfill, along with approximately 1 million miles of truck travel on public roads to deliver the needed clean capping materials for Alternative 10. Given the large volume of materials to be transported, alternate means of transport would be evaluated during the detailed design.

5.3.9.6 Implementability (Alternative 10: T1-T72 Dredging/Capping)

Implementability issues for this alternative, including technical and administrative feasibility, are discussed in Section 5.2.6. As documented during the NTCRA and ROPS activities and discussed previously, site-specific conditions affect the practicability of removing sediment from the targeted main channel areas.

Based on the anticipated production rates, in-water construction under Alternative 10 would be spread over approximately 18 construction seasons. Alcoa's on-site Secure Landfill would be utilized to permanently contain a portion of the sediment dredged under Alternative 10, with the majority of sediment requiring off-site disposal at an approved landfill(s).

As discussed in Section 5.2.6, necessary personnel and services are likely to be available for the 18-year project duration to implement Alternative 10. However, prediction of local equipment availability for such long duration projects is uncertain.

5.3.9.7 Cost (Alternative 10: T1-T72 Dredging/Capping)

The estimated present worth of Alternative 10 is approximately $1.27 billion (B). This cost is based on the anticipated construction period for dredging and cap placement (18 years), followed by a 30-year post-construction monitoring and maintenance period using a 7 percent discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in present day dollars, and all capital cost expenditures are assumed to occur at the start of the project. Details of this cost estimate are provided in Appendix C.

6. Comparative Analysis of Alternatives

6.1 Introduction

Section 5 presents a detailed individual analysis of each of the 10 remedial alternatives developed for the lower Grasse River against seven of the nine NCP evaluation criteria. The results of that analysis are used in this section to compare relative advantages and disadvantages of the alternatives, consistent with USEPA guidance (October 1988; December 2005). The list of remedial alternatives is provided in Table 4-6, along with the alternative number (and descriptions) used throughout this section.

6.2 Overall Protection of Human Health and the Environment

As discussed in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 7-7) and in Section 5.2, the NCP evaluation of overall protectiveness of MNR, capping, and dredging remedies is highly site-specific, and addresses the following general attributes of these remedial technologies:

- **MNR**: Generally relies upon natural processes to provide for relatively low levels of short-term protection, but may provide potentially acceptable long-term protection.

- **Capping**: Generally relies upon adequate cap placement and maintenance for protection, and may provide moderate to high level of protection, depending upon areal extent, design of cap, and long-term maintenance.

- **Dredging**: Generally relies upon effective removal and low residual levels for protection, and may provide moderate to high level of protection, depending on resuspension, releases, residual characteristics and whether the remedy is combined with backfilling, capping, and/or MNR.

As described in Section 3.2, protection of human health and the environment is achieved by reducing PCB levels in fish and other biota. To accomplish this reduction, the remedial alternatives would need to address the diffusive flux of PCBs from surface sediments, which currently is the primary source of PCBs to the lower Grasse River fish. This is achieved through the placement of sand/topsoil caps (with or without armoring, as necessary) over the river sediments and ongoing natural recovery. The design thickness and armoring of the caps included in the alternatives is dependent on the location within the river and the specific application, as discussed in Section 5.2.3.3. As discussed in Section 5, activated carbon technology could be used to supplement or replace some of the sand/topsoil cap applications outlined in this AA Report (Alcoa, November 2010a).

Although the level of protectiveness and time frames vary, all of the alternatives listed in Table 4-6 are projected to reduce PCB levels in fish over time and, therefore, offer varying degrees of protection to human health and the environment. Those remedial alternatives that include provisions to prevent remobilization of PCBs in the main channel sediments vulnerable to ice jam-related scour (main channel sediments between T1 and T21) would provide more protectiveness than those that do not. Remedial actions with capping or dredging in combination with capping to address ice jam-related scour are included in all alternatives with

active remediation (i.e., all but Alternatives 1 and 2). These actions include placing a 25-inch thick armored cap over either the existing native sediments (Alternatives 3 through 6) or post-dredge residual sediments (Alternatives 7 through 10). It is anticipated that all of the alternatives would require maintenance of the current fish consumption advisories until the NYSDOH determines they are no longer necessary and modifies the fish consumption advisory.

Each alternative relies in part on ongoing site-wide natural recovery processes. Long-term site-specific monitoring data have demonstrated that these processes are effective (a 90 percent reduction in fish tissue PCB concentrations since the 1990s) due to the reduction of PCB discharges to the river through land-based source control efforts previously completed by Alcoa (see Section 2.2.2) and ongoing natural sedimentation (see Section 5.2.1.1). The natural recovery processes have and would continue to reduce surficial sediment PCB concentrations, resulting in reduced PCB levels in Grasse River fish tissue and PCB loading to the St. Lawrence River. Alternatives 1 and 2 rely solely on these processes.

Alternatives 1 and 2 are also the only alternatives where provisions (i.e., armored capping) are not included to address ice jam-related scour in the main channel. The absence of these provisions could slow the rate of natural recovery through the periodic (on order of once a decade) ice jam-related scour events that are capable of disturbing PCBs in the deeper portion of main channel sediments in the reach of the river vulnerable to ice jam scour. However, as discussed in Section 5.2.3.1, site data do not indicate that such events substantively disrupt river-wide natural recovery. No significant changes in water column, sediment, and fish tissue PCB concentrations were observed as a result of the 2003 ice jam event (Alcoa, April 2009).

Alternatives 3 through 10 include combination remedies of dredging (between approximately 26,000 and 1,664,000 in-situ cy) and capping (325 acres), including capping of all areas targeted for dredging based on expected PCB residuals. The removal of sediment under these dredging alternatives is not expected to result in a reduction of the PCB flux from surface sediments. Site-specific data from the NTCRA and ROPS indicate that main channel surface sediment PCB concentrations would increase as a result of dredging, primarily due to the inability of dredging equipment to remove all sediments from the target area (Bridges et al., February 2008), along with higher PCB levels that typically exist at depth in the lower Grasse River which contribute to post-dredge residuals (see Section 5.2.1.2).

Conversely, placement of clean capping materials is an effective means of reducing surface sediment PCB concentrations and is, therefore, incorporated as a post-dredge residuals management technique for each of the alternatives that have a dredging component. The extensive modeling and monitoring work conducted on the river, taken together in a weight of evidence evaluation, support the conclusion that properly designed caps are expected to be stable over the long term.

Capping-only Alternative 3 (T1-T72 Capping) provides overall protection of human health and the environment through completed source control actions, the isolation of PCB-containing sediments through capping (armored, main channel, and near shore), and ongoing natural recovery processes. These actions directly address the sources of PCBs to fish and other biota including the diffusive flux of PCBs from surface sediments to the water column. As discussed previously, the extensive modeling and monitoring work conducted on the river, taken together in a weight of evidence evaluation, support the conclusion that properly designed caps are expected to be stable over the long term. Potential negative impacts on water

quality, habitat, and human health with this alternative are lower than any of the other alternatives except for Alternatives 1 and 2 (No Further Action and MNR, respectively).

6.3 Compliance with ARARs

As discussed in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 7-7), the NCP evaluation of ARARs is also highly site-specific, and addresses the following general attributes of these remedial technologies:

- **MNR**: Generally, only chemical-specific ARARs apply (these would also apply to other remedial approaches).

- **Capping**: Generally, key ARARs to be addressed include CWA §404 (which regulates discharge of dredged or fill materials into waters of the U.S.) and the Rivers and Harbors Act (which prohibits obstruction or alteration of a navigable waterway).

- **Dredging**: Generally, CWA §404 and the Rivers and Harbors Act are also ARARs for dredging, and treatment facilities should meet substantive requirements of the CWA §§404 and 401 for discharge of effluents into waters of the U.S. State solid and hazardous waste rules and RCRA are also generally ARARs for disposal of dredged material in solid or hazardous waste landfills.

Identified chemical-specific, action-specific, and location-specific ARARs (presented in detail in Tables 3-1 through 3-3) and compliance with these ARARs are discussed in Section 5.2.2. Table 6-1 summarizes the time to achieve the chemical-specific ARARs for each alternative based on 30-year projections of the river-wide average water column PCB levels from the Study Area-specific modeling (Appendix A).

Table 6-1: Time to Achieve ARARs

Alternative	Time To Achieve River-wide Average Water Quality Criteria			
	CWA		New York State Surface Water Standard	
	Chronic aquatic life 0.014 µg/L	Navigable water 0.001 µg/L	Wildlife 1.2×10^{-4} µg/L	Human health 1×10^{-6} µg/L
1 / 2	2011	>2036	>2036	>2036
3	2011	2026	>2036	>2036
4	2014	2031	>2036	>2036
5	2015	2031	>2036	>2036
6	2016	2031	>2036	>2036
7	2017	>2036	>2036	>2036
8	2020	>2036	>2036	>2036
9	2021	>2036	>2036	>2036
10	2026	>2036	>2036	>2036

Based on site-specific modeling, none of the alternatives evaluated are capable of achieving all potential chemical-specific ARARs. Alternatives including the most significant dredging components (Alternatives 7 through 10) are projected to require the longest time to achieve the chemical-specific ARARS; longer than the no further action and MNR alternatives (Alternatives 1 and 2, respectively) or the alternatives with less significant dredging volumes. All of the alternatives with active remediation (Alternatives 3 through 10) achieve the CWA aquatic life criterion for chronic exposure to PCBs and those with a capping focus (Alternatives 3 through 6) achieve the CWA-AWQC for navigable waters within the projection period. None of the alternatives achieve the New York State standard for the protection of wildlife or the New York State Surface Water Quality Standard for PCBs within the projection period. This is due to site background PCB loading conditions, which have been accounted for in model projections. As such, it is anticipated that a technical impracticability waiver would be required for these ARARs under any remedial alternative.

It is anticipated that all applicable action-specific and location-specific ARARs could be met during implementation of all alternatives.

6.4 Long-term Effectiveness and Permanence

As discussed in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 7-7, 7-8), the NCP evaluation of long-term effectiveness and permanence addresses the following general attributes of remedial technologies with respect to the magnitude of risk reduction, residual risk, and adequacy and reliability of controls for residual risk:

- **MNR**: With respect to the magnitude of risk reduction and residual risk, may provide low to high level of risk reduction depending on processes being relied upon and site-specific characteristics that might enhance the long-term isolation or destruction of contaminants. With respect to the adequacy and reliability of controls for residual risk, may provide low control, but potentially acceptable, depending on processes being relied upon and site-specific conditions.

- **Capping**: With respect to the magnitude of risk reduction and residual risk, may provide moderate to high level of risk reduction and low to moderate residual risk, depending on cap design, placement, construction and maintenance to address site characteristics that might otherwise prevent long-term isolation of contaminants**.** With respect to the adequacy and reliability of controls for residual risk, may provide moderate to high control, depending on cap stability and contaminant migration through cap.

- **Dredging**: With respect to the magnitude of risk reduction and residual risk, may provide moderate to high level of risk reduction and low to moderate residual risk, depending on the effectiveness of dredging and use of backfill material. With respect to the adequacy and reliability of controls for residual risk, may provide high control due to removal of contaminants, if residual contamination is below cleanup levels or addressed through backfilling or capping.

Evaluations of the long-term effectiveness and permanence provided by each alternative considered factors such as the magnitude of risk remaining following implementation and the adequacy of control measures. The potential success of each alternative in meeting the RAOs identified in Section 3.3 forms the basis for the comparative assessment of long-term effectiveness and permanence, as summarized below.

RAOs #1, #2, and #5: Reduce PCBs in fish to levels protective of potential human and ecological consumers, and minimize the transport of PCBs from the lower Grasse River to the St. Lawrence River.

To quantitatively compare each alternative's ability to meet these RAOs, site-specific modeling (described in detail in Appendix A and summarized in Section 5) was performed to predict PCB levels in Grasse River fish tissue and PCB loading to the St. Lawrence River. Metrics included the time necessary to achieve river-wide average fish tissue PCB concentrations (i.e., 0.36 mg/kg, 0.26 mg/kg, and 0.05 mg/kg), as well as an 85 percent reduction in PCB loading to the St. Lawrence River. Table 6-2 summarizes these predictions for the list of alternatives presented in Table 4-6. Time-trend plots of the Grasse River fish tissue and PCB loadings to the St. Lawrence River over the 30-year projection period are presented for all alternatives on Figures 6-1 and 6-2.

Based on the results of the modeling work, the alternatives can be grouped into four general categories:

- Alternatives 1 and 2 would result in gradual improvements in river-wide average fish tissue PCB concentrations and PCB loadings to the St. Lawrence River over time, but do not reach either a 0.36 mg/kg tissue concentration or an 85 percent St. Lawrence River loading reduction within the 30-year model projection period (i.e., after approximately 2036);

- Alternatives 3 through 6 would result in short-term reductions in Grasse River fish tissue PCB levels, and would achieve a 0.36 mg/kg tissue concentration by 2018 to 2019 and an 85 percent St. Lawrence River loading reduction by approximately 2016 to 2018;

- Alternatives 7 through 9 would result in significant short-term increases in Grasse River fish tissue PCB levels (relative to natural recovery trajectories; see Figure 6-1), and these alternatives would achieve a 0.36 mg/kg tissue concentration by 2022 to 2025 and an 85 percent St. Lawrence River loading reduction by approximately 2022 to 2027; and

- Alternative 10 would result in significant short-term increases in Grasse River fish tissue PCB levels (relative to natural recovery trajectories; see Figure 6-1), and this alternative would achieve a 0.36 mg/kg tissue concentration by 2032 and an 85 percent St. Lawrence River loading reduction sometime after 2035.

Table 6-2: Model Predictions of PCB Levels in Grasse River Fish Tissue and PCB Loading to the St. Lawrence River

Alternative [2][3]		River-wide Average Fish Tissue PCB Levels			Average PCB Loading to St. Lawrence River [1]
		Estimated Dates to Reach			Estimated Dates to Reach
		0.36 mg/kg	0.26 mg/kg	0.05 mg/kg	85% Reduction
1	No Further Action	>2036	>2036	>2036	>2035
2	Monitored Natural Recovery	>2036	>2036	>2036	>2035
3	T1-T72 Capping	2018	2019	>2036	2016
4	T1-T21 Near Shore Dredging//Backfilling and Main Channel Capping, T21-T72 Capping	2018	2019	>2036	2016
5	T1-T72 Near Shore Dredging >10, Near Shore Capping >1, and Main Channel Capping	2019	2020	>2036	2017
6	T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping	2019	2020	>2036	2018
7	T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping 1/1	2022	2026	>2036	2022
8	T1-T21 Dredging/Capping, T21-T72 Capping	2025	2031	>2036	2027
9	T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping	2025	2029	>2036	2027
10	T1-T72 Dredging/Capping	2032	2035	>2036	>2035

[1] Percent reductions for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2010 and 2012.
[2] For purposes of these predictions, all caps were assumed to be 95 percent effective in reducing sediment PCB concentrations (see Appendix A).
[3] For purposes of these predictions, PCB releases during dredging were assumed to equal 3 percent of the PCB mass removed and the post-dredging PCB residual was assumed equal to the SLWA PCB concentration of the removed sediments (see Appendix A).

Based on evaluation of the information presented in this AA Report, a comparison of the different remedial components for each of the alternatives relative to the model projections provided above supports the following observations:

- The no further action alternative and MNR alternatives (Alternatives 1 and 2) provide for reductions in PCB concentrations in fish tissue over time, but the rate of recovery is slower than the other alternatives. Additionally, the recovery of the system under Alternatives 1 and 2 could be periodically interrupted by ice jam-related scour events, which could further slow the rate of natural recovery.

- Primarily capping-based alternatives (Alternatives 3 through 6) can accelerate the rate of decline for both PCB levels in Grasse River fish and PCB loading to the St. Lawrence River relative to natural recovery.

- The addition of a significant amount of main channel dredging does not improve the rate of reduction for PCB levels in Grasse River fish or PCB loading to the St. Lawrence River regardless of the volume

dredged, and the larger dredging remedies (Alternatives 7 through 10) are projected to significantly extend the time frame for achieving the metrics for both Grasse River fish tissue and PCB loading to the St. Lawrence River.

- The protectiveness and effectiveness of the dredging in combination with capping alternatives (Alternatives 4 through 10) are driven by placement of a cap over the dredged areas to reduce surface PCB levels and not by dredging.

- Considering each alternative's relative ability to achieve these RAOs and the limitations of dredging effectiveness based on site-specific conditions, the alternative with river-wide capping in combination with natural recovery (Alternative 3) provides the greatest and most rapid reductions in PCBs in fish tissue to levels that are protective of potential human and ecological consumers. Alternatives 4 through 6 which include limited dredging and river-wide capping in combination with natural recovery will achieve similar fish tissue concentrations.

RAO #3: Minimize the current and potential future bioavailability of PCBs in sediments.

This evaluation is similar to that for RAOs #1, 2, and #5, as achievement of this objective would be reflected in reductions in PCB levels in Grasse River fish and the water column (as evidenced by the PCB loading to the St. Lawrence River).

RAO #4: Protect the ecosystem of the lower Grasse River.

This RAO would be addressed through implementation of Alternatives 1 and 2, as neither contains any actions that would disturb the ecosystem. However, effects to the ecosystem resulting from the presence of PCBs would continue for a longer period of time for Alternatives 1 and 2 relative to the other alternatives involving capping or capping in combination with dredging.

Implementation of Alternatives 3 through 10 would have varying levels of impacts to the ecosystem depending on the nature of the remedial action and the duration of the implementation phase. Alternatives that include more extensive dredging would result in increased impacts to the ecosystem resulting from resuspension and destruction of benthic habitat during dredging (Alternatives 7 through 10).

Alternatives that rely on capping as the primary remedial action would result in lesser impacts to the ecosystem than those that have significant dredging components. The placement of capping materials (i.e., sand/topsoil mix), as well as anticipated natural sedimentation on top of the placed caps, are expected to promote benthic recolonization due to the similarities of the capping material to the existing Grasse River sediments.

Based on the considerations outlined above (i.e., spatial areas impacted, duration of remediation, extent of dredging components, and post-construction substrate conditions), Alternatives 7 through 10 are expected to result in the largest impacts to the ecosystem. These alternatives target the largest areas/volumes for dredging (between approximately 258,000 to 1,664,000 cy over 59 to 246 acres) and would extend over the

longest time period (5 to 18 years). Alternative 3, which includes capping without dredging over the shortest duration (3 years), would result in the least impact to the existing ecosystem relative to the other intrusive alternatives.

Long-Term Stability of Sediments and Permanence

USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 3-15) specifically states that capping is capable of reaching acceptable levels of both short-term and long-term effectiveness and permanence, based on site-specific circumstances. This is also consistent with the NCP requirements to evaluate remedy permanence on a site-specific basis. Caps can be designed to ensure their stability and control contaminant migration, such that the long-term effectiveness and permanence of capping alternatives can be similar to that provided by alternatives including dredging with capping to address dredging residuals. The long-term effectiveness and permanence provided by each alternative is determined based on the magnitude of risk remaining following implementation, and the adequacy of residual risk control measures.

The detailed analysis of individual alternatives presented in Section 5 included an assessment of the long-term stability and permanence of currently buried PCB- impacted sediments as well as the stability and permanence of capping materials placed as a component of each alternative. Issues related to long-term capping effectiveness and permanence of caps include understanding cap stability, as well as the ability of the cap to isolate PCB-containing sediments from the water column and biota. As discussed in detail in Section 2.4, a significant amount of information relevant to this issue has been developed to date, including:

- Fish, sediment, and water column monitoring performed prior to and following a significant high-flow event;
- Extensive hydrodynamic, ice, and sediment transport modeling incorporating laboratory measurements and site-specific field measurements;
- Bathymetric comparisons collected over various points in time;
- High-resolution sediment core analysis; and
- Water column TSS/PCB data collected during both normal and high-flow events.

The weight of evidence from these studies indicates that both the native sediments and a cap constructed from similar materials are expected to remain stable under non-ice conditions.

The 2003 ice jam event demonstrated that ice jam-related scour is a mechanism that can mobilize and re-distribute buried sediments and PCBs in the upper reach[8] of the lower Grasse River. PCBs in buried main channel sediments upstream of T21 are potentially vulnerable to ice jam-related scour, while PCBs in buried sediments downstream of T21 are currently stable and effectively sequestered. PCBs in buried sediments in the main channel within the ice scour prone section of the river can be stabilized and effectively sequestered through placement of an armored cap designed in accordance with USEPA and USACE guidance (see Section 4.4).

Effects of propeller wash, scour from recreational boats, and placement of anchors on the cap (see Section 2.4.6 and Appendix B) have been evaluated, and the results of this work indicate that these activities are expected to have little effect on the overall stability of a cap.

With regard to PCB migration through the cap, PCBs isolated under the cap would migrate into the cap very slowly via molecular diffusion, and the fastest migration rate would be lower than the lower-bound estimated sedimentation rate of about 0.2 cm/yr (see Section 2.4.3 and Appendices A and D). Finally, groundwater passing through the deeper sediments was evaluated through both modeling and field measurements and found not to be an important transport process for moving PCBs from deeper sediments into the water column (see Section 2.4.5).

6.5 Reduction of Toxicity, Mobility, or Volume through Treatment

As discussed in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 7-8), the NCP evaluation of reduction of toxicity, mobility, or volume through treatment addresses the following general attributes of remedial technologies:

- **MNR**: No treatment is involved beyond natural in-situ processes.

- **Capping**: Typically, no treatment is involved in capping. However, the potential mobility and bioavailability of the contaminants is significantly reduced by placement of the cap material. Additionally, studies such as the Grasse River ACPS described in Section 2.5.4 suggest that promising in-situ treatment options (activated carbon) could be applied at the site.

- **Dredging**: Sediment is treated in some cases if practical and cost-effective (stabilization is the most common form), and the potential exists for beneficial reuse of relatively clean components of dredged sediment (e.g., sand, gravel, and woody debris). Mobility can be eliminated to the extent that the PCB mass is successfully removed; however, the post-dredge residuals that remain can be more mobile than

[8] As discussed in Section 4.4.1, the results of the river ice investigation identified the T1 to T19 reach of river as potentially vulnerable to ice jam-induced scour (Alcoa, April 2009). For the purposes of remedy development, however, T21 has been used to define the downstream extent of this reach. This was done to recognize the fact that the contiguous fine sediment deposit in this portion of the river extends beyond T19 down to T21, and that any remedy developed to address this deposit would consider the entire deposit and not just the portion that is susceptible to ice jam-induced scour.

prior to dredging, due to the disturbance of the cohesive sediment bed and/or the exposure of higher subsurface PCB concentrations that are present at depth.

Under this NCP criterion, the degree to which each alternative reduces the toxicity, mobility, or volume through treatment was evaluated in Section 5.3. Presently, none of the alternatives include treatment, although activated carbon technology could potentially be integrated into one or more of the remedial alternatives listed in Table 4-6.

In-river reductions in mobility and toxicity are expected to occur through implementation of all potential alternatives. Natural recovery processes (a component of all alternatives) are expected to reduce the quantity and concentration of PCBs available for biological exposure and downstream transport over the longer term as evidenced by the declines in fish tissue and water column PCB levels at the site. Placement of caps, which is a component of all remediation alternatives except Alternatives 1 and 2, would further reduce the potential future bioavailability and mobility of PCBs through isolation of PCBs contained beneath the cap.

Implementation of those alternatives that include dredging (Alternatives 4 through 10) would reduce the mass of PCBs in the lower Grasse River through permanent removal of this material; however, reduction of PCB mass does not necessarily equate to a reduction in risk (NRC, 2007). In addition, alternatives that include a dredging component could result in a greater bioavailability and mobility of PCBs in targeted sediments over the short term, depending on the degree of resuspension, release, and the residual PCB concentrations observed. The magnitude of this concern is related to the size (volume and duration) of the dredging program. Thus, the larger dredging programs (Alternatives 7 through 10) would result in the greatest increase in the bioavailability and mobility of PCBs in the sediments.

6.6 Short-Term Effectiveness

As discussed in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 7-9, 7-10), the NCP evaluation of short-term effectiveness addresses the following general attributes of remedial technologies:

- **MNR**: Generally, this technology is associated with the longest time to achieve protection, depending on rates of natural processes and bioavailability of the contaminants, but there are no additional impacts to ecological communities and public/worker protection from the remedy itself.

- **Capping**: Typically, this technology is associated with the shortest time to achieve protection, and complete biota recovery can take several years; generally, there is a low potential for health impacts to community and workers from contaminant releases during cap placement.

- **Dredging**: The time to achieve protection varies depending on the size (volume and duration) and complexity of the project and is generally more uncertain than for capping due to difficulty of accurately predicting target sediment volumes and residual contamination; environmental impacts may occur from resuspension and releases to the environment during dredging; and there is a low to moderate potential for health impacts to community and workers from contaminant releases during dredging.

This criterion is used to evaluate the effects and risks associated with alternative implementation considering protection of the community and workers and the expected effects on the environment. This criterion also considers the effectiveness of mitigation measures and the time until protection is achieved through consideration of near-term improvements resulting from alternative implementation. Key considerations in the assessment of short-term effectiveness include the following:

- **Duration of the remedial action**: Longer duration alternatives would pose increased short-term impacts to the ecosystem, the community, and workers.

- **Type and extent of the remedial action**: The dredging components of the alternatives are expected to result in a significantly higher degree of short-term impacts compared to the capping components. As discussed in Section 5.2.3.2, dredging activities during the ROPS resulted in PCBs being released to the water column, and a residual PCB mass remained in the post-dredge surface sediments (an average of 150 mg/kg of PCBs and 16 inches of remaining sediment) (Alcoa, May 2006). While the rate of sediment dredging would likely be limited by water quality constraints, periodic exceedances of water quality corrective action levels for PCBs at the downstream compliance point could still occur during debris removal and/or dredging operations, consistent with the findings of the NTCRA and ROPS. Measures will be taken to minimize the downstream transport of PCBs contaminated sediment during dredging. Short-term impacts associated with cap placement are expected (primarily turbidity and surface foam from the capping materials themselves), but the results of both the CPS and ROPS indicate that resuspension of PCB-containing material and associated adverse effects on the water column were minimal.

- **Potential community impacts**: Potential impacts to the community could result from increased traffic (either over land or in-water) associated with the transport of dredged material to disposal facilities or the transport of clean capping materials to the site. In addition, there are potential risks to site workers. Alternatives involving larger impacts and longer durations (such as those that include a significant volume of dredging) generally expose workers to higher risks. The dredging components of the alternatives also generally represent a higher risk to site workers than the capping components due to the potential exposure to contaminated sediments.

Table 6-3 presents a summary of dredge/removal and cap quantities, anticipated transportation distances, and project durations for each of the alternatives. The alternatives are listed and described below in terms of the least to greatest anticipated short-term impacts.

Table 6-3: Summary of Short-Term Impacts from Transportation

Alternative	Dredging/Removal			Capping		Total Duration (years)
	Approximate Expected Volume [1] (in-situ cy)	Expected Area [1] (acres)	Total Truck Miles (millions of miles) [2,3,4]	Area (acres)	Total Truck Miles (millions of miles) [5]	
1	---	---	---	---	---	---
2	---	---	---	---	---	---
3	0	0	---	325	890,000	3
4	25,900	10	2,000	325	920,000	3
5	46,100	13	4,000	325	940,000	4
6	108,700	41	250,000	325	1,000,000	4
7	258,300	60	4,450,000	325	1,010,000	5
8	355,100	59	7,160,000	325	920,000	8
9	633,200	117	14,960,000	325	1,010,000	7
10	1,663,500	246	43,860,000	325	1,000,000	18

(1) Expected dredge/removal volumes and areas based on previous site investigations and the inclusion of site-specific volume increase factors; volumes are used in AA cost estimates.
(2) Assumes 20 cy per truck.
(3) Assumes 1 cy of in-situ sediment is equivalent to approximately 0.85 cy of dewatered sediment per ROPS data.
(4) Assumes 2 miles roundtrip to Alcoa's on-site Secure Landfill and 660 miles roundtrip to suitable regional landfill facilities.
(5) Assumes an average 30 mile roundtrip from local capping material sources, based on recent St. Lawrence River project experience.

Alternatives 1 and 2 do not involve capping and/or dredging, so there would be no short-term risks to site workers, the environment, or the community associated with each of these alternatives. With respect to near-term improvements related to alternative implementation, these alternatives would require the longest period of time for reduction of PCB levels in Grasse River fish and PCB loading to the St. Lawrence River.

For the remaining alternatives, Alternative 3 (capping only T1 to T72), would have the lowest short-term impact based on the duration for implementation (see Table 6-3) and the lack of environmental impacts observed during similar remedial actions (e.g., the CPS and capping aspects of the ROPS). Possible impacts associated with Alternative 3 would include disruption to recreational boating, transportation accidents, and short-term impacts on the ecosystem, which are also potential impacts associated with Alternative 4 through 10.

The application of cap materials in all alternatives would not be expected to result in water quality or air quality impacts based on the results of the CPS and ROPS (as described in Sections 2.5.2 and 2.5.3, respectively). Cap placement methods to minimize mixing with underlying sediments would be evaluated during remedial design.

Alternatives 4 through 6 rank next after Alternative 3 with respect to potential short-term impacts. In general, the durations of Alternatives 4 through 6 are equal to or slightly longer in duration than Alternative 3 and target similar areas of the river for active remediation (see Table 6-3). However, in addition to capping, Alternatives 4, 5, and 6 include dredging, which is expected to result in increased short-term impacts

compared to Alternative 3 (capping without dredging). Potential short-term impacts associated with dredging include resuspension and release of PCBs during dredging and transport to the disposal area, potential increases in PCB levels in the water column and fish, impacts to the ecosystem from habitat removal, disruption to recreational boating, and exposure of site workers to contaminated sediments. Potential short-term environmental impacts of dredging can result from technical limitations associated with the presence of rocks/cobbles/debris on the river bottom and the presence of bedrock/hardpan under the PCB-containing sediments. These factors limit removal efficiency and contribute to resuspension and release of PCBs, which can affect both PCB levels in fish and the water column as was observed during the NTCRA and ROPS.

Alternatives that include dredging of the near shore areas also have the potential to destabilize the adjacent banks due to the physical removal of material at the toe of the slopes, removal of SAV root systems, and injury to root systems for shore-based vegetation. These impacts would be greatest for the alternatives that include significant near shore dredging in the T1 to T72 reach (Alternatives 4, 6, 7, 9, and 10), less for those which only include focused near shore dredging (Alternatives 4, 5, and 8) and would not occur for the alternatives which strictly employ near shore capping (Alternative 3).

Additional impacts associated with the dredging and capping alternatives (Alternatives 4 through 10) compared to the capping-only alternative (Alternative 3) include increased opportunity for risk to site workers and the community due to the nature of the operations (e.g., more equipment, traffic, potential for air emissions, and exposure to contaminated sediments). The estimated miles of truck travel for transporting potential contaminated materials for disposal and capping materials for placement is provided in Table 6-3. Truck transport for disposal of removed materials in the on-site landfill would be limited to Alcoa's property and County Route 42 for Alternatives 3 through 5, and Alternatives 6 through 10 would also include truck travel on public roads for transport potentially contaminated materials to an off-site landfill. All alternatives would include truck travel on public roads to deliver the needed clean backfill and capping materials.

Alternatives 7 through 9 would rank next in terms of short-term effectiveness, as they include significantly more dredging that would result in additional short-term impacts. Alternatives 7 through 9 have a longer duration (5 to 8 construction seasons) compared to Alternatives 4, 5, and 6 (3 to 4 seasons). Short-term impacts associated with dredging would be similar to those described above for Alternatives 4 through 6, but on a larger scale and for a longer period of time.

Alternative 10 provides the lowest degree of short-term effectiveness, as the largest area of the river would be impacted by dredging for an extended period of time (18 construction seasons – see Table 6-3). The magnitude of the potential short-term impacts associated with dredging would increase greatly for this alternative in all aspects (environmental impacts, community impacts, and worker safety) because of the dredge volume (approximately 1,664,000 in-situ cy) and duration of dredging.

6.7 Implementability

As discussed in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 7-10, 7-11), the NCP evaluation of implementability addresses the following general attributes of remedial technologies:

- **MNR**: Generally, no construction is required, and thus MNR is relatively easy to implement.

- **Capping**: Typically, cap placement methods are well established, and reliability is generally high depending on site-specific conditions and the degree of monitoring and maintenance.

- **Dredging**: While dredging methods are also well established, the technical feasibility of dredging is highly site-specific, dependent on the extent of debris and dredge residual contamination; disposal capacity may also be an issue.

This criterion includes an evaluation of the ease or difficulty of implementing the alternative by considering technical feasibility, administrative feasibility, and availability of services and materials required during implementation. In general, all potential alternatives are considered to be implementable within the lower Grasse River. Design and implementation of both capping and dredging are administratively feasible, as no permits are required for in-river activities (although such activities would comply with substantive requirements of otherwise required permits), and construction would be performed in accordance with the substantive requirements of ARARs.

Based on site-specific experience during the CPS and ROPS, the design and placement of armored, main channel, and near shore caps/backfill (components of all alternatives except Alternatives 1 and 2) are expected to be technically feasible. Some of the larger dredging alternatives (Alternatives 7 through 10) could require significant off-site landfill capacity for the dredged sediments. Since all of the alternatives include significant capping quantities, coordination with multiple cap material sources may be required to support the project. Alternatives with significant dredging components have increased project durations which increase uncertainty regarding the local availability of necessary materials, equipment, supplies, and services including landfill capacity and capping materials.

Dredging of various sediment volumes is a component of the Alternatives 4 through 10. Operational problems with the dredge were encountered during both the NTCRA and ROPS removal operations in the main channel area. The presence of complex site bottom conditions and debris is expected to reduce the practicability and/or efficiency of removing sediment from the targeted areas. These limitations would be present for all dredging alternatives, but would be amplified for the large dredging components, Alternatives 7 through 10 (dredging ranging from approximately 258,000 to 1,664,000 in-situ cy).

6.8 Cost

As discussed in USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, December 2005 – p. 7-12), the NCP evaluation of cost addresses the following general attributes of remedial technologies:

- **MNR**: Generally, no capital cost, but long-term monitoring costs typically continue until cleanup levels are met.

- **Capping**: Typically, capital costs for capping are generally higher than MNR and lower than dredging.

- **Dredging**: Typically, capital costs for dredging are generally higher than for capping.

An additional consideration with dredging costs is the degree of uncertainty in the volume of sediments to be dredged/removed. As discussed in Sections 4.4.1 and 5.2.6.2, site-specific factors were used to account for constructability considerations (e.g., stable side slopes, efficient dredge lane widths, and overdredge allowances) and uncertainty in the current delineation of contaminated sediments. These site specific volume increase factors (ranging from 1.1x to 1.5x) were applied to the neatline volumes, and are presented as "expected" dredge volumes. These volume increase factors were developed based on site-specific evaluations of site conditions and USACE guidance (Palermo et al., September 2008), which recommends that neatline dredge volumes should be increased by roughly 50 percent from pre-design evaluations to account for the constructability considerations described above.

Table 4-5 presents a summary of the expected dredge volumes compared to the "neatline" volumes used in the cost evaluation of this AA Report.

The NCP cost criterion was used to evaluate the total present worth cost for implementation of each alternative based on the alternative descriptions provided in Section 4.5. Estimated present worth costs for each of the alternatives are provided in the Table 6-4 and these costs form the basis for the discussion which follows. A detailed presentation of these cost estimates is provided in Appendix C. In addition Appendix C presents a sensitivity analysis of costs based on variable unit costs (e.g., dewatering, disposal, silt curtains, and engineering fees) for particular components of the remedy, as requested by USEPA.

Table 6-4: Estimated Costs

Alternative		Estimated Costs (present day $) [1]
1	No Further Action	-
2	Monitored Natural Recovery	$3,400,000
3	T1-T72 Capping	$114,100,000
4	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping	$147,200,000
5	T1-T72 Near Shore Dredging >10, Near Shore Capping >1, and Main Channel Capping	$175,200,000
6	T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping	$243,100,000
7	T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping	$351,600,000
8	T1-T21 Dredging/Capping, T1-T72 Capping	$388,000,000
9	T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping	$588,500,000
10	T1-T72 Dredging/Capping	$1,273,500,000

[1] Specific details of these cost estimates are provided in Appendix C.

In view of the overall objective of reducing PCB levels in fish and other biota, costs for each of the alternatives are plotted versus the projected average river-wide fish tissue PCB concentrations in the year

2036 (Figure 6-3[9]). The alternatives can be grouped into three general categories relative to the projected fish tissue concentrations in 2036. Alternatives 1 and 2 (No Further Action and MNR) are projected to achieve an average 2036 fish tissue PCB concentration of about 0.46 mg/kg at a cost of $0 to $3.4 MM. Alternative 3 is projected to achieve an average 2036 fish tissue PCB concentration of about 0.07 mg/kg or lower at a cost of $114 MM. Alternatives 4 through 6 are projected to achieve a similar average 2036 fish tissue PCB concentration as Alternative 3 (about 0.07 to 0.08 mg/kg) at higher costs that range between $147 MM and $243 MM. Lastly, Alternatives 7 through 10 are projected to achieve the highest 2036 fish tissue PCB concentration (about 0.13 to 0.24 mg/kg) relative to the other active remedial alternatives at significantly higher costs (range between $352 MM and $1.27 B).

In comparing cost effectiveness among the alternative groupings described above, the following observations can be made:

- No Further Action and MNR (Alternatives 1 and 2) are expected to result in a reduction in fish tissue PCB concentrations over time relative to projected 2011 conditions, with river-wide average concentrations projected to decline from about 2.2 mg/kg to 0.46 mg/kg in 2036 (77 percent reduction) at a cost of $0 and $3.4 MM, respectively;

- Alternative 3 is expected to provide additional reductions in fish tissue PCB concentrations relative to MNR (Alternative 2), with river-wide average concentrations projected to decline to about 0.07 mg/kg or less in 2036 (95 percent reduction), at an added cost of about $111 MM (comparing Alternative 3 to Alternative 2);

- Alternatives 4 through 6 achieve essentially the same level of risk reduction by 2036 as Alternative 3, but at an incremental additional cost ranging from $33 MM (comparing Alternative 3 to Alternative 4) to $129 MM (comparing Alternative 3 to Alternative6); and

- Alternatives 7 through 10 achieve less risk reduction by 2036 relative to the other alternatives (89 to 94 percent reduction), and carry a significantly greater cost. In comparison, Alternative 7 costs up to $238 MM more than Alternative 3 and Alternative 10 costs up to approximately $1.16 B more than Alternative 3, with Alternative 3 providing a higher degree of risk reduction based on model projections.

[9] River-wide average fish tissue PCB concentrations in 2036 are presented as predicted by the model, but are rounded throughout the text in consideration of the accuracy of the model predictions.

7. References

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Tables

Table 2-1

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Grasse River Supplemental Remedial Studies Program - Major Studies

Medium	Approximate Number of Sampling Events	Years	Approximate Number of PCB Analyses[1]
Routine Water Column	185	1995-2011	1,891
High Flow	5	1995-1998	120[2]
Tributaries and Plant Outfalls	11	1995-1997	110
Temperature and Conductivity Survey	1	1997	2,400[2]
Dye Study (water)	1	1997	1,000[2]
Float Survey	2	2000-2001	120
Semi-Permeable Membrane Devices	30	1995-1999, 2001	200
Caged Mussels	2	1998	48
Resident Fish	19	1995-2011	3,016
Young-of-Year	3	1998-1999	90
Mark/Recapture Program	5	1998-2000	1,850[2]
Caged Fish	3	1995-1996	150
Benthos	2	1996, 1998	100[2]
Sediment	11	1995, 1997, 2000-2001, 2003, 2004, 2006, 2007, 2010	5,049
Shaker Studies	2	1998, 2000	60[2]
Habitat Survey	1	1997, 2010	37[2]
Groundwater Seepage	2	1998-1999	66[2]
PCB Biodegradation Lab Studies	2+	1995-2000+	100+
PCB Flux Experiments (Lab)	2	1996	120

1. Count does not include QA/QC samples or other analyses (i.e., TSS or TOC).
2. For general characterization (no PCB analyses).
3. Certain sampling events occurring in 1998-2000 were conducted as part of the pre-implementation monitoring associated with the Capping Pilot Study as described in BBL, November 1998.

Acronyms:
PCB = Polychlorinated Biphenyl
QA/QC = Quality Assurance/Quality Control
TOC = Total Organic Carbon
TSS = Total Suspended Solids

Table 2-3.

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Reductions in Tissue and Aqueous PCB Concentrations

Location	Average Percent Reduction in Total PCB Concentration								
	2007			2008			2009		
	Bioaccumulation		Aqueous	Bioaccumulation		Aqueous	Bioaccumulation		Aqueous
	In-situ	Ex-situ		In-situ	Ex-situ		In-situ	Ex-situ	
Background Reference Location									
BG1	53	56	-51	52	67	-58	51	80	58
BG2*	NT	NT	NT	52	57	-118	60	83	68
BG3*	NT	NT	NT	72	81	40	27	81	54
Mixed Tiller Treatment Area									
M1	50	75	82	91	94	99	88	94	99
M2	83	92	99.4	94	93	99	88	95	99
Re-M2	82	NT	NT	NT	NT	NT	NT	NT	NT
M3	88	93	99.0	94	96	98	85	89	93
M4	90	95	99.8	94	97	99	97	97	99.5
M5	91	95	99.8	85	97	95	96	96	99.6
M6	92	94	99.6	93	99	99.6	96	98	99.7
Tine Sled Injected Treatment Area									
UTA 3	NT	84	95	NT	82	76	NT	96	99.9
UTA 5	NT	79	98	NT	86	99.9	NT	90	99.8
UTA 9	NT	53	21	NT	76	64	NT	91	99.6
Unmixed Tiller Layered Treatment Area									
UTA 14	NT	73	95	NT	68	81	NT	93	99.9
UTA 15	NT	69	93	NT	76	94	NT	95	99.9
UTA 17	NT	71	97	NT	85	96	NT	92	99.5

* Percent reduction is determined compared to baseline measurement at reference site BG1

Table 3-1

Grasse River Study Area
Massena, New York
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Chemical-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
FEDERAL ARARs AND TBCs				
Clean Water Act [Federal Water Pollution Control Act, as amended]	33 USC §§ 1251-1387; 40 CFR § 129.105(a)(4)	ARAR	The ambient water quality criterion for navigable waters is 0.001 ug/L total PCBs.	Applicable to Grasse River surface water.
Clean Water Act	33 USC § 1314(a); 63 Fed. Reg. 68354 (December 10, 1998)	ARAR	Criterion for continuous concentration (chronic) for PCBs is 0.014 ug/L in freshwater.	Relevant and appropriate water quality criteria to protect against chronic effects in aquatic life during remedial action.
Guidance on Remedial Actions for Superfund Sites with PCB Contamination	OSWER Directive No. 9355.4-01 dated August 1990	TBC	Provides guidance in the investigation and remedy selection process for PCB-contaminated Superfund sites. Provides preliminary remediation goals for various contaminated media, including sediment (p. 34-36) and identifies other considerations important to the protection of human health and the environment.	May be considered when assessing sediment remediation.
STATE ARARs AND TBCs				
Surface Water and Groundwater Quality Standards	New York State ECL Article 15, Title 3 and Article 17, Titles 3 and 8, 6 NYCRR § 703.5	ARAR	Establishes New York State Water Quality Standards for almost 200 contaminants. For PCBs in surface water, the values are (a) $1x10^{-6}$ ug/L for protection of health of human consumers of fish; and (b) 1.2×10^{-4} ug/L for protection of wildlife.	Applicable requirements for PCB water column concentrations.
"Contained In" Criteria for Environmental Media	TAGM 3028	TBC	Sets minimum values for soil, sediment and groundwater which must be met to preclude its management as hazardous waste.	May be considered in dealing with low level PCB-containing materials.
TRIBAL TBCs				
Sediment Cleanup Standard	St. Regis Mohawk Tribal Council Resolution No. 89-19	TBC	Establishes the St. Regis Mohawk Tribe standard for PCBs in sediments of 0.1 ppm. This is applicable to ambient conditions and cleanup standards.	Will be considered by USEPA in establishing a remedial goal for PCBs in fish that is protective of a Mohawk angler.

Note:
1. Table provides the federal, state, and tribal chemical-specific ARARs and TBC items (guidance materials that have not been promulgated or regulatory standards that are not applicable or relevant that may be considered). While TBCs may be considered along with ARARs, they are not legally binding and do not have the status of ARARs.

Table 3-1
(cont'd)

Grasse River Study Area
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Chemical-Specific ARARs and TBCs

Acronyms:

ARAR = Applicable, Relevant, and Appropriate Requirement
CFR = Code of Federal Regulations
ECL = Environmental Conservation Law
NYCRR = New York Codes, Rules and Regulations
OSWER = USEPA's Office of Solid Waste and Emergency Response
TAGM = Technical and Administrative Guidance Memorandum
ppm = parts per million
PCBs = polychlorinated biphenyls
TBC = "to be considered"
ug/L = micrograms per liter
USC = United States Code
USEPA = United States Environmental Protection Agency

Table 3-2

Grasse River Study Area
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Action-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
FEDERAL ARARs AND TBCs				
Clean Water Act [Federal Water Pollution Control Act, as amended]	Section 404(b) of the Clean Water Act, 33 USC § 1344(b); 40 CFR Part 230	ARAR	Guidelines for Specification of Disposal Sites for Dredged or Fill Material. Except as otherwise provided under Clean Water Act Section 404(b)(2), no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. If there is no other practical alternative, impacts must be minimized. Includes criteria for evaluating whether a particular discharge site may be specified.	Applicable to alternatives that include dredging/filling and pier-type ice control structures.
	Section 404(c) of the Clean Water Act, 33 USC § 1344(c); 40 CFR Part 231; 33 CFR Parts 320-329	ARAR	These regulations apply to all existing, proposed, or potential disposal sites for discharges of dredged or fill materials into U.S. waters, including wetlands. Includes special policies, practices, and procedures to be followed by the USACE in connection with the review of applications for permits to authorize the discharge of dredged or fill material into waters of the U.S. pursuant to Section 404 of the Clean Water Act. In accordance with CERCLA Section 121(e), a permit is not required for on-site CERCLA response actions, although such activities must comply with substantive requirements of these regulations.	Applicable to alternatives that include discharges of dredged or fill materials into U.S. waters.
Solid Waste Disposal Act, as amended - Regulated Levels for TCLP Constituents	40 CFR Part 261	ARAR	Specifies TCLP constituent levels for identifying wastes that exhibit toxicity characteristics.	Provisions of this Part, or equivalent authorized New York State regulations, may be applicable in determining whether sediments removed from the river must be managed (handling and disposition) as a hazardous waste.
Solid Waste Disposal Act, as amended - Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	ARAR	Includes manifest, record keeping and other requirements applicable to generators of hazardous waste.	Provisions of this Part, or equivalent authorized New York State regulations, may be applicable in determining whether sediments removed from the river must be managed (handling and disposition) as a hazardous waste.
Solid Waste Disposal Act, as amended - Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	ARAR	Sets forth standards for transporters of hazardous wastes, including the receipt of an USEPA identification number and manifesting requirements.	Provisions of this Part, or equivalent authorized New York State regulations, may apply to remedial alternatives that include dredging of sediments from the Grasse River that are hazardous wastes.

Table 3-2
(cont'd)

Grasse River Study Area
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Action-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
FEDERAL ARARs AND TBCs (cont'd)				
Solid Waste Disposal Act, as amended - Standards for Owners and Operators of Hazardous Waste, Treatment and Storage Facilities	40 CFR Parts 264 and 265	ARAR	Provides management standards including record keeping, requirements for particular units such as tanks or containers, and other requirements applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities.	For dredging alternatives, if it is determined that sediments removed from the Grasse River contain hazardous waste(s), provisions of this Part, or equivalent authorized New York State regulations, may apply to the sediment transfer facility(ies).
Solid Waste Disposal Act, as amended - Land Disposal Restrictions	40 CFR Part 268	ARAR	Places land disposal restrictions, including treatment standards and related testing, tracking and record keeping requirements, on hazardous waste(s).	Provisions of this Part, or equivalent authorized New York State regulations, may apply to remedial alternatives that include dredging of sediments from the Grasse River that are hazardous wastes.
TSCA	40 CFR Part 761	ARAR	Provides regulations for storage, handling, and disposal of sediment containing PCBs greater than 50 mg/kg.	Applicable to remedial alternatives that include removal and management of sediment with greater than 50 mg/kg PCBs.
USDOT Placarding and Handling	49 CFR Part 171	ARAR	Provides transportation and handling requirements for materials containing PCBs.	Applicable to remedial alternatives that include transport of materials containing PCBs on public roadways.
Rivers and Harbors Act (Section 10)	33 USC § 403; 33 CFR Parts 320, 321 and 322	ARAR	Prohibits unauthorized obstruction or alteration of any navigable water in the U.S. (dredging, fill, cofferdams, piers, etc.). USACE approval is generally required to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of the channel of any navigable water of the U.S. On-site CERCLA response actions are exempt from permit requirements pursuant to CERCLA Section 121(e), although such activities must comply with substantive requirements of these regulations.	Applicable to remedial activities that include dredging, capping, and/or pier-type ice control structures.
Clean Air Act	42 USC §§ 7401-7671q; 40 CFR Parts 50, 51 and 52; NAAQs	ARAR	Identifies emissions requirements for "major" sources of lead, NO_x, CO, PM_{10}, and SO_2 in attainment and non-attainment areas.	Sediment processing facility(ies) required for dredging alternatives would not be a "major" source for purposes of the NAAQs, although the NAAQs would be relevant and appropriate for such a facility(ies).
USEPA Remedial Design/Remedial Action Handbook	EPA 540-R-95-059 OSWER Directive 9355.0-4B	TBC	General reference manual that provides remedial project managers with an overview of the remedial design and remedial action processes.	Would be consulted during remedial design and remedial action.

Table 3-2
(cont'd)

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Action-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
FEDERAL ARARs AND TBCs (cont'd)				
USACE – Design of Breakup Ice Control Structures	USACE Manual No. 1110-2-1612	TBC	Guidance document that describes basic ice control structure types, purposes, and advantages and disadvantages, and provides engineering design guidance for their use.	Would be consulted during remedial design and remedial action.
Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites	OSWER Directive 9285.6-08	TBC	Guidance document that helps USEPA site managers make scientifically sound and nationally consistent risk management decisions at contaminated sediment sites.	Would be consulted during remedy selection, remedial design and remedial action.
Contaminated Sediment Remediation Guidance for Hazardous Waste Sites	EPA 540-R-05-012 OSWER 9355.0-85	TBC	Guidance document that provides technical and policy guidance for project managers and management teams making remedy decisions for contaminated sediment sites.	Would be consulted during remedy selection, remedial design and remedial action.
STATE ARARs AND TBCs				
Solid Waste Management Facilities	New York State ECL Article 27, Title 7, 6 NYCRR Part 360	ARAR	New York State regulations for design, construction, operation, and closure requirements for solid waste management facilities.	Applicable to sediment processing facility(ies) that would be constructed and used in connection with remedial alternatives that include dredging.
Standards for Waste Transportation	New York State ECL Article 27, Title 3, 6 NYCRR Part 364	ARAR	Regulations governing the collection, transport and delivery of regulated wastes, including hazardous wastes.	Applicable to for dredging alternatives that include transport of dredged sediments for disposal.
Identification and Listing of Hazardous Wastes	New York State ECL Article 27, Title 9, 6 NYCRR Part 371	ARAR	Establishes procedures for identifying solid wastes which are subject to regulation as hazardous wastes.	Identifies media containing PCBs in excess of 50 mg/kg as a hazardous waste.
Hazardous Waste Manifest System and Related Standards for Generators, Transporters, and Facilities	New York State ECL Article 3, Title 3; Article 27, Titles 7 and 9; 6 NYCRR Part 372	ARAR	Hazardous Waste Manifest System requirements for generators, transporters, and treatment, storage or disposal facilities, and other requirements applicable to generators and transporters of hazardous waste.	Applicable to the transportation of dredged sediments with greater than 50 mg/kg PCBs.
Hazardous Waste Treatment, Storage, and Disposal Facility Permitting Requirements	New York State ECL Article 3, Title 3; Article 27, Titles 7 and 9; 6 NYCRR Part 373	ARAR	Establishes requirements for treatment, storage, and disposal of hazardous waste; permit requirements (from which on-site response actions are exempt, although substantive requirements would be met); and construction and operation standards for hazardous waste management facilities.	May be applicable to on- and off-site facilities receiving greater than 50 mg/kg PCB materials.

Table 3-2
(cont'd)

Grasse River Study Area
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Action-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
STATE ARARs AND TBCs (cont'd)				
Land Disposal Restrictions	New York State ECL Article 27, Title 9; 6 NYCRR Part 376	ARAR	Identifies hazardous wastes that are restricted from land disposal and defines those circumstances under which an otherwise prohibited waste may be land disposed.	May be applicable to remedial alternatives that include the removal and land disposal of contaminated sediments from the Grasse River.
Use and Protection of Waters	New York State ECL Article 15, Title 5; Article 17, Title 3; 6 NYCRR Part 608	ARAR	A permit is required to change, modify, or disturb any protected stream, its bed or banks, or remove from its bed or banks sand or gravel or any other material; or to excavate or place fill in any of the navigable waters of the state. Any applicant for a federal license or permit to conduct any activity which may result in any discharge into navigable waters must obtain a State Water Quality Certification under Section 401 of the Federal Water Pollution Control Act, 33 USC § 1341. In accordance with CERCLA Sections 121(d)(2) and 121(e), neither a permit nor a water quality certification is required for on-site CERCLA response actions, although such actions would comply with substantive requirements of 6 NYCRR Part 608.	Applicable to remedial activities that include dredging, capping, and/or pier-type ice control structures.
New York State Pollution Discharge Elimination System (SPDES)	6 NYCRR Parts 750 – 758	ARAR	Details the specific permit requirements for the discharge of chemicals to the waters of New York State. In general, no person shall discharge or cause a discharge to New York State waters of any pollutant without a permit under the SPDES program. In accordance with CERCLA Section 121(e), a permit is not required for on-site CERCLA response actions, although on-site CERCLA response actions would comply with substantive requirements of 6 NYCRR Parts 750 - 758.	Applicable to alternatives that include discharge of water back into the River.
Surface Water Regulations	New York ECL § 17-0501 and 17-0301; 6 NYCRR Parts 701 and 703	ARAR	Establishes that it shall be unlawful for any person, directly or indirectly, to throw, drain, run or otherwise discharge into such waters organic or inorganic matter that shall cause or contribute to a condition in contravention of applicable standards adopted by NYSDEC pursuant to § ECL 17-0301.	Applicable to alternatives that include discharge of water back into the River.

Table 3-2
(cont'd)

Grasse River Study Area
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Action-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
STATE ARARs AND TBCs (cont'd)				
Air Pollution Control Law	New York State ECL, Article 19, Title 3. Promulgated pursuant to the Federal Clean Air Act, 42 USC § 7401	ARAR	Establishes that the emission of air contaminants to the outside atmosphere that jeopardize human, plant, or animal life, or are ruinous to property, or which unreasonably interfere with the comfortable enjoyment of life or property, is prohibited (6 NYCRR 211.2). New York State Air Quality Standards are promulgated at 6 NYCRR Part 257.	Applicable to activities that may result in the discharge of contaminants to the outside atmosphere.
Fish and Wildlife Management Practices Cooperative Program – Polluting Streams Prohibited	New York ECL § 11-0503	ARAR	Establishes that no deleterious or poisonous substances shall be thrown or allowed to run into any public or private waters in quantities injurious to fish life, protected wildlife or waterfowl inhabiting those waters, or injurious to the propagation of fish, protected wildlife or waterfowl therein.	Applicable to alternatives that include discharge of water back into the River.
Village of Massena Floodplain Use Permit (to comply with the New York State Emergency Compensation Program and National Flood Insurance Program)	New York State ECP Article 36, 6 NYCRR Part 502 and 44CFR § 60.3 (d)(3)	ARAR	Establishes that work within a river channel that contains a defined special flood hazard area (i.e., implementation of the ice control structure) requires a floodplain use or development permit issued by the local floodplain administrator in order to comply with the requirements of the National Flood Insurance Program. In accordance with CERCLA Section 121(e), a permit is not required for on-site CERCLA response actions, although such response actions must comply with substantive provisions of these regulations.	May be applicable to the construction of a pier-type ice control structure in the Grasse River.
NYSDEC Generic Community Air Monitoring Program	NYSDOH gCAMP rev 1	TBC	Provides measure of protection for downgrade community from potential airborne contaminants.	Would be consulted, as appropriate, with respect to potential air-borne contaminant releases during implementation remedial activities.
NYSDEC Air Guide 1 - Guidelines for the Control of Toxic Ambient Air Contaminants, 2000	NYSDEC Policy DAR-1	TBC	Provides guidance for the control of toxic ambient air contaminants in New York State.	Would be consulted during remedial design and remedial construction in connection with potential emission of air contaminants from implementation of remedial action.

Table 3-2
(cont'd)

Grasse River Study Area
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Action-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
STATE ARARs AND TBCs (cont'd)				
NYSDEC TAGM 4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites	TAGM 4031	TBC	Provides guidance on fugitive dust suppression and particulate monitoring for inactive hazardous waste sites.	Would be consulted, as appropriate, with respect to potential emissions of dust and particulate matter during implementation of remedial activities.

Note:
1. Table provides the federal and state action-specific ARARs and TBC items (guidance materials that have not been promulgated or regulatory standards that are not applicable or relevant that may be considered). While TBCs may be considered along with ARARs, they are not legally binding and do not have the status of ARARs.

Acronyms:
ARAR = Applicable, Relevant, and Appropriate Requirement
CFR = Code of Federal Regulations
CO = carbon monoxide
CERCLA = Comprehensive Environmental Response, Compensation, and Recovery Act
ECL = Environmental Conservation Law
ECP = Emergency Compensation Program
gCAMP = Generic Community Air Monitoring Program
mg/kg = milligrams per kilogram
NAAQs = National Primary and Secondary Ambient Air Quality Standards
NO_x = nitrogen oxide
NYCRR = New York Codes, Rules and Regulations
NYSDEC = New York State Department of Environmental Conservation
NYSDOH = New York State Department of Health
OSWER = USEPA's Office of Solid Waste and Emergency Response
PCBs = polychlorinated biphenyls
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
SPDES = State Pollutant Discharge Elimination System
TAGM = Technical and Administrative Guidance Memorandum
TBC = "to be considered"
TCLP = Toxic Characteristic Leaching Procedure
TSCA = Toxic Substances Control Act
U.S. = United States
USACE = United States Army Corps of Engineers
USC = United States Code
USDOT = United States Department of Transportation
USEPA = United States Environmental Protection Agency

Table 3-3

Grasse River Study Area
Massena, New York
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Location-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
FEDERAL ARARs AND TBCs				
Bald and Golden Eagle Protection Act	16 USC §§ 668	ARAR	Prohibits anyone, without a permit issued by the Secretary of the Interior, from knowingly taking and disturbing any bald eagle (commonly known as the American eagle), any golden eagle, or associated nest and/or egg.	The Grasse River is proximate to territory used by eagles.
CZMA	16 USC §§ 1451- 1465; 15 CFR Parts 923 and 930	ARAR	Establishes that federal agencies that conduct or support activities that directly affect a coastal use or resource must undertake those activities in a manner that is consistent, to the maximum extent practicable, with State coastal zone management programs that have been approved by the NOAA.	The Grasse River is designated a significant fish and wildlife coastal habitat within the New York State Coastal Zone and covered by the New York State CMP. A Coastal Zone Consistency Assessment will be prepared during the remedial design phase.
Endangered Species Act	16 USC §§ 1531- 1544; 50 CFR Part 17, Subpart I; 50 CFR Part 402	ARAR	Establishes that federal agencies are required to verify that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of a critical habitat of such species, unless such agency has been granted an appropriate exemption by the Endangered Species Committee (16 USC § 1536).	Per an October 3, 2001 letter from Mark W. Clough (acting for David A. Stilwell), USDOI, "except for occasional transient individuals, no Federally listed or proposed endangered or threatened species under our jurisdiction are known to exist in the project impact area. In addition, no habitat in the project impact area is currently designated or proposed as 'critical habitat.'" An updated determination of impacts to endangered species would be made following the process outlined on the U. S. Fish and Wildlife Service website (see note 2). This website process would be consulted in regard to remedial activities that include dredging, capping, and/or pier-type ice control structures.
Fish and Wildlife Coordination Act	16 USC §§ 622	ARAR	Requires the lead agency to develop measures to prevent "loss of and damage to" fish and wildlife resources "whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose whatsoever."	Will be evaluated by USEPA in evaluating potential remedies for the Grasse River and during the remedial design phase.

Table 3-3
(cont'd)

Grasse River Study Area
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Location-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
FEDERAL ARARs AND TBCs (cont'd)				
National Historic Preservation Act	16 USC §§ 470 – 470x-6; 36 CFR Part 800	ARAR	Establishes that response actions must take into account effect on properties currently listed or eligible for inclusion on the National Registry of Historic Places. Requires federal agencies to take into account the effects of their undertakings on historic properties and afford the Council a reasonable opportunity to comment on such undertakings. This will include consultation with state and local governments, Indian tribes, and private organizations as necessary.	Previous correspondence made with NYSDEC and New York State Office of Parks, Recreation and Historic Preservation which indicated significant archeological sites exist on or in the vicinity of this site. A Phase 1 Assessment was conducted in support of ROPS activities, during which no archaeological sites were located within the area of potential effects. Additional evaluations will be performed once remedy is selected. These evaluations will include consultation with the St. Regis Mohawk Tribe historic preservation officer.
Statement of Procedures on Floodplain Management and Wetlands Protections	40 CFR Part 6, Appendix A	ARAR	Sets forth USEPA's policy and guidance for carrying out Executive Orders 11990 and 11988. Executive Order 11988: Floodplain management requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists. Executive Order 11990: Protection of wetlands requires federal agencies conducting certain activities to avoid, to the extent possible, adverse impacts associated with the destruction or loss of wetlands if a practicable alternative exists. Federal agencies are required to avoid adverse impacts or minimize them if no practicable alternative exists.	To be considered if remedial action is expected to take place within the 100-year and 500-year floodplain or identified wetland areas. A floodplain and wetlands assessment will be prepared as necessary during the remedial design phase. Note that an initial evaluation has been conducted considering the alternative with the greatest aerial impact (see Appendix F). Figure 1-2 identifies the wetlands in the project area using U.S Fish & Wildlife national wetlands inventory maps.
USEPA Office of Solid Waste and Emergency Response - Policy on Floodplains and Wetland Assessments for CERCLA Actions, August 1985	OSWER Directive No. 9280.0-2	TBC	This memorandum discusses situations that require preparation of a floodplains or wetlands assessment, and the factors that should be considered in preparing an assessment, for response actions taken pursuant to Section 104 or 106 of CERCLA.	Would be consulted with respect to any floodplains or wetlands assessments that need to be performed.

Table 3-3
(cont'd)

Grasse River Study Area
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Location-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
STATE ARARs AND TBCs				
New York State Freshwater Wetlands Law	6 NYCRR Parts 662-665	ARAR	Defines procedural requirements for undertaking different activities in and adjacent to freshwater wetlands, and establishes standards governing the issuance of permits to alter or fill freshwater wetlands. In accordance with CERCLA Section 121(e), a permit is not required for on-site CERCLA response actions, although such response actions must comply with substantive provisions of these regulations.	Substantive requirements of the New York State Freshwater Wetlands Law are applicable for remedial activities that are undertaken in and adjacent to freshwater wetlands.
New York Endangered Species Act	New York State ECL Article 11, Title 5; 6NYCRR Part 182	ARAR	Lists endangered, threatened species and species of special concern. The taking of any endangered or threatened species is prohibited except under a permit or license issued by NYSDEC. The NYSDEC must be consulted for a determination of whether an activity is likely to result in the incidental take of a listed species. Specific substantive requirements for permitting would be provided by NYSDEC if an incidental take is expected.	Currently 16 species of state listed endangered, threatened, or species of special concern are documented in or around the Grasse River site and reasonably expected to occur in the project area. Continued consultation with the NYSDEC is necessary for updates and changes to the list of species present in the project area (see note 2). Current listing of species documented in or near the Grasse River includes the following: endangered – Black Tern (*Chlidonias niger*); threatened – Bald Eagle (*Haliaeetus leucocephalus*), Blanding's Turtle (*Emydoidea blandingii*), Common Tern (*Sterna hirundo*), Eastern Sand Darter (*Ammocrypta pellucid*), Lake Sturgeon (*Acipenser fulvescens*), Mooneye (*Hiodon tergisus*), and Upland Sandpiper (*Bartramia longicauda*); and special concern – Osprey (*Pandion haliaetus*) and Wood Turtle (*Glyptemys insculpta*).

Table 3-3
(cont'd)

Grasse River Study Area
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Location-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
STATE ARARs AND TBCs (cont'd)				
New York State Protected Native Plants	ECL Article 9, Title 16, 6 NYCRR Part 193	ARAR	Lists endangered, threatened, rare, and exploitable vulnerable native plants. All listed species are "protected plants" and may not be removed or damaged without consent of the owner.	Six species of endangered or threatened plants have been documented on or near the Grasse River site (note 2). Damage to any protected plants during remediation is regulated and permission would need to be obtained. Current listing of species documented in or near the Grasse River includes the following: endangered – American Dragonhead (*Dracocephalum parviflorum*), Emory's Sedge (*Carex emoryi*), Scarlet Indian-paintbrush (*Castilleja coccinea*), Slender Pondweed (*Stuckenia filiformis ssp. Alpine*), and Sparse-flowered Sedge (*Carex tenuiflora*); and threatened – Riverweed (*Podostemum ceratophyllum*).
New York State Waterfront Revitalization of Coastal Areas and Inland Waterways	New York State Law: Executive Article 42; Sections 910-923	ARAR	Defines policy on designation of use of coastal and inland waterway resources while preventing the loss of living marine resources and wildlife, diminution of open space area or public access to the waterfront, shoreline erosion, and impairment of scenic beauty or permanent adverse changes to ecological systems.	The Grasse River is within the listing of coastal waterbodies and designated inland waterways included under the Lower Waterfront Revitalization Program
STATE ARARs AND TBCs (cont'd)				
SWG Program	CWCS for the Northeast Lake Ontario-St. Lawrence Basin	TBC	The NYSDEC has developed a CWCS for the Northeast Lake Ontario-St. Lawrence Basin, which includes the Grasse River, to meet the federal requirements of the SWG program. This document includes specific actions for the research, preservation, or management of habitats or species that occur in the project area. Species that have been identified by the CWCS are listed as SGCN.	The CWCS identifies 110 SGCN in the Basin that includes the Grasse River, although not all species will occur at the site. The NYSDEC will consider species and habitats identified in the CWCS when reviewing habitat assessment, impact of remedial actions, and habitat restoration in the Grasse River.

Notes:
1. Table provides the federal and state location-specific ARARs and TBC items (guidance materials that have not been promulgated or regulatory standards that are not applicable or relevant that may be considered). While TBCs may be considered along with ARARs, they are not legally binding and do not have the status of ARARs.
2. The process for determining impacts to endangered species under the Federal ARARs is provided on the USFWS service website at http://www.fws.gov/northeast/nyfo/es/section7.htm. NYSDEC has recently updated the regulations, and these can be found at http://www.dec.ny.gov/regs/3932.html (following link explains the changes: http://www.dec.ny.gov/animals/68645.html). The listing of the New York State protected native plants can be found at http://www.dec.ny.gov/regs/15522.html.

Table 3-3
(cont'd)

Grasse River Study Area
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Location-Specific ARARs and TBCs

Acronyms:

ARAR = Applicable, Relevant, and Appropriate Requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Recovery Act
CFR = Code of Federal Regulations
CMP = Coastal Management Program
CWCS = Comprehensive Wildlife Conservation Strategy
CZMA = Coastal Zone Management Act
ECL = Environmental Conservation Law
NOAA = National Oceanic and Atmospheric Administration
NYCRR = New York Codes, Rules and Regulations
NYSDEC = New York State Department of Environmental Conservation
OSWER = USEPA's Office of Solid Waste and Emergency Response
ROPS = Grasse River Remedial Options Pilot Study
SGCN = Species of Greatest Conservation Need
SWG = State Wildlife Grants
TBC = "to be considered"
USC = United States Code
USDOI = United States Department of the Interior
USEPA = United States Environmental Protection Agency
USFWS = United States Fish and Wildlife Service

Table 4-1

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
A. No Further Action			
	----	No further active remedial activities performed beyond the previously completed 1995 NTCRA, 2001 CPS, 2005 ROPS, 2006 ACPS, and on-site source control activities.	This alternative is required to be evaluated under CERCLA.
B. Monitoring			
	Site-Wide Monitoring	Periodic visual observations and/or field sampling would be used to monitor Study Area conditions.	Implementable; already in place.
C. Institutional Controls			
	Access Restrictions	Constraints, such as fencing and signs, would be placed along river to limit access.	Potentially implementable.
	Consumption Advisories	Advisories to indicate how consumption of some fish should be limited.	Implementable; already in place.
	Deed Restrictions	Constraints would be placed on future river use.	Inappropriate for application to a water body.
D. Source Control/Natural Recovery			
I. Source Control	Source Control	Constraints/controls placed on point sources to reduce discharge of PCBs to the Grasse River.	Implementable; on-site source control activities completed in 2001.
II. Natural Recovery	Sedimentation	Natural recovery from on-going process of clean sediment deposition over PCB-containing sediment.	Implementable; has occurred historically in the lower Grasse River and is expected to continue, although current sedimentation rates may be lower than average historic rates.
	Biodegradation	Naturally occurring PCB degradation by microorganisms present at the Study Area in an aerobic or anaerobic environment.	Implementable; both field data and laboratory testing demonstrated that this is on-going and is expected to continue; however, this does not appear to be an important near-term process.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
E. In-Place Containment			
I. Capping	Armored Capping	Placement of a cap typically comprised of layered materials (e.g., sand, gravel, cobbles, geotextile) placed over in-situ sediment where added stability of an armored layer is required to protect against erosion forces in ice scour prone areas to isolate constituents from biota and mitigate chemical flux.	Implementable; successfully placed as part of the 2005 ROPS.
	Aqua-Blok™	Engineered pellets are placed through the water column settling over the sediment. The bentonite coated pellets absorb water, coalesce, and form a relatively impermeable layer.	Implementable; successfully placed during the 2001 CPS.
	Asphalt Cap	Application of an asphalt or concrete layer over sediment.	Not practical for submerged sediment.
	Multi-Media Cap	Clay and synthetic membrane covered by soil over sediment.	Not practical for submerged sediment.
	Sand/Topsoil Cap	Application of a sand/topsoil mixture over in-situ sediment. The make-up of the cap material is designed to provide for both cap stability and chemical retardation with the potential for chemical degradation beneath the cap.	Implementable; thin-layer cap placed during the 2001 CPS and 2005 ROPS.
	Reactive Cap	Application of reactive core mat or reactive elements over sediments to sorb to PCBs.	Potentially implementable.
	Near Shore Capping	Placement of 6 inches of clean cap material (e.g., sand/topsoil) over contaminated sediment in near shore areas (i.e., areas with less than 5 feet of water).	Implementable; successfully placed in the near shore area during the 2005 ROPS.
II. Rechannelization	----	Creation of a newly constructed channel to permanently redirect the river, and material in the original channel would be contained in place.	Not feasible due to size of Grasse River and available space in floodplain.
F. Sediment Treatment			
I. In-Situ Treatment	Biodegradation	Addition of nutrients (e.g., oxygen, minerals, etc.) or cultured microorganisms to the sediment to facilitate or improve the rate of natural biodegradation.	Process has not been demonstrated at full-scale with PCBs.
	Activated Carbon Application	Mixing of activated carbon into the top layer of sediments to mitigate the bioavailability of PCBs in sediments to fish and other organisms.	Implementable; successfully placed during the 2006 ACPS.
	Stabilization/Solidification	Immobilize materials by injecting and mixing a stabilization/solidification agent (e.g., Portland cement, etc.) into the in-situ sediment.	In-situ process not yet sufficiently developed for sediment.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
I. In-Situ Treatment (cont'd)	Chemical	Injection of chemical surfactants/solvents or oxidants into the treatment area to remove or destroy PCB constituents.	Not feasible for submerged sediments.
	Extraction	Vacuum - Create vacuum in soil through a well; chemical constituents drawn in and extracted. Steam - Inject steam into soil, so that chemical constituents volatilize and are removed via extraction wells. Liquid - Solvents introduced in soil via injection wells, extraction wells recover solvent and extracted chemical constituents. Thermal Wells - PCB-containing soil is heated; vacuum applied to well; removes vapor phase PCBs.	Not feasible for submerged sediment.
II. Ex-Situ Treatment	Immobilization - Stabilization/Solidification	Sediments are mixed ex-situ with Portland cement, fly ash, or some other stabilization agent. May be used for dewatering only, or to reduce the mobility of the chemical constituents.	Implementable; already utilized at the Study Area to stabilize removed sediments as part of 1995 NTCRA and 2005 ROPS.
	Maectite	Process converts leachable materials into mineral crystal species within the soil matrix.	Process has not been demonstrated at full-scale with sediment.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
II. Ex-Situ Treatment (cont'd)	Chemical	Solvent Extraction - Extraction of constituents from sediments using an organic solvent. Examples include: • Basic Extraction Sludge Treatment (BEST™) - Solvent (having inverse miscibility in water) used to remove PCBs from solids. Sediment and solvent extractant are mixed in an extractor, dissolving the inorganic chemicals. The extracted solution is then placed in a separator, where the chemicals and extractant are separated for treatment and further use. • Low Energy Extraction Process (META LEEP℠) - Acetone, kerosene and other solvents are used to extract organic and inorganic chemical constituents from solids. • CF Systems® Solvent Extraction Process - Critical fluids and liquefied gases such as carbon dioxide, propane, or other liquid hydrocarbons used at high pressure to separate and extract PCBs from wastewater, sludge, sediment, and soil. • Terra Kleen Solvent Extraction - Solvent used to extract PCBs and other organics from sediments. The solvent is separated from the materials and reused. • Biotherm (former Carver-Greenfield) Process - Oil-soluble organic constituents extracted from sludge, soil, and sediment using a food-grade carrier oil.	Potentially implementable; process (e.g., Terra Kleen solvent extraction) has been applied at other sites or in full-scale demonstration.
	Chemical	Soil Washing - Process which removes contaminants from soils by either dissolving or suspending them in a wash solution. For example: • Biogenesis - Soil washing process isolates individual particles and removes the adsorbed chemicals and naturally occurring organic material from fine-grained (silt and sand) sediment.	Process is currently undergoing full-scale demonstration on sediments with low PCB concentrations.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
II. Ex-Situ Treatment (cont'd)	Chemical	Chemical Destruction - Process which degrades PCBs by adding reagents. Examples include: • Base-Catalyzed Dechlorination (BCD) - Chlorine is stripped off PCB molecules using sodium bicarbonate in a rotary reactor. • Reduction (Eco Logic) - Various chemical agents (e.g., sodium borohydride, sulfur dioxide) used to destroy PCBs through gas phase reduction. Chemical constituents are transferred to the gas phase through volatilization (thermal desorption unit). • Sodium-Based Reactions (NaPEG) - PCBs broken down into oxygenated organics, sodium chloride (salt), and biodegradable glycols.	Process has not been successfully demonstrated at full-scale with sediments similar to what is found at the Grasse River.
	Thermal Desorption	Process which uses heat to increase the volatility of contaminants such that they can be removed (separated) from the solid matrix. Examples include: • X*TRAX™ - Solids heated in the presence of nitrogen, followed by PCB extraction. • Electrochemical Geo-Oxidation (Weiss Associates) - Proprietary technology in which an array of single steel piles is installed and low current is applied to stimulate oxidation of organics. • Vitrification (Geosafe) - Uses an electric current to melt soil or other earthen materials at extremely high temperatures (2,900 to 3,650 degrees F). Inorganic compounds are incorporated into the vitrified glass and crystalline mass and organic pollutants are destroyed by pyrolysis. In-situ applications use graphite electrodes to heat soil.	Potentially implementable; process (e.g., X*Trax ™) has been applied at other sites or in full-scale demonstration.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
II. Ex-Situ Treatment (cont'd)	UV Destruction	Process which uses ultraviolet treatment to destroy contaminants in soils. Examples include: • UV/Ozone/Ultrasonics - Ultrasonics used to extract PCBs from solids. PCBs destroyed by subsequent UV/ozone treatment. • UV/Hydrogen/Ultrasonics - Ultrasonics used to extract PCBs from solids. PCBs destroyed by subsequent UV/hydrogen treatment. • Ozonation - Ozone used to decompose PCBs in conjunction with UV radiation. • Radiant Energy - UV light energy, combined with a reducing agent, used to dechlorinate PCBs.	Process still under development or is not technically feasible for the site.
	Thermal Destruction	Process which uses high heat to remove or destroy PCBs in sediments. Examples include: • Incineration - Sediment thermally treated in a fluidized bed, rotary kiln, or infrared incinerator, all of which would require TSCA permitting. • Glass Furnace Technology (Minergy Corp.) - Sediment treated in a Holoflite dryer followed by a melting oven. A glass aggregate is produced that can be used in the construction fill market. • Pyrolysis - Chemical decomposition is induced in organic materials by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash. • Westinghouse Plasma Corp. – Harbor Sediment Treatment (formerly Plasma Arc) - PCBs thermally destroyed at very high temperatures. • Cement Lock (GTI) - Process uses a thermochemical manufacturing, which converts dredged sediments, mixed with specific modifiers into materials that can be used as a cement base.	Potentially implementable; process (e.g., incineration) has been applied at other sites.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
II. Ex-Situ Treatment (cont'd)	Low Temperature Thermal Destruction	Process which uses low temperatures and high pressure to destroy PCBs. Examples include: • Wet Air Oxidation - A proprietary process that uses special catalysts and relatively low temperature and high pressure to decompose PCBs. • Supercritical Water Oxidation - Temperature and pressure of supercritical water dissolve materials that are oxidized into carbon dioxide, water, and salts.	Destruction efficiency is reported to be low for sediments or not implementable at the Study Area due to sediment particle size.
G. Sediment Removal			
I. Dredging	Mechanical	Remove bottom sediment by directly applying mechanical force to dislodge and excavate materials (e.g., clamshell).	Implementable; already used in the Study Area during the 1995 NTCRA and 2005 ROPS.
	Hydraulic	Removal and transportation of bottom sediment in a liquid slurry form using hydraulic pumps (e.g., horizontal auger, cutterhead dredge).	Implementable; already used at the Study Area during the 1995 NTCRA and 2005 ROPS.
	Pneumatic	Removal of bottom sediment by compressed air (e.g., PNEUMA pump).	Potentially implementable.
II. Excavation (in-the-dry)	Mechanical	Temporary structures used to create "dry" areas in the river to allow use of standard excavation equipment.	Potentially implementable.
H. Sediment Dewatering			
I. Filtration	Plate and Frame Filter Press	Sediment slurry pumped into cavities formed by a series of plates covered by a filter cloth. Liquids are forced through filter cloth and dewatered solids collected in the filter cavities.	Implementable; already utilized at the Study Area during the 1995 NTCRA and 2005 ROPS.
	Belt Filter Press	Sediment slurry drops onto a perforated belt where gravity drainage takes place. Thickened solids are pressed between a series of rollers to further dewater solids.	Potentially implementable.
	Geotubes	Sediments are pumped into the geotubes and excess water drips through the small pores in the geotextiles, resulting in effective dewatering and volume reduction of the contaminated materials.	Implementable; already utilized at the Study Area during the 2005 ROPS.
II. Centrifuge	Solid-Bowl	Sediment slurry fed through a central pipe that sprays into a rotating bowl. Centrate discharges out the large end of the bowl and solids are removed from tapered end of the bowl by means of a screw conveyer.	Potentially implementable.
III. Evaporator	Evaporator	Excess water evaporated from sediment slurry.	Potentially implementable.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
IV. Hydrocyclone	Hydrocyclone	Sediment slurry fed tangentially into a funnel-shaped unit to facilitate centrifugal forces necessary to separate solids from liquids. Dewatered solids collected and overflow liquid discharged.	Potentially implementable; pilot tested during the 2005 ROPS.
V. Gravity Settling	Thickener or Settling Basin	Sediment slurry enters thickener and settles into circular tank or settling basin. Sediment thickens and consolidates at the bottom of the tank. Pretreatment with chemical addition used to enhance settleability.	Implementable; already utilized at the Study Area during the 1995 NTCRA and 2005 ROPS.
I. Sediment Disposal			
I. On-Site Disposal	Confined Disposal Facility	Sediment or residuals placed in disposal facility consisting of sheet piling and/or earthen dikes within a water body.	Suitable site has not been identified in the Grasse River.
	Local Landfill	Use of Alcoa's on-site Secure Landfill (RCRA/TSCA permitted) for disposal of solids or residuals; additional capacity remaining in Cell 3 of the on-site Secure Landfill or, if additional capacity is needed, new cells could be designed and constructed.	Implementable; already utilized at the Study Area during the 1995 NTCRA and 2005 ROPS.
II. Off-Site Disposal	TSCA Landfill	Disposal of solids or residuals in existing TSCA permitted landfill.	Potentially implementable.
	Solid Waste Landfill	Disposal of solids or residuals (containing less than 50 mg/kg PCBs) in existing off-site permitted solid waste landfill.	Potentially implementable.
J. Water Treatment			
I. Oily Residuals	Liquid Incineration	PCBs from above-referenced extraction processes destroyed in off-site TSCA incinerator.	Potentially implementable.
II. Water Treatment	Activated Carbon Adsorption	PCBs in aqueous phase are removed with granular activated carbon.	Implementable; already utilized at the Study Area during the 1995 NTCRA and 2005 ROPS.
	Distillation	PCBs separated from aqueous stream by vaporization and condensation.	Likely not applicable for PCBs in aqueous stream.
	Filtration	PCBs filtered out through various media (i.e., sand) from the liquid stream.	Implementable; already utilized at the Study Area during the 1995 NTCRA and 2005 ROPS.
K. Ice Management			
I. Structural	Pier-Type Structure	Stops ice at piers and allows river flow to pass beneath the ice accumulation or through adjacent floodplain or bypassed channel.	Potentially implementable based on computer and physical modeling results.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1,2]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
I. Structural (cont'd)	Dams	Restoration of breached dam in Village of Massena.	Not feasible as ice jams occurred prior to breaching of dam.
	Ice Booms	Floating structures (e.g., timbers, logs, etc.) placed across river surfaces to arrest the downstream movement of ice.	Not feasible for Study Area based on expected river flows and ice volumes during extreme ice breakup events.
II. Non-Structural	Thermal or Chemical Ice Melting	Use of heat or chemicals to melt ice prior to formation of ice jams.	Not feasible due to lack of economical source of warm water and insufficient late winter sunshine in Massena to deteriorate ice cover.
	Ice Breaking	Mechanical break up of ice in advance of the natural ice breakup to allow the ice to pass through the river without jamming.	Implementable; site-specific Ice Breaking Demonstration Project performed in 2007.

Notes:
1. This screening analysis is based on technical implementability without consideration of cost. Remedial technologies that have not been demonstrated full-scale with sediment were not retained for further analysis; although this does not preclude their potential use during remedial design. Shaded process options have been retained for further analysis on Table 4-2.
2. Preliminary assessment completed using publically available information.

Acronyms:
ACPS = Activated Carbon Pilot Study
CERCLA = Comprehensive Environmental Response, Compensation, and Recovery Act
CPS = Capping Pilot Study
F = Fahrenheit
mg/kg = milligrams per kilogram
NTCRA = Non-Time-Critical Removal Action
PCBs = polychlorinated biphenyls
RCRA = Resource Conservation and Recovery Act
ROPS = Remedial Options Pilot Study
TSCA = Toxic Substances Control Act
UV = Ultraviolet

Table 4-2

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
A. No Further Action							
	---	Historic trends in water column and fish PCB levels support progress towards RAOs over time. Periodic ice jam events can potentially affect both the ability and time required to achieve RAOs.	None.	Reliable.	Readily implementable.	Readily implementable with no permits/equipment required.	Negligible.
B. Monitoring							
	Site-Wide Monitoring	Historic trends in water column and fish PCB levels support progress towards RAOs over time. Periodic ice jam events can potentially affect both the ability and time required to achieve RAOs.	Minimal.	Reliable means to track Study Area conditions as this approach has been applied at this and numerous other aquatic sites.	Readily implementable.	Readily implementable, with specialized services required and available. Permits not required under CERCLA, although substantive requirements should be met.	Low to Moderate.
C. Institutional Controls							
	Access Restrictions	Deters public (e.g., by signs) from accessing river. Expected to reduce potential for ingestion of fish containing PCBs. Historic trends in water column and fish PCB levels support progress towards RAOs over time. Periodic ice jam events can potentially affect both the ability and time required to achieve RAOs.	None.	Reliable; however, restriction relies on public compliance and length of Study Area may limit effectiveness.	Readily implementable. Routine maintenance may be necessary.	Readily implementable, but may present maintenance difficulties over long periods of time and substantial lengths of river.	Low.
	Consumption Advisories	Reduces potential for ingestion of fish containing PCBs. Historic trends in water column and fish PCB levels support progress towards RAOs over time. Periodic ice jam events can potentially affect both the ability and time required to achieve RAOs.	None.	Reliable as this approach has been applied at this and numerous other aquatic sites.	Readily implementable; already in place.	Readily implementable; already in place.	Low.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
D. Source Control/Natural Recovery							
I. Source Control	Source Control	Reduces PCB influx to Grasse River thus enhancing natural recovery and lessening the time to reach RAOs. Historic trends in water column and fish PCB levels support progress towards RAOs over time. Periodic ice jam events can potentially affect both the ability and time required to achieve RAOs.	On-site source control activities have been completed and have dramatically reduced PCB discharges to the river.	On-site activities have been reliable in reducing PCB concentrations.	Technically feasible based on current discharge requirements. On-site activities have been completed.	Implementable since on-site activities complete; future permits, if necessary, are expected to be obtainable.	Specific to source under evaluation.
II. Natural Recovery	Sedimentation	Reduces PCB flux and downstream PCB loading due to natural attenuation processes including dilution primarily through natural deposition/mixing. This option can also be used in combination with other process options to achieve RAOs. Historic trends in water column and fish PCB levels support progress towards RAOs over time. Periodic ice jam events can potentially affect both the ability and time required to achieve RAOs.	None.	Various studies (including the SRS Program) indicate the potential for natural mechanisms, including burial, to contribute to the long-term fate of PCBs in the lower Grasse River, but would require a significant period of time to be effective site wide as a stand-alone remedial option. Could be affected by periodic ice jams.	Readily implementable; naturally occurring.	Natural process; no permits, specialized equipment, or personnel are necessary.	Negligible.
	Biodegradation	Biodegradation breaks down PCBs in sediment, eventually resulting in reduced toxicity. Not likely to achieve prompt reduction of PCBs in fish or downstream PCB loading, but together with other natural processes could result in eventual reduction in PCB bioavailability and transport, which would result in eventual achievement of RAOs. However, this process is not expected to be an important near-term process at this site.	None.	Various studies (including the SRS Program) indicate the potential for natural mechanisms, including biodegradation, to contribute to the long-term fate of PCBs in the lower Grasse River, but it does not appear that it currently is an important near-term process at the site.	Readily implementable; naturally occurring.	Natural process; no permits, specialized equipment, or personnel required.	Negligible.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
E. In-Place Containment							
I. Capping	Armored Capping	Should be effective in reducing PCB flux to the water column and downstream PCB loading to achieve RAOs. This option would be selectively applied in areas where additional cap stability may be required (i.e., ice-scour prone areas) and would need to be used in combination with other process options to achieve RAOs.	Results of 2005 ROPS indicate that implementation effects on water quality are minimal. Short-term effects on benthic community expected during placement. With large volumes of capping materials potentially being brought to the Study Area, the high volume of truck traffic in the area must be considered.	USACE has demonstrated armored capping of PCB-containing sediments at a number of sites nationwide (and under a variety of aquatic sites conditions) to reduce flux and isolate sediments. Further, armored capping successfully completed in the main channel of the Grasse River during 2005 ROPS.	Implementable. Placed during 2005 ROPS.	Implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Moderate to High.
	AquaBlok™	Based on available information, should be effective in reducing PCB flux to the water column and downstream PCB loading to achieve RAOs. This option would likely need to be applied in combination with other process options for ice-scour prone areas of the river to achieve RAOs.	Results of 2001 CPS indicate that implementation effects on water quality are minimal. Short-term effects on benthic community expected during placement. With large volumes of capping materials potentially being brought to the Study Area, the high volume of truck traffic in the area must be considered.	Concerns raised about viability of bentonite as a substrate for benthos. Material has been placed as part of 2001 CPS. Monitoring results indicate benthic organisms successfully recolonized the cap material within 6 to 12 months.	Implementable. Placed during 2001 CPS.	Implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Moderate to High.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
I. Capping (cont'd)	Sand/Topsoil Cap	Based on available information, should be effective in reducing PCB flux to the water column and downstream PCB loading to achieve RAOs. This option would likely need to be applied in combination with other process options for ice-scour prone areas of the river to achieve RAOs.	Results of 2001 CPS and 2005 ROPS indicate that implementation effects on water quality are minimal. Short-term effects on benthic community expected during placement. With large volumes of capping materials potentially being brought to the Study Area, the high volume of truck traffic in the area must be considered.	USACE has demonstrated capping of PCB-containing sediments at a number of sites nationwide. Material has been placed as part of 2001 CPS and 2005 ROPS. Monitoring results indicate benthic organisms successfully recolonized the cap within 6 to 12 months.	Implementable. Placed during 2001 CPS and 2005 ROPS.	Implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Low to Moderate.
	Reactive Cap	Based on available information, should be effective in reducing PCB flux to the water column and downstream PCB loading to achieve RAOs. This option would likely need to be applied in combination with other process options for ice-scour prone areas of the river to achieve RAOs.	Implementation effects on water quality are minimal. Short-term effects on benthic community expected during placement.	Has been demonstrated at other project sites with more limited areal coverage than what would be required at the Study Area.	Implementable; not tested at Study Area, would likely require additional pilot testing.	Implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Moderate.
	Near Shore Capping	Based on available information, should be effective in reducing the bioavailability of PCBs in sediments, fish, and other organisms to achieve RAOs. This option would likely need to be applied in combination with other process options for ice-scour prone areas of the river to achieve RAOs.	Results of 2005 ROPS indicate that implementation effects on water quality would be expected to be minimal. Short-term effects on benthic community expected during placement.	Near shore caps successfully placed at Ketchikan Pulp and Wycoff/Eagle Harbor Sites. Thin-layer cap (3- to 6-inches) completed in Grasse River near shore area during 2005 ROPS. Monitoring results indicate benthic organisms successfully recolonized the cap within 6 to 12 months.	Implementable. Thin-layer cap (3- to 6-inches) placed during 2005 ROPS.	Implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Low to Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
F. Sediment Treatment							
I. In-Situ Treatment	Activated Carbon Application	Based on available information, should be effective in reducing the bioavailability of PCBs in sediments, fish, and other organisms to achieve RAOs. This option would likely need to be applied in combination with other process options for ice-scour prone areas of the river to achieve RAOs.	Results of 2006 ACPS indicate that implementation effects on water quality are minimal. Short-term effects on benthic community expected during placement.	Several laboratory and focused field studies conducted by Stanford University, University of Maryland Baltimore County, and others have demonstrated that applying activated carbon into surface sediments is effective in reducing the bioavailability of PCBs in sediments to fish and other river-dwelling organisms. Application of activated carbon successfully implemented in main channel of Grasse River during 2006 ACPS. Monitoring results three years after construction indicate applied carbon remained in place, reductions in PCB concentrations in test organism and aqueous PCB concentrations, and little impact to the benthic community.	Implementable. Placed during 2006 ACPS.	Implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Low to Moderate.
II. Ex-Situ Treatment	Immobilization - Stabilization/ Solidification	Does not meet RAOs alone, but may be considered in conjunction with other technologies to form potential remedial actions (e.g., removal, dewatering, disposal, residuals management) that eventually would be expected to meet RAOs.	Reduces mobility of PCBs but increases disposal volume. Potential safety concerns during material transport, handling, and processing would be managed through implementation of a HASP.	Process option has been shown to be effective ex-situ and demonstrated full-scale at several Superfund sites. Commonly used to reduce free moisture for disposal purposes. Utilized prior to sediment disposal during 1995 NTCRA and 2005 ROPS.	Implementable; utilized during the 1995 NTCRA and 2005 ROPS.	Implementable.	Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
II. Ex-Situ Treatment (cont'd)	Chemical - Solvent Extraction	Does not meet RAOs alone, but may be considered in conjunction with other technologies to form potential remedial actions (e.g., removal, dewatering, disposal, residuals management) that eventually would be expected to meet RAOs.	Extracts PCBs from sediments using an organic solvent.	Process option has been used at other sites (New Bedford Harbor) to reduce PCB concentrations (either common chemicals or proprietary products). Treatability tests would likely be required to determine effectiveness and selection of appropriate solvent.	Implementable, but would require specialized equipment, materials, and operating personnel. Concentrated PCBs in the extract would require proper disposal. Traces of chemical/solvent remaining in the treated solids may need to be addressed. Would require sufficient space to conduct the treatment and processing activities, as well as an agreement with the relevant property owner.	Implementable.	High.
	Thermal Desorption	Does not meet RAOs alone, but may be considered in conjunction with other technologies (e.g., removal, dewatering, residuals management) to form potential remedial actions that eventually may meet RAOs.	Potential impacts could be mitigated through use of engineering controls. Extraction residuals may have limited disposal options. Emissions data collected during full-scale operations of similar thermal processes have indicated that emissions may be an issue. Risk of release and potential exposures increased due to additional material transport, handling, and processing.	Used full-scale at the Resolve Superfund Site in Dartmouth, Massachusetts. A site-specific study would be required to assess treatment effectiveness and potential process emissions.	Implementable, but would require specialized equipment, materials, and operating personnel.	Availability of equipment is questionable. Meeting substantive permit requirements may be difficult due to public resistance.	High.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
II. Ex-Situ Treatment (cont'd)	Thermal Destruction	Does not meet RAOs alone, but may be considered in conjunction with other technologies to form potential remedial actions (e.g., removal, dewatering, disposal, residuals management) that eventually would be expected to achieve RAOs.	Emissions of PICs and unburned PCBs during implementation are of concern. Risk of release and potential exposures increased due to additional material transport, handling, and processing.	Has been demonstrated at New Bedford Harbor.	Implementable, but would require specialized equipment, materials, and operating personnel. Low moisture content materials preferable.	Full-scale units and technical assistance/support currently are available for mobile incineration. Public resistance to technology may be encountered. Permits may be required for off-site implementation.	Very High.
G. Sediment Removal							
I. Dredging	Mechanical	Ability to meet RAOs is dependent on post-dredging residual PCB concentrations achieved and degree of PCB release during dredging. Based on the site-specific characteristics of the river system, it is anticipated that dredging would need to be combined with other process options such as capping to meet RAOs.	Would disturb/remove benthic habitat, may result in increased residual PCB concentrations at locations where higher PCB concentrations exist at depth and/or release of PCBs during remedial activities. Should large sediment volumes be removed/dewatered, the high volume of truck traffic in the area must be considered. Potential risk of release and exposure also exists during material transport, handling, and processing.	Has been applied at other locations nationwide. Post-dredging residuals and releases during dredging are difficult to predict. Typically used for removal of boulders/debris.	Implementable. River bottom conditions, such as the inability to overdredge due to hardpan/bedrock bottom will limit effectiveness/ implementability.	Permits not required under CERCLA, although substantive requirements should be met.	Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
I. Dredging (cont'd)	Hydraulic	Ability to meet RAOs is dependent on post-dredging residual PCB concentrations achieved and degree of PCB release during dredging. Based on the site-specific characteristics of the river system and the results of the 1995 NTCRA and 2005 ROPS, it is anticipated that dredging would need to be combined with other process options, such as capping to meet RAOs.	Would disturb/remove benthic habitat, and may result in increased residual PCB concentrations at locations where higher PCB concentrations exist at depth and/or release of PCBs during remedial activities. Typically resuspends less sediment than mechanical dredging. Should large sediment volumes be removed/dewatered, materials can be pumped to the staging/disposal areas. Potential risk of release and exposure also exists during material transport, handling, and processing.	Implemented at Study Area during NTCRA. Removed approximately 2,600 in-situ cubic yards of sediment via hydraulic dredging during the NTCRA. Removed approximately 24,400 cubic yards of sediment via hydraulic dredging during the 2005 ROPS. Residual material (average of 4 and 16 inches) remained after the 1995 NTCRA and 2005 ROPS due to subsurface conditions (i.e., bedrock).	Implementable. River bottom conditions, such as presence of boulders/debris and inability to overdredge due to hardpan/bedrock bottom, will limit effectiveness/ implementability. Would need to be coupled with mechanical removal to manage large rocks/debris known to exist at the site. Can operate in shallow water. High flexibility for varying dredge thicknesses.	Permits not required under CERCLA, although substantive requirements should be met.	Moderate.
	Pneumatic	Ability to meet RAOs is dependent on post-dredging residual PCB concentrations achieved and degree of PCB release during dredging. Based on the site-specific characteristics of the river system, it is anticipated that dredging would need to be combined with other process options such as capping to meet RAOs.	Would disturb/remove benthic habitat, and may result in increased residual PCB concentrations at locations where higher PCB concentrations exist at depth and/or release of PCBs during remedial activities. Resuspends sediment similar to hydraulic dredging. Should large sediment volumes be removed/dewatered, materials can be pumped to the staging/disposal areas. Potential risk of release and exposure also exists during material transport, handling, and processing. Potential to be equally effective in removal of thin lifts as hydraulic dredging.	Not widely used, especially for environmental dredging. Post-dredging residuals and releases during dredging are difficult to predict.	Implementable. Requires adequate water depth for operation. Sufficient water depth is available within the center channel of the Study Area only. River bottom conditions, such as presence of boulders and inability to overdredge due to hardpan/bedrock bottom, may limit effectiveness/ implementability. Would need to be coupled with mechanical removal to manage large rocks/debris known to exist at the site. Potential to be effective at removal of thin lifts, but has low flexibility for varying dredge thicknesses. May encounter areas too shallow to dredge vs. hydraulic dredging.	Requires specialty equipment which is available on a limited basis.	High.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
II. Excavation (in-the-dry)	Mechanical	Ability to meet RAOs is dependent on post-dredging residual PCB concentrations achieved and degree of PCB release during excavation. It is anticipated that excavation would need to be combined with other process options, such as capping, to achieve RAOs.	Risks to workers are greater due to the need to work within a cofferdammed area below water surface elevation. Increased potential for localized flooding exists. Can better handle large rocks and debris. Greater removal precision than dredging through water column. Would disturb/remove benthic habitat. Less potential for PCB release than other removal methods with possible exception of catastrophic overtopping of cofferdam. Should large sediment volumes be removed/dewatered, the high volume of truck traffic in the area must be considered. Potential risk of release and exposure also exists during material transport, handling, and processing.	Typically applied on a small scale to address localized areas of affected sediment. However, experience at other PCB sites indicates that residual PCB concentrations exist at highly variable levels even in "dry conditions."	Questionable due to water depths of 12 to 20 feet and uncertainty regarding maintenance of a dry river bed. Bed material must be able to consolidate (gain strength) in a reasonable time period and support excavation equipment and install cofferdam. Unknown ability to install sheeting into river bed. Can better handle large rocks and debris. Greater removal precision than dredging through water column. Steep slopes of river channel may present implementation problems.	Permits not required under CERCLA, although substantive requirements should be met.	High (due to the efforts involved with cofferdam construction and attempts to keep work area dry).
H. Sediment Dewatering							
I. Filtration	Plate and Frame Filter Press	Does not meet RAOs on its own, but may be necessary for removed sediments that are high in water content prior to disposal.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Treated water likely would be discharged back to river.	Reliable, with proper pre-treatment steps. Demonstrated during 1995 NTCRA and 2005 ROPS.	Implementable.	Implementable.	Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
I. Filtration (cont'd)	Belt Filter Press	Does not meet RAOs on its own, but may be necessary for removed sediments that are high in water content prior to disposal.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Treated water likely would be discharged back to river.	Reliable. A site-specific study would be required to assess treatment effectiveness.	Implementable.	Implementable.	Moderate.
II. Geotubes	Geotubes	Does not meet RAOs on its own, but may be necessary for removed sediments that are high in water content prior to disposal.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Treated water likely would be discharged back to river.	Pilot tested at the Study Area during the 2005 ROPS.	Potentially implementable; use of geotubes would require addressing issues such as capacity, need for lime stabilization prior to transport, impact of lime stabilization on the volume of material to be landfilled, and impacts on the wastewater treatment system.	Implementable.	Moderate.
III. Centrifuge	Solid-Bowl	Does not meet RAOs on its own, but may be necessary for removed sediments that are high in water content prior to disposal.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Treated water likely would be discharged back to river.	Historically, process has required frequent maintenance and often experienced operational difficulties. A site-specific study would be required to assess treatment effectiveness.	Implementable.	Implementable.	Moderate.
IV. Evaporator	Evaporator	Does not meet RAOs on its own, but may be necessary for removed sediments that are high in water content prior to disposal.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Treated water likely would be discharged back to river.	Reliable. A site-specific study would be required to assess treatment effectiveness.	Implementable; may produce drier cake than required, not usually employed for sediments.	Implementable.	High.
V. Hydrocyclone	Hydrocyclone	Does not meet RAOs on its own, but may be necessary for removed sediments that are high in water content prior to disposal.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Treated water likely would be discharged back to river.	Reliable; used at Manistique Harbor, Michigan and Cumberland Bay in Plattsburgh, New York. Pilot-tested at the Study Area during the 2005 ROPS; results indicated that the hydrocyclone could be used in the future as part of the dewatering and treatment process.	Implementable for certain portions of removed sediment depending on sediment characteristics. Most effective on feed with high coarse particle content (i.e., sand) and solids content 5 to 25%.	Implementable.	Low to Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
VI. Gravity Settling	Thickener or Settling Basin	Does not meet RAOs on its own, but may be necessary for removed sediments that are high in water content prior to disposal.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Treated water likely would be discharged back to river.	Reliable. A site-specific study would be required to assess treatment effectiveness.	Implementable.	Implementable.	Low.
I. Sediment Disposal							
I. On-Site Disposal	Local Landfill (Alcoa Secure Landfill)	Does not meet RAOs alone, but can be used in conjunction with other technologies to form remedial actions (e.g., removal, dewatering, and residuals management) that eventually would be expected to meet RAOs.	Effects could be reduced through use of proper engineering controls. Some risk of worker exposure. Potential transportation accidents, although expected to be minimal due to short haul distances.	Widely used. Used for disposal of 1995 NTCRA and 2005 ROPS materials.	Implementable. An additional cell was built in 2004 in association with the ROPS, and has approximately 60,000 cubic yards remaining for the storage of dredged sediments. Additional capacity could be provided through increasing the current cell or construction of an additional landfill cell(s) on-site. On-site landfill is currently permitted for one more cell. Space exists at the Alcoa facility for additional disposal area, although siting/design work would need to be conducted.	Implementable. Providing additional capacity would require regulatory approval and permitting; this process would be more extensive and may require additional studies and time to complete for construction of new cells, with no certainty in final outcome of this process.	Moderate.
II. Off-Site Disposal	TSCA Landfill	Does not meet RAOs alone, but can be used in conjunction with other technologies to form remedial actions (e.g., removal, dewatering, residuals management) that eventually would be expected to meet RAOs.	Effects could be reduced through use of proper engineering controls. Risks of exposure and transportation accidents increase with significantly increased haul distances of materials.	Widely used.	Implementable. Depends on landfill location, availability, and capacity.	Implementable. Additional restrictions and requirements apply for transport of materials with greater than 50 mg/kg PCBs.	Moderate to High.
	Solid Waste Landfill	Does not meet RAOs alone, but can be used in conjunction with other technologies to form remedial actions (e.g., removal, dewatering, residuals management) that eventually would be expected to meet RAOs.	Effects could be reduced through use of proper engineering controls. Risks of exposure and transportation accidents increase with significantly increased haul distances of materials.	Widely used.	Implementable. Depends on landfill location, availability, and capacity.	Implementable. Equipment and technical support available for sediments containing <50 mg/kg PCBs.	Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
J. Water Treatment							
I. Oily Residuals	Liquid Incineration	Does not meet RAOs alone, but can be used in conjunction with other technologies to form remedial actions (e.g., removal, dewatering, disposal) that eventually would be expected to meet RAOs.	Increased risks due to possible emissions of PICs and unburned PCBs. Risks of exposure and transportation accidents increase with significantly increased haul distances of materials.	Technology shown to effectively destroy PCBs in liquid stream.	Expected to be implementable. May be only option for handling PCB oils from PCB extraction processes, if selected.	Limited full-scale permitted facilities in operation. Public opposition possible.	Very High.
II. Water Treatment	Activated Carbon Adsorption	Does not meet RAOs alone, but can be used in conjunction with other technologies to form remedial actions (e.g., removal, dewatering, disposal) that eventually would be expected to meet RAOs. Could be applied to aqueous-based residuals from PCB treatment technologies or water generated during sediment dewatering.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water. Spent carbon would require proper disposal.	Activated carbon commonly used for water treatment. Used during 1995 NTCRA and 2005 ROPS, although majority of PCBs were not soluble but instead associated with sediments.	Implementable.	Implementable.	Low to Moderate.
	Filtration	Does not meet RAOs alone, but can be used in conjunction with other technologies to form remedial actions (e.g., removal, dewatering, disposal) that eventually would be expected to meet RAOs. Could be applied to aqueous-based residuals from PCB treatment technologies or water generated during sediment dewatering.	Minimal, assuming waste streams are properly managed. Possible worker exposure to PCB-containing sediment and water.	Reliable, with pre-treatment steps (i.e., screening). Demonstrated during 1995 NTCRA.	Implementable.	Implementable.	Low to Moderate.
K. Ice Management							
I. Structural	Pier-Type Structures	Should be effective in reducing ice-jamming (and therefore ice-jam related sediment scour) in the lower Grasse River. It is anticipated that structural ice management would need to be combined with other process options to meet RAOs.	Short-term effects to benthic habitat during construction. Minimal effects to water quality.	Utilized at Cazenovia Creek in West Seneca (New York) and the Salmon River (Connecticut).	Implementable.	Implementable; construction of piers not recommended due to public safety concerns associated with the piers in the river.	Low to Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Evaluation of Process Options for PCB-Containing Sediment

General Response Action/Remedial Technology	Process Option	EFFECTIVENESS			IMPLEMENTABILITY		RELATIVE COST[1]
		Ability to Meet RAOs	Implementation Effects	How Proven and Reliable is the Technology?	Technical Feasibility	Administrative Feasibility	
II. Non-Structural	Ice Breaking	Should be effective in reducing ice-jamming (and therefore ice jam-related sediment scour) in the lower Grasse River. It is anticipated that non-structural ice management would need to be combined with other process options to meet RAOs.	Increased safety risks to public due to ongoing winter recreational use of river. Increases in turbidity would potentially be observed during ice breaking in shallow stretches of the river.	Technology implemented during 2007 Ice Breaking Demonstration Project; however, not a true test of effectiveness in reducing ice jamming as upstream ice melted in place and a major ice run did not occur. Has been used at other sites including Rideau River (Ottawa), Chateauguay River (Chateauguay), Riviere-des-Prairies (Montreal and Laval), and L'Assomption (Joliette).	Implementable. Would need to be performed on a yearly basis.	Potentially implementable; ice breaking not recommended for future due to potential community safety risks relative to risks associated with potential future ice jams.	Low to Moderate.

Note:
1. Costs are relative to other process options within each general response action.

Acronyms:
ACPS = Activated Carbon Pilot Study
CPS = Capping Pilot Study
CERCLA = Comprehensive Environmental Response, Compensation, and Recovery Act
HASP = Health and Safety Plan
mg/kg = milligrams per kilogram
NTCRA = Non-Time-Critical Removal Action
PCBs = polychlorinated biphenyls
PICs = products of incomplete combustion
RAOs = Remedial Action Objectives
ROPS = Remedial Options Pilot Study
TSCA = Toxic Substances Control Act
SRS Program = Supplemental Remedial Studies Program
USACE = United States Army Corps of Engineers

Table 4-3

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Representative Process Options

General Response Action/ Remedial Technology	Representative Process Option(s)
A) No Further Action	No Further Action
B) Monitoring	Site-Wide Monitoring
C) Institutional Controls	Consumption Advisories
D) Source Control/Natural Recovery	Source Control Natural Recovery (via sedimentation/ biodegradation)
E) In-Place Containment Capping	 Armored Capping Sand/Topsoil Cap Near Shore Capping
F) Sediment Treatment In-Situ Treatment Ex-Situ Treatment	 Activated Carbon Application Immobilization - Stabilization/Solidification
G) Sediment Removal Dredging	 Hydraulic Dredging Mechanical Dredging
H) Sediment Dewatering Filtration	 Plate and Frame Filter Press
I) Sediment Disposal On-Site Disposal	 Local Landfill (Alcoa Secure Landfill)
J) Water Treatment	Filtration Activated Carbon Adsorption

Table 4-6

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

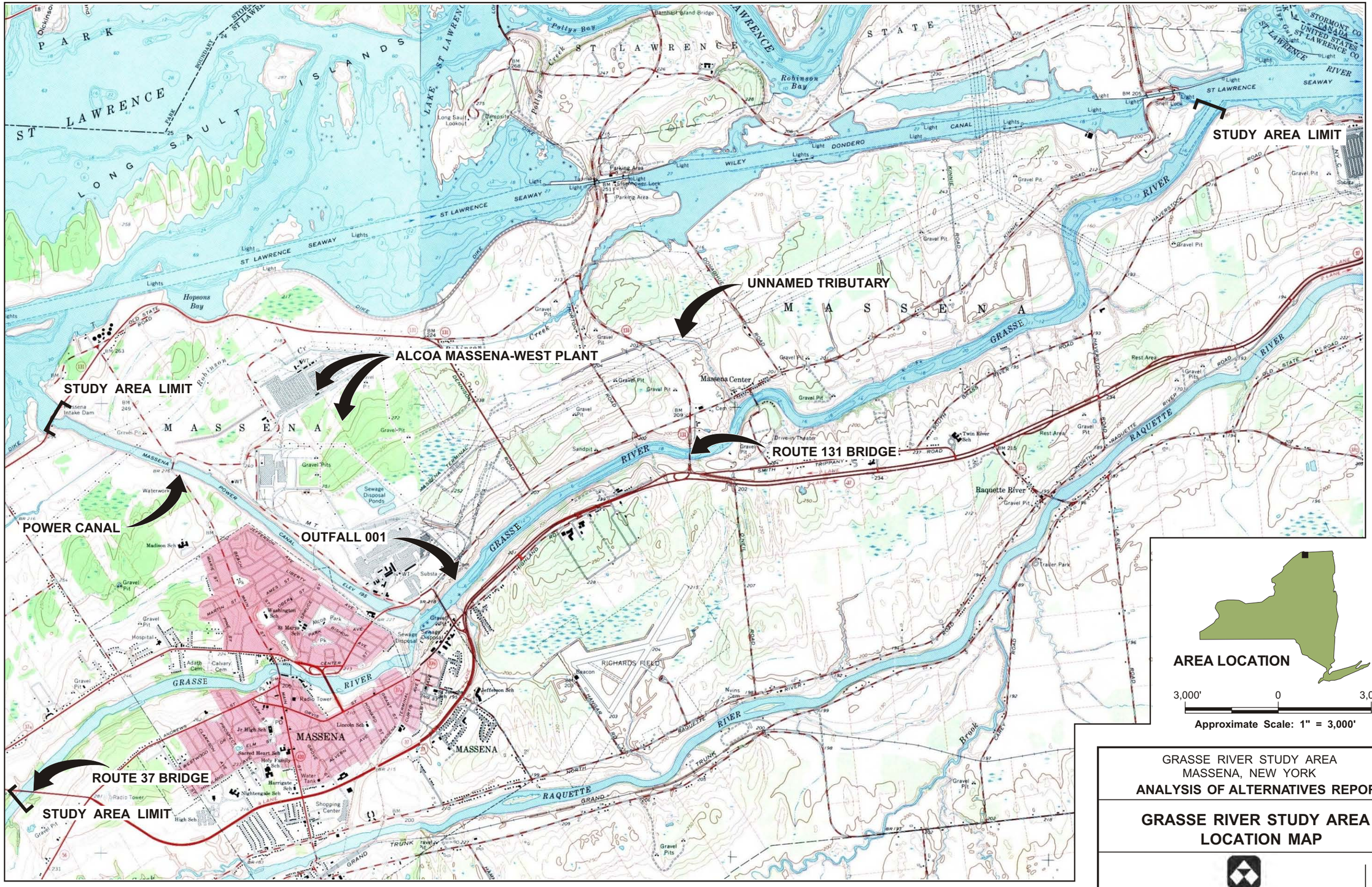
Grasse River Alternatives

Alternative (Number, Name, Description)			T1 to T21													T21 to T72													Estimated Cost ($)
			NEAR SHORE AREA					MAIN CHANNEL								NEAR SHORE AREA					MAIN CHANNEL								
			Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped	Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped Fine	Acres Capped Coarse	Acres Capped Total		Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped	Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped Fine	Acres Capped Coarse	Acres Capped Total	
No Further Action and Monitored Natural Recovery Alternatives																													
1	No Further Action	No Further Action	None	---	---	0	0	None	---	---		0	0	0		None	---	---	0	0	None	---	---	0	0	0	0		$ -
2	Monitored Natural Recovery	Monitored Natural Recovery	Monitor	---	---	0	0	Monitor	---	---		0	0	0		Monitor	---	---	0	0	Monitor	---	---		0	0	0		$ 3,400,000
Dredging and/or Capping Alternatives																													
3	T1-T72 Capping	T1-T21 Near Shore and Main Channel Capping T21-T72 Near Shore and Main Channel Capping	Near Shore Cap	SLWA / 0-12 MAX	1	0	10	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Near Shore Cap	0-12 MAX	1	0	31	Main Channel Cap	0-6 MAX	1	0	156	69	225		$ 114,100,000
4	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping T21-T72 Near Shore and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Near Shore Cap	0-12 MAX	1	0	31	Main Channel Cap	0-6 MAX	1	0	156	69	225		$ 147,200,000
5	T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling, Capping 1/10 and Main Channel Capping 1/1 T21-T72 Near Shore Dredging/Backfilling1/10 and Main Channel Capping 1/1	Near Shore Cap	SLWA / 0-12 MAX	1-10	0	4	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Near Shore Cap	0-12 MAX	1-10	0	24	Main Channel Cap	0-6 MAX	1	0	156	69	225		$ 175,200,000
			Dredge / Backfill to Grade		10	18,300	6									Dredge / Backfill to Grade		10	27,800	7									
6	T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping T21-T72 Near Shore Dredging/Backfilling and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Main Channel Cap	0-6 MAX	1	0	156	69	225		$ 243,100,000
7	T1-T72 Near Shore Dredging/Backfilling, Select T1-T19.5 Main Channel Dredging, T1-T72 Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging (T1-T19.5) T21-T72 Near Shore Dredging/Backfilling and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	31	9	40		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Main Channel Cap	0-6 MAX	1	0	156	69	225		$ 351,600,000
								Dredge (ROPS and T16.5-T19.5) / Armored Cap	--[8]	--	149,600	18	1	19															
8	T1-T21 Dredging/Capping, T21-T72 Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging/Capping T21-T72 Near Shore and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Dredge / Armored Cap	SLWA / 0-6 MAX	1	329,200	49	10	59		Near Shore Cap	0-12 MAX	1	0	31	Main Channel Cap	0-6 MAX	1	0	156	69	225		$ 388,000,000
9	T1-T72 Near Shore Dredging/Backfilling, Select T1-T46 Main Channel Dredging/Capping, T1-T72 Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging (ROPS, T16.5-T19.5), Main Channel Capping T21-T72 Near Shore Dredging/Backfilling and Main Channel Dredging (T27-T37, T43-T46), Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	31	9	40		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Main Channel Cap	0-6 MAX	1	0	114	54	168		$ 588,500,000
								Dredge (ROPS and T16.5-T19.5) / Armored Cap	--[8]	--	149,600	18	1	19							Dredge (T27-T37 and T43-T46) / Main Channel Cap	--[8]	--	374,900	42	15	57			
10	T1-T72 Dredging/Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging/Capping T21-T72 Near Shore and Main Channel Dredging/Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Dredge / Armored Cap	SLWA / 0-6 MAX	1	329,200	49	10	59		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Dredge / Main Channel Cap	0-6 MAX	1	1,225,600	156	69	225		$ 1,273,500,000

Notes:
1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Removal volumes for near shore area dredging components reflect removal of entire depth of contamination.
3) Removal components in the main channel consider fine sediment areas only.
4) Capping components in the main channel consider both fine and coarse sediment areas.
5) Estimated costs based on assumptions provided on Table Y, and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
6) Dredging volumes and cap areas based on 2010 near shore update.
7) Expected Volume includes volume considerations for over dredging and side slopes.
8) Alternatives 7 and 9: if no PCB metric is defined, dredging in the main channel targets all sediment within the identified transects.

Acronyms:
CY = cubic yards
CPS = Capping Pilot Study
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
mg/kg = milligram per kilogram
T = transect

Figures



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

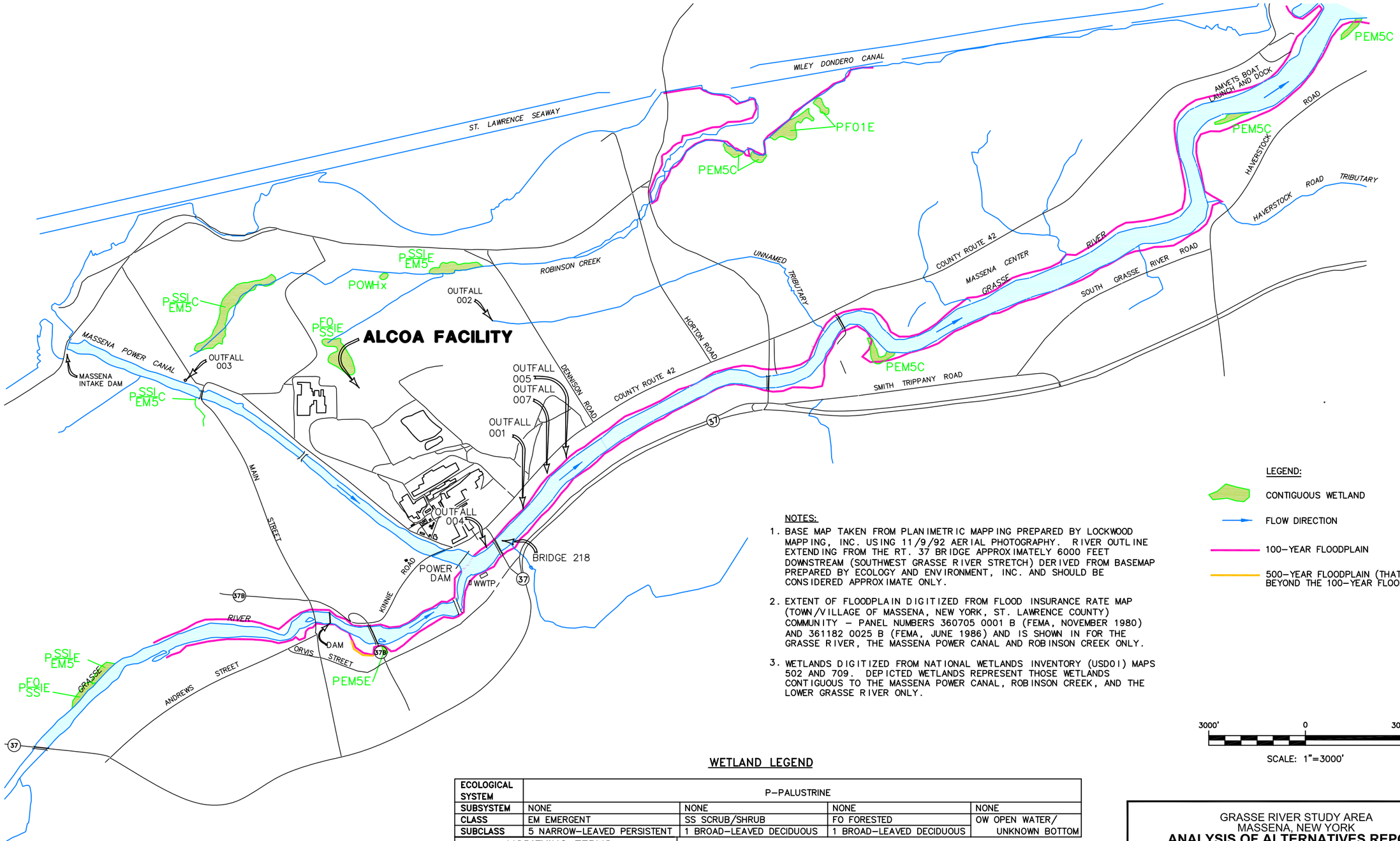
GRASSE RIVER STUDY AREA - LOCATION MAP

ALCOA

FIGURE
1-1

12/13/07 SYR-D85-DJH
10829001/10829n01.cdr

REFERENCE: MASSENA, NEW YORK-ONTARIO USGS QUAD. 1964 RAQUETTE RIVER, NEW YORK-ONTARIO USGS QUAD. 1964



LEGEND:

- CONTIGUOUS WETLAND
- FLOW DIRECTION
- 100-YEAR FLOODPLAIN
- 500-YEAR FLOODPLAIN (THAT EXTENDS BEYOND THE 100-YEAR FLOODPLAIN)

NOTES:

1. BASE MAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY. RIVER OUTLINE EXTENDING FROM THE RT. 37 BRIDGE APPROXIMATELY 6000 FEET DOWNSTREAM (SOUTHWEST GRASSE RIVER STRETCH) DERIVED FROM BASEMAP PREPARED BY ECOLOGY AND ENVIRONMENT, INC. AND SHOULD BE CONSIDERED APPROXIMATE ONLY.
2. EXTENT OF FLOODPLAIN DIGITIZED FROM FLOOD INSURANCE RATE MAP (TOWN/VILLAGE OF MASSENA, NEW YORK, ST. LAWRENCE COUNTY) COMMUNITY – PANEL NUMBERS 360705 0001 B (FEMA, NOVEMBER 1980) AND 361182 0025 B (FEMA, JUNE 1986) AND IS SHOWN IN FOR THE GRASSE RIVER, THE MASSENA POWER CANAL AND ROBINSON CREEK ONLY.
3. WETLANDS DIGITIZED FROM NATIONAL WETLANDS INVENTORY (USDOI) MAPS 502 AND 709. DEPICTED WETLANDS REPRESENT THOSE WETLANDS CONTIGUOUS TO THE MASSENA POWER CANAL, ROBINSON CREEK, AND THE LOWER GRASSE RIVER ONLY.

3000' 0 3000'

SCALE: 1"=3000'

WETLAND LEGEND

ECOLOGICAL SYSTEM	P–PALUSTRINE			
SUBSYSTEM	NONE	NONE	NONE	NONE
CLASS	EM EMERGENT	SS SCRUB/SHRUB	FO FORESTED	OW OPEN WATER/ UNKNOWN BOTTOM
SUBCLASS	5 NARROW–LEAVED PERSISTENT	1 BROAD–LEAVED DECIDUOUS	1 BROAD–LEAVED DECIDUOUS	

MODIFYING TERMS

WATER REGIME	SPECIAL MODIFIERS
NON–TIDAL	x EXCAVATED
C SEASONAL	
E SEASONAL SATURATED	
H PERMANENT	

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

100/500-YEAR FLOODPLAIN AND CONTIGUOUS WETLAND AREAS

ALCOA

FIGURE
1-2

CITY: SYRACUSE DIV/GROUP: ENVCAD DB: G. STOWELL L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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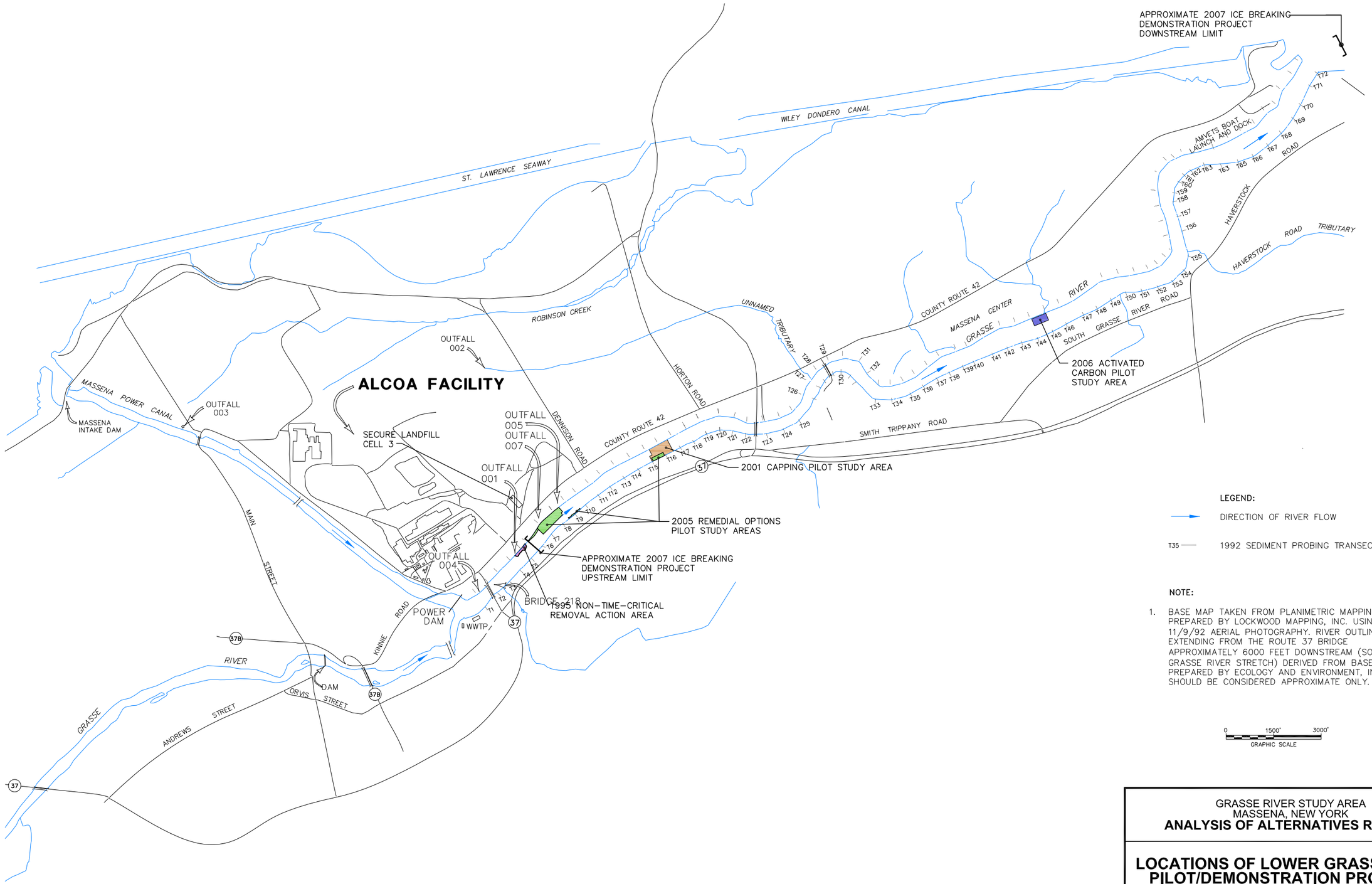


LEGEND:

DIRECTION OF RIVER FLOW

T35 — 1992 SEDIMENT PROBING TRANSECTS

NOTE:

1. BASE MAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY. RIVER OUTLINE EXTENDING FROM THE ROUTE 37 BRIDGE APPROXIMATELY 6000 FEET DOWNSTREAM (SOUTHWEST GRASSE RIVER STRETCH) DERIVED FROM BASEMAP PREPARED BY ECOLOGY AND ENVIRONMENT, INC. AND SHOULD BE CONSIDERED APPROXIMATE ONLY.

0 1500' 3000'
GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

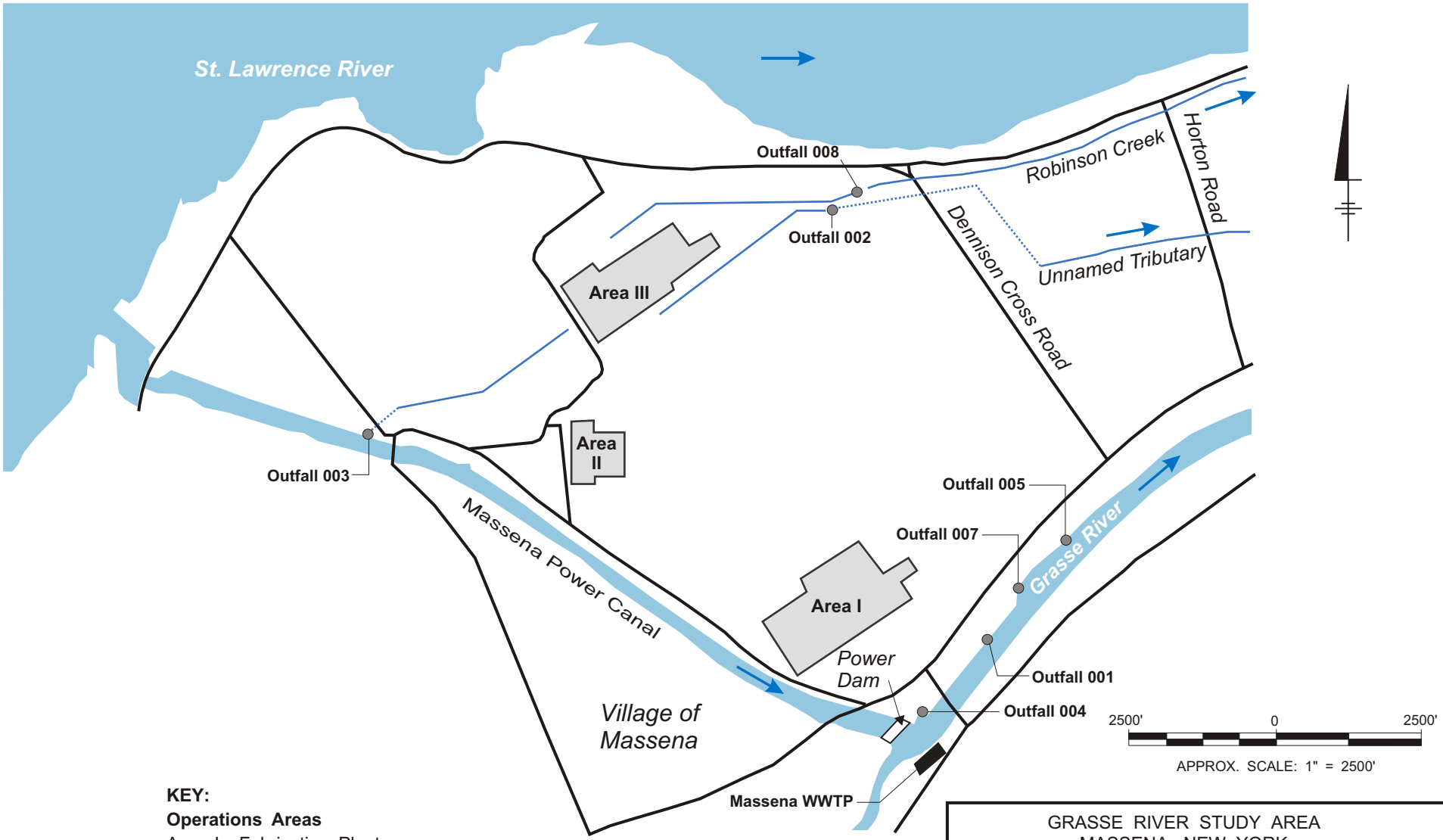
LOCATIONS OF LOWER GRASSE RIVER PILOT/DEMONSTRATION PROJECTS

ALCOA

FIGURE
1-3

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K.DAVIS L.FORAKER LD: L.POSENAUER PIC: H.VANDEWALKER PM: H.VANDEWALKER TM: S.HILL LYR: ON=*; OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0010875\0000\00001\DWG\AOA\RDATA10875G04.DWG LAYOUT: 1-3 SAVED: 3/22/2012 8:37 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: C-LD2B-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/22/2012 8:37 AM BY: FORAKER, LYDIA
XREFS: IMAGES:
10875X01 10875X01.TIF
10875X00

04/02/08 SYR-141/ENV-DJH-KLS
B0010829/0000/00001/CDR/10829G01.CDR



KEY:

Operations Areas

Area I Fabricating Plant
Area II Ingot and Extrusion Plant
Area III Smelting Plant

Flow Direction
Underground Line

NOTES:

1. Locations of outfalls are approximate only.
2. Only external outfalls depicted.
3. All outfalls are permitted.

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

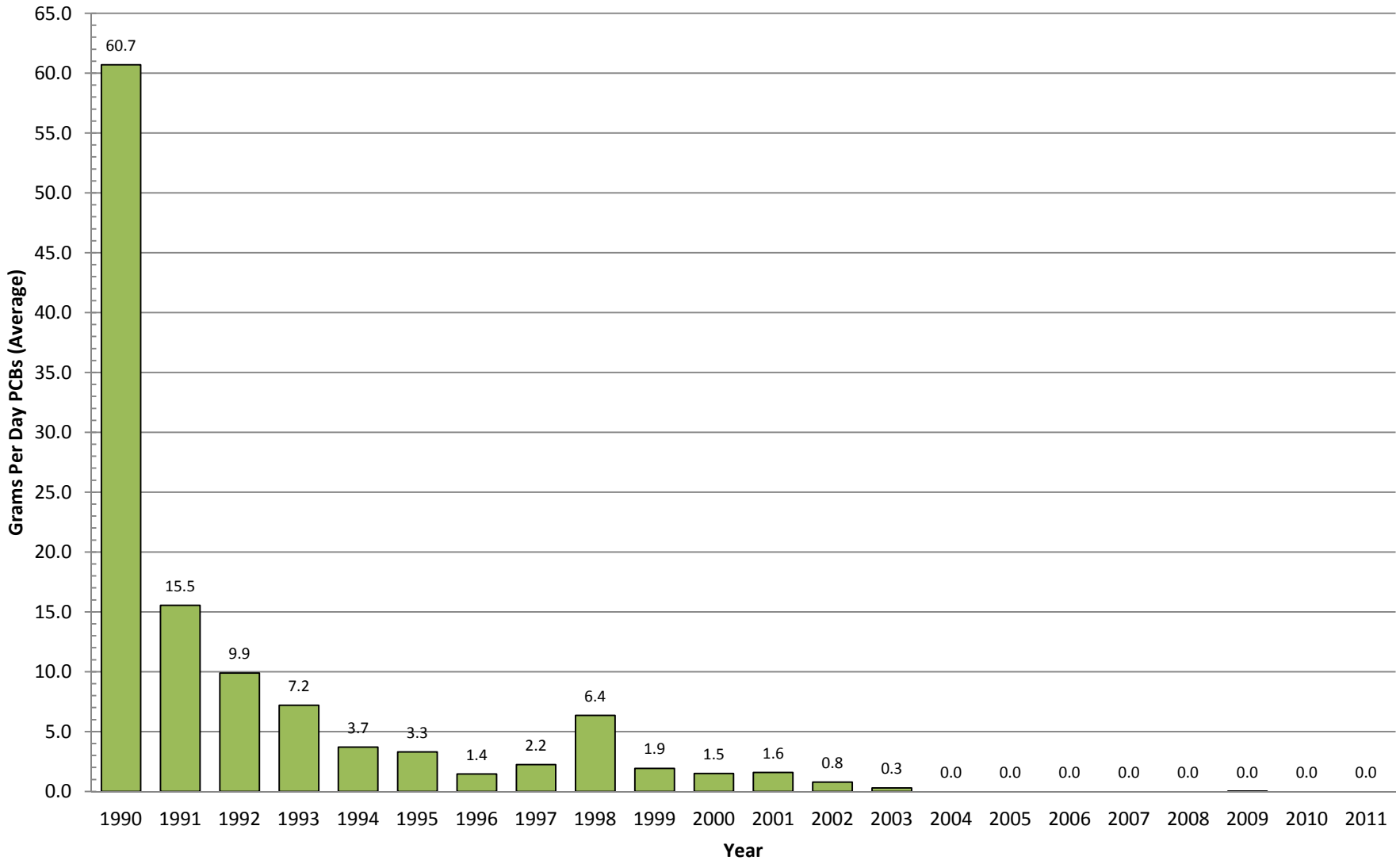
ALCOA MASSENA - WEST PLANT PRODUCTION FACILITIES AND OUTFALLS

ALCOA

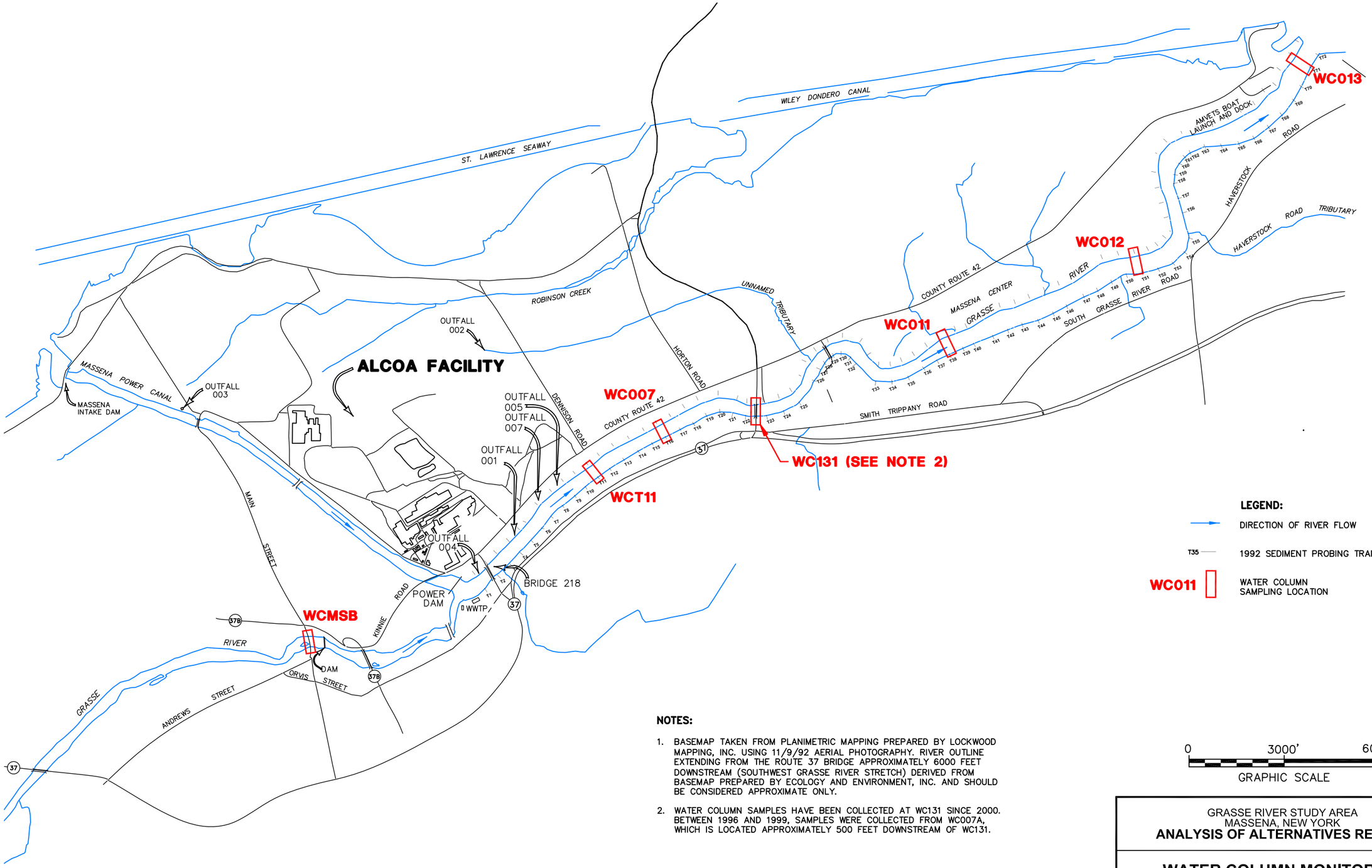
FIGURE 1-4

Figure 1-5
Alcoa Massena-West Plant Average Daily PCB Discharge at Outfall 001

Analysis of Alternatives Report
Grasse River Study Area, Massena, New York



Note: Non-detect values set equal to zero prior to averaging.



LEGEND:

DIRECTION OF RIVER FLOW

T35 — 1992 SEDIMENT PROBING TRANSECTS

WC011 — WATER COLUMN SAMPLING LOCATION

NOTES:

1. BASEMAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY. RIVER OUTLINE EXTENDING FROM THE ROUTE 37 BRIDGE APPROXIMATELY 6000 FEET DOWNSTREAM (SOUTHWEST GRASSE RIVER STRETCH) DERIVED FROM BASEMAP PREPARED BY ECOLOGY AND ENVIRONMENT, INC. AND SHOULD BE CONSIDERED APPROXIMATE ONLY.
2. WATER COLUMN SAMPLES HAVE BEEN COLLECTED AT WC131 SINCE 2000. BETWEEN 1996 AND 1999, SAMPLES WERE COLLECTED FROM WC007A, WHICH IS LOCATED APPROXIMATELY 500 FEET DOWNSTREAM OF WC131.

0 3000' 6000'

GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

WATER COLUMN MONITORING LOCATIONS

ALCOA

FIGURE
2-1

CITY: SYRACUSE DIV/GROUP: ENVCAD DB: G. STOWELL L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0010875\0000\00001\DWG\AOAR\DATA\10875G05.DWG LAYOUT: 2-1 SAVED: 3/22/2012 8:38 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: C-LB-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/22/2012 8:38 AM BY: FORAKER, LYDIA
XREFS: 10875X01 IMAGES: 10875X01.TIF PROJECTNAME: ---

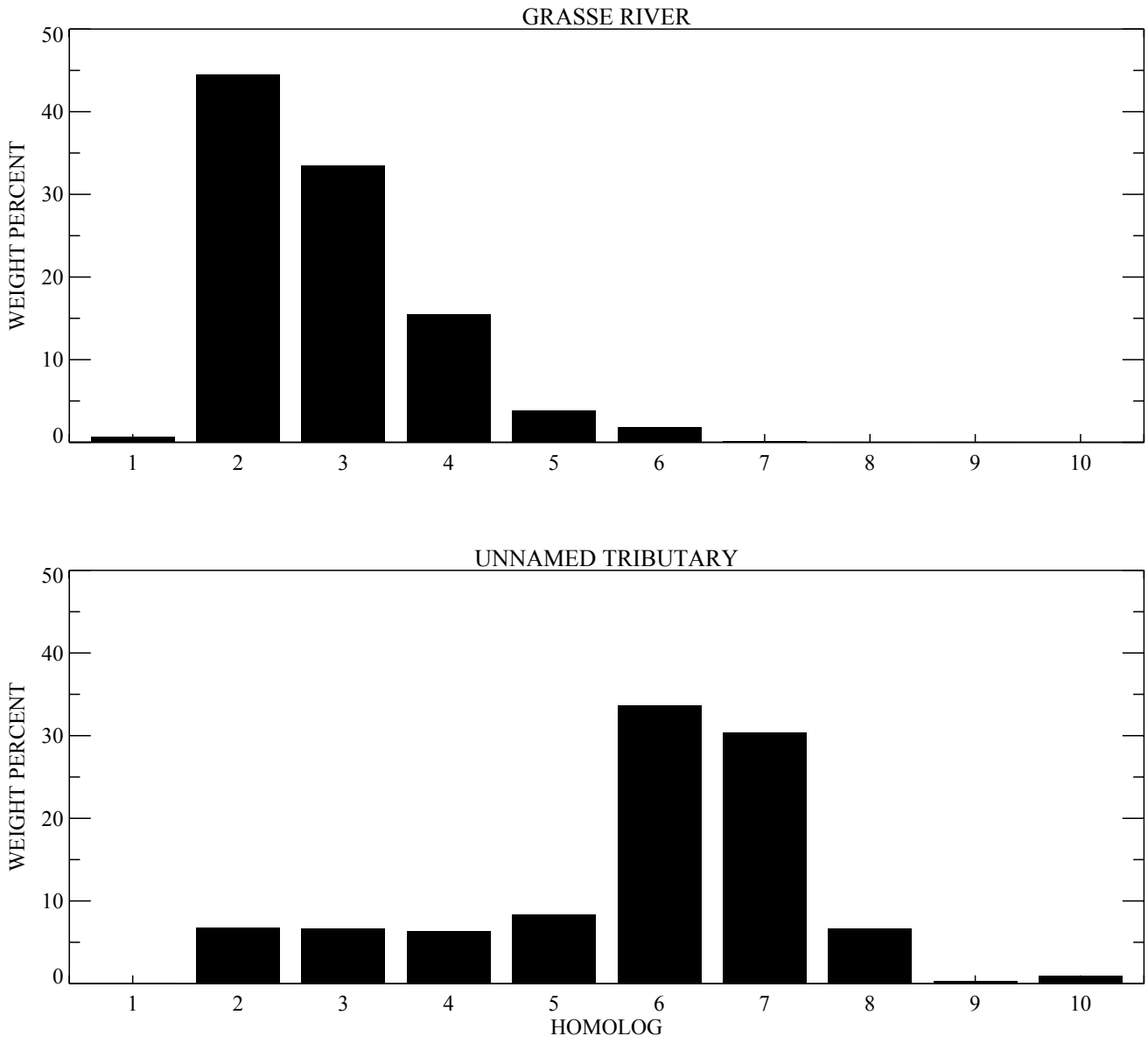
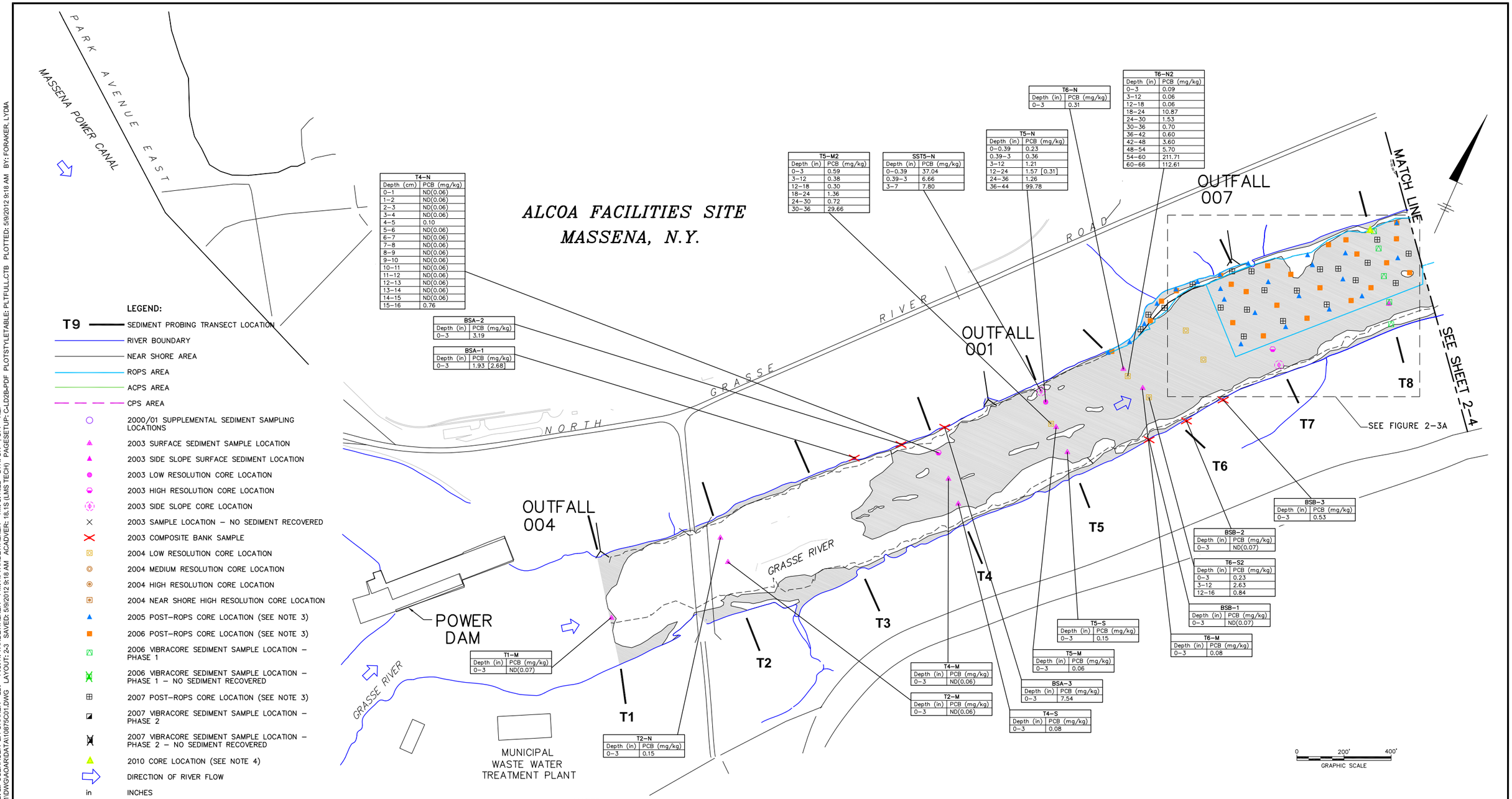


Figure 2-2. Average PCB Homolog Distributions in Water Samples Collected from the Grasse River and the Unnamed Tributary.

River values represent average of data collected from Transects WC007, WC007A, WC011 and WC012 during non-stratified periods in 1997 (all surveys except Rounds 5, 6 and 7).

Unnamed Tributary values represent average of data collected during the 1997 Storm Sampling Program.

Data tables: water_bz and outfalls_storms



T4–N	
Depth (cm)	PCB (mg/kg)
0–1	ND(0.06)
1–2	ND(0.06)
2–3	ND(0.06)
3–4	ND(0.06)
4–5	0.10
5–6	ND(0.06)
6–7	ND(0.06)
7–8	ND(0.06)
8–9	ND(0.06)
9–10	ND(0.06)
10–11	ND(0.06)
11–12	ND(0.06)
12–13	ND(0.06)
13–14	ND(0.06)
14–15	ND(0.06)
15–16	0.76

BSA–2	
Depth (in)	PCB (mg/kg)
0–3	3.19

BSA–1	
Depth (in)	PCB (mg/kg)
0–3	1.93 [2.68]

T5–M2	
Depth (in)	PCB (mg/kg)
0–3	0.59
3–12	0.38
12–18	0.30
18–24	1.36
24–30	0.72
30–36	29.66

SST5–N	
Depth (in)	PCB (mg/kg)
0–0.39	37.04
0.39–3	6.66
3–7	7.80

T5–N	
Depth (in)	PCB (mg/kg)
0–0.39	0.23
0.39–3	0.36
3–12	1.21
12–24	1.57 [0.31]
24–36	1.26
36–44	99.78

T6–N	
Depth (in)	PCB (mg/kg)
0–3	0.31

T6–N2	
Depth (in)	PCB (mg/kg)
0–3	0.09
3–12	0.06
12–18	0.06
18–24	10.87
24–30	1.53
30–36	0.70
36–42	0.60
42–48	3.60
48–54	5.70
54–60	211.71
60–66	112.61

BSB–3	
Depth (in)	PCB (mg/kg)
0–3	0.53

BSB–2	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)

T6–S2	
Depth (in)	PCB (mg/kg)
0–3	0.23
3–12	2.63
12–16	0.84

BSB–1	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)

T6–M	
Depth (in)	PCB (mg/kg)
0–3	0.08

T5–S	
Depth (in)	PCB (mg/kg)
0–3	0.15

T5–M	
Depth (in)	PCB (mg/kg)
0–3	0.06

BSA–3	
Depth (in)	PCB (mg/kg)
0–3	7.54

T4–M	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)

T2–M	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)

T4–S	
Depth (in)	PCB (mg/kg)
0–3	0.08

T1–M	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)

T2–N	
Depth (in)	PCB (mg/kg)
0–3	0.15

LEGEND:

- T9 — SEDIMENT PROBING TRANSECT LOCATION
- RIVER BOUNDARY
- NEAR SHORE AREA
- ROPS AREA
- ACPS AREA
- CPS AREA
- 2000/01 SUPPLEMENTAL SEDIMENT SAMPLING LOCATIONS
- 2003 SURFACE SEDIMENT SAMPLE LOCATION
- 2003 SIDE SLOPE SURFACE SEDIMENT LOCATION
- 2003 LOW RESOLUTION CORE LOCATION
- 2003 HIGH RESOLUTION CORE LOCATION
- 2003 SIDE SLOPE CORE LOCATION
- 2003 SAMPLE LOCATION – NO SEDIMENT RECOVERED
- 2003 COMPOSITE BANK SAMPLE
- 2004 LOW RESOLUTION CORE LOCATION
- 2004 MEDIUM RESOLUTION CORE LOCATION
- 2004 HIGH RESOLUTION CORE LOCATION
- 2004 NEAR SHORE HIGH RESOLUTION CORE LOCATION
- 2005 POST–ROPS CORE LOCATION (SEE NOTE 3)
- 2006 POST–ROPS CORE LOCATION (SEE NOTE 3)
- 2006 VIBRACORE SEDIMENT SAMPLE LOCATION – PHASE 1
- 2006 VIBRACORE SEDIMENT SAMPLE LOCATION – PHASE 1 – NO SEDIMENT RECOVERED
- 2007 POST–ROPS CORE LOCATION (SEE NOTE 3)
- 2007 VIBRACORE SEDIMENT SAMPLE LOCATION – PHASE 2
- 2007 VIBRACORE SEDIMENT SAMPLE LOCATION – PHASE 2 – NO SEDIMENT RECOVERED
- 2010 CORE LOCATION (SEE NOTE 4)
- DIRECTION OF RIVER FLOW

in	INCHES
ND (0.06)	NON–DETECT (DETECTION LIMIT)
cm	CENTIMETERS
J	ESTIMATED VALUE
mg/kg	MILLIGRAMS PER KILOGRAM (TOTAL AROCLOR)
[ ]	DUPLICATE RESULT
PCB	POLYCHLORINATED BIPHENYL

- TYPE II SEDIMENT (FINE – SEE NOTE 2)
- TYPE I SEDIMENT (COARSE – SEE NOTE 2)

NOTES:

1. GRASSE RIVER BASE MAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY. ST. LAWRENCE RIVER WATERLINE GENERATED USING 5/1/01 AERIAL PHOTOGRAPHY.
2. BOTTOM TYPE DEFINITIONS REPORTED BY OCEAN SURVEYS, INC. (OSI, AUGUST 2003). TYPE I SEDIMENT INDICATES THAT THE RIVER BED APPEARS IRREGULAR AND IS PRINCIPALLY REPRESENTED BY POSSIBLE ROCK OUTCROPS AND/OR ASSEMBLAGES OF BOULDERS/COBBLES WHICH MAY BE OVERLAIN BY A THIN VENEER OF SEDIMENTS COMPOSED OF SANDS AND GRAVEL. TYPE II SEDIMENT INDICATES THAT THE RIVER BED APPEARS FLAT/SMOOTH AND IS PRINCIPALLY COMPOSED OF SEDIMENT DEPOSITS OF CLAY, SAND AND GRAVEL.
3. POST–ROPS CORES WERE COLLECTED ALONG THE GRID ESTABLISHED AND USED FOR SEDIMENT BED ELEVATION/PROBING MEASUREMENTS DURING THE ROPS, AND THEREFORE THESE CORES ARE IDENTIFIED BY THE GRID NODE NUMBER FROM WHICH IT WAS COLLECTED (i.e., 23, 64, 659, ETC.).
4. A SINGLE 2010 CORE (SED–T8–NSNB) COLLECTED AS PART OF THE NEAR SHORE SAMPLING PROGRAM FELL OUTSIDE OF THE NEAR SHORE AREA DELINEATION AND WITHIN THE MAIN CHANNEL OF THE RIVER.
5. DATA PRESENTED FOR TRANSECTS T1 THROUGH T19 COLLECTED BETWEEN 2003 AND 2007. DATA PRESENTED FOR TRANSECTS T19 THROUGH T72 AND ST. LAWRENCE RIVER SAMPLES COLLECTED BETWEEN 2000 AND 2007.
6. ALL NEAR SHORE SAMPLE LOCATIONS AND PCB RESULTS ARE PRESENTED ON FIGURES 2–12 THROUGH 2–19.

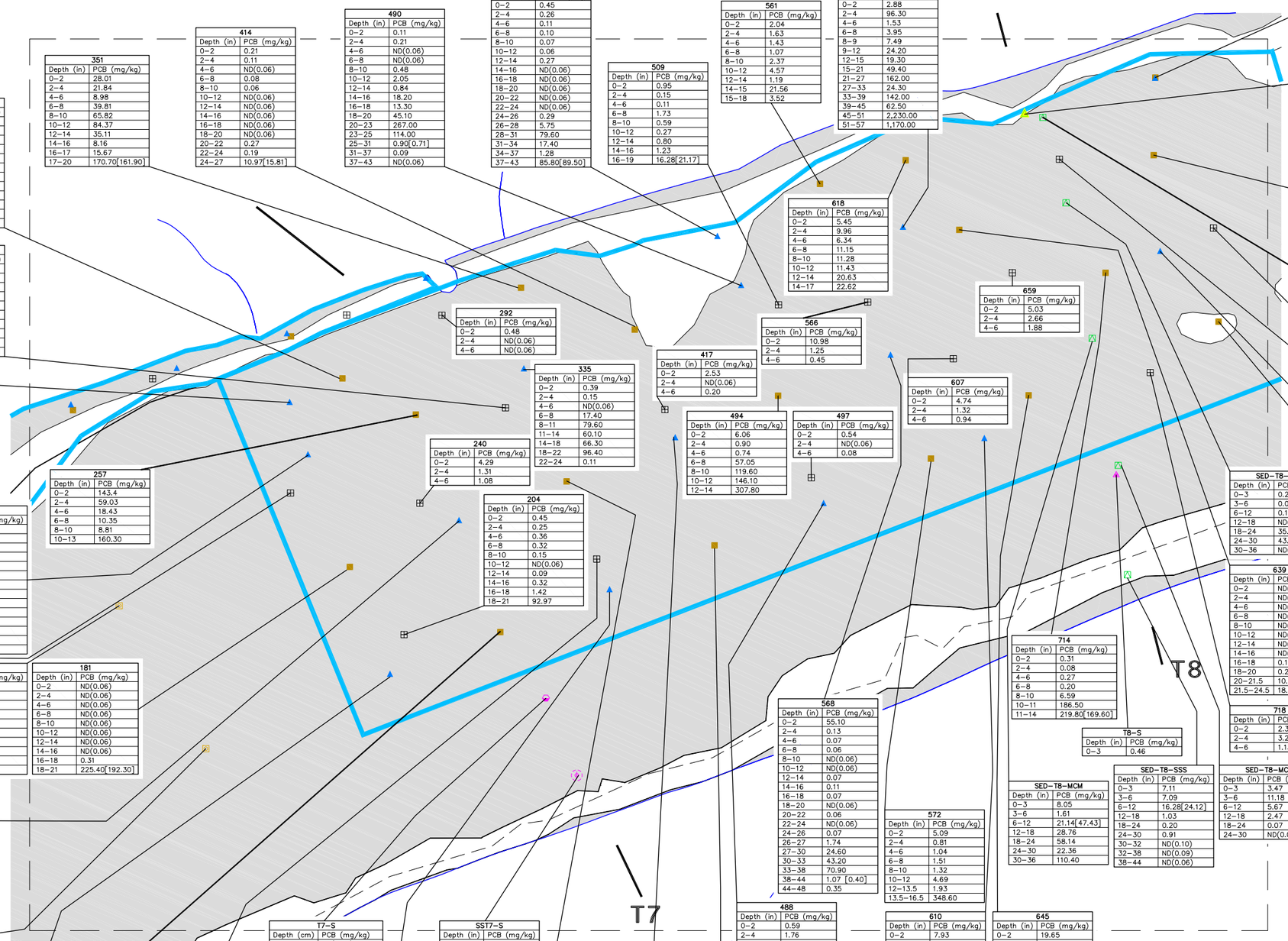
GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T1 - T8

ALCOA

FIGURE
2-3

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0010875\0000\00001\DWG\AOAR\DATA\10875C01.DWG LAYOUT: 2-3 SAVED: 5/9/2012 9:18 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: C-LD2B-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 5/9/2012 9:18 AM BY: FORAKER, LYDIA
XREFS: 10875X02 10875X00 10875X03 IMAGES: 10875X01.TIF



175	
Depth (in)	PCB (mg/kg)
0–2	0.27
2–4	ND(0.06)
4–6	0.07
6–8	ND(0.06)
8–10	ND(0.06)
10–12	0.25
12–14	0.20
14–16	0.24
16–18	0.52
18–20	0.43
20–22	22.60
22–25	54.80
25–28	64.20
28–34	42.00 [40.30]
34–36	98.10

215	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	ND(0.06)
18–20	ND(0.06)
20–22	0.99
22–25	25.82[18.43]

316	
Depth (in)	PCB (mg/kg)
0–2	ND(0.07)
2–4	ND(0.06)
4–6	ND(0.06)
6–8	0.12
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	0.06
16–18	104.70
18–21	29.99[24.83]

351	
Depth (in)	PCB (mg/kg)
0–2	28.01
2–4	21.84
4–6	8.98
6–8	39.81
8–10	65.82
10–12	84.37
12–14	35.11
14–16	8.16
16–17	15.67
17–20	170.70[161.90]

414	
Depth (in)	PCB (mg/kg)
0–2	0.21
2–4	0.11
4–6	ND(0.06)
6–8	0.08
8–10	0.06
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	ND(0.06)
18–20	ND(0.06)
20–22	0.27
22–24	0.19
24–27	10.97[15.81]

490	
Depth (in)	PCB (mg/kg)
0–2	0.11
2–4	0.21
4–6	ND(0.06)
6–8	ND(0.06)
8–10	0.48
10–12	2.05
12–14	0.84
14–16	18.20
16–18	13.30
18–20	45.10
20–23	267.00
23–25	114.00
25–31	0.90[0.71]
31–37	0.09
37–43	ND(0.06)

498	
Depth (in)	PCB (mg/kg)
0–2	0.45
2–4	0.26
4–6	0.11
6–8	0.10
8–10	0.07
10–12	0.06
12–14	0.27
14–16	ND(0.06)
16–18	ND(0.06)
18–20	ND(0.06)
20–22	ND(0.06)
22–24	ND(0.06)
24–26	0.29
26–28	5.75
28–31	79.60
31–34	17.40
34–37	1.28
37–43	85.80[89.50]

509	
Depth (in)	PCB (mg/kg)
0–2	0.95
2–4	0.15
4–6	0.11
6–8	1.73
8–10	0.59
10–12	0.27
12–14	0.80
14–16	1.23
16–19	16.28[21.17]

561	
Depth (in)	PCB (mg/kg)
0–2	2.04
2–4	1.63
4–6	1.43
6–8	1.07
8–10	2.37
10–12	4.57
12–14	1.19
14–15	21.56
15–18	3.52

602	
Depth (in)	PCB (mg/kg)
0–2	2.88
2–4	96.30
4–6	1.53
6–8	3.95
8–9	7.49
9–12	24.20
12–15	19.30
15–21	49.40
21–27	162.00
27–33	24.30
33–39	142.00
39–45	62.50
45–51	2,230.00
51–57	1,170.00

779	
Depth (in)	PCB (mg/kg)
0–2	1.03
2–4	2.87
4–6	7.33
6–7	13.50
7–10	39.10
10–13	15.10
13–19	2.49 [2.65]
19–25	7.22
25–31	7.38
31–37	14.10
37–43	70.80
43–49	150.00
49–55	338.00
55–61	949.00

SED–T8–NSNB	
Depth (in)	PCB (mg/kg)
0–3	0.91
3–6	1.87
6–12	3.31
12–18	0.09
18–24	ND(0.07)
24–30	0.12
30–36	ND(0.07)
36–42	ND(0.07)
42–48	ND(0.07)
48–54	0.12
54–60	5.74
60–66	169.72
66–72	1,534.00
72–78	758.80

618	
Depth (in)	PCB (mg/kg)
0–2	5.45
2–4	9.96
4–6	6.34
6–8	11.15
8–10	11.28
10–12	11.43
12–14	20.63
14–17	22.62

659	
Depth (in)	PCB (mg/kg)
0–2	5.03
2–4	2.66
4–6	1.88

SED–T8–SSN	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)
3–6	ND(0.06)
6–12	0.06[0.12]
12–18	5.04
18–24	0.41
24–30	1.30
30–36	12.61
36–42	20.54
42–48	220.50
48–54	197.50
54–60	2,139.00
60–66	764.80
66–68	865.70

765	
Depth (in)	PCB (mg/kg)
0–2	2.72
2–4	0.87
4–6	1.45
6–8	1.54
8–10	1.09
10–12	0.78
12–14	0.89
14–16	0.86
16–18	2.09
18–20	1.59
20–22	1.69
22–24	4.55
24–26	4.09
26–27	132.90[101.80]

292	
Depth (in)	PCB (mg/kg)
0–2	0.48
2–4	ND(0.06)
4–6	ND(0.06)

566	
Depth (in)	PCB (mg/kg)
0–2	10.98
2–4	1.25
4–6	0.45

417	
Depth (in)	PCB (mg/kg)
0–2	2.53
2–4	ND(0.06)
4–6	0.20

335	
Depth (in)	PCB (mg/kg)
0–2	0.39
2–4	0.15
4–6	ND(0.06)
6–8	17.40
8–11	79.60
11–14	60.10
14–18	66.30
18–22	96.40
22–24	0.11

607	
Depth (in)	PCB (mg/kg)
0–2	4.74
2–4	1.32
4–6	0.94

494	
Depth (in)	PCB (mg/kg)
0–2	6.06
2–4	0.90
4–6	0.74
6–8	57.05
8–10	119.60
10–12	146.10
12–14	307.80

497	
Depth (in)	PCB (mg/kg)
0–2	0.54
2–4	ND(0.06)
4–6	0.08

710	
Depth (in)	PCB (mg/kg)
0–2	0.48
2–4	0.17
4–6	ND(0.06)

785	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	13.93
4–6	0.36

240	
Depth (in)	PCB (mg/kg)
0–2	4.29
2–4	1.31
4–6	1.08

257	
Depth (in)	PCB (mg/kg)
0–2	143.4
2–4	59.03
4–6	18.43
6–8	10.35
8–10	8.81
10–13	160.30

204	
Depth (in)	PCB (mg/kg)
0–2	0.45
2–4	0.25
4–6	0.36
6–8	0.32
8–10	0.15
10–12	ND(0.06)
12–14	0.09
14–16	0.32
16–18	1.42
18–21	92.97

177	
Depth (in)	PCB (mg/kg)
0–2	25.80
2–4	10.90
4–6	13.10
6–8	2.93
8–10	2.32
10–12	1.11
12–14	0.20
14–16	0.27
16–18	0.20
18–20	1.14
20–23	33.30
23–26	74.40
26–29	63.60
29–34	0.07

159	
Depth (in)	PCB (mg/kg)
0–2	11.08
2–4	7.80
4–6	3.27
6–8	0.62
8–10	0.26
10–12	1.03
12–14	0.62
14–16	0.90
16–18	1.75
18–20	1.87
20–22	5.46
22–23	4.19
23–26	7.75[5.49]

T6.5–N2	
Depth (in)	PCB (mg/kg)
0–3	0.43
3–12	1.53
12–18	0.07
18–24	1.49
24–30	15.48
30–36	7.62
36–42	2.12
42–48	2.67
48–54	5.05
54–57	22.70

181	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	0.31
18–21	225.40[192.30]

261	
Depth (in)	PCB (mg/kg)
0–2	0.62
2–4	1.11
4–6	9.76
6–9	289.00
9–12	135.00
12–18	363.00[426.00]
18–24	481.00
24–27	197.00
27–33	12.40
33–39	0.24
39–45	0.27
45–49	0.07
49–55	ND(0.06)
55–62	ND(0.06)

T6.5–S2	
Depth (in)	PCB (mg/kg)
0–3	0.57
3–12	0.60
12–18	0.07
18–24	ND(0.06)
24–30	0.41
30–36	1.94
36–42	5.51 [2.54]
42–48	0.79
48–54	2.83
54–60	1.43 J
60–66	2.00
66–72	4.87
72–75	4.91

185	
Depth (in)	PCB (mg/kg)
0–2	12.70
2–4	2.75
4–6	1.64
6–8	3.59
8–10	3.35
10–12	14.00
12–14	4.00
14–16	3.73
16–18	5.57
18–20	0.27
20–21	4.32
21–25	26.60

265	
Depth (in)	PCB (mg/kg)
0–2	35.32
2–4	54.34
4–6	20.70
6–8	5.16
8–10	2.55
10–12	3.10
12–14	1.56
14–16	2.32
16–19	15.78[32.69]

342	
Depth (in)	PCB (mg/kg)
0–2	1.46
2–4	0.12
4–6	0.09
6–8	0.09
8–10	0.14
10–12	2.27
12–14	167.20
14–16	111.00
16–18	80.21
18–20	13.85
20–22	1.17
22–25	0.22[0.09]

T7–S	
Depth (cm)	PCB (mg/kg)
0–1	ND(0.08)
1–2	0.62
2–3	ND(0.07)
3–4	0.07 [ND(0.07)]
4–5	ND(0.07)
5–6	ND(0.07)
6–7	0.27
7–8	0.09
9–10	0.13
14–15	1.60
19–20	1.15
24–25	3.26
29–30	1.16
34–35	1.92
39–40	3.14
44–45	55.99
49–50	422.10
54–55	98.07

SS17–S	
Depth (in)	PCB (mg/kg)
0–0.39	15.70
0.39–3	0.67
3–12	2.60
12–15	2.84

343	
Depth (in)	PCB (mg/kg)
0–2	1.51
2–4	0.19
4–6	1.94
6–8	0.27
8–10	ND(0.06)
10–12	0.11
12–14	1.30
14–15	22.30

339	
Depth (in)	PCB (mg/kg)
0–2	161.20
2–4	190.20
4–6	198.30
6–8	33.05
8–10	17.72
10–12	10.54
12–14	8.43
14–16	3.68
16–18	31.30
18–20	3.83
20–23	384.30[429.70]

418	
Depth (in)	PCB (mg/kg)
0–2	0.13
2–4	0.07
4–6	0.11
6–8	0.18
8–10	0.07
10–12	0.11
12–14	ND(0.06)
14–16	ND(0.06)
16–18	0.07
18–20	0.10
20–22	ND(0.06)
22–24	ND(0.06)
24–26	ND(0.06)
26–28	ND(0.06)
28–30	0.49
30–33	2.26
33–36	ND(0.05)

422	
Depth (in)	PCB (mg/kg)
0–2	3.19
2–4	1.91
4–6	2.20
6–8	0.21
8–10	1.02
10–12	ND(0.06)
12–14	0.06
14–16	1.63
16–19	37.61

488	
Depth (in)	PCB (mg/kg)
0–2	0.59
2–4	1.76
4–6	0.11
6–8	0.12
8–10	ND(0.06)
10–12	ND(0.06)
12–14	0.98
14–17	19.20
17–20	32.30
20–25	0.41
25–29	0.54[1.05]

568	
Depth (in)	PCB (mg/kg)
0–2	55.10
2–4	0.13
4–6	0.07
6–8	0.06
8–10	ND(0.06)
10–12	ND(0.06)
12–14	0.07
14–16	0.11
16–18	0.07
18–20	ND(0.06)
20–22	0.06
22–24	ND(0.06)
24–26	0.07
26–27	1.74
27–30	24.60
30–33	43.20
33–38	70.90
38–44	1.07 [0.40]
44–48	0.35

572	
Depth (in)	PCB (mg/kg)
0–2	5.09
2–4	0.81
4–6	1.04
6–8	1.51
8–10	1.32
10–12	4.69
12–13.5	1.93
13.5–16.5	348.60

610	
Depth (in)	PCB (mg/kg)
0–2	7.93
2–4	12.90
4–6	1.79
6–8	0.82
8–10	0.62
10–12	0.33
12–14	0.24
14–16	1.99
16–18	6.18
18–20	6.20
20–23	159.00
23–26	124.00
26–32	20.20[30.90]
32–38	5.36
38–44	21.80
44–50	26.10
50–56	137.00
56–62	1,760.00
62–68	325.00
68–74	26.90
74–80	ND(0.05)
80–86	ND(0.05)

645	
Depth (in)	PCB (mg/kg)
0–2	19.65
2–4	10.75
4–6	5.83
6–8	5.18
8–10	2.38
10–12	39.97
12–14	15.42
14–17	13.00

714	
Depth (in)	PCB (mg/kg)
0–2	0.31
2–4	0.08
4–6	0.27
6–8	0.20
8–10	6.59
10–11	186.50
11–14	219.80[169.60]

T8–S	
Depth (in)	PCB (mg/kg)
0–3	0.46

SED–T8–MCM	
Depth (in)	PCB (mg/kg)
0–3	8.05
3–6	1.61
6–12	21.14[47.43]
12–18	28.76
18–24	58.14
24–30	22.36
30–36	110.40

SED–T8–SSS	
Depth (in)	PCB (mg/kg)
0–3	7.11
3–6	7.09
6–12	16.28[24.12]
12–18	1.03
18–24	0.20
24–30	0.91
30–32	ND(0.10)
32–38	ND(0.09)
38–44	ND(0.06)

SED–T8–MCS	
Depth (in)	PCB (mg/kg)
0–3	3.47
3–6	11.18
6–12	5.67
12–18	2.47
18–24	0.07
24–30	ND(0.05)

SED–T8–MCN	
Depth (in)	PCB (mg/kg)
0–3	0.22
3–6	0.08
6–12	0.19
12–18	ND(0.05)
18–24	35.89
24–30	43.95
30–36	ND(0.05)

639	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	0.10
18–20	0.28
20–21.5	10.51
21.5–24.5	18.85[27.17]

718	
Depth (in)	PCB (mg/kg)
0–2	2.32
2–4	3.28
4–6	1.13

771	
Depth (in)	PCB (mg/kg)
0–2	9.37
2–4	0.74
4–6	0.08
6–8	ND(0.06)
8–10	0.07
10–12	0.81
12–14	0.63
14–16	2.16
16–18	0.79
18–20	0.87
20–22.5	1.02
22.5–25.5	1.36

750	
Depth (in)	PCB (mg/kg)
0–2	1.43
2–4	3.44
4–6	0.63
6–8	0.60
8–10	0.47
10–12	0.51
12–14	0.52
14–16	0.71
16–18	15.90
18–21	2,710.00
21–24	626.00
24–30	79.30
30–37	65.20[0.53]

0 50' 100'
GRAPHIC SCALE

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T1 - T8

ALCOA

FIGURE
2-3A

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L.FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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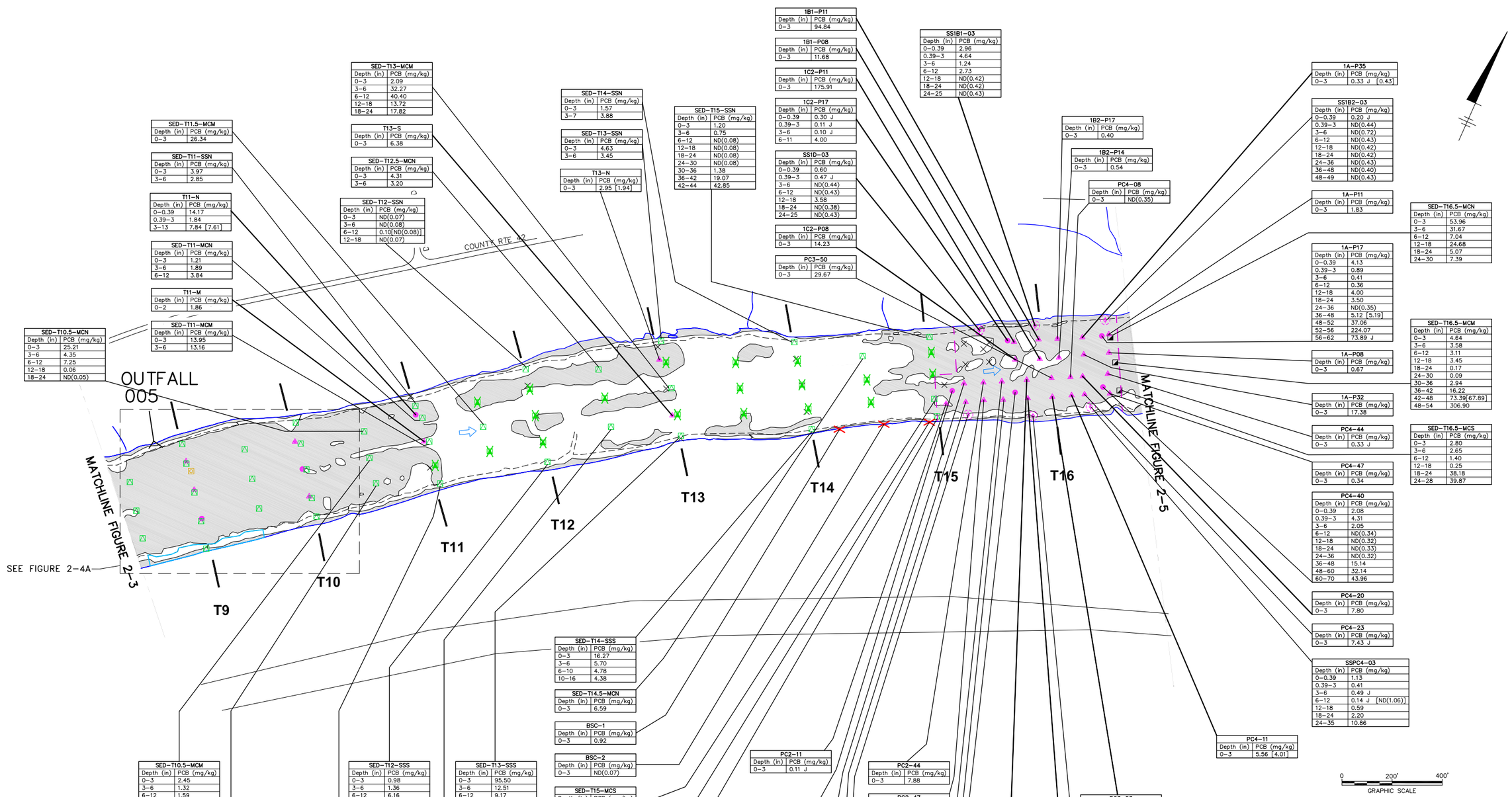

SED-T10.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	25.21
3-6	4.35
6-12	7.25
12-18	0.06
18-24	ND(0.05)

SED-T11.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	26.34

SED-T11-SSN	
Depth (in)	PCB (mg/kg)
0-3	3.97
3-6	2.85

T11-N	
Depth (in)	PCB (mg/kg)
0-0.39	14.17
0.39-3	1.84
3-13	7.84 [7.61]

SED-T11-MCN	
Depth (in)	PCB (mg/kg)
0-3	1.21
3-6	1.89
6-12	3.84

T11-M	
Depth (in)	PCB (mg/kg)
0-2	1.86

SED-T11-MCM	
Depth (in)	PCB (mg/kg)
0-3	13.95
3-6	13.16

SED-T13-MCM	
Depth (in)	PCB (mg/kg)
0-3	2.09
3-6	32.27
6-12	40.40
12-18	13.72
18-24	17.82

T13-S	
Depth (in)	PCB (mg/kg)
0-3	6.38

SED-T12.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.31
3-6	3.20

SED-T12-SSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.08)
6-12	0.10[ND(0.08)]
12-18	ND(0.07)

SED-T14-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.57
3-7	3.88

SED-T13-SSN	
Depth (in)	PCB (mg/kg)
0-3	4.63
3-6	3.45

T13-N	
Depth (in)	PCB (mg/kg)
0-3	2.95 [1.94]

SED-T15-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.20
3-6	0.75
6-12	ND(0.08)
12-18	ND(0.08)
18-24	ND(0.08)
24-30	ND(0.08)
30-36	1.38
36-42	19.07
42-44	42.85

1B1-P11	
Depth (in)	PCB (mg/kg)
0-3	94.84

1B1-P08	
Depth (in)	PCB (mg/kg)
0-3	11.68

1C2-P11	
Depth (in)	PCB (mg/kg)
0-3	175.91

1C2-P17	
Depth (in)	PCB (mg/kg)
0-0.39	0.30 J
0.39-3	0.11 J
3-6	0.10 J
6-11	4.00

SS1D-03	
Depth (in)	PCB (mg/kg)
0-0.39	0.60
0.39-3	0.47 J
3-6	ND(0.44)
6-12	ND(0.43)
12-18	3.58
18-24	ND(0.38)
24-25	ND(0.43)

1C2-P08	
Depth (in)	PCB (mg/kg)
0-3	14.23

PC3-50	
Depth (in)	PCB (mg/kg)
0-3	29.67

SS1B1-03	
Depth (in)	PCB (mg/kg)
0-0.39	2.96
0.39-3	4.64
3-6	1.24
6-12	2.73
12-18	ND(0.42)
18-24	ND(0.42)
24-25	ND(0.43)

1B2-P17	
Depth (in)	PCB (mg/kg)
0-3	0.40

1B2-P14	
Depth (in)	PCB (mg/kg)
0-3	0.54

PC4-08	
Depth (in)	PCB (mg/kg)
0-3	ND(0.35)

1A-P35	
Depth (in)	PCB (mg/kg)
0-3	0.33 J [0.43]

SS1B2-03	
Depth (in)	PCB (mg/kg)
0-0.39	0.20 J
0.39-3	ND(0.44)
3-6	ND(0.72)
6-12	ND(0.43)
12-18	ND(0.42)
18-24	ND(0.42)
24-36	ND(0.43)
36-48	ND(0.40)
48-49	ND(0.43)

1A-P11	
Depth (in)	PCB (mg/kg)
0-3	1.83

1A-P17	
Depth (in)	PCB (mg/kg)
0-0.39	4.13
0.39-3	0.89
3-6	0.41
6-12	0.36
12-18	4.00
18-24	3.50
24-36	ND(0.35)
36-48	5.12 [5.19]
48-52	37.06
52-56	224.07
56-62	73.89 J

1A-P08	
Depth (in)	PCB (mg/kg)
0-3	0.67

1A-P32	
Depth (in)	PCB (mg/kg)
0-3	17.38

PC4-44	
Depth (in)	PCB (mg/kg)
0-3	0.33 J

PC4-47	
Depth (in)	PCB (mg/kg)
0-3	0.34

PC4-40	
Depth (in)	PCB (mg/kg)
0-0.39	2.08
0.39-3	4.31
3-6	2.05
6-12	ND(0.34)
12-18	ND(0.32)
18-24	ND(0.33)
24-36	ND(0.32)
36-48	15.14
48-60	32.14
60-70	43.96

PC4-20	
Depth (in)	PCB (mg/kg)
0-3	7.80

PC4-23	
Depth (in)	PCB (mg/kg)
0-3	7.43 J

SSPC4-03	
Depth (in)	PCB (mg/kg)
0-0.39	1.13
0.39-3	0.41
3-6	0.49 J
6-12	0.14 J [ND(1.06)]
12-18	0.59
18-24	2.20
24-35	10.86

SED-T16.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	53.96
3-6	31.67
6-12	7.04
12-18	24.68
18-24	5.07
24-30	7.39

SED-T16.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	4.64
3-6	3.58
6-12	3.11
12-18	3.45
18-24	0.17
24-30	0.09
30-36	2.94
36-42	16.22
42-48	73.39[67.89]
48-54	306.90

SED-T16.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	2.80
3-6	2.65
6-12	1.40
12-18	0.25
18-24	38.18
24-28	39.87

PC4-11	
Depth (in)	PCB (mg/kg)
0-3	5.56 [4.01]

SED-T10.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	2.45
3-6	1.32
6-12	1.59
12-18	7.47
18-24	ND(0.05)
24-30	ND(0.05)

SED-T10.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	8.72
3-6	0.59
6-12	0.98
12-18	2.56
18-24	211.7
24-26	476.8

SED-T12-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.98
3-6	1.36
6-12	6.16
12-15	3.98

SED-T11-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.17
3-6	0.12
6-12	0.50

SED-T12.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	20.18
3-6	2.01
6-12	9.48
12-16	7.54

SED-T13-SSS	
Depth (in)	PCB (mg/kg)
0-3	95.50
6-12	12.51
6-12	9.17

SED-T14-SSS	
Depth (in)	PCB (mg/kg)
0-3	16.27
3-6	5.70
6-10	4.78
10-16	4.38

SED-T14.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	6.59

BSC-1	
Depth (in)	PCB (mg/kg)
0-3	0.92

BSC-2	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)

SED-T15-MCS	
Depth (in)	PCB (mg/kg)
0-3	6.14
3-6	0.80
6-12	1.05

BSC-3	
Depth (in)	PCB (mg/kg)
0-3	ND(0.06)

SED-T15-SSS	
Depth (in)	PCB (mg/kg)
0-3	2.54
3-6	2.40
6-12	9.59[13.10]
12-18	74.56
18-24	0.35
24-30	ND(0.05)

PC2-11	
Depth (in)	PCB (mg/kg)
0-3	0.11 J

PC2-15	
Depth (in)	PCB (mg/kg)
0-0.39	23.86
0.39-3	80.90
3-6	73.55

PC2-26	
Depth (in)	PCB (mg/kg)
0-3	1.94

PC2-29	
Depth (in)	PCB (mg/kg)
0-3	2.80

SSPC2-03	
Depth (in)	PCB (mg/kg)
0-0.39	0.37
0.39-3	0.10 J
3-6	1.45
6-12	13.36 [13.79]
12-16	0.54

PC2-44	
Depth (in)	PCB (mg/kg)
0-3	7.88

PC2-47	
Depth (in)	PCB (mg/kg)
0-3	0.91

PC3-02	
Depth (in)	PCB (mg/kg)
0-3	3.70

PC3-05	
Depth (in)	PCB (mg/kg)
0-3	3.27

PC3-16	
Depth (in)	PCB (mg/kg)
0-0.39	1.19
0.39-3	0.39
3-6	2.20
6-12	5.98
12-18	46.21
18-24	78.17
24-36	60.32
36-45	18.43

PC3-26	
Depth (in)	PCB (mg/kg)
0-3	5.68

PC3-29	
Depth (in)	PCB (mg/kg)
0-3	ND(0.36)

SSPC3-03	
Depth (in)	PCB (mg/kg)
0-0.39	0.59
0.39-3	0.37
3-6	0.22 J
6-12	0.33 J
12-18	2.19
18-24	9.20
24-36	21.66 [25.11]
36-41	0.76 J

PC3-53	
Depth (in)	PCB (mg/kg)
0-3	1.57

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T9 - T16

ALCOA

FIGURE
2-4

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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IMAGES: 10875X01.TIF

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L.FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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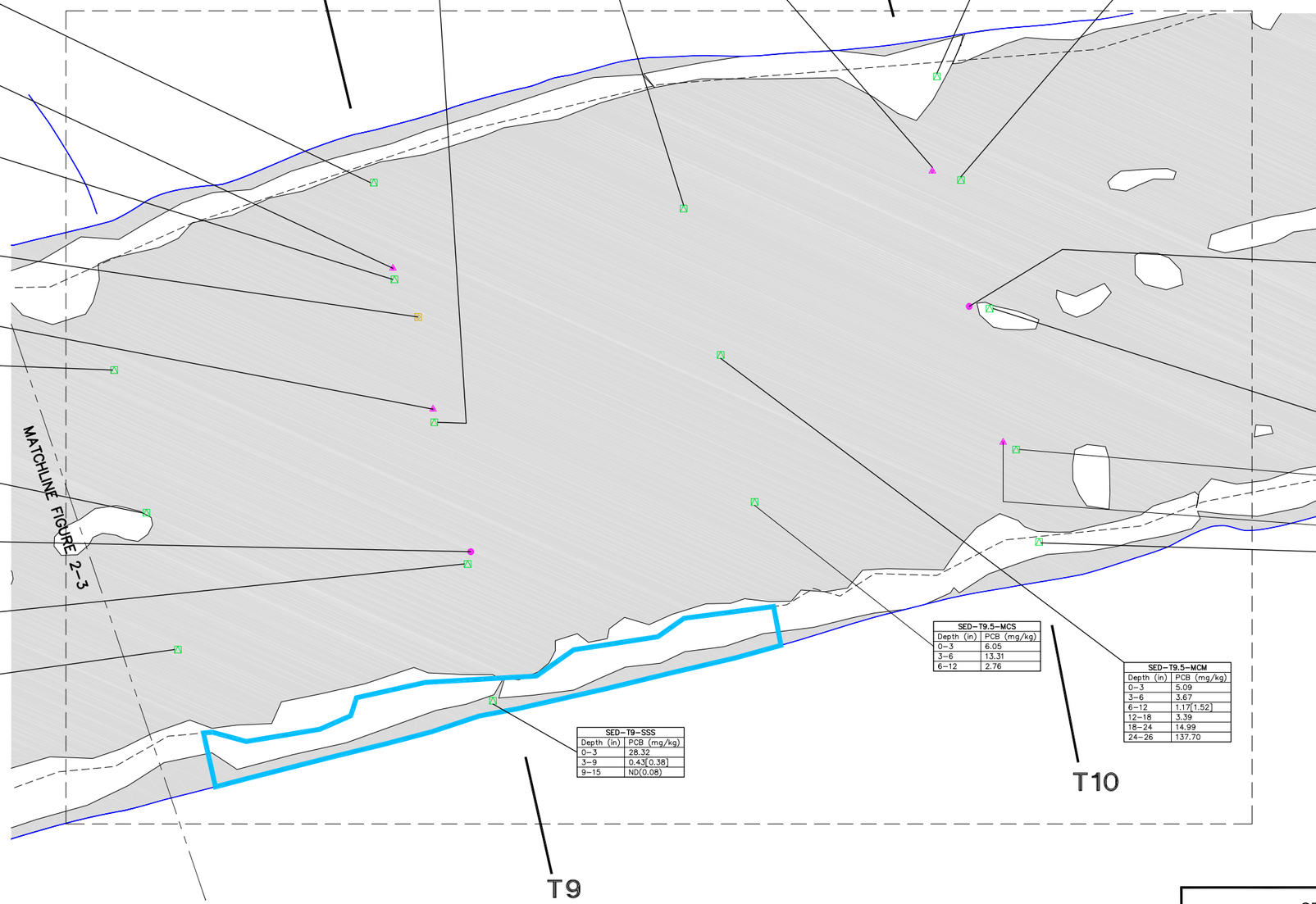


SED-T9-SSN	
Depth (in)	PCB (mg/kg)
0-3	9.54
3-6	7.22
6-12	16.29[28.34]
12-18	30.21

SED-T9-MCM	
Depth (in)	PCB (mg/kg)
0-3	62.60
3-6	34.50
6-12	6.34
12-18	6.99
18-24	13.78
24-30	384.40
30-36	78.06
36-42	3106.00
42-48	581.40
48-54	26.08
54-60	0.06

SED-T9.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.44
3-6	2.30
6-12	6.18
12-18	6.65

T10-N	
Depth (in)	PCB (mg/kg)
0-3	16.92

SED-T10-SSN	
Depth (in)	PCB (mg/kg)
0-3	0.40
3-6	0.22
6-12	ND (0.07)
12-18	ND (0.07)

SED-T10-MCN	
Depth (in)	PCB (mg/kg)
0-3	3.86
3-6	7.29
6-12	5.09
12-18	15.88
18-24	46.40
24-30	822.00

T9-N	
Depth (in)	PCB (mg/kg)
0-3	2.52[1.62]

SED-T9-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.98
3-6	46.21
6-12	93.07[43.77]
12-18	80.68
18-24	2,773.00
24-30	1.86
30-35	0.07

T9-N2	
Depth (in)	PCB (mg/kg)
0-3	0.78
3-12	2.81
12-18	4.56
18-24	2.92
24-30	85.49
30-36	97.01
36-42	147.40
42-48	1030.60
48-51	189.84

T9-M	
Depth (in)	PCB (mg/kg)
0-3	3.63

SED-T8.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.39
3-6	1.33
6-12	5.65[4.51]
12-18	2.62
18-24	100.7
24-30	969.00

SED-T8.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	40.10
3-6	21.13
6-12	7.13
12-18	23.11
18-24	1.97
24-27	1,423.00

T9-S	
Depth (in)	PCB (mg/kg)
0-0.39	2.39
0.39-3	4.56
3-12	3.55
12-24	19.02
24-32	2.43

SED-T9-MCS	
Depth (in)	PCB (mg/kg)
0-3	4.04
3-6	0.80
6-12	0.61
12-18	12.25
18-24	5.20
24-27	12.87

SED-T8.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	3.49
3-6	4.03
6-12	4.58
12-18	0.62

T10-M	
Depth (cm)	PCB (mg/kg)
0-1	1.50
1-2	4.54
2-3	1.34
3-4	2.79
4-5	8.97
5-6	2.58
6-7	7.34
7-8	5.47
9-10	5.18
14-15	4.36
19-20	13.18
24-25	3.16[2.99]
29-30	3.88
34-35	6.33
39-40	3.01
44-45	3.69
49-50	9.45
54-55	6.57
59-60	5.66
64-65	8.54
69-70	47.77
74-75	265.90

SED-T10-MCM	
Depth (in)	PCB (mg/kg)
0-3	9.33
3-6	5.38
6-12	3.97
12-16	0.85

SED-T10-MCS	
Depth (in)	PCB (mg/kg)
0-3	0.86
3-6	1.35

T10-S	
Depth (in)	PCB (mg/kg)
0-3	4.65

SED-T10-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.12
3-6	0.08
6-12	ND (0.07)[ND(0.06)]
12-18	0.12
18-24	0.59
24-30	3.33
30-34	65.15

SED-T9.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	6.05
3-6	13.31
6-12	2.76

SED-T9.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	5.09
3-6	3.67
6-12	1.17[1.52]
12-18	3.39
18-24	14.99
24-26	137.70

SED-T9-SSS	
Depth (in)	PCB (mg/kg)
0-3	28.32
3-9	0.43[0.38]
9-15	ND(0.08)

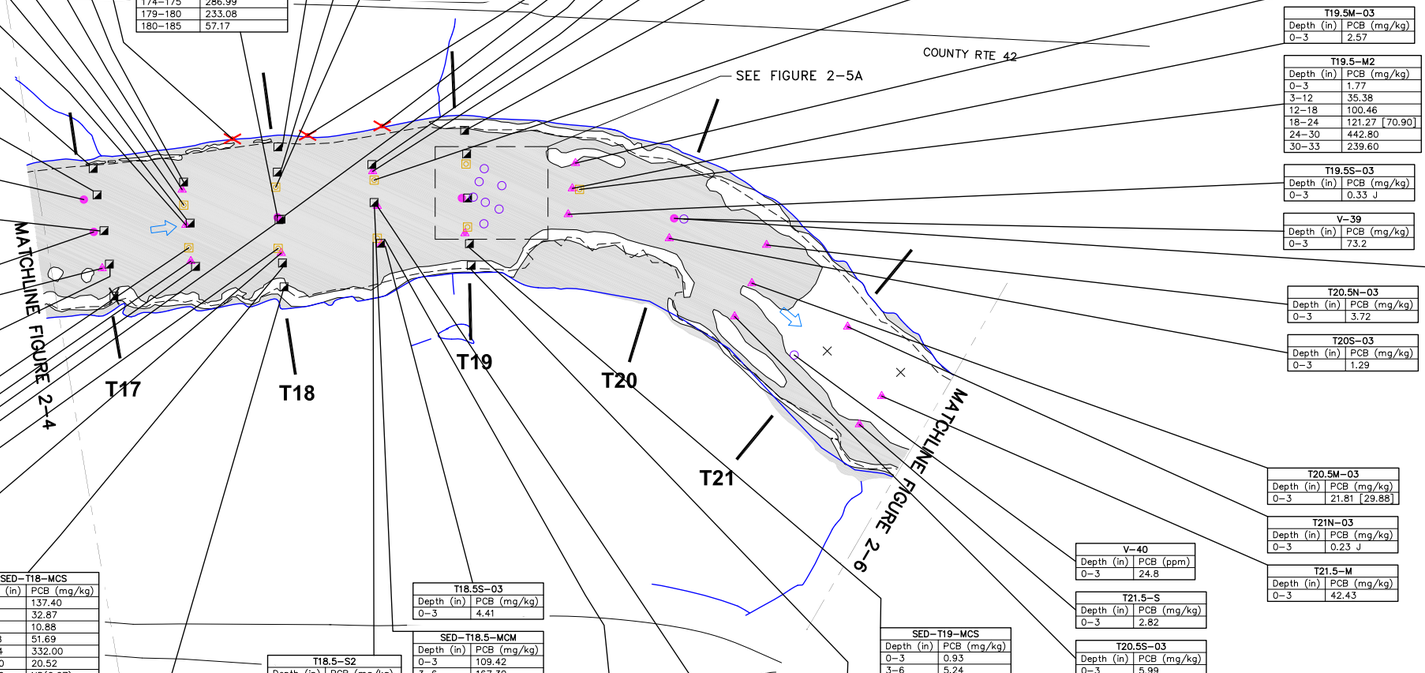
SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T9 - T16

ALCOA

FIGURE
2-4A



T17.5-N2	
Depth (in)	PCB (mg/kg)
0-3	3.18
3-12	8.83
12-18	24.23
18-24	33.89
24-30	54.59
30-36	120.65 [57.89]
36-42	17.83
42-48	41.73
48-52	27.88

SED-T17.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	3.87
3-6	1.69
6-12	52.23
12-18	23.85
18-24	17.30
24-30	1.71
30-36	ND(0.05)
36-42	0.08
42-48	ND(0.05)[ND(0.06)]
48-54	ND(0.07)
54-60	ND(0.06)
60-66	ND(0.06)

T18M-03	
Depth (cm)	PCB (mg/kg)
0-1	6.96
1-2	15.13
2-3	13.35
3-4	13.91
4-5	11.16
5-6	5.01
6-7	3.32
7-8	6.79
9-10	5.72
14-15	19.49
19-20	7.17
24-25	1.88
29-30	4.20 [2.88]
34-35	6.97
39-40	18.64 J
44-45	225.44 [270.09]
49-50	542.28
54-55	533.07
59-60	406.57
64-65	930.22
69-70	125.85
74-75	80.50
79-80	80.61
84-85	10.37
89-90	12.60
94-95	34.15
99-100	12.56
104-105	7.65
109-110	12.82
114-115	8.30
119-120	4.52
124-125	6.89
129-130	15.71
134-135	18.80
139-140	31.56
144-145	46.91
149-150	106.85
154-155	210.13
159-160	723.60
164-165	964.51
169-170	554.27
174-175	286.99
179-180	233.08
180-185	57.17

SED-T18-SSN	
Depth (in)	PCB (mg/kg)
0-3	5.63
3-6	8.55
6-12	15.07
12-18	15.58
18-24	33.62[36.64]
24-30	62.35
30-36	188.50
36-42	18.29
42-48	0.35
48-54	2.36
54-60	ND(0.08)
60-66	ND(0.08)

BSE-2	
Depth (in)	PCB (mg/kg)
0-3	0.37

BSE-3	
Depth (in)	PCB (mg/kg)
0-3	0.42

SED-T18-MCM-CC	
Depth (in)	PCB (mg/kg)
0-3	45.42
3-6	239.10
6-12	165.14
12-18	56.35
18-24	117.45
24-30	53.53
30-36	19.93
36-42	30.81
42-48	11.29
48-54	38.54
54-60	481.00
60-66	97.90
66-72	0.19
72-78	0.88

SED-T18.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.65
3-6	61.49
6-12	46.06
12-18	39.58
18-24	21.99
24-30	112.03[96.32]
30-36	63.30
36-42	212.70
42-48	103.80
48-54	262.30
54-57	14.68
57-63	ND(0.07)
63-69	0.09

T18.5N-03	
Depth (in)	PCB (mg/kg)
0-3	6.66

SED-T19-SSN	
Depth (in)	PCB (mg/kg)
0-3	7.79
3-6	29.17
6-12	23.86
12-18	11.07
18-24	0.75
24-30	0.38
30-36	0.08[0.10]
36-42	ND(0.07)
42-48	ND(0.08)
48-54	ND(0.08)
54-60	ND(0.07)
60-66	ND(0.07)
66-72	ND(0.07)
72-74	ND(0.07)

T18.5-N2	
Depth (in)	PCB (mg/kg)
0-3	98.10
3-12	68.19
12-18	42.36
18-24	110.53
24-30	253.30
30-36	104.42
36-42	176.22
42-48	320.20
48-53	848.00

T19.5N-03	
Depth (in)	PCB (mg/kg)
0-3	3.57

T19.5M-03	
Depth (in)	PCB (mg/kg)
0-3	2.57

T19.5-M2	
Depth (in)	PCB (mg/kg)
0-3	1.77
3-12	35.38
12-18	100.46
18-24	121.27 [70.90]
24-30	442.80
30-33	239.60

T19.5S-03	
Depth (in)	PCB (mg/kg)
0-3	0.33 J

V-39	
Depth (in)	PCB (mg/kg)
0-3	73.2

T20.5N-03	
Depth (in)	PCB (mg/kg)
0-3	3.72

T20S-03	
Depth (in)	PCB (mg/kg)
0-3	1.29

T20.5M-03	
Depth (in)	PCB (mg/kg)
0-3	21.81 [29.88]

T21N-03	
Depth (in)	PCB (mg/kg)
0-3	0.23 J

T21.5-M	
Depth (in)	PCB (mg/kg)
0-3	42.43

V-40	
Depth (in)	PCB (ppm)
0-3	24.8

T21.5-S	
Depth (in)	PCB (mg/kg)
0-3	2.82

T20.5S-03	
Depth (in)	PCB (mg/kg)
0-3	5.99

T20M-03	
Depth (cm)	PCB (mg/kg)
0-1	2.79
1-2	4.92
2-3	3.70
3-4	15.51
4-5	8.66
5-6	5.79
6-7	3.64 [3.31]
7-8	2.22
9-10	4.77
14-15	2.23
19-20	191.46
24-25	58.41
29-30	23.04
34-35	3.75
39-40	8.16
44-45	13.14 [13.19]
49-50	28.14 J
54-55	12.95
59-60	35.74
64-65	21.02
69-70	40.47
74-75	237.85
79-80	37.91
84-85	52.54
89-90	17.59
94-95	32.74
99-100	33.65
104-105	84.08
106-110	134.98
114-115	348.90
119-120	949.52
124-125	1213.75
129-130	451.07
134-135	273.66
139-140	109.58

T17N-03	
Depth (cm)	PCB (mg/kg)
0-1	2.93
1-2	3.84
2-3	9.06 [6.08]
3-4	9.61
4-5	3.46
5-6	1.46
6-7	1.11 J
7-8	0.54 J
9-10	1.03 J
14-15	1.76
19-20	1.79
24-25	9.16 [2.67]
29-30	2.64
34-35	2.29
39-40	9.09
44-45	7.87
49-50	9.61
54-55	16.10
59-60	32.91
64-65	7.18
69-70	49.12
74-75	126.93
79-80	149.85
84-85	17.75
89-90	15.71
94-95	33.76
99-100	6.27
104-105	46.80
109-110	52.03
114-115	16.60
119-120	18.37

SED-T17.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	3.66
3-6	2.21
6-12	3.55
12-18	4.81[3.46]
18-24	72.39
24-30	33.95
30-36	216.50
36-42	126.00
42-48	9.09
48-54	35.80
54-60	21.28
60-66	60.10
66-72	195.00[279.50]
72-78	804.60
78-84	362.30
84-87	191.95
87-93	ND(0.07)
93-99	0.27

T17.5N-03	
Depth (in)	PCB (mg/kg)
0-3	8.65

BSE-1	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)

SED-T18-MCM	
Depth (in)	PCB (mg/kg)
0-3	110.37
3-6	99.70
6-12	94.53
12-18	146.63
18-24	175.54[77.37]
24-30	73.83
30-36	19.06
36-42	18.53
42-48	176.38
48-54	338.50
54-60	217.30
60-66	17.17

T18-N2	
Depth (in)	PCB (mg/kg)
0-3	6.50
3-12	32.71
12-18	68.94
18-24	14.23
24-30	17.01
30-36	35.54
36-42	88.36
42-48	114.58
48-54	139.19
54-60	1030.40
60-67	600.20

T17.5M-03	
Depth (in)	PCB (mg/kg)
0-3	1.65

SED-T17-SSN	
Depth (in)	PCB (mg/kg)
0-3	6.77
3-6	3.12
6-12	0.27
12-18	0.07

SED-T17-MCN	
Depth (in)	PCB (mg/kg)
0-3	24.20
3-6	16.92
6-12	104.51
12-18	45.86
18-24	17.21
24-30	29.64
30-36	32.90
36-38	18.09
38-44	ND(0.08)
44-50	ND(0.07)

T17M-03	
Depth (cm)	PCB (mg/kg)
0-1	1.26
1-2	4.91
2-3	1.00
3-4	1.68
4-5	2.20
5-6	0.82
6-7	0.51
7-8	1.25
9-10	3.28
14-15	2.51
19-20	3.24 [7.61]
24-25	2.59
29-30	3.84
34-35	2.68 [1.76 J]
39-40	8.70 [3.31]
44-45	3.49
49-50	12.11
54-55	6.21
59-60	24.31
64-65	5.68
69-70	54.20
74-75	57.51
79-80	10.27
84-85	8.56
89-90	5.41 J
94-95	14.31
99-100	7.79
104-105	20.18
109-110	56.53
114-115	25.08
119-120	9.71
124-125	8.18
129-130	21.67
134-135	92.70
139-140	237.26
144-145	953.45
149-150	895.67
154-155	173.29
159-160	274.00
164-165	71.75
169-170	0.44
174-175	1.31

SED-T17-MCM	
Depth (in)	PCB (mg/kg)
0-3	59.61
3-6	6.54
6-12	6.25
12-18	16.30
18-24	6.23
24-30	25.94
30-36	49.87[13.73]
36-42	19.11
42-48	34.81
48-54	10.46
54-60	372.80
60-66	510.00
66-71	28.01
71-75	1.12

T17S-03	
Depth (in)	PCB (mg/kg)
0-3	1.95

SED-T17-MCS	
Depth (in)	PCB (mg/kg)
0-3	13.78
3-6	5.52
6-12	9.21
12-18	17.77
18-24	10.48
24-26	4.57
26-32	ND(0.07)
32-38	ND(0.07)

T17.5S-03	
Depth (in)	PCB (mg/kg)
0-3	0.60

T17.5-S2	
Depth (in)	PCB (mg/kg)
0-3	1.77
3-12	80.40
12-18	57.56
18-24	12.24 [9.11]
24-30	18.71
30-36	44.06
36-42	23.41
42-48	10.01
48-54	2.29
54-60	0.23
60-66	0.15
66-69	0.21

SED-T17.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	6.56
3-6	19.84
6-12	7.81
12-18	8.00
18-24	21.63[17.04]
24-30	56.73
30-36	51.68
36-42	ND(0.07)
42-48	ND(0.08)

SED-T18-MCN	
Depth (in)	PCB (mg/kg)
0-3	59.07
3-6	69.07
6-12	60.88
12-18	74.91[33.49]
18-24	34.44
24-30	40.19
30-36	13.69
36-42	23.43
42-48	173.30
48-54	150.60
54-60	0.48
60-62	0.73

T18S-03	
Depth (in)	PCB (mg/kg)
0-3	0.77 [0.63]

T18-S2	
Depth (in)	PCB (mg/kg)
0-3	2.95
3-12	0.54
12-18	16.00
18-24	10.16
24-30	24.21
30-36	41.14
36-42	42.19
42-48	117.06
48-54	91.26
54-60	40.53
60-66	105.10
66-72	649.30 [647.10]
72-76	121.13

SED-T18-MCS	
Depth (in)	PCB (mg/kg)
0-3	137.40
3-6	32.87
6-12	10.88
12-18	51.69
18-24	332.00
24-30	20.52
30-36	ND(0.07)
36-42	ND(0.07)

SED-T18-SSS	
Depth (in)	PCB (mg/kg)
0-3	5.38
3-6	2.29
6-12	3.62
12-18	90.09
18-24	18.03
24-30	0.33
30-37	ND(0.08)[ND(0.07)]

T18.5-S2	
Depth (in)	PCB (mg/kg)
0-3	26.88
3-12	7.66
12-18	71.08
18-24	143.70
24-30	93.45
30-36	84.98
36-42	36.30
42-48	48.50 [79.55]
48-54	838.40
54-60	67.33
60-66	0.29

T18.5S-03	
Depth (in)	PCB (mg/kg)
0-3	4.41

SED-T18.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	109.42
3-6	167.30
6-12	91.22
12-18	39.64
18-24	10.99
24-30	16.00[24.25]
30-36	109.10
36-42	18.69
42-48	24.97
48-54	196.40
54-60	573.00
60-66	228.40
66-69	11.33

SED-T18.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	3.26
3-6	5.20
6-12	6.84
12-18	85.50
18-24	123.50
24-30	91.69
30-36	20.02
36-42	44.43
42-48	340.70
48-54	105.07
54-60	0.49
60-66	0.32

T18.5M-03	
Depth (in)	PCB (mg/kg)
0-3	25.32

SED-T19-MCS	
Depth (in)	PCB (mg/kg)
0-3	0.93
3-6	5.24
6-14	9.77

SED-T19-SSS	
Depth (in)	PCB (mg/kg)
0-3	1.10
3-6	0.61
6-12	0.32
12-18	3.30
18-24	17.44
24-30	8.58[7.38]
30-36	0.34

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T17 - T21

ALCOA

FIGURE
2-5

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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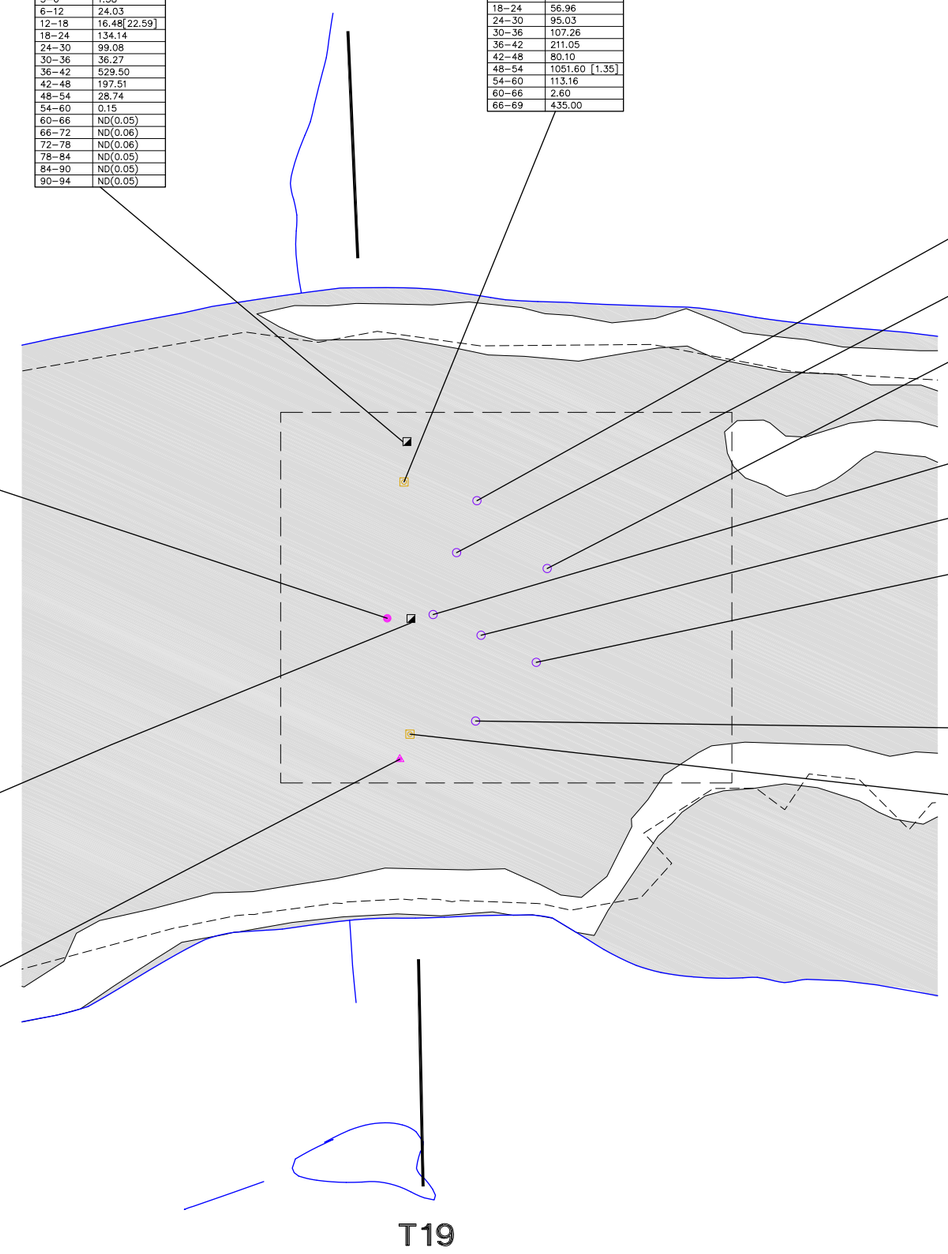


SED–T19–MCN	
Depth (in)	PCB (mg/kg)
0–3	62.03
3–6	1.38
6–12	24.03
12–18	16.48 [22.59]
18–24	134.14
24–30	99.08
30–36	36.27
36–42	529.50
42–48	197.51
48–54	28.74
54–60	0.15
60–66	ND(0.05)
66–72	ND(0.06)
72–78	ND(0.06)
78–84	ND(0.05)
84–90	ND(0.05)
90–94	ND(0.05)

T19–N2	
Depth (in)	PCB (mg/kg)
0–3	6.59
3–12	51.76
12–18	29.62
18–24	56.96
24–30	95.03
30–36	107.26
36–42	211.05
42–48	80.10
48–54	1051.60 [1.35]
54–60	113.16
60–66	2.60
66–69	435.00

T19M–03	
Depth (cm)	PCB (mg/kg)
0–1	37.47
1–2	11.64
2–3	23.44
3–4	5.88
4–5	9.15
5–6	1.92 J
6–7	5.02
7–8	3.53
9–10	1.07
14–15	21.80
19–20	8.22
24–25	6.77
29–30	3.28 J
34–35	2.68 [3.25]
39–40	8.85
44–45	39.56 [32.59]
49–50	57.88 J
54–55	182.78
59–60	165.14
64–65	162.86
69–70	121.60
74–75	15.49
79–80	12.61
84–85	33.04
89–90	14.81
94–95	6.73
99–100	15.75
104–105	12.58
109–110	6.83
114–115	145.44
119–120	50.44
124–125	25.59
129–130	367.17
134–135	25.31
139–140	16.15
144–145	16.11
149–150	31.63
154–155	85.20
159–160	281.44
164–165	1031.74
169–170	876.90
174–175	223.40
179–180	73.91

SED–T19–MCM	
Depth (in)	PCB (mg/kg)
0–3	96.31
3–6	9.42
6–12	4.91
12–18	66.88
18–24	113.10 [74.27]
24–30	39.92
30–36	31.31
36–42	88.73
42–48	91.75
48–54	39.94
54–60	252.50
60–66	239.10
66–72	1.37
72–78	ND(0.05)
78–84	ND(0.05)

T19S–03	
Depth (in)	PCB (mg/kg)
0–3	0.95

V–9–E	
Depth (in)	PCB (mg/kg)
0–3	6.85

V–9–A	
Depth (in)	PCB (mg/kg)
0–3	17.5

V–9–F	
Depth (in)	PCB (mg/kg)
0–3	11.0

V–9	
Depth (in)	PCB (mg/kg)
0–3	42.4
3–12	93.1
12–24	13.0
24–36	62.4
36–48	62.4
48–56	586

V–9–B	
Depth (in)	PCB (mg/kg)
0–3	57.5

V–9–G	
Depth (in)	PCB (mg/kg)
0–3	56.7

V–9–H	
Depth (in)	PCB (mg/kg)
0–3	148

T19–S2	
Depth (in)	PCB (mg/kg)
0–3	5.98
3–12	1.20
12–18	0.49
18–24	12.18
24–30	42.11
30–36	8.14
36–42	130.99
42–48	27.38 [28.78]
48–54	88.16
54–60	71.64
60–66	59.67
66–67	375.10

0 50' 100'
GRAPHIC SCALE

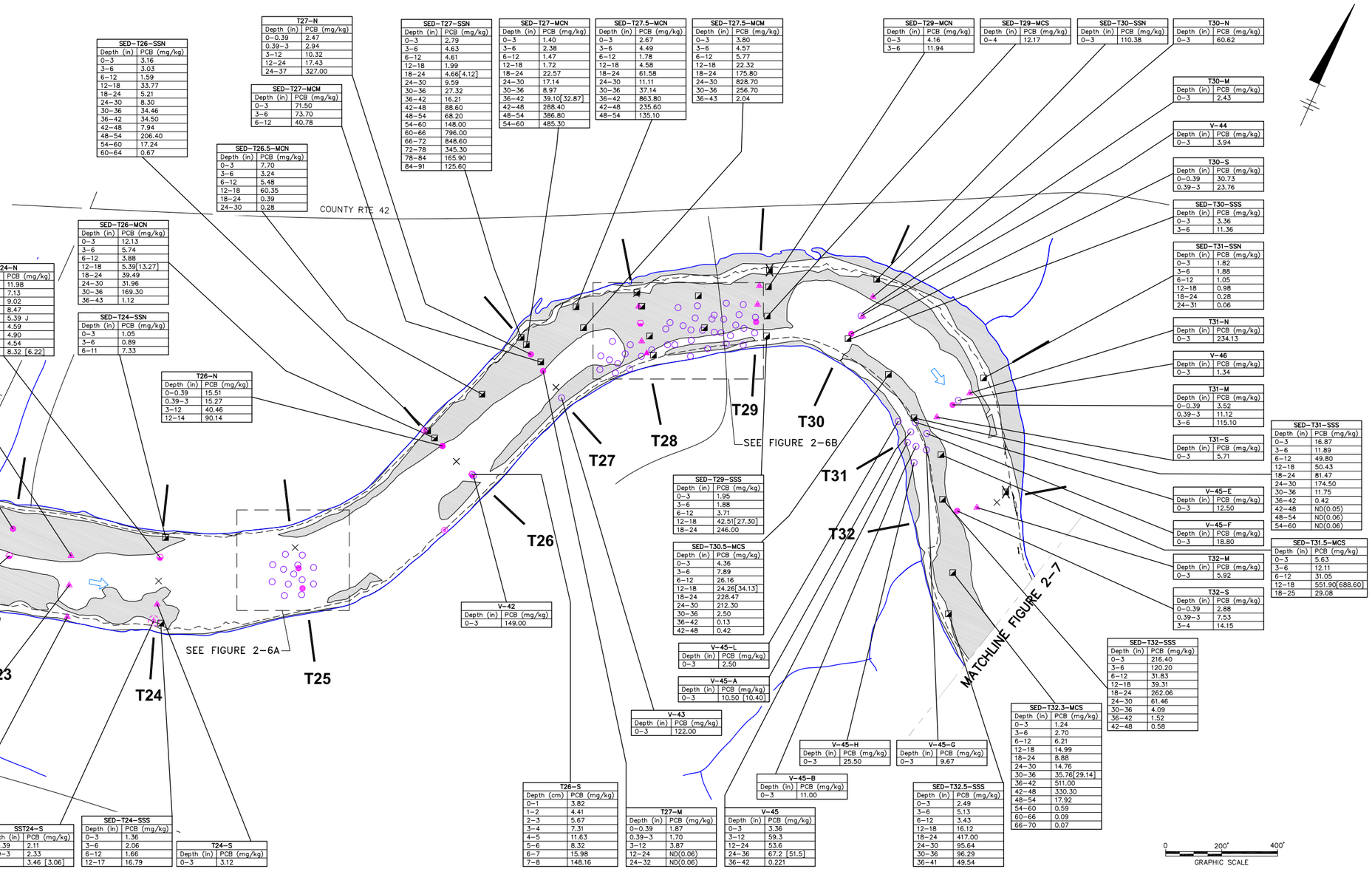
SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T17 - T21

ALCOA

FIGURE
2-5A



T23.5-N	
Depth (in)	PCB (mg/kg)
0-3	9.76

T23-N	
Depth (in)	PCB (mg/kg)
0-0.39	33.18
0.39-3	12.60
3-12	166.70
12-16	251.30

T22.5-N	
Depth (in)	PCB (mg/kg)
0-3	16.59

T22.5-M	
Depth (in)	PCB (mg/kg)
0-3	279.90

SED-T22-SSN	
Depth (in)	PCB (mg/kg)
0-3	82.47
3-5	6.50

SST22-N	
Depth (in)	PCB (mg/kg)
0-0.39	2.70
0.39-3	4.74
3-11	28.34

T22-N	
Depth (in)	PCB (mg/kg)
0-3	3.45

T22-M	
Depth (cm)	PCB (mg/kg)
0-1	31.52
1-2	52.79
2-3	55.20
3-4	91.00
4-5	62.88
5-6	13.21
6-7	24.53
7-8	14.08
9-10	3.96

T22-S	
Depth (in)	PCB (mg/kg)
0-0.39	6.12
0.39-3	5.58
3-8	5.90
8-12	16.22
12-24	37.92
24-34	133.20

SED-T22-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.15
3-6	ND(0.08)
6-12	ND(0.08)
12-18	ND(0.08)[ND(0.08)]
18-24	ND(0.08)
24-30	ND(0.08)
30-33	ND(0.08)

T22.5-S	
Depth (in)	PCB (mg/kg)
0-3	3.90

T23-M	
Depth (cm)	PCB (mg/kg)
0-1	21.30
1-2	5.96
2-3	12.58
3-4	3.48
4-5	6.60
5-6	9.49
6-7	12.47
7-8	57.87
9-10	149.93
14-15	7.52
19-20	0.15
24-25	0.47

T23-S	
Depth (in)	PCB (mg/kg)
0-3	2.37

T23.5-M	
Depth (in)	PCB (mg/kg)
0-3	24.66

T23.5-S	
Depth (in)	PCB (mg/kg)
0-3	0.49

SST24-S	
Depth (in)	PCB (mg/kg)
0-0.39	2.11
0.39-3	2.33
3-9	3.46 [3.06]

SED-T24-SSS	
Depth (in)	PCB (mg/kg)
0-3	1.36
3-6	2.06
6-12	1.66
12-17	16.79

T24-S	
Depth (in)	PCB (mg/kg)
0-3	3.12

T24-N	
Depth (cm)	PCB (mg/kg)
0-1	11.98
1-2	7.13
2-3	9.02
3-4	8.47
4-5	5.39 J
5-6	4.59
6-7	4.90
7-8	4.54
9-10	8.32 [6.22]

SED-T26-SSN	
Depth (in)	PCB (mg/kg)
0-3	3.16
3-6	3.03
6-12	1.59
12-18	33.77
18-24	5.21
24-30	8.30
30-36	34.46
36-42	34.50
42-48	7.94
48-54	206.40
54-60	17.24
60-64	0.67

SED-T26-MCN	
Depth (in)	PCB (mg/kg)
0-3	12.13
3-6	5.74
6-12	3.88
12-18	5.39[13.27]
18-24	39.49
24-30	31.96
30-36	169.30
36-43	1.12

SED-T24-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.05
3-6	0.89
6-11	7.33

T26-N	
Depth (in)	PCB (mg/kg)
0-0.39	15.51
0.39-3	15.27
3-12	40.46
12-14	90.14

T26-S	
Depth (cm)	PCB (mg/kg)
0-1	3.82
1-2	4.41
2-3	5.67
3-4	7.31
4-5	11.63
5-6	8.32
6-7	15.98
7-8	148.16

T27-N	
Depth (in)	PCB (mg/kg)
0-0.39	2.47
0.39-3	2.94
3-12	10.32
12-24	17.43
24-37	327.00

SED-T27-MCM	
Depth (in)	PCB (mg/kg)
0-3	71.50
3-6	73.70
6-12	40.78

SED-T26.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	7.70
3-6	3.24
6-12	5.48
12-18	60.35
18-24	0.39
24-30	0.28

SED-T27-SSN	
Depth (in)	PCB (mg/kg)
0-3	2.79
3-6	4.63
6-12	4.61
12-18	1.99
18-24	4.66[4.12]
24-30	9.59
30-36	27.32
36-42	16.21
42-48	88.60
48-54	68.20
54-60	148.00
60-66	796.00
66-72	848.60
72-78	345.30
78-84	165.90
84-91	125.60

SED-T27-MCN	
Depth (in)	PCB (mg/kg)
0-3	1.40
3-6	2.38
6-12	1.47
12-18	1.72
18-24	22.57
24-30	17.14
30-36	8.97
36-42	39.10[32.87]
42-48	288.40
48-54	386.80
54-60	485.30

SED-T27.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	2.67
3-6	4.49
6-12	1.78
12-18	4.58
18-24	61.58
24-30	11.11
30-36	37.14
36-42	863.80
42-48	235.60
48-54	135.10

SED-T27.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	3.80
3-6	4.57
6-12	5.77
12-18	22.32
18-24	175.80
24-30	828.70
30-36	256.70
36-43	2.04

V-42	
Depth (in)	PCB (mg/kg)
0-3	149.00

SED-T29-SSS	
Depth (in)	PCB (mg/kg)
0-3	1.95
3-6	1.88
6-12	3.71
12-18	42.51[27.30]
18-24	246.00

SED-T30.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	4.36
3-6	7.89
6-12	26.16
12-18	24.26[34.13]
18-24	228.47
24-30	212.30
30-36	2.50
36-42	0.13
42-48	0.42

V-45-L	
Depth (in)	PCB (mg/kg)
0-3	2.50

V-45-A	
Depth (in)	PCB (mg/kg)
0-3	10.50 [10.40]

V-43	
Depth (in)	PCB (mg/kg)
0-3	122.00

T27-M	
Depth (in)	PCB (mg/kg)
0-0.39	1.87
0.39-3	1.70
3-12	3.87
12-24	ND(0.06)
24-32	ND(0.06)

V-45	
Depth (in)	PCB (mg/kg)
0-3	3.36
3-12	59.3
12-24	53.6
24-36	67.2 [51.5]
36-42	0.221

V-45-B	
Depth (in)	PCB (mg/kg)
0-3	11.00

V-45-H	
Depth (in)	PCB (mg/kg)
0-3	25.50

V-45-G	
Depth (in)	PCB (mg/kg)
0-3	9.67

SED-T32.5-SSS	
Depth (in)	PCB (mg/kg)
0-3	2.49
3-6	5.13
6-12	3.43
12-18	16.12
18-24	417.00
24-30	95.64
30-36	96.29
36-41	49.54

SED-T32.3-MCS	
Depth (in)	PCB (mg/kg)
0-3	1.24
3-6	2.70
6-12	6.21
12-18	14.99
18-24	8.88
24-30	14.76
30-36	35.76[29.14]
36-42	511.00
42-48	330.30
48-54	17.92
54-60	0.59
60-66	0.09
66-70	0.07

SED-T29-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.16
3-6	11.94

SED-T29-MCS	
Depth (in)	PCB (mg/kg)
0-4	12.17

SED-T30-SSN	
Depth (in)	PCB (mg/kg)
0-3	110.38

T30-N	
Depth (in)	PCB (mg/kg)
0-3	60.62

T30-M	
Depth (in)	PCB (mg/kg)
0-3	2.43

V-44	
Depth (in)	PCB (mg/kg)
0-3	3.94

T30-S	
Depth (in)	PCB (mg/kg)
0-0.39	30.73
0.39-3	23.76

SED-T30-SSS	
Depth (in)	PCB (mg/kg)
0-3	3.36
3-6	11.36

SED-T31-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.82
3-6	1.88
6-12	1.05
12-18	0.98
18-24	0.28
24-31	0.06

T31-N	
Depth (in)	PCB (mg/kg)
0-3	234.13

V-46	
Depth (in)	PCB (mg/kg)
0-3	1.34

T31-M	
Depth (in)	PCB (mg/kg)
0-0.39	3.52
0.39-3	11.12
3-6	115.10

T31-S	
Depth (in)	PCB (mg/kg)
0-3	5.71

V-45-E	
Depth (in)	PCB (mg/kg)
0-3	12.50

V-45-F	
Depth (in)	PCB (mg/kg)
0-3	18.80

T32-M	
Depth (in)	PCB (mg/kg)
0-3	5.92

T32-S	
Depth (in)	PCB (mg/kg)
0-0.39	2.88
0.39-3	7.53
3-4	14.15

SED-T31-SSS	
Depth (in)	PCB (mg/kg)
0-3	16.87
3-6	11.89
6-12	49.80
12-18	50.43
18-24	81.47
24-30	174.50
30-36	11.75
36-42	0.42
42-48	ND(0.05)
48-54	ND(0.06)
54-60	ND(0.06)

SED-T31.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	5.63
3-6	12.11
6-12	31.05
12-18	551.90[688.60]
18-25	29.08

SED-T32-SSS	
Depth (in)	PCB (mg/kg)
0-3	216.40
3-6	120.20
6-12	31.83
12-18	39.31
18-24	262.06
24-30	61.46
30-36	4.09
36-42	1.52
42-48	0.58

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T22 - T32

ALCOA

FIGURE
2-6

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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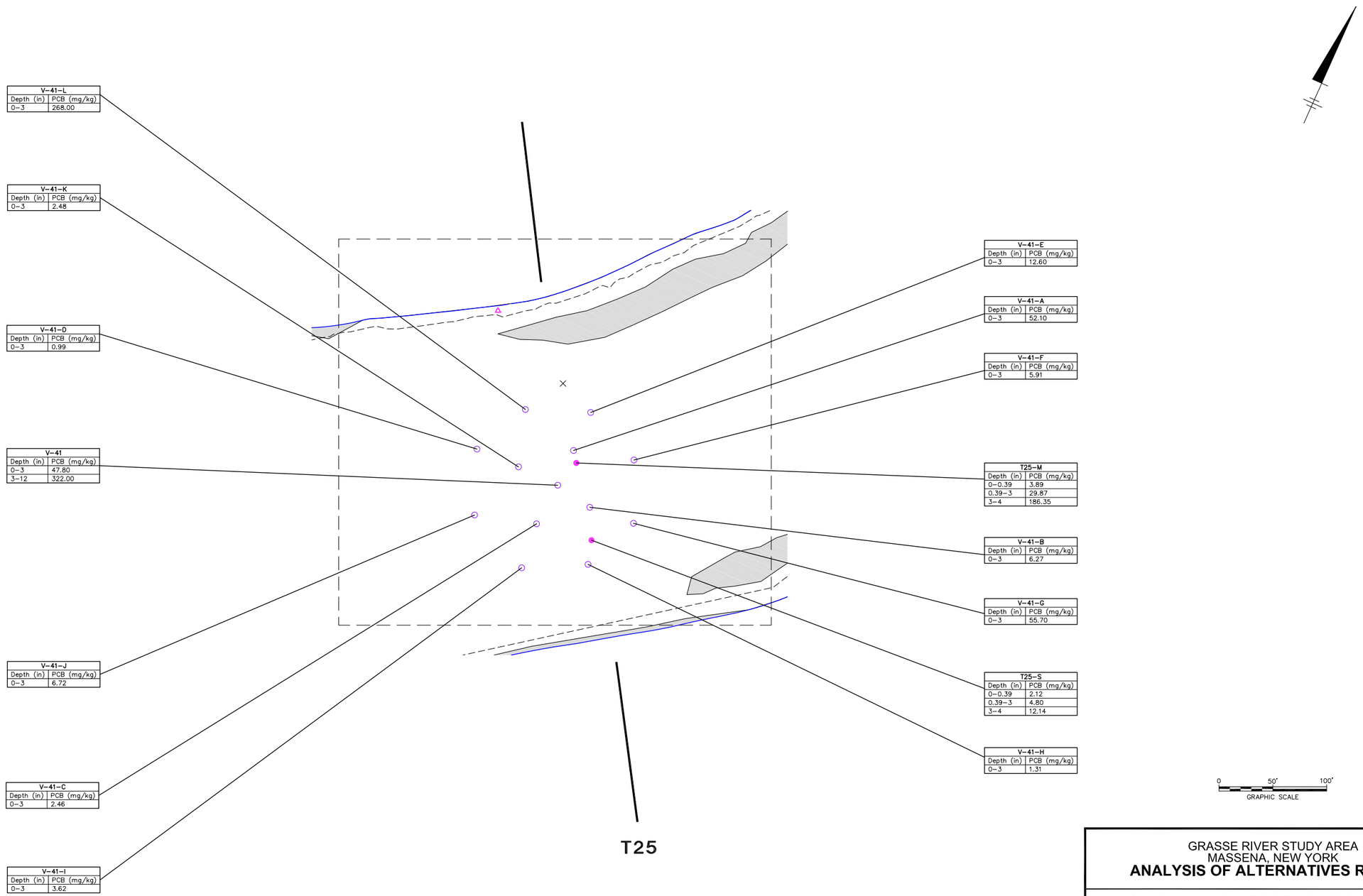

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T22 - T32

ALCOA

FIGURE
2-6A

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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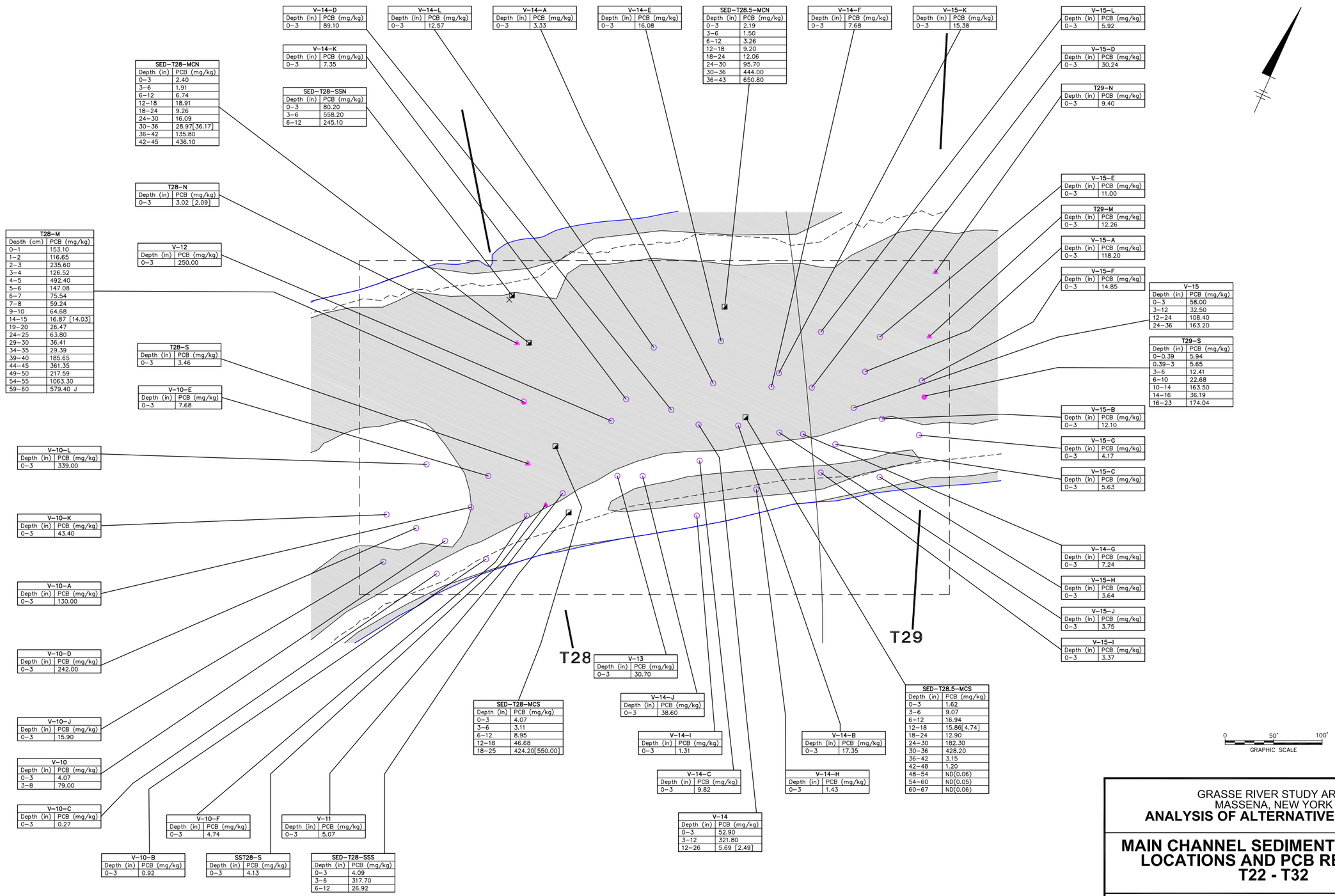

V-14-D	
Depth (in)	PCB (mg/kg)
0-3	89.10

V-14-L	
Depth (in)	PCB (mg/kg)
0-3	12.57

V-14-A	
Depth (in)	PCB (mg/kg)
0-3	3.33

V-14-E	
Depth (in)	PCB (mg/kg)
0-3	16.08

SED-T28.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	2.19
3-6	1.50
6-12	3.26
12-18	9.20
18-24	12.06
24-30	95.70
30-36	444.00
36-43	650.80

V-14-F	
Depth (in)	PCB (mg/kg)
0-3	7.68

V-15-K	
Depth (in)	PCB (mg/kg)
0-3	15.38

V-15-L	
Depth (in)	PCB (mg/kg)
0-3	5.92

V-15-D	
Depth (in)	PCB (mg/kg)
0-3	30.24

T29-N	
Depth (in)	PCB (mg/kg)
0-3	9.40

V-14-K	
Depth (in)	PCB (mg/kg)
0-3	7.35

SED-T28-SSN	
Depth (in)	PCB (mg/kg)
0-3	80.20
3-6	558.20
6-12	245.10

SED-T28-MCN	
Depth (in)	PCB (mg/kg)
0-3	2.40
3-6	1.91
6-12	6.74
12-18	18.91
18-24	9.26
24-30	16.09
30-36	28.97[36.17]
36-42	135.80
42-45	436.10

T28-N	
Depth (in)	PCB (mg/kg)
0-3	3.02 [2.09]

V-15-E	
Depth (in)	PCB (mg/kg)
0-3	11.00

T29-M	
Depth (in)	PCB (mg/kg)
0-3	12.26

V-15-A	
Depth (in)	PCB (mg/kg)
0-3	118.20

T28-M	
Depth (cm)	PCB (mg/kg)
0-1	153.10
1-2	116.65
2-3	235.60
3-4	126.52
4-5	492.40
5-6	147.08
6-7	75.54
7-8	59.24
9-10	64.68
14-15	16.87 [14.03]
19-20	26.47
24-25	63.80
29-30	36.41
34-35	29.39
39-40	185.65
44-45	361.35
49-50	217.59
54-55	1063.30
59-60	579.40 J

V-12	
Depth (in)	PCB (mg/kg)
0-3	250.00

V-15-F	
Depth (in)	PCB (mg/kg)
0-3	14.85

V-15	
Depth (in)	PCB (mg/kg)
0-3	58.00
3-12	32.50
12-24	108.40
24-36	163.20

T29-S	
Depth (in)	PCB (mg/kg)
0-0.39	5.94
0.39-3	5.65
3-6	12.41
6-10	22.68
10-14	163.50
14-16	36.19
16-23	174.04

T28-S	
Depth (in)	PCB (mg/kg)
0-3	3.46

V-10-E	
Depth (in)	PCB (mg/kg)
0-3	7.68

V-15-B	
Depth (in)	PCB (mg/kg)
0-3	12.10

V-15-G	
Depth (in)	PCB (mg/kg)
0-3	4.17

V-15-C	
Depth (in)	PCB (mg/kg)
0-3	5.63

V-10-L	
Depth (in)	PCB (mg/kg)
0-3	339.00

V-10-K	
Depth (in)	PCB (mg/kg)
0-3	43.40

V-14-G	
Depth (in)	PCB (mg/kg)
0-3	7.24

V-15-H	
Depth (in)	PCB (mg/kg)
0-3	3.64

V-10-A	
Depth (in)	PCB (mg/kg)
0-3	130.00

V-15-J	
Depth (in)	PCB (mg/kg)
0-3	3.75

V-15-I	
Depth (in)	PCB (mg/kg)
0-3	3.37

V-10-D	
Depth (in)	PCB (mg/kg)
0-3	242.00

V-13	
Depth (in)	PCB (mg/kg)
0-3	30.70

SED-T28-MCS	
Depth (in)	PCB (mg/kg)
0-3	4.07
3-6	3.11
6-12	8.95
12-18	46.68
18-25	424.20[550.00]

V-14-J	
Depth (in)	PCB (mg/kg)
0-3	38.60

SED-T28.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	1.62
3-6	9.07
6-12	16.94
12-18	15.86[4.74]
18-24	12.90
24-30	182.30
30-36	428.20
36-42	3.15
42-48	1.20
48-54	ND(0.06)
54-60	ND(0.05)
60-67	ND(0.06)

V-10-J	
Depth (in)	PCB (mg/kg)
0-3	15.90

V-14-I	
Depth (in)	PCB (mg/kg)
0-3	1.31

V-14-B	
Depth (in)	PCB (mg/kg)
0-3	17.35

V-10	
Depth (in)	PCB (mg/kg)
0-3	4.07
3-8	79.00

V-14-C	
Depth (in)	PCB (mg/kg)
0-3	9.82

V-14-H	
Depth (in)	PCB (mg/kg)
0-3	1.43

V-10-C	
Depth (in)	PCB (mg/kg)
0-3	0.27

V-10-F	
Depth (in)	PCB (mg/kg)
0-3	4.74

V-11	
Depth (in)	PCB (mg/kg)
0-3	5.07

V-14	
Depth (in)	PCB (mg/kg)
0-3	52.90
3-12	321.80
12-26	5.69 [2.49]

V-10-B	
Depth (in)	PCB (mg/kg)
0-3	0.92

SST28-S	
Depth (in)	PCB (mg/kg)
0-3	4.13

SED-T28-SSS	
Depth (in)	PCB (mg/kg)
0-3	4.09
3-6	317.70
6-12	26.92

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T22 - T32

ALCOA

FIGURE
2-6B

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L.FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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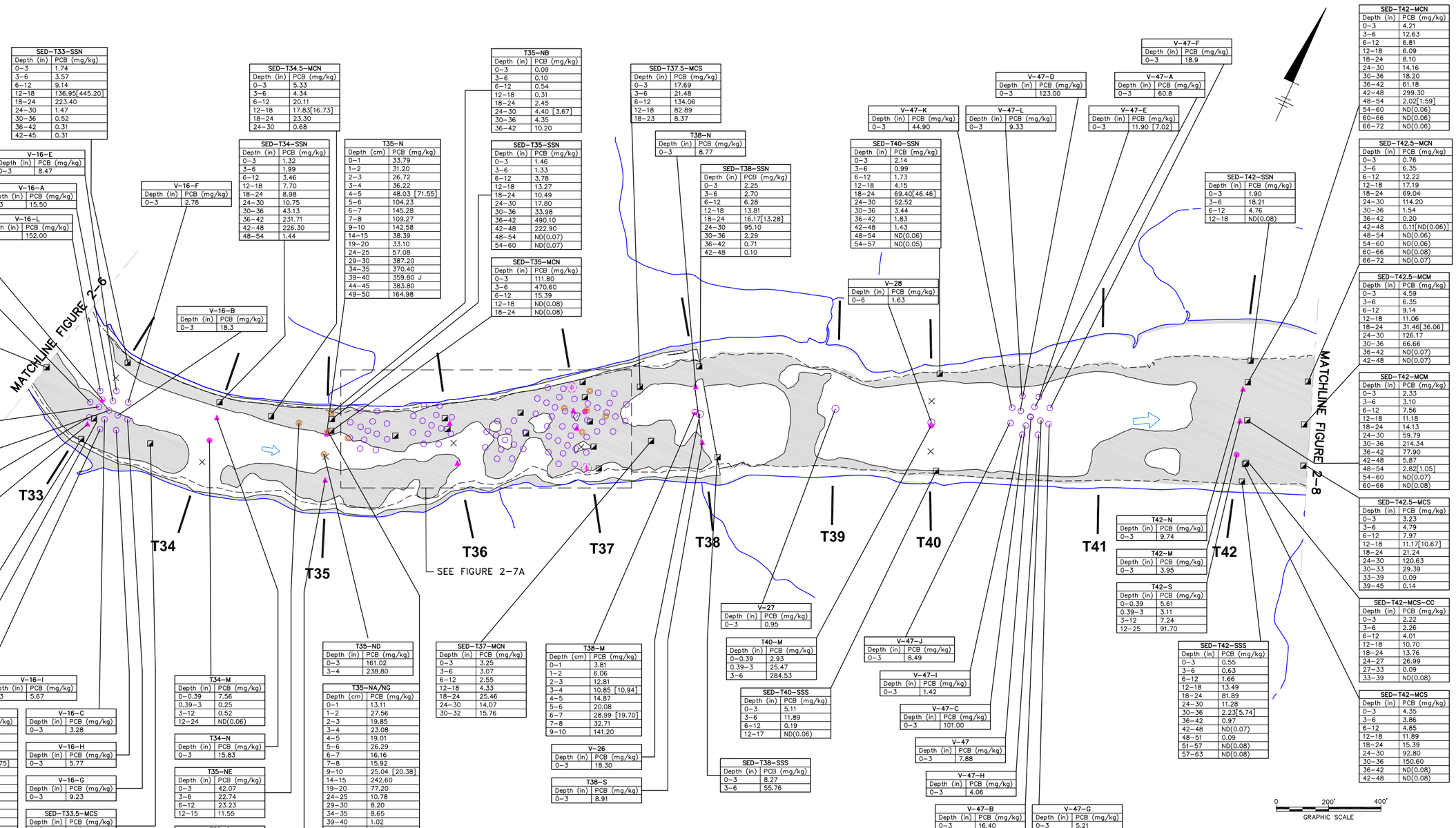
XREFS: 10875X02 10875X03 10875X00 IMAGES: 10875X01.TIF



SED-T33-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.74
3-6	3.57
6-12	9.14
12-18	136.95[445.20]
18-24	223.40
24-30	1.47
30-36	0.52
36-42	0.31
42-45	0.31

V-16-E	
Depth (in)	PCB (mg/kg)
0-3	8.47

T33-M	
Depth (cm)	PCB (mg/kg)
0-1	7.61
1-2	5.43
2-3	7.50
3-4	11.27
4-5	33.95
5-6	38.98
6-7	46.53
7-8	60.78
9-10	89.77

V-16-A	
Depth (in)	PCB (mg/kg)
0-3	15.50

V-16-L	
Depth (in)	PCB (mg/kg)
0-3	152.00

V-16-F	
Depth (in)	PCB (mg/kg)
0-3	2.78

SED-T34.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	5.33
3-6	4.34
6-12	20.11
12-18	17.83[16.73]
18-24	23.30
24-30	0.68

SED-T34-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.32
3-6	1.99
6-12	3.46
12-18	7.70
18-24	8.98
24-30	10.75
30-36	43.13
36-42	231.71
42-48	226.30
48-54	1.44

T35-N	
Depth (cm)	PCB (mg/kg)
0-1	33.79
1-2	31.20
2-3	26.72
3-4	36.22
4-5	48.03 [71.55]
5-6	104.23
6-7	145.28
7-8	109.27
9-10	142.58
14-15	38.39
19-20	33.10
24-25	57.08
29-30	387.20
34-35	370.40
39-40	359.80 J
44-45	383.80
49-50	164.98

T35-NB	
Depth (in)	PCB (mg/kg)
0-3	0.09
3-6	0.10
6-12	0.54
12-18	0.31
18-24	2.45
24-30	4.40 [3.67]
30-36	4.35
36-42	10.20

SED-T35-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.46
3-6	1.33
6-12	3.78
12-18	13.27
18-24	10.49
24-30	17.80
30-36	33.98
36-42	490.10
42-48	222.90
48-54	ND(0.07)
54-60	ND(0.07)

SED-T35-MCN	
Depth (in)	PCB (mg/kg)
0-3	111.80
3-6	470.60
6-12	15.39
12-18	ND(0.08)
18-24	ND(0.08)

SED-T37.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	17.69
3-6	21.48
6-12	134.06
12-18	82.89
18-23	8.37

T38-N	
Depth (in)	PCB (mg/kg)
0-3	8.77

SED-T38-SSN	
Depth (in)	PCB (mg/kg)
0-3	2.25
3-6	2.70
6-12	6.28
12-18	13.81
18-24	16.17[13.28]
24-30	95.10
30-36	2.29
36-42	0.71
42-48	0.10

V-47-K	
Depth (in)	PCB (mg/kg)
0-3	44.90

SED-T40-SSN	
Depth (in)	PCB (mg/kg)
0-3	2.14
3-6	0.99
6-12	1.73
12-18	4.15
18-24	69.40[46.46]
24-30	52.52
30-36	3.44
36-42	1.83
42-48	1.43
48-54	ND(0.06)
54-57	ND(0.05)

V-28	
Depth (in)	PCB (mg/kg)
0-6	1.63

V-47-D	
Depth (in)	PCB (mg/kg)
0-3	123.00

V-47-L	
Depth (in)	PCB (mg/kg)
0-3	9.33

V-47-F	
Depth (in)	PCB (mg/kg)
0-3	18.9

V-47-A	
Depth (in)	PCB (mg/kg)
0-3	60.8

V-47-E	
Depth (in)	PCB (mg/kg)
0-3	11.90 [7.02]

SED-T42-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.90
3-6	18.21
6-12	4.76
12-18	ND(0.08)

SED-T42-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.21
3-6	12.63
6-12	6.81
12-18	6.09
18-24	8.10
24-30	14.16
30-36	18.20
36-42	61.18
42-48	299.30
48-54	2.02[1.59]
54-60	ND(0.06)
60-66	ND(0.06)
66-72	ND(0.06)

SED-T42.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	0.76
3-6	6.35
6-12	12.22
12-18	17.19
18-24	69.04
24-30	114.20
30-36	1.54
36-42	0.20
42-48	0.11[ND(0.06)]
48-54	ND(0.06)
54-60	ND(0.06)
60-66	ND(0.08)
66-72	ND(0.07)

SED-T42.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	4.59
3-6	6.35
6-12	9.14
12-18	11.06
18-24	31.46[36.06]
24-30	126.17
30-36	66.66
36-42	ND(0.07)
42-48	ND(0.07)

SED-T42-MCM	
Depth (in)	PCB (mg/kg)
0-3	2.33
3-6	3.10
6-12	7.56
12-18	11.18
18-24	14.13
24-30	59.79
30-36	214.34
36-42	77.90
42-48	5.87
48-54	2.82[1.05]
54-60	ND(0.07)
60-66	ND(0.08)

SED-T42.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	3.23
3-6	4.79
6-12	7.97
12-18	11.17[10.67]
18-24	21.24
24-30	120.63
30-33	29.39
33-39	0.09
39-45	0.14

SED-T42-MCS-CC	
Depth (in)	PCB (mg/kg)
0-3	2.22
3-6	2.26
6-12	4.01
12-18	10.70
18-24	13.76
24-27	26.99
27-33	0.09
33-39	ND(0.08)

SED-T42-MCS	
Depth (in)	PCB (mg/kg)
0-3	4.35
3-6	3.86
6-12	4.85
12-18	11.89
18-24	15.39
24-30	92.80
30-36	150.60
36-42	ND(0.08)
42-48	ND(0.08)

V-16-K	
Depth (in)	PCB (mg/kg)
0-3	23.40 [28.60]

SED-T32.6-MCS	
Depth (in)	PCB (mg/kg)
0-3	3.12
3-6	3.51
6-12	5.51
12-18	10.58[12.11]
18-24	17.56
24-30	27.83
30-36	250.92
36-42	330.50
42-48	69.40
48-51	0.13

V-16-B	
Depth (in)	PCB (mg/kg)
0-3	18.3

V-16-D	
Depth (in)	PCB (mg/kg)
0-3	5.70

V-16	
Depth (in)	PCB (mg/kg)
0-3	2.01
3-12	ND(0.07)

V-16-J	
Depth (in)	PCB (mg/kg)
0-3	4.24

T33-S	
Depth (in)	PCB (mg/kg)
0-3	2.93

SED-T33-SSS	
Depth (in)	PCB (mg/kg)
0-3	7.04
3-6	12.78
6-12	2.86
12-18	5.46[5.80]
18-24	140.50
24-30	172.30
30-36	80.09
36-42	37.09
42-48	6.42
48-54	5.19
54-60	ND(0.06)
60-66	0.06
66-69	ND(0.05)

V-16-I	
Depth (in)	PCB (mg/kg)
0-3	5.67

SED-T33-MCS	
Depth (in)	PCB (mg/kg)
0-3	1.76
3-6	2.88
6-12	5.55
12-18	10.96
18-24	33.21[13.75]
24-30	187.35
30-36	339.40
36-42	34.61
42-48	0.43
48-54	1.39
54-60	0.53
60-66	84.00
66-72	34.97
72-78	83.70
78-84	105.60[54.64]
84-89	132.73

V-16-C	
Depth (in)	PCB (mg/kg)
0-3	3.28

V-16-H	
Depth (in)	PCB (mg/kg)
0-3	5.77

V-16-G	
Depth (in)	PCB (mg/kg)
0-3	9.23

SED-T33.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	1.62
3-6	2.93

T34-M	
Depth (in)	PCB (mg/kg)
0-0.39	7.56
0.39-3	0.25
3-12	0.52
12-24	ND(0.06)

T34-N	
Depth (in)	PCB (mg/kg)
0-3	15.83

T35-NE	
Depth (in)	PCB (mg/kg)
0-3	42.07
3-6	22.74
6-12	23.23
12-15	11.55

T35-S	
Depth (in)	PCB (mg/kg)
0-3	3.33

T35-ND	
Depth (in)	PCB (mg/kg)
0-3	161.02
3-4	238.80

T35-NA/NG	
Depth (cm)	PCB (mg/kg)
0-1	13.11
1-2	27.56
2-3	19.85
3-4	23.08
4-5	19.01
5-6	26.29
6-7	16.16
7-8	15.92
9-10	25.04 [20.38]
14-15	242.60
19-20	77.20
24-25	10.78
29-30	8.20
34-35	8.65
39-40	1.02
44-45	0.17
49-50	0.46
54-55	1.41

SED-T37-MCN	
Depth (in)	PCB (mg/kg)
0-3	3.25
3-6	3.07
6-12	2.55
12-18	4.33
18-24	25.46
24-30	14.07
30-32	15.76

T38-M	
Depth (cm)	PCB (mg/kg)
0-1	3.81
1-2	6.06
2-3	12.81
3-4	10.85 [10.94]
4-5	14.87
5-6	20.08
6-7	28.99 [19.70]
7-8	32.71
9-10	141.20

V-26	
Depth (in)	PCB (mg/kg)
0-3	18.30

T38-S	
Depth (in)	PCB (mg/kg)
0-3	8.91

V-27	
Depth (in)	PCB (mg/kg)
0-3	0.95

T40-M	
Depth (in)	PCB (mg/kg)
0-0.39	2.93
0.39-3	25.47
3-6	284.53

SED-T40-SSS	
Depth (in)	PCB (mg/kg)
0-3	5.11
3-6	11.89
6-12	0.19
12-17	ND(0.06)

SED-T38-SSS	
Depth (in)	PCB (mg/kg)
0-3	8.27
3-6	55.76

V-47-J	
Depth (in)	PCB (mg/kg)
0-3	8.49

V-47-I	
Depth (in)	PCB (mg/kg)
0-3	1.42

V-47-C	
Depth (in)	PCB (mg/kg)
0-3	101.00

V-47	
Depth (in)	PCB (mg/kg)
0-3	7.88

V-47-H	
Depth (in)	PCB (mg/kg)
0-3	4.06

V-47-B	
Depth (in)	PCB (mg/kg)
0-3	16.40

V-47-G	
Depth (in)	PCB (mg/kg)
0-3	5.21

T42-N	
Depth (in)	PCB (mg/kg)
0-3	9.74

T42-M	
Depth (in)	PCB (mg/kg)
0-3	3.95

T42-S	
Depth (in)	PCB (mg/kg)
0-0.39	5.61
0.39-3	3.11
3-12	7.24
12-25	91.70

SED-T42-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.55
3-6	0.63
6-12	1.66
12-18	13.49
18-24	81.89
24-30	11.28
30-36	2.23[5.74]
36-42	0.97
42-48	ND(0.07)
48-51	0.09
51-57	ND(0.08)
57-63	ND(0.08)

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

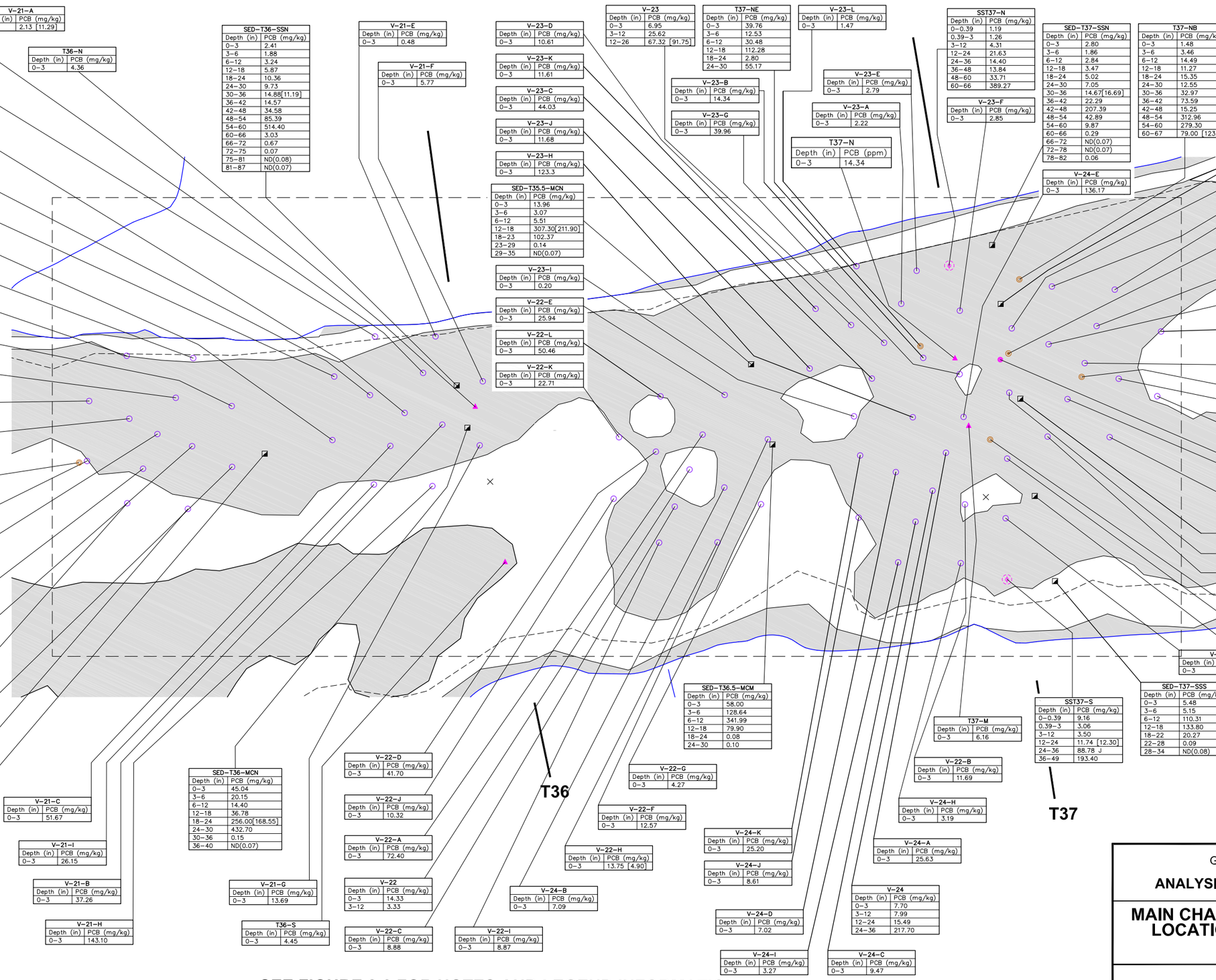
GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T33 - T42

ALCOA

FIGURE
2-7

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0010875\0000\00001\DWG\AOAR\DATA\10875C10.DWG LAYOUT: 2-7 SAVED: 3/21/2012 11:36 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: C-LD02B-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/21/2012 11:36 AM BY: FORAKER, LYDIA
XREFS: 10875X02 10875X03 10875X00 IMAGES: 10875X01.TIF



V-21-A		
Depth (in)	PCB (mg/kg)	
0-3	2.13	[11.29]

T36-N	
Depth (in)	PCB (mg/kg)
0-3	4.36

SED-T36-SSN	
Depth (in)	PCB (mg/kg)
0-3	2.41
3-6	1.88
6-12	3.24
12-18	5.87
18-24	10.36
24-30	9.73
30-36	14.88 [11.19]
36-42	14.57
42-48	34.58
48-54	85.39
54-60	514.40
60-66	3.03
66-72	0.67
72-75	0.07
75-81	ND(0.08)
81-87	ND(0.07)

V-21-E	
Depth (in)	PCB (mg/kg)
0-3	0.48

V-21-F	
Depth (in)	PCB (mg/kg)
0-3	5.77

V-23-D	
Depth (in)	PCB (mg/kg)
0-3	10.61

V-23-K	
Depth (in)	PCB (mg/kg)
0-3	11.61

V-23-C	
Depth (in)	PCB (mg/kg)
0-3	44.03

V-23-J	
Depth (in)	PCB (mg/kg)
0-3	11.68

V-23-H	
Depth (in)	PCB (mg/kg)
0-3	123.3

SED-T35.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	13.96
3-6	3.07
6-12	5.51
12-18	307.30 [211.90]
18-23	102.37
23-29	0.14
29-35	ND(0.07)

V-23-I	
Depth (in)	PCB (mg/kg)
0-3	0.20

V-22-E	
Depth (in)	PCB (mg/kg)
0-3	25.94

V-22-L	
Depth (in)	PCB (mg/kg)
0-3	50.46

V-22-K	
Depth (in)	PCB (mg/kg)
0-3	22.71

V-23	
Depth (in)	PCB (mg/kg)
0-3	6.95
3-12	25.62
12-26	67.32 [91.75]

T37-NE	
Depth (in)	PCB (mg/kg)
0-3	39.76
3-6	12.53
6-12	30.48
12-18	112.28
18-24	2.80
24-30	55.17

V-23-B	
Depth (in)	PCB (mg/kg)
0-3	14.34

V-23-G	
Depth (in)	PCB (mg/kg)
0-3	39.96

V-23-L	
Depth (in)	PCB (mg/kg)
0-3	1.47

V-23-E	
Depth (in)	PCB (mg/kg)
0-3	2.79

V-23-A	
Depth (in)	PCB (mg/kg)
0-3	2.22

T37-N	
Depth (in)	PCB (ppm)
0-3	14.34

SST37-N	
Depth (in)	PCB (mg/kg)
0-0.39	1.19
0.39-3	1.26
3-12	4.31
12-24	21.63
24-36	14.40
36-48	13.84
48-60	33.71
60-66	389.27

V-23-F	
Depth (in)	PCB (mg/kg)
0-3	2.85

SED-T37-SSN	
Depth (in)	PCB (mg/kg)
0-3	2.80
3-6	1.86
6-12	2.84
12-18	3.47
18-24	5.02
24-30	7.05
30-36	14.67 [16.69]
36-42	22.29
42-48	207.39
48-54	42.89
54-60	9.87
60-66	0.29
66-72	ND(0.07)
72-78	ND(0.07)
78-82	0.06

V-24-E	
Depth (in)	PCB (mg/kg)
0-3	136.17

T37-NB	
Depth (in)	PCB (mg/kg)
0-3	1.48
3-6	3.46
6-12	14.49
12-18	11.27
18-24	15.35
24-30	12.55
30-36	32.97
36-42	73.59
42-48	15.25
48-54	312.96
54-60	279.30
60-67	79.00 [123.50]

SED-T37-MCN	
Depth (in)	PCB (mg/kg)
0-3	3.25
3-6	3.07
6-12	2.55
12-18	4.33
18-24	25.46
24-30	14.07
30-32	15.76

V-25-K	
Depth (in)	PCB (mg/kg)
0-3	7.37

V-25-L	
Depth (in)	PCB (mg/kg)
0-3	4.02 [7.39]

V-25-E	
Depth (in)	PCB (mg/kg)
0-3	6.88

V-25-A	
Depth (in)	PCB (mg/kg)
0-3	13.64

V-25-D	
Depth (in)	PCB (mg/kg)
0-3	10.98

V-25-F	
Depth (in)	PCB (mg/kg)
0-3	34.55

V-25	
Depth (in)	PCB (mg/kg)
0-3	72.64
3-12	219.50

V-25-B	
Depth (in)	PCB (mg/kg)
0-3	10.81

V-25-G	
Depth (in)	PCB (mg/kg)
0-3	172.00

V-25-C	
Depth (in)	PCB (mg/kg)
0-3	6.40

V-25-H	
Depth (in)	PCB (mg/kg)
0-3	5.42

V-25-I	
Depth (in)	PCB (mg/kg)
0-3	25.71

V-24-F	
Depth (in)	PCB (mg/kg)
0-3	10.26

T37-NA/NG	
Depth (cm)	PCB (mg/kg)
0-1	14.55
1-2	19.15
2-3	18.87
3-4	17.97
4-5	16.31
5-6	9.35
6-7	10.21
7-9	11.15
9-10	17.87 [31.63]
14-15	58.63
19-20	83.70
24-25	135.70
29-30	369.70
34-35	315.40
39-40	392.80
44-45	384.80
49-50	367.70
54-55	245.78

T37-NC	
Depth (in)	PCB (mg/kg)
0-3	72.23
3-6	21.78
6-12	36.05
12-18	182.69
18-24	141.50 [194.80]
24-30	9.03
30-36	234.78

T37-N	
Depth (in)	PCB (mg/kg)
0-0.39	5.88
0.39-3	28.38
3-5	34.30
5-7	153.00
7-13	6.42
13-18	201.20

SED-T37-MCM	
Depth (in)	PCB (mg/kg)
0-3	43.91
3-6	37.54
6-12	190.87
12-18	1.03
18-24	ND(0.08)

V-25-J	
Depth (in)	PCB (mg/kg)
0-3	13.23

T37-ND	
Depth (in)	PCB (mg/kg)
0-3	8.26
3-6	10.64
6-12	191.29
12-18	86.10
18-26	172.40

V-24-G	
Depth (in)	PCB (mg/kg)
0-3	5.08

SED-T37-MCS	
Depth (in)	PCB (mg/kg)
0-3	1.44
3-6	6.86
6-12	8.18
12-18	10.10
18-24	12.02
24-30	19.89 [22.26]
30-36	290.41
36-42	144.54
42-46	96.28
46-52	ND(0.07)
52-58	0.08

SED-T37-SSS	
Depth (in)	PCB (mg/kg)
0-3	5.48
3-6	5.15
6-12	110.31
12-18	133.80
18-22	20.27
22-28	0.09
28-34	ND(0.08)

SST37-S	
Depth (in)	PCB (mg/kg)
0-0.39	9.16
0.39-3	3.06
3-12	3.50
12-24	11.74 [12.30]
24-36	88.78 J
36-49	193.40

T37-M	
Depth (in)	PCB (mg/kg)
0-3	6.16

V-22-B	
Depth (in)	PCB (mg/kg)
0-3	11.69

V-24-H	
Depth (in)	PCB (mg/kg)
0-3	3.19

V-24-A	
Depth (in)	PCB (mg/kg)
0-3	25.63

V-24	
Depth (in)	PCB (mg/kg)
0-3	7.70
3-12	7.99
12-24	15.49
24-36	217.70

V-24-C	
Depth (in)	PCB (mg/kg)
0-3	9.47

V-21-L	
Depth (in)	PCB (mg/kg)
0-3	1.96

V-21	
Depth (in)	PCB (mg/kg)
0-3	9.44
3-12	57.96
12-24	19.43
24-36	61.47

V-21-D	
Depth (in)	PCB (mg/kg)
0-3	3.67

V-21-K	
Depth (in)	PCB (mg/kg)
0-3	28.27

V-21-J	
Depth (in)	PCB (mg/kg)
0-3	18.67

V-20-E	
Depth (in)	PCB (mg/kg)
0-3	1.58

V-20-L	
Depth (in)	PCB (mg/kg)
0-3	7.89

V-20-F	
Depth (in)	PCB (mg/kg)
0-3	2.58

V-20-A	
Depth (in)	PCB (mg/kg)
0-3	2.07

V-20-K	
Depth (in)	PCB (mg/kg)
0-3	9.74

V-20-D	
Depth (in)	PCB (mg/kg)
0-3	31.87

T35-NC	
Depth (in)	PCB (mg/kg)
0-3	39.85
3-6	28.69
6-12	7.47
12-16	10.82

V-20-J	
Depth (in)	PCB (mg/kg)
0-3	62.97 [40.06]

V-20	
Depth (in)	PCB (mg/kg)
0-3	25.35
3-12	1.09

V-20-C	
Depth (in)	PCB (mg/kg)
0-3	27.92

V-20-B	
Depth (in)	PCB (mg/kg)
0-3	40.41

V-20-I	
Depth (in)	PCB (mg/kg)
0-3	45.42

V-20-G	
Depth (in)	PCB (mg/kg)
0-3	17.23

V-20-H	
Depth (in)	PCB (mg/kg)
0-3	315.80

SED-T36.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	3.40
3-6	5.54
6-12	16.37
12-18	11.09
18-24	14.12
24-30	24.75
30-36	317.80
36-42	127.50
42-45	5.18
45-51	ND(0.07)
51-57	ND(0.08)

V-21-C	
Depth (in)	PCB (mg/kg)
0-3	51.67

V-21-I	
Depth (in)	PCB (mg/kg)
0-3	26.15

V-21-B	
Depth (in)	PCB (mg/kg)
0-3	37.26

V-21-H	
Depth (in)	PCB (mg/kg)
0-3	143.10

SED-T36-MCN	
Depth (in)	PCB (mg/kg)
0-3	45.04
3-6	20.15
6-12	14.40
12-18	36.78
18-24	256.00 [168.55]
24-30	432.70
30-36	0.15
36-40	ND(0.07)

V-21-G	
Depth (in)	PCB (mg/kg)
0-3	13.69

T36-S	
Depth (in)	PCB (mg/kg)
0-3	4.45

V-22-D	
Depth (in)	PCB (mg/kg)
0-3	41.70

V-22-J	
Depth (in)	PCB (mg/kg)
0-3	10.32

V-22-A	
Depth (in)	PCB (mg/kg)
0-3	72.40

V-22	
Depth (in)	PCB (mg/kg)
0-3	14.33
3-12	3.33

V-22-C	
Depth (in)	PCB (mg/kg)
0-3	8.88

V-22-I	
Depth (in)	PCB (mg/kg)
0-3	8.87

V-24-B	
Depth (in)	PCB (mg/kg)
0-3	7.09

V-22-H	
Depth (in)	PCB (mg/kg)
0-3	13.75 [4.90]

V-22-F	
Depth (in)	PCB (mg/kg)
0-3	12.57

V-22-G	
Depth (in)	PCB (mg/kg)
0-3	4.27

SED-T36.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	58.00
3-6	128.64
6-12	341.99
12-18	79.90
18-24	0.08
24-30	0.10

V-24-K	
Depth (in)	PCB (mg/kg)
0-3	25.20

V-24-J	
Depth (in)	PCB (mg/kg)
0-3	8.61

V-24-D	
Depth (in)	PCB (mg/kg)
0-3	7.02

V-24-I	
Depth (in)	PCB (mg/kg)
0-3	3.27

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T33 - T42

ALCOA

FIGURE
2-7A

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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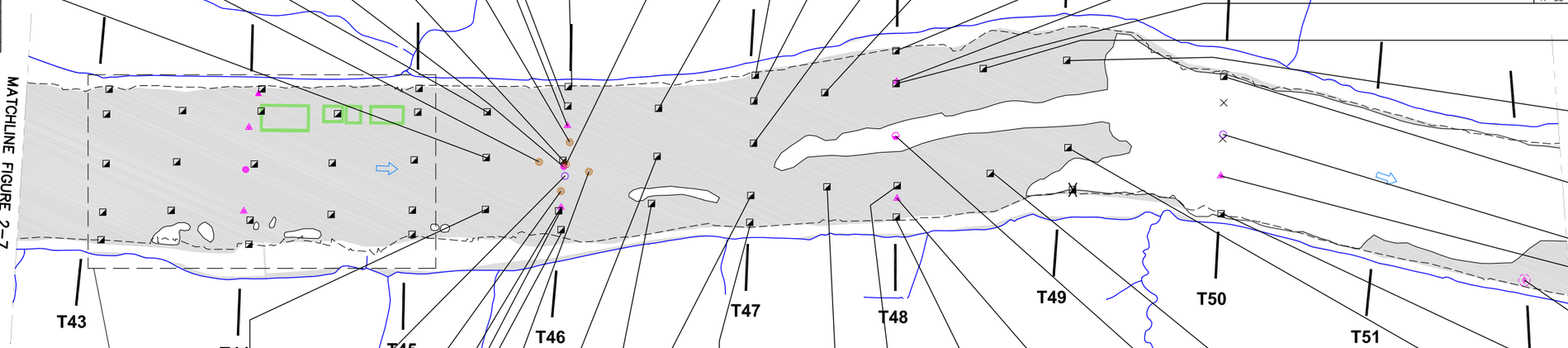

SED-T45.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	3.12
3-6	4.95
6-12	5.94
12-18	4.51
18-24	16.70
24-30	9.05
30-36	455.20 [393.10]
36-42	69.20
42-48	41.85
48-54	134.93
54-57	112.73
57-63	ND(0.08)
63-69	0.13

T46-M	
Depth (in)	PCB (mg/kg)
0-0.39	6.82
0.39-3	3.05
3-12	11.85
12-24	195.18
24-36	100.24 [73.04]
36-44	147.58
44-46	18.23
46-51	146.18

SED-T46-MCM	
Depth (in)	PCB (mg/kg)
0-3	3.32
3-6	3.72
6-12	3.94
12-18	6.23
18-24	12.81
24-30	14.36[3.15]
30-36	181.36
36-42	79.95
42-48	69.67
48-54	106.98
54-56	48.11
56-62	0.08
62-68	3.38

T46-MB	
Depth (in)	PCB (mg/kg)
0-3	4.58
3-6	2.64
6-12	5.96 [6.23]
12-18	5.84
18-24	17.82
24-30	281.50
30-36	259.70
36-42	77.00
42-48	147.24
48-54	127.30
54-57	94.49

T46-N	
Depth (in)	PCB (mg/kg)
0-3	5.59 J

SED-T46-MCN	
Depth (in)	PCB (mg/kg)
0-3	3.11
3-6	3.46
6-12	3.74
12-18	9.30
18-24	13.82
24-30	41.59
30-36	459.90
36-42	57.95
42-48	37.43[41.47]
48-52	100.71
54-60	122.00
60-66	ND(0.08)
66-72	ND(0.08)

SED-T46-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.12
3-6	1.11
6-12	8.99
12-18	6.51
18-24	9.18
24-30	3.42
30-36	2.37
36-42	2.47
42-48	ND(0.07)

T46-MA/MG	
Depth (cm)	PCB (mg/kg)
0-1	1.79
1-2	3.05
2-3	6.35
3-4	7.96
4-5	8.18
5-6	7.99
6-7	4.23
7-8	2.35
9-10	1.75
14-15	2.26
19-20	3.39
24-25	4.67
29-30	4.59
34-35	6.75
39-40	15.71 [16.83]
44-45	7.58
49-50	9.35 [11.61]
54-55	26.63
59-60	3.02
64-65	1.49
69-70	14.21
74-75	72.25
79-80	252.10
84-85	342.40
89-90	629.60
94-95	699.00
99-100	469.50
104-105	48.71
109-110	59.70
114-115	111.05
119-120	77.57
124-125	35.15
129-130	53.15
134-135	120.47
139-140	425.20
144-145	119.10
149-150	55.62

SED-T46.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	4.07
3-6	1.98
6-12	4.25
12-18	12.06
18-24	10.40
24-30	45.80
30-36	113.10
36-42	75.08
42-48	85.02[151.36]
48-51	67.40
51-57	ND(0.08)
57-63	ND(0.07)

SED-T47-SSN	
Depth (in)	PCB (mg/kg)
0-3	0.54
3-6	0.57
6-12	1.73
12-18	5.66
18-24	6.81
24-30	21.34
30-36	57.65
36-42	0.08
42-48	ND(0.07)

SED-T47-MCN	
Depth (in)	PCB (mg/kg)
0-3	171.40
3-6	257.49
6-12	42.35
12-16	178.67

SED-T47-MCM	
Depth (in)	PCB (mg/kg)
0-3	2.07
3-6	2.60
6-12	7.63
12-18	14.30
18-24	47.17
24-30	138.37
30-32	19.19
32-38	0.08
38-44	ND(0.06)

SED-T47.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	7.00
3-6	13.44
6-12	17.69
12-18	73.66
18-24	38.79
24-30	54.17
30-36	138.01[156.63]
36-42	1.97
42-48	ND(0.08)

SED-T48-SSN	
Depth (in)	PCB (mg/kg)
0-3	0.74
3-6	1.57
6-11	7.05

T48-N	
Depth (in)	PCB (mg/kg)
0-3	2.77

SED-T48-MCN	
Depth (in)	PCB (mg/kg)
0-3	2.90
3-6	3.84
6-12	9.63
12-18	25.64
18-24	92.38[192.60]
24-30	74.54
30-36	122.57
36-41	2.75
41-47	ND(0.08)
47-53	ND(0.08)

SED-T48.5-MCN	
Depth (in)	PCB (mg/kg)
0-3	2.28
3-6	3.68
6-12	9.45
12-18	16.86
18-24	98.35
24-30	73.59
30-36	109.35
36-42	7.10
42-48	ND(0.08)
48-54	ND(0.08)

SED-T49-MCN	
Depth (in)	PCB (mg/kg)
0-3	9.07
3-6	16.87
6-12	30.58
12-18	82.59
18-23	41.06[50.98]
23-29	0.11
29-35	ND(0.08)

SED-T50-SSN	
Depth (in)	PCB (mg/kg)
0-3	0.27
3-6	0.11
6-12	0.23
12-18	0.13

V-49	
Depth (in)	PCB (mg/kg)
0-3	20.90

T50-S	
Depth (in)	PCB (mg/kg)
0-3	11.64

SST52-S	
Depth (in)	PCB (mg/kg)
0-0.39	1.23
0.39-3	1.20
3-12	2.59 [2.28]
12-24	9.05
24-34	40.92
34-42	0.60

T46-ME	
Depth (in)	PCB (mg/kg)
0-3	5.58
3-6	4.79
6-12	22.37
12-18	53.08
18-24	425.60
24-30	111.20
30-36	78.85
36-42	253.86
42-45	116.30

SED-T45.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	2.55
3-6	3.20
6-12	3.39
12-18	11.95
18-24	20.44
24-30	89.96
30-36	627.10
36-42	95.39
42-48	87.01 [98.53]
48-54	85.14
54-61	181.00
61-67	0.09
67-73	ND(0.08)

V-48	
Depth (in)	PCB (mg/kg)
0-3	7.24 [7.59]

SED-T45.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	2.11
3-6	2.67
6-12	10.13
12-18	19.51
18-24	36.31
24-30	114.97
30-36	0.55
36-42	ND(0.07)

T46-MD	
Depth (in)	PCB (mg/kg)
0-3	5.59
3-6	2.63
6-12	5.27
12-18	17.04
18-24	16.47
24-30	43.89
30-36	61.45
36-42	187.50
42-48	8.45
48-51	0.26

SED-T46-MCS	
Depth (in)	PCB (mg/kg)
0-3	3.81
3-6	15.54
6-12	13.62
12-18	18.54
18-24	48.31[43.84]
24-30	41.58
30-36	1.86
36-42	0.14

T46-S	
Depth (in)	PCB (mg/kg)
0-3	4.43

SED-T46-SSS	
Depth (in)	PCB (mg/kg)
0-3	1.59
3-9	ND(0.08)
9-15	ND(0.08)

T46-MC	
Depth (in)	PCB (mg/kg)
0-3	4.03
3-6	2.35
6-12	4.81
12-18	11.14
18-24	14.85
24-30	71.86
30-36	53.21
36-42	136.98
42-47	78.92

SED-T47-SSS	
Depth (in)	PCB (mg/kg)
0-3	6.05
3-6	47.36
6-9	46.39
9-12	1.33
12-18	ND(0.08)
18-24	ND(0.07)

SED-T46.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	18.46
3-6	23.06
6-10	37.30
10-16	0.08
16-22	ND(0.05)

SED-T46.5-MCM	
Depth (in)	PCB (mg/kg)
0-3	2.20
3-6	2.97
6-12	10.36
12-18	50.22
18-24	36.45
24-28	166.91

SED-T47-MCS	
Depth (in)	PCB (mg/kg)
0-3	4.27
3-6	ND(0.10)
6-12	ND(0.09)
12-18	ND(0.10)
18-24	ND(0.10)
24-30	ND(0.11)
30-36	ND(0.10)
36-42	ND(0.11)
42-48	ND(0.10)
48-54	ND(0.09)[ND(0.09)]
54-60	ND(0.06)
60-66	ND(0.07)
66-72	ND(0.06)
72-78	ND(0.06)
78-80	ND(0.07)
80-86	ND(0.09)
86-92	ND(0.08)

SED-T47.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	7.00
3-6	38.92
6-12	0.92
12-18	ND(0.10)
18-24	ND(0.10)
24-30	ND(0.10)
30-36	ND(0.10)[0.13]
36-42	ND(0.08)
42-48	ND(0.11)
48-54	ND(0.10)
54-60	ND(0.11)
60-66	ND(0.11)
66-72	ND(0.10)
72-78	ND(0.09)
78-81	ND(0.09)

SED-T48-MCS	
Depth (in)	PCB (mg/kg)
0-3	40.58
3-6	4.50
6-12	0.72
12-18	1.38
18-24	0.20[ND(0.09)]
24-30	ND(0.10)
30-36	ND(0.10)
36-42	ND(0.09)
42-48	ND(0.10)
48-54	ND(0.11)
54-60	ND(0.10)
60-66	ND(0.10)
66-72	ND(0.11)
72-78	ND(0.11)
78-84	ND(0.10)
84-86	ND(0.11)

T48-S	
Depth (in)	PCB (mg/kg)
0-3	7.95

SED-T48-SSS	
Depth (in)	PCB (mg/kg)
0-3	1.83
3-6	4.51
6-12	16.58
12-18	0.26
18-24	ND(0.07)

T48-M	
Depth (cm)	PCB (mg/kg)
0-1	0.78
1-2	0.66
2-3	0.45
3-4	0.54
4-5	1.05
5-6	0.33
6-7	0.50
7-8	1.12
9-10	7.81
14-15	8.77

SED-T48.5-MCS	
Depth (in)	PCB (mg/kg)
0-3	4.06
3-6	16.96
6-12	6.27
12-18	ND(0.08)
18-24	ND(0.09)
24-30	0.13
30-36	ND(0.10)
36-42	ND(0.10)
42-48	ND(0.10)
48-54	ND(0.10)[ND(0.09)]
54-60	ND(0.10)
60-66	ND(0.10)
66-72	ND(0.11)
72-78	ND(0.10)
78-80	0.22

SED-T49-MCS	
Depth (in)	PCB (mg/kg)
0-3	11.05
3-6	16.86
6-12	4.47
12-18	0.10
18-24	ND(0.10)
24-30	ND(0.10)
30-36	ND(0.10)
36-42	ND(0.10)
42-48	ND(0.10)
48-54	0.23
54-60	ND(0.10)
60-65	ND(0.11)

SED-T50-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.25
3-6	0.64

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T43 - T52

ALCOA

FIGURE
2-8

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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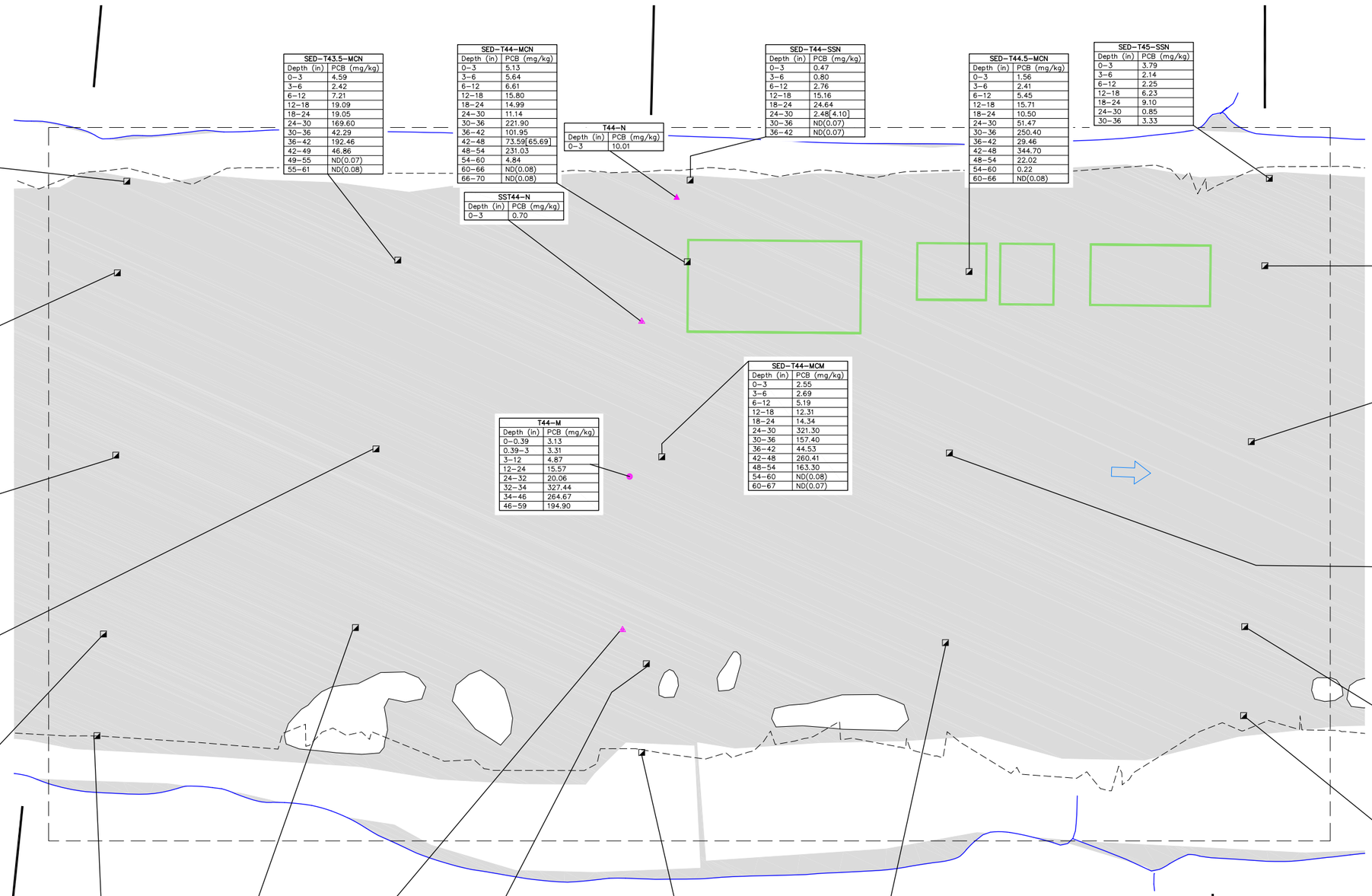
XREFS: 10875X02 10875X03 10875X00 IMAGES: 10875X01.TIF



SED–T43–SSN	
Depth (in)	PCB (mg/kg)
0–3	1.39
3–6	0.81
6–12	1.50
12–18	4.74
18–24	22.65
24–30	35.13
30–36	49.88
36–42	8.30
42–48	ND(0.07)
48–54	ND(0.08)
54–60	ND(0.08)
60–66	ND(0.09)
66–72	ND(0.10)
72–78	ND(0.10)
78–84	ND(0.09)
84–90	ND(0.09)
90–92	ND(0.09)
92–98	ND(0.08)

SED–T43–MCN	
Depth (in)	PCB (mg/kg)
0–3	5.07
3–6	2.92
6–12	12.92
12–18	15.53
18–24	86.44
24–30	57.98
30–36	223.70
36–42	51.05
42–47	1.63
47–53	ND(0.08)
53–59	ND(0.07)

SED–T43–MCM	
Depth (in)	PCB (mg/kg)
0–3	3.15
3–6	2.49
6–12	5.91
12–18	7.78
18–24	9.05
24–30	91.17
30–36	46.11
36–42	249.43
42–47	58.68
47–53	ND(0.08)
53–59	ND(0.08)

SED–T43.5–MCM	
Depth (in)	PCB (mg/kg)
0–3	4.10
3–6	5.27
6–12	13.45
12–18	14.40
18–24	93.27
24–30	99.76[4.10]
30–36	124.52
36–39	24.67
39–45	ND(0.08)
45–51	ND(0.08)

SED–T43–MCS	
Depth (in)	PCB (mg/kg)
0–3	2.35
3–6	7.06
6–12	3.03
12–18	7.60
18–24	12.88
24–30	57.83
30–36	62.46
36–43	64.65
43–49	ND(0.08)
49–55	ND(0.08)

SED–T43.5–MCN	
Depth (in)	PCB (mg/kg)
0–3	4.59
3–6	2.42
6–12	7.21
12–18	19.09
18–24	19.05
24–30	169.60
30–36	42.29
36–42	192.46
42–49	46.86
49–55	ND(0.07)
55–61	ND(0.08)

SED–T44–MCN	
Depth (in)	PCB (mg/kg)
0–3	5.13
3–6	5.64
6–12	6.61
12–18	15.80
18–24	14.99
24–30	11.14
30–36	221.90
36–42	101.95
42–48	73.59[65.69]
48–54	231.03
54–60	4.84
60–66	ND(0.08)
66–70	ND(0.08)

T44–N	
Depth (in)	PCB (mg/kg)
0–3	10.01

SST44–N	
Depth (in)	PCB (mg/kg)
0–3	0.70

SED–T44–SSN	
Depth (in)	PCB (mg/kg)
0–3	0.47
3–6	0.80
6–12	2.76
12–18	15.16
18–24	24.64
24–30	2.48[4.10]
30–36	ND(0.07)
36–42	ND(0.07)

SED–T44.5–MCN	
Depth (in)	PCB (mg/kg)
0–3	1.56
3–6	2.41
6–12	5.45
12–18	15.71
18–24	10.50
24–30	51.47
30–36	250.40
36–42	29.46
42–48	344.70
48–54	22.02
54–60	0.22
60–66	ND(0.08)

SED–T45–SSN	
Depth (in)	PCB (mg/kg)
0–3	3.79
3–6	2.14
6–12	2.25
12–18	6.23
18–24	9.10
24–30	0.85
30–36	3.33

SED–T45–MCN	
Depth (in)	PCB (mg/kg)
0–3	4.03
3–6	4.49
6–12	1.97
12–18	10.36
18–24	8.35
24–30	29.33
30–36	322.90[357.10]
36–42	24.35
42–48	168.67
48–54	68.99
54–60	0.43
60–66	ND(0.08)

SED–T45–MCM	
Depth (in)	PCB (mg/kg)
0–3	2.16
3–6	2.67
6–12	5.38
12–18	14.18
18–24	17.37
24–30	529.60
30–36	185.30
36–42	73.18
42–48	103.27
48–54	98.11
54–60	ND(0.08)
60–66	ND(0.08)

T44–M	
Depth (in)	PCB (mg/kg)
0–0.39	3.13
0.39–3	3.31
3–12	4.87
12–24	15.57
24–32	20.06
32–34	327.44
34–46	264.67
46–59	194.90

SED–T44–MCM	
Depth (in)	PCB (mg/kg)
0–3	2.55
3–6	2.69
6–12	5.19
12–18	12.31
18–24	14.34
24–30	321.30
30–36	157.40
36–42	44.53
42–48	260.41
48–54	163.30
54–60	ND(0.08)
60–67	ND(0.07)

SED–T44.5–MCM	
Depth (in)	PCB (mg/kg)
0–3	ND(0.14)
3–6	3.26
6–12	5.43
12–18	12.96
18–24	30.42
24–30	321.40
30–36	53.60
36–42	118.71[125.01]
42–48	108.46
48–51	9.22
51–57	ND(0.08)
57–63	ND(0.08)

SED–T45–MCS	
Depth (in)	PCB (mg/kg)
0–3	5.18
3–6	4.52
6–12	14.60
12–18	20.74
18–24	45.31
24–30	49.69[47.63]
30–36	2.88
36–42	ND(0.08)
42–48	ND(0.08)

SED–T45–SSS	
Depth (in)	PCB (mg/kg)
0–3	2.63
3–6	4.30
6–12	3.89
12–18	3.24
18–24	62.45
24–30	2.84
30–36	0.31
36–42	ND(0.06)

SED–T43–SSS	
Depth (in)	PCB (mg/kg)
0–3	4.69
3–6	23.06
6–12	9.61
12–18	1.30[0.55]
18–24	0.25
24–28	0.49
28–34	ND(0.08)
34–40	ND(0.08)

SED–T43.5–MCS	
Depth (in)	PCB (mg/kg)
0–3	3.58
3–6	3.20
6–12	3.31
12–18	9.88
18–24	12.48
24–30	101.68
30–36	46.14[51.58]
36–42	195.94
42–48	ND(0.08)
48–54	ND(0.08)

T44–S	
Depth (in)	PCB (mg/kg)
0–3	3.91

SED–T44–MCS	
Depth (in)	PCB (mg/kg)
0–3	2.13
3–6	2.68
6–12	3.49
12–18	12.99
18–24	12.68
24–30	24.30
30–36	65.82
36–42	6.36
42–48	ND(0.05)
48–55	ND(0.05)

SED–T44–SSS	
Depth (in)	PCB (mg/kg)
0–3	2.77
3–6	2.55
6–12	12.11

SED–T44.5–MCS	
Depth (in)	PCB (mg/kg)
0–3	2.96
3–6	2.48
6–12	5.14
12–18	11.06
18–24	16.96
24–30	35.47
30–36	164.41
36–42	104.17
42–48	0.16
48–54	ND(0.08)

0 50' 100'
GRAPHIC SCALE

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T43 - T45

ALCOA

FIGURE
2-8A

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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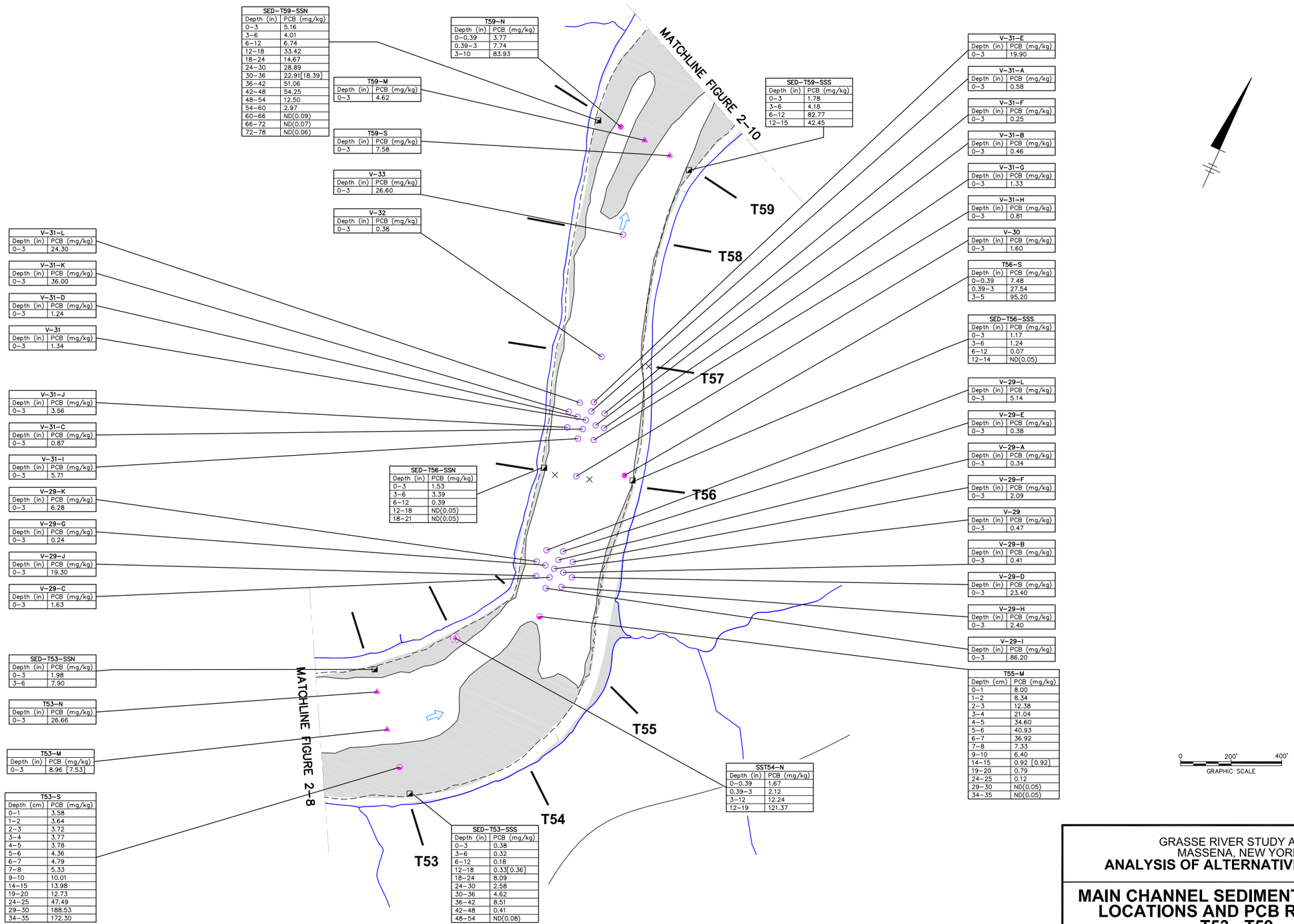
IMAGES: 10875X01.TIF



SED-T59-SSN	
Depth (in)	PCB (mg/kg)
0-3	5.16
3-6	4.01
6-12	6.74
12-18	33.42
18-24	14.67
24-30	28.89
30-36	22.91[18.39]
36-42	51.06
42-48	54.25
48-54	12.50
54-60	2.97
60-66	ND(0.09)
66-72	ND(0.07)
72-78	ND(0.06)

T59-N	
Depth (in)	PCB (mg/kg)
0-0.39	3.77
0.39-3	7.74
3-10	83.93

T59-M	
Depth (in)	PCB (mg/kg)
0-3	4.62

T59-S	
Depth (in)	PCB (mg/kg)
0-3	7.58

V-33	
Depth (in)	PCB (mg/kg)
0-3	26.60

V-32	
Depth (in)	PCB (mg/kg)
0-3	0.38

SED-T59-SSS	
Depth (in)	PCB (mg/kg)
0-3	1.78
3-6	4.18
6-12	82.77
12-15	42.45

V-31-E	
Depth (in)	PCB (mg/kg)
0-3	19.90

V-31-A	
Depth (in)	PCB (mg/kg)
0-3	0.58

V-31-F	
Depth (in)	PCB (mg/kg)
0-3	0.25

V-31-B	
Depth (in)	PCB (mg/kg)
0-3	0.46

V-31-G	
Depth (in)	PCB (mg/kg)
0-3	1.33

V-31-H	
Depth (in)	PCB (mg/kg)
0-3	0.81

V-30	
Depth (in)	PCB (mg/kg)
0-3	1.60

T56-S	
Depth (in)	PCB (mg/kg)
0-0.39	7.48
0.39-3	27.54
3-5	95.20

SED-T56-SSS	
Depth (in)	PCB (mg/kg)
0-3	1.17
3-6	1.24
6-12	0.07
12-14	ND(0.05)

V-29-L	
Depth (in)	PCB (mg/kg)
0-3	5.14

V-29-E	
Depth (in)	PCB (mg/kg)
0-3	0.38

V-29-A	
Depth (in)	PCB (mg/kg)
0-3	0.34

V-29-F	
Depth (in)	PCB (mg/kg)
0-3	2.09

V-29	
Depth (in)	PCB (mg/kg)
0-3	0.47

V-29-B	
Depth (in)	PCB (mg/kg)
0-3	0.41

V-29-D	
Depth (in)	PCB (mg/kg)
0-3	23.40

V-29-H	
Depth (in)	PCB (mg/kg)
0-3	2.40

V-29-I	
Depth (in)	PCB (mg/kg)
0-3	86.20

T55-M	
Depth (cm)	PCB (mg/kg)
0-1	8.00
1-2	8.34
2-3	12.38
3-4	21.04
4-5	34.60
5-6	40.93
6-7	36.92
7-8	7.33
9-10	6.40
14-15	0.92 [0.92]
19-20	0.79
24-25	0.12
29-30	ND(0.05)
34-35	ND(0.05)

SST54-N	
Depth (in)	PCB (mg/kg)
0-0.39	1.67
0.39-3	2.12
3-12	12.24
12-19	121.37

SED-T53-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.38
3-6	0.32
6-12	0.18
12-18	0.33[0.36]
18-24	8.09
24-30	2.58
30-36	4.62
36-42	8.51
42-48	0.41
48-54	ND(0.08)

SED-T56-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.53
3-6	3.39
6-12	0.39
12-18	ND(0.05)
18-21	ND(0.05)

V-31-L	
Depth (in)	PCB (mg/kg)
0-3	24.30

V-31-K	
Depth (in)	PCB (mg/kg)
0-3	36.00

V-31-D	
Depth (in)	PCB (mg/kg)
0-3	1.24

V-31	
Depth (in)	PCB (mg/kg)
0-3	1.34

V-31-J	
Depth (in)	PCB (mg/kg)
0-3	3.56

V-31-C	
Depth (in)	PCB (mg/kg)
0-3	0.87

V-31-I	
Depth (in)	PCB (mg/kg)
0-3	5.71

V-29-K	
Depth (in)	PCB (mg/kg)
0-3	6.28

V-29-G	
Depth (in)	PCB (mg/kg)
0-3	0.24

V-29-J	
Depth (in)	PCB (mg/kg)
0-3	19.30

V-29-C	
Depth (in)	PCB (mg/kg)
0-3	1.63

SED-T53-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.98
3-6	7.90

T53-N	
Depth (in)	PCB (mg/kg)
0-3	26.66

T53-M	
Depth (in)	PCB (mg/kg)
0-3	8.96 [7.53]

T53-S	
Depth (cm)	PCB (mg/kg)
0-1	3.58
1-2	3.64
2-3	3.72
3-4	3.77
4-5	3.78
5-6	4.36
6-7	4.79
7-8	5.33
9-10	10.01
14-15	13.98
19-20	12.73
24-25	47.49
29-30	188.53
34-35	172.30

SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T53 - T59

ALCOA

FIGURE
2-9

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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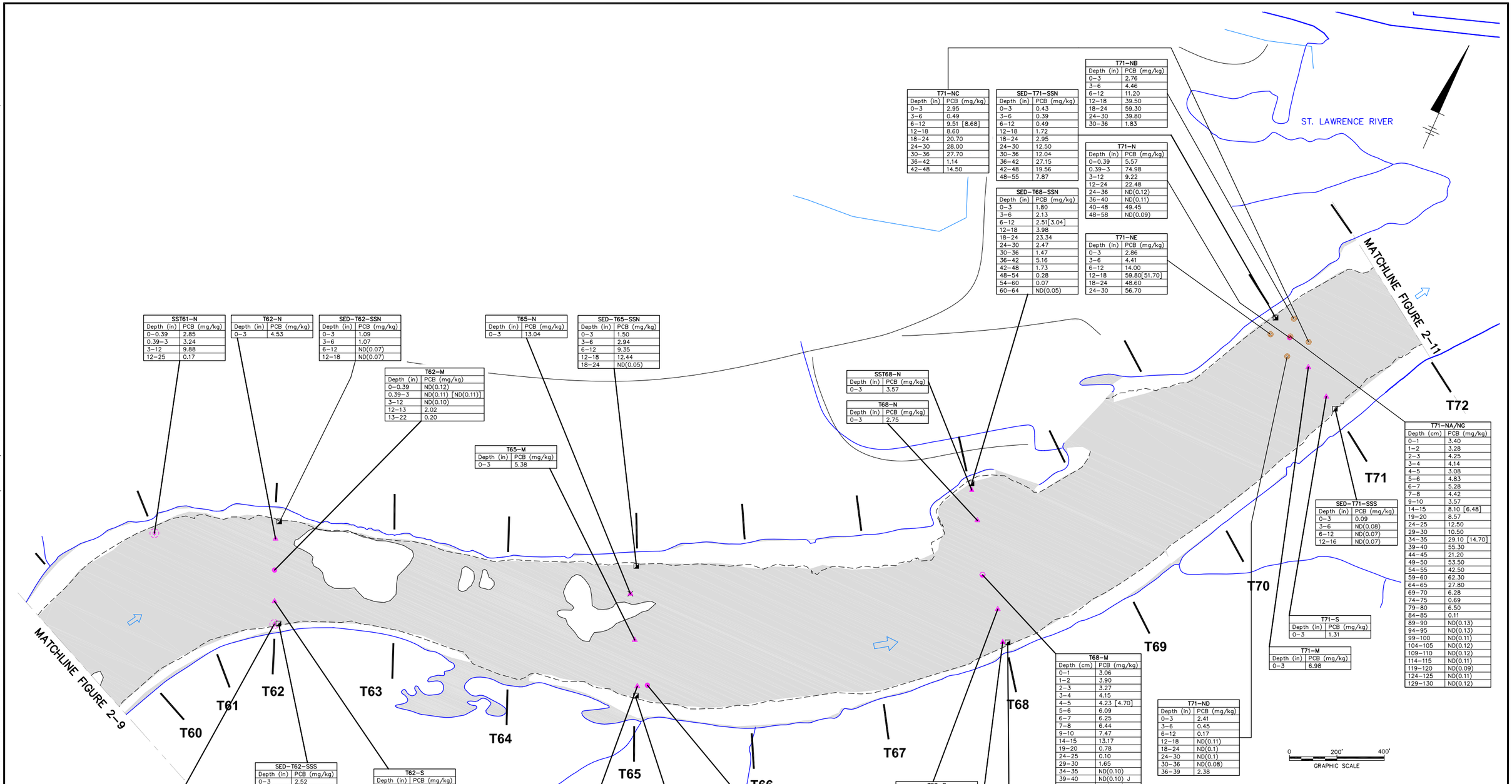


SST61-N	
Depth (in)	PCB (mg/kg)
0-0.39	2.85
0.39-3	3.24
3-12	9.88
12-25	0.17

T62-N	
Depth (in)	PCB (mg/kg)
0-3	4.53

SED-T62-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.09
3-6	1.07
6-12	ND(0.07)
12-18	ND(0.07)

T62-M	
Depth (in)	PCB (mg/kg)
0-0.39	ND(0.12)
0.39-3	ND(0.11) [ND(0.11)]
3-12	ND(0.10)
12-13	2.02
13-22	0.20

T65-N	
Depth (in)	PCB (mg/kg)
0-3	13.04

SED-T65-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.50
3-6	2.94
6-12	9.35
12-18	12.44
18-24	ND(0.05)

T65-M	
Depth (in)	PCB (mg/kg)
0-3	5.38

T71-NC	
Depth (in)	PCB (mg/kg)
0-3	2.95
3-6	0.49
6-12	9.51 [8.68]
12-18	8.60
18-24	20.70
24-30	28.00
30-36	27.70
36-42	1.14
42-48	14.50

SED-T71-SSN	
Depth (in)	PCB (mg/kg)
0-3	0.43
3-6	0.39
6-12	0.49
12-18	1.72
18-24	2.95
24-30	12.50
30-36	12.04
36-42	27.15
42-48	19.56
48-55	7.87

SED-T68-SSN	
Depth (in)	PCB (mg/kg)
0-3	1.80
3-6	2.13
6-12	2.51[3.04]
12-18	3.98
18-24	23.34
24-30	2.47
30-36	1.47
36-42	5.16
42-48	1.73
48-54	0.28
54-60	0.07
60-64	ND(0.05)

T71-NB	
Depth (in)	PCB (mg/kg)
0-3	2.76
3-6	4.46
6-12	11.20
12-18	39.50
18-24	59.30
24-30	39.80
30-36	1.83

T71-N	
Depth (in)	PCB (mg/kg)
0-0.39	5.57
0.39-3	74.98
3-12	9.22
12-24	22.48
24-36	ND(0.12)
36-40	ND(0.11)
40-48	49.45
48-58	ND(0.09)

T71-NE	
Depth (in)	PCB (mg/kg)
0-3	2.86
3-6	4.41
6-12	14.00
12-18	59.80[51.70]
18-24	48.60
24-30	56.70

SST68-N	
Depth (in)	PCB (mg/kg)
0-3	3.57

T68-N	
Depth (in)	PCB (mg/kg)
0-3	2.75

T71-NA/NG	
Depth (cm)	PCB (mg/kg)
0-1	3.40
1-2	3.28
2-3	4.25
3-4	4.14
4-5	3.08
5-6	4.83
6-7	5.28
7-8	4.42
9-10	3.57
14-15	8.10 [6.48]
19-20	8.57
24-25	12.50
29-30	10.50
34-35	29.10 [14.70]
39-40	55.30
44-45	21.20
49-50	53.50
54-55	42.50
59-60	62.30
64-65	27.80
69-70	6.28
74-75	0.69
79-80	6.50
84-85	0.11
89-90	ND(0.13)
94-95	ND(0.13)
99-100	ND(0.11)
104-105	ND(0.12)
109-110	ND(0.12)
114-115	ND(0.11)
119-120	ND(0.09)
124-125	ND(0.11)
129-130	ND(0.12)

SED-T71-SSS	
Depth (in)	PCB (mg/kg)
0-3	0.09
3-6	ND(0.08)
6-12	ND(0.07)
12-16	ND(0.07)

T71-S	
Depth (in)	PCB (mg/kg)
0-3	1.31

T71-M	
Depth (in)	PCB (mg/kg)
0-3	6.98

T71-ND	
Depth (in)	PCB (mg/kg)
0-3	2.41
3-6	0.45
6-12	0.17
12-18	ND(0.11)
18-24	ND(0.1)
24-30	ND(0.1)
30-36	ND(0.08)
36-39	2.38

T68-M	
Depth (cm)	PCB (mg/kg)
0-1	3.06
1-2	3.90
2-3	3.27
3-4	4.15
4-5	4.23 [4.70]
5-6	6.09
6-7	6.25
7-8	6.44
9-10	7.47
14-15	13.17
19-20	0.78
24-25	0.10
29-30	1.65
34-35	ND(0.10)
39-40	ND(0.10) J
44-45	ND(0.09)
49-50	ND(0.10)
54-55	ND(0.11)
59-60	ND(0.10)
64-65	ND(0.09)
69-70	ND(0.10)
74-75	ND(0.11)
79-80	ND(0.10)
84-85	ND(0.11)
89-90	ND(0.10)
94-95	ND(0.11)

SST62-S	
Depth (in)	PCB (mg/kg)
0-0.39	1.26
0.39-3	1.12
3-12	4.98
12-24	35.86
24-32	1.49

SED-T62-SSS	
Depth (in)	PCB (mg/kg)
0-3	2.52
3-6	3.04
6-12	10.12
12-18	9.30
18-24	7.89
24-30	10.42
30-36	5.99
36-42	1.12
42-48	0.51
48-54	ND(0.10)
54-60	ND(0.08)
60-66	ND(0.07)

T62-S	
Depth (in)	PCB (mg/kg)
0-3	6.02

T65-S	
Depth (in)	PCB (mg/kg)
0-3	1.32

SED-T65-SSS	
Depth (in)	PCB (mg/kg)
0-3	2.18
3-6	7.80
6-12	30.78
12-18	14.92
18-24	0.83
24-30	ND(0.06)
30-36	0.88
36-42	ND(0.10)
42-48	0.61
48-54	ND(0.12)
54-60	ND(0.12)
60-66	ND(0.12)
66-72	ND(0.12)

T65-S	
Depth (in)	PCB (mg/kg)
0-0.39	3.28
0.39-3	2.88
3-12	7.93
12-24	29.62
24-28	74.06
28-36	5.55
36-48	ND(0.12)
48-60	ND(0.12)
60-62	ND(0.12)
62-65	ND(0.08)
65-76	ND(0.11)

T68-S	
Depth (in)	PCB (mg/kg)
0-3	8.63

SST68-S	
Depth (in)	PCB (mg/kg)
0-3	ND(0.09)

SED-T68-SSS	
Depth (in)	PCB (mg/kg)
0-3	4.02
3-6	0.41
6-12	ND(0.07)
12-18	ND(0.07)

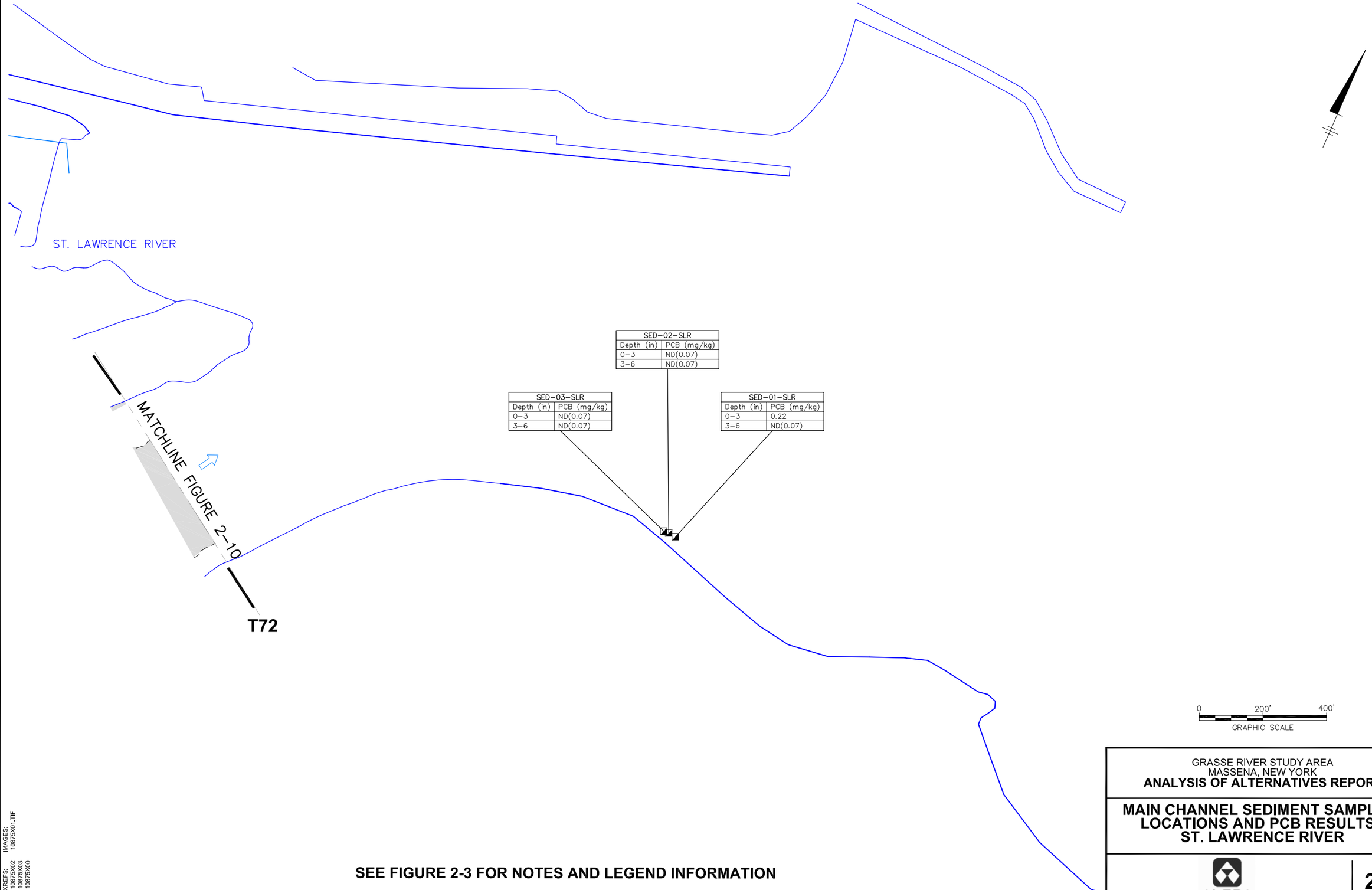
SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T60 - T72

ALCOA

FIGURE
2-10



SEE FIGURE 2-3 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

MAIN CHANNEL SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - ST. LAWRENCE RIVER

ALCOA

FIGURE
2-11

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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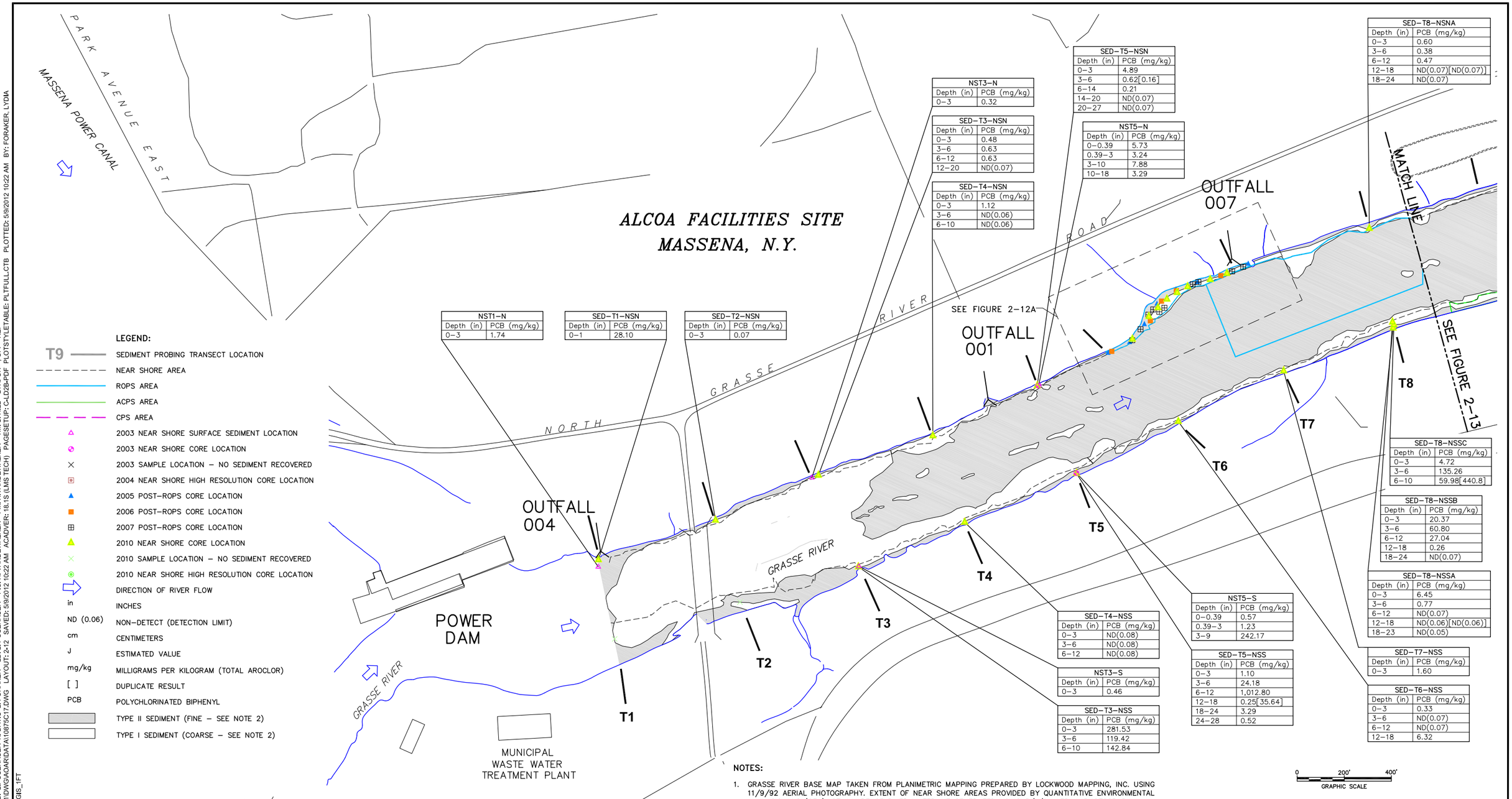

NST1–N	
Depth (in)	PCB (mg/kg)
0–3	1.74

SED–T1–NSN	
Depth (in)	PCB (mg/kg)
0–1	28.10

SED–T2–NSN	
Depth (in)	PCB (mg/kg)
0–3	0.07

NST3–N	
Depth (in)	PCB (mg/kg)
0–3	0.32

SED–T3–NSN	
Depth (in)	PCB (mg/kg)
0–3	0.48
3–6	0.63
6–12	0.63
12–20	ND(0.07)

SED–T4–NSN	
Depth (in)	PCB (mg/kg)
0–3	1.12
3–6	ND(0.06)
6–10	ND(0.06)

SED–T5–NSN	
Depth (in)	PCB (mg/kg)
0–3	4.89
3–6	0.62[0.16]
6–14	0.21
14–20	ND(0.07)
20–27	ND(0.07)

NST5–N	
Depth (in)	PCB (mg/kg)
0–0.39	5.73
0.39–3	3.24
3–10	7.88
10–18	3.29

SED–T8–NSNA	
Depth (in)	PCB (mg/kg)
0–3	0.60
3–6	0.38
6–12	0.47
12–18	ND(0.07)[ND(0.07)]
18–24	ND(0.07)

SED–T8–NSSC	
Depth (in)	PCB (mg/kg)
0–3	4.72
3–6	135.26
6–10	59.98[440.8]

SED–T8–NSSB	
Depth (in)	PCB (mg/kg)
0–3	20.37
3–6	60.80
6–12	27.04
12–18	0.26
18–24	ND(0.07)

SED–T8–NSSA	
Depth (in)	PCB (mg/kg)
0–3	6.45
3–6	0.77
6–12	ND(0.07)
12–18	ND(0.06)[ND(0.06)]
18–23	ND(0.05)

SED–T7–NSS	
Depth (in)	PCB (mg/kg)
0–3	1.60

SED–T6–NSS	
Depth (in)	PCB (mg/kg)
0–3	0.33
3–6	ND(0.07)
6–12	ND(0.07)
12–18	6.32

NST5–S	
Depth (in)	PCB (mg/kg)
0–0.39	0.57
0.39–3	1.23
3–9	242.17

SED–T5–NSS	
Depth (in)	PCB (mg/kg)
0–3	1.10
3–6	24.18
6–12	1,012.80
12–18	0.25[35.64]
18–24	3.29
24–28	0.52

SED–T4–NSS	
Depth (in)	PCB (mg/kg)
0–3	ND(0.08)
3–6	ND(0.08)
6–12	ND(0.08)

NST3–S	
Depth (in)	PCB (mg/kg)
0–3	0.46

SED–T3–NSS	
Depth (in)	PCB (mg/kg)
0–3	281.53
3–6	119.42
6–10	142.84

NOTES:

1. GRASSE RIVER BASE MAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY. EXTENT OF NEAR SHORE AREAS PROVIDED BY QUANTITATIVE ENVIRONMENTAL ANALYSIS, LLC (QEA). ST. LAWRENCE RIVER WATERLINE GENERATED USING 5/1/01 AERIAL PHOTOGRAPHY.
2. BOTTOM TYPE DEFINITIONS REPORTED BY OCEAN SURVEYS, INC. (OSI, AUGUST 2003). TYPE I SEDIMENT INDICATES THAT THE RIVER BED APPEARS IRREGULAR AND IS PRINCIPALLY REPRESENTED BY POSSIBLE ROCK OUTCROPS AND/OR ASSEMBLAGES OF BOULDERS/COBBLES WHICH MAY BE OVERLAIN BY A THIN VENEER OF SEDIMENTS COMPOSED OF SANDS AND GRAVEL. TYPE II SEDIMENT INDICATES THAT THE RIVER BED APPEARS FLAT/SMOOTH AND IS PRINCIPALLY COMPOSED OF SEDIMENT DEPOSITS OF CLAY, SAND AND GRAVEL.
3. PCB GRADIENT CORES WERE COLLECTED IN THE NEAR SHORE AREA IN 2010 (T8, T12, T19, T30, T40, T44, T49, T53). CORES WERE COLLECTED STARTING APPROXIMATELY 5 FEET FROM THE WATER'S EDGE AND CONTINUING AT APPROXIMATE 10-FOOT INTERVALS TO THE EXTENT OF THE NEAR SHORE AREAS. CORES COLLECTED CLOSEST TO SHORE ARE IDENTIFIED WITH AN "A", WITH ALL SUBSEQUENT CORES IDENTIFIED WITH SEQUENTIAL LETTERS.
4. 2003 NEAR SHORE SURFACE SEDIMENT DATA ARE NOT SHOWN IN THE ROPS NNS AND SNS AREAS AS DREDGING AND/OR CAPPING WAS PERFORMED IN THESE AREAS IN 2005.
5. ALL MAIN CHANNEL SAMPLE LOCATIONS AND PCB RESULTS ARE PRESENTED ON FIGURES 2–3 THROUGH 2–11.

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T1 - T8

ALCOA

FIGURE
2-12

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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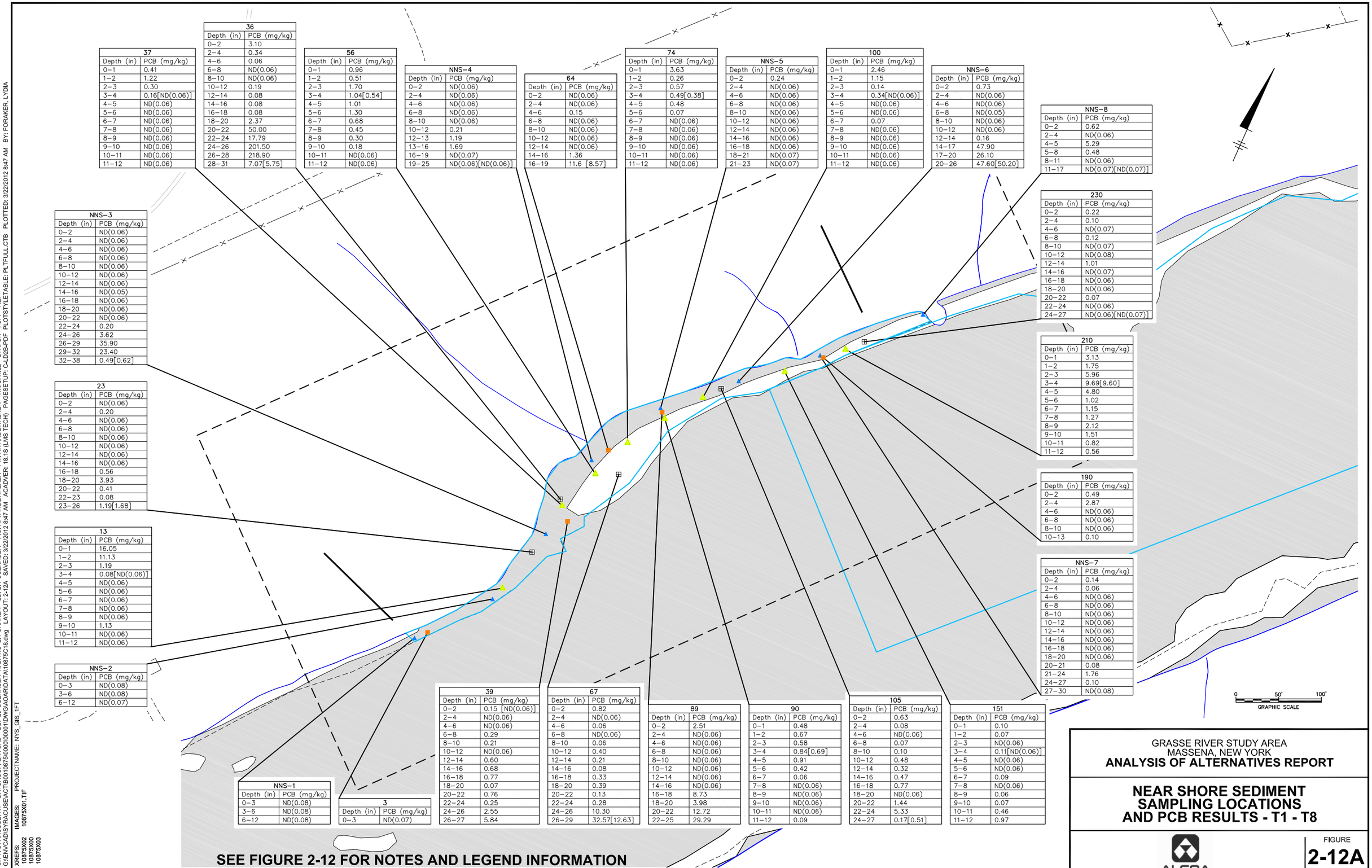
XREFS: 10875X02 10875X00 10875X03 IMAGES: 10875X01.TIF PROJECTNAME: NYS_GIS_1FT



37	
Depth (in)	PCB (mg/kg)
0–1	0.41
1–2	1.22
2–3	0.30
3–4	0.16[ND(0.06)]
4–5	ND(0.06)
5–6	ND(0.06)
6–7	ND(0.06)
7–8	ND(0.06)
8–9	ND(0.06)
9–10	ND(0.06)
10–11	ND(0.06)
11–12	ND(0.06)

36	
Depth (in)	PCB (mg/kg)
0–2	3.10
2–4	0.34
4–6	0.06
6–8	ND(0.06)
8–10	ND(0.06)
10–12	0.19
12–14	0.08
14–16	0.08
16–18	0.08
18–20	2.37
20–22	50.00
22–24	17.79
24–26	201.50
26–28	218.90
28–31	7.07[5.75]

56	
Depth (in)	PCB (mg/kg)
0–1	0.96
1–2	0.51
2–3	1.70
3–4	1.04[0.54]
4–5	1.01
5–6	1.30
6–7	0.68
7–8	0.45
8–9	0.30
9–10	0.18
10–11	ND(0.06)
11–12	ND(0.06)

NNS–4	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	0.21
12–13	1.19
13–16	1.69
16–19	ND(0.07)
19–25	ND(0.06)[ND(0.06)]

64	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	ND(0.06)
4–6	0.15
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	1.36
16–19	11.6 [8.57]

74	
Depth (in)	PCB (mg/kg)
0–1	3.63
1–2	0.26
2–3	0.57
3–4	0.49[0.38]
4–5	0.48
5–6	0.07
6–7	ND(0.06)
7–8	ND(0.06)
8–9	ND(0.06)
9–10	ND(0.06)
10–11	ND(0.06)
11–12	ND(0.06)

NNS–5	
Depth (in)	PCB (mg/kg)
0–2	0.24
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	ND(0.06)
18–21	ND(0.07)
21–23	ND(0.07)

100	
Depth (in)	PCB (mg/kg)
0–1	2.46
1–2	1.15
2–3	0.14
3–4	0.34[ND(0.06)]
4–5	ND(0.06)
5–6	ND(0.06)
6–7	0.07
7–8	ND(0.06)
8–9	ND(0.06)
9–10	ND(0.06)
10–11	ND(0.06)
11–12	ND(0.06)

NNS–6	
Depth (in)	PCB (mg/kg)
0–2	0.73
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.05)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	0.16
14–17	47.90
17–20	26.10
20–26	47.60[50.20]

NNS–8	
Depth (in)	PCB (mg/kg)
0–2	0.62
2–4	ND(0.06)
4–5	5.29
5–8	0.48
8–11	ND(0.06)
11–17	ND(0.07)[ND(0.07)]

230	
Depth (in)	PCB (mg/kg)
0–2	0.22
2–4	0.10
4–6	ND(0.07)
6–8	0.12
8–10	ND(0.07)
10–12	ND(0.08)
12–14	1.01
14–16	ND(0.07)
16–18	ND(0.06)
18–20	ND(0.06)
20–22	0.07
22–24	ND(0.06)
24–27	ND(0.06)[ND(0.07)]

210	
Depth (in)	PCB (mg/kg)
0–1	3.13
1–2	1.75
2–3	5.96
3–4	9.69[9.60]
4–5	4.80
5–6	1.02
6–7	1.15
7–8	1.27
8–9	2.12
9–10	1.51
10–11	0.82
11–12	0.56

190	
Depth (in)	PCB (mg/kg)
0–2	0.49
2–4	2.87
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–13	0.10

NNS–7	
Depth (in)	PCB (mg/kg)
0–2	0.14
2–4	0.06
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	ND(0.06)
18–20	ND(0.06)
20–21	0.08
21–24	1.76
24–27	0.10
27–30	ND(0.08)

NNS–3	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.05)
16–18	ND(0.06)
18–20	ND(0.06)
20–22	ND(0.06)
22–24	0.20
24–26	3.62
26–29	35.90
29–32	23.40
32–38	0.49[0.62]

23	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	0.20
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	0.56
18–20	3.93
20–22	0.41
22–23	0.08
23–26	1.19[1.68]

13	
Depth (in)	PCB (mg/kg)
0–1	16.05
1–2	11.13
2–3	1.19
3–4	0.08[ND(0.06)]
4–5	ND(0.06)
5–6	ND(0.06)
6–7	ND(0.06)
7–8	ND(0.06)
8–9	ND(0.06)
9–10	1.13
10–11	ND(0.06)
11–12	ND(0.06)

NNS–2	
Depth (in)	PCB (mg/kg)
0–3	ND(0.08)
3–6	ND(0.08)
6–12	ND(0.07)

39	
Depth (in)	PCB (mg/kg)
0–2	0.15 [ND(0.06)]
2–4	ND(0.06)
4–6	ND(0.06)
6–8	0.29
8–10	0.21
10–12	ND(0.06)
12–14	0.60
14–16	0.68
16–18	0.77
18–20	0.07
20–22	0.76
22–24	0.25
24–26	2.55
26–27	5.84

67	
Depth (in)	PCB (mg/kg)
0–2	0.82
2–4	ND(0.06)
4–6	0.06
6–8	ND(0.06)
8–10	0.06
10–12	0.40
12–14	0.21
14–16	0.08
16–18	0.33
18–20	0.39
20–22	0.13
22–24	0.28
24–26	10.30
26–29	32.57[12.63]

89	
Depth (in)	PCB (mg/kg)
0–2	2.51
2–4	ND(0.06)
4–6	ND(0.06)
6–8	ND(0.06)
8–10	ND(0.06)
10–12	ND(0.06)
12–14	ND(0.06)
14–16	ND(0.06)
16–18	8.73
18–20	3.98
20–22	12.72
22–25	29.29

90	
Depth (in)	PCB (mg/kg)
0–1	0.48
1–2	0.67
2–3	0.58
3–4	0.84[0.69]
4–5	0.91
5–6	0.42
6–7	0.06
7–8	ND(0.06)
8–9	ND(0.06)
9–10	ND(0.06)
10–11	ND(0.06)
11–12	0.09

105	
Depth (in)	PCB (mg/kg)
0–2	0.63
2–4	0.08
4–6	ND(0.06)
6–8	0.07
8–10	0.10
10–12	0.48
12–14	0.32
14–16	0.47
16–18	0.77
18–20	ND(0.06)
20–22	1.44
22–24	5.33
24–27	0.17[0.51]

151	
Depth (in)	PCB (mg/kg)
0–1	0.10
1–2	0.07
2–3	ND(0.06)
3–4	0.11[ND(0.06)]
4–5	ND(0.06)
5–6	ND(0.06)
6–7	0.09
7–8	ND(0.06)
8–9	0.06
9–10	0.07
10–11	0.46
11–12	0.97

NNS–1	
Depth (in)	PCB (mg/kg)
0–3	ND(0.08)
3–6	ND(0.08)
6–12	ND(0.08)

3	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T1 - T8

ALCOA

FIGURE
2-12A

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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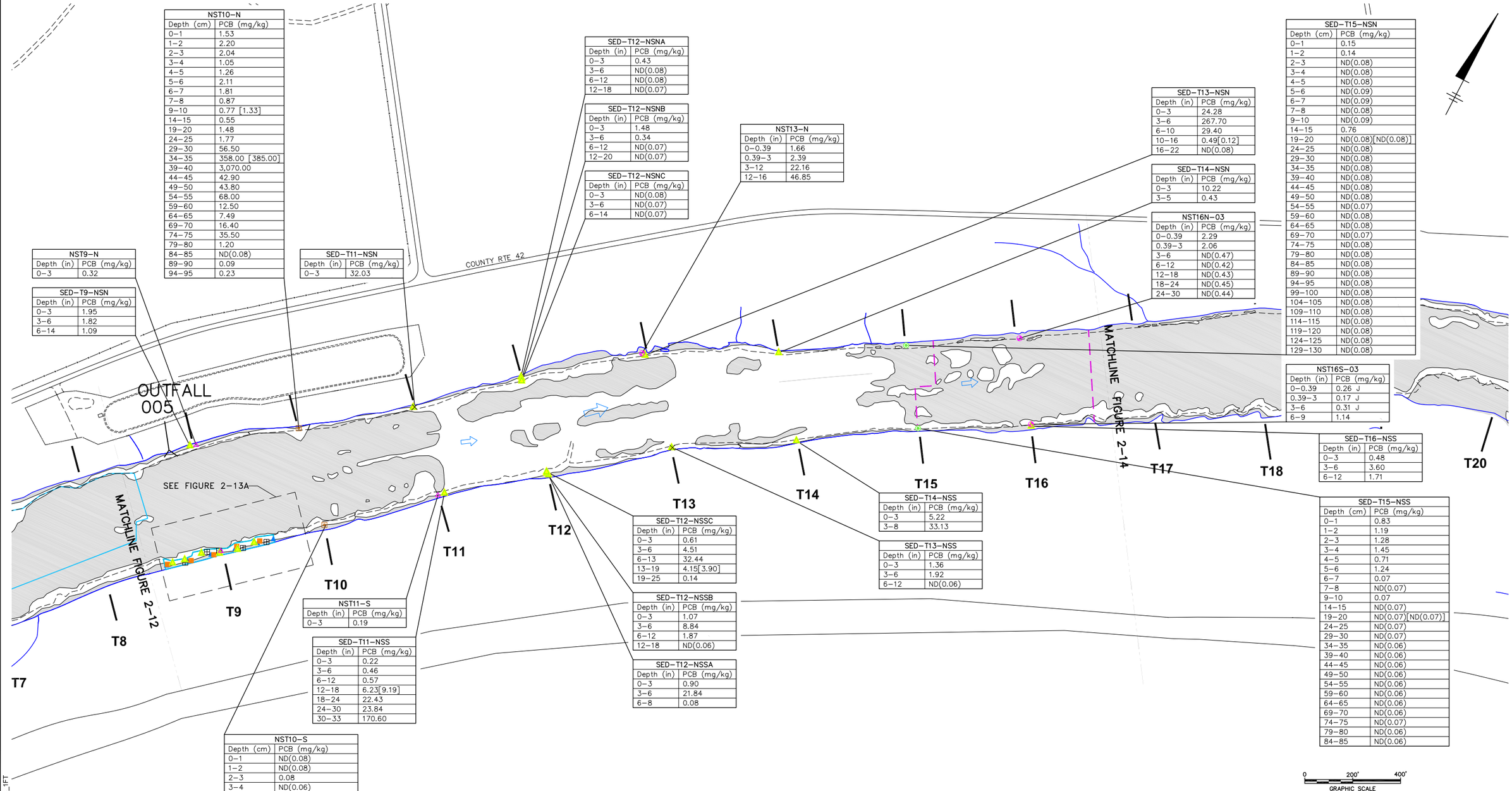
XREFS: 10875X02 10875X00 10875X03 IMAGES: 10875X01.TIF PROJECTNAME: NYS_GIS_1FT



NST10-N	
Depth (cm)	PCB (mg/kg)
0-1	1.53
1-2	2.20
2-3	2.04
3-4	1.05
4-5	1.26
5-6	2.11
6-7	1.81
7-8	0.87
9-10	0.77 [1.33]
14-15	0.55
19-20	1.48
24-25	1.77
29-30	56.50
34-35	358.00 [385.00]
39-40	3,070.00
44-45	42.90
49-50	43.80
54-55	68.00
59-60	12.50
64-65	7.49
69-70	16.40
74-75	35.50
79-80	1.20
84-85	ND(0.08)
89-90	0.09
94-95	0.23

SED-T12-NSNA	
Depth (in)	PCB (mg/kg)
0-3	0.43
3-6	ND(0.08)
6-12	ND(0.08)
12-18	ND(0.07)

SED-T12-NSNB	
Depth (in)	PCB (mg/kg)
0-3	1.48
3-6	0.34
6-12	ND(0.07)
12-20	ND(0.07)

SED-T12-NSNC	
Depth (in)	PCB (mg/kg)
0-3	ND(0.08)
3-6	ND(0.07)
6-14	ND(0.07)

NST13-N	
Depth (in)	PCB (mg/kg)
0-0.39	1.66
0.39-3	2.39
3-12	22.16
12-16	46.85

SED-T13-NSN	
Depth (in)	PCB (mg/kg)
0-3	24.28
3-6	267.70
6-10	29.40
10-16	0.49[0.12]
16-22	ND(0.08)

SED-T14-NSN	
Depth (in)	PCB (mg/kg)
0-3	10.22
3-5	0.43

NST16N-03	
Depth (in)	PCB (mg/kg)
0-0.39	2.29
0.39-3	2.06
3-6	ND(0.47)
6-12	ND(0.42)
12-18	ND(0.43)
18-24	ND(0.45)
24-30	ND(0.44)

SED-T15-NSN	
Depth (cm)	PCB (mg/kg)
0-1	0.15
1-2	0.14
2-3	ND(0.08)
3-4	ND(0.08)
4-5	ND(0.08)
5-6	ND(0.09)
6-7	ND(0.09)
7-8	ND(0.08)
9-10	ND(0.09)
14-15	0.76
19-20	ND(0.08)[ND(0.08)]
24-25	ND(0.08)
29-30	ND(0.08)
34-35	ND(0.08)
39-40	ND(0.08)
44-45	ND(0.08)
49-50	ND(0.08)
54-55	ND(0.07)
59-60	ND(0.08)
64-65	ND(0.08)
69-70	ND(0.07)
74-75	ND(0.08)
79-80	ND(0.08)
84-85	ND(0.08)
89-90	ND(0.08)
94-95	ND(0.08)
99-100	ND(0.08)
104-105	ND(0.08)
109-110	ND(0.08)
114-115	ND(0.08)
119-120	ND(0.08)
124-125	ND(0.08)
129-130	ND(0.08)

NST9-N	
Depth (in)	PCB (mg/kg)
0-3	0.32

SED-T9-NSN	
Depth (in)	PCB (mg/kg)
0-3	1.95
3-6	1.82
6-14	1.09

SED-T11-NSN	
Depth (in)	PCB (mg/kg)
0-3	32.03

NST16S-03	
Depth (in)	PCB (mg/kg)
0-0.39	0.26 J
0.39-3	0.17 J
3-6	0.31 J
6-9	1.14

SED-T16-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.48
3-6	3.60
6-12	1.71

SED-T14-NSS	
Depth (in)	PCB (mg/kg)
0-3	5.22
3-8	33.13

SED-T13-NSS	
Depth (in)	PCB (mg/kg)
0-3	1.36
3-6	1.92
6-12	ND(0.06)

SED-T12-NSSC	
Depth (in)	PCB (mg/kg)
0-3	0.61
3-6	4.51
6-13	32.44
13-19	4.15[3.90]
19-25	0.14

SED-T12-NSSB	
Depth (in)	PCB (mg/kg)
0-3	1.07
3-6	8.84
6-12	1.87
12-18	ND(0.06)

SED-T12-NSSA	
Depth (in)	PCB (mg/kg)
0-3	0.90
3-6	21.84
6-8	0.08

NST11-S	
Depth (in)	PCB (mg/kg)
0-3	0.19

SED-T11-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.22
3-6	0.46
6-12	0.57
12-18	6.23[9.19]
18-24	22.43
24-30	23.84
30-33	170.60

NST10-S	
Depth (cm)	PCB (mg/kg)
0-1	ND(0.08)
1-2	ND(0.08)
2-3	0.08
3-4	ND(0.06)
4-5	ND(0.06)
5-6	ND(0.06)
6-7	ND(0.06)
7-8	ND(0.06)
9-10	0.09
14-15	ND(0.06)
19-20	ND(0.06) [ND(0.07)]
24-25	ND(0.06)
29-30	ND(0.07)
34-35	ND(0.07)

SED-T15-NSS	
Depth (cm)	PCB (mg/kg)
0-1	0.83
1-2	1.19
2-3	1.28
3-4	1.45
4-5	0.71
5-6	1.24
6-7	0.07
7-8	ND(0.07)
9-10	0.07
14-15	ND(0.07)
19-20	ND(0.07)[ND(0.07)]
24-25	ND(0.07)
29-30	ND(0.07)
34-35	ND(0.06)
39-40	ND(0.06)
44-45	ND(0.06)
49-50	ND(0.06)
54-55	ND(0.06)
59-60	ND(0.06)
64-65	ND(0.06)
69-70	ND(0.06)
74-75	ND(0.07)
79-80	ND(0.06)
84-85	ND(0.06)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T9 - T16

ALCOA

FIGURE
2-13

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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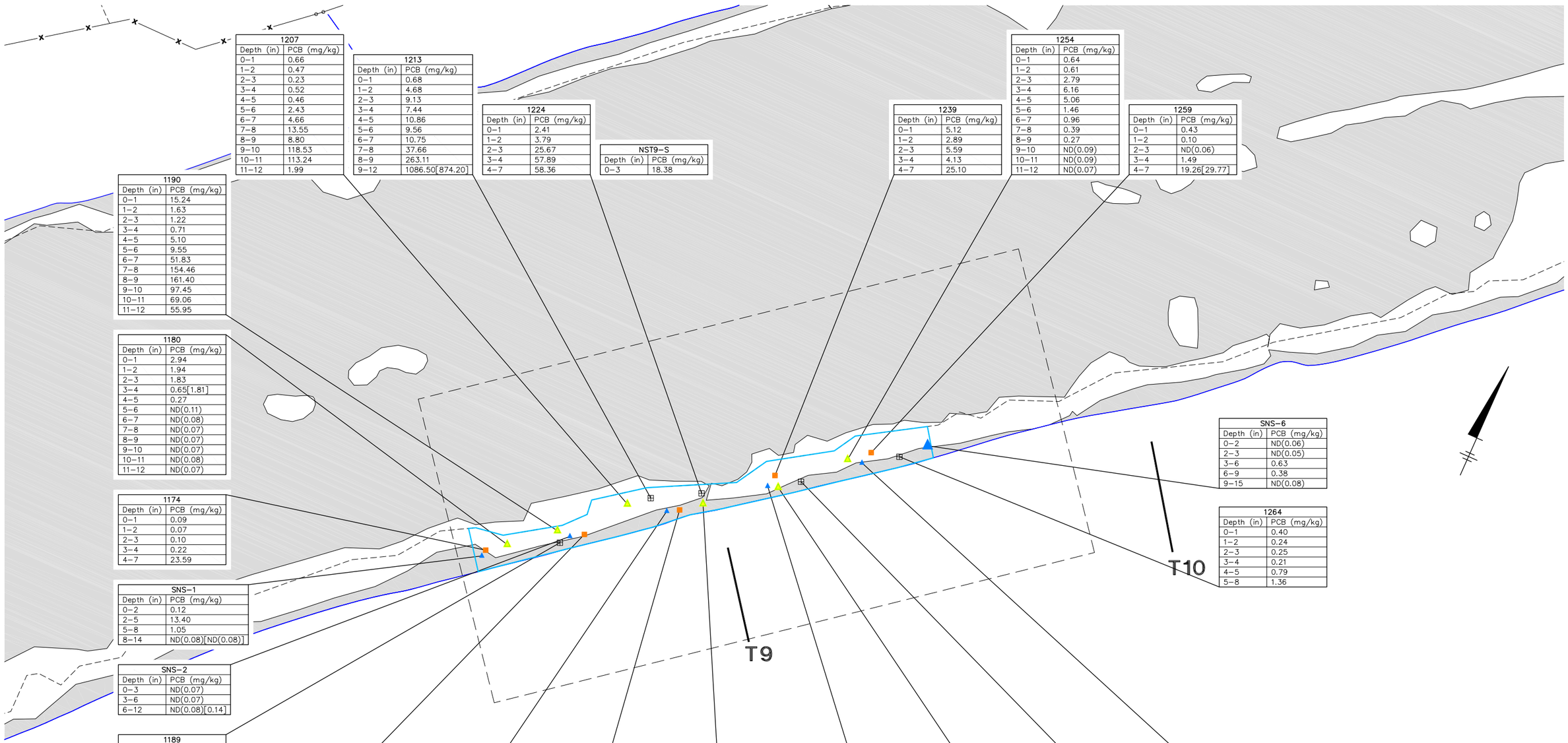
XREFS: 10875X02 10875X00 10875X03 IMAGES: 10875X01.TIF PROJECTNAME: NYS_GIS_1FT



1207	
Depth (in)	PCB (mg/kg)
0–1	0.66
1–2	0.47
2–3	0.23
3–4	0.52
4–5	0.46
5–6	2.43
6–7	4.66
7–8	13.55
8–9	8.80
9–10	118.53
10–11	113.24
11–12	1.99

1213	
Depth (in)	PCB (mg/kg)
0–1	0.68
1–2	4.68
2–3	9.13
3–4	7.44
4–5	10.86
5–6	9.56
6–7	10.75
7–8	37.66
8–9	263.11
9–12	1086.50[874.20]

1224	
Depth (in)	PCB (mg/kg)
0–1	2.41
1–2	3.79
2–3	25.67
3–4	57.89
4–7	58.36

NST9–S	
Depth (in)	PCB (mg/kg)
0–3	18.38

1239	
Depth (in)	PCB (mg/kg)
0–1	5.12
1–2	2.89
2–3	5.59
3–4	4.13
4–7	25.10

1254	
Depth (in)	PCB (mg/kg)
0–1	0.64
1–2	0.61
2–3	2.79
3–4	6.16
4–5	5.06
5–6	1.46
6–7	0.96
7–8	0.39
8–9	0.27
9–10	ND(0.09)
10–11	ND(0.09)
11–12	ND(0.07)

1259	
Depth (in)	PCB (mg/kg)
0–1	0.43
1–2	0.10
2–3	ND(0.06)
3–4	1.49
4–7	19.26[29.77]

1190	
Depth (in)	PCB (mg/kg)
0–1	15.24
1–2	1.63
2–3	1.22
3–4	0.71
4–5	5.10
5–6	9.55
6–7	51.83
7–8	154.46
8–9	161.40
9–10	97.45
10–11	69.06
11–12	55.95

1180	
Depth (in)	PCB (mg/kg)
0–1	2.94
1–2	1.94
2–3	1.83
3–4	0.65[1.81]
4–5	0.27
5–6	ND(0.11)
6–7	ND(0.08)
7–8	ND(0.07)
8–9	ND(0.07)
9–10	ND(0.07)
10–11	ND(0.08)
11–12	ND(0.07)

1174	
Depth (in)	PCB (mg/kg)
0–1	0.09
1–2	0.07
2–3	0.10
3–4	0.22
4–7	23.59

SNS–1	
Depth (in)	PCB (mg/kg)
0–2	0.12
2–5	13.40
5–8	1.05
8–14	ND(0.08)[ND(0.08)]

SNS–2	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)
3–6	ND(0.07)
6–12	ND(0.08)[0.14]

1189	
Depth (in)	PCB (mg/kg)
0–1	0.10
1–2	0.22
2–3	1.82
3–4	2.11
4–7	0.37

SNS–6	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–3	ND(0.05)
3–6	0.63
6–9	0.38
9–15	ND(0.08)

1264	
Depth (in)	PCB (mg/kg)
0–1	0.40
1–2	0.24
2–3	0.25
3–4	0.21
4–5	0.79
5–8	1.36

1194	
Depth (in)	PCB (mg/kg)
0–1	0.26
1–2	0.48
2–5	4.68

SNS–3	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	0.33
4–7	0.13
7–10	ND(0.08)
10–16	ND(0.07)[ND(0.07)]

1217	
Depth (in)	PCB (mg/kg)
0–3	0.56

1223	
Depth (in)	PCB (mg/kg)
0–1	0.22
1–2	0.26
2–3	0.80
3–4	5.86
4–5	47.81
5–6	83.63
6–7	12.02
7–8	ND(0.08)
8–9	ND(0.08)
9–10	ND(0.08)
10–11	0.09
11–12	ND(0.08)

SNS–4	
Depth (in)	PCB (mg/kg)
0–2	3.34
2–5	1.53
5–8	ND(0.07)
8–14	ND(0.07)[ND(0.08)]

1238	
Depth (in)	PCB (mg/kg)
0–1	ND(0.08)
1–2	ND(0.08)
2–3	ND(0.08)
3–4	ND(0.08)
4–5	ND(0.08)
5–6	ND(0.08)
6–7	ND(0.08)
7–8	ND(0.07)
8–9	ND(0.08)
9–10	ND(0.07)
10–11	ND(0.07)
11–12	ND(0.07)

1243	
Depth (in)	PCB (mg/kg)
0–1	0.40
1–4	0.70

SNS–5	
Depth (in)	PCB (mg/kg)
0–2	ND(0.06)
2–4	0.34
4–7	1.91
7–10	13.30
10–16	9.20[10.20]

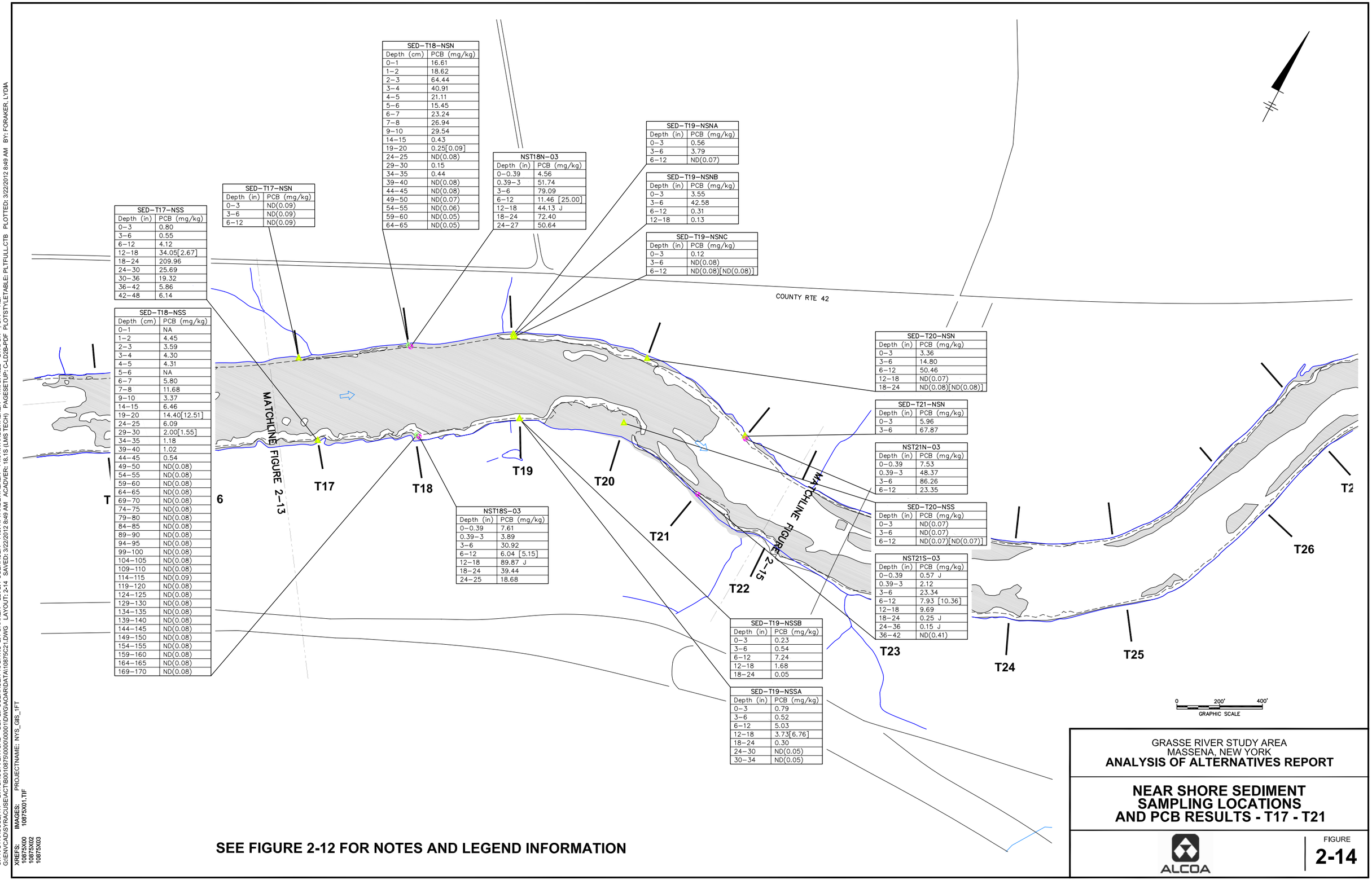
SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T9 - T16

ALCOA

FIGURE
2-13A



SED-T17-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.80
3-6	0.55
6-12	4.12
12-18	34.05[2.67]
18-24	209.96
24-30	25.69
30-36	19.32
36-42	5.86
42-48	6.14

SED-T18-NSS	
Depth (cm)	PCB (mg/kg)
0-1	NA
1-2	4.45
2-3	3.59
3-4	4.30
4-5	4.31
5-6	NA
6-7	5.80
7-8	11.68
9-10	3.37
14-15	6.46
19-20	14.40[12.51]
24-25	6.09
29-30	2.00[1.55]
34-35	1.18
39-40	1.02
44-45	0.54
49-50	ND(0.08)
54-55	ND(0.08)
59-60	ND(0.08)
64-65	ND(0.08)
69-70	ND(0.08)
74-75	ND(0.08)
79-80	ND(0.08)
84-85	ND(0.08)
89-90	ND(0.08)
94-95	ND(0.08)
99-100	ND(0.08)
104-105	ND(0.08)
109-110	ND(0.08)
114-115	ND(0.09)
119-120	ND(0.08)
124-125	ND(0.08)
129-130	ND(0.08)
134-135	ND(0.08)
139-140	ND(0.08)
144-145	ND(0.08)
149-150	ND(0.08)
154-155	ND(0.08)
159-160	ND(0.08)
164-165	ND(0.08)
169-170	ND(0.08)

SED-T17-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.09)
3-6	ND(0.09)
6-12	ND(0.09)

SED-T18-NSN	
Depth (cm)	PCB (mg/kg)
0-1	16.61
1-2	18.62
2-3	64.44
3-4	40.91
4-5	21.11
5-6	15.45
6-7	23.24
7-8	26.94
9-10	29.54
14-15	0.43
19-20	0.25[0.09]
24-25	ND(0.08)
29-30	0.15
34-35	0.44
39-40	ND(0.08)
44-45	ND(0.08)
49-50	ND(0.07)
54-55	ND(0.06)
59-60	ND(0.05)
64-65	ND(0.05)

NST18N-03	
Depth (in)	PCB (mg/kg)
0-0.39	4.56
0.39-3	51.74
3-6	79.09
6-12	11.46 [25.00]
12-18	44.13 J
18-24	72.40
24-27	50.64

NST18S-03	
Depth (in)	PCB (mg/kg)
0-0.39	7.61
0.39-3	3.89
3-6	30.92
6-12	6.04 [5.15]
12-18	89.87 J
18-24	39.44
24-25	18.68

SED-T19-NSNA	
Depth (in)	PCB (mg/kg)
0-3	0.56
3-6	3.79
6-12	ND(0.07)

SED-T19-NSNB	
Depth (mg/kg)	PCB (mg/kg)
0-3	3.55
3-6	42.58
6-12	0.31
12-18	0.13

SED-T19-NSNC	
Depth (in)	PCB (mg/kg)
0-3	0.12
3-6	ND(0.08)
6-12	ND(0.08)[ND(0.08)]

SED-T19-NSSB	
Depth (in)	PCB (mg/kg)
0-3	0.23
3-6	0.54
6-12	7.24
12-18	1.68
18-24	0.05

SED-T19-NSSA	
Depth (in)	PCB (mg/kg)
0-3	0.79
3-6	0.52
6-12	5.03
12-18	3.73[6.76]
18-24	0.30
24-30	ND(0.05)
30-34	ND(0.05)

SED-T20-NSN	
Depth (in)	PCB (mg/kg)
0-3	3.36
3-6	14.80
6-12	50.46
12-18	ND(0.07)
18-24	ND(0.08)[ND(0.08)]

SED-T21-NSN	
Depth (in)	PCB (mg/kg)
0-3	5.96
3-6	67.87

NST21N-03	
Depth (in)	PCB (mg/kg)
0-0.39	7.53
0.39-3	48.37
3-6	86.26
6-12	23.35

SED-T20-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.07)
6-12	ND(0.07)[ND(0.07)]

NST21S-03	
Depth (in)	PCB (mg/kg)
0-0.39	0.57 J
0.39-3	2.12
3-6	23.34
6-12	7.93 [10.36]
12-18	9.69
18-24	0.25 J
24-36	0.15 J
36-42	ND(0.41)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T17 - T21

ALCOA

FIGURE
2-14

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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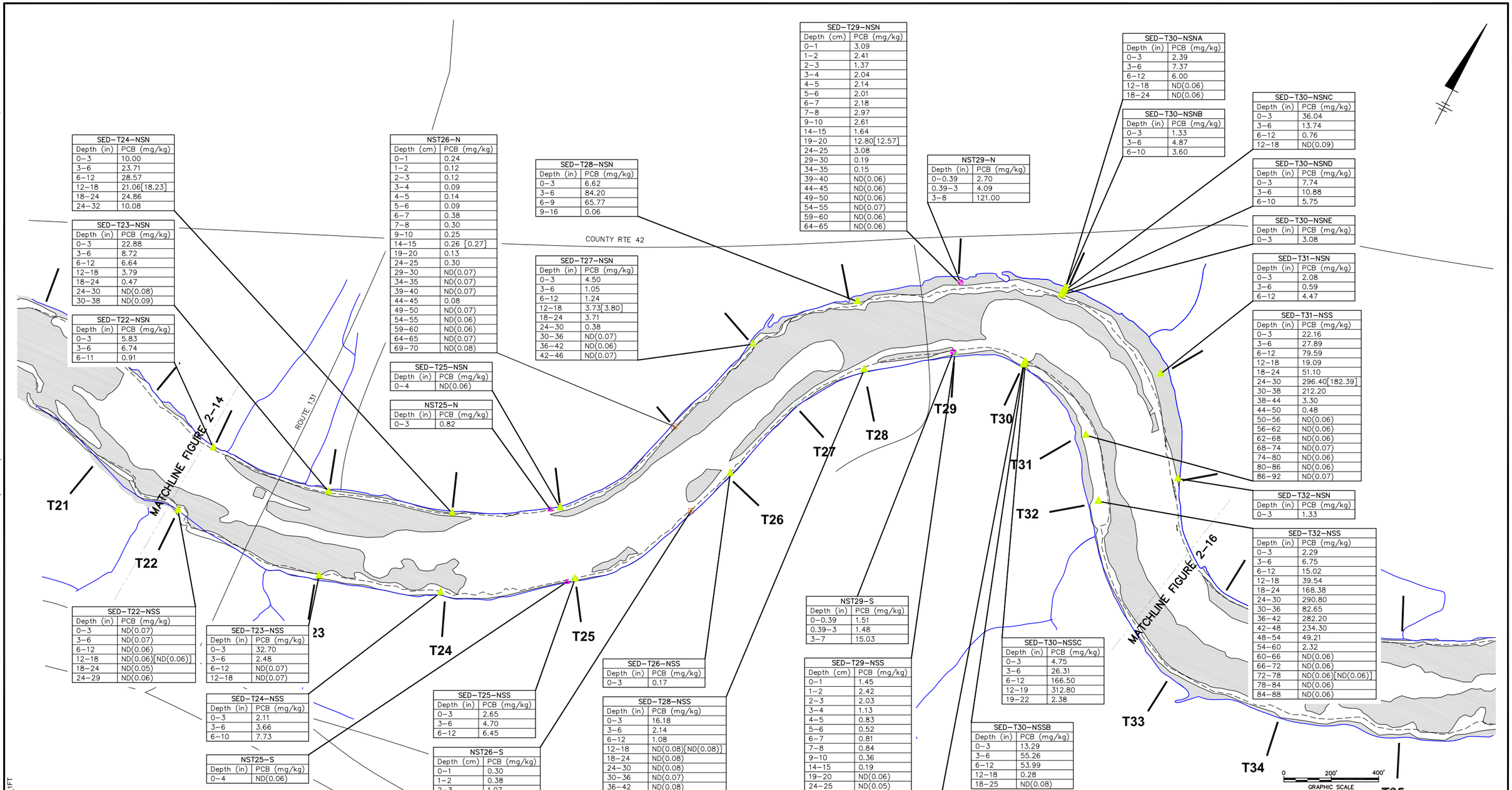
XREFS: 10875X00 10875X02 10875X03 IMAGES: 10875X01.TIF PROJECTNAME: NYS_GIS_1FT



SED-T24-NSN	
Depth (in)	PCB (mg/kg)
0-3	10.00
3-6	23.71
6-12	28.57
12-18	21.06[18.23]
18-24	24.86
24-32	10.08

SED-T23-NSN	
Depth (in)	PCB (mg/kg)
0-3	22.88
3-6	8.72
6-12	6.64
12-18	3.79
18-24	0.47
24-30	ND(0.08)
30-38	ND(0.09)

SED-T22-NSN	
Depth (in)	PCB (mg/kg)
0-3	5.83
3-6	6.74
6-11	0.91

NST26-N	
Depth (cm)	PCB (mg/kg)
0-1	0.24
1-2	0.12
2-3	0.12
3-4	0.09
4-5	0.14
5-6	0.09
6-7	0.38
7-8	0.30
9-10	0.25
14-15	0.26 [0.27]
19-20	0.13
24-25	0.30
29-30	ND(0.07)
34-35	ND(0.07)
39-40	ND(0.07)
44-45	0.08
49-50	ND(0.07)
54-55	ND(0.06)
59-60	ND(0.06)
64-65	ND(0.07)
69-70	ND(0.08)

SED-T25-NSN	
Depth (in)	PCB (mg/kg)
0-4	ND(0.06)

NST25-N	
Depth (in)	PCB (mg/kg)
0-3	0.82

SED-T28-NSN	
Depth (in)	PCB (mg/kg)
0-3	6.62
3-6	84.20
6-9	65.77
9-16	0.06

SED-T27-NSN	
Depth (in)	PCB (mg/kg)
0-3	4.50
3-6	1.05
6-12	1.24
12-18	3.73[3.80]
18-24	3.71
24-30	0.38
30-36	ND(0.07)
36-42	ND(0.06)
42-46	ND(0.07)

SED-T29-NSN	
Depth (cm)	PCB (mg/kg)
0-1	3.09
1-2	2.41
2-3	1.37
3-4	2.04
4-5	2.14
5-6	2.01
6-7	2.18
7-8	2.97
9-10	2.61
14-15	1.64
19-20	12.80[12.57]
24-25	3.08
29-30	0.19
34-35	0.15
39-40	ND(0.06)
44-45	ND(0.06)
49-50	ND(0.06)
54-55	ND(0.07)
59-60	ND(0.06)
64-65	ND(0.06)

NST29-N	
Depth (in)	PCB (mg/kg)
0-0.39	2.70
0.39-3	4.09
3-8	121.00

SED-T30-NSNA	
Depth (in)	PCB (mg/kg)
0-3	2.39
3-6	7.37
6-12	6.00
12-18	ND(0.06)
18-24	ND(0.06)

SED-T30-NSNB	
Depth (in)	PCB (mg/kg)
0-3	1.33
3-6	4.87
6-10	3.60

SED-T30-NSNC	
Depth (in)	PCB (mg/kg)
0-3	36.04
3-6	13.74
6-12	0.76
12-18	ND(0.09)

SED-T30-NSND	
Depth (in)	PCB (mg/kg)
0-3	7.74
3-6	10.88
6-10	5.75

SED-T30-NSNE	
Depth (in)	PCB (mg/kg)
0-3	3.08

SED-T31-NSN	
Depth (in)	PCB (mg/kg)
0-3	2.08
3-6	0.59
6-12	4.47

SED-T31-NSS	
Depth (in)	PCB (mg/kg)
0-3	22.16
3-6	27.89
6-12	79.59
12-18	19.09
18-24	51.10
24-30	296.40[182.39]
30-38	212.20
38-44	3.30
44-50	0.48
50-56	ND(0.06)
56-62	ND(0.06)
62-68	ND(0.06)
68-74	ND(0.07)
74-80	ND(0.06)
80-86	ND(0.06)
86-92	ND(0.07)

SED-T32-NSN	
Depth (in)	PCB (mg/kg)
0-3	1.33

SED-T32-NSS	
Depth (in)	PCB (mg/kg)
0-3	2.29
3-6	6.75
6-12	15.02
12-18	39.54
18-24	168.38
24-30	290.80
30-36	82.65
36-42	282.20
42-48	234.30
48-54	49.21
54-60	2.32
60-66	ND(0.06)
66-72	ND(0.06)
72-78	ND(0.06)[ND(0.06)]
78-84	ND(0.06)
84-88	ND(0.06)

SED-T22-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.07)
6-12	ND(0.06)
12-18	ND(0.06)[ND(0.06)]
18-24	ND(0.05)
24-29	ND(0.06)

SED-T23-NSS	
Depth (in)	PCB (mg/kg)
0-3	32.70
3-6	2.48
6-12	ND(0.07)
12-18	ND(0.07)

SED-T24-NSS	
Depth (in)	PCB (mg/kg)
0-3	2.11
3-6	3.66
6-10	7.73

NST25-S	
Depth (in)	PCB (mg/kg)
0-4	ND(0.06)

SED-T25-NSS	
Depth (in)	PCB (mg/kg)
0-3	2.65
3-6	4.70
6-12	6.45

NST26-S	
Depth (cm)	PCB (mg/kg)
0-1	0.30
1-2	0.38
2-3	1.07
3-4	0.95
4-5	1.05
5-6	0.61
6-7	4.00
7-8	0.46
9-10	3.92
14-15	0.07 [0.70]
19-20	ND(0.05)
24-25	ND(0.06)
29-30	ND(0.06)
34-35	ND(0.06)
39-40	ND(0.06)
44-45	1.06

SED-T26-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.17

SED-T28-NSS	
Depth (in)	PCB (mg/kg)
0-3	16.18
3-6	2.14
6-12	1.08
12-18	ND(0.08)[ND(0.08)]
18-24	ND(0.08)
24-30	ND(0.08)
30-36	ND(0.07)
36-42	ND(0.08)
42-48	ND(0.07)
48-53	ND(0.07)

NST29-S	
Depth (in)	PCB (mg/kg)
0-0.39	1.51
0.39-3	1.48
3-7	15.03

SED-T29-NSS	
Depth (cm)	PCB (mg/kg)
0-1	1.45
1-2	2.42
2-3	2.03
3-4	1.13
4-5	0.83
5-6	0.52
6-7	0.81
7-8	0.84
9-10	0.36
14-15	0.19
19-20	ND(0.06)
24-25	ND(0.05)
29-30	ND(0.06)
34-35	ND(0.06)
39-40	ND(0.06)
44-45	ND(0.06)

SED-T30-NSSC	
Depth (in)	PCB (mg/kg)
0-3	4.75
3-6	26.31
6-12	166.50
12-19	312.80
19-22	2.38

SED-T30-NSSB	
Depth (in)	PCB (mg/kg)
0-3	13.29
3-6	55.26
6-12	53.99
12-18	0.28
18-25	ND(0.08)

SED-T30-NSSA	
Depth (in)	PCB (mg/kg)
0-3	0.57
3-6	4.68
6-12	0.12
12-18	22.31[23.14]
18-24	ND(0.06)
24-30	ND(0.06)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T22 - T32

ALCOA

FIGURE
2-15

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L.FORAKER LD: L.POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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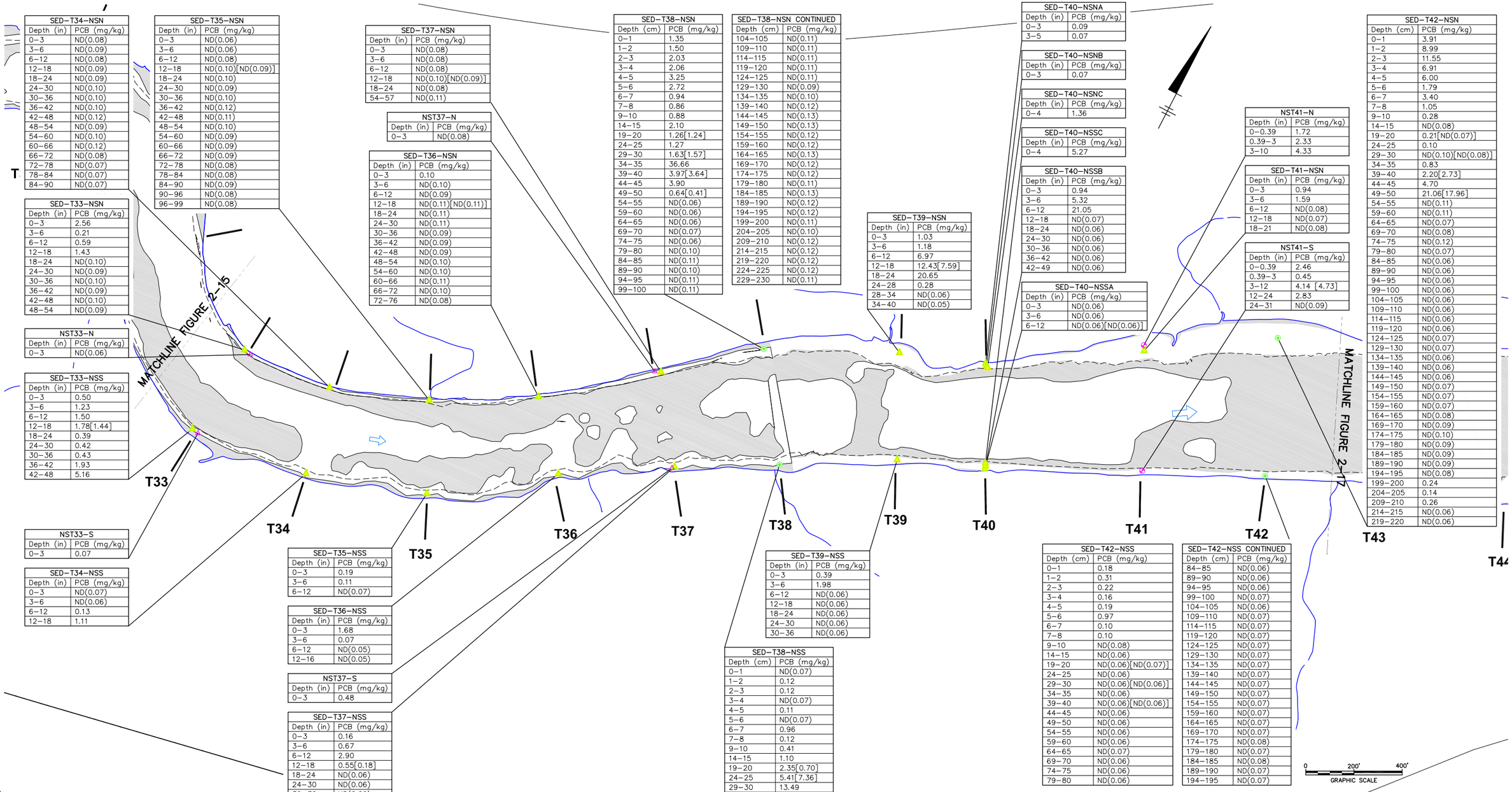
XREFS: 10875X00 10875X02 10875X03 IMAGES: 10875X01.TIF PROJECTNAME: NYS_GIS_1FT



SED-T34-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.08)
3-6	ND(0.09)
6-12	ND(0.08)
12-18	ND(0.09)
18-24	ND(0.09)
24-30	ND(0.10)
30-36	ND(0.10)
36-42	ND(0.10)
42-48	ND(0.12)
48-54	ND(0.09)
54-60	ND(0.10)
60-66	ND(0.12)
66-72	ND(0.08)
72-78	ND(0.07)
78-84	ND(0.07)
84-90	ND(0.07)

SED-T33-NSN	
Depth (in)	PCB (mg/kg)
0-3	2.56
3-6	0.21
6-12	0.59
12-18	1.43
18-24	ND(0.10)
24-30	ND(0.09)
30-36	ND(0.10)
36-42	ND(0.09)
42-48	ND(0.10)
48-54	ND(0.09)

NST33-N	
Depth (in)	PCB (mg/kg)
0-3	ND(0.06)

SED-T33-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.50
3-6	1.23
6-12	1.50
12-18	1.78[1.44]
18-24	0.39
24-30	0.42
30-36	0.43
36-42	1.93
42-48	5.16

NST33-S	
Depth (in)	PCB (mg/kg)
0-3	0.07

SED-T34-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.06)
6-12	0.13
12-18	1.11

SED-T35-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.06)
3-6	ND(0.06)
6-12	ND(0.08)
12-18	ND(0.10)[ND(0.09)]
18-24	ND(0.10)
24-30	ND(0.09)
30-36	ND(0.10)
36-42	ND(0.12)
42-48	ND(0.11)
48-54	ND(0.10)
54-60	ND(0.09)
60-66	ND(0.09)
66-72	ND(0.09)
72-78	ND(0.08)
78-84	ND(0.08)
84-90	ND(0.09)
90-96	ND(0.08)
96-99	ND(0.08)

SED-T35-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.19
3-6	0.11
6-12	ND(0.07)

SED-T36-NSS	
Depth (in)	PCB (mg/kg)
0-3	1.68
3-6	0.07
6-12	ND(0.05)
12-16	ND(0.05)

NST37-S	
Depth (in)	PCB (mg/kg)
0-3	0.48

SED-T37-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.16
3-6	0.67
6-12	2.90
12-18	0.55[0.18]
18-24	ND(0.06)
24-30	ND(0.06)
30-36	ND(0.06)
36-42	ND(0.06)
42-48	ND(0.06)
48-54	ND(0.06)
54-60	ND(0.07)
60-64	ND(0.07)
64-70	ND(0.06)
70-74	ND(0.06)

SED-T37-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.08)
3-6	ND(0.08)
6-12	ND(0.08)
12-18	ND(0.10)[ND(0.09)]
18-24	ND(0.08)
54-57	ND(0.11)

NST37-N	
Depth (in)	PCB (mg/kg)
0-3	ND(0.08)

SED-T36-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.10
3-6	ND(0.10)
6-12	ND(0.09)
12-18	ND(0.11)[ND(0.11)]
18-24	ND(0.11)
24-30	ND(0.11)
30-36	ND(0.09)
36-42	ND(0.09)
42-48	ND(0.09)
48-54	ND(0.10)
54-60	ND(0.10)
60-66	ND(0.11)
66-72	ND(0.10)
72-76	ND(0.08)

SED-T38-NSN	
Depth (cm)	PCB (mg/kg)
0-1	1.35
1-2	1.50
2-3	2.03
3-4	2.06
4-5	3.25
5-6	2.72
6-7	0.94
7-8	0.86
9-10	0.88
14-15	2.10
19-20	1.26[1.24]
24-25	1.27
29-30	1.63[1.57]
34-35	36.66
39-40	3.97[3.64]
44-45	3.90
49-50	0.64[0.41]
54-55	ND(0.06)
59-60	ND(0.06)
64-65	ND(0.06)
69-70	ND(0.07)
74-75	ND(0.06)
79-80	ND(0.10)
84-85	ND(0.11)
89-90	ND(0.10)
94-95	ND(0.11)
99-100	ND(0.11)

SED-T38-NSN CONTINUED	
Depth (cm)	PCB (mg/kg)
104-105	ND(0.11)
109-110	ND(0.11)
114-115	ND(0.11)
119-120	ND(0.11)
124-125	ND(0.11)
129-130	ND(0.09)
134-135	ND(0.10)
139-140	ND(0.12)
144-145	ND(0.13)
149-150	ND(0.13)
154-155	ND(0.12)
159-160	ND(0.12)
164-165	ND(0.13)
169-170	ND(0.12)
174-175	ND(0.12)
179-180	ND(0.11)
184-185	ND(0.13)
189-190	ND(0.12)
194-195	ND(0.12)
199-200	ND(0.11)
204-205	ND(0.10)
209-210	ND(0.12)
214-215	ND(0.12)
219-220	ND(0.12)
224-225	ND(0.12)
229-230	ND(0.11)

SED-T39-NSN	
Depth (in)	PCB (mg/kg)
0-3	1.03
3-6	1.18
6-12	6.97
12-18	12.43[7.59]
18-24	20.65
24-28	0.28
28-34	ND(0.06)
34-40	ND(0.05)

SED-T39-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.39
3-6	1.98
6-12	ND(0.06)
12-18	ND(0.06)
18-24	ND(0.06)
24-30	ND(0.06)
30-36	ND(0.06)

SED-T38-NSS	
Depth (cm)	PCB (mg/kg)
0-1	ND(0.07)
1-2	0.12
2-3	0.12
3-4	ND(0.07)
4-5	0.11
5-6	ND(0.07)
6-7	0.96
7-8	0.12
9-10	0.41
14-15	1.10
19-20	2.35[0.70]
24-25	5.41[7.36]
29-30	13.49
34-35	10.86
39-40	9.64
44-45	4.69
49-50	0.85
54-55	0.11
59-60	ND(0.07)
64-65	ND(0.07)
69-70	ND(0.07)
74-75	ND(0.07)
79-80	ND(0.07)
84-85	ND(0.07)
89-90	ND(0.07)
94-95	ND(0.07)
99-100	ND(0.07)
104-105	ND(0.07)
109-110	ND(0.07)

SED-T40-NSNA	
Depth (in)	PCB (mg/kg)
0-3	0.09
3-5	0.07

SED-T40-NSNB	
Depth (in)	PCB (mg/kg)
0-3	0.07

SED-T40-NSNC	
Depth (in)	PCB (mg/kg)
0-4	1.36

SED-T40-NSSC	
Depth (in)	PCB (mg/kg)
0-4	5.27

SED-T40-NSSB	
Depth (in)	PCB (mg/kg)
0-3	0.94
3-6	5.32
6-12	21.05
12-18	ND(0.07)
18-24	ND(0.06)
24-30	ND(0.06)
30-36	ND(0.06)
36-42	ND(0.06)
42-49	ND(0.06)

SED-T40-NSSA	
Depth (in)	PCB (mg/kg)
0-3	ND(0.06)
3-6	ND(0.06)
6-12	ND(0.06)[ND(0.06)]

NST41-N	
Depth (in)	PCB (mg/kg)
0-0.39	1.72
0.39-3	2.33
3-10	4.33

SED-T41-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.94
3-6	1.59
6-12	ND(0.08)
12-18	ND(0.07)
18-21	ND(0.08)

NST41-S	
Depth (in)	PCB (mg/kg)
0-0.39	2.46
0.39-3	0.45
3-12	4.14 [4.73]
12-24	2.83
24-31	ND(0.09)

SED-T42-NSN	
Depth (cm)	PCB (mg/kg)
0-1	3.91
1-2	8.99
2-3	11.55
3-4	6.91
4-5	6.00
5-6	1.79
6-7	3.40
7-8	1.05
9-10	0.28
14-15	ND(0.08)
19-20	0.21[ND(0.07)]
24-25	0.10
29-30	ND(0.10)[ND(0.08)]
34-35	0.83
39-40	2.20[2.73]
44-45	4.70
49-50	21.06[17.96]
54-55	ND(0.11)
59-60	ND(0.11)
64-65	ND(0.07)
69-70	ND(0.08)
74-75	ND(0.12)
79-80	ND(0.07)
84-85	ND(0.06)
89-90	ND(0.06)
94-95	ND(0.06)
99-100	ND(0.06)
104-105	ND(0.06)
109-110	ND(0.06)
114-115	ND(0.06)
119-120	ND(0.06)
124-125	ND(0.07)
129-130	ND(0.07)
134-135	ND(0.06)
139-140	ND(0.06)
144-145	ND(0.06)
149-150	ND(0.07)
154-155	ND(0.07)
159-160	ND(0.07)
164-165	ND(0.08)
169-170	ND(0.09)
174-175	ND(0.10)
179-180	ND(0.09)
184-185	ND(0.09)
189-190	ND(0.09)
194-195	ND(0.08)
199-200	0.24
204-205	0.14
209-210	0.26
214-215	ND(0.06)
219-220	ND(0.06)

SED-T42-NSS	
Depth (cm)	PCB (mg/kg)
0-1	0.18
1-2	0.31
2-3	0.22
3-4	0.16
4-5	0.19
5-6	0.97
6-7	0.10
7-8	0.10
9-10	ND(0.08)
14-15	ND(0.06)
19-20	ND(0.06)[ND(0.07)]
24-25	ND(0.06)
29-30	ND(0.06)[ND(0.06)]
34-35	ND(0.06)
39-40	ND(0.06)[ND(0.06)]
44-45	ND(0.06)
49-50	ND(0.06)
54-55	ND(0.06)
59-60	ND(0.06)
64-65	ND(0.07)
69-70	ND(0.06)
74-75	ND(0.06)
79-80	ND(0.06)

SED-T42-NSS CONTINUED	
Depth (cm)	PCB (mg/kg)
84-85	ND(0.06)
89-90	ND(0.06)
94-95	ND(0.06)
99-100	ND(0.07)
104-105	ND(0.06)
109-110	ND(0.07)
114-115	ND(0.07)
119-120	ND(0.07)
124-125	ND(0.07)
129-130	ND(0.07)
134-135	ND(0.07)
139-140	ND(0.07)
144-145	ND(0.07)
149-150	ND(0.07)
154-155	ND(0.07)
159-160	ND(0.07)
164-165	ND(0.07)
169-170	ND(0.07)
174-175	ND(0.08)
179-180	ND(0.07)
184-185	ND(0.08)
189-190	ND(0.07)
194-195	ND(0.07)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T33 - T42

ALCOA

FIGURE
2-16

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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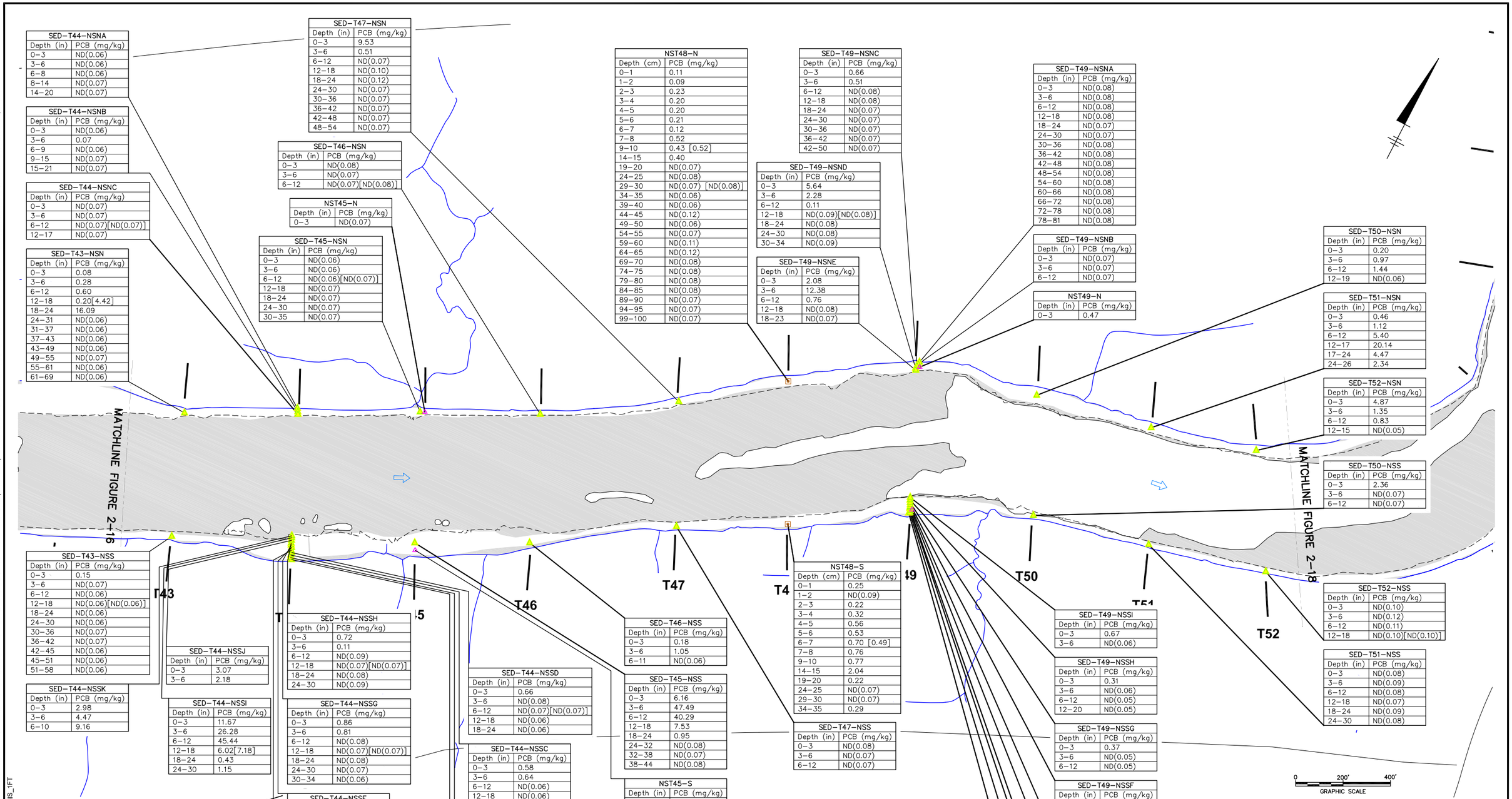
XREFS: 10875X00 10875X02 10875X03 IMAGES: 10875X01.TIF PROJECTNAME: NYS_GIS_1FT



SED–T44–NSNA	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)
3–6	ND(0.06)
6–8	ND(0.06)
8–14	ND(0.07)
14–20	ND(0.07)

SED–T44–NSNB	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)
3–6	0.07
6–9	ND(0.06)
9–15	ND(0.07)
15–21	ND(0.07)

SED–T44–NSNC	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)
3–6	ND(0.07)
6–12	ND(0.07)[ND(0.07)]
12–17	ND(0.07)

SED–T43–NSN	
Depth (in)	PCB (mg/kg)
0–3	0.08
3–6	0.28
6–12	0.60
12–18	0.20[4.42]
18–24	16.09
24–31	ND(0.06)
31–37	ND(0.06)
37–43	ND(0.06)
43–49	ND(0.06)
49–55	ND(0.07)
55–61	ND(0.06)
61–69	ND(0.06)

SED–T47–NSN	
Depth (in)	PCB (mg/kg)
0–3	9.53
3–6	0.51
6–12	ND(0.07)
12–18	ND(0.10)
18–24	ND(0.12)
24–30	ND(0.07)
30–36	ND(0.07)
36–42	ND(0.07)
42–48	ND(0.07)
48–54	ND(0.07)

SED–T46–NSN	
Depth (in)	PCB (mg/kg)
0–3	ND(0.08)
3–6	ND(0.07)
6–12	ND(0.07)[ND(0.08)]

NST45–N	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)

SED–T45–NSN	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)
3–6	ND(0.06)
6–12	ND(0.06)[ND(0.07)]
12–18	ND(0.07)
18–24	ND(0.07)
24–30	ND(0.07)
30–35	ND(0.07)

NST48–N	
Depth (cm)	PCB (mg/kg)
0–1	0.11
1–2	0.09
2–3	0.23
3–4	0.20
4–5	0.20
5–6	0.21
6–7	0.12
7–8	0.52
9–10	0.43 [0.52]
14–15	0.40
19–20	ND(0.07)
24–25	ND(0.08)
29–30	ND(0.07) [ND(0.08)]
34–35	ND(0.06)
39–40	ND(0.06)
44–45	ND(0.12)
49–50	ND(0.06)
54–55	ND(0.07)
59–60	ND(0.11)
64–65	ND(0.12)
69–70	ND(0.08)
74–75	ND(0.08)
79–80	ND(0.08)
84–85	ND(0.08)
89–90	ND(0.07)
94–95	ND(0.07)
99–100	ND(0.07)

SED–T49–NSNC	
Depth (in)	PCB (mg/kg)
0–3	0.66
3–6	0.51
6–12	ND(0.08)
12–18	ND(0.08)
18–24	ND(0.07)
24–30	ND(0.07)
30–36	ND(0.07)
36–42	ND(0.07)
42–50	ND(0.07)

SED–T49–NSND	
Depth (in)	PCB (mg/kg)
0–3	5.64
3–6	2.28
6–12	0.11
12–18	ND(0.09)[ND(0.08)]
18–24	ND(0.08)
24–30	ND(0.08)
30–34	ND(0.09)

SED–T49–NSNE	
Depth (in)	PCB (mg/kg)
0–3	2.08
3–6	12.38
6–12	0.76
12–18	ND(0.08)
18–23	ND(0.07)

SED–T49–NSNA	
Depth (in)	PCB (mg/kg)
0–3	ND(0.08)
3–6	ND(0.08)
6–12	ND(0.08)
12–18	ND(0.08)
18–24	ND(0.07)
24–30	ND(0.07)
30–36	ND(0.08)
36–42	ND(0.08)
42–48	ND(0.08)
48–54	ND(0.08)
54–60	ND(0.08)
60–66	ND(0.08)
66–72	ND(0.08)
72–78	ND(0.08)
78–81	ND(0.08)

SED–T49–NSNB	
Depth (in)	PCB (mg/kg)
0–3	ND(0.07)
3–6	ND(0.07)
6–12	ND(0.07)

NST49–N	
Depth (in)	PCB (mg/kg)
0–3	0.47

SED–T50–NSN	
Depth (in)	PCB (mg/kg)
0–3	0.20
3–6	0.97
6–12	1.44
12–19	ND(0.06)

SED–T51–NSN	
Depth (in)	PCB (mg/kg)
0–3	0.46
3–6	1.12
6–12	5.40
12–17	20.14
17–24	4.47
24–26	2.34

SED–T52–NSN	
Depth (in)	PCB (mg/kg)
0–3	4.87
3–6	1.35
6–12	0.83
12–15	ND(0.05)

SED–T50–NSS	
Depth (in)	PCB (mg/kg)
0–3	2.36
3–6	ND(0.07)
6–12	ND(0.07)

SED–T43–NSS	
Depth (in)	PCB (mg/kg)
0–3	0.15
3–6	ND(0.07)
6–12	ND(0.06)
12–18	ND(0.06)[ND(0.06)]
18–24	ND(0.06)
24–30	ND(0.06)
30–36	ND(0.07)
36–42	ND(0.07)
42–45	ND(0.06)
45–51	ND(0.06)
51–58	ND(0.06)

SED–T44–NSSK	
Depth (in)	PCB (mg/kg)
0–3	2.98
3–6	4.47
6–10	9.16

SED–T44–NSSJ	
Depth (in)	PCB (mg/kg)
0–3	3.07
3–6	2.18

SED–T44–NSSI	
Depth (in)	PCB (mg/kg)
0–3	11.67
3–6	26.28
6–12	45.44
12–18	6.02[7.18]
18–24	0.43
24–30	1.15

SED–T44–NSSH	
Depth (in)	PCB (mg/kg)
0–3	0.72
3–6	0.11
6–12	ND(0.09)
12–18	ND(0.07)[ND(0.07)]
18–24	ND(0.08)
24–30	ND(0.09)

SED–T44–NSSG	
Depth (in)	PCB (mg/kg)
0–3	0.86
3–6	0.81
6–12	ND(0.08)
12–18	ND(0.07)[ND(0.07)]
18–24	ND(0.08)
24–30	ND(0.07)
30–34	ND(0.06)

SED–T44–NSSF	
Depth (in)	PCB (mg/kg)
0–3	0.89
3–6	0.79
6–12	ND(0.09)
12–18	ND(0.08)
18–24	ND(0.07)
24–30	0.43
30–33	1.19

SED–T44–NSSE	
Depth (in)	PCB (mg/kg)
0–3	0.64
3–6	0.36
6–12	ND(0.09)
12–18	ND(0.07)
18–24	ND(0.07)

SED–T44–NSSD	
Depth (in)	PCB (mg/kg)
0–3	0.66
3–6	ND(0.08)
6–12	ND(0.07)[ND(0.07)]
12–18	ND(0.06)
18–24	ND(0.06)

SED–T44–NSSC	
Depth (in)	PCB (mg/kg)
0–3	0.58
3–6	0.64
6–12	ND(0.06)
12–18	ND(0.06)
18–24	0.08

SED–T44–NSSB	
Depth (in)	PCB (mg/kg)
0–3	0.50
3–6	ND(0.06)
6–12	ND(0.06)
12–15	ND(0.06)

SED–T44–NSSA	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)
3–6	ND(0.06)
6–12	ND(0.06)
12–17	ND(0.06)

SED–T46–NSS	
Depth (in)	PCB (mg/kg)
0–3	0.18
3–6	1.05
6–11	ND(0.06)

SED–T45–NSS	
Depth (in)	PCB (mg/kg)
0–3	6.16
3–6	47.49
6–12	40.29
12–18	7.53
18–24	0.95
24–32	ND(0.08)
32–38	ND(0.07)
38–44	ND(0.08)

NST45–S	
Depth (in)	PCB (mg/kg)
0–3	6.77

NST48–S	
Depth (cm)	PCB (mg/kg)
0–1	0.25
1–2	ND(0.09)
2–3	0.22
3–4	0.32
4–5	0.56
5–6	0.53
6–7	0.70 [0.49]
7–8	0.76
9–10	0.77
14–15	2.04
19–20	0.22
24–25	ND(0.07)
29–30	ND(0.07)
34–35	0.29

SED–T47–NSS	
Depth (in)	PCB (mg/kg)
0–3	ND(0.08)
3–6	ND(0.07)
6–12	ND(0.07)

SED–T49–NSSA	
Depth (in)	PCB (mg/kg)
0–4	0.46

SED–T49–NSSB	
Depth (in)	PCB (mg/kg)
0–3	0.36

SED–T49–NSSC	
Depth (in)	PCB (mg/kg)
0–3	3.71
3–6	1.74
6–10	12.88

SED–T49–NSSI	
Depth (in)	PCB (mg/kg)
0–3	0.67
3–6	ND(0.06)

SED–T49–NSSH	
Depth (in)	PCB (mg/kg)
0–3	0.31
3–6	ND(0.06)
6–12	ND(0.05)
12–20	ND(0.05)

SED–T49–NSSG	
Depth (in)	PCB (mg/kg)
0–3	0.37
3–6	ND(0.05)
6–12	ND(0.05)

SED–T49–NSSF	
Depth (in)	PCB (mg/kg)
0–3	ND(0.06)
3–6	ND(0.05)
6–14	ND(0.05)

NST49–S	
Depth (in)	PCB (mg/kg)
0–3	0.55

SED–T49–NSSE	
Depth (in)	PCB (mg/kg)
0–3	0.33
3–6	6.98

SED–T49–NSSD	
Depth (in)	PCB (mg/kg)
0–4	8.67

SED–T52–NSS	
Depth (in)	PCB (mg/kg)
0–3	ND(0.10)
3–6	ND(0.12)
6–12	ND(0.11)
12–18	ND(0.10)[ND(0.10)]

SED–T51–NSS	
Depth (in)	PCB (mg/kg)
0–3	ND(0.08)
3–6	ND(0.09)
6–12	ND(0.08)
12–18	ND(0.07)
18–24	ND(0.09)
24–30	ND(0.08)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T43 - T52

ALCOA

FIGURE
2-17

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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XREFS: IMAGES: PROJECTNAME: NYS_GIS_1FT
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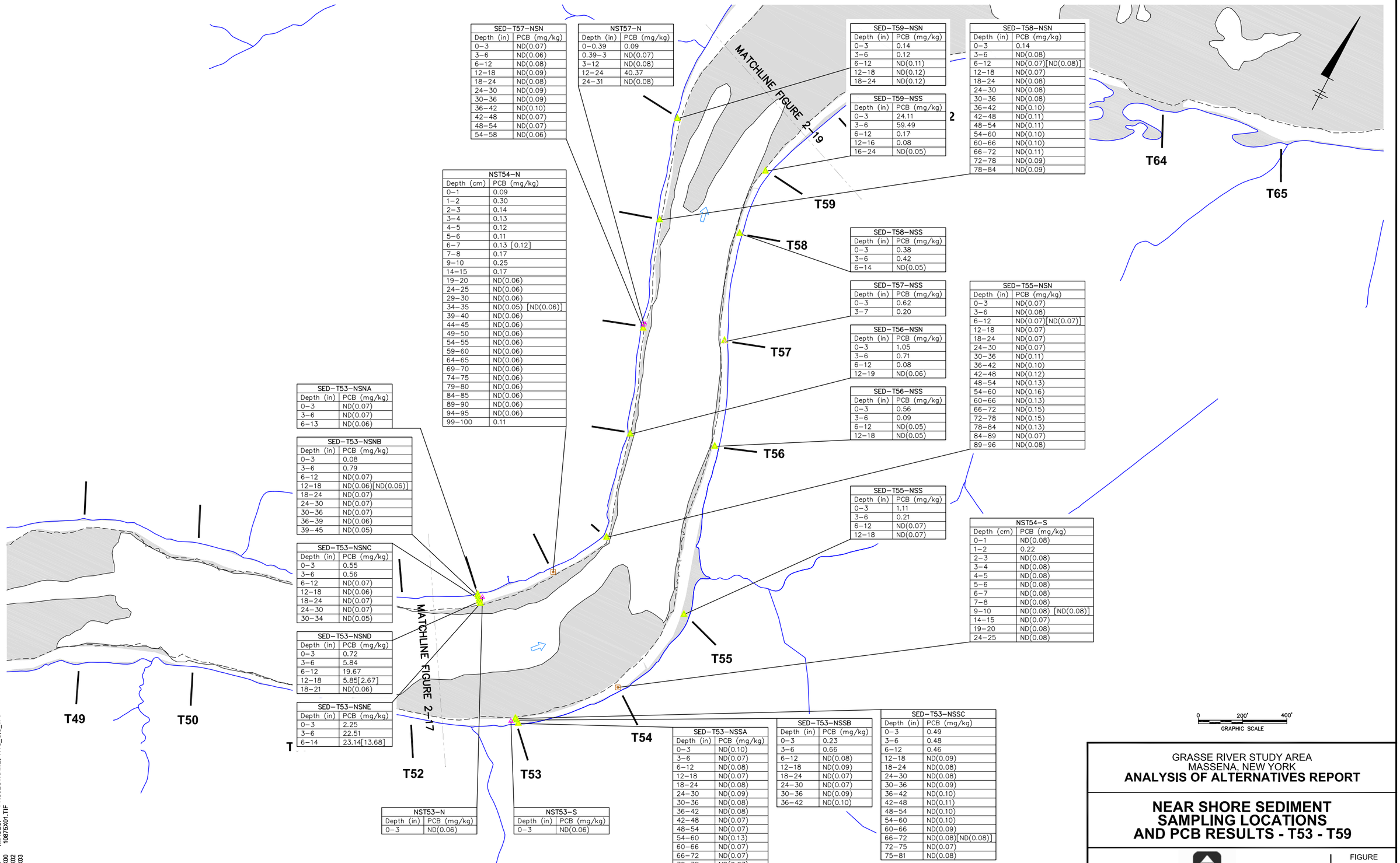
10875X02
10875X03



SED-T57-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.06)
6-12	ND(0.08)
12-18	ND(0.09)
18-24	ND(0.08)
24-30	ND(0.09)
30-36	ND(0.09)
36-42	ND(0.10)
42-48	ND(0.07)
48-54	ND(0.07)
54-58	ND(0.06)

NST57-N	
Depth (in)	PCB (mg/kg)
0-0.39	0.09
0.39-3	ND(0.07)
3-12	ND(0.08)
12-24	40.37
24-31	ND(0.08)

SED-T59-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.14
3-6	0.12
6-12	ND(0.11)
12-18	ND(0.12)
18-24	ND(0.12)

SED-T59-NSS	
Depth (in)	PCB (mg/kg)
0-3	24.11
3-6	59.49
6-12	0.17
12-16	0.08
16-24	ND(0.05)

SED-T58-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.14
3-6	ND(0.08)
6-12	ND(0.07)[ND(0.08)]
12-18	ND(0.07)
18-24	ND(0.08)
24-30	ND(0.08)
30-36	ND(0.08)
36-42	ND(0.10)
42-48	ND(0.11)
48-54	ND(0.11)
54-60	ND(0.10)
60-66	ND(0.10)
66-72	ND(0.11)
72-78	ND(0.09)
78-84	ND(0.09)

NST54-N	
Depth (cm)	PCB (mg/kg)
0-1	0.09
1-2	0.30
2-3	0.14
3-4	0.13
4-5	0.12
5-6	0.11
6-7	0.13 [0.12]
7-8	0.17
9-10	0.25
14-15	0.17
19-20	ND(0.06)
24-25	ND(0.06)
29-30	ND(0.06)
34-35	ND(0.05) [ND(0.06)]
39-40	ND(0.06)
44-45	ND(0.06)
49-50	ND(0.06)
54-55	ND(0.06)
59-60	ND(0.06)
64-65	ND(0.06)
69-70	ND(0.06)
74-75	ND(0.06)
79-80	ND(0.06)
84-85	ND(0.06)
89-90	ND(0.06)
94-95	ND(0.06)
99-100	0.11

SED-T58-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.38
3-6	0.42
6-14	ND(0.05)

SED-T57-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.62
3-7	0.20

SED-T56-NSN	
Depth (in)	PCB (mg/kg)
0-3	1.05
3-6	0.71
6-12	0.08
12-19	ND(0.06)

SED-T56-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.56
3-6	0.09
6-12	ND(0.05)
12-18	ND(0.05)

SED-T55-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.08)
6-12	ND(0.07)[ND(0.07)]
12-18	ND(0.07)
18-24	ND(0.07)
24-30	ND(0.07)
30-36	ND(0.11)
36-42	ND(0.10)
42-48	ND(0.12)
48-54	ND(0.13)
54-60	ND(0.16)
60-66	ND(0.13)
66-72	ND(0.15)
72-78	ND(0.15)
78-84	ND(0.13)
84-89	ND(0.07)
89-96	ND(0.08)

SED-T55-NSS	
Depth (in)	PCB (mg/kg)
0-3	1.11
3-6	0.21
6-12	ND(0.07)
12-18	ND(0.07)

NST54-S	
Depth (cm)	PCB (mg/kg)
0-1	ND(0.08)
1-2	0.22
2-3	ND(0.08)
3-4	ND(0.08)
4-5	ND(0.08)
5-6	ND(0.08)
6-7	ND(0.08)
7-8	ND(0.08)
9-10	ND(0.08) [ND(0.08)]
14-15	ND(0.07)
19-20	ND(0.08)
24-25	ND(0.08)

SED-T53-NSNA	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.07)
6-13	ND(0.06)

SED-T53-NSNB	
Depth (in)	PCB (mg/kg)
0-3	0.08
3-6	0.79
6-12	ND(0.07)
12-18	ND(0.06)[ND(0.06)]
18-24	ND(0.07)
24-30	ND(0.07)
30-36	ND(0.07)
36-39	ND(0.06)
39-45	ND(0.05)

SED-T53-NSNC	
Depth (in)	PCB (mg/kg)
0-3	0.55
3-6	0.56
6-12	ND(0.07)
12-18	ND(0.06)
18-24	ND(0.07)
24-30	ND(0.07)
30-34	ND(0.05)

SED-T53-NSND	
Depth (in)	PCB (mg/kg)
0-3	0.72
3-6	5.84
6-12	19.67
12-18	5.85[2.67]
18-21	ND(0.06)

SED-T53-NSNE	
Depth (in)	PCB (mg/kg)
0-3	2.25
3-6	22.51
6-14	23.14[13.68]

NST53-N	
Depth (in)	PCB (mg/kg)
0-3	ND(0.06)

NST53-S	
Depth (in)	PCB (mg/kg)
0-3	ND(0.06)

SED-T53-NSSA	
Depth (in)	PCB (mg/kg)
0-3	ND(0.10)
3-6	ND(0.07)
6-12	ND(0.08)
12-18	ND(0.07)
18-24	ND(0.08)
24-30	ND(0.09)
30-36	ND(0.08)
36-42	ND(0.08)
42-48	ND(0.07)
48-54	ND(0.07)
54-60	ND(0.13)
60-66	ND(0.07)
66-72	ND(0.07)
72-78	ND(0.07)

SED-T53-NSSB	
Depth (in)	PCB (mg/kg)
0-3	0.23
3-6	0.66
6-12	ND(0.08)
12-18	ND(0.09)
18-24	ND(0.07)
24-30	ND(0.07)
30-36	ND(0.09)
36-42	ND(0.10)

SED-T53-NSSC	
Depth (in)	PCB (mg/kg)
0-3	0.49
3-6	0.48
6-12	0.46
12-18	ND(0.09)
18-24	ND(0.08)
24-30	ND(0.08)
30-36	ND(0.09)
36-42	ND(0.10)
42-48	ND(0.11)
48-54	ND(0.10)
54-60	ND(0.10)
60-66	ND(0.09)
66-72	ND(0.08)[ND(0.08)]
72-75	ND(0.07)
75-81	ND(0.08)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T53 - T59

ALCOA

FIGURE
2-18

CITY: SYRACUSE, NY DIV/GROUP: ENVCAD DB: L.POSENAUER K. DAVIS L. FORAKER LD: L. POSENAUER PIC: H. VANDEWALKER PM: H.VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
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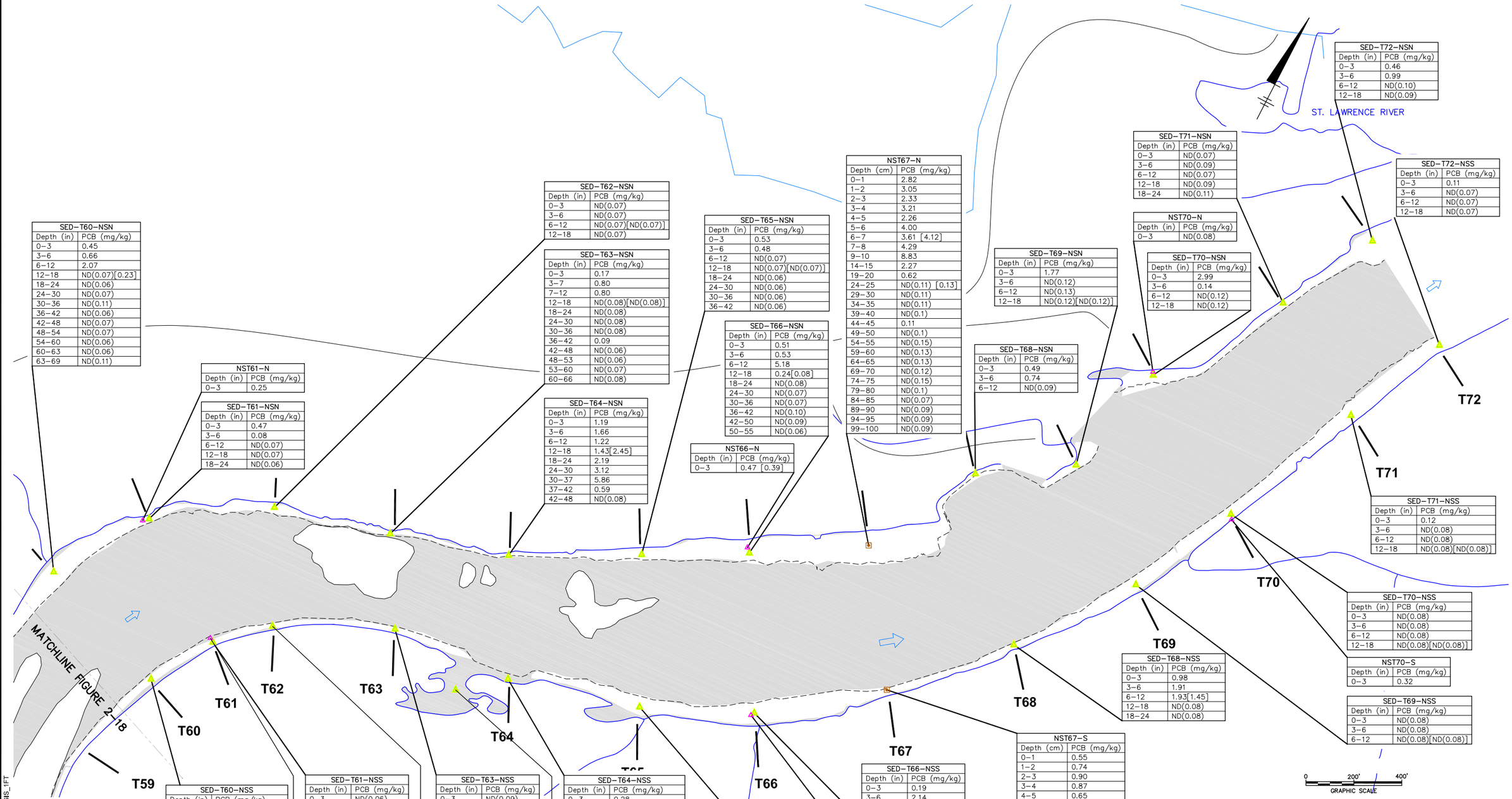
XREFS: 10875X00 10875X02 10875X03 IMAGES: 10875X01.TIF PROJECTNAME: NYS_GIS_1FT



SED-T60-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.45
3-6	0.66
6-12	2.07
12-18	ND(0.07)[0.23]
18-24	ND(0.06)
24-30	ND(0.07)
30-36	ND(0.11)
36-42	ND(0.06)
42-48	ND(0.07)
48-54	ND(0.07)
54-60	ND(0.06)
60-63	ND(0.06)
63-69	ND(0.11)

NST61-N	
Depth (in)	PCB (mg/kg)
0-3	0.25

SED-T61-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.47
3-6	0.08
6-12	ND(0.07)
12-18	ND(0.07)
18-24	ND(0.06)

SED-T62-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.07)
6-12	ND(0.07)[ND(0.07)]
12-18	ND(0.07)

SED-T63-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.17
3-7	0.80
7-12	0.80
12-18	ND(0.08)[ND(0.08)]
18-24	ND(0.08)
24-30	ND(0.08)
30-36	ND(0.08)
36-42	0.09
42-48	ND(0.06)
48-53	ND(0.06)
53-60	ND(0.07)
60-66	ND(0.08)

SED-T64-NSN	
Depth (in)	PCB (mg/kg)
0-3	1.19
3-6	1.66
6-12	1.22
12-18	1.43[2.45]
18-24	2.19
24-30	3.12
30-37	5.86
37-42	0.59
42-48	ND(0.08)

SED-T65-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.53
3-6	0.48
6-12	ND(0.07)
12-18	ND(0.07)[ND(0.07)]
18-24	ND(0.06)
24-30	ND(0.06)
30-36	ND(0.06)
36-42	ND(0.06)

SED-T66-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.51
3-6	0.53
6-12	5.18
12-18	0.24[0.08]
18-24	ND(0.08)
24-30	ND(0.07)
30-36	ND(0.07)
36-42	ND(0.10)
42-50	ND(0.09)
50-55	ND(0.06)

NST66-N	
Depth (in)	PCB (mg/kg)
0-3	0.47 [0.39]

NST67-N	
Depth (cm)	PCB (mg/kg)
0-1	2.82
1-2	3.05
2-3	2.33
3-4	3.21
4-5	2.26
5-6	4.00
6-7	3.61 [4.12]
7-8	4.29
9-10	8.83
14-15	2.27
19-20	0.62
24-25	ND(0.11) [0.13]
29-30	ND(0.11)
34-35	ND(0.11)
39-40	ND(0.1)
44-45	0.11
49-50	ND(0.1)
54-55	ND(0.15)
59-60	ND(0.13)
64-65	ND(0.13)
69-70	ND(0.12)
74-75	ND(0.15)
79-80	ND(0.1)
84-85	ND(0.07)
89-90	ND(0.09)
94-95	ND(0.09)
99-100	ND(0.09)

SED-T69-NSN	
Depth (in)	PCB (mg/kg)
0-3	1.77
3-6	ND(0.12)
6-12	ND(0.13)
12-18	ND(0.12)[ND(0.12)]

SED-T68-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.49
3-6	0.74
6-12	ND(0.09)

SED-T71-NSN	
Depth (in)	PCB (mg/kg)
0-3	ND(0.07)
3-6	ND(0.09)
6-12	ND(0.07)
12-18	ND(0.09)
18-24	ND(0.11)

NST70-N	
Depth (in)	PCB (mg/kg)
0-3	ND(0.08)

SED-T70-NSN	
Depth (in)	PCB (mg/kg)
0-3	2.99
3-6	0.14
6-12	ND(0.12)
12-18	ND(0.12)

SED-T72-NSN	
Depth (in)	PCB (mg/kg)
0-3	0.46
3-6	0.99
6-12	ND(0.10)
12-18	ND(0.09)

SED-T72-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.11
3-6	ND(0.07)
6-12	ND(0.07)
12-18	ND(0.07)

SED-T71-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.12
3-6	ND(0.08)
6-12	ND(0.08)
12-18	ND(0.08)[ND(0.08)]

SED-T70-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.08)
3-6	ND(0.08)
6-12	ND(0.08)
12-18	ND(0.08)[ND(0.08)]

NST70-S	
Depth (in)	PCB (mg/kg)
0-3	0.32

SED-T69-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.08)
3-6	ND(0.08)
6-12	ND(0.08)[ND(0.08)]

SED-T68-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.98
3-6	1.91
6-12	1.93[1.45]
12-18	ND(0.08)
18-24	ND(0.08)

NST67-S	
Depth (cm)	PCB (mg/kg)
0-1	0.55
1-2	0.74
2-3	0.90
3-4	0.87
4-5	0.65
5-6	0.86
6-7	1.20
7-8	1.18
9-10	3.74
14-15	8.43 [9.69]
19-20	12.20
24-25	7.88
29-30	0.23

SED-T66-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.19
3-6	2.14
6-12	ND(0.08)
12-18	ND(0.08)

NST66-S	
Depth (in)	PCB (mg/kg)
0-3	1.45

SED-T65-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.08
3-6	ND(0.06)
6-12	ND(0.06)
12-18	ND(0.08)[ND(0.08)]

SED-T64-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.28
3-6	0.42
6-12	0.36
12-18	ND(0.11)[ND(0.11)]
18-24	ND(0.08)
24-30	ND(0.09)
30-36	ND(0.10)
36-42	ND(0.12)
42-48	ND(0.13)

SED-T63.5-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.10)
3-6	ND(0.09)
6-12	ND(0.10)
12-18	ND(0.11)[ND(0.12)]

SED-T63-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.09)
3-6	ND(0.10)
6-12	ND(0.09)
12-18	ND(0.08)
18-24	ND(0.08)
24-30	ND(0.07)
30-36	ND(0.07)
36-42	ND(0.10)

SED-T62-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.17
3-6	0.37
6-12	ND(0.08)
12-18	ND(0.08)

NST61-S	
Depth (in)	PCB (mg/kg)
0-3	0.61

SED-T61-NSS	
Depth (in)	PCB (mg/kg)
0-3	ND(0.06)
3-6	ND(0.09)
6-12	ND(0.09)
12-18	ND(0.09)
18-24	ND(0.09)
24-30	ND(0.10)
30-36	ND(0.11)
36-42	ND(0.12)

SED-T60-NSS	
Depth (in)	PCB (mg/kg)
0-3	0.45
3-6	ND(0.07)
6-12	ND(0.08)
12-18	ND(0.11)[ND(0.12)]
18-24	ND(0.12)

SEE FIGURE 2-12 FOR NOTES AND LEGEND INFORMATION

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

NEAR SHORE SEDIMENT SAMPLING LOCATIONS AND PCB RESULTS - T60 - T72

ALCOA

FIGURE
2-19

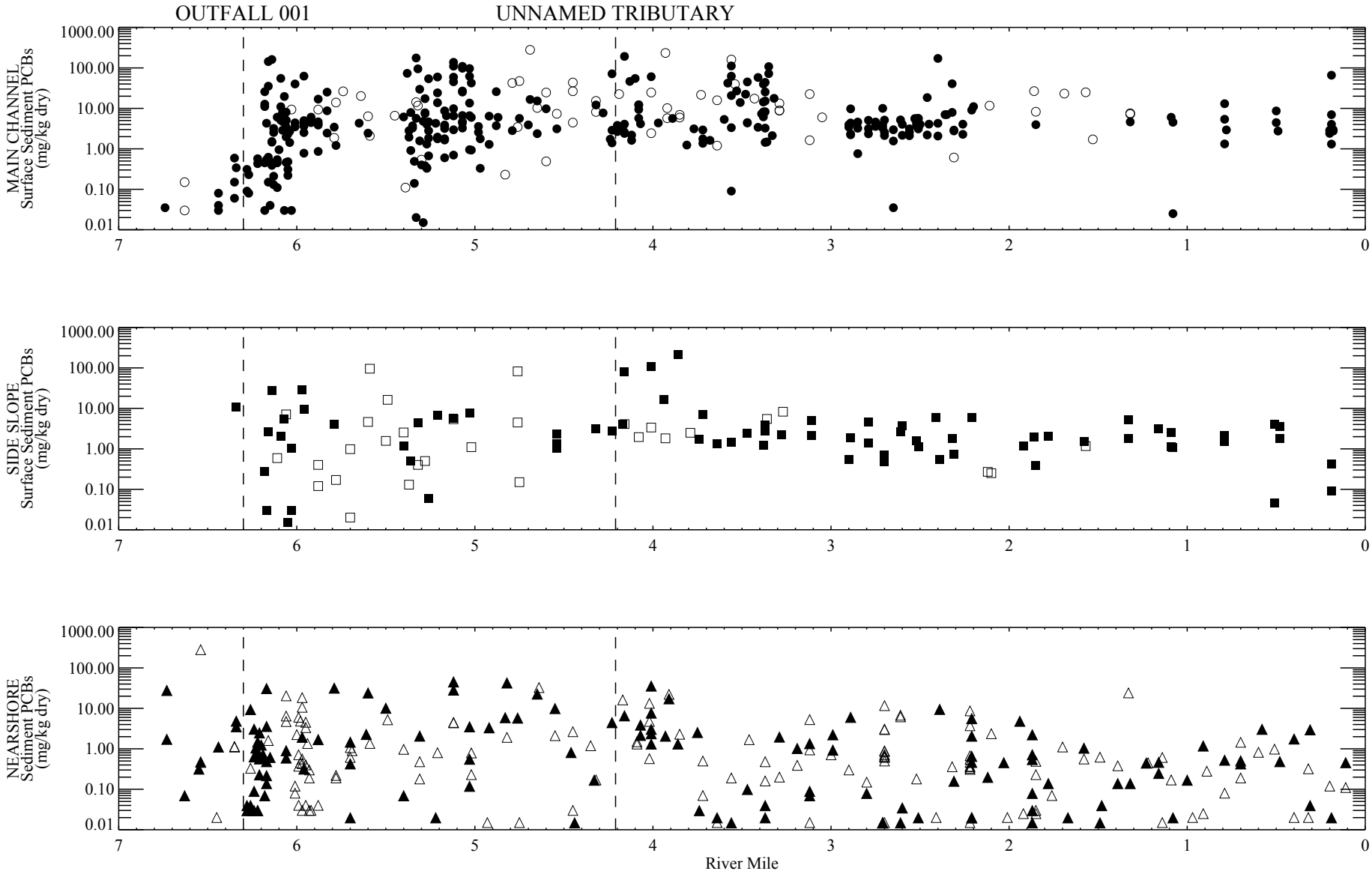


Figure 2-20. Current Sediment PCB Concentrations in the Lower Grasse River (2000-2010).

Sediment depth from 0-3" (depth-weighted); values below detection set to half the PQL; duplicates are averaged.
2003-2010 data used for T1-T19 and 2000-2010 used for T19-T72. Transects are approximate.

Data table: sediment_aro, sed_aro_ROPS, sediment_bz

- ● Main Channel Fine
- ○ Main Channel Coarse
- ■ Side Slope Fine
- □ Side Slope Coarse
- ▲ Nearshore North
- △ Nearshore South

ARC - C:\Jobs\ALCgra\Analysis\Sediment\Near_Shore_all\2010\pcb_surface_1_2_ns_ss_all_transects_probplot.pro
Tue Mar 20 16:03:26 2012

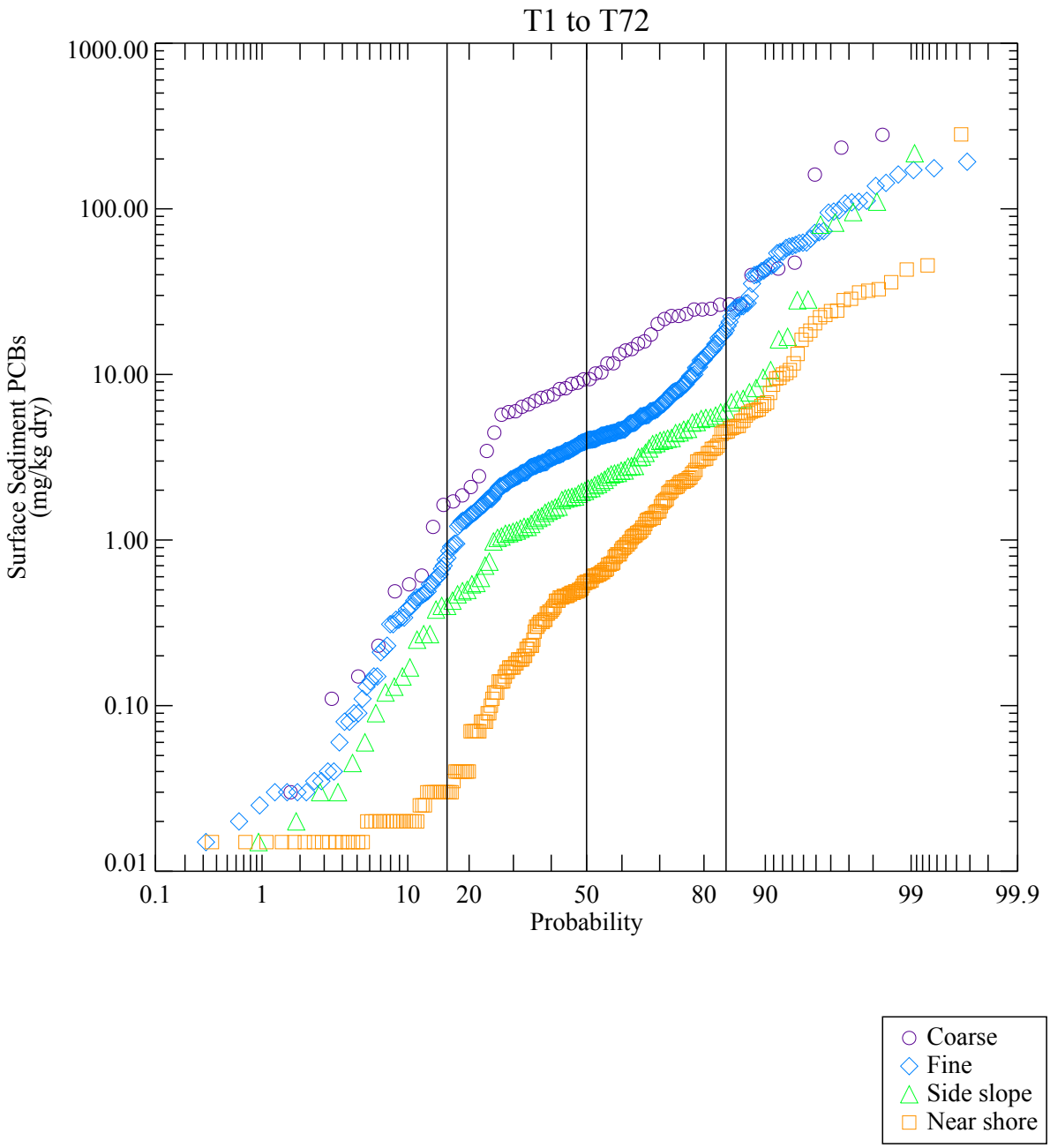


Figure 2-21. Probability Distributions of Current Sediment PCB Concentrations in the Lower Grasse River.

Sediment depth from 0-3" (depth-weighted); values below detection set to half the PQL. Duplicates are averaged.

Data table: sediment_aro, sed_aro_ROPS, sediment_bz

ARC - C:\Jobs\ALCgra\Analysis\Sediment\Near_Shore_all\2010\pcb_surface_1_2_ns_ss_all_transects_probplot.pro
Tue Feb 21 08:52:10 2012

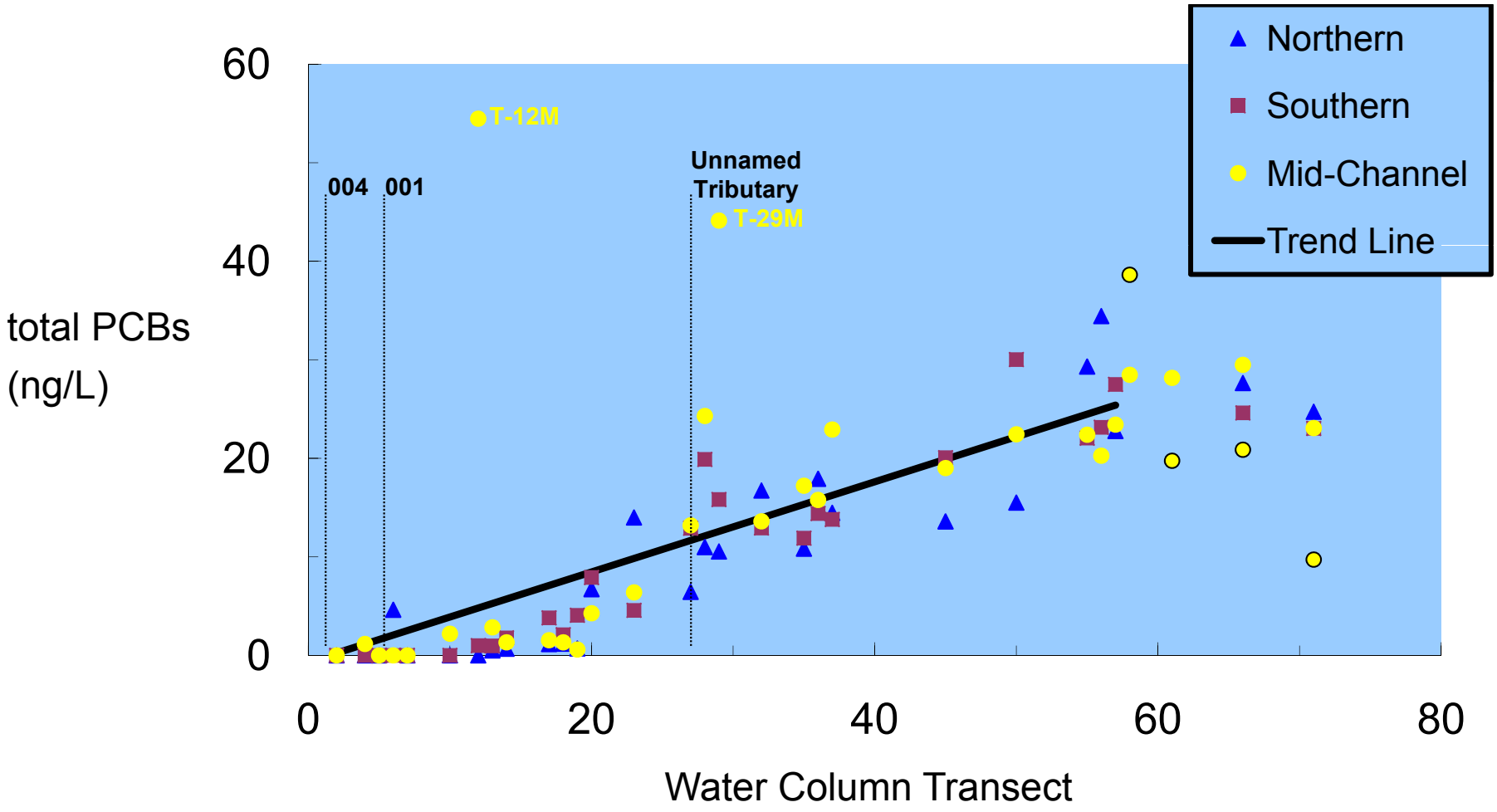


Figure 2-22. Water Column PCBs Measured During 2000 Float Survey.

Yellow circles at Transects T58, T61, T66 and T71 represent surface samples.
Yellow circles with black outlines at Transects T58, T61, T66 and T71 represent deep samples.
Data table: water_iupac

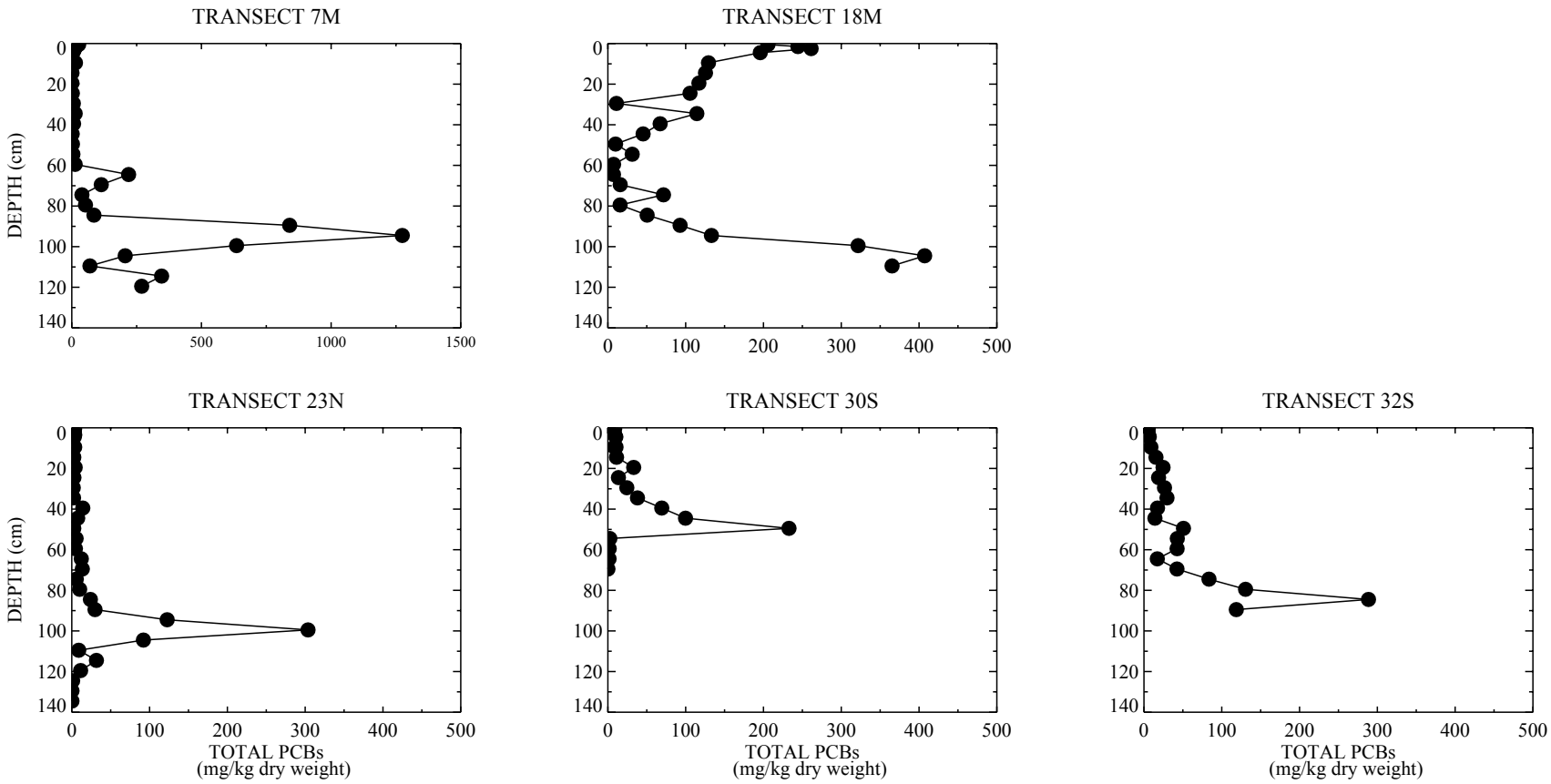


Figure 2-23. Vertical Distribution of Total PCB Levels in Sediment Cores Collected from the Lower Grasse River.

Data from 1997 SRS Sediment Core Sampling Program.

Data table: sediment_bz

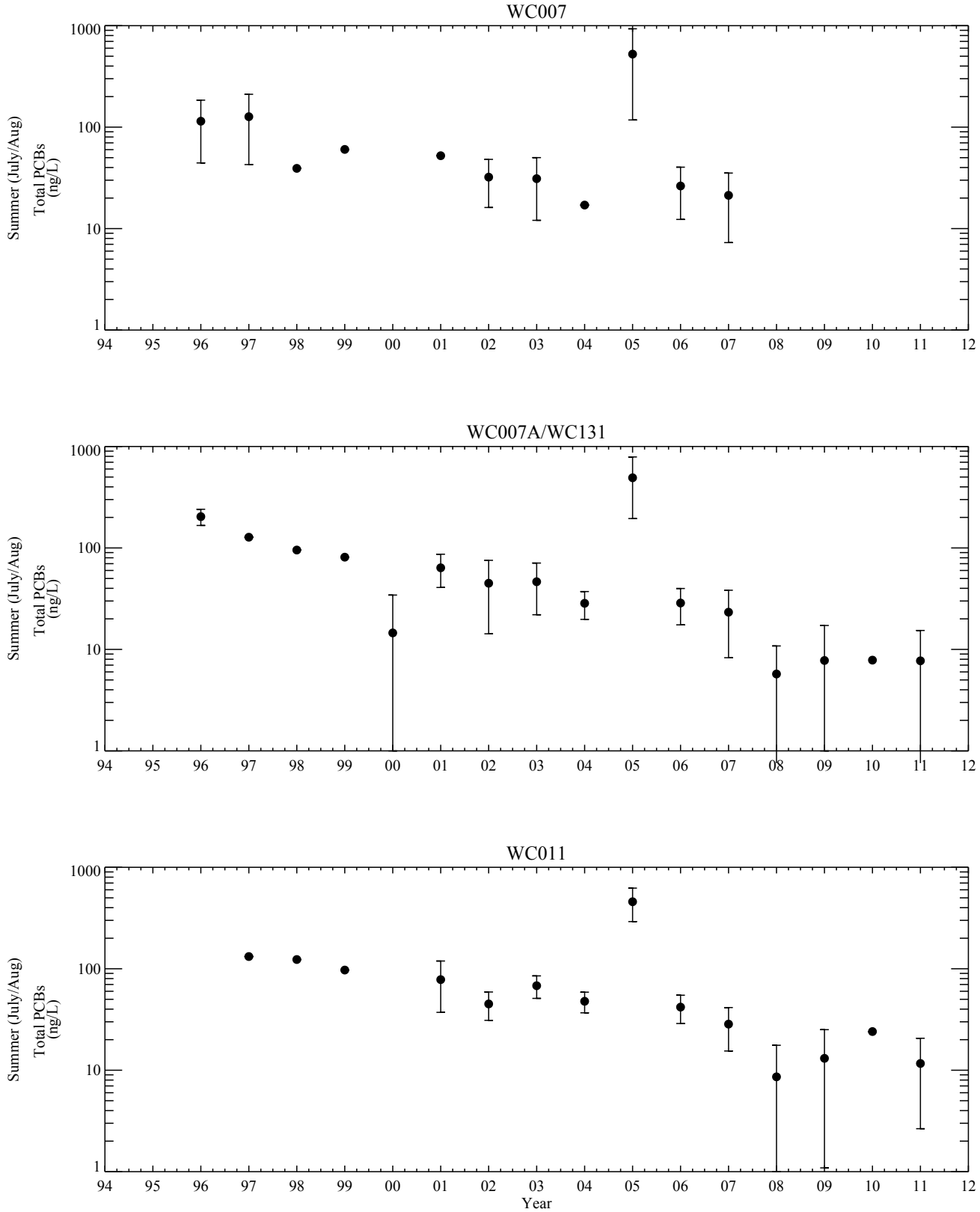
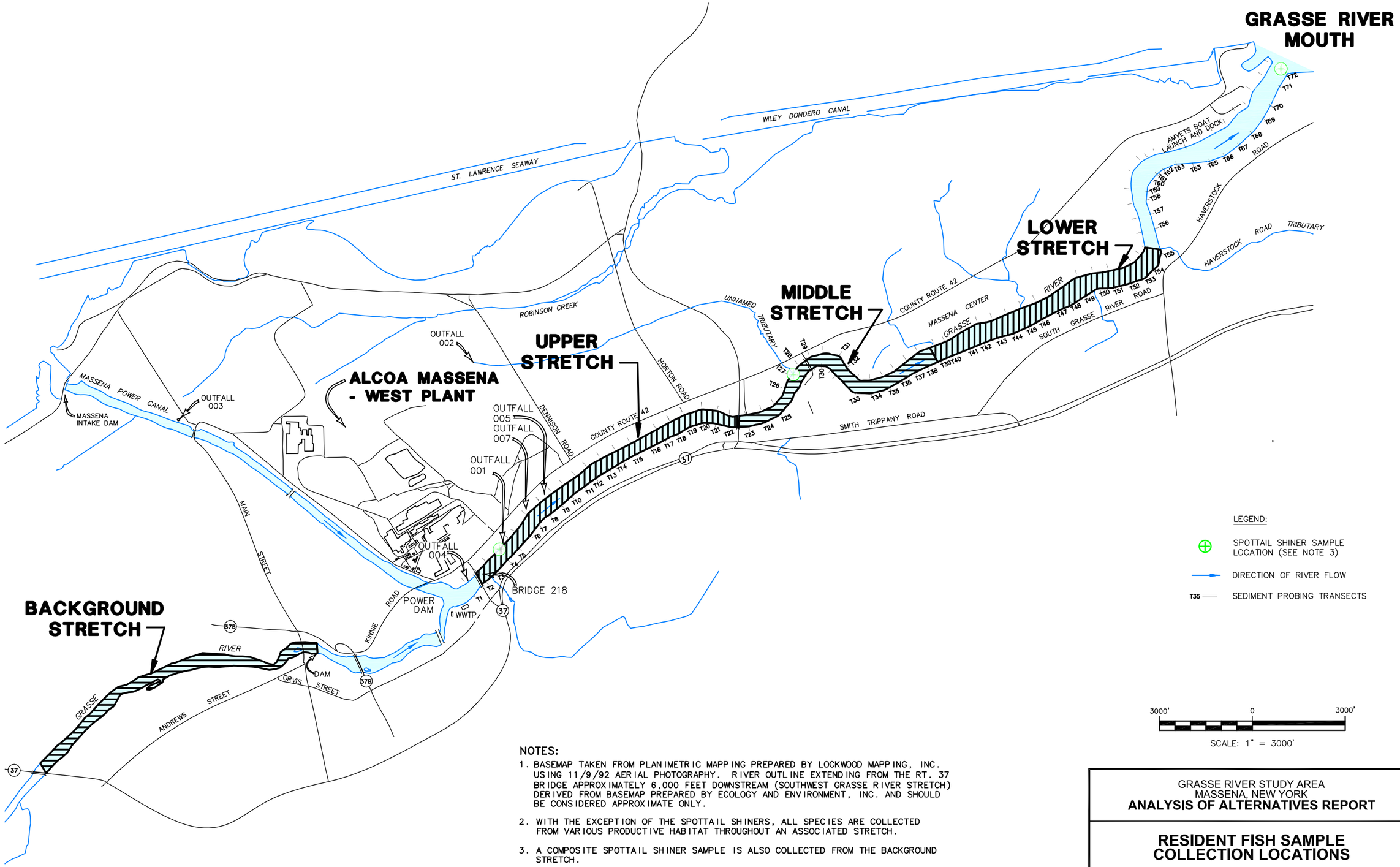


Figure 2-24. Seasonal Average Water Column PCB Concentrations Measured During Non-Stratified Periods (WC007, WC007A/WC131, and WC011)

Data represent samples collected when river flow was less than or equal to 2200 cfs.
1995 to 1999 data represent composite samples collected during non-stratified periods.
2000 to 2011 data represent surface samples collected at 0.2 times the total water depth.
Error bars represent two standard errors of the mean; no error bars shown if sample count is fewer than three.
Duplicates averaged; data collected on same day averaged.

Data tables: riverflow_hist, water_bz, water_peak, water_iupac



NOTES:

1. BASEMAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY. RIVER OUTLINE EXTENDING FROM THE RT. 37 BRIDGE APPROXIMATELY 6,000 FEET DOWNSTREAM (SOUTHWEST GRASSE RIVER STRETCH) DERIVED FROM BASEMAP PREPARED BY ECOLOGY AND ENVIRONMENT, INC. AND SHOULD BE CONSIDERED APPROXIMATE ONLY.
2. WITH THE EXCEPTION OF THE SPOTTAIL SHINERS, ALL SPECIES ARE COLLECTED FROM VARIOUS PRODUCTIVE HABITAT THROUGHOUT AN ASSOCIATED STRETCH.
3. A COMPOSITE SPOTTAIL SHINER SAMPLE IS ALSO COLLECTED FROM THE BACKGROUND STRETCH.
4. SMALLMOUTH BASS SAMPLES WERE ALSO COLLECTED FROM THE POWER CANAL FROM 2002 THROUGH 2011.

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

RESIDENT FISH SAMPLE COLLECTION LOCATIONS

ALCOA

FIGURE
2-25

CITY: SYRACUSE DIV/GROUP: ENVCAD DB: G. STOWELL L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0010875\0000\00001\DWG\AOAR\DATA\10875G01.DWG LAYOUT: 2-25 SAVED: 4/3/2012 7:33 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: C-LB-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 4/3/2012 7:34 AM BY: FORAKER, LYDIA
XREFS: 10875X01 IMAGES: 10875X01.TIF PROJECTNAME: ---

Smallmouth Bass

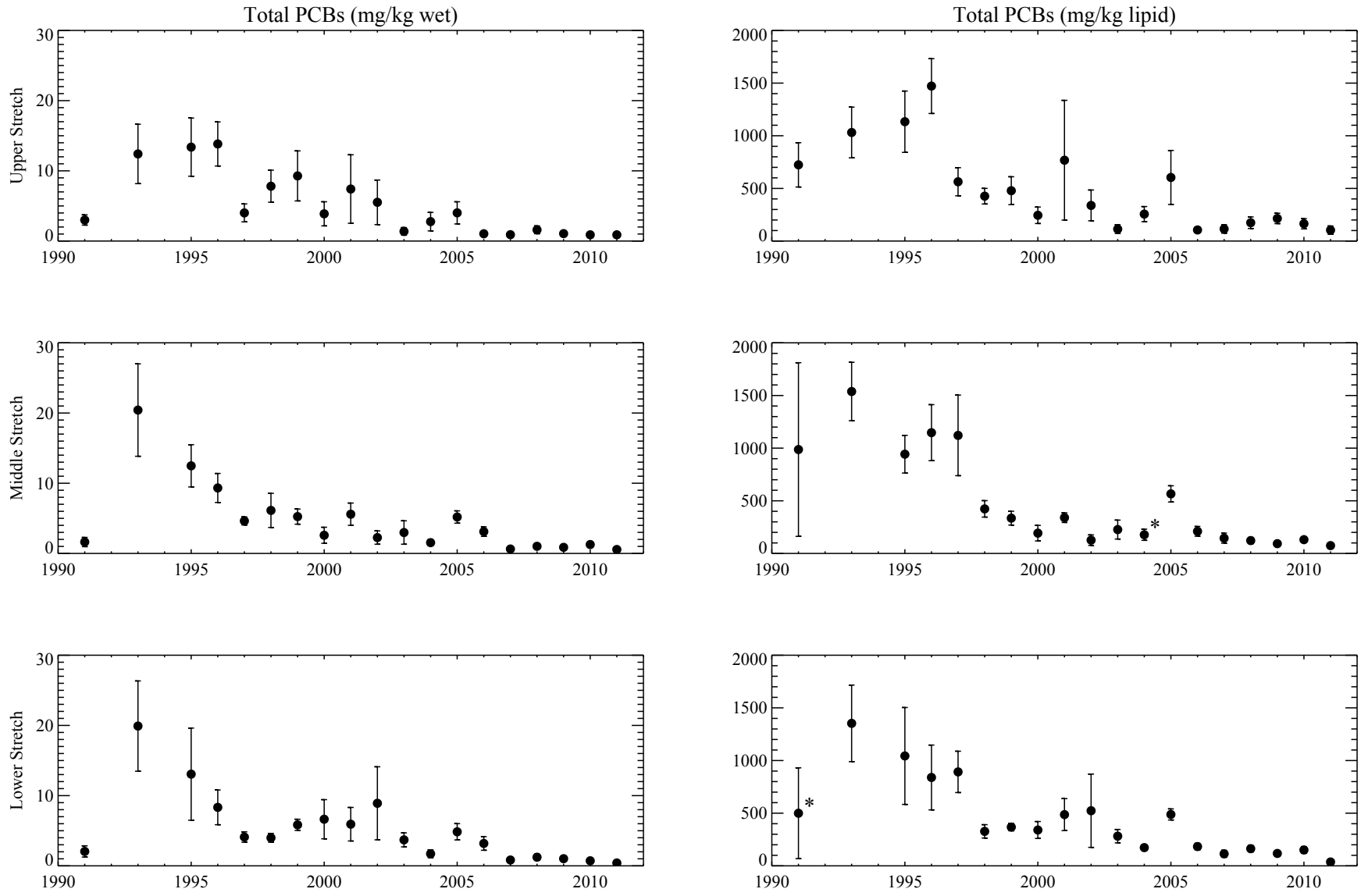


Figure 2-26. Average PCB Levels in Smallmouth Bass (1991 - 2011)
Data are arithmetic means +/- two standards errors of the mean.
Values below detection set to half the detection limit. If no detection limit reported, 0.05 mg/kg wet weight assumed.
Analytical methods employed by the laboratories have changed over time and thus, may affect comparability of these results.
**One 1991 and one 2004 sample were excluded due to unreasonably low lipid content (<0.1%).*

Data tables: resfish_aro

ARC - C:\Jobs\ALCgra\Analysis\ResFish\IDL\fall11\allspec_allloc_PCBwetlip.pro
Tue Nov 01 10:53:17 2011

Brown Bullhead

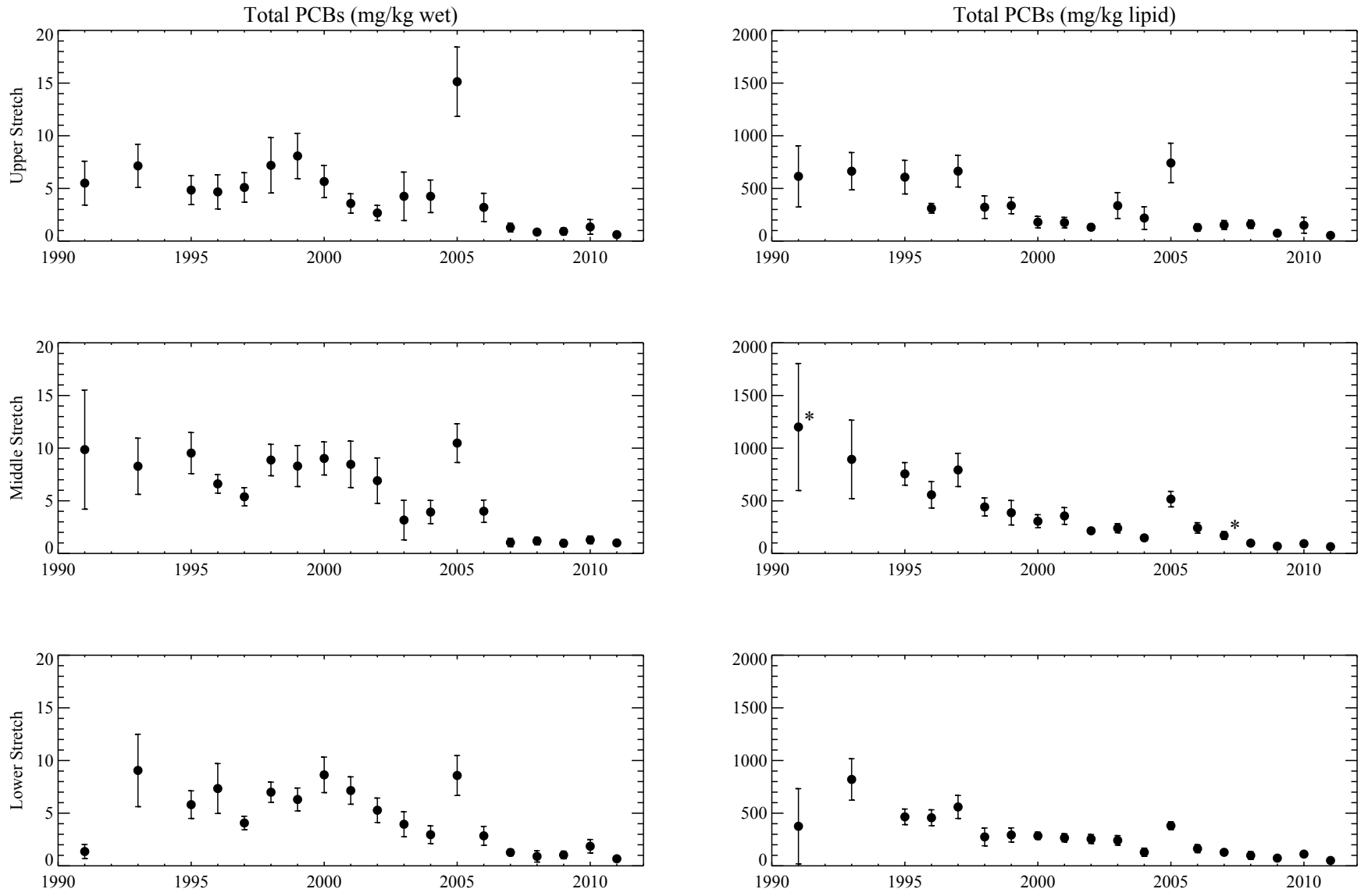


Figure 2-27. Average PCB Levels in Brown Bullhead (1991 - 2011)
Data are arithmetic means +/- two standards errors of the mean.
Values below detection set to half the detection limit. If no detection limit reported, 0.05 mg/kg wet weight assumed.
Analytical methods employed by the laboratories have changed over time and thus, may affect comparability of these results.
**One 1991 and one 2007 sample was excluded due to unreasonably low lipid content (<0.1%).*

Data tables: resfish_aro

ARC - C:\Jobs\ALCgra\Analysis\ResFish\IDL\fall11\allspec_allloc_PCBwetlip.pro
Tue Nov 01 10:53:17 2011

Young-of-Year Spottail Shiner

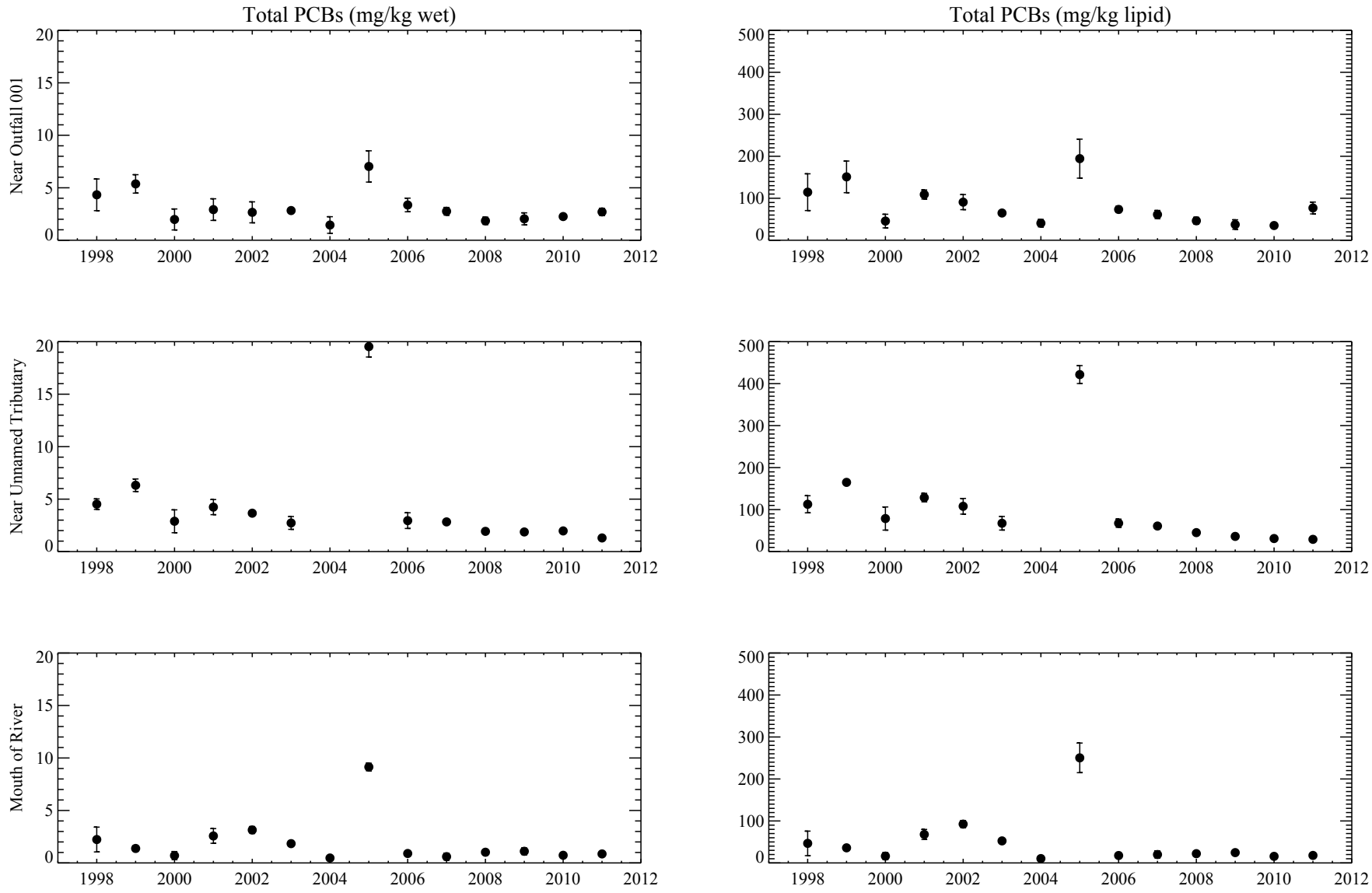


Figure 2-28. Average PCB Levels in Young-of-Year Spottail Shiner (1998 - 2011)
Data are arithmetic means +/- two standards errors of the mean.
Values below detection set to half the detection limit. If no detection limit reported, 0.05 mg/kg wet weight assumed.
Analytical methods employed by the laboratories have changed over time and thus, may affect comparability of these results.
Samples analyzed as whole body composites. Composite was considered as YOY if all lengths were <6.5 cm.

Data tables: resfish_aro

ARC - C:\Jobs\ALCgra\Analysis\ResFish\IDL\fall11\allspec_allloc_PCBwetlip.pro
Tue Nov 01 10:53:17 2011

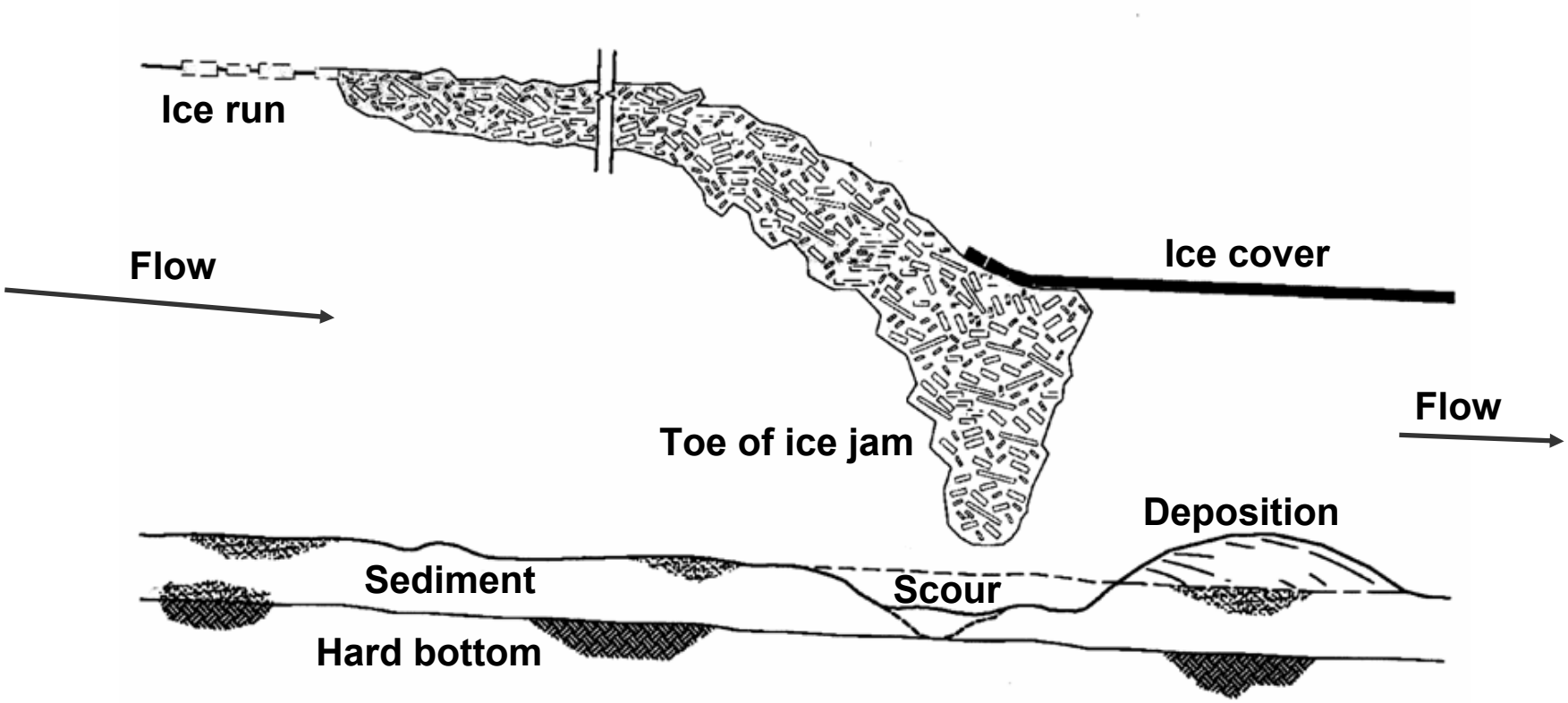
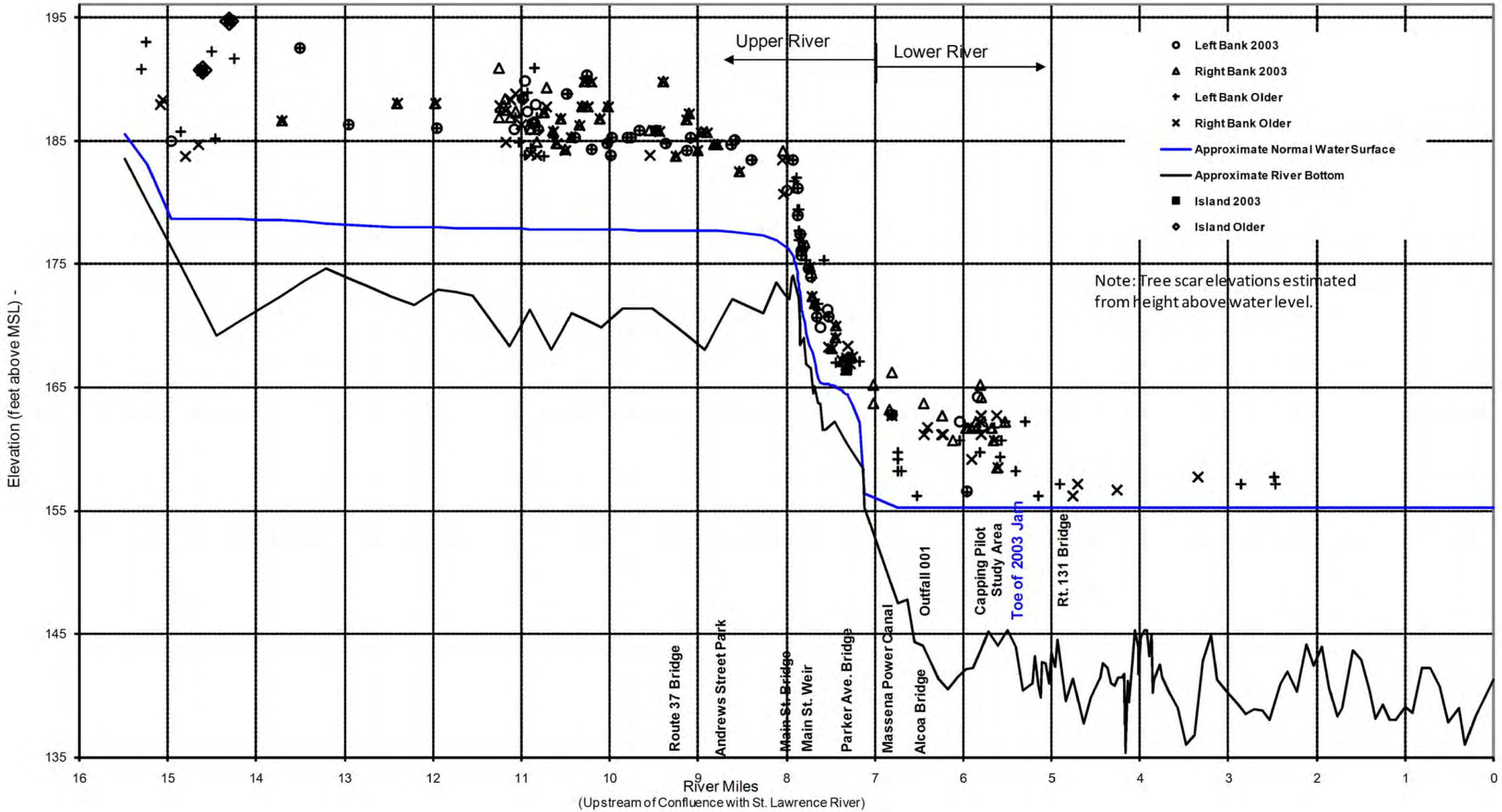


Figure 2-29. Generalized Cross-Section of an Ice Jam

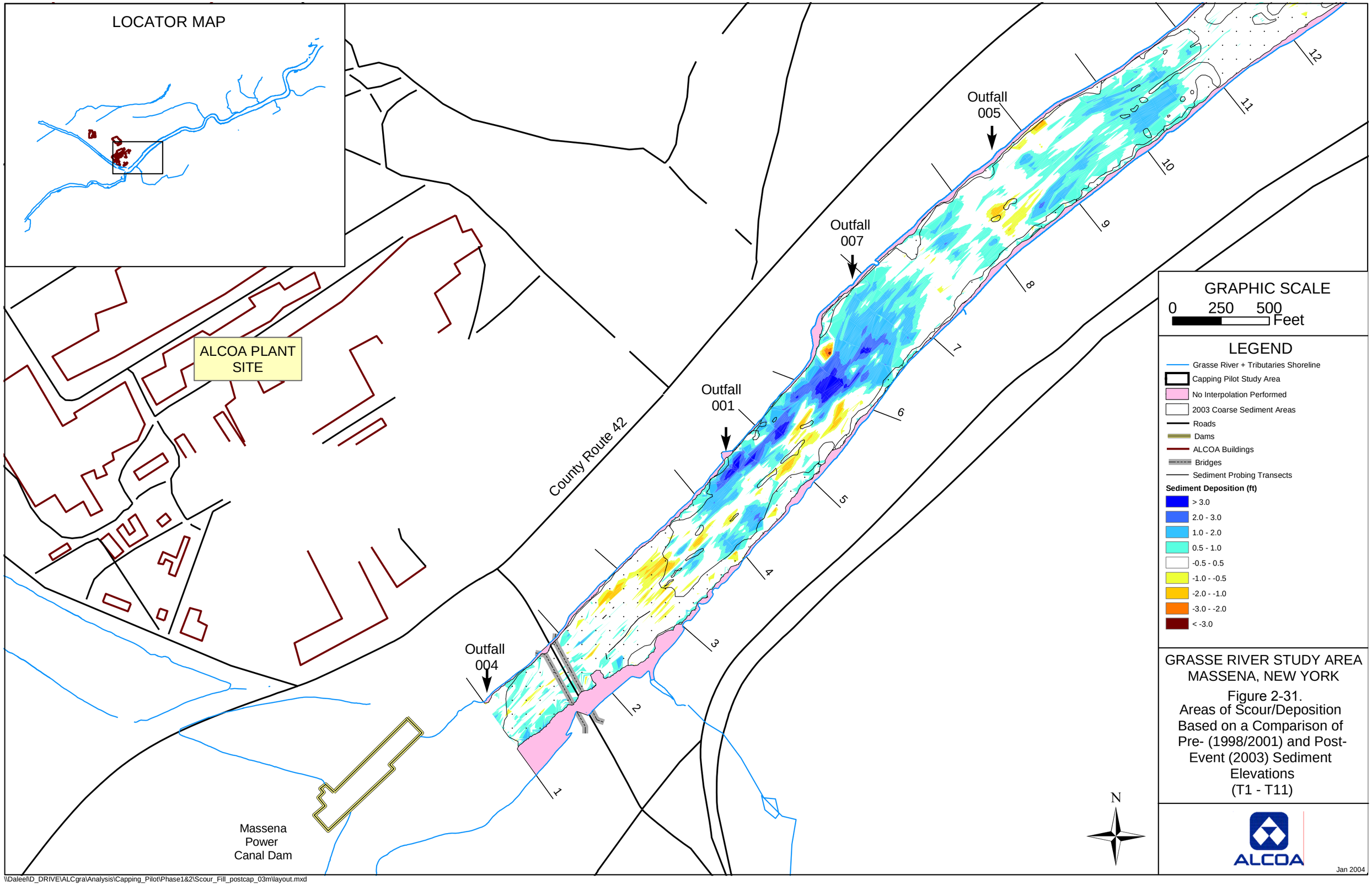


ALCOA

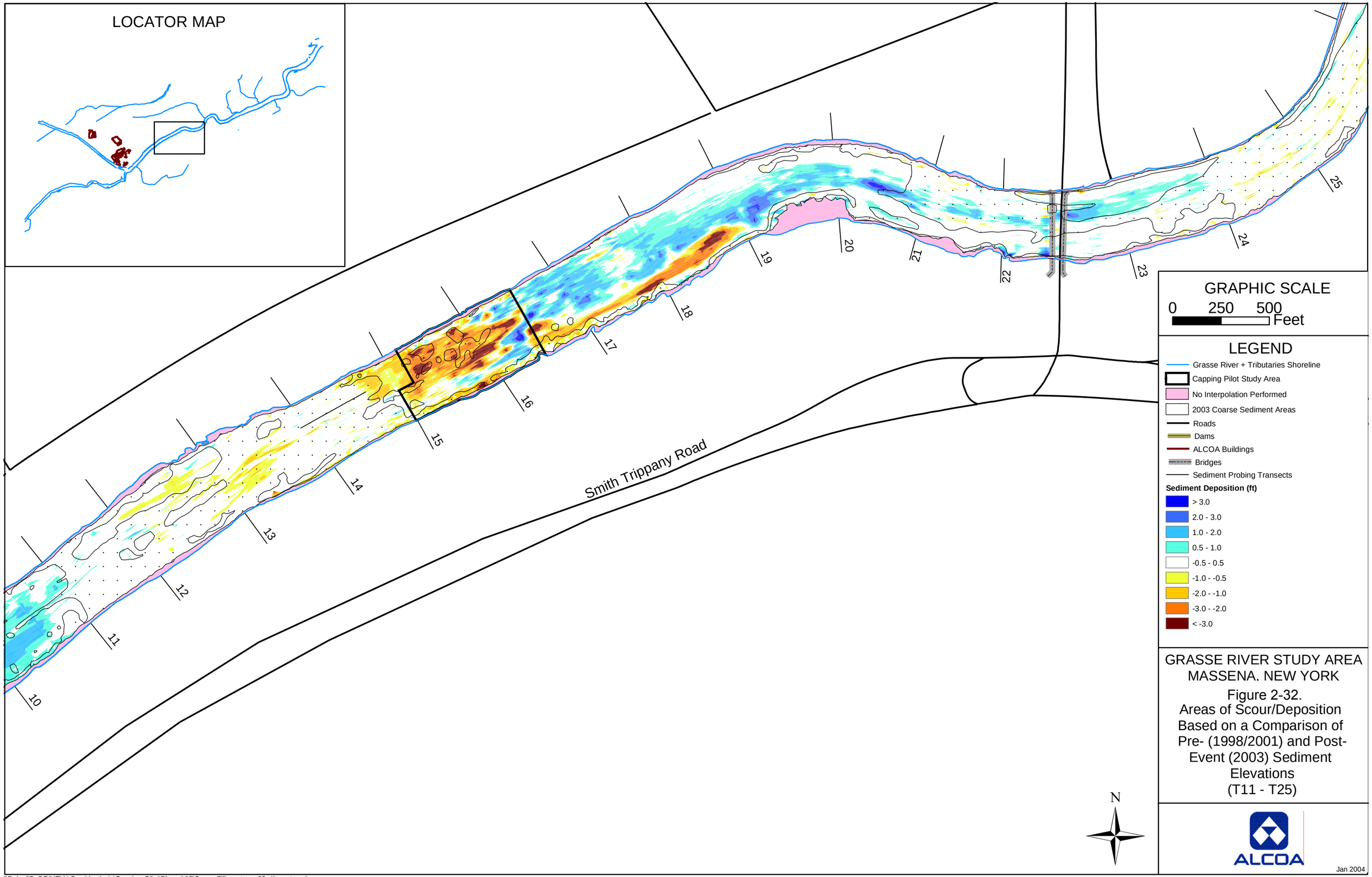
NOT TO SCALE

MAXIMUM TREE SCAR HEIGHTS
GRASSE RIVER TREE SCAR SURVEY

FIGURE 2-30.



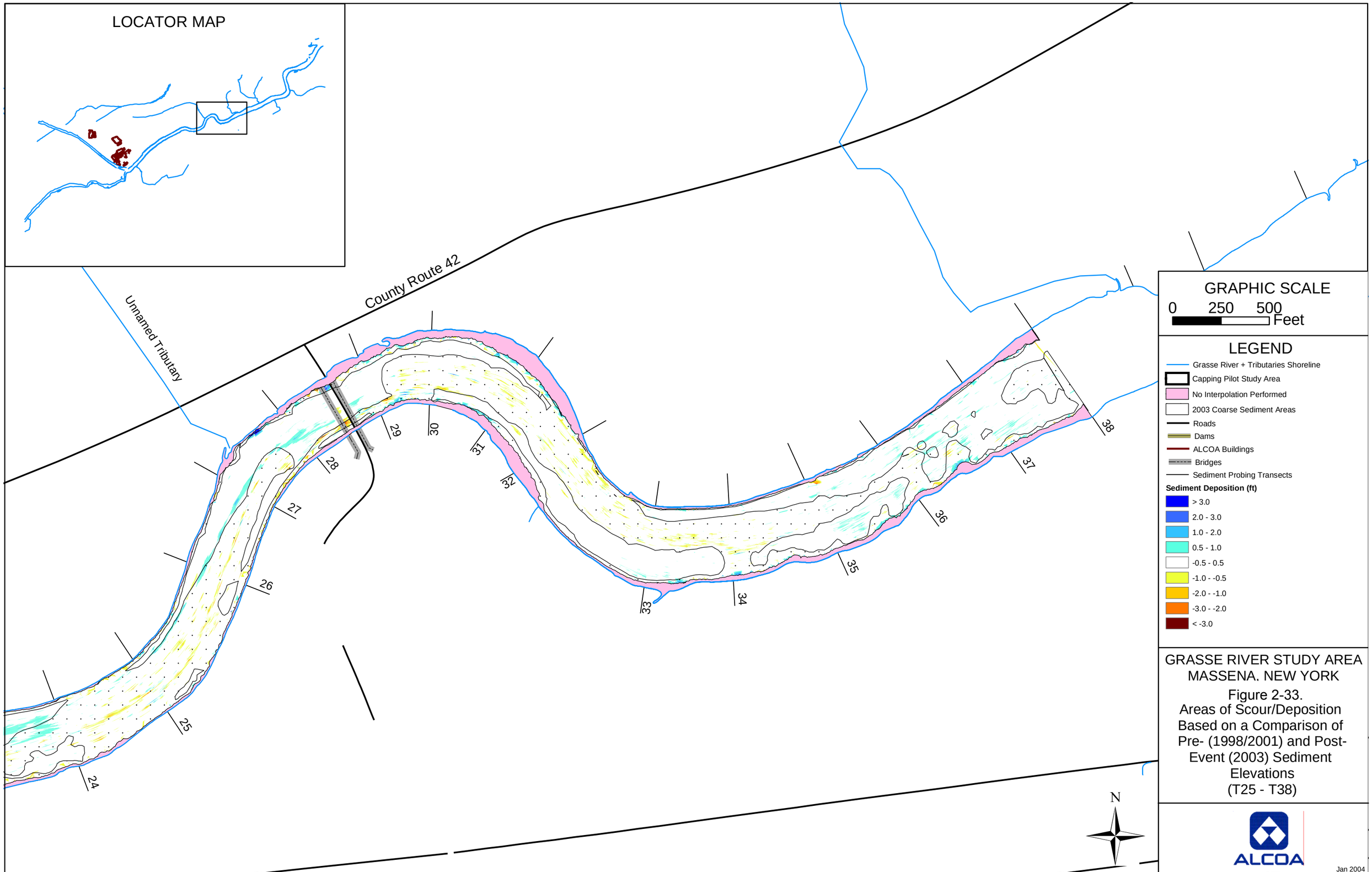
\\Daleel\D_DRIVE\ALCgra\Analysis\Capping_Pilot\Phase1&2\Scour_Fill_postcap_03m\layout.mxd



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

Figure 2-32.
Areas of Scour/Deposition Based on a Comparison of Pre- (1998/2001) and Post-Event (2003) Sediment Elevations
(T11 - T25)

\\Daleel\D_DRIVE\ALCgra\Analysis\Capping_Pilot\Phase1&2\Scour_Fill_postcap_03m\layout.mxd



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

Figure 2-33.
Areas of Scour/Deposition Based on a Comparison of Pre- (1998/2001) and Post-Event (2003) Sediment Elevations
(T25 - T38)

\\Daleel\D_DRIVE\ALCgra\Analysis\Capping_Pilot\Phase1&2\Scour_Fill_postcap_03m\layout.mxd

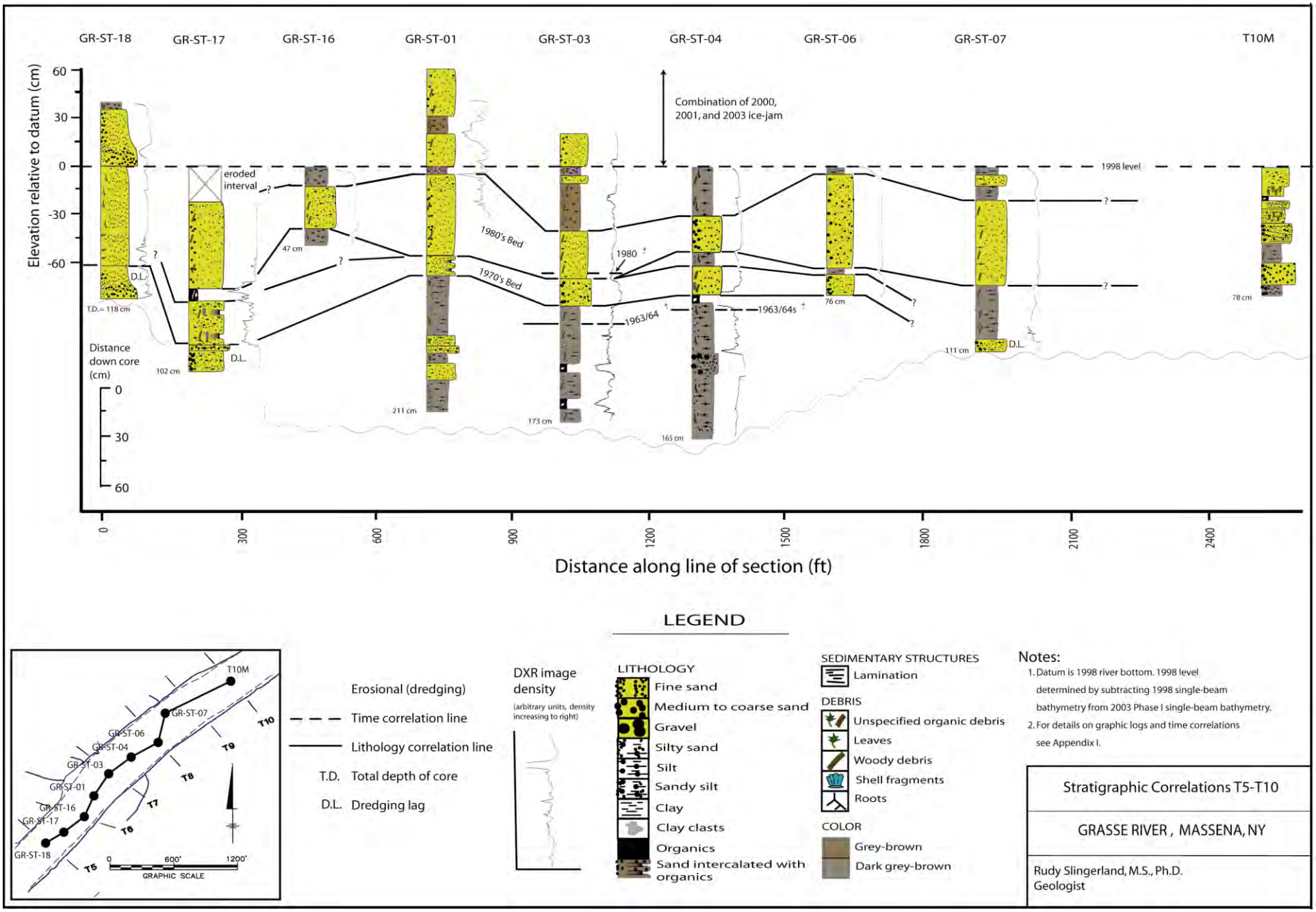


Figure 2-34. Correlation Diagram from Stratigraphic Analysis of Sediment Cores (T5 to T10)

Only cores lying along the channel centerline are shown.

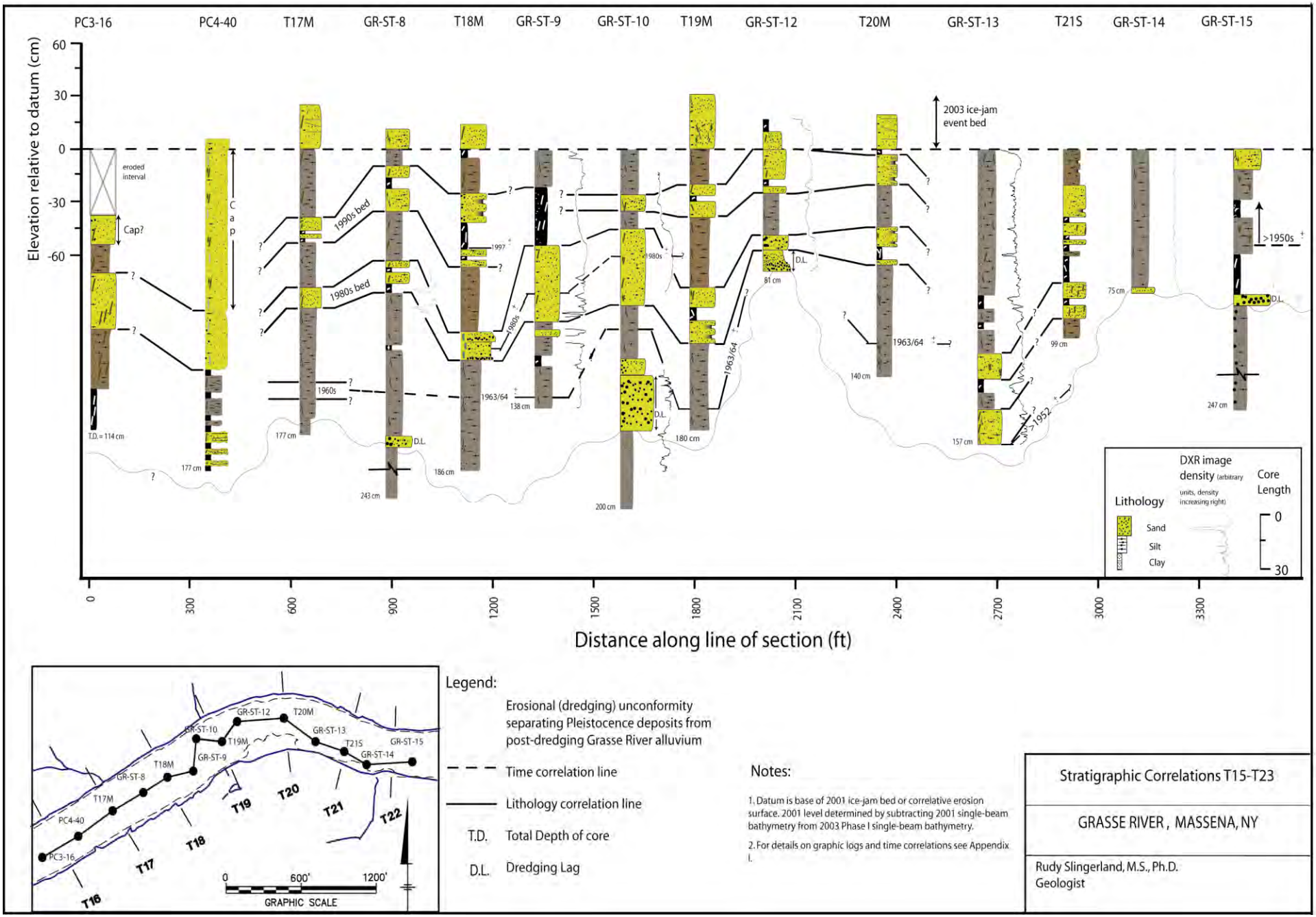


Figure 2-35. Correlation Diagram from Stratigraphic Analysis of Sediment Cores (T15 to T23)

Only cores lying along the channel centerline are shown.

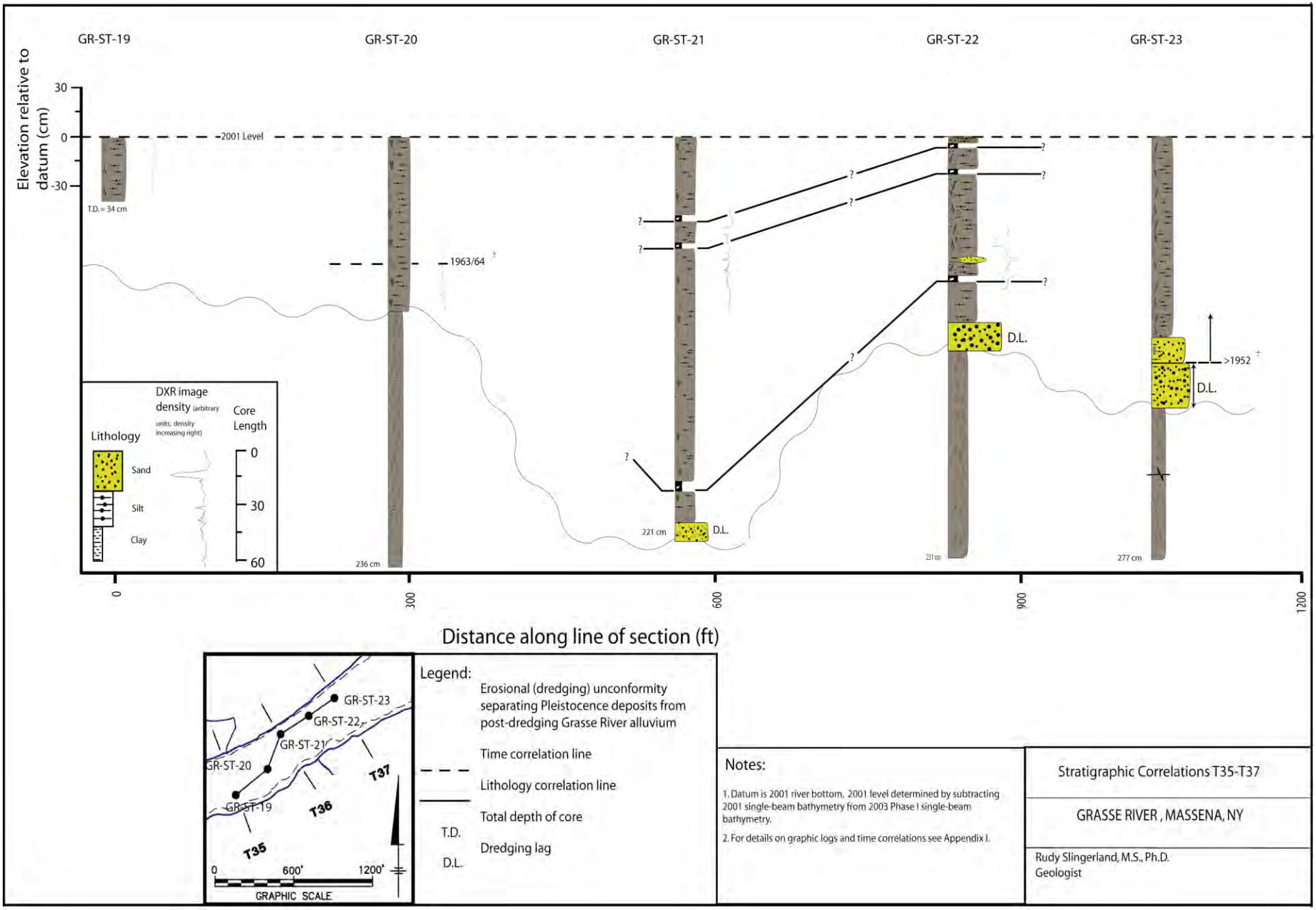
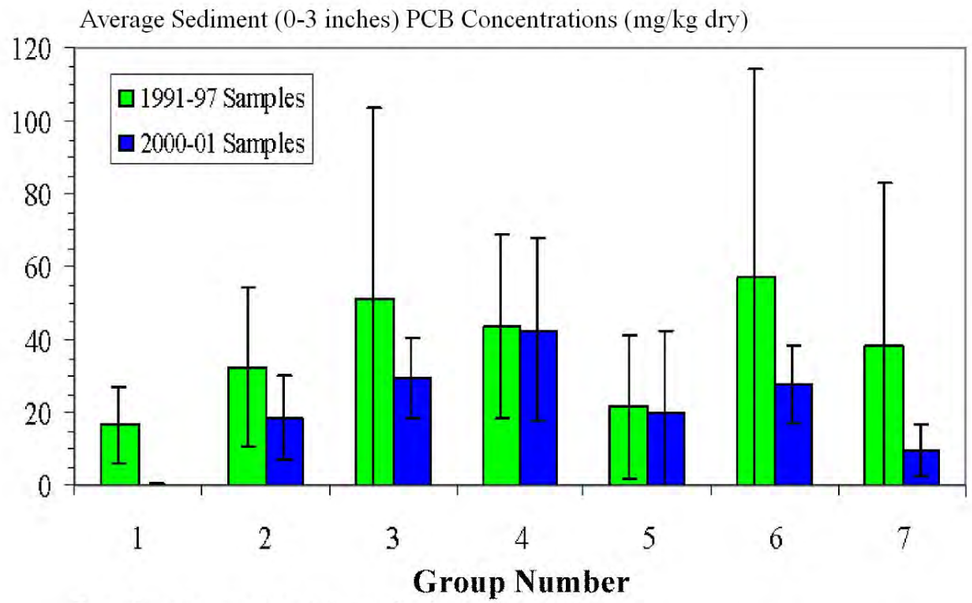
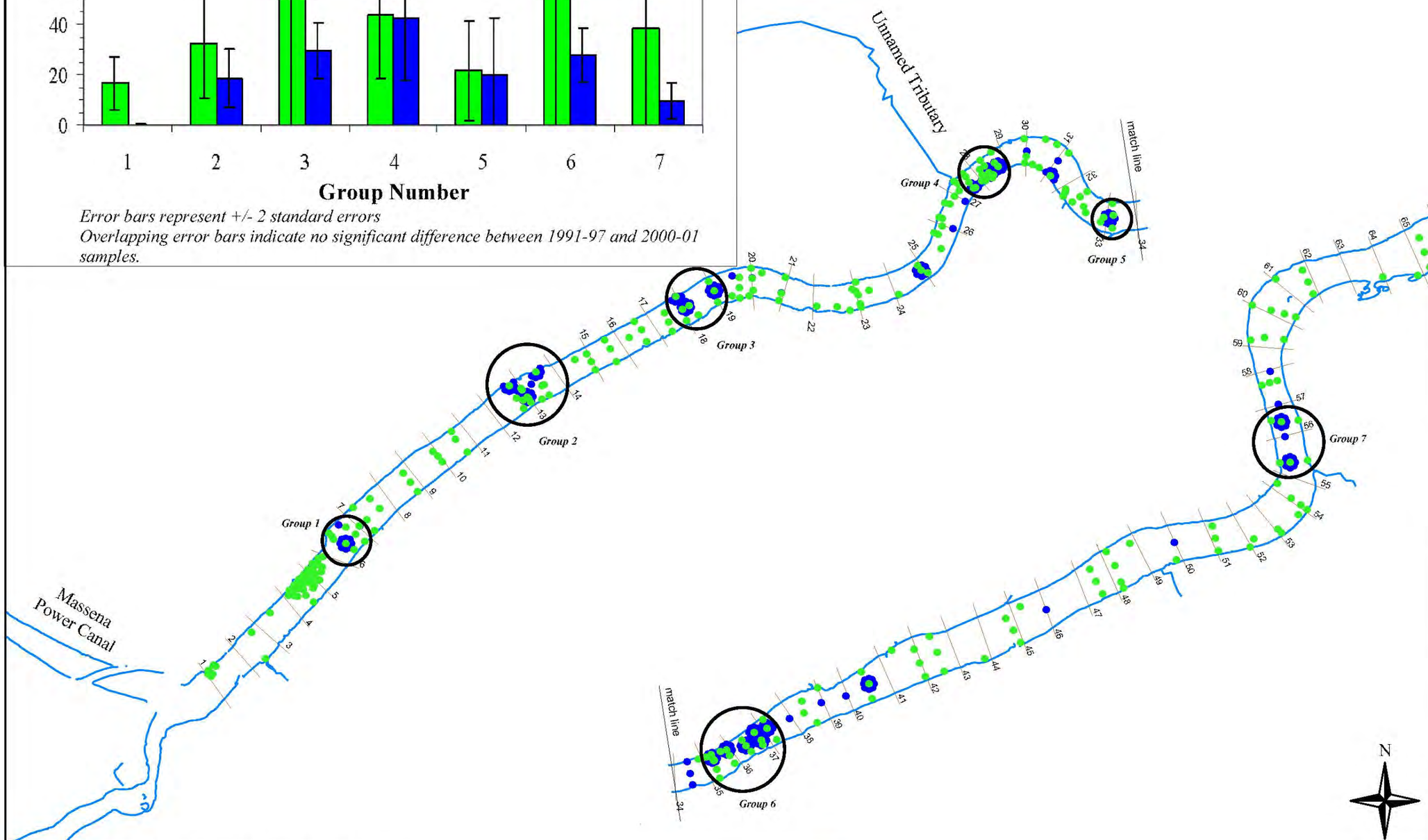


Figure 2-36. Correlation Diagram from Stratigraphic Analysis of Sediment Cores (T35 to T37)

Only cores lying along the channel centerline are shown.



Error bars represent +/- 2 standard errors
Overlapping error bars indicate no significant difference between 1991-97 and 2000-01 samples.



GRAPHIC SCALE

0.2 0 0.2 Miles

LEGEND

- 1991-97 Samples
- 2000-01 Samples
- Probing Transect

Lower Grasse River Study Area
Massena, New York

Figure 2-37.

Average PCB Concentrations in Surface Sediments Collected Prior to and After January 1998 High Flow

ALCOA

Jan 2002

\\emity\D_drive\ALCgra\documents\reports\AcfA_202\main_report\sss_vs_preSSS_fig\sss_vs_preSSS_fig.apr

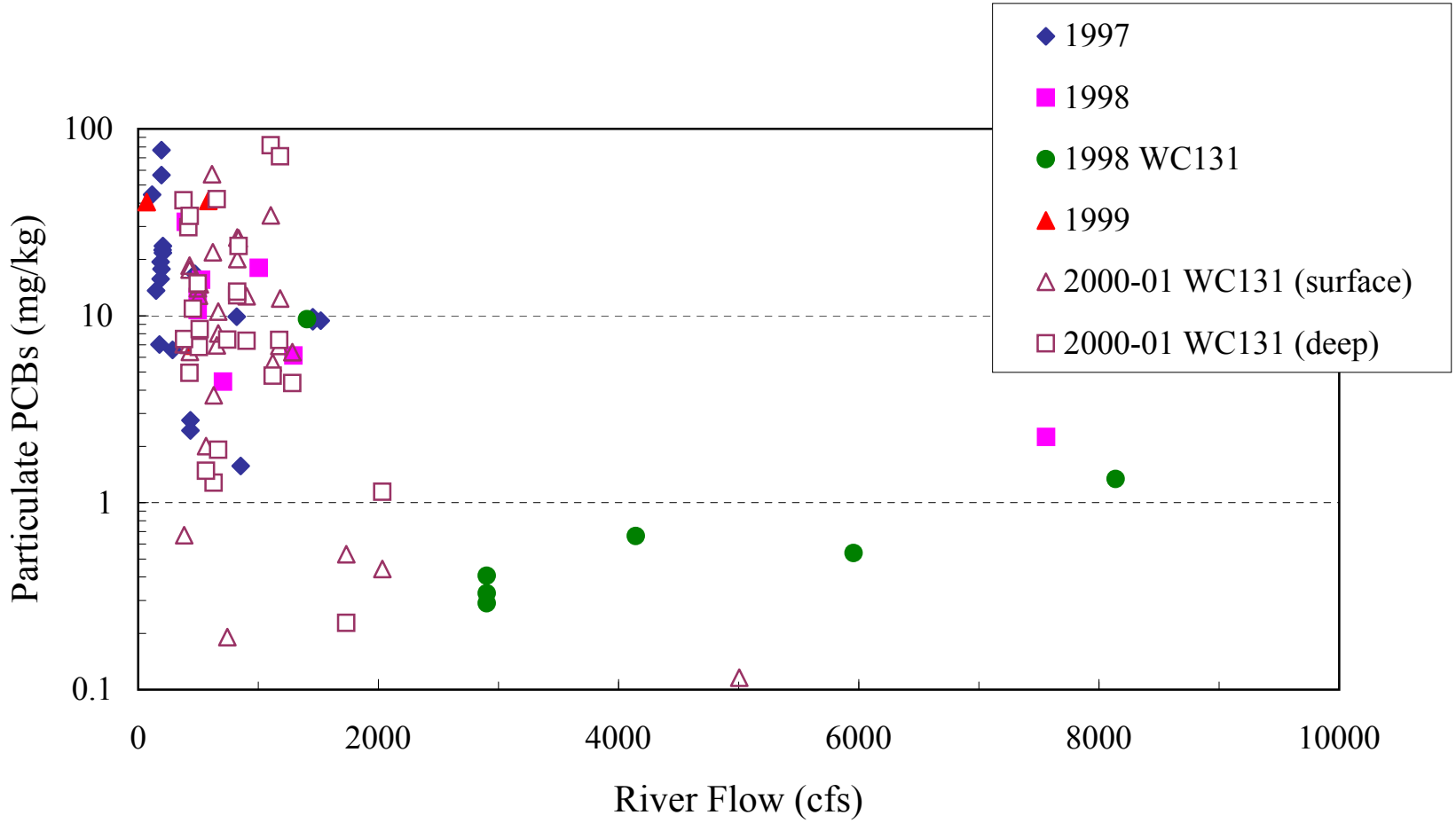


Figure 2-38. Comparison of Computed Particulate PCB Concentrations in Unfiltered Water Column Samples from Several SRS Surveys.

Water samples collected from WC007A and Route 131 Bridge during spring, summer, and fall time periods.

Data collected during 2001 Capping Pilot Study (7/23-10/9) not included.

Data tables: water_bz and water_iupac

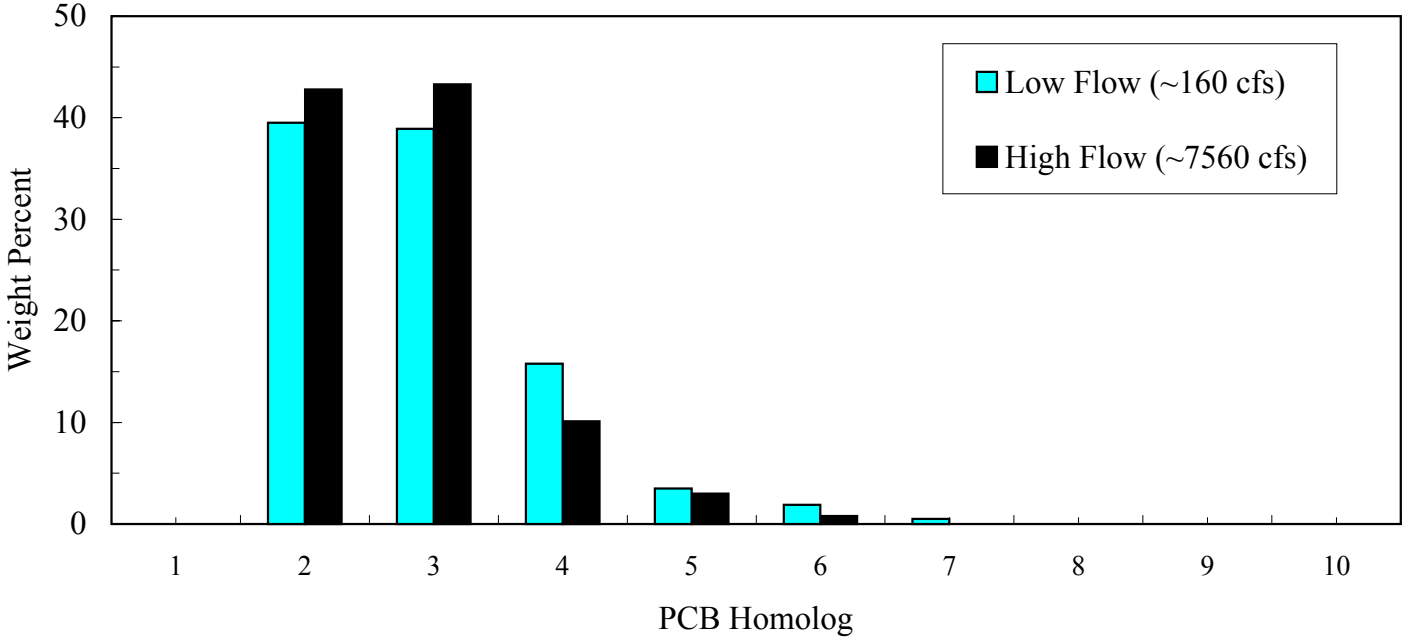


Figure 2-39. Comparison of PCB Homolog Distributions in Unfiltered Water Samples Collected During Low and High Flow Conditions.

Low flow values represent average of samples collected from Transects WC007, WC007A, WC011 and WC012 in August and September 1997.
High flow values represent average of samples collected from Transects WC007, WC007A and WC011 in March 1998.
Data table: water_bz

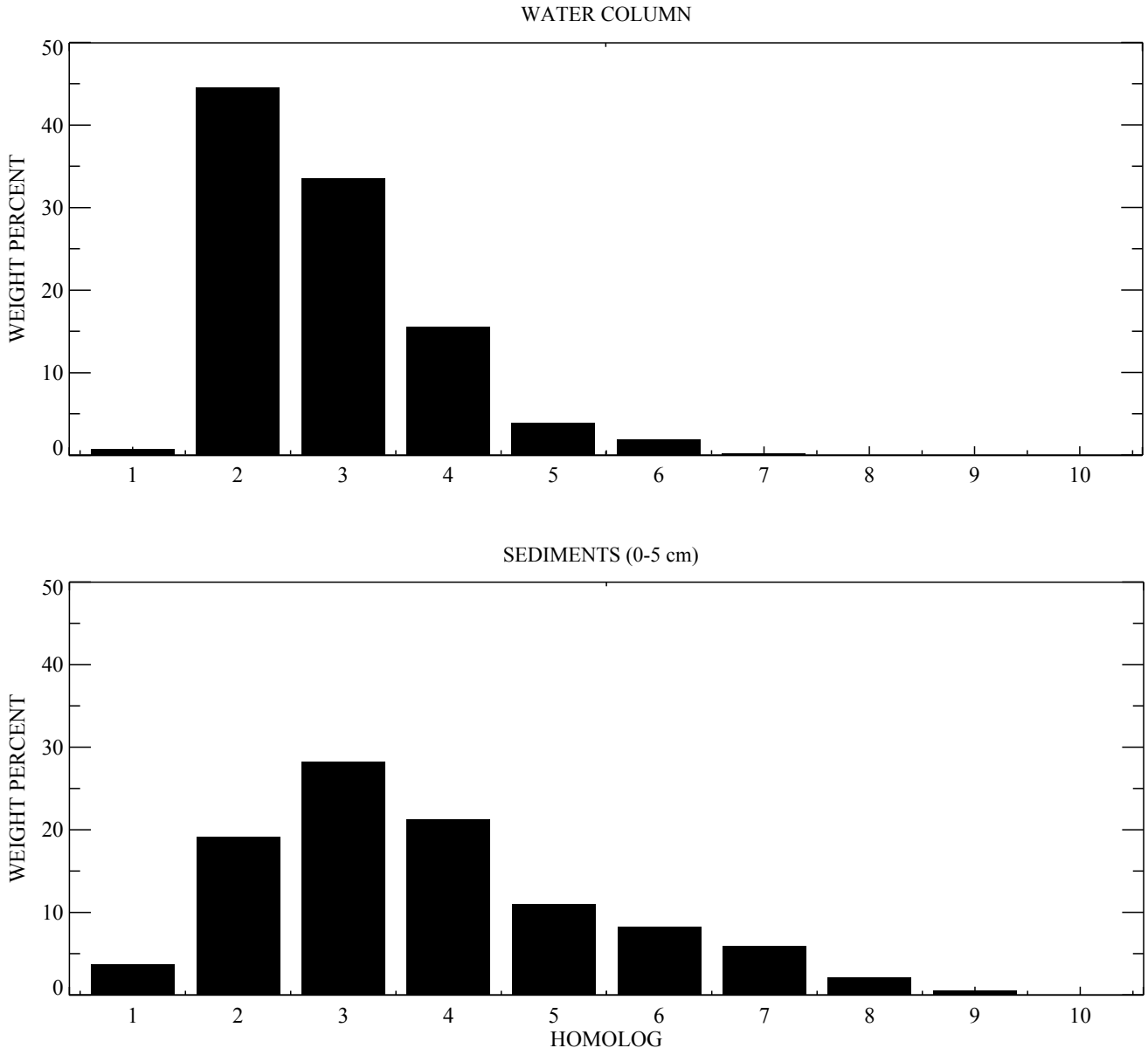


Figure 2-40. Average PCB Homolog Distributions in Water Column and Sediment (0-5 cm) Samples Collected from the Lower Grasse River.

Water column values represent average of data collected from Transects WC007, WC007A, WC011 and WC012 during non-stratified periods in 1997 (all surveys except Rounds 5, 6 and 7).

Surface sediment values represent average of PCB levels measured in the top 5 cm of the high-resolution core PCB data collected in 1997.

Data tables: water_bz and sediment_bz

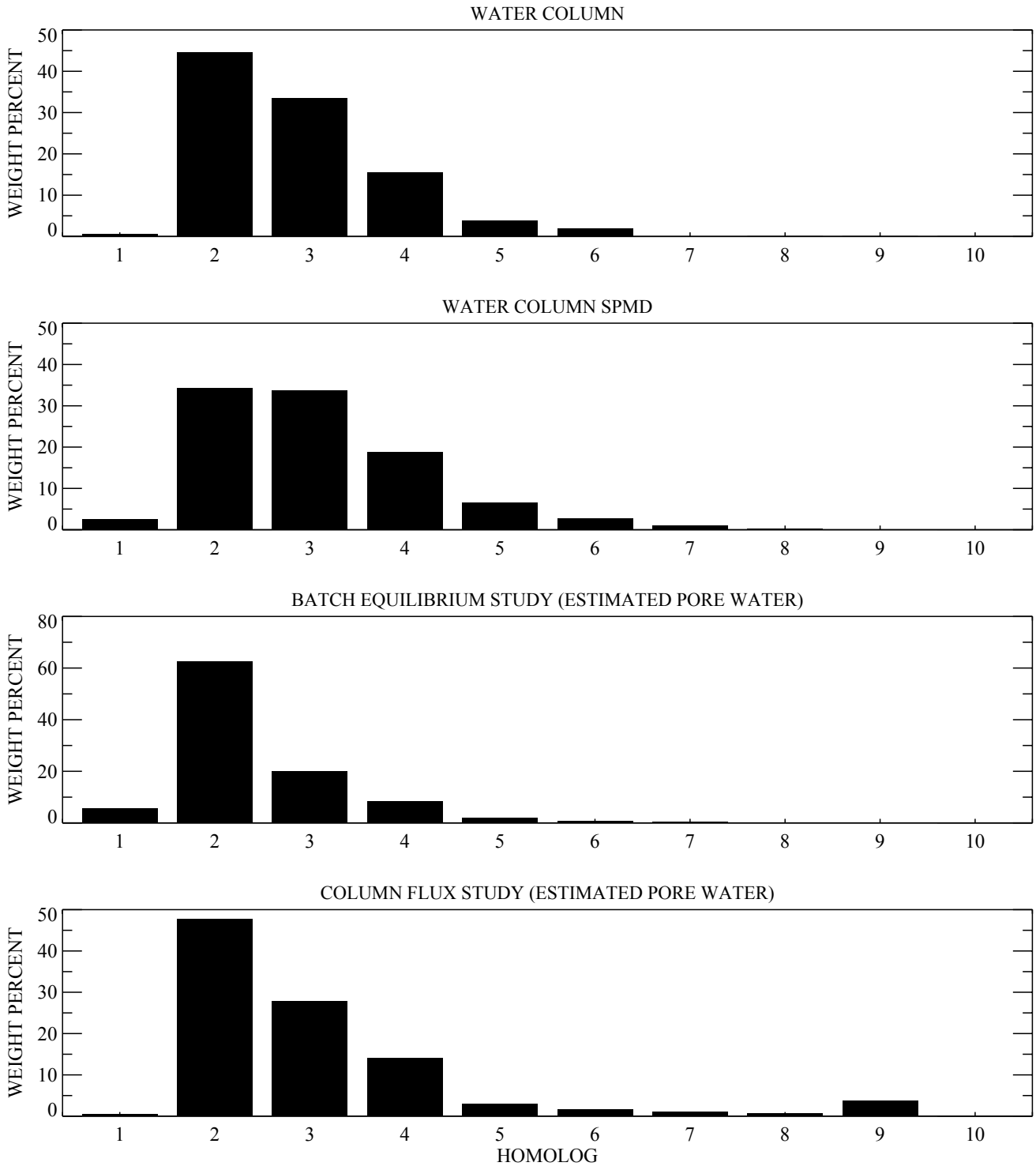


Figure 2-41. PCB Homolog Distributions in Grasse River Water and SPMD Samples and Water Samples from CMU Lab Studies.

Water column and SPMD values represent average of data collected from Transects WC007, WC007A, WC011 and WC012 during non-stratified periods in 1997 (all surveys except Rounds 5, 6 and 7).

Laboratory values represent averages of Column 2 data.

Data tables: water_bz, spmd_bz, batch_equil and column_flux

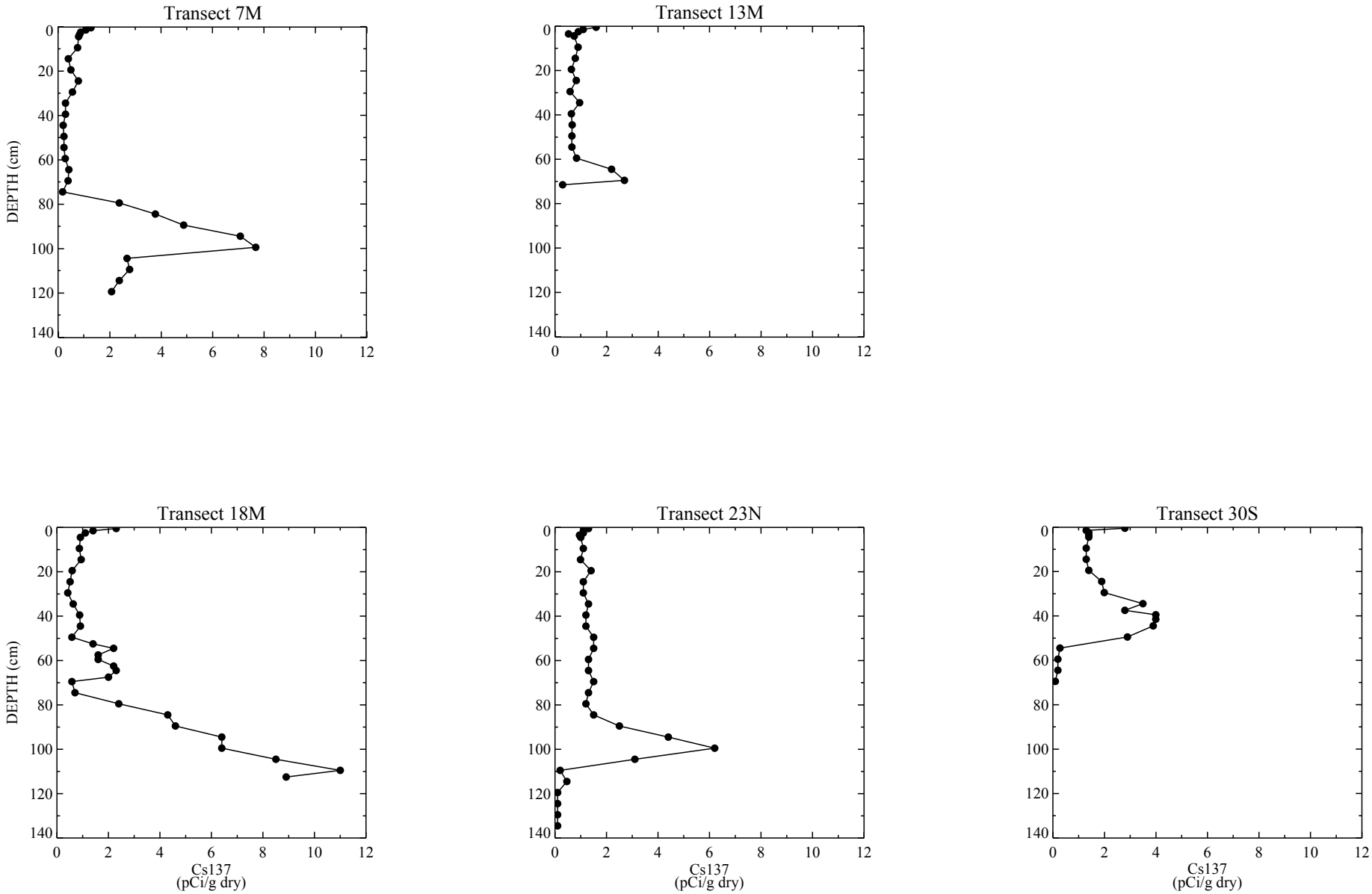


Figure 2-42. Vertical Distribution of Cesium Levels in Sediment Cores Collected from the Lower Grasse River.

Data from 1997 SRS Sediment Sampling Program.

Data table: sediment_bz

JimQ/DN - \\Jimq\D_Drive\ALCgra\Reports\AA_0102\Figures\cs_depth1.pro
Thu May 23 13:31:16 2002

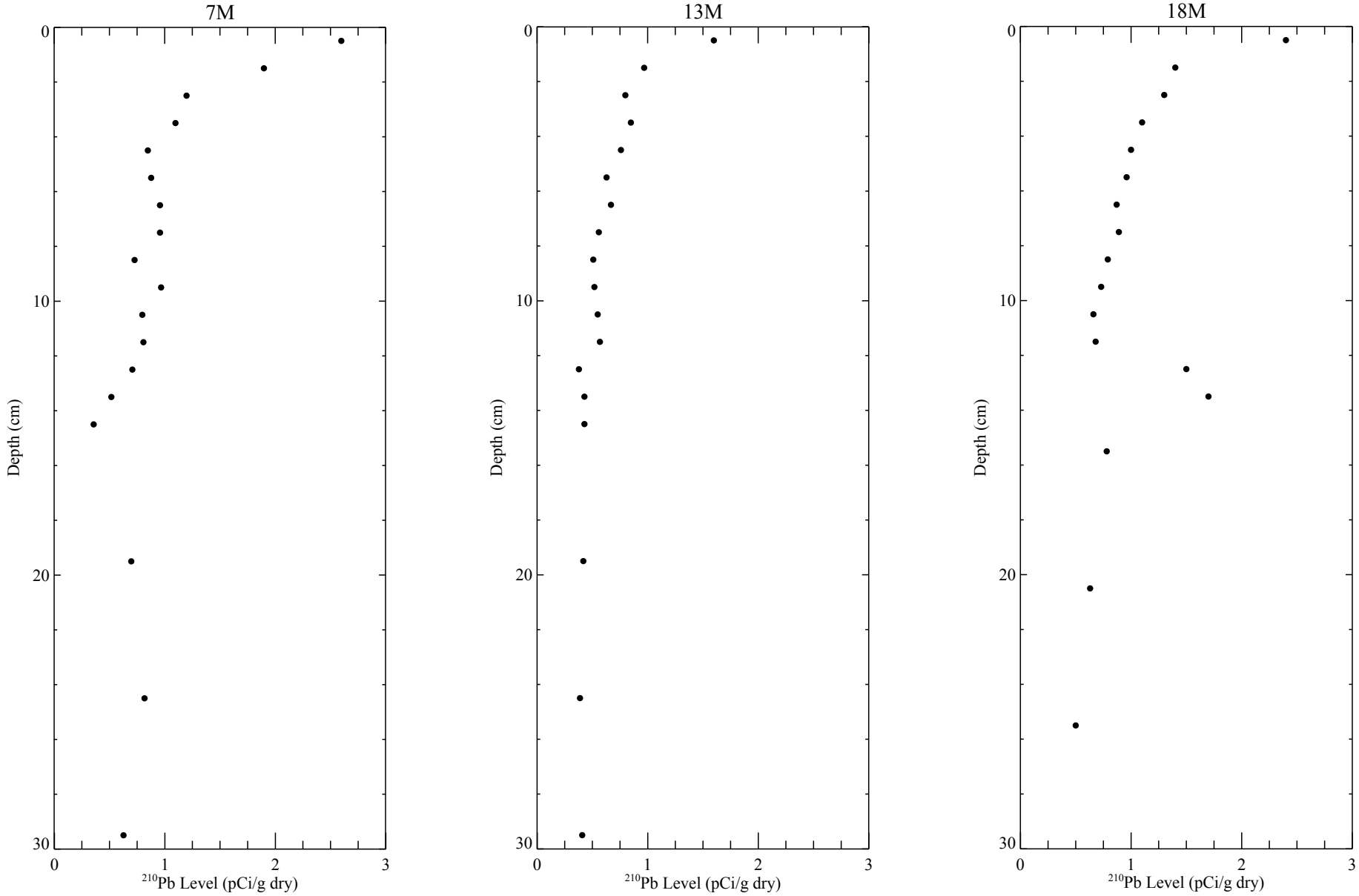


Figure 2-43. ^{210}Pb Concentrations in Lower Grasse River Sediment

Data collected during 1997 SRS Sediment Survey Program.
Circles represent measured ^{210}Pb levels.
Data table: sediment_bz

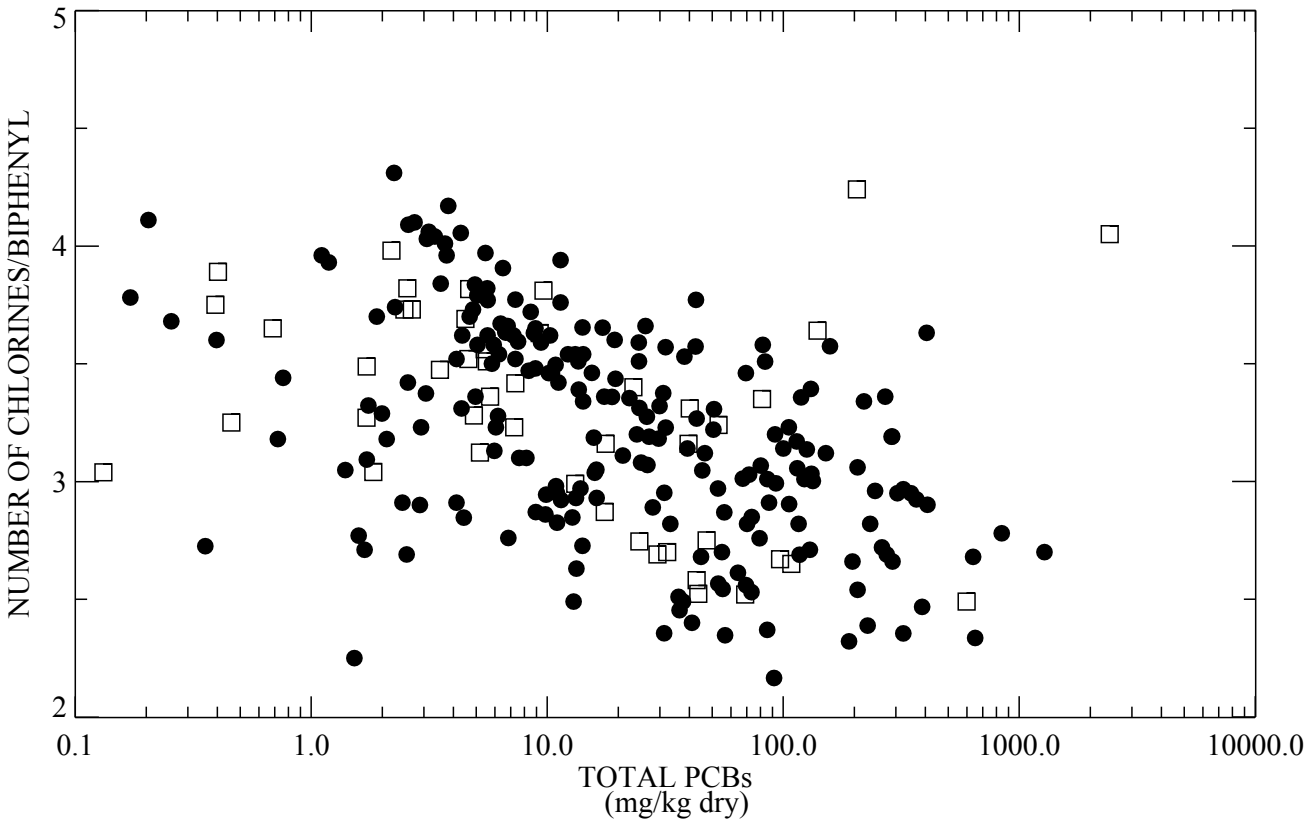


Figure 2-44. Number of Chlorines per Biphenyl and Total PCBs in Lower Grasse River Sediments.

Data collected as part of the 1997 SRS and 2000-01 SSS Programs.

Circles represent core samples.

Squares represent grab samples.

Data table: sediment_bz

Figure 2-45a
Underwater Video Still Images of ROPS Armored Cap – November 22, 2005

Figure 2-45b
Underwater Video Still Images of ROPS Armored Cap – August 4, 2006

Figure 2-45c
Underwater Video Still Images of ROPS Armored Cap – October 11, 2007

Figure 2-45d
Underwater Video Still Images of ROPS Armored Cap – October 22, 2009

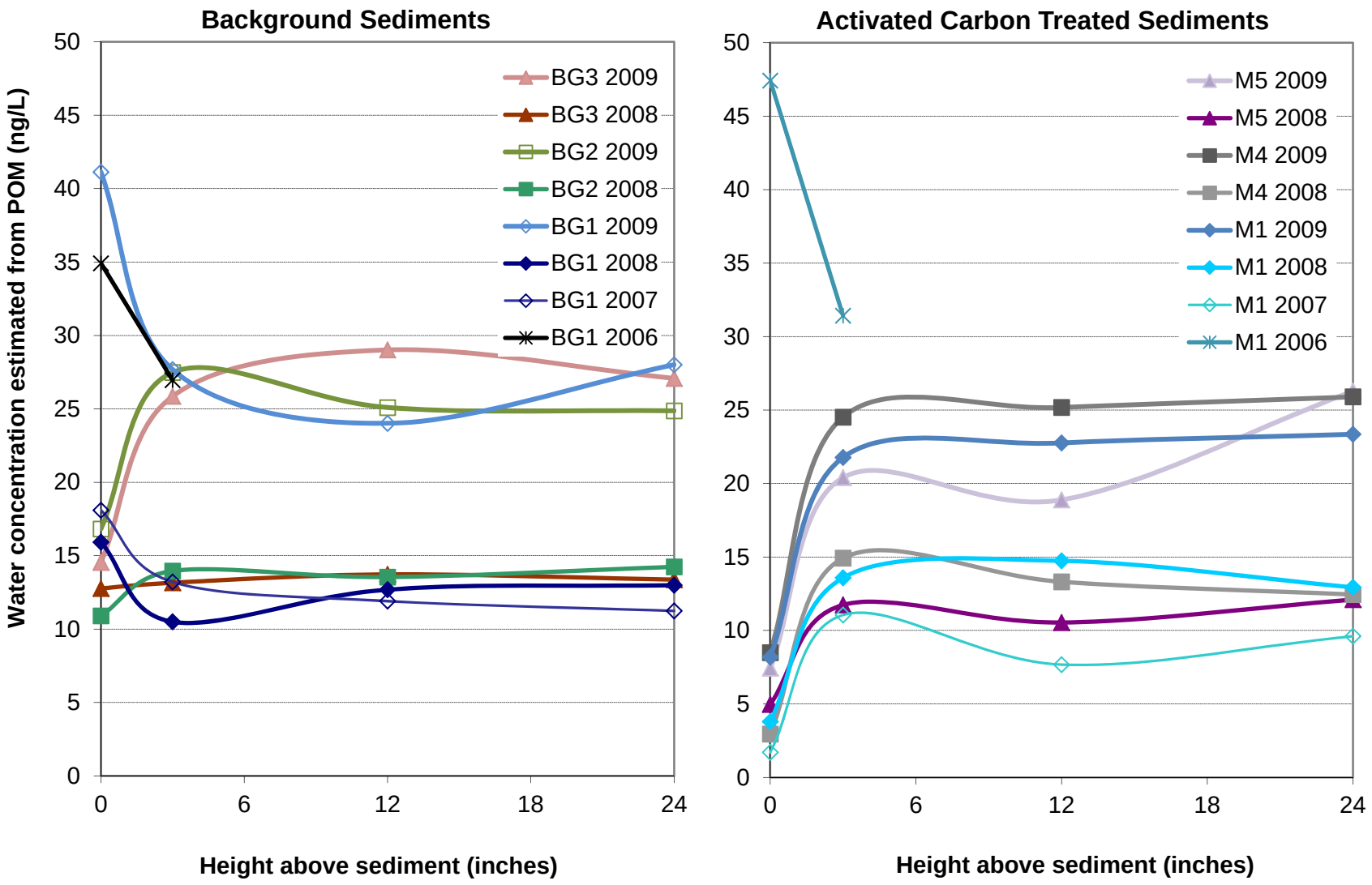
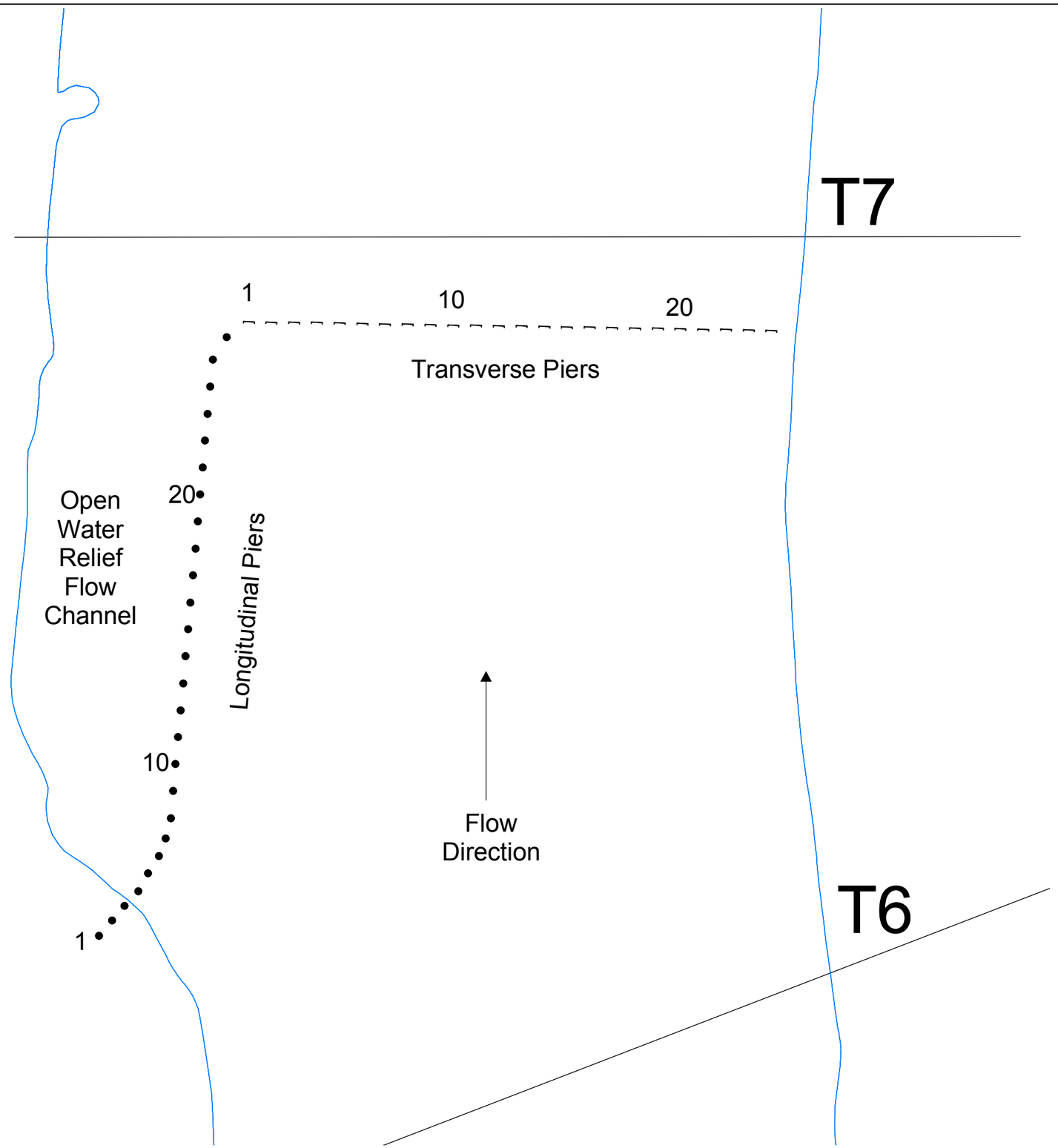


Figure 2-46. PCB Concentration in Water Estimated from Uptake in Polyoxymethylene Passive Samplers.
The samplers (strips of plastic) were deployed for 14 days in 2006, 2007, 2008 and 2009 as part of the Activated Carbon Pilot Study. They were located on the sediment surface (0”) and at various heights (3”, 12”, and 24”) in the water column above the sediment surface, attached to the deployed worm cages.



GRAPHIC SCALE

0 50 100 Feet

LEGEND

ICS Piers
- Longitudinal
- Transverse
- Grasse River Shoreline
- Sediment Probing Transects

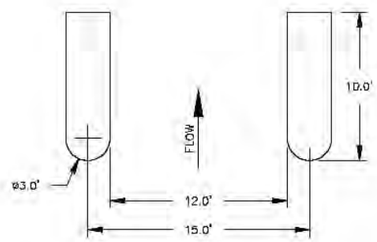
GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

Figure 2-47.
Plan View of T6.75
ICS Configuration

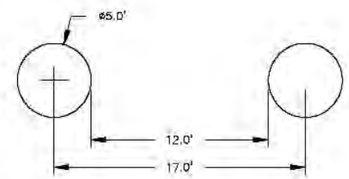
ALCOA

Aug 2007

\\Adrianne\D_Drive\ALCgra\Analysis\ICS\GIS\ICS_T675_070726.mxd



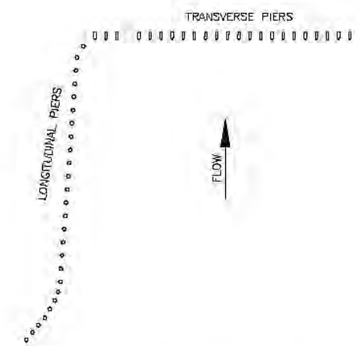
TRANSVERSE PIERS



LONGITUDINAL PIERS

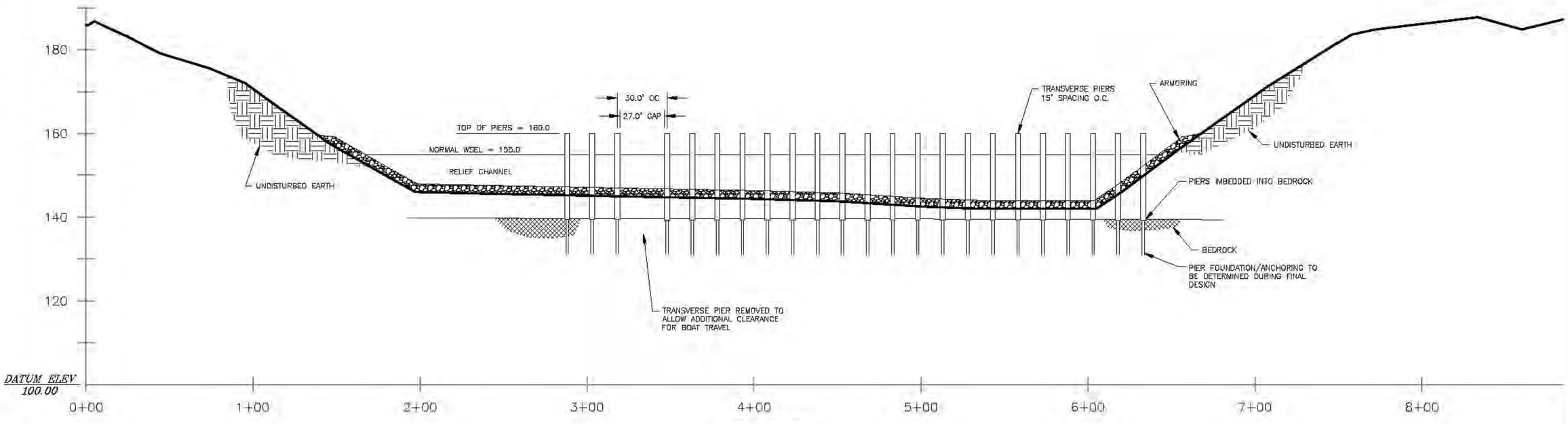
ICS PIER CONFIGURATION

1"=10'



ICS PIER ARRANGEMENT

1"=200'



PROFILE

SCALE IN FEET

60 0 60 120 HORIZ.

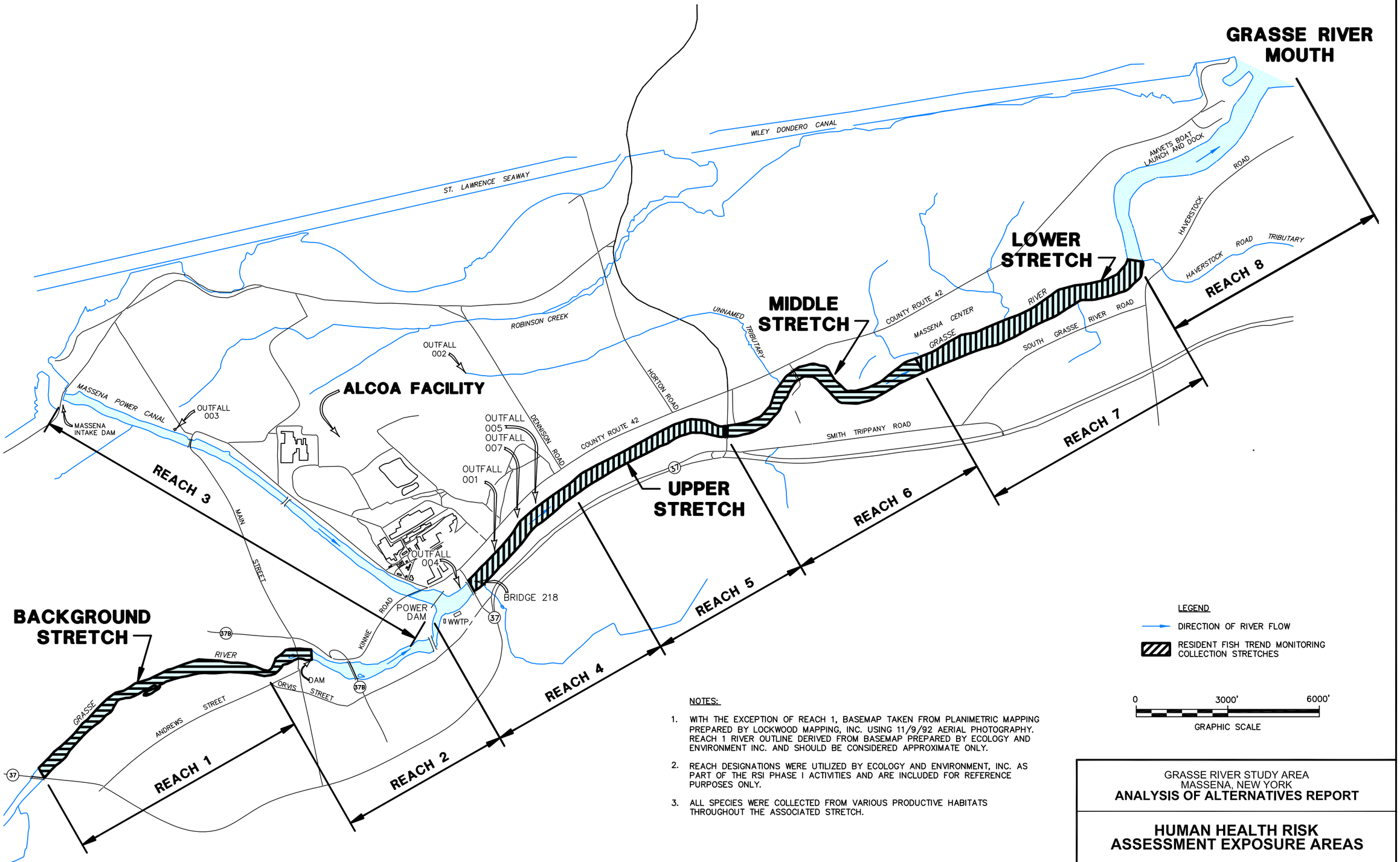
24 0 24 48 VERT.

Grasse River - Massena, New York

ICE CONTROL STRUCTURE
CONCEPTUAL PROFILE AT TRANSECT T-6.75

FIGURE 2-48.

L:\1902-Alcoa\46108 - Ice Control-Grasse River\engineering analysis report\REV FOR BODR\ Figure 3-8 08/16/07 11:39 Koskiar XREFS: 11x17 SHBD



NOTES:

1. WITH THE EXCEPTION OF REACH 1, BASEMAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY. REACH 1 RIVER OUTLINE DERIVED FROM BASEMAP PREPARED BY ECOLOGY AND ENVIRONMENT INC. AND SHOULD BE CONSIDERED APPROXIMATE ONLY.
2. REACH DESIGNATIONS WERE UTILIZED BY ECOLOGY AND ENVIRONMENT, INC. AS PART OF THE RSI PHASE I ACTIVITIES AND ARE INCLUDED FOR REFERENCE PURPOSES ONLY.
3. ALL SPECIES WERE COLLECTED FROM VARIOUS PRODUCTIVE HABITATS THROUGHOUT THE ASSOCIATED STRETCH.

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK
ANALYSIS OF ALTERNATIVES REPORT

HUMAN HEALTH RISK ASSESSMENT EXPOSURE AREAS

ALCOA

FIGURE
3-1

CITY: SYRACUSE DIV/GROUP: ENVCAD DB: G. STOWELL L. FORAKER LD: PIC: H. VANDEWALKER PM: H. VANDEWALKER TM: S. HILL LYR: ON=*; OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0010875\0000\00001\DWG\AOA\R\DATA\10875G02.DWG LAYOUT: 3-1 SAVED: 3/22/2012 8:36 AM ACADVER: 18.1S (LMS TECH) PAGESETUP: C-LB-PDF PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/22/2012 8:36 AM BY: FORAKER, LYDIA
XREFS: 10875X01 IMAGES: 10875X01.TIF PROJECTNAME: ---

Procedure for Calculating SLWA

1. Determine the segment length **(d)** for each segment by subtracting its start depth **(a)** from its end depth **(b)**. That is, **(d) = (b) - (a)**.

2. Compute the weighted total PCB concentration for each segment **(e)** by multiplying the total PCB concentration for that segment **(c)** by its segment length **(d)**. That is, **(e) = (c)** x **(d)**. For complete cores, repeat this calculation for each segment located above the identified depth of contamination. For incomplete cores, repeat this calculation for all recovered/sampled segments.

3. Determine the total length of contaminated sediment **(f)** by summing the individual segment lengths **(d)** for segments above the depth of contamination. For incomplete cores, the total length of contaminated sediment is the depth of the recovered/sampled sediments. That is, for Example (1) below, **(f)** = $(d_{0\text{-}3})$ + $(d_{3\text{-}6})$ + $(d_{6\text{-}12})$.

4. Determine the total segment weighted PCB concentration **(g)** by summing the individual segment values **(e)** for segments above the depth of contamination. For incomplete cores, the total segment weighted PCB concentration is the sum of all values full depth of the recovered sediments. That is, for Example (1) below, **(g)** = $(e_{0\text{-}3})$ + $(e_{3\text{-}6})$ + $(e_{6\text{-}12})$.

5. Compute the SLWA PCB concentration **(h)** by dividing the sum of the segment weighted total PCB concentrations **(g)** by the total length of contaminated sediment **(f)**. That is, **(h) = (g) ÷ (f)**.

(a) COMPLETE CORE - Core T10.5-MCN (2006 Phase 1 Vibracoring)

---------- REPORTED VALUES ----------			-------- CALCULATED VALUES ----------	
(a) Start Depth (inches)	**(b)** End Depth (inches)	**(c)** Total PCBs (mg/kg)	**(d)** Segment Length (inches)	**(e)** Total PCBs x Segment Length
0	3	25.21	3	75.63
3	6	4.35	3	13.06
6	12	7.25	6	43.47
12	18	0.06	Below depth of contamination, therefore not used in calculations	
18	24	0.03		

Depth of contamination (depth to which total PCBs reach and remain below 1 mg/kg)

Bottom of core

Total length of contaminated sediment **(f)**: 12

Sum of segment weighted total PCBs **(g)**: 132.16

SLWA PCB concentration **(h)**: **11.01**

(b) INCOMPLETE CORE - Core T14-SSS (2006 Phase 1 Vibracoring)

---------- REPORTED VALUES ----------			-------- CALCULATED VALUES ----------	
(a) Start Depth (inches)	**(b)** End Depth (inches)	**(c)** Total PCBs (mg/kg)	**(d)** Segment Length (inches)	**(e)** Total PCBs x Segment Length
0	3	16.27	3	48.81
3	6	5.70	3	17.09
6	10	4.78	4	19.12
10	16	4.38	6	26.28

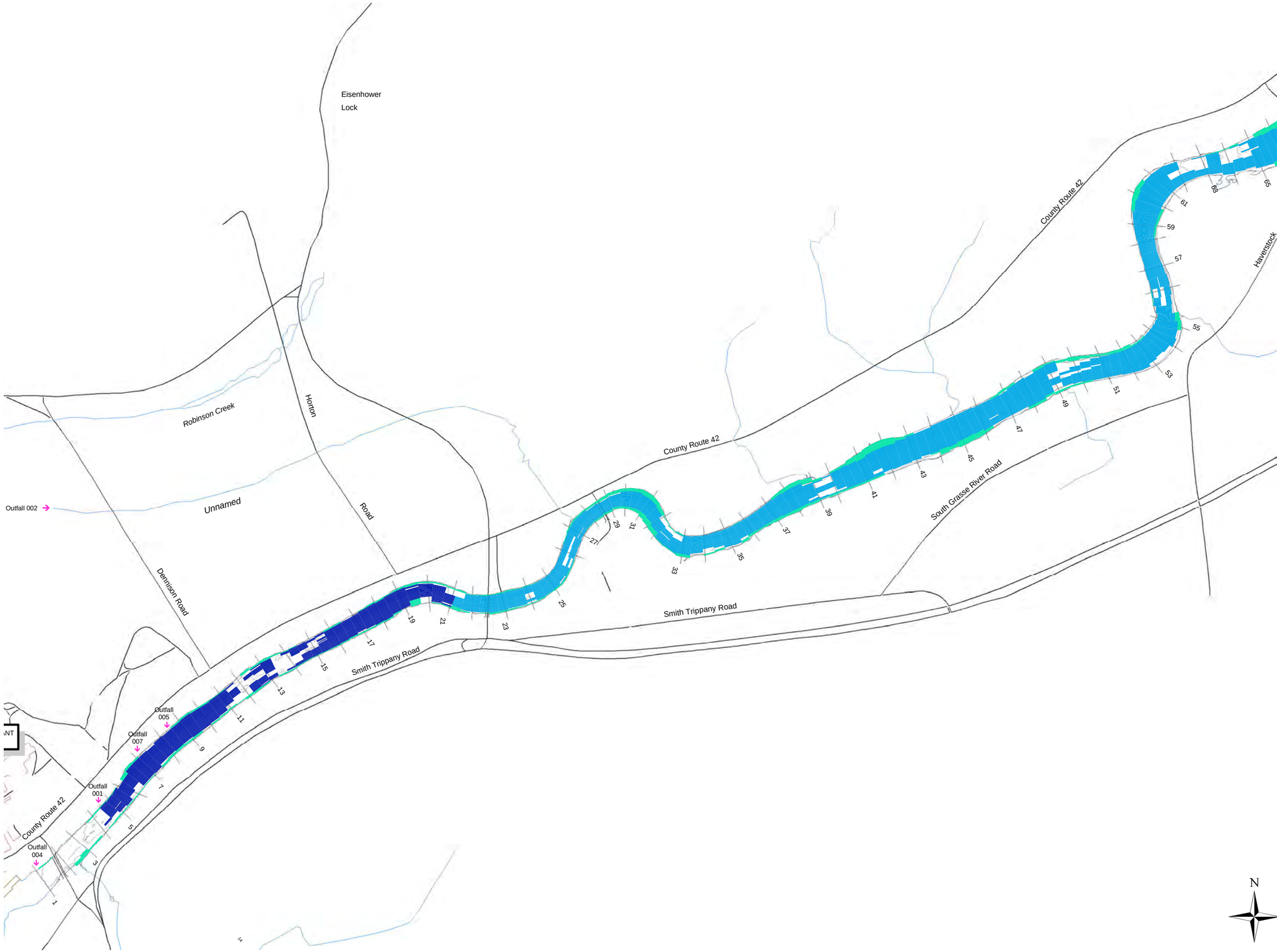
Bottom of core

Total length of contaminated sediment **(f)**: 16

Sum of segment weighted total PCBs **(g)**: 111.30

SLWA PCB concentration **(h)**: **6.96**

Figure 4-1. Example Calculation of Segment Length-Weighted Average (SLWA) PCB Concentration for (a) Complete and (b) Incomplete Cores.



GRAPHIC SCALE

0 850 1,700 3,400 Feet

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-2
Alternative 3:
T1-T72 Capping

N

ALCOA

May 2012

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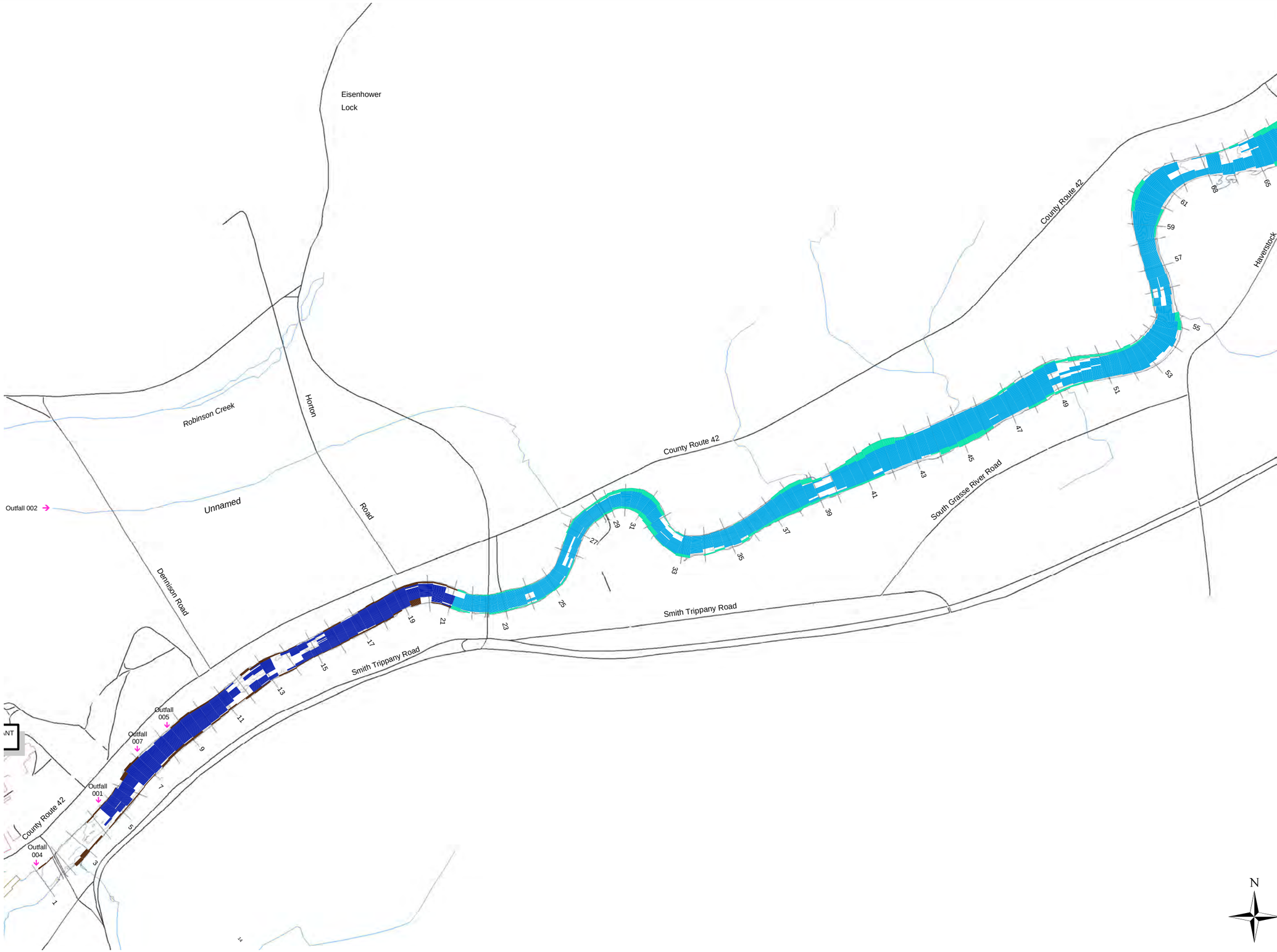

GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-3
Alternative 4:
T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping

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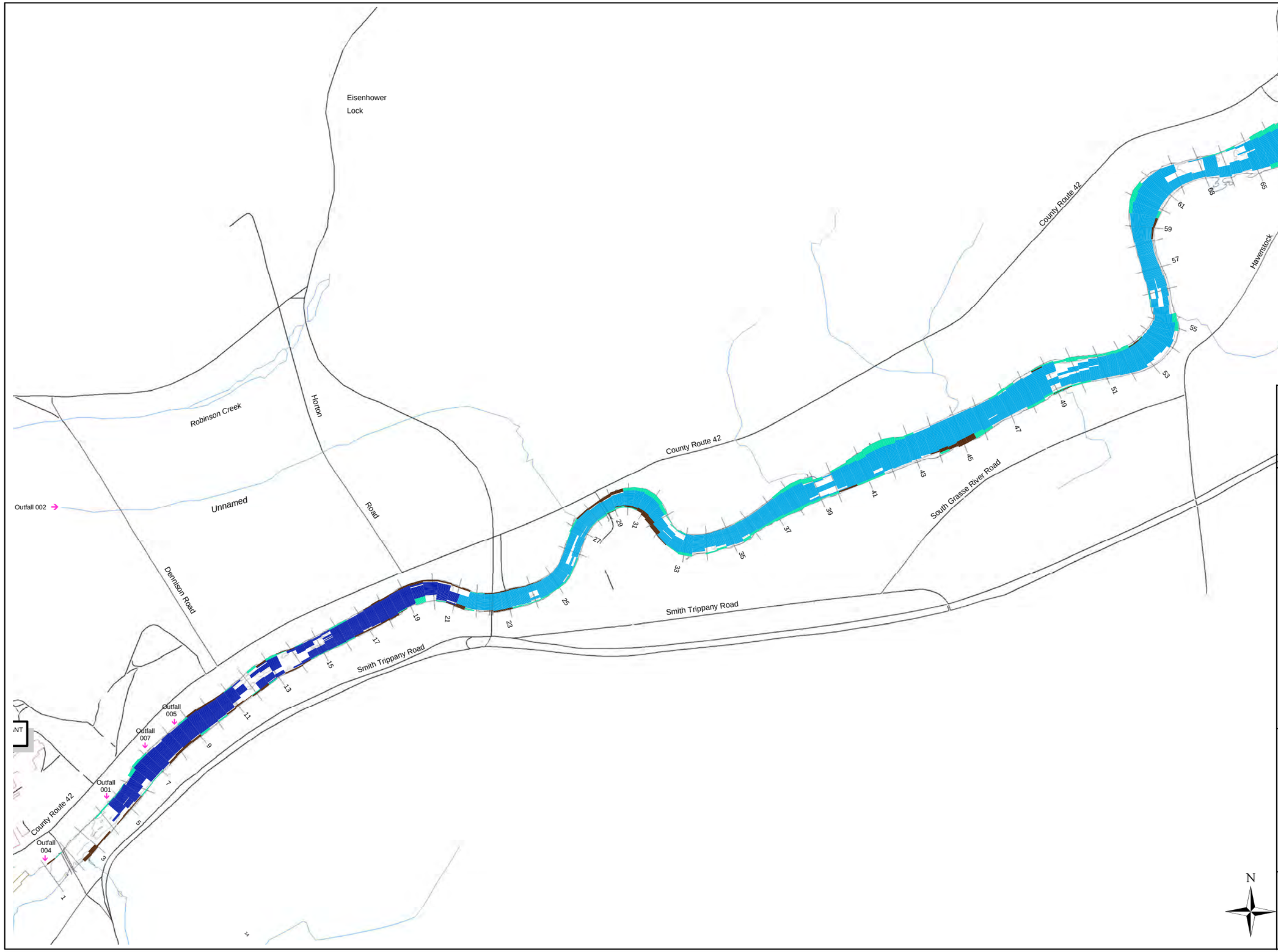

GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-4
Alternative 5:
T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping

N

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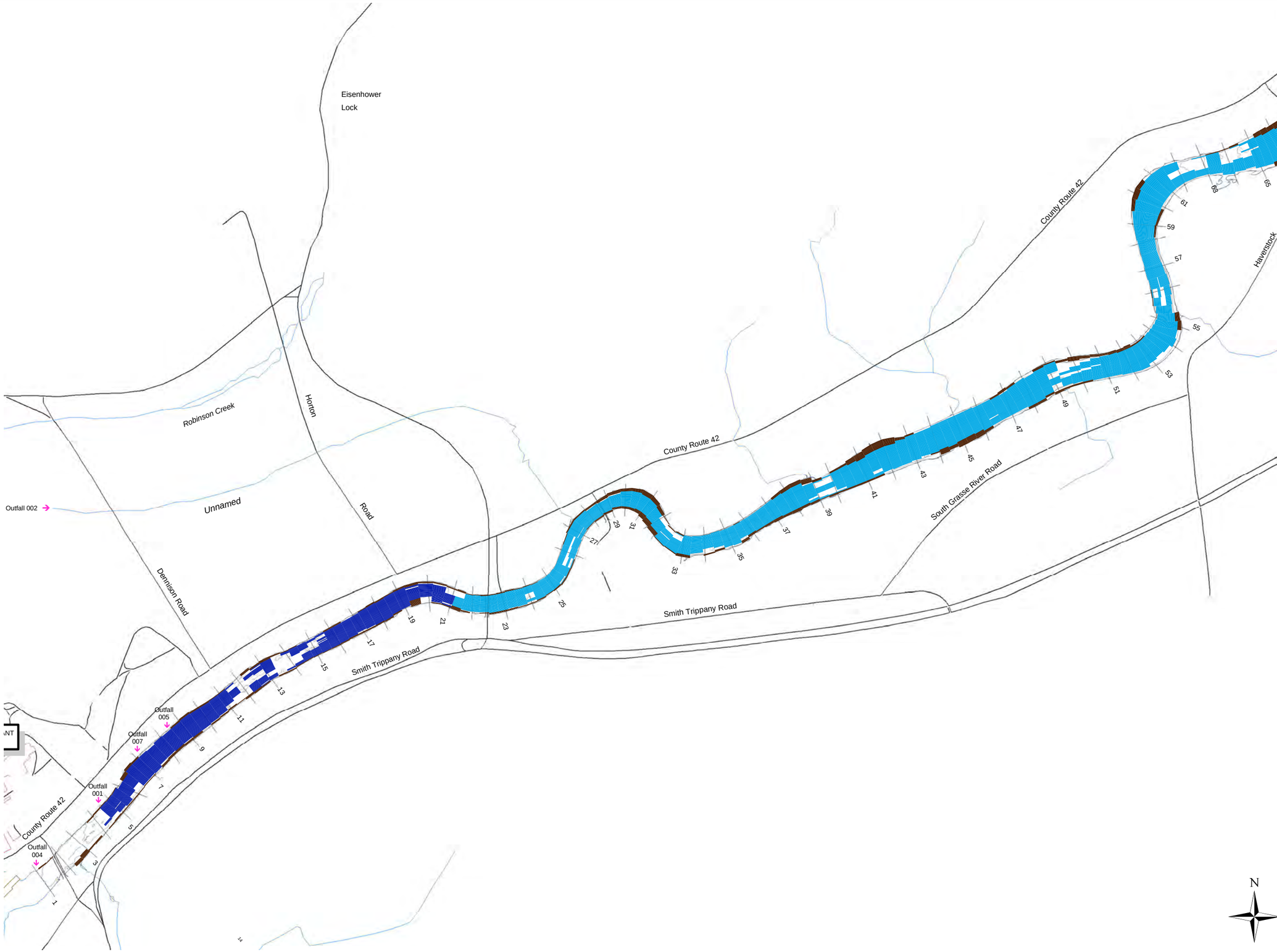

GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-5
Alternative 6:
T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping

N

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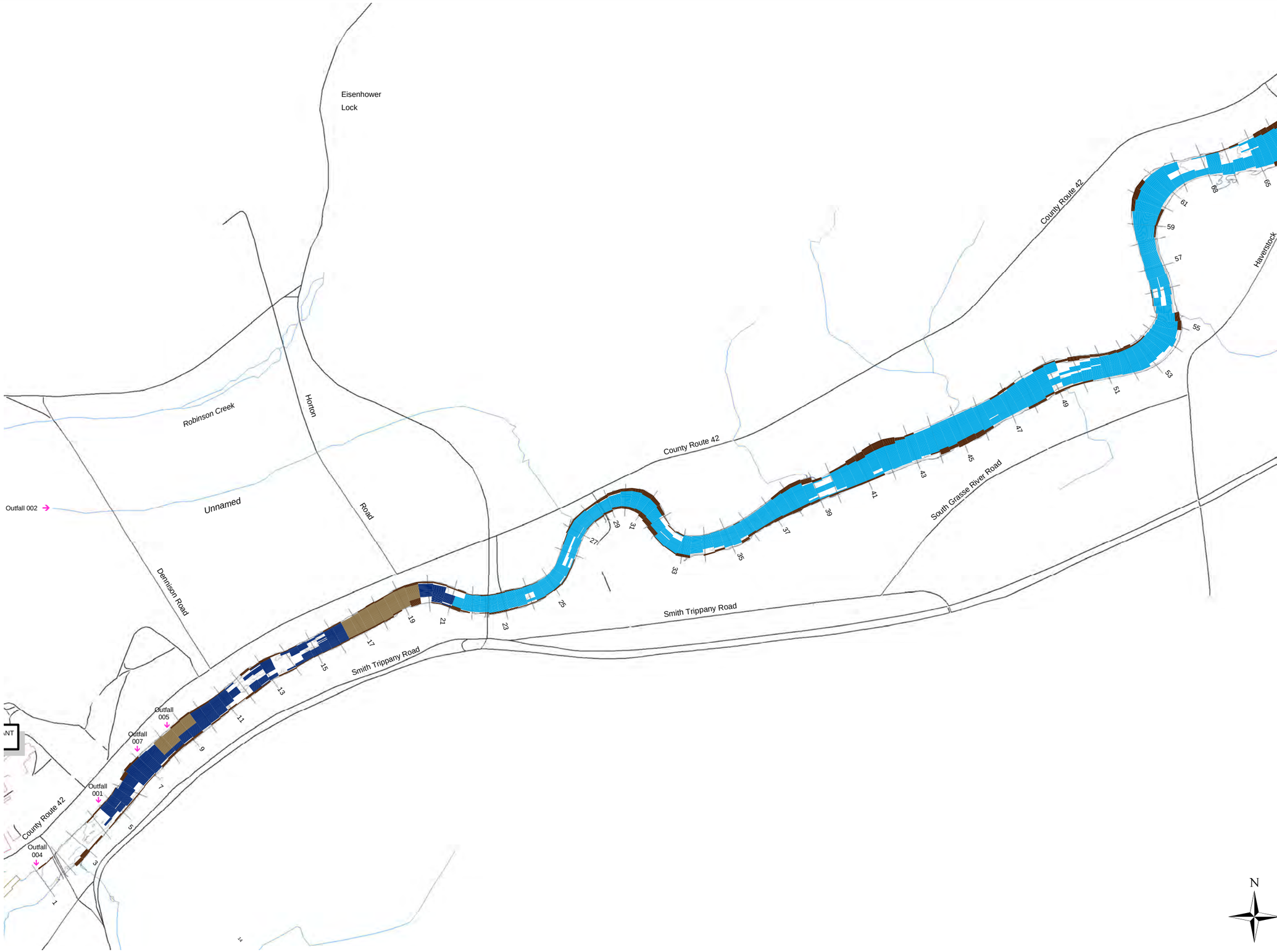

GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-6
Alternative 7:
T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping

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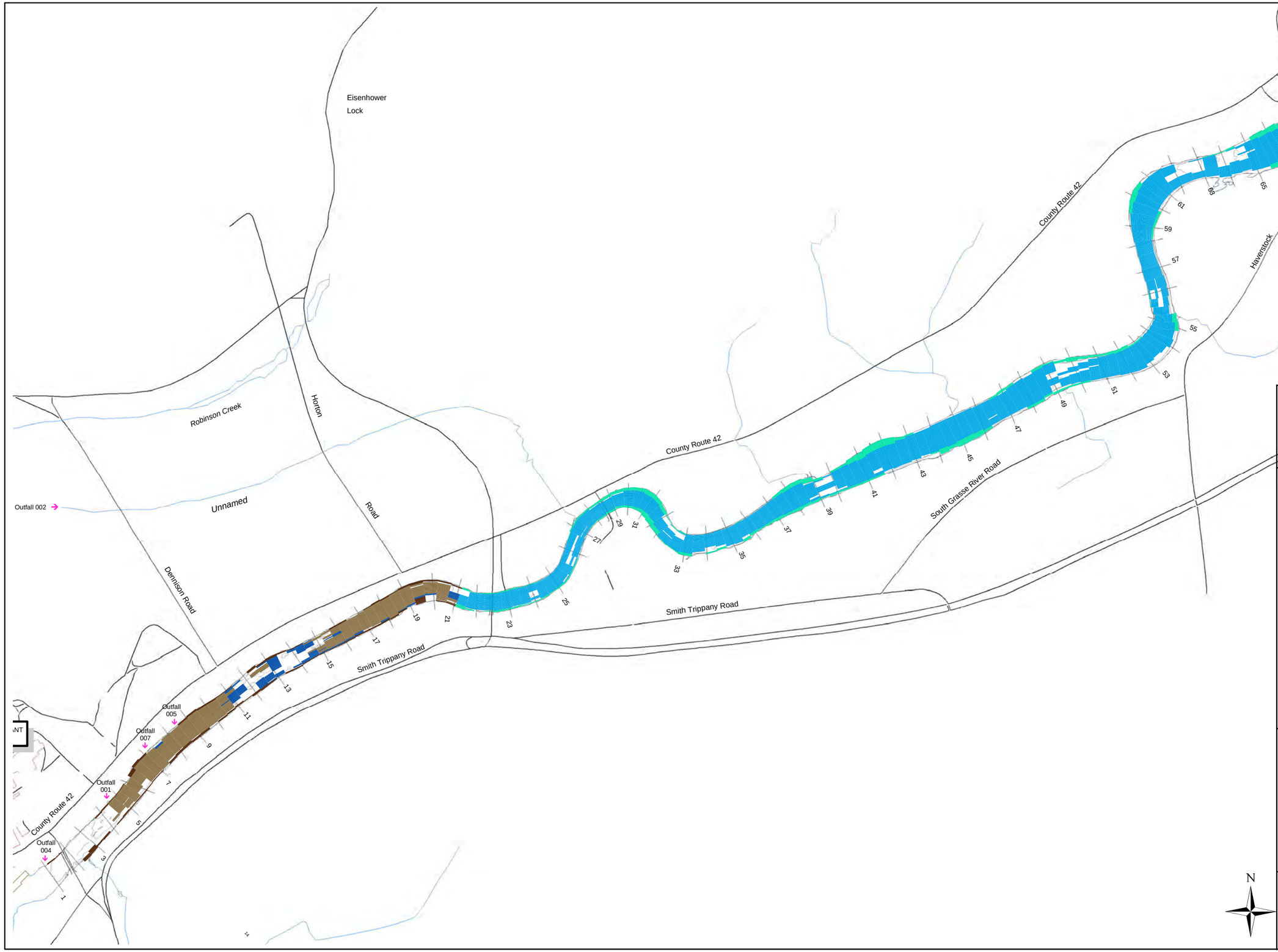

GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-7
Alternative 8:
T1-T21 Dredging/Capping,
T21-T72 Capping

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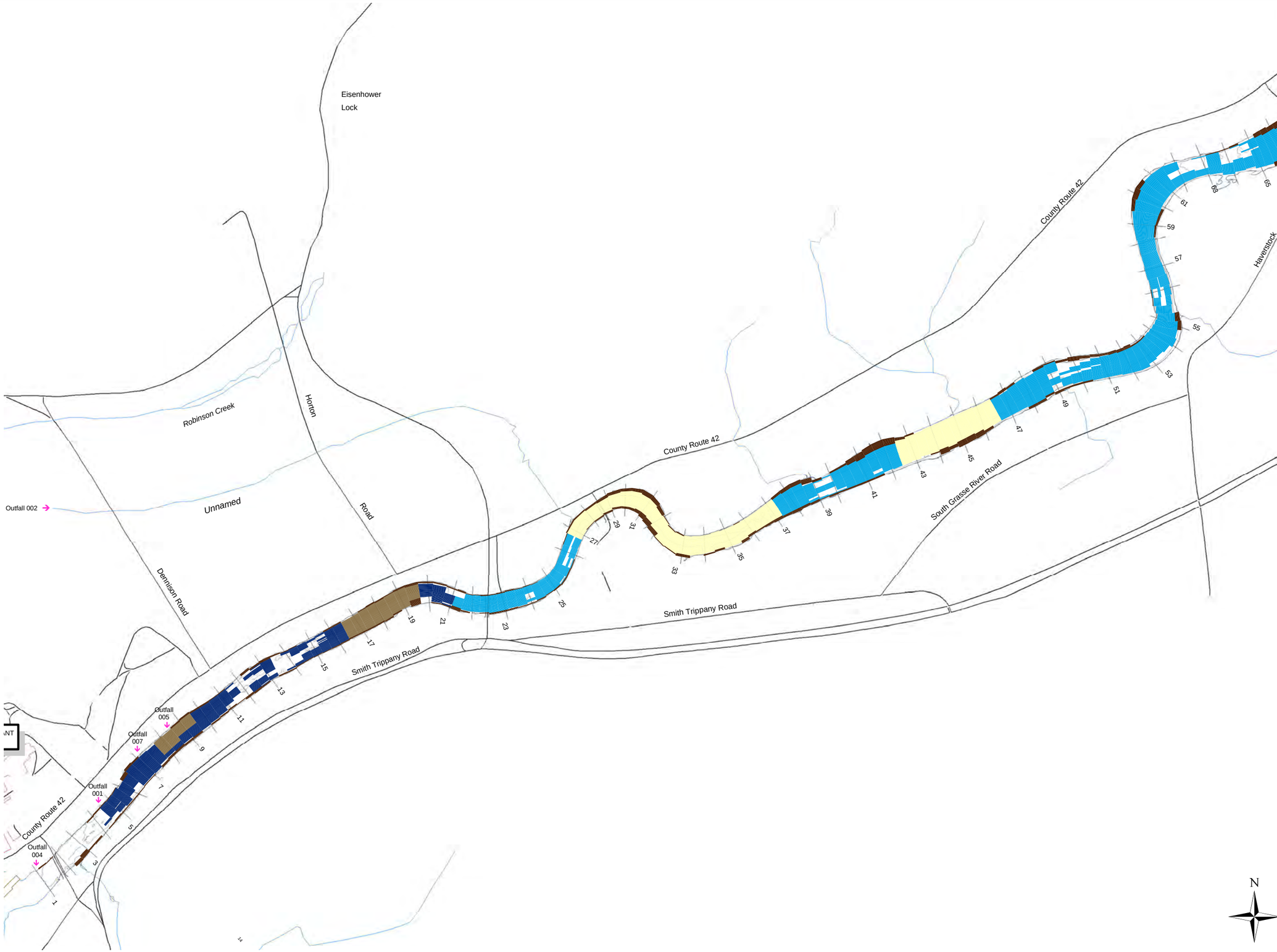

GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-8
Alternative 9:
T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping

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GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure 4-9
Alternative 10:
T1-T72 Dredging/Capping

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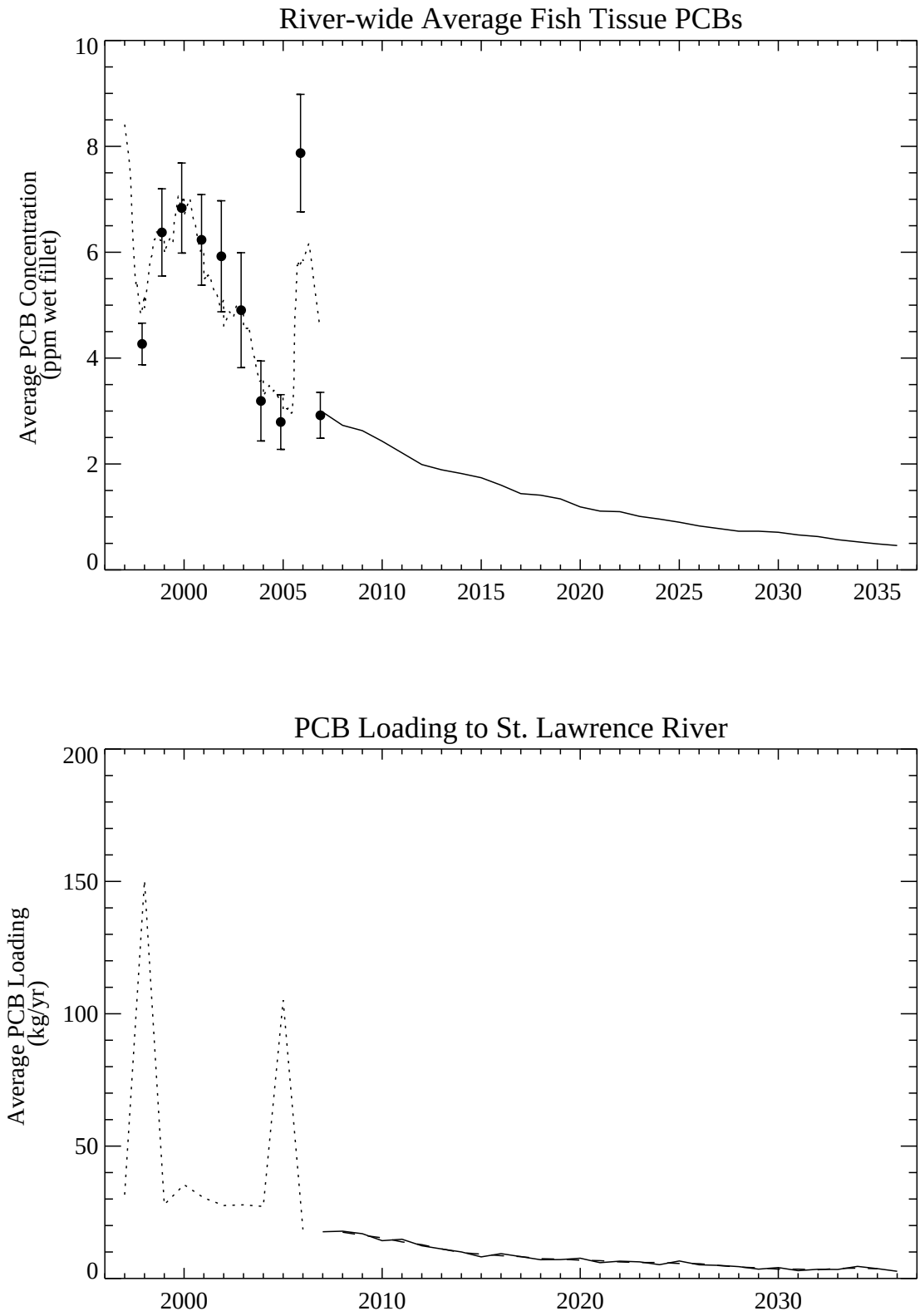

Figure 5-1. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternatives 1: No Further Action and 2: Monitored Natural Recovery.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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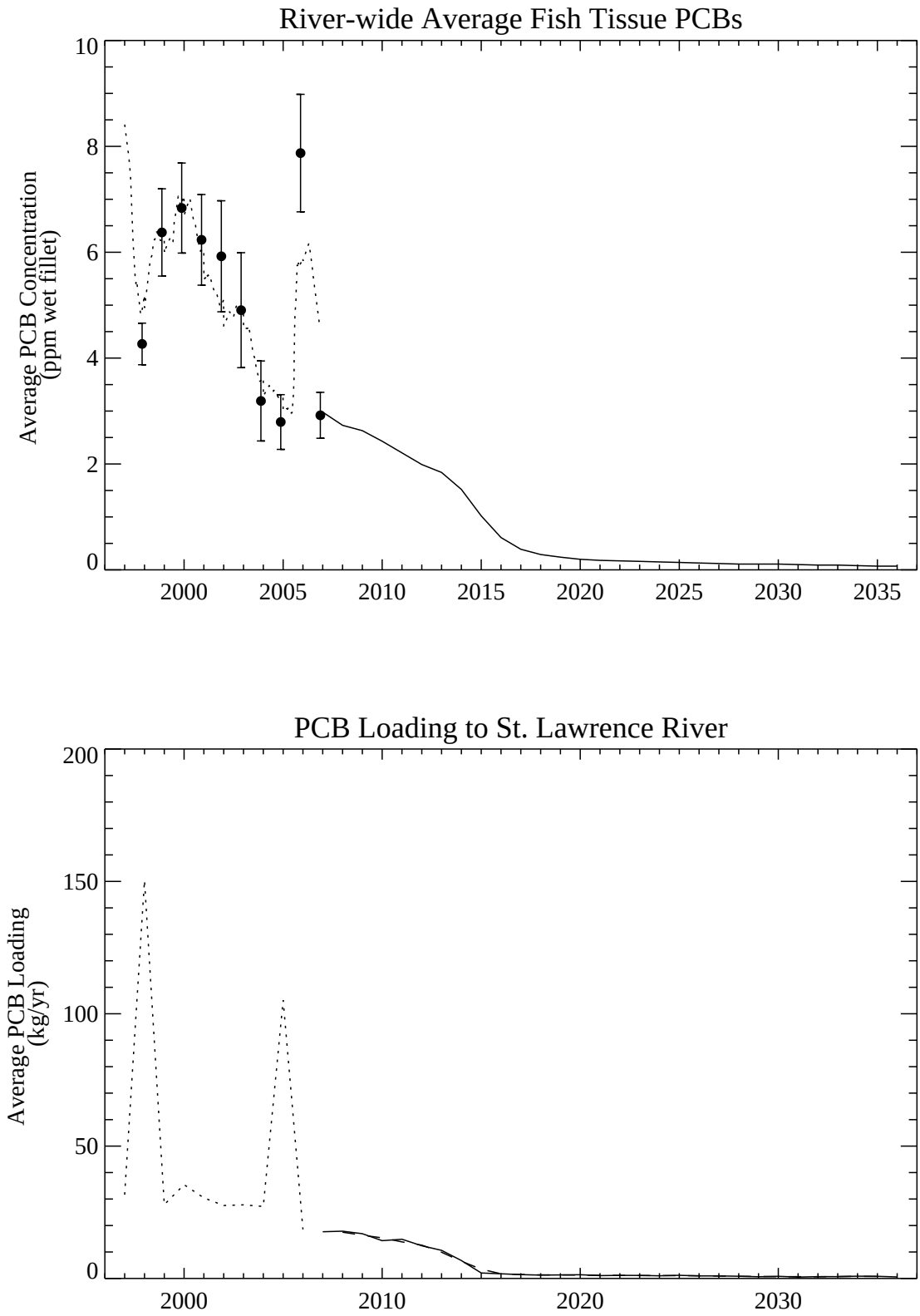

Figure 5-2. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 3: T1-T72 Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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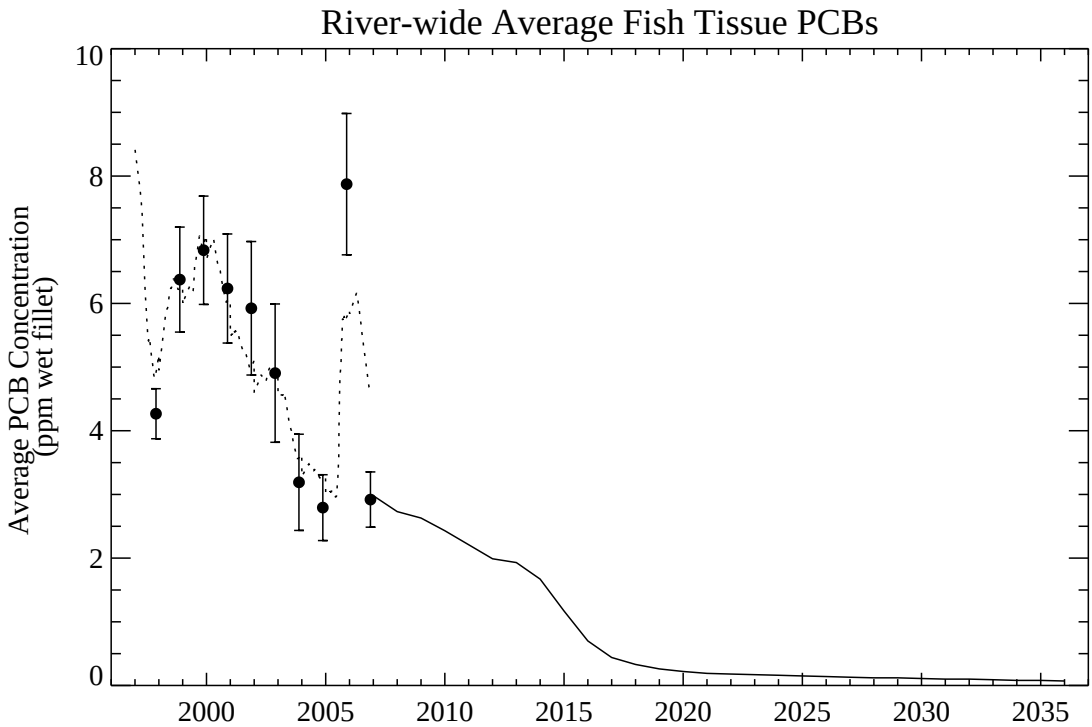

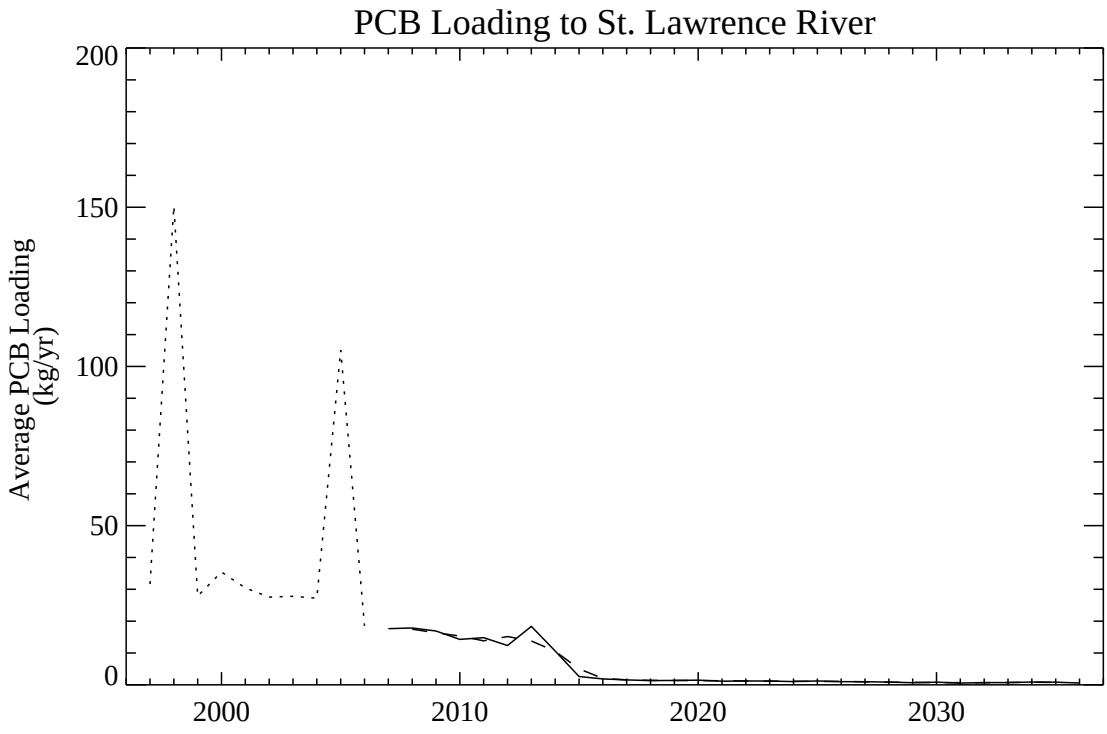

Figure 5-3. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 4: T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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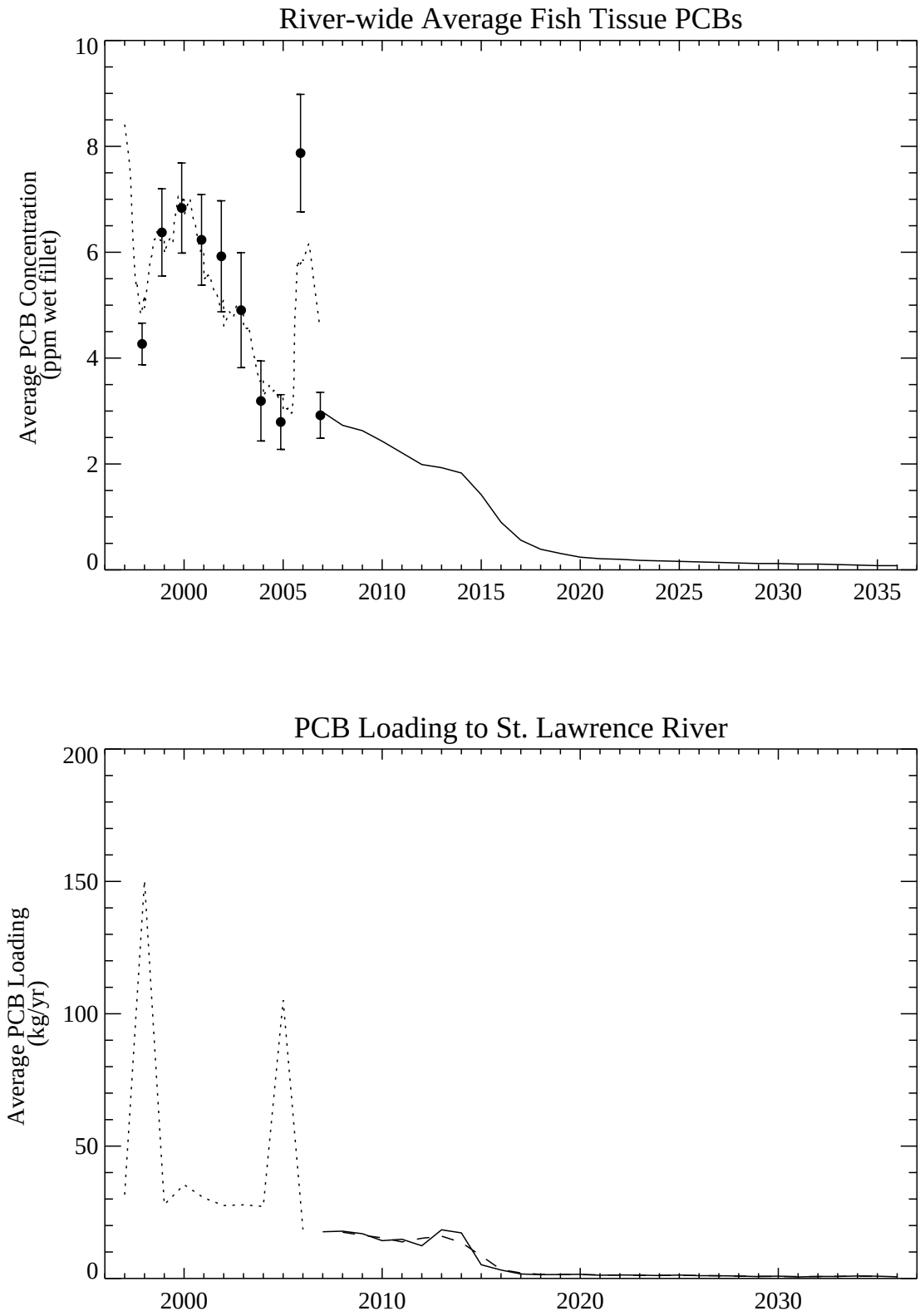
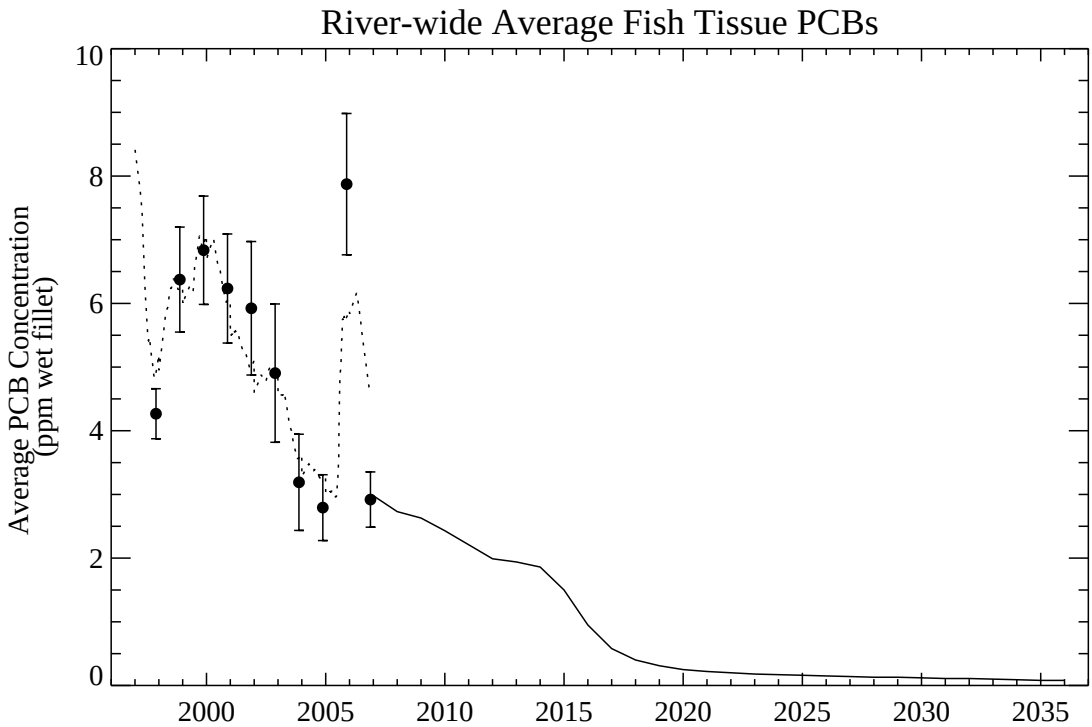


Figure 5-4. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 5: T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.



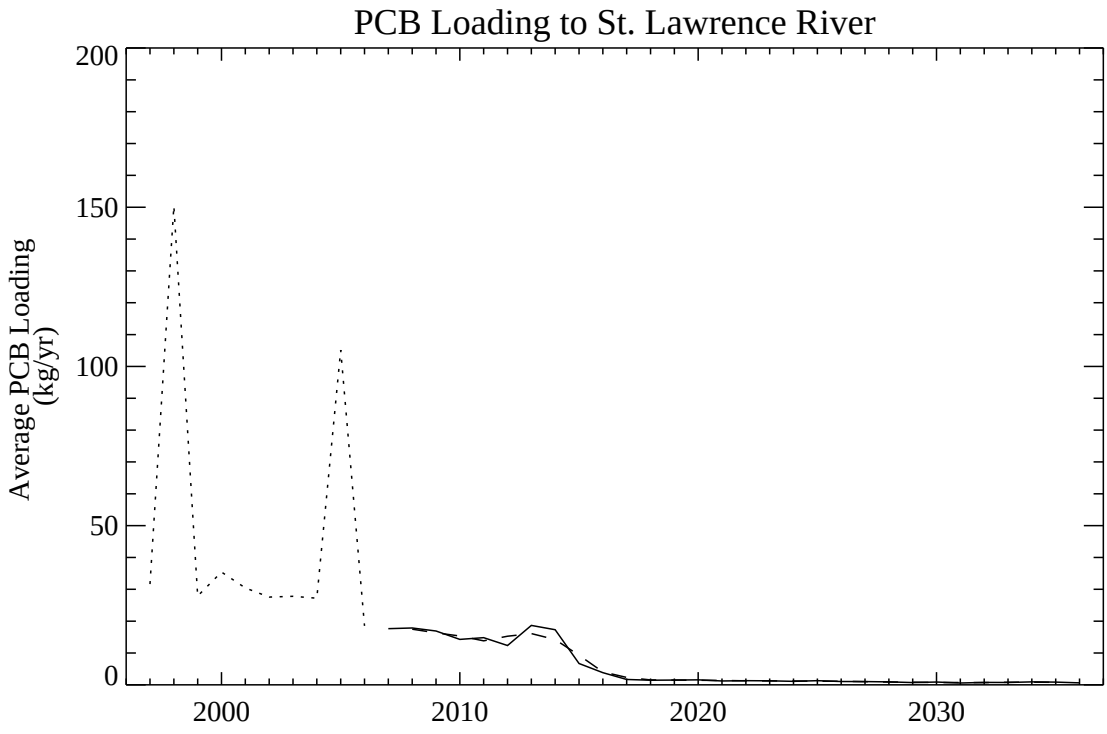


Figure 5-5. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 6: T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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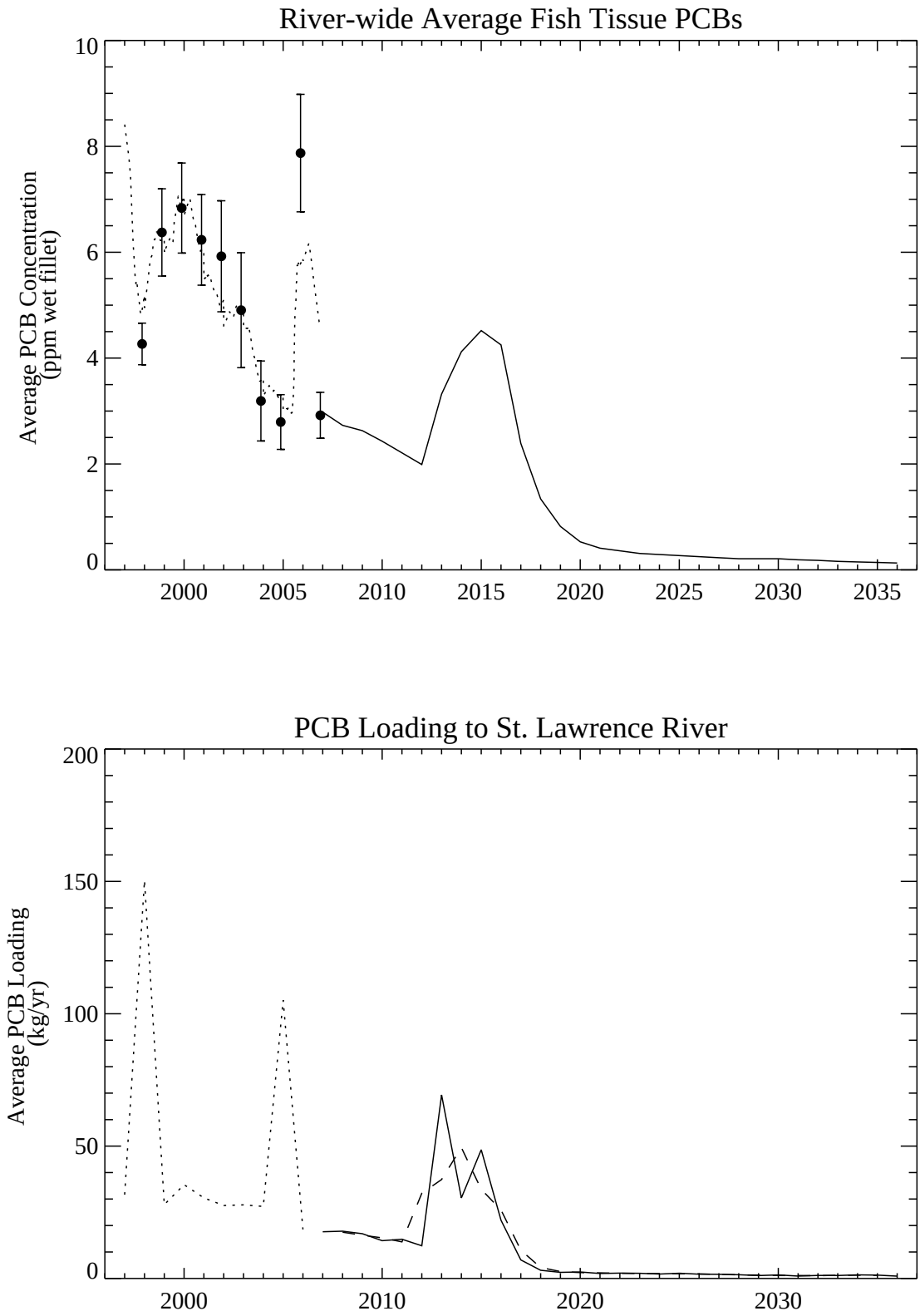

Figure 5-6. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 7: T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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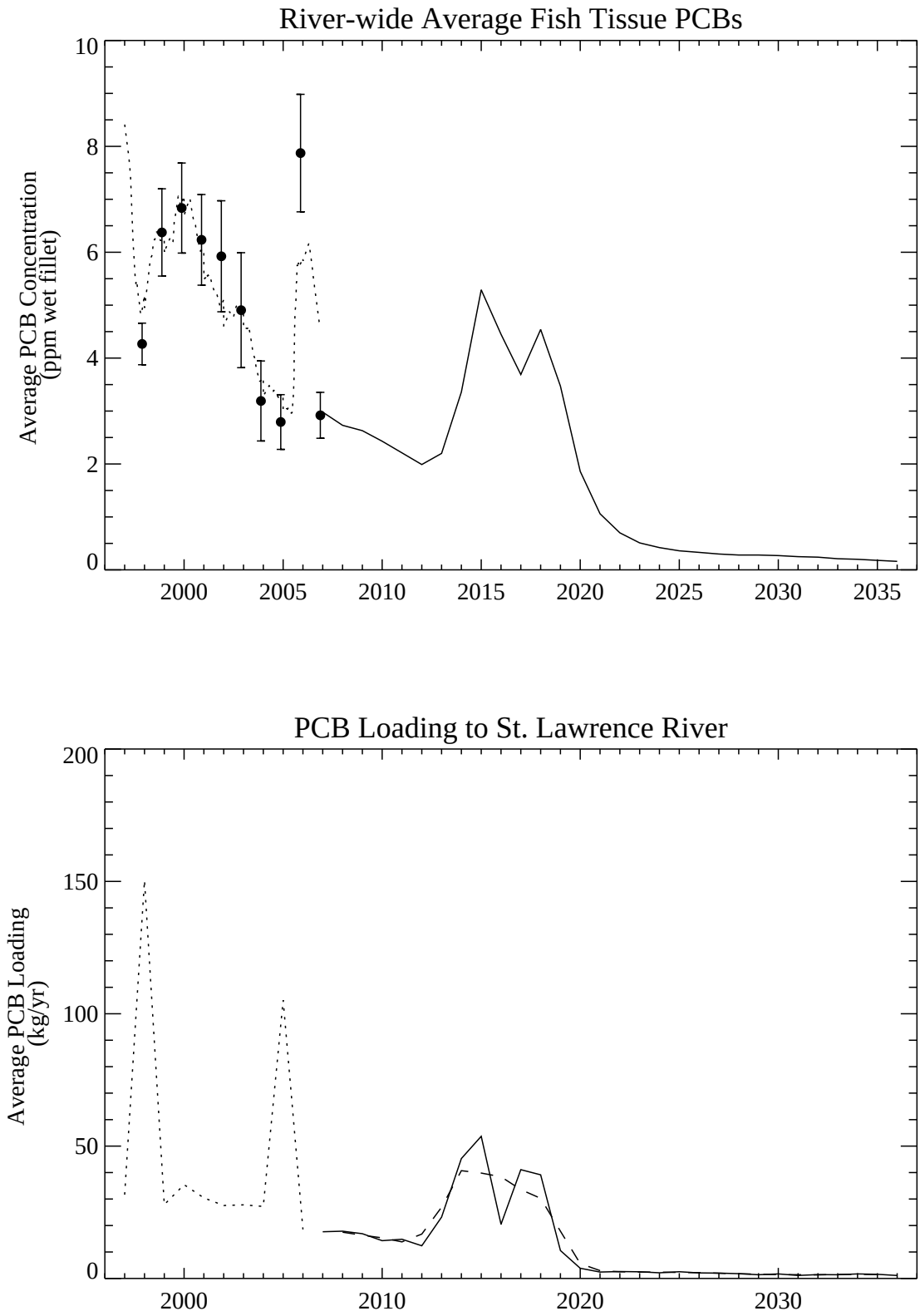

Figure 5-7. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 8: T1-T21 Dredging/Capping, T21-T72 Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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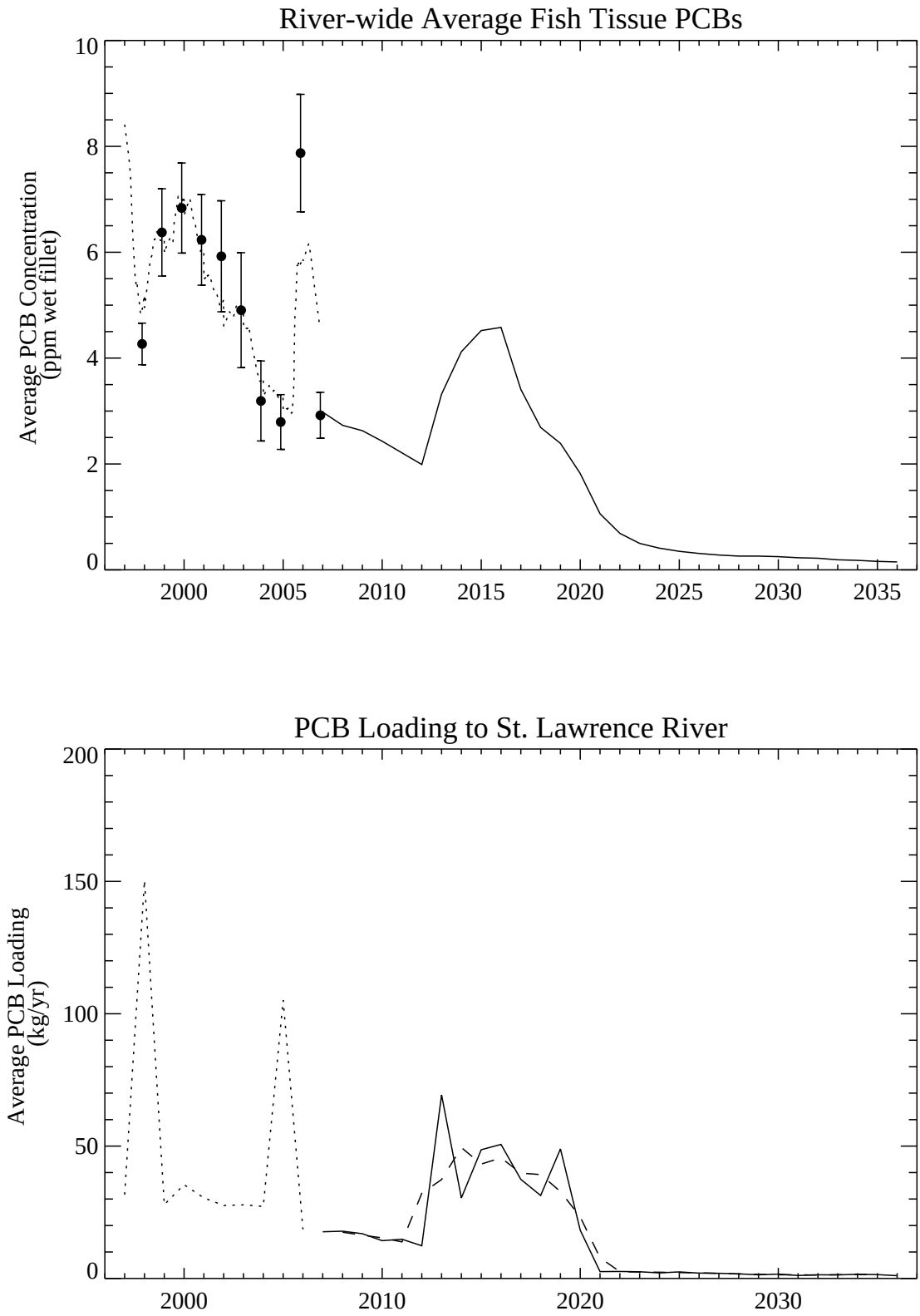

Figure 5-8. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 9: T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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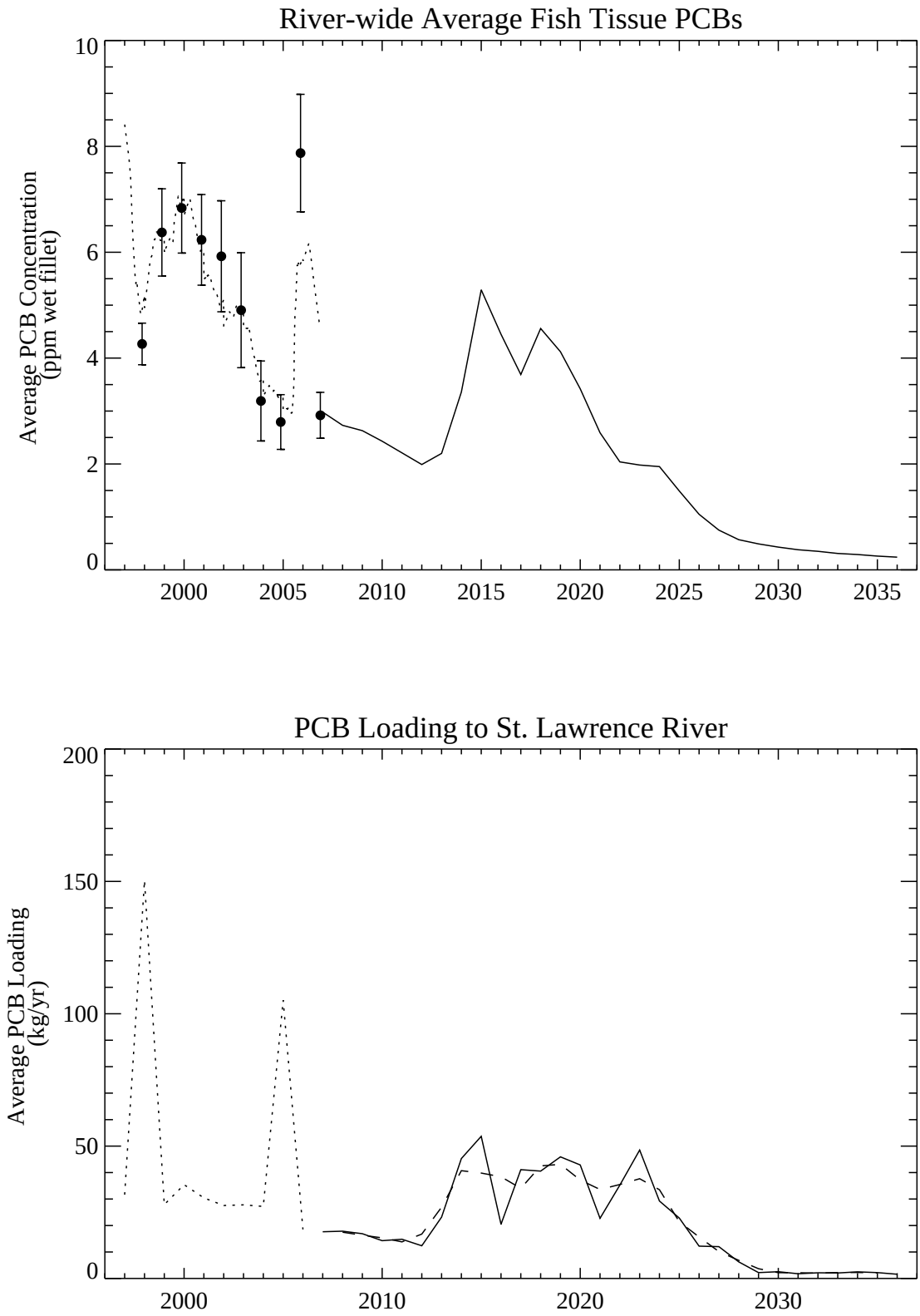

Figure 5-9. Predicted fish tissue PCB concentrations in the Grasse River and PCB loading to the St. Lawrence River. Alternative 10: T1-T72 Dredging/Capping.

Symbols represent annual average fish PCB data, +/- two standard errors.
Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages; PCB loadings are annual averages.
Solid lines represent annual average results from model projection. Dashed line in the bottom panel represents 3-year moving average.

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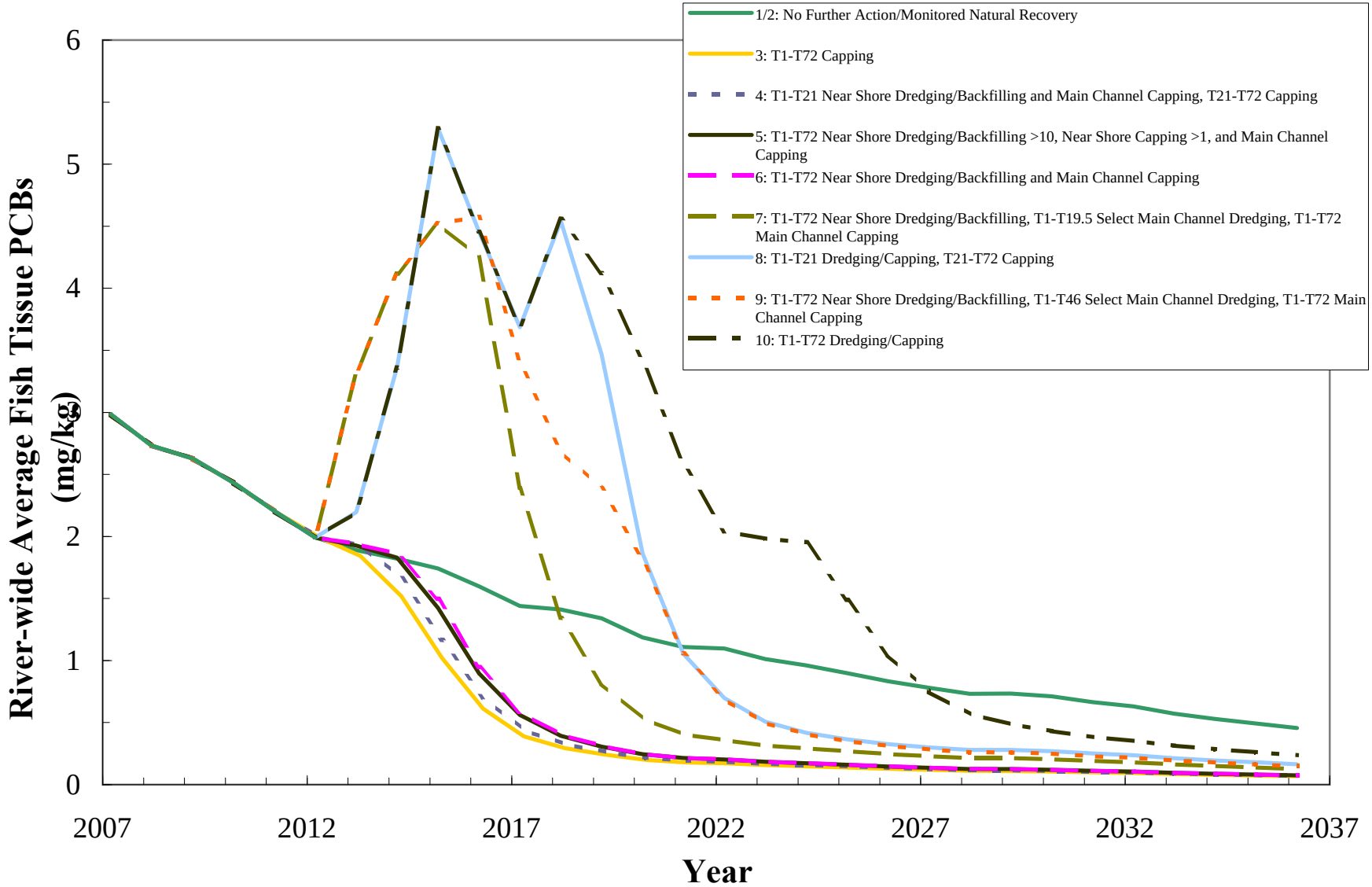

Figure 6-1. Comparison of Predicted River-wide Average Fish Tissue PCB Levels for Each Alternative.

Values represent annual species-average computed from predicted PCB levels in smallmouth bass and brown bullhead in the Grasse River.

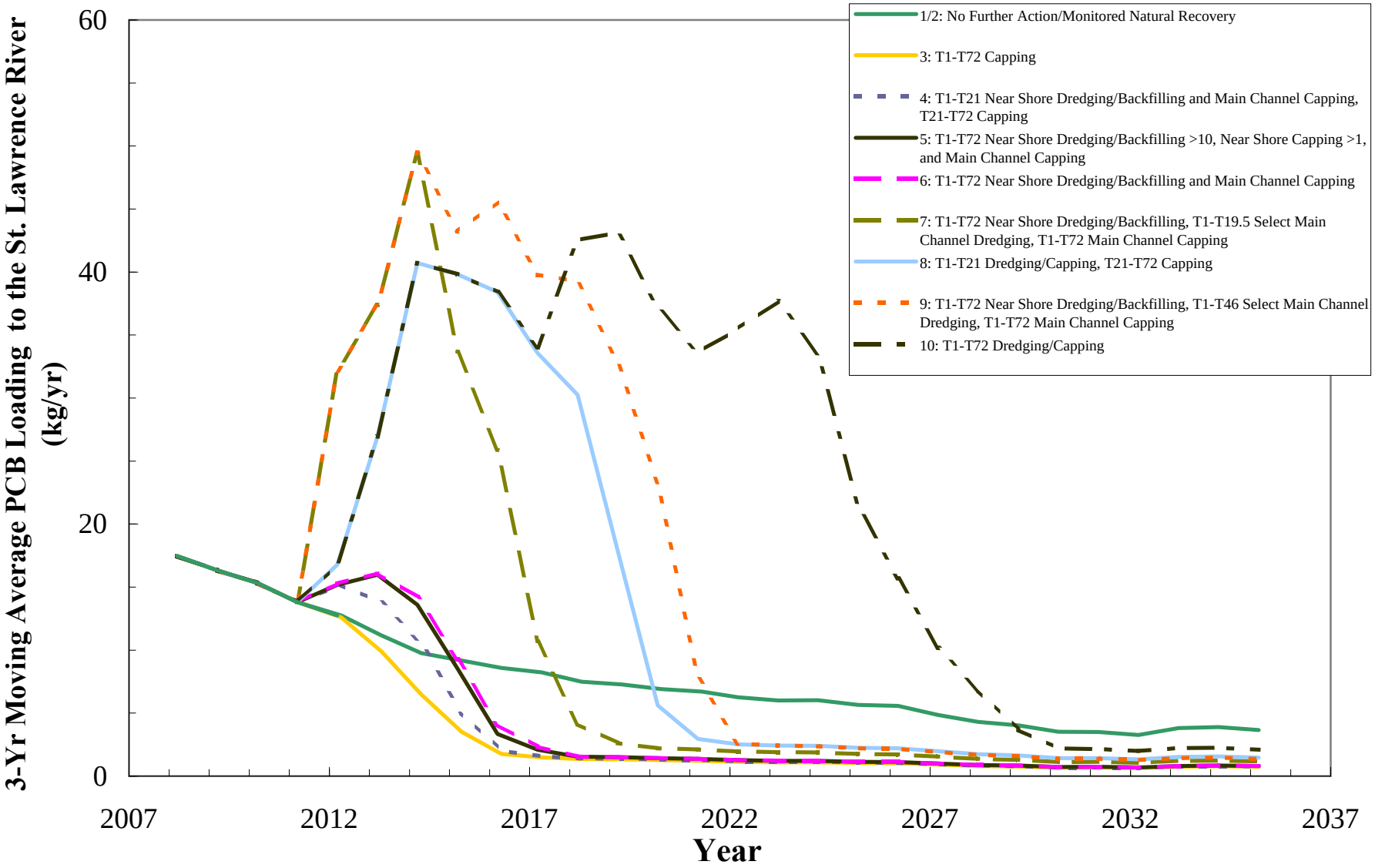

Figure 6-2. Comparison of Predicted PCB Loads to the St. Lawrence River for Each Alternative.
Values represent three-year moving averages (plotted at mid-point of averaging period).
Moving averages computed to damp the year-to-year variations associated with fluctuations in annual river flows used in the synthetic hydrograph.

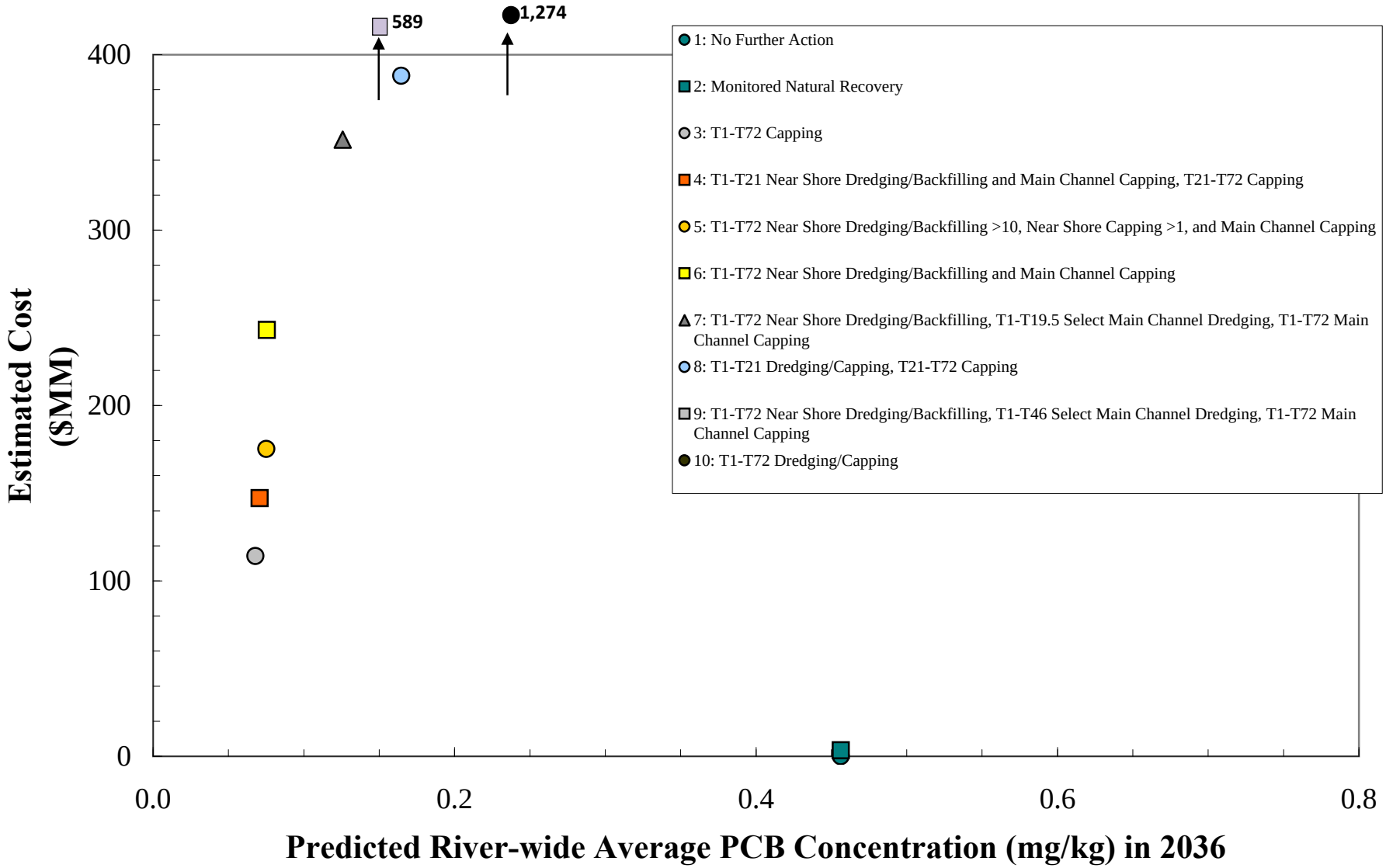

Figure 6-3. Cost as a Function of Predicted River-wide Average Fish Tissue PCB Levels in 2036.
Values represent annual species-average computed from predicted PCB levels in smallmouth bass and brown bullhead in the Grasse River.

Appendix A

Modeling PCB Fate in the Lower Grasse River

Appendix A

Modeling PCB Fate in the Lower Grasse River

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

The Supplemental Remedial Studies (SRS) Program was initiated in 1995 to provide information to support the identification and evaluation of potential remedial alternatives aimed at reducing polychlorinated biphenyl (PCB) levels in the lower Grasse River. An integral part of this program was the development of a numerical model to describe the fundamental processes that can affect movement of PCBs within the river and PCB transfer from sediments and water to fish. The model was developed using the information generated from field sampling, laboratory experiments, data evaluation and interpretation and literature reviews that were performed during the SRS program. The model mechanistically describes the PCB dynamics within the system and, therefore, provides a useful tool for the evaluation of potential remedial alternatives for reducing PCB levels in the water and biota of the lower Grasse River.

The development and calibration of the hydrodynamic, sediment transport, PCB fate and bioaccumulation components or sub-models of the lower Grasse River model were originally presented in the Comprehensive Characterization of the Lower Grasse River (CCLGR) Report (Alcoa, April 2001). This modeling framework was subsequently updated and presented in the June 2002 Analysis of Alternatives (AA) Report (Alcoa, June 2002). Since its presentation in the AA Report, the model has been updated to include pertinent data that were collected during subsequent field sampling activities performed as part of Alcoa's river ice investigation, sediment vibracore sampling, near shore sampling, and continued monitoring of PCB trends in the lower Grasse River. Information from Alcoa's technology evaluation activities (i.e., Capping Pilot Study [CPS], Remedial Options Pilot Study [ROPS], Activated Carbon Pilot Study, and T6.75 Ice Control Structure) and physical modeling activities were also incorporated to support an understanding of current and post-remedy conditions in the river.

This appendix presents the updates made to the model since the 2002 AA Report and the use of the model to evaluate future conditions in the river resulting from ongoing natural recovery processes and the effects of active remediation. Specifically, Section 2 through 5 present the development and calibration of the hydrodynamic, sediment transport, PCB fate and bioaccumulation sub-models, respectively, that constitute the lower Grasse River model. Section 6 presents the evaluation of a 100-year flood event in the river. Section 7 details the approach, development, and assumptions used to simulate future conditions under several remedial alternatives, as well as the simulation results.

SECTION 2
HYDRODYNAMIC MODEL

Hydrodynamics refers to the movement of water through the river and the friction or shear stress that this movement causes at the water column-sediment bed interface. A hydrodynamic model computes the velocity and water surface elevation, as well as the shear stress at the sediment-water interface, in response to upstream flows and to flows entering the river from other sources (e.g., tributaries and plant outfalls). The conditions predicted by the hydrodynamic model are used in the sediment transport model to evaluate sediment scour, resuspension, and downstream transport. Additionally, the PCB fate model uses the hydrodynamic model output to compute transport of PCBs.

2.1 MODEL DESCRIPTION

The hydrodynamic model used in this study is the Environmental Fluid Dynamics Code (EFDC), which was originally developed by Dr. John Hamrick (Hamrick, 1992). EFDC is a general purpose hydrodynamic model capable of simulating flow in rivers, lakes, reservoirs, estuaries, and coastal oceans. This model solves the conservation of mass and momentum equations, which are the fundamental equations governing the movement of water in a river. A complete description of the model is given in Hamrick (1992).

A two-dimensional (2-D), vertically-averaged approach has been applied to model the lower Grasse River. Although stratification does occur in the lower Grasse River during summer low flow conditions, its effect on sediment transport is negligible. In addition, it does not affect the net flow of Grasse River water, but, instead, stratification affects only the vertical variability in velocity and the vertical mixing of dissolved and suspended constituents. Therefore, it is expected to have a minimal effect on PCB fate. These conditions make it reasonable to assume that the water column is vertically well-mixed. Thus, the two-dimensional, vertically-averaged equations are an accurate approximation to the general three-dimensional equations of motion for an incompressible fluid. The conservation of mass and momentum equations applied to the Grasse River are (Ziegler et al., 2000):

$$\frac{\partial \eta}{\partial t} + \frac{\partial (uh)}{\partial x} + \frac{\partial (vh)}{\partial y} = 0 \tag{2-1}$$

$$\frac{\partial (uh)}{\partial t} + \frac{\partial (u^2 h)}{\partial x} + \frac{\partial (uvh)}{\partial y} = -gh\frac{\partial \eta}{\partial x} - C_f qu + \frac{\partial}{\partial x}\left(hB_H \frac{\partial u}{\partial x}\right) + \frac{\partial}{\partial y}\left(hB_H \frac{\partial u}{\partial y}\right) \tag{2-2}$$

$$\frac{\partial (vh)}{\partial t} + \frac{\partial (uvh)}{\partial x} + \frac{\partial (v^2 h)}{\partial y} = -gh\frac{\partial \eta}{\partial y} - C_f qv + \frac{\partial}{\partial x}\left(hB_H \frac{\partial v}{\partial x}\right) + \frac{\partial}{\partial y}\left(hB_H \frac{\partial v}{\partial y}\right) \tag{2-3}$$

where:

h	=	total water depth ($h_o+\eta$);
h_o	=	reference water depth;
η	=	water surface displacement with respect to reference depth;
u, v	=	velocities along the x- and y-axes, respectively;
q	=	$(u^2 + v^2)^{1/2}$; and
C_f	=	bottom friction factor; and B_H is horizontal eddy viscosity.

Note that the x-axis is oriented in the longitudinal (along-channel) direction and the y-axis is oriented in the lateral (cross-channel) direction. Equations 2-1 to 2-3 were transformed from Cartesian coordinates to orthogonal, curvilinear coordinates (see Hamrick [1992] for detailed discussion) in order to resolve the complex geometry and bathymetry of Grasse River more accurately.

An important variable in the hydrodynamic and sediment transport models is bottom shear stress (τ_b), which represents the frictional force exerted on the sediment bed by moving water in the river. The bottom shear stress is related to depth-averaged current velocity by the quadratic stress law:

$$\tau_b = \rho\, C_f\, q^2 \tag{2-4}$$

where:

ρ = water density.

The bottom friction factor in Equation (2-4) is dependent on the local water depth and effective bottom roughness (Ziegler et al., 2000).

$$C_f = MAX\left[\frac{\kappa^2}{\left(\ln\frac{h}{2z_o}\right)^2} \quad , \quad C_{f,\min}\right] \tag{2-5}$$

where:

κ = von Karman's constant (0.4);

z_o = the effective bottom roughness; and

$C_{f,min}$ = the minimum bottom friction factor (typically, set at 0.0025).

The bottom friction factor (C_f) thus varies both spatially and temporally due to changes in total water depth (h) and effective bottom roughness (z_o). As total water depth increases, due to changes in bathymetry (h_o) or water surface elevation (θ), C_f decreases.

2.2 APPLICATION TO THE LOWER GRASSE RIVER

The stretch of the lower Grasse River considered in this study covers approximately 7.4 miles and extends from just downstream of the Route 37B Bridge (also referred to as the Main Street Bridge), to the confluence with the St. Lawrence River (**Figure A2-1**). The lower Grasse River is a backwater to the St. Lawrence River. Consequently, water surface elevation varies little and current velocities are low during typical flow conditions. Typical water depths range from a few feet (ft) near the Massena weir to over 20 ft near the St. Lawrence River. Generally, the river has steep side slopes (on average, 10 percent [%] to 20% grade) and a flat bottom. The

long-term average flow rate in the lower Grasse River is approximately 1,100 cubic feet per second (cfs).

The lower Grasse River was discretized using approximately 5,460 model grid elements (205 longitudinal and up to 30 lateral grid cells) (**Figure A2-2**). The average longitudinal cell length is 190 ft and the average lateral cell length is 17 ft.

2.2.1 Bathymetry

Over the 10-year calibration period (i.e., 1997-2006), the lower Grasse River was subject to a number of events, both human-made and natural, that affected the river bottom. These events included:

- 2001 CPS (Alcoa, April 2002);
- 2003 ice scour event (Alcoa, April 2009); and
- 2005 ROPS (Alcoa, May 2006).

To best approximate the changing river bottom, different model bathymetries were constructed to represent river bottom elevations for four time periods:

- pre-2001 CPS (January 1997 to September 2001);
- post-2001 CPS (October 2001 to March 2003);
- post-2003 ice event (April 2003 to October 2005); and
- post-2005 ROPS (November 2005 to December 2006).

The most comprehensive bathymetric data were collected during the post-2003 ice event period (April 2003 to October 2005). It is for this reason that this data coverage is used as the basis for all four time periods with specific adjustments made in relevant portions of the model grid affected by each event.

Pre-2001 CPS

Data from two remote sensing surveys conducted by Ocean Surveys, Inc. (OSI) in 2003 were used to specify the majority of sediment elevations for the pre-2001 CPS timeframe. The extent of the surveys stretched from T1 to T72, with almost bank-to-bank coverage except for the shallow near shore areas. These surveys provided multibeam sediment elevation measurements at a density of one measurement for every square foot of river bottom. Thus, measurements that fell within each model grid cell were combined and used to estimate the mean sediment elevation for that cell.

For model grid cells that did not contain any multibeam sediment elevation measurements from 2003 (i.e., primarily the shallow near shore areas), sediment elevations were assigned in the following order:

1. The locations of sediment elevation measurements from manual sediment surveys were mapped and where the data intersected a model grid cell, the average of the data was assigned. Sediment elevations were calculated from water elevation and water depth. The data sets used in this characterization included the 1992 sediment probing survey, 2001 sediment probing survey, 2003 Phase I sediment probing survey, 2003 Phase II sediment survey, 2004 Phase II sediment probing survey, January 2004 sediment survey, 2004 Focused Study, and 2004 pre-ROPS sediment probing survey. For the 1992 and 2001 probing surveys, only measurements downstream of T19 were included because sediments downstream of T19 were not significantly affected by the 2003 ice scour event (Alcoa, April 2009).

2. The locations of water depth measurements from manual surveys (no water surface or sediment elevations measurements made) were mapped and where the data intersected a model grid cell, sediment elevation was calculated by subtracting water depth from average water surface elevations of 154.1 ft (USLS 1935) from T1 to T38 and 155.0 ft (USLS 1935) from T38 to T72, as reported by OSI during the 2003 remote sensing surveys. The data sets without water surface or sediment elevation measurements included the 1992 probing survey and 2003 pre-Phase I sediment probing survey. The 1992 sediment probing survey results

were used to help define sediment elevations in the near shore areas upstream of T19 due to the limited information that existed from other surveys.

3. Lateral linear interpolation was performed for model grid cells that did not intersect any data. For cells at the shoreline, adjacent imaginary cells on land with sediment elevations set to the average 2003 OSI water surface elevation were used in the lateral interpolation.

Because no data were available for the last row of model grid cells downstream of T72 (i.e., in the St. Lawrence River), the same sediment elevations in the adjacent upstream cells were specified.

Upstream of T1, three data sets were used to specify initial sediment elevations: 2003 Phase I sediment probing survey; 2006 PB Power survey (Kolerski and Shen, June 2008); and sediment elevations used by Clarkson University in their ice modeling work (Kolerski and Shen, June 2008). From these data, an elevation surface was created using a triangulated irregular network (TIN) in ESRI's ArcMap. Elevations for each model grid were assigned through the grid cell's intersection with the TIN. These elevations were then artificially lowered to maintain model stability. As such, this portion of the river was not explicitly modeled.

Additionally, the hydrodynamic model requires that all grid cells stay wet throughout simulation. A maximum bathymetry value of 153.7 ft (USLS 1935) was imposed to ensure model grid cells do not dry out during periods of depressed water surface elevations. This sediment elevation ceiling affected less than 1% of the model grid cells downstream of T1.

Adjustments to the bathymetry coverage resulting from the preceding data analyses were made to account for river bathymetry prior to the 2001 CPS. This resulted in replacement of three sections of the base model bathymetry: 1) T1 to T14, 2) T14 to T18, and 3) T18 to T38.

1. From T1 to T14, data from a remote sensing survey by OSI in 1998 were used to define the river bottom in the main channel. These data were single beam with a spacing of about every 100 ft longitudinally and 5 ft laterally.

2. From T14 to T18, data from a remote sensing survey by OSI in 2001 (after the CPS) were used to define the sediment elevations. This single beam survey had a resolution of about every 50 ft longitudinally and 1 ft laterally. For the area that was capped during the CPS, the sediment elevations in corresponding grid cells were replaced with mean elevations from the July 2001 remote sensing survey, which was conducted by OSI prior to the CPS. These single beam data had a resolution of about every 40 to 60 ft longitudinally and 1 ft laterally. The mean elevation of data within each intersecting grid cell was assigned to each cell.

3. From T18 to T38, data from a remote sensing survey by OSI in 2001 were used to define the river bottom for the main channel. These single beam data were spaced about every 40 to 50 ft longitudinally and 1 ft laterally.

Data from the various data sets were merged and processed into a TIN. The TIN was then converted into a 1-ft by 1-ft grid and then the mean sediment elevation from the grid was assigned to each model grid cell. For model grid cells between T1 and T38 that did not intersect data from the three remote surveys, mean sediment elevations from the probing survey in 2001 were assigned based on spatial location. This occurred for 28 model grid cells.

The resulting bathymetry for the pre-2001 CPS is shown in **Figure A2-2**.

Post-2001 CPS

The river section between T1 and T38 was replaced to represent the post-2001 CPS/pre-2003 ice scour in the development of the values that represent bottom elevations after the CPS. The model bathymetry differences from the pre-2001 CPS to post-2001 CPS are shown in **Figure A2-3**. The data sets used were the remote sensing surveys conducted in 1998 between T1 and T14, in 2001 (after the CPS) between T14 and T18, and in 2001 between T18 and T38. These data sets are described in more detail above under "Pre-2001 CPS". Data from all three data sets were merged and processed into a TIN. The TIN was then converted into a 1-ft by 1-ft grid and then the mean sediment elevation from the grid was assigned to each model grid cell. For grid elements where data were not available (in near shore areas), the mean sediment

elevation measurements and/or sediment elevations calculated from water depth measurements from probing surveys in 1992 and 2001 were used. All three data sets were combined.

Post-2003 ice event

The post-2003 ice event bathymetry was developed as described above for the pre-2001 CPS bathymetry, except the final adjustments of T1 to T14, T14 to T18, and T18 to T38 were not applied. The model bathymetry differences due to the 2003 ice scour event was obtained by comparison of the post-2001 CPS bathymetry to the post-2003 ice scour event bathymetry are shown in **Figure A2-4**.

Post-2005 ROPS

The model bathymetry for the post-2005 ROPS conditions were obtained by making adjustments to the post-2003 ice scour bathymetry in the regions where the remedial actions took place. The sediment elevations in model grid cells that intersected the study area for the ROPS were replaced by the mean sediment elevations measured in August 2006 during a post-ROPS multibeam survey conducted by OSI (**Figure A2-5**). The mean elevations were processed using ArcMap by taking the point measurements, creating a raster, and then assigning the average value to the model grid cell. The survey area included the main channel and adjacent northern side slope area approximately between T6.75 and T8.5 (dredging and capping) and an area in the southern half of the river between T15 and T16 (armored capping).

2.2.2 Boundary Conditions

The hydrodynamic model requires specification of three time-variable boundary conditions: 1) inflow at the upstream boundary; 2) plant outfall discharges; and 3) stage height at the St. Lawrence River. Tributary inflows into the lower Grasse River are small relative to the inflow at Massena and have a negligible effect on river hydrodynamics. Therefore, these flows were not considered in the hydrodynamic simulations.

Upstream Inflows

Due to the lack of historic flow records for the Grasse River at Massena, several methods were employed to estimate lower Grasse River flows.

For the period between 1924 and 1977, flows in the lower Grasse River were estimated from historic daily discharge data measured at the United States Geological Survey (USGS) gaging station in the Grasse River at Pyrites, New York (USGS Gage 04265000). This station is located approximately 35 miles upstream of the Massena Dam. Flow records from the Pyrites gage were adjusted for differences in drainage area as follows (Federal Emergency Management Agency [FEMA], 1980):

$$Q_M = Q_P \left[\frac{DA_M}{DA_P} \right]^{0.96} \tag{2-6}$$

where:

Q_M = estimated flow in the Grasse River at Massena ($L^3\ T^{-1}$);

Q_P = measured flow in the Grasse River at Pyrites ($L^3\ T^{-1}$);

DA_M = drainage area of the Grasse River at Massena (L^2) (606 square miles [mi^2]); and

DA_P = drainage area of the Grasse River at Pyrites (L^2) (333 mi^2).

Because the Grasse River at Pyrites gaging station became inactive in 1977, the USGS gage located on the West Branch of the Oswegatchie River at Harrisville (USGS Gage 04262500, 1916 to present) was selected as a surrogate to estimate flows in the lower Grasse River. The Oswegatchie River was selected for three reasons: 1) the river is in an adjacent drainage basin; 2) its gage is active; and 3) its land use and drainage characteristics are similar to those of the Grasse River. For the period between 1977 and 1997, estimation of Grasse River flows at Massena was accomplished in several steps. First, relationships between paired Grasse River at Pyrites flows and flows measured in the West Branch of the Oswegatchie River at Harrisville were developed using data collected between 1924 and 1977 (**Figure A2-6**):

$$Q_P = 5.74 Q_O^{0.725}, \qquad Q_O < 300 \text{ cfs}$$

$$= 1.50 Q_O^{0.955}, \qquad Q_O > 300 \text{ cfs} \tag{2-7}$$

where:

Q_P = flow in the Grasse River at Pyrites (cfs); and

Q_O = flow in the Oswegatchie River (cfs).

Second, flow rates in the Grasse River at Pyrites were estimated using data from the Oswegatchie River and the relationships developed above. Finally, the estimated flows in the Grasse River at Pyrites were adjusted for drainage area differences (using Equation 2-6). These transformed flows were used for all periods when site-specific flow data were not available.

From May 1997 through November 1999, flow rates in the Grasse River were estimated from water levels measured at the Main Street Bridge in Massena. The measured water levels then were converted to river flow using relationships developed between measured flows (via cross-sectional profile measurements at water column Transect WC001) and tapedown measurements from the Main Street Bridge. Due to the continuing structural degradation of the Massena weir (located immediately downstream of the Main Street Bridge), different relationships between water level and flow were developed for 1997, 1998, and 1999 (**Figures A2-7**, **A2-8** and **A2-9**, respectively). In spring 1999, mechanical problems with the pressure transducer, as well as vandalism of the transducer housing unit, forced Alcoa to abandon the monitoring of Grasse River flow at the Main Street Bridge.

In October 2003, the USGS installed a gaging station in the Grasse River at Chase Mills, New York (USGS Gage 04265432). This station is approximately 16 miles upstream of Massena. The drainage area of the Grasse River at Chase Mills is 598 mi^2; the drainage area of the Grasse River at Massena is only 1% higher at 606 mi^2. Therefore, when available, the daily river flows at Chase Mills are used to represent the flows at Massena.

The resulting hydrograph used as model input for the 10-year simulation period (1997-2006) is presented in **Figure A2-10**. When possible, river flows estimated from the pressure transducer measurements or from the Chase Mills gage were used directly. For periods in which neither data were available, including periods when the river was covered in ice, the Oswegatchie River flow records were used to estimate flows in the Grasse River.

Outfall flows

Flow discharges from the Alcoa plant outfalls were defined using data collected as part of Alcoa's State Pollution Discharge Elimination System (SPDES) discharge permit and during several high flow storm events in 1997. Flows from four plant outfalls were included in the hydrodynamic simulation: Outfalls 001, 004, 005, and 007. The development of the daily flow hydrographs for each of the plant outfalls is discussed below.

Flows from Outfall 001 for the model calibration period were based mainly upon flow monitoring data generated in accordance with Alcoa's SPDES discharge permit. As shown in **Figure A2-11a**, the record is well defined for the calibration period, containing over 600 flow measurements. These flow data were directly input into the model. Flows on days without data were defined through the linear interpolation of the SPDES data. Finally, average daily flows measured during the four storm sampling events in the summer of 1997 were included.

The same approach was employed in developing the flow input to the hydrodynamic model for Outfall 004 (**Figure A2-11a**): flow measurements (both SPDES and storm sampling) were used directly and flows for days without data were estimated by linear interpolation. In addition to SPDES and storm flow data, bypass flow data were added to the outfall discharge, when applicable. The bypass measurements were taken at times when the capacity of the treatment facility at Outfall 004 was exceeded and excess flow was discharged directly to the river.

Outfall 005 was in operation from October 5, 1998 through February 23, 2000. Because relatively few flow measurements were taken during this period, an average flow discharge was

computed from the existing data and applied to times when no data were recorded (**Figure A2-11b)**.

Between 1998 and 2000, flow discharges from Outfall 007 were defined using SPDES flow information. As with Outfalls 001 and 004, flows for days without data were determined by linearly interpolation. Since 1997 flow data were uncharacteristically low, flows for this year were defined using the 1998 flow records prorated by the 1997:1998 average monthly precipitation ratio. After 1999, an average flow discharge was computed from the existing SPDES data and applied where no data was recorded. The temporal profile used in the model is shown in **Figure A2-11b**.

Downstream Stage Height

The Canadian Federal Department of Fisheries and Oceans collects stage data in the St. Lawrence River at Cornwall near the confluence of the Grasse River and the St. Lawrence River. Hourly-averaged data collected at this location were used to specify stage height at the downstream boundary of the model. A minimum stage height of 153.8 ft (USLS 1935) was established to ensure model grid cells did not dry out from the stage height going below the bathymetry. This floor affected less than 1% of the stage height values. The stage height in the St. Lawrence River is presented for the 10-year calibration in **Figure A2-12**.

Information from the 2-D hydrodynamic model (i.e., vertically-averaged velocity and water depth) was transferred to the sediment transport and PCB fate models for use in simulating water column transport of suspended sediment and to calculate bottom shear stress. The three models performed simulations on the same numerical grid, so spatial collapsing of hydrodynamic model output was not necessary. Temporal averaging of the hydrodynamic results was performed to provide input to the sediment transport and PCB fate models on the appropriate time scales.

2.3 MODEL CALIBRATION

The hydrodynamic model contains two adjustable parameters: effective bottom roughness (z_o) and horizontal eddy viscosity (B_H). The bottom roughness coefficient, z_o, was calibrated with two Acoustic Doppler Current Profiler (ADCP) data sets from 2001 and 2002. The horizontal eddy viscosity (B_H) typically varies between 0.1 and 1.0 square meters per second (m^2/s); a value of 0.6 m^2/s was chosen for calibration.

Velocity measurements were obtained between August 10, 2001 and September 10, 2001 from a study to investigate flow reversals during the 2001 CPS (Alcoa, April 2002). For this study, three ADCPs were deployed at 0.25, 0.5 and 0.75 of the total river width at T19. **Figure A2-13** shows the location of the ADCPs as well as the silt curtain that was used to mitigate the migration of capping material during placement. Velocity measurements were collected every 30 seconds at 0.5-meter intervals and then averaged to produce depth averaged velocity measurements at every hour. Velocity magnitude was chosen as the calibration metric because the flow direction did not significantly change on an hourly basis.

The measurements showed a pronounced lateral variation during higher flows (**Figure A2-14**). Initial calibrations did not include the silt curtain and were unable to reproduce the observed lateral variability. However, by treating the silt curtain as a solid barrier in the model (see **Figure A2-13**), the observed lateral pattern could be reproduced. A bottom roughness coefficient of 1.0 millimeter (mm) provided the best match with the observed velocity magnitude profiles (**Figure A2-14**). Velocity magnitudes are over predicted across the transect. Velocity magnitudes are driven by the upstream flow and the over estimation is likely attributed to the use of Oswegatchie River flow records as an approximation of the upstream flow conditions in the Grasse River. This calibrated value of z_o is consistent with Manning's n values that can be estimated from a standard open-channel hydraulics reference (Chow, 1959), based on the physical features of the river.

Longitudinal velocity measurements were obtained between May 2, 2002 and June 4, 2002 from a study conducted to investigate potential near-bed transport during spring

high flows (Alcoa, September 2003). Four ADCPs were deployed at mid-channel transects T16, T26, T36, and T57 (**Figure A2-15**). Velocity measurements were collected every five minutes at 0.5-meter intervals and then averaged to produce depth averaged velocity measurements at every hour. The measurements showed very little longitudinal variation. The bottom roughness of z_o = 1.0 mm obtained from the 2001 ADCP calibration was used to simulate the 2002 ADCP velocity magnitude (**Figure A2-16**). The model reproduced the overall magnitude but did not reproduce the double peak observed in the data. Furthermore, the timing of the rising limb was initially off by about one-half day. Shifting the model by one-half day aligned the rising limb of the velocity profile and is reasonable given that the timing of the upstream flow boundary conditions is based on the transformation of the Oswegatchie River flow records. The longitudinal velocity profiles were generally not sensitive to bottom roughness and were more sensitive to the boundary conditions.

2.4 MODEL UNCERTAINTY

Uncertainties associated with two key model parameters were identified: Grasse River flow and the potential impacts of stratification. A discussion for each parameter is provided below.

Uncertainty associated with river flow originates from the extrapolation of Oswegatchie River flow records to the Grasse River for portions of the calibration period. The appropriateness of this extrapolation was examined in the previous modeling report (Section 2.4 of Appendix C of the CCLGR; Alcoa, April 2001). This analysis indicated that the flow estimation technique using the Oswegatchie River flow records provides a reasonable estimate of flow in the Grasse River, especially during higher flow conditions.

Potential impacts associated with the stratification in the lower Grasse River were not considered in the hydrodynamic model. However, because stratification only occurs in the lower Grasse River during summer low flow conditions, the effects of stratification on hydrodynamic conditions in the river is temporary. In addition, the existence of stratification indicates that the movement of the St. Lawrence River water into the Grasse River is slow and, thus, likely has

limited effects on current velocities and shear stresses at the sediment-water interface. Stratification does not affect the flow conditions in the lower Grasse River during seasonal high flow events.

SECTION 3
SEDIMENT TRANSPORT MODEL

Sediment transport includes the movement of suspended solids within the river and the deposition and resuspension that occurs at the sediment-water interface. The sediment transport model uses the output of the hydrodynamic model and the results of field studies to describe the resuspension, deposition, and downstream transport of sediments within the lower Grasse River. Results of the sediment transport model (in the form of a spatial and temporal matrix of total suspended solids (TSS), and as resuspension and deposition fluxes) are used directly by the PCB fate model.

3.1 MODEL STRUCTURE AND EQUATIONS

The sediment transport model discussed herein is a modified version of the SEDZL sediment transport model that was originally developed by Ziegler and Lick (1986). This model has been applied to several sites, including the Buffalo River (Gailani et al., 1996) and the Saginaw River (Cardenas et al., 1995). Various versions of SEDZL have been used in other sediment transport studies, including: Upper Hudson River (Quantitative Environmental Analysis [QEA], 1999), Fox River in Wisconsin (Gailani et al., 1991), Pawtuxet River in Rhode Island (Ziegler and Nisbet, 1994), Lake Erie (Lick and Ziegler, 1994), and Watts Bar Reservoir in Tennessee (Ziegler and Nisbet, 1995).

Suspended sediment particles in a river have a large range of sizes, from less than 1 micron (μm) clays to medium sands on the order of 400 μm. Simulation of the entire particle size spectrum is impractical. Therefore, particles were broadly segregated into two groups: 1) silts and clays that may interact and form flocs; and 2) sands that are transported as discrete particles. The model uses this approach to approximate the particle size spectrum. "Class 1" particles include all flocculent particles (i.e., clays and silts, with disaggregated particle diameters of less than 62 μm) while "Class 2" particles include coarser, non-flocculating particles, primarily fine sands with diameters between 62 and 250 μm.

The lower Grasse River water column is well-mixed, and suspended fine-grained sediment concentrations are assumed to be uniformly distributed within the water column. For these conditions, a 2-D vertically-averaged sediment transport equation for size-class k (k = 1,2) was applied (Ziegler and Nisbet, 1994):

$$\frac{\partial(hC_k)}{\partial t} + \frac{\partial(u_x hC_k)}{\partial x} + \frac{\partial(u_y hC_k)}{\partial y} = \frac{\partial}{\partial x}\left(hE_x \frac{\partial C_k}{\partial x}\right) + \frac{\partial}{\partial y}\left(hE_y \frac{\partial C_k}{\partial y}\right) + R_k - D_k \qquad (3\text{-}1)$$

where:

C_k	=	concentration of suspended sediment of size-class k ($M\ L^{-3}$);
E_x, E_y	=	horizontal eddy diffusivities along the x- and y-axes, respectively ($L^2\ T^{-1}$);
R_k	=	resuspension (erosion) flux of size-class k ($M\ L^{-2}\ T^{-1}$); and
D_k	=	deposition flux of size-class k ($M\ L^{-2}\ T^{-1}$).

Results from the 2-D hydrodynamic model provide information about the transport field in Equation 3-1; that is, u_x, u_y and h. Equation 3-1 has been transformed into a curvilinear coordinate system and solved numerically.

As mentioned above, flocculent particles in the water column range from clay particles smaller than 1 µm up to about 62 µm silts. The discrete particles aggregate and form flocs that can vary greatly in size and effective density. Variations in concentration and shear stress affect both floc diameter and settling speed (Burban et al., 1990). Modeling the settling characteristics and associated depositional fluxes of flocculent particles in a natural water system is difficult. One way to model flocculent particle deposition is to use multiple size classes to simulate particle/floc heterogeneity in the water column. Difficulties with this approach include: 1) specification of composition of sediment loading from tributaries; 2) obtaining data for model calibration/validation; and 3) computational constraints.

Previous modeling studies (Ziegler and Nisbet, 1994; 1995; Gailani et al., 1996; QEA, 1999) have shown that an effective approximation is to treat suspended flocculent particles as a single class. This approach assumes that the settling and depositional characteristics of

flocculent particles can be represented by average values of a distribution of properties. Using this approximation, the deposition flux of flocculent (Class 1) particles to the sediment bed is expressed as (Ziegler and Nisbet, 1994):

$$D_1 = P_1 \; W_{s,1} \; C_1 \tag{3-2}$$

where:

$W_{s,1}$ = flocculent particle settling speed (L T^{-1}); and

P_1 = probability of deposition for flocculent particles.

Settling speeds of flocs have been measured over a large range of concentrations and shear stresses in freshwater (Burban et al., 1990). The Burban settling speed data for flocs in freshwater were analyzed to develop a formulation to approximate the effects of flocculation on settling speed. This analysis indicated that the settling speed is dependent on the product of the concentration (C_1) and the water column shear stress (G) at which the flocs are formed, resulting in the following relationship (QEA, 1999):

$$W_{s,1} = 3.3 \left(C_1 G\right)^{0.12} \tag{3-3}$$

where the units of $W_{s,1}$, C_1, and G are meters per day (m/day), milligrams per liter (mg/L) and dynes per square centimeter (dynes/cm^2), respectively (**Figure A3-1**). For a depth-averaged model, as used in this study, the relevant shear stress for use in Equation 3-3 is the bottom shear stress (τ_b), i.e., $G = \tau_b$.

Modeling suspended flocculent particles as a single class, with an effective $W_{s,1}$ given by Equation 3-3, makes it necessary to use a probability of deposition (P_1) to parameterize the effects of particle/floc size heterogeneity and near-bed turbulence on the deposition rate. The complex interactions occurring in the vicinity of the sediment-water interface cause only a certain fraction of the settling flocculent particles, represented by P_1, to become incorporated into the bed (Krone, 1962; Partheniades, 1992). An experimentally-based formulation that

represents the effects of variable floc size on probability of deposition was developed by Partheniades (1992), see **Figure A3-2**:

$$P_1 = 1 - (2\pi)^{-1/2} \int_{-\infty}^{Y} e^{-\frac{w^2}{2}} dw \tag{3-4}$$

where:

$$Y = 2.04 \ln\left[0.25\left(\frac{\tau_b}{\tau_{b,\min}} - 1 \right) e^{1.27\tau_{b,\min}} \right] \tag{3-5}$$

and:

$\tau_{b,min}$ = bottom shear stress below which $P_1 = 1$ (dynes/cm^2).

Class 2 particles (i.e., fine sands) suspended in the water column are assumed to have an effective settling speed ($W_{s,2}$) that corresponds to an effective particle diameter (d_2). The depositional flux for this sediment class is then:

$$D_2 = P_2 W_{s,2} \Gamma C_2 \tag{3-6}$$

where:

P_2 = probability of deposition for non-flocculent sediments; and

Γ = Class 2 stratification correction factor.

Details concerning methods for calculating Γ, $W_{s,2}$ and P_2 are presented in QEA (1999). Significant vertical stratification of Class 2 sediment can occur in the water column due to the high settling speeds of fine sands. This characteristic means that accurate calculation of Class 2 deposition flux requires use of the near-bed concentration ($C_{a,2}$), where $C_{a,2} = \Gamma C_2$ and $\Gamma > 1$. Note that Γ is dependent upon $W_{s,2}$, τ_b, bottom roughness and local depth (QEA, 1999). The

relationship between $W_{s,2}$ and d_2, which was developed by Cheng (1997), is presented in **Figure A3-3**.

Only a finite amount of material can be resuspended from a fine-grained, cohesive sediment bed exposed to a constant bottom shear stress. This phenomenon, referred to as bed armoring, has been observed and quantified in a number of laboratories (Parchure and Mehta, 1985; Tsai and Lick, 1987; Graham et al., 1992) and field studies (Hawley, 1991; Amos et al., 1992). The amount of fine-grained sediment resuspended from a cohesive deposit is given by (Gailani et al., 1991):

$$\in = \frac{a_o}{T_d^N}\left(\frac{\tau_b - \tau_{cr}}{\tau_{cr}}\right)^n \quad , \quad \tau_b \geq \tau_{cr} \tag{3-7}$$

where:

$\in$	=	net mass of resuspended sediment per unit surface area (M L^{-2});
a_o	=	site-specific constant;
T_d	=	time after deposition in days;
N, n	=	exponents dependent upon the deposition environment; and
τ_{cr}	=	effective critical shear stress (dynes cm^{-2}).

Note that $\in$ is referred to as the resuspension potential.

Experimental results show that cohesive sediment is eroded over a time period on the order of one hour (Tsai and Lick, 1987; MacIntyre et al., 1990). Thus, the total resuspension rate (R_{tot}) is given by:

$$R_{tot,coh} = \frac{\in}{3600} \tag{3-8}$$

where R_{tot} is assumed to be constant until all available sediment is eroded. Once the amount $\in$ has been resuspended, R_{tot} is set to zero until additional sediment is deposited and available for

resuspension or until the shear stress increases (Gailani et al., 1991). The resuspension rate of class k (R_k) sediment from the cohesive bed is then given by:

$$R_k = f_k R_{tot,coh} \tag{3-9}$$

where:

f_k = fraction of class k sediment in the surficial layer of the cohesive bed.

The present study models two classes of suspendable sediment, with f_1 corresponding to the fraction of flocculent particles (clay and silt) in the bed and f_2 corresponding to the fraction of suspendable non-flocculent particles (fine and medium sand with particle diameters between 62 and 425 µm). The total fraction of suspendable sediment in the bed ($f_{sus} = f_1 + f_2$) is equal to one in the cohesive bed.

The effects of bed consolidation with depth and horizontal variations in bed composition are simulated using a three-dimensional (3-D) model of the cohesive sediment bed. The layered bed model conserves mass, with mass flux occurring only at the sediment-water interface due to deposition and resuspension. Vertical variations of sediment bed consolidation, or equivalently porosity, are accounted for by discretizing the bed into seven layers. The time after deposition of the layers increases linearly from one day at the surface, which is composed of freshly deposited sediment, to seven days in the bottom layer. Previous laboratory studies (Tsai and Lick, 1987; MacIntyre et al., 1990) indicate that consolidation effects on resuspension are minimal after about seven days of consolidation. Therefore, the maximum age of deposited sediments was set at seven days. Consolidation effects on resuspension are accounted for in Equation 3-7 by the $(T_d)^{-N}$ term, which causes the resuspension potential ($\in$) to decrease as the bed consolidates with time. The critical shear stress, τ_{cr}, was assumed to be constant in all layers of the bed. The model accounts for changes in bed composition; that is, f_1 and f_2, due to resuspension and deposition during the course of a simulation.

3.2 APPLICATION TO THE LOWER GRASSE RIVER

Representation of the River

Field studies were conducted during November 1998 and November 2000 to measure in-situ resuspension properties of cohesive sediments in the lower Grasse River. During each study, a device called a shaker (Tsai and Lick, 1987) was used to test surficial cores collected from the river. A shaker test simulates the shearing effects of elevated flows on surface sediments by creating turbulence in the water column directly above an undisturbed sediment sample. The extent of the turbulence can be controlled to correspond to various shear stresses. TSS measurements collected from the overlying water before and after the test are analyzed to determine the resuspension properties of the cohesive sediments. For the shaker tests, two sediment cores were collected from each of 33 locations (19 in 1998 and 14 in 2000) throughout the lower river (**Figure A3-4**), except for three locations where duplicate cores could not be obtained. Prior to testing, initial solids concentrations in the overlying water column were measured from each core. Each core was then placed in the shaker apparatus and subjected to turbulence (equivalent to a shear stress of 3 dynes/cm^2) for a period of ten minutes. After the ten-minute test period, suspended solids in the overlying water were again measured. This process was repeated for each core at shear stresses of 5 and 9 dynes/cm^2. Using these TSS measurements, relationships between erosion potential (i.e., $\in$ in Equation 3-7), and applied shear stress were developed for each sampling location. Upon analysis of the observed data, the results for seven of the cores were excluded from the analysis presented below. Four of these seven samples were discarded because the TSS concentration at the beginning of the shaker test was higher than during the test, preventing measurement of the mass resuspended during the test. The remaining three samples were discarded because the results indicated decreasing resuspension with increasing shear stress, which is inconsistent with known behavior of cohesive bed erosion. Including the results from these three samples in the calculation of average resuspension parameters would cause a decrease in the calculated averages and, thus, excluding these cores from the analysis results in a conservative estimate of average cohesive resuspension.

Resuspension potential data from the 56 cores were analyzed to determine values for the site-specific parameters (a_o and n) in Equation 3-7 using values of T_d equal to 7 days, τ_{cr} equal to

1.0 dynes/cm^2, and N equal to 0.5. Examination of sediment properties (bulk density and percent fine sediment, see below) revealed that the river sediments tend to group into three stretches (upstream, midstream, downstream) and by sediment type (Type 1 [coarse] and Type 2 [fine]). Inspection of the shaker data also indicated that the sediments exhibit different erosional potential among these three stretches of the river (**Figure A3-5**). This is consistent with the shallower water depths and coarser sediments found in the region upstream of T21 (**Figure A3-6**). Analysis confirmed that the erosional properties of sediments in the upper portion (between T1 and T21) of the river were statistically different from the middle (between T21 and T36) and lower portions (between T36 and T72; **Figure A3-7**). To provide a conservative estimate of sediment scour in the three portions of the river, erosion potential functions were developed from the upper confidence limits of the data and used in the sediment transport model simulations (**Figures A3-8** through **A3-10** and **Table A3-1**).

Sediment bulk property parameters (i.e., bulk [dry] density and composition) also had to be specified for model input. Surficial sediment data (grabs and cores within the top 5 centimeters [cm]) were used to determine bulk density and the initial composition of the sediment bed (i.e., f_1 or the Class 1 fraction). Only sediment data collected since 2000 were included in this analysis because those data are representative of current conditions.[1] Some data collected after 2000 were excluded if they were not representative of the current river bottom. For example, data collected between transects T1 to T19 prior to 2003 were excluded because some sediments in this region were disturbed during the 2003 ice jam. Data in locations affected by 2005 ROPS activities were also excluded.

The bulk density and sediment composition data were assessed separately for Type 1 (coarse) and Type 2 (fine) sediments in the main channel and for the northern and southern near shore areas. Based on spatial patterns in these sediment properties, as well as the shaker data discussed above, the main channel was divided into three regions: T1 to T21 (River Mile [RM]

[1] The following datasets were used: 2000 Supplemental Sediment Sampling; 2001 Supplemental Sediment Sampling; 2001 Probing Survey; 2003 Phase I Sediment Sampling Program; 2003 Phase II Sediment Sampling Program; 2003 Post-Capping Pilot Study Monitoring (sediment composition only); 2004 Focused Studies; January 2004 Sediment Sampling Program; 2005 Post-ROPS Monitoring; 2006 Phase 1 Sediment Sampling Program; 2007 Phase 2 Sediment Sampling Program (dry density only); 2006 Post-ROPS Monitoring; and 2007 Post-ROPS Monitoring (dry density only).

7.0 to 4.96); T21 to T36 (RM 4.86 to RM 3.5), and T36 to T72 (RM 3.5 to RM 0.0) (**Figures A3-11** and **A3-12**). The sediment properties of the northern and southern near shore areas that were capped during the 2005 ROPS were defined separately from the other near shore areas due to differences in sediment characteristics (**Figures A3-11** and **A3-12**). The sediment areas used for averaging of these sediment properties is shown in **Figure A3-6**. Average bulk density and percent fines were calculated for each of the 10 regions (**Table A3-2**).

The bed map for the sediment transport model requires the specifying the bed type of each grid cell as cohesive, non-cohesive, or hard bottom. The bed map for the lower Grasse River model was developed using data obtained during the hydrographic/geophysical surveys of the river bed in 2003 (Alcoa, April 2009). These surveys used side scan sonar imagery, sounding data, push probes and field observations to delineate the river bottom generically into Type 1 (fine), Type 2 (coarse) and rocky zones (**Figure A3-13**). Data collected in these zones were analyzed to further classify the river bottom as cohesive, non-cohesive or hard bottom as needed for the sediment transport model.

Sediment beds with median particle diameter (D_{50}) less than 250 μm and clay/silt content of 15% or higher are considered to be cohesive (Ziegler and Nisbet, 1994). Grain size data were obtained from sediment cores and grab samples from recent sediment characterization surveys (2001 – 2006, excluding those samples affected by the 2003 ice jam and 2005 ROPS). The distribution of median particle diameter for the Type 1 (coarse) and Type 2 (fine) sediment areas are shown in **Figure A3-14**. The fraction of silt/clay, defined here as the fraction passing through a 75 μm sieve, for these sediment areas are shown in **Figure A3-15**. From these figures, the majority of the sediments in both Type 1 (coarse) and Type 2 (fine) sediment areas have D_{50} values less than 250 μm and silt/clay content greater than 15%.

Based on the analysis described above, grid cells in Type 1 (coarse) and Type 2 (fine) sediment areas were specified as cohesive sediments on the bed map. No sediments were recovered from cores and grab samples collected from Type 1 (coarse) sediment areas upstream of T15, suggesting that these areas are hard bottom. Thus, all Type 1 (coarse) sediment areas upstream of T15 were specified as hard bottom in the bed map. The bed map used for the model

is shown in **Figure A3-16**. This definition of the bed map is consistent with the previous modeling effort where all areas of the bed map other than hard bottom were defined as cohesive sediments (Alcoa, April 2001, June 2002).

Boundary Conditions

Sediment loading at the upstream boundary of the model must be specified for all sediment transport simulations. Time-varying suspended sediment concentration is input to the model at this boundary. TSS concentration data were used to specify model inputs during periods when data were available. To estimate TSS concentrations for periods when data were not available, a sediment rating curve (i.e., TSS concentration as a function of flow rate) was developed using available TSS concentration and river flow data. TSS concentration data were collected at the Main St. Bridge between 1997 and 2007. In addition, surveys were conducted during the rising limb of two spring ice breakup events; one during March 25-28, 2004 and one during March 31-April 3, 2005. Examination of these data suggested that for high flow events that occur under non-ice conditions TSS concentration is relatively constant for flow rates less than about 1,100 cfs, with an average value of 2.8 mg/L. For flows greater than 1,100 cfs, TSS concentration increases with flow rate (**Figure A3-17**). Based on these observations, the following sediment rating curve was developed:

$$C_{in} = 0.00285Q^{0.99} \tag{3-10}$$

where:

C_{in} = TSS concentration (mg/L)

Q = flow rate (cfs).

For periods when ice breakup occurred during a high flow event, the data suggests that TSS concentration is relatively constant at 2.8 mg/L up to 500 cfs, then increases with flow rate as defined by the following sediment rating curve:

$$C_{in} = 0.00243Q^{1.14} \tag{3-11}$$

The bias correction factor developed by Ferguson (1986) was applied to correct for bias introduced when performing log-linear regression analysis on the high flow data. The resulting daily TSS concentrations specified at the upstream boundary are shown in **Figure A3-18**.

As discussed earlier, two classes of suspended sediment were used in the lower Grasse River sediment transport model (i.e., Class 1 represented fine, flocculent particles and Class 2 corresponded to coarse, non-flocculent particles). Therefore, the composition of the total sediment loads specified at the upstream boundary and from the outfalls needed to be specified. No particle size distribution data are available for suspended sediments in the lower Grasse River. Examination of limited composition data for the St. Regis and Raquette Rivers showed no relationship between composition and flow rate. However, initial model testing suggested that the composition of the suspended sediment load (i.e., relative fractions of Class 1 and 2 particles) in the lower Grasse River probably does change as flow rate varies. A relationship between the fraction of Class 2 in the incoming load and flow rate was developed during model calibration. This relationship was based on the assumption that Class 2 fraction would be low at low flow rates and increase during high flows, which is qualitatively consistent with higher turbulent energy levels during high flows being able to transport coarser sediments. This function is identical to that used in prior modeling activities (Alcoa, April 2001, June 2002) and is shown in **Figure A3-19**.

In addition to the specification of upstream sediment loading, time-varying TSS concentrations for Outfalls 001, 004, 005, and 007 also were included in the model. The solids record for Outfall 001 was defined using TSS concentration measurements made during SPDES monitoring, and linear interpolation of these data for days without TSS concentration measurements. Three storm TSS concentrations measured in summer 1997 also were included in discharges from Outfall 001 (**Figure A3-20**, **top panel**).

For Outfall 004, TSS concentration data collected as part of Alcoa's SPDES discharge permit were used directly. For days without measurements, TSS concentrations were determined through linear interpolation of the available data. A rating curve based on 1997 storm TSS concentration and flow rate data was developed and applied to storm and bypass flows in order

to represent TSS inputs during bypass events (**Figure A3-21**). The resulting TSS concentration temporal is shown in **Figure A3-20 (bottom panel**). During the time period when Outfall 005 was in operation (October 28, 1998 through February 23, 2000), an average of the available TSS concentration data was applied to days when no data existed (**Figure A3-22, top panel**). Similar to Outfall 005, TSS concentration measurements for Outfall 007 were used directly and an average of the available data was applied to days without measurements (**Figure A3-22, bottom panel**).

Flow reversals occasionally occur at the mouth of the Grasse River due to stage height variations in the St. Lawrence River. Suspended sediment concentration at this boundary had to be specified during flow reversals. Because no data exist for solids loading from the St. Lawrence River during flow reversals, it was assumed that the load was zero; that is, suspended sediment concentration was set to zero at the downstream boundary during periods of flow reversal.

3.3 MODEL CALIBRATION AND VALIDATION

The sediment transport model was calibrated during the 43-day period between March 1 and April 12, 1998. Two high flow events occurred during this period, with peak flow rates of 4,200 cfs on March 11, 1998 and 6,600 cfs on March 29, 1998. This period was selected for calibration because of the availability of high flow TSS concentration data at the Main Street Bridge and the Route 131 Bridge. The locations of the two sampling stations are shown in **Figure A2-1**.

The model was calibrated using the model grid discussed in Section 2.2 and shown in **Figure A2-2**. Three parameters were adjusted during the model calibration: 1) composition of the incoming load; 2) bottom shear stress below which P_1=1 ($\tau_{b,min}$); and 3) effective particle diameter of Class 2 solids (d_2).

The composition of the incoming suspended solids was specified using the function shown in **Figure A3-19**. This function was based on the observation that a relatively low

amount of deposition occurs between the Main Street Bridge and Route 131 Bridge during moderately high flows. As a result, Class 2 sediment was only input during flows that exceeded 2,200 cfs (i.e., $2Q_{avg}$). A maximum Class 2 content of 10% was set for discharge greater than 6,600 cfs. Based on composition data collected from the St. Regis and Raquette Rivers, this maximum value is probably a lower-bound estimate. As discussed in Appendix C of the CCLGR (Alcoa, April 2001), a sensitivity analysis was included in which a constant Class 2 content of 25% was assumed, based upon the limited composition data from the St. Regis and Raquette Rivers. Results of this simulation indicated that deposition rates downstream of RM 6.0 are relatively insensitive to the composition of incoming solids. However, unreasonably high deposition rates were predicted between RM 6.0 and 7.0 under these conditions. Therefore, consistent with prior modeling efforts, the conservative function presented in **Figure A3-19** was used during model calibration.

The best model-data agreement during the calibration period was found using $\tau_{b,min}$ = 0.05 dyne/cm^2 and d_2 = 65 μm. A d_2 value of 65 μm corresponds to very fine sand, which is consistent with the assumed range of Class 2 particle diameters. A temporal plot of predicted and observed TSS concentrations at the Route 131 Bridge during the calibration period is shown in **Figure A3-23**. Predicted TSS concentrations compare well to observed values for both events. Unfortunately, the second and larger of the two high flow events only had TSS concentration measurements on the falling limb of the hydrograph. This lack of data prevents the construction of a sediment mass balance that can be used as an additional tool for calibrating sediment bed dynamics during high flow events.

The full 10-year model simulation extended from January 1, 1997 through December 31, 2000. The predicted spatial distribution of net deposition for the 10-year simulation is presented in **Figure A3-24,** while a sediment mass balance on the lower Grasse River for the 10-year simulation period is presented in **Figure A3-25**. The net sediment mass deposited in the lower Grasse River during the 10-year simulation was about 1,880 metric tons per year (MT/yr), which corresponds to a trapping efficiency of about 22%. The predicted average sedimentation rate for this period was 0.15 centimeters per year (cm/yr). To validate the 10-year simulation, model-

data comparisons were done for the following variables: 1) TSS concentrations; and 2) long-term deposition rates.

During the 10-year simulation, predicted TSS concentrations were compared to measured values collected in conjunction with the routine monitoring program at multiple stations along the river. Initial evaluation of model-data comparisons using the calibration parameters developed from the high flow simulation indicated that the model was over-predicting sediment deposition during low flow periods ($Q < Q_{avg}$). This observation suggested the existence of a third particle size class with a very low effective settling speed. To approximate this phenomenon in the model, the settling speed of Class 1 particles was reduced during low flow periods. The settling speed predicted by Equation 3-3 was only applied at flows greater than Q_{avg}. At flows below 0.5 Q_{avg}, the Class 1 settling speed ($W_{s,1}$) was reduced by a factor of 10. For flows between 0.5 Q_{avg} and Q_{avg}, the settling speed multiplier was linearly ramped from 0.1 to 1.0. **Figures A3-26** and **A3-27** shows a series of temporal plots of predicted and observed TSS concentrations at four water column monitoring stations. The figures demonstrate that the model yielded reasonable predictions of TSS concentration trends.

Long-term deposition rates in a riverine system can be estimated by examining vertical profiles of Cesium-137 (^{137}Cs) in the sediment bed. Since peak ^{137}Cs concentrations are expected to coincide with the period of peak nuclear testing in 1963, the depth at which the peak is buried is an indication of the amount of sediment deposited since that time. Estimating a peak in this fashion yields an upper-bound of the observed deposition rate, since it ignores the impact of sediment mixing in surficial sediments. The accuracy of the estimated value also is dependent on the assumption that solids loading to the river has not changed significantly since 1963.

Long-term deposition rates predicted by the model were compared to high resolution cores with identifiable peaks, collected in 1997 and 2003 (**Figure A3-28**). For the 1997 cores, long-term sedimentation rates were determined through age-dating of the sediments using peak ^{137}Cs levels (Alcoa, April 2001). For the 2003 cores, long-term sedimentation rates were determined through the age-dating of sediments using peak organic carbon-normalized PCB concentrations (Alcoa, April 2009). This assumption was based on the fact that the high

resolution cores collected from the river in 1997 showed that the peak PCB concentration and peak ^{137}Cs were found at similar depths (Alcoa, April 2001).

The predicted area-weighted average deposition rates for Type 1 (coarse) sediment areas are comparable to those determined from the high-resolution cores (**Figure A3-28, top panel**). In these areas, predicted long-term deposition rates average 0.15 cm/yr. For the Type 2 (fine) sediment areas, however, predicted area-weighted deposition rates over the 10-year model simulation are consistently lower than those determined from the 1997 and 2003 high resolution sediment cores (**Figure A3-28, bottom panel**). Greater differences observed in the T7 to T10 and T17 to T23 reaches of the river are likely due to the deposition of solids that was documented to occur after the 2003 ice scour event (Alcoa, April 2009). Better agreement between the predicted and observed long-term deposition rates is observed for the downstream reaches that were not significantly affected by the 2003 ice scour event (i.e., T28 to T35 and T53 to T68), although the model consistently underestimates rates by about a factor of 4 to 10 (**Figure A3-28, bottom panel**). Overall, the model predicts a long-term average deposition rate of 0.14 cm/yr for the Type 2 (fine) sediment areas.

The differences between the predicted and observed deposition rates are attributed to two factors: 1) long-term deposition rates in the lower Grasse River have likely changed since 1963 (Alcoa, April 2001); and 2) the 10-year simulation period included a 100-year flood event, which could possibly influence predicted deposition rates in the river, especially during a relatively short-term simulation. For this reason, a 30-year model simulation was performed (without the influence of a 100-year flood event) to evaluate predicted deposition rates in the river over a longer time period. The average deposition rate predicted during this 30-year period is 0.17 cm/yr (**Figure A3-29**), which is comparable to that determined from the 10-year simulation. These sedimentation rates are more consistent with sedimentation rates estimated from Lead-210 (^{210}Pb) measurements (about 0.2 cm/yr; Alcoa, April 2001). Although the simulations suggest that the model accurately describes sediment resuspension and deposition in the lower Grasse River, the model is relatively unconstrained with respect to burial rates due to the lack of reliable estimates of sedimentation rate and high-flow suspended sediment dynamics. One of the primary causes for the relatively low sedimentation rate is the low fraction (10%) of Class 2

solids specified in the incoming load during high-flow events. Increasing this value would cause sedimentation rates to increase, especially in the upstream portion of the river. For this reason, the current parameterization was selected as a conservative assumption with respect to long-term burial rates (i.e., natural recovery).

3.4 MODEL UNCERTAINTY

In the original modeling effort documented in CCLGR (Alcoa, April 2001), sensitivity analyses were performed to evaluate changes in model predictions resulting from changes in several parameters. Based on the results of the sensitivity analyses, a conservatively low estimate of coarse-grained solids entering the river from upstream was selected and used during model calibration. This assumption was also applied to the current model calibration discussed herein.

In addition to the sensitivity analyses, uncertainties associated with the erosion potential functions, limited TSS concentration data used in assessing model calibration and potential impacts of stratification were identified. A discussion for each parameter is provided below.

Bounding estimates of several key model parameters, including erosion potential, were incorporated into the sediment transport model for the lower Grasse River. Two erosion potential studies were performed in the lower Grasse River, resulting in about 60 samples collected from over 30 locations in the river (see Section 3.2). Although the erosion potential data were consistent with other physical characteristics of the river (e.g., water depth and median particle size), the extrapolation of these data to the entire river introduces some level of uncertainty into the modeling analysis. In previous modeling efforts (Alcoa, April 2001), multiple simulations were performed with several sets of bounding parameters so that a conservative estimate of sediment scour during model calibration and an extreme flood event could be attained. Results of these simulations indicated that, for a variety of bounding parameters values, the extent of sediment scour during calibration and, thus, an extreme flood event did not change appreciably. To maintain a consistent level of conservatism, upper-bound estimates were selected in the current calibration.

Due to limited TSS concentration data available for model-data comparisons, the construction of a sediment mass balance, which has been shown to be useful for calibrating sediment bed dynamics during high flow events, was not possible. Additional TSS concentration data collected during higher flow events in the river, especially on the rising limb of the hydrograph, would provide more confidence that the sediment transport processes are characterized properly in the model. Moreover, there is only a limited amount of TSS concentration data during periods of ice breakup. However, results of the modeling analyses compare reasonably well with the available data and are consistent with other information collected in the river, suggesting the model has accurately described the principal processes governing sediment transport in the lower Grasse River.

Potential impacts associated with water column stratification in the lower Grasse River were not considered in the sediment transport model. As discussed in Section 2.4 of the CCLGR (Alcoa, April 2001), stratification only occurs during summer low flow conditions and likely has limited effects on sediment transport processes in the river.

SECTION 4
PCB FATE MODEL

PCB fate includes the transport of PCBs dissolved in the water or sorbed to solids, transfer between the dissolved and sorbed phases, transfer between the water and atmosphere, and biochemical degradation. The PCB fate model includes mechanistic descriptions of these transport, transfer and reaction processes. PCBs are assumed to partition between dissolved and particulate phases, with partitioning assumed to be rapid, such that equilibrium conditions are generally well approximated. The dissolved phase is composed of freely-dissolved PCBs and PCBs sorbed to dissolved and colloidal organic matter. Freely-dissolved PCBs are transferred from the water column to the atmosphere by volatilization across the water-air interface. Particulate phase PCBs settle from the water column to the sediment bed, and are resuspended from the sediment bed into the water column. Dissolved PCBs are exchanged between the water column and sediment bed and within the sediment in accordance with the laws of diffusion, that is, from a region of higher concentration to one of lower concentration, with the rate of transfer controlled by a mass transfer coefficient.

The output from the hydrodynamic and sediment transport models provides much of the information necessary to predict PCB fate and transport trends in the lower Grasse River. This information is supplemented by laboratory and field data to refine the relevant process descriptions.

4.1 MODEL STRUCTURE AND EQUATIONS

4.1.1 Water Column Mass Balance

The processes that determine the fate of PCBs in the lower Grasse River may be divided into two classes: 1) transport; and 2) transfer and reaction. Transport is the physical movement of PCBs caused by the net advective movement of water, mixing, and resuspension/deposition of solids to which PCBs are adsorbed. It is specified by the flow and dispersion characteristics in the water column and the settling velocity and resuspension rate of the solids. Transfer and

reaction include movement of PCBs among the air, water, and solid phases of the system and biological (or biochemical) transformation or degradation of the compound. The processes involved in transfer and reaction include volatilization, adsorption, dechlorination, and biodegradation.

PCBs are present in the lower Grasse River in three interacting phases: 1) freely dissolved; 2) sorbed to particulate matter or solids; and 3) complexed with dissolved (or colloidal) organic matter (DOM). PCB concentration is affected by transport, transfer and reaction processes as well as by external loadings from Alcoa's plant outfalls. A mathematical model of the lower Grasse River system was developed by application of the principle of mass conservation. Using this principle, mechanistic descriptions of the various processes were combined to form the basic mass balance equations that constitute the model. The external loadings were incorporated as forcing functions in the solution of the equations.

Consider the concentration, c, to be the freely dissolved PCB component in water. It interacts with the particulate component (i.e., the component sorbed to particulate matter) at concentration p, through an adsorption-desorption reaction. The particulate PCB concentration is expressed as:

$$p = rm \tag{4-1}$$

where:

p = particulate PCB concentration ($M\ L^{-3}$);

r = mass of chemical/unit mass of solids ($M\ M^{-1}$); and

m = concentration of the solids ($M\ L^{-3}$).

Initially ignoring the component sorbed to DOM, the equations governing the distribution of the dissolved and particulate components in any surface water system may be written as follows (Connolly and Winfield, 1984):

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial x}\left(E_x \frac{\partial c}{\partial x}\right) + \frac{\partial}{\partial y}\left(E_y \frac{\partial c}{\partial y}\right) + \frac{\partial}{\partial z}\left(E_z \frac{\partial c}{\partial z}\right) - \frac{\partial}{\partial x} u_x c$$
$$- \frac{\partial}{\partial y} u_y c - \frac{\partial}{\partial z} u_z c - K_o mc + K_2 p \pm S_1(s, y, z, t) \tag{4-2}$$

$$\frac{\partial p}{\partial t} = \frac{\partial}{\partial x}\left(E_x \frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial y}\left(E_y \frac{\partial p}{\partial y}\right) + \frac{\partial}{\partial z}\left(E_z \frac{\partial p}{\partial z}\right) - \frac{\partial}{\partial x} u_x p$$
$$- \frac{\partial}{\partial y} u_y p - \frac{\partial}{\partial z} u_z p + \frac{\partial}{\partial z} w_s p + K_o mc - K_2 p \pm S_2(s, y, z, t) \tag{4-3}$$

where:

E	=	dispersion coefficient ($L^2 T^{-1}$) ;
u	=	velocity ($L T^{-1}$) ;
w_s	=	settling velocity of the particulates ($L T^{-1}$);
K_o	=	adsorption coefficient ($L^3 M^{-1} T^{-1}$) ;
K_2	=	desorption coefficient (T^{-1}) ;
x,y,z	=	coordinate directions (L) ;
t	=	time (T); and
S_i	=	sources and sinks of the component due to reactions, phase transfers, resuspension of PCB-containing bed sediments, volatilization, and external loadings ($M L^{-3} T^{-1}$).

The first three terms in each equation represent dispersion or mixing due to temporal and spatial velocity gradients and density differences within the river. The next three terms represent longitudinal, lateral and vertical advection, respectively. The seventh term in Equation 4-3 accounts for the vertical advection of the particulate component due to settling. The following two terms (and the seventh and eighth terms in Equation 4-2) define the rate of adsorption and desorption, respectively. The last term in both equations accounts for the chemical and biological reactions and volatilization (water column only) that may produce or degrade the component.

Adsorption is generally treated as a rapid process relative to other processes affecting PCB fate. Following the conventional assumption, local instantaneous equilibrium is assumed. Moreover, the assumption of a vertically mixed water column permits the reduction of the equations for dissolved and particulate chemical within the water column (Equations 4-2 and 4-3) to the following single two-dimensional equation for total chemical concentration, c_T:

$$\frac{\partial c_T}{\partial t} = \frac{\partial}{\partial x}\left(E_x \frac{\partial c_T}{\partial x}\right) + \frac{\partial}{\partial y}\left(E_y \frac{\partial c_T}{\partial y}\right) - \frac{\partial (U_x c_T)}{\partial x} - \frac{\partial (U_y c_T)}{\partial y} - \frac{D_{tot}}{hm}\left(f_p c_T\right) + \frac{R_{tot}}{h\rho_{bed}}\left(f_p c_T\right)_{bed} - \frac{k_f}{z_1}\left[\left(f_d c_T + f_{doc} c_T\right) - \left(f_d c_T + f_{doc} c_T\right)_{bed}\right] - \frac{S_v}{h} \pm S \tag{4-4}$$

where:

S	=	external sources for PCBs (M $L^{-3}T^{-1}$) ;
D_{tot}	=	depositional flux of solids (M $L^{-2}T^{-1}$);
R_{tot}	=	resuspension flux of solids (M $L^{-2}T^{-1}$);
ρ_{bed}	=	dry bulk density of the sediment bed surface (M L^{-3});
h	=	depth of the water column (L);
$U_{x,y}$	=	vertically-averaged velocity in x- and y-directions (M T^{-1});
k_f	=	sediment-water mass transfer coefficient (L T^{-1});
z_1	=	thickness of the surface sediment layer (L); and
S_v	=	PCB flux due to volatilization (M $L^{-2}T^{-1}$).

and:

$$c = f_d c_T \tag{4-5}$$

$$p = f_p c_T \tag{4-6}$$

$$c_{doc} = f_{doc} c_T \tag{4-7}$$

where:

f_d = fraction dissolved;

f_p = fraction particulate; and

f_{dom} = fraction sorbed to DOM.

The DOM sorbed phase component can be expressed in a manner analogous to the particulate PCB concentration:

$$c_{dom} = r_{dom} m_{dom} \tag{4-8}$$

where:

r_{dom} = mass of chemical/unit mass of DOM (M M^{-1}); and

m_{dom} = concentration of DOM (M L^{-3}).

The expressions for fraction dissolved and fraction particulate are derived from the relationship defining equilibrium adsorption. For organic chemicals whose adsorption is classified as hydrophobic bonding, equilibrium adsorption at environmentally relevant concentrations (i.e., less than one-half water solubility) is linearly related to dissolved chemical concentration (Karickhoff, 1984) and may be written as:

$$r = K_p c \tag{4-9}$$

where K_p is the adsorption partition coefficient. Using Equations 4-5 through 4-9, the resulting expressions for fraction dissolved and fraction particulate are:

$$f_d = \frac{\theta}{\theta + K_p m} \tag{4-10}$$

$$f_p = \frac{K_p m}{\theta + K_p m} \tag{4-11}$$

where θ is the porosity (water volume/total volume) and m is the concentration of suspended or bed solids.

Inclusion of the component sorbed to DOM alters Equation 4-4 by changing the definitions of f_d and f_p and adding a third component equation for the fraction sorbed to DOM (f_{dom}). Applying the local instantaneous equilibrium assumption and expressing the DOM concentration as mass of organic carbon per unit volume, the expressions for fraction dissolved, fraction particulate and fraction sorbed to DOM become:

$$f_d = \frac{\theta}{\theta + K_p m + K_{doc} m_{dom}} \tag{4-12}$$

$$f_p = \frac{K_p m}{\theta + K_p m + K_{doc} m_{dom}} \tag{4-13}$$

$$f_{dom} = \frac{K_{doc} m_{dom}}{\theta + K_p m + K_{doc} m_{dom}} \tag{4-14}$$

where:

K_{doc} = the partition coefficient between PCBs sorbed to DOM and freely dissolved (liters/kilogram organic carbon); and

m_{dom} = concentration of DOM expressed in terms of organic carbon (kilogram organic carbon/liter).

The component fractions are applied to the various processes included in the source/sink terms in Equation 4-4.

The fifth, sixth, and seventh terms of Equation 4-4 represent PCB deposition flux, resuspension flux, and dissolved-phase exchange flux, respectively. These processes have been included in the general water column mass balance equation to demonstrate the explicit linkage between the water column and sediment bed mass balance (expressions subscripted with "bed" indicate that these represent sediment bed surface concentrations). These three source/sink terms are discussed in further detail below in conjunction with the mass balance equation describing PCB dynamics of the sediment bed.

4.1.2 Sediment Mass Balance

Vertical transport of PCBs within the sediment bed is simulated using two mechanisms: dispersion and molecular diffusion. Dispersion affects the total chemical concentration (particulate and dissolved components) and is due to biological activity in surface sediments as well as the propagation of water turbulence into the bed. Molecular diffusion applies only to the dissolved component and is parameterized by diffusion coefficients for the dissolved and DOM-sorbed components. Assuming that the diffusion coefficients for these two phases are equal, they can be described by a single diffusion coefficient (D_s), and PCB transport in the sediment bed is simulated using:

$$\frac{\partial c_{T,bed}}{\partial t} = \frac{\partial}{\partial z}\left(E_{disp} \frac{\partial c_{T,bed}}{\partial z} \right) + \frac{\partial}{\partial z}\left[D_s \frac{\partial (c_{bed} + c_{dom,bed})}{\partial z} \right] + \frac{\partial (U_{bed}\, p)}{\partial z} - S_b \qquad (4\text{-}15)$$

where:

U_{bed} = particle-bound flux "velocity" (L T^{-1});

E_{disp} = bed dispersion coefficient (mixing) (L^2 T^{-1});

D_s = molecular diffusion coefficient (L^2 T^{-1}); and

S_b = decay processes such as biodegradation and dechlorination.

In solving Equation 4-15, the component concentrations are expressed as the product of the component fraction and the total chemical concentration, e.g., $c_{bed} = f_d\, c_{T,bed}$. Vertically-

averaged water column concentrations are represented by c and c_{dom} while $c_{T,bed}$, c_{bed}, and $c_{dom,bed}$ represent sediment bed surface concentrations.

The sediment bed and water column transport equations, Equations 4-15 and 4-4, are linked by fluxes of PCBs in both particulate and dissolved phases at the sediment-water interface. The deposition and resuspension fluxes of particulate phase PCBs are determined from the solids deposition and resuspension fluxes calculated by the sediment transport model. Equations 4-15 and 4-4 are solved numerically with the interface fluxes (i.e., settling, resuspension, and diffusion) specified as boundary conditions.

Vertical Diffusion within the Sediment Bed

Vertical pore water diffusive transport within the sediment is mathematically described as a Fickian process, in which the diffusive flux is expressed as the product of the vertical gradient of dissolved plus DOM-bound pore water concentration and a diffusion coefficient (D_s):

$$J_{i,j} = \frac{D_s}{l_{i,j}} \left[\left(c + c_{dom} \right)_i - \left(c + c_{dom} \right)_j \right]_{bed} \tag{4-16}$$

where:

$J_{i,j}$ = vertical diffusive flux from sediment (M T^{-1});

i,j = indices of adjacent vertical segments; and

$l_{i,j}$ = mixing length between adjacent bed segments i and j.

The mixing length $l_{i,j}$ is set equal to the distance between segment midpoints. The pore water diffusion coefficient is based on the molecular diffusion coefficient for PCB in aqueous solution, adjusted for the tortuosity of the sediment bed. The effect of tortuosity is to decrease the rate of diffusion, as the solid matrix impedes the Brownian motion of dissolved PCB molecules. Experimental data have shown that the effect of tortuosity can be expressed by multiplying the molecular diffusion coefficient in solution by the bed porosity raised to an exponent of approximately two (Lerman, 1978).

Sorption Processes

PCBs sorb to inorganic and detrital organic particulate material, microorganisms and "dissolved" humic material. For uncharged organic chemicals of limited water solubility, such as PCBs, organic matter is the predominant sorptive component of the sorbant (Karickhoff, 1984). Generally, the sorptive tendency of such chemicals is described by an organic carbon-referenced sorption partition coefficient (K_{oc}). This partition coefficient describes the ratio of sorbed chemical concentration (mass of chemical sorbed per unit mass of organic carbon) to dissolved chemical concentration after the sorption reaction has attained equilibrium. K_{oc} is typically treated as a basic property of an organic chemical that is independent of the sorbant material. Since the sorption of uncharged organic chemicals is essentially a physical association between the chemical and the sorbant resulting from the hydrophobic nature of the chemical, the value of K_{oc} is proportional to other properties of the chemical that are related to hydrophobicity. By convention, the partitioning of an organic chemical between water and octanol, a hydrophobic organic solvent, is used as a measure of the chemical's hydrophobicity. The octanol/water partition coefficient (K_{ow}), has been shown to be approximately linearly related to laboratory determined K_{oc} values (Karickhoff, 1981, 1984; Baker et al., 1997) and it is commonly assumed that K_{oc} is equal to K_{ow}. Since K_{ow} values of PCBs range over three orders of magnitude, increasing with increasing chlorination, the appropriate K_{oc} value to describe partitioning of PCBs as a group depends on congener composition.

The use of an equilibrium partition coefficient to describe PCB sorption (see Equations 4-12, 4-13, and 4-14) requires the assumption that the kinetics of adsorption and desorption are much faster than other processes affecting PCBs. Sorption has fast and slow stages (Pignatello and Xing, 1996). The fast stage has a time scale of minutes to hours, whereas the slow stage's time scale is weeks to months. This biphasic process may be caused by a number of phenomena, including: 1) kinetics of intra-particle and/or intra-organic matter diffusion; 2) different extents of sorption among the multiple types of organic matter present on the particle; and 3) rearrangement of the organic matter matrix after the chemical is sorbed. The conventional conceptual model of biphasic sorption includes a reversibly sorbing component with fast stage kinetics and a resistantly bound component with slow stage kinetics. Reversible

sorption is adequately described by the equilibrium partitioning model (DiToro and Horzempa, 1982), while resistant sorption is not.

The resistant component is sometimes small and can be neglected. For example, McGroddy et al. (1996) found that equilibrium partitioning accurately described the partitioning of PCB congeners in Boston Harbor sediments and their desorption from those sediments in laboratory experiments. It appears that sediments have a limited capacity for resistant sorption. Studies with Hudson River sediments containing PCBs (Carroll et al., 1994) and spiked laboratory sediments (Kan et al., 1997) indicate a saturation of the resistant compartment at environmentally relevant concentrations of sorbed chemicals.

Ignoring biphasic sorption by assuming instantaneous equilibrium introduces error in the PCB fate model. The model will over-estimate desorption of PCBs from resuspended sediment and may over-estimate desorption of PCBs from sediments into pore water, depending on the time scales of diffusion and the slow stage of desorption. Overestimation of desorption from resuspended sediments results in over-estimation of PCB flux from sediments and downstream transport of PCBs. The significance of this over-estimation depends on the relative contributions of intermittent resuspension events and continuous flux from pore water to downstream PCB transport, as well as the fraction of the sediment PCB that is resistantly sorbed.

PCBs are known to partition to dissolved and colloidal organic matter in both the water column and sediment. This phenomenon affects the distribution of PCBs between the aqueous and particulate phases. Sorption of PCBs within the aqueous phase reduces bioavailability because only freely dissolved chemical can be taken up through the respiratory surfaces of aquatic animals (Landrum et al., 1985; 1987). The partition coefficient describing the equilibrium sorption of PCBs to dissolved/colloidal organic matter is typically expressed on an organic carbon basis and is termed K_{doc}. The value of K_{doc} is typically less than that of K_{oc}. For example, Evans (1988) found that K_{doc} values for three PCB congeners sorbing to natural dissolved/colloidal organic matter from ten lakes and two streams in south-central Ontario were 0.2% to 4% of the corresponding K_{ow} values. The difference is likely a consequence of differences in size, complexity and polarity of dissolved/colloidal and particulate organic matter.

Sorption partition coefficients (K_p) for hydrophobic organic compounds vary with temperature (T). This effect can be described by the following equation (QEA, 1999):

$$\ln \frac{K_{p2}}{K_{p1}} = -\frac{\Delta H^{\circ}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \tag{4-17}$$

where:

K_{p2}	=	partition coefficient at temperature T_2 ($L^3 M^{-1}$);
K_{p1}	=	partition coefficient at temperature T_1 ($L^3 M^{-1}$);
ΔH^{o}	=	net change in entropy (heat content) of the reaction (kJ mol^{-1}); and
R	=	universal gas constant (kJ K^{-1} mol^{-1}).

By rearranging Equation 4-17 an expression for the equilibrium partition coefficient at temperature T_2 can be obtained knowing K_{p1}, T_1, and ΔH^o. For large non-polar compounds such as PCBs, ΔH^o is negative (exothermic). This indicates that PCB adsorption to natural particles will decrease as temperature increases. Knowing the equilibrium partition coefficient at more than one temperature allows the solution of Equation 4-17 for the constant ΔH^o.

Volatilization

Volatilization is the process by which PCBs are transported across the air-water interface. A chemical's tendency to volatilize is determined by the ratio of its equilibrium activities in air and water (Henry's constant). This ratio is a fundamental property of the chemical that is defined by Henry's Law. Henry's constant equals the vapor pressure divided by its solubility in water and can be calculated from the equilibrium ratio of gas phase and water phase concentrations in a laboratory experiment. A high Henry's constant is indicative of a volatile chemical that preferentially accumulates in the air phase. A low Henry's constant is indicative of a non-volatile chemical that preferentially accumulates in the water phase. Values of Henry's constant are presented either in units of partial pressure per unit aqueous concentration (e.g., atm-m^3/mol, or as a dimensionless ratio of concentrations – [mol/m^3]/[mol/m^3]). The

dimensionless ratio is derived from the dimensioned ratio by dividing by the product of the universal gas constant and absolute temperature, i.e., *RT*, thus converting pressure into concentration using the Ideal Gas Law.

Numerous experimental determinations of dimensionless Henry's constants for PCBs have been published (e.g., Bopp, 1983; Burkhard et al., 1985; Murphy et al., 1987; Dunnivant and Elzerman, 1988; Brunner et al., 1990). These studies have used various methodologies that have yielded differing estimates. Values range from about 0.0005 to 0.05. They are highest for the lowest chlorinated congeners and decrease as chlorination increases. Values for Aroclors 1242 and 1254, as reported by Murphy et al. (1987), are about 0.01 and 0.008, respectively. These dimensionless Henry's constant values for PCBs are of sufficient magnitude to make volatilization a potentially significant process, particularly in systems with large surface areas and long residence times.

The rate at which volatilization occurs is dependent on the mass transfer coefficient at the air-water interface and the concentration of PCBs in the water column. Only freely-dissolved PCB can be transported across the interface, so sorption to particulate or dissolved organic carbon reduces volatilization. The expression used to incorporate PCB flux due to volatilization (S_v) into the water column mass transport equation (Equation 4-4) is as follows:

$$S_v = k_L \left(c - \frac{c_{air}}{H} \right) \tag{4-18}$$

where:

k_L = volatilization mass transfer coefficient ($L\ T^{-1}$);

c_{air} = vapor phase PCB concentration in air ($M\ L^{-3}$); and

H = dimensionless Henry's constant.

The mass transfer coefficient is dependent on the rates of mass transfer through relatively thin layers of water and air at the interface, which are in turn dependent on the concentration gradients in the layers, and the diffusivity of PCBs in the layers (O'Connor, 1983; 1984):

$$k_L = \frac{k_g k_l}{k_g + \frac{k_l}{H}} \tag{4-19}$$

where:

k_g = vapor phase mass transfer constant (L T^{-1}); and

k_l = water phase mass transfer constant (L T^{-1}).

4.2 APPLICATION TO THE LOWER GRASSE RIVER

4.2.1 Model Configuration

Model Discretization

The domain of the lower Grasse River PCB fate model was the same as that of the hydrodynamic and sediment transport models: extending from just downstream of the Route 37B Bridge to the St. Lawrence River. The fine resolution vertically integrated grid used for the long-term hydrodynamic and sediment transport simulations was also used in the PCB fate calculations (see **Figure A2-2**).

The assumption of a vertically-averaged water column was considered sufficient to model PCB fate in the lower Grasse River despite the observation that the river exhibits intermittent thermal stratification during low flow periods. Such thermal stratification is due to the intrusion of St. Lawrence River water under the warmer Grasse River water (Alcoa, April 2001). While thermal stratification may affect the vertical mixing of dissolved and particulate phase PCBs, stratification generally is weak, characterized by a less than 5 degrees Celsius (°C) temperature differential between upper and lower waters. Such weak stratification

may be frequently disturbed by wind-induced mixing. As a result, thermal stratification may affect discrete PCB measurements, but was not considered to have a significant effect on the long-term fate of PCBs within the system.

The bed map was the same as that used in the sediment transport model (**Figure A3-16**) and was segmented into discrete regions consisting of hard bottom and cohesive sediment areas. The bed model was constructed using 12 1-inch layers to simulate PCB transport in the sediments. This resolution was based on the existing database that generally consisted of PCB and other sediment measurements at a core segmentation interval of 3 inches.

The PCB fate model of the lower Grasse River was directly coupled to the hydrodynamic and sediment models. Velocities (U_x, U_y) and water depths (h) computed by the hydrodynamic model were used to simulate water column transport of PCBs using Equation 4-4. The sediment transport model provided TSS concentrations (m), deposition fluxes (D_{tot}) and resuspension fluxes (R_{tot}) that were used by the PCB fate model (Equation 4-4).

Boundary Conditions

Simulation of PCB dynamics within the lower Grasse River through simultaneous solution of the water column and sediment mass balance equations (Equations 4-4 and 4-15, respectively) required the specification of certain water column and sediment boundary conditions. First, both the upstream and downstream water column boundaries located just below the Route 37B Bridge and at the confluence with the St. Lawrence River were specified as constant concentration boundaries, with inter-annual variations, based on an analysis of field data (discussed below).

Second, transfer from the sediment to the water column across the sediment-water interface occurs only by diffusion, deposition, and resuspension fluxes (i.e., dispersive fluxes are incorporated into the mass transfer coefficient k_f; see below). That is:

$$\left(E_{disp} \frac{\partial c_{T,bed}}{\partial z} \right)\Bigg|_{z=0} = 0 \tag{4-20}$$

Since the transfer of dissolved phase PCBs from the bed to the overlying water occurs via some combination of diffusion and advection, the flux is dependent on the concentration gradient between the water column and the surface sediment, as specified by the third boundary condition:

$$\left(D_s \frac{\partial (c_{bed} + c_{doc,bed})}{\partial z} \right)\Bigg|_{z=0} = k_f \left[\left(c + c_{doc} \right) - \left(c_{bed} + c_{doc,bed} \right) \right] \tag{4-21}$$

The mass transfer coefficient (k_f) is an empirical parameter that incorporates a number of processes occurring in the surface sediments, including molecular diffusion, turbulence, bioirrigation, bioturbation and advection. As such, its value is best determined through the analysis of field data.

The fourth boundary condition considers the flux of PCBs across the lower boundary of the sediment column. For the purposes of maintaining an accounting of total PCB mass, flux across this boundary was set at zero. This was accomplished by expanding the bottom sediment layer as materials passed into it from the adjoining upper layer.

The fifth boundary condition allows particle-bound PCBs to be transferred to the water column *via* deposition and resuspension. It makes use of the lumped-parameter variable U_{bed}, a particle-bound chemical flux "velocity" defined only at the sediment water interface, as a means to incorporate deposition and resuspension chemical fluxes into the bed equation, such that:

$$(U_{bed}\, p)\big|_{z>0} = 0 \tag{4-22}$$

$$(U_{bed}\,p)\big|_{z=0} = \frac{D_{tot}}{m}(p) - \frac{R_{tot}}{\rho}(p_{bed}) \tag{4-23}$$

Finally, the boundary condition at the air-water interface was defined by the flux of PCBs via volatilization (i.e., Equation 4-18).

Initial Conditions

To solve the coupled water column and sediment mass balance equations (i.e., Equations 4-4 and 4-15), initial conditions must be set for PCB concentrations in the water and sediment bed. These initial conditions are starting points for the PCB fate model calibration. Water column initial conditions have little impact on models of flowing river systems due to the relatively small hydraulic residence time (e.g., on the order of 5 to 10 days in the modeled reach of the lower Grasse River under low flow conditions [< 200 cfs]). However, due to the relatively slower dynamics in the sediment bed, an accurate representation of the PCB concentrations in the surface sediments is required for the model calibration.

As discussed in Section 4.3.1, the model calibration period was initiated in 1997 in order to evaluate changes in PCB concentrations due to an approximate 100-year flow open water event that occurred in January 1998. The initial conditions established for 1997 are somewhat uncertain, however, particularly with regard to the vertical patterns of PCB concentrations in sediments, since most of the sediment data collected in the 1990s are surficial grab samples that provide no information about PCBs at depth. For this reason, the sediment bed PCB concentrations were re-initialized in 2000 to provide a better representation of the vertical patterns of PCBs to support simulations of sediment remediation. For the sediment initial conditions in 1997, surface grab and core data collected in the 1990s were used. Core data collected from 2003 to present (for T1 to T19) and 2000 to present (for T19 to T72) were used to re-initialize sediment PCB concentration in 2000.

1997 Initial Conditions

The data sets used for initial sediment PCB concentrations in 1997 are listed in **Table A4-1**. Due to differences in vertical segmentation schemes among the various sampling

programs, the first step in developing initial conditions was to convert the data from each unique sampling location into a common vertical segmentation. Based on the segmentation used in a majority of the lower Grasse River sediment samples (**Table A4-1**), four 3-inch layers were selected (i.e., 0 to 3 inches, 3 to 6 inches, 6 to 9 inches, and 9 to 12 inches). For samples with coarser segmentation, a uniform concentration was specified for the corresponding averaging layers (e.g., for a sample with a 0- to 6-inch core segment, the same concentration was specified for 0 to 3 inches and 3 to 6 inches). For samples with a finer segmentation, depth-weighted averages were computed for all samples within a particular averaging strata (e.g., for a core with 1-cm slices throughout, the top seven slices with a weight of 1.0 and the 7 to 8 cm slice with a weight of 0.62 were combined to produce a single 0 to 3 inches [0 to 7.5 cm] average).

Once the data from each sediment sampling location were defined for each of the four 3-inch layers, the averages were assigned to corresponding model grid elements by creating Thiessen polygons and then taking an area-weighted average concentration within each model grid element for the four averaging strata (i.e., 0 to 3 inches, 3 to 6 inches, 6 to 9 inches, and 9 to 12 inches). Maps of the Thiessen polygons for the 0- to 3-inch slices are presented in **Figure A4-1**. Similar polygons were developed for the remaining strata (3 to 6 inches, 6 to 9 inches, and 9 to 12 inches). Values from individual layers (i.e., four 3-inch layers) then were uniformly assigned to the twelve 1-inch layers used in the bed model (e.g., layers 1 to 3 were assigned the same concentration as the 0 to 3 inch average).

All grid elements upstream of the Massena Power Canal were assumed not to be influenced by the PCBs discharged from the Alcoa facility, and were therefore assigned the average of background samples collected from the Grasse River between the Main Street Bridge and the Power Canal. Initial sediment PCB concentrations for model grid elements at the downstream boundary were assigned the average from samples collected at the confluence of the Grasse and St. Lawrence Rivers.

The resulting 0 to 3 inch, 3 to 6 inch, 6 to 9 inch, and 9 to 12 inch average PCB concentrations for the lower Grasse River PCB fate model grid are shown in **Figures A4-2**

through **A4-5**. The model was then run from 1997 through 2003 to represent pre-ice jam conditions.

2000 Initial Conditions

The sediment core data used to set initial sediment PCB concentrations in 2000 are shown in **Table A4-2**. The same approach described above was adopted in regularizing the different segmentation schemes in the available sediment cores. Upstream of T19, data collected prior to 2003 were not included in the initial condition to ensure that the model would be accurate for post-2003 ice scour conditions (the model does not simulate the ice jam scour event). Also, for the ROPS area, only cores collected as part of post-implementation monitoring were used.

The resulting 0 to 3 inch, 3 to 6 inch, 6 to 9 inch and 9 to 12 inch average PCB concentrations used to set initial sediment PCB concentrations are shown in **Figures A4-6** through **A4-9**, respectively. The model was then run from 2000 through 2006. Model results for the 2004 through 2006 period were then appended to the 1997 through 2003 results (as discussed above) and used as input to the bioaccumulation model. The two models were then overlapped to smooth out differences that would exist if the model was just reset in 2000.

External Loadings

External PCB loadings to the river (i.e., *S* in Equation 4-4) during the 1997-2006 model calibration period consisted of PCBs entering the river at the upstream boundary, and PCBs discharged from the Alcoa facility at Outfalls 001, 004, 005, and 007. Although the data are limited, PCB concentrations at the upstream boundary are consistent with PCB levels measured in remote, un-impacted streams and precipitation in the eastern U.S. during the late 1990s and 2000s (0.4 to 0.5 nanograms per liter [ng/L]; VanRy et al., 2002; 0.3 ng/L, U.S. Environmental Protection Agency [USEPA], March 2004; 0.1 to 0.4 ng/L, Glaser et al., November 2006; 0.1 to 0.4 ng/L, Interstate Commission on the Potomac River Basin, January 2007). The background level at the upstream boundary for each year of simulation was estimated as the average annual concentration measured at Main Street Bridge and WC001. The same value was used for the downstream boundary.

PCB loadings from Outfall 001 for the model calibration period were based largely upon flow and PCB concentration monitoring data generated in accordance with Alcoa's SPDES discharge permit. As shown in the temporal profile of the 1997-2006 Outfall 001 flow and PCB concentration data (**Figure A4-10**, symbols in **panels a and b**), the record was well defined for the calibration period. Flows and PCB concentrations on days without data were estimated based upon linear interpolation between available measurements. In addition, for the four storm sampling events in summer 1997, the daily average flow and PCB concentrations from the storm monitoring data were used to calculate Outfall 001 PCB loadings. The resulting Outfall 001 loading history used in the model was calculated from the interpolated flows and concentrations, and is shown in **Figure A4-10** (line in **panel c**). The increased loadings in 1998 were likely the result of sewer cleaning activities undertaken in the fall 1998, as well as the lowering of the detection limit for reporting PCBs by the Alcoa Massena Operations ChemLab (Alcoa, April 2001).[2] All data collected between 2004 and 2006 were non-detect (see footnote below for detection limits). The variability in the loads specified to the model reflects the variability in the flow.

Due to operational differences, a modified approach was used to develop PCB loadings from Outfall 004. Effluent from Outfall 004 undergoes carbon treatment, and as a result, monitored effluent PCB concentrations are largely non-detect. During wet weather, the capacity of the Outfall 004 treatment facility is sometimes exceeded, and the excess flow bypasses treatment and is discharged directly to the river. Bypass volumes and duration are monitored during these events, but the bypass flow is not sampled for PCBs under the SPDES program. The Outfall 004 bypass was, however, sampled during five of the summer 1997 storm sampling events.

Based on the differences in dry and wet weather discharges, the PCB loading from Outfall 004 used in the model was developed based on the sum of two components:

[2] The Alcoa Massena Operations ChemLab detection limits for PCB Method 608 were lowered in October 1998. The method detection limit was lowered from 0.175 :g/L for Aroclors 1242, 1248 and 1254 and 0.125 :g/L for Aroclor 1260 to 0.065 :g/L for all Aroclors.

1. The dry-weather base load was defined by flow and PCB concentrations from SPDES monitoring data, as plotted in **Figure A4-11** (**panels a and b**). As shown in **Figure A4-11** (**panel a**), the base flow was relatively constant throughout the calibration period, and missing values were based on the mean of approximately 400 gallons per minute (gpm) prior to October 1997, and on linear interpolation thereafter. Base PCB concentrations for Outfall 004 during the calibration period were set to one-half the method detection limit (MDL), except for the two samples in which PCBs were detected, and PCB concentration on days with missing data were estimated by linear interpolation (**Figure A4-11, panel b**). The resulting dry-weather base load was calculated from the flow and concentration values, and averaged less than 0.15 grams per day (g/day) over the calibration period (**Figure A4-11, panel c**).

2. The wet-weather bypass load was characterized based upon bypass data and a PCB-discharge rating curve developed from the storm monitoring data. For each day with a bypass event, the mean instantaneous bypass flow was calculated based on the total volume and duration of the bypass(es). As shown in **Figure A4-11** (**panel a**), instantaneous bypass flows were typically less than 1000 gpm, but exceeded 2000 gpm for a number of events. Based on the instantaneous bypass flow, the PCB concentration of the Outfall 004 bypass was estimated according to the rating curve plotted in **Figure A4-12.** As shown in **Figure A4-11** (**panel b**), Outfall 004 bypass PCB concentrations (estimated and data) were between 1 and 8 micrograms per liter (µg/L). Instantaneous bypass PCB loadings then were calculated based on the instantaneous bypass flow and the estimated bypass concentration. These loads were converted to a mean daily loading by prorating the instantaneous values by the bypass duration. For example, the instantaneous bypass load for a 6-hour bypass event was multiplied by 0.25 to calculate the mean daily load. On days in which bypass flow and concentration were monitored during the storm sampling, the mean daily flow and concentration data were used to estimate the daily bypass loading. The Outfall 004 bypass loading was zero on days without bypass events. As shown in **Figure A4-11** (**panel c**), the PCB loading during bypass events typically was 1 to 5 g/day, but exceeded 10 g/day on a few events.

The total load from Outfall 004 during the calibration period was calculated as the sum of the base and bypass loads. Loads from Outfall 004 are generally lower than the loads from Outfall 001. Moreover additional source control efforts that were implemented after 1999 have resulted in substantial reductions in PCB levels. Nearly all the data reported post 1999 are non-detects. The levels at which non-detects are plotted in **Figure A4-11, panel b**, reflect the different detection limits reported in the SPDES permits.

PCB loading for Outfall 005 was calculated based on flows and PCB concentrations measured during the time when the outfall was in operation (i.e., October 5, 1998 through February 23, 2000). Computed PCB loadings were used directly for days when measurements were available, while the average of these calculated loadings was applied to times when data were not available (**Figure A4-13, panel c**). Outfall 005 loadings, almost all of which were lower than 0.02 g/day, were about two orders of magnitude lower than those from Outfall 001.

Outfall 007 PCB loadings also were lower than those from Outfall 001 (by about one order of magnitude). Since there were only three data points available for 1997, the loading temporal developed for 1998 was repeated for 1997. For all other times when PCB and flow data were not collected, an average PCB discharge value of 0.06 g/day used in the earlier modeling efforts (Alcoa, April 2001) was also used here. This average excluded the three samples taken on the same dates as the TSS samples that were excluded from the Outfall 007 TSS average used for the sediment transport model. The PCB loading temporal for Outfall 007 is shown in **Figure A4-14** (**panel c**).

4.2.2 Model Parameterization

Partitioning

The organic carbon-based PCB partition coefficient (K_{oc}) used in the lower Grasse River model was based on an average value from batch laboratory studies conducted by Nadal (1998) using lower Grasse River sediments. These studies showed that relationships between water and sediment PCBs were adequately described using a two-phase partitioning approach. Based on the results of these studies, an average two-phase total PCB K_{oc} value of 1.55×10^5 liters per

kilogram organic carbon (L/kg OC; log K_{oc} = 5.19) was used in the model to represent partitioning in both the water column and the sediment bed. In order to account for the effects of temperature on the partition coefficient, an excess enthalpy of reaction equal to 23.9 kiloJoules per mole (kJ/mol; i.e., ΔH^o in Equation 4-17) was specified. This value was based on congener-specific ΔH^o values developed from Hudson River data (QEA, 1999) and the mean PCB congener distribution from lower Grasse River sediment data. Using this ΔH^o value, temperature-adjusted K_{oc} values were computed in the model according to Equation 4-17, with the base value of K_{oc} (i.e., 1.55×10^5 L/kg OC) corresponding to that at 20 ºC. As a result, K_{oc} more than doubles as temperature decreases from 20 ºC to 0 ºC.

Organic Carbon

Analysis of available data indicated that water column organic carbon levels varied little throughout the river. On a temporal scale, a seasonal trend was observed in water column organic carbon fraction, ranging from approximately 10% during winter months to approximately 30% during spring/summer. The previous modeling investigated the importance of seasonal carbon dynamics on predicted water column PCB levels in the river (Alcoa, April 2001). Changes in predicted PCB levels were relatively insignificant to changes in water column organic carbon levels. Therefore, the mean value of 13%, the same value used in the prior modeling efforts, was held constant during model calibration.

Organic carbon values were specified in the model for the sediment bed using the same datasets employed to estimate the total PCB sediment concentrations for model projections (see Section 7.4.1). The river was broken up into 10 divisions as was done for bulk density and sediment composition. An area-weighted average total organic carbon value was calculated for each of these 10 divisions for four depth intervals (0 to 3 inches, 3 to 6 inches, 6 to 9 inches, and 9 to 12 inches).[3] The fraction of organic carbon (f_{oc}) in the upstream portion of the model grid is relatively low, which is consistent with the bed map used in the sediment transport model (see **Figure A3-16**). Values of f_{oc} within the middle portion of the model domain are higher,

[3] First, Thiessen polygons were used to calculate an area-weighted average fraction organic carbon value for each grid cell/depth interval combination. Then, grid cell fraction organic carbon values were used to calculate an area-weighted average for each depth in each of the 10 divisions.

averaging approximately 5%. In the downstream-most portion of the model grid, the surface sediment f_{oc} used in the model is typically less than 5%.

Temperature

To accurately account for temperature effects on partitioning and volatilization in the model, a mean annual temperature function was developed to represent seasonal variations in water column temperature. Temperature measurements made during routine water column sampling from 1997 to 2006 at stations WC007, WC011, WC012 and WC013 (see **Figure A4-19** for locations) were used to develop four sinusoidal functions – one for each location. The resultant functions are shown compared with temperature data measured during routine sampling in **Figure A4-15**. Since the annual variations in the measured temperature at four locations were small and also because the amplitudes and the day of maximum temperature estimated from the location-specific data were similar, data from the four locations were pooled and a single function was developed for the river. The resulting temperature function used in the model is shown compared to the data from all locations in **Figure A4-16**. The median relative percent difference (RPD) between the temperature function and the measured temperatures at WC007, WC011, WC012 and WC013 are 10.2, 10.2, 10.5 and 15.1, respectively.

Volatilization

Calculation of volatilization flux in the model (i.e., Equations 4-18 and 4-19) required parameterization of the air-phase PCB concentration, the Henry's Law Constant, and the liquid and vapor phase mass transfer coefficients. For the purposes of the lower Grasse River PCB fate model, ambient air-phase PCB concentrations (c_{air} in Equation 4-18) were assumed to be negligible (QEA, 1999). A mean Henry's Law constant of 21.2 Pascal-cubic meter per mole (Pa-m^3/mol), which corresponds to a dimensionless value (i.e., H in Equation 4-18) of 0.0087 at 20 °C, was used in the model. This value was based on published Henry's Law Constants for PCB congeners (Brunner et al., 1990) and the mean congener distribution in lower Grasse River water column PCB data.

The liquid phase mass transfer coefficient (k_l in Equation 4-19) was calculated from the O'Connor-Dobbins equation (O'Connor and Dobbins, 1958):

$$k_l = \sqrt{\frac{D_w U_{tot}}{h}} \tag{4-24}$$

where:

D_w	=	molecular diffusivity (defined below) of PCBs in water ($L^2\ T^{-1}$);
h	=	mean water depth (L); and
U_{tot}	=	depth-averaged velocity, i.e., $(U_x^2 + U_y^2)^{1/2}$ ($L\ T^{-1}$).

The vapor phase mass transfer coefficient (k_g in Equation 4-19) was assigned a constant value of 100 m/day. A constant of this magnitude is a reasonable approximation because of the limited impact of air motion (winds) on transfer in streams and rivers (O'Connor, 1983).

The overall volatilization mass transfer coefficient (k_L in Equation 4-18) was adjusted for temperature over the simulation period using the Arrhenius equation. This approach utilizes a bulk temperature correction to account for parameters that were not explicitly corrected for temperature (i.e., the dimensionless Henry's constant). A typical value of 1.025 was assumed for the Arrhenius constant, which causes the overall volatilization mass transfer coefficient to be halved as the temperature is decreased from 20 °C to 0 °C.

Molecular Diffusivity

Molecular diffusivity was used in the model to quantify mass transfer processes such as volatilization and diffusion within the sediment bed. The molecular diffusivity of PCBs in water was calculated using the equation presented by Hayduk and Laudie (1974):

$$D_w = \frac{13.26x10^{-5}}{\mu^{1.14}(\overline{V})^{0.589}} \tag{4-25}$$

where:

D_w = molecular diffusivity ($L^2\ T^{-1}$);

μ = water viscosity (centipoise); and

$\overline{V}$ = PCB molar volume (cm^3/mol).

The molar volume was assigned a mean value of 244 cubic centimeters per mole (cm^3/mol) based on the average congener composition observed in the lower Grasse River water column data and published homolog-specific molar volumes for PCBs (Mackay et al., 1992). Viscosity, and therefore molecular diffusivity, varied with temperature throughout the model simulations according to published viscosity-temperature values (CRC, 1995).

Sediment Bed Properties

Sediment properties specified in the PCB fate model included the bulk density and porosity. The average bulk density values used in the PCB fate model were the same as those used in the sediment transport model as described in Section 3.2. An average porosity of 59% was incorporated into the model to represent elements classified as hard-bottom in the bed map, while an average porosity of 73% was used to represent cohesive grid elements (see **Figure A3-16**). Bulk density and porosity were assumed constant over the depth of the simulated sediment bed (12 inches).

4.2.3 Representation of Mass Transport Processes

Vertical PCB Transport within the Sediment Bed

PCB transport within the bed included pore water diffusion and bulk mixing (i.e., dispersion). The vertical pore water diffusion coefficient (i.e., D_s in Equation 4-16) used in the lower Grasse River model was based on the molecular diffusivity for total PCBs in aqueous solution (see preceding discussion of molecular diffusivity, D_w), adjusted for the tortuosity of the sediment bed, as represented by $D_s = D_w 2^2$. Applying this relationship, the vertical sediment pore water diffusion coefficient at 20 ºC was estimated to be 0.2 square centimeters per day

(cm^2/day) for both sediment bed types. This value was held vertically and temporally constant for all model simulations.

The varied feeding and burrowing activities of the lower Grasse River benthic invertebrate community result in the random movement of sediment particles and entrained sediment pore waters. This process of bioturbation is mathematically described as a "particle dispersion" process. The parameterization of this process in the model (depth and intensity of surface sediment mixing) was inferred from the structure and abundance of the benthic macroinvertebrate community and observed surface sediment gradients in ^{210}Pb levels.

Chironomids and oligochaetes were the predominate organisms measured during the benthic community studies performed in the lower Grasse River. The depth to which these organisms burrow is species-, substrate- and environment-specific. Most of the available studies of the effects of these organisms on sediment bed mixing have been conducted in lake sediments. These studies indicate that chironomids and oligochaetes generally burrow to depths of 8 to 10 cm (Matisoff and Wang, 2000; McCall and Tevesz, 1982; Ford, 1962). However, several studies suggest most of the population of benthic organisms is found closer to the surface than the maximum depth of occurrence. For example, independent studies by Milbrink (1973) and Ford (1962) found that most chironomids were concentrated in the upper 2 to 4 cm of lake mud. Milbrink (1973) also reported that tubificids penetrated lake muds to 15 cm, with a maximum abundance observed between 2 and 4 cm. Matisoff and Wang (2000) observed maximum sediment mixing by *Chironomus* sp. in a lab study at a depth of about 5 cm. Krezoski et al. (1978) observed some mixing down to 3 cm in a lake sediment core, with the peak abundance of oligochaetes occurring at 1 to 3 cm. In another core, mixing was found to 6 cm, but the depth of maximum abundance was observed at 2 to 3 cm. Charbonneau and Hare (1998) observed a mean burrow depth for *Chironomus* sp. in muddy sediments incubated in the lab of about 5 cm.

These studies are consistent with other information from the site, as well as USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (December 2005), which states *"population density has a tremendous effect on whether organisms present at the site may have a significant effect on the mixing zone depth"* and *"typically the population of*

benthic organisms is greatest in the top few centimeters of sediment" (pg 2-30). It is also consistent with USEPA's use of the top 5 cm in defining surface sediments in EPA's Contaminated Sediment Management Strategy (USEPA, April 1998). Individual organisms can be found at deeper depths, however, the fact that individuals can reach depths deeper than the bulk of the community is not evidence that substantive vertical mixing occurs to these depths or that these individuals provide a substantive vector of PCB transfer up the food chain. Therefore, based on the information listed above, some mixing in the lower Grasse River to at least a depth of about 5 cm would be expected.

The extent of bioturbation in the surface sediments of the lower Grasse River was assessed through the examination of the vertical distribution of ^{210}Pb levels in surface sediments of three of the 12 high-resolution cores collected in 1997. In all three cores, ^{210}Pb levels range from about 1.6 to 2.6 picoCurie per gram (pCi/gram) dry weight at the surface and decline exponentially to values of about 0.5 pCi/gram dry weight (at 30 cm below the sediment-water interface; **Figure A4-17**). The existence of large gradients in ^{210}Pb levels within the top few centimeters of each core suggest limited bioturbation is occurring in surface sediments of the lower Grasse River. To quantify this biological mixing, a one-dimensional (1-D) fine-layered contaminant transport model of the sediment bed was constructed and calibrated using the excess ^{210}Pb data (^{210}Pb concentration minus background levels) to estimate the depth and intensity of biological mixing in the surface sediments of these three high-resolution cores. A full description of this model was presented in Alcoa (April 2001).

Based upon the results of the ^{210}Pb cores and the presence of aquatic worms and midges, as well as model calibration, a partially mixed surficial sediment layer depth of 3 inches (approximately 8 cm) was chosen to represent conditions within the lower Grasse River. Sedimentation rates determined during calibration ranged from 0.075 cm/yr to 0.10 cm/yr. Although the ^{210}Pb modeling suggested that levels in the lower Grasse River can be achieved in the absence of mixing (i.e., sedimentation only), this analysis was based on three cores and may not be representative of the river as a whole. Therefore, the magnitude of the particle-mixing coefficient was based on values from the published literature. Thoms et al. (1995) presented a compilation of the available data that indicate that the mixing process varies seasonally and from

site-to-site. Values of the particle dispersion coefficient (i.e., E_{disp} in Equation 4-15) range from about 10^{-9} to 10^{-6} square centimeters per second (cm^2/s). Based on this range, the assumption that mixing intensity decreases with depth, and model sensitivity analyses, values of 5.0×10^{-7} cm^2/s and 1.0×10^{-7} cm^2/s were used in the model to mix sediment layers 1 and 2 (1 to 2 inches) and layers 2 and 3 (2- to 3-inch segment), respectively. No mixing occurred below a depth of 3 inches. This mixing regime was spatially and temporal constant for the model simulations.

PCB Exchange at the Sediment/Water Interface

Dissolved phase mass transport at the sediment water interface is represented in the model as a Fickian process. The concentration gradient is expressed as the difference between the pore water concentration in the surficial bed layer and the concentration in the overlying water column segment. The overall sediment-water mass transfer coefficient (k_f in Equations 4-4 and 4-21), which combines the effects of the various physical, biological, and chemical mass transfer mechanisms, was used as a calibration parameter to represent non-hydrodynamically induced PCB exchange across the sediment-water interface. This exchange is facilitated by numerous mechanisms, including diffusion, groundwater advection, propagation of turbulence, and biological activity. The approach of combining these processes into a single exchange coefficient has been used in other modeling studies (QEA, 1999; USEPA, 1999).

Parameterization of k_f in the model built upon the seasonal function that was empirically developed in the 2001 CCLGR (Alcoa, April 2001) from observed sediments and water column PCB data. This function was calibrated to the water column and sediment PCB data collected over a 10-year period as discussed in the following section.

4.3 MODEL CALIBRATION AND VALIDATION

4.3.1 Model Calibration Approach

Calibration/validation of the lower Grasse River PCB fate model was accomplished by comparing predicted and observed water column total PCB concentrations under both low-and

high-flow conditions. Sediment concentrations were not used as a calibration target because of the limited temporal coverage of sediment PCB data and the much longer time-scales over which significant changes in sediment PCB concentrations occur (e.g. several years to decades). In order to evaluate changes in PCB concentrations due to an approximate 100-year flow open water event that occurred in January 1998, the fate model calibration was initiated in 1997 and extended through 2006. Calibration under both low and high flows allowed the assessment of the model's ability to represent different mechanisms of PCB transport (e.g., diffusion under low flow and resuspension under high flow).

The calibration approach minimized the number of parameters and coefficients that had to be adjusted. Efforts were undertaken to determine values from independent analysis of data and theory, as discussed above. The only significant parameter whose value was not tightly constrained by data or theory was the sediment-water mass transfer coefficient.

Determination of the sediment-water mass transfer coefficient in the current modeling effort built upon the seasonal profile developed during prior modeling activities (Alcoa, April 2001). The original function was scaled up to produce reasonable agreement in the surface sediment and water column PCB concentration between model predictions and data measured over the 10-year calibration period. The seasonal sediment-water mass transfer coefficient function used in the model is shown in **Figure A4-18**. The mass transfer coefficient values ranges from about 2 cm/day in winter and fall to about 7 cm/day in summer. This is within the range of typically used values for sediment-water diffusive transfer of PCBs (QEA, 1999). This profile was replicated annually and applied to all cohesive model grid elements on the sediment surface.

4.3.2 Model Calibration Results

Water Column

Water column sampling locations are shown in **Figure A4-19**. Comparisons of predicted and measured water column PCB concentrations at WC007, WC007A, WC011, and WC012 during 1997 through 2006 are presented in **Figures A4-20** through **A4-23**. At all four locations a

general seasonal cycle in concentration is evident in the predicted water column PCBs. Concentrations are minimum in winter and maximum in mid-summer. In some years, in the summer, the model tends to under-predict the PCB concentrations at the upstream location (WC007) and slightly over-predict PCB concentration at the downstream location (WC011). However, the model generally reproduces the seasonal trends as well as the peaks for most years. The impact of PCB released during ROPS, which were simulated as point source loads to the model, has resulted in accurate estimation of the unusually high PCB levels in 2005, thereby showing that the model has the ability to accurately simulate the impact of point source loads such as those encountered during dredging.

Model predictions were compared to water column data collected from the Route 131 Bridge during high-flow events in March and April 1998 (**Figure A4-24**). Although the data are limited, they do provide an additional check on the relative magnitude of sediment resuspension predicted during these flow events. The model underpredicts the peak PCB concentration observed at the Route 131 Bridge observed during the rising limb of the March 1998 hydrograph and does not taper off as rapidly as the observations suggest on the falling limb of the hydrograph. However, the model is generally consistent with the average PCB levels observed during this event, as well as observations on the falling limb of the hydrograph during the March 31, 1998 event.

The model was compared to observed mean spatial patterns in low-flow water column PCB concentrations during September and October 1997 (**Figure A4-25**). PCBs generally increase from near the MDL of 22 ng/L at WC004 to approximately 100 ng/L at WC012, located about 5 miles downstream. The decline in PCB levels in the last half-mile is likely a result of exchange with the downstream boundary. The model accurately reproduces this pattern as the error bars of the data generally fall within two standard errors of the model predictions over the same period. This favorable model-data comparison indicates that the model is accurately reproducing the average low-flow spatial patterns observed in the river.

A probability distribution of the ratio of model predictions to field observations was developed as an additional check on the ability of the model to reproduce observed water column

PCB concentrations (**Figure A4-26**). The ratio calculated here is based on all measured data, except those affected by stratification, and the corresponding model predictions at three water column sampling locations: WC007, WC007A/WC131 and WC011. The median ratio of model predictions to water column PCB observations was 1.0, with approximately 70% of the ratios between 0.5 and 2.0, indicating the majority of the model predictions were within a factor of two of the field observations. As shown in **Figure A4-26**, all of the water column model-data comparisons are within an order-of-magnitude of each other, which indicates that there are no gross over- or under-predictions of the observed data. Moreover, the ratios are log-normally distributed, as indicated by the linearity on the normal probability plot, and its center (median) is at the ratio of 1.0. This indicates that there is no high or low bias in the model predictions. In summary, the model is unbiased, predicting observed water column PCB concentrations generally within a factor of two.

Finally, the performance of the model on a seasonal scale was evaluated by comparing the average values predicted by the model with the average values measured during spring, summer, and fall each year (**Figure A4-27**). The model generally captures the seasonal trends well. The peak in 2005 is due to ROPS. To evaluate the performance objectively, the root mean squared error (RMSE) and the Nash-Sutcliffe coefficient (Nash and Sutcliffe, 1970) are also shown in each panel of the figure. Values from 2005-2006 were not included in the calculation of the statistics because these years were affected by the ROPS.

RMSE is a common measure of goodness-of-fit while the Nash-Sutcliffe coefficient (NS) is frequently used in hydrology and water quality modeling. NS varies from $-\infty$ to 1: a value of 1 signifies a perfect fit; a value of 0 signifies that model estimate is no better than the average of the data; a negative value signifies poor model performance. Given the order of magnitude annual variability in the results, the RMSE between the model and data are generally low (< 50 ng/L). NS is generally consistent with RMSE and is mostly above zero showing that the model does a reasonable job of explaining the annual variability during the three seasons.

Sediments

Predicted surface sediment (0 to 3 inches) PCB concentrations at the end of the model simulation (i.e., 2006) were compared to PCB levels measured in 2006 and 2007 to ensure the model was reasonably reproducing concentrations trends over the calibration period (**Figure A4-28**). Sediment data shows considerable variability as evidenced in the Type 1 (coarse) as well as Type 2 (fine) areas in the main channel. Despite this variability, the range of model results is consistent with and within the range of the available data. Overall model predictions are generally less variable than the data but exhibit spatial trends that are consistent with the data.

The ability of the model to accurately predict water column PCB concentrations and spatial trends in surface sediment concentrations during the calibration period indicated that it properly represents the transfer of PCBs between the sediment and the water column. These results provided evidence that the model has accurately described the principal processes governing PCB fate in the lower Grasse River and support its use to predict the potential impacts of various remedial actions on PCB transport within the system. The model's ability to generally predict increases in water column PCBs associated with substantial flow events supports the use of the model to predict sediment resuspension and deposition processes.

4.4 MODEL UNCERTAINTY

The only significant parameters whose values were not tightly constrained by data or theory were the depth and extent of particle mixing in the surface sediments. Although estimates for these parameters were developed from the modeling of excess ^{210}Pb gradients observed in lower Grasse River sediments (Alcoa, April 2001), uncertainties were introduced due to the lack of information regarding some of the model inputs as well as the limited number of high-resolution cores. Despite these uncertainties, the results of the ^{210}Pb modeling are consistent with other information for the site, and suggest that significant bioturbation of lower Grasse River sediments is restricted to the upper few centimeters of the sediment bed. In an effort to provide conservatism to the PCB fate model predictions (i.e., predict reasonable minimum rates

of natural recovery), a partially mixed surficial sediment depth of 8 cm was assumed in the model.

In addition, despite the observation that the river exhibits intermittent thermal stratification during low flow periods, a vertically-averaged water column was considered sufficient to model PCB fate in the lower Grasse River. While this thermal stratification may affect the vertical mixing of dissolved and particulate phase PCBs, stratification generally is weak and may be frequently disturbed by wind-induced mixing. Although thermal stratification may affect discrete PCB measurements during the summer months, it is not believed to have a significant effect on the long-term fate of PCBs within the system.

SECTION 5
BIOACCUMULATION MODEL

PCB bioaccumulation involves the uptake of water- and sediment-borne PCBs by invertebrates and the sequential transfer of those PCBs through the food web *via* predation. The bioaccumulation model consists of a simplified food web, empirically defined trophic transfer factors for calculating PCB levels in invertebrates and a mechanistic, dynamic simulation framework for computing PCB levels in fish.

The dynamic PCB bioaccumulation model is based on the principles of conservation of mass and energy and mechanistically describes the uptake and loss of PCBs by fish. PCBs are taken up during respiration and ingestion and are lost by diffusion across the respiratory surfaces. Rates of PCB uptake and loss are calculated from computed rates of feeding and respiration and empirically defined transfer efficiencies of PCBs. Finally, dissolved and particulate PCB concentrations computed by the PCB fate model provide the PCB exposure for the food web.

5.1 MODEL STRUCTURE AND EQUATIONS

The bioaccumulation model is a mathematical description of PCB transfer within the food web. The food web is comprised of the primary energy transfer pathways from the exposure sources (sediment and water) to the species of interest. These pathways include: chemical uptake across the gill surface, chemical uptake from food and chemical losses due to excretion and growth dilution. The mathematical descriptions are generic (common to all aquatic food webs) and form the basis for the computer source code. The bioaccumulation modeling framework was originally developed approximately 23 years ago and has been updated since that time. It has been applied in a variety of aquatic systems to a variety of compounds, the most common of which has been PCBs (**Table A5-1**).

The accumulation of PCBs by aquatic animals is described by the following:

$$\frac{dv_i}{dt} = K_{ui}c_d + \alpha_c \sum_{j=1}^{n} C_{ij}v_j - (K_i + G_i)v_i \tag{5-1}$$

where:

i & j	=	indices for predator and prey, respectively;
v_i	=	concentration of chemical in species i (micrograms per gram wet [µg/g wet]);
v_j	=	concentration of chemical in species j (µg/g wet);
K_{ui}	=	rate constant for respiratory chemical uptake by species i (L/g wet-day);
K_i	=	rate constant for excretion of chemical by species i (1/day);
c_d	=	concentration of PCBs in the water (µg/L);
α_c	=	efficiency at which ingested chemical is assimilated from prey;
C_{ij}	=	predation or consumption rate of species i on species j (g wet prey/g wet predator-day);
G_i	=	growth rate of species i (g wet/g wet-day); and
n	=	number of species (including different year classes of a single species) preyed upon by species i.

The first term in Equation 5-1 represents the direct uptake of PCBs by the animal from water. The second term represents the flux of PCBs into the animal through feeding. The third term represents the loss of chemical due to diffusion across the gill and the change in concentration due to growth. The gill is the major site of depuration; the fecal elimination rate is much less than the growth rate and is not included in the model. The dynamic bioaccumulation model is applied to each fish species, accounting for species-specific differences in growth rate, consumption rate and elimination rate. A brief discussion of the individual processes within Equation 5-1 is provided below. A more detailed discussion can be found in Connolly (1991), Connolly et al. (1992), HydroQual (1996), and QEA (1999).

The uptake rate from water is a diffusive process that occurs at the gill surface. The rate is determined by the rate at which water passes over the gill, which is in turn estimated from the respiration rate (Equation 5-2):

$$K_{ui} = \frac{\varepsilon \kappa R_i}{c_{o_2}} \tag{5-2}$$

where:

ε	=	ratio of uptake efficiencies of PCBs/oxygen;
κ	=	conversion factor (gO_2/kJ);
R_i	=	respiration rate of species *i* (kJ/g wet-day); and
C_{O2}	=	concentration of oxygen in the water (gO_2/L).

The bioenergetic component of the model computes the respiration rate, accounting for the metabolism in the absence of feeding (standard metabolism) and the added effects of specific dynamic action and swimming. The concentration of oxygen in water is calculated assuming saturation, incorporating corrections for temperature and salinity. The ratio of chemical to oxygen uptake efficiencies is estimated from experimental data.

The uptake rate from food is a function of the concentration of chemical in the prey (v_j), the consumption rate of the species on the prey (C_{ij}) and the efficiency at which ingested chemical is assimilated from the prey (α_c). The rate of consumption of food is calculated from the rate of energy usage, which in turn is estimated from the rates of production and metabolism.

$$C_{ij} = \frac{(R_i + G_i)}{\alpha_F} \frac{\lambda_i}{\lambda_j} \tag{5-3}$$

where:

G_i	=	growth rate of species *i* (g wet/g wet-day);
α_F	=	efficiency at which ingested energy is assimilated from prey species *j;*
λ_i	=	energy density of species *i* (kJ/g wet); and
λ_j	=	energy density of prey species *j* (kJ/g wet).

Several lines of evidence suggest the loss of chemical due to diffusion across the gill is a two-step process; the release of chemical from the storage compartment followed by release to the environment (QEA, 1999). Under these conditions, the elimination rate is controlled by the rate of mass transfer from the storage compartment to the blood (QEA, 1999). The number of storage compartments can range from two, dissolved in blood and associated with lipid, to many. Equation 5-4 describes the contaminant dynamics in the fish assuming that the mass of PCBs resides in two compartments, blood, and lipid.

$$K_i = K_{ui} c_R v_B = K_{ui} \left(\frac{1}{f_{B_i} + \pi_{LB_i} f_{L_i}} \right) v_i \tag{5-4}$$

where:

c_R	=	factor accounting for the slow transfer of PCBs from lipid to blood;
v_{Bi}	=	concentration of chemical dissolved in blood (μg/L);
f_{Bi}	=	fraction aqueous blood of species *i* (g blood/g wet);
f_{Li}	=	fraction lipid of species *i* (g lipid/g wet); and
π_{LB}	=	partition coefficient of chemical between lipid and blood (g blood/g lipid).

The model accounts for the additional resistance due to relatively slow transfer between storage compartments and blood by computing the elimination rate across the gill (assuming equilibrium between lipid and blood) and reducing this rate by a "resistance" factor, c_R.

Finally, the model computes growth rates for individual species (G_i) based upon a relationship between age and weight (W_i) that is determined from data:

$$G_i = \frac{1}{W_i} \frac{dW_i}{dt} \tag{5-5}$$

5.2 APPLICATION TO THE LOWER GRASSE RIVER

In the Upper Hudson River, a comprehensive bioaccumulation model was developed for three resident fish species (largemouth bass, brown bullhead and pumpkinseed) (QEA, 1999). This Upper Hudson River framework was successfully calibrated and accurately reproduced PCB levels in all three species at two different locations over an 18-year period. The model's ability to reproduce long-term trends in PCB concentrations in all three species provides confidence that the modeling framework accurately represents the important processes controlling PCB dynamics in the Upper Hudson River. For this reason, and because these same species inhabit the lower Grasse River, the food web structure and model parameterization employed in the Upper Hudson River model was used as the foundation for the development of a bioaccumulation model for the lower Grasse River. This was done to take advantage of the strong empirical and theoretical bases of the Upper Hudson River model to establish an initial hypothesis regarding PCB bioaccumulation in the lower Grasse River. Dietary preferences for brown bullhead and smallmouth bass were adjusted during calibration to improve the comparison of predicted and measured fish tissue PCB levels for the Grasse River.

Food Web Structure

A brief discussion of the food web structure is provided below. A more detailed discussion of the development of the largemouth bass, pumpkinseed and brown bullhead food webs can be found in QEA (1999).

The modeled Grasse River food web includes three fish species; one top predator (smallmouth bass) and two forage fish (pumpkinseed and brown bullhead). Yearling and older bass consume only fish, with a ratio of 70% pumpkinseed to 30% brown bullhead. This dietary split was determined during model calibration (see Section 5.3). Young-of-the-year (YOY) bass consume 50% invertebrates (Carlander, 1977), equally split between species consuming algae or fresh organic matter and deposit-feeding species, and 50% forage fish (with the same 70/30 split as the diets of adult bass). The diet of these young bass changes based on the feeding season. Early in the season, bass feed on yearling forage fish, and then switch to consuming YOY fish

for the second half of the season. This was done since bass are not likely to feed on the YOY fish early in the season given their small size.

Pumpkinseed and brown bullhead consume a mixture of water column- and sediment-based invertebrates.

To account for water column and sediment exposure sources, two classes of invertebrates are included in the model: algae/detritus-feeding invertebrates and deposit-feeding invertebrates. Algae/detritus-feeding invertebrates represent chironomids, Cladocera and other species of invertebrates that accumulate PCBs from the water column, whereas deposit-feeding invertebrates represent oligochaetes and other species that derive their PCBs from the sediment. Bioaccumulation factors (BAFs) for algae/detritus-feeding invertebrates were determined from paired phytoplankton/zooplankton samples collected in Green Bay as part of the Green Bay Mass Balance Study (Connolly et al., 1992; HydroQual, 1995). Biota-to-sediment accumulation factors (BSAFs) for deposit-feeding invertebrates were determined from USEPA data collected in the Upper Hudson River. BAFs of 3 gOC/g lipid and BSAFs of 1.55 gOC/g lipid were used in the model for algae/detritus-feeding invert and deposit-feeding invertebrates, respectively (QEA, 1999). The pumpkinseed diet is represented as 75% algae/detritus-feeding invertebrates and 25% deposit-feeding invertebrates. The brown bullhead diet, which was determined through model calibration, consists of 40% algae/detritus-feeding invertebrates and 60% deposit-feeding invertebrates.

Model Parameterization

Several site-specific parameters were incorporated into the model framework, including lipid contents of fish inhabiting the river, annual water temperature profiles observed in the river, and exposure concentrations measured in the river. A discussion of the model parameterization specific to the lower Grasse River is provided below.

Bioenergetics and Body Composition - Respiration rates used in the model were determined from the available literature. For smallmouth bass, respiration rates were determined from a study by Beamish (1970) and an associated bioenergetics model (Rice, 1981). Experimental

studies served as the basis for respiration rates for pumpkinseed (Evans, 1984; Burns, 1975; Brett and Sutherland, 1965) and brown bullhead (Beamish, 1964; Saunders, 1962). Growth rates for all three species were determined from weight to age relationships developed using data collected in the Upper Hudson River (QEA, 1999). In the model, each year's growth occurs between mid-April and the end of October, when the water temperatures are above 10 ^{o}C in the River (Adams et al., 1982; Carline, 1987).

Because the annual temperature profile determines seasonal changes in the respiration and growth rates as well as oxygen saturation in the water column, water temperature data collected in the lower Grasse River were examined. A single annual-average temperature profile was developed for the river based on the median peak temperature from 1997 to 2006, measured at four water quality stations (WC-007, WC-011, WC-012, and WC-013). This annual-average temperature profile was input into the bioaccumulation model.

The average lipid fraction for each species was determined from lipid measurements made in fish collected in the lower Grasse River. Annual-average lipid contents for each year were input directly into the model for smallmouth bass and brown bullhead as large variations in lipid contents were observed year-to-year (**Figure A5-1**). For example, in 1997, lipid levels measured in smallmouth bass and brown bullhead fillets averaged about 0.6% and 0.8%, respectively. Lipid contents measured in 1998, 1999, and 2000 were similar and 2 to 4 times higher than those observed in 1997, averaging about 1.6% and 2.9% in smallmouth bass and brown bullhead fillets, respectively. Collection of YOY pumpkinseed was conducted in 1998 and 1999, and was limited to areas immediately downstream of Alcoa's plant facility. The average measured lipid content for each year was used for 1998 and 1999, while an overall average of lipid data from this sampling was assumed for the remaining years in the model (2000-2006).

<u>Exposure Levels</u> - PCB levels for each stretch were calculated from the results of the fate model. Prior to input into the bioaccumulation model, volume-weighted river-wide water column PCB concentrations (dissolved [µg/L] and particulate [mg/kg OC]) were determined. Daily-average values then were computed and supplied to the bioaccumulation model. For the sediment, area-

weighted PCB concentrations in the top one-inch of sediment were computed. The use of this layer was based on the presumption from the large ^{210}Pb gradients observed in the high-resolution sediment cores collected in the lower Grasse River, that most of the benthic biomass was associated with this layer. Similar to the water column PCBs, daily-average sediment PCBs were calculated and used in the bioaccumulation model.

Evaluation of the PCB homolog data indicate that mono- and di-chlorinated PCBs do not significantly bioaccumulate in the resident fish, typically constituting less than 5% of the total PCB concentration. Since the principal goal of the bioaccumulation modeling is to examine the relative benefits that potential remedial alternatives have on fish PCB levels, total PCB levels in water column and sediment were modified to represent tri- through nona-PCBs (PCB_{3+}). In the lower Grasse River, the average composition of tri- through nona-PCBs ranged from 43% to 69%, and 67% to 75%, of the total PCBs measured in the water column and sediment, respectively. Therefore, exposure concentrations from the fate model were adjusted to represent PCB_{3+} levels prior to being input into the bioaccumulation model. The PCB_{3+} exposure concentrations used in the bioaccumulation model are presented in **Figure A5-2**.

Initial Conditions – PCB concentrations in smallmouth bass and brown bullhead at the beginning of the simulation were determined from the Aroclor-based PCB data measured in October 1996. PCB levels in smallmouth bass and brown bullhead were set to 10.6 and 6.2 mg/kg fillet, respectively. Because the bioaccumulation model requires PCB levels on a whole-body basis, these fillet values were multiplied by 2.5 (HydroQual, 1995) prior to being inputted into the model. PCB_{3+} levels in pumpkinseed were determined using Aroclor-based PCB_{3+} concentrations measured in YOY samples collected in October 1998. An initial PCB_{3+} concentration of 4.3 mg/kg whole-body was applied to pumpkinseed.

5.3 MODEL CALIBRATION

Model results and data collected in the lower Grasse River were compared on an age-specific basis. Smallmouth bass and brown bullhead were primarily ages 3 through 6. Because

PCB_{3+} constitutes over 95% of the total PCB levels in the resident fish, model results (PCB_{3+}) and total (Aroclor-based) PCB data were compared directly.

The brown bullhead component of the model was calibrated by adjusting dietary preferences between algae/detritus-feeding invertebrates and deposit-feeding invertebrates. As discussed in Section 5.2, the final calibration split between deposit-feeding invertebrates and algae/detritus-feeding invertebrates is 60:40. This determination was made based on the results of several simulations with varying diets (i.e., 50:50, 60:40, and 70:30), with the ultimate goal of: 1) minimizing the RMSE between average predicted and measured values; and 2) yielding RPDs between predicted and measured PCB concentrations that were not statistically different from zero. The analyses conducted to support this evaluation included the following:

- Visual review of predicted and measured PCB concentration trends over the calibration period
- Visual review of cross plots of predicted and measured PCB concentrations
- Review of RMSE values between predicted and measured PCB concentrations
- Review of cumulative frequency distributions of RPDs between predicted and measured PCB concentrations
- T-tests on RPDs between predicted and measured PCB concentrations

For these analyses, predicted values from the September and October months (i.e., the typical period when fish tissue samples were collected from the river) for each species and year were averaged prior to comparison to average measured PCB concentrations (also averaged by species and year). Additionally, predicted and measured PCB concentrations from 2005 were excluded in the calculations of RMSE and RPD. These data were excluded so that the statistical metrics being used to assess model calibration were not unduly influenced by the elevated PCB concentrations experienced during the 2005 ROPS dredging activities.

Once the calibration of the brown bullhead was complete, a similar calibration process was followed for smallmouth bass. The final calibration split benthic- and pelagic-based forage

fish is 30:70. This determination was made based on the results of several simulations with varying diets (i.e., 20:80, 30:70, and 40:60).

Model calibration results are presented in **Figure A5-3** (trends over the 10-year calibration period), **Figure A5-4** (cross plots of predicted and measured PCB concentrations), and **Figure A5-5** (cumulative frequency plots of RPDs between predicted and measured PCB concentrations). Statistics summarizing the various dietary preferences examined during model calibration are provided in **Table A5-2**. Overall, predicted PCB_{3+} levels in smallmouth bass and brown bullhead generally reproduce the levels and trends observed over the simulation period. Computed PCB_{3+} levels remain within a factor of two of the data and generally follow the patterns seen in the observed data for both smallmouth bass and brown bullhead. For 2005 and 2006, the model captures the increase in PCB levels in smallmouth bass associated with the ROPS activities in 2005 and the subsequent response in declining exposure concentrations in 2006. The model also captures this trend in brown bullhead but to a lesser extent. RPDs between predicted and measured values for brown bullhead are 8% and 0% on wet weight and lipid-normalized bases, respectively. For smallmouth bass, RPDs between predicted and measured values are 14% and 10% on wet weight and lipid-normalized bases, respectively. Fo-tests indicated RPD values that were not statistically different from zero, indicating the model is not biased.

5.4 MODEL UNCERTAINTY

Several factors may account for the differences observed between model and data. For example, seasonal variations in lipid content are not represented in the model due to a lack of site data. In addition, growth rates for all three species were determined from weight to age relationships developed using data from the Upper Hudson River, which may be different than those for fish from the Grasse River. Finally, given the opportunistic nature of the modeled species, changes in the food web structure (i.e., changes in the relative contribution of waterborne and sediment-borne PCBs) may vary over the course of the year and from year to year. Despite these uncertainties, the model predicts PCB_{3+} concentrations in smallmouth bass

and brown bullhead reasonably well, indicating the model can provide reasonable projections of fish tissue PCB_{3+} concentrations under natural recovery and active remediation scenarios.

SECTION 6
SIMULATION OF A 100-YEAR HIGH FLOW EVENT

6.1 APPROACH

The hydrodynamic model was developed in order to predict bottom shear stresses for the range of flows to which the river is subjected. These bottom shear stresses, along with the erosion potential functions developed from the sediment shaker studies and applied in the sediment transport model), provide a basis for evaluating the frequency and extent of resuspension in the lower Grasse River. Together, the hydrodynamic and sediment transport models were used to evaluate the extent of sediment scour during an extreme flood event (i.e., a 100-year flood) in the lower Grasse River.

The 100-year flood at Massena has been estimated to correspond to a daily-average flow rate of 15,080 cfs (FEMA, 1980). A flood of similar magnitude occurred during January 1998 and was included in the 10-year sediment transport and PCB fate simulations discussed in Sections 3 and 4. Therefore, the effects of this rare flood, which is defined as having a 1% chance of occurring in any given year, was determined by analyzing the model results for the January 1998 flood.

The hydrograph for the January 1998 flood is presented in **Figure A6-1**. The flood was defined as the 11-day period delineated by the dashed lines on that figure (January 6 to 16). This period was chosen because it approximately corresponds to a flood flow regime where discharge exceeds $2Q_{avg}$ (2,200 cfs). No parameters were adjusted during this simulation. As discussed in previous sections, the bounding estimates of several key model parameters were used so that a conservative estimate of sediment scour during an extreme flood event could be attained.

6.2 SHORT-TERM EFFECT ON SEDIMENTS

The sediment transport model results for this 11-day period are presented in **Figure A6-2**. The model predicts that, on average, about 0.1 cm of erosion occurs during a flood of this magnitude, with all of the cohesive sediments in the river experiencing less than 1 cm of erosion. The maximum erosion predicted during the 100-year flood was about 0.9 cm. A mass balance for this high-flow period showed that 890 MT of net sediment erosion occurred (**Figure A6-3**). In addition, deposition was predicted in some areas of the river, with the maximum deposition of about 0.8 cm. The results of this simulation indicate that, even under extreme flow conditions, little sediment resuspension is expected within the river.

SECTION 7
SIMULATION OF FUTURE CONDITIONS

7.1 APPROACH

The model of PCB fate and bioaccumulation in the lower Grasse River was used to forecast future conditions in the river as a result of natural recovery processes, in-place containment (i.e., capping) and sediment removal (i.e., dredging). These forecasts use assumptions about future river flow, solids loading, PCB loading, geomorphology and the structure and function of the food web that are based on site-specific data, laboratory studies, field studies and published literature. The conservative model parameter values used during model calibration were carried forward and applied to the model projections to provide a conservative analysis of future conditions under the natural recovery scenario.

This section describes the approach, development, and assumptions used in each model to simulate future conditions in the river.

7.2 HYDRODYNAMIC MODEL

The 30-year projection simulations required a synthetic hydrograph to specify river flow at the upstream boundary of the Study Area. A time series of annual average flows was generated by a lag-one, Markovian series statistical analyses of historical annual flow rates that accounts for year-to-year correlation and random variability. Each of the annual average flows in the generated series of flows was converted to daily-average flow rates by applying the daily hydrograph from the year in the historical record whose annual average most closely matched the generated value. A summary of the hydrograph development process is provided below.

Historical USGS flow rate data collected at the Grasse River at Pyrites gaging station were used to develop the synthetic hydrograph (see Section 2.2.2). A Markovian (lag-one) flow

model was developed to predict annual average flow rates for year n (Q_n) based on the previous annual-average discharge (Q_{n-1}) (Fiering and Jackson, 1971; QEA, 1999):

$$Q_n = Q_{mean} + R_a\left(Q_{n-1} - Q_{mean}\right) + t_n S_a\left(1 - R_a^2\right)^{1/2} \qquad \text{(A7-2)}$$

where:

Q_{mean}	=	mean of historical annual average flow rates;
S_a	=	standard deviation of historical annual average flow rates;
R_a	=	correlation coefficient for historical annual average flow rates; and
t_n	=	normally distributed, serially independent random variable with zero mean and unit standard deviation.

Equation A7-2 produces a synthetic hydrograph with normally distributed flows that preserves the mean, variance and first-order correlation coefficient of the historical discharge record (Fiering and Jackson, 1971).

Statistical analysis of the annual average flow rates yielded values for Q_{mean}, S_a and R_a that were used in Equation A7-2. A random number generator was used to specify t_n in year n. A synthetic hydrograph was generated using Equation A7-2 that was 1,000 years long (i.e., a time-series of 1,000 annual-average flow rates). To eliminate the transient effects due to initial conditions, the first 200 years of the synthetic hydrograph were discarded, leaving a synthetic hydrograph that was 800 years long (i.e., years 201 to 1,000). A random number was used to specify the year at which to begin analyzing the synthetic hydrograph. Starting from this year, the next year with an annual average discharge closely corresponding to the observed annual average for the last year of calibration was identified. Thus, the following year in the synthetic hydrograph was chosen as the first year of the projection hydrograph and extended for thirty years after. The resulting synthetic hydrograph is seen to be a realistic extension of the observed hydrograph. The original projections developed from the previous modeling study (Alcoa, June 2002) started in 2001, so the synthetic hydrograph represented an extension of conditions observed in 2000. Although the current set of model projections start in 2007, the identical

hydrograph used in previous modeling was used for the present analysis. **Figure A7-1** shows the generated synthetic hydrograph together with estimated historical flows at Massena.

The estimated historical record of daily flows at Massena was used in conjunction with the annual-average synthetic hydrograph to generate the necessary model inputs. Annual-average discharge for the first year in the synthetic hydrograph was compared to the historical record of annual-average flows. The minimum deviation between year 1 of the synthetic hydrograph and historical annual-average discharges occurred for 1925. Thus, the daily-average hydrograph for 1925 was used for year 1 of the synthetic hydrograph. Next, the second year of the synthetic hydrograph was compared to the remaining record of historical discharge; 1925 was removed from the historical record after it was used for year 1. For the second year of the synthetic hydrograph, the annual-average discharge for 1963 was in best agreement. This process then was repeated until all 30 years of the synthetic hydrograph were replaced with historical data.

Generating a 30-year hydrograph for daily-average flow rate at Massena by piecing together different years from the historical record created discontinuities at the end of each year (i.e., between December 31 of year n and January 1 of year $n+1$). Generally, the flow rate discontinuities were not large. However, to provide a smooth transition between years, discharge was linearly varied from 1 to 5 days before and after January 1, depending upon the degree of the discontinuity. The 30-year hydrograph resulting from this process, and used in projection simulations, is shown in **Figure A7-2**. It was assumed that the projection simulation began on January 1, 2007.

Although flow discharges from the plant facility outfalls are minor relative to flows that enter from upstream, these inflows were included in the long-term water balance. Effluent flows from Outfalls 001, 004, and 007 were assumed to remain constant over the projection period at the average of the flows reported in the 1996 to 2000 SPDES permit records (6.78, 0.67, and 0.14 cfs, respectively). As of February 2000, effluent from Outfall 005 was redirected to the Outfall 004 treatment system and, thus, was not included in the water balance.

Stage height at the downstream boundary (mouth of Grasse River) was specified using stage height data collected in the St. Lawrence River at Cornwall. As discussed in the CCLGR Report (Alcoa, April 2001), minimal correlation exists between stage height at the mouth and flow rate in the Grasse River. Thus, it was assumed that historical stage height data from 1968 through 1997 could be used to specify stage height at the open boundary of the model for the 30-year projection period. The time history of stage height input to the model for this simulation is presented in **Figure A7-3**.

The values assigned to other model parameters during calibration were carried forward and applied to the model projections.

7.3 SEDIMENT TRANSPORT MODEL

Future solids loading at the upstream boundary of the Study Area was calculated by applying the ice-break-up and non-ice-break-up sediment rating curves, discussed in Section 3.2, to the 30-year synthetic hydrograph. Composition of the incoming sediment load was specified using the same flow-dependent relation developed in Section 3.2. Annual sediment loading to the lower Grasse River during the 30-year projection period is presented in **Figure A7-4**.

For the calibration period, the cumulative solids loading from Outfalls 001, 004, and 007 accounted for about 3.5% of the total solids loads entering from the upstream boundary. Furthermore, much of the solids concentrations from the outfalls in recent years have been at non-detectable levels. Assuming solids concentrations at half the detection limit (1.4 mg/L), solids loads from outfalls would have contributed less than 1% of the loads specified for the upstream boundary during the projections. Thus, solids loads from the outfalls were not included in the projections. Due to the redirection of Outfall 005 effluent to the Outfall 004 treatment system, discharges from Outfall 005 were not included in the solids balance.

The values assigned to other model parameters during calibration, including the upper-bound estimates of sediment erosion potential and incoming solids composition, were carried forward and applied to the model projections.

7.4 PCB FATE MODEL

Simulating future PCB levels required specifying initial conditions, a future time series of boundary conditions, and external PCB loadings to the river and the nature and effectiveness of each potential remedial process option (i.e., natural recovery, capping and dredging). A discussion of each is provided below. The values of other model parameters were the same as used during calibration.

7.4.1 Boundary and Initial Conditions

The PCB fate model was coupled with the sediment transport and hydrodynamic models. The hydrodynamic model provided water depths and velocities, while the sediment transport model provided suspended solids concentrations along with deposition and resuspension fluxes.

Initial sediment PCB concentrations were derived from predicted concentrations at the end of the calibration period (i.e., 2006). Initial water column PCB concentration is unimportant as the river flushes rapidly.

7.4.2 External PCB Loading

While the sediments are the predominant source of PCBs, the upstream boundary also brings in PCBs to the lower Grasse River. Data collected in 2006 and 2007 at the Main Street Bridge indicate average PCB levels of 0.2 to 0.4 ng/L. These levels are similar to those measured in remote, un-impacted streams and precipitation in the eastern U.S. during the late 1990s and 2000s (0.4 to 0.5 ng/L, VanRy et al., 2002; 0.3 ng/L, USEPA, March 2004; 0.1 to 0.4 ng/L, Glaser et al., November 2006; 0.1 to 0.4 ng/L, Interstate Commission on the Potomac River Basin, January 2007). Based on this information, a constant concentration of 0.3 ng/L was used for the upstream boundary in the projections.

In recent years PCB concentrations from Outfalls 001 (from 2004 onwards), 004 (from 1999 onwards), and 007 (from 2000 onwards) have been below detection limits (see **Figures**

A4-10, A4-11, and **A4-12**). In order to reflect contemporary and likely future conditions in the projections, PCB loads from outfalls were set to zero. Sensitivity analysis performed in the 2002 AA Report with outfall loads based on half the detection limit did not produce any significant difference (less than 2%) in the water column and fish tissue PCB levels from the case where outfall loads were set to zero (Alcoa, June 2002). Outfall 005 stopped discharging in 2000 and was not included in the projections.

7.4.3 Remediation Scope and Schedule

A Geographic Information System (GIS)-based model matrix was developed to aid in the identification of sediments meeting criteria used in the development of the alternatives. The matrix is a compilation of the results of field and modeling studies performed in the river and contains information on the sediment characteristics pertinent to the selection of remedial alternatives. Included are water depth, the type, depth, volume and PCB concentration, and the net erosion predicted to occur in the river under a rare flood event (i.e., 100-year flood event). This information was mapped onto the model grid such that each model grid element contained a single value for each of the various parameters. The matrix was incorporated into a GIS framework to facilitate visual display of areas meeting various selection criteria. This tool was used to identify the model grid elements targeted for remediation for each of the alternatives.

Table A7-1 lists the potential remedial alternatives that were developed for the lower Grasse River including the criteria used for identifying the remediation areas. Maps showing the areas to be addressed under each of the active remedial alternatives are also provided in **Figures A7-5** through **A7-12**.

Assumptions made for the modeling of proposed remedial alternatives are presented in **Table A7-2**. Remediation was assumed to begin in May 2013. Remediation rates for armored capping, main channel capping, near shore capping and dredging were based on site-specific experience as well as experience from other sites. These remediation rates, along with the duration of the construction season in Massena (i.e., May to October), were used to develop remediation schedules for each alternative.

Remediation schedules were developed for dredging and capping based on the spatial grid used for modeling. It was assumed that remediation progresses from upstream to downstream with no overlap between capping and dredging operations within the same transect. Dredging was assumed to be conducted in advance of capping in order to enable dredging to proceed far enough downstream such that capping never takes place at or downstream of a transect where dredging, when required, has not been completed. Capping at both near-shore and main-channel areas were allowed to proceed concurrently. For alternatives that include both capping and dredging, the only restriction imposed on the downstream progress of capping was the rate of downstream dredging progress. Remediation schedules were discretized over time according to when remediation would be completed in each group of model grid elements. For capping, the time required to complete remediation within a group of model grid elements was calculated based upon the completion time of the upstream element(s), the areal rate for installation of the cap, and the surface area of the model elements targeted for capping. For dredging, the time required to complete remediation within a group of model grid elements was calculated based upon the completion time of the upstream element(s), the volumetric rate for sediment removal, and the volume of soft sediments targeted for removal.

7.4.4 Capping Assumptions

Cap Designs

In accordance with the design guidance set forth by the USEPA (Palermo et al., September 1998) and U.S. Army Corps of Engineers (USACE; USACE, June 1998), any cap placed within the river would be designed to mimic the physical properties of the native sediments and, thus, provide a suitable substrate for the current benthic community. The main channel cap thickness was determined through the evaluation of site-specific information so that the cap would provide: 1) physical isolation of the PCBs in the sediment from the benthic environment; 2) erosion protection (i.e., mitigate the resuspension and transport of sediments to downstream areas); and 3) chemical isolation (i.e., reduce the flux of dissolved PCBs to the water column). In accordance with the design guidance, the total thickness of the cap (i.e., 12 inches) is the sum of the thicknesses required to achieve each of these objectives. A factor of safety also has been incorporated into the design. The design thickness of the physical isolation

component is 5 inches and is based on the diversity and abundance of organisms that predominate the benthic community of the river, review of published literature, results of ^{210}Pb modeling in the surface sediments of the river, USACE guidance (June 1998) and consolidation testing performed as part of the pre-engineering design studies (Alcoa, March 2001). The design thickness of the erosion component is 1 inch and is based on conservative estimates of sediment scour predicted during a 100-year flood event[4] (via hydrodynamic and sediment transport modeling), site-specific analysis of potential resuspension due to recreational boat activity in the river (i.e., prop wash, see Appendix B to the main report). Erosion during a more extreme flood event in the river is not expected to be substantially greater, as the 1-in-500 year flood flow of 17,070 cfs is only 13% greater than the 1-in-100 year flow of 15,080 cfs (FEMA, May 1980). The design thickness for the chemical isolation component is 6 inches. Although laboratory studies have demonstrated that very thin layers (1 to 8 mm) of materials can effectively reduce chemical flux from sediments to the overlying water column (Talbert et al., 2001), a conservative thickness of 6 inches was selected and evaluated using a one-dimensional transport model (see Appendix D to the main report). Results of the evaluation, which included the effects of biological mixing, indicate that a 6-inch cap is sufficient to effectively reduce the diffusive PCB flux from the PCB-containing sediments to the overlying water column (see Appendix D to the main report). It is important to note that conservative assumptions were employed in the design of each of the individual cap components and, when considered together, provide an additional protective component to the overall cap design. Therefore, cap design thicknesses of 12 inches and 6 inches are assumed for the main channel and near shore caps, respectively.

Design of the armored cap was based on available guidance (U.S. Department of Agriculture [USDA], July 1989; U.S. Amy Corps of Engineers [USACE], July 1991; Maynard and Oswalt, 1993; Palermo et al., June 1998, September 1998; and Palermo, March 2000), as well as modeling of turbulent energy beneath ice covers that may occur during severe ice jam events (Alcoa, September 2004). An armored cap would consist of a 6-inch base layer of

[4] For the design of the erosion component, USACE (1998) guidance suggests the use of either: 1) erosion during a 100-year flood event; or 2) the net erosion over 20 years of normal current/wave energies. The design of the erosion component presented here uses the more stringent criterion of net erosion during a 100-year flood.

sand/topsoil (i.e., same material used for capping), a 6-inch filter layer of 4- to 15-mm gravel, and a 13-inch armor layer of 3- to 10-inch diameter cobbles.

PCB Resuspension During Capping

PCB releases during capping were based on results of the 2001 CPS and 2005 ROPS. Extensive water column monitoring of PCB, TSS and turbidity levels during these studies showed that water quality impacts associated with capping were minimal. During the capping of native sediments in 2001, average PCB levels measured inside and adjacent to the capping area during implementation generally were near or below the detection limit and well within the range of water column samples historically analyzed from a monitoring station near this area. In addition, PCB concentrations measured at the station downstream of the capping area were non-detect (i.e., less than 50 ng/L) in all samples collected during the study (Alcoa, April 2002). Little to no PCB release was observed during thin-layer and armored capping activities during the 2005 ROPS (Alcoa, May 2006).

Monitoring during post-dredge capping in 2005 indicated some PCB resuspension and transport downstream occurred. The net PCB transport computed from these data was about 40% lower than that estimated during debris and sediment removal activities (Alcoa, May 2006).

Capping Effectiveness

Capping effectiveness is defined by two components: 1) the ability to cover the targeted area; and 2) the ability to minimize entrainment of PCBs from native sediments into the cap materials during placement. These considerations were evaluated using information collected from the 2001 CPS and 2005 ROPS.

Several techniques were used during the capping study to evaluate cap coverage, including cap thickness measurements using global positioning system (GPS) surveying techniques, observation of cap material thickness in sediment cores submitted for physical and chemical analyses and other visual observations during underwater videography. Details regarding these measurement techniques are provided in the Grasse River Capping Pilot Study Documentation Report (Alcoa, April 2002) and Grasse River Remedial Options Pilot Study

Documentation Report (Alcoa, May 2006). Results of these studies indicated that, for caps applied using a clamshell bucket, the average cap thickness either met or exceeded the target cap thickness. In addition, vertical profiles of TOC and grain size in the in-place cap material suggest no significant loss of fine-grained material or separation by grain size. These results indicate that, with the exception of side slope areas, as evidenced during the 2001 CPS, application of a 12-inch cap during full-scale implementation should be attainable.

The potential entrainment of sediment PCBs into the capping materials during placement was evaluated through the examination of vertical PCB concentration profiles in the sediment cores collected from each of the capped areas. For the 2001 CPS, each sediment core was segmented at 2-inch intervals within the cap material and analyzed for PCBs. For the pilot cells, PCBs were non-detect in 95% (153 of 161 samples) of the cap material samples. When detected, PCBs were less than 1 mg/kg (except for one sample at 1.51 mg/kg), and were almost exclusively seen at the interval immediately above the native sediments. These data suggest a typical cap/native sediment mixing zone of about 2 inches and, thus, a 12-inch cap should be sufficient for isolating the cap surface from the underlying PCB-containing sediments (Alcoa, April 2002).

Post-dredge capping conducted during the 2005 ROPS was accomplished in a single 12-inch lift. Sediment cores collected immediately after post-dredge capping were segmented at 2-inch intervals within the cap material and analyzed for PCBs. Approximately 82% of the 136 individual in-place cap material samples collected immediately after post-dredge capping contained detectable PCBs, much higher than the 5% observed after capping of native (un-dredged) sediments during the 2001 CPS (Alcoa, May 2006). Placement of a cap in two lifts may help reduce the extent of contamination within the post-dredge cap by limiting the mixing/entrainment to the material placed in the first lift.

Representation of Capping in the Model

Based on the results from the 2001 CPS and 2005 ROPS, a capping effectiveness of 95% was assumed. Main channel capping was simulated by adding twelve new 1-inch layers to each model grid element targeted for remediation, each assigned with the same PCB concentration

equal to 5% of the surface sediment (0 to 3 inch) PCB concentration prior to capping. For example, if a model element targeted for capping contained a surface sediment PCB concentration of 10 mg/kg, capping was simulated by assigning each of the 12 new 1-inch layers a PCB concentration of 0.5 mg/kg. The bottom layer was expanded so that all sediment and PCB mass was accounted for in the model simulations. This modeling assumption would only affect results if a model element experienced gross erosion on the order of one foot, which was not encountered in the long-term sediment transport model projections. Near shore capping was treated the same way, except only 6 new 1-inch layers were simulated.

PCB release during main channel and near shore capping of native (un-dredged) sediments was assumed to be negligible (i.e., set equal to zero), based on results of the 2001 CPS, while releases during post-dredge capping were assumed to equal 1% of the post-dredge residual PCB mass being capped, based on results of the 2005 ROPS. Finally, the cap material was assumed to possess the same physical properties as the native sediment (i.e., bulk density and erosion potential).

Armored capping was simulated in the same manner as main channel capping. The only difference between main channel capping and armored capping in the model was the rate at which each of these caps was placed (see **Table A7-2**).

7.4.5 Dredging Assumptions

To simulate dredging in the lower Grasse River, estimates of the amount of resuspended PCB released to the water column during the dredging operations and the average PCB concentration in residual sediment that remains in the river after dredging were required. Data from the 2005 ROPS were evaluated to develop estimates for these parameters.

PCB Resuspension during Dredging

Release of PCBs during dredging was simulated as an external loading to the water column and was assumed to occur uniformly over the area undergoing dredging. Based on a

PCB mass balance conducted for the 2005 ROPS dredging activities, a PCB release rate during dredging of 3.0% of the targeted PCB mass was assumed in the model projections.

Post-dredging Residual PCB Concentration

Residual PCB concentrations after dredging were simulated in the model by adding twelve new 1-inch layers to each model grid targeted for remediation, each assigned with a uniform PCB concentration. PCB measurements in sediment cores collected immediately after 2005 ROPS dredging were comparable to segment length-weighted average PCB concentrations computed prior to dredging (Alcoa, May 2006). Based on these results, the post-dredging surface sediment PCB concentration was set equal to the pre-dredge depth-weighted average PCB concentration for the targeted sediments.

It was assumed that the sediment bed properties were unaffected by dredging (i.e., the remaining sediments were assigned the same organic carbon fraction, bulk density, and porosity as specified in the model inputs). Although this may not be the case, any error has only a short-term impact, if any, because all model segments that were dredged were subsequently remediated by capping.

7.5 FOOD WEB MODEL ASSUMPTIONS

The structure and parameterization for the food web model projections were the same as those specified for the calibration period, except for the lipid content of the resident fish. Because lipid content affects excretion of PCBs across the gill surface, variations in lipid contents affect PCB levels in the fish. For the model projections, the average lipid content of samples collected from 1997 to 2006 were used. Values of 1.3% and 2.2% (fillet basis) were applied to smallmouth bass and brown bullhead, respectively. For pumpkinseed, an average lipid content of 3.5% (whole body) was computed from the 1998 and 1999 surveys and used in the model. Lipid levels were assumed to remain constant for the 30-year projection period.

7.6 MODEL UNCERTAINTY

The uncertainties identified during model development were discussed for each sub-model (i.e., hydrodynamic, sediment transport, PCB fate and transport, and PCB bioaccumulation models) in Sections 2.4, 3.4, 4.4, and 5.4, respectively. Predictions of time trends in fish PCBs due to natural recovery and active remediation are subject to uncertainty in two additional key parameters: future flows in the river and future lipid contents in fish. As discussed in Section 7.5, the flow conditions assumed for the model projections are based on a synthetic hydrograph that was constructed from historic flow records. Because future flow conditions are not known and they may differ from those experienced historically, the use of a synthetic hydrograph introduces uncertainty into the projected PCB concentrations in the system.

Fish lipid content changes in response to variations in environmental conditions. Significant year-to-year variability is evident in the record assembled since the mid-1990s. Since PCBs levels in fish are typically proportional to lipid content, the uncertainty of future lipid contents introduces uncertainty into the projected PCB concentrations in fish. The use of the long-term average lipid content for model predictions probably negates the long-term influence of this uncertainty, but does not address the uncertainty of predictions for any one year.

Despite the uncertainties discussed above, the model predicts PCB concentrations that are reasonably accurate, as documented by the post-auditing of the predictions made as part of the 2002 AA Report. This is demonstrated in **Figure A5-13**, which compares model predictions made during development of the 2002 AA Report to the data collected since that time. In this figure, predicted lipid-normalized PCB concentrations for a natural recovery scenario (solid blue line) are compared to the averages of measured fish tissue PCB concentrations (circles and error bars). Overall, the model predicts fish tissue PCB concentrations that compare well with the observed data. The one exception is 2005, where elevated PCB concentrations from the ROPS dredging activities resulted in elevated fish tissue PCB concentrations (that were not simulated in the 2002 model predictions).

7.7 SIMULATION OF REMEDIAL ACTIONS

7.7.1 Remedial Alternatives

The projected impacts of remediation on downstream PCB transport and PCB levels in fish were predicted for the 14 potential remedial alternatives identified above (see Section 7.4.3 and **Table A7-1**). Alternatives 1 (No Further Action) and 2 (Monitored Natural Recovery) are the same from a modeling standpoint and, therefore, a single model projection was performed to assess the effectiveness of these alternatives. For Alternatives 3 through 10, active remediation (i.e., capping, dredging or both) was simulated. The assumptions used to simulate these alternatives are provided in **Table A7-2**.

7.7.2 Evaluation Metrics

Model predictions of PCB concentrations in water, sediment, and fish were studied using indicators illustrative of the components of river recovery: PCB loading from the lower Grasse River to the St. Lawrence River, river-wide average sediment (0 to 3 inches) PCB concentration, and river-wide average fish tissue PCB concentration. For the water column metric, the estimated date to achieve an 85% reduction in PCB loading to the St. Lawrence River was used. A projected value of 13.8 kg, which represents the average PCB loading to the St. Lawrence River predicted by the PCB fate model between 2010 and 2012, is used as the baseline condition (i.e., prior to active remediation in the river). The average PCB loading over this three-year period was used to damp the year-to-year variations associated with fluctuations in annual river flows used in the synthetic hydrograph for the model projections. For sediments, the estimated date to achieve a sediment (0 to 3 inches) PCB concentration of 1 mg/kg was used. For fish, river-wide average fish tissue PCB concentration at the end of the projection period (i.e., 2036) was used. In addition, the estimated dates to achieve 0.36 mg/kg, 0.26 mg/kg, and 0.05 mg/kg were examined at the request of USEPA. These metrics are used in the evaluation of the long-term effectiveness provided by each potential remedial alternative.

7.7.3 Predicted PCB Concentrations in Water, Sediment and Fish Tissue

Trajectories of PCB loading to the St. Lawrence River, river-wide average sediment (0 to 3 inches) PCB concentration, and river-wide average fish tissue PCB concentrations are presented for each alternative over the 30-year simulation period in **Figures A7-14** through **A7-31**. In these figures, PCB loadings to the St. Lawrence River are presented as annual averages (solid lines) as well as 3-year moving averages (dashed lines). For sediments, area-weighted average surface (0 to 3 inch) sediment PCB concentrations are presented. For fish, annual average PCB levels in smallmouth bass (dotted lines), brown bullhead (dashed lines), and a species average (solid lines) are presented for the entire lower river. A summary of the average metrics are provided in **Table A7-3**.

All modeled alternatives reduce PCB loading to the St. Lawrence River and average fish tissue PCB levels from the base condition. For example, natural recovery alone (Alternatives 1 and 2) provides for reductions in PCB loading to the St. Lawrence River and average fish tissue PCB concentrations over time, but the rate of recovery is slower than the other alternatives (**Figures A7-14** and **A7-15**, and **Table A7-3**). The break in slope at about year 2012 is an artifact of plotting an exponentially declining trend in PCB concentration over time. Review of fish tissue PCB concentrations over the first 20 years of the projection (**Figure A7-15**) indicates a continual decline in PCB concentrations: approximately 8% per year between 2007 and 2012; approximately 6% per year between 2012 and 2017; approximately 5% per year between 2017 and 2022; and approximately 3% per year between 2022 and 2027. This trend is consistent with the continual declines projected in water column and sediment PCB exposure concentrations.

The capping-only alternative (Alternative 3) can accelerate the rate of decline for both PCB levels in fish and PCB loading to the St. Lawrence River to the greatest extent relative to natural recovery. Alternative 3 is predicted to achieve a 0.36 mg/kg fish tissue PCB concentration, an 85% reduction in PCB loading to the St. Lawrence River, and an average sediment (0 to 3 inches) PCB concentration of 1 mg/kg in the 2015 to 2018 timeframe (**Figures A7-16** and **A7-17**, and **Table A7-3**). Capping-focused alternatives with smaller dredging components (Alternatives 4 through 6) achieve these metrics in a similar timeframe (i.e., 2016 to 2019) (**Figures A7-18** through **A7-23**, and **Table A7-3**).

Alternatives with significant dredging components (Alternatives 7 through 10) are projected to significantly extend the time frame for achieving the evaluation metrics. For example, Alternatives 7 through 9, which include relatively smaller dredging volumes, are predicted to achieve a 0.36 mg/kg fish tissue PCB concentration, an 85% reduction in PCB loading to the St. Lawrence River, and an average sediment (0 to 3 inches) PCB concentration of 1 mg/kg by about 2018 to 2027(**Figures A7-24** through **A7-29**, and **Table A7-3**). Alternative 10, which includes the largest dredging volumes, is not predicted to achieve these evaluation metrics between 2028 and 2035 (**Figures A7-30** and **A7-31** and **Table A7-3**). This is a result of two factors: 1) the longer time required to complete the dredging program; and 2) the higher PCB concentration in post-dredge sediments (relative to pre-dredge conditions) that remain in the river after dredging is complete.

Similarly, adding dredging to the capping alternatives results in no incremental reductions in fish tissue PCB levels predicted in 2036, and in some instances result in higher PCB levels (**Table A7-3**). For example, fish tissue PCB concentration in 2036 for Alternative 3 is predicted to be about 0.07 mg/kg. The addition of near shore dredging components (e.g., Alternatives 4 through 6) is not predicted to achieve any additional reduction in fish tissue PCB levels in 2036 relative to capping only; both result in 2036 fish tissue PCB levels of about 0.07 to 0.08 mg/kg. The addition of main channel dredging components (e.g., Alternatives 7 through 10) is predicted to increase average fish tissue levels in 2036 by as much as about 0.16 mg/kg (to about 0.13 to 0.24 mg/kg).

Benefits due to dredging are not evident because the reductions in sediment PCB exposure levels are being controlled by the placement of a cap over the dredged areas, not the removal of sediments from the river.

7.7.4 Sensitivity to Initial Sediment PCB Concentrations

The effect of uncertainty in the sediment PCB concentrations at the start of the model projection period was examined by comparing predicted fish tissue PCB concentrations for the No Further Action alternative under alternative sets of initial sediment PCB concentrations:

those predicted by the PCB fate model at the end of the model calibration period (termed model-based initial conditions), and those developed by interpolating on the model grid the sediment PCB concentrations measured in cores collected from the river between 2000 and 2007 and used to identify target areas for remediation for each alternative (as described in Section 4.2.1; termed core-based initial conditions). The model-based initial sediment PCB concentration used in this evaluation is about 40% lower than the data-based value (170 µg/g OC versus 300 µg/g OC), which results in lower PCB exposure concentrations to the resident fish over the course of the model projection. All other assumptions used in the modeling remained identical.

Predicted river-wide fish tissue PCB concentrations for the two simulations are compared in **Figure A7-32**. For the No Further Action and Monitored Natural Recovery alternatives (Alternatives 1 and 2), predicted fish tissue PCB concentrations are directly related to differences in the sediment exposure concentration trajectories. For the core-based initial condition scenario, predicted river-wide fish tissue PCB concentrations start at about 3.6 mg/kg in 2007, increase to about 4 mg/kg by about 2009, and then decline over time (due to natural recovery processes) and reach about 0.7 mg/kg by 2036. The initial increase in fish tissue PCB concentrations over the first two years is due to the increase in sediment exposure PCB concentrations between the end of the model calibration and beginning of the model projection. For the model-based initial condition scenario, which continues the sediment exposure concentration trajectory that was predicted during the model calibration period, predicted river-wide fish tissue PCB concentrations start at about 1.8 mg/kg in 2007 and gradually decline to about 0.4 mg/kg by 2036. The No Further Action/Monitored Natural Recovery alternatives are more sensitive to the initial condition than dredging or capping because the reductions in sediment concentration that result from dredging or capping reduce the differences in sediment concentrations.

The use of the sediment PCB concentrations predicted by the model as initial conditions for the model projections avoids a discontinuity that exists when the model results are replaced by the interpolated data and provides an uninterrupted continuation of the sediment PCB trends. It also results in predicted fish tissue PCB concentrations that more closely match the measured values from 2007 through 2009 (collected after the model calibration period). Although the bioaccumulation model still over-estimates fish tissue PCB concentrations relative to the 2007 to

2009 trend monitoring data, much of the difference is attributable to differences in lipid contents. For the model projection, an average lipid content of 1.3% and 2.2% was assumed for smallmouth bass and brown bullhead, respectively (see Section 7.5). These values were based on the lipid contents measured in each species during the calibration period. Between 2007 and 2009, however, measured lipid contents in smallmouth bass and brown bullhead samples were lower, averaging 0.8% and 1.1%, respectively. Using the 2007 to 2009 average lipid contents for the first three years of the model projection would yield predicted fish tissue concentrations that are lower relative to the current (i.e., model-based initial condition) results and more closely match the observed PCB levels for these years.

SECTION 8
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Table A3-1. Bed resuspension parameters used for model input.

Location	Number of Samples	$\tau \leq 5$ dynes/cm^2		$\tau > 5$ dynes/cm^2	
		a_o	n	a_o	n
T1 to T21	19	5.89	1.52	8.97	1.22
T21 to T36	15	37.25	0.58	9.14	1.59
T36 to T72	21	19.28	0.86	5.56	1.76

Table A3-2. Average dry density and percent fines used for model input.

Transect Location	River Area	Sediment Type	Average Dry Density (g/cm^3)	Average Percent Fines[1]
T1-T21	Main Channel	Coarse sediments (Type I)	1.08	23.3
T1-T21	Main Channel	Fine sediments (Type II)	1.03	14.9
T21-T36	Main Channel	Coarse sediments (Type I)	0.66	41.3
T21-T36	Main Channel	Fine sediments (Type II)	0.51	48.3
T36-T72	Main Channel	Coarse sediments (Type I)	0.61	64.1
T36- T72	Main Channel	Fine sediments (Type II)	0.49	78.0
T1-T6, T7-T72	Near Shore	North Shore (non-ROPS area)	0.96	37.6
T6-T7	Near Shore	North Shore (ROPS area)	1.2	32.03
T1-T8.5, T9.5-T72	Near Shore	South Shore (non-ROPS area)	0.87	39.91
T8.5-T9.5	Near Shore	South Shore (ROPS area)	1.29	26.56

Note:

1. Average percent fines was estimated as the percent of sediment passing through the 75 µm sieve.

Table A4-1. Sediment data used to develop initial sediment PCB concentrations in 1997.

Sampling Program	Segmentation	Approximate Number of Locations
1991 RSI Phase I	0 - 3 inches, 3 - 12 inches	90
1993 RSI Phase II	Variable (0 - <12 inches, 0 - >12 inches)	40
1995 Pre-NTCRA	0-1 inches, 1-6 inches, 6-12 inches	5
1995 Post-NTCRA	Variable (0 - <8 inches)	10
1997 SRS	Surface Grabs (top 3 inches) High Resolution Cores (1-cm slices)	140 5
2000 SSS	Surface Grabs (top 3 inches) Cores (3-inch slices)	120 10

Notes:
NTCRA = Non-Time-Critical Removal Action
RSI = River and Sediment Investigation
SRS = Supplemental Remedial Studies
SSS = Supplemental Sediment Sampling

Table A4-2. Sediment core data used to develop initial sediment PCB concentrations in 2000.

Sampling Program	River Stretch	Core Segmentation (top 12 inches only)	Approximate Number of Cores
2000 SSS	T19-T72	0 - 3 inches, 3 - 12 inches	10
2001 SSS	T19-T72	0 - 3 inches, 3 - 12 inches	4
2003 Phase I River Ice Investigation	T1-T72	Variable (0-1cm, 1cm -3 inches, 3-6 inches, 6-12 inches) (1-cm slides in top 8cm, every 5th cm thereafter)	28
2003 Phase II River Ice Investigation	T1-T72	Variable (0-1cm, 1cm -3 inches, 3-6 inches, 6-12 inches) (1-cm slides in top 8cm, every 5th cm thereafter)	68
January 2004 SSS	T1-T72	0 - 3 inches, 3-6 inches, 6-12 inches	20
2004 Focused Studies	T1-T72	Variable (0-3 inches, 3-6 inches, 6-12 inches (1-cm slides in top 8cm, every 5th cm thereafter)	30
2005-2007 Post-ROPS	T1-T72	Variable (Every 1 or 2 inches in cap, top 3 inches in native sediments)	77
2006 Phase I Vibracoring	T1-T72	0 - 3 inches, 3-6 inches, 6-12 inches	61
2007 Phase II Vibracoring	T1-T72	0 - 3 inches, 3-6 inches, 6-12 inches	154

Notes:
ROPS = Remedial Options Pilot Study
SSS = Supplemental Sediment Sampling

Table A5-1. Previous applications of the bioaccumulation model.

System	Chemical	Food Web Leading to	Reference
Lake Michigan	PCBs	Lake trout	Thomann and Connolly, 1984
Lake Ontario	PCBs	Lake trout	Connolly and Thomann, 1992
James River Estuary	Kepone	Striped bass	Connolly and Tonelli, 1985
Hudson River Estuary	PCBs	Striped bass	Thomann et al., 1989
New Bedford Harbor	PCBs, Cd, Cu, Pb	Winter flounder, lobster	Connolly, 1991
Green Bay	PCBs	Walleye, brown trout	Connolly et al., 1992
Southern California Bight	PCBs, DDE	White croaker, Kelp bass, Dover sole	HydroQual, 1994
Upper Hudson River	PCBs	Largemouth bass	QEA, 1999

Table A5-2. Statistical analysis of bioaccumulation model calibration.

Root Mean Square Error and Relative Percent Difference Statistics

Scenario Number	Scenario Description	Wet-Weight						Lipid-Based					
		Smallmouth Bass			Brown Bullhead			Smallmouth Bass			Brown Bullhead		
		RMSE	Mean RPD	RPD 2StdErr	RMSE	Mean RPD	RPD 2StdErr	RMSE	Mean RPD	RPD 2StdErr	RMSE	Mean RPD	RPD 2StdErr
1	BBUL Diet SED:WC=50:50 and SMBS Diet PKSD:BBUL=50:50	1.2	15	20	0.7	-2	10	102	12	24	48	-9	13
2	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=50:50	1.2	20	19	0.6	8	9	105	17	24	42	0	13
3	BBUL Diet SED:WC=70:30 and SMBS Diet PKSD:BBUL=50:50	1.3	25	18	0.9	16	8	112	22	23	47	9	12
4	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=60:40	1.2	17	19	0.6	8	9	103	14	24	42	0	13
5	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=70:30	1.2	14	20	0.6	8	9	102	10	25	42	0	13
6	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=75:25	1.2	12	20	0.6	8	9	102	8	25	42	0	13
7	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=80:20	1.2	10	21	0.6	8	9	103	7	26	42	0	13
8	**BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=70:30**	**1.2**	**13**	**20**	**0.6**	**8**	**9**	**102**	**10**	**25**	**42**	**0**	**13**

Notes:

1. Root mean square error (RMSE) and relative percent difference (RPD) statistics exclude 2005 data.

2. RPD values based on actual (not absolute) differences between model predicted and actual data.

3. Scenario 8 represents the final calibration of the model.

T-test Results

Scenario Number	Scenario Description	Wet-Weight						Lipid-Based					
		Smallmouth Bass			Brown Bullhead			Smallmouth Bass			Brown Bullhead		
		StdErr	t	Probability	StdErr	t	Probability	StdErr	t	Probability	StdErr	t	Probability
1	BBUL Diet SED:WC=50:50 and SMBS Diet PKSD:BBUL=50:50	9.79	1.53	0.16	4.76	0.42	0.69	12.20	0.98	0.35	6.68	1.35	0.21
2	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=50:50	9.42	2.12	0.07	4.37	1.83	0.10	11.85	1.44	0.19	6.40	0.00	1.00
3	BBUL Diet SED:WC=70:30 and SMBS Diet PKSD:BBUL=50:50	7.33	3.41	*0.01*	4.18	3.83	*0.01*	11.54	1.91	0.09	6.25	1.44	0.19
4	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=60:40	9.69	1.75	0.12	4.37	1.83	0.10	12.13	1.15	0.28	6.40	0.00	1.00
5	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=70:30	9.99	1.40	0.20	4.37	1.83	0.10	12.44	0.80	0.44	6.40	0.00	1.00
6	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=75:25	10.15	1.18	0.27	4.37	1.83	0.10	12.61	0.63	0.54	6.40	0.00	1.00
7	BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=80:20	10.32	0.97	0.36	4.37	1.83	0.10	8.50	0.82	0.43	6.40	0.00	1.00
8	**BBUL Diet SED:WC=60:40 and SMBS Diet PKSD:BBUL=70:30**	**9.45**	**1.38**	**0.21**	**4.37**	**1.83**	**0.10**	**12.45**	**0.80**	**0.44**	**6.40**	**0.00**	**1.00**

Notes:

1. Null hypothesis: Average RPD is not different from zero.

Alternative: Average RPD is significantly different from zero.

If probability < 0.05 then significant different (shown in italics); if probability > 0.05 then not significantly different.

2. Scenario 8 represents the final calibration of the model.

Table A7-1. Grasse River alternatives.

Alternative (Number, Name, Description)			T1 to T21													T21 to T72												Estimated Cost ($)
			NEAR SHORE AREA					MAIN CHANNEL								NEAR SHORE AREA					MAIN CHANNEL							
			Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped	Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped: Fine	Acres Capped: Coarse	Acres Capped: Total		Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped	Action	PCB Metric	Threshold (mg/kg)	CY Dredged (Expected)	Acres Capped: Fine	Acres Capped: Coarse	Acres Capped: Total	
No Further Action and Monitored Natural Recovery Alternatives																												
1	No Further Action	No Further Action	None	---	---	0	0	None	---	---		0	0	0		None	---	---	0	0	None	---	---	0	0	0	0	$ -
2	Monitored Natural Recovery	Monitored Natural Recovery	Monitor	---	---	0	0	Monitor	---	---		0	0	0		Monitor	---	---	0	0	Monitor	---	---		0	0	0	$ 3,400,000
Dredging and/or Capping Alternatives																												
3	T1-T72 Capping	T1-T21 Near Shore and Main Channel Capping T21-T72 Near Shore and Main Channel Capping	Near Shore Cap	SLWA / 0-12 MAX	1	0	10	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Near Shore Cap	0-12 MAX	1	0	31	Main Channel Cap	0-6 MAX	1	0	156	69	225	$ 114,100,000
4	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping T21-T72 Near Shore and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Near Shore Cap	0-12 MAX	1	0	31	Main Channel Cap	0-6 MAX	1	0	156	69	225	$ 147,200,000
5	T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling, Capping 1/10 and Main Channel Capping 1/1 T21-T72 Near Shore Dredging/Backfilling1/10 and Main Channel Capping 1/1	Near Shore Cap	SLWA / 0-12 MAX	1-10	0	4	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Near Shore Cap	0-12 MAX	1-10	0	24	Main Channel Cap	0-6 MAX	1	0	156	69	225	$ 175,200,000
			Dredge / Backfill to Grade		10	18,300	6									Dredge / Backfill to Grade		10	27,800	7								
6	T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping T21-T72 Near Shore Dredging/Backfilling and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	49	10	59		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Main Channel Cap	0-6 MAX	1	0	156	69	225	$ 243,100,000
7	T1-T72 Near Shore Dredging/Backfilling, Select T1-T19.5 Main Channel Dredging, T1-T72 Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging (T1-T19.5) T21-T72 Near Shore Dredging/Backfilling and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	31	9	40		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Main Channel Cap	0-6 MAX	1	0	156	69	225	$ 351,600,000
								Dredge (ROPS and T16.5-T19.5) / Armored Cap	--[8]	--	149,600	18	1	19														
8	T1-T21 Dredging/Capping, T21-T72 Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging/Capping T21-T72 Near Shore and Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Dredge / Armored Cap	SLWA / 0-6 MAX	1	329,200	49	10	59		Near Shore Cap	0-12 MAX	1	0	31	Main Channel Cap	0-6 MAX	1	0	156	69	225	$ 388,000,000
9	T1-T72 Near Shore Dredging/Backfilling, Select T1-T46 Main Channel Dredging/Capping, T1-T72 Main Channel Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging (ROPS, T16.5-T19.5), Main Channel Capping T21-T72 Near Shore Dredging/Backfilling and Main Channel Dredging (T27-T37, T43-T46), Main Channel Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Armored Cap	SLWA / 0-6 MAX	1	0	31	9	40		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Main Channel Cap	0-6 MAX	1	0	114	54	168	$ 588,500,000
								Dredge (ROPS and T16.5-T19.5) / Armored Cap	--[8]	--	149,600	18	1	19							Dredge (T27-T37 and T43-T46) / Main Channel Cap	--[8]	--	374,900	42	15	57		
10	T1-T72 Dredging/Capping	T1-T21 Near Shore Dredging/Backfilling and Main Channel Dredging/Capping T21-T72 Near Shore and Main Channel Dredging/Capping	Dredge / Backfill to Grade	SLWA / 0-12 MAX	1	25,900	10	Dredge / Armored Cap	SLWA / 0-6 MAX	1	329,200	49	10	59		Dredge / Backfill to Grade	0-12 MAX	1	82,800	31	Dredge / Main Channel Cap	0-6 MAX	1	1,225,600	156	69	225	$ 1,273,500,000

Notes:
1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Removal volumes for near shore area dredging components reflect removal of entire depth of contamination.
3) Removal components in the main channel consider fine sediment areas only.
4) Capping components in the main channel consider both fine and coarse sediment areas.
5) Estimated costs based on assumptions provided on Table Y, and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
6) Dredging volumes and cap areas based on 2010 near shore update.
7) Expected Volume includes volume considerations for over dredging and side slopes.
8) Alternatives 7 and 9: if no PCB metric is defined, dredging in the main channel targets all sediment within the identified transects.

Acronyms:
CY = cubic yards
CPS = Capping Pilot Study
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
mg/kg = milligram per kilogram
T = transect

Table A7-2. Modeling assumptions for Grasse River alternatives.

Parameter	Reach	Value	Basis
Work Schedule			
In-river start date	---	May 1, 2013	Assumed project start date
Construction season	---	6 months (May through October)	Normal construction season for Massena, NY area
In-river construction schedule	---	24 hours/day; 6 days per week	Typical construction operations
Dredging-Related Parameters			
Productivity rate			
Main channel dredging	T1 to T21	400 cy/d	ROPS; water quality evaluation
	T21 to T72	800 cy/d	Assumes two dredges at T1 to T21 production rate
Near shore dredging	T1 to T21	400 cy/d	ROPS; Assumes two dredges at 200 cy/d rate
	T21 to T72	400 cy/d	ROPS; Assumes two dredges at 200 cy/d rate
During dredging releases			
TSS	T1 to T21	3% of mass of sediment removed	ROPS
PCBs	T1 to T21	3% of mass of PCBs removed	ROPS
Post-dredging residual	T1 to T21	DWA PCB concentration of material removed	ROPS; recommendations of Palermo et al.
Capping and Backfilling-Related Parameters			
Main channel capping	T21 to T72	1,080 cy/d - 1,440 cy/d	Production rate assumes multiple capping rigs operating concurrently. Rate is equivalent to 1.5x to 2.0x that of a single capping rig depending on the remediation scenario. Assumes 10% lower than T1 to T21 rate due to increased transport distance. Note: No main channel capping T1-T21
Armored capping (main channel)	T1 to T21	900 cy/d - 1,200 cy/d	Production rate assumes multiple capping rigs operating concurrently. Rate is equivalent to 1.5x to 2.0x that of a single capping rig depending on the remediation scenario. Based on previous project experience. Note: No armored capping T21-T72
Near shore capping	T1 to T21	600 cy/d - 800 cy/d	Production rate assumes multiple capping rigs operating concurrently. Rate is equivalent to 1.5x to 2.0x that of a single capping rig depending on the remediation scenario. Assumes 1/2 of main channel capping production rate due to difficult access
	T21 to T72	450 cy/d - 600 cy/d	Production rate assumes multiple capping rigs operating concurrently. Rate is equivalent to 1.5x to 2.0x that of a single capping rig depending on the remediation scenario. Single rig production rate based on ROPS; Engineer's estimate of typical Near shore cap
Backfill to grade	T1 to T21	600 cy/d	Production rate assumes multiple backfilling rigs operating concurrently. Rate is equivalent to 1.5x that of a single backfilling rig depending on the remediation scenario. Single rig production rate based on ROPS; Engineer's estimate
	T21 to T72	540 cy/d	Production rate assumes multiple backfilling rigs operating concurrently. Rate is equivalent to 1.5x that of a single backfilling rig depending on the remediation scenario. 10% lower than T1 to T21 rate due to increased transport distance
Post-dredging capping releases	---		
TSS		3% of mass of cap material added	CPS; ROPS
PCBs		1% of post-dredge residual PCB mass	ROPS
Native sediment capping releases	---		
TSS		3% of mass of cap material added	CPS; ROPS
PCBs		None	ROPS
Cap Construction	---		
Main channel cap		Two 6-inch lifts	CPS; ROPS
Near shore cap		One 6-inch lift	ROPS
Cap-effectiveness	---	95% reduction in sediment PCBs	CPS; ROPS

Notes:
CPS = Capping Pilot Study
cy/d = cubic yards per day
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
DWA = Depth-weighted average
TSS = Total suspended solids

Table A7-3. Grasse River alternatives - evaluation metrics summary.

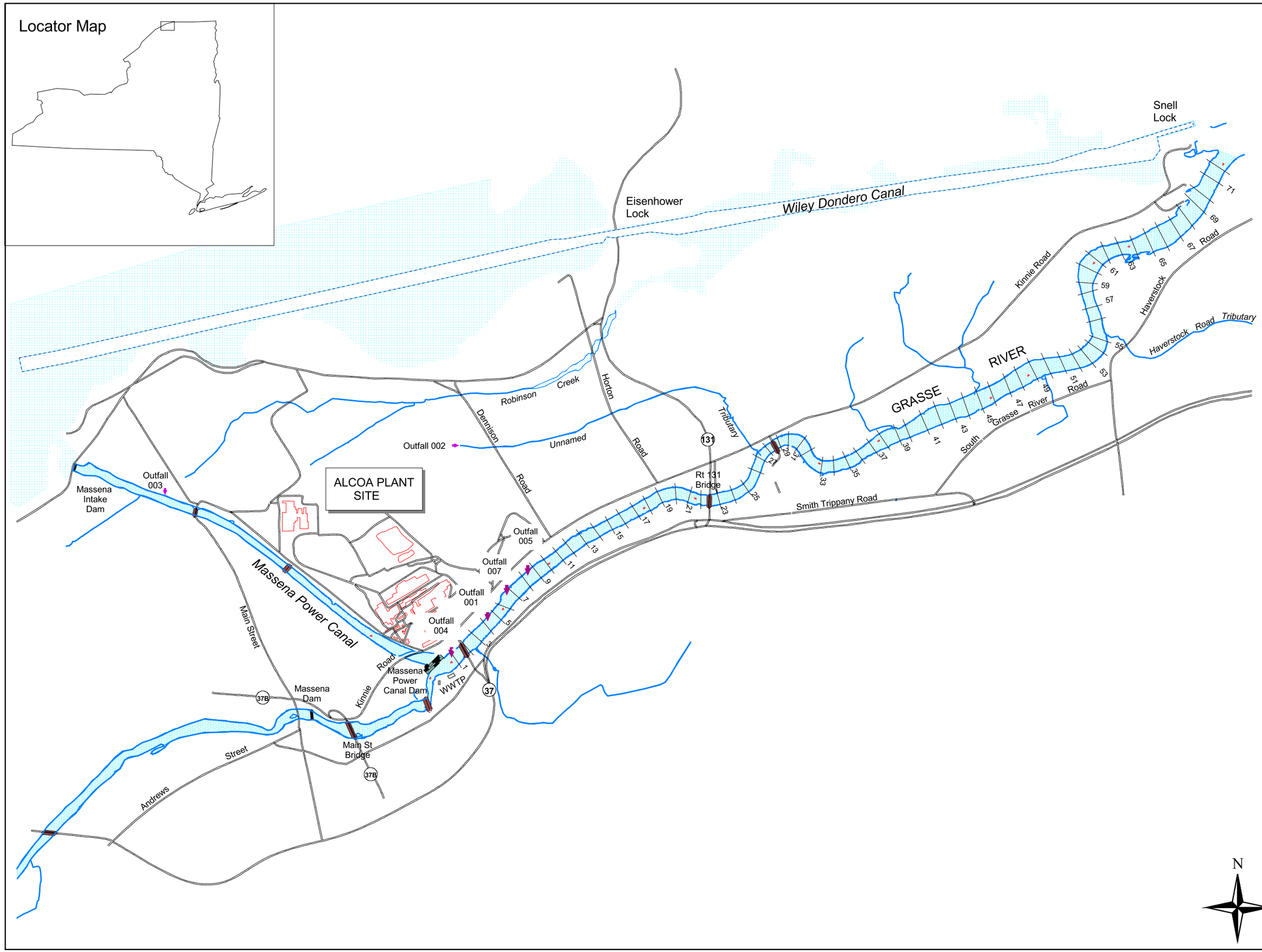
Alternative (Number, Name, Description)			River-wide Average Fish Tissue PCB Levels: Predicted Dates to Reach 0.36 mg/kg	0.26 mg/kg	0.05 mg/kg	PCB Levels in 2036 (mg/kg)	Average PCB Loading to the St. Lawrence River: Estimated Date to Reach 85% Reduction from Baseline	River-wide Average Sediment (0-3 inches) PCB Levels: Estimated Date to Reach 1 mg/kg
No Further Action and Monitored Natural Recovery Alternatives								
A1	No Further Action	No Further Action	>2036	>2036	>2036	0.5	>2035	>2036
A2	Monitored Natural Recovery	Monitored Natural Recovery	>2036	>2036	>2036	0.5	>2035	>2036
Cap Only Alternatives								
3	T1-T72 Capping	T1-T72 Main channel T1-T21: Armor cap > 1 mg/kg T21-T72: Cap > 1 mg/kg T1-T72 Near shore T1-T72: Near shore cap > 1 mg/kg	2018	2019	>2036	0.07	2016	2015
Dredge/Cap Alternatives								
4	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping	Main Channel T1-T21: Armor cap > 1 mg/kg T21-T72: Cap > 1 mg/kg Near shore T1-T21: Dredge/backfill to grade > 1 mg/kg T21-T72: Near shore cap > 1 mg/kg	2018	2019	>2036	0.07	2016	2016
5	T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping	Main Channel T1-T21: Armor cap > 1 mg/kg T21-T72: Cap > 1 mg/kg Near shore T1-T72: Dredge/backfill to grade > 10 mg/kg and near shore cap >1 and <10 mg/kg (Alt 5) > 1 mg/kg (Alt 6)	2019	2020	>2036	0.08	2018	2016
6	T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping		2019	2020	>2036	0.08	2018	2016
7	T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping	Main Channel ROPS WZ2 and 3 and T16.5 to T19.5: Dredge/armor cap T1-T21: Armor cap remaining undredged sediment > 1 mg/kg T21-T72: Cap > 1 mg/kg Near shore T1-T72: Dredge/backfill to grade > 1 mg/kg	2022	2026	>2036	0.1	2022	2018
8	T1-T21 Dredging/Capping, T21-T72 Capping	Main Channel T1-T21: Dredge/armor cap ≥ 1 mg/kg T21-T72: Cap ≥ 1 mg/kg Near shore T1-T21: Dredge/backfill to grade ≥ 1 mg/kg T21-T72: Near shore cap ≥ 1 mg/kg	2025	2031	>2036	0.2	2027	2021
9	T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping	Main Channel ROPS WZ2 and 3 and T16.5 to T19.5: Dredge/armor cap T1-T21: Armor cap remaining undredged sediment > 1 mg/kg T27 to T37 and T43 to T46: Dredge/cap T21-T72: Cap remaining undredged sediment > 1 mg/kg Near shore T1-T72: Dredge/backfill to grade > 1 mg/kg	2025	2029	>2036	0.2	2027	2021
10	T1-T72 Dredging/Capping	Main Channel T1-T21: Dredge/armor cap ≥ 1 mg/kg T21-T72: Dredge/cap ≥ 1 mg/kg Near shore T1-T72: Dredge/backfill to grade ≥ 1 mg/kg	2032	2035	>2036	0.2	2035	2028

NOTES

1) Cap definitions: Armor Cap = 25" thick design (as per ROPS); Main Channel Cap = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Removal volumes for near shore area dredging components reflect removal of entire depth of contamination.
3) Removal components in the main channel consider fine sediment areas only.
4) Capping components in the main channel consider both fine and coarse sediment areas.
5) River-wide average fish tissue PCB levels represent annual species-average computed from predicted PCB levels in smallmouth bass and brown bullhead.
6) Percent reductions for PCB loading to the St. Lawrence River are in relation to average projected PCB loadings between 2010 and 2012. Three-year moving averages were used to damp year-to-year fluctuations in assumed river flows used in the synthetic hydrograph.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
ICS = ice control structure
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average



GRAPHIC SCALE

1000 0 1000 Feet

LEGEND

- River Flow Direction Arrows
- Wiley Dondero Canal Outline
- Wiley Dondero Canal Area
- St. Lawrence Seaway Outline
- Roads
- Waste Water Treatment Plant
- ALCOA Buildings
- Bridges
- Dams
- Sediment Probing Transects
- Grasse River + Tributaries Shoreline

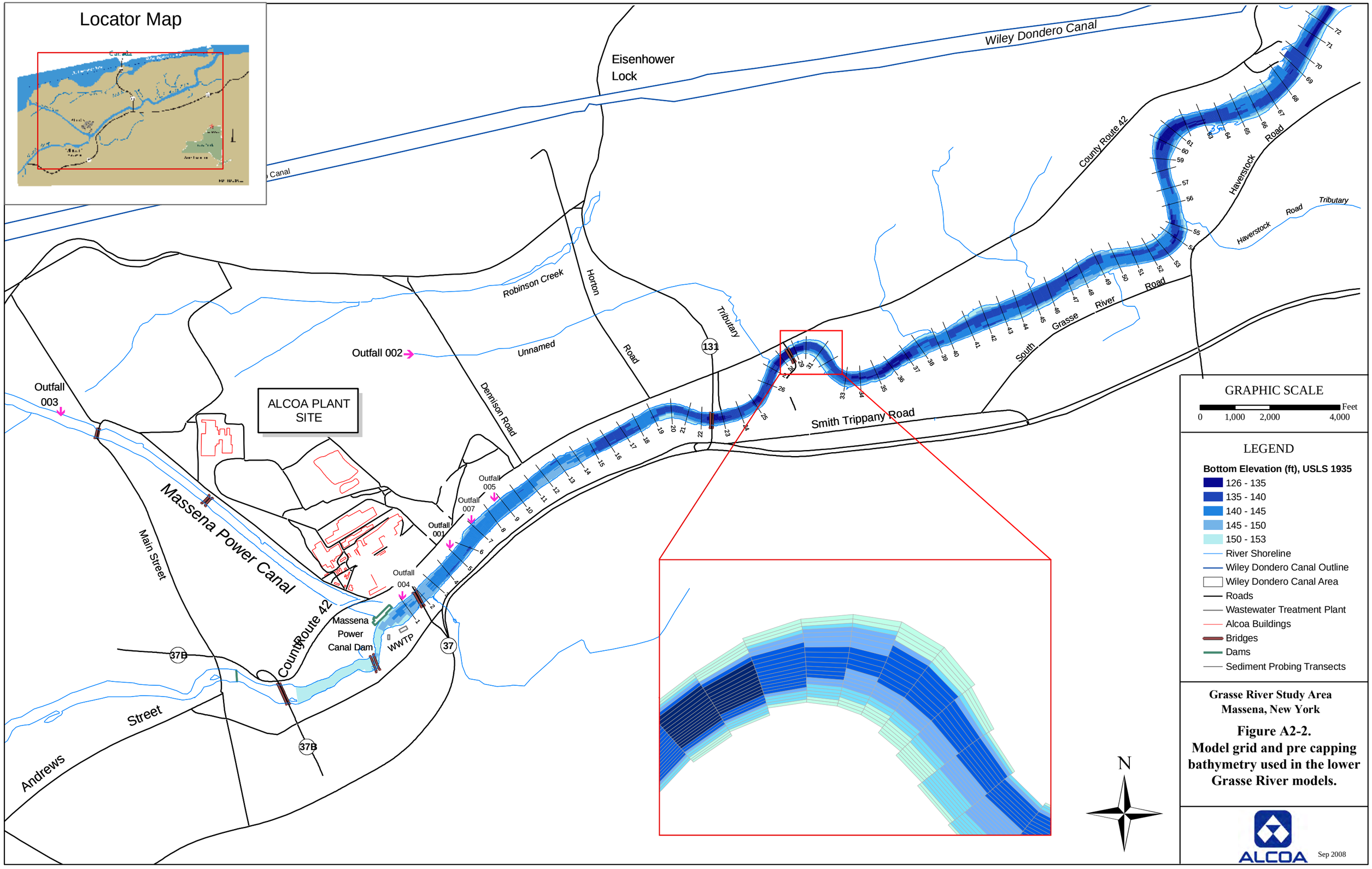
Lower Grasse River Study Area
Massena, New York

Figure A2-1.
Location map.

ALCOA

April 2001

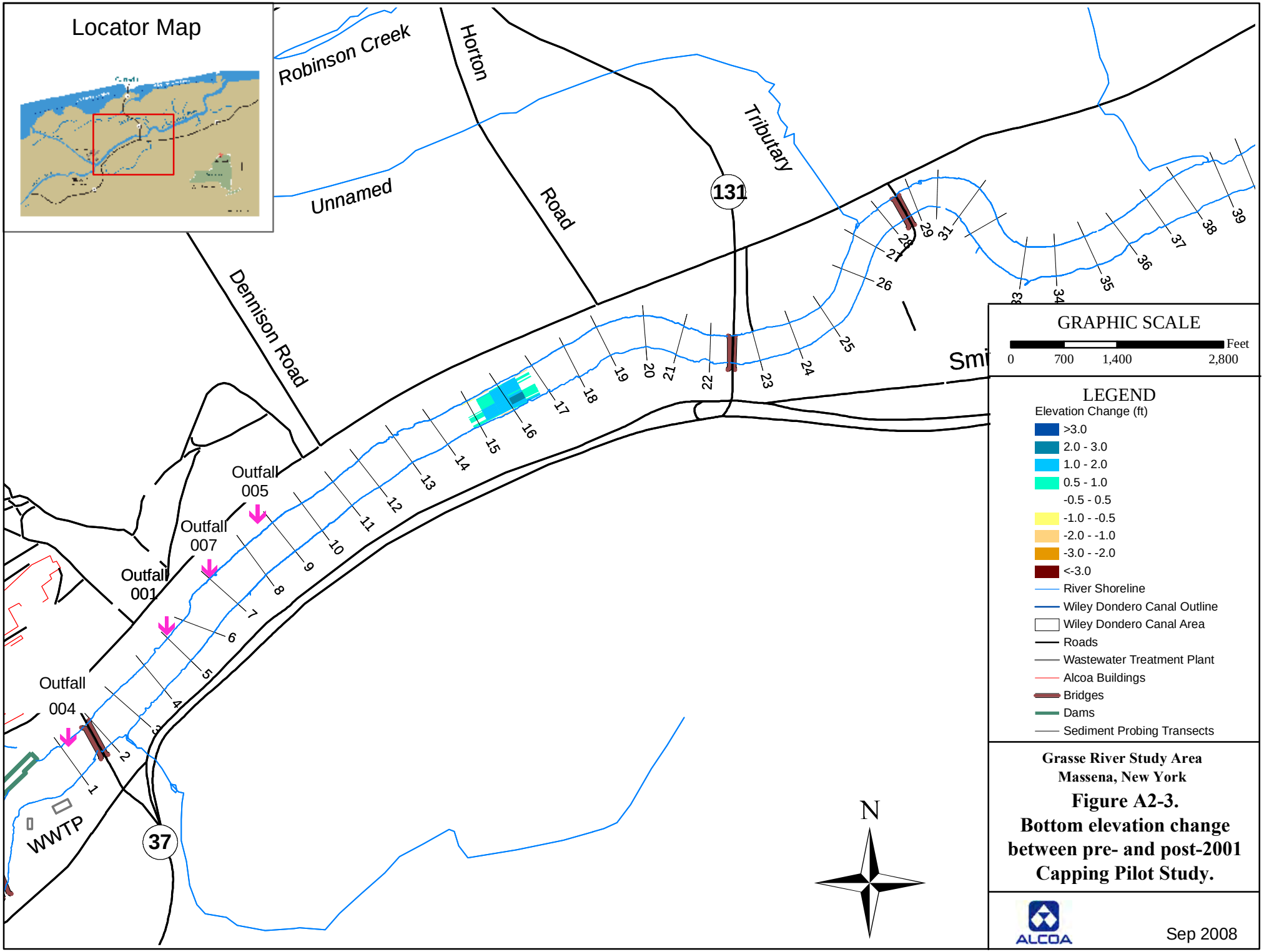
DN - \\Daleel\D_DRIVE\ALCgra\GIS\GIS_fig_C1_1\outfalls\map_of_area_1003022.apr



Grasse River Study Area
Massena, New York

Figure A2-2.
Model grid and pre capping bathymetry used in the lower Grasse River models.

BW/PMO-\\wen\D_DRIVE\ALCgra\Document\AA Report\Figures\ALCgra_Model_results_analysis11_14_08_PMO_.mxd

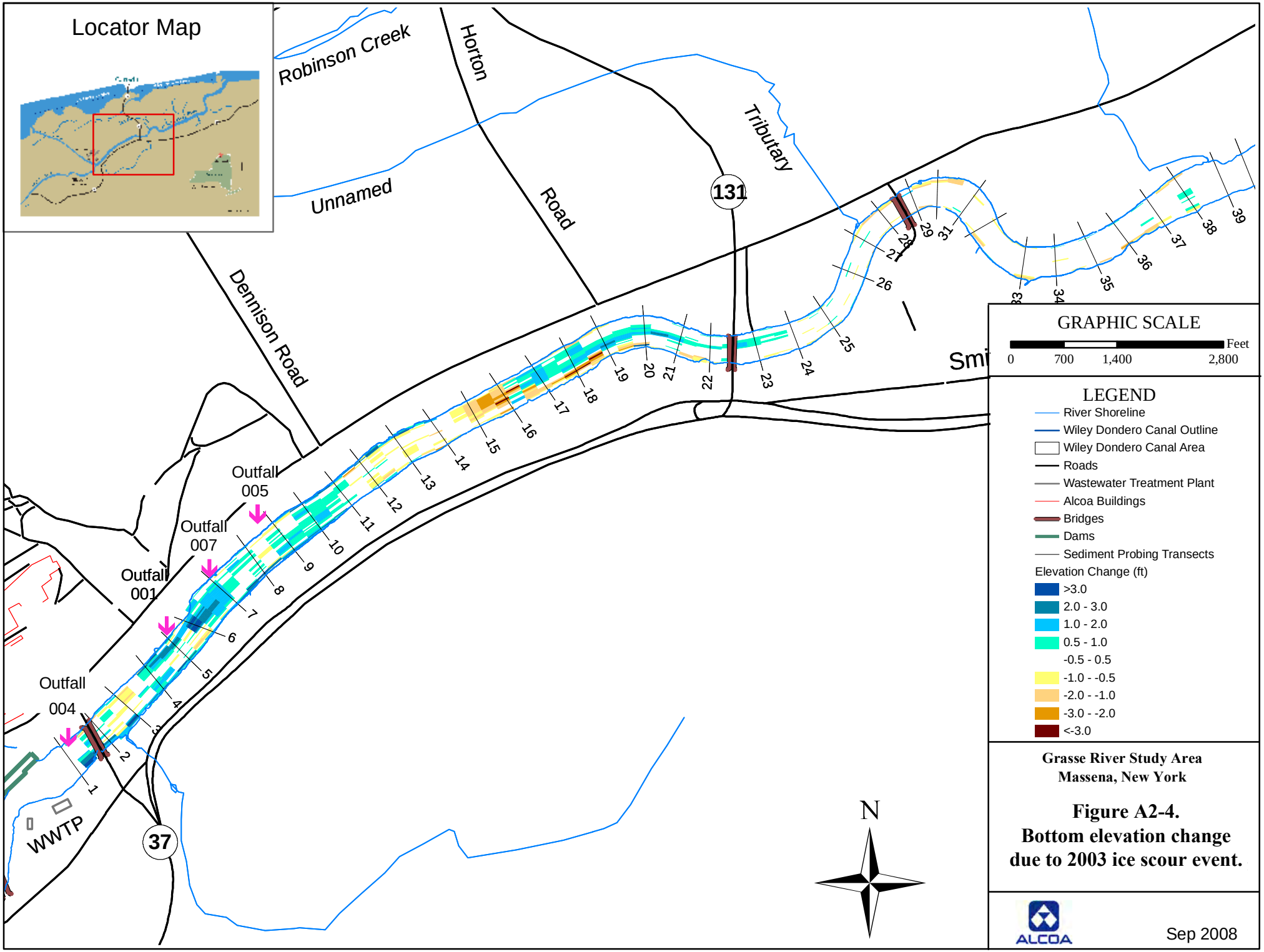


Grasse River Study Area
Massena, New York

Figure A2-3.
Bottom elevation change between pre- and post-2001 Capping Pilot Study.

Sep 2008

BW/PMO-\\wen\D_DRIVE\ALCgra\Document\AA Report\Figures\ALCgra_Model_results_analysis0908.mxd

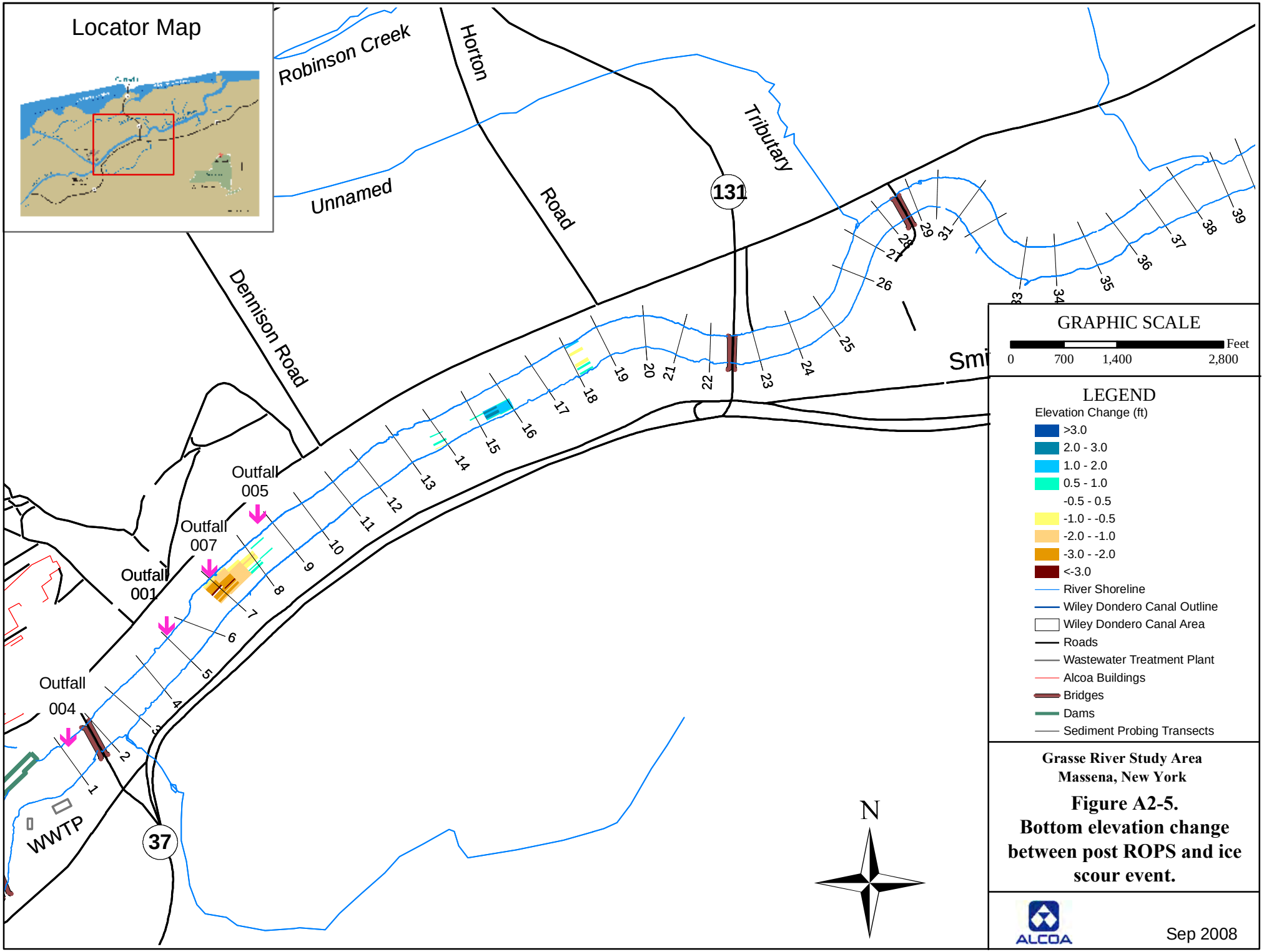


Grasse River Study Area
Massena, New York

Figure A2-4.
Bottom elevation change due to 2003 ice scour event.

Sep 2008

BW/PMO-\\wen\D_DRIVE\ALCgra\Document\AA Report\Figures\ALCgra_Model_results_analysis0908.mxd



Grasse River Study Area
Massena, New York

Figure A2-5.
Bottom elevation change between post ROPS and ice scour event.

Sep 2008

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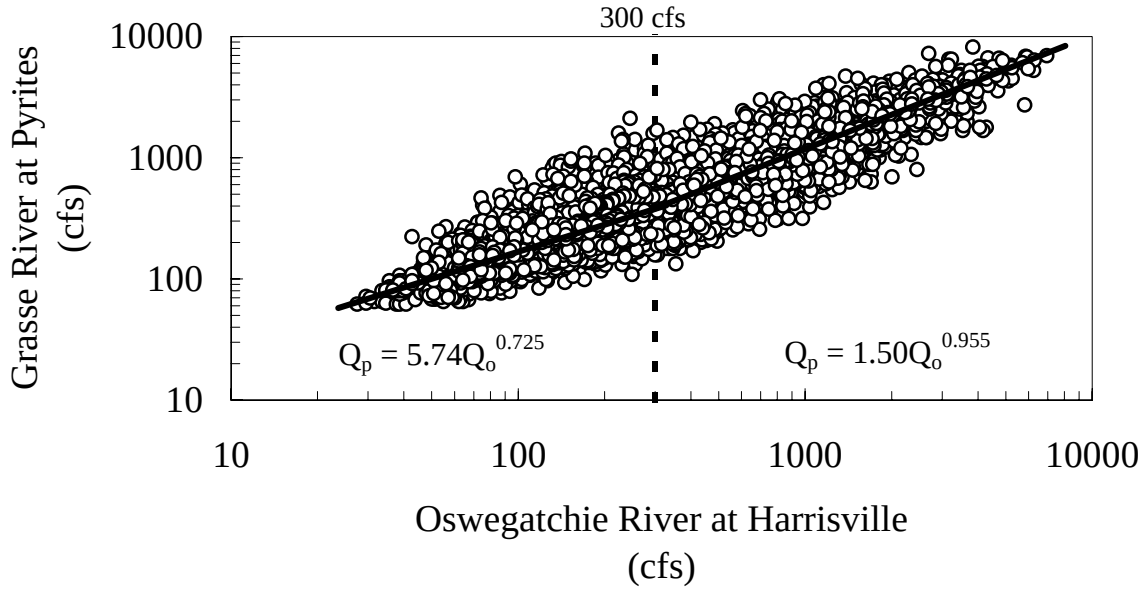

Figure A2-6. Relationship between flows measured in the Grasse River at Pyrites and West Branch of Oswegatchie River at Harrisville (1924 to 1977).

Data tables: riverflow_hist

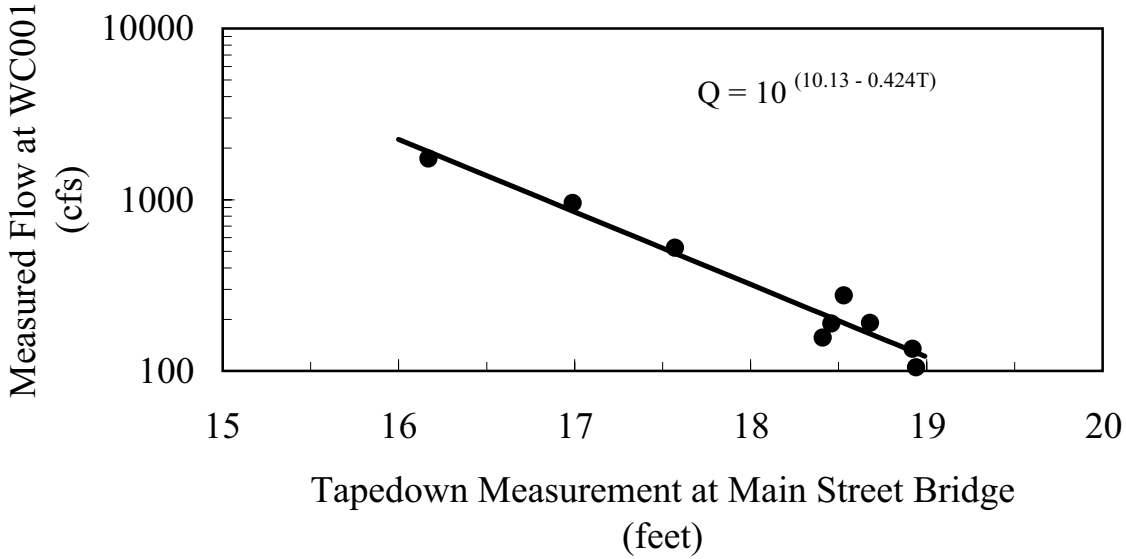

Figure A2-7. Relationship between paired flow and tapedown measurements from 1997.

Circles represent paired measurements collected during SRS surveys in 1997.
Solid line represents relationship used to estimate flows from tapedown measurements.

Data table: riverflow_tapedown

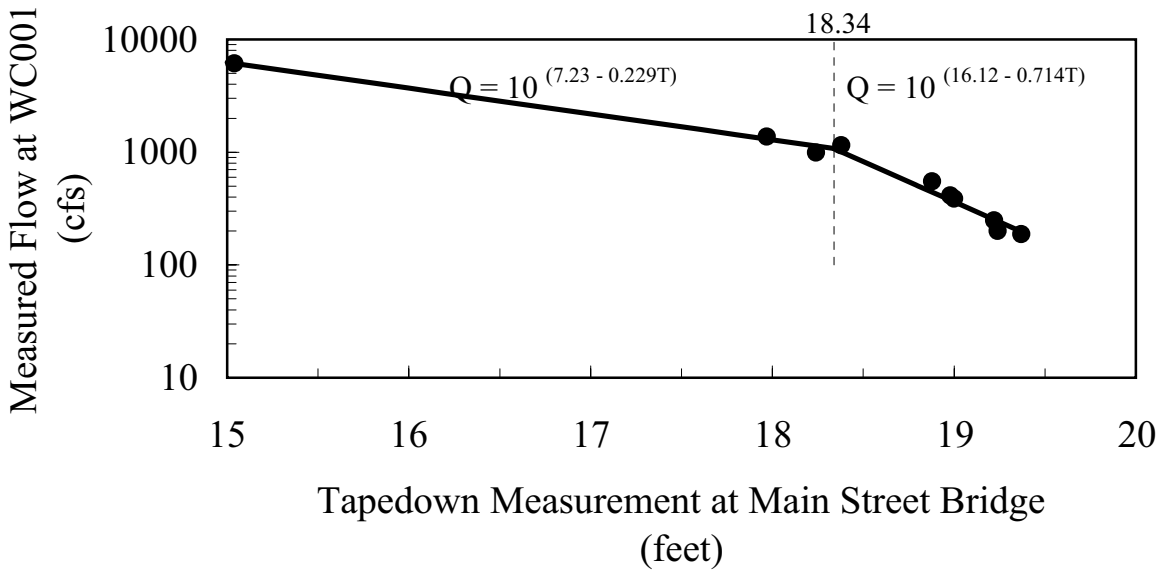

Figure A2-8. Relationship between paired flow and tapedown measurements from 1998.

Circles represent paired measurements collected during SRS surveys in 1998.
Solid line represents relationship used to estimate flows from tapedown measurements.

Data table: riverflow_tapedown

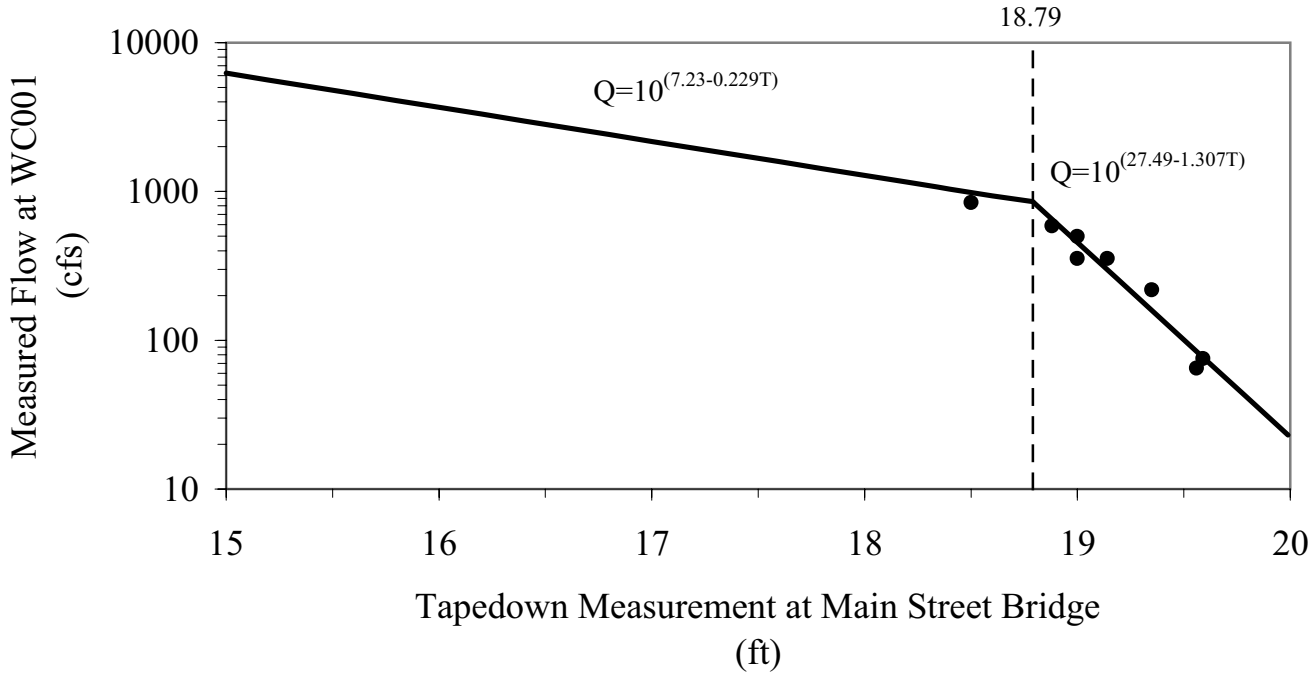

Figure A2-9. Relationship between paired flow and tapedown measurements from 1999.

Circles represent paired measurements collected during SRS surveys in 1999.
Solid line represents relationship used to estimate flows from tapedown measurements.

Data table: riverflow_tapedown

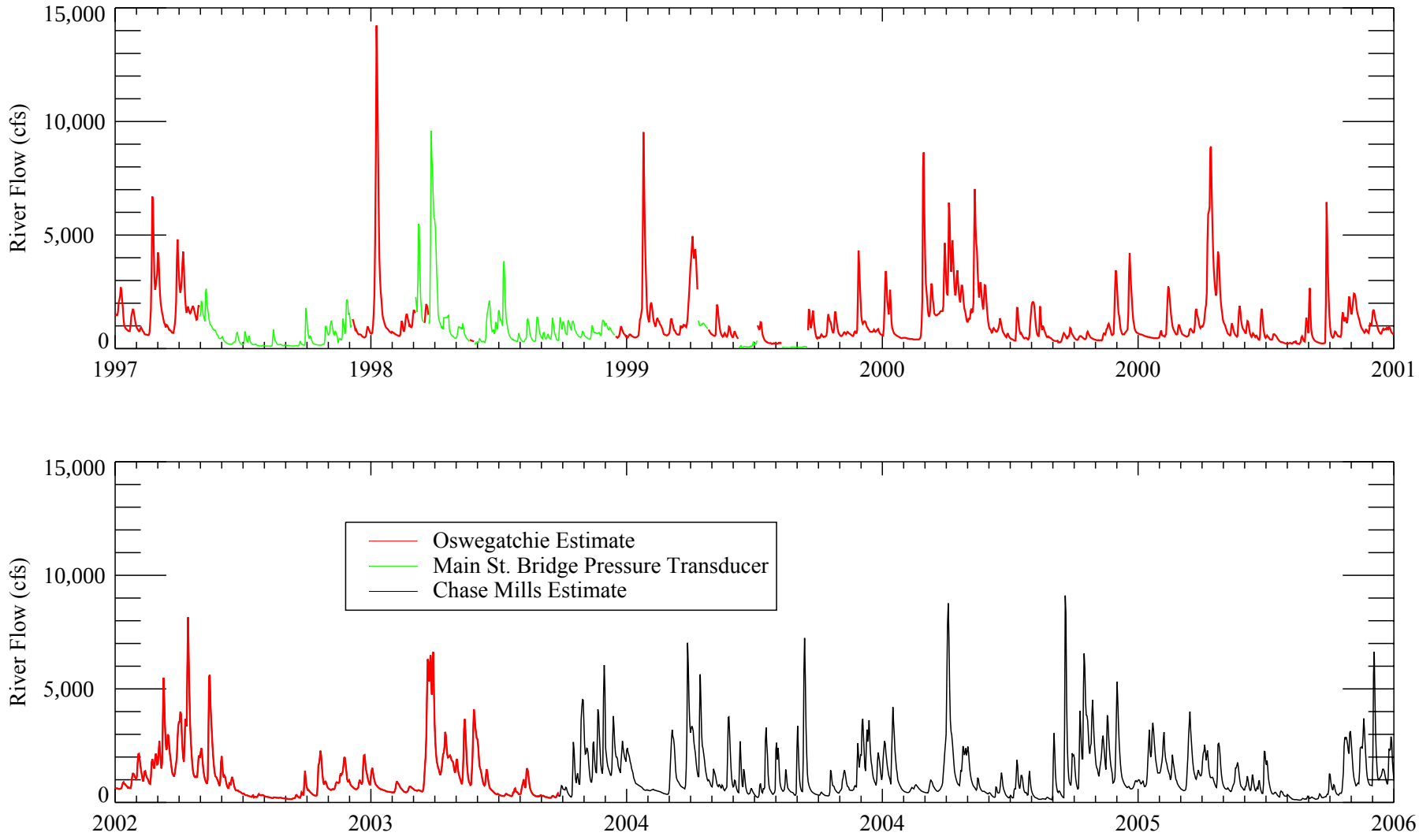

Figure A2-10. Estimated flows in the Grasse River for 1997 through 2006.

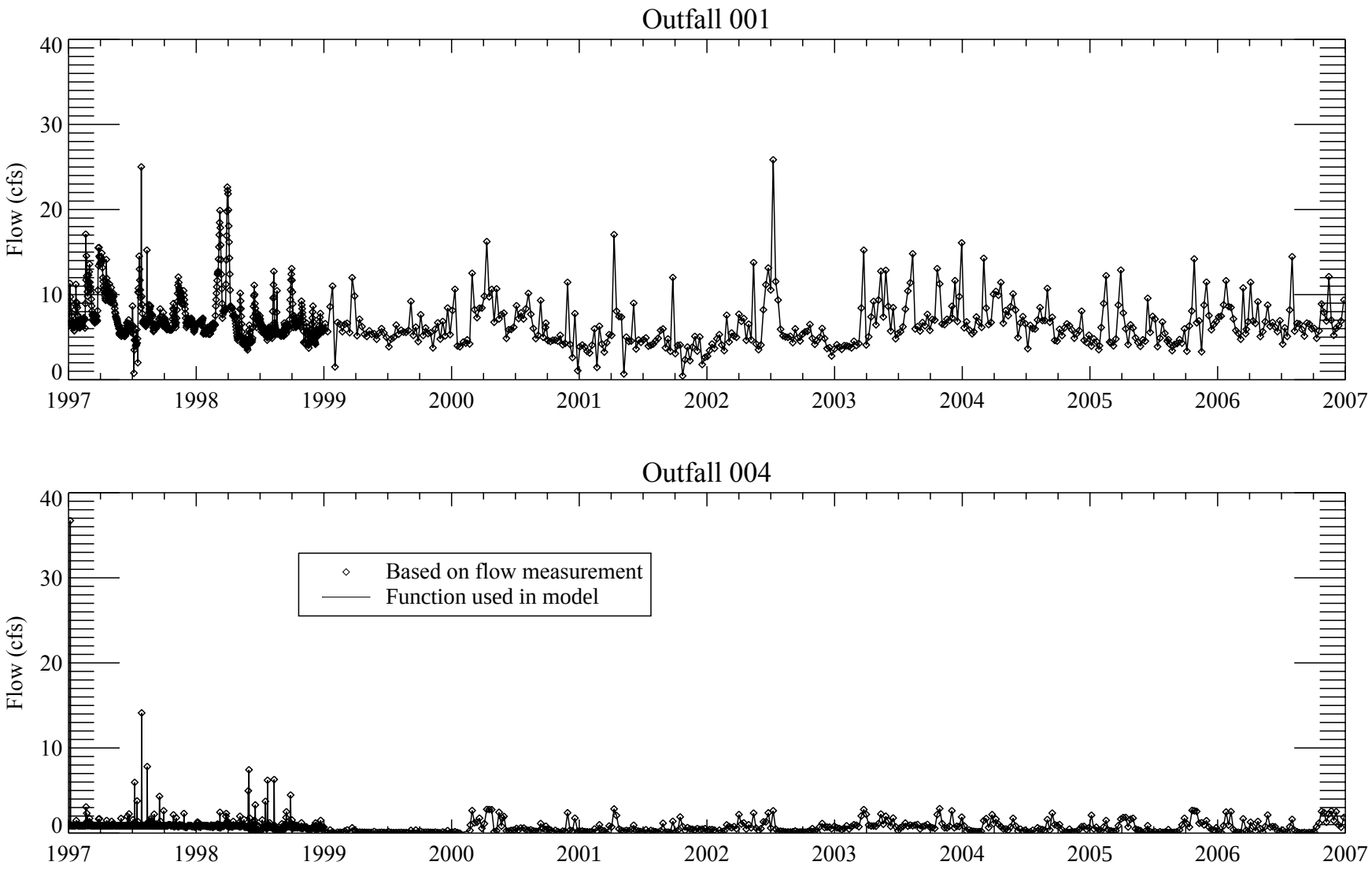

Figure A2-11a. Temporal flow profiles for Outfalls 001 and 004.

Data source: compilation of SPDES data, storm sampling data, and bypass data.

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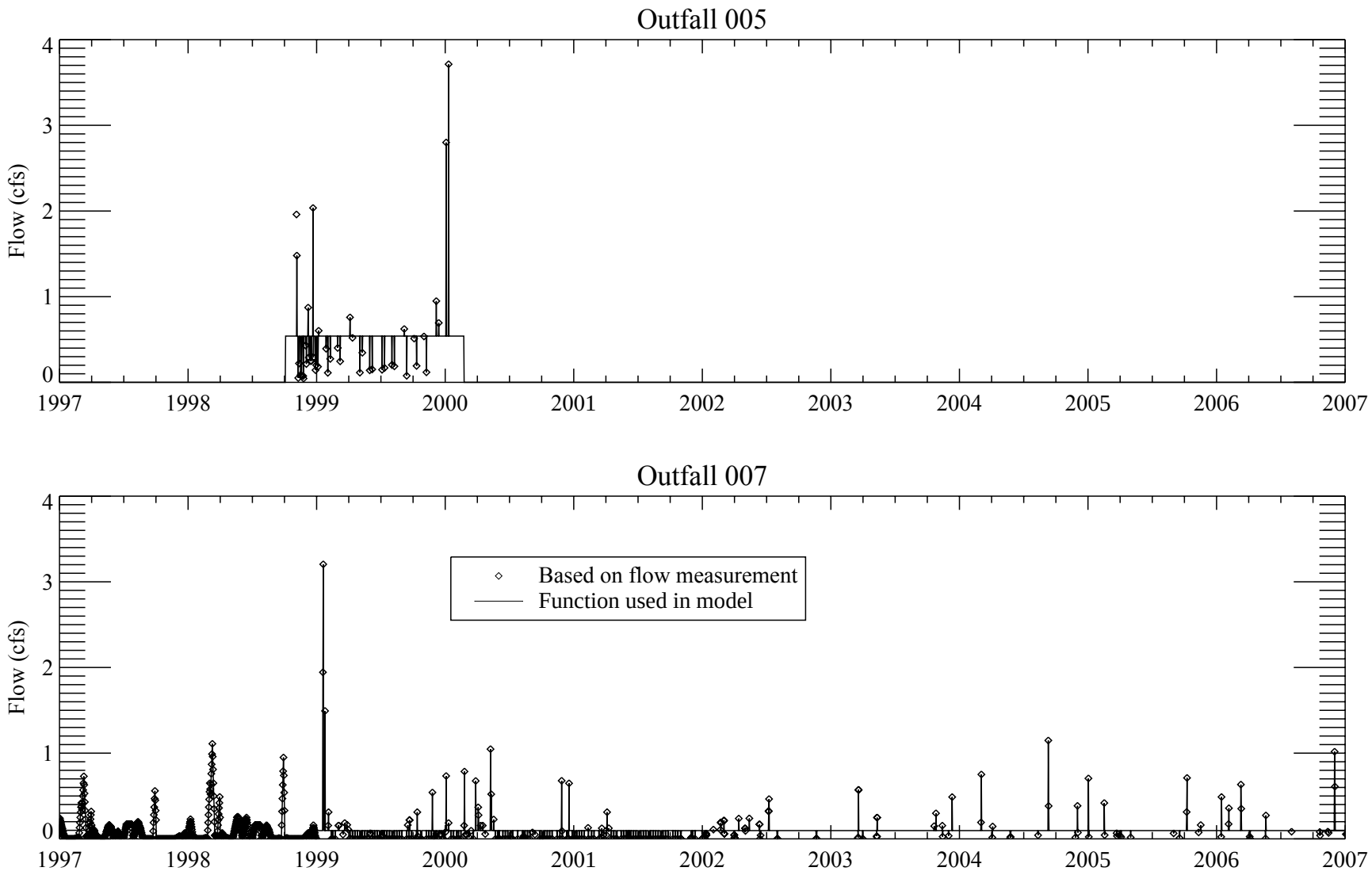

Figure A2-11b. Temporal flow profiles for Outfalls 005 and 007.

Data source: compilation of SPDES data, storm sampling data, and bypass data.

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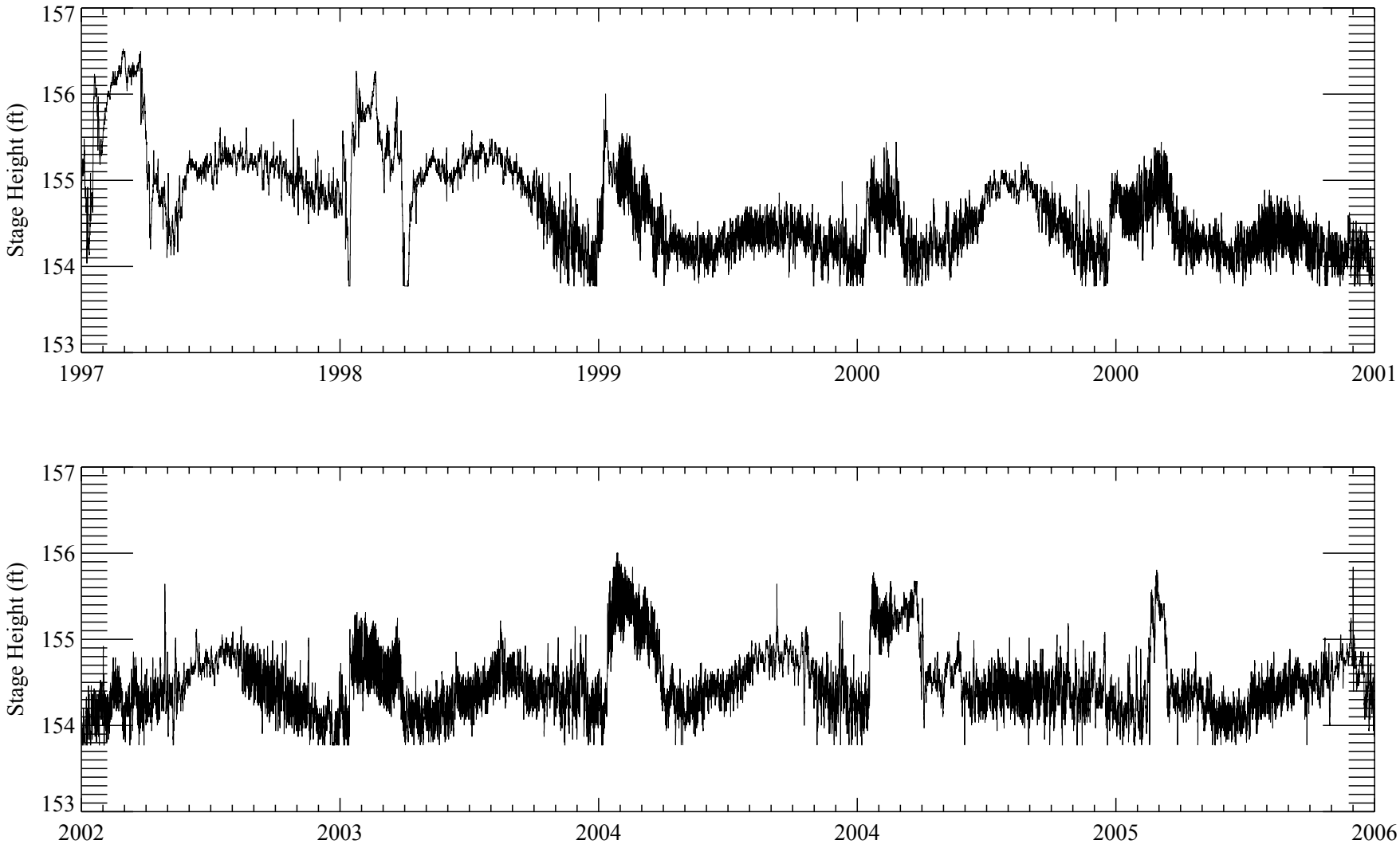
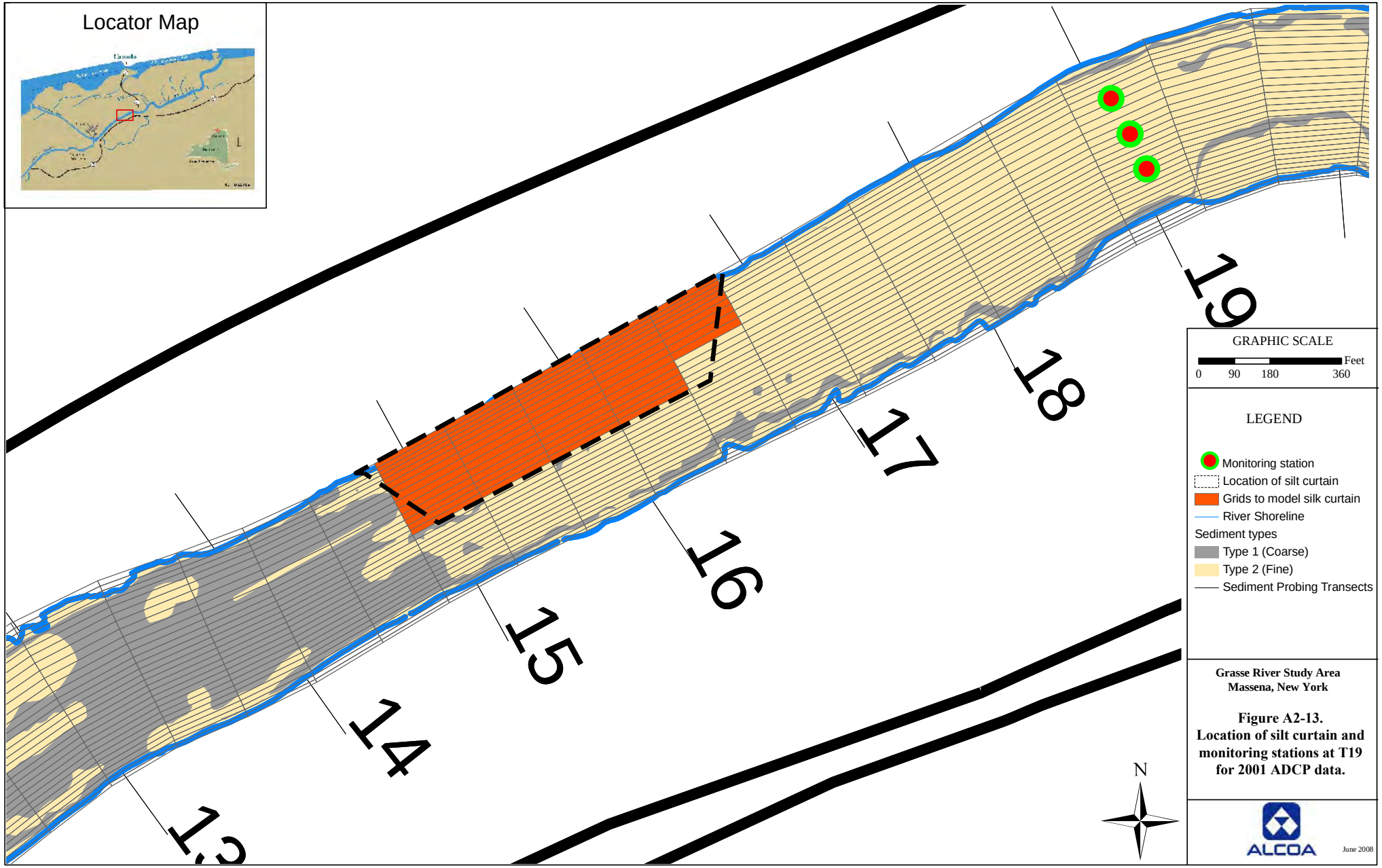


Figure A2-12. Stage height in the St. Lawrence River for 1997 through 2006.

Data source: Canadian Federal Department of Fisheries and Oceans. Datum = USLS 1935.



Grasse River Study Area
Massena, New York

Figure A2-13.
Location of silt curtain and monitoring stations at T19 for 2001 ADCP data.

BW/PMO-\\Peter\D_DRIVE\JOBS\ALC.gra\Model\EFDC\Sedtran\Calibration\Longterm\seq-2\GIS_map\98_flood_shift_coh\Model_results_silk_curtain.mxd

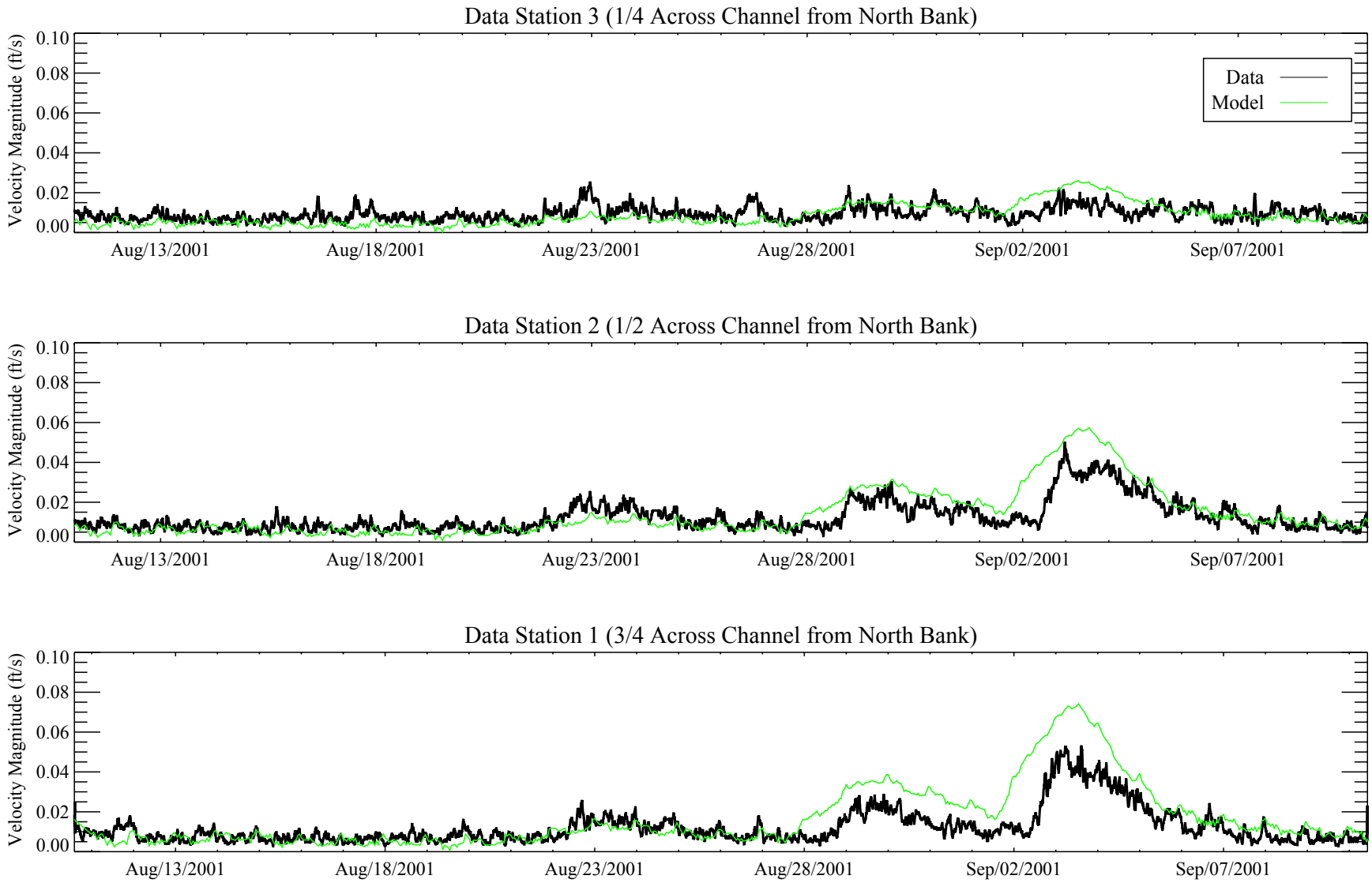


Figure A2-14. Comparison of observed and predicted velocity at T19 during 2001 ADCP survey.

Data source: Documentation Report - Grasse River Capping Pilot Study, April 2002.

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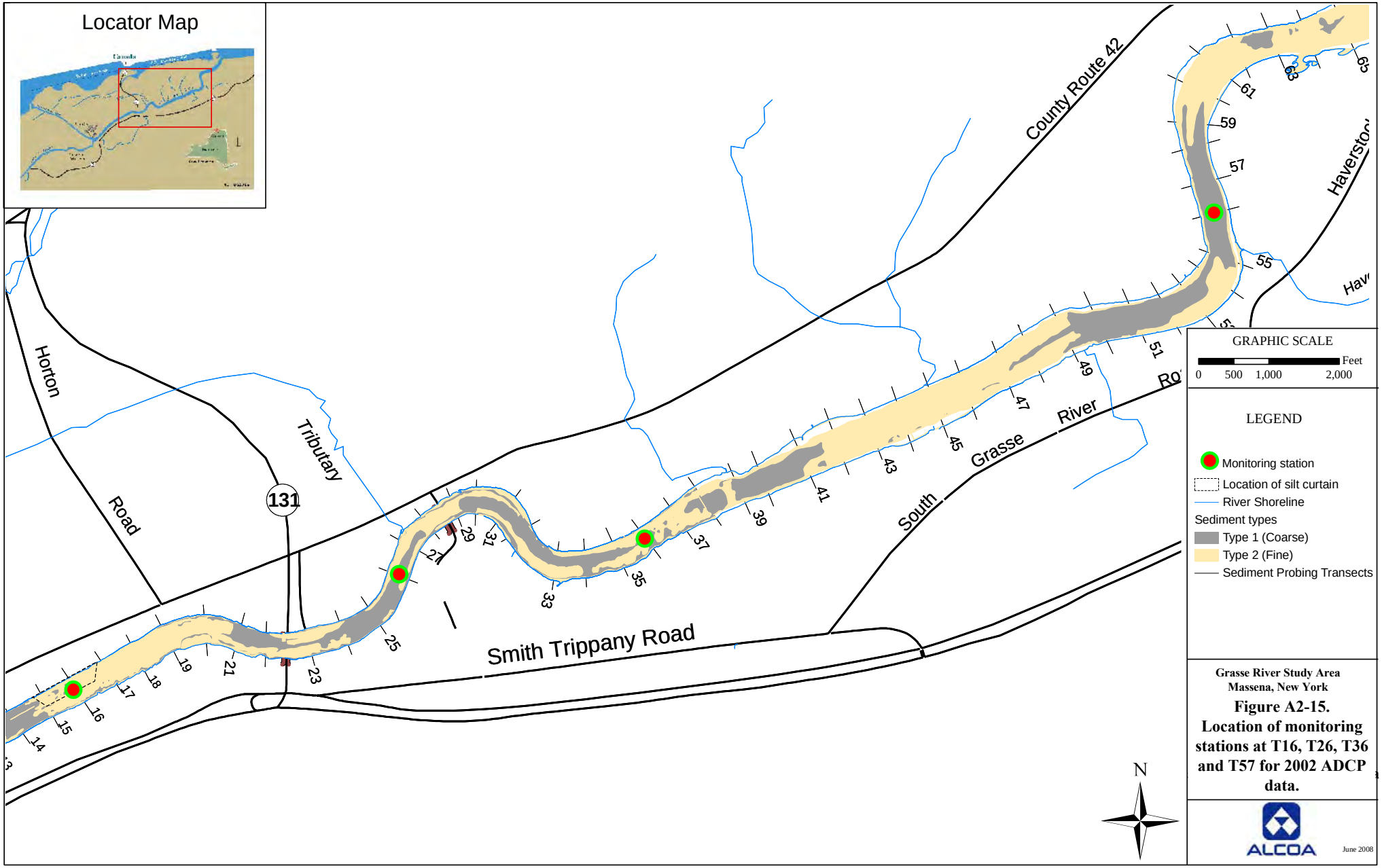


Grasse River Study Area
Massena, New York

Figure A2-15.
Location of monitoring stations at T16, T26, T36 and T57 for 2002 ADCP data.

BW/PMO-\\Peter\D_DRIVE\JOBS\ALC.gra\Model\EFDC\Sedtran\Calibration\Longterm\seq-2\GIS_map\98_flood_shift_coh\Model_results_silk_curtain.mxd

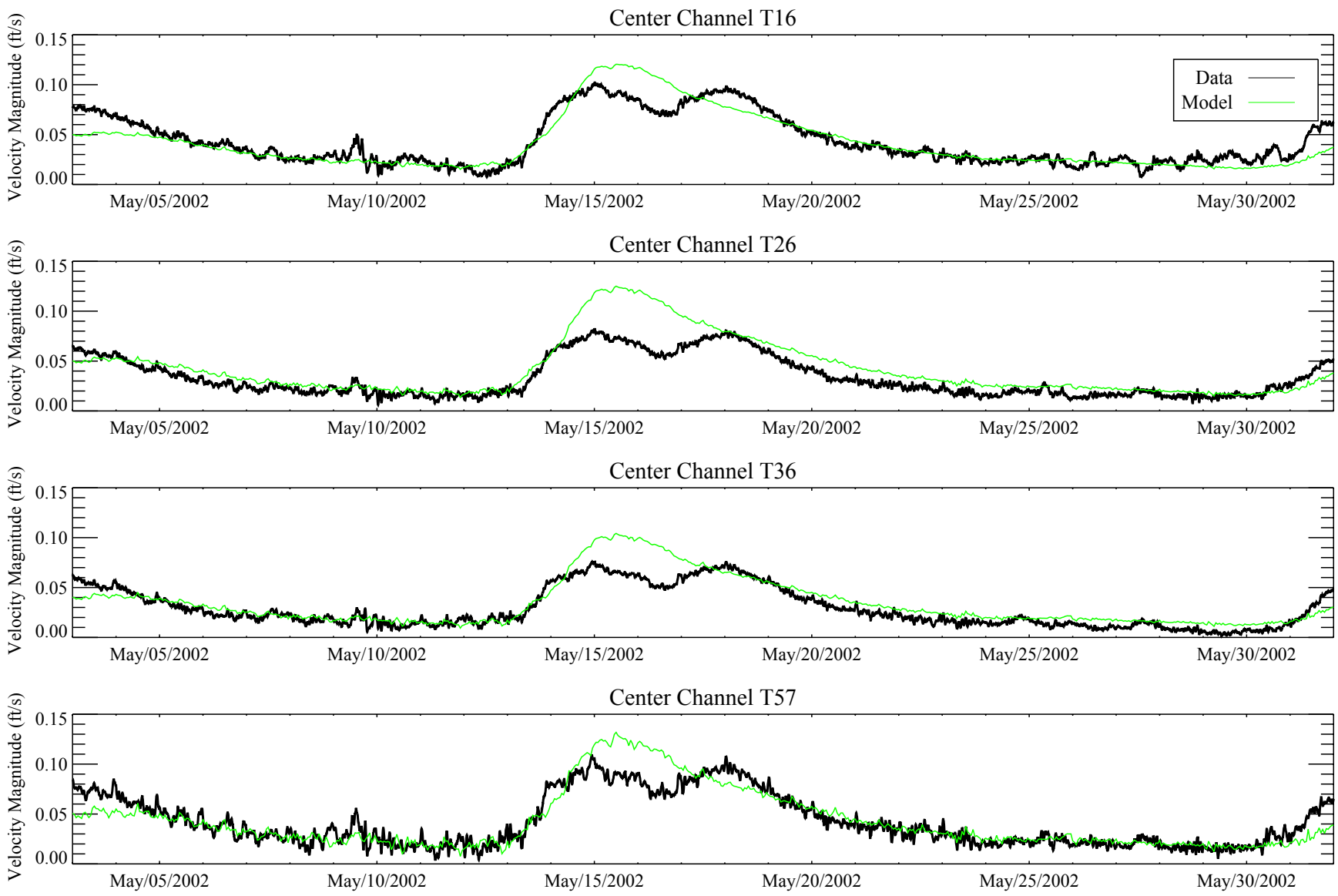


Figure A2-16. Comparison of observed and predicted velocity during 2002 ADCP survey.

Data source: 2002 Capping Pilot Study Monitoring Program Summary Report, September 2003.

PMO - D:\JOBS\ALCgra\Model\Calibration_to_Velocity_Data\Centerline\velocity_data\dt_plots.pro
Fri Oct 17 14:23:56 2008

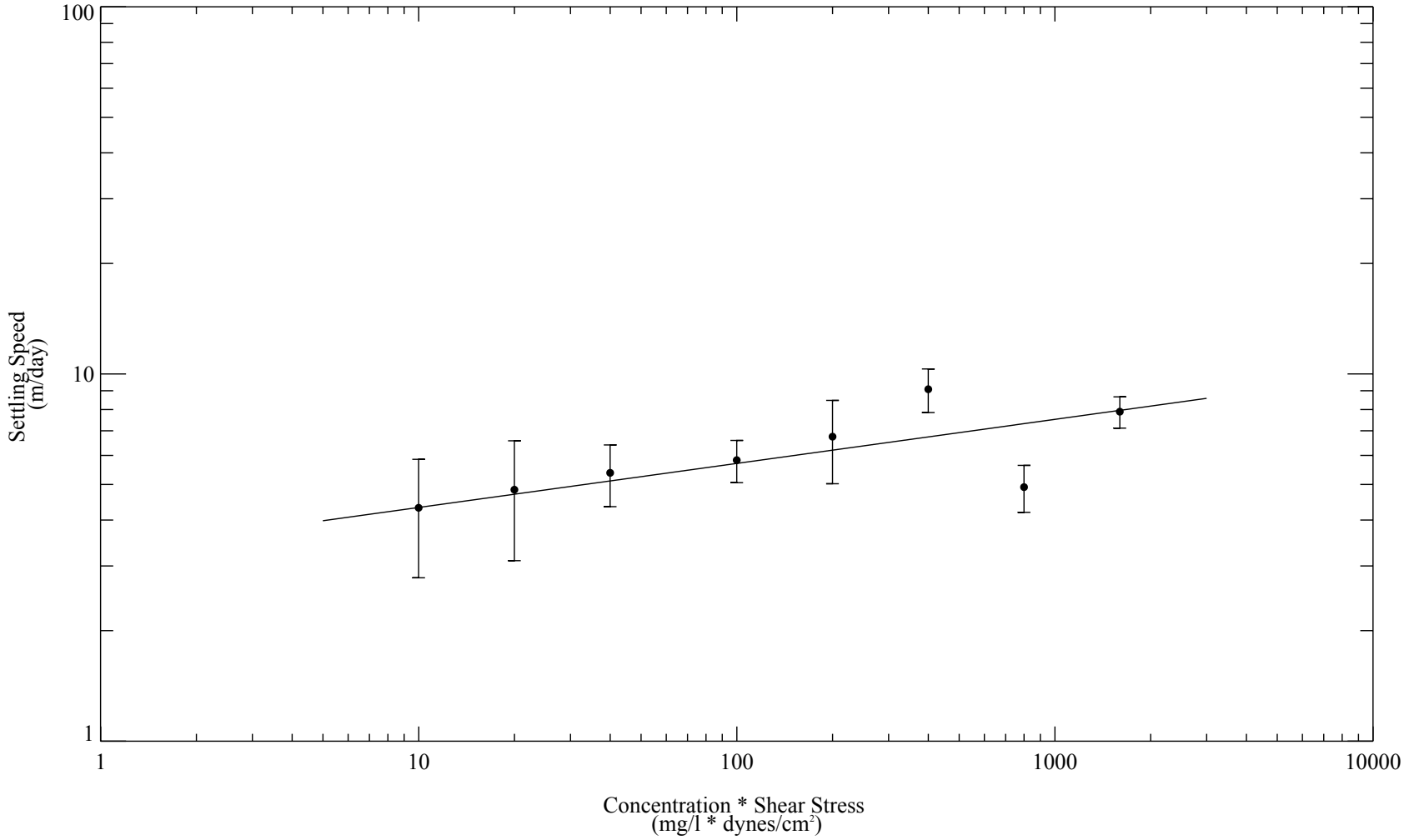


Figure A3-1. Settling speed function for cohesive (class 1) sediments (solid line) and floc settling speed data (mean +/- 95% confidence interval, Burban et al., 1990) used to construct function.

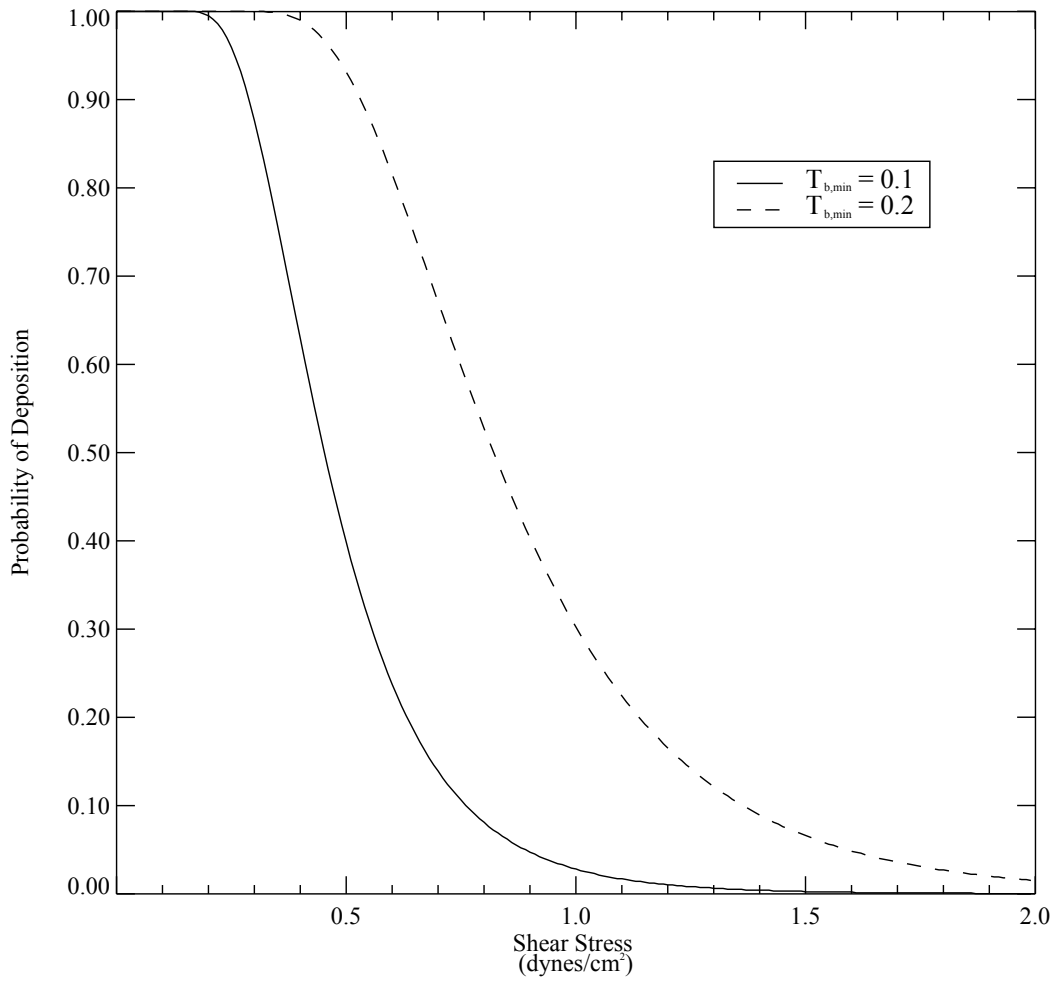


Figure A3-2. Probability of deposition function for cohesive (class 1) sediments.
$T_{b,min}$ has units of dynes/cm^2.

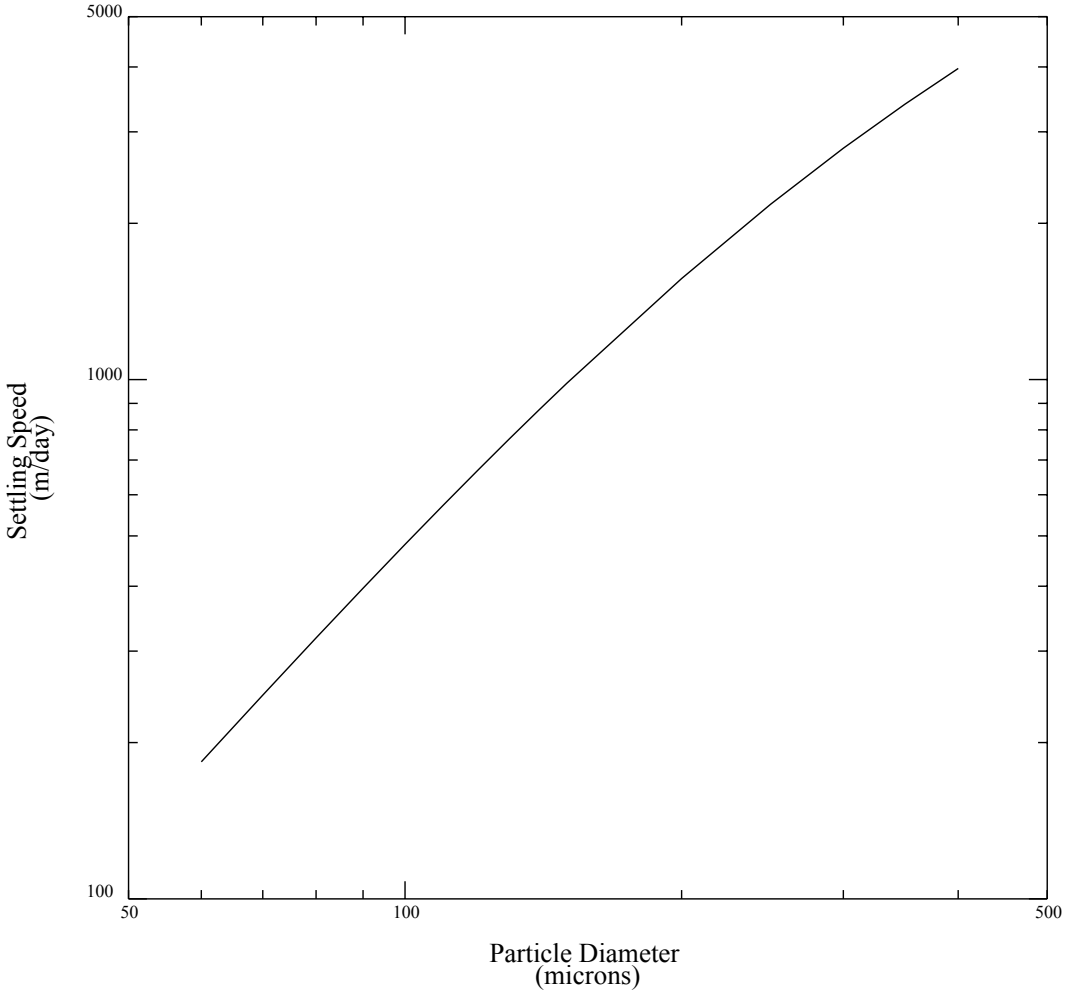
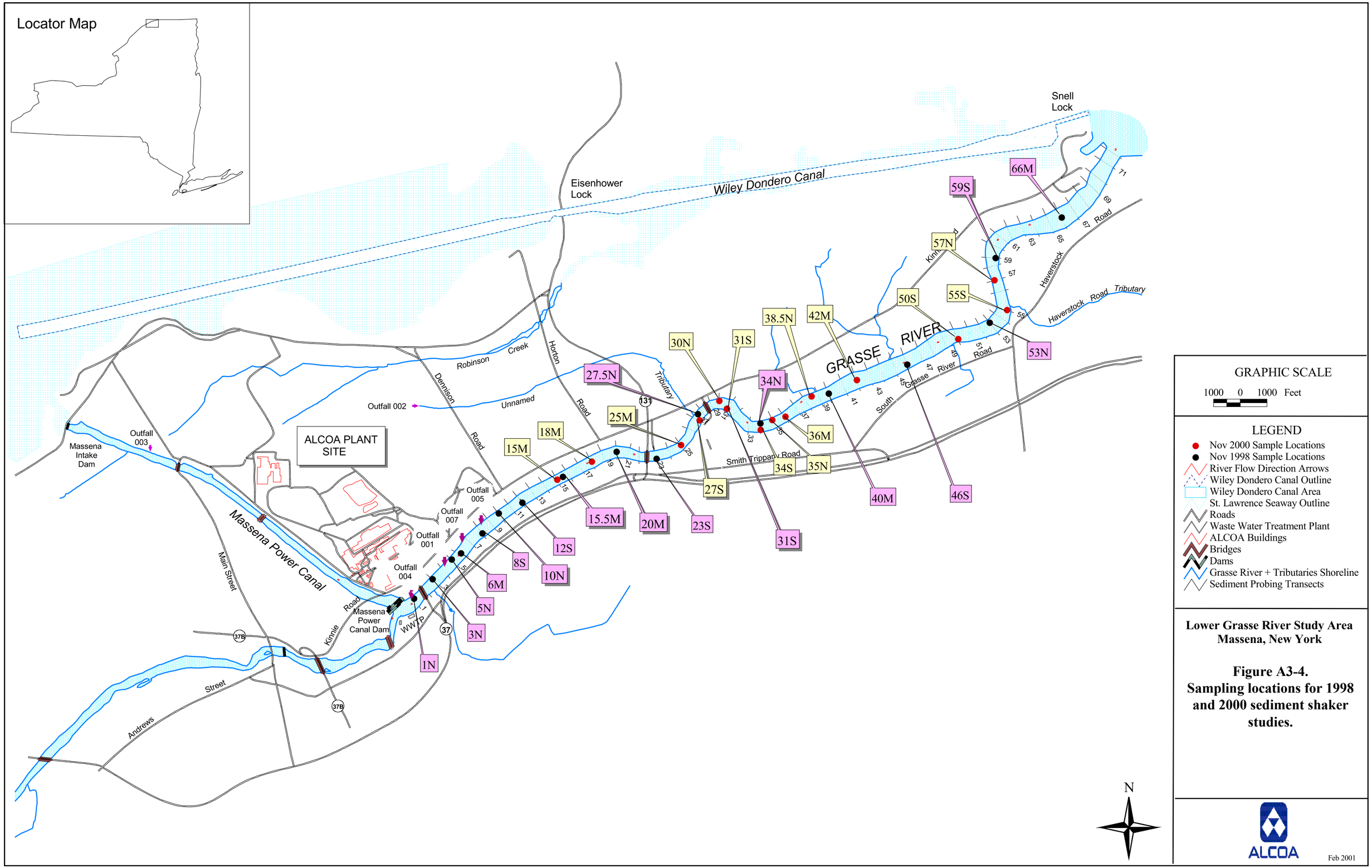


Figure A3-3. Settling speed of sand particles (class 2) as a function of particle diameter (Cheng, 1997).



Lower Grasse River Study Area
Massena, New York

Figure A3-4.
Sampling locations for 1998 and 2000 sediment shaker studies.

DN - \\Daleel\D_DRIVE\ALCgra\GIS\GIS_fig_C1_1\shaker_study.apr

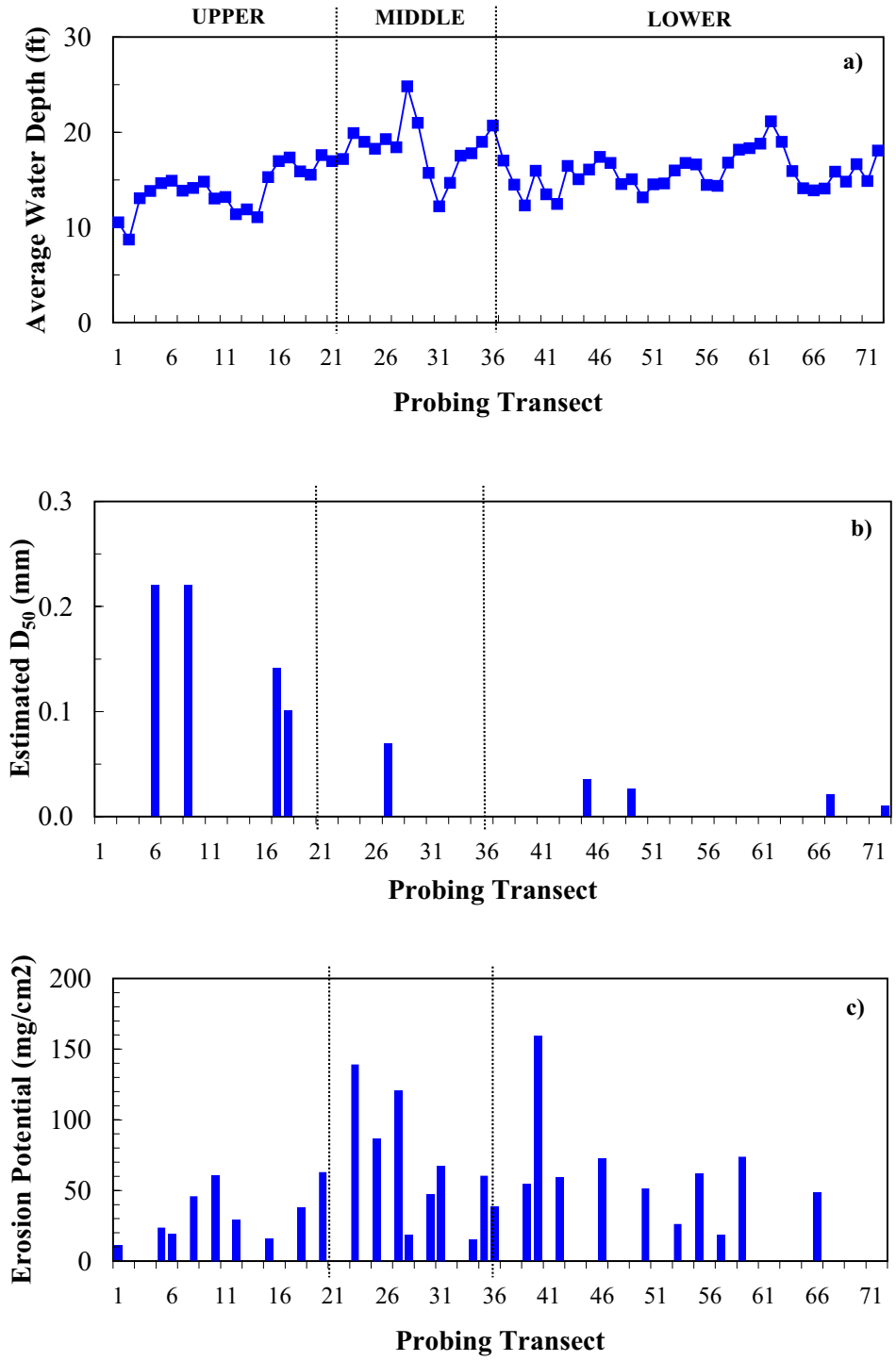


Figure A3-5. Water depth, median particle size and erosion potential data collected throughout the lower Grasse River.

Average water depths estimated from sediment probing data collected in 1992.
D50 values estimated from grain size distribution data collected during RSI Phase I (1991).
Average erosion potential functions computed using erosion study data collected in 1998 and 2000.

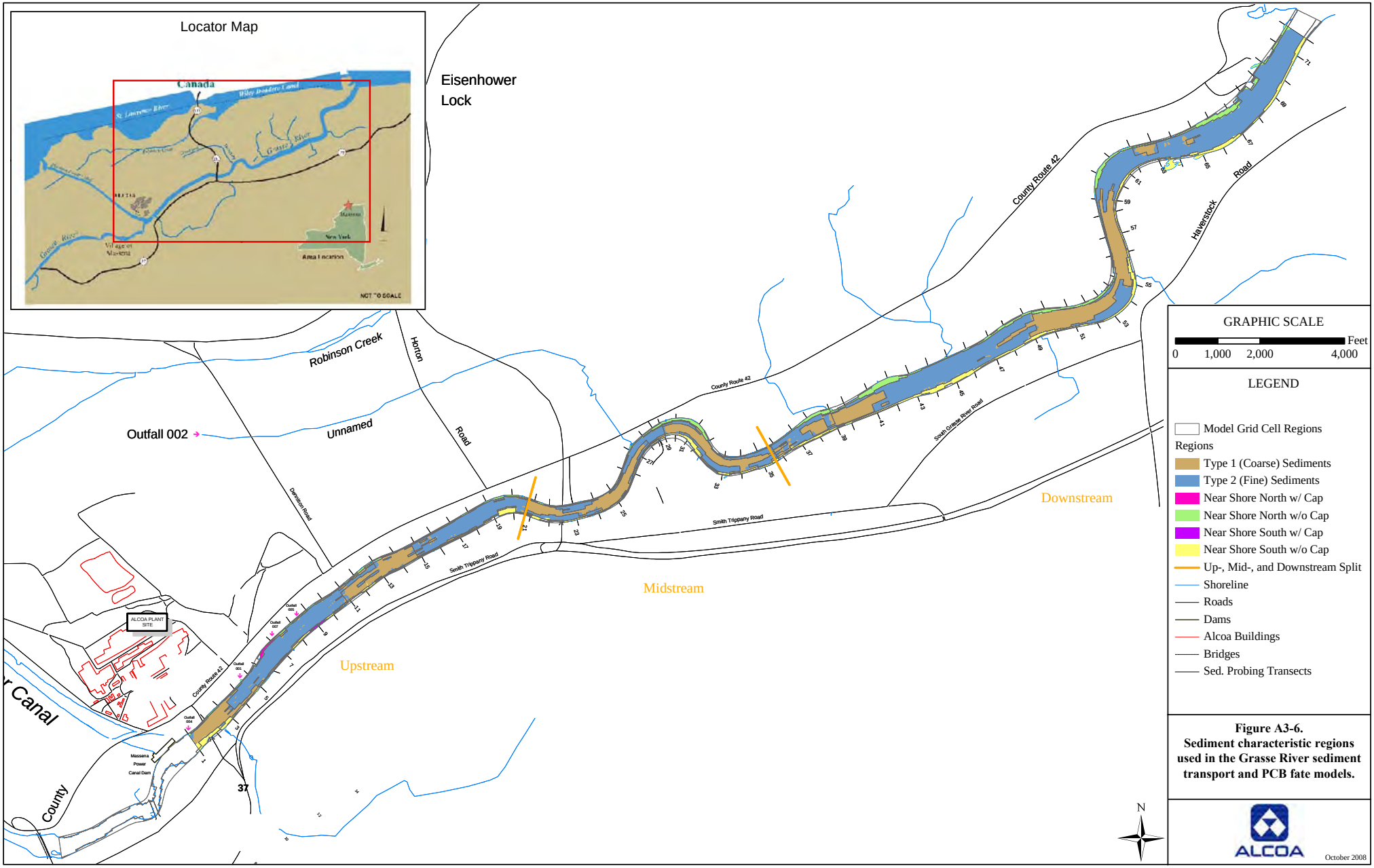


Figure A3-6.
Sediment characteristic regions used in the Grasse River sediment transport and PCB fate models.

SJRH - \\Zeus\d_drive\ALCgra\Analysis\Sediment\Sediment_Characterization\GIS\From_AST_20080625\Model_grid_map_20080903.mxd

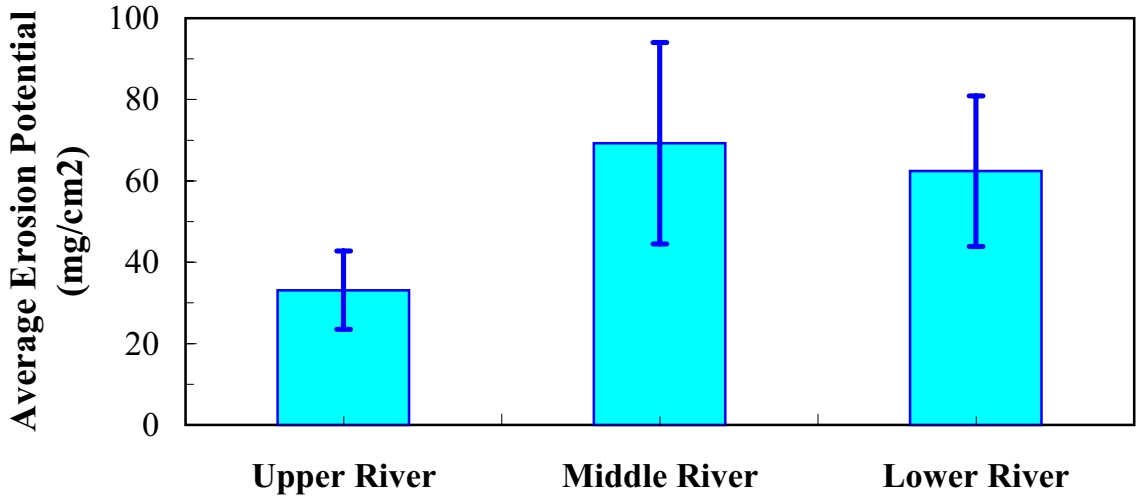


Figure A3-7. Comparison of average erosion potential of sediments in the upper, middle, and lower stretches of the Grasse River.

Averages computed using erosion potential estimates (9 dynes/cm^2) for cores collected within each sampling region. Eight cores excluded due to anomalous associated TSS concentrations.
Upper River represents Transects T1 through T21.
Middle River represents Transects T21 through T36.
Lower River represents Transects T36 through T72.

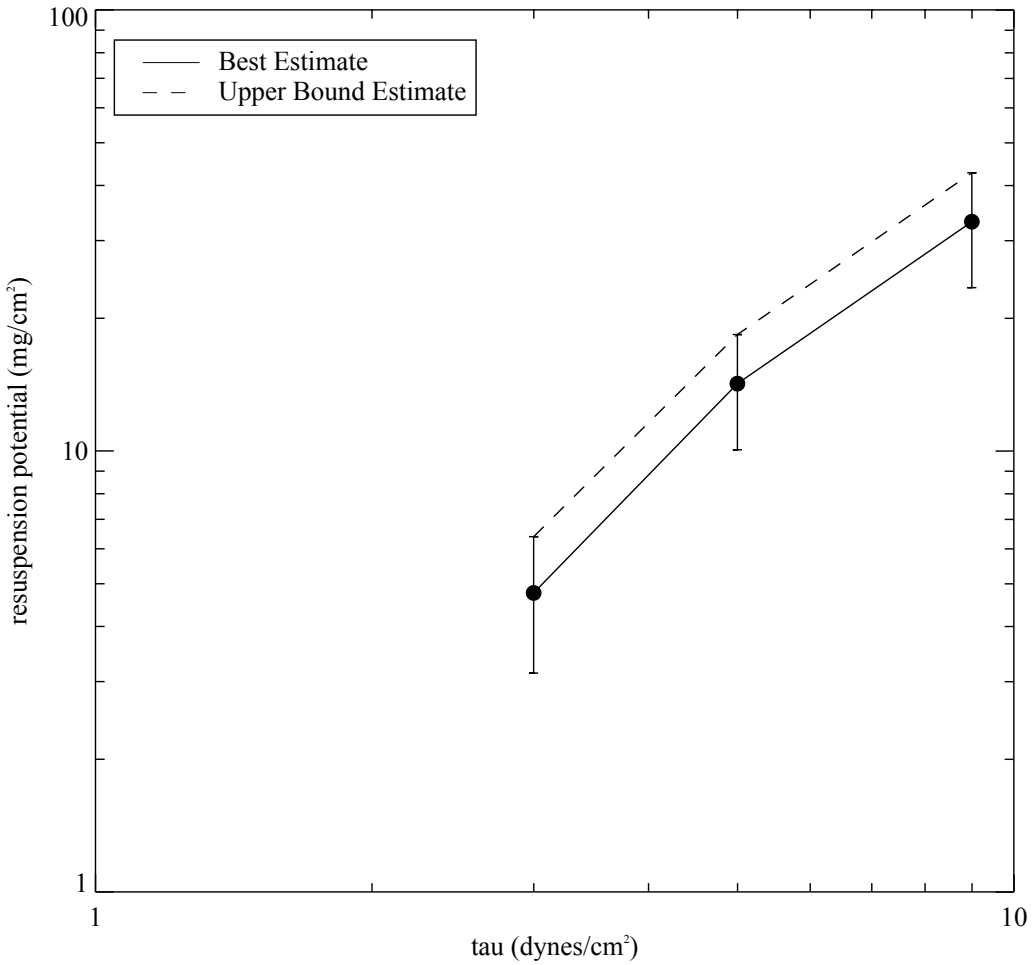


Figure A3-8. Resuspension potential versus shear stress: T1-T21.

Grasse River sediment probing transects T1-T21

Best Estimate: through means; Upper Bound Estimate: through means + 2 stderrs

Resuspension potential computed using shaker study data collected in 1998 and 2000.

EC - D:\ALCgra\Analysis\Sediment\shaker_study\reanalysis_3parts_river\shaker9800_alldata_e_vs_tau_minus_one.pro
Thu Jan 03 12:35:44 2008

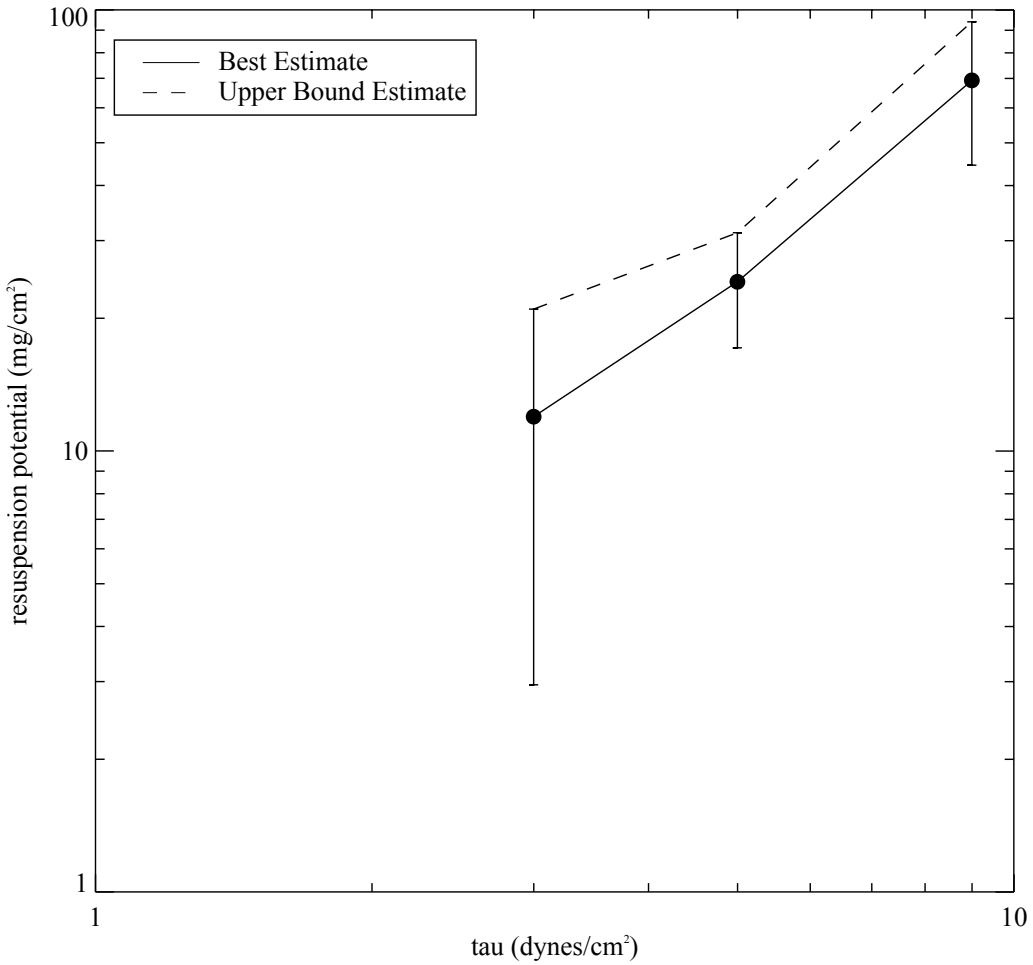


Figure A3-9. Resuspension potential versus shear stress: T21-T36.

Grasse River sediment probing transects T21-T36

Best Estimate: through means; Upper Bound Estimate: through means + 2 stderrs

Resuspension potential computed using shaker study data collected in 1998 and 2000.

EC - D:\ALCgra\Analysis\Sediment\shaker_study\reanalysis_3parts_river\shaker9800_alldata_e_vs_tau_minus_one.pro
Thu Jan 03 12:35:38 2008

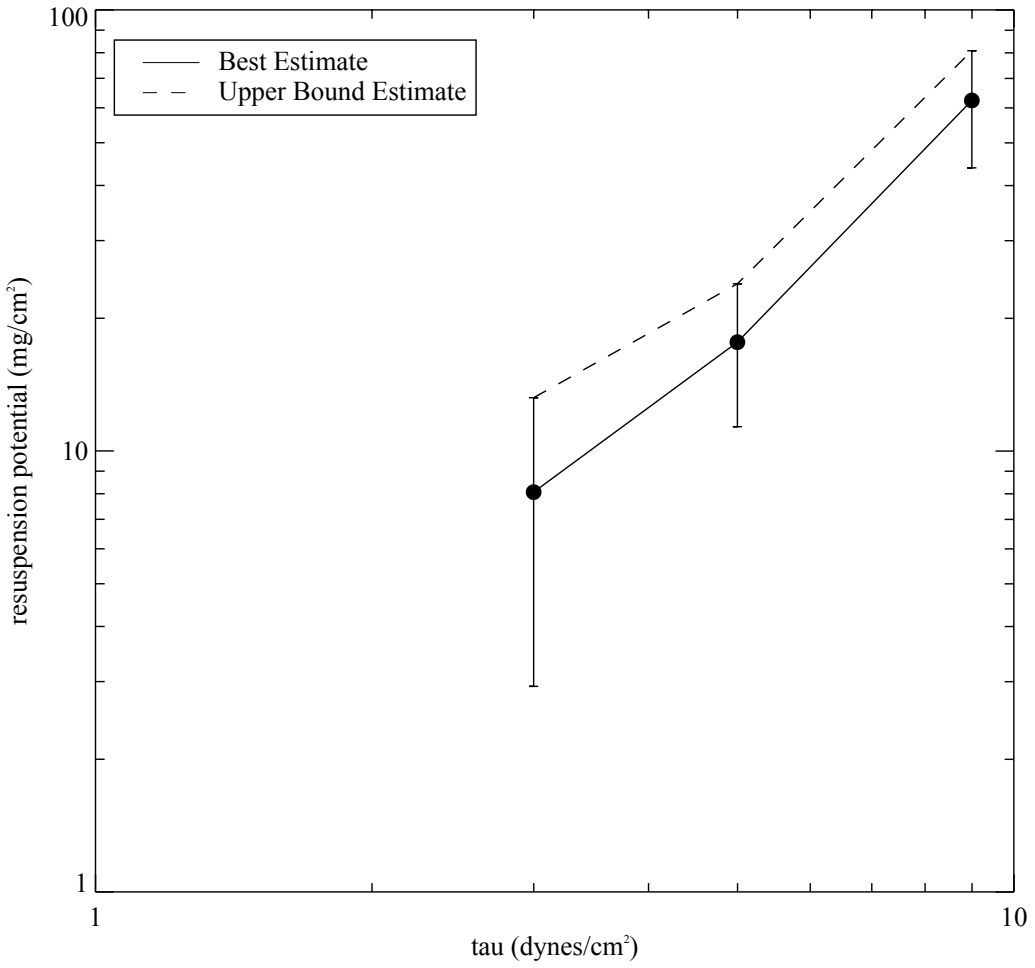


Figure A3-10. Resuspension potential versus shear stress: T36-T72.

Grasse River sediment probing transects T36-T72

Best Estimate: through means; Upper Bound Estimate: through means + 2 stderrs

Resuspension potential computed using shaker study data collected in 1998 and 2000.

EC - D:\ALCgra\Analysis\Sediment\shaker_study\reanalysis_3parts_river\shaker9800_alldata_e_vs_tau_minus_one.pro
Thu Jan 03 12:35:33 2008

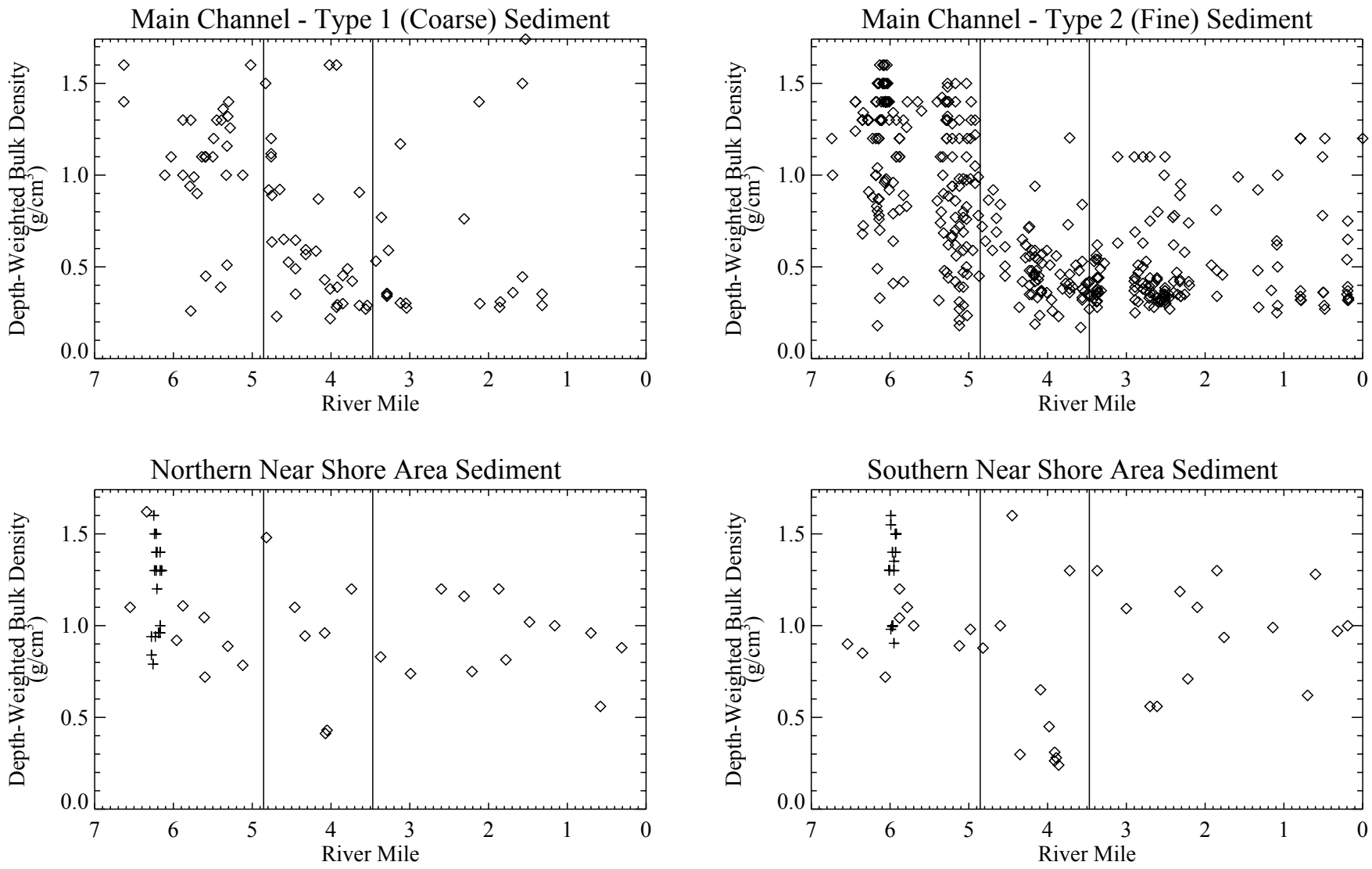


Figure A3-11. Depth-weighted bulk density vs. river mile.

Maximum depth is 5.0 cm.
Main channel: top row; Near shore areas: bottom row, plus-symbols represent locations in near shore capped areas.

RN/AST - D:\Jobs\ALCgra\Documents\2008_modeling_appendix\Figures\from_Raghav\bd_river_mile_plot.pro
Tue Oct 21 15:41:50 2008

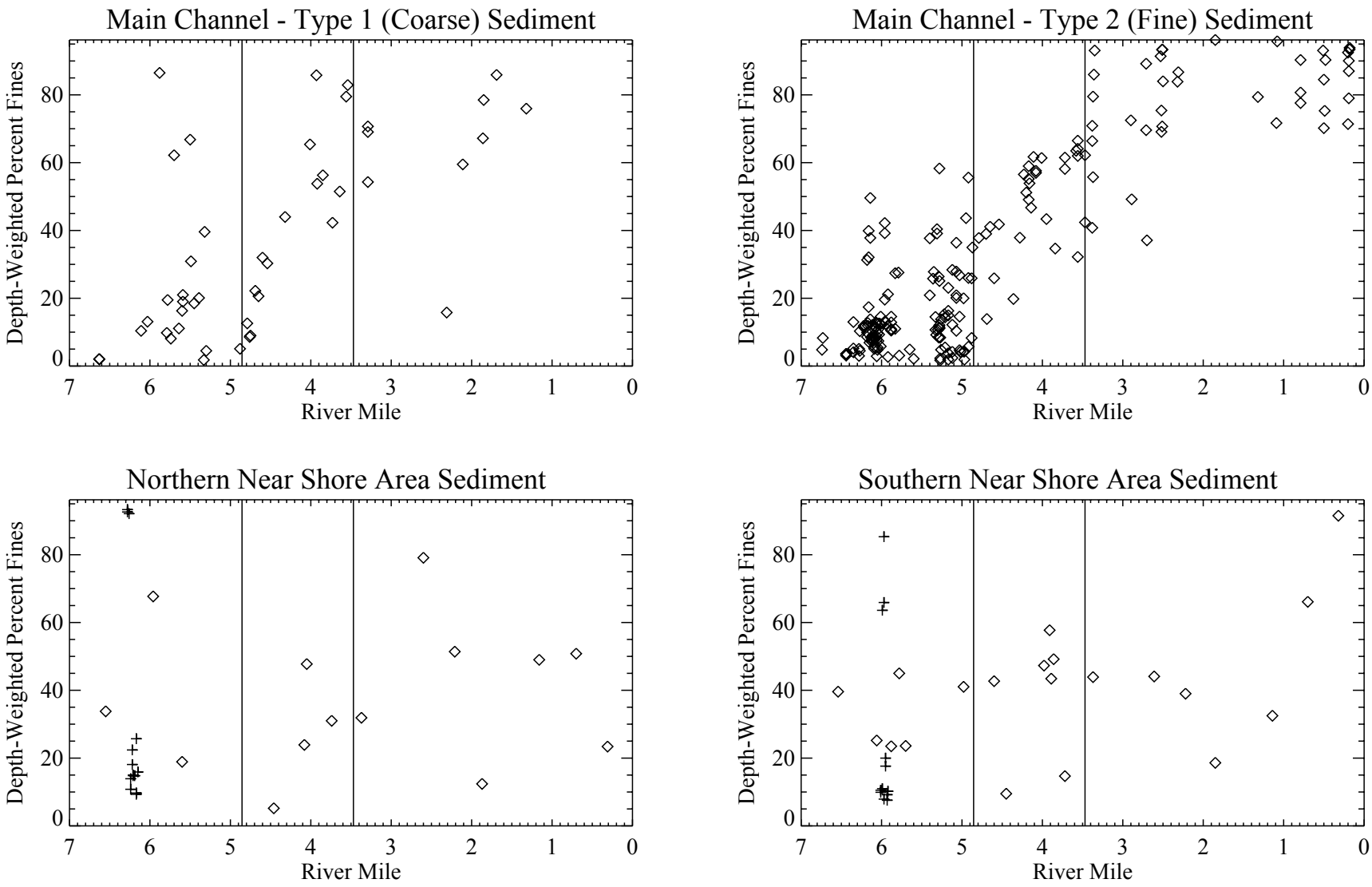
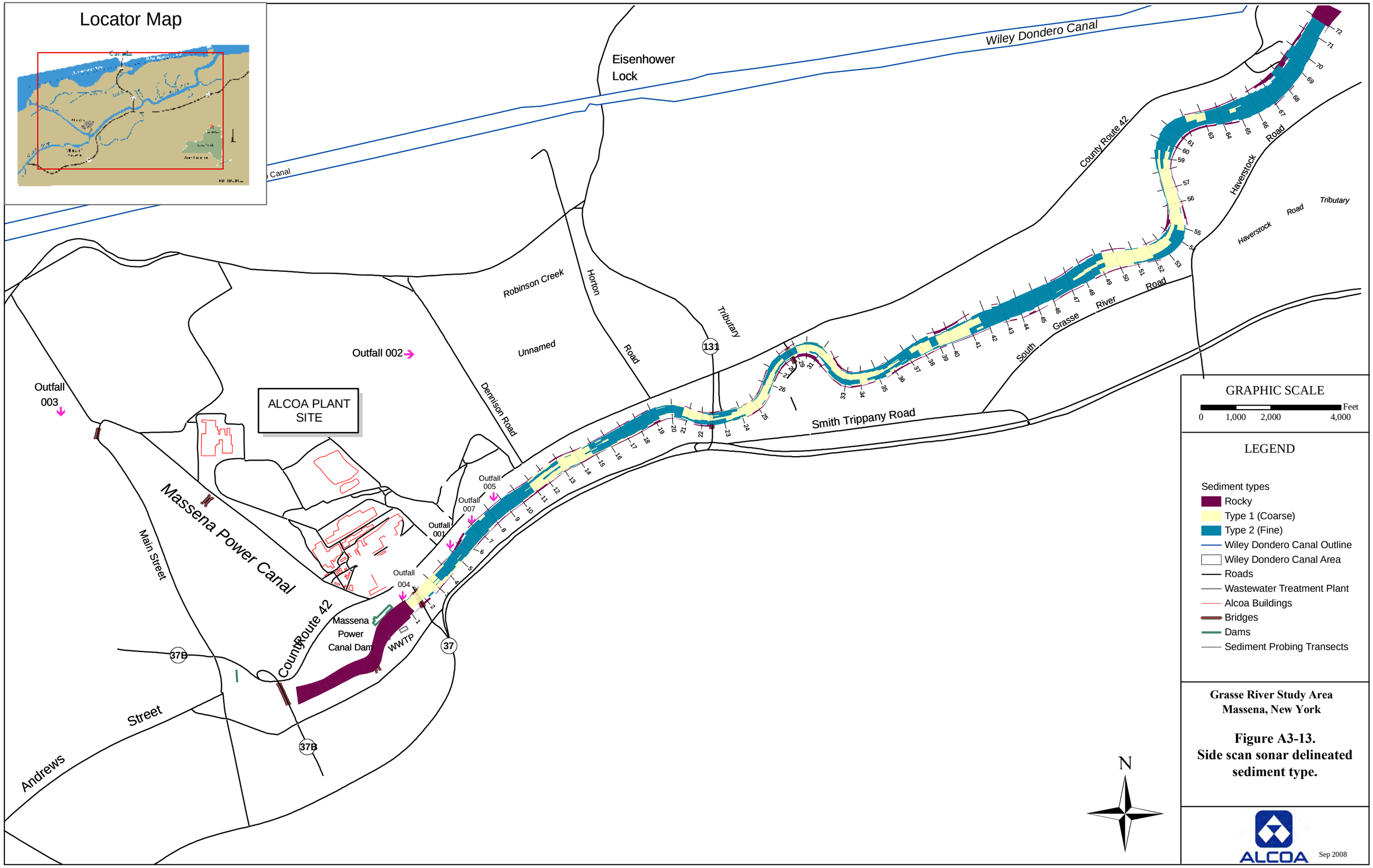


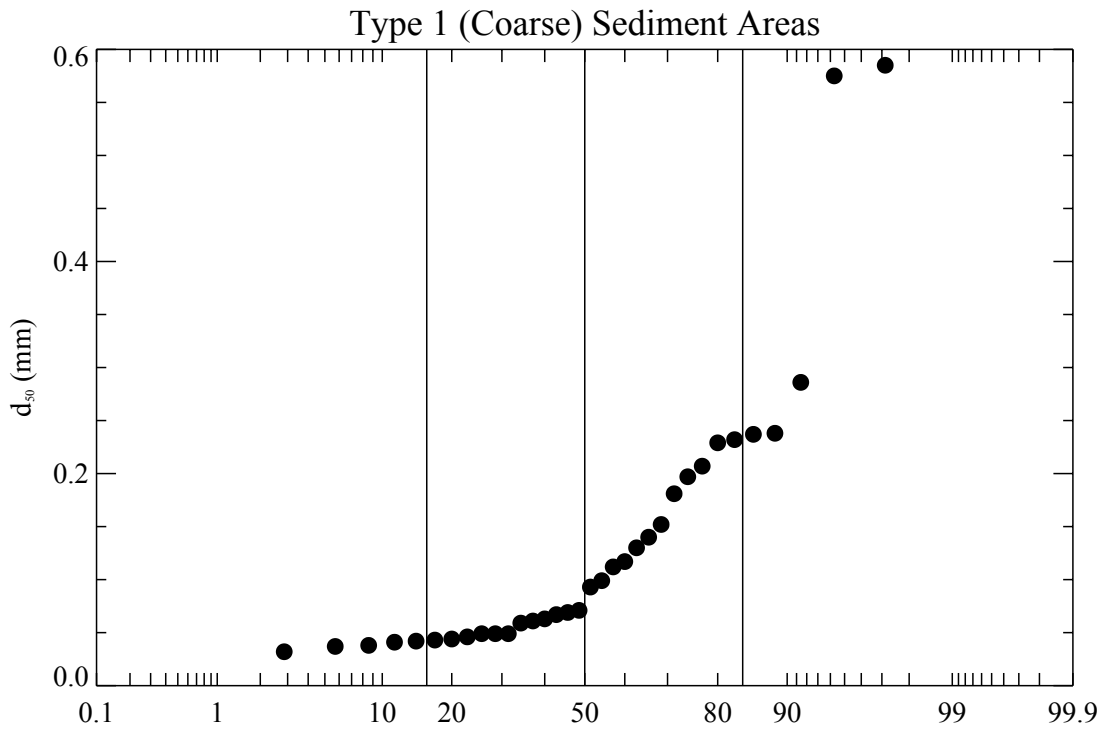
Figure A3-12. Depth-weighted percent fines vs. river mile.

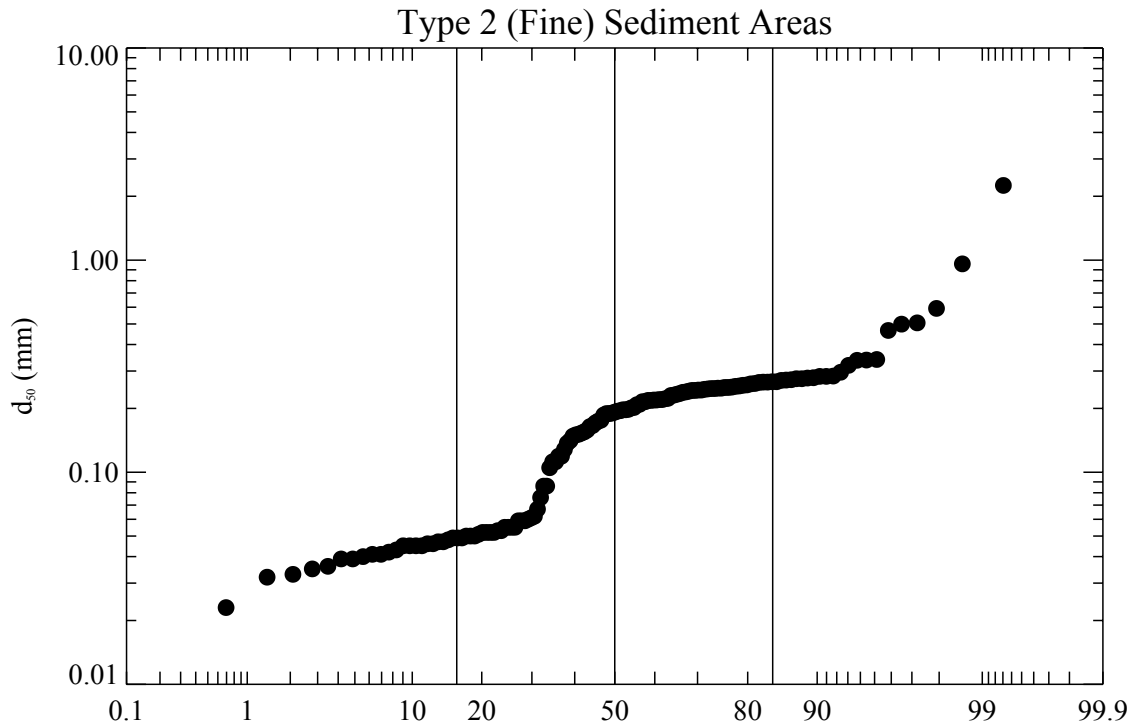
Percent fines is percent passing through 75 micron sieve. Maximum depth is 5.0 cm.
Main channel: top row; Near shore areas: bottom row, plus-symbols represent locations in near shore capped areas.

RN/AST - D:\Jobs\ALCgra\Documents\2008_modeling_appendix\Figures\from_Raghav\gs_river_mile_plot.pro
Tue Oct 21 15:42:07 2008



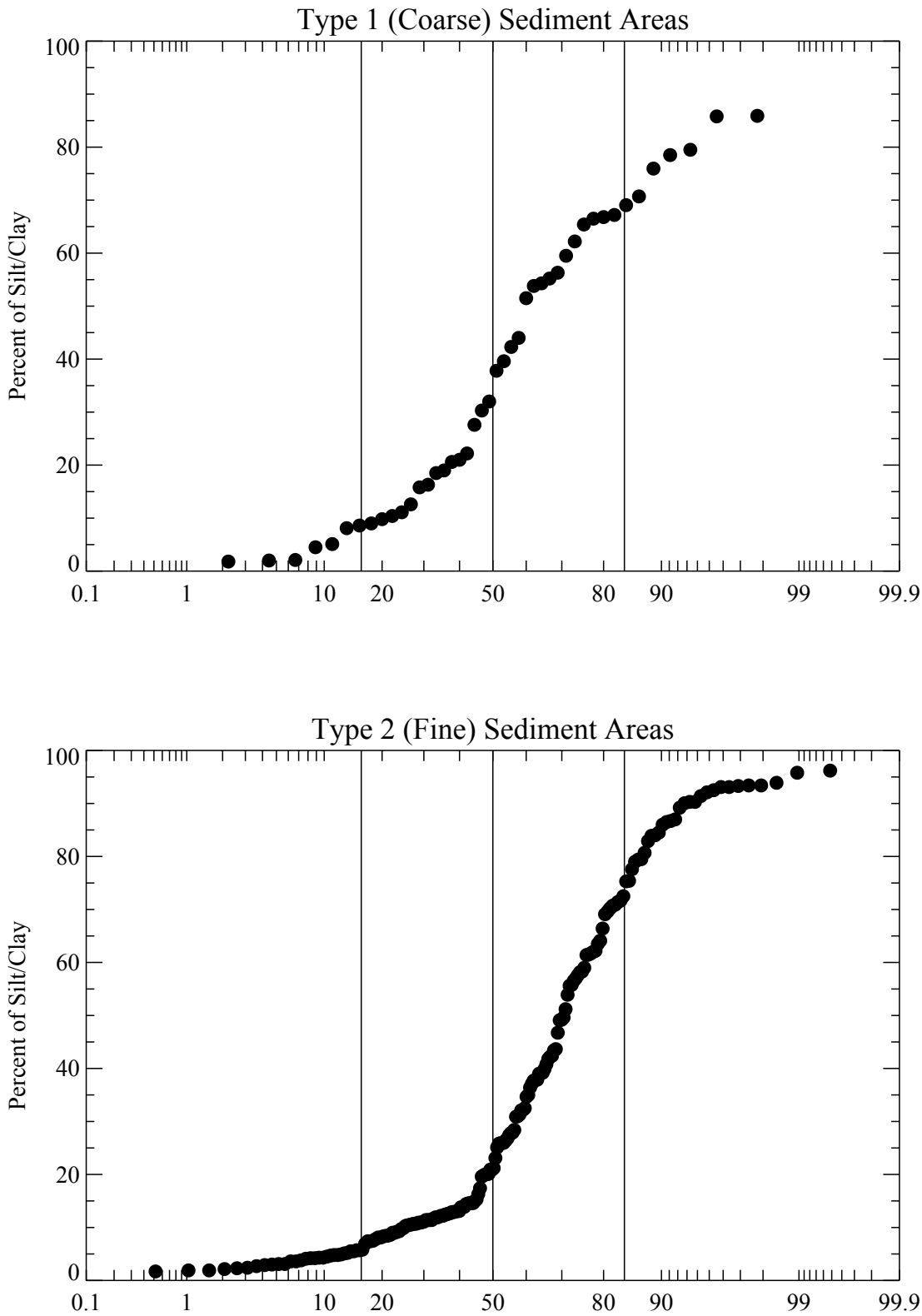
BW/PMO-\\ern\D_DRIVE\ALCgra\Document\AA Report\Figures\ALCgra_Model_results_BW1020.mxd





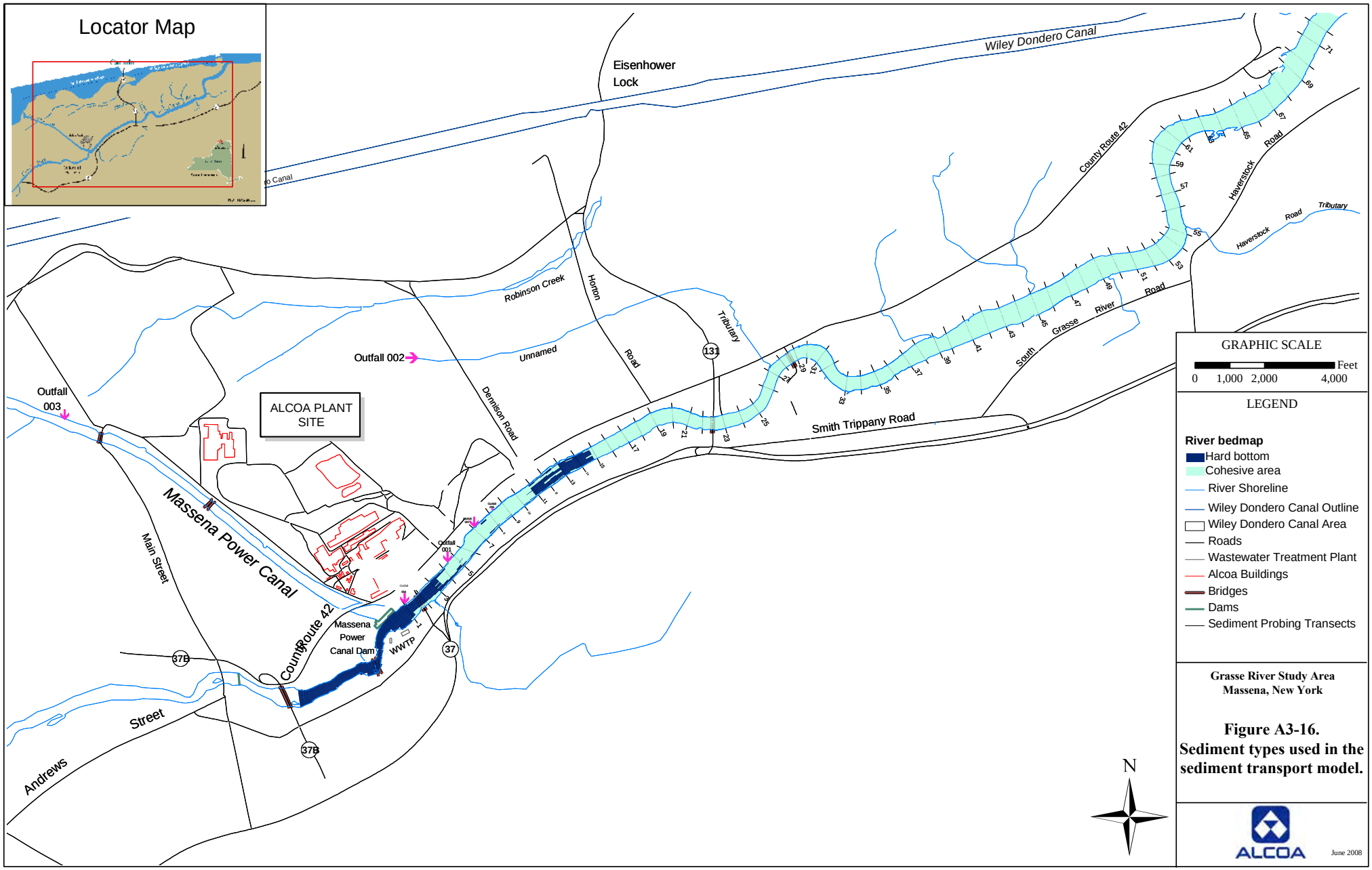
FigureA3-14. Distribution of the median particle diameter (d_{50}) in the top 3-inches of Type 1 (coarse) and Type 2 (fine) sediment areas.

PM - D:\ALCgra\Model\SEDTRAN\Inputs\Grain_size_fractions\fine_coarse_d50.pro
Fri Oct 17 13:30:47 2008



FigureA3-15. Distribution of the percentage of silt/clay in the top 3-inches Type 1 (coarse) and Type 2 (fine) sediment areas.

Silt/clay are defined as the sediments that pass through a 75μm sieve.



Grasse River Study Area
Massena, New York

Figure A3-16.
Sediment types used in the sediment transport model.

BW/PMO-\\Peter\D_DRIVE\JOBS\ALCgra\Model\EFDC\Sedtran\Calibration\Longterm\seq-2\GIS_map\98_flood_shift_coh\ALCgra_Model_results_analysis3.mxd

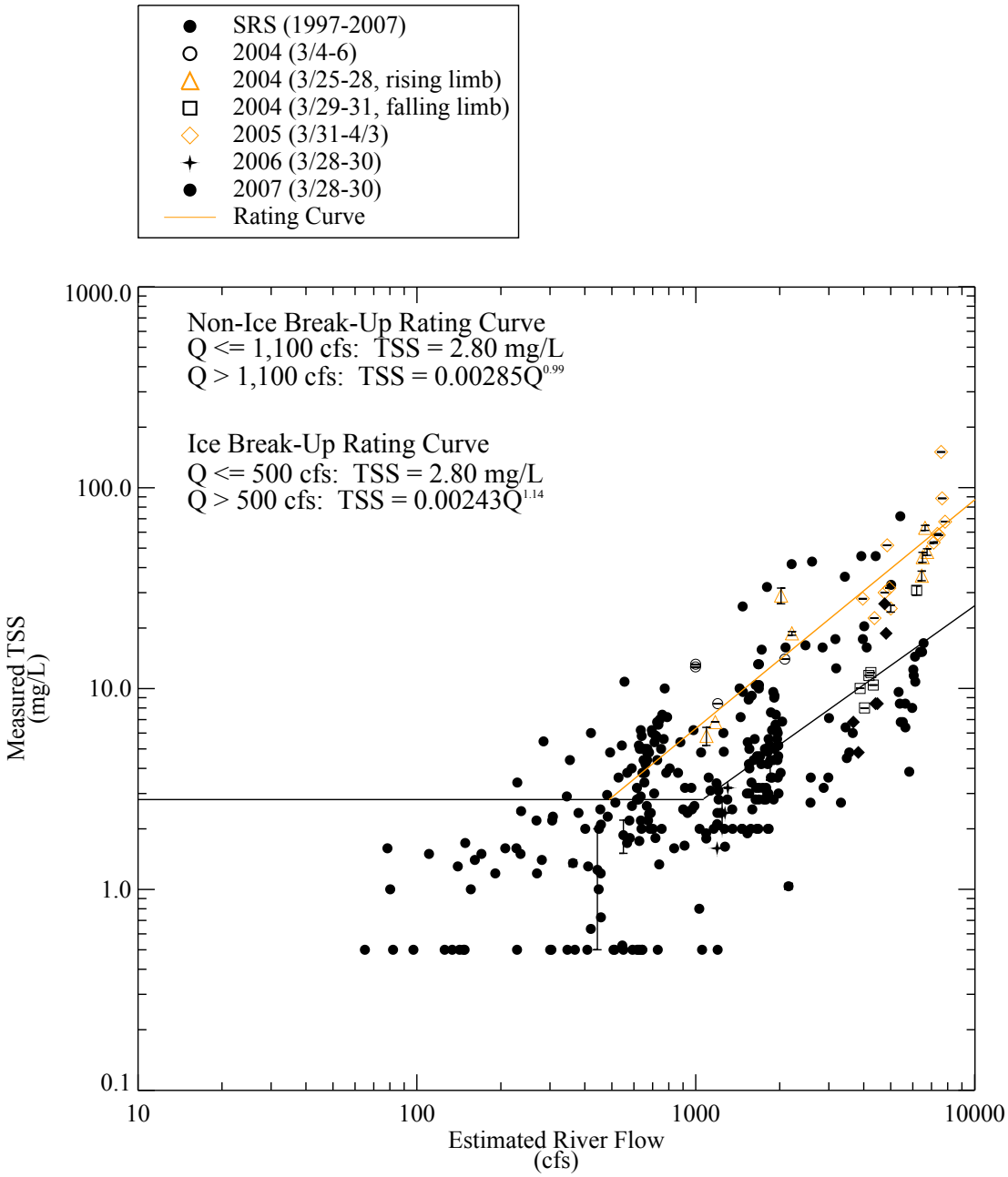


Figure A3-17. Solids concentrations measured at the Main Street Bridge as a function of river flow.

Error bars represent range in data.

Data tables: riverflow_hist, riverflow_tape, riverflow_trans, riverflow_ChaseMills, water_field.

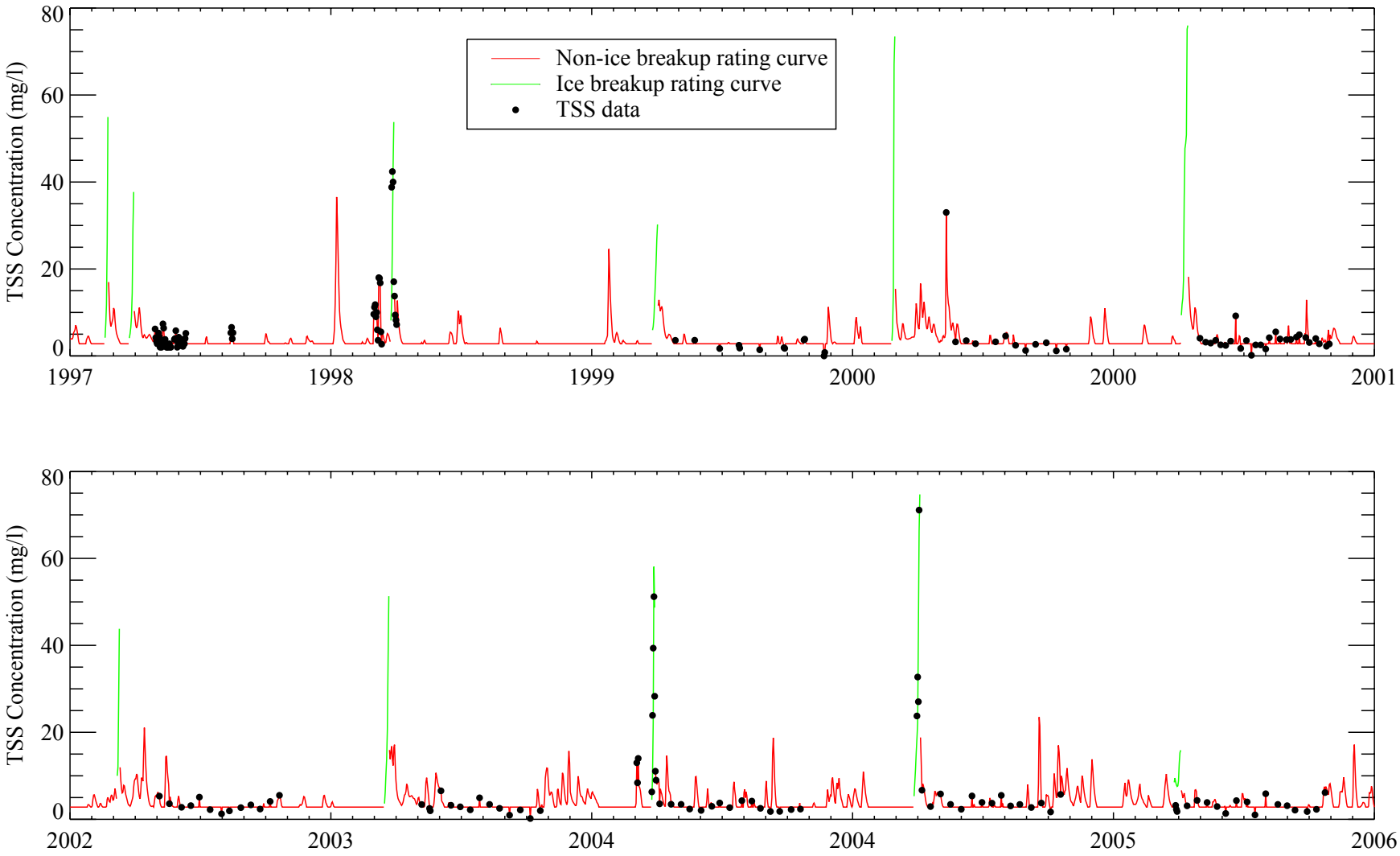


Figure A3-18. Estimated TSS profiles in the Grasse River for 1997 through 2006.

Data source: 2006 Data Summary Report, June 2007.

PMO - D:\JOBS\ALCgra\Model\EFDC\Input_Files\Sediment_conc_bc_files\icebreakupdates\bc_sed_c3_xx.pro
Fri Jun 27 11:59:21 2008

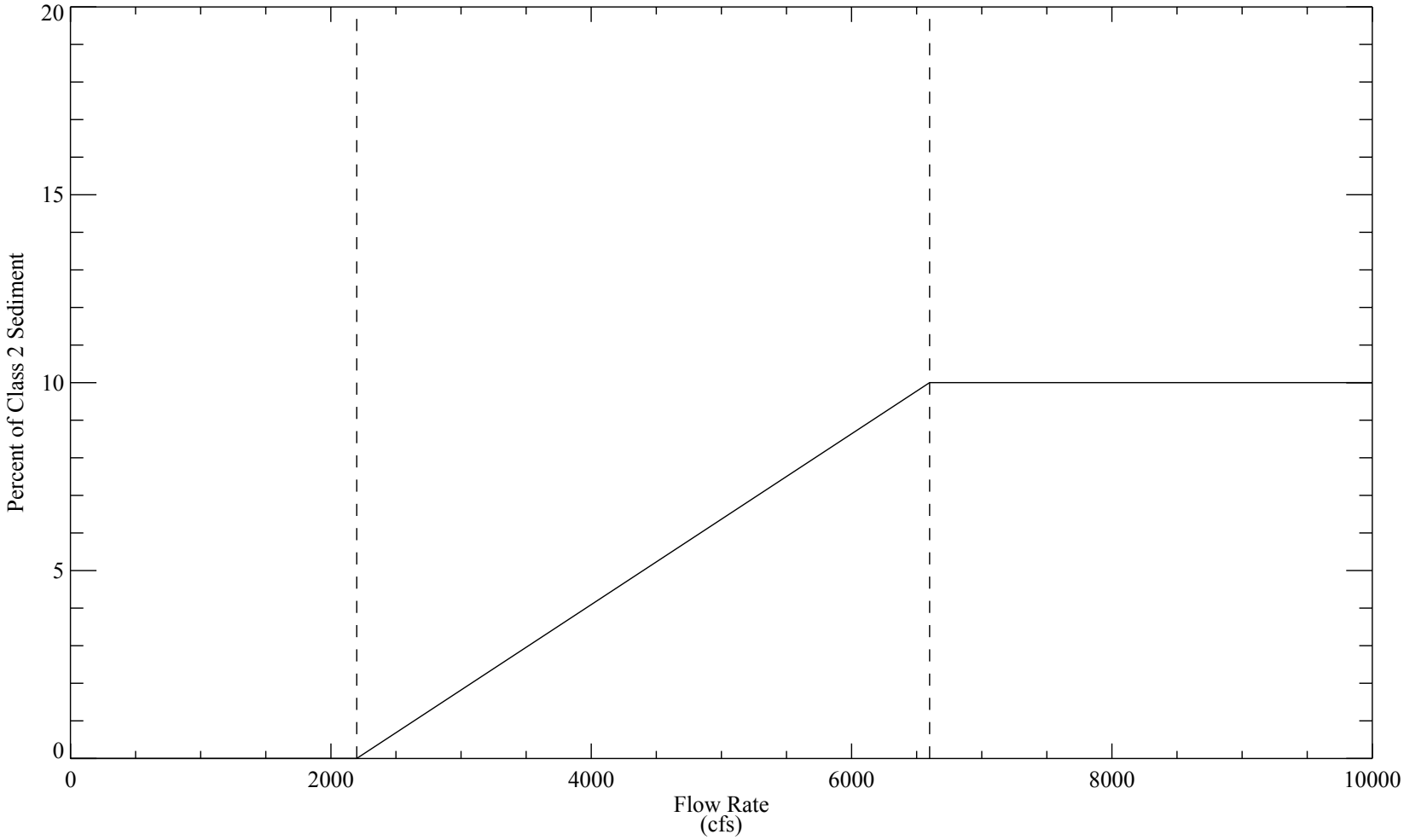


Figure A3-19. Composition of incoming sediment load as a function of flow rate.

EC - D:\ALCgra\Documents\reports\CCLGR_revised_rpt_401\model_app_C\figures\Section_C3\plot_composition_function_fig_C3_16_to_PDF.pro (haz)

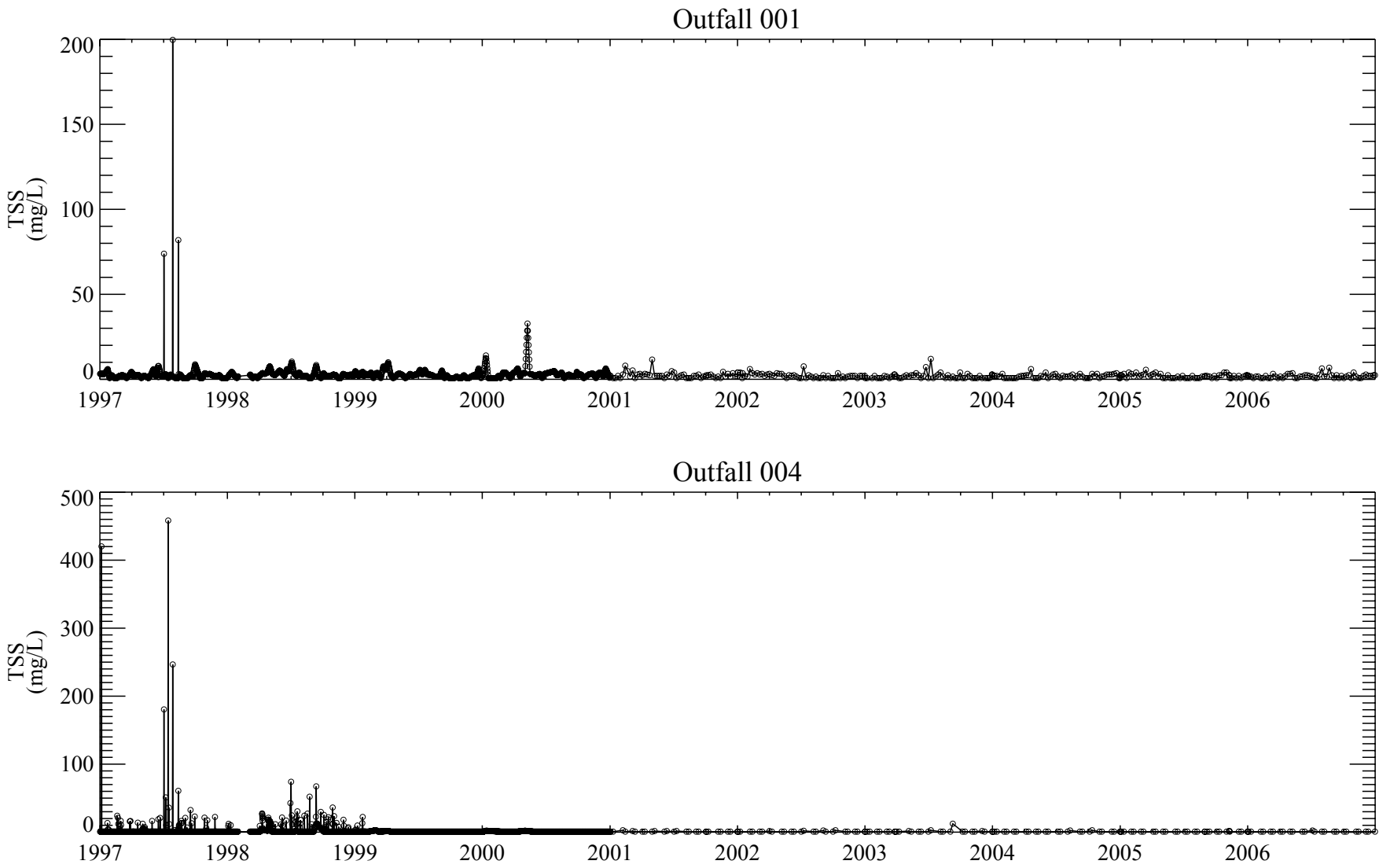


Figure A3-20. Temporal TSS profiles for Outfalls 001 and 004 (1997-2006).

○ SPDES data

RN - D:\ALCgra\Analysis\bc_tss_plot.pro
Fri Oct 24 10:56:28 2008

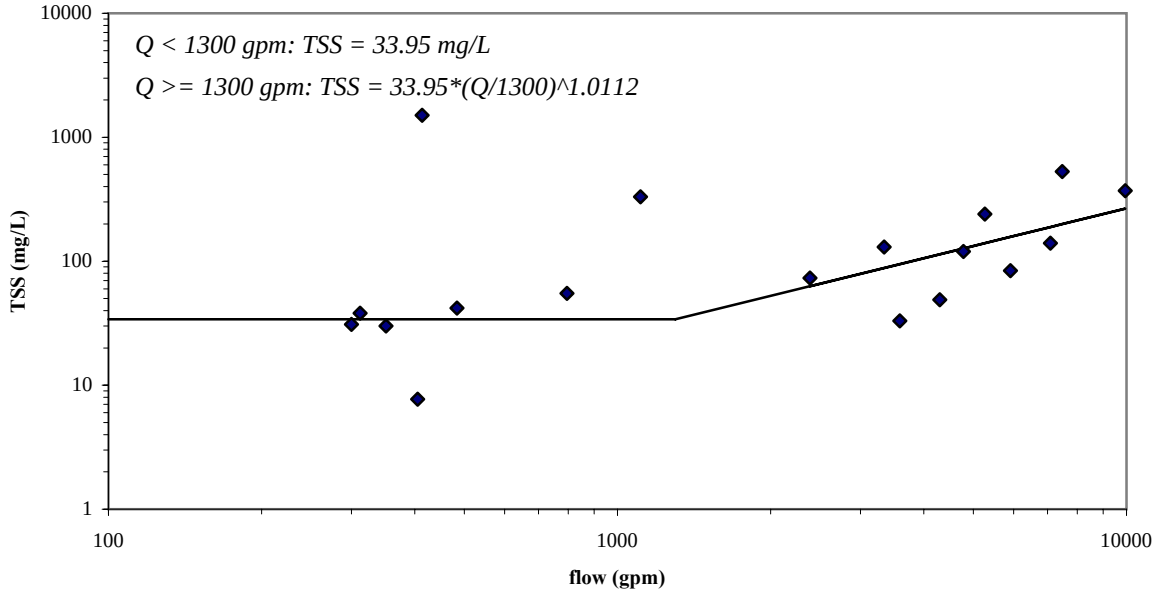


Figure A3-21. Solids concentrations measured at Outfall 004 during 1997 storms.
Data table: outfall_storms

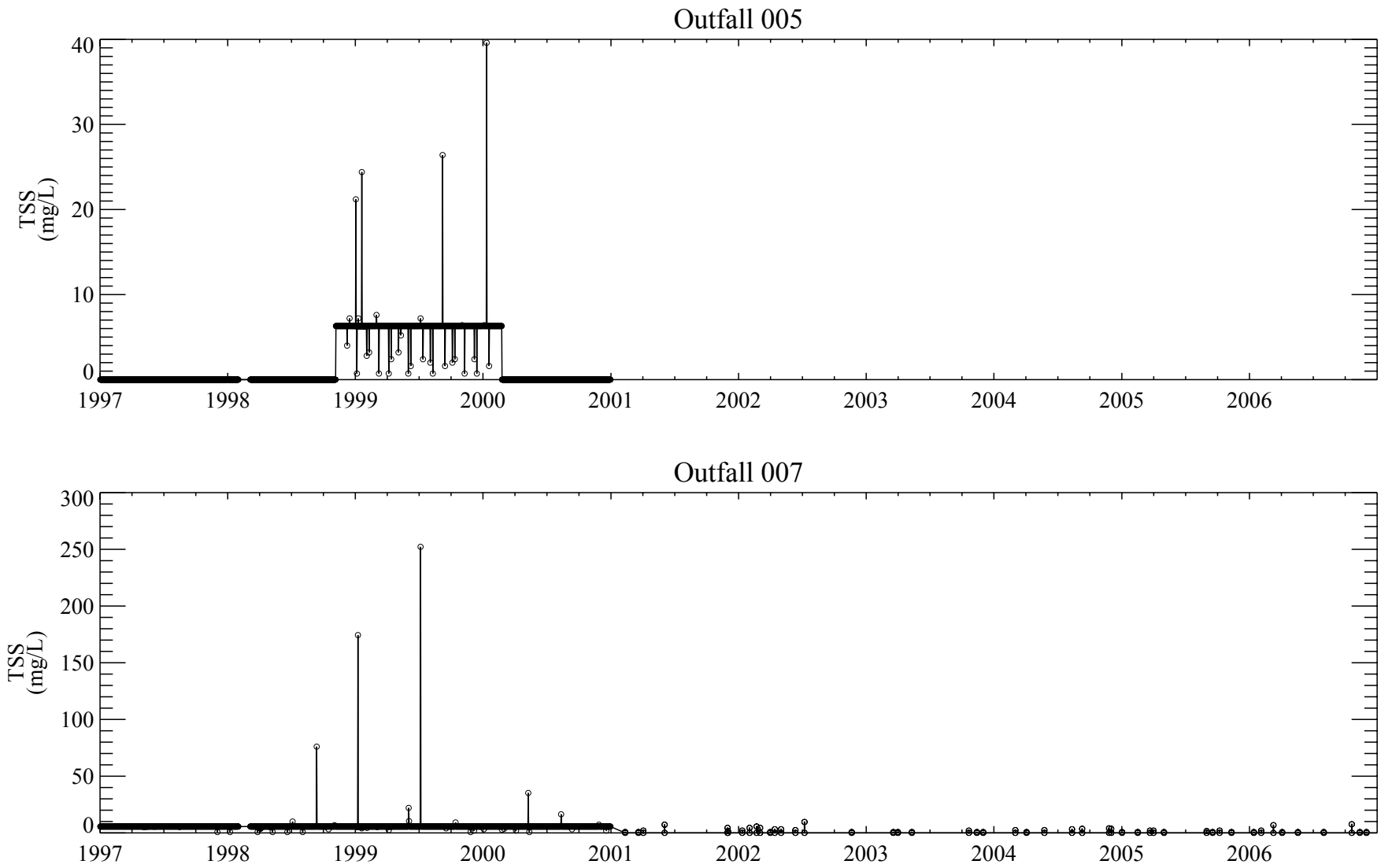


Figure A3-22. Temporal TSS profiles for Outfalls 005 and 007 (1997-2006).

○ SPDES data

RN - D:\ALCgra\Analysis\bc_tss_plot.pro
Fri Oct 24 10:56:28 2008

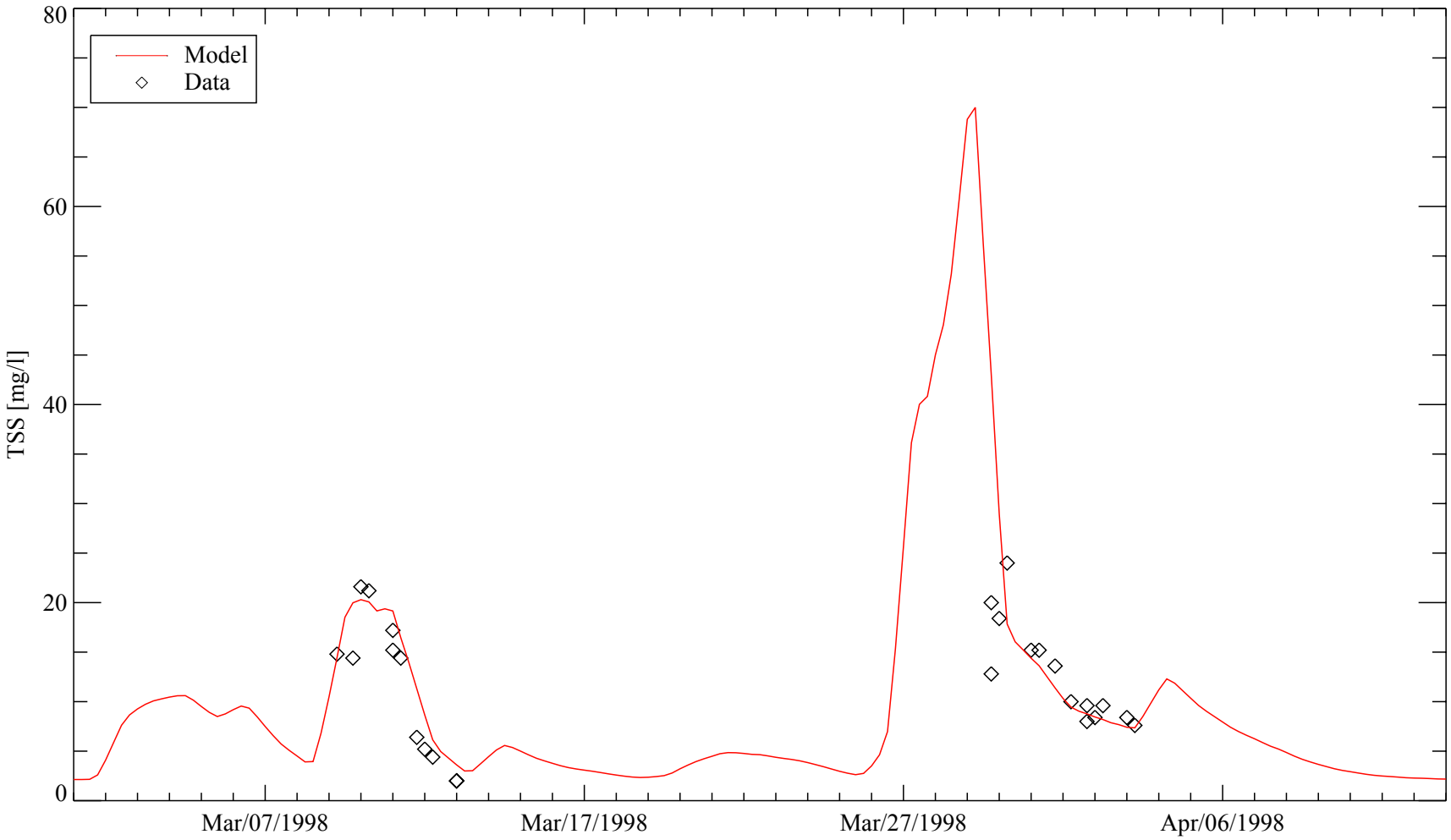
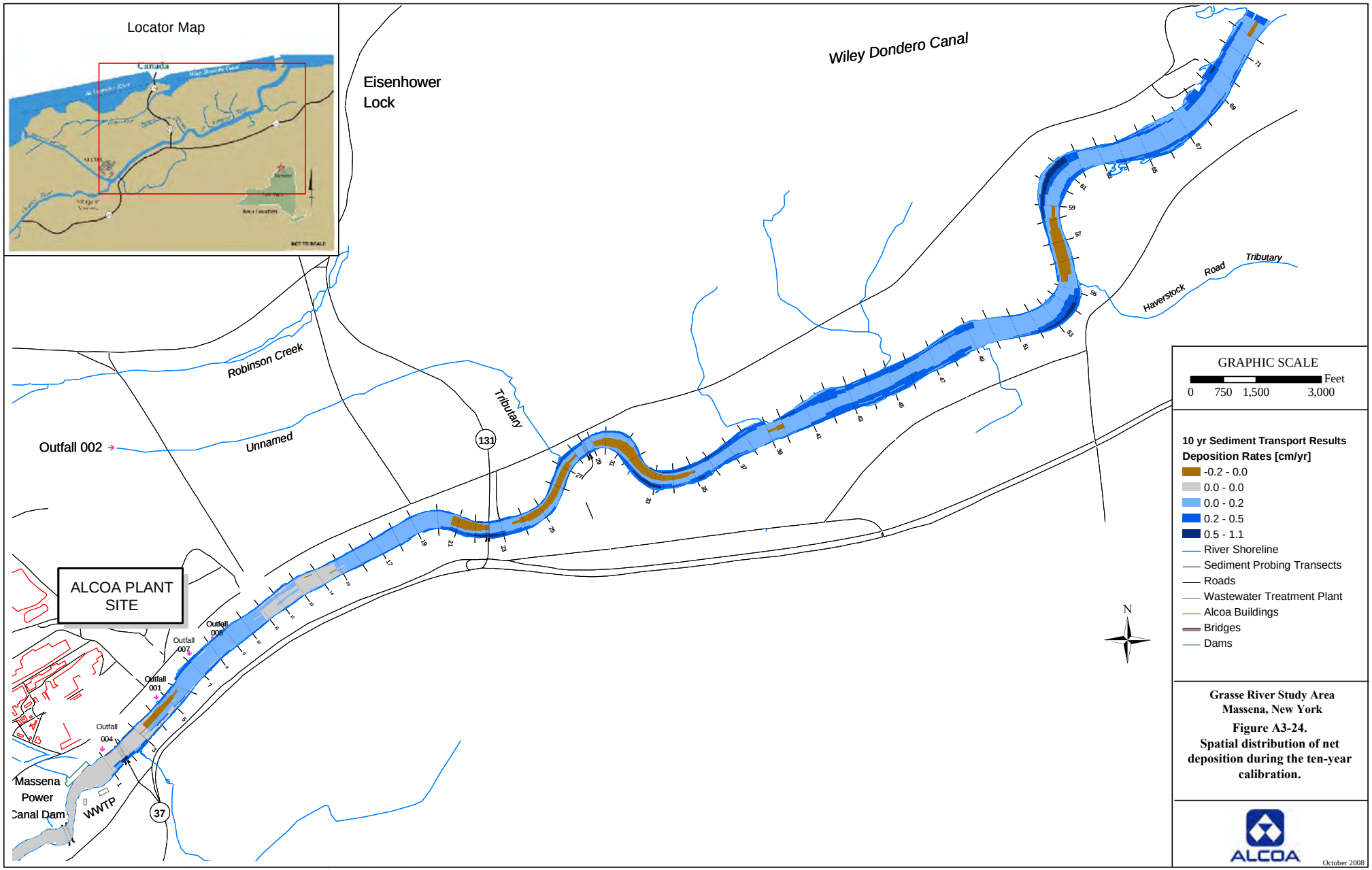


Figure A3-23. Comparision of observed and predicted TSS Concentrations at the Route 131 Bridge.

Data Source: Route 131 Bridge field sampling.

PM - D:\JOBS\ALCgra\Model\EFDC\Sedtran\Calibration\calib_05292008\ht2.pro
Thu Jun 19 16:54:01 2008



Grasse River Study Area
Massena, New York

Figure A3-24.
Spatial distribution of net deposition during the ten-year calibration.

PO - \\Peter\D_DRIVE\JOBS\ALCgra\Model\EFDC\Sedtran\Calibration\Longterm\seq-2\GIS_map\2006_map_shift\ALCgra_Model_results_analysis3.mxd

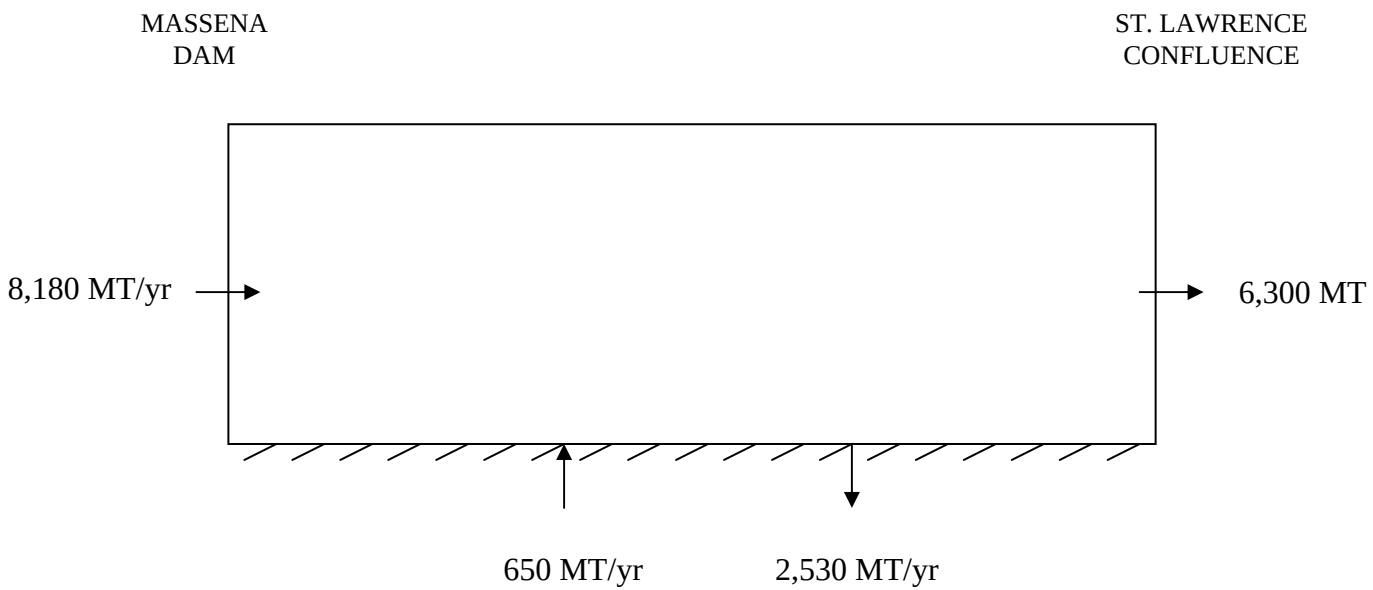


Figure A3-25. Lower Grasse River sediment mass balance for the 10-year simulation (1997-2006).

HAZ - longterm_sedtran_mass_balance_fig_A3_25.ppt
11/19/2008

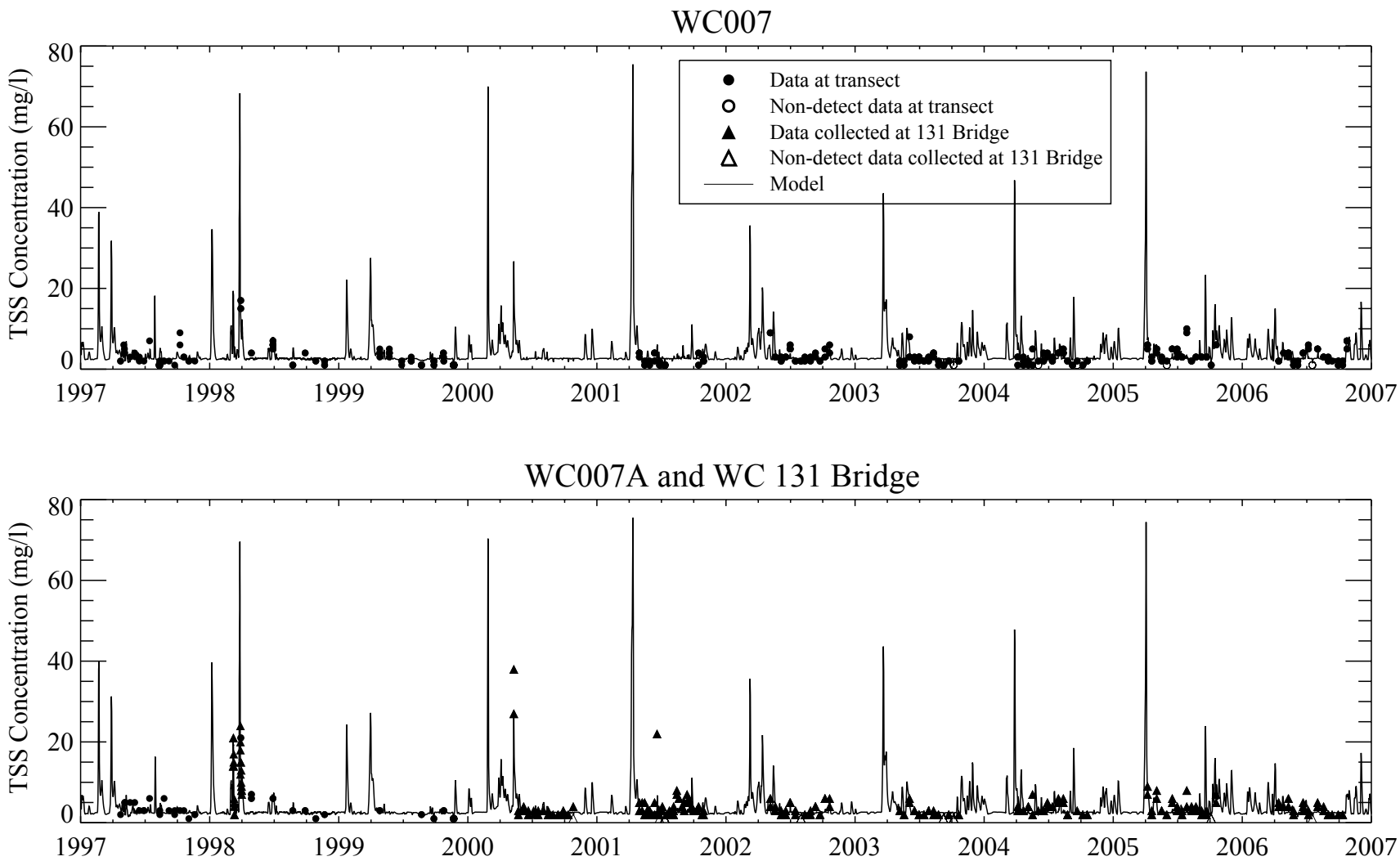


Figure A3-26. Comparison of predicted and observed TSS concentrations at two monitoring stations during 1997-2006 simulation.

Data source: 2006 Data Summary Report, June 2007.

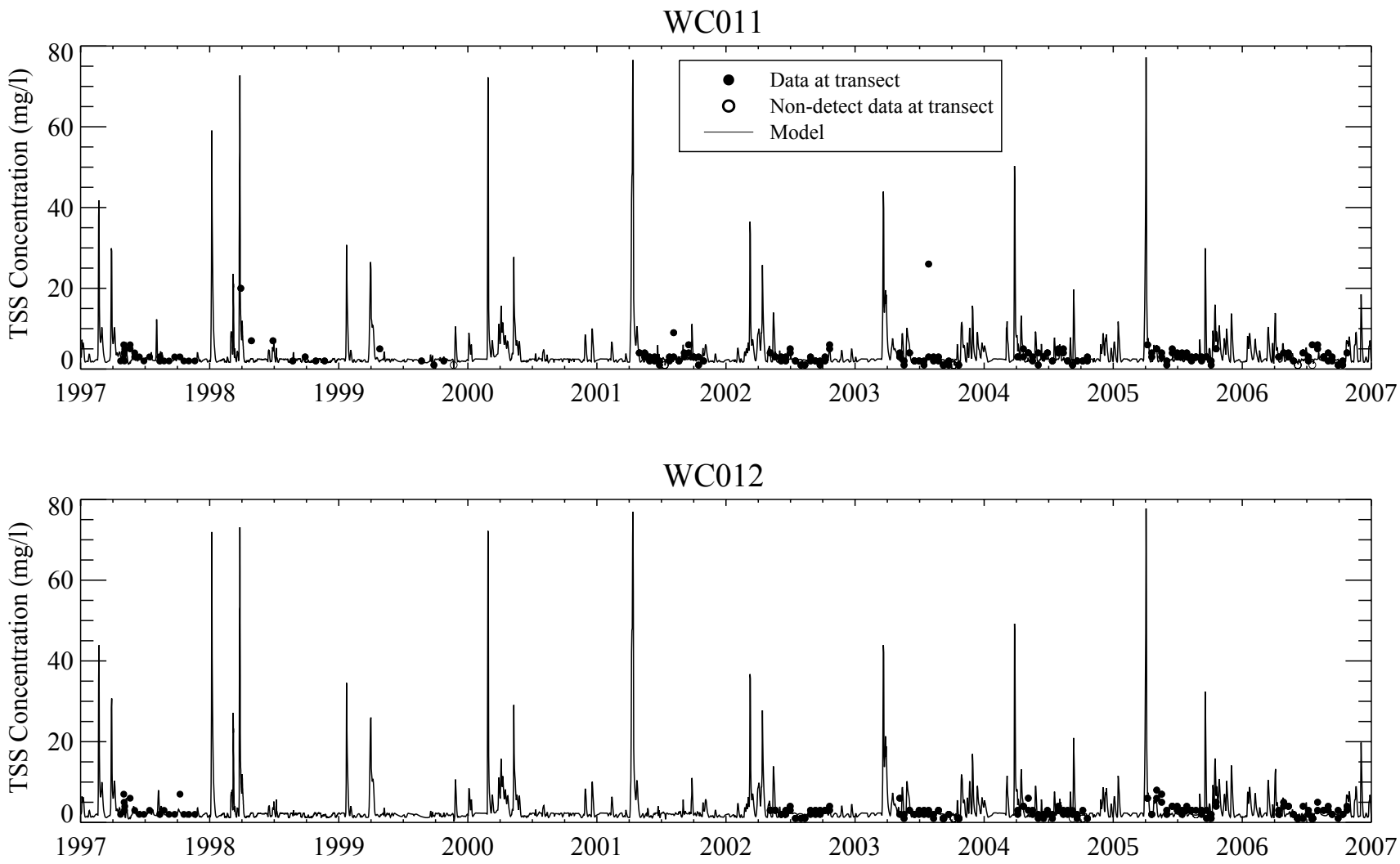


Figure A3-27. Comparison of predicted and observed TSS concentrations at two monitoring stations during 1997-2006 simulation.

Data source: 2006 Data Summary Report, June 2007.

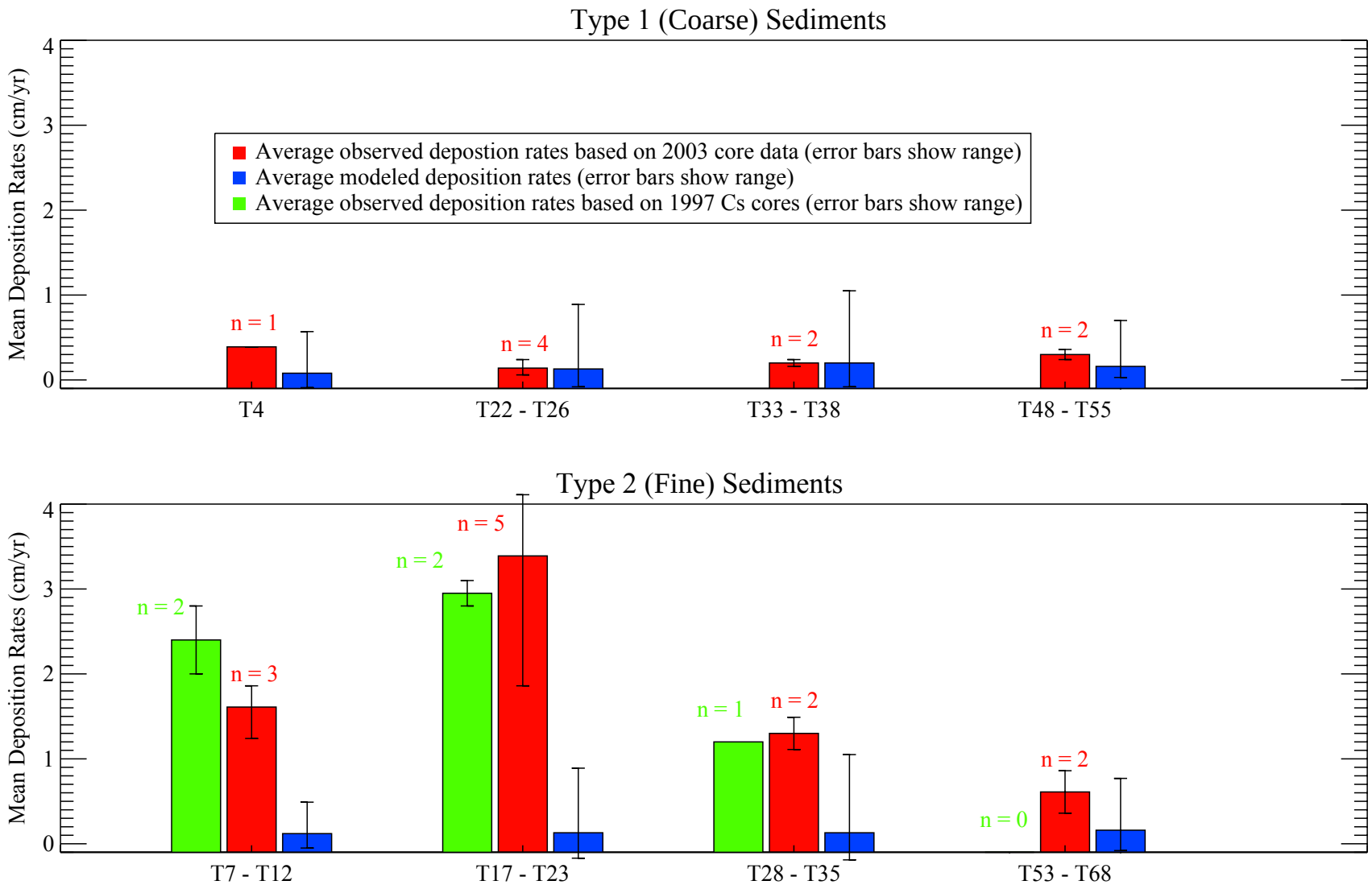
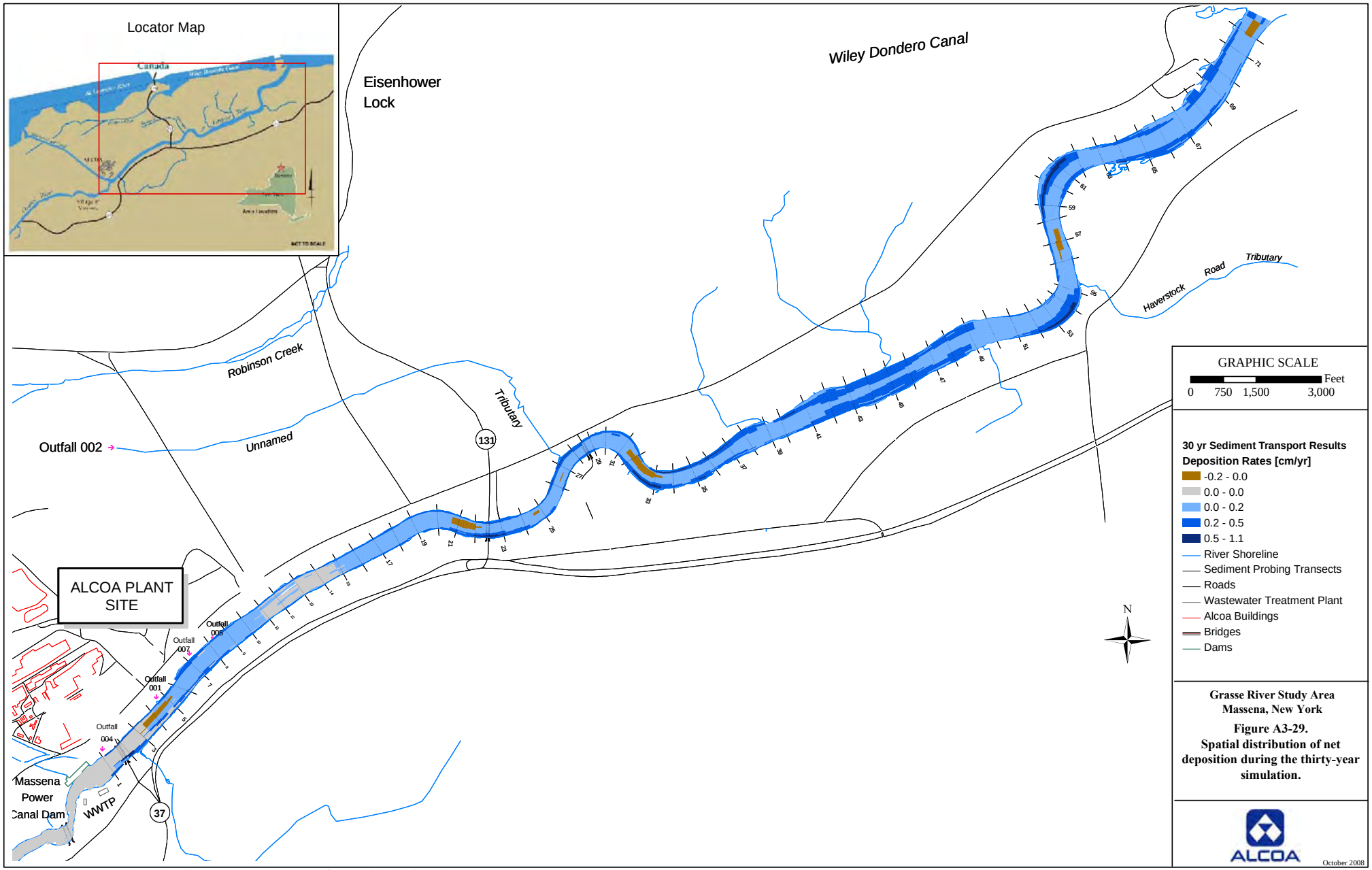


Figure A3-28. Comparison of modeled and observed deposition rates.

PMO - D:\JOBS\ALCgra\Documents\Report\Figure_C3_22\H_rez_dep_rate.pro
Mon Oct 20 16:34:06 2008



Grasse River Study Area
Massena, New York

Figure A3-29.
Spatial distribution of net deposition during the thirty-year simulation.

PO - \\Peter\D_DRIVE\JOBS\ALCgra\Model\EFDC\Sedtran\Calibration\Longterm\seq-2\GIS_map\2006_map_shift\ALCgra_Model_results_analysis3.mxd

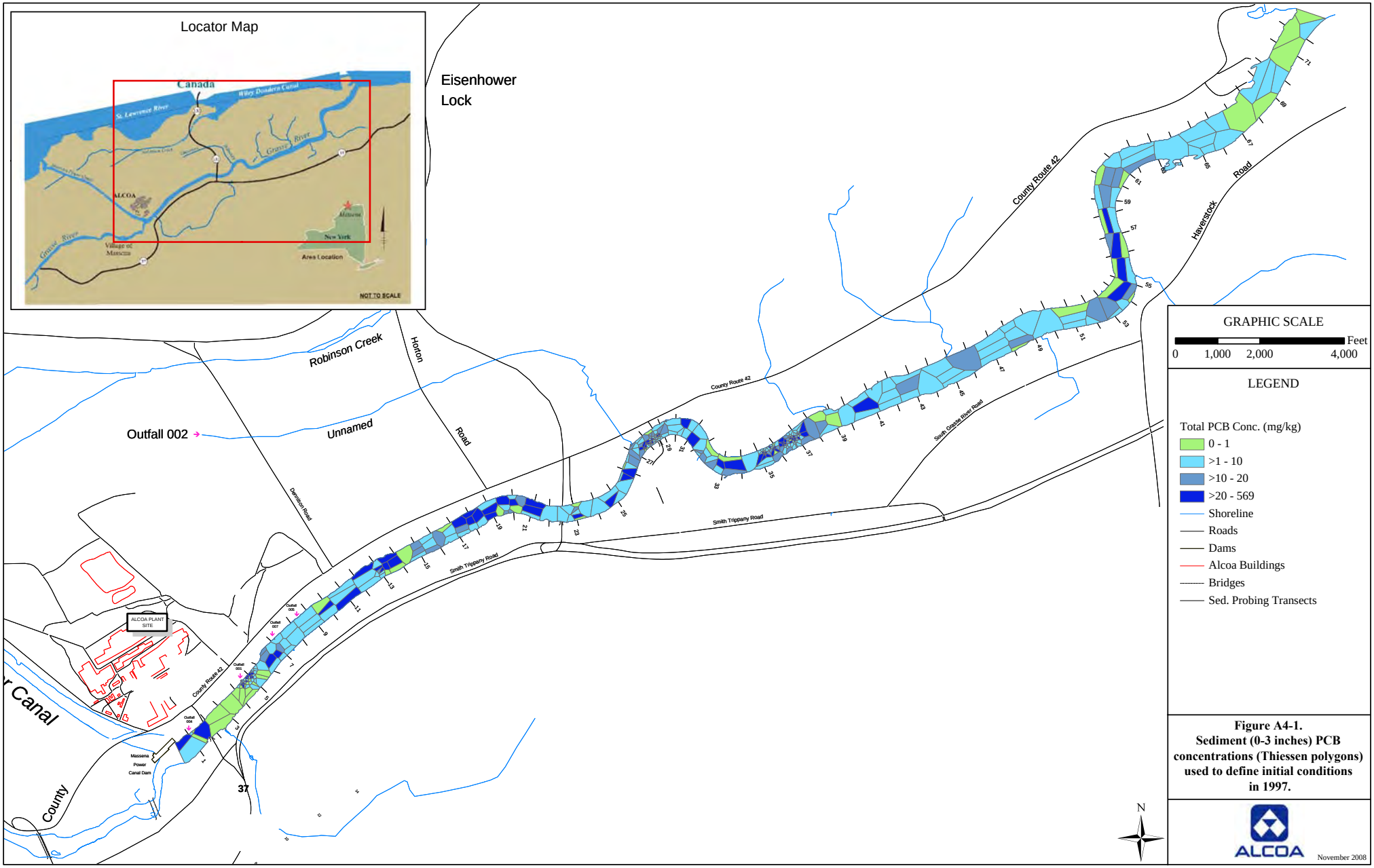


Figure A4-1.
Sediment (0-3 inches) PCB concentrations (Thiessen polygons) used to define initial conditions in 1997.

SJRH - \\Zeus\d_drive\ALCgra\Analysis\Sediment\Sediment_Characterization\GIS\From_AST_20080625\Model_grid_map_20080903.mxd

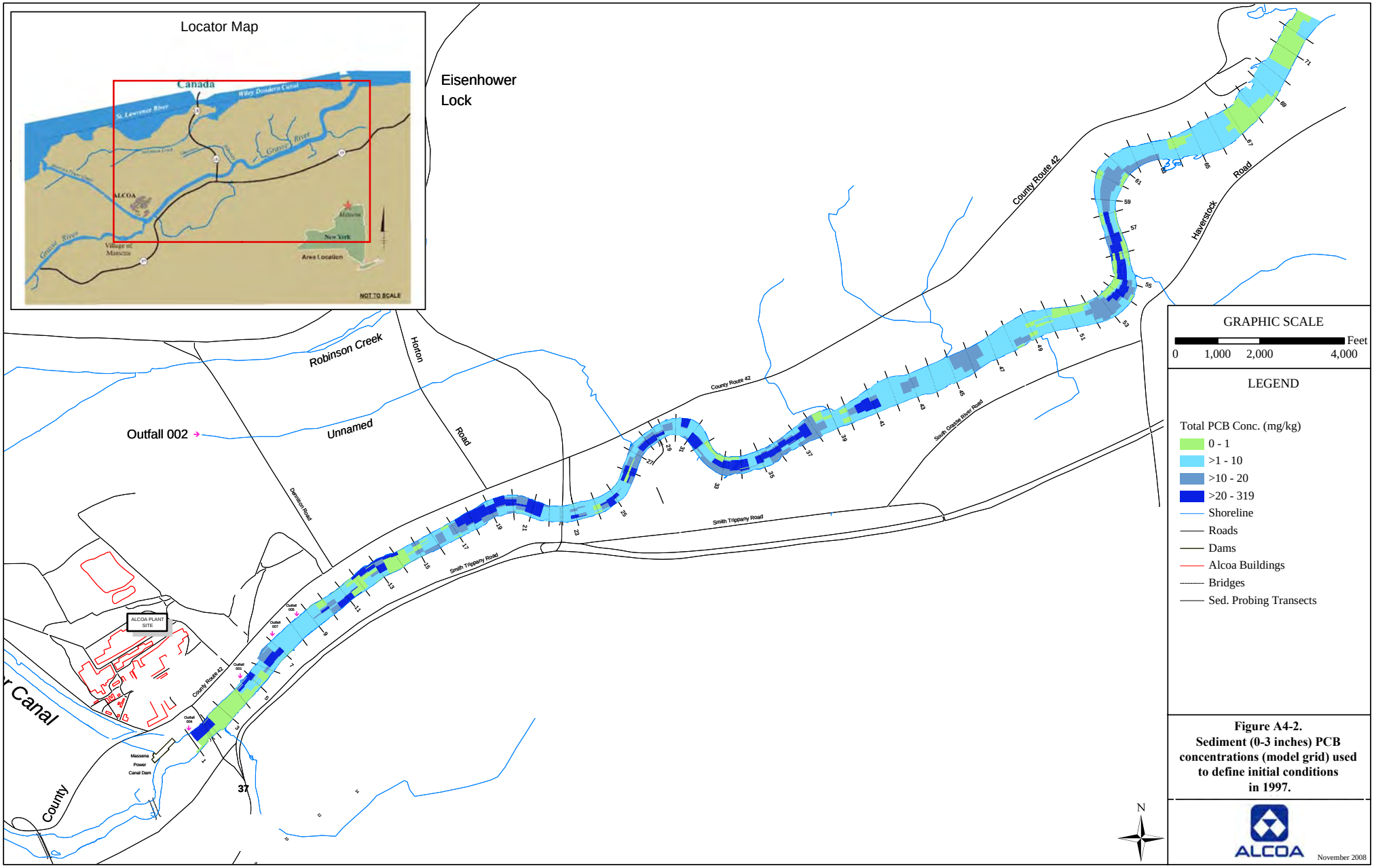


Figure A4-2.
Sediment (0-3 inches) PCB concentrations (model grid) used to define initial conditions in 1997.

SJRH - \\Zeus\d_drive\ALCgra\Analysis\Sediment\Sediment_Characterization\GIS\From_AST_20080625\Model_grid_map_20080903.mxd

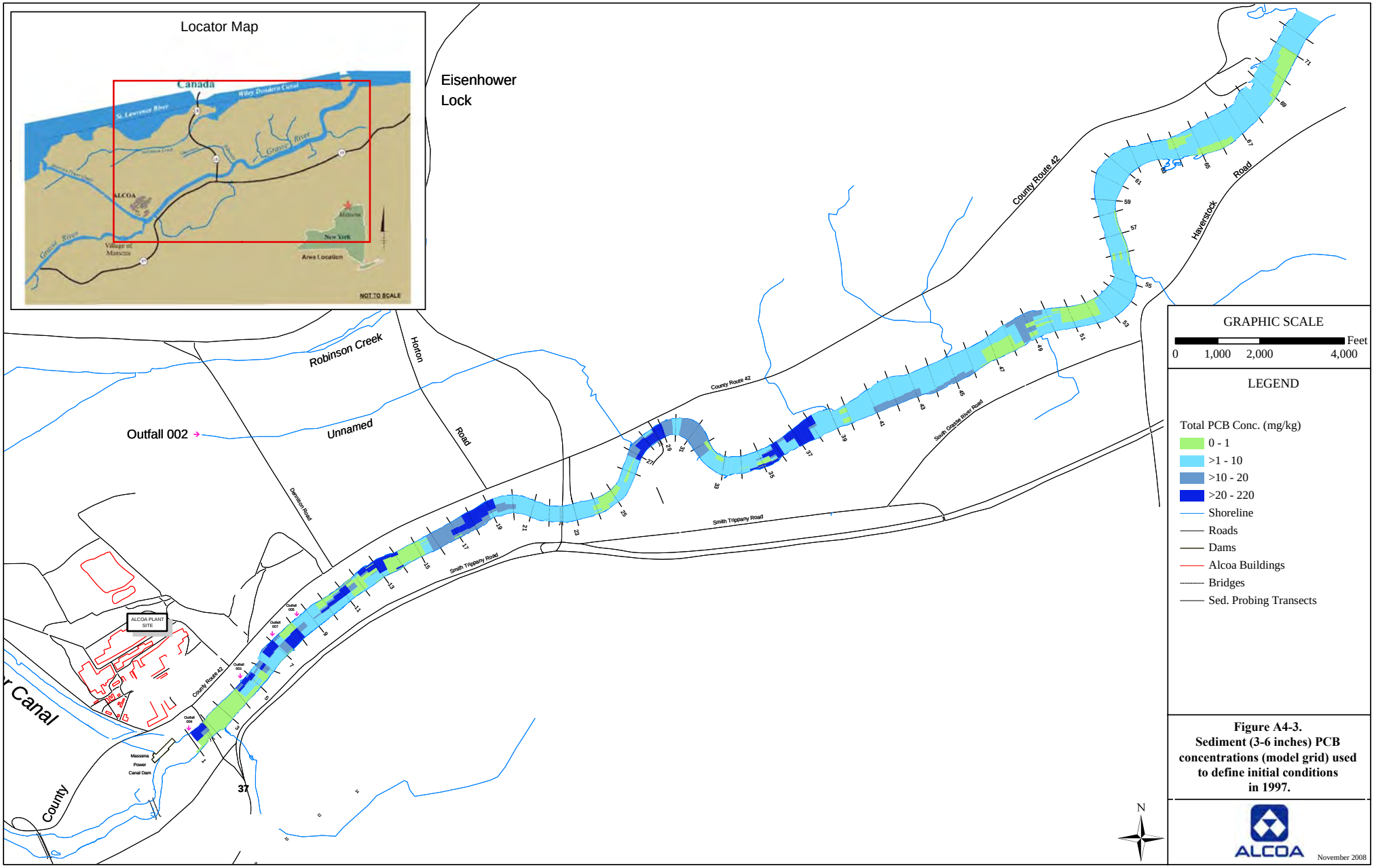


Figure A4-3.
Sediment (3-6 inches) PCB concentrations (model grid) used to define initial conditions in 1997.

SJRH - \\Zeus\d_drive\ALCgra\Analysis\Sediment\Sediment_Characterization\GIS\From_AST_20080625\Model_grid_map_20080903.mxd

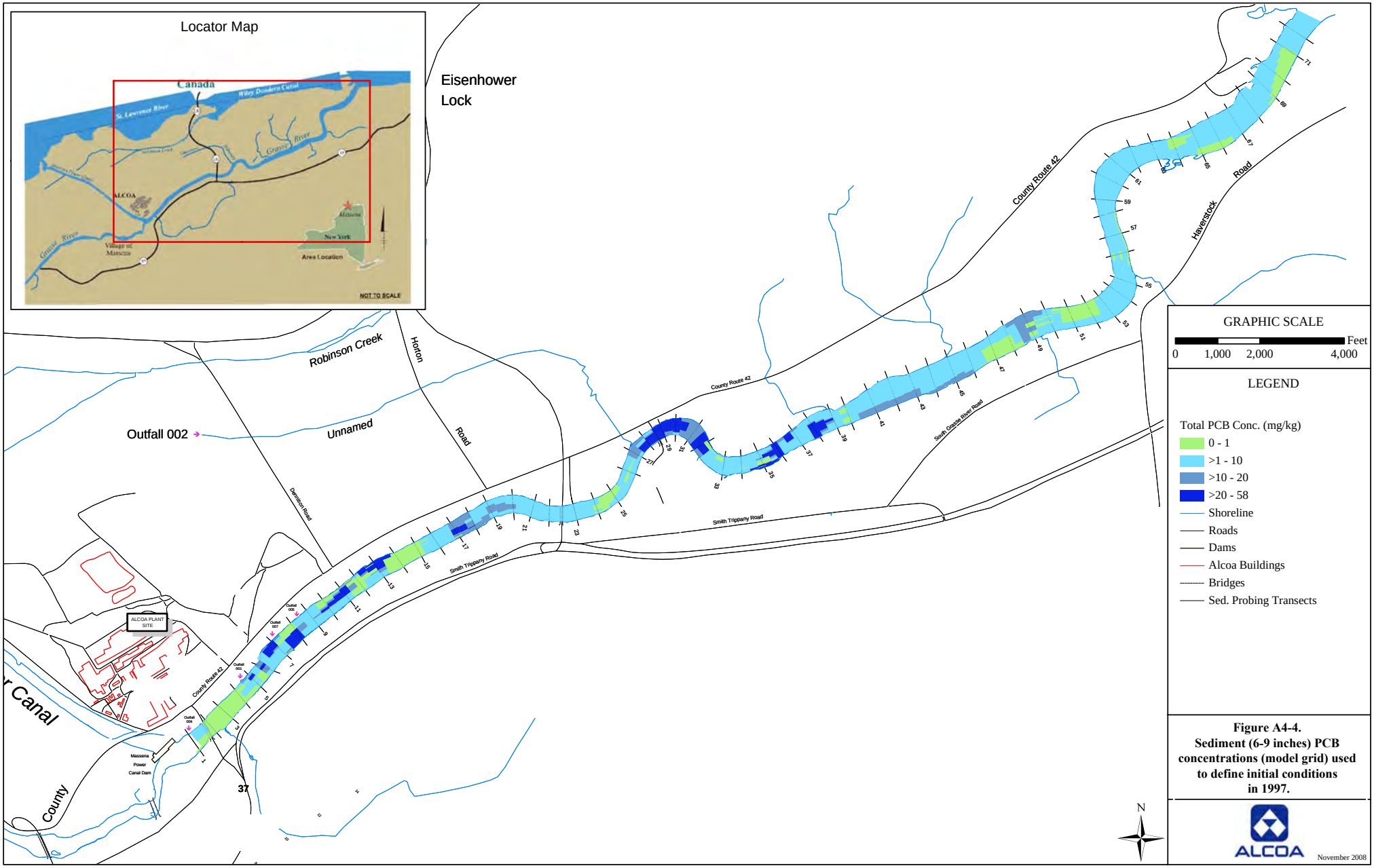


Figure A4-4.
Sediment (6-9 inches) PCB concentrations (model grid) used to define initial conditions in 1997.

SJRH - \\Zeus\d_drive\ALCgra\Analysis\Sediment\Sediment_Characterization\GIS\From_AST_20080625\Model_grid_map_20080903.mxd

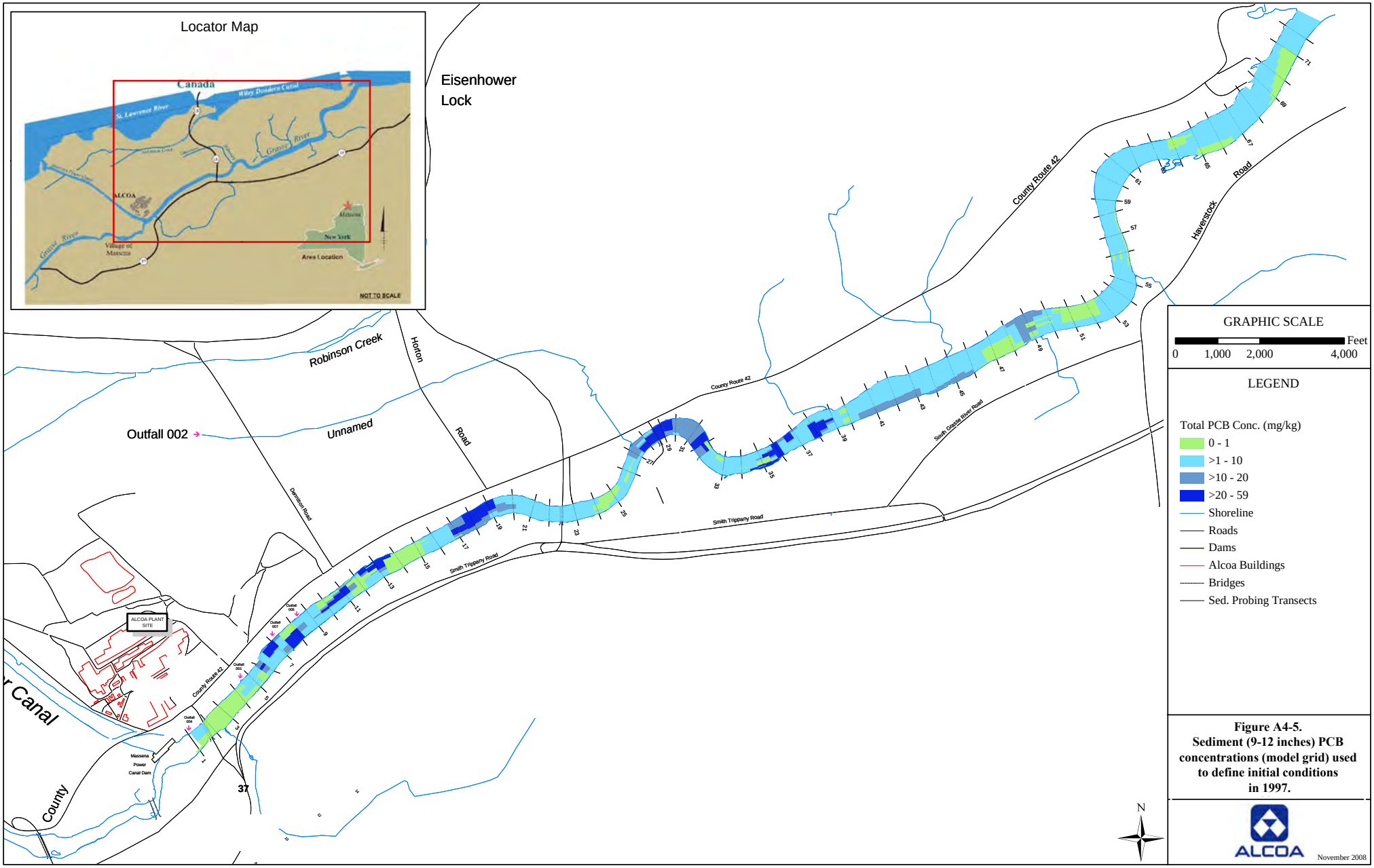


Figure A4-5.
Sediment (9-12 inches) PCB concentrations (model grid) used to define initial conditions in 1997.

SJRH - \\Zeus\d_drive\ALCgra\Analysis\Sediment\Sediment_Characterization\GIS\From_AST_20080625\Model_grid_map_20080903.mxd

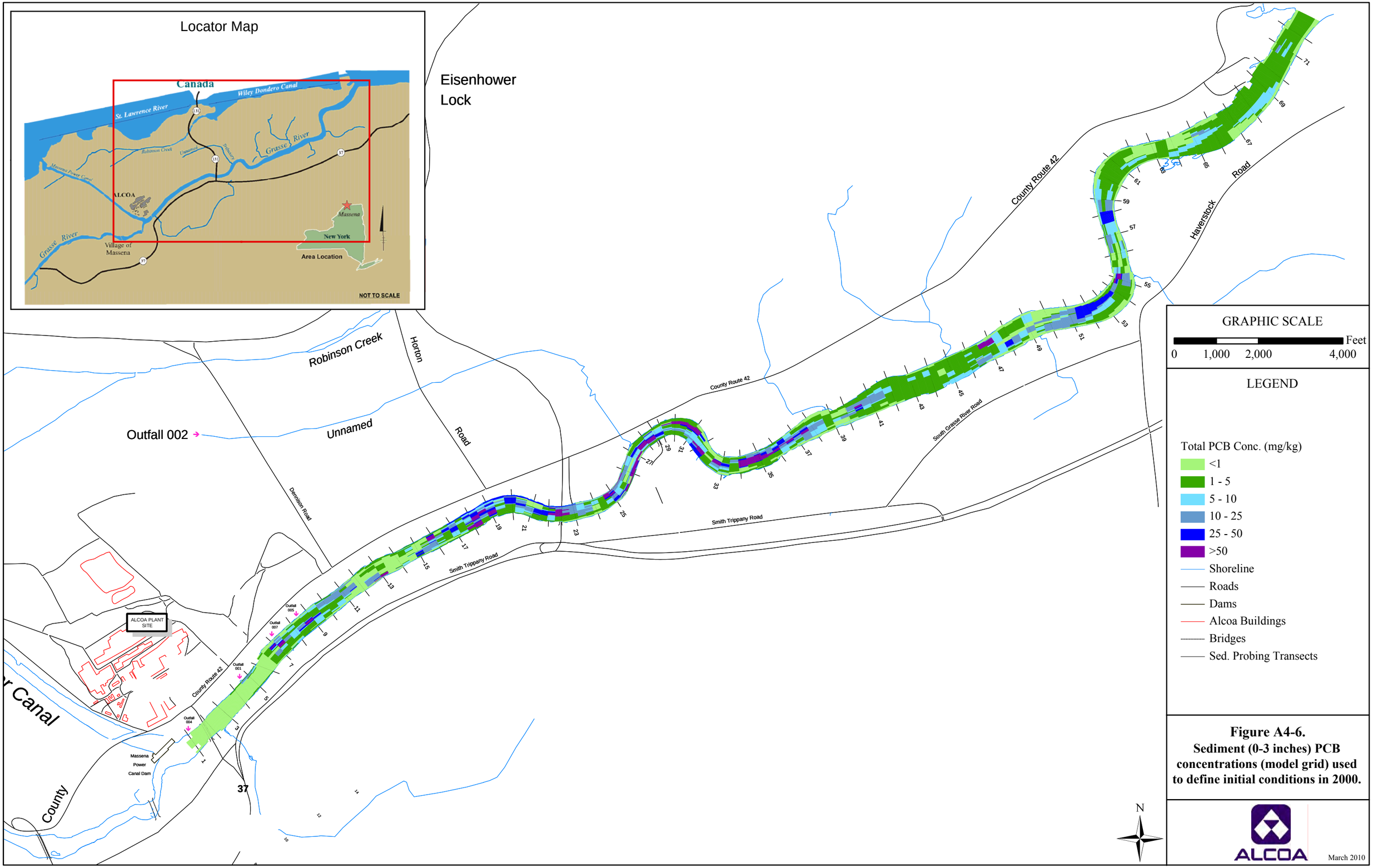


Figure A4-6.
Sediment (0-3 inches) PCB concentrations (model grid) used to define initial conditions in 2000.

CFO- D:\ALCgra\GIS\Model_grid_map_20100106.mxd

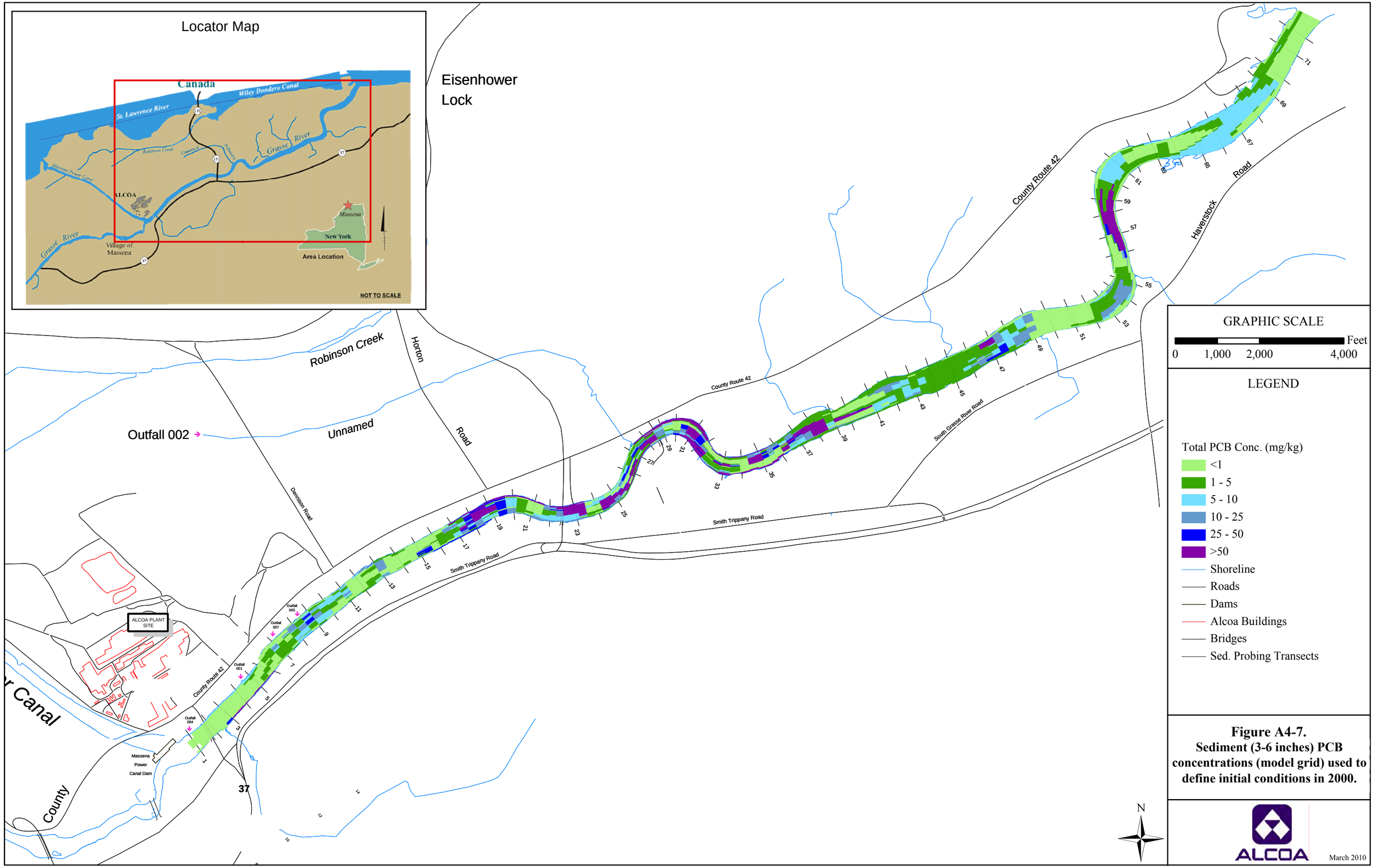


Figure A4-7.
Sediment (3-6 inches) PCB concentrations (model grid) used to define initial conditions in 2000.

CFO- D:\ALCgra\GIS\Model_grid_map_20100106.mxd

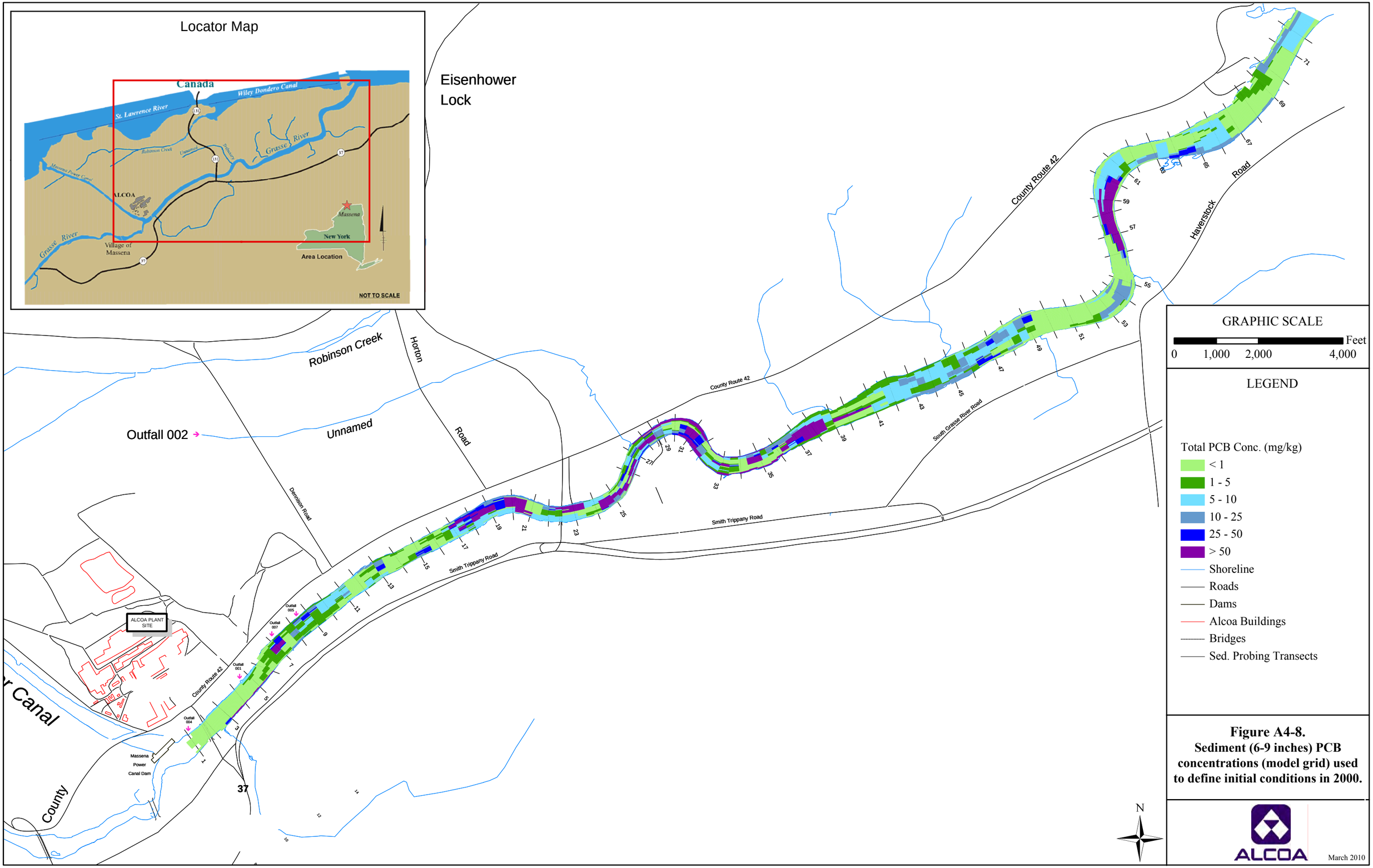


Figure A4-8.
Sediment (6-9 inches) PCB concentrations (model grid) used to define initial conditions in 2000.

CFO- D:\ALCgra\GIS\Model_grid_map_20100106.mxd

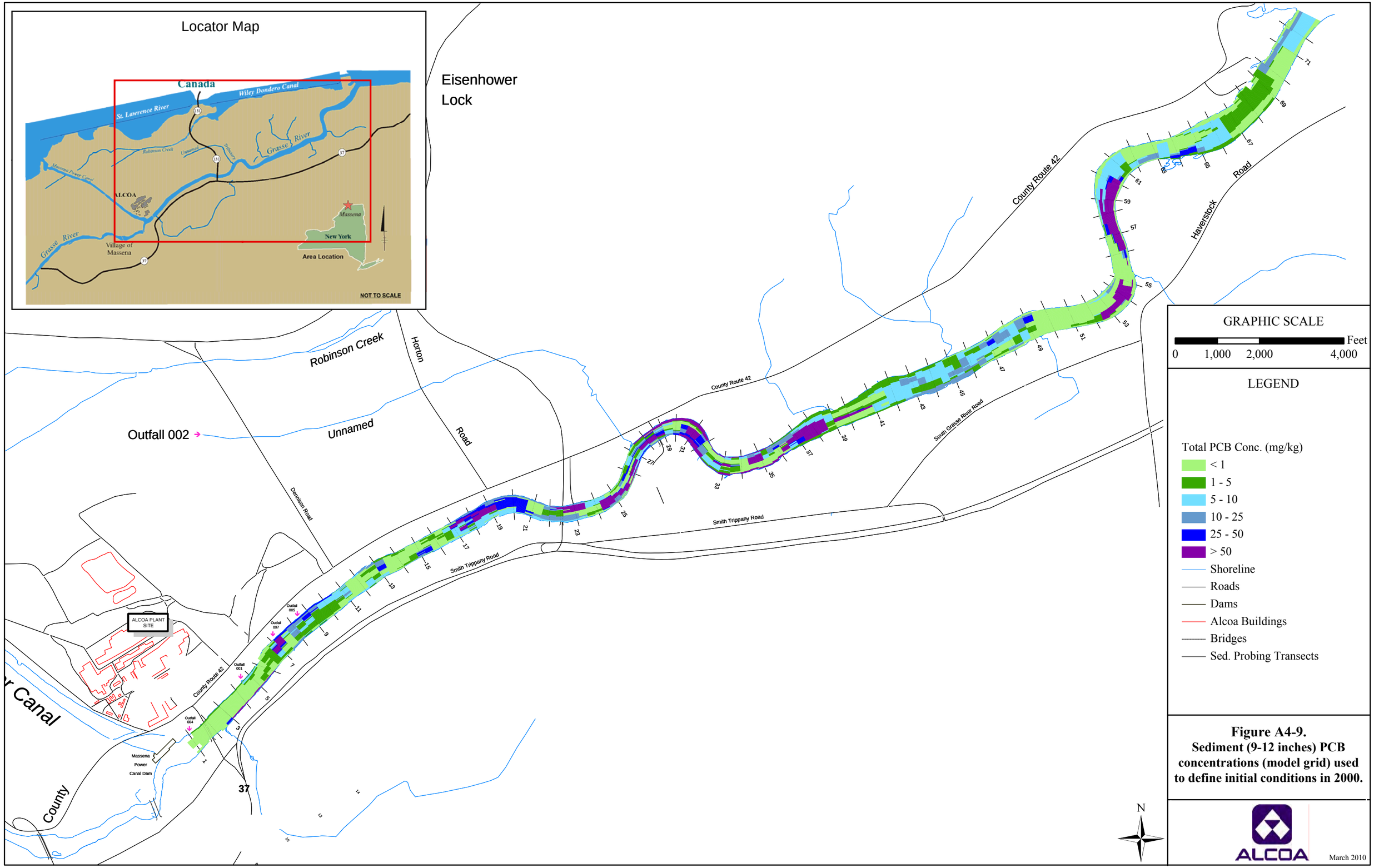


Figure A4-9.
Sediment (9-12 inches) PCB concentrations (model grid) used to define initial conditions in 2000.

CFO- D:\ALCgra\GIS\Model_grid_map_20100106.mxd

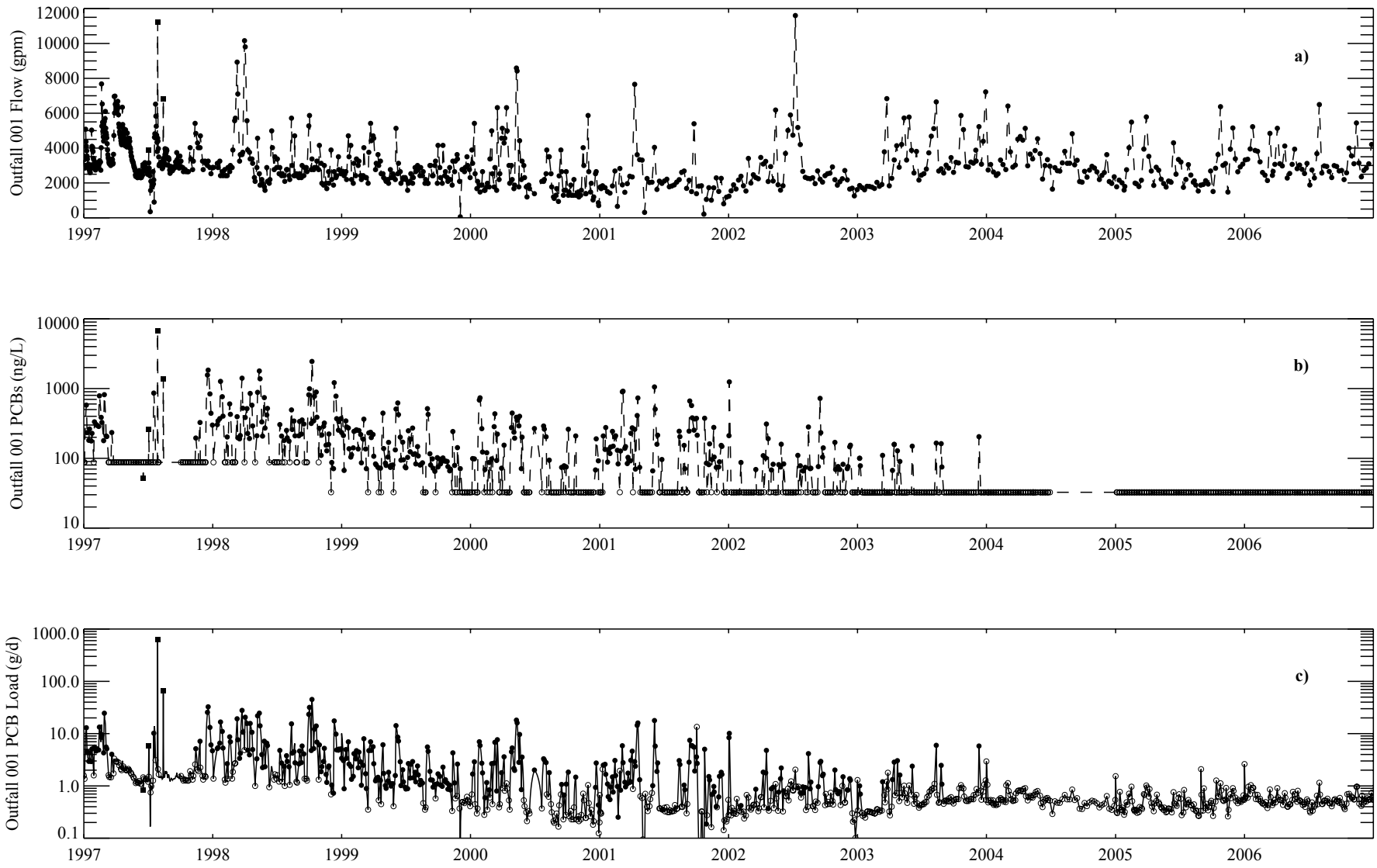


Figure A4-10. Temporal profile of (a) flow, (b) PCB concentration, and (c) the loading function for the model calibration from Outfall 001.

Circles = SPDES data, Squares = Storm data, Open Symbols = Non Detect at 1/2 MDL, Line = Function Used in Model

ec/RN - \\Raghav\d_drive\ALCgra\Analysis\BC_temporals\load_001_4yr.pro
Thu Oct 23 16:16:43 2008

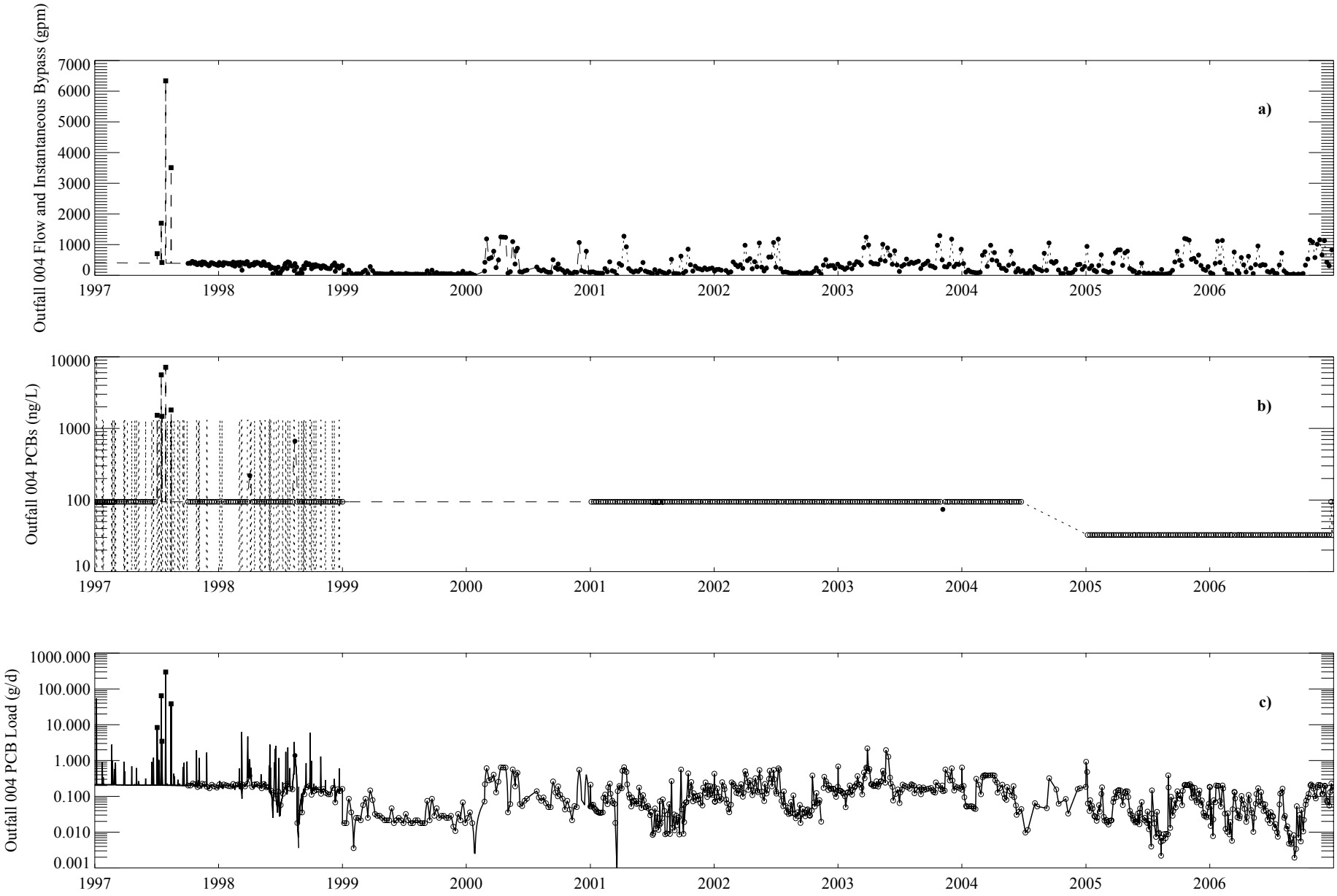


Figure A4-11. Temporal profile of (a) flow, (b) PCB concentration, and (c) the loading function for the model calibration from Outfall 004.

Symbols and Dashed Line = SPDES (Circles) and Storm (Squares) data, Open Symbols = Non Detect at 1/2 MDL, Dotted line = Values Calculated from Bypass Data, Solid Line = Total (SPDES + Bypass) Loading Function Used in Model

ec/PM/RN - \\Raghav\d_drive\ALCgra\Analysis\BC_temporals\load_004_4yr.pro
Thu Oct 23 16:34:20 2008

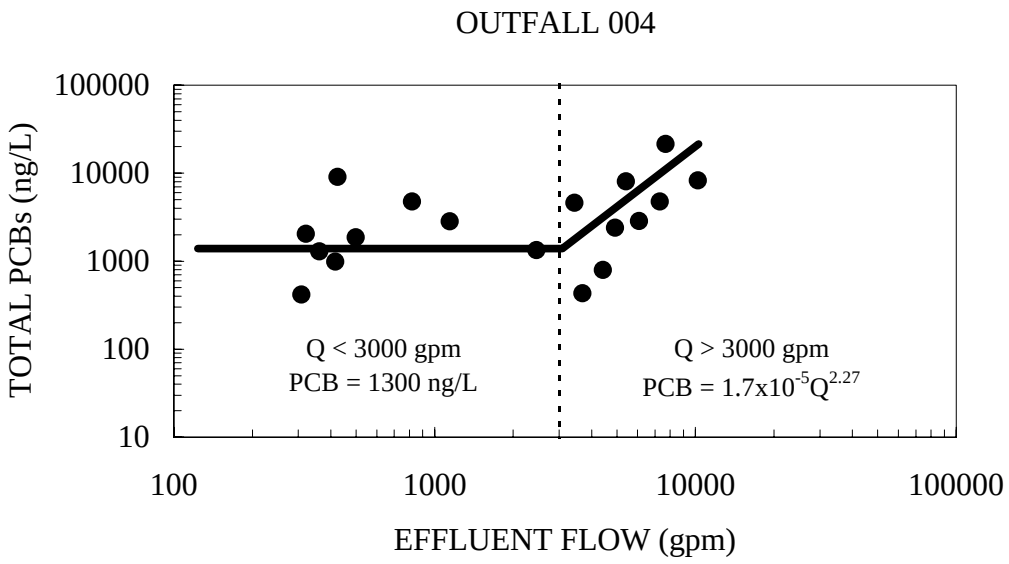


Figure A4-12. Relationship of PCB concentration and flow for Outfall 004 during bypass events.

Relationships developed using data collected during 1997 Storm Sampling Program.
Data table: outfalls_storms

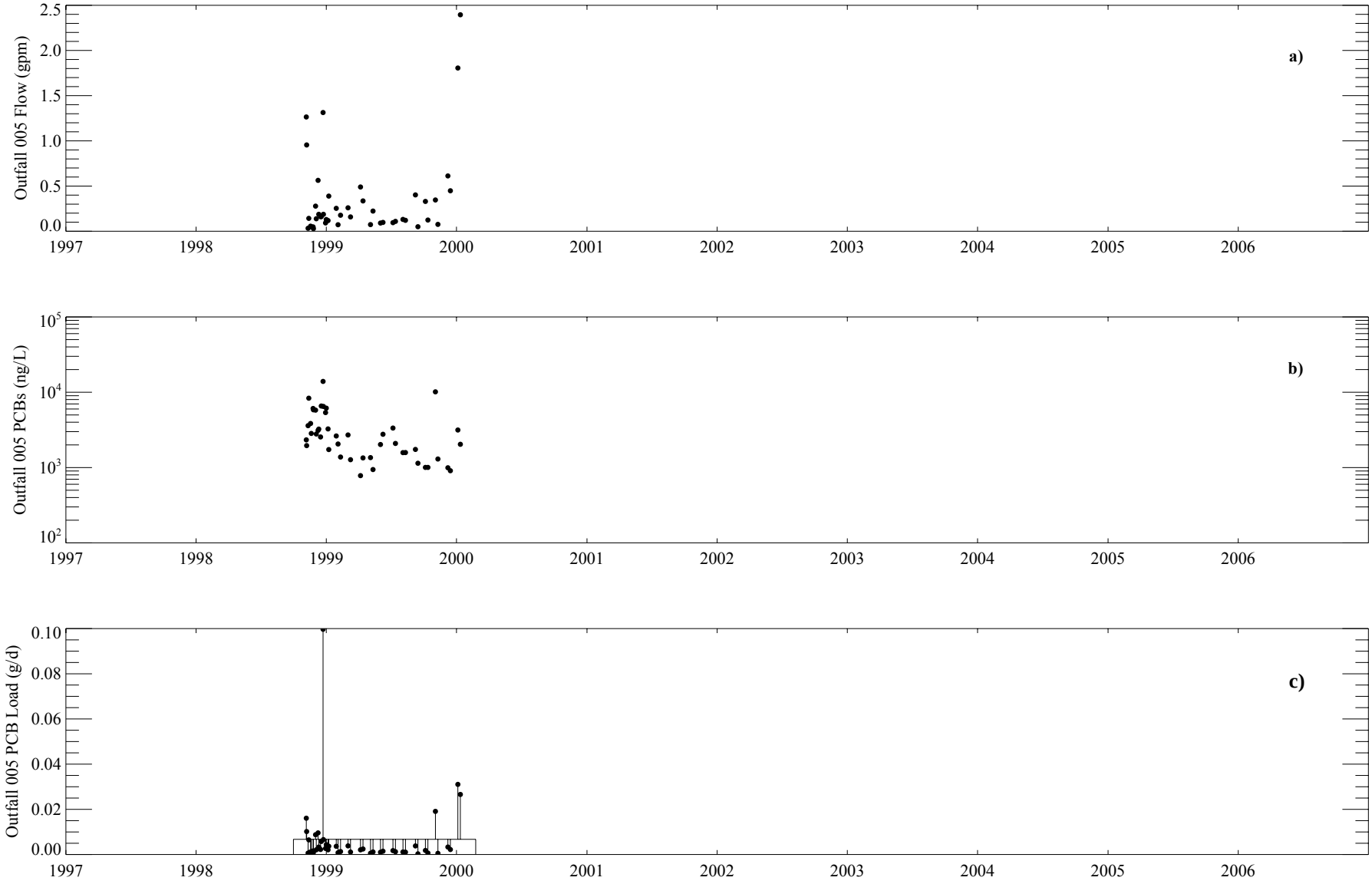


Figure A4-13. Temporal profile of (a) flow, (b) PCB concentration, and (c) the loading function for the model calibration from Outfall 005.

Circles = SPDES data, Open Symbols = Non Detect at 1/2 MDL, Line = Function Used in Model

ec/PM/RN - \\Raghav\d_drive\ALCgra\Analysis\BC_temporals\load_005_4yr.pro
Thu Oct 23 16:38:14 2008

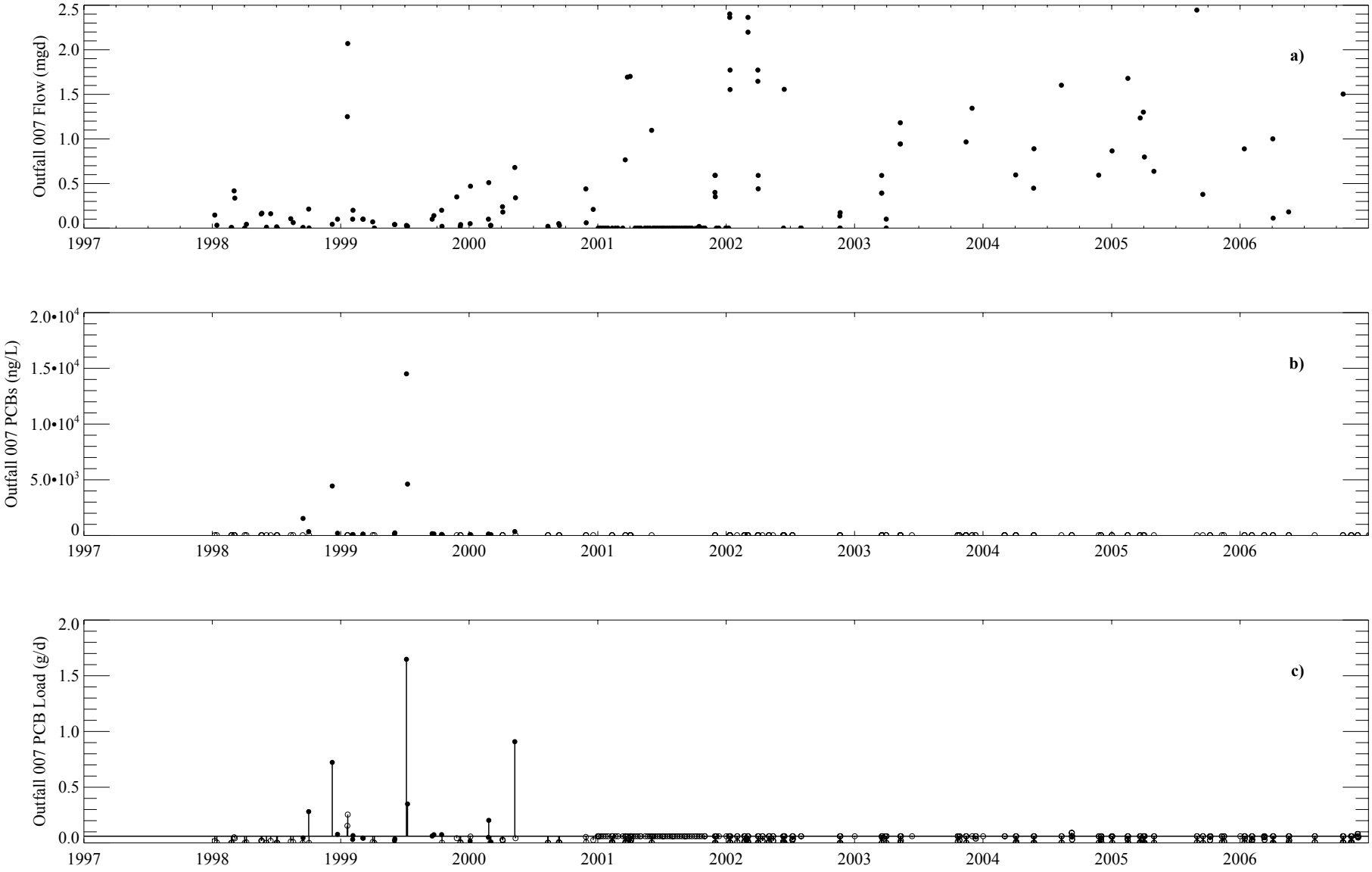


Figure A4-14. Temporal profile of (a) flow, (b) PCB concentration, and (c) the loading function for the model calibration from Outfall 007.

Circles = SPDES data, Open Symbols = Non Detect at 1/2 MDL, Line = Function Used in Model

ec/PM/RN - \\Raghav\d_drive\ALCgra\Analysis\BC_temporals\load_007_4yr.pro
Thu Oct 23 16:40:30 2008

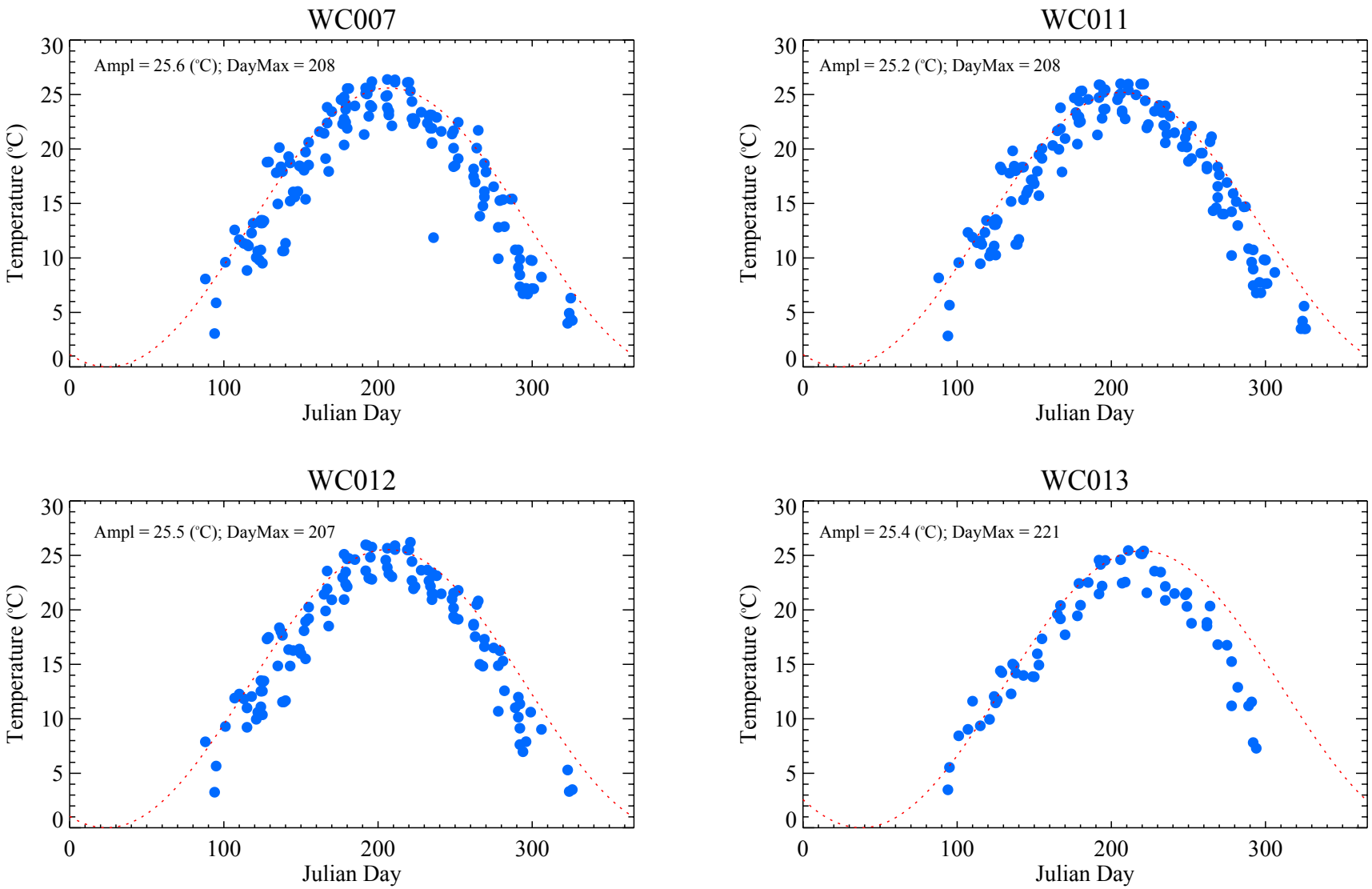


Figure A4-15. Comparison of fitted and measured temperatures by location.

The fitted model is based on the median peak temperature (over all years) measured at the water quality station.
Whenever measurements were made at multiple depths, the average temperature was used.
Databases: water_iupac; water_field

PM - D:\ALCgra\Model\PCBFATE\Inputs\PreProcessors\analyse_temp_data.pro
Thu Oct 23 16:01:35 2008

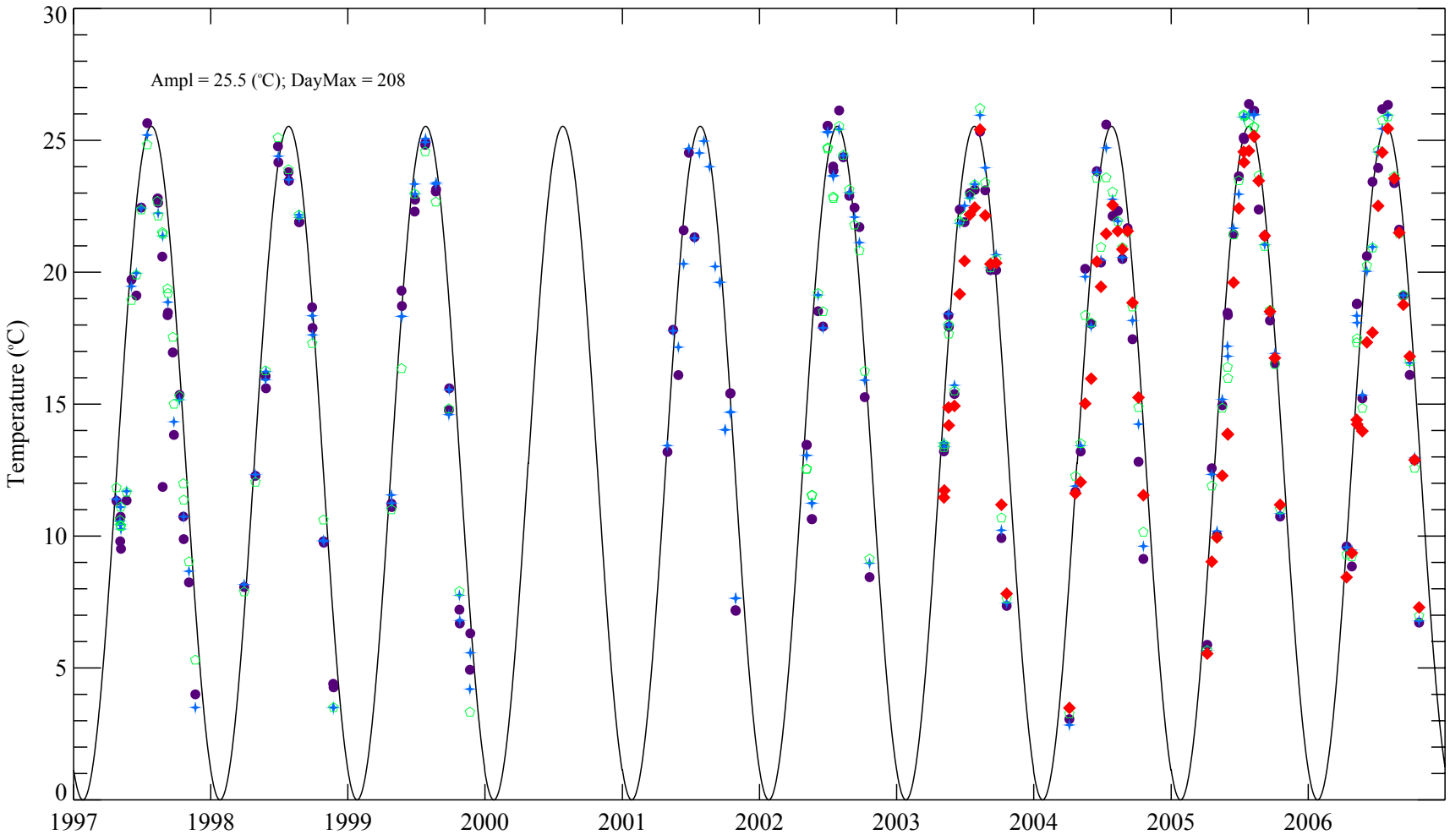


Figure A4-16. Temperature function used for the Grasse River model compared to water column data.

The fitted model is based on the median peak temperature measured at all water quality stations.
Whenever measurements were made at multiple depths, the average temperature was used.
Databases: water_iupac; water_field

WC007
WC011
WC012
WC013
Fitted

PM - D:\ALCgra\Model\PCBFATE\Inputs\PreProcessors\analyse_temp_data.pro
Thu Oct 23 16:01:36 2008

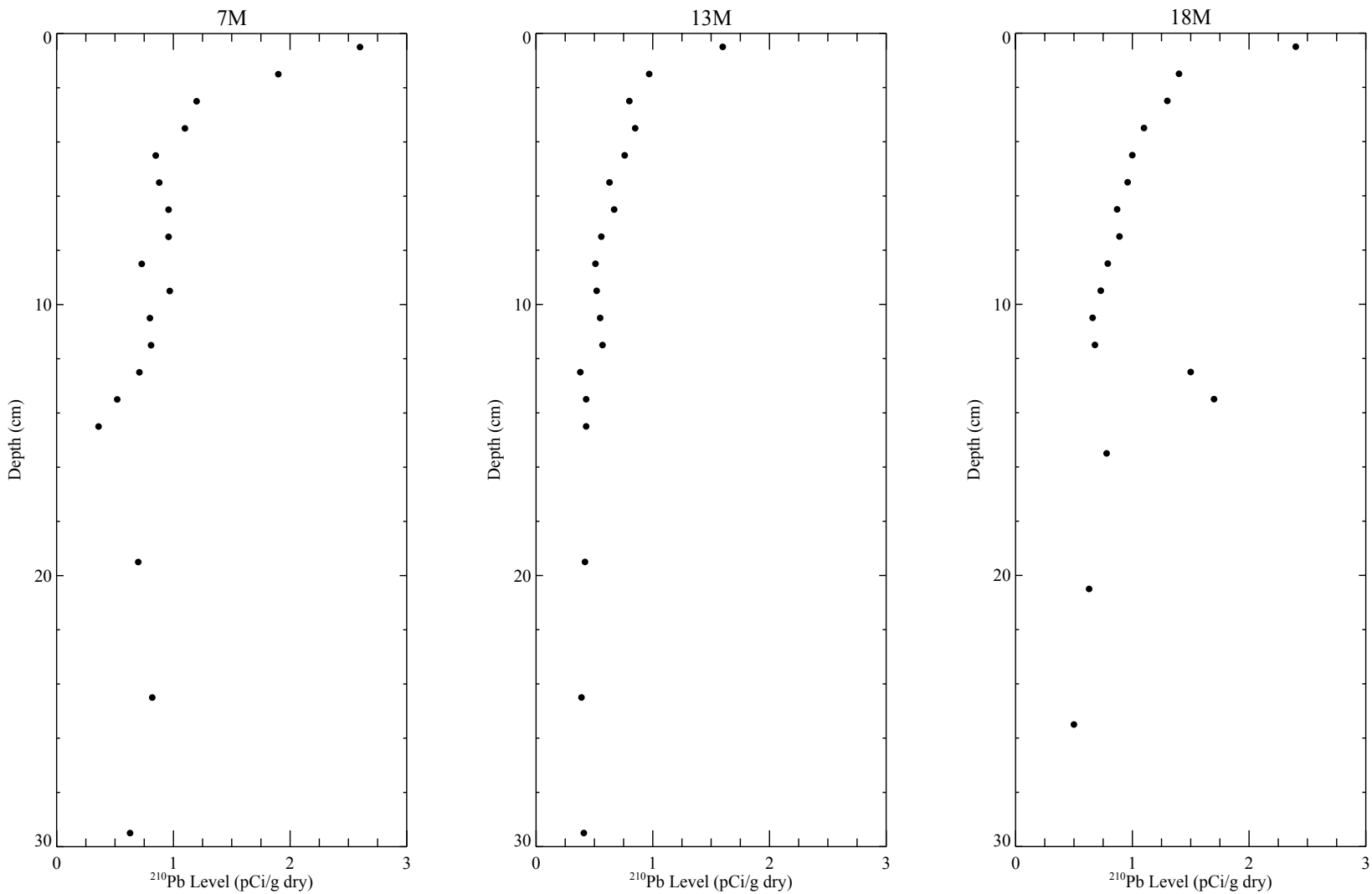


Figure A4-17. ^{210}Pb Concentrations in lower Grasse River sediment

Data collected during 1997 SRS Sediment Survey Program.
Circles represent measured ^{210}Pb levels.
Data table: sediment_bz

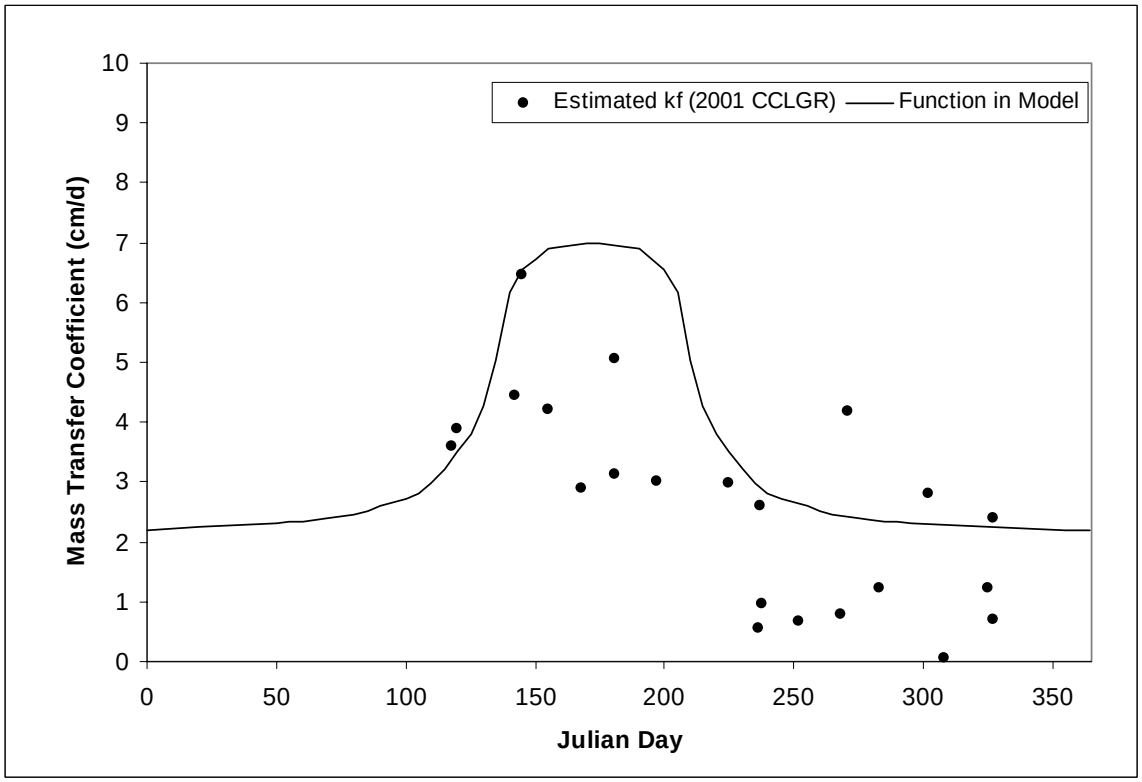
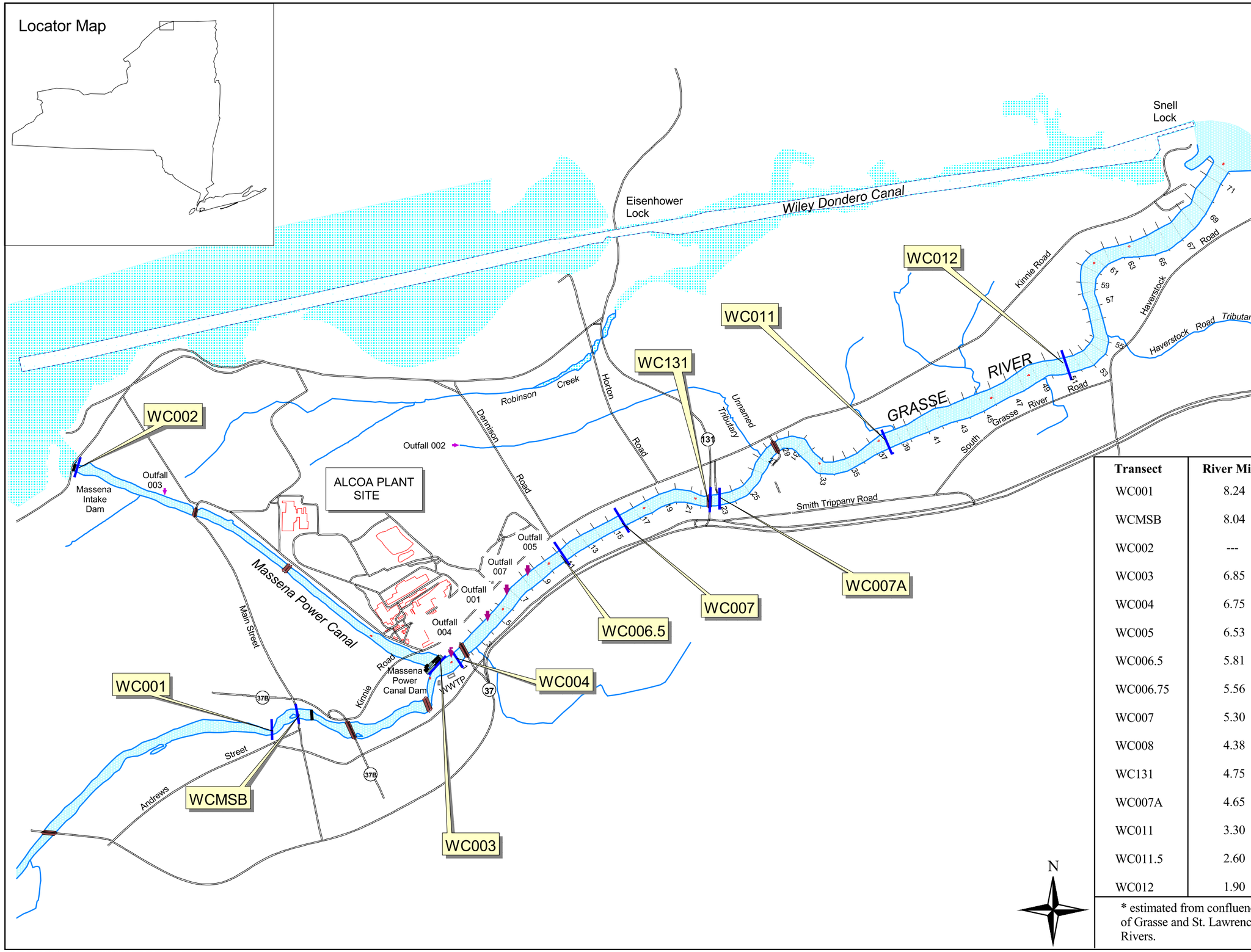


Figure A4-18. Sediment-water mass-transfer coefficient function used in cohesive elements of the lower Grasse River PCB fate model.

Source: PM – D:\ALCgra\Model\PCBFATE\Inputs\Kf\Analysis_kf_new_and_old.xls



GRAPHIC SCALE

1000 0 1000 Feet

Transect	River Mile*
WC001	8.24
WCMSB	8.04
WC002	---
WC003	6.85
WC004	6.75
WC005	6.53
WC006.5	5.81
WC006.75	5.56
WC007	5.30
WC008	4.38
WC131	4.75
WC007A	4.65
WC011	3.30
WC011.5	2.60
WC012	1.90

* estimated from confluence of Grasse and St. Lawrence Rivers.

LEGEND

- Water_Column_Sampling_Locations
- River Flow Direction Arrows
- Wiley Dondero Canal Outline
- Wiley Dondero Canal Area
- St. Lawrence Seaway Outline
- Roads
- Waste Water Treatment Plant
- ALCOA Buildings
- Bridges
- Dams
- Grasse River + Tributaries Shoreline
- Sediment Probing Transects

Lower Grasse River Study Area
Massena, New York

Figure A4-19.
Water column sampling locations.

ALCOA

April 2001

DN - \\Daleel\D_DRIVE\ALCgra\GIS\GIS_fig_C1_1\water_column_locat.apr

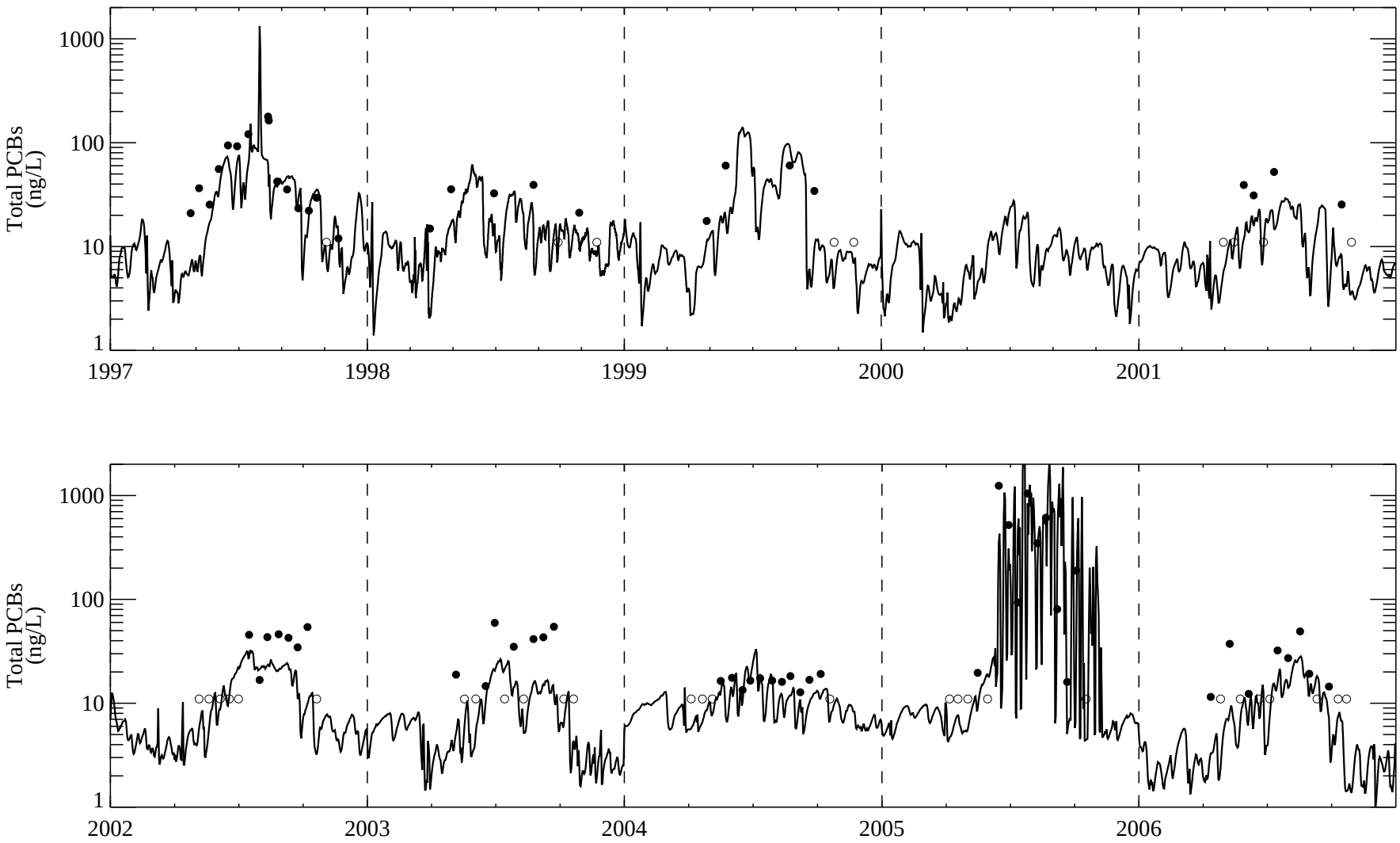


Figure A4-20. Model/Data comparison for water column PCB concentrations (1997-2006) at WC007.

Duplicates averaged; data collected on same day averaged

Non-detects plotted at 11 ng/L (half the MDL) using open symbols. Model results truncated at 11 ng/L.

Data tables: water_bz, water_iupac; RunID(s): calib_0807-03, calib_1002-02

Model
Data

RN/PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Outputs\Postprocessors\model_data_WC_pcb_temporal_v2.pro
Wed Mar 10 09:43:35 2010

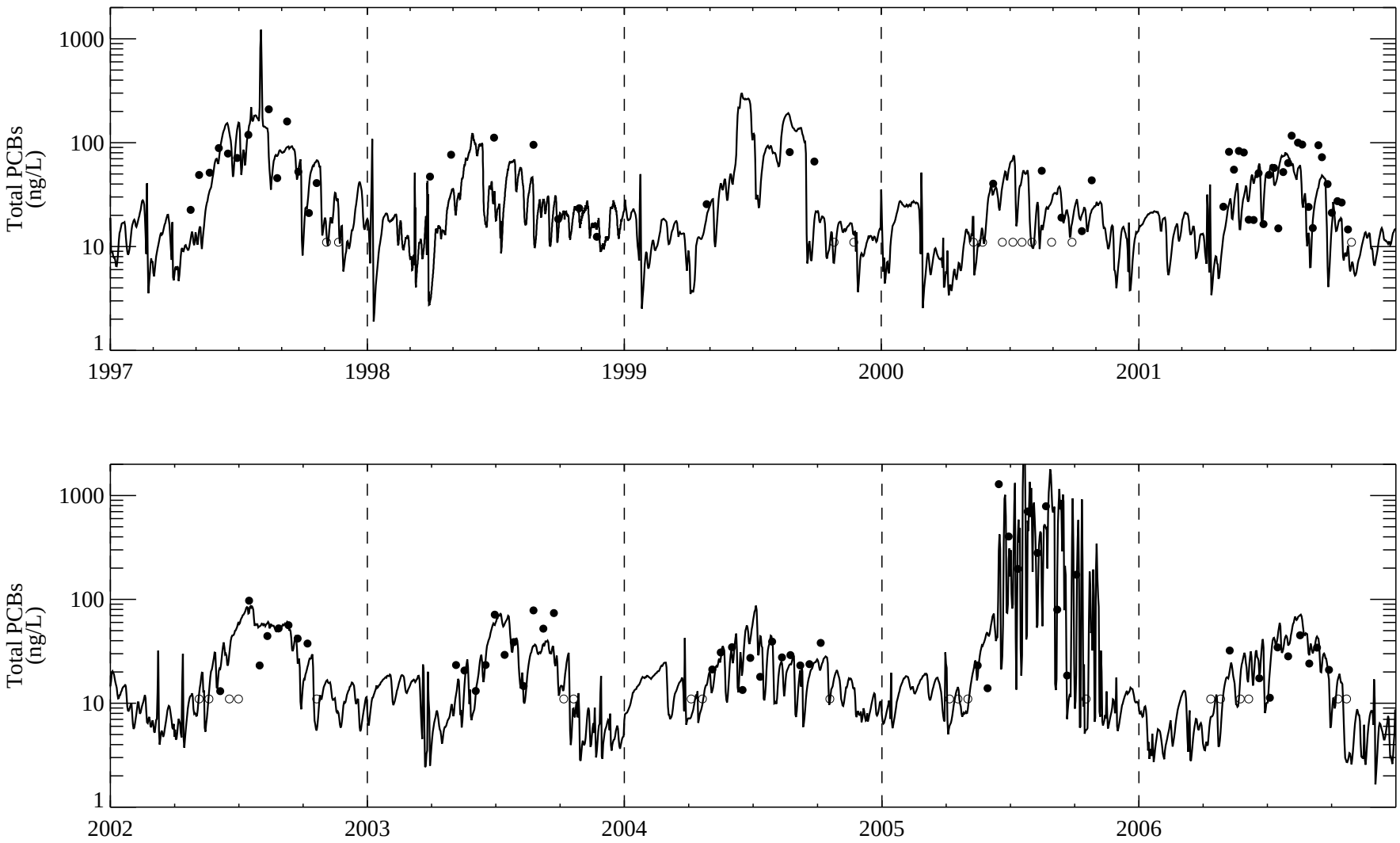


Figure A4-21. Model/Data comparison for water column PCB concentrations (1997-2006) at WC131.

Prior to 2001 WC samples from WC007A

Duplicates averaged; data collected on same day averaged

Non-detects plotted at 11 ng/L (half the MDL) using open symbols. Model results truncated at 11 ng/L.

Data tables: water_bz, water_iupac; RunID(s): calib_0807-03, calib_1002-02

Model
Data

RN/PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Outputs\Postprocessors\model_data_WC_pcb_temporal_v2.pro
Wed Mar 10 09:43:35 2010

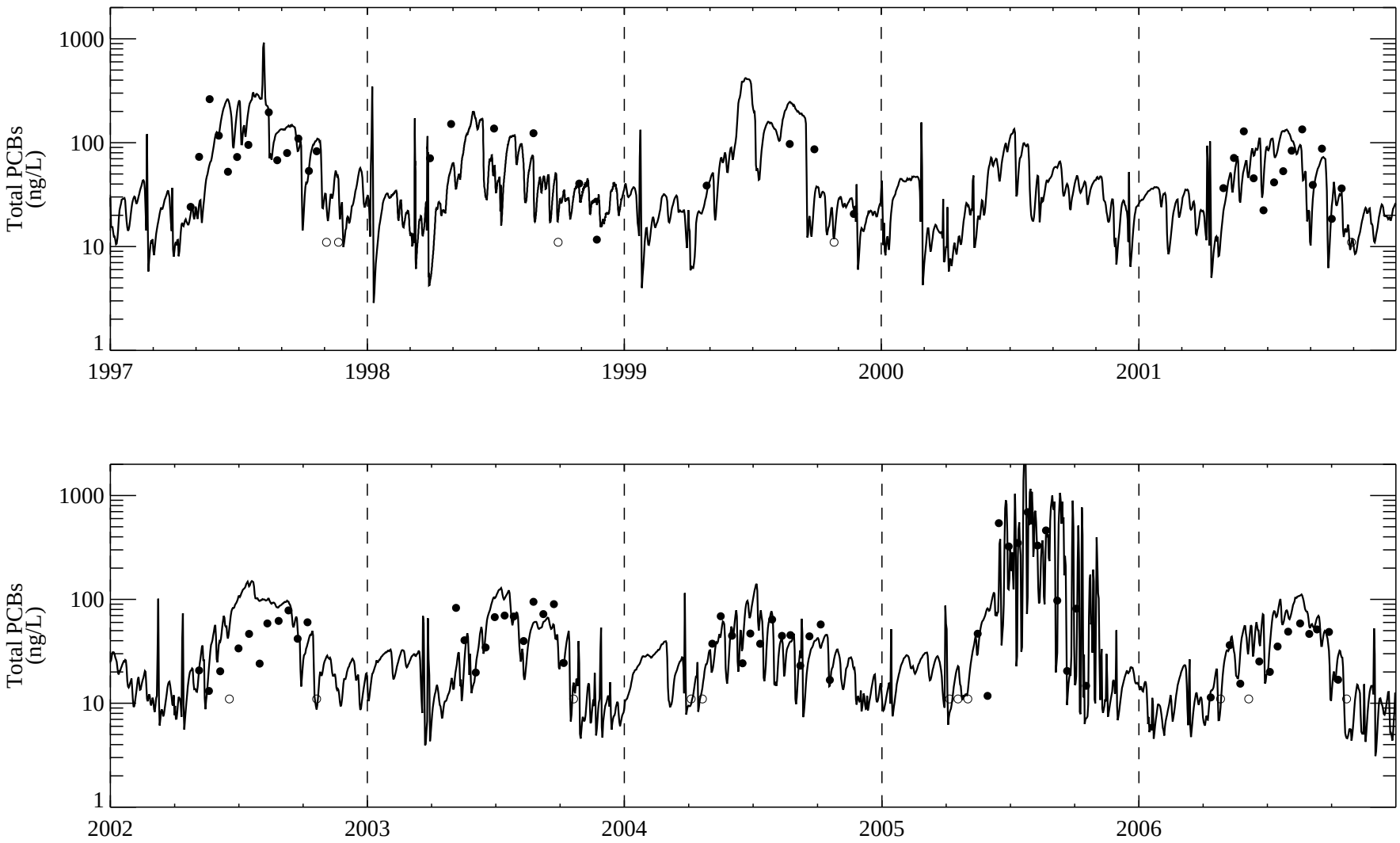


Figure A4-22. Model/Data comparison for water column PCB concentrations (1997-2006) at WC011.

Duplicates averaged; data collected on same day averaged

Non-detects plotted at 11 ng/L (half the MDL) using open symbols. Model results truncated at 11 ng/L.

Data tables: water_bz, water_iupac; RunID(s): calib_0807-03, calib_1002-02

Model
Data

RN/PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Outputs\Postprocessors\model_data_WC_pcb_temporal_v2.pro
Wed Mar 10 09:43:35 2010

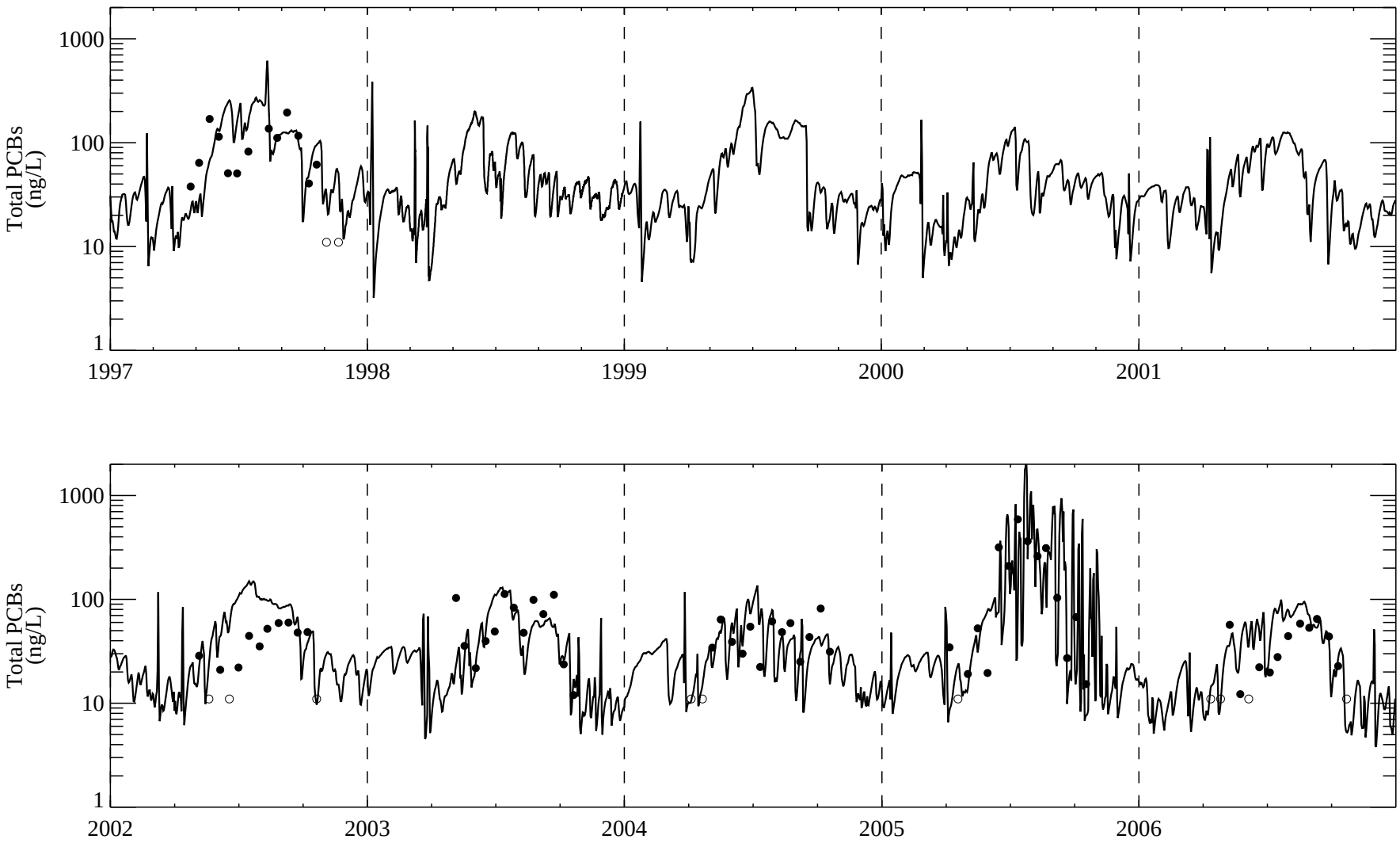


Figure A4-23. Model/Data comparison for water column PCB concentrations (1997-2006) at WC012.

Duplicates averaged; data collected on same day averaged

Non-detects plotted at 11 ng/L (half the MDL) using open symbols. Model results truncated at 11 ng/L.

Data tables: water_bz, water_iupac; RunID(s): calib_0807-03, calib_1002-02

Model
Data

RN/PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Outputs\Postprocessors\model_data_WC_pcb_temporal_v2.pro
Wed Mar 10 09:43:35 2010

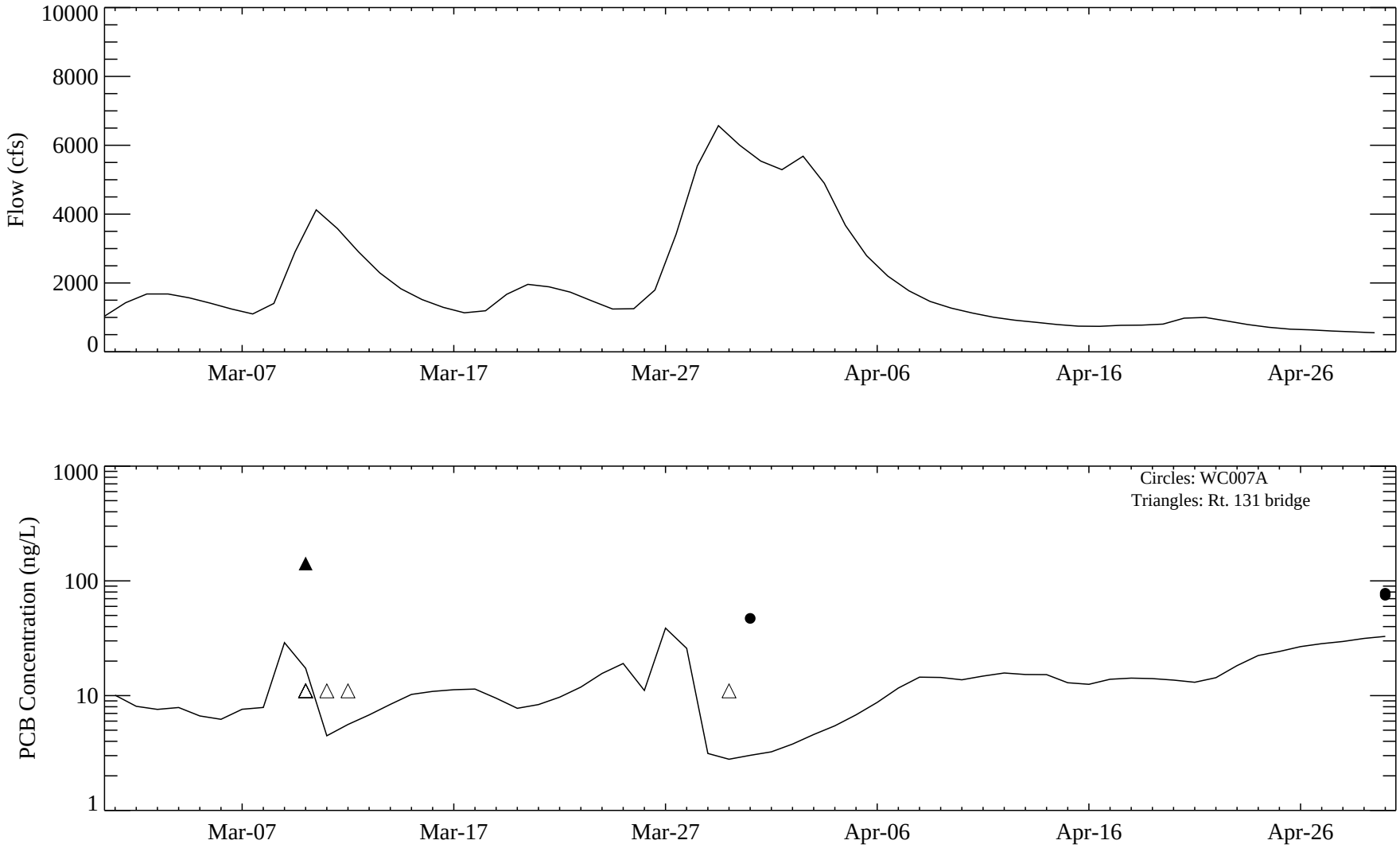


Figure A4-24. Temporal profile of water column PCB data (symbols) and model output (line) for Route 131 Bridge during the March 1998 high flow event.

Non-detects plotted at half the detection limit with open symbols (11 ng/L)

Data tables: riverflow_hist, riverflow_trans, water_iupac

PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Outputs\Postprocessors\stormflow_model_data_mar_1998_v2.pro
Wed Mar 10 09:57:00 2010

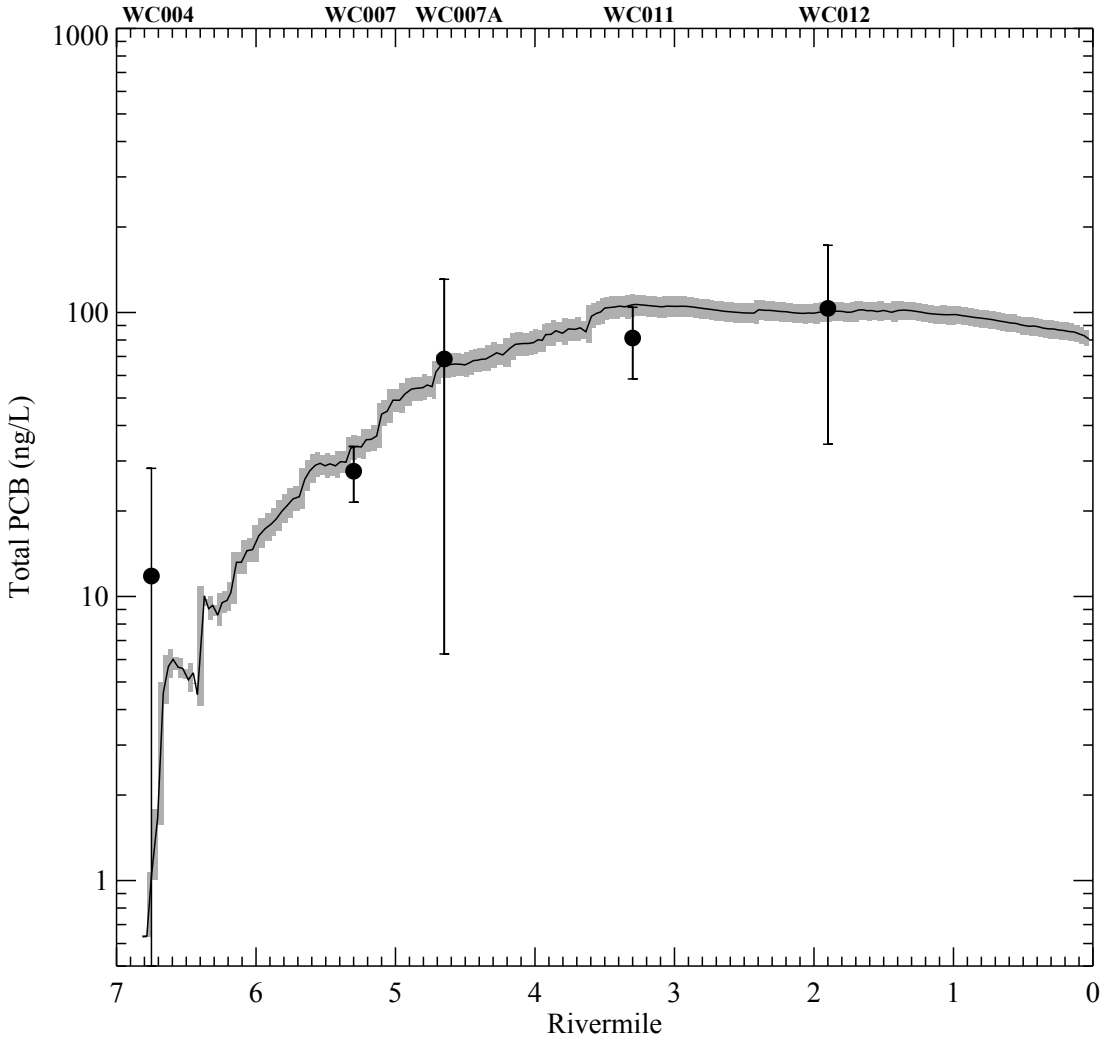


Figure A4-25. Spatial profiles of water column PCB data (symbols) and model output (line) during average low flow (< 1,100 cfs) conditions in September and October, 1997.

Error bars for data and shaded region for model show two standard errors from mean.

Data table: water_bz; Model Run: calib_0807-03.

PM - D:\ALCgra\Model\PCBFATE\Outputs\Postprocessors\low_flow_pcb_spats.pro
Thu Oct 23 10:58:28 2008

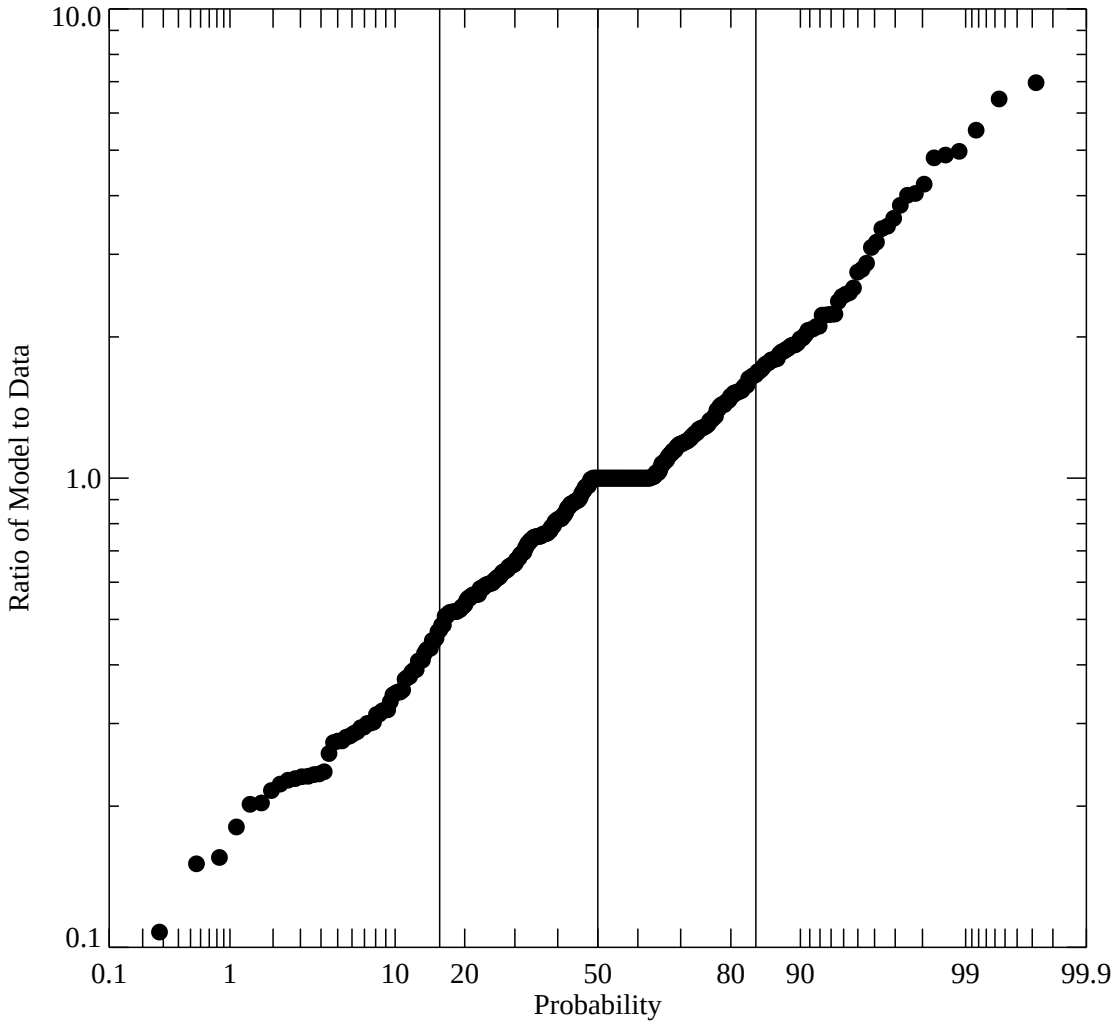


Figure A4-26. Distribution of the ratio of paired water column PCB data and model results during the calibration period (1997-2006).

Non-detects and model results below the detection limit (22 ng/L) set to half the detection limit.

Data tables: water_bz, water_iupac; Model Run: calib_1002-02.

PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Outputs\Postprocessors\wc_pcb_prob_plot_v2.pro
Wed Mar 10 10:02:37 2010

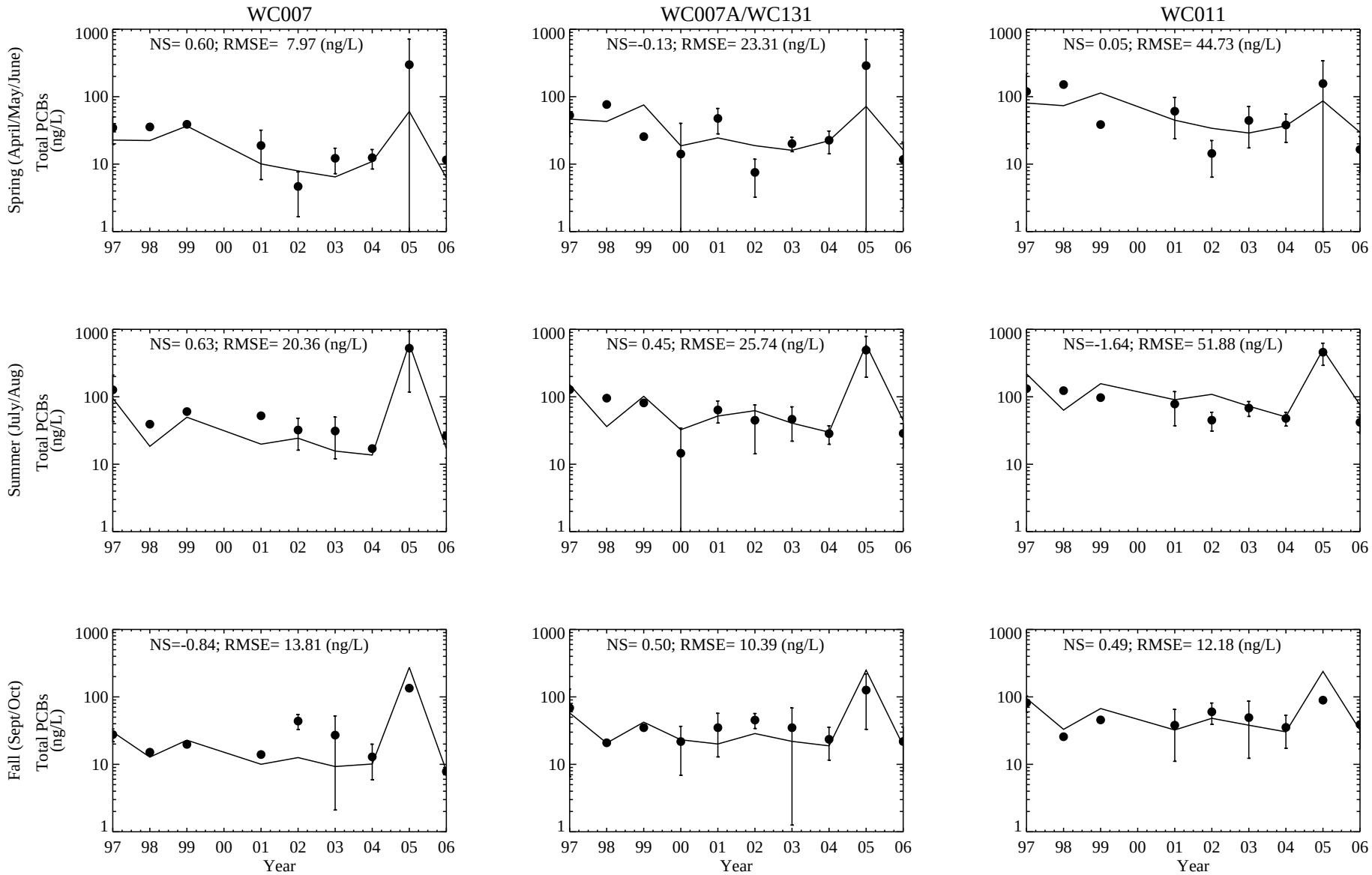
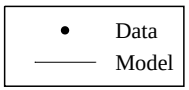


Figure A4-27. Seasonal average water column PCB concentrations: model/data comparison.
Data represent samples collected when river flow was less than or equal to 2200 cfs. 1995 to 1999 data represent composite samples collected during non-stratified periods. 2000 to 2007 data represent surface samples collected at 0.2 times the total water depth.
Error bars represent two standard errors of the mean; error bars not shown if sample count is fewer than three.
For model/data comparisons NS = Nash-Sutcliffe; RMSE = Root mean squared error. These exclude 2005-2006 data due to ROPS.
Duplicates averaged; data collected on same day averaged.
Data tables: riverflow_hist, water_bz, water_peak, water_iupac, riverflow_chasemills; RunID: calib_1002-02.



PM - D:\ALCgra\Model\PCBFATE\Outputs\Postprocessors\PCB_temporal_007_007A131_011_012_DSR_PM_v2.pro
Wed Mar 10 16:27:05 2010

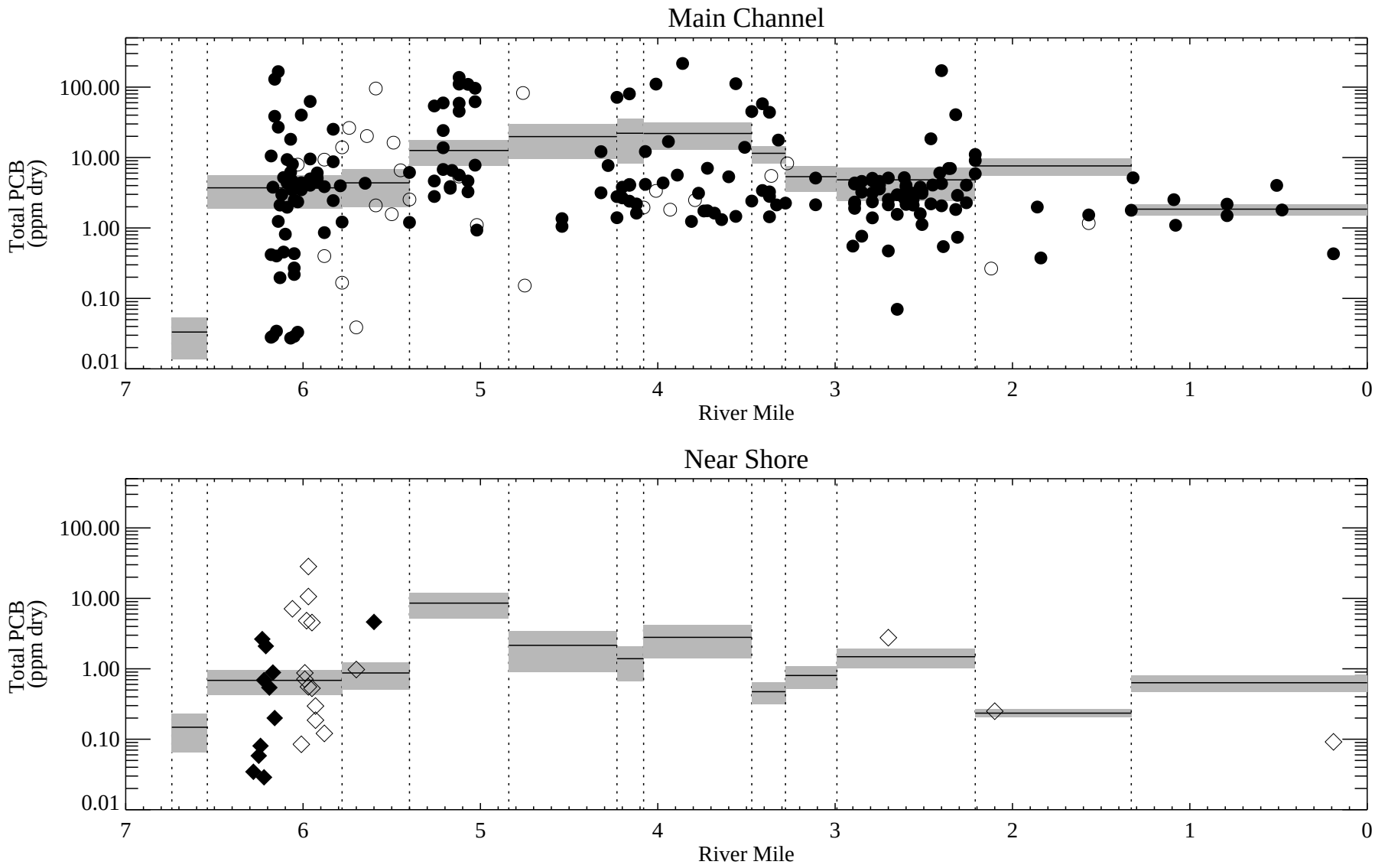


Figure A4-28. Sediment (0-3 inches) PCB concentrations in the Grasse River: model/data comparisons.

Lines represent model mean values over the river-mile interval; Shaded regions are model mean +/- 2 standard errors.
Model results from 2006. Sediment data collected in 2006-2007.
Runid: calib_1002-02

○ Type 1 (Coarse)
● Type 2 (Fine)
◇ South Shore
◆ North Shore

RN/PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Outputs\Postprocessors\sed_pcb_bands_v2.pro
Thu Mar 11 13:53:41 2010

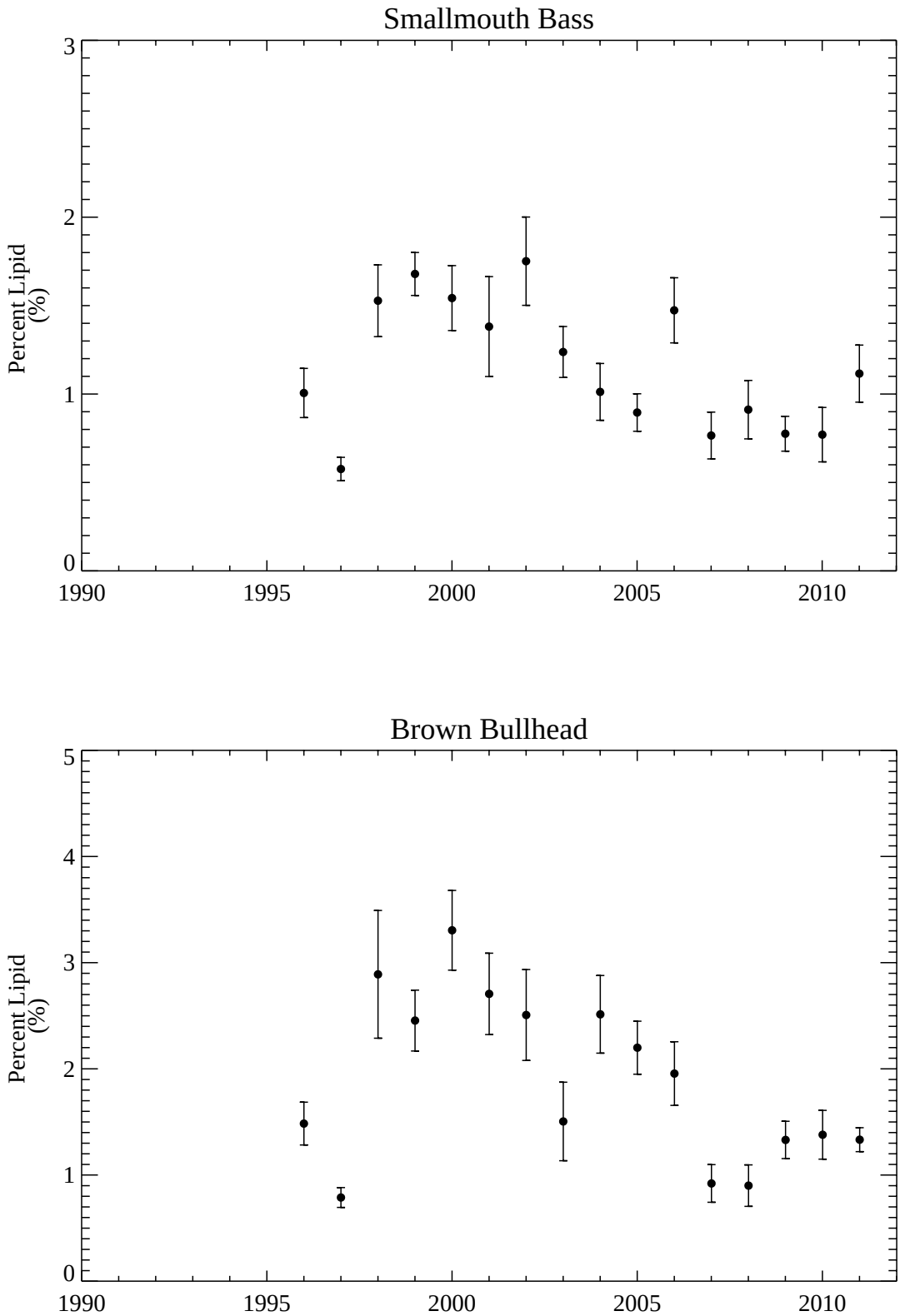


Figure A5-1. River-wide average fish lipid levels over time in the Grasse River.

River-wide average based on fish collected from the Upper, Middle, and Lower Stretches.
Values represent arithmetic averages (+/- 2 standard errors).
Smallmouth bass and brown bullhead - adult individual fillets.

Data table: resfish_aro

ARC - C:\Jobs\ALCgra\Analysis\ResFish\IDL\fall11\resfish_lipid_temporals_riverwide_avg.pro
Wed May 09 13:24:58 2012

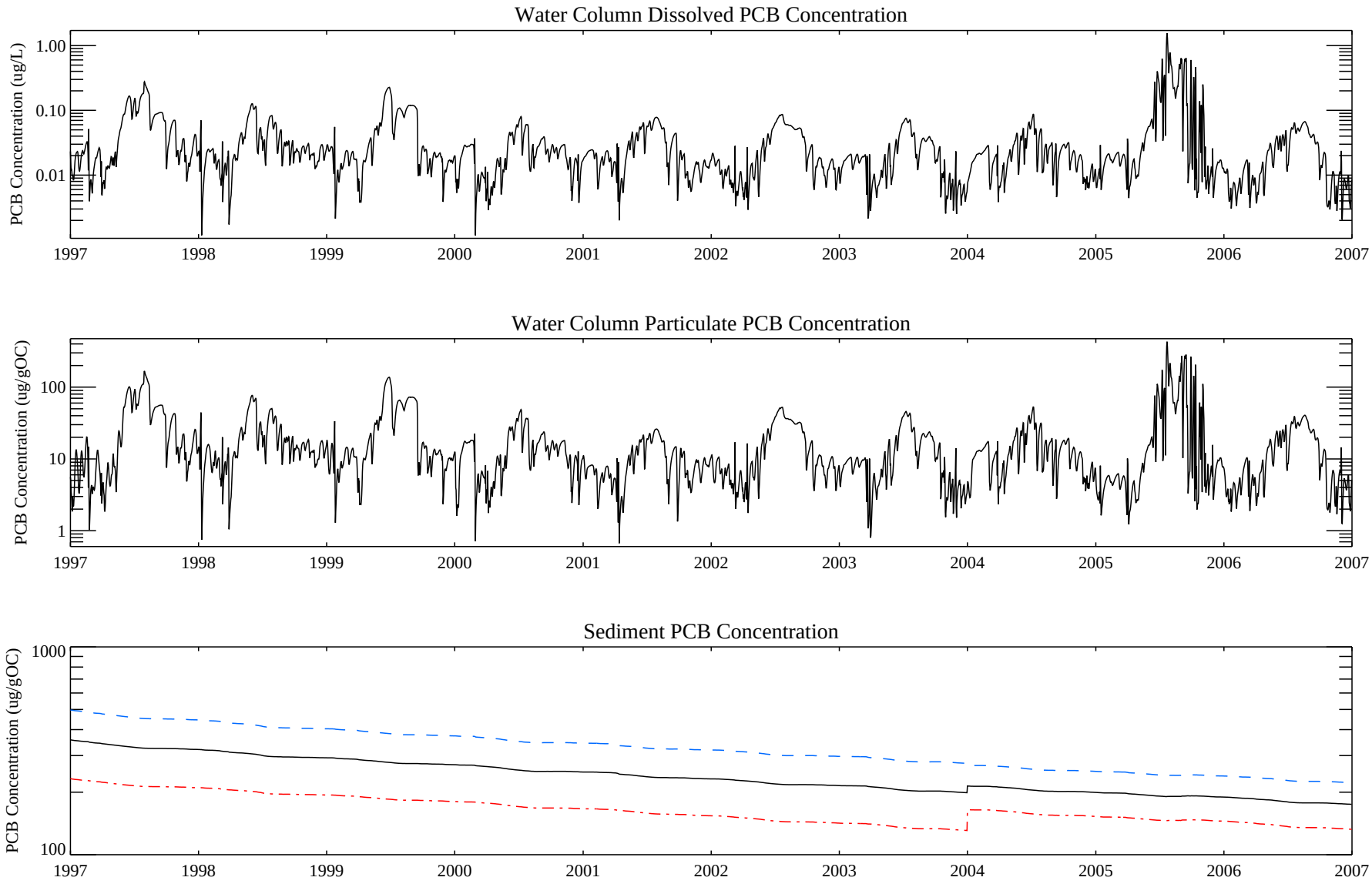


Figure A5-2. PCB exposure concentrations used in the bioaccumulation model for the reaches spanning confluence with Massena Power Canal to the mouth of the Grasse River.

PCB concentrations based on total PCB levels computed by fate model.

old: calib_0807-03; new calib_1002-02 from 2004.

PM - C:\AQ\Jobs\ALCgra\Model\PCBFATE\Calibration\Analysis\Biomod_inputs\create_biomod_inputs_ver3.pro
Mon Feb 15 16:22:05 2010

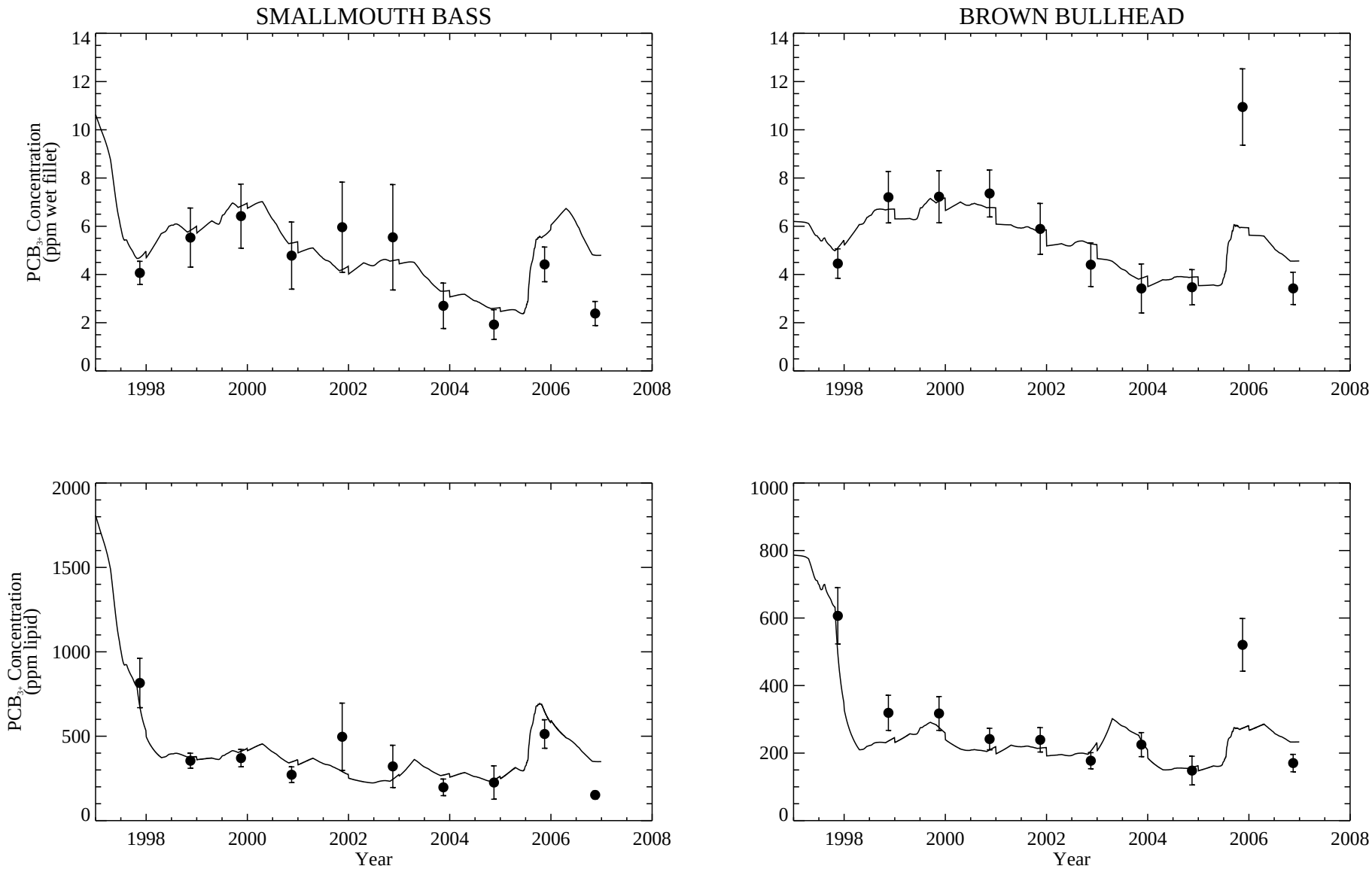


Figure A5-3. Predicted (line) and measured (symbols) PCB_{3+} concentrations in Smallmouth Bass and Brown Bullhead collected from the lower Grasse River.

Solid lines indicate model results. Model runs 01-050712(A-J)full
Circles represent arithmetic means +/- 2 standard errors of Aroclor data collected from Upper, Middle & Lower Stretches.

Data tables: resfish_aro, resfish_bz, resfish_peak

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\calib_fullriver_2010.pro
Wed May 09 13:44:52 2012

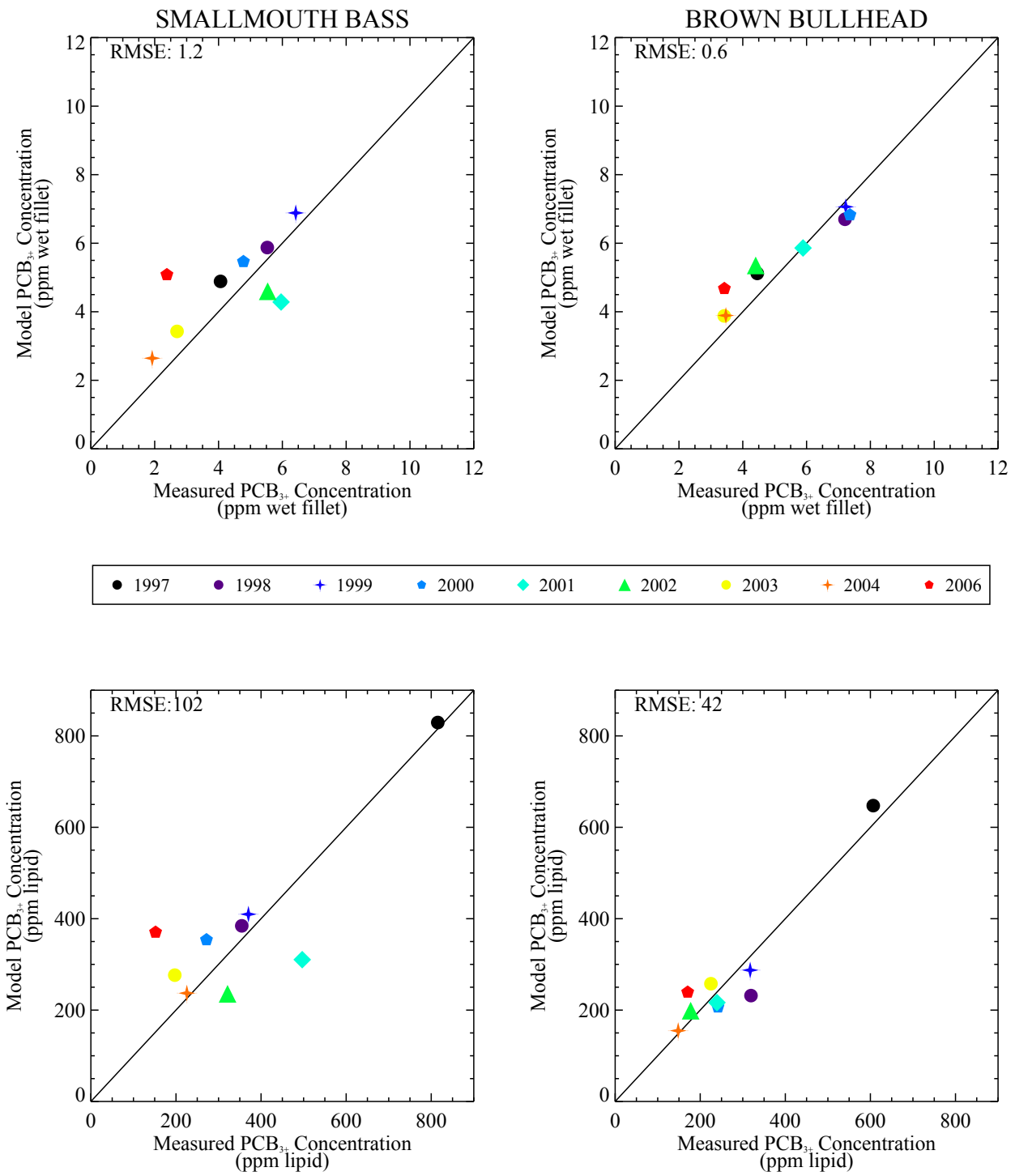
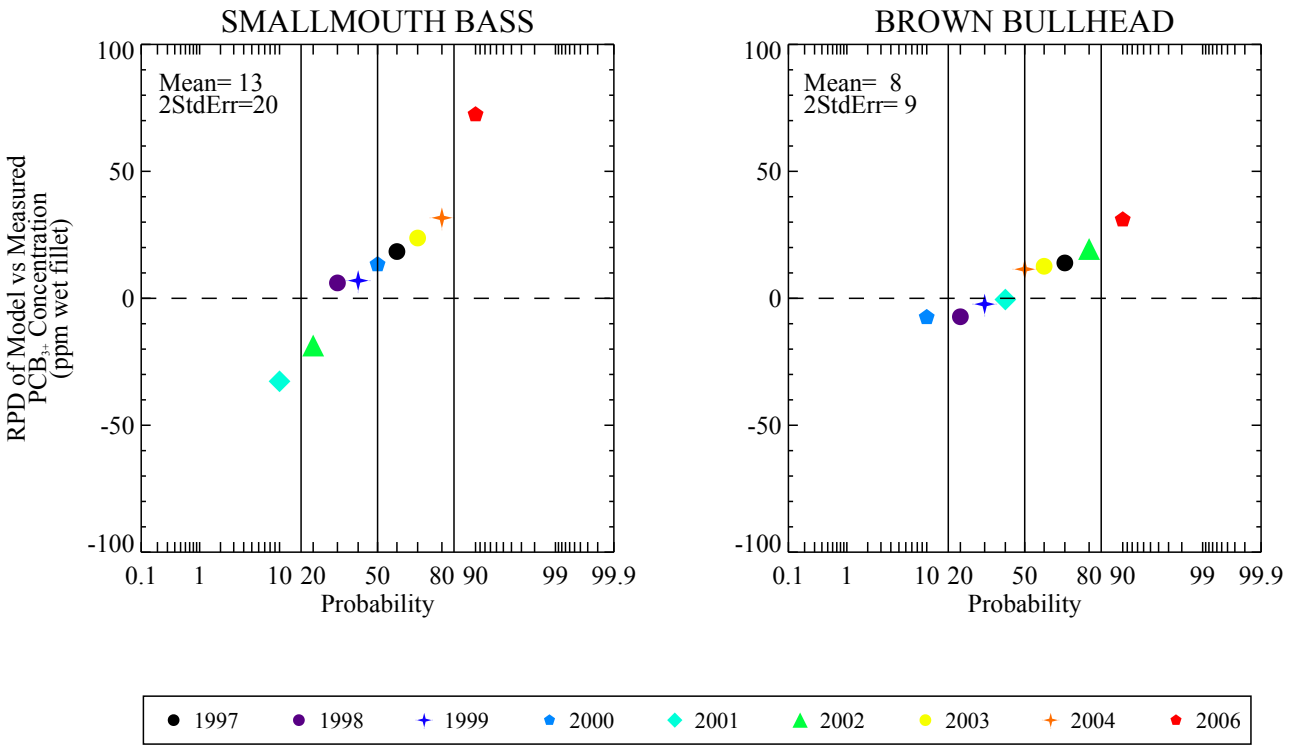


Figure A5-4. Model predicted vs measured PCB_{3+} concentrations in smallmouth bass and brown bullhead collected from the lower Grasse River.

RMSE=Root Mean Square Error. Data from 2005 is excluded from RMSE calculation
Model data based on average over Sept/Oct timeframe, run 01-050712(A-J)full.
Measured data represent arithmetic means of Aroclor data collected from Upper, Middle & Lower Stretches.

Data tables: resfish_aro, resfish_bz, resfish_peak

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\calibration_1to1_RMSEstat.pro
Mon May 07 15:17:40 2012



Positive values indicate model over-predicts concentrations; negative values indicate model under-predicts concentrations.

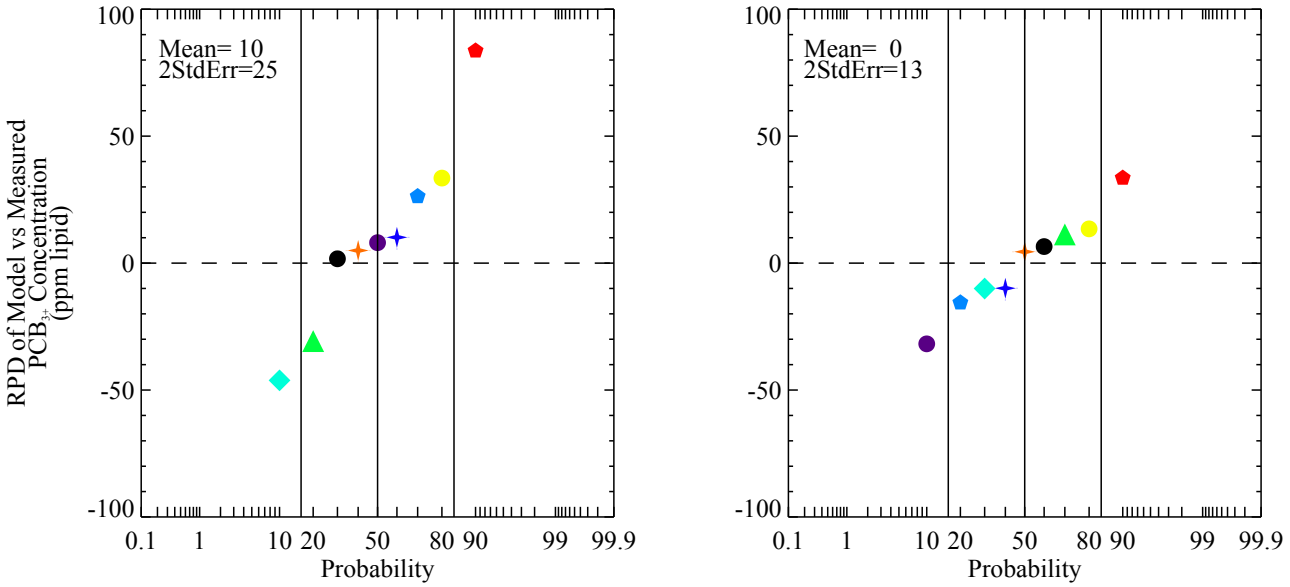


Figure A5-5. RPD distributions of model predicted vs measured PCB_{3+} concentrations in smallmouth bass and brown bullhead collected from the lower Grasse River.

RPD=Relative Percent Difference. Data from 2005 is excluded from RPD calculation
Model data based on average over Sept/Oct timeframe, run 01-050712(A-J)full.
Measured data represent arithmetic means of Aroclor data collected from Upper, Middle & Lower Stretches.

Data tables: resfish_aro, resfish_bz, resfish_peak

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\calibration_probplot_RPD.pro
Mon May 07 15:19:45 2012

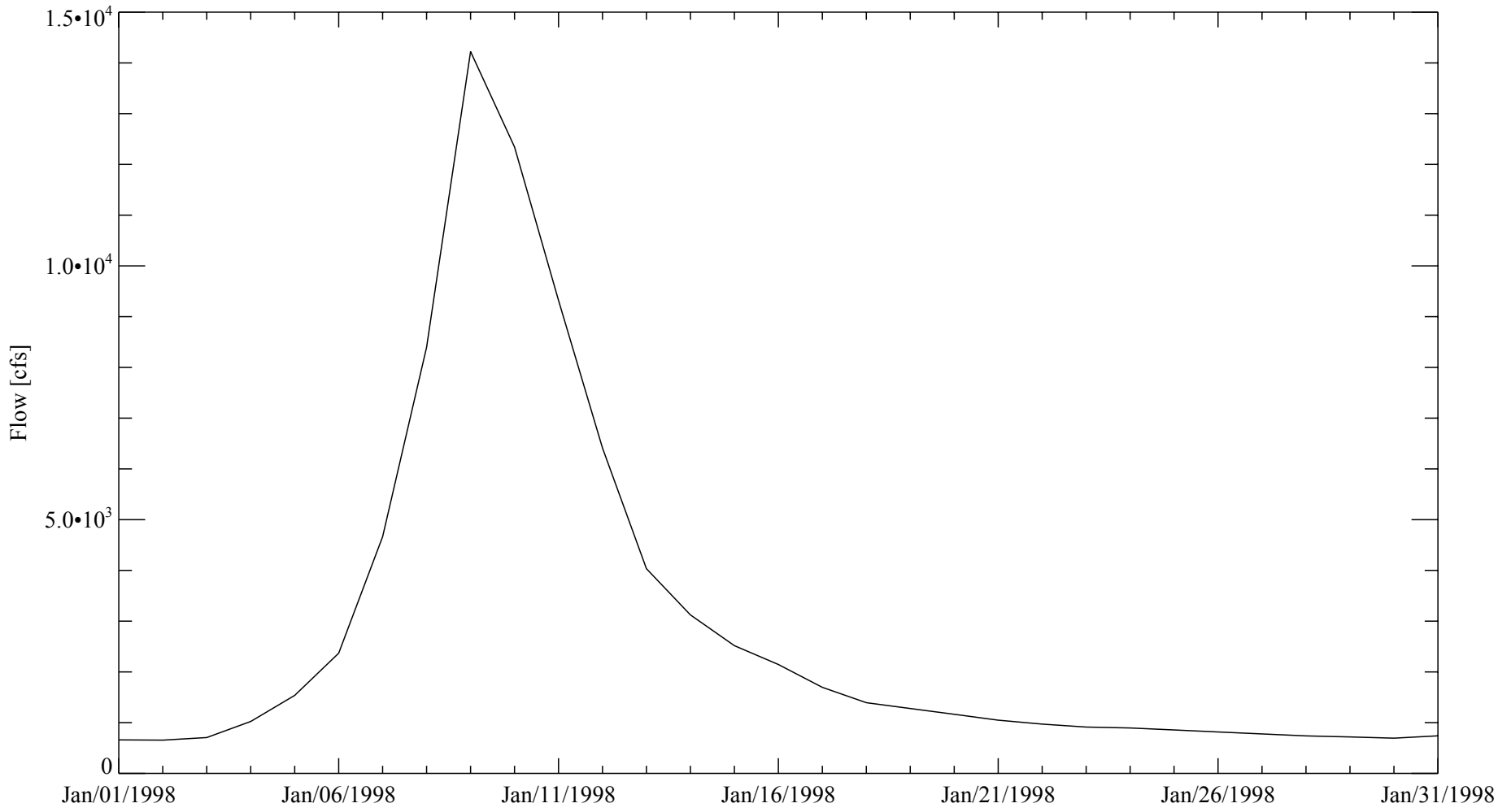
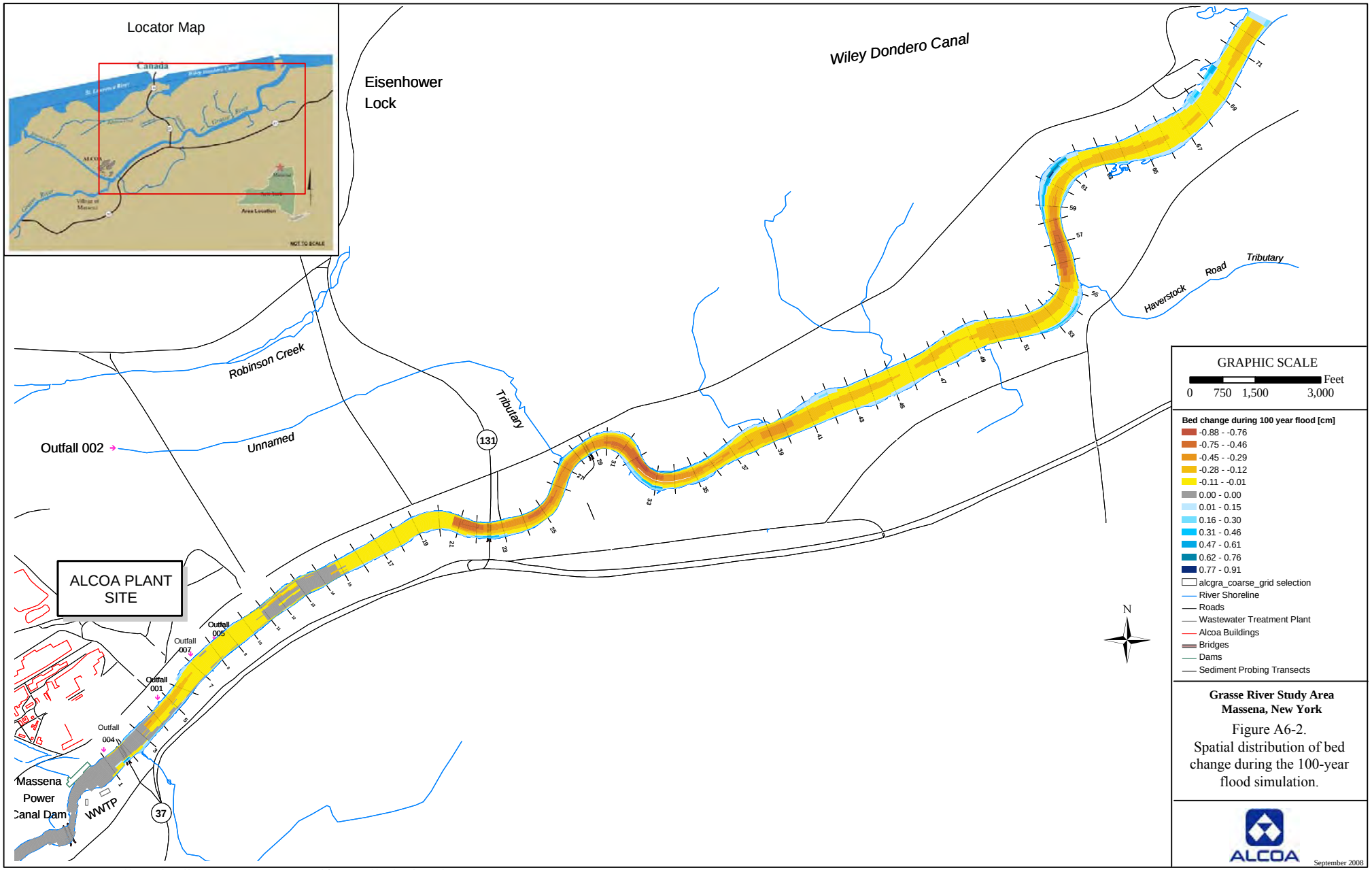


Figure A6-1. Hydrograph for 100-year flood that occurred in January 1998.

Data source: \\Peter\D_DRIVE\\JOBS\ALCgra\Model\EFDC\Input_Files\BC_Flow_Files\Oswa_n_Chase_Mills_PMO_071115.csv

PMO - D:\JOBS\ALCgra\Model\EFDC\Input_Files\BC_Flow_Files\bc_q_PMO_20071113.pro
Mon Sep 15 15:41:39 2008



Grasse River Study Area
Massena, New York

Figure A6-2.
Spatial distribution of bed change during the 100-year flood simulation.

PO - \\Peter\D_DRIVE\JOBS\ALCgra\Model\EFDC\Sedtran\Calibration\Longterm\seq-2\GIS_map\2006_map_shift\ALCgra_Model_results_analysis3.mxd

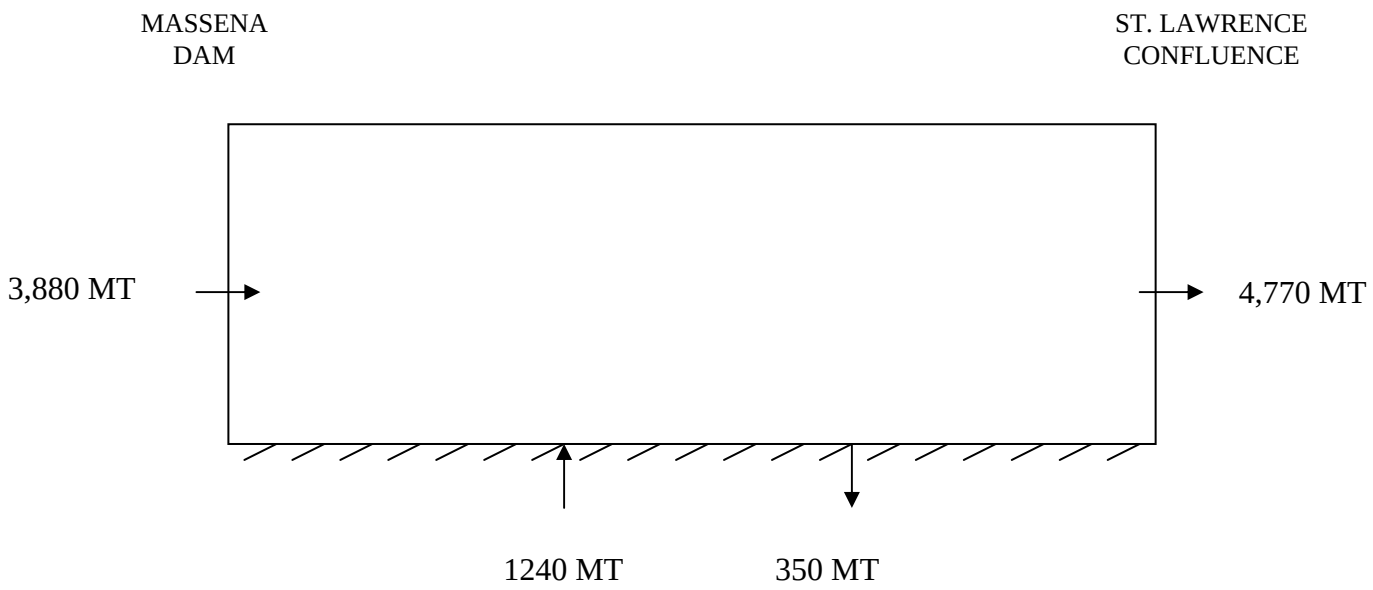


Figure A6-3. Lower Grasse River sediment mass balance for the January 1998 (100-Year) flood.

HAZ - 98flood_sedtran_mass_balance_fig_A6-3.ppt

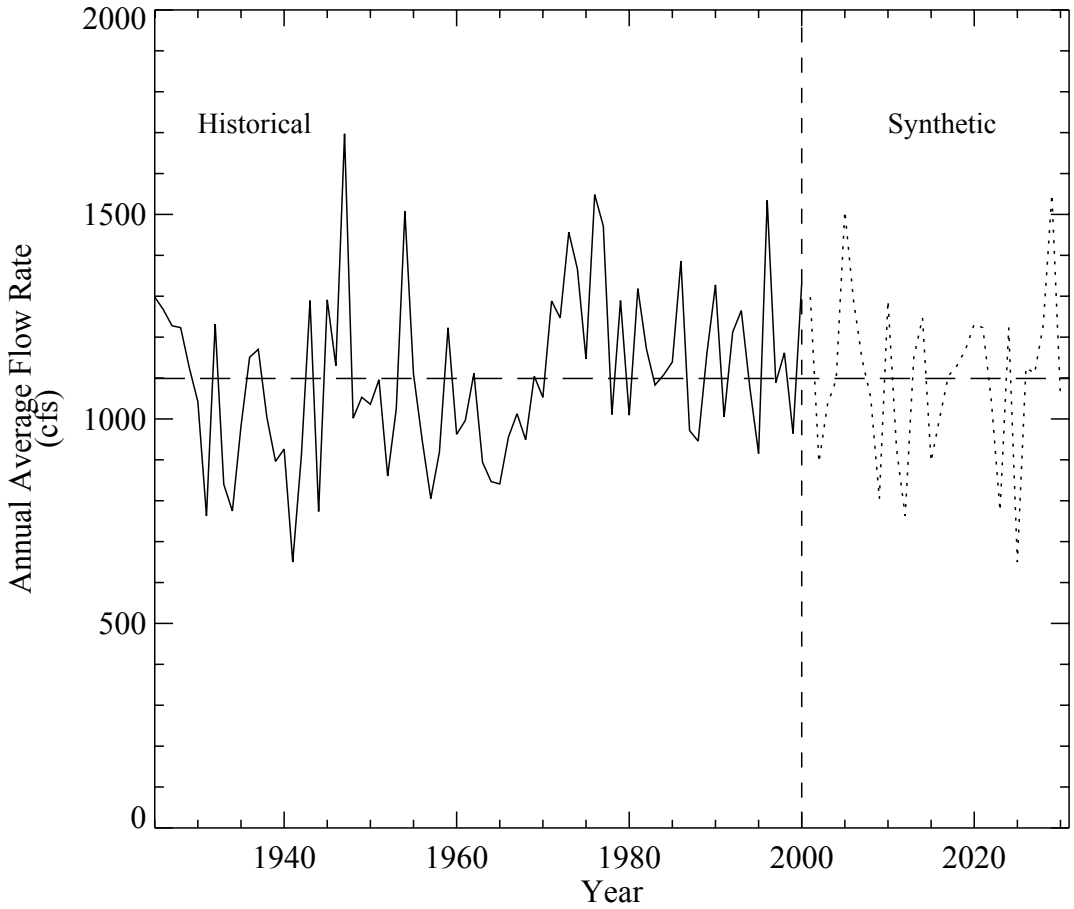


Figure. A7-1. Data-based (solid line) and synthetic (dashed line) hydrographs for annual average flow rate at Massena.

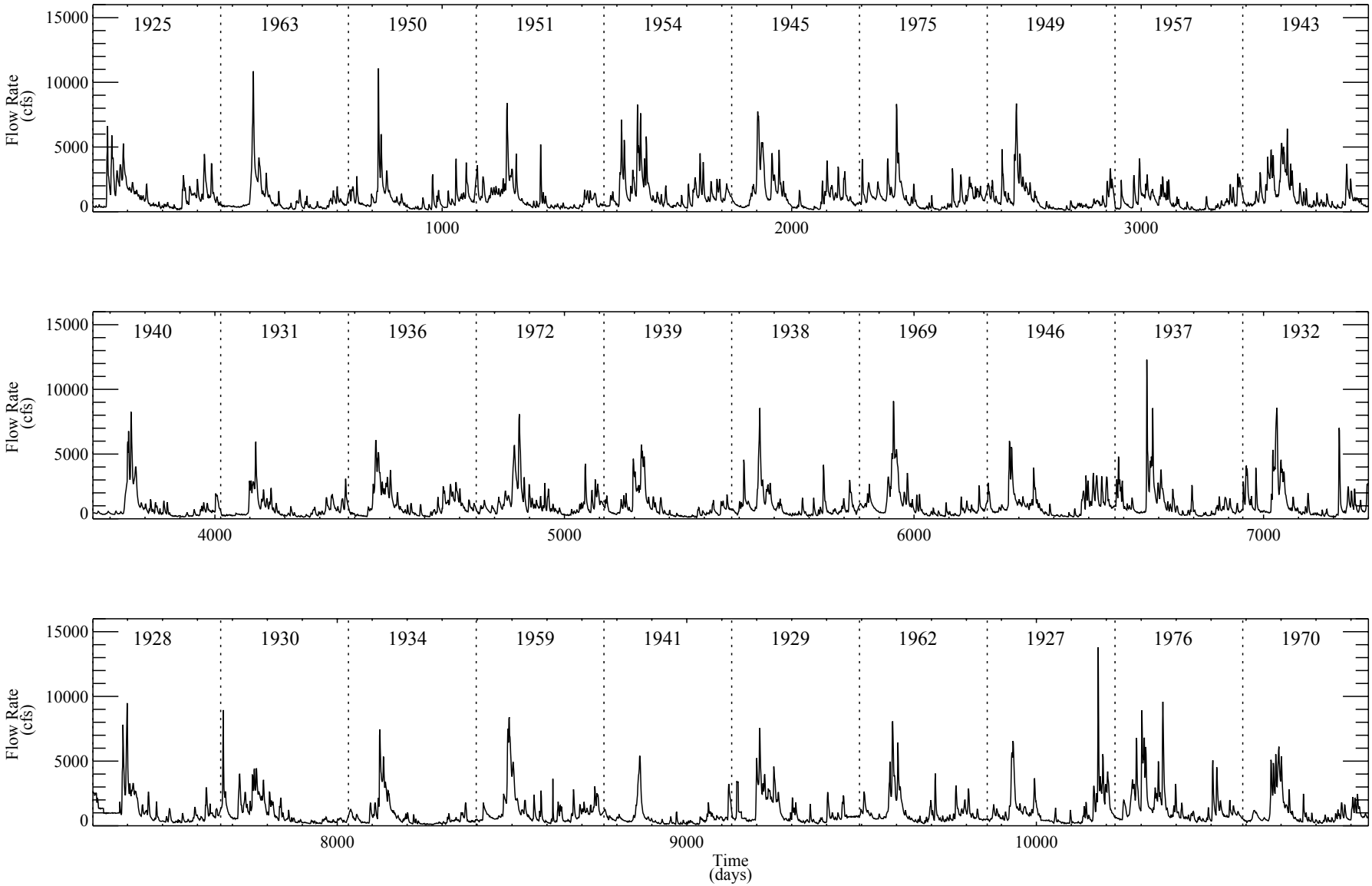


Figure A7-2. 30-year synthetic hydrograph (daily average discharge) developed from historical Grasse River flow rates.

DN - \\Daleel\D_Drive\ALCgra\Model\Hydro\Outputs\Hydro_Projection_0105-01\check_rorr_30yrs.pro (haz)
Mon Feb 11 12:21:37 2002

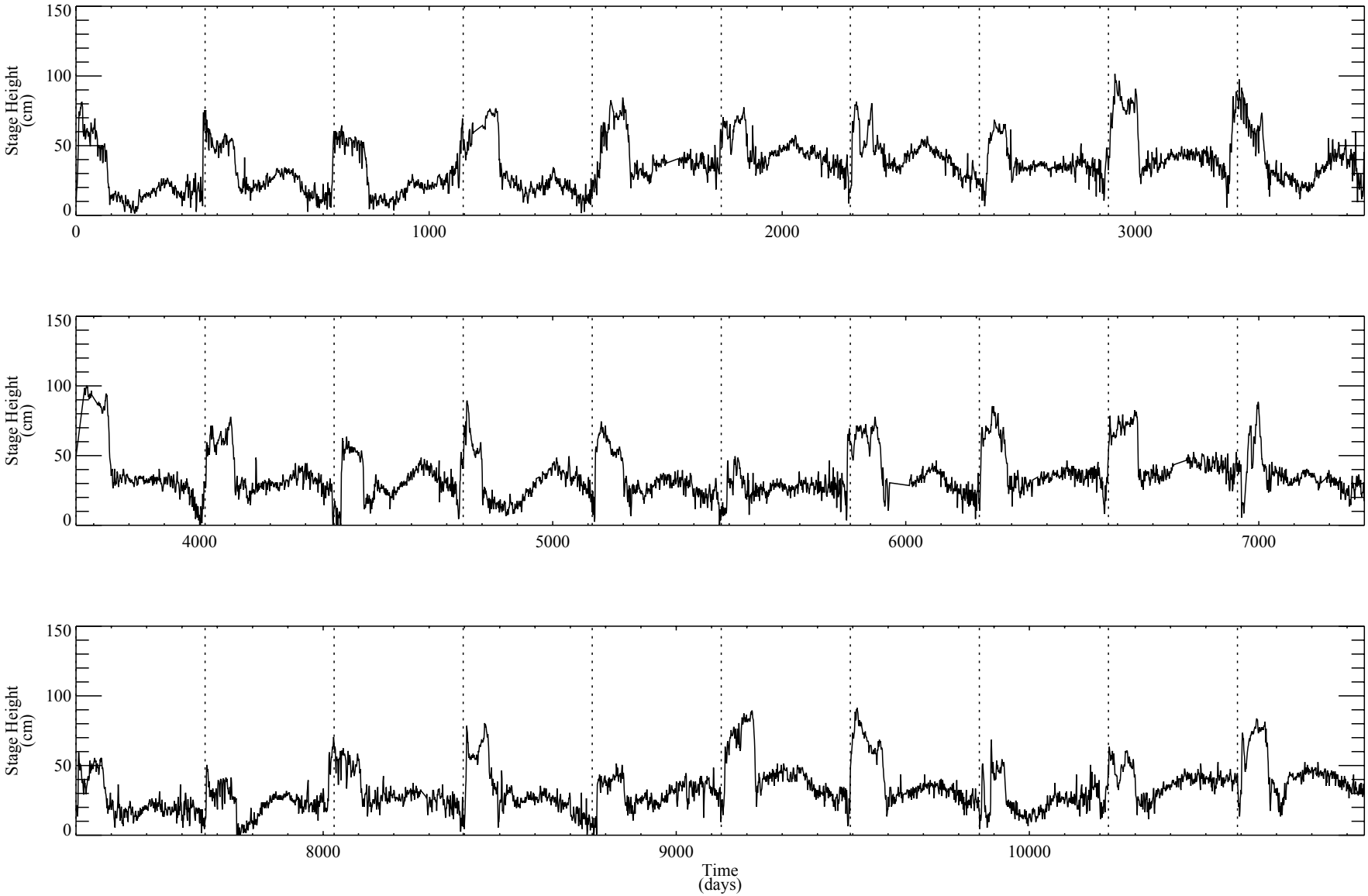


Figure A7-3. Stage height specified at downstream boundary during 30-year simulation.

DN - \\Daleel\D_Drive\ALCgra\Analysis\Water\Flow\SYN_FLOW_STAGE\SYN_Stage\plot_stage_from_out.pro (haz)
Mon Feb 11 12:24:38 2002

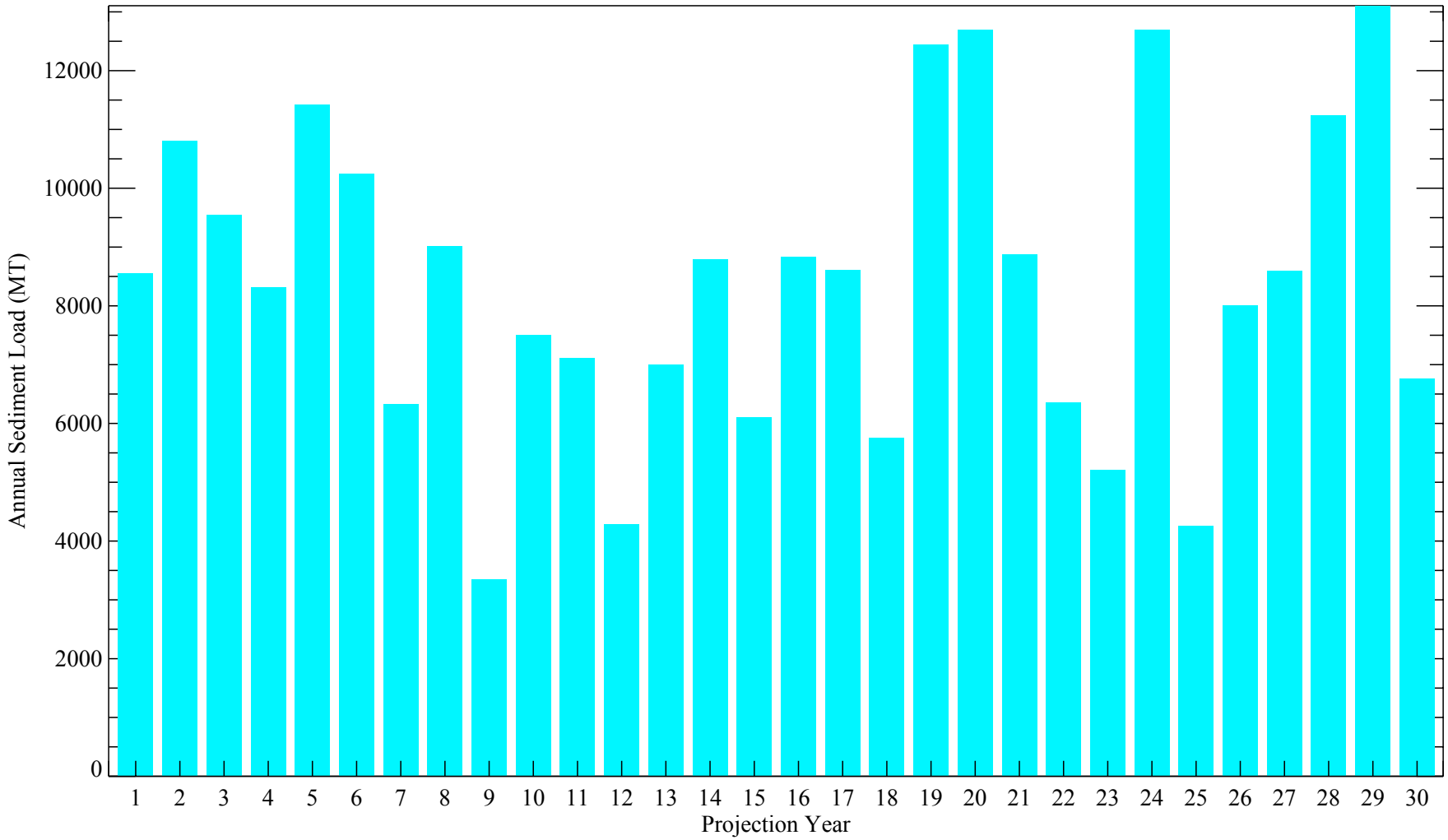


Figure A7-4. Annual sediment loading during the 30-year projection period.

Data source: \\PETER\D_DRIVE\JOBS\ALCgra\Documents\Report\B3-4\TSS_MT.csv

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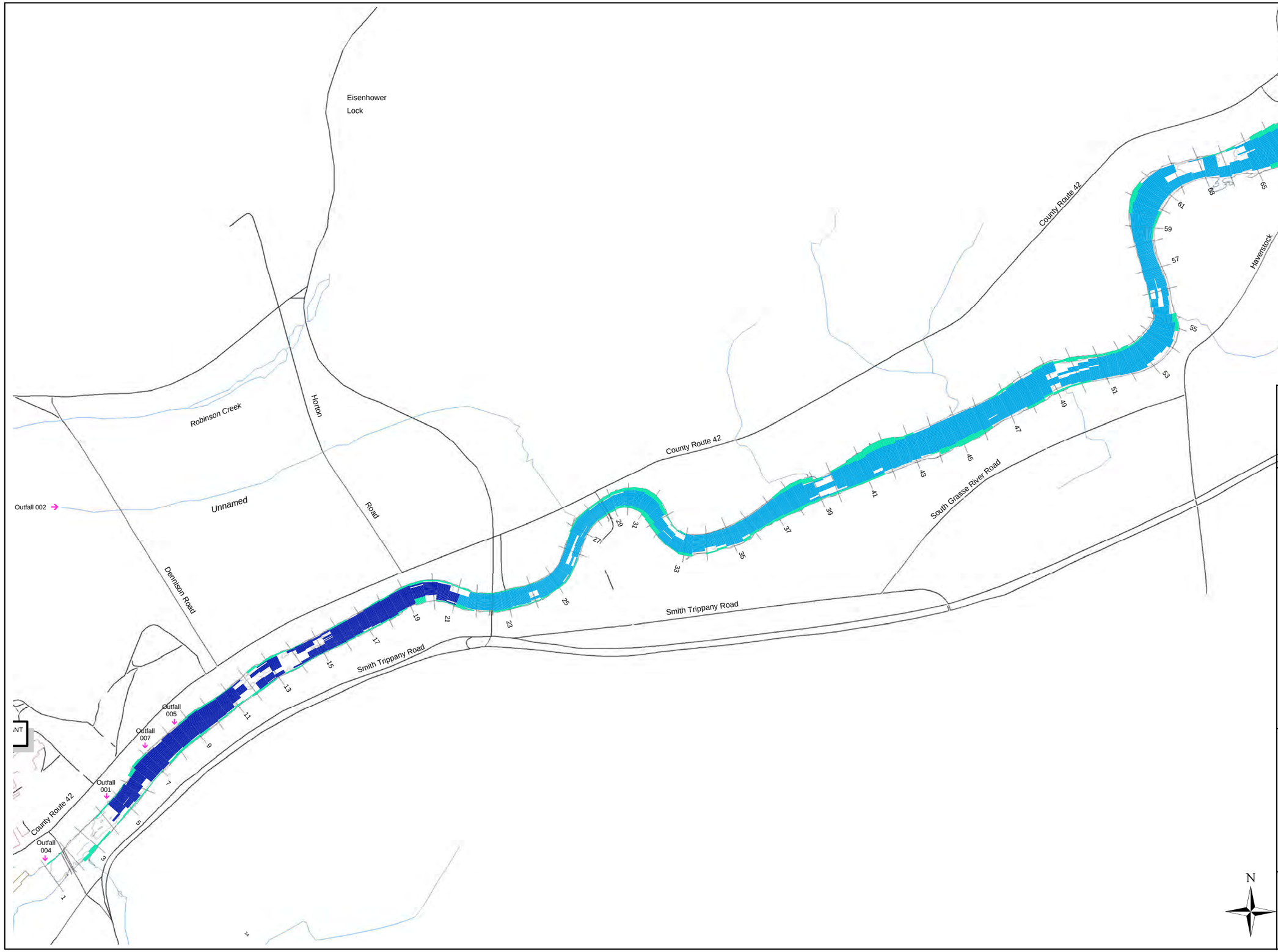


GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

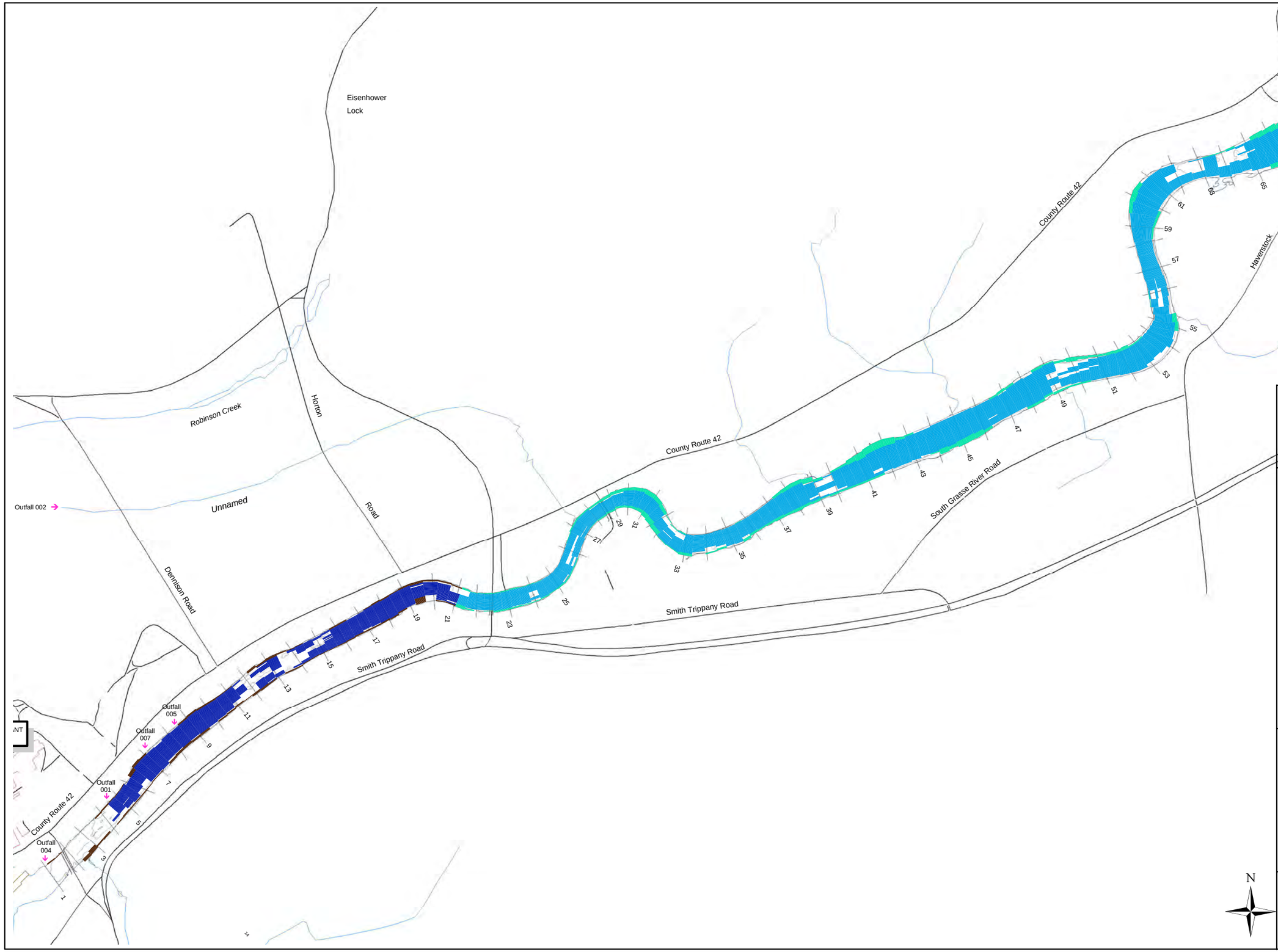
Figure A7-5
Alternative 3:
T1-T72 Capping

N

ALCOA

May 2012

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd



GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure A7-6.
Alternative 4: T1-T72 near shore dredging/backfilling and main channel capping, T21-T72 capping.

N

ALCOA

May 2012

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd

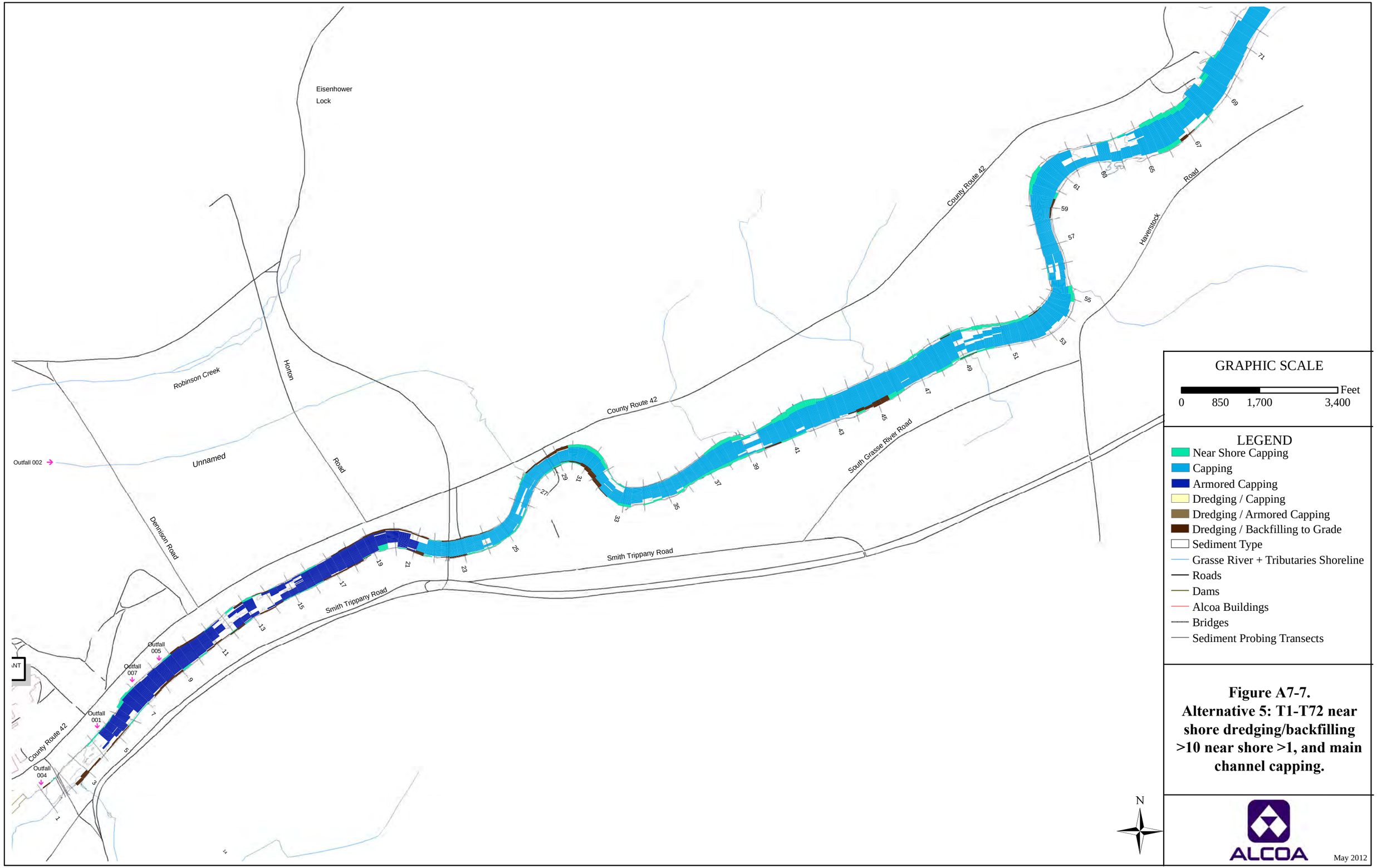
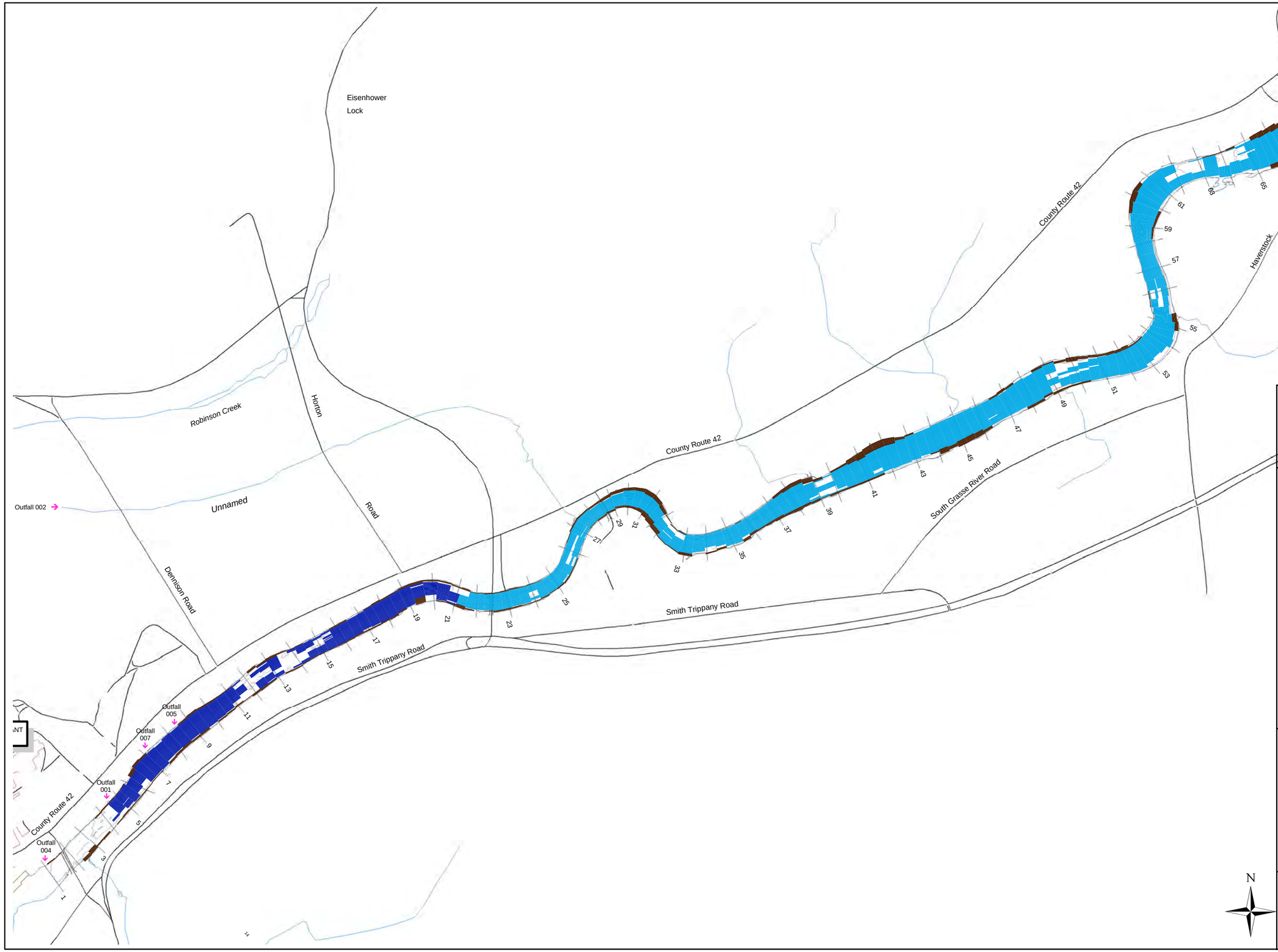


Figure A7-7.
Alternative 5: T1-T72 near shore dredging/backfilling >10 near shore >1, and main channel capping.

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd



GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure A7-8.
Alternative 6: T1-T72 near shore dredging/backfilling and main channel capping.

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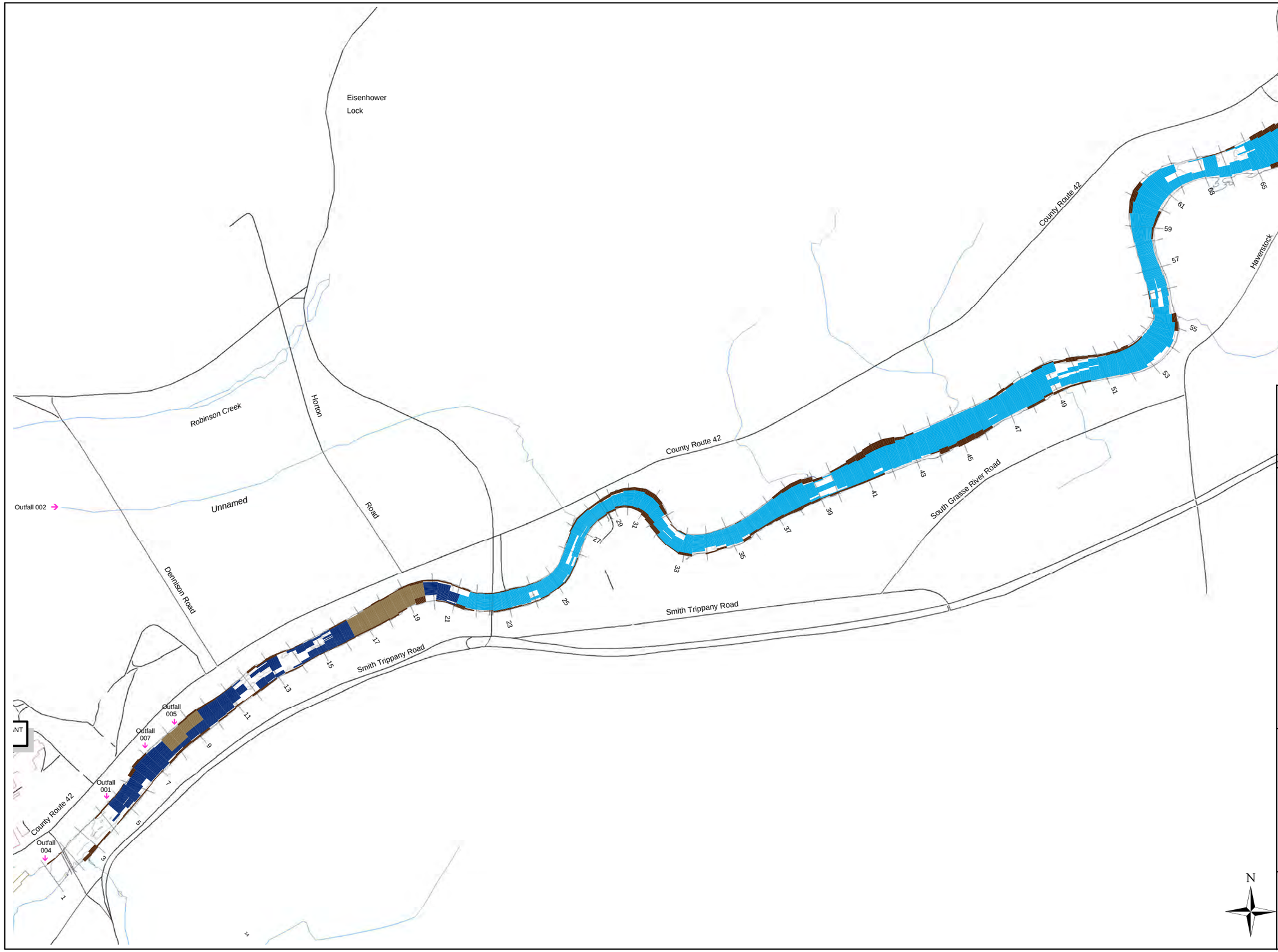
May 2012

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd



GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

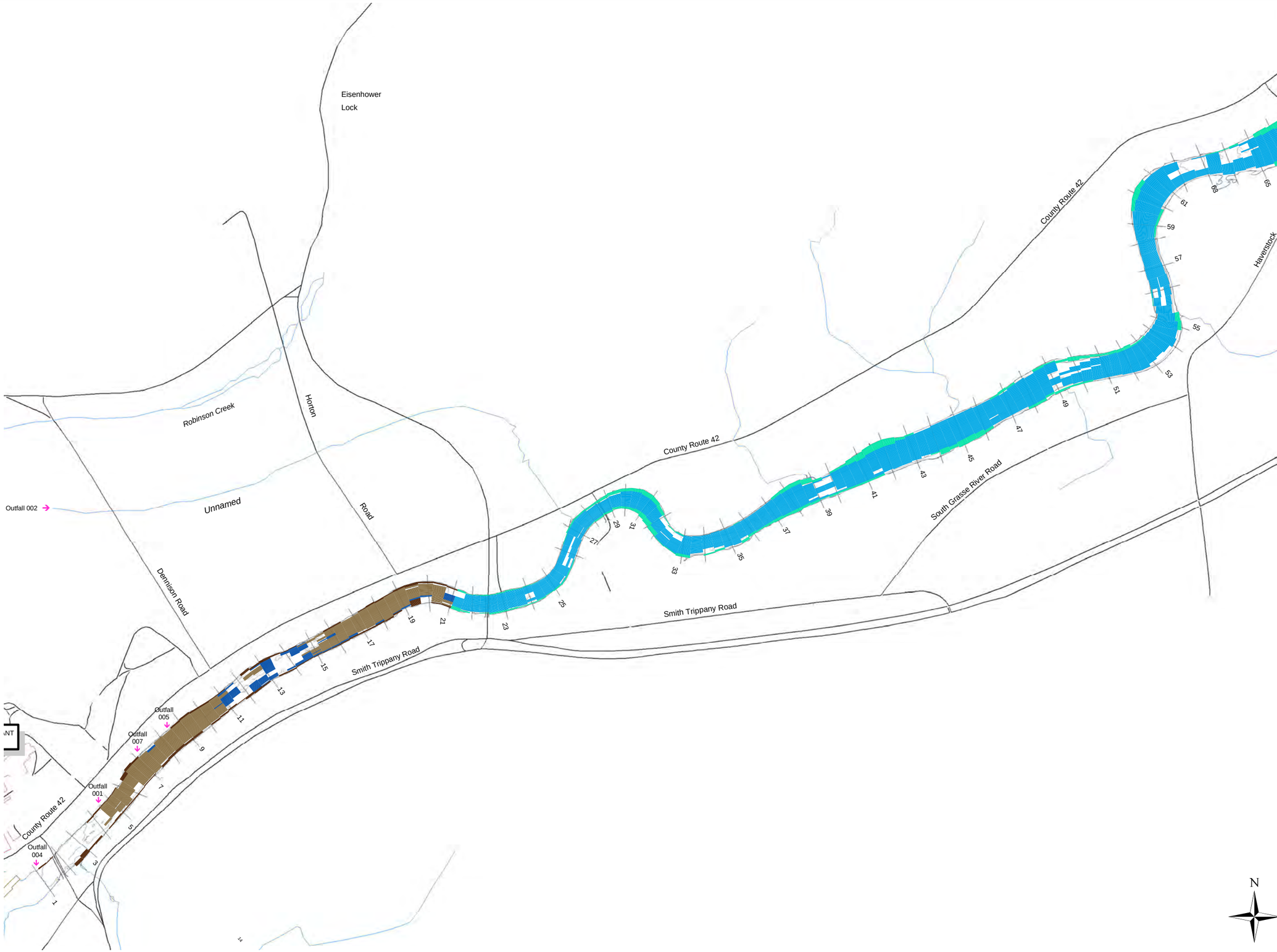
- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure A7-9.
Alternative 7: T1-T72 near shore dredging/backfilling, T1-T19.5 select main channel dredging, T1-T72 main channel capping.

ALCOA

May 2012

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd



GRAPHIC SCALE

0 850 1,700 3,400 Feet

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

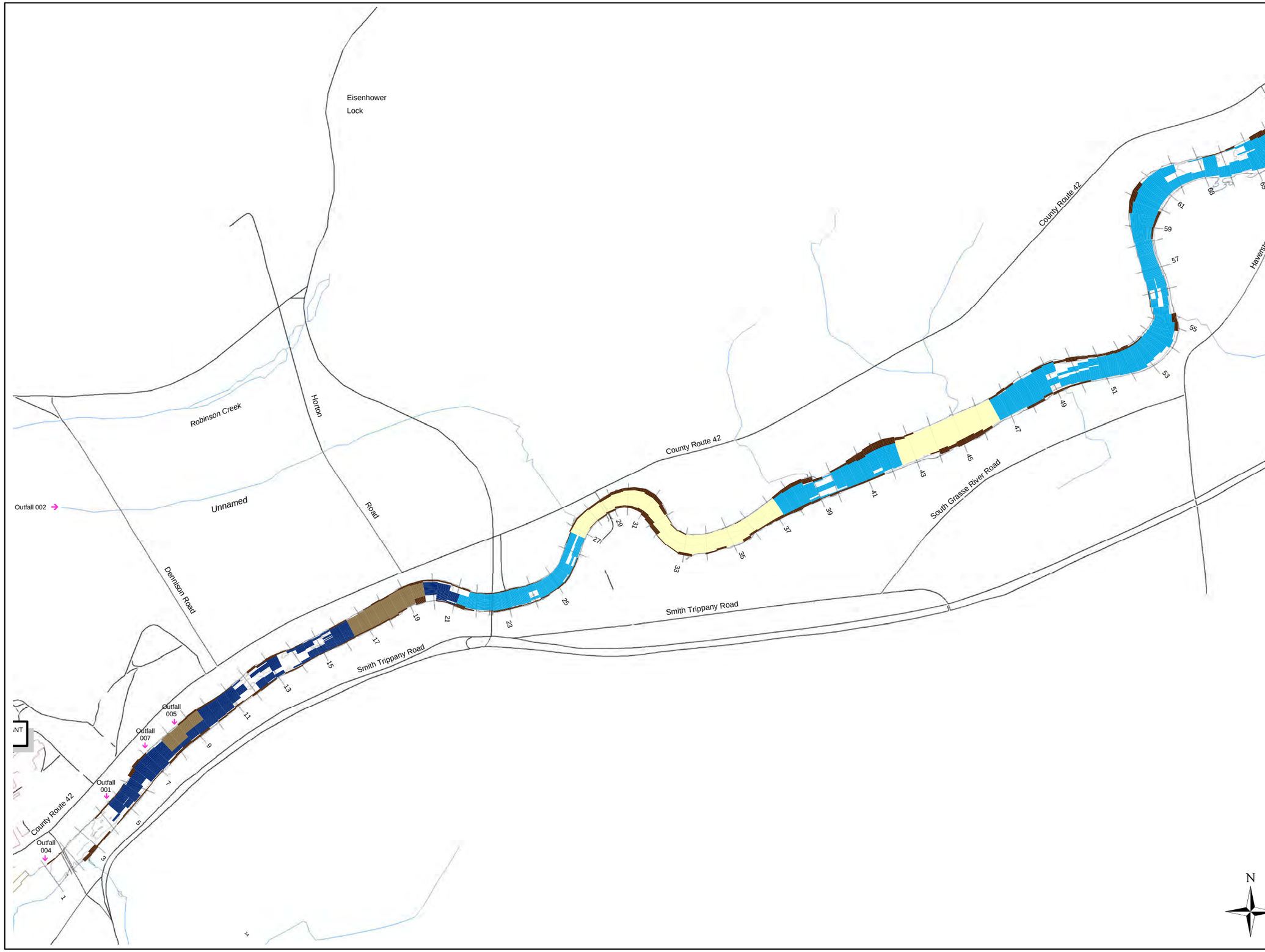
Figure A7-10.
Alternative 8: T1-T21 dredging/capping, T21-T72 capping.

N

ALCOA

May 2012

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd



GRAPHIC SCALE

0 850 1,700 3,400 Feet

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure A7-11.
Alternative 9: T1-T72 near shore dredging/backfilling, T1-T46 select main channel dredging, T1-T72 main channel capping.

ALCOA

May 2012

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd

GRAPHIC SCALE

Feet

0 850 1,700 3,400

LEGEND

- Near Shore Capping
- Capping
- Armored Capping
- Dredging / Capping
- Dredging / Armored Capping
- Dredging / Backfilling to Grade
- Sediment Type
- Grasse River + Tributaries Shoreline
- Roads
- Dams
- Alcoa Buildings
- Bridges
- Sediment Probing Transects

Figure A7-12.
Alternative 10: T1-T72
dredging/capping.

N

ALCOA

May 2012

CO - C:\D_Drive\alcgra\GIS\Alternatives_maps_20120523.mxd

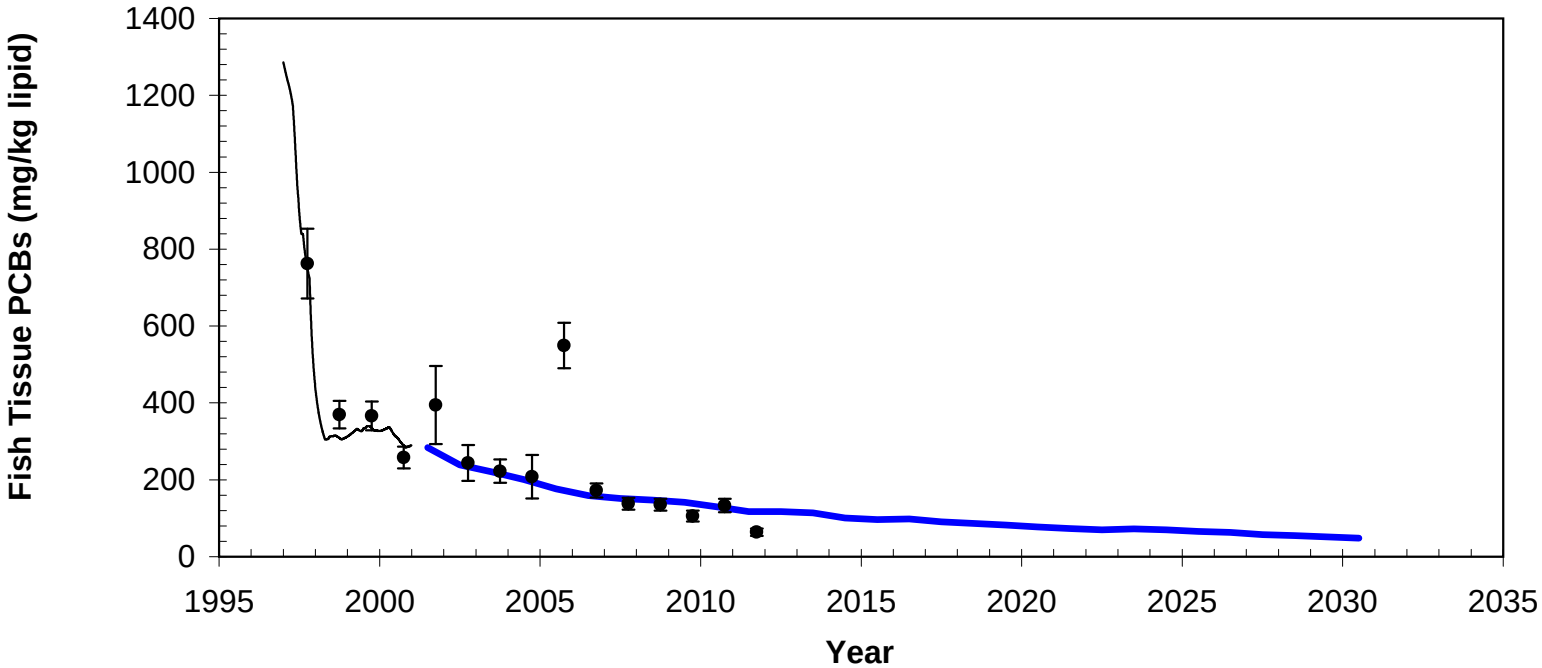


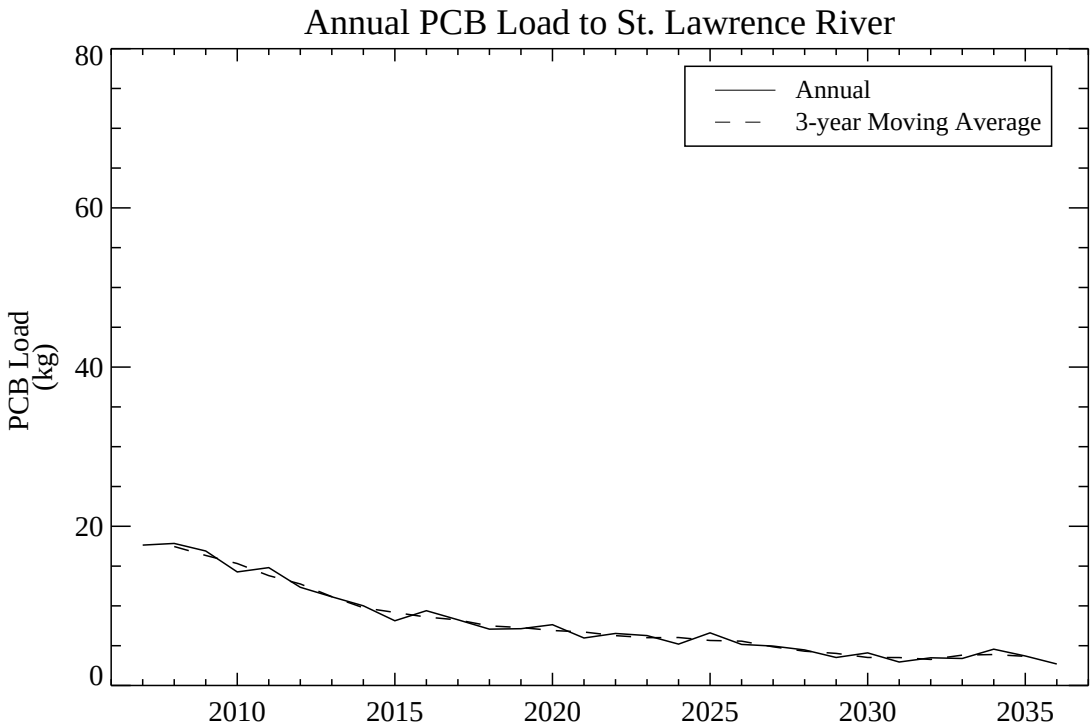
Figure A7-13. Comparison of lipid-normalized fish tissue PCB levels for monitored natural recovery.

Symbols represent lipid-normalized river-average fish tissue PCB levels computed from Trend Monitoring data collected from 1997 through 2011, +/- two standard errors.

Solid line between 1997 and 2000 represents calibration results from bioaccumulation model presented in 2002 AofA.

Solid lines after 2001 represent projected annual species-averages computed from PCB levels in smallmouth bass and brown bullhead, area-weighted by river stretch, as presented in the 2002 AofA.

Assumptions made in June 2002 AofA projections differ from those proposed for revised AofA



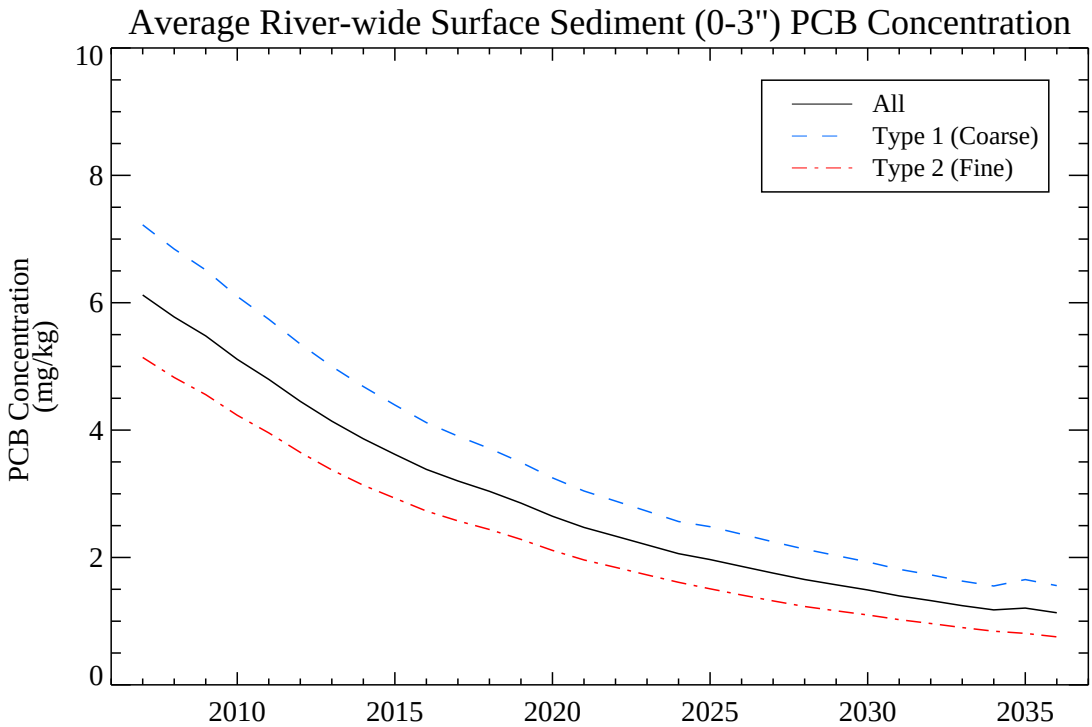


Figure A7-14. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternatives 1: no further action and 2: monitored natural recovery.

Run Path: \\NAS_ALCGRA\ALCgra\Model\Model_2008\PCBfate\Projections\proj_1002-03

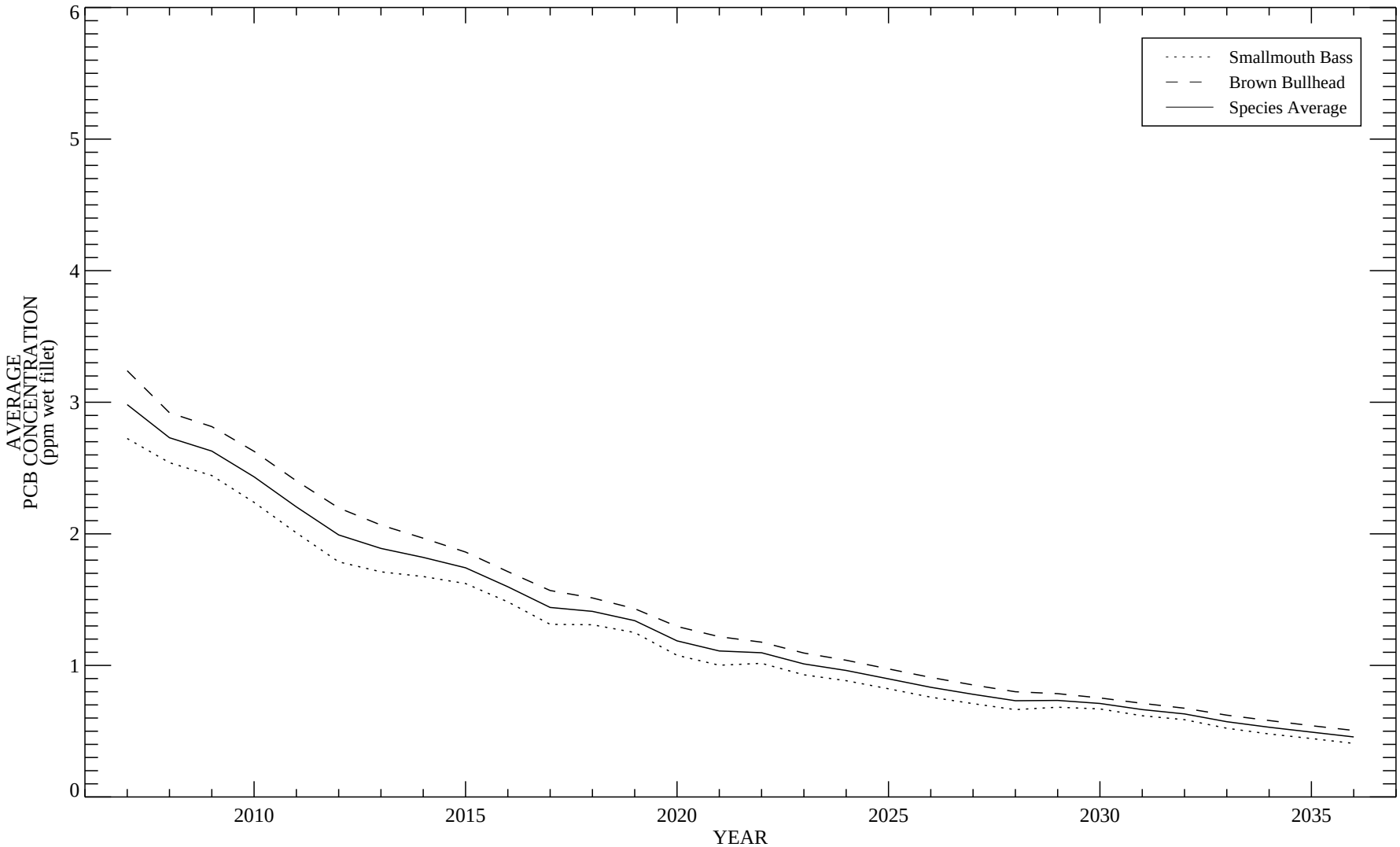


Figure A7-15. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternatives 1: no further action and 2: monitored natural recovery.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
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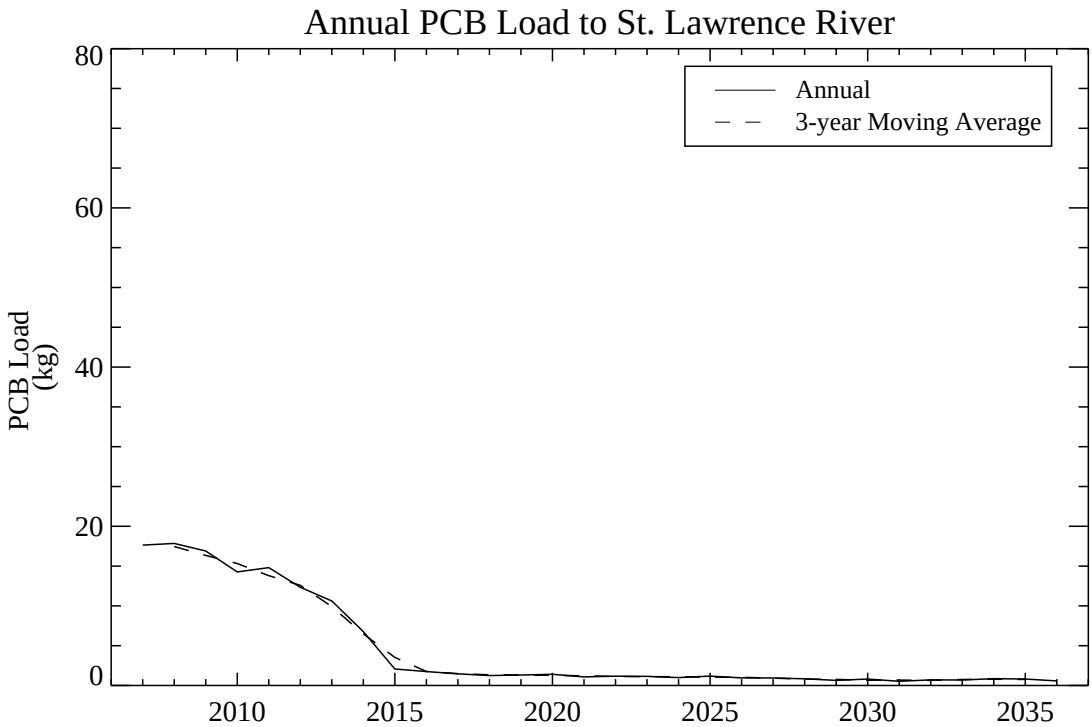

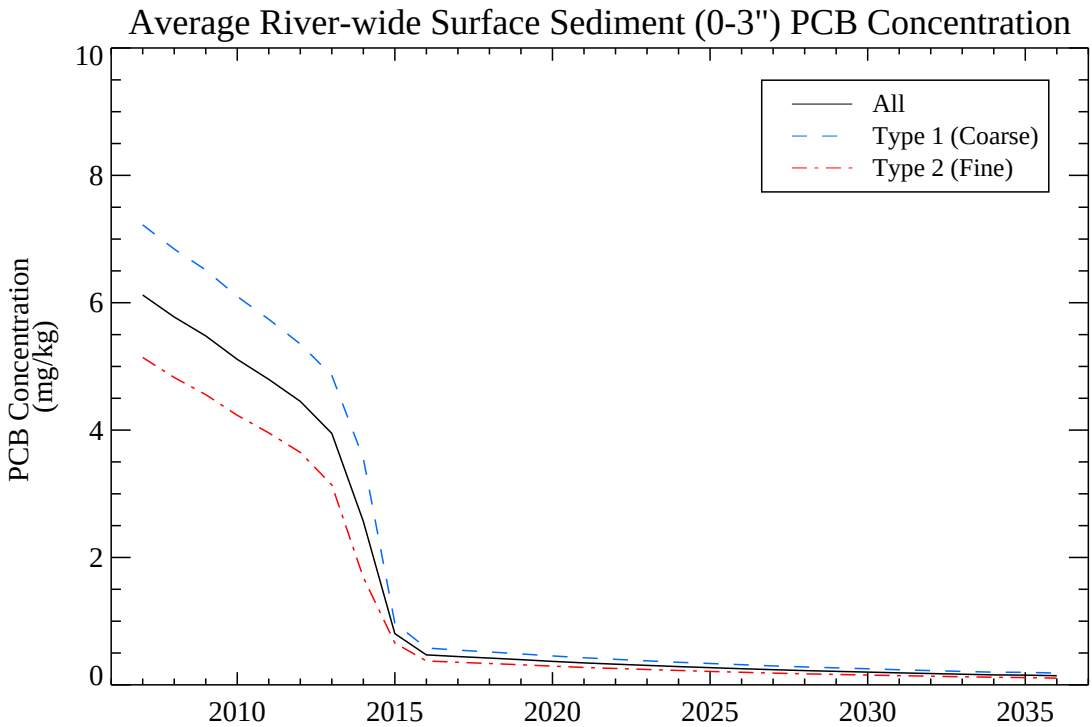

Figure A7-16. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 3: T1-T72 capping.

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PM - M:\Model\Model_2008\PCBfate\Postprocessors\proj_WC_loads_to_SLR_round12_proj.pro
Tue Jul 03 13:06:02 2012

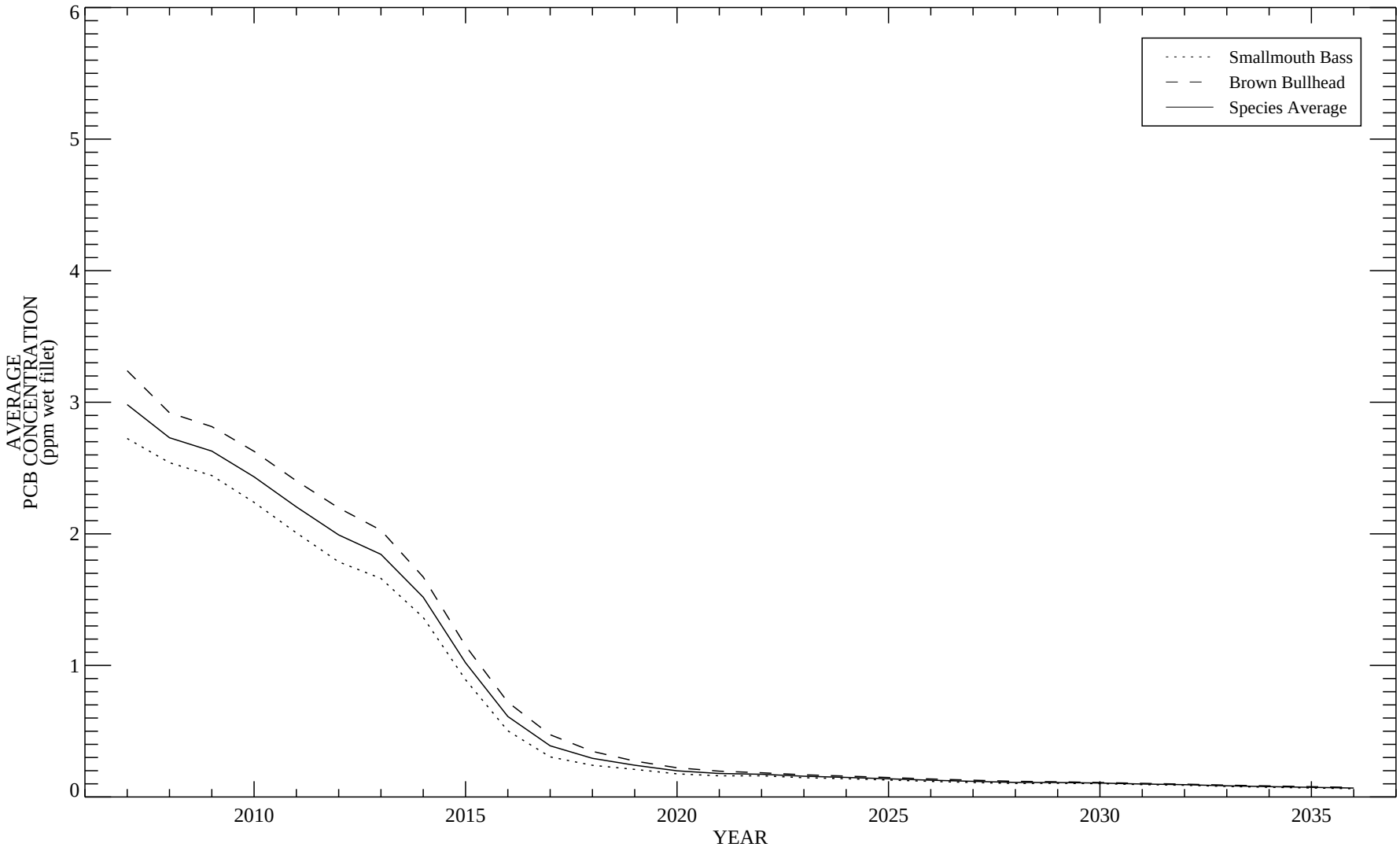
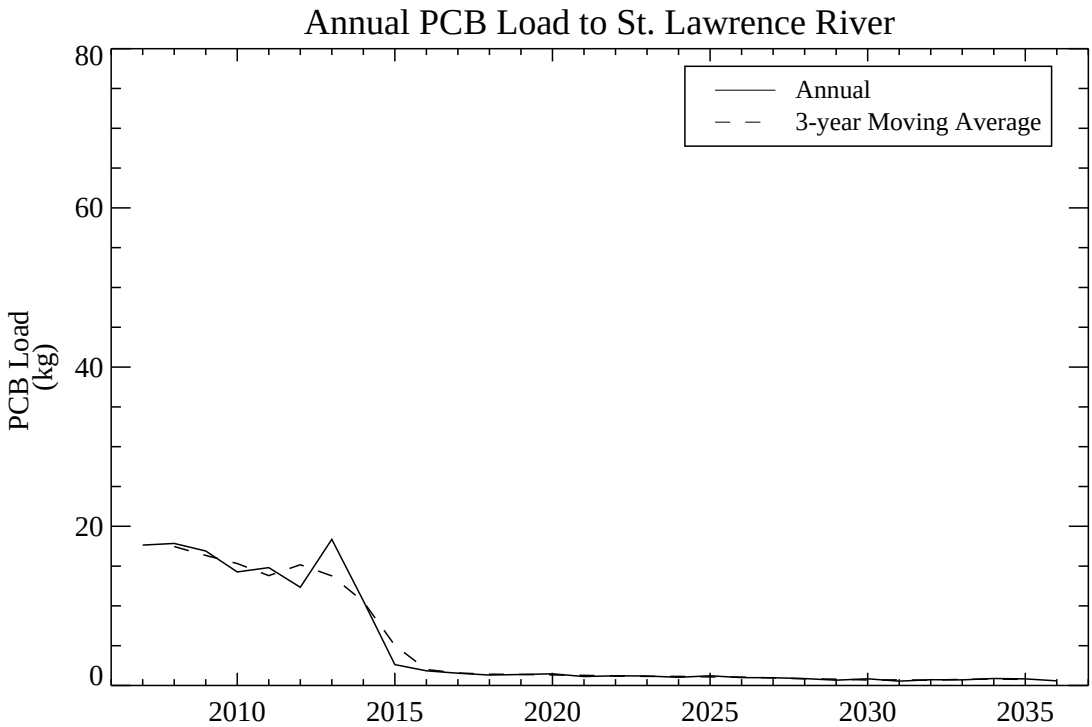


Figure A7-17. Predicted average fish tissue PCB concentrations in the lower Grasse River. Alternative 3: T1-T72 capping.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
Tue May 08 15:26:25 2012



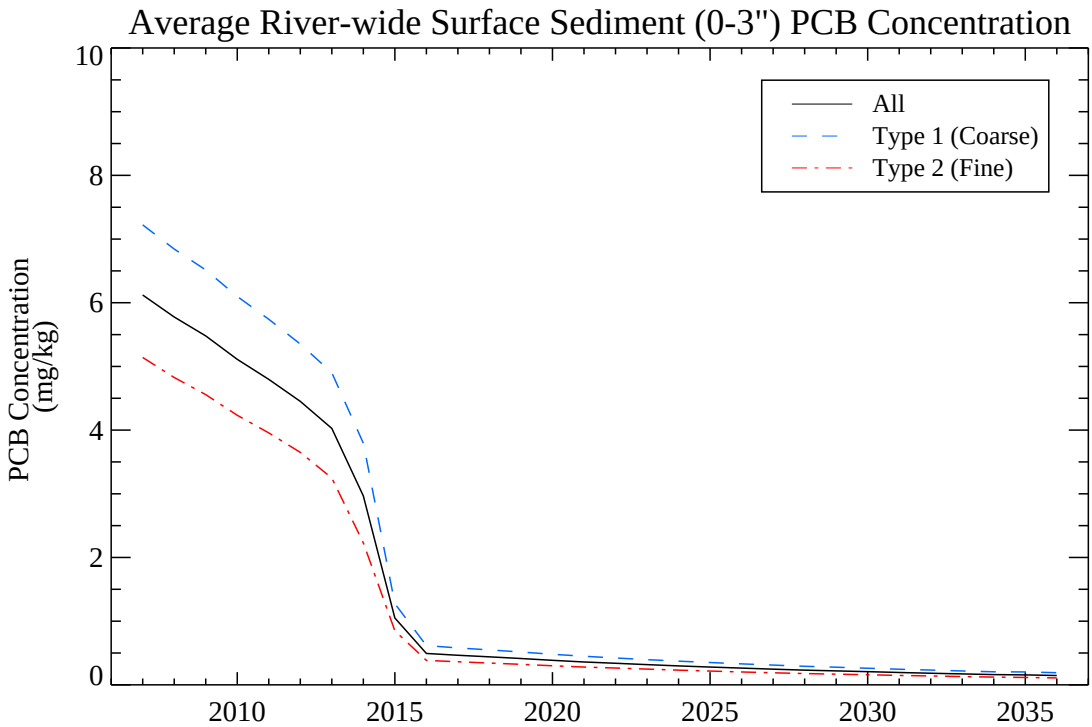


Figure A7-18. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 4: T1-T21 near shore dredging/backfilling and main channel capping, T21-T72 capping.

Run Path: \\NAS_ALCGRA\ALCgra\Model\Model_2008\PCBfate\Projections\proj_1204-02

PM - M:\Model\Model_2008\PCBfate\Postprocessors\proj_WC_loads_to_SLR_round12_proj.pro
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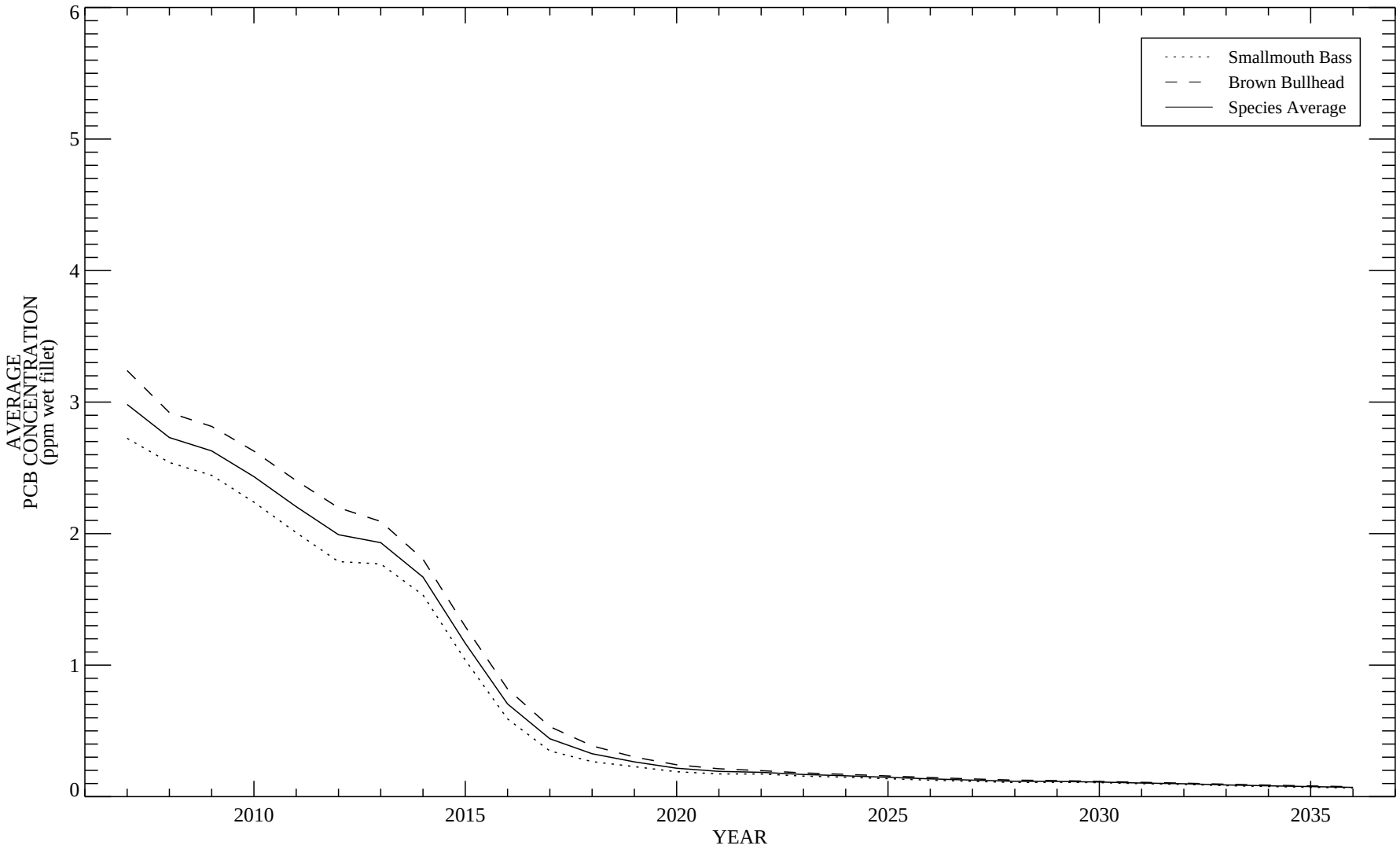

Figure A7-19. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternative 4: T1-T21 near shore dredging/backfilling and main channel capping, T21-T72 capping.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
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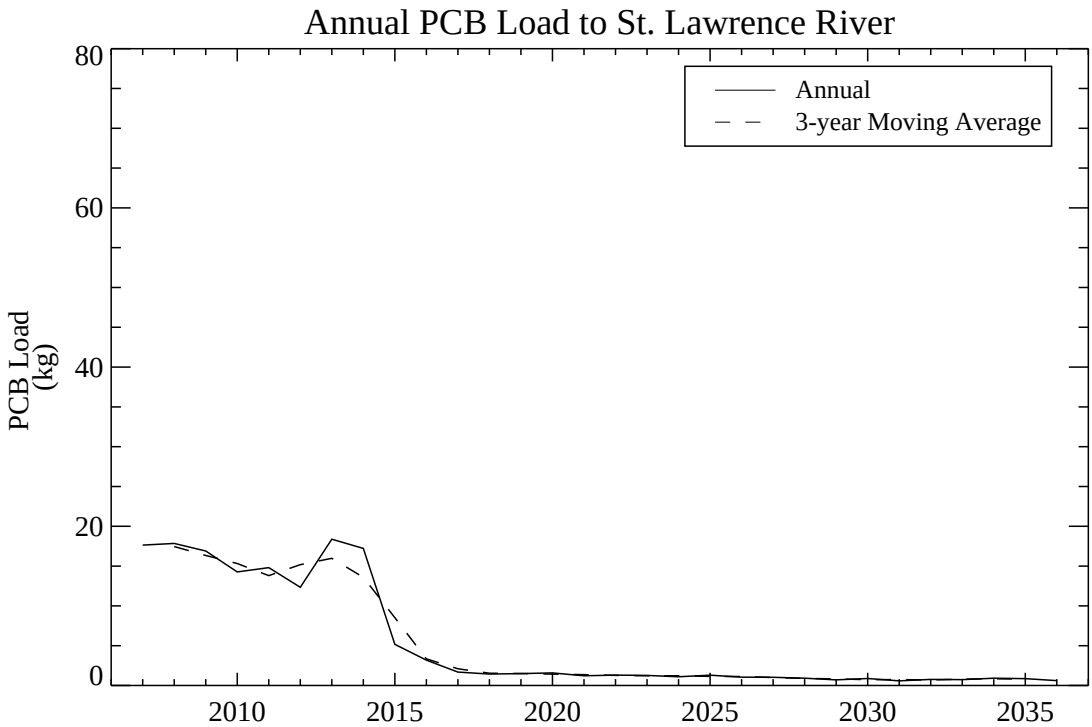

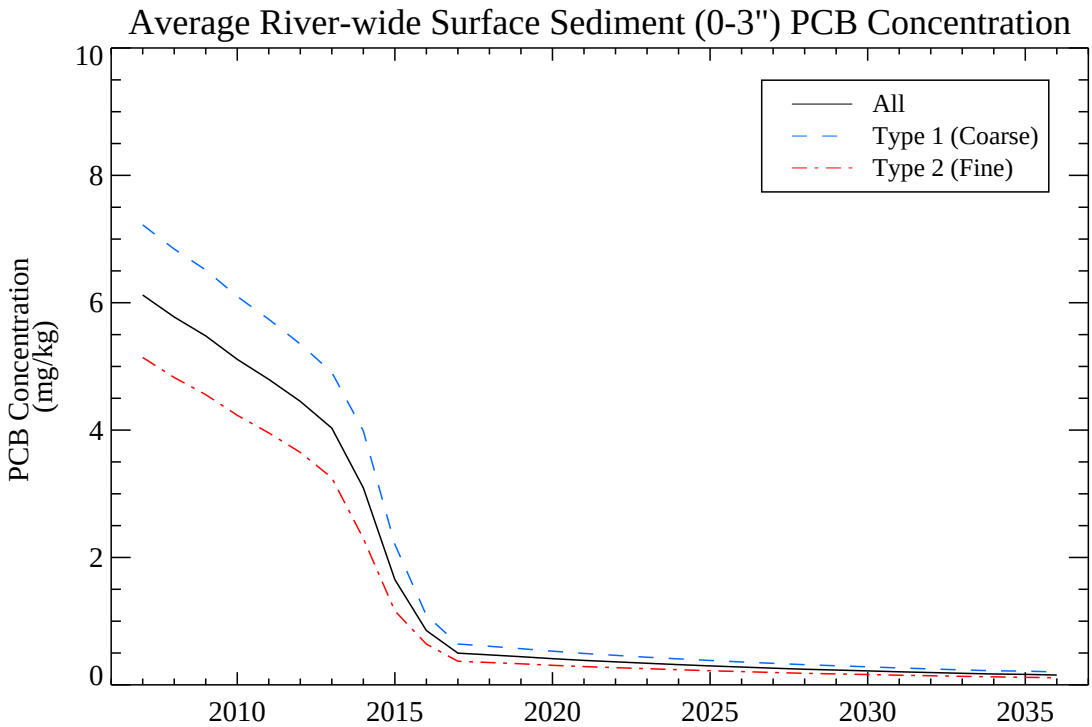

Figure A7-20. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 5: T1-T72 near shore dredging/backfilling >10, near shore capping >1, and main channel capping.

Run Path: \\NAS_ALCGRA\ALCgra\Model\Model_2008\PCBfate\Projections\proj_1204-06

PM - M:\Model\Model_2008\PCBfate\Postprocessors\proj_WC_loads_to_SLR_round12_proj.pro
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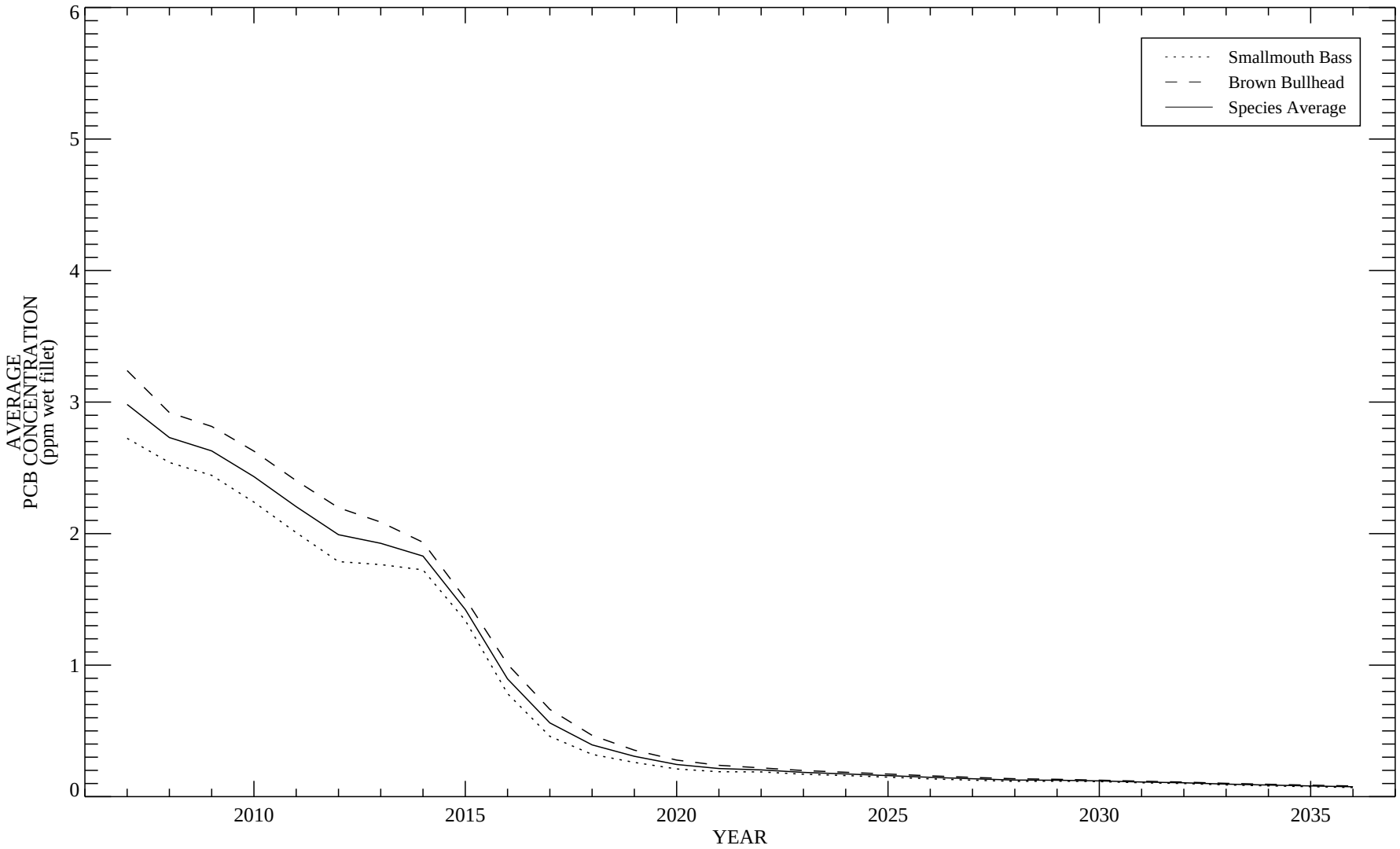
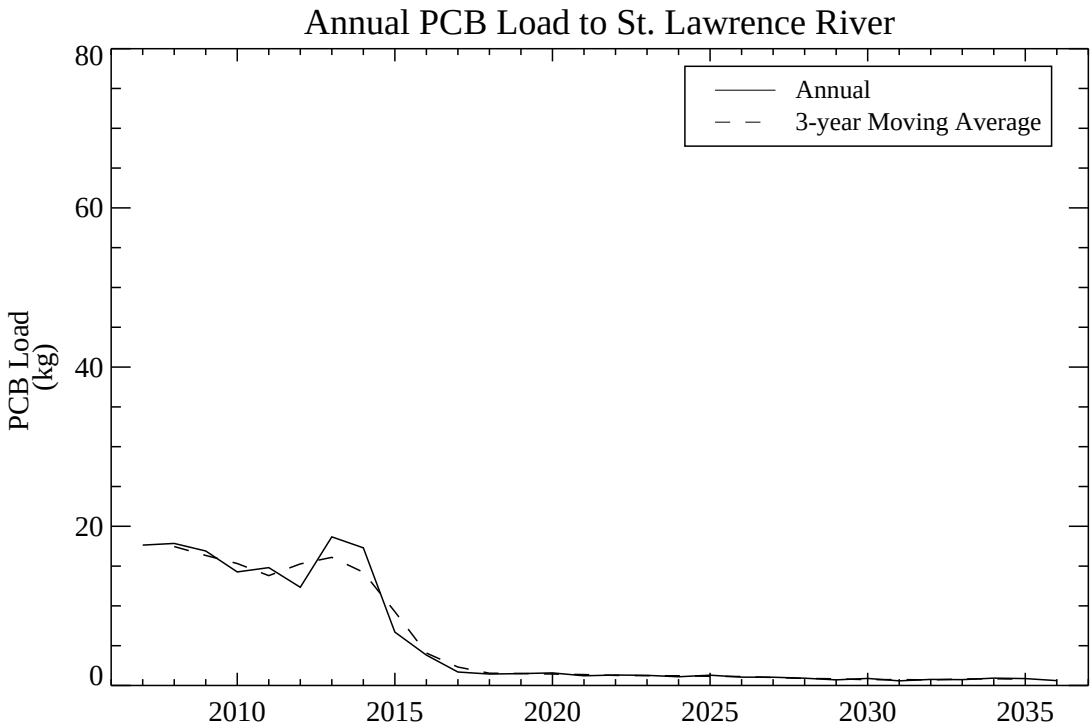


Figure A7-21. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternative 5: T1-T72 near shore dredging/backfilling >10, near shore capping >1, and main channel capping.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
Wed May 23 09:17:24 2012



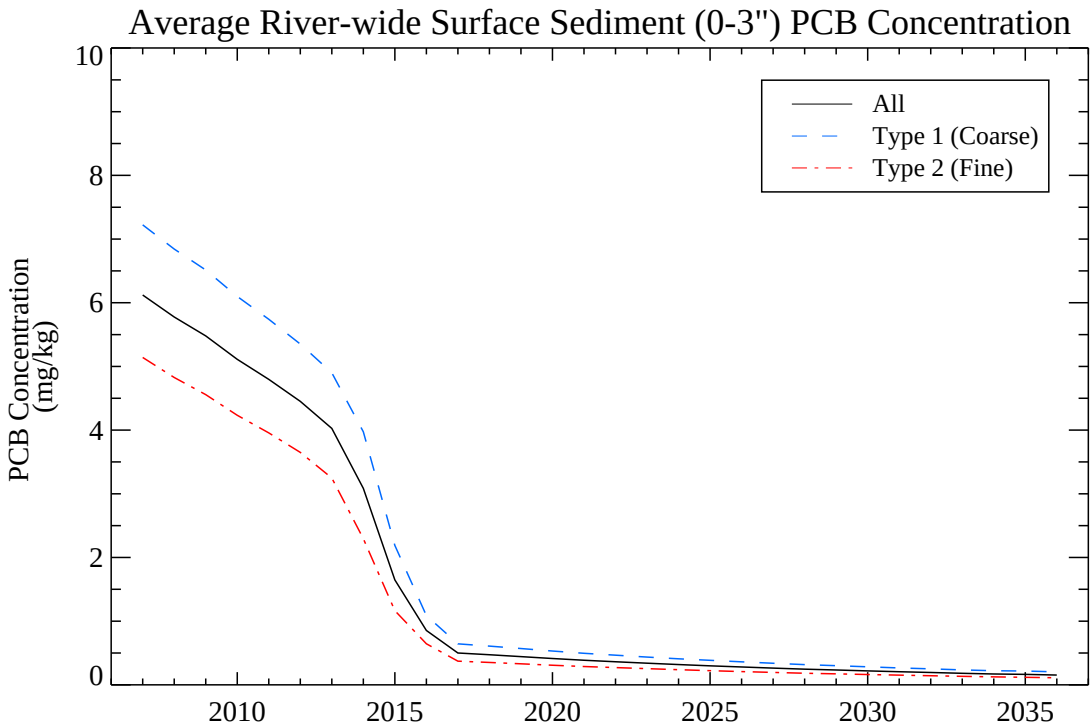


Figure A7-22. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 6: T1-T72 near shore dredging/backfilling and main channel capping.

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PM - M:\Model\Model_2008\PCBfate\Postprocessors\proj_WC_loads_to_SLR_round12_proj.pro
Tue Jul 03 13:05:50 2012

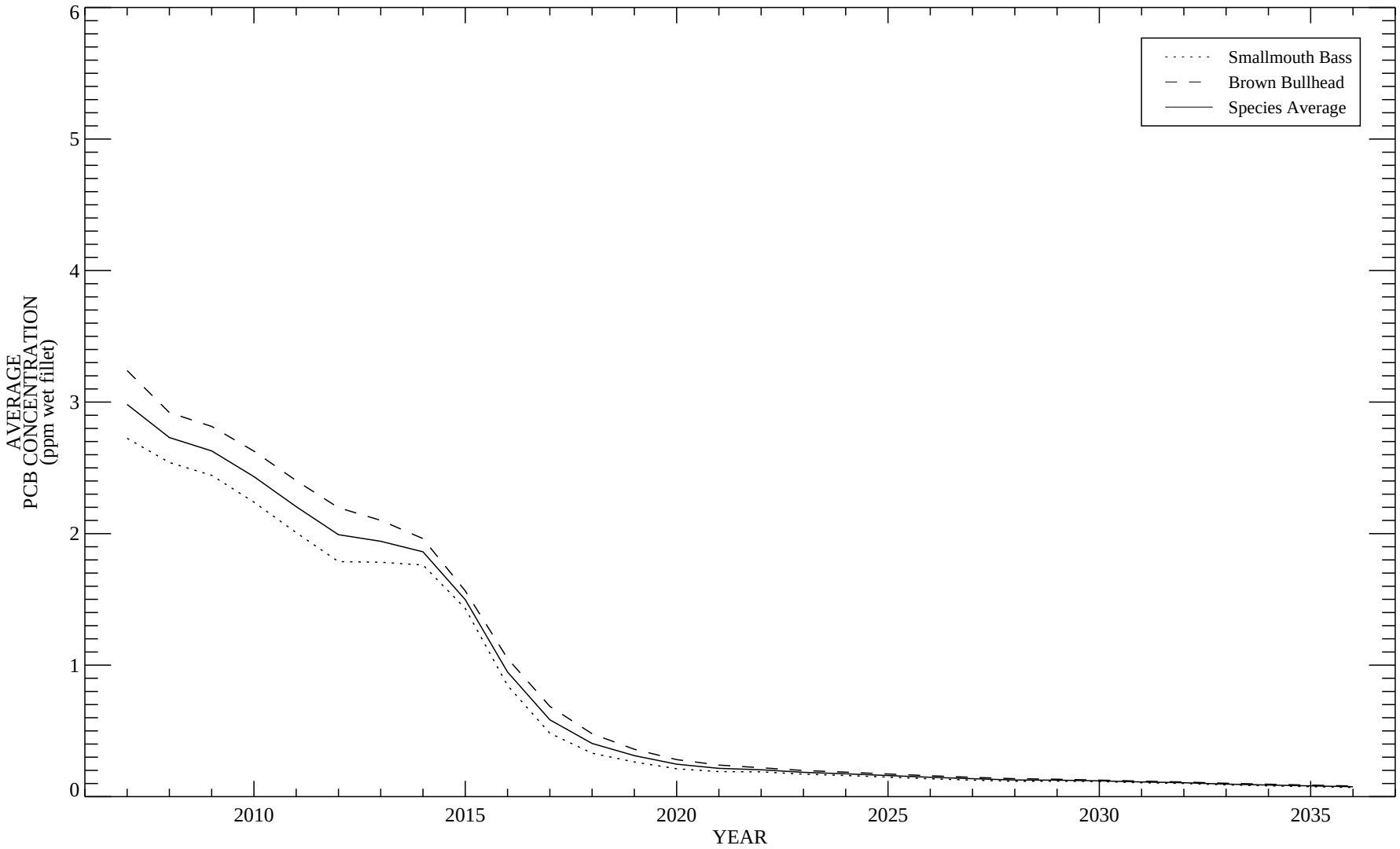
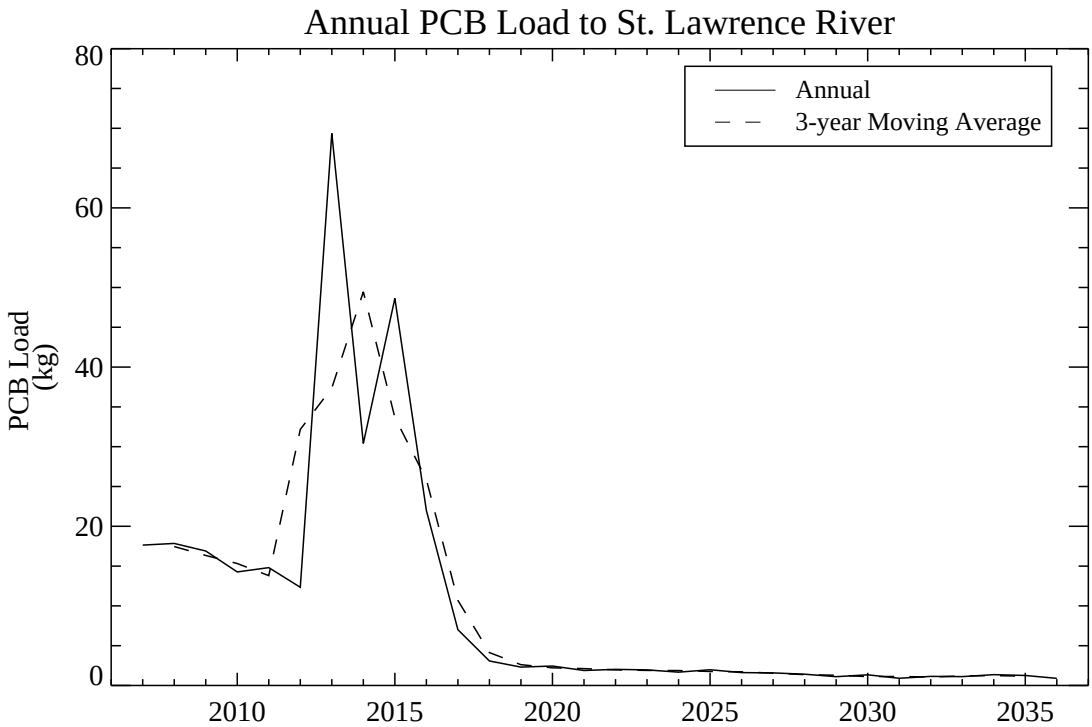


Figure A7-23. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternative 6: T1-T72 near shore dredging/backfilling and main channel capping.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
Tue May 08 15:24:42 2012



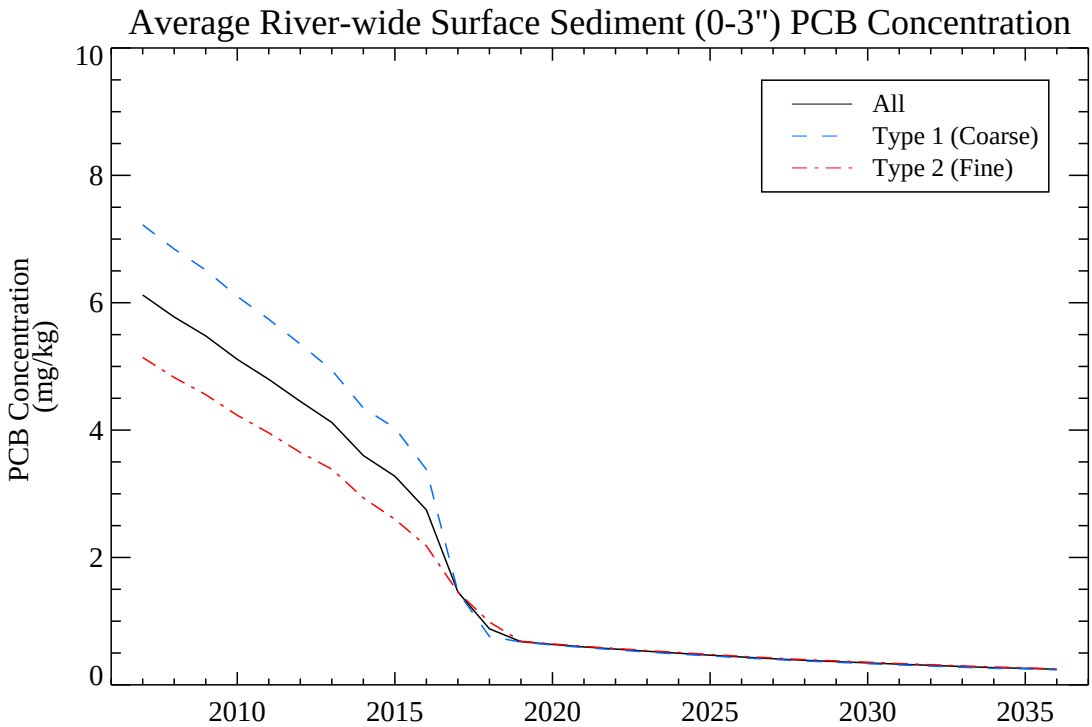


Figure A7-24. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 7: T1-T72 near shore dredging/backfilling, T1-T19.5 select main channel dredging, T1-T72 main channel capping.
Run Path: \\NAS_ALCGRA\ALCgra\Model\Model_2008\PCBfate\Projections\proj_1204-08

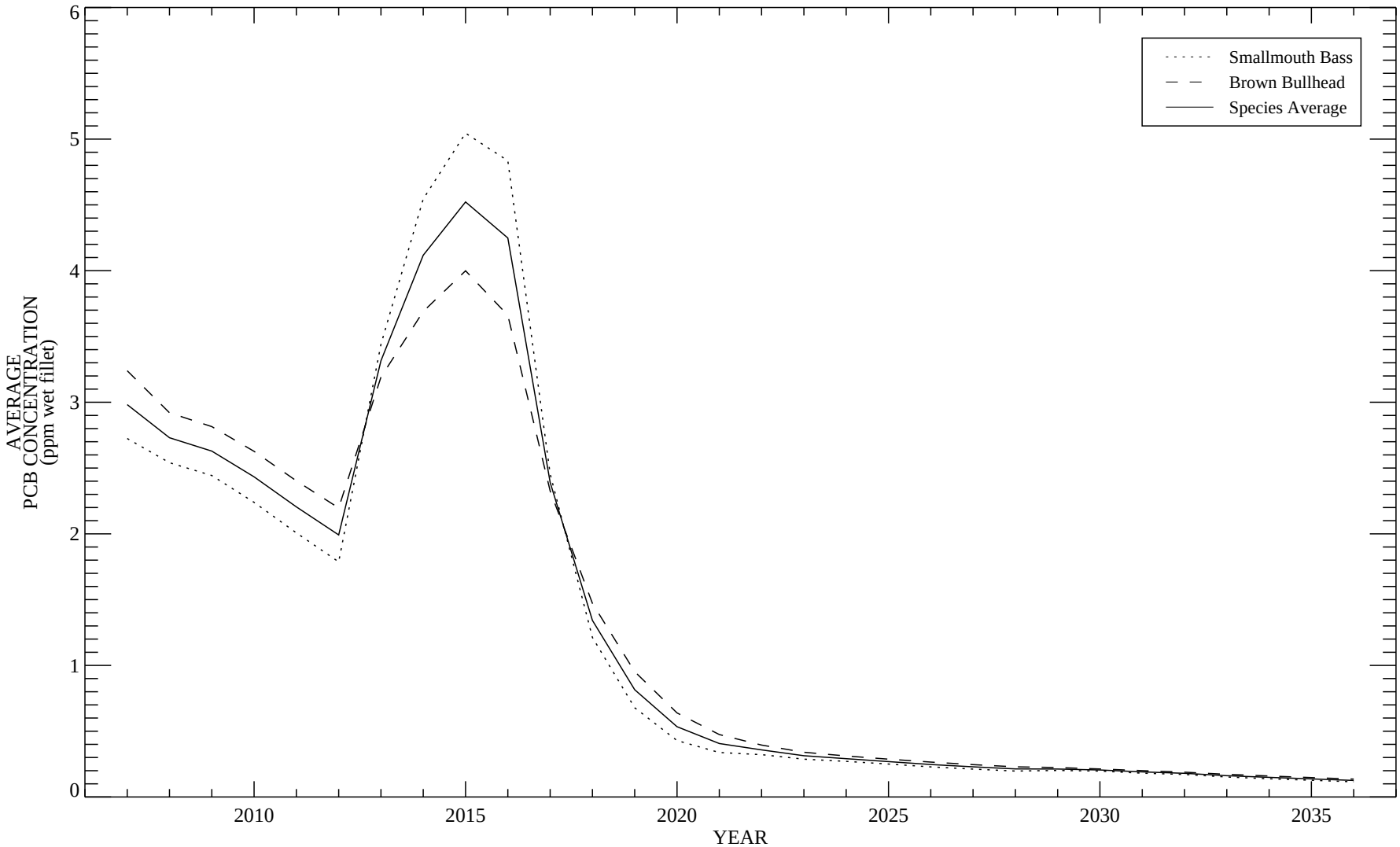
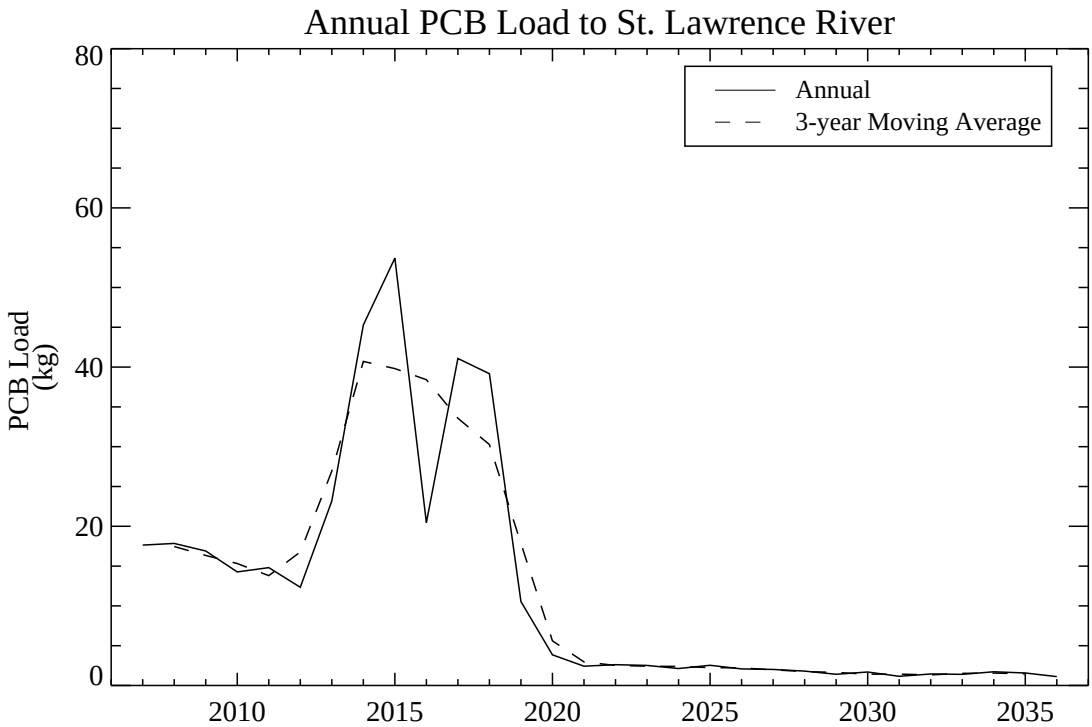


Figure A7-25. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternative 7: T1-T72 near shore dredging/backfilling, T1-T19.5 select main channel dredging, T1-T72 main channel capping.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
Tue May 08 15:23:58 2012



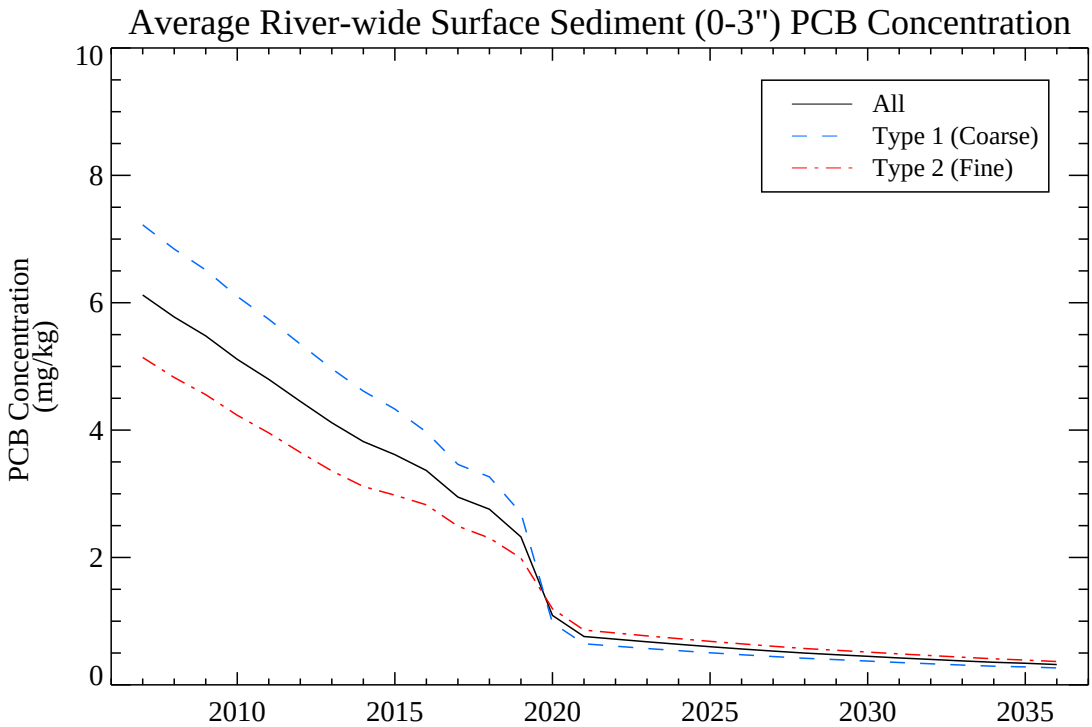


Figure A7-26. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 8: T1-T21 dredging/capping, T21-T72 capping.

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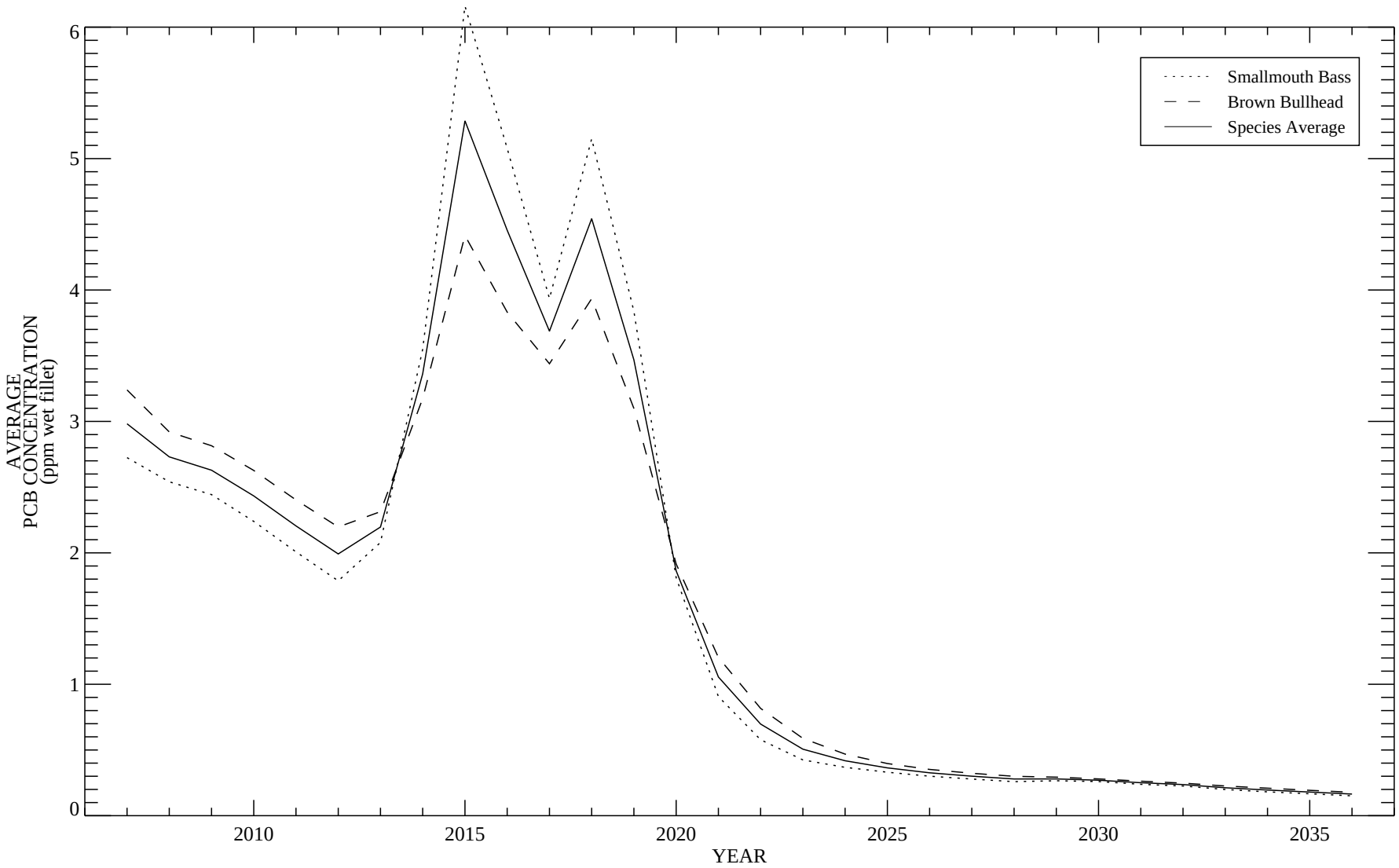
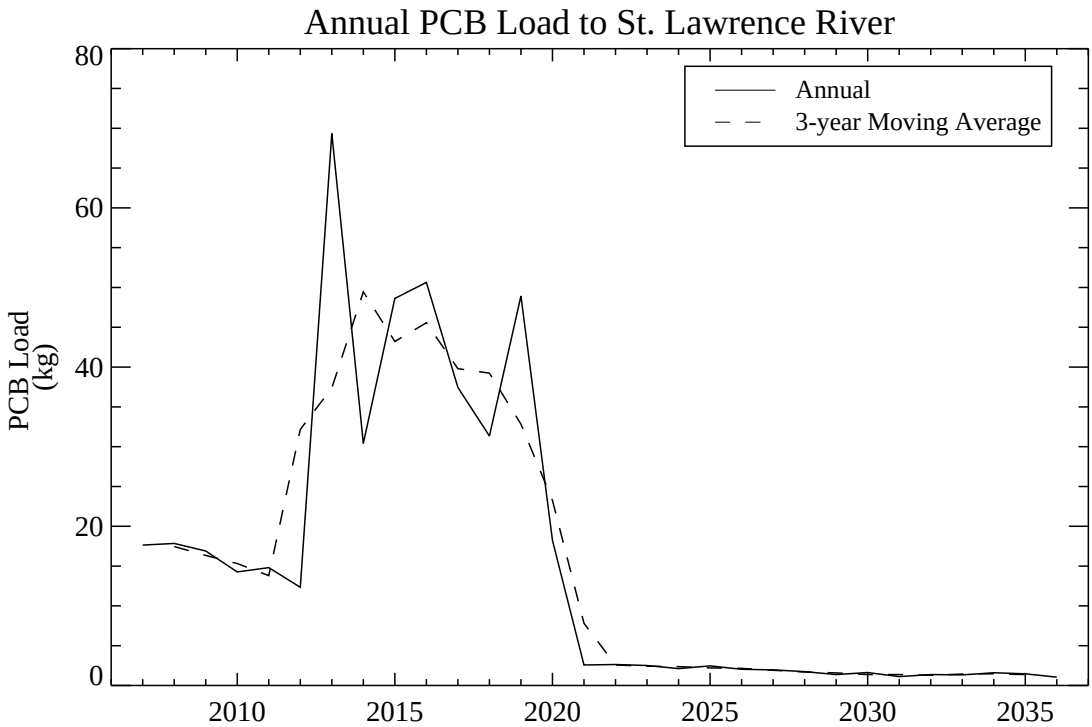


Figure A7-27. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternative 8: T1-T21 dredging/capping, T21-T72.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
Tue May 08 15:23:08 2012



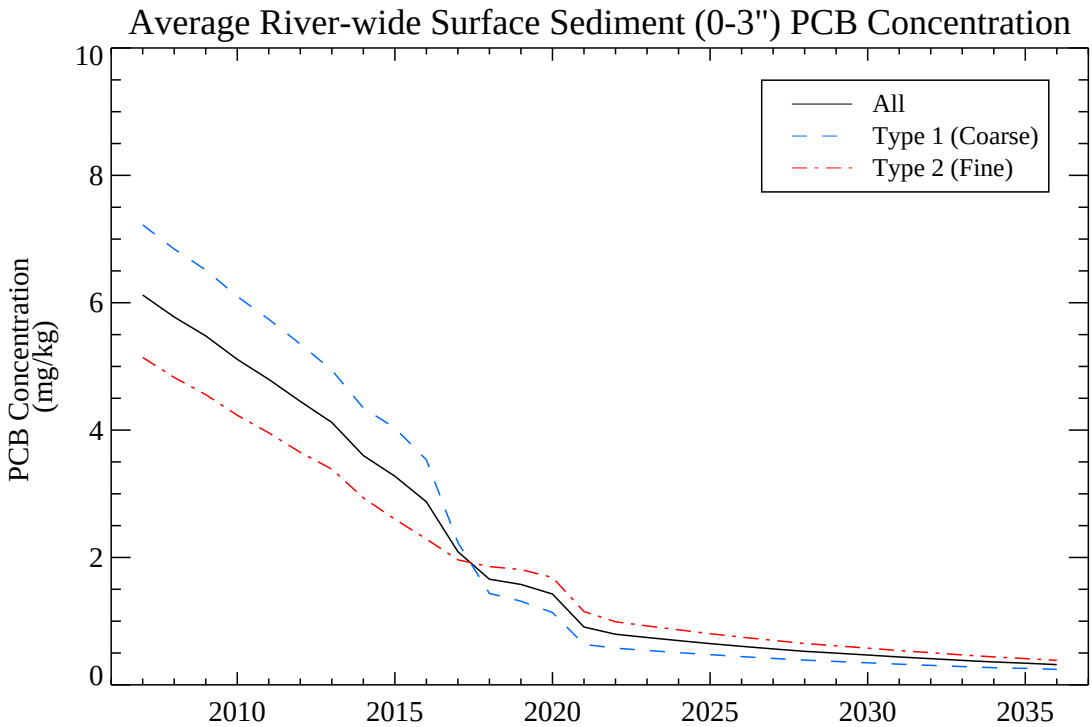


Figure A7-28. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 9: T1-T72 near shore dredging/backfilling, T1-T46 select main channel dredging, T1-T72 main channel capping.
Run Path: \\NAS_ALCGRA\ALCgra\Model\Model_2008\PCBfate\Projections\proj_1204-07

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Tue Jul 03 13:06:15 2012

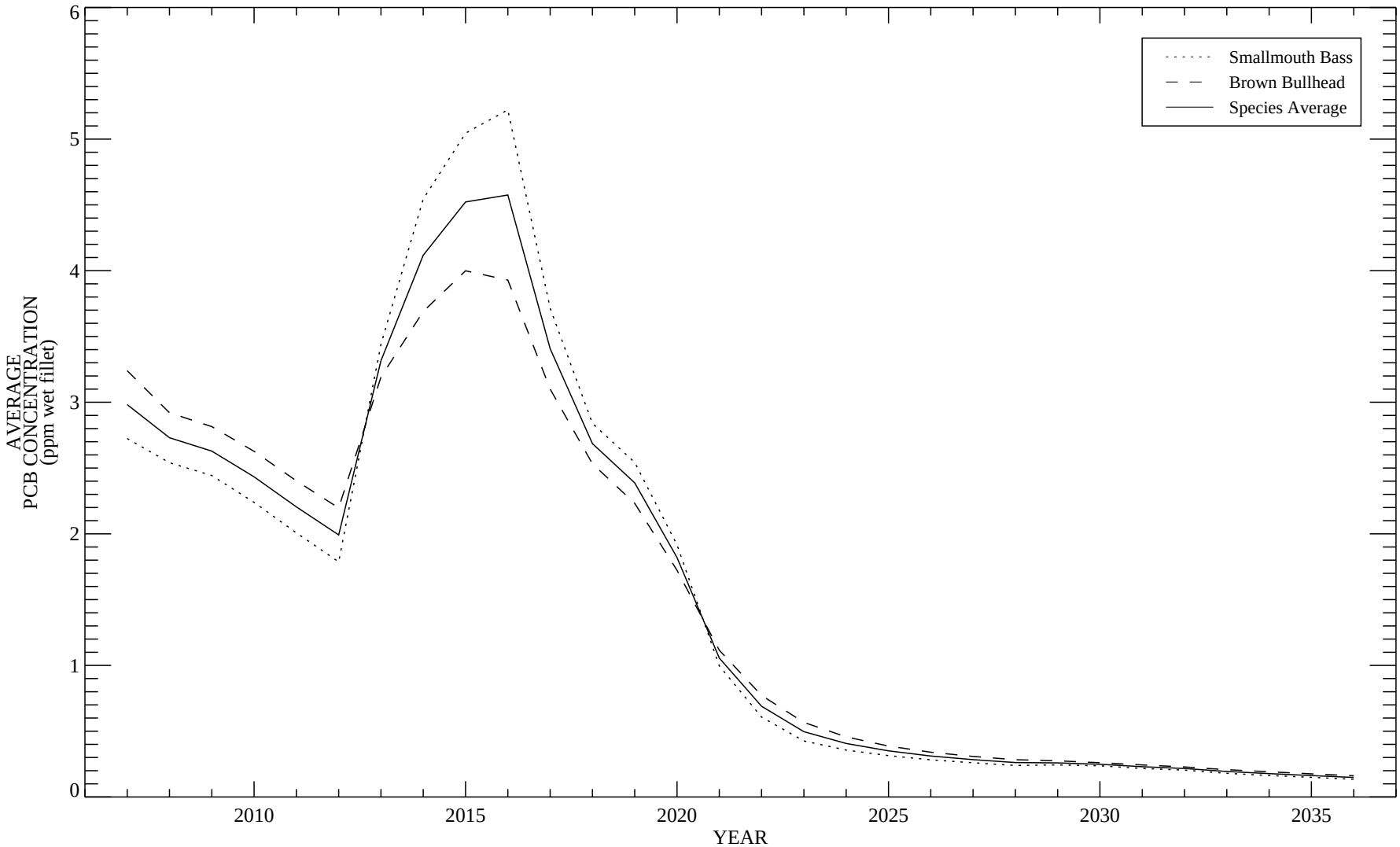
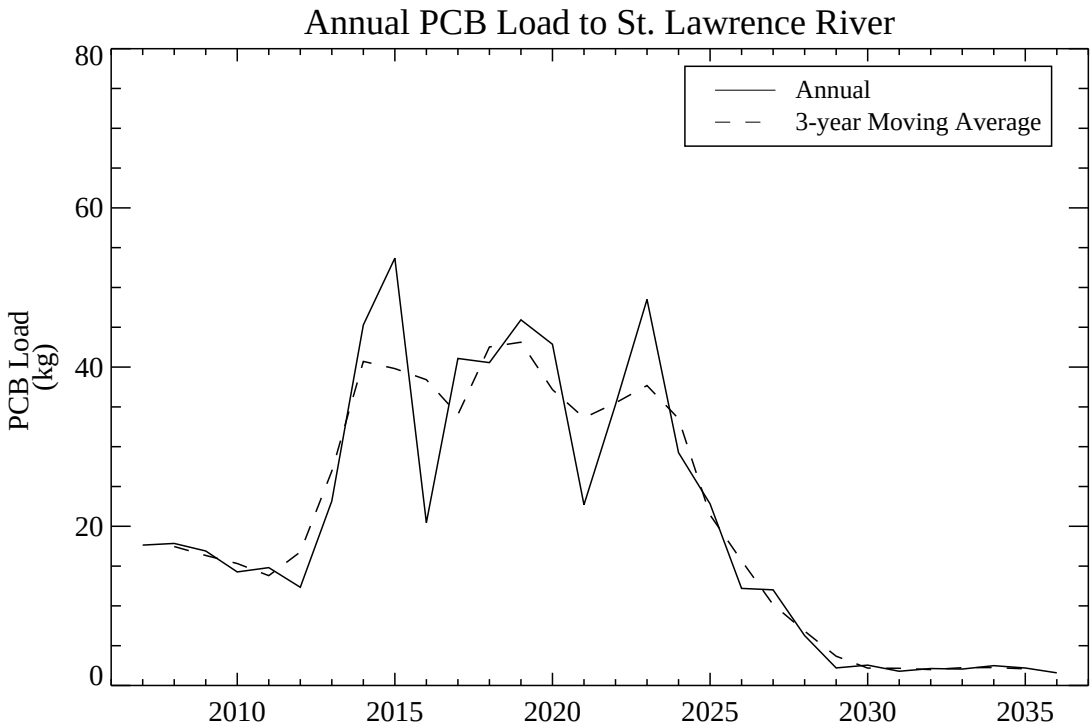


Figure A7-29. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternative 9: T1-T72 near shore dredging/backfilling, T1-T46 select main channel dredging, T1-T72 main channel capping.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

ARC - C:\Jobs\ALCgra\Analysis\BioMod\2011_Model\projtemp_riverwide_avg.pro
Tue May 08 15:22:12 2012



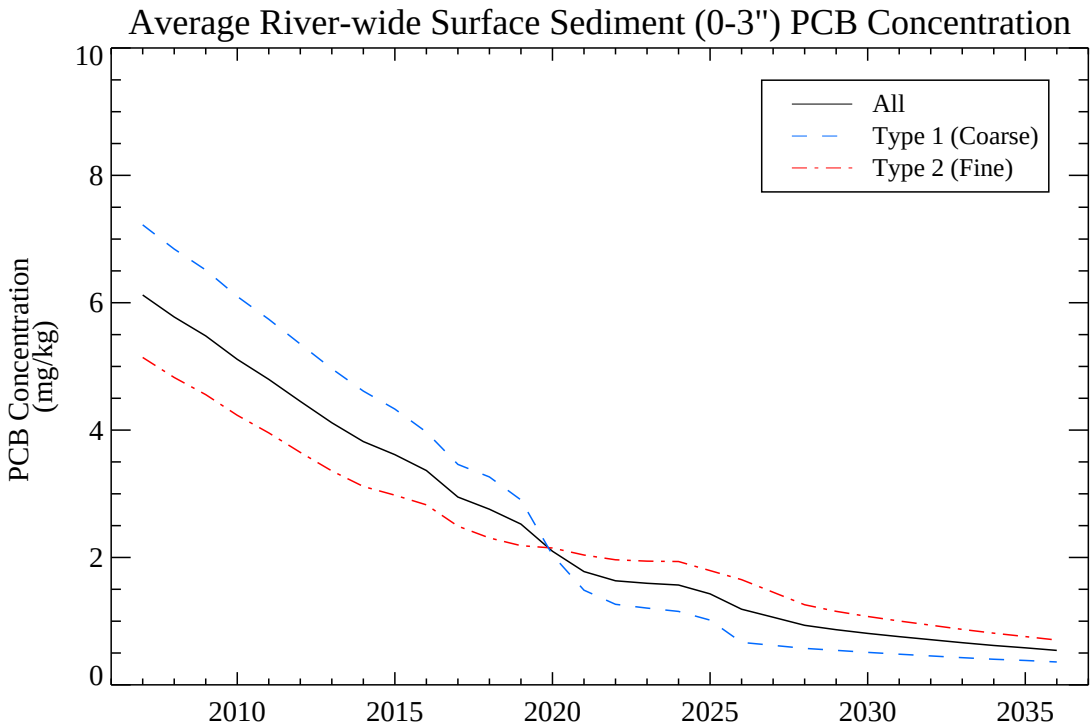


Figure A7-30. Predicted annual loading to the St. Lawrence River and average PCB concentration in surface sediments in the Grasse River. Alternative 10: T1-T72 dredging/capping.

Run Path: \\NAS_ALCGRA\ALCgra\Model\Model_2008\PCBfate\Projections\proj_1204-01

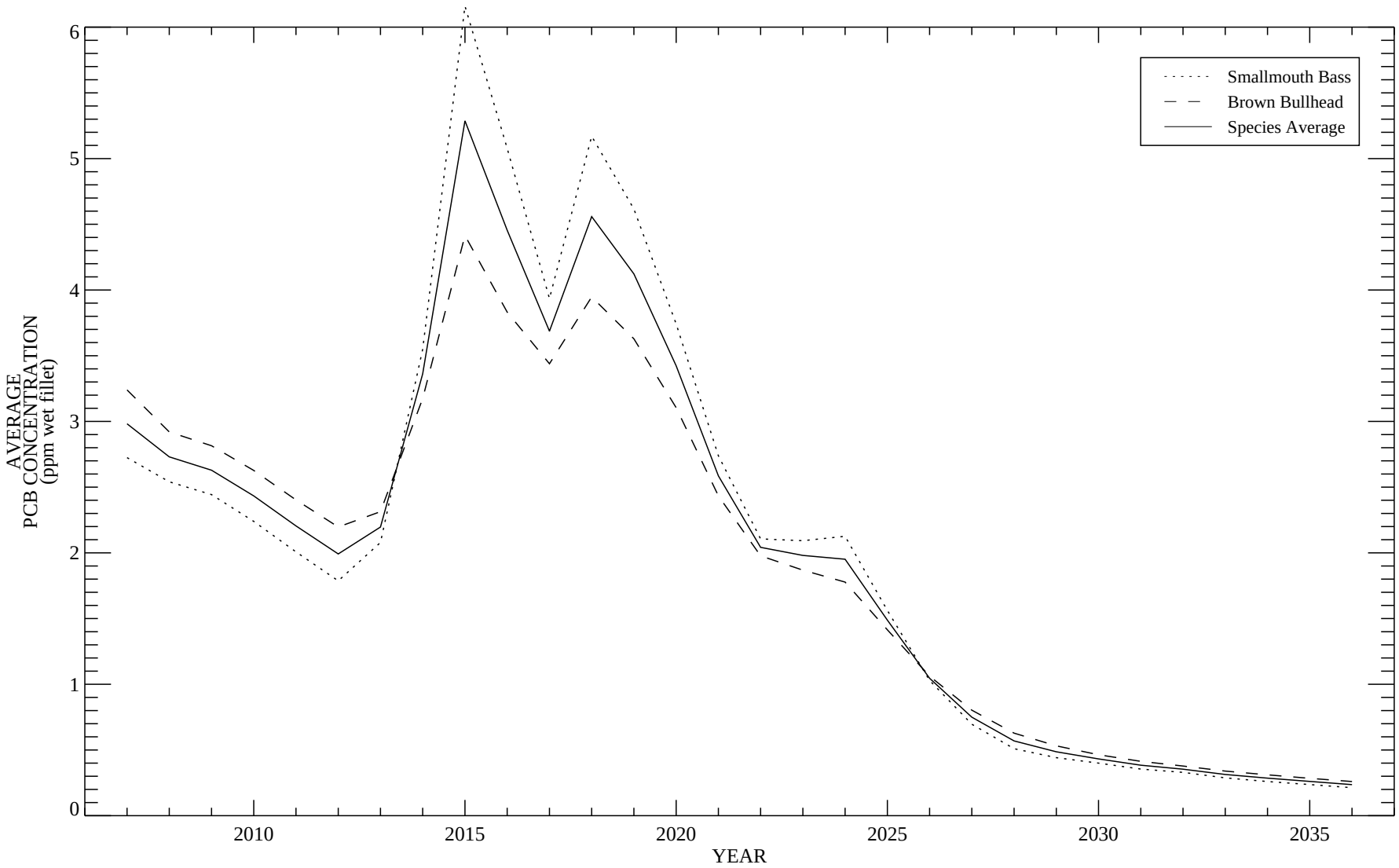


Figure A7-31. Predicted average fish tissue PCB concentrations in the lower Grasse River.
Alternative 10: T1-T72 dredging/capping.

Values represent river-wide annual avgerages.
Round 12. Projection run: 01-050712P

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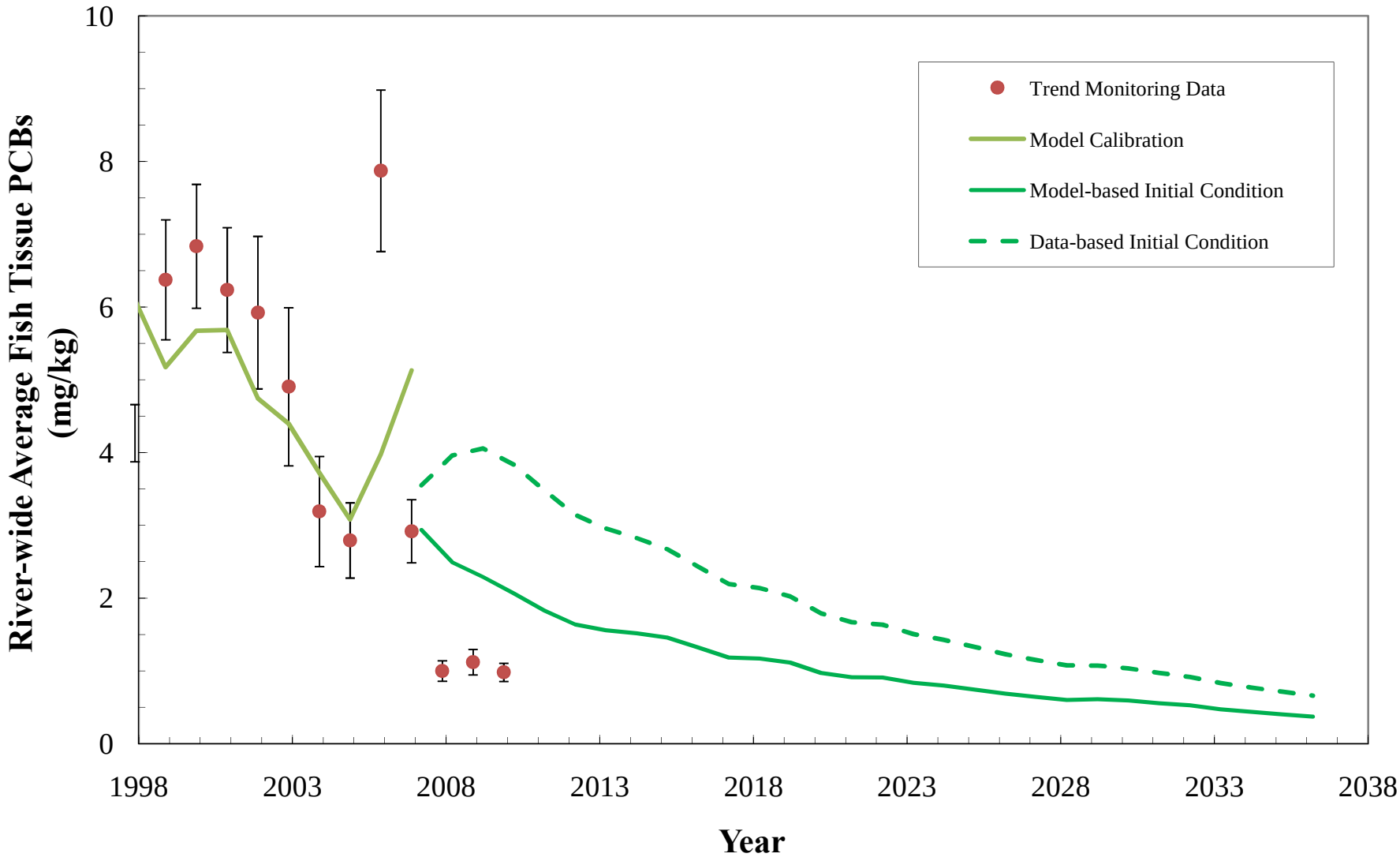

Figure A7-32. Sensitivity of predicted river-wide average fish tissue PCB levels in the Grasse River using two sets of initial sediment PCB concentrations for Alternative 1: no further action.
Values represent annual species-average computed from predicted PCB levels in smallmouth bass and brown bullhead.

Appendix B

Impacts of Boat Prop-Wash on Sediment Bed Stability in the Grasse River

IMPACTS OF BOAT PROP-WASH ON SEDIMENT BED STABILITY IN THE GRASSE RIVER

Prepared for:

Alcoa

Massena, New York

Prepared for:

March 2010

SECTION 1
INTRODUCTION

Turbulence will be generated in the water behind a recreational boat in the lower Grasse River by the propeller on the boat motor. The turbulence from the propeller, which is referred to as a boat prop-wash, spreads out behind the boat, both horizontally and vertically. At a certain distance behind the boat, the prop-wash will come in contact with the sediment bed and generate shear stress at the sediment-water interface. The bottom shear stress generated by the prop-wash may be large enough to cause erosion of the sediment bed.

The primary objective of this study was to evaluate the potential impacts of recreational boat prop-wash on sediment bed stability in the lower Grasse River. Details of the analytical approach used in this study are provided in the next section of the report. Results of the prop-wash impact analysis are presented in Section 3. Conclusions about the impacts of boat prop-wash on bed stability in the River are discussed in fourth section of the report.

SECTION 2
DESCRIPTION OF PROP-WASH IMPACT ANALYSIS

The propeller from a recreational boat creates what is referred to as a turbulent jet. The jet of water from the propeller will contact the sediment bed at a certain distance behind the boat. The sediment bed area that is impacted by the turbulence from the propeller jet may be exposed to bottom shear stresses that are high enough to cause erosion. Thus, the objectives of this analysis were to calculate: (1) bottom shear stress due to the propeller jet and (2) cohesive bed erosion corresponding to bottom shear stress generated by the boat propeller. Descriptions of both analyses are provided in this section.

2.1 Bottom Shear Stress

The first step in the analysis is to calculate the bottom shear stress generated by the jet of water from the boat propeller, i.e., prop-wash, as it impinges on the sediment bed. The maximum axial velocity generated by a non-ducted propeller is determined using (Palermo et al., 1998)

$$U_o = 9.72\left(\frac{P}{D^2}\right)^{1/3} \qquad (2\text{-}1)$$

where U_o = maximum axial (horizontal) velocity (ft/s); P = applied boat power (hp); and D = propeller diameter (ft). The assumption was made in this analysis that U_o is measured in a stationary coordinate system. This approximation produces conservative (i.e., worst case) results because movement of the boat reduces the actual prop-wash velocity impacting the bed (i.e., use of a non-stationary coordinate system may produce more accurate results).

The maximum axial velocity (U_o) occurs near the point where the jet of water leaves the propeller. The jet spreads out after it leaves the propeller, with the turbulent jet approximating the shape of a cone in the water behind the boat. The boundary between this turbulent cone and

the surrounding water, which is flowing at the ambient current velocity, has an angle of approximately 12° with respect to the propeller axis (White, 1974), and the propeller axis is assumed to be horizontal (Figure 2-1). The propeller jet is symmetric about a vertical plane through the center of the propeller and boat, i.e., the x-z plane in Figure 2-1, which will be referred to as the center-line plane.

The distance between the propeller axis and the sediment bed is

$$Z = h - Z_p \tag{2-2}$$

where Z = distance between propeller shaft and sediment bed (ft); h = water depth (ft); and Z_p = distance between water surface and propeller shaft (ft). For most recreational boats, Z_p is 2 ft, which is the value used in all calculations herein. The distance behind the propeller at which the propeller jet first impacts the sediment bed was determined using trigonometric relationships

$$X_{con} = 4.71\,Z \tag{2-3}$$

where X_{con} = distance behind propeller that jet first impacts bed (ft). Note that this contact point is in the center-line plane.

Water velocities within the turbulent jet will decrease from the maximum axial velocity (U_o) with increasing horizontal distance behind the propeller (White, 1974). Similarly, the center-line velocity exerted on the sediment bed by the propeller jet will decrease with distance behind the propeller (Blaauw et al., 1984)

$$\begin{aligned} U_b &= U_o\left(\frac{2.8D}{x}\right)e^{-15.4\left(\frac{Z}{x}\right)^2} \quad , \quad x \geq X_{con} \\ &= 0 \quad , \quad x < X_{con} \end{aligned} \tag{2-4}$$

where U_b = center-line velocity exerted on the sediment bed (ft/s) and x = distance behind propeller (ft). Note that U_b represents the maximum bed velocity generated by the propeller jet

at a particular value of x; bottom velocities decrease with increasing lateral distance from the jet center-line.

The maximum bottom shear stress generated by the propeller is of critical importance when calculating cohesive bed erosion. Bottom shear stress depends on U_b, which is spatially variable. Thus, the maximum value of U_b must be determined. To determine the location at which U_b is maximized, Equation (2-4) was differentiated with respect to x, the resulting equation set equal to zero, and then solved for X_{max} (Schwartz, 1974). This procedure resulted in

$$X_{\max} = 5.55\,Z \tag{2-5}$$

where X_{max} = distance behind propeller at which maximum U_b occurs (ft). Inserting X_{max} into Equation (2-4) yields

$$U_{b,\max} = 0.31\frac{DU_o}{Z} \tag{2-6}$$

where $U_{b,max}$ = maximum value of U_b (ft/s).

Maximum bottom shear stress due to prop-wash is calculated using the quadratic stress equation (van Rijn, 1993)

$$\tau_{\max} = \rho_w C_f U_{b,\max}^2 \tag{2-7}$$

where τ_{max} = maximum bottom shear stress (dynes/cm^2); ρ_w = density of water (assumed to be 1 g/cm^3); and C_f = bottom friction coefficient. Note that U_b is converted from ft/s to cm/s prior to use in Equation (2-7). The bottom friction coefficient for hydraulically rough flow is (van Rijn, 1993)

$$C_f = 0.24\left(\log\frac{12h}{k_s}\right)^{-2} \tag{2-8}$$

where k_s = effective sediment bed roughness (cm). Note that water depth (h) is converted from ft to cm prior to use in Equation (2-8). The effective bed roughness is determined from (van Rijn, 1993)

$$k_s = 3D_{90} \tag{2-9}$$

where D_{90} = 90th percentile bed particle diameter (0.04 cm for Grasse River cohesive sediment).

2.2 Cohesive Bed Erosion

Past laboratory research on cohesive sediment erosion (Krone, 1962; Parchure and Mehta, 1985; Tsai and Lick, 1987) demonstrated that the amount of sediment resuspended depends on the shear stress at the sediment-water interface and site-specific erosion properties of the sediment. Based upon existing laboratory and field data, the following formulation was developed to approximate the mass of sediment resuspended from a cohesive bed (Gailani et al., 1991)

$$\varepsilon = A\left(\frac{\tau - \tau_{cr}}{\tau_{cr}}\right)^n, \quad \tau > \tau_{cr} \tag{2-10}$$

where ε = resuspension potential, i.e., net mass of resuspended sediment per unit surface area (g/cm^2); A = site-specific constant (g/cm^2); n = site-specific exponent; τ = bottom shear stress (dynes/cm^2); and τ_{cr} = effective critical shear stress (1 dyne/cm^2 for lower Grasse River cohesive sediment). Site-specific values of A and n were determined from cohesive resuspension data collected during field studies on the lower Grasse River during 1998 and 2000 (Alcoa, 2001). Based on those data, upper-bound values of A and n used in this analysis were 0.0025 g/cm^2 and 1.66, respectively.

The total amount of resuspended sediment (ε) is determined from Equation (2-10), however, the resuspension rate (R, in g/cm^2-s) is needed for the prop-wash impact analysis. Experimental results show that cohesive erosion, for a bed exposed to a constant bottom shear stress, occurs over a time period on the order of one hour (i.e., γ g/cm^2 of sediment are eroded in about one hour; Tsai and Lick, 1987; MacIntyre et al., 1990). As a first-approximation, a constant resuspension rate may be assumed

$$R_{con} = \frac{\varepsilon}{3600} \tag{2-11}$$

where R_{con} = constant resuspension rate (g/s-cm^2) until all available sediment is eroded, i.e., $R = R_{con}$ for $t \leq 1$ hr and $R = 0$ for $t > 1$ hr, where $t = 0$ when the shear stress is first applied to the sediment bed. This approximation has been shown to produce realistic and accurate results in sediment transport models applied to the lower Grasse River and other riverine systems (Gailani et al., 1991; Ziegler and Nisbet, 1994; Ziegler and Nisbet, 1995; Cardenas et al., 1995; Gailani et al., 1996).

The time scale of bed erosion in a sediment transport model (i.e., hours) is significantly larger than the time scale of erosion caused by boat prop-wash, i.e., seconds. Thus, the first-order approximation for cohesive resuspension rate given by Equation (2-11) may not provide sufficient accuracy in the prop-wash impact analysis. A more accurate representation of cohesive resuspension rate was developed from laboratory data on cohesive sediment resuspension

$$R = B\, e^{-Bt} \varepsilon \tag{2-12}$$

where B = erosion rate constant (0.00068 s^{-1}) and t = time (s). If it is assumed that prop-wash from a recreational boat impacts the sediment bed at a particular location for a specific length of time, then Equation (2-12) can be integrated over that time period to determine the total mass of sediment resuspended by the boat prop-wash

$$\varepsilon_{boat} = \left(1 - e^{-BT_{bed}}\right)\varepsilon_{\max} \tag{2-13}$$

where ε_{boat} = total mass of sediment resuspended by prop-wash from a moving boat (g/cm^2); ε_{max} = total mass of resuspended sediment which is calculated using Equation (2-10) and setting $\tau = \tau_{max}$ (g/cm^2); T_{bed} = time that boat prop-wash impacts the bed at a particular location (s). Thus, maximum scour depth caused by prop-wash from a recreational boat is

$$d_{bed} = \frac{\varepsilon_{boat}}{\rho_{bed}} \tag{2-14}$$

where d_{bed} = depth of bed erosion (cm) and ρ_{bed} = dry density of bed sediment (0.7 g/cm^3 for lower Grasse River cohesive sediment). Note that using Equation (2-12) instead of the first-order approximation of a constant resuspension rate, i.e., Equation (2-11), to calculate erosion rate results in greater predicted scour depths.

The time that boat prop-wash impacts the bed at a particular location is

$$T_{bed} = 0.682\frac{L_{bed}}{V_{boat}} \tag{2-15}$$

where V_{boat} = boat velocity (mph) and L_{bed} = effective length of sediment bed over which maximum bottom shear stress due to prop-wash is applied (ft). Note that a unit conversion factor (0.682) is included in Equation (2-15). The velocity of a boat depends on the power applied by the motor (P, in hp) and the size of the boat (Baumeister, 1967)

$$V_{boat} = 16.3\frac{\left(PL_{boat}\right)^{1/3}}{W_{boat}} \tag{2-16}$$

where L_{boat} = boat length (ft) and W_{boat} = maximum boat width (ft). The distance between the point of contact of the propeller jet on the bed (X_{con}) and the point of maximum velocity, bottom shear stress and erosion (X_{max}) is 0.84 Z. The effective length of bed over which the maximum bottom shear stress due prop-wash is applied is assumed to be twice this distance

$$L_{bed} = 1.68Z \tag{2-17}$$

Bed velocities due to prop-wash are at least 96% of $U_{b,max}$ within this region of the bed, i.e., from $x = X_{con}$ to $x = X_{con} + L_{bed}$. Thus, this approximation to L_{bed} provides a reasonable estimate of the region over which maximum shear stress from the propeller jet is applied to the sediment bed; maximum shear stress determines bed erosion depth due to prop-wash.

SECTION 3
PROP-WASH IMPACT ANALYSIS RESULTS

As in any river, a range of recreational boats operate in the lower Grasse River, from large, fast water-ski boats to small, slow fishing boats. It is difficult to determine the size of an "average" boat. Thus, a range of typical boats was used in this analysis. The lower end of the range is represented by a smaller boat (denoted as case 1), with: P = 50 hp, D = 1 ft, L_{boat} = 16 ft and W_{boat} = 8 ft. The upper end of the boat range is a relatively large boat (denoted as case 2), with: P = 250 hp, D = 1.5 ft, L_{boat} = 20 ft and W_{boat} = 8 ft. While there are recreational boats on the lower Grasse River that are outside of this range, observations during field studies on the river indicate that this range is highly representative and only a small fraction of boat traffic is outside of the range, especially larger boats. Using Equation (2-16) to calculate boat speed, assuming the boat is under full power, results in boat speeds of 19 and 35 mph for cases 1 and 2, respectively. Note that prop-wash impact results for case 1 and 2 boats represent lower and upper bound limits, respectively, and that the impact of an "average" boat is between these two limits.

The impacts of boat prop-wash on cohesive bed stability in the lower Grasse River was evaluated in two ways. First, bed erosion caused by boats cruising at full power (and full speed) in the river was compared to erosion caused by floods in the lower Grasse River. Second, the impact of a boat accelerating in shallow water was determined.

3.1 Impacts of Cruising Boats

A boat cruising at full speed in the lower Grasse River will generate bottom shear stress that may cause bed erosion, with bottom shear stress increasing as water depth decreases. Scour depths in cohesive sediment caused by case 1 and 2 boats have a maximum value of 0.16 cm, which occurs in water less than five feet deep (Table 3-1). Note that in the reach of the river between the Route 131 Bridge and the river mouth, which is 4.7 miles long and has a sediment bed that is primarily composed of cohesive sediment, with approximately 17% of the bed area is

in water that is less than five feet deep. Most of the sediment bed (about 80%) is in water than is at least seven feet deep, with the maximum scour depth due to boat prop-wash in this deeper portion of the river being about 0.003 cm.

Table 3-1. Predicted Prop-Wash Scour Depths for Boats Cruising at Full Speed

Water Depth (ft)	Portion of Bed Area (%)	Maximum Erosion Depth: Case 1 (cm)	Maximum Erosion Depth: Case 2 (cm)
< 5	17	0.032	0.160
5 → 7	3	0.002	0.011
7 → 10	7	< 0.001	0.003
10 → 20	66	< 0.001	0.001
> 20	7	< 0.0001	< 0.001

To put the mass of sediment resuspended by boat prop-wash in context, estimates were made of the number of boats needed to resuspend the mass of sediment equivalent to floods that occurred in 1997 and 1998. These comparisons were made for the 4.7-mile stretch of river between the Route 131 Bridge and the river mouth because of the predominance of cohesive sediment in that area. The 1998 flood occurred in January and it was a large flood, with a return period of 100 years. A sediment transport model (Alcoa, 2009) predicted that 990 MT of sediment were eroded in this section of the river during the January 1998 flood. In contrast, the spring 1997 flood was more typical of annual high-flow events, with a return period of 1-2 years. During this flood, the sediment transport model predicted that 90 MT of sediment were eroded between the bridge and river mouth.

The following assumptions were used to estimate the number of boats that would resuspend sediment masses equivalent to the erosion that occurred during these floods. First, a boat, either case 1 or 2, traversed the entire 4.7-mile reach at full power and speed. Second, the boat path was random, which implies that the boat prop-wash would impact any portion of the river bed with equal probability. Third, the width of bed area eroded by prop-wash as a boat moved along the river was equal to the width of the propeller jet impinging on the bed at the

location of maximum bottom shear stress, i.e., $x = X_{max}$. At that location, the width of the jet on the bed (W_{max}) is

$$W_{\max} = 1.25Z \tag{3-1}$$

For a 100-year flood, such as occurred in January 1998, a large number of boats would be needed to resuspend the equivalent mass of sediment. The number of boats equivalent to the 100-year flood ranges between 15,000 and 126,000, corresponding to case 2 (250 hp, 35 mph) and case 1 (50 hp, 19 mph) boats. Maximum erosion depths caused by the 100-year flood are compared to scour depths due to boat prop-wash on Figure 3-1. Under extreme boat operating conditions (case 2), the erosion depth caused by prop-wash in shallow (i.e., less than 5 ft of water) is predicted to be comparable to that for a 100-yr flood event. Even under these conditions, the predicted amount of scour is minimal (i.e., about 1.5 mm).

The spring 1997 flood resuspended about 11 times less sediment than the 100-year flood in January 1998. The number of boats equivalent to the spring 1997 was correspondingly reduced by about a factor of 11. The number of boats equivalent to the spring 1997 flood ranges between 1,400 and 11,500, corresponding to case 2 (250 hp, 35 mph) and case 1 (50 hp, 19 mph) boats.

3.2 Impacts of Accelerating Boats

The impacts of a boat accelerating from zero to maximum velocity in shallow water were determined for case 1 and 2 boats. The following assumptions were used in these calculations: (1) constant acceleration from zero to V_{boat} (case 1 = 19 mph and case 2 = 35 mph); (2) maximum velocity was achieved after 10 s; and (3) water depth was 5 ft.

Kinematic equations were used to calculate time-variable velocity of the boat (Meriam, 1978)

$$V(t) = \left(\frac{V_{boat}}{T_{acc}} \right) t \tag{3-2}$$

where T_{acc} = time of acceleration (10 s). Similarly, the length of bed impacted by the accelerating boat is

$$L_{acc} = \frac{1}{2} V_{boat} \; t^2 \tag{3-3}$$

Thus, time-variable boat velocity, from Equation (3-2), was used to calculate scour depths, which varied spatially from $x = 0$ (starting point of boat) to $x = L_{acc}$ (end of acceleration). The maximum scour depth occurred near the starting point because the boat was under full power but moving relatively slowly during the initial phase of acceleration. Suspended sediment (TSS) concentrations due to prop-wash erosion were estimated along the boat path by assuming that the mass of eroded sediment was uniformly distributed throughout the water column and TSS concentration was calculated using

$$C_{TSS} = 32.81 \frac{\varepsilon}{h} \tag{3-4}$$

where C_{TSS} = TSS concentration (mg/L); ε = mass of resuspended sediment calculated using Equation (2-10) (mg/cm^2); and h = water depth (ft). Note that a unit conversion factor (32.81) is included in Equation (3-4).

A summary of results for case 1 and 2 boats is presented in Table 3-2. Note that maximum scour depth, TSS concentration and total mass of suspended sediment will decrease with increasing water depth, which was assumed to be 5 ft in this example. In addition, length and area of impacted bed will decrease as the time of acceleration decreases, which was assumed to be 10 s in this example.

Table 3-2. Impacts of Accelerating Boat in Shallow Water		
Parameter	Case 1 (50 hp)	Case 2 (250 hp)
Length of impacted bed (ft)	138	256
Area of impacted bed (ft^2)	520	960
Maximum scour depth (cm)	0.04	0.35
Maximum TSS concentration (mg/L)	170	1,600
Total mass of suspended sediment (kg)	4	69

SECTION 4
CONCLUSIONS

The results of the prop-wash analysis show that recreational boats have minimal impact on the stability of cohesive sediments in the lower Grasse River. An excessively large number of boats, traveling at full speed and traversing a large portion of the river, would be required to resuspend a mass of sediment equivalent to the impact of typical high-flow events. Scour depths caused by boat prop-wash are negligible (approximately 0.003 cm or less) in water greater than seven feet deep, which composes 80% of the bed area downstream of the Route 131 Bridge. Even in shallow water, i.e., less than five feet deep, maximum scour depths would be about 0.2 cm or less; approximately 17% of the bed area is in water that is this shallow and a boat operator typically avoids traveling at high speed in shallow water to prevent damage to the boat. Accelerating boats tend to cause deeper scour than cruising boats, but maximum scour depths for an accelerating boat are only about two times deeper. In addition, accelerating boats affect relatively small bed areas (less than 1,000 ft^2) and resuspend small amounts of sediment (less than 70 kg).

Results of this analysis should be considered upper-bound estimates of the impacts of boat prop-wash on bed stability in the Grasse River for the following reasons. First, various conservative assumptions were used, including: 1) D_{90} of 400 μm at all locations, whereas the bed is smoother downstream of the Route 131 Bridge, i.e., D_{90} is 100 μm in that region; 2) maximum bed velocity (U_b) is measured with respect to a stationary reference frame instead of a non-stationary reference frame; 3) acceleration time for a boat is 10 s; and 4) boats accelerate in water that is five feet deep. Second, boats were assumed to travel in all water depths with equal probability. This assumption is unrealistic, but conservative, because boat owners typically do not operate boats at high speed in shallow water, i.e., less than 5 ft in depth, due to the high probability of boat damage. Finally, the effects of cohesive bed armoring on bed stability were not considered in this analysis. For example, if a large spring flood occurs during a particular year, cohesive bed erosion would occur in various portions of the river. Bed armoring caused by

this flood would probably persist throughout a large portion of the summer of that year and this process would reduce the amount of sediment that could be resuspended by boat prop-wash.

SECTION 5
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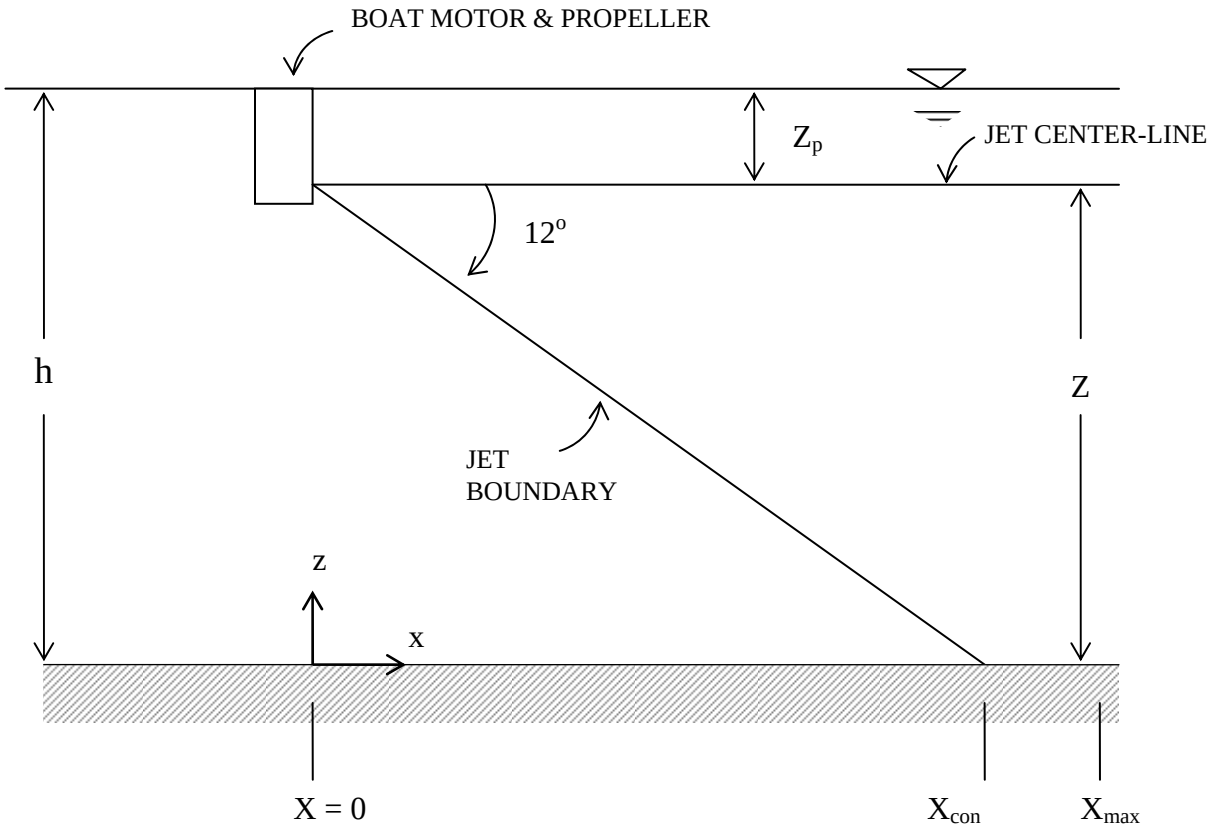

Figure 2-1. Geometry of Propeller Jet and Corresponding Nomenclature.

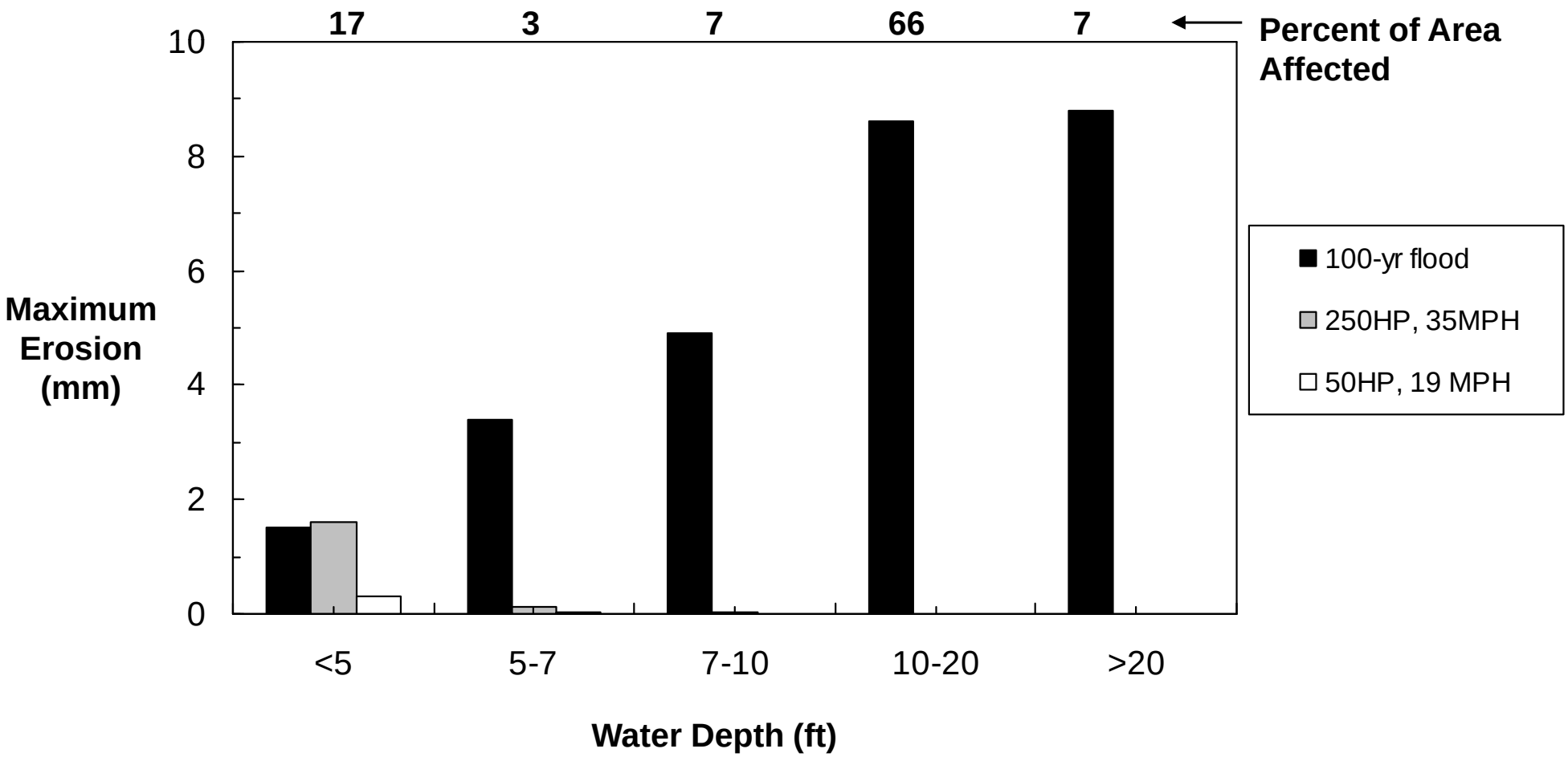

Figure 3-1. Comparison of Maximum Erosion Depths Caused by a 100-Year Flood and Boat Prop-Wash.

Values estimated for lower River between Route 131 Bridge and mouth.

Case 1 = 50 Horsepower boat with 12-inch diameter propeller travelling at 19 miles per hour.

Case 2 = 250 Horsepower boat with 18-inch diameter propeller travelling at 35 miles per hour.

Appendix C

Alternative-Specific Preliminary Cost Estimates

Appendix C

Grasse River Technical Memorandum

Cost Summary for Base Case and Cost Sensitivity Analysis

The cost estimates presented in the Final Analysis of Alternatives (AA) Report, and detailed in Appendix C were developed based on site-specific information from Alcoa Inc.'s (Alcoa's) previous experience in conducting sediment remediation work on the Grasse River and nearby St. Lawrence River, as well as experience reported for other projects in New York and across the United States. Through their review of the March 2010 Draft AA Report, the U.S. Environmental Protection Agency (USEPA) requested that Alcoa develop cost estimates for the Final AA Report using a range of unit costs for several key components of the alternatives, as described in a letter from USEPA dated July 1, 2011. Consistent with Alcoa's July 20, 2011, response to USEPA's letter, Alcoa maintains that the site-specific unit costs are the most appropriate, but the Final AA Report incorporates a range of unit costs for some components as a sensitivity analysis.

On January 31, 2012, Alcoa submitted a technical memorandum titled "Assumptions for Cost Estimate and Schedule Development," which summarized assumptions to be used in evaluating the cost and duration of remedial alternatives for the Final AA Report. The January 31, 2012, technical memorandum presented both a proposed "base case" set of assumptions that would be used to derive the costs and schedules for use in the comparative analysis of alternatives in the Final AA Report and a sensitivity discussion to address USEPA comments from July 1, 2011, regarding the impact of various other assumptions on projected costs and schedules. Subsequent to the January 31 technical memorandum, Alcoa made minor adjustments to the cost estimates based on feedback from the USEPA and for consistency with the Final AA Report. Those adjustments are reflected in this technical memorandum, which summarizes the costs for the base case and the costs for each of the four sensitivity analysis components. The remainder of Appendix C presents the detailed cost estimates for each alternative base case.

The unit costs recommended by USEPA in their July 1, 2011, letter and evaluated in the cost sensitivity analysis are summarized as follows:

- No silt curtains for dredging operations (Alcoa's base case includes silt curtains)
- $70 per cubic yard (CY) for sediment dewatering (Alcoa's base case estimate is $100 per CY)
- On-site disposal for all sediment (Alcoa's base case estimate includes on-site disposal up to 100,000 CY)
- Multiplier for routine engineering design of 11 percent of the total construction cost (Alcoa's base case estimate based on 15 percent)

As listed above, USEPA recommended that the Final AA Report assume that all sediment disposal would occur on site in Alcoa's on-site landfill, which currently has a capacity to accommodate approximately 60,000 CY of in situ sediments. On July 11, 2011, CDM Engineering provided estimates to Alcoa for landfill expansion based on ranges of dredged material requiring disposal. These estimates included the expansion of the existing on-site landfill to accommodate an additional 40,000 CY of dredged material beyond the existing capacity of 60,000 CY, for a total on-site capacity of 100,000 CY. Given the feasibility of this expansion, Alcoa incorporated this assumption (i.e., up to 100,000 CY of on-site landfill capacity) into the base case used in the Final AA Report cost estimates. In addition, the cost sensitivity analysis for the Final AA Report includes two additional ranges of disposal volume increases by construction of additional on-site landfill capacity to accommodate all dredged material for alternatives with expected dredge volumes in excess of 100,000 CY.

The three other USEPA recommendations (silt curtains, dewatering costs, and engineering fees) were not included as part of the base case but have been included as part of this sensitivity analysis. Table 1 provides a summary of the base case cost estimate and the costs including each of the four USEPA recommendations discussed above. It should be noted that there are no changes in any of the estimated project durations of the alternatives by including USEPA recommendations, although this evaluation does not consider any potential changes to total project durations based on the proposed landfill expansions.

Removal of silt curtains for dredging operations is reflected in a small cost change - less than 1.5 percent of the total cost for dredging alternatives. Decreasing the routine engineering design fee from 15 to 11 percent results in an average total project cost decrease of approximately 2.5 to 3 percent. The most significant cost deltas are seen in dredging alternatives with large expected removal volumes, based on the decreased dewatering unit cost and the landfill expansion and disposal of all dredged sediment on-site. The reduction in the dewatering costs results in a cost delta ranging from 1 to 5.5 percent and the cost deltas associated with the on-site landfill component range from a 4 percent increase (Alternative 6) to a 14 percent decrease (Alternative 10). The Alternative-specific cost deltas and percent changes are detailed in Table 1.

Table 1

Alternative	Expected Removal Volume (cy)	Alcoa Recommendations (Base Case) [a]	Sensitivity Analysis Recommendations [b]							
			No Silt Curtains for Dredging		Decreased Dewatering Cost		All Dredged Sediment Disposal On-Site		Decreased Engineering Fee	
		Estimated Cost ($MM)	Cost Delta	% Change	Cost Delta	% Change	Cost Delta	% Change	Cost Delta	% Change
1	-	$0.0	-	-	-	-	-	-	-	-
2	-	$3.4	-	-	-	-	-	-	-	-
3	-	$114.1	-	-	-	-	-	-	($3.0)	-2.6%
4	25,900	$147.2	($1.0)	-0.7%	($1.1)	-0.8%	-	-	($3.9)	-2.7%
5	46,100	$175.2	($2.1)	-1.2%	($2.0)	-1.1%	-	-	($4.7)	-2.7%
6	108,700	$243.1	($2.6)	-1.1%	($4.5)	-1.9%	$9.6	4.0%	($6.6)	-2.7%
7	258,300	$351.6	($4.1)	-1.2%	($10.8)	-3.1%	($10.7)	-3.0%	($9.7)	-2.8%
8	355,100	$388.0	($3.7)	-1.0%	($14.9)	-3.8%	($23.8)	-6.1%	($10.8)	-2.8%
9	633,200	$588.5	($7.8)	-1.3%	($26.6)	-4.5%	($41.2)	-7.0%	($16.4)	-2.8%
10	1,663,500	$1,273.5	($18.3)	-1.4%	($69.8)	-5.5%	($181.0)	-14.2%	($36.0)	-2.8%

Notes:

a. Base case costs and durations are consistent with detailed cost estimates provided in Appendix C and are based on the detailed assumptions presented in the January 31, 2012, technical memorandum titled "Assumptions for Cost Estimate and Schedule Development."

b. USEPA recommendations include no silt curtains for dredging , decreased dewatering unit cost for dredged material from $100 to $70 per CY, on-site disposal for all dredged sediment (landfill expansion costs provided by CDM Engineering, July 2011), and decreased routine engineering fee from 15 to 11 percent.

Cost Estimates

Table C-1

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Grasse River Alternatives Matrix Cost Summary

Updated 7/20/12

	Alternative	Description								Estimated Cost (Present Day $)					Duration (yrs)
											Sensitivity Analysis Recommendations [8]				
		River Stretch	Target Sediments	Action	PCB Metric	Threshold (mg/kg)	Neatline CY Dredged	Expected CY Dredged [7]	Acres Capped	Alcoa Recommendations "Base Case" [5]	No Silt Curtains for Dredging	Decreased Dewatering Unit Cost	All Dredged Sediment Disposal On-Site	Decreased Engineering Fee	
1	No Further Action	T1 to T72	All	None	---	---	0	0	0	$ -	$ -	$ -	$ -	$ -	0
2	Monitored Natural Recovery (MNR)	T1 to T72	All	Monitor	---	---	0	0	0	$ 3,400,000	$ 3,400,000	$ 3,400,000	$ 3,400,000	$ 3,400,000	0
3	T1-T72 Capping	T1 to T21	Near Shore	Near Shore Cap (6 inches)	SLWA/0-12 MAX	1	0	0	10	$ 114,100,000	$ 114,100,000	$ 114,100,000	$ 114,100,000	$ 111,100,000	3
			Main Channel	Armored Cap	SLWA/0-6 MAX	1	0	0	59						
		T21 to T72	Near Shore	Near Shore Cap (6 inches)	0-12 MAX	1	0	0	31						
			Main Channel	Main Channel Cap	0-6 MAX	1	0	0	225						
4	T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping T21-T72 Capping	T1 to T21	Near Shore	Dredge/Backfill to Grade	SLWA/0-12 MAX	1	17,200	25,900	10	$ 147,200,000	$ 146,200,000	$ 146,100,000	$ 147,200,000	$ 143,300,000	3
			Main Channel	Armored Cap	SLWA/0-6 MAX	1	0	0	59						
		T21 to T72	Near Shore	Near Shore Cap (6 inches)	0-12 MAX	1	0	0	31						
			Main Channel	Main Channel Cap	0-6 MAX	1	0	0	225						
5	T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping	T1 to T21	Near Shore	Near Shore Cap (6 inches)	SLWA/0-12 MAX	1	0	0	4	$ 175,200,000	$ 173,100,000	$ 173,200,000	$ 175,200,000	$ 170,500,000	4
				Dredge/Backfill to Grade	SLWA/0-12 MAX	10	12,200	18,300	6						
			Main Channel	Armored Cap	SLWA/0-6 MAX	1	0	0	59						
		T21 to T72	Near Shore	Near Shore Cap (6 inches)	0-12 MAX	1	0	0	24						
				Dredge/Backfill to Grade	0-12 MAX	10	18,600	27,800	7						
			Main Channel	Main Channel Cap	0-6 MAX	1	0	0	225						
6	T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping	T1 to T21	Near Shore	Dredge/Backfill to Grade	SLWA/0-12 MAX	1	17,200	25,900	10	$ 243,100,000	$ 240,500,000	$ 238,600,000	$ 252,700,000	$ 236,500,000	4
			Main Channel	Armored Cap	SLWA/0-6 MAX	1	0	0	59						
		T21 to T72	Near Shore	Dredge/Backfill to Grade	0-12 MAX	1	55,200	82,800	31						
			Main Channel	Main Channel Cap	0-6 MAX	1	0	0	225						
7	T1-T72 Near Shore Dredging/Backfilling T1-T19.5 Select Main Channel Dredging T1-T72 Main Channel Capping	T1 to T21	Near Shore	Dredge/Backfill to Grade	SLWA/0-12 MAX	1	17,200	25,900	10	$ 351,600,000	$ 347,500,000	$ 340,800,000	$ 340,900,000	$ 341,900,000	5
		WZ2	Main Channel	Dredge/Armored Cap	--	--	13,800	15,200	3						
		WZ3		Dredge/Armored Cap	--	--	22,200	24,400	2						
		T16.5-T19.5		Dredge/Armored Cap	--	--	99,900	110,000	14						
		T1 to T21 Remaining		Armored Cap	SLWA/0-6 MAX	1	0	0	40						
		T21 to T72	Near Shore	Dredge/Backfill to Grade	0-12 MAX	1	55,200	82,800	31						
			Main Channel	Main Channel Cap	0-6 MAX	1	0	0	225						
8	T1-T21 Dredging/Capping T21-T72 Capping	T1 to T21	Near Shore	Dredge/Backfill to Grade	SLWA/0-12 MAX	1	17,200	25,900	10	$ 388,000,000	$ 384,300,000	$ 373,100,000	$ 364,200,000	$ 377,200,000	8
			Main Channel	Dredge/Armored Cap	SLWA/0-6 MAX	1	299,300	329,200	59						
		T21 to T72	Near Shore	Near Shore Cap (6 inches)	0-12 MAX	1	0	0	31						
			Main Channel	Main Channel Cap	0-6 MAX	1	0	0	225						
9	T1-T72 Near Shore Dredging/Backfilling T1-T46 Select Main Channel Dredging T1-T72 Main Channel Capping	T1 to T21	Near Shore	Dredge/Backfill to Grade	SLWA/0-12 MAX	1	17,300	25,900	10	$ 588,500,000	$ 580,700,000	$ 561,900,000	$ 547,300,000	$ 572,100,000	7
		WZ2	Main Channel	Dredge/Armored Cap	--	--	13,800	15,200	3						
		WZ3		Dredge/Armored Cap	--	--	22,200	24,400	2						
		T16.5-T19.5		Dredge/Armored Cap	--	--	99,900	110,000	14						
		T1 to T21 Remaining		Armored Cap	SLWA/0-6 MAX	1	0	0	40						
		T21 to T72	Near Shore	Dredge/Backfill to Grade	0-12 MAX	1	55,200	82,800	31						
		T27-T37	Main Channel	Dredge/Main Channel Cap	--	--	106,900	132,700	34						
		T43-T46		Dredge/Main Channel Cap	--	--	161,400	242,200	23						
		T21 to T72 Remaining		Main Channel Cap	0-6 MAX	1	0	0	168						
10	T1-T72 Dredging/Capping	T1 to T21	Near Shore	Dredge/Backfill to Grade	SLWA/0-12 MAX	1	17,300	25,900	10	$ 1,273,500,000	$ 1,255,200,000	$ 1,203,700,000	$ 1,092,500,000	$ 1,237,500,000	18
			Main Channel	Dredge/Armored Cap	SLWA/0-6 MAX	1	299,300	329,200	59						
		T21 to T72	Near Shore	Dredge/Backfill to Grade	0-12 MAX	1	55,200	82,800	31						
			Main Channel	Dredge/Main Channel Cap	0-6 MAX	1	853,900	1,225,600	225						

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Removal volumes for near shore area dredging components reflect removal of entire depth of contamination.
3) Removal components in the main channel consider fine sediment areas only.
4) Capping components in the main channel consider both fine and coarse sediment areas.
5) Estimated Base Case costs based on assumptions provided on Table C-20, and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
6) Dredging volumes and cap areas based on 2010 near shore update.
7) Expected Volume includes volume considerations for over dredging and side slopes.
8) Cost sensitivity analysis based on recommendations from USEPA provided in July 1, 2011 letter.
9) Alternatives 7 and 9 do not use a PCB metric for main channel dredging because all sediment within the specified transect range would be removed.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
MC = main channel
MNR = monitored natural recovery
NS = near shore
PCB = polychlorinated biphenyl
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-2

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 1:
No Further Action

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	No Further Action	LS	1	$ -	$ -
2				Construction Total:	$ -
3				Routine Engineering Design (15%):	$ -
4				Construction Contingency (25%):	$ -
5				Long-Term Monitoring/O&M Program (Present Worth):	$ -
6				Total (Present Day):	$ -
7				Rounded Total (Present Day):	$ -

ASSUMPTIONS

1 All costs are provided in present day dollars.

ACRONYMS

LS = lump sum
O&M = operations and maintenance

Table C-3

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 2:
No Further Action / Monitored Natural Recovery (MNR)

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Long Term Monitoring/O&M Program (Present Worth)	LS	1	$ 3,400,000	$ 3,400,000
2				Construction Total:	$ -
3				Routine Engineering Design (15%):	$ -
4				Construction Contingency (25%):	$ -
5				Long-Term Monitoring/O&M Program (Present Worth):	$ -
6				Total (Present Day):	$ 3,400,000
7				Rounded Total (Present Day):	$ 3,400,000

ASSUMPTIONS

1. All costs are provided in present day dollars and all capital cost expenditures are assumed to occur in 2010.
2. This cost estimate assumes that no active remediation would be performed on the lower Grasse River. A 30-year monitoring program would be implemented to assess the natural recovery processes of the river.
3. The long-term monitoring/operation and maintenance program is assumed to include annual water column and fish monitoring. A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified. The long-term monitoring program would be conducted for a period of 30 years. The estimated cost for the long-term monitoring program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
4. Costs do not include property costs (if necessary), access costs (if necessary and not on Alcoa property), permitting costs, legal fees, Agency oversight, and public relations efforts.
5. These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

ACRONYMS

LS = lump sum
MNR = monitored natural recovery
O&M = operations and maintenance
USEPA = United Stated Environmental Protection Agency

Table C-4

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 3:
T1-T72 Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Capping Only (Year 1)	LS	1	$ 1,000,000	$ 1,000,000
2	Interim Mobilization - Capping Only (Years 2-3)	LS	2	$ 250,000	$ 500,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Near Shore Cap (6 inches) (SLWA / PCBs 0-12 Max)	Acre	10	$ 150,000	$ 1,500,000
5	T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	$ 400,000	$ 23,520,000
6	T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	31	$ 170,000	$ 5,236,000
7	T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	$ 165,000	$ 37,059,000
8	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
9	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
10	T1-T72 Disposal of Project Related Materials	Tons	288	$ 55	$ 15,884
11	Interim Demobilization (Years 1-2)	LS	2	$ 250,000	$ 500,000
12	Demobilization (Year 3)	LS	1	$ 500,000	$ 500,000
13	Construction Monitoring/Oversight	Month	21	$ 168,000	$ 3,528,000
14				Construction Total:	$ 74,211,384
15				Routine Engineering Design (15%):	$ 11,131,708
16				Construction Contingency (25%):	$ 18,552,846
17				Long-Term Monitoring/O&M Program (Present Worth):	$ 10,200,000
18				Total (Present Day):	$ 114,095,938
19				Rounded Total (Present Day):	$ 114,100,000

see Assumptions on next page

Table C-4
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 3:
T1-T72 Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 3 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month bbefore and one month after for mobilization/demobilization). Initial mobilization for capping has been estimated at $1,000,000 and subsequent re-mobilizations have been estimated at $250,000 per season. Interim demobilizations have been estimated at $250,000 per season. Final demobilization has been estimated at $500,000.

4 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

5 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

6 No more than one-half of the river would be cordoned off with silt curtains at one time.

7 Silt Curtains are included as a contingency for all capping remedies.

8 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

9 Construction sequencing and production rate assumptions include:
- Concurrent capping operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

10 Disposal of additional project materials including used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS).

11 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

12 Construction monitoring/oversight costs vary for the remedies proposed. Monitoring for capping-only remedies are assumed to be roughly half the cost than remedies with a combination of capping and moderate dredging volume.

13 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

14 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

15 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

16 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

17 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

see Notes on next page

Table C-4
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 3:
T1-T72 Capping

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-5

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 3:
T1-T72 Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Near Shore Cap (6 inches) (SLWA / PCBs 0-12 Max)	Acre	10	8,067	800	10.1	2.0
T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	197,317	1,200	164.4	2.0
T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	31	24,845	600	41.4	2.0
T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	362,355	1,440	251.6	2.0

Estimated Total Project Duration (days)	416	*< Max of River Reach Components (T1-T21 vs. T21-T72)*
Weeks (6 days per)	69.3	
Years (26 weeks per)	2.7	
Rounded Total Project Duration (years)	**3**	

NOTES
1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) For capping-only alternatives a full 26 week construction season is assumed for capping activities.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-6

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 4:
T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Dredging and Capping (Year 1)	LS	1	$ 2,900,000	$ 2,900,000
2	Interim Mobilization - Dredging and Capping (Years 2-3)	LS	2	$ 750,000	$ 1,500,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 300	$ 7,770,000
5	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Dredging Activities	LF	2,000	$ 373	$ 746,374
6	T1-T21 Debris Removal	In-situ CY	648		$ 388,500
7	T1-T21 Sediment Dewatering	In-situ CY	25,900	$ 100	$ 2,590,000
8	T1-T21 Water Treatment	In-situ CY	25,900	$ 30	$ 777,000
9	T1-T21 Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	In-situ CY	25,900	$ 66	$ 1,717,170
10	T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 186	$ 4,816,116
11	T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	$ 400,000	$ 23,520,000
12	T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	31	$ 170,000	$ 5,236,000
13	T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	$ 165,000	$ 37,059,000
14	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
15	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
16	T1-T72 Disposal of Project Related Materials	Tons	1,309	$ 55	$ 72,308
17	Interim Demobilization (Years 1-2)	LS	2	$ 500,000	$ 1,000,000
18	Demobilization (Year 3)	LS	1	$ 1,100,000	$ 1,100,000
19	Construction Monitoring/Oversight	Month	21	$ 264,000	$ 5,544,000
20				Construction Total:	$ 97,588,968
21				Routine Engineering Design (15%):	$ 14,638,345
22				Construction Contingency (25%):	$ 24,397,242
23				Long-Term Monitoring/O&M Program (Present Worth):	$ 10,600,000
24				Total (Present Day):	$ 147,224,555
25				Rounded Total (Present Day):	$ 147,200,000

see Assumptions on next page

Table C-6
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 4:
T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 3 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month before and one month after for mobilization/demobilization). Initial mobilization for dredging and capping has been estimated at $2,900,000 and subsequent re-mobilizations have been estimated at $750,000 per season. Interim demobilizations have been estimated at $500,000 per season. Final demobilization has been estimated at $1,100,000.

4 Dredging volumes include an increase factor to account for engineering considerations including over-dredging, stable side slopes, and potential additional sediment sampling and neat line delineation. A factor of 1.1x is applied to main channel dredging T1-T34 and T49-T59. A factor of 1.5x is applied to main channel dredging T34-T49 and T59-T72. A 1.5x factor is applied to near shore dredging T1-T72.

5 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

6 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

7 Dredging work would require multiple silt curtain systems to be placed around the boundary of the dredge area. The length of curtain required is based on approximate dredge volume and dredge footprint areas. The curtains would run perpendicular from shore on the downstream and upstream sides of dredging areas and then parallel to river flow along the work area. After dredging is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be removed and disposed of as applicable.

8 No more than one-half of the river would be cordoned off with silt curtains at one time.

9 Silt Curtains are included as a contingency for all dredging and capping remedies. For the cost sensitivity analysis, no silt curtains were assumed for dredging.

10 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

11 Construction sequencing and production rate assumptions include:
- Concurrent dredging and capping operations.
- Concurrent capping or dredging operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

12 The Backfill to Grade component consists of the placement of 50:50 sand/topsoil mix to return the river bottom to pre-dredge elevations. It is assumed that a volume of capping materials equal to that of in-situ dredge material removed, including over-dredge will be required. The cost for backfilling to grade is based on the unit price (per cubic yard) of Main Channel Cap (T21-T72) placement. Production rates are assumed to be the same as Main Channel Cap (T21-T72) placement.

13 Debris removal volume is estimated to be 2.5% the total volume of in-situ material removed. Removal costs are assumed to be 5% of the total dredging construction-only cost. Debris removal production is assumed to occur concurrently with dredging. The production rates for dredging consider the average rates for debris removal with typical dredging based on ROPS.

14 Disposal of additional project materials including debris, used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS). It is assumed that debris will be roughly 1.5 tons per cubic yard, similar to the density of sediment.

15 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

16 Construction monitoring/oversight costs vary for the remedies proposed. It is assumed that large volume dredging remedies (in excess of 100k CY) will require a more extensive monitoring program. Monitoring for capping-only remedies are assumed to be roughly half the cost than large volume dredging remedies. Remedies with a combination of capping and moderate dredging volume (less than 100k CY) have the above two monitoring program costs averaged.

17 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

Assumptions continued on next page

Table C-6
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 4:
T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping

ASSUMPTIONS (cont'd)

18 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

19 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

20 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

21 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Dredging volumes and cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-7

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 4:
T1-T21 Near Shore Dredging/Backfilling and Main Channel Capping, T21-T72 Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	400	64.8	1.0
T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	600	43.2	1.5
T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	197,317	1,200	164.4	2.0
T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	31	24,845	600	41.4	2.0
T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	362,355	1,440	251.6	2.0

No time offset between dredging and capping operations considered due to limited dredge volume>

Estimated Total Project Duration (days)	416	*< Max of River Reach Components (T1-T21 vs. T21-T72)*
Weeks (6 days per)	69.3	
Years (26 weeks per)	2.7	
Rounded Total Project Duration (years)	**3**	

NOTES

1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) Number of weeks per construction season is determined by the amount of dredging or capping that occurs in each season. All dredged areas must be capped before the season ends. To account for this, capping is delayed 4 weeks at the beginning of the season, and dredging stops 4 weeks prior to the end of the construction season to allow for capping for applicable Alternatives.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-8

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 5:
T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Dredging and Capping (Year 1)	LS	1	$ 2,900,000	$ 2,900,000
2	Interim Mobilization - Dredging and Capping (Years 2-4)	LS	3	$ 750,000	$ 2,250,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	18,300	$ 300	$ 5,490,000
5	T21-T72 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	27,800	$ 360	$ 10,008,000
6	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Dredging Activities	LF	4,000	$ 373	$ 1,492,747
7	T1-T72 Debris Removal	In-situ CY	1,153		$ 774,900
8	T1-T72 Sediment Dewatering	In-situ CY	46,100	$ 100	$ 4,610,000
9	T1-T72 Water Treatment	In-situ CY	46,100	$ 30	$ 1,383,000
10	T1-T72 Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	In-situ CY	46,100	$ 66	$ 3,056,430
11	T1-T21 Near Shore Cap (6 inches) (SLWA / PCBs 0-12 Max)	Acre	4	$ 150,000	$ 600,000
12	T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	18,300	$ 186	$ 3,402,893
13	T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	$ 400,000	$ 23,520,000
14	T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	24	$ 170,000	$ 4,080,000
15	T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	27,800	$ 205	$ 5,686,364
16	T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	$ 165,000	$ 37,059,000
17	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
18	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
19	T1-T72 Disposal of Project Related Materials	Tons	2,116	$ 55	$ 116,923
20	Interim Demobilization (Years 1-3)	LS	3	$ 500,000	$ 1,500,000
21	Demobilization (Year 4)	LS	1	$ 1,100,000	$ 1,100,000
22	Construction Monitoring/Oversight	Month	28	$ 264,000	$ 7,392,000
23				Construction Total:	$ 117,274,756
24				Routine Engineering Design (15%):	$ 17,591,213
25				Construction Contingency (25%):	$ 29,318,689
26				Long-Term Monitoring/O&M Program (Present Worth):	$ 11,000,000
27				Total (Present Day):	$ 175,184,659
28				Rounded Total (Present Day):	$ 175,200,000

see Assumptions on next page

Table C-8
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 5:
T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 4 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month before and one month after for mobilization/demobilization). Initial mobilization for dredging and capping has been estimated at $2,900,000 and subsequent re-mobilizations have been estimated at $750,000 per season. Interim demobilizations have been estimated at $500,000 per season. Final demobilization has been estimated at $1,100,000.

4 Dredging volumes include an increase factor to account for engineering considerations including over-dredging, stable side slopes, and potential additional sediment sampling and neat line delineation. A factor of 1.1x is applied to main channel dredging T1-T34 and T49-T59. A factor of 1.5x is applied to main channel dredging T34-T49 and T59-T72. A 1.5x factor is applied to near shore dredging T1-T72.

5 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

6 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

7 Dredging work would require multiple silt curtain systems to be placed around the boundary of the dredge area. The length of curtain required is based on approximate dredge volume and dredge footprint areas. The curtains would run perpendicular from shore on the downstream and upstream sides of dredging areas and then parallel to river flow along the work area. After dredging is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be removed and disposed of as applicable.

8 No more than one-half of the river would be cordoned off with silt curtains at one time.

9 Silt Curtains are included as a contingency for all dredging and capping remedies. For the cost sensitivity analysis, no silt curtains were assumed for dredging.

10 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

11 Construction sequencing and production rate assumptions include:
- Concurrent dredging and capping operations.
- Concurrent capping or dredging operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

12 The Backfill to Grade component consists of the placement of 50:50 sand/topsoil mix to return the river bottom to pre-dredge elevations. It is assumed that a volume of capping materials equal to that of in-situ dredge material removed, including over-dredge will be required. The cost for backfilling to grade is based on the unit price (per cubic yard) of Main Channel Cap (T21-T72) placement. Production rates are assumed to be the same as Main Channel Cap (T21-T72) placement.

13 Debris removal volume is estimated to be 2.5% the total volume of in-situ material removed. Removal costs are assumed to be 5% of the total dredging construction-only cost. Debris removal production is assumed to occur concurrently with dredging. The production rates for dredging consider the average rates for debris removal with typical dredging based on ROPS.

14 Disposal of additional project materials including debris, used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS). It is assumed that debris will be roughly 1.5 tons per cubic yard, similar to the density of sediment.

15 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

16 Construction monitoring/oversight costs vary for the remedies proposed. It is assumed that large volume dredging remedies (in excess of 100k CY) will require a more extensive monitoring program. Monitoring for capping-only remedies are assumed to be roughly half the cost than large volume dredging remedies. Remedies with a combination of capping and moderate dredging volume (less than 100k CY) have the above two monitoring program costs averaged.

17 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

Assumptions continued on next page

Table C-8
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 5:
T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping

ASSUMPTIONS (cont'd)

18 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

19 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

20 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

21 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Dredging volumes and cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-9

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 5:
T1-T72 Near Shore Dredging/Backfilling >10, Near Shore Capping >1, and Main Channel Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	18,300	n/a	400	45.8	1.0
T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	18,300	n/a	600	30.5	1.5
T1-T21 Near Shore Cap (6 inches) (SLWA / PCBs 0-12 Max)	Acre	4	3,227	600	5.4	1.5
T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	197,317	1,200	164.4	2.0
T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	27,800	n/a	400	69.5	1.0
T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	27,800	n/a	540	51.5	1.5
T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	24	19,360	450	43.0	1.5
T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	362,355	1,440	251.6	2.0

	Estimated Total Project Duration (days)	416
	Weeks (6 days per)	69.3
22 weeks per construction season assumed due to required time offset between dredging and capping operations >	Years (22 weeks per)	3.2
	Rounded Total Project Duration (years)	**4**

< Max of River Reach Components (T1-T21 vs. T21-T72)

NOTES

1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) Number of weeks per construction season is determined by the amount of dredging or capping that occurs in each season. All dredged areas must be capped before the season ends. To account for this, capping is delayed 4 weeks at the beginning of the season, and dredging stops 4 weeks prior to the end of the construction season to allow for capping for applicable Alternatives.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-10

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 6:
T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Dredging and Capping (Year 1)	LS	1	$ 2,900,000	$ 2,900,000
2	Interim Mobilization - Dredging and Capping (Years 2-4)	LS	3	$ 750,000	$ 2,250,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 300	$ 7,770,000
5	T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	82,800	$ 360	$ 29,808,000
6	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Dredging Activities	LF	5,000	$ 373	$ 1,865,934
7	T1-T72 Debris Removal	In-situ CY	2,718		$ 1,878,900
8	T1-T72 Sediment Dewatering	In-situ CY	108,700	$ 100	$ 10,870,000
9	T1-T72 Water Treatment	In-situ CY	108,700	$ 30	$ 3,261,000
10	T1-T72 Expanded Landfill Design and Permitting, Construction, Site Improvements	LS	1	$ 2,800,000	$ 2,800,000
11	T1-T72 Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	In-situ CY	100,000	$ 66	$ 6,630,000
12	T1-T72 Transportation and Disposal of Sediments Off-Site	In-situ CY	8,700	$ 163	$ 1,419,840
13	T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 186	$ 4,816,116
14	T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	$ 400,000	$ 23,520,000
15	T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	$ 205	$ 16,936,364
16	T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	$ 165,000	$ 37,059,000
17	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
18	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
19	T1-T72 Disposal of Project Related Materials	Tons	4,489	$ 136	$ 610,470
20	Interim Demobilization (Years 1-3)	LS	3	$ 500,000	$ 1,500,000
21	Demobilization (Year 4)	LS	1	$ 1,100,000	$ 1,100,000
22	Construction Monitoring/Oversight	Month	28	$ 264,000	$ 7,392,000
23				Construction Total:	$ 165,240,123
24				Routine Engineering Design (15%):	$ 24,786,019
25				Construction Contingency (25%):	$ 41,310,031
26				Long-Term Monitoring/O&M Program (Present Worth):	$ 11,800,000
27				Total (Present Day):	$ 243,136,173
28				Rounded Total (Present Day):	$ 243,100,000

see Assumptions on next page

Table C-10
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 6:
T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 4 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month before and one month after for mobilization/demobilization). Initial mobilization for dredging and capping has been estimated at $2,900,000 and subsequent re-mobilizations have been estimated at $750,000 per season. Interim demobilizations have been estimated at $500,000 per season. Final demobilization has been estimated at $1,100,000.

4 Dredging volumes include an increase factor to account for engineering considerations including over-dredging, stable side slopes, and potential additional sediment sampling and neat line delineation. A factor of 1.1x is applied to main channel dredging T1-T34 and T49-T59. A factor of 1.5x is applied to main channel dredging T34-T49 and T59-T72. A 1.5x factor is applied to near shore dredging T1-T72.

5 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

6 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

7 Dredging work would require multiple silt curtain systems to be placed around the boundary of the dredge area. The length of curtain required is based on approximate dredge volume and dredge footprint areas. The curtains would run perpendicular from shore on the downstream and upstream sides of dredging areas and then parallel to river flow along the work area. After dredging is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be removed and disposed of as applicable.

8 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on

9 Silt Curtains are included as a contingency for all dredging and capping remedies. For the cost sensitivity analysis, no silt curtains were assumed for dredging.

10 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

11 Disposal of dredged material assumes an expanded on-site landfill to accommodate up to 100k CY. Line item cost for landfill expansion of $2.8MM includes permitting, construction, and site improvements (Provided by CDM, 2011). Volume beyond 100k CY will be disposed of at an approved off-site landfill by truck transport. For the cost sensitivity analysis two additional landfill expansion options are included: Expansion to accommodate up to 500k CY for a cost of $10.5MM, and expansion to accommodate volumes in excess of 500k CY for a cost of $25MM.

12 Construction sequencing and production rate assumptions include:
- Concurrent dredging and capping operations.
- Concurrent capping or dredging operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

13 The Backfill to Grade component consists of the placement of 50:50 sand/topsoil mix to return the river bottom to pre-dredge elevations. It is assumed that a volume of capping materials equal to that of in-situ dredge material removed, including over-dredge will be required. The cost for backfilling to grade is based on the unit price (per cubic yard) of Main Channel Cap (T21-T72) placement. Production rates are assumed to be the same as Main Channel Cap (T21-T72) placement.

14 Debris removal volume is estimated to be 2.5% the total volume of in-situ material removed. Removal costs are assumed to be 5% of the total dredging construction-only cost. Debris removal production is assumed to occur concurrently with dredging. The production rates for dredging consider the average rates for debris removal with typical dredging based on ROPS.

15 Disposal of additional project materials including debris, used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS). It is assumed that debris will be roughly 1.5 tons per cubic yard, similar to the density of sediment.

16 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

17 Construction monitoring/oversight costs vary for the remedies proposed. It is assumed that large volume dredging remedies (in excess of 100k CY) will require a more extensive monitoring program. Monitoring for capping-only remedies are assumed to be roughly half the cost than large volume dredging remedies. Remedies with a combination of capping and moderate dredging volume (less than 100k CY) have the above two monitoring program costs averaged.

Assumptions continued on next page

Table C-10
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 6:
T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping

ASSUMPTIONS (cont'd)

18 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

19 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

20 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

21 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

22 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Dredging volumes and cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-11

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 6:
T1-T72 Near Shore Dredging/Backfilling and Main Channel Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	400	64.8	1.0
T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	82,800	n/a	400	207.0	1.0
T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	600	43.2	1.5
T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	197317	1,200	164.4	2.0
T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	n/a	540	153.3	1.5
T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	362355	1,440	251.6	2.0

22 weeks per construction season assumed due to required time offset between dredging and capping operations >

Estimated Total Project Duration (days)	459	*< Max of River Reach Components (T1-T21 vs. T21-T72)*
Weeks (6 days per)	76.4	
Years (22 weeks per)	3.5	
Rounded Total Project Duration (years)	**4**	

NOTES

1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) Number of weeks per construction season is determined by the amount of dredging or capping that occurs in each season. All dredged areas must be capped before the season ends. To account for this, capping is delayed 4 weeks at the beginning of the season, and dredging stops 4 weeks prior to the end of the construction season to allow for capping for applicable Alternatives.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-12

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 7:
T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Dredging and Capping (Year 1)	LS	1	$ 2,900,000	$ 2,900,000
2	Interim Mobilization - Dredging and Capping (Years 2-5)	LS	4	$ 750,000	$ 3,000,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 300	$ 7,770,000
5	T1-T21 Dredging Main Channel Sediments	In-situ CY	149,600	$ 160	$ 23,936,000
6	T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	82,800	$ 360	$ 29,808,000
7	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Dredging Activities	LF	5,000	$ 373	$ 1,865,934
8	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Dredging Activities	LF	3,000	$ 373	$ 1,119,560
9	T1-T72 Debris Removal	In-situ CY	6,458		$ 3,075,700
10	T1-T72 Sediment Dewatering	In-situ CY	258,300	$ 100	$ 25,830,000
11	T1-T72 Water Treatment	In-situ CY	258,300	$ 30	$ 7,749,000
12	T1-T72 Expanded Landfill Design and Permitting, Construction, Site Improvements	LS	1	$ 2,800,000	$ 2,800,000
13	T1-T72 Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	In-situ CY	100,000	$ 66	$ 6,630,000
14	T1-T72 Transportation and Disposal of Sediments Off-Site	In-situ CY	158,300	$ 163	$ 25,834,560
15	T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 186	$ 4,816,116
16	T1-T21 Armored Cap Main Channel Sediments	Acre	59	$ 400,000	$ 23,680,000
17	T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	$ 205	$ 16,936,364
18	T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	$ 165,000	$ 37,059,000
19	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
20	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
21	T1-T72 Disposal of Project Related Materials	Tons	10,174	$ 136	$ 1,383,630
22	Interim Demobilization (Years 1-4)	LS	4	$ 500,000	$ 2,000,000
23	Demobilization (Year 5)	LS	1	$ 1,100,000	$ 1,100,000
24	Construction Monitoring/Oversight	Month	35	$ 360,000	$ 12,600,000
25				Construction Total:	$ 242,746,364
26				Routine Engineering Design (15%):	$ 36,411,955
27				Construction Contingency (25%):	$ 60,686,591
28				Long-Term Monitoring/O&M Program (Present Worth):	$ 11,800,000
29				Total (Present Day):	$ 351,644,909
30				Rounded Total (Present Day):	$ 351,600,000

see Assumptions on next page

Table C-12
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 7:
T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 5 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month before and one month after for mobilization/demobilization). Initial mobilization for dredging and capping has been estimated at $2,900,000 and subsequent re-mobilizations have been estimated at $750,000 per season. Interim demobilizations have been estimated at $500,000 per season. Final demobilization has been estimated at $1,100,000.

4 Dredging volumes include an increase factor to account for engineering considerations including over-dredging, stable side slopes, and potential additional sediment sampling and neat line delineation. A factor of 1.1x is applied to main channel dredging T1-T34 and T49-T59. A factor of 1.5x is applied to main channel dredging T34-T49 and T59-T72. A 1.5x factor is applied to near shore dredging T1-T72.

5 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

6 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

7 Dredging work would require multiple silt curtain systems to be placed around the boundary of the dredge area. The length of curtain required is based on approximate dredge volume and dredge footprint areas. The curtains would run perpendicular from shore on the downstream and upstream sides of dredging areas and then parallel to river flow along the work area. After dredging is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be removed and disposed of as applicable.

8 No more than one-half of the river would be cordoned off with silt curtains at one time.

9 Silt Curtains are included as a contingency for all dredging and capping remedies. For the cost sensitivity analysis, no silt curtains were assumed for dredging.

10 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

11 Disposal of dredged material assumes an expanded on-site landfill to accommodate up to 100k CY. Line item cost for landfill expansion of $2.8MM includes permitting, construction, and site improvements (Provided by CDM, 2011). Volume beyond 100k CY will be disposed of at an approved off-site landfill by truck transport. For the cost sensitivity analysis two additional landfill expansion options are included: Expansion to accommodate up to 500k CY for a cost of $10.5MM, and expansion to accommodate volumes in excess of 500k CY for a cost of $25MM.

12 Construction sequencing and production rate assumptions include:
- Concurrent dredging and capping operations.
- Concurrent capping or dredging operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

13 The Backfill to Grade component consists of the placement of 50:50 sand/topsoil mix to return the river bottom to pre-dredge elevations. It is assumed that a volume of capping materials equal to that of in-situ dredge material removed, including over-dredge will be required. The cost for backfilling to grade is based on the unit price (per cubic yard) of Main Channel Cap (T21-T72) placement. Production rates are assumed to be the same as Main Channel Cap (T21-T72) placement.

14 Debris removal volume is estimated to be 2.5% the total volume of in-situ material removed. Removal costs are assumed to be 5% of the total dredging construction-only cost. Debris removal production is assumed to occur concurrently with dredging. The production rates for dredging consider the average rates for debris removal with typical dredging based on ROPS.

15 Disposal of additional project materials including debris, used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS). It is assumed that debris will be roughly 1.5 tons per cubic yard, similar to the density of sediment.

16 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

17 Construction monitoring/oversight costs vary for the remedies proposed. It is assumed that large volume dredging remedies (in excess of 100k CY) will require a more extensive monitoring program. Monitoring for capping-only remedies are assumed to be roughly half the cost than large volume dredging remedies. Remedies with a combination of capping and moderate dredging volume (less than 100k CY) have the above two monitoring program costs averaged.

Assumptions continued on next page

Table C-12
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 7:
T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping

ASSUMPTIONS (cont'd)

18 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

19 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

20 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

21 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

22 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Dredging volumes and cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-13

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 7:
T1-T72 Near Shore Dredging/Backfilling, T1-T19.5 Select Main Channel Dredging, T1-T72 Main Channel Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	400	64.8	1.0
T1-T21 Dredging Main Channel Sediments	In-situ CY	149,600	n/a	400	374.0	1.0
T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	600	43.2	1.5
T1-T21 Armored Cap Main Channel Sediments	Acre	59	198,659	900	220.7	1.5
T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	82,800	n/a	400	207.0	1.0
T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	n/a	540	153.3	1.5
T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	362,355	1,440	251.6	2.0

	Estimated Total Project Duration (days)	626
	Weeks (6 days per)	104.3
22 weeks per construction season assumed due to required time offset between dredging and capping operations >	Years (22 weeks per)	4.7
	Rounded Total Project Duration (years)	**5**

< Max of River Reach Components (T1-T21 vs. T21-T72)

NOTES

1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) Number of weeks per construction season is determined by the amount of dredging or capping that occurs in each season. All dredged areas must be capped before the season ends. To account for this, capping is delayed 4 weeks at the beginning of the season, and dredging stops 4 weeks prior to the end of the construction season to allow for capping for applicable Alternatives.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-14

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 8:
T1-T21 Dredging/Capping, T21-T72 Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Dredging and Capping (Year 1)	LS	1	$ 2,900,000	$ 2,900,000
2	Interim Mobilization - Dredging and Capping (Years 2-8)	LS	7	$ 750,000	$ 5,250,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 300	$ 7,770,000
5	T1-T21 Dredging Main Channel Sediments (SLWA / PCBs 0-6 Max)	In-situ CY	329,200	$ 160	$ 52,672,000
6	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Dredging Activities	LF	2,000	$ 373	$ 746,374
7	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Dredging Activities	LF	5,000	$ 373	$ 1,865,934
8	T1-T72 Debris Removal	In-situ CY	8,878		$ 3,022,100
9	T1-T72 Sediment Dewatering	In-situ CY	355,100	$ 100	$ 35,510,000
10	T1-T72 Water Treatment	In-situ CY	355,100	$ 30	$ 10,653,000
11	T1-T72 Expanded Landfill Design and Permitting, Construction, Site Improvements	LS	1	$ 2,800,000	$ 2,800,000
12	T1-T72 Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	In-situ CY	100,000	$ 66	$ 6,630,000
13	T1-T72 Transportation and Disposal of Sediments Off-Site	In-situ CY	255,100	$ 163	$ 41,632,320
14	T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 186	$ 4,816,116
15	T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	$ 400,000	$ 23,520,000
16	T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	31	$ 170,000	$ 5,236,000
17	T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	$ 165,000	$ 37,059,000
18	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
19	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
20	T1-T72 Disposal of Project Related Materials	Tons	13,779	$ 136	$ 1,873,910
21	Interim Demobilization (Years 1-7)	LS	7	$ 500,000	$ 3,500,000
22	Demobilization (Year 8)	LS	1	$ 1,100,000	$ 1,100,000
23	Construction Monitoring/Oversight	Month	56	$ 360,000	$ 20,160,000
24				Construction Total:	$ 269,569,253
25				Routine Engineering Design (15%):	$ 40,435,388
26				Construction Contingency (25%):	$ 67,392,313
27				Long-Term Monitoring/O&M Program (Present Worth):	$ 10,600,000
28				Total (Present Day):	$ 387,996,955
29				Rounded Total (Present Day):	$ 388,000,000

see Assumptions on next page

Table C-14
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 8:
T1-T21 Dredging/Capping, T21-T72 Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 8 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month before and one month after for mobilization/demobilization). Initial mobilization for dredging and capping has been estimated at $2,900,000 and subsequent re-mobilizations have been estimated at $750,000 per season. Interim demobilizations have been estimated at $500,000 per season. Final demobilization has been estimated at $1,100,000.

4 Dredging volumes include an increase factor to account for engineering considerations including over-dredging, stable side slopes, and potential additional sediment sampling and neat line delineation. A factor of 1.1x is applied to main channel dredging T1-T34 and T49-T59. A factor of 1.5x is applied to main channel dredging T34-T49 and T59-T72. A 1.5x factor is applied to near shore dredging T1-T72.

5 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

6 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

7 Dredging work would require multiple silt curtain systems to be placed around the boundary of the dredge area. The length of curtain required is based on approximate dredge volume and dredge footprint areas. The curtains would run perpendicular from shore on the downstream and upstream sides of dredging areas and then parallel to river flow along the work area. After dredging is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be removed and disposed of as applicable.

8 No more than one-half of the river would be cordoned off with silt curtains at one time.

9 Silt Curtains are included as a contingency for all dredging and capping remedies. For the cost sensitivity analysis, no silt curtains were assumed for dredging.

10 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

11 Disposal of dredged material assumes an expanded on-site landfill to accommodate up to 100k CY. Line item cost for landfill expansion of $2.8MM includes permitting, construction, and site improvements (Provided by CDM, 2011). Volume beyond 100k CY will be disposed of at an approved off-site landfill by truck transport. For the cost sensitivity analysis two additional landfill expansion options are included: Expansion to accommodate up to 500k CY for a cost of $10.5MM, and expansion to accommodate volumes in excess of 500k CY for a cost of $25MM.

12 Construction sequencing and production rate assumptions include:
- Concurrent dredging and capping operations.
- Concurrent capping or dredging operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

13 The Backfill to Grade component consists of the placement of 50:50 sand/topsoil mix to return the river bottom to pre-dredge elevations. It is assumed that a volume of capping materials equal to that of in-situ dredge material removed, including over-dredge will be required. The cost for backfilling to grade is based on the unit price (per cubic yard) of Main Channel Cap (T21-T72) placement. Production rates are assumed to be the same as Main Channel Cap (T21-T72) placement.

14 Debris removal volume is estimated to be 2.5% the total volume of in-situ material removed. Removal costs are assumed to be 5% of the total dredging construction-only cost. Debris removal production is assumed to occur concurrently with dredging. The production rates for dredging consider the average rates for debris removal with typical dredging based on ROPS.

15 Disposal of additional project materials including debris, used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS). It is assumed that debris will be roughly 1.5 tons per cubic yard, similar to the density of sediment.

16 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

17 Construction monitoring/oversight costs vary for the remedies proposed. It is assumed that large volume dredging remedies (in excess of 100k CY) will require a more extensive monitoring program. Monitoring for capping-only remedies are assumed to be roughly half the cost than large volume dredging remedies. Remedies with a combination of capping and moderate dredging volume (less than 100k CY) have the above two monitoring program costs averaged.

Assumptions continued on next page

Table C-14
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 8:
T1-T21 Dredging/Capping, T21-T72 Capping

ASSUMPTIONS (cont'd)

18 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

19 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

20 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

21 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

22 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Dredging volumes and cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-15

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 8:
T1-T21 Dredging/Capping, T21-T72 Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	400	64.8	1.0
T1-T21 Dredging Main Channel Sediments (SLWA / PCBs 0-6 Max)	In-situ CY	329,200	n/a	400	823.0	1.0
T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	600	43.2	1.5
T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	197,317	900	219.2	1.5
T21-T72 Near Shore Cap (6 inches) (PCBs 0-12 Max)	Acre	31	24,845	600	41.4	2.0
T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	362,355	1,440	251.6	2.0

22 weeks per construction season assumed due to required time offset between dredging and capping operations >

Estimated Total Project Duration (days)	1075	*< Max of River Reach Components (T1-T21 vs. T21-T72)*
Weeks (6 days per)	179.1	
Years (22 weeks per)	8.1	
Rounded Total Project Duration (years)	**8**	

NOTES

1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) Number of weeks per construction season is determined by the amount of dredging or capping that occurs in each season. All dredged areas must be capped before the season ends. To account for this, capping is delayed 4 weeks at the beginning of the season, and dredging stops 4 weeks prior to the end of the construction season to allow for capping for applicable Alternatives.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-16

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 9:
T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Dredging and Capping (Year 1)	LS	1	$ 3,770,000	$ 3,770,000
2	Interim Mobilization - Dredging and Capping (Years 2-7)	LS	6	$ 975,000	$ 5,850,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 300	$ 7,770,000
5	T1-T21 Dredging Main Channel Sediments	In-situ CY	149,600	$ 160	$ 23,936,000
6	T21-T72 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	82,800	$ 360	$ 29,808,000
7	T21-T72 Dredging Main Channel Sediments	In-situ CY	374,900	$ 110	$ 41,239,000
8	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Dredging Activities	LF	5,000	$ 373	$ 1,865,934
9	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Dredging Activities	LF	10,000	$ 373	$ 3,731,868
10	T1-T72 Debris Removal	In-situ CY	15,830		$ 5,137,650
11	T1-T72 Sediment Dewatering	In-situ CY	633,200	$ 100	$ 63,320,000
12	T1-T72 Water Treatment	In-situ CY	633,200	$ 30	$ 18,996,000
13	T1-T72 Expanded Landfill Design and Permitting, Construction, Site Improvements	LS	1	$ 2,800,000	$ 2,800,000
14	T1-T72 Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	In-situ CY	100,000	$ 66	$ 6,630,000
15	T1-T72 Transportation and Disposal of Sediments Off-Site	In-situ CY	533,200	$ 163	$ 87,018,240
16	T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 186	$ 4,816,116
17	T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59.200	$ 400,000	$ 23,680,000
18	T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	$ 205	$ 16,936,364
19	T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	224.60	$ 165,000	$ 37,059,000
20	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
21	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
22	T1-T72 Disposal of Project Related Materials	Tons	24,408	$ 136	$ 3,319,420
23	Interim Demobilization (Years 1-6)	LS	6	$ 700,000	$ 4,200,000
24	Demobilization (Year 7)	LS	1	$ 1,500,000	$ 1,500,000
25	Construction Monitoring/Oversight	Month	49	$ 360,000	$ 17,640,000
26				Construction Total:	$ 411,876,092
27				Routine Engineering Design (15%):	$ 61,781,414
28				Construction Contingency (25%):	$ 102,969,023
29				Long-Term Monitoring/O&M Program (Present Worth):	$ 11,900,000
30				Total (Present Day):	$ 588,526,528
31				Rounded Total (Present Day):	$ 588,500,000

see Assumptions on next page

Table C-16
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 9:
T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 7 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month before and one month after for mobilization/demobilization). Initial mobilization for dredging and capping has been estimated at $3,770,000 and subsequent re-mobilizations have been estimated at $975,000 per season. Interim demobilizations have been estimated at $700,000 per season. Final demobilization has been estimated at $1,500,000.

4 Dredging volumes include an increase factor to account for engineering considerations including over-dredging, stable side slopes, and potential additional sediment sampling and neat line delineation. A factor of 1.1x is applied to main channel dredging T1-T34 and T49-T59. A factor of 1.5x is applied to main channel dredging T34-T49 and T59-T72. A 1.5x factor is applied to near shore dredging T1-T72.

5 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

6 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

7 Dredging work would require multiple silt curtain systems to be placed around the boundary of the dredge area. The length of curtain required is based on approximate dredge volume and dredge footprint areas. The curtains would run perpendicular from shore on the downstream and upstream sides of dredging areas and then parallel to river flow along the work area. After dredging is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be removed and disposed of as applicable.

8 No more than one-half of the river would be cordoned off with silt curtains at one time.

9 Silt Curtains are included as a contingency for all dredging and capping remedies. For the cost sensitivity analysis, no silt curtains were assumed for dredging.

10 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

11 Disposal of dredged material assumes an expanded on-site landfill to accommodate up to 100k CY. Line item cost for landfill expansion of $2.8MM includes permitting, construction, and site improvements (Provided by CDM, 2011). Volume beyond 100k CY will be disposed of at an approved off-site landfill by truck transport. For the cost sensitivity analysis two additional landfill expansion options are included: Expansion to accommodate up to 500k CY for a cost of $10.5MM, and expansion to accommodate volumes in excess of 500k CY for a cost of $25MM.

12 Construction sequencing and production rate assumptions include:
- Concurrent dredging and capping operations.
- Concurrent capping or dredging operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

13 The Backfill to Grade component consists of the placement of 50:50 sand/topsoil mix to return the river bottom to pre-dredge elevations. It is assumed that a volume of capping materials equal to that of in-situ dredge material removed, including over-dredge will be required. The cost for backfilling to grade is based on the unit price (per cubic yard) of Main Channel Cap (T21-T72) placement. Production rates are assumed to be the same as Main Channel Cap (T21-T72) placement.

14 Debris removal volume is estimated to be 2.5% the total volume of in-situ material removed. Removal costs are assumed to be 5% of the total dredging construction-only cost. Debris removal production is assumed to occur concurrently with dredging. The production rates for dredging consider the average rates for debris removal with typical dredging based on ROPS.

15 Disposal of additional project materials including debris, used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS). It is assumed that debris will be roughly 1.5 tons per cubic yard, similar to the density of sediment.

16 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

17 Construction monitoring/oversight costs vary for the remedies proposed. It is assumed that large volume dredging remedies (in excess of 100k CY) will require a more extensive monitoring program. Monitoring for capping-only remedies are assumed to be roughly half the cost than large volume dredging remedies. Remedies with a combination of capping and moderate dredging volume (less than 100k CY) have the above two monitoring program costs averaged.

Assumptions continued on next page

Table C-16
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 9:
T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping

ASSUMPTIONS (cont'd)

18 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

19 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

20 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

21 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

22 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Dredging volumes and cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-17

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 9:
T1-T72 Near Shore Dredging/Backfilling, T1-T46 Select Main Channel Dredging, T1-T72 Main Channel Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	400	64.8	1.0
T1-T21 Dredging Main Channel Sediments	In-situ CY	149,600	n/a	400	374.0	1.0
T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	600	43.2	1.5
T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	198,659	900	220.7	1.5
T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	82,800	n/a	400	207.0	1.0
T21-T72 Dredging Main Channel Sediments	In-situ CY	374,900	n/a	800	468.6	1.0
T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	n/a	540	153.3	1.5
T21-T72 Main Channel Cap Sediments (PCBs 0-6 Max)	Acre	225	362,355	1,080	335.5	1.5

	Estimated Total Project Duration (days)	843
	Weeks (6 days per)	140.4
22 weeks per construction season assumed due to required time offset between dredging and capping operations >	Years (22 weeks per)	6.4
	Rounded Total Project Duration (years)	**7**

< Max of River Reach Components (T1-T21 vs. T21-T72)

NOTES

1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) Number of weeks per construction season is determined by the amount of dredging or capping that occurs in each season. All dredged areas must be capped before the season ends. To account for this, capping is delayed 4 weeks at the beginning of the season, and dredging stops 4 weeks prior to the end of the construction season to allow for capping for applicable Alternatives.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-18

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 10:
T1-T72 Dredging/Capping

Updated 7/20/12

ITEM NO.	BASE CASE (TECHNICAL MEMORANDUM TITLED "ASSUMPTIONS FOR COST ESTIMATE AND SCHEDULE DEVELOPMENT," JANUARY 31, 2012)				
	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (Present Day)
1	Mobilization - Dredging and Capping (Year 1)	LS	1	$ 3,770,000	$ 3,770,000
2	Interim Mobilization - Dredging and Capping (Years 2-18)	LS	17	$ 975,000	$ 16,575,000
3	Access Area Development/Restoration	LS	3	$ 150,000	$ 450,000
4	T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 300	$ 7,770,000
5	T1-T21 Dredging Main Channel Sediments (SLWA / PCBs 0-6 Max)	In-situ CY	329,200	$ 160	$ 52,672,000
6	T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	82,800	$ 360	$ 29,808,000
7	T21-T72 Dredging Main Channel Sediments (PCBs 0-6 Max)	In-situ CY	1,225,600	$ 110	$ 134,816,000
8	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Dredging Activities	LF	5000	$ 373	$ 1,865,934
9	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Dredging Activities	LF	30000	$ 373	$ 11,195,604
10	T1-T72 Debris Removal	In-situ CY	41,588		$ 11,253,300
11	T1-T72 Sediment Dewatering	In-situ CY	1,663,500	$ 100	$ 166,350,000
12	T1-T72 Water Treatment	In-situ CY	1,663,500	$ 30	$ 49,905,000
13	T1-T72 Expanded Landfill Design and Permitting, Construction, Site Improvements	LS	1	$ 2,800,000	$ 2,800,000
14	T1-T72 Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	In-situ CY	100,000	$ 66	$ 6,630,000
15	T1-T72 Transportation and Disposal of Sediments Off-Site	In-situ CY	1,563,500	$ 163	$ 255,163,200
16	T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	$ 186	$ 4,816,116
17	T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	$ 400,000	$ 23,520,000
18	T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	$ 205	$ 16,936,364
19	T21-T72 Main Channel Cap Main Channel Sediments (PCBs 0-6 Max)	Acre	225	$ 165,000	$ 37,059,000
20	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Near Shore Capping Activities	LF	1,500	$ 35	$ 52,500
21	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Main Channel Capping Activities	LF	10,000	$ 35	$ 350,000
22	T1-T72 Disposal of Project Related Materials	Tons	63,544	$ 136	$ 8,641,950
23	Interim Demobilization (Years 1-17)	LS	17	$ 700,000	$ 11,900,000
24	Demobilization (Year 18)	LS	1	$ 1,500,000	$ 1,500,000
25	Construction Monitoring/Oversight	Month	126	$ 360,000	$ 45,360,000
26				Construction Total:	$ 901,159,968
27				Routine Engineering Design (15%):	$ 135,173,995
28				Construction Contingency (25%):	$ 225,289,992
29				Long-Term Monitoring/O&M Program (Present Worth):	$ 11,900,000
30				Total (Present Day):	$ 1,273,523,955
31				Rounded Total (Present Day):	$ 1,273,500,000

see Assumptions on next page

Table C-18
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 10:
T1-T72 Dredging/Capping

ASSUMPTIONS

1 All costs are provided in present day dollars and all capital cost expenditures are assumed to occur at the start of construction.

2 Work to be conducted 6 days per week with a 7th day planned for regular maintenance or scheduled make-up.

3 Work is estimated to take 18 construction seasons to complete (typical construction season includes 6 months for the actual construction season plus one month before and one month after for mobilization/demobilization). Initial mobilization for dredging and capping has been estimated at $3,770,000 and subsequent re-mobilizations have been estimated at $975,000 per season. Interim demobilizations have been estimated at $700,000 per season. Final demobilization has been estimated at $1,500,000.

4 Dredging volumes include an increase factor to account for engineering considerations including over-dredging, stable side slopes, and potential additional sediment sampling and neat line delineation. A factor of 1.1x is applied to main channel dredging T1-T34 and T49-T59. A factor of 1.5x is applied to main channel dredging T34-T49 and T59-T72. A 1.5x factor is applied to near shore dredging T1-T72.

5 Two distinct areas on Alcoa's property would be used for staging areas to support Capping operations between T1 and T21. A separate staging area (not on Alcoa's property) would be used to support capping operations downstream of T21. The cost to construct/prepare/restore (post-construction) areas are estimated at $150,000 per area. The areas used for Materials Processing were constructed during the ROPS in 2005.

6 Capping work would require a single silt curtain system (with a maximum curtain length in the river of 5,000 LF) to be placed in the shape of an "L", enclosing the work area on two sides. The curtains would run perpendicular from shore on the downstream side of each area and then parallel to river flow along the work area. After capping is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be moved to the second area.

7 Dredging work would require multiple silt curtain systems to be placed around the boundary of the dredge area. The length of curtain required is based on approximate dredge volume and dredge footprint areas. The curtains would run perpendicular from shore on the downstream and upstream sides of dredging areas and then parallel to river flow along the work area. After dredging is complete at a given area, the silt curtain would remain an appropriate length of time to mitigate material release and would then be removed and disposed of as applicable.

8 No more than one-half of the river would be cordoned off with silt curtains at one time.

9 Silt Curtains are included as a contingency for all dredging and capping remedies. For the cost sensitivity analysis, no silt curtains were assumed for dredging.

10 Costs assume that the Near Shore Caps would consist of 6 inches of sand/topsoil (50:50 mix) placed atop the sediment. Armored Caps would consist of 6 inches of sand/topsoil (50:50 mix) overlain by 6 inches of a gravel filter layer, and 13 inches of 3- to 10-inch-diameter gravel/cobbles. Main Channel Caps (T21-T72) would consist of 12 inches of sand/topsoil (50:50 mix). Sand/topsoil materials would be placed in 6-inch lifts. Gravel/cobble materials would be placed in a single 13-inch lift. Cap materials would be obtained from local borrow pits.

11 Disposal of dredged material assumes an expanded on-site landfill to accommodate up to 100k CY. Line item cost for landfill expansion of $2.8MM includes permitting, construction, and site improvements (Provided by CDM, 2011). Volume beyond 100k CY will be disposed of at an approved off-site landfill by truck transport. For the cost sensitivity analysis two additional landfill expansion options are included: Expansion to accommodate up to 500k CY for a cost of $10.5MM, and expansion to accommodate volumes in excess of 500k CY for a cost of $25MM.

12 Construction sequencing and production rate assumptions include:
- Concurrent dredging and capping operations.
- Concurrent capping or dredging operations in the near shore and main channel.
- Capping production rates from Table C-20 multiplied by a 2x factor for capping only, and by 1.5x factor where there is concurrent dredging and capping to account for multiple capping rigs.

13 The Backfill to Grade component consists of the placement of 50:50 sand/topsoil mix to return the river bottom to pre-dredge elevations. It is assumed that a volume of capping materials equal to that of in-situ dredge material removed, including over-dredge will be required. The cost for backfilling to grade is based on the unit price (per cubic yard) of Main Channel Cap (T21-T72) placement. Production rates are assumed to be the same as Main Channel Cap (T21-T72) placement.

14 Debris removal volume is estimated to be 2.5% the total volume of in-situ material removed. Removal costs are assumed to be 5% of the total dredging construction-only cost. Debris removal production is assumed to occur concurrently with dredging. The production rates for dredging consider the average rates for debris removal with typical dredging based on ROPS.

15 Disposal of additional project materials including debris, used silt curtains, PPE, etc. would be disposed of in a appropriate disposal facility via truck. Quantity estimated as 0.025 tons per linear foot of silt curtains (based on ROPS). It is assumed that debris will be roughly 1.5 tons per cubic yard, similar to the density of sediment.

16 Construction monitoring/oversight includes daily oversight of construction activities and is assumed to be conducted during all in-river activities (i.e., silt curtain installation/removal, dredging, capping, etc.). For purposes of this estimate, one additional month of oversight has been assumed per construction season to account for two assumed half-time months of monitoring during mobilization/demobilization activities. The construction monitoring/oversight includes water column sampling, cap thickness monitoring, and operation of WINOPS system. The monitoring program included has been assumed to be less intensive than that performed for the Remedial Options Pilot Study.

17 Construction monitoring/oversight costs vary for the remedies proposed. It is assumed that large volume dredging remedies (in excess of 100k CY) will require a more extensive monitoring program. Monitoring for capping-only remedies are assumed to be roughly half the cost than large volume dredging remedies. Remedies with a combination of capping and moderate dredging volume (less than 100k CY) have the above two monitoring program costs averaged.

Assumptions continued on next page

Table C-18
(cont'd)

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 10:
T1-T72 Dredging/Capping

ASSUMPTIONS (cont'd)

18 Engineering fees typically range between 7 to 15% of remediation costs as recommended by the USEPA in Remedial Action Costing Procedures Manual, 600/8-87-049 (USEPA, 1987) and A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002 (USEPA, 2000). For purposes of this estimate a value of 15% has been used. For the cost sensitivity analysis, a value of 11% is used.

19 A contingency allowance has been included to account for unforeseen circumstances or variability in the volumes, labor, or material costs. The contingency typically ranges from 15 to 25% of the remediation costs as recommended by the USEPA (USEPA, 1987 and USEPA, 2000). For purposes of this estimate a value of 25% has been used.

20 The long-term monitoring/operation and maintenance program includes the following assumptions:
- Annual water column and fish monitoring, to be conducted for a period of 30 years. The estimated cost for this component of the program was calculated using the present worth analysis process outlined by the USEPA (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation and expenditures are assumed to occur at the start of construction.
- Cap maintenance and monitoring activities, including diver observation following a high energy event and lower Grasse River bathymetry surveying, assumed to be performed once every 5 years. The cost of this component was calculated as being 10 percent of the cap-only construction cost, plus and interim mobilization and an interim demobilization cost (assumed to cover the cost of all maintenance and monitoring activities mobilization/demobilization).
- A 5-year review of the long-term monitoring program would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified.

21 Costs do not include property costs (if necessary), access costs (if not on Alcoa property), permitting costs, legal fees, and Agency oversight, and public relations efforts.

22 These cost estimates were developed using current and generally accepted engineering cost estimation methods for an Analysis of Alternatives. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment, and characteristics of the river system at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.

NOTES

1) Cap definitions: Armored Cap = 25" thick design (as per ROPS); Main Channel Cap (T21-T72) = 12" thick sand/topsoil mix (as per CPS and ROPS); and Near Shore Cap = 6" thick sand/topsoil mix.
2) Capping components in the main channel consider both fine and coarse sediment areas.
3) Estimated costs based on assumptions provided in Table C-20 and in the January 31, 2012 memorandum entitled Assumptions for Cost Estimate and Schedule Development.
4) Dredging volumes and cap areas based on 2010 near shore update.

ACRONYMS

CPS = Capping Pilot Study
CY = cubic yards
LF = linear foot
LS = lump sum
MC = main channel
NS = near shore
O&M = operations and maintenance
PCB = polychlorinated biphenyl
PPE = personal protective equipment
ROPS = Remedial Options Pilot Study
SLWA = segment length-weighted average
USEPA = United Stated Environmental Protection Agency

Table C-19

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Construction Duration Estimates for Alternative 10:
T1-T72 Dredging/Capping

Updated 7/20/12

DESCRIPTION	UNIT	NO. OF UNITS	CAP/BACKFILL VOLUME (CY)	AVERAGE PRODUCTION RATE (CY PER DAY)	ESTIMATE DURATION (DAYS)	PRODUCTION RATE INCREASE FACTOR
T1-T21 Dredging Near Shore Sediments (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	400	64.8	1.0
T1-T21 Dredging Main Channel Sediments (SLWA / PCBs 0-6 Max)	In-situ CY	329,200	n/a	400	823.0	1.0
T1-T21 Near Shore Backfill to Grade (SLWA / PCBs 0-12 Max)	In-situ CY	25,900	n/a	600	43.2	1.5
T1-T21 Armored Cap Main Channel Sediments (SLWA / PCBs 0-6 Max)	Acre	59	197,317	900	219.2	1.5
T21-T72 Dredging Near Shore Sediments (PCBs 0-12 Max)	In-situ CY	82,800	n/a	400	207.0	1.0
T21-T72 Dredging Main Channel Sediments (PCBs 0-6 Max)	In-situ CY	1,225,600	n/a	800	1,532.0	1.0
T21-T72 Near Shore Backfill to Grade (PCBs 0-12 Max)	In-situ CY	82,800	n/a	540	153.3	1.5
T21-T72 Main Channel Cap Main Channel Sediments (PCBs 0-6 Max)	Acre	225	362,355	1,080	335.5	1.5

	Estimated Total Project Duration (days)	2,355
	Weeks (6 days per)	392.5
22 weeks per construction season assumed due to required time offset between dredging and capping operations >	Years (22 weeks per)	17.8
	Rounded Total Project Duration (years)	**18**

< Max of River Reach Components (T1-T21 vs. T21-T72)

NOTES

1) Estimated Total Project Duration (days) is calculated as the maximum component of remedial activities in each reach of the river (T1-T21 or T21-T72).
2) Number of weeks per construction season is determined by the amount of dredging or capping that occurs in each season. All dredged areas must be capped before the season ends. To account for this, capping is delayed 4 weeks at the beginning of the season, and dredging stops 4 weeks prior to the end of the construction season to allow for capping for applicable Alternatives.
3) Rounded Total Project Duration is the total years rounded up to nearest whole year. If the total years are less than 20 days more than a whole number year amount, then total years rounded down.
4) Estimated durations used for cost estimates may vary from that used in Alternatives modeling.
5) Capping production rate increase factors based on construction sequencing and production rate assumptions.

Table C-20

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Unit Cost and Production Rate Summary

Updated 7/20/12

TASK	UNIT COST (PRESENT DAY)	UNIT	PRODUCTION RATE	PRODUCTION UNITS	DESCRIPTION
Mobilization-T1-T72-**Capping Only**	$ 1,000,000	Year 1	1	month	
Mobilization-Interim-T1-T72-**Capping Only**	$ 250,000	Years 2 to X	1	month	X = *total duration of remedial action*
Mobilization-T1 to T21-**Dredging and Capping** (T1-T72)	$ 2,900,000	Year 1	2	month	
Mobilization-Interim-T1 to T21-**Dredging and Capping** (T1-T72)	$ 750,000	Years 2 to X	1	month	X = *total duration of remedial action*
Mobilization-T1 to T72-**Dredging and Capping** (T1-T72)	$ 3,770,000	Year 1	2	month	
Mobilization-Interim-T1 to T72-**Dredging and Capping** (T1-T72)	$ 975,000	Years 2 to X	1	month	X = *total duration of remedial action*
Main_Channel-T1-T21-**Armored_Cap**	$ 400,000	Acre	600	cy/day	(6" sand/topsoil + 6" gravel + 13" cobbles)
Main_Channel-T21-T72-**Main_Channel_Cap**	$ 165,000	Acre	720	cy/day	(12" sand/topsoil [50:50 mix])
Near_Shore-T1-T21-**Near_Shore_Cap**	$ 150,000	Acre	400	cy/day	(3-6" sand/topsoil [50:50 mix])
Near_Shore-T1-T21-**Backfill to Grade**	$ 186	cy	400	cy/day	(sand/topsoil [50:50 mix])
Near_Shore-T21-T72-**Near_Shore_Cap**	$ 170,000	Acre	300	cy/day	(3-6" sand/topsoil [50:50 mix])
Near_Shore-T21-T72-**Backfill to Grade**	$ 205	cy	360	cy/day	(sand/topsoil [50:50 mix])
Dredging-Main Channel-T1-T21-**Dredging**	$ 160	in situ cy	400	in situ cy/day	
Dredging-Main Channel-T21-T72-**Dredging**	$ 110	in situ cy	800	in situ cy/day	
Dredging-Near_Shore-T1-T21-**Dredging**	$ 300	in situ cy	200	in situ cy/day	(rate for 1 rig)
Dredging-Near_Shore-T21-T72-**Dredging**	$ 360	in situ cy	200	in situ cy/day	(rate for 1 rig)
Silt_Curtains-Capping Areas	$ 35	LF	-	-	
Silt_Curtains-Dredging Areas	$ 373	LF	-	-	
Treatment-**Sediment Dewatering/Transport**	$ 100	in situ cy	same as dredging	-	
Treatment-**Water Treatment**	$ 30	in situ cy	same as dredging	-	
Disposal-**Onsite**-Per Ton	$ 55	ton	same as dredging	-	
Disposal-**Onsite**-Per In Situ CY	$ 66	in situ cy	same as dredging	-	
Disposal-**Offsite**-Per Ton	$ 136	dewatered ton	same as dredging	-	
Disposal-**Offsite-**Per In Site CY	$ 163	in situ cy	same as dredging	-	
Demobilization-Interim-T1-T72-**Capping Only**	$ 250,000	Years 1 to (X-1)	1	month	
Demobilization-T1-T72-**Capping Only**	$ 500,000	Year X	1	month	
Demobilization-Interim-T1 to T21-**Dredging and Capping** (T1-T72)	$ 500,000	Years 1 to (X-1)	1	month	
Demobilization-T1 to T21-**Dredging and Capping** (T1-T72)	$ 1,100,000	Year X	2	month	
Demobilization-Interim-T1 to T72-**Dredging and Capping** (T1-T72)	$ 700,000	Years 1 to (X-1)	1	month	
Demobilization-T1 to T72-**Dredging and Capping** (T1-T72)	$ 1,500,000	Year X	2	month	
Infrastructure-**Access Areas**	$ 150,000	LS	-	-	
CM-**Capping Only**	$ 168,000	LS	-	month	Scaled up for 6 day work week
CM-**Dredging and Capping**	$ 360,000	LS	-	month	Scaled up for 6 day work week
CM-**Intermediate Dredging**	$ 264,000	LS	-	month	Scaled up for 6 day work week

ACRONYMS

MNR = monitored natural recovery
O&M = operations and maintenance
USEPA = United Stated Environmental Protection Agency
CM = Construction Monitoring

Appendix D

Update to the Cap Modeling Studies Presented in the June 2002 Analysis of Alternatives Report

UPDATE TO THE CAP MODELING STUDIES PRESENTED IN THE JUNE 2002 ANALYSIS OF ALTERNATIVES REPORT

Alcoa Inc.
Massena, New York

May 21, 2003

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Figure 2. Vertical Fraction Organic Carbon Profile Used in the 1-D Model Simulations

Figure 3. Vertical PCB Profile Used in the 1-D Model Simulations

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Figure 5. Variable Sedimentation Rate Function Used in the 1-D Model Simulations

Figure 6. Predicted Diffusive Flux of PCB through 12-Inch Cap to Overlying Water Column (No Sedimentation)

Figure 7. Predicted Diffusive Flux of PCB through 6-Inch Cap to Overlying Water Column (With Sedimentation)

Figure 8. Predicted Diffusive Flux of PCB through 6-Inch Cap to Overlying Water Column (No Sedimentation)

SECTION 1
INTRODUCTION

An evaluation of the long-term effectiveness of capping was presented in the Grasse River Analysis of Alternatives Report (Alcoa, June 2002). This evaluation included the development and application of a one-dimensional (1-D) model of the fate and transport of polychlorinated biphenyls (PCBs) in the sediment bed and overlying cap to determine the extent to which the cap designed for the lower Grasse River would mitigate PCB flux from the underlying sediment into the water column over the long term. This mechanistic model simulated processes within the sediment bed and overlying cap such as sorption, molecular diffusion, chemical dispersion and sedimentation.

Subsequent to the submission of the Analysis of Alternative Report, the USEPA requested that Michael Palermo, Ph.D., P.E. of the USACE review a number of technical issues related to the report, including the modeling of PCB fate and transport. In his response to USEPA dated July 24, 2002, Dr. Palermo suggested the assessment of the long-term effectiveness of the current cap design could be improved by taking into account the following processes: consolidation; groundwater advection; and the potential mixing of cap materials and native sediments during placement (Palermo, July 2002). Alcoa has since modified the modeling framework to include the processes noted by Dr. Palermo. In addition, data collected from the Grasse River over the past few years were used to refine model parameterization. These studies include:

- Capping Pre-Engineering Design Studies;
- 2000/2001 Supplemental Sediment Sampling (SSS) Program; and
- 2001/2002 Capping Pilot Study Monitoring Program.

This document presents the theory (Section 2), refined parameterization (Section 3), and results (Section 4) of the 1-D transport modeling framework and serves as an updated version of the cap modeling studies presented in Section 5 of Appendix B to the June 2002 Analysis of

Alternatives Report (Alcoa, June 2002). This updated modeling analysis considers the effects of the relevant processes identified in the USEPA and USACE cap design guidance documents (Palermo et al., September 1998; USACE, June 1998), including: sorption; molecular diffusion; biological mixing; groundwater advection; mixing of cap materials and native sediments during placement; expulsion of pore water after cap placement; consolidation of the cap after placement; and sedimentation. The results of the updated modeling study of a 12-inch cap were distributed to the USEPA and other governmental stakeholders at a meeting on February 12, 2003. As discussed during that meeting, the USEPA indicated that they may request additional data analyses and/or sensitivity analyses for select model parameters, if needed, to support pre-design or design analyses.

SECTION 2
MODEL THEORY

The transport of PCBs within the sediment bed is described using Equation 1. The first term represents the dispersive flux of total PCBs (particulate + dissolved components) to simulate biological activity in surface sediments as well as the propagation of water turbulence into the bed. The second term describes the diffusive flux of dissolved PCBs within the bed and below the region of particulate mixing. The third term represents the flux of dissolved PCBs through the sediment bed due to groundwater advection. The last term represents the net sedimentation of solids onto the sediment bed.

$$\frac{\partial C_T}{\partial t} = \frac{\partial}{\partial z}\left(E_{disp}\frac{\partial C_T}{\partial z}\right) + \frac{\partial}{\partial z}\left[D_s\frac{\partial C_d}{\partial z}\right] - \frac{\partial v_z C_d}{\partial z} - \frac{\partial u_z C_T}{\partial z} \qquad (1)$$

where:

C_T	=	total PCB concentration (sediment and pore water) (milligrams per cubic centimeter [mg/cm^3])
t	=	time of simulation (days)
z	=	segment depth (centimeters [cm])
E_{disp}	=	dispersion coefficient (square centimeters per day [cm^2/day])
D_s	=	molecular diffusion coefficient (cm^2/day)
C_d	=	dissolved PCB concentration in pore water (mg/cm^3)
v_z	=	groundwater seepage velocity (centimeters per day [cm/day])
u_z	=	sedimentation rate (cm/day)

In solving this equation, the dissolved phase PCB concentrations were computed assuming equilibrium partitioning. They were calculated as the product of the total PCB concentration (C_T) and the fraction of the total that is in dissolved form (f_d):

$$C_d = C_T f_d \qquad (2)$$

where:

$$fd = \frac{1}{\theta + K_{oc} f_{oc} \rho} \tag{3}$$

and:

f_{oc}	=	fraction organic carbon [OC] in the sediments (grams OC/gram sediment)
K_{oc}	=	organic carbon partition coefficient (cubic centimeters per gram OC [cm^3/g OC])
ρ	=	bulk density of the sediments (grams per cubic centimeter [g/cm^3])
θ	=	porosity of the sediments (unitless)

SECTION 3
MODEL PARAMETERIZATION

This section presents the development of the 1-D model used to evaluate the fate and transport of individual PCB homologs through a 12-inch cap designed for the lower Grasse River. Model coefficients and input parameters were defined using a combination of site-specific information, available literature and modeling experience on other systems in an effort to provide an accurate representation of conditions in the lower Grasse River. Updates to the modeling framework, as presented in the Analysis of Alternatives Report (Alcoa, 2002), are summarized in Table 1 and described in the sub-sections below.

The 1-D model also was used to evaluate the fate and transport of PCBs through a 6-inch cap, as a similar analysis was presented in Appendix B of the Analysis of Alternatives Report. For this evaluation, the model parameterization remained the same as the evaluation of a 12-inch cap, except for the cap thickness (see Section 3.1).

3.1 Sediment Bed Discretization

Discretization of a 12-inch Cap

The sediment bed model for the 12-inch cap simulation was constructed to represent an 11-inch cap placed on top of six feet of native sediment (a total of 83 inches or 211 cm). A cap thickness of 11 inches was selected to represent the post-consolidation thickness of a 12-inch cap placed in the river; one inch of consolidation was used based on results of the pre-engineering design studies which indicated 0.5 inches of consolidation for a 6-inch cap (Alcoa, March 2001). The effect of pore water expulsion was implicitly included by use of the post-capping cap PCB data from the Capping Pilot Study to establish the initial PCB concentrations in the cap material. The native sediment depth of six feet (i.e., 72 inches) was based on the maximum sediment depth observed in the cores collected between 1997 and 2002. In the model, the cap and sediment bed were represented by a total of 845 layers, each 0.25-cm thick (0.1 inches).

Discretization of a 6-inch Cap

The sediment bed model for the 6-inch cap simulation was constructed to represent a 5.5-inch cap placed on top of six feet of native sediment (a total of 77.5 inches or 197 cm). A cap thickness of 5.5 inches was selected to represent the post-consolidation thickness of a 6-inch cap placed in the river, based on results of the pre-engineering design studies (Alcoa, March 2001). Similar to the 12-inch cap simulation, expulsion of pore water during consolidation was not modeled, but was accounted for by using post-capping cap PCB data from the Capping Pilot Study to establish the initial PCB concentrations in the cap material. In the model, the cap and sediment bed were represented by a total of 788 layers, each 0.25-cm thick (0.1 inches).

Discretization of the Native Sediments

Data from over 100 sediment cores were used to characterize the native sediments represented in the 1-D model. Most of the sediment cores collected from the lower Grasse River were segmented into the following sample intervals: 0 to 3 inches; 3 to 12 inches; and every 12 inches thereafter down to a maximum depth of 72 inches. The exception to this are the five sediment cores collected in 1997 which were segmented in 1-cm slices. Because the segmentation schemes employed in the sediment surveys and the 1-D model differed, the following procedure was developed so that the parameterization of the sediment bed model accurately represented the sediment data:

1) Data collected in 1997 were collapsed, as appropriate, into equivalent 0 to 3-inch, 3 to 12-inch, 12 to 24-inch, 24 to 36-inch, 36 to 48-inch, 48 to 60-inch and 60 to 72-inch intervals. For example, samples from the top 7.6 cm were averaged to represent the 0 to 3-inch interval, samples collected between 7.6 cm and 30.5 cm were averaged to represent the 3 to 12-inch interval, etc.

2) The collapsed 1997 sediment cores and the 2000-2002 cores were combined and an average value was computed for each of the sample intervals (i.e., 0 to 3-inch, 3 to 12-inch, etc.).

3) The average value for each sample interval was then used to define the equivalent interval in the model. For example, the average PCB concentration in the 0 to 3-inch interval (based on data) was applied to each of the top 30 model segments (each at 0.25 cm thick for a total of 3 inches).

An illustration of this procedure is provided in Figure 1. This procedure was used to develop PCB and organic carbon inputs for the native sediments in the 1-D model.

3.2 Sediment Bed Properties

Sediment properties needed to simulate PCB flux through the cap include bulk density and fraction organic carbon. Measured bulk densities in the native sediments range from about 0.4 to 0.9 grams per milliliter (g/mL) and do not exhibit any clear trend with depth. Therefore, the average bulk density of 0.655 g/mL was computed from all sediment samples and applied to the native sediments in the model. Bulk density of the cap material was not measured during the Capping Pilot Study. Since the cap material was designed to have similar physical characteristics as native sediments, the average bulk density of the native sediments was applied to the cap material segments in the model.

Organic carbon levels in the native sediments exhibit a distinct vertical trend, averaging about 2 percent (%) in the surface sediments (i.e., 0 to 3 inches) and increasing to about 6% at depth (Figure 2). For this reason, vertically varying organic carbon levels were input in the model using the procedure described in Section 3.1. The organic carbon fraction in the cap material was based on data collected during 2001 and 2002 as part of the Capping Pilot Study. An average organic carbon fraction of 1% was computed from these data and applied to the cap material in the model (Figure 2).

3.3 Mass Transport Processes

PCBs are transported within the sediment and through the cap by molecular diffusion of pore water, bulk mixing (i.e., dispersion) and groundwater advection. The molecular diffusion

coefficient (D_s) was set to 0.21 cm^2/day based on the molecular diffusivity for total PCBs in aqueous solution, adjusted for the tortuosity of the sediment bed. This value was computed using available literature and the average sediment porosity estimated from dry bulk density and percent moisture data collected between 1997 and 2002.

The dispersion coefficient characterizing the mixing of sediment caused by bioturbation and shear stress at the sediment-water interface was based upon values applied in the PCB fate model developed for the lower Grasse River (Alcoa, April 2001) and modeling experience on other river systems. A dispersion coefficient (E_{disp}) that approximates complete mixing (4.32 x 10^{-2} cm^2/day) was applied to the top 5 cm and declined to a value of 8.64 x 10^{-4} cm^2/day at 10 cm depth and zero thereafter. Mixing sediments to a depth of 10 cm is a conservative assumption, as lead-210 (^{210}Pb) data obtained for the 1997 high-resolution sediment cores indicate a mixing depth of a few centimeters (Alcoa, April 2001).

Groundwater advection was estimated using groundwater seepage rate measurements collected in the lower Grasse River in 1998, 1999 and 2002. An average upward flowing (i.e. from the sediment bed to the water column) Darcy velocity of 0.002 cm/day was calculated from these data and used in the model. This value was held constant for the duration of the simulation.

3.4 Sorption Processes

The organic carbon partition coefficient (K_{oc}) was based on the partition coefficients measured in laboratory batch equilibration studies conducted using Grasse River sediments (Alcoa, March 2001). The organic carbon partition coefficients determined from these studies are similar to the octanol/water partition coefficient (K_{ow}) values reported by Mackay et al. (1992) except for hepta- and octa-chlorobiphenyls, which are lower relative to the published study (Table 2). The use of the lower K_{oc} values for hepta- and octa-chlorobiphenyls in the modeling simulations provides a conservative overestimate of the diffusive flux of these homologs through the cap.

3.5 Initial Conditions

PCB levels in Grasse River sediments exhibit a general increase with depth (Alcoa, April 2001). This vertical pattern was characterized in the model by using the sediment core data collected between 1997 and 2002 to develop an average PCB concentration profile throughout the sediment column (Figure 3). PCB levels in this profile average about 14 milligrams per kilogram (mg/kg) in the surface sediments and generally increase to about 400 mg/kg at depth. This vertical profile was then adjusted to represent the average surface sediment PCB concentration observed in the river (i.e., 11 mg/kg[1]). This was accomplished by multiplying the PCB levels in each sample interval of the profile by 0.79 (i.e., 11 mg/kg divided by 14 mg/kg). This adjusted profile was used to define the vertical distribution of PCBs in the model.

PCB levels in the cap material were defined using sediment core data collected in 2001 and 2002 as part of the Capping Pilot Study monitoring program. PCB levels in cap material samples collected during the study indicate a cap material-native sediment mixing depth of two inches or less (Alcoa, April 2002). This mixing was simulated in the model by assigning a PCB concentration to the bottom two inches of the cap. This PCB level was estimated to be 4.3%[2] of the surface sediment PCB concentration of the native sediments being capped based on the available data from the Capping Pilot Study. Therefore, a PCB concentration of 0.47 mg/kg (i.e., equal to 4.3% of 11 mg/kg) was applied to the bottom two inches of the cap in the model. PCB concentrations in the cap material above this two-inch "mixing layer" were set equal to zero, as PCB levels measured above the cap-sediment interface in 2001 and 2002 were typically non-detect.

PCB concentrations in the cap and native sediments in the model were defined for each of the PCB homologs using the distribution presented in Figure 4. This average PCB

[1] The average surface sediment PCB concentration for the river was based on an area-weighted polygon analysis of all available surface sediment PCB data collected between the Massena Power Canal and the river mouth (Alcoa, June 2002).

[2] This value was computed as follows: (1) where appropriate, PCB levels below detection were set to half the detection limit; (2) the ratio of the PCB concentration in the bottom two inches of the cap material to the PCB concentration in the 0 to 3-inch native surface sediment interval was computed for each sediment core collected during the 2001 and 2002 Capping Pilot Study monitoring programs; and (3) the ratios computed for the 2001 and 2002 cores were combined and an average value was computed.

composition was computed using all of the surface sediment PCB data collected between 1997 and 2002. This PCB composition was held constant over the 5,000 year simulation period.

3.6 Sedimentation

Two scenarios regarding sedimentation in the future were evaluated during the cap modeling studies: a scenario that considers continued sedimentation in the future, as recommended by Dr. Palermo during the USACE review of the Analysis of Alternatives Report (Palermo, July 2002); and, for comparative purposes, a scenario where sedimentation in the future is assumed to be zero. The parameterization applied to the modeling study for the continued sedimentation scenario is discussed below.

Contemporary sedimentation rates in the lower Grasse River are estimated to be about 0.15 cm/yr (Alcoa, April 2001). The sedimentation rate in the river is expected to decline in the future as water column depths in the river approach steady state values (i.e., water depths that result in no net deposition or resuspension). Although these steady state water depths are not known, the absence of soft sediments at sediment probing Transects T1 and T2 (as measured in 1992) indicates that the deposition of soft sediments is not occurring at these locations. The average water depth at these transects is about 8 feet, approximately 5 feet shallower than the average water depth for the lower river (i.e., 13 feet). Therefore, a sedimentation rate function was developed to simulate the reduction in sedimentation, on average, that would result in about 5 feet of deposition over the river bottom over the 5,000 year simulation period. This function is presented in Figure 5.

SECTION 4
CAP MODELING RESULTS

4.1 Model Simulations

Model simulations for each PCB homolog were performed for a period of 5,000 years. Two simulations were performed for each cap thickness: one assuming sedimentation does not continue into the future (i.e., a sedimentation rate [u_z] of zero); and one assuming sedimentation exponentially declines into the future. Results of these simulations are discussed below.

4.2 PCB Migration through a 12-inch Cap

If net sedimentation were to continue into the future as per the analysis provided in Section 3.6, PCBs would not break through a 12-inch cap based on the results of the updated model simulation, indicating that sedimentation, even at low rates, is expected to augment the performance of the cap.

The magnitude and composition of the predicted diffusive flux through a 12-inch thick cap under the conservative assumption that no sedimentation occurs over the 5,000-year simulation period are presented in Figure 6. Under this scenario, breakthrough does occur as PCBs migrating through the cap by molecular diffusion and groundwater advection eventually reach the zone of bioturbation where particle mixing makes them available at the cap surface. The top panel compares the diffusive flux of PCBs with 1, 2 and 3 or more (PCB_{3+}) chlorine atoms to the current flux in the river predicted by the PCB fate model. The current flux is representative of PCBs with 2 or more chlorine atoms due to a lack of mono-chlorinated biphenyls in lower Grasse River water (Alcoa, April 2001). The bottom panel provides the predicted composition of the total diffusive flux through the cap over the simulation period (in 200-year intervals).

Under this conservative assumption, mono-chlorobiphenyl would reach the sediment surface about 129 years after capping, using 0.001 micrograms per square centimeter per year ($\mu g/cm^2$-yr) as a threshold (Figure 6). Di-chlorobiphenyl would begin to appear after about 175 years. The flux of PCBs with 3 or more chlorine atoms (PCB_{3+}) to the water column would begin after about 2,060 years. At the end of the simulation, the total PCB flux would be about 0.025 $\mu g/cm^2$-yr, about 1.5% of the current total PCB flux (about 1.7 $\mu g/cm^2$-yr).

4.3 PCB Migration through a 6-inch Cap

If net sedimentation continues in the future as per the analysis provided in Section 3.6, some PCBs would reach the surface of a 6-inch cap after about 3 years, the PCB flux to the water column would peak at 0.008 $\mu g/cm^2$-yr (representing about 0.5% of the current total PCB flux of 1.7 $\mu g/cm^2$-yr) after about 13 years and then decline below to about 0.001 $\mu g/cm^2$-yr after about 70 years (Figure 7). This initial pulse of PCBs through the cap is the result of particle mixing transporting PCBs present in the bottom of the cap to the surface of the cap[3]. The decline after about 13 years occurs because the rate of sedimentation of clean material on top of the cap exceeds the rate of PCB migration (via molecular diffusion and groundwater advection) through the native sediments and cap.

The magnitude and composition of the predicted diffusive flux through a 6-inch thick cap under the conservative assumption that no sedimentation occurs over the 5,000-year simulation period are presented in Figure 8. In this instance, the model indicates that PCBs would reach the sediment surface about 2 years after capping; again a result of particle mixing that makes PCBs present within the zone of bioturbation at the beginning of the simulation available at the cap surface. The total PCB flux is predicted to peak after about 300 years at about 0.05 $\mu g/cm^2$-yr, representing about 2.9% of the current total PCB flux.

[3] The post-consolidation cap thickness is 5.5 inches and the bioturbation zone is assumed to extend four inches below the cap surface. PCBs are assumed to be present in the bottom two inches of the cap as a result of mixing of cap material with native sediments and/or pore water expulsion during cap placement. Therefore, at the start of the simulation, the cap material present in the bioturbation zone consists of 3.5 inches of clean cap material and 0.5 inches of cap material that contain low level PCBs. As a result, particle mixing within the bioturbation zone makes the PCBs within the 0.5 inches of cap material available at the cap surface after a relatively short period of time.

SECTION 5
SUMMARY

Results of the PCB transport modeling studies indicate that the placement of a cap over Grasse River sediment would be effective over the long term in reducing flux from the PCB-containing sediments to the overlying water column. Under the scenario that accounts for the deposition of solids within the lower Grasse River, as was recommended during the USACE review of the initial modeling effort, PCBs do not break through a 12-inch cap during the 5,000 year simulation period. Under the conservative scenario that ignores sedimentation, PCBs eventually reach the cap surface, but the PCB flux is extremely low relative to the current conditions. The peak PCB flux through the cap to the water column is predicted to occur after about 5,000 years and equal about 1.5% of the current PCB flux in the river. The 6-inch cap design also would achieve substantial mitigation of PCB flux if sedimentation continues in the future, with the peak PCB flux through the cap to the water column predicted to occur after about 13 years and would equal less than 0.5% of the current flux estimated by the PCB fate model. For the 6-inch cap design with no assumed sedimentation, the peak PCB flux through the cap to the water column is predicted to occur after about 300 years and equal about 2.9% of the current flux estimated by the PCB fate model.

These results are supported by recent research performed at Louisiana State University (Talbert et al., 2001). This study involved the use of a steady-state benzoic acid dissolution testing apparatus, designed to simulate sediment bed chemo-dynamic conditions, to measure chemical flux through thin layers (1 to 8 mm) of sand, top soil, and ideal porous media. The results of this study indicated that thin layers of these materials were very effective in reducing the rate of molecular diffusive flux. Reductions in flux ranged from 81 to 96% after steady state conditions were established, with fine sand being slightly better than topsoil.

SECTION 6
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United States Army Corps of Engineers (USACE), June 1998. *Guidance for Subaqueous Dredged Material Capping.* Technical Report DOER-1, Washington, D.C.

Table 1. Updates to the 1-D PCB Transport Calculation

Model Parameter/Process	Original Value	Revised Value	Basis for Change
Molecular diffusion coefficient (cm^2/d)	0.20	0.21	Original value based on available literature and porosity estimates for Grasse River sediments; revised value reflects updated porosity estimates for Grasse River sediments
Homolog-specific partition coefficients (L	homolog-specific	No change	Unchanged; original value determined during laboratory studies using Grasse River sediments
Bed dispersion (i.e., mixing) (cm^2/d)	varied in top 10 cm; zero below 10 cm	No change	Unchanged; original value based on conservative estimate of particle mixing used in PCB fate model
Native Sediment			
PCB concentration profile (mg/kg)	varied with depth	varies with depth	Original value based on five high-resolution sediment cores from 1997; revised value based on average vertical PCB profile computed using sediment cores collected in 1997, 2000 and 2001
PCB homolog distribution (%)	constant	homolog-specific	Original simulations assumed 50 mg/kg PCBs for each homolog; revised values based on average PCB homolog distribution computed from sediment cores collected in 1997, 2000 and 2001
Organic carbon fraction	0.02	varies with depth	Original value based on average TOC for river sediments; revised value based on average depth profile computed from 1997, 2000 and 2001 sediment cores
Bulk density (g/mL)	varied with depth	0.66	Original profile computed as average of two high-resolution sediment cores from 1997; revised value represents average of sediment core data from 1997, 2000 and 2001
Cap Material			
PCB concentration profile (mg/kg)	zero throuhgout cap	zero in top 9 inches; varies in bottom 2 inches	Revised values based on observations made during Capping Pilot Study (see "Mixing During Cap Placement" and "PCB Homolog Distribution")
Organic carbon fraction	0.02	0.01	Original value based on average TOC of river sediments; revised value based on average TOC of in-place cap (pilot cells; 2001 and 2002)
Bulk density (g/mL)	0.58	0.66	Original value computed as average of surface sediment data from 1997 high-resolution cores; revised value represents average of sediment core data from 1997, 2000 and 2001

Table 1. Updates to the 1-D PCB Transport Calculation

Model Parameter/Process	Original Value	Revised Value	Basis for Change
Additional Processes			
Future sedimentation rate (cm/yr)	zero	zero	Conservative estimate of long-term PCB flux from cap
	0.15	exponential decline from 0.15 to near zero	Original value based on estimated contemporary sedimentation rate in the river; revised function developed to simulate sedimentation of 5 feet in river (amount of sedimentation required to achieve estimated equilibrium water depth of 8 feet)
Consolidation			
Effect on cap thickness	none	1 inch for 12-inch cap; 0.5 inches for 6-inch cap	Cap thickness reduced to 11 inches (for 12-inch cap simualtion) to reflect one inch of consolidation, as observed during Pre-Engineering Cap Design Studies. Similarly, cap thickness reduced to 5.5 inches (for 6-inch cap simulation) to reflect 0.5 inches
Pore water expulsion	none	none	Not included as separate process as effects are incorporated into PCB levels assigned to bottom 2 inches of cap (see "Mixing During Cap Placement)
Mixing During Cap Placement			
Extent of mixing (in)	none	2	Mixing depth based on results of sediment core data collected during the Capping Pilot Study (2001 and 2002)
PCB levels in mixing layer (% of total PCB)	none	4.3	Revised value based on sediment core data collected during 2001 and 2002 Capping Pilot Study monitoring program (computed as average ratio of PCB concentration in the bottom 2 inches of cap to PCB concentration in surface sediment being capped)
Groundwater Seepage (cm/d)	none	0.002	Revised value based on average groundwater seepage rate measured in river (1998, 1999 and 2002)

Table 2. Partition Coefficients Used in the Simulations

Homolog	Log Koc	Log Kow[1]
Mono-	4.6	4.7
Di-	4.9	5.1
Tri-	5.7	5.5
Tetra-	6.1	5.9
Penta-	6.4	6.3
Hexa-	6.6	6.7
Hepta-	6.6	7.1
Octa-	5.9	7.5

(1) From Mackay et al. (1992)

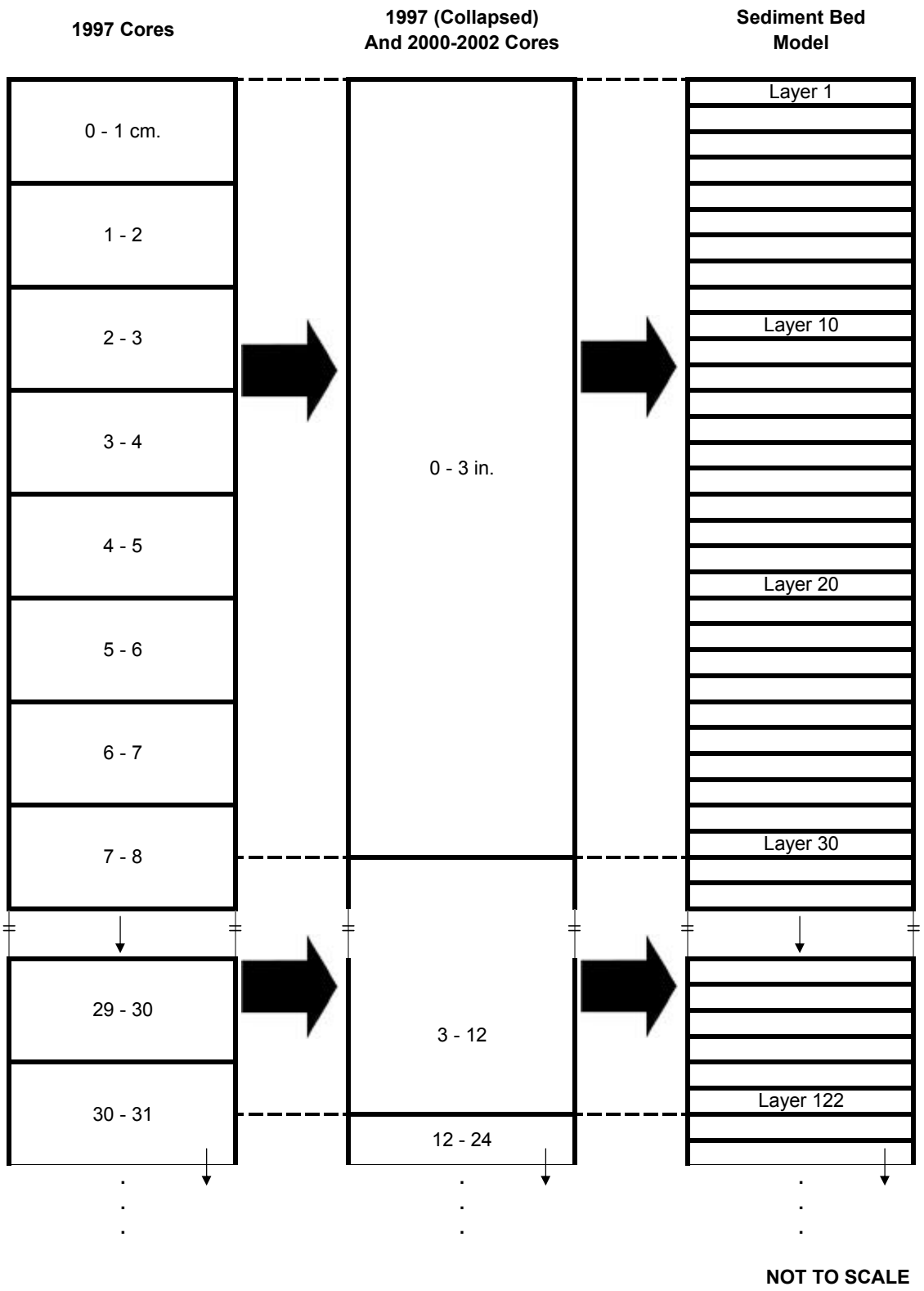

Figure 1. Illustration of Sediment Core Data Collapse Used to Define Input Parameters in the Sediment Bed Model.

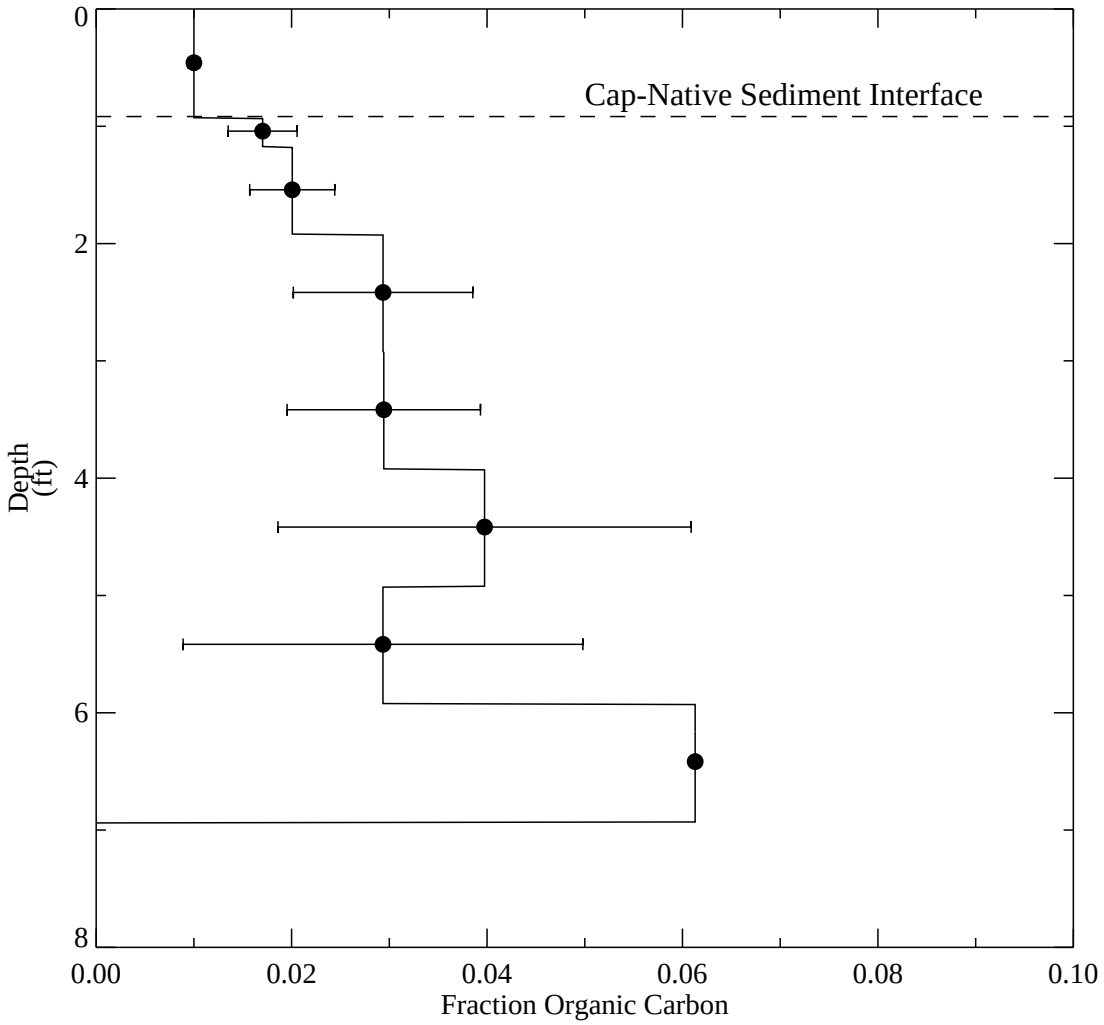

Figure 2. Vertical Fraction Organic Carbon Profile

Data from 1997 high-resolution, 2000-01 SSS, and 2001-02 CPS sediment cores.
Symbols are depth-weighted values plotted at mid-depth.
Error bars represent +/- two standard errors of the mean.

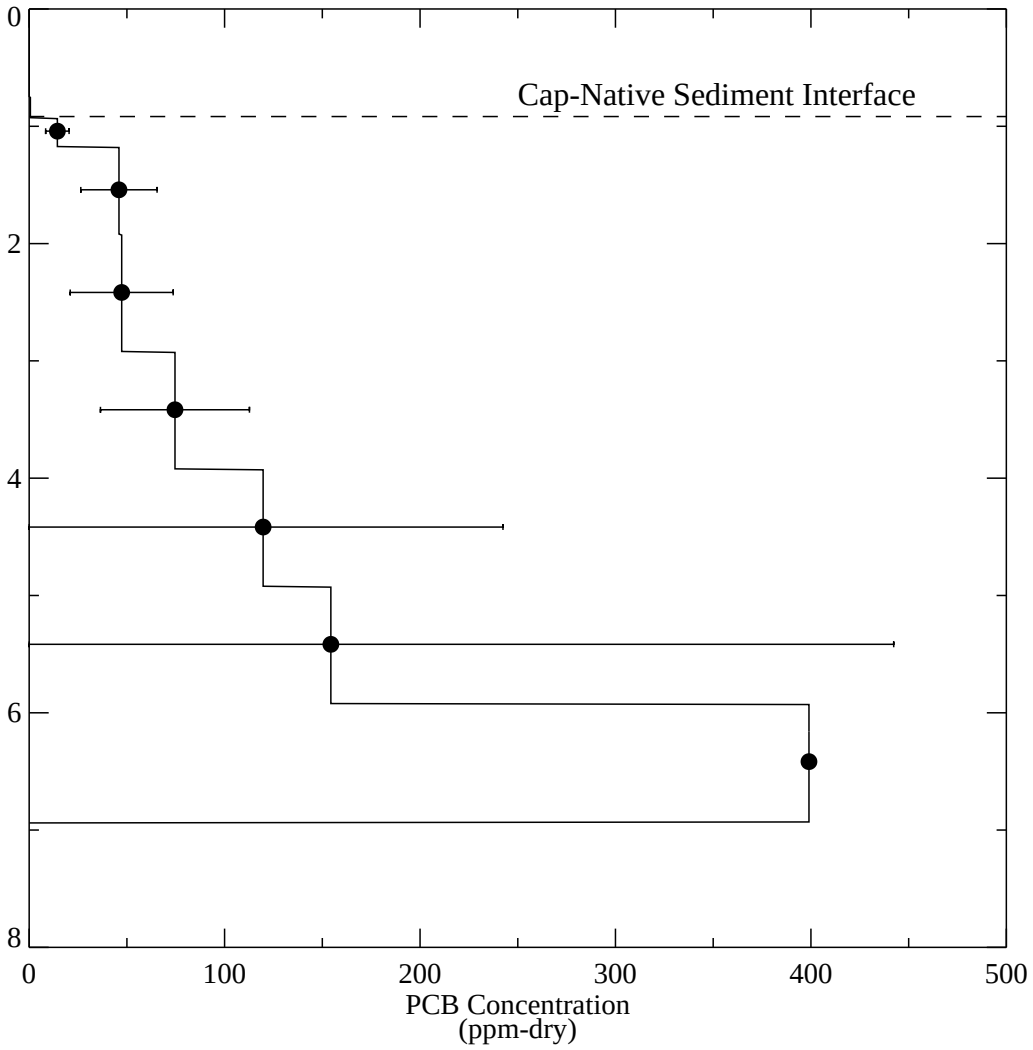

Figure 3. Vertical PCB Profile

Data from 1997 high-resolution, 2000-01 SSS, and 2001-02 native CPS sediment cores.
Symbols are depth-weighted values plotted at mid-depth.
Error bars represent +/- two standard errors of the mean.

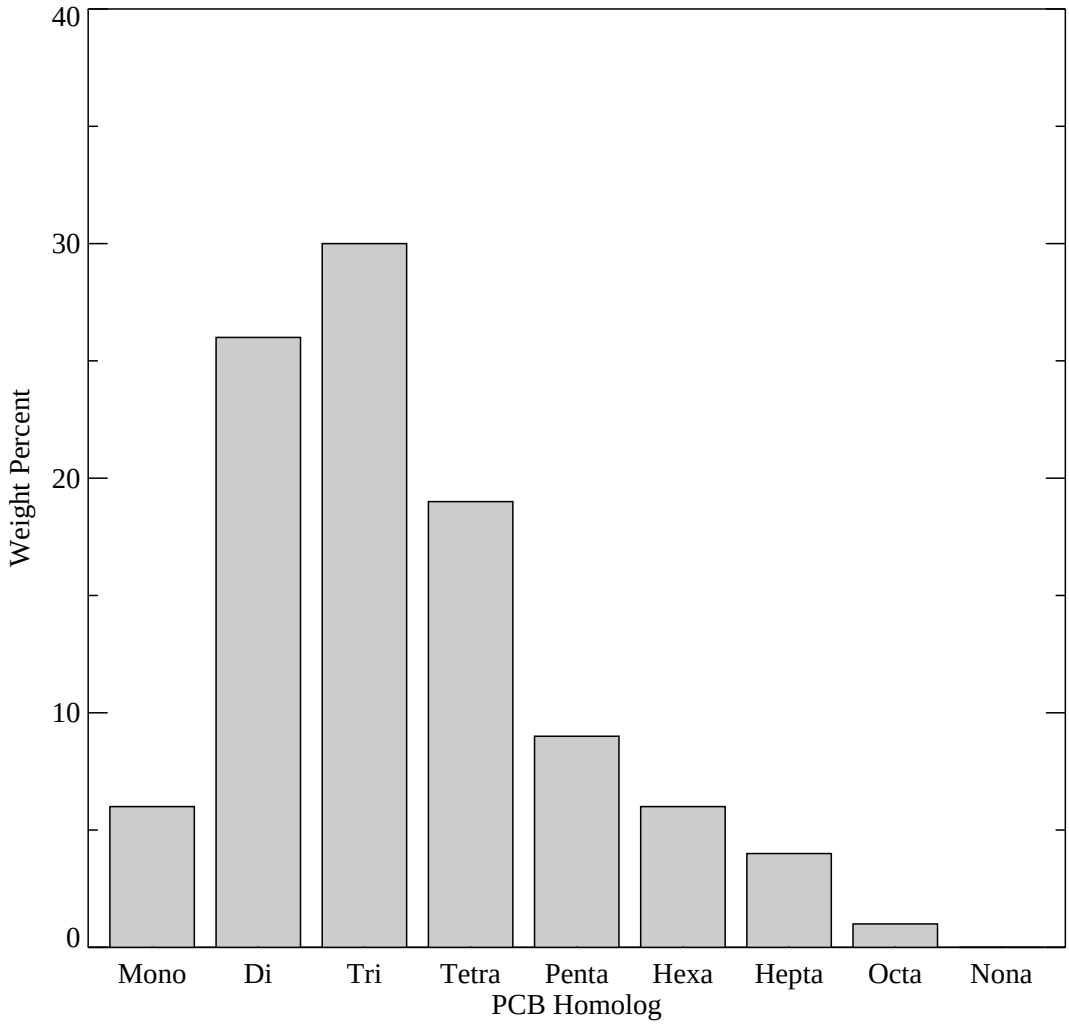

Figure 4. PCB Homolog Distribution

Values computed using surface sediment PCB data collected during the 1997 SRS, 2000/2001 SSS and 2001/2002 CPS surveys.

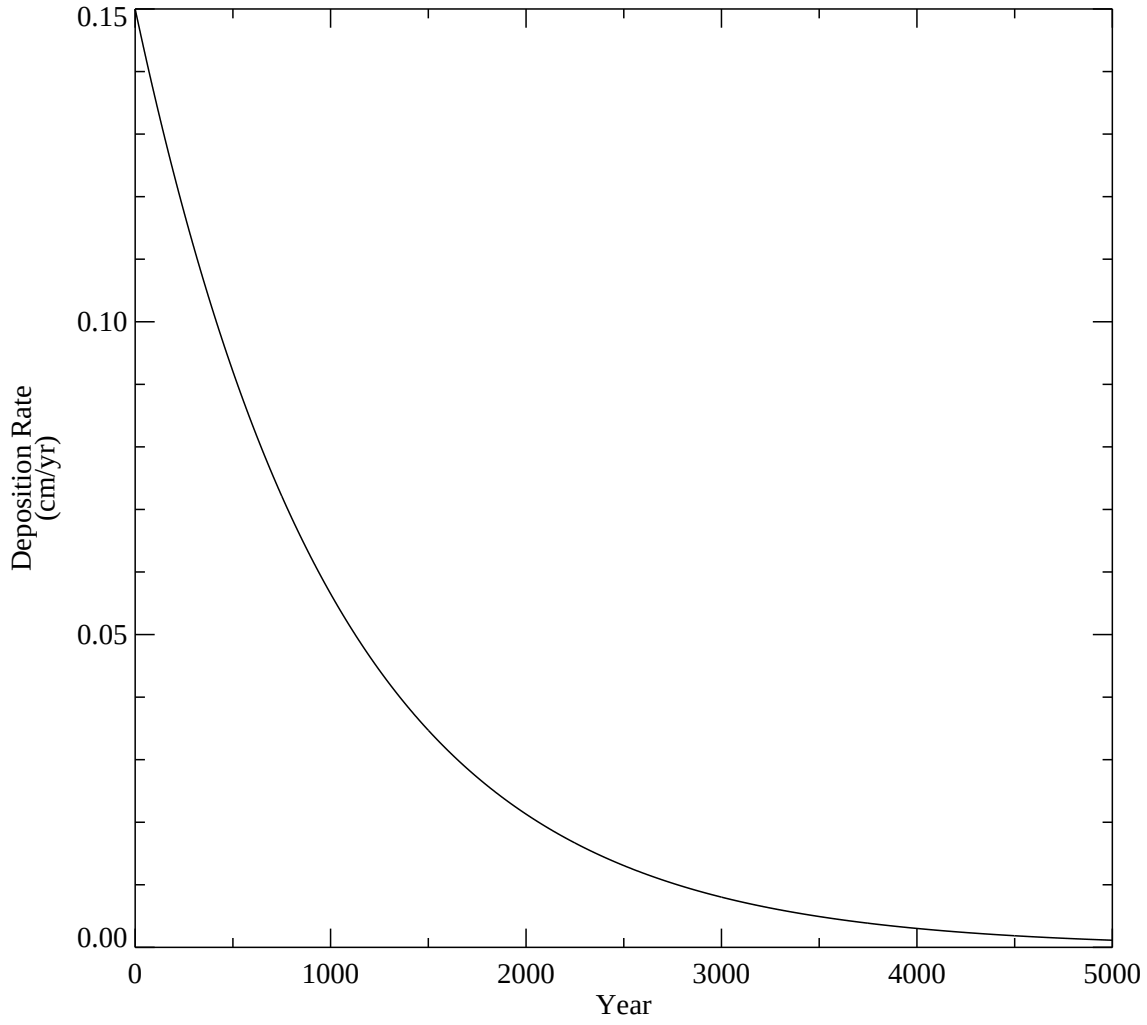

Figure 5. Variable Sedimentation Rate Function

Cumulative depth of sediments deposited over 5000 years is 5 feet.

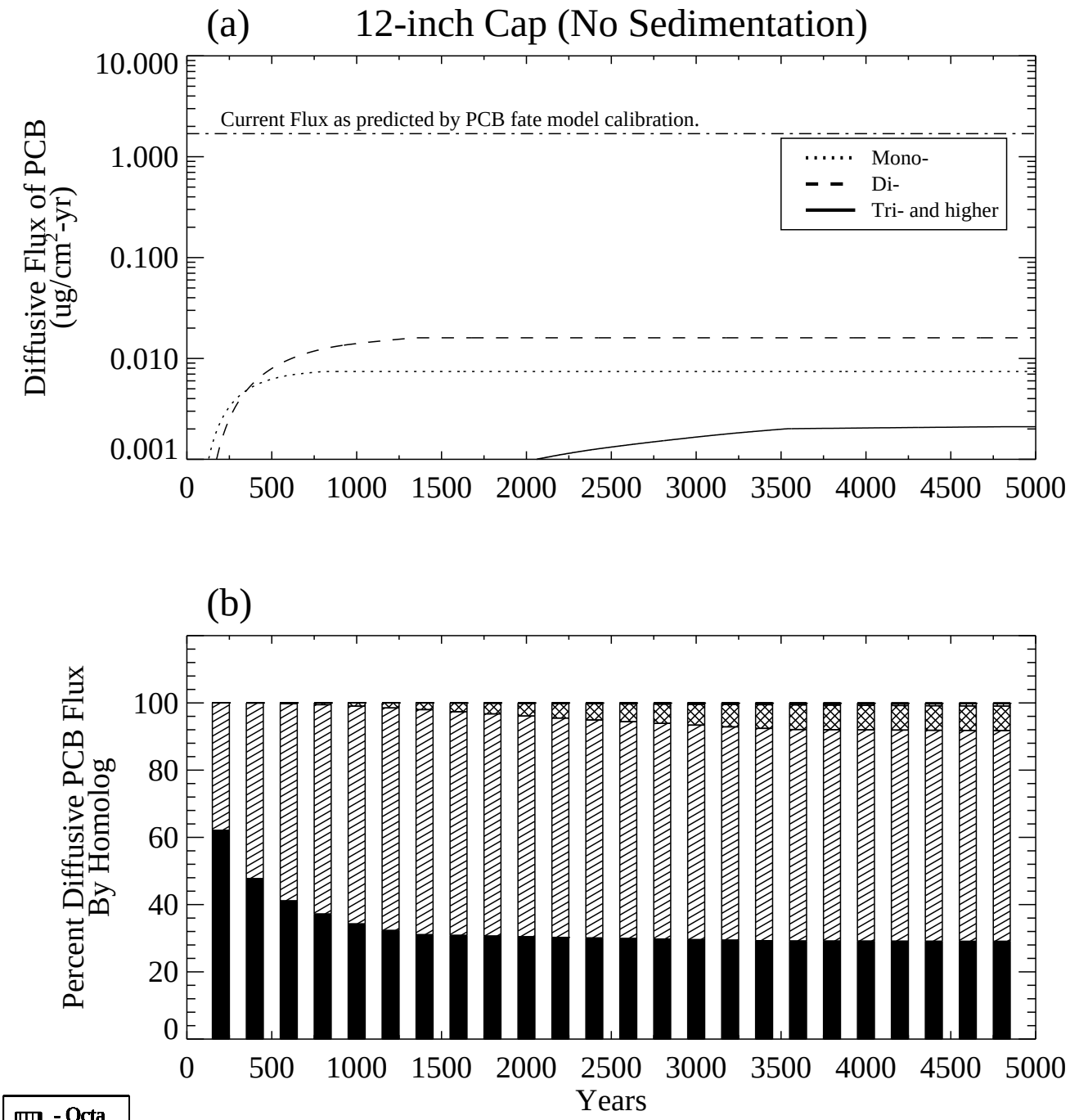

Figure 6. Predicted Diffusive Flux of PCB Through a 12-inch Cap to the Overlying Water Column (No Sedimentation).

Initial native surface (0-3") sediment PCB concentration equal to 11 ppm-dry.

Homolog distribution of 6% mono, 26% di, and 68% tri+ applied.

Modeling of 12-inch cap with sedimentation projects no breakthrough of PCBs over the 5000-year period and, therefore, no figure is presented.

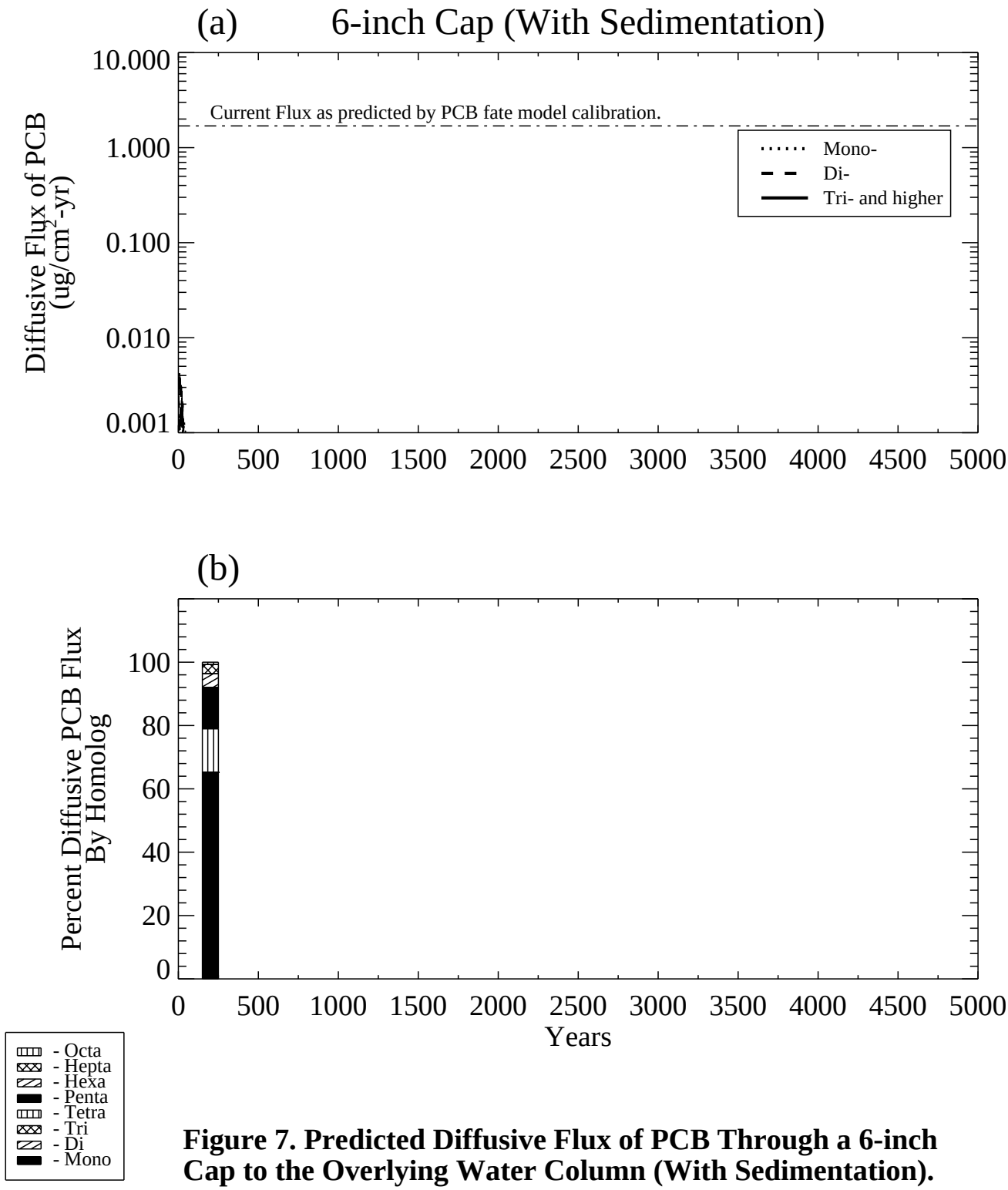

Figure 7. Predicted Diffusive Flux of PCB Through a 6-inch Cap to the Overlying Water Column (With Sedimentation).

Initial native surface (0-3") sediment PCB concentration equal to 11 ppm-dry.

Homolog distribution of 6% mono, 26% di, and 68% tri+ applied.

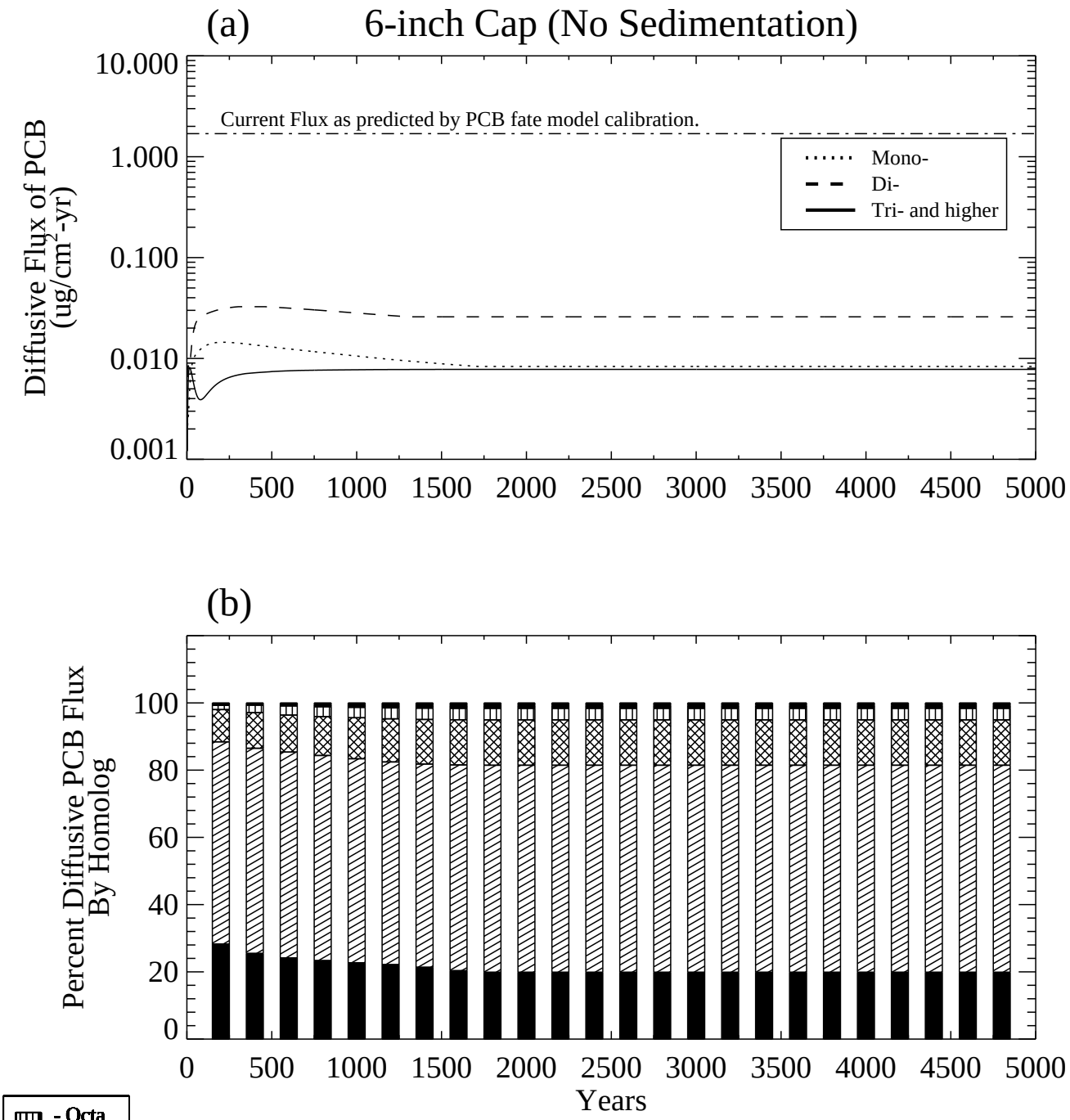

Figure 8. Predicted Diffusive Flux of PCB Through a 6-inch Cap to the Overlying Water Column (No Sedimentation).

Initial native surface (0-3") sediment PCB concentration equal to 11 ppm-dry.

Homolog distribution of 6% mono, 26% di, and 68% tri+ applied.

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Thu May 08 10:38:13 2003

Appendix E

Remedial Options Pilot Study –
Southern Near Shore Capping

Remedial Options Pilot Study – Southern Near Shore Capping

Introduction

Capping was implemented in a southern near shore area of the lower Grasse River as part of the 2005 Remedial Options Pilot Study (ROPS). The purpose of this component of the pilot study was to develop site-specific information on the effectiveness and implementability of near shore, shallow water capping, and to evaluate recovery of habitat after capping (Alcoa Inc. [Alcoa], February 2005). Specific characteristics of the near shore areas of the lower Grasse River that are relevant to the application of this remedial technology include:

- Shallow near shore areas (i.e., less than 5 feet [ft] of water depth) represent only about 15% of the overall river area (Alcoa, July 2002; Alcoa, May 2004);
- Polychlorinated biphenyl (PCB) concentrations in near shore sediments are low compared to those in main channel sediments (Alcoa, April 2009), with about 60% of the 0- to 3-inch sediment samples having PCB concentrations less than 1 milligram per kilogram (mg/kg);
- Near shore area sediments contribute less than 10% of the PCB flux to the overlying water column (Alcoa, July 2002; Alcoa, May 2004);
- Preferential PCB uptake from these local sediment areas by fish is not occurring (Alcoa, July 2002; Alcoa, May 2004);
- Velocities in the near shore areas are too low to cause substantive erosion, even during a 100-year flood event (Alcoa, July 2012); and
- Ice runs have not caused significant erosion in the near shore areas over recent time frames (decades) – it is the deeper channel area sediments that are the predominant source of PCBs to the river, and the sediments in the deeper channel areas are where the impacts from ice-related scour were observed (Alcoa, December 2009).

The study of thin-layer capping in the near shore areas was also the result of an effort to respond to concerns expressed by the New York State Department of Environmental Conservation (NYSDEC) regarding modifications to bathymetry in the near shore areas. Additionally, the approach was identified as a means by which to preserve habitat in the near shore areas and avoid destabilization of the existing shoreline, which can result if sediments are removed from these areas.

The ROPS southern near shore area covered an approximately 500 ft long by 40 ft wide portion of the river along the shoreline between river transects T8.5 and T9.5 (**Figure 1**). Selection of the area was based on two primary considerations: 1) identification of an elevated PCB measurement (18.4 mg/kg) in a surficial grab sample collected from the area in 2003; and 2) proximity of the area to the major components of the ROPS construction activities. The thin-layer cap was constructed by placing about 300 cubic yards (cy) of sand and topsoil (1:1 mix) between November 15 and 17, 2005 (Alcoa, May 2006). Post-placement elevation measurements along a regularly-spaced grid network indicated that the target cap thickness of 0.3 to 0.5 ft was achieved at all measurement locations, and post-placement core data indicated that sediment PCB concentrations were significantly reduced (Alcoa, May 2006). Monitoring in 2006 and 2007 confirmed that the cap remained in place, and that PCB concentrations at the cap surface remained significantly lower than average pre-cap conditions (Alcoa, June 2007; Alcoa, September 2008).

During a Technical Team meeting on February 2, 2010, NYSDEC expressed concerns regarding the effectiveness of capping in the near shore areas, citing specific data collected as part of the post-ROPS monitoring efforts. Alcoa agreed to critically review the ROPS-related data and address the concerns raised by NYSDEC. In addition, Alcoa designed and implemented a comprehensive investigation of the near shore areas, including the ROPS southern near shore area, in August and September 2010. This memorandum presents the results of the review of the 2006-2007 post-ROPS monitoring data and the information obtained during the 2010 Near Shore Sampling Program (Alcoa, March 2011).

Review of Pre-ROPS Conditions in Southern Near Shore Area

Monitoring of the ROPS southern near shore area was conducted in summer/fall 2004 to define baseline conditions in the area prior to cap placement. As part of this monitoring, six sediment cores were collected and analyzed for PCBs and physical properties (locations shown in **Figure 2**). Sediment (0-3 inches) PCB concentrations in these cores ranged from 1.1 to 36.5 mg/kg, with an overall average of 8.3 mg/kg (**Table 1**). With the exception of two cores, PCB concentrations decline with depth; however, all cores had non-detectable concentrations of PCBs at depths greater than 6 inches. The average depth of contamination (DoC) in the cores was 3.5 inches (range of 0 to 6 inches).

Surface sediments in the southern near shore cap area range from coarse to fine (**Table 1**). For example, sand accounted for as little as 9% (NS1-S) to as much as 86% (NS2-S) of the sediment (note all grain size percentages presented herein are on a dry weight basis), with an average sand content across the area of about 50% in the top three inches. Overall, the average composition of the baseline sediment samples (top three inches) consisted of about 47% silt, 50% sand, and 3% gravel; however, significant spatial and depth variability is evident across the area. Solids content, total organic carbon (TOC) content, and dry density measurements in the top three inches averaged 67%, 0.85% and 0.94 grams per milliliter (g/mL), respectively.

Implementability and Cap Effectiveness

Implementability

The cap was placed in the southern near shore area during the final days of the ROPS project. Placement began on November 15, 2005 with 250 cy of material, followed by 40 cy on November 16, 2005 and 10 cy on November 17, 2005 (Alcoa, May 2006). After placement in a single lift, the cap was manually surveyed along a 10 ft by 25 ft grid network to determine cap thickness via comparison of measured surface elevations. If a grid node was found to have a cap thickness outside of the 0.3 ft to 0.5 ft tolerance thickness, then either additional cap material was placed at and around the node in an approximate 10 ft diameter area (to achieve the minimum 0.3 ft thickness) or the excess cap material was spread around the node (to meet the 0.5 ft maximum thickness), and the grid node was re-surveyed to confirm cap thickness. This procedure was followed at each grid node location until all grid nodes contained cap material within the target thickness of 0.3 to 0.5 ft (Alcoa, May 2006). Overall, the average cap thickness measured by manual survey techniques immediately post-placement was 0.4 ft (range of 0.3 ft to 0.5 ft) (**Figure 3**).

Six sediment cores were collected approximately two weeks after cap placement to determine cap thickness and PCB concentrations in the cap material (**Table 2**). Four of the cores contained between 2 and 4 inches (0.17 to 0.33 ft) of cap material, while two cores (SNS-2 and SNS-4) exhibited no cap or signs of mixing of the cap with native sediments. As shown in **Figure 3**, cores SN2-S and SN4-S were taken between the cap thickness grid nodes. Visual observation of core SNS-2 indicated it did not contain cap material. Core SNS-2 was taken approximately 10 ft from the nearest grid node and, as a result, the lack of observable cap material at this location may be due to the limited areal

extent of the local adjustments to the cap that were made in response to the measurements at each grid node, as was observed in the main channel post-dredge cap surface after placement (Alcoa, May 2006). PCB concentrations in the 0 to 3, 3 to 6, and 6 to 12 inch sample intervals at this location were all non-detect.

Core SNS-4 had 18% gravel, which was inconsistent with the sand/topsoil cap material placed (range of 0.2 to 6.7% gravel) and more consistent with native sediments. This core sample was also located between grid nodes, and the lack of observable cap material at this location may be due to the limited areal extent of the local adjustments to the cap that were made in response to the measurements at each grid node (Alcoa, May 2006). Alternatively, the steeper side slopes that exist in this section of the near shore area may have been a contributing factor.

Cap Effectiveness – Reduction of Surface PCB Concentrations Immediately After Cap Placement

Surface PCB concentrations were reduced upon placement of the cap. In cores that had a visible cap present (4 of the 6 cores collected 11 days after capping), PCB concentrations in the top two inches of the cap ranged from non-detect[1] (ND; detection limit of about 0.06 mg/kg) to 0.12 mg/kg, with an overall average of 0.06 mg/kg. This represents a 99% reduction in PCB concentrations relative to the average baseline PCB concentration of 8.3 mg/kg. Considering all six post-placement cores, PCB concentrations (top two inches) ranged from ND to 3.3 mg/kg, with an overall average of about 0.6 mg/kg, which represents a 93% reduction in PCB concentration. These reductions immediately after cap placement are consistent with the 95% reduction used to simulate cap effectiveness in the evaluation of alternatives for the site (Alcoa, July 2012).

Post-Placement Monitoring in 2006, 2007 and 2010

The thin-layer cap area was revisited in 2006, 2007 and 2010. During these surveys, cores were collected from the capped area and cap thickness estimates were obtained through visual inspection of the retrieved cores. The cap thickness measurements obtained during these surveys were generally consistent with the 2005 post-placement data. As shown in **Table 3** and **Figure 4**, the six cores collected immediately after placement in 2005 indicated cap thicknesses averaged about 0.2 ft (range of 0.0 ft to 0.3

[1] PCB measurements below the detection limit were set to half the detection limit prior to averaging.

ft). In 2006, cap thickness in the ten cores averaged 0.3 ft (range of 0.0 to 0.5 ft), while in 2007 cap thickness in the five cores averaged 0.4 ft (range of 0.1 to 0.8 ft). In 2010, cap thickness in the six cores averaged 0.2 ft (range of 0.0 to 0.3 ft).

In 2006, 5 of the 10 cores were submitted for physical and chemical analysis (**Table 4**). PCB concentrations measured in the top two inches of the cap material of these cores averaged 1.06 mg/kg (range of 0.08 to 4.0 mg/kg), which is about 87% lower than that observed prior to capping (**Table 3**). No visible cap was observed for core 1217, which had a limited thickness of recoverable sediment and a PCB concentration of 0.56 mg/kg (0- to 3-inch interval). In core 1239, the PCB concentration in the top inch of the cap was measured at 5.12 mg/kg, the highest of any cap surface samples obtained in 2006. The physical characteristics of this 1-inch layer indicate it is material that deposited on the surface of the cap, given its low solids content (41%), high TOC (3.3%) and low density (0.52 g/mL) relative to the cap material of other cores collected in 2006, which had solids contents of 59 to 86%, TOC contents of ND to 1.9%, and dry densities of 1.1 to 1.6 g/mL (**Table 4**). Recontamination of the surface layer of the post-dredging cap in the northern near shore area was also observed in samples from the post-placement monitoring (Alcoa, September 2008). PCB results from the 1 to 2, 2 to 3, and 3 to 4 inch intervals in core 1239 could be reflective of limited cap coverage at this location or mixing of cap and native sediments during or after placement.

In 2007, PCB concentrations measured in the top two inches of the cap material were similar to those measured in 2006, ranging from 0.16 to 3.1 mg/kg with an overall average of 1.33 mg/kg. The average PCB concentration of 1.33 mg/kg is 84% lower than the average baseline PCB concentration of 8.3 mg/kg (**Table 3**), and similar to that observed in the post-dredging cap at the northern near shore area (2007 average of 0.96 mg/kg; Alcoa, September 2008).

Physical characteristics of cores collected in the southern near shore area in 2007 are shown in **Table 5**. Core 1213, which contained nine inches of cap material, exhibits properties that are consistent with mixing of cap material with native sediments, as evidenced by grain size distribution information and dry density measurements that fall between that expected for the cap material (e.g., 85 to 90% sand, and dry density of 1.2 to 1.6 g/mL) and those of the native sediments at this location (12% sand and dry density of 0.45 g/mL). Cores 1224 and 1243 also exhibited similar signs of possible mixing of cap material and native sediments.

In 2010, PCB concentrations measured in the top two inches of the cap material were relatively low (less than 1 mg/kg) except for cores 1180 and 1190, which had PCB concentrations of 2.94 and 15.24 mg/kg in the top 1-inch section, respectively (**Table 6**). The solids content of these samples is slightly lower than that measured in deeper segments, indicating that these materials are likely to have settled on top of the cap post-placement. Overall, ROPS southern near shore area sediment PCB concentrations measured in the top 2 inches in 2010 averaged 2.0 mg/kg (range of non-detect to 8.4 mg/kg); this average is driven by the elevated PCB concentration of 15.24 mg/kg measured in the top inch of core 1190, which when averaged with the 1- to 2-inch interval for this core, yields the maximum concentration of 8.4 mg/kg. Excluding the core 1190 samples yields an average PCB concentration of 0.77 mg/kg. This average is within the range of average post-ROPS surface (0 to 2 inches) PCB concentrations (see **Table 3**).

One measure of cap performance has been the percent reduction in surface PCBs compared to pre-ROPS conditions. However, recontamination of the cap (i.e., deposition of material on the cap surface) is evident, which confounds the evaluation of cap performance five years after placement. In the segments that are identified as containing cap material, PCB concentrations in 2010 range from 0.22 to 6.16 mg/kg (see **Table 6**); these levels are slightly higher than those measured post-cap placement in 2005, and indicate that mixing of the cap with re-deposited sediments may have occurred.

Relationship to Physical Site Characteristics

Site physical characteristics were reviewed to evaluate if specific factors could explain cap thickness and surface PCB concentrations that appeared anomalous relative to the original cap design. As discussed in the ROPS Documentation Report (Alcoa, May 2006), cap thickness varied due to a number of issues related to the 2005 construction methods and cap placement quality control. Among these is the fact that the majority of the cap was placed in one day due to schedule constraints near the conclusion of the ROPS project. The variations in cap thickness were observed as early as the initial set of post placement thickness measurements taken in 2005.

The review of site physical characteristics did not identify any obvious correlations between physical site characteristics and trends in cap thickness or surface PCB concentrations. Maps of cap thickness, surface PCB concentrations, and edge slopes at each survey transect are provided in **Figures 4** and **5**. Cross sections showing the slope

profiles for each of the southern near shore transects are shown in **Figure 6a** and **b**. Despite the variability in the cap thickness measurements, the majority (17 of 23) of the 0 to 2 inch samples in this area collected over the 5-year span of post -placement sampling have been below 1 mg/kg PCBs (**Figure 5**).

Habitat Recovery in Southern Near Shore Area

Ecological monitoring was performed in the southern near shore area in 2006, 2007 and 2010 to assess the effect of the cap on the benthic community and aquatic habitat. Spring and fall baseline monitoring (2004/2005 pre-construction) and post-construction monitoring (2006 and 2007) were performed. An aquatic habitat survey was also conducted as part of the 2010 Near Shore Sampling Program (Alcoa, March 2011). Upstream control locations for the benthic community study were selected to have similar habitat and substrate characteristics as the site location. However, due to slight habitat differences between the near shore area and upstream control locations, only general comparisons (i.e., qualitative) were made. The aquatic habitat evaluation consisted of visual observation according to modified USEPA rapid bioassessment protocols (USEPA, July 1999). To assess potential changes in the benthic community, post-construction data are compared to the baseline data in a weight-of-evidence approach in accordance with the Near Shore Benthic Community Data Evaluation Framework (Alcoa, September 2007).

Results of the benthic community analysis indicate that the southern near shore area is being recolonized by a benthic community similar to the one present prior to implementation of construction activities. Analyses of various benthic metrics are presented in the 2007 Data Summary Report (Alcoa, September 2008). Twelve benthic orders were observed in spring 2005 prior to construction, and 10 and 12 were observed post-construction in spring 2006 and spring 2007, respectively. In the fall sampling, 14 orders were observed in 2004, 14 in 2006, and 15 in 2007. As compared to the northern near shore area, where sediments and vegetation were dredged prior to cap placement, these results suggest that the major benthic community groups returned to the southern near shore area more quickly and did not have as long a recovery period. Habitat differences in the southern near shore upstream control area (substrates with much more clay) prevent direct comparisons to be made to the metric results.

The most prevalent aquatic habitats identified in the ROPS southern near shore area in 2010 were aquatic vegetation (80 percent by area) and bare substrate/sediment (20

percent by area) (**Table 7**). Bare substrate/sediment was comprised of approximately 85 percent sand/silt/clay and 15 percent gravel, cobble and boulder. In addition, a few pieces of large woody debris were observed. The aquatic habitat types observed in 2010 show an increase in vegetation coverage as compared to pre-implementation conditions observed in 2004 which were 55 percent aquatic vegetation cover and 45 percent bare substrate/sediment. The upstream control results showed 35-40 percent aquatic vegetation and 60-65 percent bare substrate/sediment in 2004, 2006 and 2010 and a higher level of aquatic vegetation (65 percent) in 2007.

The aquatic plant species identified during the 2010 observations are similar to the species present prior to capping (**Table 7**). In total, 9 plant species were identified during the 2004 pre-construction survey, 8 plant species were identified during the 2006 post-construction survey, and 7 plant species each were identified during the 2007 and 2010 post-construction surveys. The dominant aquatic plant species observed were wild celery (*Vallisneria americana*) and filamentous algae (*Cladophora sp.*). The high percent vegetation cover and similar number of plant species observed in 2010 reflect a plant community that has re-established. Temporal differences appear to be negligible as the vegetation cover and number of plant species observed in the ROPS southern near shore control area remained relatively similar.

ROPS Data Summary

The objectives of the ROPS thin-layer capping component were to evaluate the ability to place a cap in the shallow near shore areas of the river, determine the effectiveness of a placed cap in reducing surface sediment PCB concentrations, and evaluate habitat impacts and recovery in the capped areas. The review of this information yields the following observations:

- Overall, capping in the southern near shore areas was successful. The average cap thickness, as measured by the post-placement cores, in 2006 (0.2 ft), 2007 (0.4 ft) and 2010 (0.2 ft) were consistent with those measured immediately after cap placement in 2005 (0.3 ft), although variability was greater in the 2006 and 2007 measurements. The data, however, identify areas where improvements in characterizing the target cap areas and placement/measurement procedures would help ensure more uniform cap coverage and longer-term stability of the in-place cap.

- Cap placement successfully reduced sediment PCB concentrations. As shown in **Table 3**, sediment PCB concentrations were reduced by 93 to 99% immediately after placement of the cap, depending on the post-placement cores used for the estimation of post-cap conditions. Despite the absence of cap material in some cores and evidence of some mixing of cap material and native sediments in cores collected in 2006, 2007 and 2010, PCB concentrations were still 84% to 91% lower than baseline conditions. Recent improvements in cap placement technologies are expected to result in more uniform cap placement.

- Cap placement had no apparent long-term impact on benthic and aquatic plant habitat. Within 2 years following placement, benthic community and aquatic habitats recovered to pre-construction conditions. In 2007, 12 benthic orders were observed during spring sampling compared to 12 observed prior to construction. The aquatic plants also recovered with 7 and 8 species noted in 2007/2010 and 2006, respectively, compared to 9 species in 2004.

The findings of the ROPS thin-layer capping are consistent with other thin-layer capping projects, including those from Ketchikan Pulp Company Site, which employed capping along the shallow north shore of Ward Cove in Ketchikan, Alaska in 2000. Subsequent monitoring at the site since 2001 has included sediment toxicity relative to a reference site, benthic community structure and composition relative to a reference site, temporal trends in sediment toxicity, and temporal trends in benthic community structure and composition. Cap effectiveness was determined by the successful placement of the cap and by reducing toxicity in surface sediment (Merritt et al., 2009).

Thin caps provide a surface layer of cleaner sediment, resulting in an immediate reduction in surface chemical concentrations to facilitate the re-establishment of benthic organisms, concurrently minimizing short-term disruption of the benthic community, and accelerating the process of physical isolation continued over time by natural sediment deposition. Comparison of the Grasse River ROPS southern near shore area (capping only, no dredging) to the north near shore area (dredging and capping) indicates that the southern near shore area recolonized more quickly than the northern near shore area as fewer statistical differences in the benthic metrics were observed immediately following construction activities in 2006 (Alcoa, September 2008). Re-vegetation and overall coverage of aquatic plant species was also observed in 2006, 2007 and 2010 in the southern near shore area.

Summary of Findings and Recommendations

Capping in near shore areas is a viable option for remediating the shallow near shore areas of the lower Grasse River. The results of the placement and post-construction monitoring support the following:

- Caps with thicknesses in the 3 to 6 inch range can be successfully placed in the shallow water areas of the lower Grasse River;
- Enhanced quality control measures beyond those used in during the ROPS are warranted to ensure adequate coverage;
- An increase to the minimum cap thickness is warranted to allow for some mixing with native sediments;
- Areas of the near shore with steeper sides slopes may require modification to the design and placement techniques that were used during the ROPS to ensure cap stability; and
- Even in consideration of some of the challenges posed by the area selected for the southern near shore capping, as well as evidence of surface recontamination in some cores, significant reductions in average surface (0 to 2 inches) sediment PCB concentrations were maintained over the duration of the monitoring program.

Specific potential construction improvements include modified placement procedures such as the use of alternative placement equipment, consideration for multi-lift placement, the use of a 6 inch target cap thickness, and more rigorous quality control procedures for establishing cap coverage and thickness. These considerations, in addition to the potential design-related modifications described above, would be addressed during the remedial design phase.

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Table 1
2004 ROPS Baseline Monitoring Results

Core ID	Core Interval (inches)	PCB (mg/kg)	% Solids	TOC (%)	Dry Density (g/mL)	% Gravel	% Sand	% Silt
NS1-S	0 – 3	1.61	59.6	1.6	0.84	0.4	9.0	90.9
	3 – 6	26.6	58.9	0.8	0.82	0.6	7.4	92.0
	6 – 8	ND	61.1	0.4	0.91	0.0	7.7	92.3
NS2-S	0 – 3	36.45	68.9	0.6	1.10	0.2	86.2	13.6
	3 – 6	0.55	63.4	0.5	0.96	0.7	35.9	63.4
	6 – 10	ND	61.0	0.5	0.85	1.9	6.5	91.3
NS3-S	0 – 3	0.38	62.0	0.5	0.92	0.3	69.0	30.7
	3 – 6	0.1	61.2	0.4	0.91	0.6	56.8	42.6
	6 – 12	ND	62.3	0.3	0.93	0.0	2.4	97.6
	12-14	ND	59.6	0.5	0.84	1.3	9.7	89.0
NS4-S	0 – 3	9.08	64.0	0.6	0.85	3.0	19.6	77.4
	3 – 6	ND	65.8	0.4	0.95	0.0	12.9	87.1
	6 – 12	ND	71.6	0.3	1.10	1.3	27.3	71.4
NS5-S	0 – 3	1.24	74.7	1.1	0.82	3.7	62.9	33.4
	3 – 6	20.50	64.3	0.8	0.91	4.4	25.2	70.4
	6 – 12	ND	64.5	0.4	0.90	0.9	4.9	94.2
	12 - 16	ND	63.3	0.3	0.82	0.0	3.2	96.8
NS6-S	0 – 3	1.07	70.5	0.7	1.10	9.5	55.7	34.8
	3 – 6	ND	62.7	0.5	0.86	1.0	18.2	80.8
	6 – 12	ND	66.4	0.4	0.88	0.8	7.4	91.8

Notes:

g/mL = grams per milliliter
mg/kg = milligram per kilogram
ND = Non-detect
TOC = Total Organic Carbon
See Figure 2 for core locations

Table 2
2005 Post-ROPS Monitoring Results

Core ID	Core Interval (inches)	PCB (mg/kg)	% Solids	TOC (%)	Dry Density (g/mL)	% Gravel	% Sand	% Silt	% Clay
SNS-1	0 – 2	0.12	79.4	0.57	1.30	0.8	89.3	4.0	5.9
	2 – 5	13.40	64.4	0.61	1.00	4.8	34.3	39.3	21.6
	5 – 8	1.05	64.4	0.49	0.97	1.0	20.5	57.4	21.1
	8 – 14	ND	60.8	0.47	0.91	2.9	5.6	69.0	22.5
SNS-2	0 – 3	ND	63.8	0.52	0.98	0.5	35.9	62.7	0.9
	3 – 6	ND	64.2	0.73	1.00	0.6	34.6	49.7	15.1
	6 - 12	ND	60.6	0.51	0.93	3.9	21.0	56.4	18.7
SNS-3	0 – 2	ND	79.9	ND	1.40	0.5	91.6	7.9	0.0
	2 – 4	0.33	83.6	0.53	1.30	6.7	85.7	7.6	0.0
	4 – 7	0.13	62.5	0.39	0.89	0.0	5.0	90.6	4.4
	7 – 10	ND	63.8	0.53	0.99	0.0	0.9	97.3	1.8
	10 - 16	ND	62.7	0.46	0.84	0.0	1.1	80.7	18.2
SNS-4	0 – 2	3.34	77.2	0.57	1.30	18.8	61.2	10.2	9.8
	2 – 5	1.53	68.9	0.34	1.00	0.0	13.5	58.1	28.4
	5 – 8	ND	67.1	0.40	1.00	0.0	9.9	71.7	18.4
	8 - 14	ND	65.2	0.51	0.95	12.0	4.2	77.2	6.6
SNS-5	0 – 2	ND	83.7	0.35	1.40	0.2	90.6	9.2	0.0
	2 – 4	0.34	80.2	0.74	1.40	1.1	84.6	14.3	0.0
	4 – 7	1.91	64.7	1.20	1.10	1.9	67.1	30.9	0.1
	7 – 10	13.30	66.4	1.00	1.00	14.0	52.1	23.6	10.3
	10 - 16	9.20	66.6	0.43	1.10	34.1	34.1	38.0	20.8
SNS-6	0 – 2	ND	83.1	0.39	1.50	3.3	86.5	0.5	9.7
	2 – 3	ND	86.3	0.32	1.60	1.3	89.5	9.2	0.0
	3 – 6	0.63	8.0	0.59	1.40	4.9	70.8	21.1	3.2
	6 – 9	0.38	71.6	0.42	1.00	3.1	24.5	67.9	4.5
	9 - 15	ND	63.1	0.48	1.10	4.9	7.0	81.5	6.6

Notes:

g/mL = grams per milliliter
mg/kg = milligrams per kilogram
ND = Non-detect
TOC = Total Organic Carbon
See Figure 3 for core locations

Table 3
Post-ROPS Cap Thicknesses and Surface Concentrations

Metric	Pre-ROPS	Post-ROPS					
	2005	**2005 (Cap only)**	**2005 (All cores)**	**2006 (Cap only)**	**2006 (All cores)**	**2007**	**2010**
Number of cores	6	4	6	9 (thickness) 4 (PCBs)	10 (thickness) 5 (PCBs)	5	6
Cap Thickness (ft) Average (range)	N/A	0.3 (0.2 to 0.3)	0.2 (0.0 to 0.3)	0.3 (0.2 to 0.5)	0.3 (0.0 to 0.5)	0.4 (0.1 to 0.8)	0.2 (0.0 to 0.3)
Surface[1] PCBs (mg/kg) Average (range)	8.3 (1.1 to 36.5)	0.06 (ND to 0.12)	0.60 (ND to 3.3)	1.18 (0.08 to 4.0)	1.06 (0.08 to 4.0)	1.33 (0.16 to 3.1)	0.77[2] (ND to 2.4)
Reduction in Surface[1] PCBs (from pre-ROPS; %)	N/A	99%	93%	86%	87%	84%	91%[2]

Notes:

1) Surface defined as 0-3 inches for pre-ROPS samples and 0-2 inches for post-ROPS samples.
2) Excludes surface samples from Core 1190, which contained PCB concentrations of 15.2 mg/kg in the top 1 inch.
3) N/A – Not Applicable; ND – Non-detect

Table 4
2006 Post-ROPS Monitoring Results

Core ID	Core Interval (inches)	PCB (mg/kg)	% Solids	TOC (%)	Dry Density (g/mL)	% Gravel	% Sand	% Silt	% Clay
1174	0 – 1	0.09	84.6	1.80	1.50	0.0	88.3	11.6	0.1
	1 – 2	0.07	84.0	0.69	1.10	1.1	89.6	9.3	0.0
	2 – 3	0.10	75.8	1.10	1.50	0.0	85.8	14.1	0.1
	3 – 4	0.22	83.1	1.90	1.50	0.9	79.9	19.2	0.0
	4 – 7	23.59	63.6	2.20	0.93	11.2	50.7	34.4	3.7
1194	0 – 1	0.26	82.7	0.24	1.50	0.0	90.0	8.6	1.4
	1 – 2	0.48	85.9	0.65	1.60	18.0	70.0	10.8	1.2
	2 – 5	4.68	62.1	0.43	1.00	0.0	12.6	67.5	19.9
1217	0 – 3	0.56	65.3	0.37	1.00	0.0	14.7	42.0	43.3
1239	0 – 1	5.12	40.9	3.30	0.52	0.0	84.1	15.9	0.0
	1 – 2	2.89	63.0	0.94	1.30	0.0	80.6	18.9	0.5
	2 – 3	5.59	73.3	0.48	1.20	0.0	86.2	12.2	1.6
	3 – 4	4.13	71.4	0.71	1.20	7.2	71.6	19.1	2.1
	4 – 7	25.10	67.9	ND	1.10	1.4	42.8	38.3	17.5
1259	0 – 1	0.43	81.7	0.14	1.50	3.2	89.2	7.3	0.3
	1 – 2	0.10	85.5	0.22	1.50	4.6	87.9	6.5	1.0
	2 – 3	ND	87.3	0.76	1.50	11.1	81.4	7.4	0.1
	3 – 4	1.49	58.9	0.98	1.10	4.8	77.2	17.5	0.5
	4 – 7	19.26	61.7	2.50	1.00	1.2	65.3	29.7	3.8

Notes:

g/mL = grams per milliliter
mg/kg = milligrams per kilogram
ND = Non-detect
TOC = Total Organic Carbon
See Figure 4 for core locations

Table 5
2007 Post-ROPS Monitoring Results

Core ID	Core Interval (inches)	PCB (mg/kg)	% Solids	TOC (%)	Dry Density (g/mL)	% Gravel	% Sand	% Silt	% Clay
1189	0 – 1	0.10	81.0	0.25	1.60	0.0	90.6	8.3	1.1
	1 – 2	0.22	85.7	0.15	1.60	0.1	90.8	8.0	1.1
	2 – 3	1.82	78.3	0.26	1.60	3.6	66.0	20.9	9.5
	3 – 4	2.11	73.4	0.71	1.20	2.2	49.6	20.3	27.9
	4 – 7	0.37	64.8	0.34	1.00	6.1	17.6	25.1	51.2
1213	0 – 1	0.68	70.3	0.77	0.92	8.8	87.2	2.2	1.8
	1 – 2	4.68	72.8	1.20	1.10	0.0	66.0	31.1	2.9
	2 – 3	9.13	53.5	3.00	0.78	0.0	64.7	34.6	0.7
	3 – 4	7.44	59.6	1.70	0.87	0.8	64.6	27.3	7.3
	4 – 5	10.86	64.1	1.40	1.10	1.6	74.3	15.1	9.0
	5 – 6	9.56	67.8	1.00	1.10	---	---	---	---
	6 – 7	10.75	69.3	1.30	1.40	5.1	64.3	23.3	7.3
	7 – 8	37.66	60.8	3.50	1.00	0.0	60.8	27.0	12.2
	8 – 9	263.11	42.3	5.10	0.50	0.0	22.1	54.8	23.1
	9 – 12	1086.50	36.5	5.50	0.45	0.0	11.8	62.7	25.5
1224	0 – 1	2.41	54.6	2.40	0.70	8.3	64.4	12.7	14.6
	1 – 2	3.79	65.7	0.89	1.30	---	---	---	---
	2 – 3	25.67	67.9	1.40	1.20	30.7	44.7	14.0	10.6
	3 – 4	57.89	61.6	0.95	0.96	4.4	35.9	19.5	40.2
	4 – 7	58.36	58.9	2.30	0.88	14.3	26.7	56.4	2.6
1243	0 – 1	0.40	78.3	0.76	1.40	1.0	79.5	15.6	3.9
	1 – 4	0.70	65.6	0.46	1.30	5.5	18.2	22.9	53.4
1264	0 – 1	0.40	75.3	0.49	1.40	0.0	74.8	20.9	4.3
	1 – 2	0.24	78.5	0.28	1.60	0.0	77.0	19.2	3.8
	2 – 3	0.25	79.9	0.28	1.60	0.0	87.4	7.8	4.8
	3 – 4	0.21	82.0	0.27	1.60	0.0	78.6	15.7	5.7
	4 – 5	0.79	73.5	0.71	1.30	0.0	64.7	27.6	7.7
	5 – 8	1.36	66.0	0.41	1.20	0.5	12.8	26.5	60.2

Notes:

g/mL = grams per milliliter
mg/kg = milligrams per kilogram
ND = Non-detect
TOC = Total Organic Carbon
See Figure 4 for core locations

Table 6
2010 Post ROPS Monitoring

Core ID	Core Interval (inches)	PCB (mg/kg)	% Solids	TOC (%)	Dry Density (g/mL)
1180	0 – 1	2.94	65.4	1.30	1.10
	1 – 2	1.94	68.8	1.50	1.30
	2 – 3	1.83	74.5	0.60	1.30
	3 – 4	0.65 (1.81)	68.1 (69.7)	0.82 (0.38)	1.10 (1.40)
	4 – 5	0.27	64.6	0.33	1.10
	5 – 6	ND	46.2	0.72	1.00
	6 – 7	ND	64.5	0.38	1.00
	7 – 8	ND	65.9	0.60	1.00
	8 – 9	ND	66.2	0.30	1.10
	9 – 10	ND	67.1	0.67	1.10
	10 – 11	ND	65.8	0.45	1.00
	11 – 12	ND	68.0	0.34	1.10
1190	0 – 1	15.24	67.2	0.58	1.30
	1 – 2	1.63	70.8	0.65	1.30
	2 – 3	1.22	78.7	1.10	1.60
	3 – 4	0.71	77.7	0.73	1.40
	4 – 5	5.10	69.8	1.10	1.30
	5 – 6	9.55	65.8	0.99	1.10
	6 – 7	51.83	60.7	2.00	1.10
	7 – 8	154.46	54.8	2.50	1.00
	8 – 9	161.40	54.2	2.40	0.92
	9 – 10	97.45	59.6	1.10	1.10
	10 – 11	69.06	63.2	0.86	1.00
	11 – 12	55.95	60.7	0.40	1.10
1207	0 – 1	0.66	60.9	1.80	1.10
	1 – 2	0.47	71.7	0.97	1.30
	2 – 3	0.23	62.6	1.90	1.20
	3 – 4	0.52	72.9	1.10	1.30
	4 – 5	0.46	77.1	0.42	1.50
	5 – 6	2.43	67.7	1.30	1.40
	6 – 7	4.66	68.8	0.76	1.20
	7 – 8	13.55	64.3	1.60	1.20
	8 – 9	8.80	73.2	1.30	1.30
	9 – 10	118.53	65.0	1.40	0.94
	10 – 11	113.24	60.6	2.00	1.10
	11 – 12	1.99	78.1	0.52	1.60

Table 6
2010 Post ROPS Monitoring

Core ID	Core Interval (inches)	PCB (mg/kg)	% Solids	TOC (%)	Dry Density (g/mL)
1223	0 – 1	0.22	79.8	0.26	1.60
	1 – 2	0.26	81.2	0.19	1.70
	2 – 3	0.80	78.8	0.33	1.50
	3 – 4	5.86	79.6	0.49	1.50
	4 – 5	47.81	71.2	0.73	1.10
	5 – 6	83.63	67.4	0.43	1.10
	6 – 7	12.02	60.8	0.36	1.00
	7 – 8	ND	62.4	0.75	1.00
	8 – 9	ND	62.2	0.31	0.93
	9 – 10	ND	63.0	0.33	0.96
	10 – 11	0.09	66.7	0.30	1.00
	11 – 12	ND	62.6	0.41	0.97
1238	0 – 1	ND	60.5	0.51	1.00
	1 – 2	ND	62.7	0.33	0.96
	2 – 3	ND	63.3	0.48	1.00
	3 – 4	ND	64.6	0.59	1.00
	4 – 5	ND	65.2	0.30	1.00
	5 – 6	ND	64.8	0.67	1.00
	6 – 7	ND	65.9	0.49	1.00
	7 – 8	ND	69.5	0.41	1.10
	8 – 9	ND	65.6	0.45	1.10
	9 – 10	ND	68.2	0.53	1.10
	10 – 11	ND	69.8	0.40	1.10
	11 – 12	ND	74.8	0.33	1.30
1254	0 – 1	0.64	68.1	0.73	1.30
	1 – 2	0.61	73.7	0.55	1.30
	2 – 3	2.79	70.1	0.53	1.30
	3 – 4	6.16	66.3	0.90	1.20
	4 – 5	5.06	40.0	4.20	0.84
	5 – 6	1.46	49.0	2.70	0.83
	6 – 7	0.96	61.7	1.30	1.00
	7 – 8	0.39	59.2	0.43	0.91
	8 – 9	0.27	54.8	0.62	0.86
	9 – 10	ND	55.4	0.39	0.85
	10 – 11	ND	58.3	0.39	1.10
	11 – 12	ND	72.2	0.25	1.30

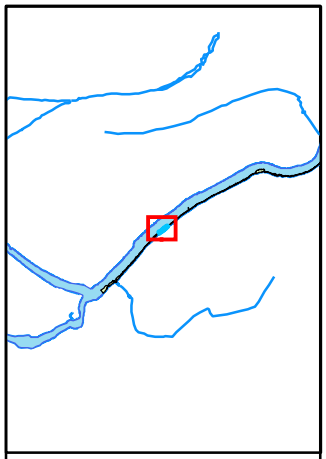
Notes:

ND – Non-detect
TOC – Total Organic Content
See Figure 4 for core locations

Table 7
Summary of ROPS Substrate, Aquatic Vegetation and Percent Abundance

Location	Event	Percent Bare Substrate	Percent Vegetation Cover	Vegetation Species and Percent Abundance																					
				Wild celery *Vallisneria americana*	Water weed *Elodea canadensis*	Floating-leaf pondweed *Potamogeton natans*	Filamentous algae *Cladophora sp.*	Clasping-leaf pondweed *Potamogeton richardsonii*	Long-leaf pondweed *Potamogeton nodosus*	Flat-stem pondweed *Potamogeton zosteriformis*	Pickerelweed *Pontederia cordata*	Curly-leaf pondweed *Potamogeton crispus*	Ribbonleaf pondweed *Potamogeton epihydrus*	White water lily *Nymphaea odorata*	Sedges *Carex spp.*	Common bur-reed *Sparganium eurycarpum*	Softstem bulrush *Scirpus validus*	Arrow arum *Peltandra virginica*	Arrowhead *Sagittaria spp.*	Common reed grass *Phragmites australis*	Rush *Juncus spp.*	Sweet flag *Acorus calamus*	Water stargrass *Heteranthera dubia*	Iris *Iris spp.*	Nitellas *Nitella spp.*
South Shore	2004	45%	55%	30%	--	10%	35%	10%	<5%	10%	--	--	--	<5%	--	<5%	--	--	--	--	--	<5%	--	--	--
	2006	45%	55%	75%	--	<5%	15%	--	<5%	--	--	--	--	<5%	<5%	<5%	<5%	--	--	--	--	--	--	--	--
	2007	30%	70%	60%	--	--	30%	<5%	5%	<5%	--	--	--	5%	--	<5%	--	--	--	--	--	--	--	--	--
	2010	20%	80%	50%	<5%	--	25%	--	--	5%	--	--	--	10%	--	<5%	<5%	--	--	--	--	--	--	--	--
South Control	2004	60%	40%	55%	10%	--	25%	--	10%	--	--	--	--	--	--	--	--	--	--	--	--	<5%	--	--	--
	2006	65%	35%	70%	10%	--	15%	<5%	--	--	--	--	--	--	--	--	--	--	--	--	--	<5%	--	--	--
	2007	35%	65%	65%	10%	--	10%	--	--	--	--	<5%	<5%	5%	--	--	<5%	--	--	--	--	5%	--	--	--
	2010	60%	40%	70%	10%	--	15%	--	--	--	--	--	--	--	--	5%	--	--	--	--	--	--	--	--	--

Notes:
1. The pre- and post-construction aquatic vegetation fall surveys were conducted 9/14/04-9/16/04 (pre) and 9/21/06, 9/19/07, and 9/17/10. The data are presented in chronological order for each location.
2. Sampling peformed in the ROPS southern near shore area (south shore) and southern shore control area (south control; adjacent to T4).



Legend

- Thin Layer Cap Boundary
- River Transect

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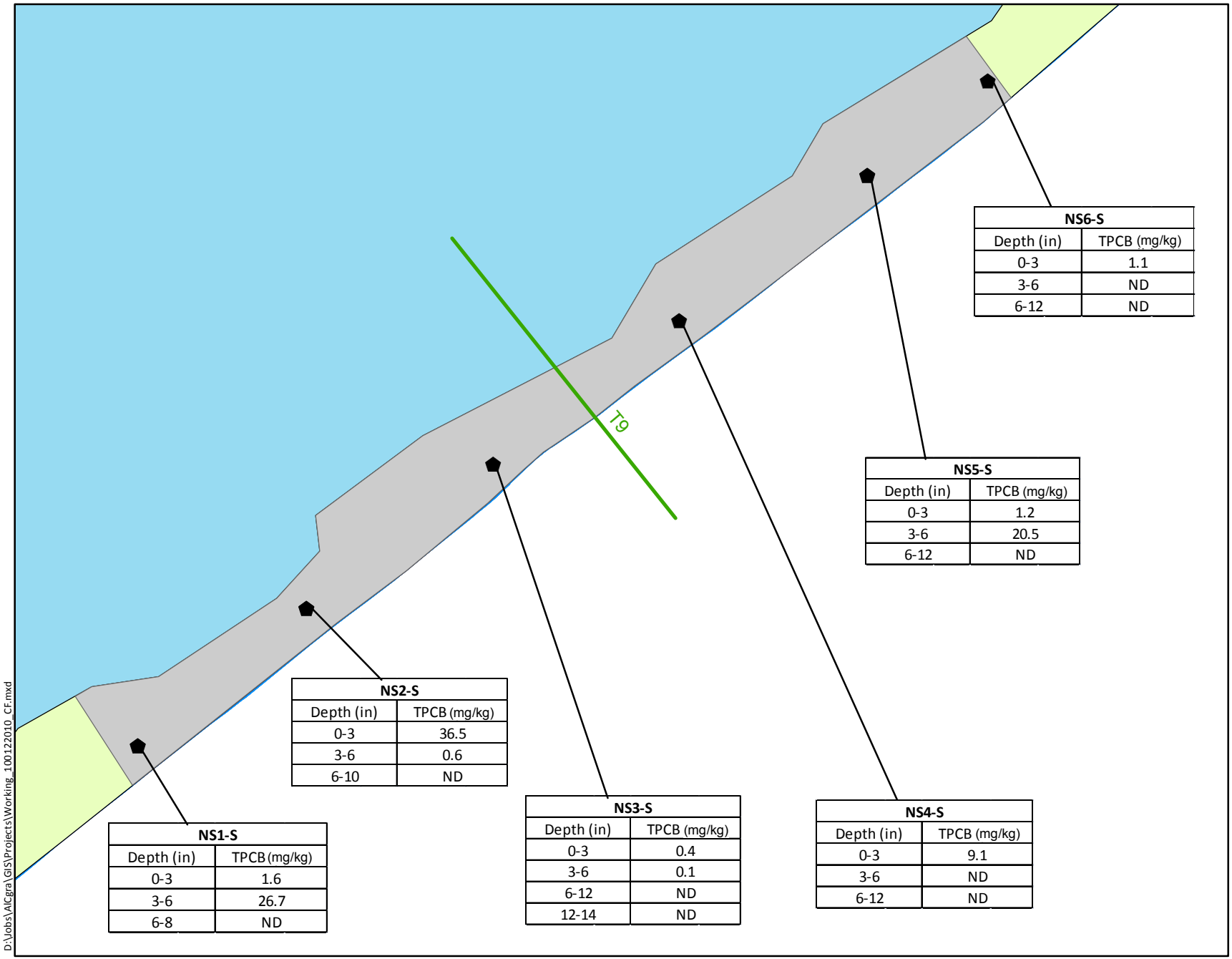
N
W E
S

75 37.5 0 75 Feet

Figure 1
ROPS Thin Layer Cap Area
ALCgra



NS1-S	
Depth (in)	TPCB (mg/kg)
0-3	1.6
3-6	26.7
6-8	ND

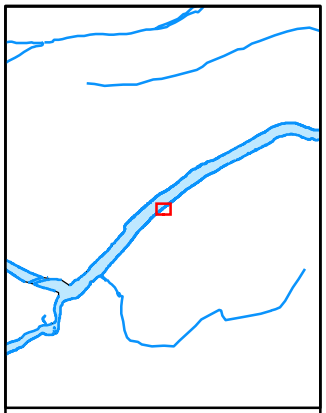
NS2-S	
Depth (in)	TPCB (mg/kg)
0-3	36.5
3-6	0.6
6-10	ND

NS3-S	
Depth (in)	TPCB (mg/kg)
0-3	0.4
3-6	0.1
6-12	ND
12-14	ND

NS4-S	
Depth (in)	TPCB (mg/kg)
0-3	9.1
3-6	ND
6-12	ND

NS5-S	
Depth (in)	TPCB (mg/kg)
0-3	1.2
3-6	20.5
6-12	ND

NS6-S	
Depth (in)	TPCB (mg/kg)
0-3	1.1
3-6	ND
6-12	ND



Legend

- Transect 9
- Near Shore Thin Layer Cap
- Near Shore Area
- Grasse River

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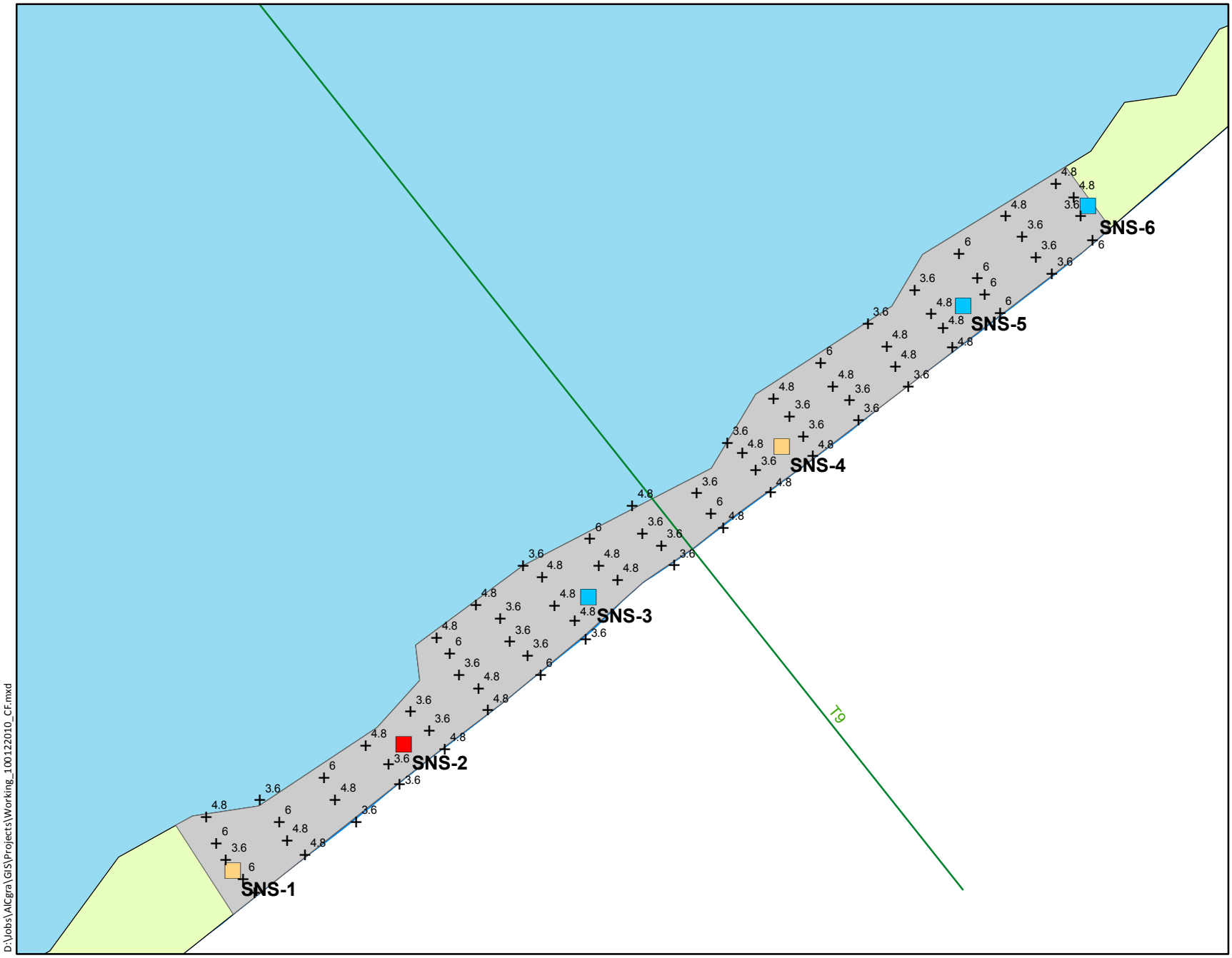
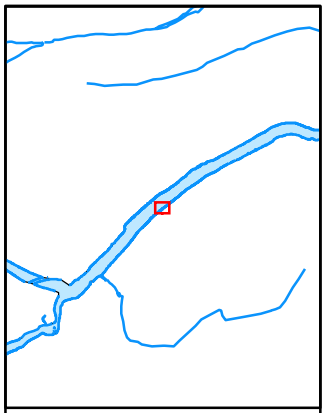
ALCOA

0 30 60 Feet

Figure 2
2004 Pre-ROPS Sediment PCB Concentrations
ALCgra





Notes:

Legend

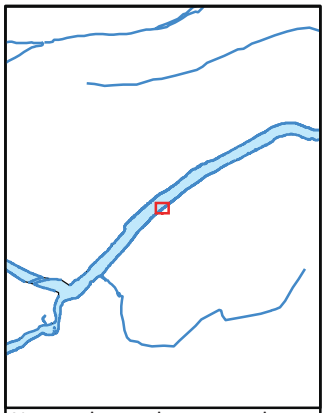
Cap Thickness (in)
- 0
- 0.1 - 1
- 1.1 - 2
- 2.1 - 3
- 3.1 - 6
- >6

Year
- 2005
- 2006
- 2007
- Probing Cap Thickness (in)
- Transect 9
- Near Shore Thin Layer Cap
- Near Shore Area
- Grasse River

ALCOA

0 30 60 Feet

Figure 3
Cap Thickness in Southern Near Shore Area 2005
ALCgra



Notes: slopes shown are the slope of the sediment bed in the vicinity of the 5 foot water depth

Legend

+ 2005 Probe Location

Cap Thickness (in)

- < 1.0
- 1.1 - 3.0
- 3.1 - 6.0
- > 6.0

Year

- 2005
- 2006
- 2007
- 2010

2010 Transect Effort

River Transect

Near Shore Thin Layer Cap

Grasse River

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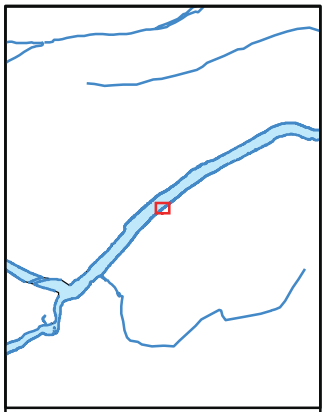
ALCOA

0 75 150 Feet

Figure 4
SNS Post-ROPs Cap Thickness
ALCgra



Notes: slopes shown are the slope of the sediment bed in the vicinity of the 5 foot water depth

Legend

0-2" PCB (mg/kg)

- < 1
- 1 - 5
- 5 - 10
- > 10
- 2010 Transect Effort
- River Wide Transect

Year

- 2005
- 2006
- 2007
- 2010
- Near Shore Area

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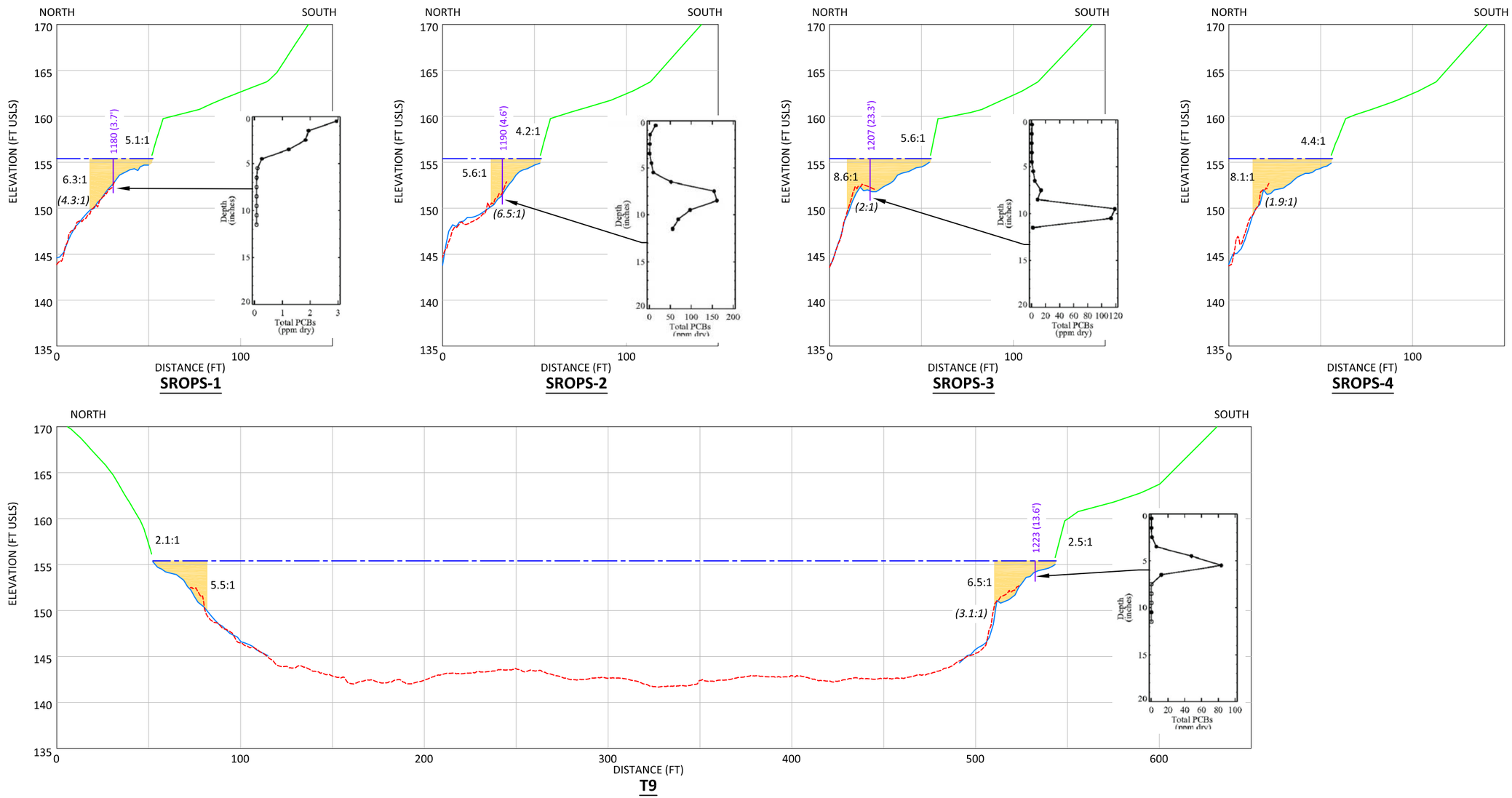
ALCOA

0 60 120 Feet

Figure 5
SNS Post-ROPS Surface PCB Concentrations
ALCgra



K:\Jobs_Syracuse\100002-ALCOA GRASSE RIVER\100002-08\100002-08-RP-003.dwg FIGURE 4-9a

Mar 29, 2011 1:08pm dholmer

HORIZONTAL DATUM: New York State Plane, East Zone, NAD83.
VERTICAL DATUM: United States Lake Survey (USLS), 1935.
NOTES:
1. 2010 near shore sediment elevations provided by ARCADIS.
2. Upland topography for transects T1 through T22 from mapping provided by Barton Aerial Technologies, LLC using photography flown on 4/12/05.
3. Approximate slope calculated for the first 5 feet of elevation change for the upland topography and the 2010 near shore sediment elevation.
4. ROPS core locations projected perpendicular to the nearest transect, their locations on the transect are approximate.
5. See figure 1-1 for transect locations.

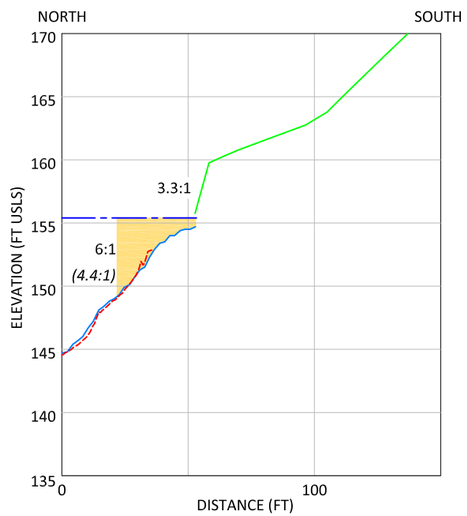
LEGEND:
- Upland Topography
- 2010 Near Shore Sediment Elevation
- 2003 Bathymetry
- Approximate 2010 Surface Water Elevation

3:1 Approximate Slope (H:V)
(1.7:1) Approximate Slope at Cap Edge (H:V)
Near Shore Area
1180 (3.7') ROPS Core (Distance Offset from Transect)

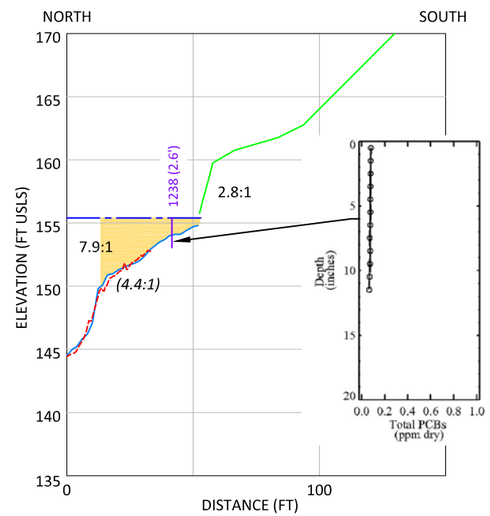
0 60 Horizontal Scale in Feet
0 12 Vertical Scale in Feet
Vertical Exaggeration = 5x

Figure 6a
Comparison of 2010 Near Shore Bathymetry, 2003 River Bathymetry and Upland Topography - SROPS-1 to SROPS-4, T9
Alcoa Inc. / Grasse River Project

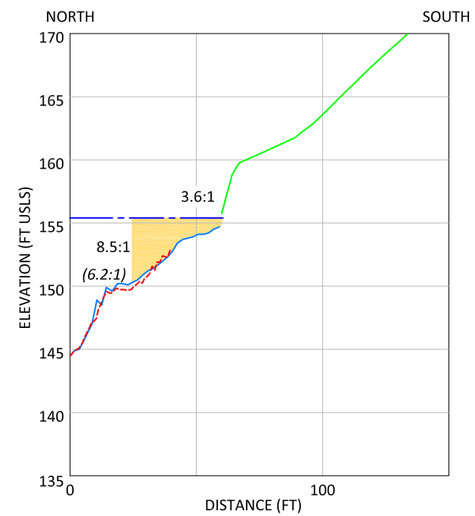
ALCOA



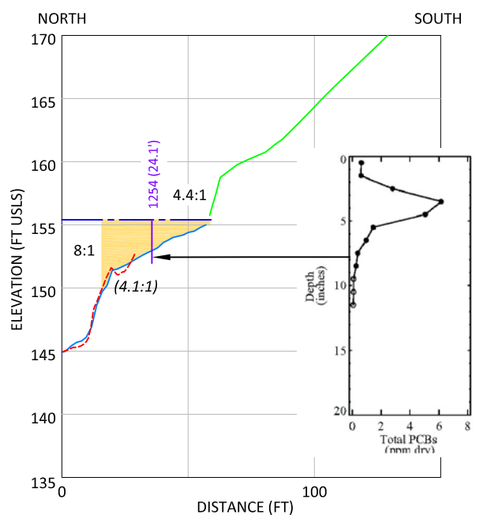
SROPS-6



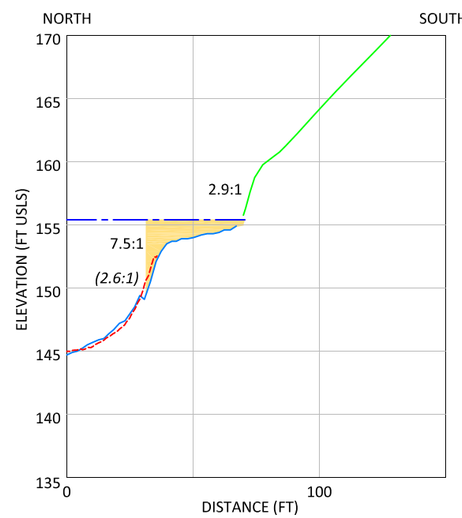
SROPS-7



SROPS-8



SROPS-9



SROPS-10

HORIZONTAL DATUM: New York State Plane, East Zone, NAD83.
VERTICAL DATUM: United States Lake Survey (USLS), 1935.
NOTES:
1. 2010 near shore sediment elevations provided by ARCADIS.
2. Upland topography for transects T1 through T22 from mapping provided by Barton Aerial Technologies, LLC using photography flown on 4/12/05.
3. Approximate slope calculated for the first 5 feet of elevation change for the upland topography and the 2010 near shore sediment elevation.
4. ROPS core locations projected perpendicular to the nearest transect, their locations on the transect are approximate.
5. See figure 1-1 for transect locations.

LEGEND:

- Upland Topography
- 2010 Near Shore Sediment Elevation
- 2003 Bathymetry
- Approximate 2010 Surface Water Elevation
- 3:1 Approximate Slope (H:V)
- (1.7:1) Approximate Slope at Cap Edge (H:V)
- Near Shore Area
- 1238 (2.6') ROPS Core (Distance Offset from Transect)

0 60 Horizontal Scale in Feet

0 12 Vertical Scale in Feet

Vertical Exaggeration = 5x

K:\Jobs_Syracuse\100002-ALCOA GRASSE RIVER\100002-08\100002-08-RP-003.dwg FIGURE 4-9b

Mar 29, 2011 1:09pm dholmer

ALCOA

Figure 6b

Comparison of 2010 Near Shore Bathymetry, 2003 River Bathymetry and Upland Topography - SROPS-5to SROPS-10
Alcoa Inc. / Grasse River Project

Appendix F

Assessment of Capping Impacts on the Grasse River Floodplain

Assessment of Capping Impacts on the Grasse River Floodplain

Numerical model simulations were performed to examine the projected post-capping water levels in the Grasse River floodplain during a 100-year flood event relative to baseline (pre-capping) conditions. The results of this evaluation were presented at the November 4, 2010 Grasse River Technical Team meeting in Albany, NY. This memorandum summarizes the approach, assumptions and results of the flood evaluation discussed at the November 4, 2010 meeting.

Approach

Numerical modeling was performed to evaluate the effects of placed caps in the river on water levels during a 100-year flood event in the river. For this assessment, the site hydrodynamic model was used to establish a baseline (pre-remedy) water surface elevation within the study area (defined as the lower river between the Massena Power Canal [at T1] and the river mouth [at T72]) for a 100-year flood of 15,080 cubic feet per second (cfs) (FEMA, May 1980). The hydrograph used in this simulation is presented in Figure 1. The simulation was conducted using the current day river bathymetry (as defined using the 2003 multibeam bathymetry, adjusted for changes resulting from the 2005 Remedial Options Pilot Study [ROPS] activities) and model parameters determined during model calibration (Alcoa, 2010). The results of this simulation served as the baseline condition upon which the post-capping simulations discussed below were compared.

For the post-cap condition, the alternative with the greatest areal extent of main channel capping (Alternative C1 from the March 2010 *Draft Analysis of Alternatives Report*) was simulated. This alternative includes placement of a 25-inch armored cap over 59 acres of the main channel between T1 and T21 and placement of a 12-inch sand/topsoil cap over 225 acres of the main channel between T21 and T72. This scenario is herein referred to as the No Habitat Layer scenario. In addition to the No Habitat Layer scenario, two additional simulations were performed to evaluate the impacts of 6-inch and 12-inch habitat layers placed on the top of the armored cap; these scenarios are referred to herein as the 6-inch Habitat Layer and 12-inch Habitat Layer scenarios. No adjustments were made to the near shore bathymetry consistent with discussions in the meeting when the request for the evaluation was initially made.

For each post-cap simulation, the river bathymetry in the target cap areas was adjusted to reflect post-cap placement conditions in the river. In all cases, the bathymetry in the target cap areas between T21 and T72 were revised to reflect the presence of a 12-inch sand/topsoil cap. For the target armored cap areas between T1 and T21, river bathymetry was adjusted to reflect the following:

- No Habitat Layer scenario: 25-inch armored cap
- 6-inch Habitat Layer scenario: 25-inch armored cap covered by 6 inches of sand/topsoil
- 12-inch Habitat Layer scenario: 25-inch armored cap covered by 12 inches of sand/topsoil

To simulate the rough surface of the armor layer in the No Habitat Layer scenario, the effective bottom roughness (Z_o) was set to 20 millimeters (mm). This value was computed assuming an armor layer with a D_{90} stone size of 10 inches, which is based on the armor layer design presented in the *Armored Cap Basis of Design Memorandum* (Alcoa, 2004), and the relationship below (Parker, 2004; Van Rijn, 1993).

$$Z_o = \frac{2D_{90}}{30}$$

For the 6-inch and 12-inch Habitat Layer scenarios, the effective bottom roughness for the target armored cap areas was set equal to that of the native sediments (i.e., 1.2 mm), which was established as an upper-bound estimate during earlier model calibration efforts (Alcoa, 2001). This assumption was based on the cap design, which was developed to mimic the properties of the native sediments (Alcoa, 2010). For all post-cap scenarios, the effective bottom roughness of the 12-inch sand/topsoil cap placed in areas downstream of T21 was assumed to be the same as the native sediments (i.e., 1.2 mm).

Results

Maximum predicted water surface elevations for the three post-cap scenarios are compared to the baseline (pre-cap) condition in Figure 2. Maximum predicted water surface elevations are greatest for the No Habitat Layer scenario, with a maximum increase in water surface elevation of about 1.2 feet above the baseline (pre-cap) condition. Water surface elevations for the 12-inch Habitat Layer and 6-inch Habitat Layer scenarios are predicted to increase by about 0.55 feet and 0.45 feet, respectively, relative to the baseline (pre-cap) water surface elevation. The higher water surface elevations predicted for the No Habitat Layer scenario are the result of the increased friction along the river bed that is caused by the roughness of the armor stone (20 mm vs. 1.2 mm for the 6-inch and 12-inch Habitat Layer scenarios). In all cases, the maximum increase in water surface elevation is predicted to occur at the upper portion of the lower river (i.e., T1). Increases in water surface elevation downstream of T21 (due to the main channel cap) are much less than those observed in the T1 to T21 reach of the river.

The lateral extent of the increase in water levels predicted for the No Habitat Layer scenario is presented in relation to the 100-year open water flow condition in Table 1 and Figures 3 through 11. The No Habitat Layer scenario is used for this comparison as it is predicted to result in the highest post-cap water surface elevations (i.e., it represents a worst case post-cap scenario). Results of this

comparison indicate that the post-remedy water surface elevations do not extend significantly outside of the baseline (current) 100-year flood elevation. Overall, capping under the No Habitat Layer scenario is predicted to affect a total of about 0.7 acres beyond that predicted for the 100-yr open water flood condition. This equates to a lateral distance of, on average, less than 2 feet over the approximate 3.8 miles of shoreline between T1 and T21. About two-thirds of the affected area is predicted to occur along the southern shoreline. In most instances the lateral extent of the predicted effects are limited to less than 10 feet. Areas where effects extend beyond 10 feet are observed where small drainage pathways and/or tributaries enter the river.

Table 1. Summary of Predicted Areal and Lateral Effects Beyond 100-Year Open Water Flood Condition

Reach	Northern Shore				Southern Shore			
	Areal Extent		Lateral Extent (feet)		Areal Extent		Lateral Extent (feet)	
	Sq. Feet	acres	Average	Maximum	Sq. Feet	acres	Average	Maximum
T1-T2	900	0.02	1.6	3.1	4,500	0.10	0.8	3.4
T2-T3	600	0.01	1.4	2.9	1,700	0.04	15.8	69.9
T3-T4	700	0.02	1.3	2.7	1,800	0.04	3.1	10.9
T4-T5	600	0.01	1.3	4.0	1,100	0.03	2.0	2.4
T5-T6	400	0.01	1.3	3.9	1,400	0.03	2.9	8.9
T6-T7	1,600	0.04	2.1	8.8	500	0.01	1.0	1.9
T7-T8	700	0.02	1.4	6.3	800	0.02	1.7	8.0
T8-T9	700	0.02	1.3	1.7	700	0.02	1.4	1.8
T9-T10	500	0.01	1.0	1.5	700	0.02	1.5	2.7
T10-T11	400	0.01	0.8	1.5	900	0.02	1.8	3.6
T11-T12	400	0.01	0.9	1.4	700	0.02	1.5	3.5
T12-T13	800	0.02	1.7	9.1	700	0.02	1.3	1.9
T13-T14	1,000	0.02	2.0	14.5	500	0.01	1.0	1.4
T14-T15	500	0.01	0.9	2.0	500	0.01	0.9	1.3
T15-T16	300	0.01	0.7	2.0	300	0.01	0.7	1.3
T16-T17	300	0.01	0.7	4.6	1,200	0.03	2.1	4.2
T17-T18	300	0.01	0.6	1.0	1,000	0.02	1.8	5.9
T18-T19	400	0.01	1.4	19.1	400	0.01	0.6	1.1
T19-T20	300	0.01	0.4	1.2	400	0.01	0.5	1.3
T20-T21	100	0.00	0.2	0.3	200	0.00	0.3	1.1

Notes

1 - Values are differences between the No Habitat Layer scenario and 100-year open water flood condition.

2 - Lateral extent calculated approximately every 1 foot along the contour.

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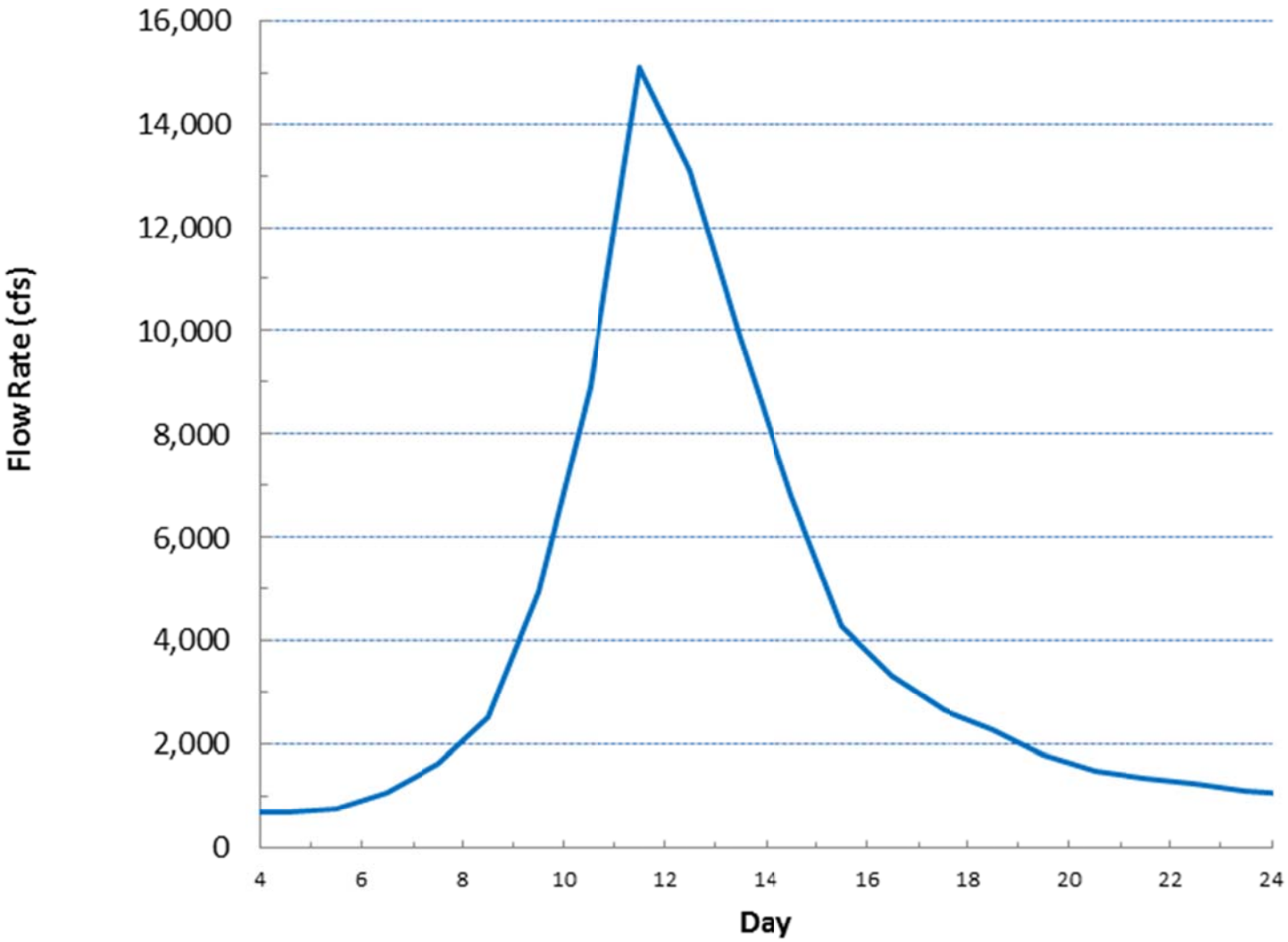


Figure 1
100-Year Hydrograph Used in Model Simulations
Grasse River Capping Floodplain Assessment
Alcoa Inc.

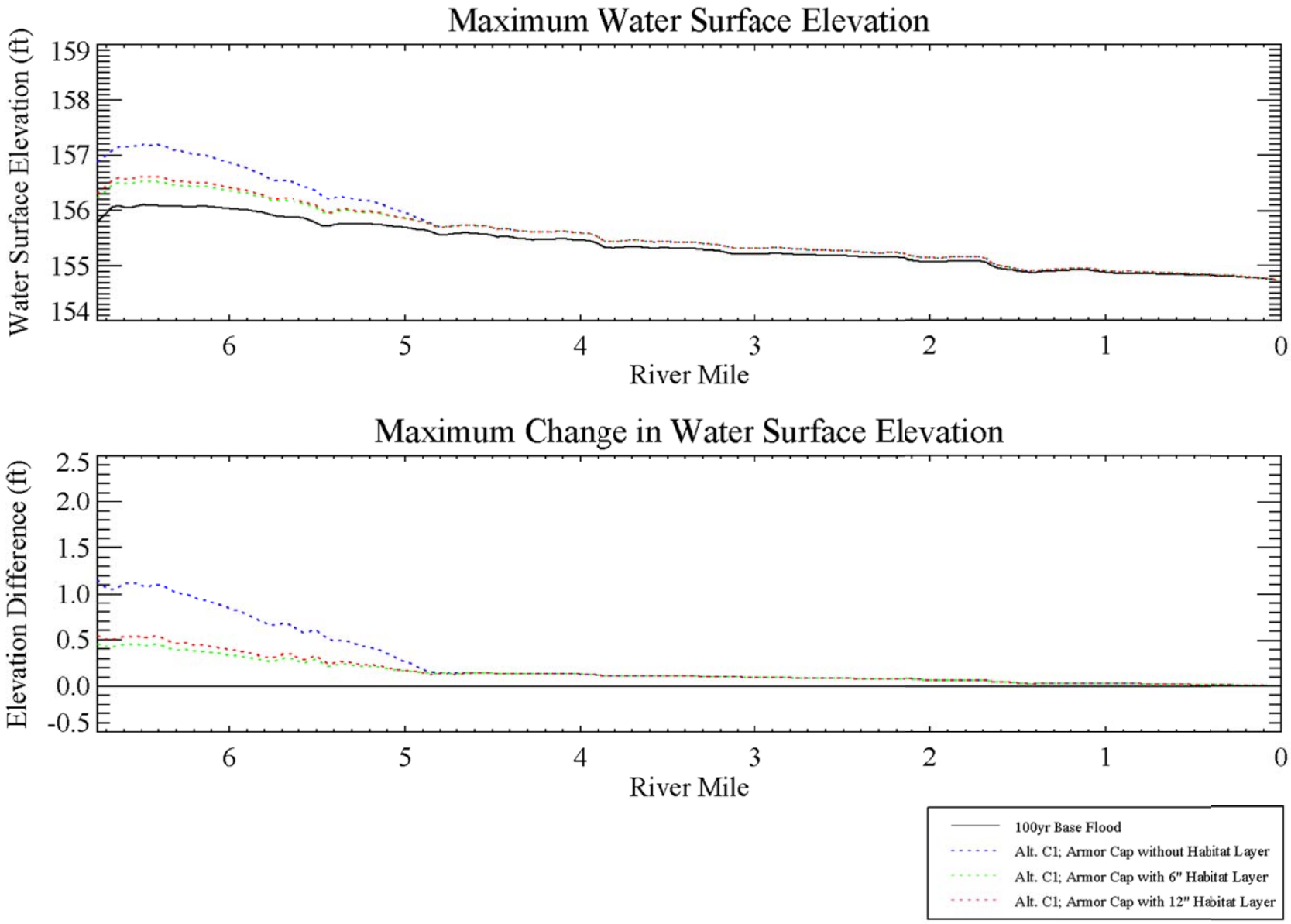
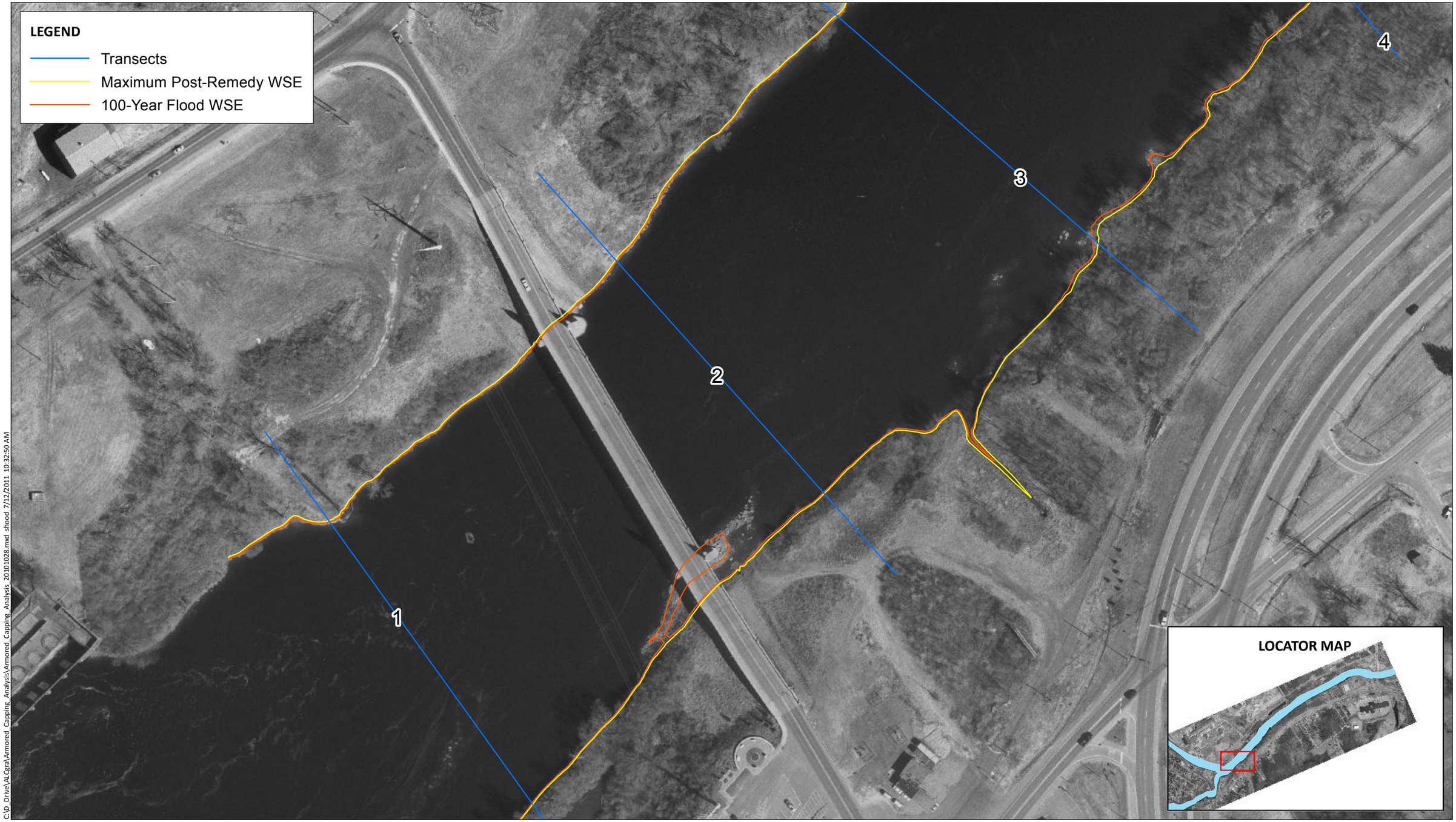


Figure 2
Predicted Changes in Water Surgface Elevation During 100-Year Flood Event
Grasse River Capping Floodplain Assessment
Alcoa Inc.



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ALCOA

Feet
0 75 150 225 300

Figure 3
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 1-3

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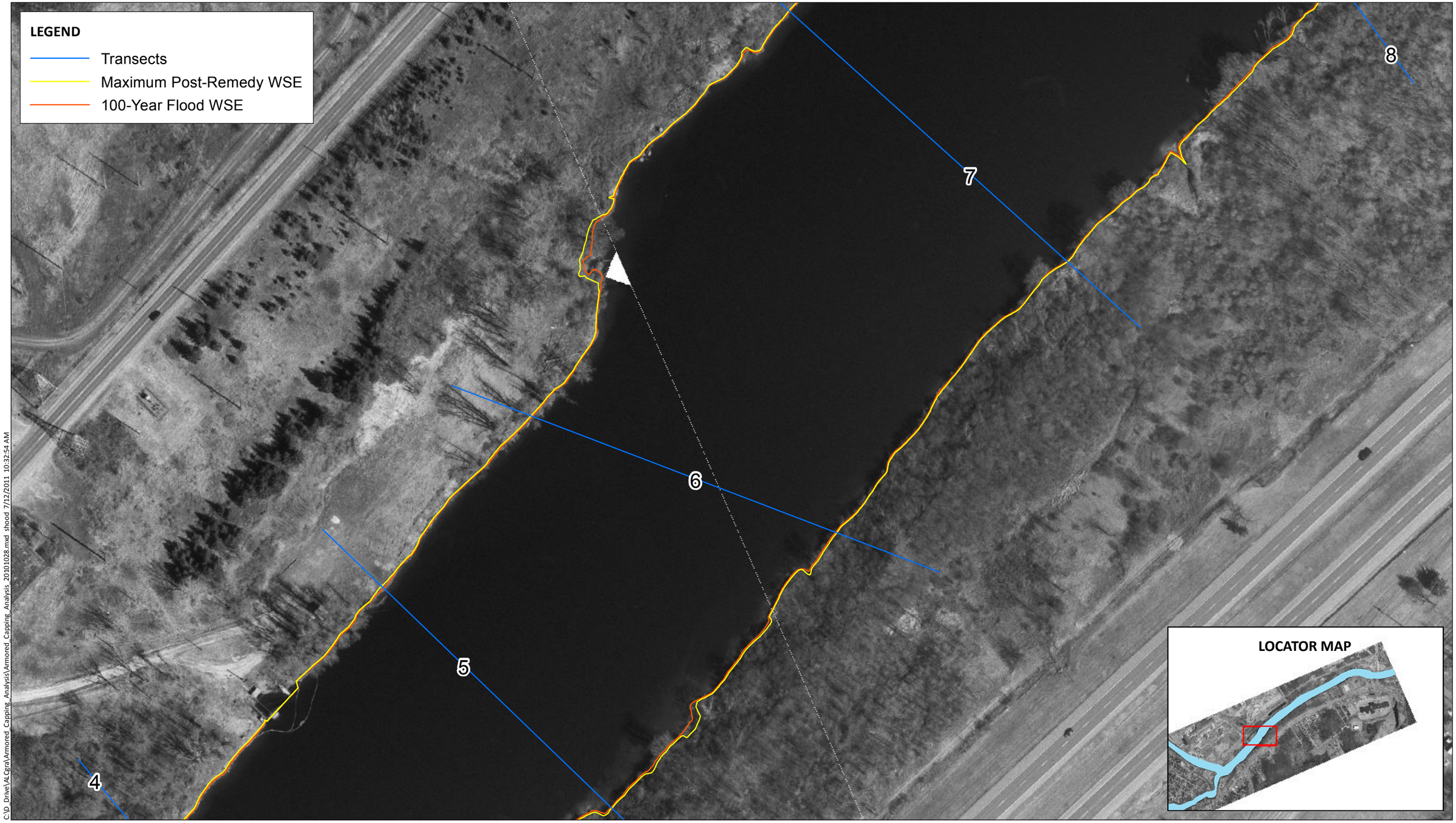
ALCOA

Feet
0 75 150 225 300

Figure 4
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 3-5



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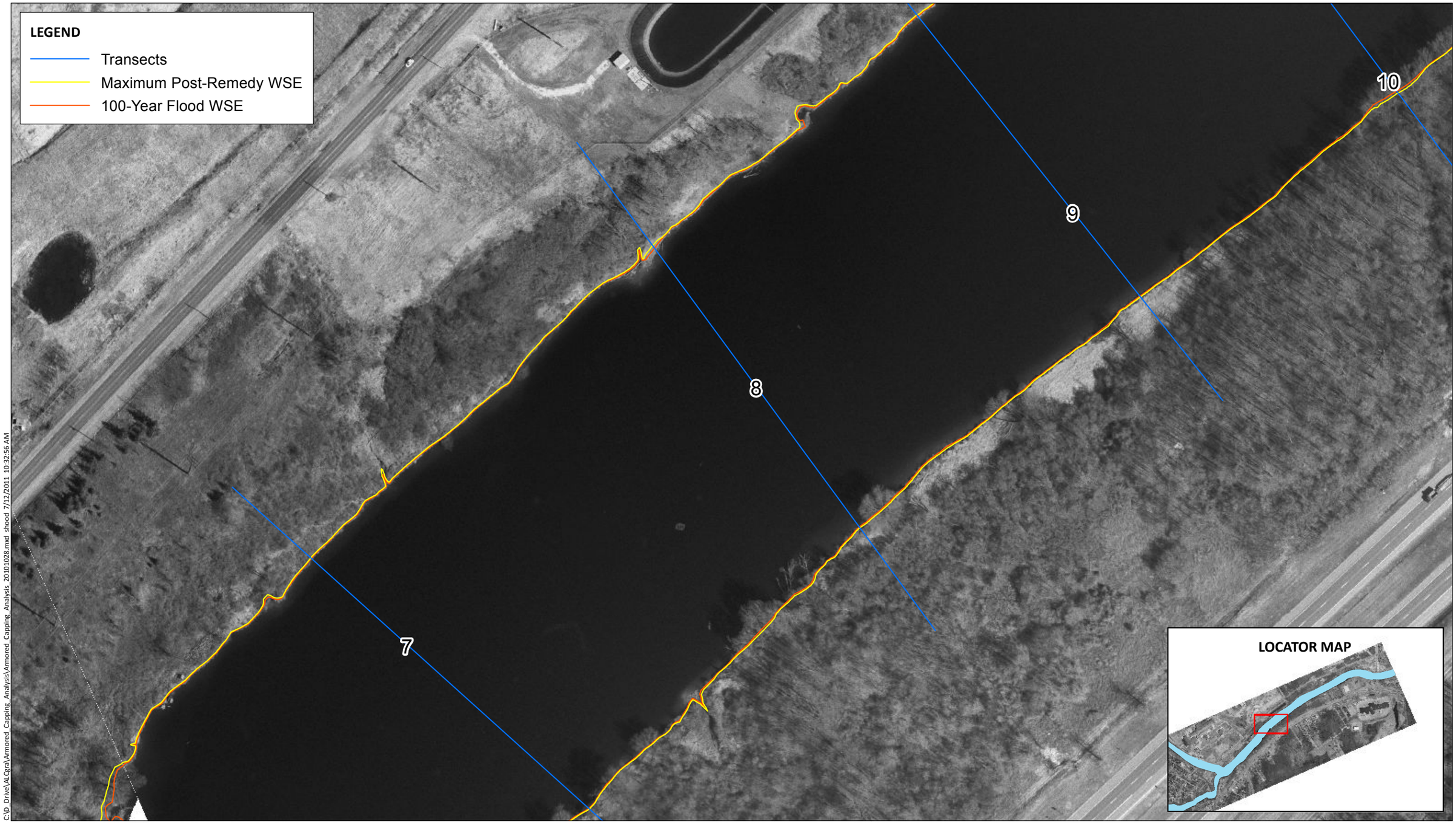
ALCOA

Feet
0 75 150 225 300

Figure 5
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 5-7



ALCOA

Feet
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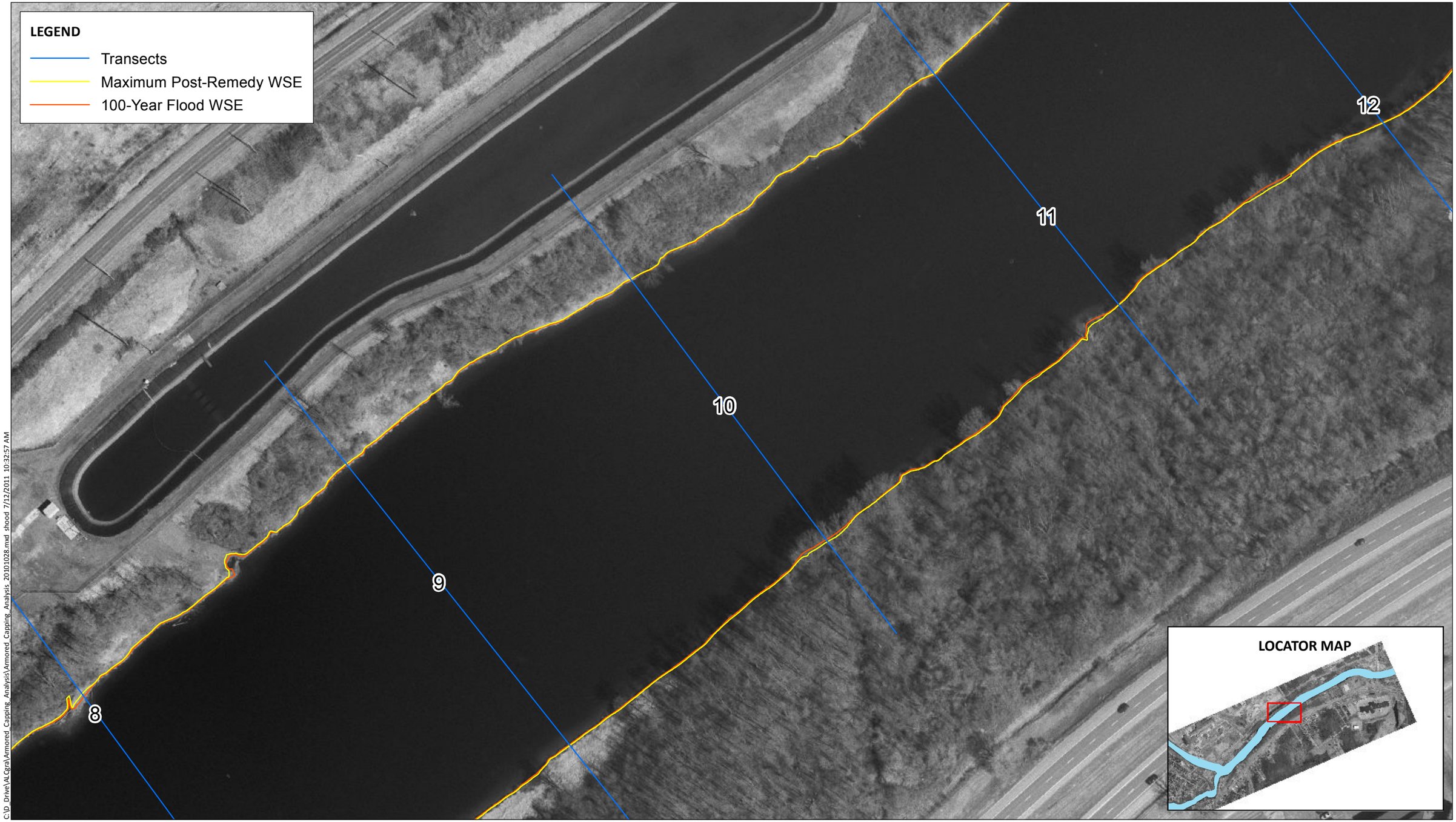
Figure 6
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 7-9



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Feet
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Figure 7
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 9-11

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Feet
0 75 150 225 300

Figure 8
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 11-13

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Feet
0 75 150 225 300

Figure 9
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 13-16

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ALCOA

Feet
0 75 150 225 300

Figure 10
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 16-18

ALCOA

Feet
0 75 150 225 300

Figure 11
Grasse River Post-Remedy 100-Year Flood Assessment
Alternative C1 – Habitat Layer Thickness Sensitivity Analysis
Transects 18-21

Appendix G

Risk-Related Supporting Information

Appendix G1: Recalculating Human Health and Hazards for Grasse River Non-PCBs Chemicals of Concern

Recalculating Human Health Risk and Hazards for Grasse River Non-PCB Chemicals of Concern

This document is an addendum to the 1993 *Revised Risk Assessment, Aluminum Company of America (ALCOA) Study Area, Massena, NY* (1993 Risk Assessment; TRC, 1993) and the 2002 *Human Health Risk Assessment Update, Grasse River Study Area, Massena, NY* dated July 1, 2002 (2002 RA Update; Alcoa, 2002) which addressed changes in toxicity values for polychlorinated biphenyls (PCBs) and exposure assumptions after 1993. The original 1993 Risk Assessment and the 2002 Update found that PCBs were the primary risk driver for fish consumption in the Lower Grasse River with cancer risks exceeding the risk range established by the NCP of one in a million to one in ten thousand (10-6 to 10-4, respectively) and the goal of protection of a Hazard Index of 1. Details of the analysis are provided in the 1993 Risk Assessment (TRC, 1993) and the 2002 RA Update (Alcoa, 2002).

As requested by the United States Environmental Protection Agency (USEPA), risks and hazards were recalculated for non-PCB chemicals of concern (COCs) in the Grasse River Study Area (Study Area) that were identified in the 1993 Risk Assessment. The revised estimates are based on changes in the toxicity factors (reference doses and cancer slope factors) that were identified by USEPA and conveyed to Alcoa via e-mail on June 3, 2009. Since USEPA provided the 2009 update to Alcoa, the toxicity information for several of the COCs were updated. Specifically, the oral Reference Dose for dioxin was issued on February 17, 2012; in 2010, USEPA issued "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8 Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds" that adopted the 2005 World Health Organization (WHO) TEFs, and the toxicity values for trichloroethylene and aluminum were updated. USEPA updated this document to reflect the current information as described below.

In addition, the risk and hazard calculations were revised to include updates in exposure factors from the USEPA-approved 2002 Risk Assessment Update. Since the 1993 Risk Assessment identified PCBs as the primary risk driver, the 2002 RA Update addressed only PCBs in the various media of the Grasse River (e.g., fish, sediments and surface water). The 2002 RA Update included exposure factors that were consistent with current scientific knowledge and regulatory approaches to assess exposures at the Study Area. These revised exposure pathways and assumptions are incorporated in the calculations presented herein for non-PCB COCs. In order to maintain consistency with the 1993 Risk Assessment and 2002 Update, the COCs, receptor populations and exposure pathways were the same as those evaluated in the prior reports. Revised exposure frequencies for the young child and adult were applied, and one additional receptor population (youth recreator) was incorporated along with the new toxicity factors identified by the USEPA. Attachment A provides the revised exposure factors, along with

tables outlining the equations and assumptions used in this assessment. A summary of the recalculated risks and hazards is included as Attachment B, including the spreadsheets showing the risks and hazards associated with the individual chemicals and exposure pathways.

Because this recalculation is designed to update the existing USEPA (1993) risk assessment for non-PCB chemicals it does not include a detailed discussion of each process involved in conducting a human health risk assessment. The reader is referred to the USEPA (1993) baseline risk assessment for more detailed discussion of the site, receptor populations, media to which receptors are potentially exposed, potential routes of exposures and the risk assessment process. The reader is also referred to the *Comprehensive Characterization of the Lower Grasse River Report* (Alcoa, 2001) and *Draft Comprehensive Characterization of the Lower Grasse River Report* (Alcoa, 2009) which provides a description of the physical and biological characteristics of the River, summarizes PCB nature and extent data, and discusses the sources and fate of PCBs in the lower Grasse River.

Results

As detailed in Attachments A and B, using the site characterization data contained in the 1993 Risk Assessment, and incorporating the updated toxicity and exposure factors resulted in revised individual hazard quotients (HQs) or non-PCB cumulative hazard indices (HIs) of less than unity (1), except as described below. Exposure to sediment and surface water were assumed to occur during recreational use of the river. Because exposure to these media was expected to occur concurrently, the risks and hazards resulting from exposure to the individual media were added together to assess cumulative cancer risks and noncancer hazards. Risks and hazards for recreational receptors exposed to both surface water and sediments are within USEPA's risk range (e.g., less than one and equal to or less than 1E-04). Consistent with the 2002 RA Update, the recreational exposure was assumed to be non-continuous; in other words, the exposure was assumed to occur only during the exposure period for the individual receptors (as a child, youth or adult), and not over an entire lifetime of a single recreator. As a result, the risks and hazards for these incremental age groups were not summed to calculate a lifetime cancer risk or noncancer hazard for a single recreational receptor. If cumulative risks and hazards were considered over the lifetime of a single recreator, the resulting hazard quotient and lifetime cancer risks would not exceed the USEPA risk range of 1 in 1,000,000 or 1 in 10,000 or the goal of protection of a Hazard Index = 1.

Likewise, recalculating cancer risks to local anglers from non-PCB COCs [i.e., polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)] resulted in none of the cancer risks exceeding the upper end of USEPA's risk range (1 in 10,000 or 1E-04) with the

exception of consumption of fish within Reaches 4 to 8. Risks to a local angler in Reaches 4 through 8 were calculated using fish PCDD and PCDF congener data contained in both the *Phase I Grasse River and Sediment Investigation* (Ecology and Environment, Inc., 1992) and *River and Sediment Investigation (RSI) Phase II Report, Volume I Grasse River Study Area Massena, New York* (BBL, 1994). Congener data from the 14 fish were converted to dioxin equivalent concentrations using the 2005 World Health Organization's TEFs (Van den Berg et al., 2006; USEPA, 2010), resulting in a "dioxin-equivalent" concentration for each fish (i.e., fish tissue in TCDD equivalents). Tables A4 and A5 provide the data and calculations of the TEQ. Table A6 provides the ProUCL output with the calculated 95% upper confidence limit of the mean (95% UCL). The 95% UCL dioxin equivalent concentration from these 14 fish were used as the exposure point concentration (EPC) for Reaches 4 through 8. Resulting risk from the 95% UCL PCDD and PCDF congeners (including 2,3,7,8-TCDD) was 1×10^{-4}. This calculated risk is within the risk range of 10^{-4} to 10^{-6}. Based on the uncertainty associated with the data (described below), the risks were also calculated assuming a mean exposure concentration value to provide a bounding estimate. The resulting risks associated including the mean exposure concentration were 7×10^{-5}.

Because TCDD was detected infrequently in only one media (fish tissue) cancer risks were determined using a data set without the single value for 2,3,7,8-TCDD. Risks to the local angler in Reaches 4 through 8 from 95% UCL PCDDs and PCDF congeners concentrations other than 2,3,7,8-TCDD was 9.3E-05 (Table B3). Based on the uncertainty associated with the data (described below), the risks were also calculated assuming a mean concentration to provide a bounding estimate. The resulting risks were 5.1×10^{-5}. These risk estimates are nearly 100-fold lower than those calculated from PCBs in fish tissue (RME risks of 3×10^{-3}). These results support the conclusion from the original risk assessment (TRC, 1993) that PCBs are the primary driver of cancer risks in the Grasse River.

In February 2012, USEPA published a reference dose (RfD) for 2,3,7,8-TCDD on IRIS and recommended the use of this value in risk assessments (USEPA, 2012). The RfD is 0.7 pg/kg-day and was used to evaluate the Hazard Quotient (HQ) from dioxin-like compounds detected in Grasse River fish in the early 1990s. The resulting non-cancer HQ from the 95% UCL concentration (including 2,3,7,8-TCDD) is an HQ = 3. Calculating the 95% UCL without the single detected 2,3,7,8-TCDD value resulted in an HQ = 2 (Table B7). To provide a bounding estimate, the resulting non-cancer HQ from the mean concentration (including 2,3,7,8-TCDD) was calculated and the HQ = 2. Calculating the mean without the single detected 2,3,7,8-TCDD value resulted in an HQ = 1 (Table B7). Similar to the cancer risk estimates described above, the HQs estimated from the historical PCDD and PCDF congener data were approximately 100-fold lower than those calculated for PCBs (RME HQ = 160). These results support the conclusion from the original risk assessment (TRC, 1993) that PCBs are the primary driver of the non-cancer HQ in the Grasse River.

As with all risk assessments, there is a degree of uncertainty inherent in the estimates of risks and hazards. This is true with respect to the analysis of risks associated with exposure to dioxin-like compounds. USEPA is re-evaluating the toxicity of dioxins for cancer assessments as part of the Agency's dioxin science plan (www.epa.gov/dioxin and *http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=57036*).

In addition, the data set used for dioxin-like compounds added to the uncertainty in determining risks and hazards. Some of the issues associated with these data include:

- The samples were collected and analyzed more than 20 years ago. Analytical methods have improved substantial over the last two decades and thus, the detection limits reported for these samples were higher than those that would be expected today.
- No congeners were detected in 4 of the 14 fish (28%).
- Six of the 17 PCDD and PCDF congeners (35%) were not detected in any fish.
- The most commonly detected congeners were 2,3,7,8-tetrachlorodibenzofuran and octachlorodibenzofuran, and both were detected in only 6 of the 14 fish (43%). All other PCDD and PCDF congeners were detected in less than 30% of the fish tissue samples.
- Seventeen congeners were analyzed in 14 fish samples, or 238 individual analyses; measurable congener concentrations were detected in only 35 (15%) of these analyses.
- 2,3,7,8-TCDD was not detected in water or sediment near or downstream of the facility, and this congener was detected in only 1 of the 14 samples as described above.

Additionally, the potential exists that adult anglers may share their catch with family members including young children and adolescents. Risks to young children and adolescents may be comparable or slightly higher than those presented in this document for adults.

Other factors, including exposure parameters like fish ingestion rates, contribute to the overall uncertainty.

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Attachment A

Summary of Revised Exposure Factors from 1993 Risk Assessment (TRC, 1993) to the 2002 Updated RA (Alcoa, 2002).

Exposure Factors	1993 Adult	2002 Adult	1993 Youth	2002 Youth	1993 Child	2002 Child	1993 Mohawk	2002 Mohawk
Fish Ingestion Rate (kg/day)	0.054	0.032	NA	NA	NA	NA	0.200	0.142
Sediment Ingestion Rate (mg/day)	100	50	NA	100	200	100	100	50
Surface Area - Sediment (cm^2)	9290	6073	NA	4283	3680	2792	3120	3120
Soil Skin Adherence Factor (mg/cm^2)	1	0.3	NA	0.25	1	0.2	1	0.3
Surface Area –River Water – Wading (cm^2)	9290	6073	NA	4283	3680	2792	3120	3120
Exposure Frequency – recreator (days)	78	13	NA	39	143	13	260	65
Exposure Duration – recreator (yrs)	24	12	NA	12	6	6	64	64
Averaging Time – noncancer (days)	8760	4380	NA	4380	2160	2190	23360	23360

Revised Exposure Assumptions

Because the purpose of this memorandum is to update the USEPA (1993) Risk Assessment, the exposure pathway and receptors evaluated here are essentially the same (with the exception of the addition of the youth recreator) as those in the 1993 document. This assessment incorporates current USEPA toxicity factors as provided by the USEPA, as well as exposure factors used in the 2002 RA Update that more accurately reflect exposures at the Study Area. A detailed explanation of the exposure factors can be found in the *Human Health Risk Assessment Update, Grasse River Study Area* (Alcoa, 2002). A brief summary adopted from the 2002 RA Update is included below.

1.0 Exposure Factors

The 2002 RA Update used exposure factors that reflect current scientific and regulatory policy to assess conditions at the Study Area. While some exposure factors were agency default values, there were site- specific values that are more relevant for exposures at Grasse River. Both reasonable maximum exposure (RME) and central tendency (CT) exposure scenarios were evaluated in the 2002 document, however in assessing the non-PCB COCs, only the RME case is considered. The RME scenario is intended to represent the highest exposure that is reasonably expected to occur.

1.1 Fish Consumption

Local and Mohawk anglers[1] were assumed to be exposed to PCBs through consumption of fish from the Grasse River. Local anglers were assumed to fish in Reaches 1 and 2 (Background Reach), and Reaches 4 through 8 (Upper, Middle, and Lower Reaches), while Mohawk anglers were assumed to fish in only Reaches 7 and 8 (Lower Reach). For the RME scenario, local anglers consumed

[1] The RA Update originally included references to SRMT anglers; these references are intended to indicate Mohawk anglers.

self-caught fish for 350 days per year for 30 years at an ingestion rate of 32 g/day. At the request of USEPA, the fish ingestion rate of 142 g/day was used for the Mohawk scenario.

Other than PCBs, the only other class of chemicals for which there are fish tissue data are polychlorinated benzodioxins and polychlorinated dibenzofurans. A summary of the data used in the calculations of risk and hazards is provided in the Tables A4 and A5.

1.2 Sediment

The 2002 RA Update assumed that Mohawk anglers involved in gill netting activities would potentially be exposed to sediment during the summer months only (end of May to beginning of September), when use of protective clothing is not required due to warmer water temperatures. As a result, the Mohawk anglers were assumed to be exposed for 65 days per year (exposure of 5 days per week for 13 weeks) for 64 years (70 years minus 6 years of childhood exposure).

Under the recreational exposure scenario, use of the river occurred during the summer months only, when water temperatures are more favorable for swimming**.** Both children and adults were assigned an exposure frequency of 13 days per year (one day per week for 13 weeks during the summer months). In addition to child and adult recreational users, an additional receptor (youth aged 7 to 18) was evaluated. This youth receptor was assumed to visit the Grasse River 3 days per week for 13 weeks (39 days per year). Under the RME scenario, the exposure duration for children was 6 years, and 12 years for youths and adults.

Because sediment-based ingestion rates are not available in the published literature, USEPA-recommended soil ingestion rates were used. For the RME exposure scenarios, Mohawk anglers and adult recreational users an ingestion rate of 50 milligrams (mg) of sediment per day was used. Child and youth recreational users were assumed to consume 100 mg of sediment per day.

It was also assumed that Mohawk anglers were exposed to sediment during gill netting activities, and that only the arms and hands would be exposed. This corresponds to an average surface area of 3,120 square centimeters (cm^2). For the recreational exposure scenario, it was assumed that individuals wading in Grasse River might have their arms, hands, feet, and legs exposed to sediment. At the request of USEPA, average skin surface areas of 6,073 cm^2, 2,792 cm^2, and 4,283 cm^2 were used to evaluate dermal risks to adults, children, and youths, respectively.

For the RME exposure scenarios, adherence factors of 0.2 milligrams per square centimeter (mg/cm^2) for children and 0.3 mg/cm^2 for adults, as listed in the Dermal Risk Assessment Interim Guidance (USEPA, 2004), was used. The average of the child and adult dermal adherence factors (0.25 mg/cm^2) was used for youths.

The following is a summary of the dermal absorption factor used for the revised assessment of non-PCB COCs. The USEPA (2004) dermal guidance does not provide default dermal absorption values for volatile organic compounds nor inorganic classes of compounds.

Dermal Absorption Factors from Soil
as recommended by USEPA, 2004

Compounds	Dermal Absorption Faction (ABS)
Arsenic	0.03
TCDD and other dioxins	0.03
Benzo(a)pyrene and other PAHs	0.13
Semivolatile organic compounds	0.1

1.3 Surface Water - Incidental Ingestion and Dermal Contact

The RME exposure frequencies and exposure durations for surface waters were the same as those used for sediment: adults and children were assumed to visit Reaches 4 through 8 of the lower Grasse River for recreational activities for 13 days per year for 12 years and 6 years, respectively; and youths (aged 7 to 18) were assumed to use the same exposure area for recreational purposes for 39 days per year. Each RME recreational event (swimming) was assumed to last for 2 hours.

It was assumed that 50 milliliters (mL) of surface water is ingested for every hour spent swimming (USEPA, 1989). The total body surface area available for contact with surface water was assumed to be the 50th percentile body surface area for adults (20,000 cm^2), children aged 0 to 6 (6,640 cm^2), and youths aged 7 to 18 (13,500 cm^2), as defined in the USEPA (1997) Exposure Factors Handbook.

To assess dermal uptake from surface water, the approach outlined in the 2004 Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) was used (USEPA, 2004). The physical and chemical parameters applied are included in the following table.

Chemical Specific Values Used to Calculate Dermal Absorbed Dose from Water as recommended by USEPA, 2004

	Permeability Coefficient (cm/hr)	Molecular Weight (3) (gm/ml)	Log Kow (3)	Fraction Absorbed Water (4)	Lag Time per Event (hr/event) (4)	Time to Reach Steady State (hr) (4)	B (5)
	PC	MW	LogKow	FA	Tevent	t*	B
Trichloroethene	1.2E-02 (1)	131.4	2.42	1	0.6	1.43	1
Bis(2-Ethylhexyl)Phthalate	2.5E-02 (1)	391.0	5.11	0.8	16.64	39.93	0.2
1,2,3,4,6,7,8-HPCDD	1.3E+1 (1)	425.2	8.00	0.5 (6)	6.82 (6)	30.09 (6)	5.6 (6)
2,3,7,8-TCDF	3.4E-1 (1)	306.0	6.10	0.5 (6)	6.82 (6)	30.09 (6)	5.6 (6)
OCDD	1.2E+1 (1)	460.0	8.20	0.5 (6)	6.82 (6)	30.09 (6)	5.6 (6)
Aluminum	1E-03 (2)	-	-	-	-	-	-
Fluoride Total	1E-03 (2)	-	-	-	-	-	-
Lead	1E-04 (2)	-	-	-	-	-	-

(1) Calculated from Part E Spreadsheets, http://www.epa.gov/oswer/riskassessment/ragse/index.htm
(2) From Exhibit 3-1 in USEPA, 2004
(3) From USEPA (1993) Baseline Risk Assessment
(4) From USEPA, 2004
(5) Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (ve) (dimensionless) (4)
(6) Values from TCDD were applied

Consistent with the 1993 Risk Assessment, exposure to Reach 9 surface water, which was not addressed in the 2002 RA Update, was assumed to be limited to wading activities. As a result, exposure time was limited to one hour and the exposed surface area used was consistent with the previous sediment scenario. These values are the 50th percentile values (average for male and females) for hands, lower legs, forearms, feet and face based on data presented in the USEPA (1997) Exposure Factors Handbook.

TABLE A1

VALUES USED FOR DAILY INTAKE CALCULATIONS

GRASSE RIVER STUDY AREA, MASSENA, NY

Scenario Timeframe: Current/Future
Medium: Fish Exposure
Medium: Fish Exposure
Point: Fish Receptor
Population: Angler
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	Parameter Code	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CF	Chemical concentration in fish	mg/kg	CF IR		See Table 3.1	Intake = CF*IR*FI*EF*ED/BW*AT
	IR	Ingestion rate - local angler	kg/day	IRsrmt	0.032	Connelly et al (1992)	
	IR	Ingestion rate - Mohawk	kg/day	FI	0.142	NYSDOH, 1995	
	FI	Fraction Ingested from contaminated source	uniltess	EF ED	1	USEPA, 1989	
	EF	Exposure frequency	days/year	EDsrmt	350	USEPA, 1991	
	ED	Exposure duration - local angler	years	BW	30	USEPA, 1989	
	ED	Exposure duration - Mohawk	years	ATc	70	USEPA, 1989	
	BW	Body weight	kg	ATnc	70	USEPA, 1989	
	AT	Averaging time (Carcinogenic)	days	ATncsrmt	25,550	USEPA, 1989	
	AT	Averaging time (Non-carcinogenic) - local angler	days		10,950	USEPA, 1989	
	AT	Averaging time (Non-carcinogenic) - Mohawk	days		25,550	USEPA, 1989	

Sources:

USEPA, 1989. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part A).

USEPA, 1991. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals).

Connelly et al. 1992. Effects of health advisory and health advisory changes on fishing habits and fish consumption in New York State sport fisheries (RME is the 90th percentile fish ingestion rate)

(RME is the 90th percentile fish ingestion rate)

NYSDOH. 1995. Forti, A., Bogdan, K.G., and E. Horn. Health Risk Assessment for the Akwesasne Mohawk Population from Exposure to Chemical Contaminants in Fish and Wildlife. NYSDOH Center for Environmental Health, Bureau of Toxic Substances Assessment. Albany, New York 1995.

(a) Assumes that 50% of fish consumed are from the Grasse River (see text).

(b) National median time at one residence.

TABLE A2

VALUES USED FOR DAILY INTAKE CALCULATIONS

GRASSE RIVER STUDY AREA, MASSENA, NY

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Sediment
Receptor Population: Recreational User
Receptor Age: Adult, Youth, Child

Exposure Route	Parameter Code	Parameter Definition	Units	Parameter Code	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in sediment	mg/kg	CS		See Table 3.4	Intake = CS*IR*CF*FI*EF*ED/BW*AT
	IR	Ingestion rate - adult	mg/day	IRa	50	USEPA, 1997	
		Ingestion rate - youth		IRy	100		
		Ingestion rate - child		IRc	100		
		Ingestion rate - Mohawk		IRsrmt	50		
	CF	Conversion factor	kg/mg	CF	1.00E-06	USEPA, 1989	
	FI	Fraction ingested from contaminated source	unitless	FI	1	USEPA, 1989	
	EF	Exposure frequency - adult	days/year	EFa	13	(a)	
		Exposure frequency - youth		EFy	39		
		Exposure frequency - child		EFc	13		
		Exposure frequency - Mohawk		EFsrmt	65		
	ED	Exposure duration - adult	years	EDa	12	(b)	
		Exposure duration - youth		EDy	12		
		Exposure duration - child		EDc	6		
		Exposure duration - Mohawk		EDsrmt	64		
	BW	Body weight - adult	kg	BWa	70	USEPA, 1989	
		Body weight - youth		BWy	47		
		Body weight - child		BWc	15		
		Body weight - Mohawk		BWsrmt	70		
	AT	Averaging time (Carcinogenic)	days	ATc	25,550	USEPA, 1989	
		Averaging time (Non-carcinogenic) - adult		ATnca	4380	USEPA, 1989	
		Averaging time (Non-carcinogenic) - youth		ATncy	4380		
		Averaging time (Non-carcinogenic) - child		ATncc	2190		
		Averaging time (Non-carcinogenic) - Mohawk		ATncsrmt	23360		
Dermal	CS	Chemical concentration in sediment	mg/kg	CS		See Table 3.4	Absorbed Dose = CS*CF*SA*AF*ABS*EF*ED/BW*AT
	CF	Conversion factor	kg/mg cm2	CF	10-6	USEPA, 1989	
	SA	Skin surface area available for contact - adult		SAa	6,073	USEPA (1997)	
		Skin surface area available for contact - youth		SAy	4283		
		Skin surface area available for contact - child		SAc	2792		
		Skin surface area available for contact - Mohawk	mg/cm2	SAsrmt	3120		
	AF	Soil to skin adherence factor - adult		AFa	0.3	USEPA, 1998	
		Soil to skin adherence factor - youth		AFy	0.25		
		Soil to skin adherence factor - child		AFc	0.2		
		Soil to skin adherence factor - Mohawk	unitless	AFsrmt	0.3		
	ABS	Absorption factor		ABS	chem spec	USEPA, 1998	

Sources:

USEPA, 1989. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part A).

USEPA, 1997. Exposure Factors Handbook

USEPA, 1998. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance, Dermal Risk Assessment Interim Guidance.

(a) Assumes exposure for one day per week for 13 weeks.

(b) 90th percentile for time spent at a single residence (RAGS Part A, USEPA, 1989) minus 6 childhood years and 12 youth years.

TABLE A3

VALUES USED FOR DAILY INTAKE CALCULATIONS

GRASSE RIVER STUDY AREA, MASSENA, NY

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Surface Water
Exposure Point: Surface Water
Receptor Population: Recreational User
Receptor Age: Adult, Youth, Child

Exposure Route	Parameter Code	Parameter Definition	Units	Parameter Code	RME Value	RME Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CS	Chemical concentration in sediment	mg/kg	CS CRa		See Table 3.4	Intake = CS*IR*CF*FI*EF*ED/BW*AT
	CR	Contact rate - adult	liter/hour	CRy	0.05	USEPA, 1997	
		Contact rate - youth		CRc	0.05		
		Contact rate - child		CRsrmt	0.05		
		Contact rate - Mohawk		ETa	0.05		
	ET	Exposure Time - adult	hours/event	ETy	2		
		Exposure Time - youth		ETc	2		
		Exposure Time - child		ETsrmt	2		
		Exposure Time - Mohawk		ETw	2		
		Exposure Time - wading		EFa	1		
	EF	Exposure frequency - adult	days/year	EFy	13	(a)	
		Exposure frequency - youth		EFc	39		
		Exposure frequency - child		EFsrmt	13		
		Exposure frequency - Mohawk		EDa	65		
	ED	Exposure duration - adult	years	EDy	12	(b)	
		Exposure duration - youth		EDc	12		
		Exposure duration - child		EDsrmt	6		
		Exposure duration - Mohawk		BWa	64		
	BW	Body weight - adult	kg	BWy	70	USEPA, 1989	
		Body weight - youth		BWc	47		
		Body weight - child		BWsrmt	15		
		Body weight - Mohawk		ATc	70		
	AT	Averaging time (Carcinogenic)	days	ATnca	25,550	USEPA, 1989	
		Averaging time (Non-carcinogenic) - adult		ATncy	4380	USEPA, 1989	
		Averaging time (Non-carcinogenic) - youth		ATncc	4380		
		Averaging time (Non-carcinogenic) - child		ATncsrmt	2190		
		Averaging time (Non-carcinogenic) - Mohawk			23360		
Dermal	CS	Chemical concentration in sediment	mg/kg	CS		See Table 3.4	Absorbed Dose = CS*CF*SA*AF*ABS*EF*ED/BW*AT
	CF	Conversion factor	1 liter/1000 cm3	CF	1.00E-03	USEPA, 1989	
	SA	Skin surface area - swimming adult	cm2	SAa	20,000	USEPA (1997)	
		Skin surface area - swimming youth		SAy	13500		
		Skin surface area - swimming child		SAc	6640		
		Skin surface area - swimming Mohawk		SAsrmt	20000		
		Skin surface area - wading adult Skin		SAwa	6073		
		surface area - wading youth Skin		SAwy	4283		
		surface area - wading child Dermal		SAwc	2792 chem		
	PC	Permeability Constant	cm/hour	PC	spec	USEPA, 1998	

Sources:

USEPA, 1989. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part A).

USEPA, 1997. Exposure Factors Handbook

USEPA, 1998. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance, Dermal Risk Assessment Interim Guidance.

(a) Assumes exposure for one day per week for 13 weeks.

(b) 90th percentile for time spent at a single residence (RAGS Part A, USEPA, 1989) minus 6 childhood years and 12 youth years.

(c) CT value is 50% of RME.

TABLE A4

CONCENTRATIONS OF POLYCHLORINATED DIBENZODIOXINS AND POLYCHLORINATED DIBENZOFURANS IN HISTORICAL FISH TISSUE FROM REACHES 4 THROUGH 8

		RSI PCDD/PCDF Biota Sample Results (picograms/gram (pg/g))						RSI Phase II PCDD/PCDF Concentrations ng/kg in Brown Bullhead Fillets From Upper Stretch				RSI Phase II PCDD/PCDF Concentrations ng/kg in Smallmouth Bass Fillets From Upper Stretch			
Compound	# detects	Smallmouth Bass R4-XF-S10-D-S	Brown Bullhead R4-XF-S50-C-S	Rock Bass R4-XF-S51-C-S	Pumpkin Seed R4-XF-S52-C-S	Pumpkinseed Sunfish R6-XF-S40-C-S	Rock Bass R6-XF-S41-C-S	FS-220	FS-222	FS-224	FS-226	FS-230	FS-232	FS-233	FS-236
2,3,7,8-TCDD	1		9.1												
12,,3,7,8-PeCDD	0														
1,2,3,4,7,8-HxCDD	0														
1,2,3,6,7,8-HxCDD	0														
1,2,3,7,8,9-HxCDD	0														
1,2,3,4,6,7,8-HPCDD	4		19.9	16.9	5				50						
OCDD	3	986							620			620			
2,3,7,8-TCDF	6		28.3	29.3	3.4	5.7							2.3	1.6	
1,2,3,7,8-PeCDF	2	120	18.6												
2,3,4,7,8-PeCDF	3		8.4	13		2									
1,2,3,4,7,8-HXCDF	2		17.6	16.9											
1,2,3,6,7,8-HXCDF	1		12.6												
1,2,3,7,8,9-HxCDF	0														
2,3,4,6,7,8-HXCDF	2		6.9	9.4											
1,2,3,4,6,7,8-HPCDF	4		20.6	23.1		1.1			17						
1,2,3,4,7,8,9-HPCDF	0														
OCDF	6	595	13.3	8.7		4	2.2		97						

Source: Ecology and the Environment. 1992. Grasse River - River and Sediment Investigation, prepared for Aluminum Company of America, Massena, NY. February 1992. And BBL. 1994. River and Sediment Investigation (RSI) Phase II Report, Volume I Grasse River Study Area Massena, New York. December 1994

TABLE A5

DIOXIN TOXIC EQUIVALENT CONCENTRATIONS HISTORICAL FISH DATA FROM REACHES 4 THROUGH 8

		RSI PCDD/PCDF Biota Sample Results (picograms/gram (pg/g))						RSI Phase II PCDD/PCDF Concentrations ng/kg in Brown Bullhead Fillets From Upper Stretch				RSI Phase II PCDD/PCDF Concentrations ng/kg in Smallmouth Bass Fillets From Upper Stretch			
TEQ Values	TEF	Smallmouth Bass R4-XF-S10-D-S	Brown Bullhead R4-XF-S50-C-S	Rock Bass R4-XF-S51-C-S	Pumpkin Seed R4-XF-S52-C-S	Pumpkinseed Sunfish R6-XF-S40-C-S	Rock Bass R6-XF-S41-C-S	FS-220	FS-222	FS-224	FS-226	FS-230	FS-232	FS-233	FS-236
2,3,7,8-TCDD	1	0	9.1	0	0	0	0	0	0	0	0	0	0	0	0
12,,3,7,8-PeCDD		0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,2,3,4,7,8-HxCDD		0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,2,3,6,7,8-HxCDD		0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,2,3,7,8,9-HxCDD		0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,2,3,4,6,7,8-HPCDD	0.01	0	0.199	0.169	0.05	0	0	0	0.5	0	0	0	0	0	0
OCDD	0.0003	0.2958	0	0	0	0	0	0	0.186	0	0	0.186	0	0	0
2,3,7,8-TCDF	0.1	0	2.83	2.93	0.34	0.57	0	0	0	0	0	0	0.23	0.16	0
1,2,3,7,8-PeCDF	0.03	3.6	0.558	0	0	0	0	0	0	0	0	0	0	0	0
2,3,4,7,8-PeCDF	0.3	0	2.52	3.9	0	0.6	0	0	0	0	0	0	0	0	0
1,2,3,4,7,8-HXCDF	0.1	0	1.76	1.69	0	0	0	0	0	0	0	0	0	0	0
1,2,3,6,7,8-HXCDF	0.1	0	1.26	0	0	0	0	0	0	0	0	0	0	0	0
1,2,3,7,8,9-HxCDF		0	0	0	0	0	0	0	0	0	0	0	0	0	0
2,3,4,6,7,8-HXCDF	0.1	0	0.69	0.94	0	0	0	0	0	0	0	0	0	0	0
1,2,3,4,6,7,8-HPCDF	0.01	0	0.206	0.231	0	0.011	0	0	0.17	0	0	0	0	0	0
1,2,3,4,7,8,9-HPCDF		0	0	0	0	0	0	0	0	0	0	0	0	0	0
OCDF	0.0003	0.1785	0.00399	0.00261	0	0.0012	0.00066	0	0.0291	0	0	0	0	0	0
Sum of TEQ		4.0743	19.12699	9.86261	0.39	1.1822	0.00066	0	0.8851	0	0	0.186	0.23	0.16	0

Source: Ecology and the Environment. 1992. Grasse River - River and Sediment Investigation, prepared for Aluminum Company of America, Massena, NY. February 1992. And BBL. 1994. River and Sediment Investigation (RSI) Phase II Report, Volume I Grasse River Study Area Massena, New York. December 1994.

TABLE A6

PROUCL OUTPUT WITH CALCULATED 95% UCL

		General UCL Statistics for Data Sets with Non-Detects			
User Selected Options					
From File	P:\Projects\Alcoa\Grasse_River\Data Analysis\ProUCL 4.1\Input_Data\TEF dioxin congener data.3.xls.wst				
Full Precision	OFF				
Confidence Coefficient		95%			
Number of Bootstrap Operations		2000			
TEQ_DLeq0					
General Statistics					
Number of Valid Data			14	Number of Detected Data	10
Number of Distinct Detected Data			10	Number of Non-Detect Data	4
				Percent Non-Detects	28.57%
Raw Statistics				Log-transformed Statistics	
Minimum Detected			6.60E-04	Log Statistics Not Avaliable	
Maximum Detected			10.03		
Mean of Detected			2.7		
Mean of Detected			2.7		
Mean of Detected			2.7		
Maximum Non-Detect			0		
UCL Statistics					
Normal Distribution Test with Detected Values Only				Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic			0.683	Not Available	
5% Shapiro Wilk Critical Value			0.842		
Data not Normal at 5% Significance Level					
Assuming Normal Distribution				Assuming Lognormal Distribution	
DL/2 Substitution Method				DL/2 Substitution Method	N/A
Mean			1.929		
SD			3.561		
95% DL/2 (t) UCL			3.614		
Maximum Likelihood Estimate(MLE) Method				Log ROS Method	N/A
Mean			1.038		
SD			4.346		
95% MLE (t) UCL			3.095		
95% MLE (Tiku) UCL			3.164		
Gamma Distribution Test with Detected Values Only				Data Distribution Test with Detected Values Only	
Gamma Statistics Not Available				Data appear Gamma Distributed at 5% Significance Level	
Potential UCLs to Use				Nonparametric Statistics	
95% KM (Percentile Bootstrap) UCL			3.461	Kaplan-Meier (KM) Method	
				Mean	1.929
				SD	3.431
				SE of Mean	0.967
				95% KM (t) UCL	3.641
				95% KM (z) UCL	3.519
				95% KM (jackknife) UCL	3.583
				95% KM (bootstrap t) UCL	6.646
				95% KM (BCA) UCL	3.72
				95% KM (Percentile Bootstrap) UCL	3.461
				95% KM (Chebyshev) UCL	6.142
				97.5% KM (Chebyshev) UCL	7.966
				99% KM (Chebyshev) UCL	11.55
Note: DL/2 is not a recommended method.					
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.					
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).					
For additional insight, the user may want to consult a statistician.					

Attachment B

Summary of Carcinogenic/Non-Carcinogenic non-PCB Risk/Hazards Estimated for the Grasse River Study Area

SUMMARY OF CARCINOGENIC NON-PCB RISK

Scenario	Receptor	Total Lifetime Cancer Risk	Table Number (9)
FISH INGESTION			
Reaches 1&2	Local Fishermen	(1)	B1
Reach 3	Local Fishermen	(1)	B2
Reach 4 through 8	Local Fishermen	1E-04 (4)	B3
Reaches 7&8	Mohawk Angler	(1)	B4
SEDIMENT			
Reaches 1&2	Recreational User – Adult (2)	3E-07	B9
	Recreational User – Youth (2)	2E-06	B10
	Recreational User – Child (2)	3E-06	B11
	Sum	5E-06	
Reach 4 through 8	Recreational User – Adult (2)	2E-06	B12
	Recreational User – Youth (2)	1E-05	B13
	Recreational User – Child (2)	1E-05	B14
	Sum	3E-05	
Reach 9	Recreational User – Adult (2)	5E-08	B15
	Recreational User – Youth (2)	3E-07	B16
	Recreational User – Child (2)	3E-07	B17
	Sum	6E-07	
Reach 7&8	Mohawk Angler (2)	5E-06	B18
SURFACE WATER			
Reaches 1&2 (swimming)	Recreational User – Adult (2)	(1)	B29
	Recreational User – Youth (2)	(1)	B30
	Recreational User – Child (2)	(1)	B31
Reach 4 through 8 (swimming)	Recreational User – Adult (2)	4E-08	B32
	Recreational User – Youth (2)	2E-07	B33
	Recreational User – Child (2)	9E-08	B34
	Sum	3E-07	
Reach 9 (wading)	Recreational User – Adult (3)	(1)	B41
	Recreational User – Youth (3)	(1)	B42
	Recreational User – Child (3)	(1)	B43
SEDIMENT AND SURFACE WATER (5)			
Reach 4 through 8 (swimming)	Recreational User – Adult (2)	2E-06	NA
	Recreational User – Youth (2)	1E-05	NA
	Recreational User – Child (2)	1E-05	NA
	Sum	3E-05	

(1) No non-PCB carcinogens
(2) Includes both incidental ingestion and dermal pathways
(3) Wading scenario includes dermal exposure only
(4) Used Dioxin TEQ, as described in text for EPC
(5) Cumulative risk were calculated by summing risk posed by exposure to sediment with those posed by exposure to surface water
(6) Includes both incidental ingestion and dermal pathways
(7) Wading scenario includes dermal exposure only
(8) Cumulative hazards were calculated by summing risk posed by exposure to sediment with those posed by exposure to surface water
(9) Indicates table number in spreadsheets included as Attachment B

SUMMARY OF NON-CARCINOGENIC NON-PCB HAZARD

Scenario	Receptor	Non-Cancer Hazard Quotient	Table Number (9)
FISH INGESTION			
Reaches 1&2	Local Fishermen	0.006	B5
Reach 3	Local Fishermen	0.004	B6
Reach 4 through 8	Local Fishermen	3 (10)	B7
Reaches 7&8	Mohawk Angler	0.06	B8
SEDIMENT			
Reaches 1&2	Recreational User – Adult (6)	0.0003	B19
	Recreational User – Youth (6)	0.002	B20
	Recreational User – Child (6)	0.002	B21
Reach 4 through 8	Recreational User – Adult (6)	0.0009	B22
	Recreational User – Youth (6)	0.007	B23
	Recreational User – Child (6)	0.005	B24
Reach 9	Recreational User – Adult (6)	0.001	B25
	Recreational User – Youth (6)	0.009	B26
	Recreational User – Child (6)	0.01	B27
Reach 7&8	Mohawk Angler (6)	0.01	B28
SURFACE WATER			
Reaches 1&2 (swimming)	Recreational User – Adult (6)	0.02	B35
	Recreational User – Youth (6)	0.08	B36
	Recreational User – Child (6)	0.07	B37
Reach 4 through 8 (swimming)	Recreational User – Adult (6)	0.03	B38
	Recreational User – Youth (6)	0.1	B39
	Recreational User – Child (6)	0.09	B40
Reach 9 (wading)	Recreational User – Adult (7)	0.003	B44
	Recreational User – Youth (7)	0.01	B45
	Recreational User – Child (7)	0.007	B46
SEDIMENT AND SURFACE WATER (8)			
Reaches 1&2 (swimming)	Recreational User – Adult (6)	0.02	NA
	Recreational User – Youth (6)	0.08	NA
	Recreational User – Child (6)	0.07	NA
Reach 4 through 8 (swimming)	Recreational User – Adult (6)	0.03	NA
	Recreational User – Youth (6)	0.1	NA
	Recreational User – Child (6)	0.1	NA
Reach 9 (wading)	Recreational User – Adult (7)	0.005	NA
	Recreational User – Youth (7)	0.02	NA
	Recreational User – Child (7)	0.02	NA

(1) No non-PCB carcinogens
(2) Includes both incidental ingestion and dermal pathways
(3) Wading scenario includes dermal exposure only
(4) Used Dioxin TEQ, as described in text for EPC
(5) Cumulative risk were calculated by summing risk posed by exposure to sediment with those posed by exposure to surface water
(6) Includes both incidental ingestion and dermal pathways
(7) Wading scenario includes dermal exposure only
(8) Cumulative hazards were calculated by summing risk posed by exposure to sediment with those posed by exposure to surface water
(9) Indicates table number in spreadsheets included as Attachment B
(10) Hazard quotient calculated with 2,3,7,8-TCDD data.

Table B1
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reaches 1 & 2
Receptor Population:	Local Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Aluminum	1.30E+01	mg/kg	1.30E+01	mg/kg	M	2.5E-03	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Lead	1.00E-01	mg/kg	1.00E-01	mg/kg	M	2.0E-05	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
										Total Risk	NA

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 32 grams/day * 365 days/year * 0.001 kg/g * 30 years) / (70 kg * 365 day/year * 70 years)

Table B2
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reach 3
Receptor Population:	Local Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Diethylphthalate	4.20E+00	mg/kg	4.20E+00	mg/kg	M	8.2E-04	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Aluminum	3.10E+00	mg/kg	3.10E+00	mg/kg	M	6.1E-04	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Lead	5.50E-02	mg/kg	5.50E-02	mg/kg	M	1.1E-05	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
										Total Risk	NA

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 32 grams/day * 365 days/year * 0.001 kg/g * 30 years) / (70 kg * 365 days/year * 70 years)

Table B3
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reaches 4-8
Receptor Population:	Local Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Diethylphthalate	6.79E-01	mg/kg	6.79E-01	mg/kg	M	7.60E+04	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Total - Dioxin TEQ (3)	5.23E-06	mg/kg	5.23E-06	mg/kg	M	8.97E-10	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1.4E-04
	Total - Dioxin TEQ (4)	3.46E-06	mg/kg	3.46E-06	mg/kg	M	5.93E-10	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	9.3E-05
	Aluminum	1.02E+00	mg/kg	1.02E+00	mg/kg	M	2.00E-04	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Cadmium	2.75E-02	mg/kg	2.75E-02	mg/kg	M	5.39E-06	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Lead	6.79E-02	mg/kg	6.79E-02	mg/kg	M	1.33E-05	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
										Total Risk	1.4E-04 (3)

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 32 grams/day * 365 days/year * 0.001 kg/g * 30 years) / (70 kgs * 365 day/year * 70 years)
(3) Dioxin TEQ included 2,3,7,8-TCDD
(4) Dioxin TEQ does not included 2,3,7,8-TCDD

Table B4
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reaches 7 & 8
Receptor Population:	Mohawk Nation Population
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Aluminum	1.45E+00	mg/kg	1.45E+00	mg/kg	M	2.73E-03	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Cadmium	3.00E-02	mg/kg	3.00E-02	mg/kg	M	5.65E-05	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
	Lead	8.32E-02	mg/kg	8.32E-02	mg/kg	M	1.57E-04	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA
										Total Risk	NA

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 142 grams/day * 365 days/year * 0.001 kg/g * 64 years) / (70 kg * 365 day/year * 70 years)

Table B5
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reaches 1 & 2
Receptor Population:	Local Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	(Non-Cancer) (2)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Aluminum	1.30E+01	mg/kg	1.3E+01	mg/kg	M	5.9E-03	(mg/kg-day)	1.00E+00	(mg/kg-day)	NA	NA	6E-03
	Lead	1.00E-01	mg/kg	1.0E-01	mg/kg	M	4.6E-05	(mg/kg-day)	NA	(mg/kg-day)	NA	NA	NA
												Total Hazard	6E-03

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 32 grams/day * 365 days/year * 0.001 kg/g * 30 years)/ (70 kgs * 365 days/year * 30 years).

Table B6
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reach 3
Receptor Population:	Local Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	(Non-Cancer) (2)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Diethylphthalate	4.2E+00	mg/kg	4.2E+00	mg/kg	M	1.9E-03	(mg/kg-day)	8E-01	(mg/kg-day)	NA	NA	2E-03
	Aluminum	3.1E+00	mg/kg	3.1E+00	mg/kg	M	1.4E-03	(mg/kg-day)	1E+00	(mg/kg-day)	NA	NA	1E-03
	Lead	5.5E-02	mg/kg	5.5E-02	mg/kg	M	2.5E-05	(mg/kg-day)	NA	(mg/kg-day)	NA	NA	NA
												Total Risk	4E-03

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 32 grams/day * 365 days/year * 0.001 kg/g * 30 years)/ (70 kgs * 365 day/year * 30 years)

Table B7
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reaches 4-8
Receptor Population:	Local Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Non-Cancer) (3)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Diethylphthalate	6.79E-01	mg/kg	6.79E-01	mg/kg	M	3.1E-04	(mg/kg-day)	8.0E-01	(mg/kg-day)	NA	NA	4E-04
	Dioxin TEQ (3)	5.23E-06	mg/kg	5.23E-06	mg/kg	M	2.4E-09	(mg/kg-day)	7.0E-10	(mg/kg-day)	NA	NA	3E+00
	Dioxin TEQ (4)	3.46E-06	mg/kg	3.46E-06	mg/kg	M	1.6E-09	(mg/kg-day)	7.0E-10	(mg/kg-day)	NA	NA	2E+00
	Aluminum	1.02E+00	mg/kg	1.02E+00	mg/kg	M	4.7E-04	(mg/kg-day)	1E+00	(mg/kg-day)	NA	NA	5E-04
	Cadmium	2.75E-02	mg/kg	2.75E-02	mg/kg	M	1.3E-05	(mg/kg-day)	1E-03	(mg/kg-day)	NA	NA	1E-02
	Lead	6.79E-02	mg/kg	6.79E-02	mg/kg	M	3.1E-05	(mg/kg-day)	NA	(mg/kg-day)	NA	NA	
												Total Hazard	3 (3)

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 32 grams/day * 365 days/year * 0.001 kg/g * 30 years)/ (70 kg * 365 day/year * 30 years)
(3) Dioxin TEQ includes 2,3,7,8-TCDD
(4) Dioxin TEQ does not include 2,3,7,8-TCDD

Table B8
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Fish
Exposure Medium:	Fish
Expsoure Point:	Fish - Reaches 7 & 8
Receptor Population:	Mohawk Nation Population
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Value	EPC Selected Units	EPC Selected For Hazard Calculation (1)	(Non-Cancer) (2)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	Aluminum	1.45E+00	mg/kg	1.45E+00	mg/kg	M	2.9E-03	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	NA	NA	3E-03
	Cadmium	3.00E-02	mg/kg	3.00E-02	mg/kg	M	6.1E-05	(mg/kg-day)	1.0E-03	$(mg/kg\text{-}day)^{-1}$	NA	NA	6E-02
	Lead	8.32E-02	mg/kg	8.32E-02	mg/kg	M	1.7E-04	(mg/kg-day)	NA	$(mg/kg\text{-}day)^{-1}$	NA	NA	NA
												Total Hazard	6E-02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Assumptions: (Concentration * 142 grams/day * 365 days/year * 0.001 kg/g * 64 years)/ (70 kg * 365 days/year * 64 years)

Table B9
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1 - 2
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M	2.63E-10	(mg/kg-day)			
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M	3.80E-11	(mg/kg-day)			
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M	9.46E-11	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	1.9E-13
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	5.50E-11	(mg/kg-day)	4.6E-02	$(mg/kg\text{-}day)^{-1}$	2.5E-12
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	1.45E-09	(mg/kg-day)			
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	3.31E-09	(mg/kg-day)			
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	4.13E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3.0E-09
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	3.66E-09	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	2.7E-08
	Benzo(b)fluoranthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	4.49E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3.3E-09
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	2.79E-09	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	3.31E-09	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	4.6E-11
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	3.95E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	2.9E-11
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	2.14E-09	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1.6E-08
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	4.75E-09	(mg/kg-day)			
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	2.36E-09	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	3.45E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2.5E-09
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	4.80E-09	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	5.54E-09	(mg/kg-day)			
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	1.68E-15	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	2.6E-10
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.70E-06	mg/kg (wet)	M					
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M					
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M					
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	1.88E-09	(mg/kg-day)			
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M	1.64E-05	(mg/kg-day)			
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	2.97E-09	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	4.4E-09
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M	5.80E-08	(mg/kg-day)			
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M	2.04E-08	(mg/kg-day)			
	Fluoride Total	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M	8.16E-07	(mg/kg-day)			
										Total Risk From Ingestion Pathway	5.6E-08

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 50 mg/kg * 0.000001 mg/kg * 13 days/year * 12 years) / (70 kgs * 365 days/year * 70 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
Dioxin TEF			3.85E-07

Table B9
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1 - 2
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Dermal Absorption Factor	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Dermal	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M						
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M						
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M						
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M						
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	0.13	6.86E-09	(mg/kg-day)			
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	0.13	1.57E-08	(mg/kg-day)			
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	0.13	1.96E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1.4E-08
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	0.13	1.74E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1.3E-07
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	0.13	2.13E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1.6E-08
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	0.13	1.32E-08	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	0.1	1.21E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1.7E-10
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	0.13	1.87E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	1.4E-10
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	0.13	1.01E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	7.4E-08
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	0.13	2.25E-08	(mg/kg-day)			
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	0.13	1.12E-08	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	0.13	1.63E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1.2E-08
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	0.13	2.27E-08	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	0.13	2.62E-08	(mg/kg-day)			
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	0.03	1.84E-15	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	2.9E-10
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	5.70E-06	mg/kg	5.70E-06	mg/kg (wet)	M						
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M						
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M						
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	0.1	6.83E-09	(mg/kg-day)			
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M						
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	0.03	3.24E-09	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	4.9E-09
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M						
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M						
	Fluoride Total	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M						
											Total Risk From Dermal Pathway	2.5E-07
											Total Risk From Ingestion and Dermal Pathways	3.0E-07

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 6073 cm2 * 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 12 years) / (70 kgs * 365 days/year * 70 years)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
Dioxin TEF			3.85E-07

Table B10
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1 - 2
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factor	Cancer Risk
Ingestion	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M	2.35E-09	(mg/kg-day)				
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M	3.39E-10	(mg/kg-day)				
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M	8.46E-10	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	3	5.1E-12
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	4.91E-10	(mg/kg-day)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	3	1.4E-11
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	4.91E-10	(mg/kg-day)	3.7E-02	$(mg/kg\text{-}day)^{-1}$	1	1.8E-11
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	1.29E-08	(mg/kg-day)				
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	2.96E-08	(mg/kg-day)				
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	3.69E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	8.1E-08
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	3.27E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	7.2E-07
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	4.01E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	8.8E-08
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	2.49E-08	(mg/kg-day)				
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	2.96E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	4.1E-10
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	3.53E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	7.7E-10
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	1.91E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	4.2E-07
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	4.25E-08	(mg/kg-day)				
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	2.10E-08	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	3.08E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	6.8E-08
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	4.29E-08	(mg/kg-day)				
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	4.95E-08	(mg/kg-day)				
	Dioxin TEQ (3)	3.86E-07	mg/kg	3.85E-07	mg/kg (wet)	M	1.50E-14	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	2.3E-09
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	5.70E-06	mg/kg	5.70E-06	mg/kg (wet)	M						
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M						
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M						
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	1.68E-08	(mg/kg-day)				
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M	1.46E-04	(mg/kg-day)				
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	2.65E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	4.0E-08
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M	5.18E-07	(mg/kg-day)				
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M	1.82E-07	(mg/kg-day)				
	Fluoride Total	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M	7.29E-06	(mg/kg-day)				
											Total Risk from Ingestion Pathway	1.4E-06

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 100 mg/day * 0.000001 kg/mg * 39 days/year * 12 years) / (70 years * 365 days/year * 47 kgs).

(3)Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.70E-06	0.01	5.70E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
TOTAL TEQ			3.86E-07

Table B10
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1 - 2
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor (Unitless)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factor	Cancer Risk
Dermal	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M							
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M							
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M							
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M							
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	0.13	1.80E-08	(mg/kg-day)				
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	0.13	4.12E-08	(mg/kg-day)				
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	0.13	5.14E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.1E-07
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	0.13	4.56E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	1.0E-06
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	0.13	5.59E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.2E-07
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	0.13	3.47E-08	(mg/kg-day)				
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	0.1	3.17E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	4.4E-10
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	0.13	4.91E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	1.1E-09
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	0.13	2.66E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	5.8E-07
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	0.13	5.90E-08	(mg/kg-day)				
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	0.13	2.90E-08	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	0.13	4.29E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	9.4E-08
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	0.13	6.00E-08	(mg/kg-day)				
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	0.13	6.90E-08	(mg/kg-day)				
	Dioxin TEQ (3)	3.85E-07	mg/kg	1.27E+00	mg/kg (wet)	M	0.13	2.09E-14	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	3.3E-09
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M	0.03	3.56E-13	(mg/kg-day)				
	1,2,3,4,6,7,8-HpCDF	5.70E-06	mg/kg	5.70E-06	mg/kg (wet)	M	0.03	7.14E-14	(mg/kg-day)				
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M	0.03	1.77E-12	(mg/kg-day)				
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M	0.03	1.21E-13	(mg/kg-day)				
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	0.1	1.79E-08	(mg/kg-day)				
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M			(mg/kg-day)				
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	0.03	8.51E-09	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	1.3E-08
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M			(mg/kg-day)				
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M			(mg/kg-day)				
	Fluoride Total	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M			(mg/kg-day)				
												Total Risk from Dermal Pathway	1.9E-06
												Total Risk from Ingestion and Dermal Pathway	3.3E-06

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 4283 cm2 * 0.25 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 39 days/year * 12 years) / (70 years * 365 days/year * 47 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.70E-06	0.01	5.70E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
TOTAL TEQ			3.86E-07

Table B11
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1 & 2
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (3)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factor	Cancer Risk
Ingestion	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M	1.23E-09	(mg/kg-day)				
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M	1.77E-10	(mg/kg-day)				
	Methylene Chloride (0 to < 2)	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M	1.47E-10	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	10	2.9E-12
	Methylene Chloride (> 2 to 6)	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M	2.94E-10	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	3	1.8E-12
	Trichloroethylene (0 to < 2)	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	8.55E-11	(mg/kg-day)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	10	7.9E-12
	Trichloroethylene (0 to < 2)	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	8.55E-11	(mg/kg-day)	3.7E-02	$(mg/kg\text{-}day)^{-1}$	1	3.2E-12
	Trichloroethylene (2 to 6)	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	1.71E-10	(mg/kg-day)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	3	4.8E-12
	Trichloroethylene (2 to 6)	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	1.71E-10	(mg/kg-day)	3.7E-02	$(mg/kg\text{-}day)^{-1}$	1	6.3E-12
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	6.76E-09	(mg/kg-day)				
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	1.55E-08	(mg/kg-day)				
	Benzo(A)anthracene (0 to < 2)	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	6.42E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	4.7E-08
	Benzo(A)anthracene (2 to 6)	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	1.28E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	2.8E-08
	Benzo(a)pyrene (0 to < 2)	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	5.70E-09	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	4.2E-07
	Benzo(a)pyrene (2 to 6)	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	1.14E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	2.5E-07
	Benzo(b)fluoroanthene (0 to < 2)	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	6.99E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	5.1E-08
	Benzo(b)fluoroanthene (2 to 6)	1.03E+00	mg/kg	8.40E-01	mg/kg (wet)	M	1.40E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	1.0E-07
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	1.30E-08	(mg/kg-day)				
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	1.54E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	2.2E-10
	Chrysene (0 to 2)	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	6.14E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	10	4.5E-10
	Chrysene (2 to 6)	9.05E-01	mg/kg	8.40E-01	mg/kg (wet)	M	6.14E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	1.3E-10
	Dibenzo(a,h)anthracene (0 to < 2)	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	6.65E-09	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	4.9E-07
	Dibenzo(a,h)anthracene (2 to 6)	4.90E-01	mg/kg	8.40E-01	mg/kg (wet)	M	3.32E-09	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	7.3E-08
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	1.48E-08	(mg/kg-day)				
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	1.10E-08	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene (0 to < 2)	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	5.37E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	3.9E-08
	Indeno(1,2,3-cd)pyrene (2 to 6)	7.91E-01	mg/kg	8.40E-01	mg/kg (wet)	M	5.37E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.2E-08
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	1.49E-08	(mg/kg-day)				
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	2.58E-08	(mg/kg-day)				
	Dioxin TEQ (3)	3.86E-07	mg/kg	1.27E+00	mg/kg (wet)	M	7.86E-15	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	1.2E-09
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	5.70E-06	mg/kg	5.70E-06	mg/kg (wet)	M						
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M						
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M						
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	8.75E-09	(mg/kg-day)				
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M	7.63E-05	(mg/kg-day)				
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.38E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	2.1E-08
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M	2.71E-07	(mg/kg-day)				
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M	9.50E-08	(mg/kg-day)				
	Fluoride Total	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M	3.81E-06	(mg/kg-day)				
											Total Risk from Ingestion Pathway	1.5E-06

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 100 mg/day * 0.000001 kg/mg * 13 days/year * 6 years) / (70 years * 365 days/year * 15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.70E-06	0.01	5.70E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.86E-07

Table B11
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1 - 2
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 Years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor (Unitless)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factor	Cancer Risk
Dermal	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M							
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M							
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M							
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M							
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	0.13	3.77E-10	(mg/kg-day)				
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	0.13	8.64E-10	(mg/kg-day)				
	Benzo(A)anthracene (0 to < 2 years)	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	0.13	3.59E-10	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	2.6E-09
	Benzo(A)anthracene (2 to 6 years)	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	0.13	7.17E-10	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.6E-09
	Benzo(a)pyrene (0 to < 2 years)	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	0.13	3.18E-10	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	2.3E-08
	Benzo(a)pyrene (2 to 6 years)	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	0.13	6.36E-10	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	1.4E-08
	Benzo(b)fluoroanthene (0 to < 2 years)	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	0.13	3.90E-10	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	2.8E-09
	Benzo(b)fluoroanthene (2 to 6 years)	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	0.13	7.80E-10	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.7E-09
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	0.13	7.27E-10	(mg/kg-day)				
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	0.1	6.64E-10	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	9.3E-12
	Chrysene (0 to < 2 years)	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	0.13	3.43E-10	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	10	2.5E-11
	Chrysene (2 to 6 years)	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	0.13	6.86E-10	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	1.5E-11
	Dibenzo(a,h)anthracene (0 to < 2 years)	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	0.13	1.86E-10	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	1.4E-08
	Dibenzo(a,h)anthracene (2 to 6 years)	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	0.13	3.71E-10	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	8.1E-09
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	0.13	1.24E-09	(mg/kg-day)				
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	0.13	6.14E-10	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene (0 to < 2 years)	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	0.13	3.00E-10	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	2.2E-09
	Indeno(1,2,3-cd)pyrene (2 to 6 years)	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	0.13	5.99E-10	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.3E-09
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	0.13	1.25E-09	(mg/kg-day)				
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	0.13	1.44E-09	(mg/kg-day)				
	Dioxin TEQ (3)	3.86E-07	mg/kg	3.85E-07	mg/kg (wet)	M	0.03	1.01E-16	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	1.6E-11
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M	0.03		(mg/kg-day)				
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.60E-06	mg/kg (wet)	M	0.03		(mg/kg-day)				
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M	0.03		(mg/kg-day)				
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M	0.03		(mg/kg-day)				
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	0.1	3.76E-10	(mg/kg-day)				
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M							
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	0.03	2.32E-09	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	3.5E-09
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M							
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M							
	Fluoride (Tota)	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M							
											Total Risk from Dermal Pathway		7.5E-08
											Total Risk from Ingestion and Dermal Pathway		2E-06

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 2792 cm2 * 0.2 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 6 years) / (70 years * 365 days/year * 15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.70E-06	0.01	5.70E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.86E-07

Table B12
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M	3.7E-10	(mg/kg-day)			
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M	6.4E-11	(mg/kg-day)			
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M	6.0E-11	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	1.2E-13
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	6.9E-09	(mg/kg-day)			
	Benzo(A)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	3.1E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2.3E-08
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	1.4E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1.1E-07
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	3.9E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2.8E-08
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	1.0E-08	(mg/kg-day)			
	Benzo(k)fluoroanthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	1.1E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	7.8E-09
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	7.9E-09	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1.1E-10
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	4.4E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3.2E-10
	Di-N-butylphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	9.1E-09	(mg/kg-day)			
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	6.6E-09	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	4.8E-08
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	4.5E-08	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	9.3E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	6.8E-09
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	1.5E-08	(mg/kg-day)			
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	4.4E-08	(mg/kg-day)			
	Dioxin TEQ (3)	4.54E-04	mg/kg	4.54E-04	mg/kg (wet)	M	2.0E-12	(mg/kg-day)	1.6E+05	(mg/kg-day)	3.1E-07
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M					
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M					
	1,2,3,4,7,8-HXCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M					
	1,2,3,6,7,8-HXCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M					
	1,2,3,7,8,9-HXCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M					
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M					
	2,3,4,6,7,8-HXCDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M					
	2,3,4,7,8-PECDF	6.30E-04	mg/kg	6.30E-04	mg/kg (wet)	M					
	2,3,7,8-TCDF	5.25E-04	mg/kg	5.25E-04	mg/kg (wet)	M					
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M					
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M					
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M	4.7E-05	(mg/kg-day)			
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	9.5E-09	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1.4E-08
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	3.0E-09	(mg/kg-day)			
	Fluoride (Tota)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M	2.0E-06	(mg/kg-day)			
								Total Risk from Ingestion Pathway			5.4E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 50 mg/day * 0.000001 kg/mg * 13 days/year * 12 years) / (70 kgs * 365 days/year * 70 years)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HXCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HXCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HXCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-HXCDF	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.30E-04	0.3	1.89E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	Dioxin TEQ		4.54E-04

Table B12
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor (Unitless)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Dermal	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M						
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M						
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M						
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	0.13	3.26E-08				
	Benzo(A)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	0.13	1.48E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1.1E-07
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	0.13	6.86E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	5.0E-07
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	0.13	1.84E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1.3E-07
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	0.13	4.79E-08				
	Benzo(k)fluoroanthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	0.13	5.08E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3.7E-08
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	0.1	2.88E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	4.0E-10
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	0.13	2.11E-07	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	1.5E-09
	Di-N-butylphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M						
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	0.13	3.12E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	2.3E-07
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	0.13	2.13E-07	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	0.13	4.42E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3.2E-08
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M						
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M						
	Dioxin TEQ (3)	4.54E-04	mg/kg	4.54E-04	mg/kg (wet)	M	0.03	2.16E-12	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	3.4E-07
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M						
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M						
	1,2,3,4,7,8-HXCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M						
	1,2,3,6,7,8-HXCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M						
	1,2,3,7,8,9-HXCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M						
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M						
	2,3,4,6,7,8-HXCDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M						
	2,3,4,7,8-PECDF	6.30E-04	mg/kg	6.30E-04	mg/kg (wet)	M						
	2,3,7,8-TCDF	5.25E-04	mg/kg	5.25E-04	mg/kg (wet)	M						
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M						
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M						
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M						
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	0.03	1.03E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1.6E-08
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M						
	Fluoride (Tota)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M						
									Total Risk from Dermal Pathway			1.4E-06
									Total Risk from Ingestion and Dermal Pathway			1.94E-06

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 6073 cm2 * 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 12 years) / (70 kgs * 365 days/year * 70 years)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HXCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HXCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HXCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-HXCDF	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.30E-04	0.3	1.89E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	Dioxin TEQ		4.54E-04

Table B13
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
Ingestion	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M	3.27E-09	(mg/kg-day)				
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M	5.73E-10	(mg/kg-day)				
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M	5.38E-10	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	1	1.1E-12
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	6.16E-08	(mg/kg-day)				
	Benzo(A)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	2.79E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	6.1E-07
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	1.29E-07	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	2.8E-06
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	3.48E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	7.6E-07
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	9.04E-08	(mg/kg-day)				
	Benzo(k)fluoroanthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	9.59E-08	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	3	2.1E-08
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	7.05E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	9.9E-10
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	3.98E-07	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	8.7E-09
	Di-N-butylphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	8.15E-08	(mg/kg-day)				
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	5.88E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	1.3E-06
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	4.01E-07	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	8.34E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.8E-07
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	1.31E-07	(mg/kg-day)				
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	3.94E-07	(mg/kg-day)				
	Dioxin TEQ (3)	4.54E-04	mg/kg	4.54E-04	mg/kg (wet)	M	1.77E-11	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	2.8E-06
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M						
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M						
	1,2,3,4,7,8-HXCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M						
	1,2,3,6,7,8-HXCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M						
	1,2,3,7,8,9-HXCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M						
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M						
	2,3,4,6,7,8-HXCDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M						
	2,3,4,7,8-PECDF	6.30E-04	mg/kg	6.30E-04	mg/kg (wet)	M						
	2,3,7,8-TCDF	5.25E-04	mg/kg	5.25E-04	mg/kg (wet)	M						
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M						
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M						
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M	4.17E-04	(mg/kg-day)				
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	8.46E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	1.3E-07
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	2.65E-08	(mg/kg-day)				
	Fluoride (Tota)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M	1.75E-05	(mg/kg-day)				
											Total Risk for Ingestion Pathway	9E-06

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (Concentration * 100 mg/day * 0.000001 kg/mg * 39 days/year * 12 years) / (70 kgs * 365 days/year * 47 years)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HXCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HXCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HXCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-HXCDF	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.30E-04	0.3	1.89E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	Dioxin TEQ		4.54E-04

Table B13
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor (Unitless))	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
Dermal	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M							
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M							
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M							
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	0.13	8.57E-08	(mg/kg-day)				
	Benzo(A)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	0.13	3.89E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	8.5E-07
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	0.13	1.80E-07	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	3.9E-06
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	0.13	4.84E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.1E-06
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	0.13	1.26E-07	(mg/kg-day)				
	Benzo(k)fluoroanthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	0.13	1.33E-07	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	3	2.9E-08
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	0.1	7.55E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	1.1E-09
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	0.13	5.53E-07	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	1.2E-08
	Di-N-butylphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	0.13	1.13E-07	(mg/kg-day)				
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	0.13	8.19E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	1.8E-06
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	0.13	5.59E-07	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	0.13	1.16E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	2.5E-07
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	0.13	1.83E-07	(mg/kg-day)				
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	0.13	5.48E-07	(mg/kg-day)				
	Dioxin TEQ (3)	4.54E-04	mg/kg	4.54E-04	mg/kg (wet)	M	0.03	5.68E-12	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	8.9E-07
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M							
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M							
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M							
	1,2,3,4,7,8-HXCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M							
	1,2,3,6,7,8-HXCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M							
	1,2,3,7,8,9-HXCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M							
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M							
	2,3,4,6,7,8-HXCDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M							
	2,3,4,7,8-PECDF	6.30E-04	mg/kg	6.30E-04	mg/kg (wet)	M							
	2,3,7,8-TCDF	5.25E-04	mg/kg	5.25E-04	mg/kg (wet)	M							
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M							
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M							
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M							
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	0.03	2.72E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	4.1E-08
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M							
	Fluoride (Total)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M							
											Total Risk for Ingesiton Pathway		9E-06
											Total Risk from Ingestion and Dermal Pathways		2E-05

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (4283 cm2* 0.25 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 39 days/year * 12 years) / (70 yearss * 365 days/year * 47 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HXCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HXCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HXCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-HXCDF	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.30E-04	0.3	1.89E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
			4.54E-04

Table B14
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
ingestion	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M	1.71E-09	(mg/kg-day)				
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M	2.99E-10	(mg/kg-day)				
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M	2.81E-10	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	1	5.6E-13
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	3.22E-08	(mg/kg-day)				
	Benzo(A)anthracene (0 to 2 years)	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	4.86E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	3.6E-07
	Benzo(A)anthracene (> 2 to 6 years)	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	9.73E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	2.1E-07
	Benzo(a)pyrene (0 to 2 years)	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	2.25E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	1.6E-06
	Benzo(a)pyrene (2 to 6 years)	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	4.50E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	9.9E-07
	Benzo(b)fluoroanthene (0 to 2 years)	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	6.05E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	4.4E-07
	Benzo(b)fluoroanthene (2 to 6 years)	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	1.21E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	2.7E-07
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	4.72E-08	(mg/kg-day)				
	Benzo(k)fluoroanthene (0 to 2 years)	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	1.67E-08	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	10	1.2E-08
	Benzo(k)fluoroanthene (2 to 6 years)	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	3.34E-08	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	3	7.3E-09
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	3.68E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	5.2E-10
	Chrysene (0 to 2 years)	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	6.92E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	10	5.1E-09
	Chrysene (2 to 6 years)	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	1.38E-07	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	3.0E-09
	Di-N-butylphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	4.25E-08	(mg/kg-day)				
	Dibenzo(a,h)anthracene (0 to < 2)	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	1.02E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	7.5E-07
	Dibenzo(a,h)anthracene (> 2 to 6)	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	2.05E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	4.5E-07
	Fluoroanthene (0 to < 2)	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	6.99E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	5.1E-06
	Fluoroanthene (> 2 to 6)	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	1.40E-07	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	3.1E-06
	Indeno(1,2,3-cd)pyrene (0 to 2 years)	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	1.45E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	1.1E-07
	Indeno(1,2,3-cd)pyrene (2 to 6 years)	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	2.90E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	6.4E-08
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	6.86E-08	(mg/kg-day)				
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	2.06E-07	(mg/kg-day)				
	Dioxin TEQ (3)	4.54E-04	mg/kg	4.54E-04	mg/kg (wet)	M	9.24E-12	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	1.4E-06
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M						
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M						
	1,2,3,4,7,8-HXCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M						
	1,2,3,6,7,8-HXCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M						
	1,2,3,7,8,9-HXCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M						
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M						
	2,3,4,6,7,8-HXCDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M						
	2,3,4,7,8-PECDF	6.30E-04	mg/kg	6.30E-04	mg/kg (wet)	M						
	2,3,7,8-TCDF	5.25E-04	mg/kg	5.25E-04	mg/kg (wet)	M						
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M						
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M						
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M	2.18E-04	(mg/kg-day)				
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	4.42E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	6.6E-08
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.38E-08	(mg/kg-day)				
	Fluoride (Tota)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M	9.14E-06	(mg/kg-day)				
											Total Risk for Ingestion Pathway	1.5E-05

(1) Specify Medium-Specific (M) or Route-Specific * EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day * 0.000001 kg/mg * 13 days/year *6 years) / (70 years * 365 days/year * 15 years)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HXCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HXCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HXCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-HXCDF	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.30E-04	0.3	1.89E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	Dioxin TEQ		4.54E-04

Table B14
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorptiobn Factor Unitless	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
Dermal	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M							
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M							
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M							
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	0.13	2.33E-08	(mg/kg-day)				
	Benzo(A)anthracene (0 to 2 years)	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	0.13	3.53E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	2.6E-07
	Benzo(A)anthracene (2 to 6 years)	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	0.13	7.06E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.5E-07
	Benzo(a)pyrene (0 to 2 years)	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	0.13	1.64E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	1.2E-06
	Benzo(a)pyrene (2 to 6 years)	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	0.13	3.27E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	7.2E-07
	Benzo(b)fluoroanthene (0 to 2 years)	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	0.13	4.39E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	3.2E-07
	Benzo(b)fluoroanthene (2 to 6 years)	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	0.13	8.79E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.9E-07
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	0.13	7.91E-09	(mg/kg-day)				
	Benzo(k)fluoroanthene (0 to 2 years)	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	0.13	1.21E-08	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	10	8.8E-09
	Benzo(k)fluoroanthene (2 to 6 years)	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	0.13	2.42E-08	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	3	5.3E-09
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	0.1	2.06E-08	(mg/kg-day)	1.4E-02	$(mg/kg\text{-}day)^{-1}$	1	2.9E-10
	Chrysene (0 to 2 years)	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	0.13	5.02E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	10	3.7E-09
	Chrysene (2 to 6 years)	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	0.13	1.00E-07	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	2.2E-09
	Di-N-butylphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	0.13	3.09E-08	(mg/kg-day)				
	Dibenzo(a,h)anthracene (0 to 2 years)	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	0.13	7.44E-09	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	10	5.4E-07
	Dibenzo(a,h)anthracene (2 to 6 years)	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	0.13	1.49E-08	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3	3.3E-07
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	0.13	1.52E-07	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene (0 to 2 years)	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	0.13	1.05E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	7.7E-08
	Indeno(1,2,3-cd)pyrene (2 to 6 years)	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	0.13	2.11E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	4.6E-08
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	0.13	3.32E-08	(mg/kg-day)				
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	0.13	1.49E-07	(mg/kg-day)				
	Dioxin TEQ (3)	4.54E-04	mg/kg	4.54E-04	mg/kg (wet)	M	0.03	1.55E-12	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	2.4E-07
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M							
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M							
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M							
	1,2,3,4,7,8-HXCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M							
	1,2,3,6,7,8-HXCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M							
	1,2,3,7,8,9-HXCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M							
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M							
	2,3,4,6,7,8-HXCDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M							
	2,3,4,7,8-PECDF	6.30E-04	mg/kg	6.30E-04	mg/kg (wet)	M							
	2,3,7,8-TCDF	5.25E-04	mg/kg	5.25E-04	mg/kg (wet)	M							
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M							
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M							
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M							
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	0.03	7.40E-09	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	1.1E-08
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M							
	Fluoride (Tota)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M							
											Total Risk for Ingestion Pathway		4.1E-06
											Total Risk for Ingestion and Dermal Pathways		2E-05

(1) Specify Medium-Specific (M) or Route-Specific ® EPC selected for risk calculation.
(2) Exposure Factors: (2792 cm2* 0.2 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 6 years) / (70 years * 365 days/year * 15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HXCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HXCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HXCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-HXCDF	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.30E-04	0.3	1.89E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	Dioxin TEQ		4.54E-04

Table B15
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M	5.32E-10	(mg/kg-day)			
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M	4.67E-11	(mg/kg-day)			
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M	5.36E-11	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	1.1E-13
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	9.99E-11	(mg/kg-day)	4.6E-02	$(mg/kg\text{-}day)^{-1}$	4.6E-12
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	2.78E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2.0E-09
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	1.58E-09	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	1.99E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	1.5E-11
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	1.61E-09	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	1.54E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1.1E-09
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	1.65E-09	(mg/kg-day)			
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	5.89E-16	(mg/kg-day)	1.56E+05	$(mg/kg\text{-}day)^{-1}$	9.2E-11
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M					
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M					
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M	8.72E-05	(mg/kg-day)			
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	1.14E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1.7E-08
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M	8.42E-09	(mg/kg-day)			
	Fluoride (Tota)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M	2.63E-06	(mg/kg-day)			
								Total Risk from Ingestion Pathway			2.0E-08

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day * 0.000001 kg/mg * 13 days/year *12 years) / (70 kgs* 365 days/year * 70 years)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	Dioxin TEQ		1.35E-07

Table B15
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor Unitless	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Dermal	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M						
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M						
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M						
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M						
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	0.13	1.32E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	9.6E-09
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	0.13	7.48E-09	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	0.13	9.44E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	6.9E-11
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	0.13	7.64E-09	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	0.13	7.29E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	5.3E-09
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	0.13	7.83E-09	(mg/kg-day)			
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	0.03	6.44E-16	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1.0E-10
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M						
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M						
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M						
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	0.03	1.24E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1.9E-08
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M						
	Fluoride (Total)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M						
									Total Risk from Dermal Pathway			3.4E-08
									Total Risks from Ingestion and Dermal Pathways			5.4E-08

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (6073 cm2* 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 12 years) / (70 kgs * 365 days/year * 70 years)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
			1.35E-07

Table B16
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
Ingestion	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M	4.75E-09	(mg/kg-day)				
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M	4.17E-10	(mg/kg-day)				
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M	4.79E-10	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	3	2.9E-12
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	8.92E-10	(mg/kg-day)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	3	2.5E-11
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	8.92E-10	(mg/kg-day)	3.7E-02	$(mg/kg\text{-}day)^{-1}$	1	3.3E-11
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	2.48E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	5.4E-08
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	1.41E-08	(mg/kg-day)				
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	1.78E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	3.9E-10
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	1.44E-08	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	1.38E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	3.0E-08
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	1.48E-08	(mg/kg-day)				
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	5.26E-15	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	8.2E-10
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M						
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M						
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M	7.79E-04	(mg/kg-day)				
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	1.02E-07	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	1.5E-07
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M	7.52E-08	(mg/kg-day)				
	Fluoride (Tota)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M	2.35E-05	(mg/kg-day)				
											Total Risk from Ingestion Pathway	2.4E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day * 0.000001 kg/mg * 39 days/year *12 years) / (70 years * 365 days/year * 47 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	Dioxin TEQ		1.35E-07

Table B16
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor Unitless	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
Dermal	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M							
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M							
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M							
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M							
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	0.13	3.46E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	7.6E-08
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	0.13	1.96E-08	(mg/kg-day)				
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	0.13	2.48E-08	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	5.4E-10
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	0.13	2.01E-08	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	0.13	1.91E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	4.2E-08
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	0.13	2.06E-08	(mg/kg-day)				
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	0.03	1.69E-15	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	2.6E-10
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M							
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M							
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M							
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M							
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	0.03	3.27E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	4.9E-08
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M							
	Fluoride (Tota)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M							
											Total Risk from Dermal Pathway		1.7E-07
											Total Risk for Ingestion and Dermal Pathways		4E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (4283 cm2* 0.25 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 39 days/year * 12 years) / (70 years * 365 days/year * 47 kgs)
(3)Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	Dioxin TEQ		1.35E-07

Table B17
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
Ingestion	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M	2.48E-09	(mg/kg-day)				
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M	2.18E-10	(mg/kg-day)				
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M	2.50E-10	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	1	5.0E-13
	Trichloroethylene (0 to 2 years)	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	1.55E-10	(mg/kg-day)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	10	1.4E-11
	Trichloroethylene (0 to 2 years)	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	1.55E-10	(mg/kg-day)	3.7E-02	$(mg/kg\text{-}day)^{-1}$	1	5.7E-12
	Trichloroethylene (2 to 6 years)	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	3.11E-10	(mg/kg-day)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	3	8.7E-12
	Trichloroethylene (2 to 6 years)	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	3.11E-10	(mg/kg-day)	3.7E-02	$(mg/kg\text{-}day)^{-1}$	1	1.1E-11
	Benzo(b)fluoroanthene (0 to 2 years)	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	4.32E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	3.2E-08
	Benzo(b)fluoroanthene (2 to 6 years)	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	8.64E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.9E-08
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	2.46E-09	(mg/kg-day)				
	Chrysene (0 to 2 years)	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	3.10E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	10	2.3E-10
	Chrysene (2 to 6 years)	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	6.20E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	1.4E-10
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	7.53E-09	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene (0 to 2 years)	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	2.39E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	1.7E-08
	Indeno(1,2,3-cd)pyrene (2 to 6 years)	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	4.79E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	1.0E-08
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	7.71E-09	(mg/kg-day)				
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	2.75E-15	(mg/kg-day)	1.6E+05	$(mg/kg\text{-}day)^{-1}$	1	4.3E-10
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M						
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M						
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M	4.07E-04	(mg/kg-day)				
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	5.31E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	8.0E-08
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M	3.93E-08	(mg/kg-day)				
	Fluoride (Tota)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M	1.23E-05	(mg/kg-day)				
										Total Risk from Ingestion Pathway		1.6E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day * 0.000001 kg/mg * 13 days/year *6 years) / (70 years * 365 days/year * 15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	Dioxin TEQ		1.35E-07

Table B17
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Child

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor Unitless ABS	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Age Dependent Adjustment Factors	Cancer Risk
Ingestion	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M							
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M							
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M							
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M							
	Benzo(b)fluoroanthene (0 to < 2 years)	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	0.13	7.24E-10	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	5.3E-09
	Benzo(b)fluoroanthene (2 to 6 years)	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	0.13	1.45E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	3.2E-09
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	0.13	1.23E-09	(mg/kg-day)				
	Chrysene (0 to 2 years)	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	0.13	2.25E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	10	1.6E-10
	Chrysene (2 to 6 years)	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	0.13	4.50E-09	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	3	9.9E-11
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	0.13	1.26E-09	(mg/kg-day)				
	Indeno(1,2,3-cd)pyrene (0 to < 2 years)	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	0.13	1.74E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	10	1.3E-08
	Indeno(1,2,3-cd)pyrene (2 to 6 years)	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	0.13	3.48E-09	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3	7.6E-09
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	0.13	5.60E-09	(mg/kg-day)				
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	0.03	4.60E-16	(mg/kg-day)			1	0.0E+00
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M							
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M							
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M							
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M							
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	0.03	8.90E-09	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1	1.3E-08
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M							
	Fluoride (Tota)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M							
											Total Risk from Ingestion Pathway		4.2E-08
											Total Risk from Ingestion and Dermal Pathway		2.0E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (2792 cm2* 0.2 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 6 years) / (70 years * 3665 days/year * 15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	Dioxin TEQ		1.35E-07

Table B18
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 7 and 8
Receptor Population:	Mohawk Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Ingestion	Acetone	2.26E-01	mg/kg	2.26E-01	mg/kg (wet)	M	2.63E-08	(mg/kg-day)			
	2-Butanone	3.65E-02	mg/kg	3.65E-02	mg/kg (wet)	M	4.24E-09	(mg/kg-day)			
	Carbon Disulfide	1.50E-02	mg/kg	1.50E-02	mg/kg (wet)	M	1.74E-09	(mg/kg-day)			
	Methylene Chloride	3.31E-02	mg/kg	3.31E-02	mg/kg (wet)	M	3.85E-09	(mg/kg-day)	2.0E-03	$(mg/kg\text{-}day)^{-1}$	7.7E-12
	Benzo(a)anthracene	1.04E+00	mg/kg	1.04E+00	mg/kg (wet)	M	1.21E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	8.8E-08
	Benzo(a)pyrene	9.73E-01	mg/kg	9.73E-01	mg/kg (wet)	M	1.13E-07	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	8.3E-07
	Benzo(b)fluoroanthene	2.83E+00	mg/kg	2.83E+00	mg/kg (wet)	M	3.29E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2.4E-07
	Benzo(ghi)perylene	7.63E-01	mg/kg	7.63E-01	mg/kg (wet)	M	8.87E-08	(mg/kg-day)			
	Benzo(k)fluoroanthene	7.64E-01	mg/kg	7.64E-01	mg/kg (wet)	M	8.89E-08	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	6.5E-09
	Chrysene	2.10E+00	mg/kg	2.10E+00	mg/kg (wet)	M	2.44E-07	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	1.8E-09
	Fluoroanthene	9.77E-01	mg/kg	9.77E-01	mg/kg (wet)	M	1.14E-07	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	7.27E-01	mg/kg	7.27E-01	mg/kg (wet)	M	8.45E-08	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	6.2E-08
	Pyrene	8.58E-01	mg/kg	8.58E-01	mg/kg (wet)	M	9.98E-08	(mg/kg-day)			
	Aluminum	1.55E+04	mg/kg	1.55E+04	mg/kg (wet)	M	1.80E-03	(mg/kg-day)			
	Arsenic	1.45E+00	mg/kg	1.45E+00	mg/kg (wet)	M	1.69E-07	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	2.5E-07
	Fluoride (Total)	9.32E+03	mg/kg	9.32E+03	mg/kg (wet)	M	1.08E-03	(mg/kg-day)			
								Total Risk from Ingestion Pathway			1.5E-06

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (50 mg/day *0.000001 kg/mg*65 days/year * 64 years)/(70 years *365 days/year *70 kgs)

Table B18
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 7 and 8
Receptor Population:	Mohawk Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Risk Calculation (1)	Absorption Factor Unitless ABS	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Dermal	Acetone	2.26E-01	mg/kg	2.26E-01	mg/kg (wet)	M						
	2-Butanone	3.65E-02	mg/kg	3.65E-02	mg/kg (wet)	M						
	Carbon Disulfide	1.50E-02	mg/kg	1.50E-02	mg/kg (wet)	M						
	Methylene Chloride	3.31E-02	mg/kg	3.31E-02	mg/kg (wet)	M						
	Benzo(a)anthracene	1.04E+00	mg/kg	1.04E+00	mg/kg (wet)	M	0.13	2.94E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2.1E-07
	Benzo(a)pyrene	9.73E-01	mg/kg	9.73E-01	mg/kg (wet)	M	0.13	2.75E-07	(mg/kg-day)	7.3E+00	$(mg/kg\text{-}day)^{-1}$	2.0E-06
	Benzo(b)fluoroanthene	2.83E+00	mg/kg	2.83E+00	mg/kg (wet)	M	0.13	8.01E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	5.8E-07
	Benzo(ghi)perylene	7.63E-01	mg/kg	7.63E-01	mg/kg (wet)	M	0.13	2.16E-07	(mg/kg-day)			
	Benzo(k)fluoroanthene	7.64E-01	mg/kg	7.64E-01	mg/kg (wet)	M	0.13	2.16E-07	(mg/kg-day)	7.3E-02	$(mg/kg\text{-}day)^{-1}$	1.6E-08
	Chrysene	2.10E+00	mg/kg	2.10E+00	mg/kg (wet)	M	0.13	5.94E-07	(mg/kg-day)	7.3E-03	$(mg/kg\text{-}day)^{-1}$	4.3E-09
	Fluoroanthene	9.77E-01	mg/kg	9.77E-01	mg/kg (wet)	M	0.13	2.77E-07	(mg/kg-day)			
	Indeno(1,2,3-cd)pyrene	7.27E-01	mg/kg	7.27E-01	mg/kg (wet)	M	0.13	2.06E-07	(mg/kg-day)	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1.5E-07
	Pyrene	8.58E-01	mg/kg	8.58E-01	mg/kg (wet)	M	0.13	2.43E-07	(mg/kg-day)			
	Aluminum	1.55E+04	mg/kg	1.55E+04	mg/kg (wet)	M						
	Arsenic	1.45E+00	mg/kg	1.45E+00	mg/kg (wet)	M	0.03	9.47E-08	(mg/kg-day)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	1.4E-07
	Fluoride (Total)	9.32E+03	mg/kg	9.32E+03	mg/kg (wet)	M						
									Total Risk from Ingestion Pathway			3.1E-06
									Total Risk from Ingestion and Dermal Pathways			5E-06

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (3120 cm2* 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 65 days/year * 64 years) / (70 kgs * 365 days/year * 70 kgs)

Table B19
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M	1.53E-09	(mg/kg-day)	9.00E-01	$(mg/kg\text{-}day)^{-1}$	1.70E-09
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M	2.22E-10	(mg/kg-day)			
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M	5.52E-10	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	9.20E-09
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	3.21E-10	(mg/kg-day)	5.0E-04	$(mg/kg\text{-}day)^{-1}$	6.41E-07
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	8.45E-09	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	1.41E-07
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	1.93E-08	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	6.44E-08
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	2.41E-08	(mg/kg-day)			
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	2.14E-08	(mg/kg-day)			
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	2.62E-08	(mg/kg-day)			
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	1.63E-08	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	1.93E-08	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	9.65E-07
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	2.30E-08	(mg/kg-day)			
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	1.25E-08	(mg/kg-day)			
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	2.77E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	6.93E-07
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	1.37E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.43E-07
	Indeno(1,2,3-cd)pyrene	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	2.01E-08	(mg/kg-day)			
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	2.80E-08	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	3.23E-08	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	1.08E-06
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	9.79E-15	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.40E-05
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.60E-06	mg/kg (wet)	M					
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M					
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M					
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	1.09E-08	(mg/kg-day)			
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M	9.54E-05	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	9.54E-05
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.73E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	5.77E-05
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M	3.38E-07	(mg/kg-day)	2.0E-01	$(mg/kg\text{-}day)^{-1}$	1.69E-06
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M	1.19E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.97E-06
	Fluoride (Total)	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M	4.76E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	1.19E-04
								Total Risk from Ingestion Pathway			2.9E-04

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (50 mg/day *0.000001 kg/mg* 13 days/year * 12 years)/(12 years *365 days/year *70 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.85E-07

Table B19
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer) (3)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M						
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M						
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M						
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M						
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	0.13	4.00E-08	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	6.67E-07
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	0.13	9.16E-08	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	3.05E-07
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	0.13	1.14E-07	(mg/kg-day)			
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	0.13	1.01E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	0.13	1.24E-07	(mg/kg-day)			
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	0.13	7.71E-08	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	0.1	7.04E-08	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	3.52E-06
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	0.13	1.09E-07	(mg/kg-day)			
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	0.13	5.90E-08	(mg/kg-day)			
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	0.13	1.31E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.28E-06
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	0.13	6.51E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	1.63E-06
	Indeno(1,2,3-cd)pyrene	7.91E-01	mg/kg	7.91E-01	mg/kg (wet)	M	0.13	9.53E-08	(mg/kg-day)			
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	0.13	1.33E-07	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	0.13	1.53E-07	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	5.10E-06
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	0.03	1.07E-14	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.53E-05
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.60E-06	mg/kg (wet)	M						
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M						
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M						
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	0.1	3.99E-08	(mg/kg-day)			
	Aluminum	3.75E+03	mg/kg	3.75E+03	mg/kg (wet)	M						
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	0.03	1.89E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	6.30E-05
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M						
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M						
	Fluoride (Total)	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M						
											Total Risk from Ingestion Pathway	9.3E-05
											Total Risk from Ingestion and Dermal Pathways	3.8E-04

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (6073 cm2* 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 12 years) / (12 years * 365 days/year * 70 kgs)

(3)Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.85E-07

Table B20
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M	1.37E-08	(mg/kg-day)	9.00E-01	$(mg/kg\text{-}day)^{-1}$	1.52E-08
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M	1.98E-09	(mg/kg-day)			
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M	4.93E-09	(mg/kg-day)	6.0E-03	$(mg/kg\text{-}day)^{-1}$	8.22E-07
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	2.86E-09	(mg/kg-day)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	3.08E-07
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	7.55E-08	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	1.26E-06
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	1.73E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	5.76E-07
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	2.15E-07	(mg/kg-day)			
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	1.91E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	2.34E-07	(mg/kg-day)			
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	1.45E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	1.73E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	8.63E-06
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	2.06E-07	(mg/kg-day)			
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	1.11E-07	(mg/kg-day)			
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	2.48E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	6.19E-06
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	1.23E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.07E-06
	Indeno(1,2,3-cd)pyrene	7.90E-01	mg/kg	7.90E-01	mg/kg (wet)	M	1.80E-07	(mg/kg-day)			
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	2.50E-07	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	2.89E-07	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	9.62E-06
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	8.75E-14	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.25E-04
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)						
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.60E-06	mg/kg (wet)						
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)						
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)						
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	9.78E-08	(mg/kg-day)			
	Aluminum	3.78E+03	mg/kg	3.78E+03	mg/kg (wet)	M	8.59E-04	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	8.59E-04
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.55E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	5.15E-04
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M	3.02E-06	(mg/kg-day)	2.0E-01	$(mg/kg\text{-}day)^{-1}$	1.51E-05
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M	1.06E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.65E-05
	Fluoride (Total)	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M	4.25E-05	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	1.06E-03
										Total Non-Cancer Health Hazard from Ingestion Pathway	2.6E-03

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day *0.000001 kg/mg* 39 days/year * 12 years)/(12 years *365 days/year *47 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.85E-07

Table B20
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M						
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M						
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M						
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M						
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	0.13	1.05E-07	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	1.75E-06
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	0.13	2.41E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	8.02E-07
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	0.13	3.00E-07	(mg/kg-day)			
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	0.13	2.66E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	0.13	3.26E-07	(mg/kg-day)			
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	0.13	2.03E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	0.1	1.85E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	9.24E-06
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	0.13	2.86E-07	(mg/kg-day)			
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	0.13	1.55E-07	(mg/kg-day)			
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	0.13	3.45E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	8.62E-06
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	0.13	1.71E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	4.27E-06
	Indeno(1,2,3-cd)pyrene	7.90E-01	mg/kg	7.90E-01	mg/kg (wet)	M	0.13	2.50E-07	(mg/kg-day)			
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	0.13	3.48E-07	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	0.13	4.02E-07	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	1.34E-05
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	0.03	2.81E-14	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	4.02E-05
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.60E-06	mg/kg (wet)	M						
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M						
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M						
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	0.1	1.05E-07	(mg/kg-day)			
	Aluminum	3.78E+03	mg/kg	3.78E+03	mg/kg (wet)	M						
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	0.03	4.97E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	1.66E-04
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M						
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M						
	Fluoride (Total)	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Ingestion Pathway	2.4E-04
											Total Non-Cancer Health Hazards from Ingestion and Dermal Pathways	0.003

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (4283 cm2* 0.25 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 39 days/year * 12 years) / (12 years * 365 days/year * 70 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.85E-07

Table B21
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M	1.43E-08	(mg/kg-day)	9.00E-01	$(mg/kg\text{-}day)^{-1}$	1.59E-08
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M	2.07E-09	(mg/kg-day)			
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M	5.15E-09	(mg/kg-day)	6.0E-03	$(mg/kg\text{-}day)^{-1}$	8.59E-07
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M	2.99E-09	(mg/kg-day)	5.0E-04	$(mg/kg\text{-}day)^{-1}$	5.98E-06
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	7.88E-08	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	1.31E-06
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	1.80E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	6.02E-07
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	2.25E-07	(mg/kg-day)			
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	1.99E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	2.45E-07	(mg/kg-day)			
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	1.52E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	1.80E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	9.01E-06
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	2.15E-07	(mg/kg-day)			
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	1.16E-07	(mg/kg-day)			
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	2.59E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	6.47E-06
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	1.28E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.21E-06
	Indeno(1,2,3-cd)pyrene	7.90E-01	mg/kg	7.90E-01	mg/kg (wet)	M	1.88E-07	(mg/kg-day)			
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	2.61E-07	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	3.02E-07	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	1.01E-05
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	9.14E-14	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.31E-04
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.60E-06	mg/kg (wet)	M					
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M					
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M					
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	1.02E-07	(mg/kg-day)			
	Aluminum	3.78E+03	mg/kg	3.78E+03	mg/kg (wet)	M	8.98E-04	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	8.98E-04
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.61E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	5.38E-04
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M	3.16E-06	(mg/kg-day)	2.0E-01	$(mg/kg\text{-}day)^{-1}$	1.58E-05
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M	1.11E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.77E-05
	Fluoride (Total)	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M	4.44E-05	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	1.11E-03
										Total Non-Cancer Health Hazard from Ingestion Pathway	2.8E-03

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (100 mg/day *0.000001 kg/mg* 13 days/year * 6 years)/(6 years *365 days/year *15 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.85E-07

Table B21
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	6.02E-02	mg/kg	6.02E-02	mg/kg (wet)	M						
	Chloromethane	8.71E-03	mg/kg	8.71E-03	mg/kg (wet)	M						
	Methylene Chloride	2.17E-02	mg/kg	2.17E-02	mg/kg (wet)	M						
	Trichloroethylene	1.26E-02	mg/kg	1.26E-02	mg/kg (wet)	M						
	Acenaphthene	3.32E-01	mg/kg	3.32E-01	mg/kg (wet)	M	0.13	5.72E-08	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	9.54E-07
	Anthracene	7.60E-01	mg/kg	7.60E-01	mg/kg (wet)	M	0.13	1.31E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	4.37E-07
	Benzo(a)anthracene	9.47E-01	mg/kg	9.47E-01	mg/kg (wet)	M	0.13	1.63E-07	(mg/kg-day)			
	Benzo(a)pyrene	8.40E-01	mg/kg	8.40E-01	mg/kg (wet)	M	0.13	1.45E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	1.03E+00	mg/kg	1.03E+00	mg/kg (wet)	M	0.13	1.78E-07	(mg/kg-day)			
	Benzo(ghi)perylene	6.40E-01	mg/kg	6.40E-01	mg/kg (wet)	M	0.13	1.10E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	7.59E-01	mg/kg	7.59E-01	mg/kg (wet)	M	0.1	1.01E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	5.03E-06
	Chrysene	9.05E-01	mg/kg	9.05E-01	mg/kg (wet)	M	0.13	1.56E-07	(mg/kg-day)			
	Dibenzo(a,h)anthracene	4.90E-01	mg/kg	4.90E-01	mg/kg (wet)	M	0.13	8.45E-08	(mg/kg-day)			
	Fluoroanthene	1.09E+00	mg/kg	1.09E+00	mg/kg (wet)	M	0.13	1.88E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	4.70E-06
	Fluorene	5.40E-01	mg/kg	5.40E-01	mg/kg (wet)	M	0.13	9.31E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.33E-06
	Indeno(1,2,3-cd)pyrene	7.90E-01	mg/kg	7.90E-01	mg/kg (wet)	M	0.13	1.36E-07	(mg/kg-day)			
	Phenanthrene	1.10E+00	mg/kg	1.10E+00	mg/kg (wet)	M	0.13	1.90E-07	(mg/kg-day)			
	Pyrene	1.27E+00	mg/kg	1.27E+00	mg/kg (wet)	M	0.13	2.19E-07	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	7.30E-06
	Dioxin TEQ (3)	3.85E-07	mg/kg	3.85E-07	mg/kg (wet)	M	0.03	1.53E-14	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	2.19E-05
	1,2,3,4,6,7,8-HpCDD	2.84E-05	mg/kg	2.84E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	5.60E-06	mg/kg	5.60E-06	mg/kg (wet)	M						
	OCDD	1.41E-04	mg/kg	1.41E-04	mg/kg (wet)	M						
	OCDF	9.70E-06	mg/kg	9.70E-06	mg/kg (wet)	M						
	Carbazole	4.30E-01	mg/kg	4.30E-01	mg/kg (wet)	M	0.1	5.70E-08	(mg/kg-day)			
	Aluminum	3.78E+03	mg/kg	3.78E+03	mg/kg (wet)	M						
	Arsenic	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	0.03	2.70E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	9.02E-05
	Barium	1.33E+01	mg/kg	1.33E+01	mg/kg (wet)	M						
	Copper	4.67E+00	mg/kg	4.67E+00	mg/kg (wet)	M						
	Fluoride (Total)	1.87E+02	mg/kg	1.87E+02	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Ingestion Pathway	1.3E-04
											Total Non-Cancer Health Hazards from Dermal and Ingestion Pathways	0.003

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (2792 cm2* 0.2 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 6 years) / (6 years * 365 days/year * 15 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	2.84E-05	0.01	2.84E-07
1,2,3,4,6,7,8-HpCDF	5.60E-06	0.01	5.60E-08
OCDD	1.41E-04	0.0003	4.23E-08
OCDF	9.70E-06	0.0003	2.91E-09
	Dioxin TEQ		3.85E-07

Table B22
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M	2.13E-09	(mg/kg-day)	9.0E-01	(mg/kg-day)$^{-1}$	2.37E-09
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M	3.74E-10	(mg/kg-day)	6.0E-01	(mg/kg-day)$^{-1}$	6.23E-10
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M	3.51E-10	(mg/kg-day)	6.0E-03	(mg/kg-day)$^{-1}$	5.85E-08
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	4.02E-08	(mg/kg-day)	3.0E-01	(mg/kg-day)$^{-1}$	1.34E-07
	Benzo(a)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	1.82E-07	(mg/kg-day)			
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	8.45E-08	(mg/kg-day)			
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	2.27E-07	(mg/kg-day)			
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	5.90E-08	(mg/kg-day)			
	Benzo(k)fluoranthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	6.26E-08	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	4.60E-08	(mg/kg-day)	2.0E-02	(mg/kg-day)$^{-1}$	2.30E-06
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	2.59E-07	(mg/kg-day)			
	Di-N-butlyphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	5.32E-08	(mg/kg-day)	1.0E-01	(mg/kg-day)$^{-1}$	5.32E-07
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	3.84E-08	(mg/kg-day)			
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	2.62E-07	(mg/kg-day)	4.0E-02	(mg/kg-day)$^{-1}$	6.55E-06
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	5.44E-08	(mg/kg-day)			
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	8.57E-08	(mg/kg-day)			
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	2.57E-07	(mg/kg-day)	3.00E-02	(mg/kg-day)$^{-1}$	8.56E-06
	Dioxin TEQ (3)	4.55E-04	mg/kg	4.55E-04	mg/kg (wet)	M	1.16E-11	(mg/kg-day)	7.00E-10	(mg/kg-day)$^{-1}$	1.65E-02
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M					
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M					
	1,2,3,4,7,8-HxCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M					
	1,2,3,6,7,8-HxCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M					
	1,2,3,7,8,9-HxCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M					
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M					
	2,3,4,6,7,8-Hxcdf	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M					
	2,3,4,7,8-PECDF	6.34E-04	mg/kg	6.34E-04	mg/kg (wet)	M					
	2,3,7,8-TCDF	5.25E-04	mg/kg	5.25E-04	mg/kg (wet)	M					
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M					
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M					
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M	2.72E-04	(mg/kg-day)	1.0E+00	(mg/kg-day)$^{-1}$	2.72E-04
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	5.52E-08	(mg/kg-day)	3.0E-04	(mg/kg-day)$^{-1}$	1.84E-04
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.73E-08	(mg/kg-day)	2.0E-02	(mg/kg-day)$^{-1}$	8.65E-07
	Fluoride (Total)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M	1.14E-05	(mg/kg-day)	6.0E-02	(mg/kg-day)$^{-1}$	1.90E-04
										Total Non-Cancer Health Hazard from Ingestion Pathway	1.7E-02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (50 mg/day *0.000001 kg/mg* 13 days/year * 12 years)/(12 years *365 days/year *70 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HxCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HxCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HxCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-Hxcdf	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.34E-04	0.3	1.90E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
			4.55E-04

Table B22
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M						
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M						
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M						
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	0.13	1.90E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	6.35E-07
	Benzo(a)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	0.13	8.64E-07	(mg/kg-day)			
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	0.13	4.00E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	0.13	1.07E-06	(mg/kg-day)			
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	0.13	2.80E-07	(mg/kg-day)			
	Benzo(k)fluoranthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	0.13	2.96E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	0.1	1.68E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	8.39E-06
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	0.13	1.23E-06	(mg/kg-day)			
	Di-N-butlyphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M						
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	0.13	1.82E-07	(mg/kg-day)			
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	0.13	1.24E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.10E-05
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	0.13	2.58E-07	(mg/kg-day)			
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	0.13	4.06E-07	(mg/kg-day)			
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	0.13	1.22E-06	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	4.06E-05
	Dioxin TEQ	4.55E-04	mg/kg	4.55E-04	mg/kg (wet)	M	0.03	1.27E-11	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.81E-02
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M						
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M						
	1,2,3,4,7,8-HxCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M						
	1,2,3,6,7,8-HxCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M						
	1,2,3,7,8,9-HxCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M						
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M						
	2,3,4,6,7,8-HxcdfPECDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M						
	2,3,4,7,8-PECDF	6.34E-04	mg/kg	6.34E-04	mg/kg (wet)	M						
	2,3,7,8-TCDF	5.25EE-04	mg/kg	5.25EE-04	mg/kg (wet)	M						
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M						
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M						
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M						
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	0.03	6.03E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	2.01E-04
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M						
	Fluoride (Total)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Ingestion Pathway	1.8E-02
											Total Non-Cancer Health Hazards from Ingestion and Dermal Pathways	0.04

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (6073 cm2* 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 12 years) / (12 years * 365 days/year * 70 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HxCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HxCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HxCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-Hxcdf	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.34E-04	0.3	1.90E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
		TEQ	4.55E-04

Table B23
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M	1.91E-08	(mg/kg-day)	9.00E-01	$(mg/kg\text{-}day)^{-1}$	2.12E-08
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M	3.34E-09	(mg/kg-day)	6.00E-01	$(mg/kg\text{-}day)^{-1}$	5.57E-09
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M	3.14E-09	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	5.23E-08
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	3.59E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	1.20E-06
	Benzo(a)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	1.63E-06	(mg/kg-day)			
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	7.55E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	2.03E-06	(mg/kg-day)			
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	5.27E-07	(mg/kg-day)			
	Benzo(k)fluoranthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	5.59E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	4.11E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	2.06E-05
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	2.32E-06	(mg/kg-day)			
	Di-N-butlyphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	4.75E-07	(mg/kg-day)	1.0E-01	$(mg/kg\text{-}day)^{-1}$	4.75E-06
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	3.43E-07	(mg/kg-day)			
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	2.34E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	5.85E-05
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	4.87E-07	(mg/kg-day)			
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	7.66E-07	(mg/kg-day)			
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	2.30E-06	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	7.65E-05
	Dioxin TEQ	4.55E-04	mg/kg	4.55E-04	mg/kg (wet)	M	1.03E-10	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.48E-01
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M					
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M					
	1,2,3,4,7,8-HxCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M					
	1,2,3,6,7,8-HxCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M					
	1,2,3,7,8,9-HxCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M					
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M					
	2,3,4,6,7,8-HxcdfPECDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M					
	2,3,4,7,8-PECDF	6.34E-04	mg/kg	6.34E-04	mg/kg (wet)	M					
	2,3,7,8-TCDF	5.25EE-04	mg/kg	5.25EE-04	mg/kg (wet)	M					
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M					
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M					
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M	2.43E-03	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	2.43E-03
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	4.93E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	1.64E-03
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.55E-07	(mg/kg-day)	6.0E-04	$(mg/kg\text{-}day)^{-1}$	2.58E-04
	Fluoride (Total)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M	1.02E-04	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	1.70E-03
								Total Non-Cancer Health Hazard from Ingestion Pathway			1.5E-01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (100 mg/day *0.000001 kg/mg* 39 days/year * 12 years)/(12 years *365 days/year *47 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HxCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HxCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HxCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-Hxcdf	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.34E-04	0.3	1.90E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
			4.55E-04

Table B23
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M						
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M						
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M						
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	0.13	5.00E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	1.67E-06
	Benzo(a)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	0.13	2.27E-06	(mg/kg-day)			
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	0.13	1.05E-06	(mg/kg-day)			
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	0.13	2.82E-06	(mg/kg-day)			
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	0.13	7.34E-07	(mg/kg-day)			
	Benzo(k)fluoranthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	0.13	7.78E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	0.1	4.41E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	2.20E-05
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	0.13	3.23E-06	(mg/kg-day)			
	Di-N-butlyphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	0.13	6.61E-07	(mg/kg-day)	1.0E-01	$(mg/kg\text{-}day)^{-1}$	6.61E-06
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	0.13	4.78E-07	(mg/kg-day)			
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	0.13	3.26E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	8.15E-05
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	0.13	6.77E-07	(mg/kg-day)			
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	0.13	1.07E-06	(mg/kg-day)			
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	0.13	3.20E-06	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	1.07E-04
	Dioxin TEQ	4.55E-04	mg/kg	4.55E-04	mg/kg (wet)	M	0.03	3.32E-11	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	4.75E-02
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M						
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M						
	1,2,3,4,7,8-HxCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M						
	1,2,3,6,7,8-HxCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M						
	1,2,3,7,8,9-HxCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M						
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M						
	2,3,4,6,7,8-HxcdfPECDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M						
	2,3,4,7,8-PECDF	6.34E-04	mg/kg	6.34E-04	mg/kg (wet)	M						
	2,3,7,8-TCDF	5.25EE-04	mg/kg	5.25EE-04	mg/kg (wet)	M						
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M						
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M						
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M						
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	0.03	1.58E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	5.28E-04
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M						
	Fluoride (Total)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Ingestion Pathway	4.8E-02
											Total Non-Cancer Health Hazard from Ingestion and Dermal Pathways	0.2

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (4283 cm2* 0.25 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 39 days/year * 12 years) / (12 years * 365 days/year * 47 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HxCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HxCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HxCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-Hxcdf	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.34E-04	0.3	1.90E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	TEQ		4.55E-04

Table B24
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Child

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M	1.99E-08	(mg/kg-day)	9.00E-01	$(mg/kg\text{-}day)^{-1}$	2.21E-08
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M	3.49E-09	(mg/kg-day)	6.00E-01	$(mg/kg\text{-}day)^{-1}$	5.82E-09
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M	3.28E-09	(mg/kg-day)	6.0E-03	$(mg/kg\text{-}day)^{-1}$	5.46E-07
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	3.75E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	1.25E-06
	Benzo(a)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	1.70E-06	(mg/kg-day)			
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	7.88E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	2.12E-06	(mg/kg-day)			
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	5.51E-07	(mg/kg-day)			
	Benzo(k)fluoranthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	5.84E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	4.30E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	2.15E-05
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	2.42E-06	(mg/kg-day)			
	Di-N-butlyphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	4.96E-07	(mg/kg-day)	1.0E-01	$(mg/kg\text{-}day)^{-1}$	4.96E-06
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	3.59E-07	(mg/kg-day)			
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	2.45E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	6.11E-05
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	5.08E-07	(mg/kg-day)			
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	8.00E-07	(mg/kg-day)			
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	2.40E-06	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	7.99E-05
	Dioxin TEQ	4.55E-04	mg/kg	4.55E-04	mg/kg (wet)	M	1.08E-10	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.54E-01
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M					
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M					
	1,2,3,4,7,8-HxCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M					
	1,2,3,6,7,8-HxCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M					
	1,2,3,7,8,9-HxCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M					
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M					
	2,3,4,6,7,8-HxcdfPECDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M					
	2,3,4,7,8-PECDF	6.34E-04	mg/kg	6.34E-04	mg/kg (wet)	M					
	2,3,7,8-TCDF	5.25EE-04	mg/kg	5.25EE-04	mg/kg (wet)	M					
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M					
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M					
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M	2.54E-03	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	2.54E-03
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	5.15E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	1.72E-03
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M	1.61E-07	(mg/kg-day)	6.0E-04	$(mg/kg\text{-}day)^{-1}$	2.69E-04
	Fluoride (Total)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M	1.07E-04	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.67E-03
										Total Non-Cancer Health Hazard from Ingestion Pathway	2E-01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day *0.000001 kg/mg* 13 days/year * 12 years)/(12 years *365 days/year *15 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HxCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HxCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HxCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-Hxcdf	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.34E-04	0.3	1.90E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	TEQ		4.55E-04

Table B24
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 4 - 8
Receptor Population:	Recreational User
Receptor Age:	Child

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Dermal Absorption Unitless	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	8.39E-02	mg/kg	8.39E-02	mg/kg (wet)	M						
	2-Butanone	1.47E-02	mg/kg	1.47E-02	mg/kg (wet)	M						
	Methylene Chloride	1.38E-02	mg/kg	1.38E-02	mg/kg (wet)	M						
	Anthracene	1.58E+00	mg/kg	1.58E+00	mg/kg (wet)	M	0.13	2.72E-07	(mg/kg-day)	3.0E-01	$(mg/kg\text{-}day)^{-1}$	9.08E-07
	Benzo(a)anthracene	7.17E+00	mg/kg	7.17E+00	mg/kg (wet)	M	0.13	1.24E-06	(mg/kg-day)			
	Benzo(a)pyrene	3.32E+00	mg/kg	3.32E+00	mg/kg (wet)	M	0.13	5.72E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	8.92E+00	mg/kg	8.92E+00	mg/kg (wet)	M	0.13	1.54E-06	(mg/kg-day)			
	Benzo(ghi)perylene	2.32E+00	mg/kg	2.32E+00	mg/kg (wet)	M	0.13	4.00E-07	(mg/kg-day)			
	Benzo(k)fluoranthene	2.46E+00	mg/kg	2.46E+00	mg/kg (wet)	M	0.13	4.24E-07	(mg/kg-day)			
	Bis(2-ethylhexyl)phthalate	1.81E+00	mg/kg	1.81E+00	mg/kg (wet)	M	0.1	2.40E-07	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	1.20E-05
	Chrysene	1.02E+01	mg/kg	1.02E+01	mg/kg (wet)	M	0.13	1.76E-06	(mg/kg-day)			
	Di-N-butlyphthalate	2.09E+00	mg/kg	2.09E+00	mg/kg (wet)	M	0.13	3.60E-07	(mg/kg-day)	1.0E-01	$(mg/kg\text{-}day)^{-1}$	3.60E-06
	Dibenzo(a,h)anthracene	1.51E+00	mg/kg	1.51E+00	mg/kg (wet)	M	0.13	2.60E-07	(mg/kg-day)			
	Fluoroanthene	1.03E+01	mg/kg	1.03E+01	mg/kg (wet)	M	0.13	1.78E-06	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	4.44E-05
	Indeno(1,2,3-cd)pyrene	2.14E+00	mg/kg	2.14E+00	mg/kg (wet)	M	0.13	3.69E-07	(mg/kg-day)			
	Phenanthrene	3.37E+00	mg/kg	3.37E+00	mg/kg (wet)	M	0.13	5.81E-07	(mg/kg-day)			
	Pyrene	1.01E+01	mg/kg	1.01E+01	mg/kg (wet)	M	0.13	1.74E-06	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	5.80E-05
	Dioxin TEQ (3)	4.55E-04	mg/kg	4.55E-04	mg/kg (wet)	M	0.03	1.81E-11	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	2.59E-02
	1,2,3,4,6,7,8-HpCDD	6.92E-05	mg/kg	6.92E-05	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	8.29E-04	mg/kg	8.29E-04	mg/kg (wet)	M						
	1,2,3,4,7,8,9-HpCDF	4.42E-04	mg/kg	4.42E-04	mg/kg (wet)	M						
	1,2,3,4,7,8-HxCDF	1.31E-03	mg/kg	1.31E-03	mg/kg (wet)	M						
	1,2,3,6,7,8-HxCDF	3.66E-04	mg/kg	3.66E-04	mg/kg (wet)	M						
	1,2,3,7,8,9-HxCDD	2.64E-05	mg/kg	2.64E-05	mg/kg (wet)	M						
	1,2,3,7,8-PECDF	2.34E-04	mg/kg	2.34E-04	mg/kg (wet)	M						
	2,3,4,6,7,8-HxcdfPECDF	2.09E-04	mg/kg	2.09E-04	mg/kg (wet)	M						
	2,3,4,7,8-PECDF	6.34E-04	mg/kg	6.34E-04	mg/kg (wet)	M						
	2,3,7,8-TCDF	5.25EE-04	mg/kg	5.25EE-04	mg/kg (wet)	M						
	OCDD	3.10E-04	mg/kg	3.10E-04	mg/kg (wet)	M						
	OCDF	2.24E-03	mg/kg	2.24E-03	mg/kg (wet)	M						
	Aluminum	1.07E+04	mg/kg	1.07E+04	mg/kg (wet)	M						
	Arsenic	2.17E+00	mg/kg	2.17E+00	mg/kg (wet)	M	0.03	8.63E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	2.88E-04
	Cyanide	6.80E-01	mg/kg	6.80E-01	mg/kg (wet)	M						
	Fluoride (Total)	4.49E+02	mg/kg	4.49E+02	mg/kg (wet)	M						
										Total Non-Cancer Health Hazard from Ingestion Pathway		2.6E-02
										Total Non-Cancer Health Hazard from Ingestion and Dermal Pathways		0.2

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (2792 cm2* 0.2 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 6 years) / (6 years * 365 days/year * 15 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	6.92E-05	0.01	6.92E-07
1,2,3,4,6,7,8-HpCDF	8.29E-04	0.01	8.29E-06
1,2,3,4,7,8,9-HpCDF	4.42E-04	0.01	4.42E-06
1,2,3,4,7,8-HxCDF	1.31E-03	0.1	1.31E-04
1,2,3,6,7,8-HxCDF	3.66E-04	0.1	3.66E-05
1,2,3,7,8,9-HxCDD	2.64E-05	0.1	2.64E-06
1,2,3,7,8-PECDF	2.34E-04	0.03	7.02E-06
2,3,4,6,7,8-Hxcdf	2.09E-04	0.1	2.09E-05
2,3,4,7,8-PECDF	6.34E-04	0.3	1.90E-04
2,3,7,8-TCDF	5.25E-04	0.1	5.25E-05
OCDD	3.10E-04	0.0003	9.30E-08
OCDF	2.24E-03	0.0003	6.72E-07
	TEQ		4.55E-04

Table B25
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M	3.10E-09	(mg/kg-day)	9.0E-01	$(mg/kg\text{-}day)^{-1}$	3.45E-09
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M	2.72E-10	(mg/kg-day)	6.0E-01	$(mg/kg\text{-}day)^{-1}$	4.54E-10
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M	3.13E-10	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	5.22E-09
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	5.83E-10	(mg/kg-day)	5.0E-04	$(mg/kg\text{-}day)^{-1}$	1.17E-06
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	1.62E-08	(mg/kg-day)			
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	9.21E-09	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	1.16E-08	(mg/kg-day)			
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	9.41E-09	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.35E-07
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	8.98E-09	(mg/kg-day)			
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	9.64E-09	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	3.21E-07
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	3.43E-15	(mg/kg-day)	7.0E-10	$(mg/kg\text{-}day)^{-1}$	4.91E-06
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M					
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M					
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M	5.09E-04	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	5.09E-04
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	6.64E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	2.21E-04
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M	4.91E-08	(mg/kg-day)	2.0E-02	$(mg/kg\text{-}day)^{-1}$	2.45E-06
	Fluoride (Total)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M	1.54E-05	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	2.56E-04
										Total Non-Cancer Health Hazard from Ingestion Pathway	0.001

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.

(2) Exposure Factors: (50 mg/day *0.000001 kg/mg* 13 days/year * 12 years)/(12 years *365 days/year *70 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	TEQ		1.35E-07

Table B25
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M						
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M						
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M						
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M						
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	0.13	7.68E-08	(mg/kg-day)			
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	0.13	4.36E-08	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	0.13	5.51E-08	(mg/kg-day)			
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	0.13	4.46E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	1.11E-06
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	0.13	4.25E-08	(mg/kg-day)			
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	0.13	4.57E-08	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	1.52E-06
	Dioxin TEQ	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	0.03	3.75E-15	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	5.36E-06
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M						
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M						
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M						
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	0.03	7.26E-08	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	2.42E-04
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M						
	Fluoride (Total)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Dermal Pathway	2.5E-04
											Total Non-Cancer Health Hazard from Ingestion and Dermal Pathways	0.001

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (6073 cm2* 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 12 years) / (12 years * 365 days/year * 70 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	TEQ		1.35E-07

Table B26
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 9
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M	2.77E-08	(mg/kg-day)	9.0E-01	$(mg/kg\text{-}day)^{-1}$	3.08E-08
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M	2.43E-09	(mg/kg-day)	6.0E-01	$(mg/kg\text{-}day)^{-1}$	4.05E-09
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M	2.80E-09	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	4.66E-08
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	5.21E-09	(mg/kg-day)	5.0E-04	$(mg/kg\text{-}day)^{-1}$	1.04E-05
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	1.45E-07	(mg/kg-day)			
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	8.23E-08	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	1.04E-07	(mg/kg-day)			
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	8.41E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.10E-06
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	8.03E-08	(mg/kg-day)			
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	8.62E-08	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	2.87E-06
	Dioxin TEQ	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	3.07E-14	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	4.38E-05
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M					
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M					
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M	4.55E-03	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	4.55E-03
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	5.93E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	1.98E-03
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M	4.39E-07	(mg/kg-day)	6.0E-04	$(mg/kg\text{-}day)^{-1}$	7.31E-04
	Fluoride (Total)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M	1.37E-04	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.43E-03
										Total Non-Cancer Health Hazard from Ingestion Pathway	1.1E-02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day *0.000001 kg/mg* 39 days/year * 12 years)/(12 years *365 days/year *47 kgs)

(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	TEQ		1.35E-07

Table B26
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M						
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M						
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M						
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M						
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	0.13	2.02E-07	(mg/kg-day)			
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	0.13	1.15E-07	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	0.13	1.45E-07	(mg/kg-day)			
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	0.13	1.17E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.93E-06
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	0.13	1.12E-07	(mg/kg-day)			
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	0.13	1.20E-07	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	4.00E-06
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	0.03	9.86E-15	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	1.41E-05
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M						
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M						
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M						
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	0.03	1.91E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	6.35E-04
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M						
	Fluoride (Total)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Dermal Pathway	6.6E-04
											Total Non-Cancer Health Hazard from Ingestion and Dermal Pathways	0.01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (4283 cm2* 0.25 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 39 days/year * 12 years) / (12 years * 365 days/year * 47 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds",

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	TEQ		1.35E-07

Table B27
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer) (2)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M	2.90E-08	(mg/kg-day)	9.0E-01	$(mg/kg\text{-}day)^{-1}$	3.22E-08
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M	2.54E-09	(mg/kg-day)	6.0E-01	$(mg/kg\text{-}day)^{-1}$	4.23E-09
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M	2.92E-09	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	4.87E-08
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M	5.44E-09	(mg/kg-day)	5.0E-04	$(mg/kg\text{-}day)^{-1}$	1.09E-05
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	1.51E-07	(mg/kg-day)			
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	8.60E-08	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	1.09E-07	(mg/kg-day)			
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	8.79E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	2.20E-06
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	8.38E-08	(mg/kg-day)			
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	9.00E-08	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	3.00E-06
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	3.21E-14	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	4.58E-05
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M					
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M					
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M					
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M	4.75E-03	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	4.75E-03
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	6.20E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	2.07E-03
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M	4.58E-07	(mg/kg-day)	6.0E-04	$(mg/kg\text{-}day)^{-1}$	7.64E-04
	Fluoride (Total)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M	1.43E-04	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.59E-03
										Total Non-Cancer Health Hazard from Ingestion Pathway	1.1E-02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (100 mg/day *0.000001 kg/mg* 13 days/year * 6 years)/(6 years *365 days/year *15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	TEQ		1.35E-07

Table B27
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reach 9
Receptor Population:	Recreational User
Receptor Age:	Child

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Absorption Factor Unitless	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Dermal	Acetone	1.22E-01	mg/kg	1.22E-01	mg/kg (wet)	M						
	2-Butanone	1.07E-02	mg/kg	1.07E-02	mg/kg (wet)	M						
	Methylene Chloride	1.23E-02	mg/kg	1.23E-02	mg/kg (wet)	M						
	Trichloroethylene	2.29E-02	mg/kg	2.29E-02	mg/kg (wet)	M						
	Benzo(b)fluoroanthene	6.37E-01	mg/kg	6.37E-01	mg/kg (wet)	M	0.13	1.10E-07	(mg/kg-day)			
	Benzo(ghi)perylene	3.62E-01	mg/kg	3.62E-01	mg/kg (wet)	M	0.13	6.24E-08	(mg/kg-day)			
	Chrysene	4.57E-01	mg/kg	4.57E-01	mg/kg (wet)	M	0.13	7.88E-08	(mg/kg-day)			
	Fluoroanthene	3.70E-01	mg/kg	3.70E-01	mg/kg (wet)	M	0.13	6.38E-08	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	1.59E-06
	Indeno(1,2,3-cd)pyrene	3.53E-01	mg/kg	3.53E-01	mg/kg (wet)	M	0.13	6.08E-08	(mg/kg-day)			
	Pyrene	3.79E-01	mg/kg	3.79E-01	mg/kg (wet)	M	0.13	6.53E-08	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	2.18E-06
	Dioxin TEQ (3)	1.35E-07	mg/kg	1.35E-07	mg/kg (wet)	M	0.03	5.37E-15	(mg/kg-day)	7.00E-10	$(mg/kg\text{-}day)^{-1}$	7.67E-06
	1,2,3,4,6,7,8-HpCDD	8.50E-06	mg/kg	8.50E-06	mg/kg (wet)	M						
	1,2,3,4,6,7,8-HpCDF	3.40E-06	mg/kg	3.40E-06	mg/kg (wet)	M						
	OCDD	5.34E-05	mg/kg	5.34E-05	mg/kg (wet)	M						
	Aluminum	2.00E+04	mg/kg	2.00E+04	mg/kg (wet)	M						
	Arsenic	2.61E+00	mg/kg	2.61E+00	mg/kg (wet)	M	0.03	1.04E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	3.46E-04
	Cyanide	1.93E+00	mg/kg	1.93E+00	mg/kg (wet)	M						
	Fluoride (Total)	6.04E+02	mg/kg	6.04E+02	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Dermal Pathway	3.6E-04
											Total Non-Cancer Health Hazard from Ingestion and Dermal Pathways	0.01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (2792 cm2* 0.2 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 13 days/year * 6 years) / (6 years * 365 days/year * 15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds",

1,2,3,4,6,7,8-HpCDD	8.50E-06	0.01	8.50E-08
1,2,3,4,6,7,8-HpCDF	3.40E-06	0.01	3.40E-08
OCDD	5.34E-05	0.0003	1.60E-08
	TEQ		1.35E-07

Table B28
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 7&8
Receptor Population:	Mohawk Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer)	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	2.26E-01	mg/kg	2.26E-01	mg/kg (wet)	M	2.87E-08	(mg/kg-day)	9.00E-01	$(mg/kg\text{-}day)^{-1}$	3.19E-08
	2-Butanone	3.65E-02	mg/kg	3.65E-02	mg/kg (wet)	M	4.64E-09	(mg/kg-day)	6.00E-01	$(mg/kg\text{-}day)^{-1}$	7.74E-09
	Carbon Disulfide	1.50E-02	mg/kg	1.50E-02	mg/kg (wet)	M	1.91E-09	(mg/kg-day)	1.00E-01	$(mg/kg\text{-}day)^{-1}$	1.91E-08
	Methylene Chloride	3.31E-02	mg/kg	3.31E-02	mg/kg (wet)	M	4.21E-09	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	7.02E-08
	Benzo(a)anthracene	1.04E+00	mg/kg	1.04E+00	mg/kg (wet)	M	1.32E-07	(mg/kg-day)			
	Benzo(a)pyrene	9.73E-01	mg/kg	9.73E-01	mg/kg (wet)	M	1.24E-07	(mg/kg-day)			
	Benzo(b)fluoroanthene	2.83E+00	mg/kg	2.83E+00	mg/kg (wet)	M	3.60E-07	(mg/kg-day)			
	Benzo(ghi)perylene	7.63E-01	mg/kg	7.63E-01	mg/kg (wet)	M	9.71E-08	(mg/kg-day)			
	Benzo(K)fluoroanthene	7.64E-01	mg/kg	7.64E-01	mg/kg (wet)	M	9.72E-08	(mg/kg-day)			
	Chrysene	2.10E+00	mg/kg	2.10E+00	mg/kg (wet)	M	2.67E-07	(mg/kg-day)			
	Fluoroanthene	9.77E-01	mg/kg	9.77E-01	mg/kg (wet)	M	1.24E-07	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	3.11E-06
	Indeno(1,2,3-cd)pyrene	7.27E-01	mg/kg	7.27E-01	mg/kg (wet)	M	9.25E-08	(mg/kg-day)			
	Pyrene	8.58E-01	mg/kg	8.58E-01	mg/kg (wet)	M	1.09E-07	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	3.64E-06
	Aluminum	1.55E+04	mg/kg	1.55E+04	mg/kg (wet)	M	1.97E-03	(mg/kg-day)	1.0E+00	$(mg/kg\text{-}day)^{-1}$	1.97E-03
	Arsenic	1.45E+00	mg/kg	1.45E+00	mg/kg (wet)	M	1.84E-07	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	6.15E-04
	Fluoride (Total)	3.92E+03	mg/kg	3.92E+03	mg/kg (wet)	M	4.99E-04	(mg/kg-day)	6.0E-02	$(mg/kg\text{-}day)^{-1}$	8.31E-03
										Total Non-Cancer Health Hazard from Ingestion Pathway	1.1E-02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (50 mg/day *0.000001 kg/mg* 65 days/year * 64 years)/(64 years *365 days/year *70 kgs)

Table B28
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment
Expsoure Point:	Sediment - Reaches 7&8
Receptor Population:	Mohawk Angler
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Route EPC Units	Route EPC Values	Route EPC Units	EPC Selected for Hazard Calculation (1)	Intake (Non Cancer)	Absorption Factor Unitless ABS	Intake (Non Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Acetone	2.26E-01	mg/kg	2.26E-01	mg/kg (wet)	M						
	2-Butanone	3.65E-02	mg/kg	3.65E-02	mg/kg (wet)	M						
	Carbon Disulfide	1.50E-02	mg/kg	1.50E-02	mg/kg (wet)	M						
	Methylene Chloride	3.31E-02	mg/kg	3.31E-02	mg/kg (wet)	M						
	Benzo(a)anthracene	1.04E+00	mg/kg	1.04E+00	mg/kg (wet)	M	3.22E-07	0.13	(mg/kg-day)			
	Benzo(a)pyrene	9.73E-01	mg/kg	9.73E-01	mg/kg (wet)	M	3.01E-07	0.13	(mg/kg-day)			
	Benzo(b)fluoroanthene	2.83E+00	mg/kg	2.83E+00	mg/kg (wet)	M	8.76E-07	0.13	(mg/kg-day)			
	Benzo(ghi)perylene	7.63E-01	mg/kg	7.63E-01	mg/kg (wet)	M	2.36E-07	0.13	(mg/kg-day)			
	Benzo(K)fluoroanthene	7.64E-01	mg/kg	7.64E-01	mg/kg (wet)	M	2.37E-07	0.13	(mg/kg-day)			
	Chrysene	2.10E+00	mg/kg	2.10E+00	mg/kg (wet)	M	6.50E-07	0.13	(mg/kg-day)			
	Fluoroanthene	9.77E-01	mg/kg	9.77E-01	mg/kg (wet)	M	3.02E-07	0.13	(mg/kg-day)	4.0E-02	$(mg/kg\text{-}day)^{-1}$	7.56E-06
	Indeno(1,2,3-cd)pyrene	7.27E-01	mg/kg	7.27E-01	mg/kg (wet)	M	2.25E-07	0.13	(mg/kg-day)			
	Pyrene	8.58E-01	mg/kg	8.58E-01	mg/kg (wet)	M	2.66E-07	0.13	(mg/kg-day)	3.00E-02	$(mg/kg\text{-}day)^{-1}$	8.85E-06
	Aluminum	1.55E+04	mg/kg	1.55E+04	mg/kg (wet)	M						
	Arsenic	1.45E+00	mg/kg	1.45E+00	mg/kg (wet)	M	1.04E-07	0.03	(mg/kg-day)	3.0E-04	$(mg/kg\text{-}day)^{-1}$	3.45E-04
	Fluoride (Total)	3.92E+03	mg/kg	3.92E+03	mg/kg (wet)	M						
											Total Non-Cancer Health Hazard from Ingestion Pathway	3.6E-04
											Total Non-Cancer Health Hazard from Ingestion and Dermal Pathways	0.01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for risk calculation.
(2) Exposure Factors: (3120 cm2* 0.3 mg/cm2 * Dermal Absorption Factor * 1E-06 kg/mg * 65 days/year * 64 years) / (64 years * 365 days/year * 70 kgs)

Table B29
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake Cancer (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Units	Cancer Risk
Ingestion	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M		1.2E-03	(mg/kg-day)		(mg/kg-day)	
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M		4.8E-05	(mg/kg-day)		(mg/kg-day)	
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M		8.3E-06	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk Ingestion				0E+00
Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake Cancer (3)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Units	Cancer Risk
Dermal	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M	1.00E-03	9.4E-04	(mg/kg-day)		(mg/kg-day)	
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M	1.00E-03	3.8E-05	(mg/kg-day)		(mg/kg-day)	
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M	1.00E-04	6.6E-07	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk - Dermal				0E+00
								Total Lifetime Cancer Risk from Ingestion and Dermal Pathways				0E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (0.05 L/day * 2 hours/day * 13 days/year * 12 years)/(70 years * 365 days/year * 70 kgs)
(3) Exposure Factors: (1 liter/1000 cm2 *13500 cm2 * dermal permeability constant *13 days/year * 12 years)/(70 years *365 days/year * 70 kgs)

Table B30
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Units	Cancer Risk
Ingestion	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M		5.3E-03	(mg/kg-day)		(mg/kg-day)	
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M		2.1E-04	(mg/kg-day)		(mg/kg-day)	
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M		3.7E-05	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk Ingestion				0E+00
Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake (Cancer) (3)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Units	Cancer Risk
Dermal	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M	1.00E-03	2.8E-03	(mg/kg-day)		(mg/kg-day)	
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M	1.00E-03	1.2E-04	(mg/kg-day)		(mg/kg-day)	
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M	1.00E-04	2.0E-06	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk - Dermal				0E+00
								Total Lifetime Cancer Risk from Ingestion and Dermal Pathways				0E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (0.05 L/day * 2 hours/day * 39 days/year * 12 years)/(70 years * 365 days/year * 47 kgs)
(3) Exposure Factors: (1 liter/1000 cm2 *13500 cm2 * dermal permeability constant (cm/hour) * 39 days/year * 12 years)/(70 years *365 days/year * 47 kgs)

Table B31
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Units	Cancer Risk
Ingestion	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M		2.7E-03	(mg/kg-day)		(mg/kg-day)	
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M		1.1E-04	(mg/kg-day)		(mg/kg-day)	
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M		1.9E-05	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk Ingestion				0E+00
Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake (Cancer) (3)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Units	Cancer Risk
Dermal	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M	1.00E-03	7.3E-04	(mg/kg-day)		(mg/kg-day)	
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M	1.00E-03	3.0E-05	(mg/kg-day)		(mg/kg-day)	
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M	1.00E-04	5.1E-07	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk - Dermal				0E+00
								Total Lifetime Cancer Risk from Ingestion and Dermal Pathways				0E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (0.05 L/day * 2 hours/day * 13 days/year * 6 years)/(70 years * 365 days/year * 15 kgs)
(3) Exposure Factors: (1 liter/1000 cm2 *13500 cm2 * dermal permeability constant (cm/hour) *13 days/year * 6 years)/(70 years *365 days/year * 15 kgs)

Table B32
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 4-8
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Molecular Weight (MW)	Log Kow log/kow	Permeability Coefficient cm/hr PC	Fraction Absorbed Water FA	Lag Time per event T lag	Time to Reach Steady State t* lag	Permeability coefficient across epidermis B	Dose per event mg/c2 event Daevent	Intake (Cancer) (2)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risks
Ingestion	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M									5.1E-06	(mg/kg-day)	4.6E-02	(mg/kg-day)	2.3E-07
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M									3.7E-07	(mg/kg-day)	1.4E-02	(mg/kg-day)	5.1E-09
	Dioxin TEQ (4)	2.40E-09	mg/l	2.40E-09	mg/l	M									2.1E-14	(mg/kg-day)	1.6E+05	(mg/kg-day)	3.3E-09
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M									2.6E-13	(mg/kg-day)			
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M									1.7E-13	(mg/kg-day)			
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M									2.9E-12	(mg/kg-day)			
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M									4.2E-03	(mg/kg-day)			
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M									3.3E-05	(mg/kg-day)			
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M									5.1E-05	(mg/kg-day)			
																Total Cancer Risks - Ingestion			2E-07

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Molecular Weight (MW)	Log Kow log/kow	Permeability Coefficient cm/hr PC	Fraction Absorbed Water FA	Lag Time per event T lag	Time to Reach Steady State t* lag	Permeability coefficient across epidermis B	Dermal Absorbed Dose per event mg/c2 event Daevent	Intake (Cancer) (3)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risks
Dermal	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	3.6E-08	(mg/kg-day)	4.6E-02	(mg/kg-day)	1.7E-09
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M	391	5.11	2.50E-02	0.8	20	40	0.2	3.40E-06	2.3E-08	(mg/kg-day)	1.4E-02	(mg/kg-day)	3.2E-10
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M	425.2	8	1.30E+00	0.5	7	30	6	2.04E-10	3.6E-13	(mg/kg-day)	1.6E+03	(mg/kg-day)	5.8E-10
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M	306	6.1	3.40E-01	0.5	7	30	6	3.47E-11	6.1E-14	(mg/kg-day)	1.6E+04	(mg/kg-day)	9.8E-10
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M	460	8.2	1.20E+00	0.5	7	30	6	1.95E-09	3.4E-12	(mg/kg-day)	4.8E+01	(mg/kg-day)	1.6E-10
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M			1.00E-03					9.60E-01	1.7E-03	(mg/kg-day)			
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M			1.00E-03					7.60E-03	1.3E-05	(mg/kg-day)			
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M			1.00E-04					1.18E-03	2.1E-06	(mg/kg-day)			
																Total Cancer Risks Dermal			4E-09
																Total Cancer Risks for Ingestion and Dermal Exposures			2E-07

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (0.05 L/day * 2 hours/day * 13 days/year * 12 years)/(70 years * 365 days/year * 70 kgs)
(3) Exposure Factors: (1 liter/1000 cm2 *13500 cm2 * dermal permeability constant *13 days/year * 12 years)/(70 years *365 days/year * 70 kgs)

(4) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HPCDD	3.00E-08	0.01	3E-10
2,3,7,8-TCDF	2.00E-08	0.1	2E-09
OCDD	3.30E-07	0.0003	9.9E-11
	TEQ		2.4E-09

Table B33
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 4-8
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Molecular Weight (MW)	Log Kow log/kow	Permeability Coefficient cm/hr PC	Fraction Absorbed Water FA	Lag Time per event T lag	Time to Reach Steady State t* lag	Permeability coefficient across epidermis B	Dose per event mg/c2 event Daevent	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	ADAF Factor	Cancer Risks
Ingestion	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M									2.3E-05	(mg/kg-day)	9.3E-03	(mg/kg-day)	3	6.3E-07
	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M									2.3E-05	(mg/kg-day)	3.7E-02	(mg/kg-day)	1	8.4E-07
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M									1.6E-06	(mg/kg-day)	1.4E-02	(mg/kg-day)	1	2.3E-08
	Dioxin TEQ (4)	2.40E-09	mg/l	2.40E-09	mg/l	M									9.4E-14	(mg/kg-day)	1.6E+05	(mg/kg-day)	1	1.5E-08
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M														
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M														
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M														
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M														
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M														
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M														
																Total Cancer Risks Ingestion				2E-06
Dermal	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	1.1E-07	(mg/kg-day)	4.6E-02	(mg/kg-day)	3	1.5E-08
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M	391	5.11	2.50E-02	0.8	20	40	0.2	3.40E-06	7.0E-08	(mg/kg-day)	1.3E-02	(mg/kg-day)	1	3.0E-10
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M	425.2	8	1.30E+00	0.5	7	30	6	2.04E-10	1.1E-12	(mg/kg-day)	1.6E+03	(mg/kg-day)	1	6.0E-10
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M	306	6.1	3.40E-01	0.5	7	30	6	3.47E-11	1.8E-13	(mg/kg-day)	1.6E+04	(mg/kg-day)	1	1.00E-09
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M	460	8.2	1.20E+00	0.5	7	30	6	1.95E-09	1.0E-11	(mg/kg-day)	4.8E+01	(mg/kg-day)	1	2.00E-10
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M									5.1E-03	(mg/kg-day)				
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M									4.0E-05	(mg/kg-day)				
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M									6.2E-06	(mg/kg-day)				
																Total Cancer Risks Dermal				2E-08
																Total Cancer Risks for Ingestion and Dermal Exposures				2E-06

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (0.05 L/day * 2.6 hours/day * 39 days/year * 12 years)/(70 years * 365 days/year * 47 kgs)
(3) Exposure Factors: (1 liter/1000 cm2 *13500 cm2 * dermal permeability constant (cm/hour) * 39 days/year * 12 years)/(70 years *365 days/year * 47 kgs)

(4) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HPCDD	3.00E-08	0.01	3E-10
2,3,7,8-TCDF	2.00E-08	0.1	2E-09
OCDD	3.30E-07	0.0003	9.9E-11
	TEQ		2.4E-09

Table B34
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 4-8
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Molecular Weight (MW)	Log Kow log/kow	Permeability Coefficient cm/hr PC	Fraction Absorbed Water FA	Lag Time per event T lag	Time to Reach Steady State t* lag	Permeability coefficient across epidermis B	Dose per event mg/c2 event Daevent	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	ADAFs	Cancer Risks
Ingestion	Trichloroethylene (1 to < 2 years)	5.80E-01	mg/l	5.80E-01	mg/l	M									3.9E-06	(mg/kg-day)	9.3E-03	(mg/kg-day)	10	3.7E-07
	Trichloroethylene (1 to < 2 years)	5.80E-01	mg/l	5.80E-01	mg/l	M									3.9E-06	(mg/kg-day)	3.7E-02	(mg/kg-day)	1	1.5E-07
	Trichloroethylene (2 to 6 years)	5.80E-01	mg/l	5.80E-01	mg/l	M									7.9E-06	(mg/kg-day)	9.7E-03	(mg/kg-day)	3	2.3E-07
	Trichloroethylene (2 to 6 years)	5.80E-01	mg/l	5.80E-01	mg/l	M									7.9E-06	(mg/kg-day)	3.7E-02	(mg/kg-day)	1	2.9E-07
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M									8.5E-07	(mg/kg-day)	1.4E-02	(mg/kg-day)	1	1.2E-08
	Dioxin TEQ (4)	2.40E-09	mg/l	2.40E-09	mg/l	M									4.9E-14	(mg/kg-day)	1.6E+05	(mg/kg-day)	1	7.6E-09
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M														
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M														
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M														
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M														
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M														
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M														
																		Total Cancer Risks Ingestion		1E-06
Dermal	Trichloroethylene (0 to < 2 years)	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	9.3E-09	(mg/kg-day)	9.3E-03	(mg/kg-day)	10	8.7E-11
	Trichloroethylene (0 to < 2 years)	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	9.3E-09	(mg/kg-day)	3.7E-02	(mg/kg-day)	1	3.5E-10
	Trichloroethylene (2 to 6 years)	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	1.9E-08	(mg/kg-day)	9.7E-03	(mg/kg-day)	3	1.8E-10
	Trichloroethylene (2 to 6 years)	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	1.9E-08	(mg/kg-day)	3.7E-02	(mg/kg-day)	1	6.9E-10
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M	391	5.11	2.50E-02	0.8	20	40	0.2	3.40E-06	2.3E-08	(mg/kg-day)	1.4E-02	(mg/kg-day)	1	3.0E-10
	Dioxin TEQ (4)	2.40E-09	mg/l	2.40E-09	mg/l	M								3.47E-11	6.1E-14	(mg/kg-day)	1.6E+04	(mg/kg-day)	1	1.00E-09
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M	425.2	8	1.30E+00	0.5	7	30	6	2.04E-10	3.6E-13	(mg/kg-day)	1.6E+03	(mg/kg-day)	1	6.0E-10
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M	306	6.1	3.40E-01	0.5	7	30	6	3.47E-11	6.1E-14	(mg/kg-day)	1.6E+04	(mg/kg-day)	1	1.00E-09
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M	460	8.2	1.20E+00	0.5	7	30	6	1.95E-09	3.4E-12	(mg/kg-day)	4.8E+01	(mg/kg-day)	1	2.00E-10
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M														
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M														
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M														
																		Total Cancer Risks Dermal		4E-09
																		Total Cancer Risks for Ingestion and Dermal Exposures		1E-06

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (0.05 L/day * 2.6 hours/day * 13 days/year * 6 years)/(70 years * 365 days/year * 15 kgs)
(3) Exposure Factors: (1 liter/1000 cm2 *13500 cm2 * dermal permeability constant (cm/hour) * 39 days/year * 12 years)/(70 years *365 days/year * 47 kgs)
(4) Calculated TEQ Based on 2010 TEFs.

1,2,3,4,6,7,8-HPCDD	3.00E-08	0.01	3E-10
2,3,7,8-TCDF	2.00E-08	0.1	2E-09
OCDD	3.30E-07	0.0003	9.9E-11
			2.4E-09

Table B35
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M		1.4E-02	(mg/kg-day)	1E+00	(mg/kg-day)	1E-02
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M		5.6E-04	(mg/kg-day)	6E-02	(mg/kg-day)	5E-03
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M		9.7E-05	(mg/kg-day)			
								Total Lifetime Cancer Risk Ingestion				2E-02
Dermal	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M	1.00E-03	2.7E-03	(mg/kg-day)	1E+00	(mg/kg-day)	3E-03
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M	1.00E-03	1.1E-04	(mg/kg-day)	6E-02	(mg/kg-day)	2E-03
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M	1.00E-04	1.9E-06	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk - Dermal				5E-03
								Total Lifetime Cancer Risk from Ingestion and Dermal Pathways				0.02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (Concentration * 0.05 L/day * 2 hours/day * 13 days/year * 12 years)/(12 years * 365 days/year * 70 kgs)
(3) Exposure Factors: (Concentration * 1 liter/1000 cm2 * 20000 cm2 * dermal permeability constant (cm/hour) * 13 days/year * 12 years)/(12 years *365 days/year * 70 kgs)

Table B36
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M		6.14E-02	(mg/kg-day)	1E+00	(mg/kg-day)	6E-02
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M		2.50E-03	(mg/kg-day)	6E-02	(mg/kg-day)	5E-03
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M		4.32E-04	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk Ingestion				7E-02
Dermal	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M	1.00E-03	8.29E-03	(mg/kg-day)	1E+00	(mg/kg-day)	8E-03
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M	1.00E-03	3.38E-04	(mg/kg-day)	6E-02	(mg/kg-day)	6E-03
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M	1.00E-04	5.83E-06	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk - Dermal				1E-02
								Total Lifetime Cancer Risk from Ingestion and Dermal Pathways				0.09

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (Concentration * 0.05 L/day * 2 hours/day * 39 days/year * 12 years)/(70 years * 365 days/year * 47 kgs)
(3) Exposure Factors: (Concentration * 1 liter/1000 cm2 *13500 cm2 * dermal permeability constant (cm/hour) * 39 days/year * 12 years)/(70 years *365 days/year * 47 kgs)

Table B37
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 1-2
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient cm/hr	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Reference Dose	Reference Dose Units	Hazard Quotient
Ingestion	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M		6.41E-02	(mg/kg-day)	1E+00	(mg/kg-day)	6E-02
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M		2.61E-03	(mg/kg-day)	6E-02	(mg/kg-day)	5E-03
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M		4.51E-04	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk Ingestion				7E-02
Dermal	Aluminum	2.70E+02	mg/l	2.70E+02	mg/l	M	1.00E-03	4.26E-03	(mg/kg-day)	1E+00	(mg/kg-day)	4E-03
	Fluoride	1.10E+01	mg/l	1.10E+01	mg/l	M	1.00E-03	3.38E-04	(mg/kg-day)	6E-02	(mg/kg-day)	6E-03
	Lead	1.90E+00	mg/l	1.90E+00	mg/l	M	1.00E-04	5.83E-06	(mg/kg-day)		(mg/kg-day)	
								Total Lifetime Cancer Risk - Dermal				1E-02
								Total Lifetime Cancer Risk from Ingestion and Dermal Pathways				0.09

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (Concentration * 0.05 L/day * 2 hours/day * 139 days/year * 6 years)/(6 years * 365 days/year * 15 kgs)
(3) Exposure Factors: (Concentration * 1 liter/1000 cm2 *6640 cm2 * dermal permeability constant (cm/hour) * 13 days/year * 6 years)/(6 years *365 days/year * 15 kgs)

Table B38
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 4-8
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Molecular Weight (MW)	Log Kow log/kow	Permeability Coefficient cm/hr PC	Fraction Absorbed Water FA	Lag Time per event T lag	Time to Reach Steady State t* lag	Permeability coefficient across epidermis B	Dose per event mg/c2 event Daevent	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Haard Index
Ingestion	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M									3.0E-05	(mg/kg-day)	5.0E-04	(mg/kg-day)	5.9E-02
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M									2.1E-06	(mg/kg-day)	2.0E-02	(mg/kg-day)	1.1E-04
	Dioxin TEQ (4)	3.13E-06	mg/l	3.13E-06	mg/l	M									1.6E-10		7.0E-10	(mg/kg-day)	2.3E-01
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M													
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M													
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M													
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M									2.4E-02	(mg/kg-day)			
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M									1.9E-04	(mg/kg-day)			
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M									3.0E-04	(mg/kg-day)			
															Total Non-Cancer Hazards - Ingestion				3E-01
Dermal	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	6.3E-07	(mg/kg-day)	5.0E-04	(mg/kg-day)	1.3E-03
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M	391	5.11	2.50E-02	0.8	20	40	0.2	3.40E-06	4.1E-07	(mg/kg-day)	2.0E-02	(mg/kg-day)	2.1E-05
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M	425.2	8	1.30E+00	0.5	7	30	6	2.04E-10	6.3E-12	(mg/kg-day)	1.6E+03	(mg/kg-day)	3.9E-15
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M	306	6.1	3.40E-01	0.5	7	30	6	3.47E-11	1.1E-12	(mg/kg-day)	1.6E+04	(mg/kg-day)	6.9E-17
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M	460	8.2	1.20E+00	0.5	7	30	6	1.95E-09	6.0E-11	(mg/kg-day)	4.8E+01	(mg/kg-day)	1.3E-12
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M			1.00E-03					9.60E-01	2.9E-02	(mg/kg-day)	1.0E+00	(mg/kg-day)	2.9E-02
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M			1.00E-03					7.60E-03	2.3E-04	(mg/kg-day)	6.0E-02	(mg/kg-day)	3.8E-03
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M			1.00E-04					1.18E-03	3.6E-05	(mg/kg-day)			
															Total Non-cancer Hazards - Dermal				3E-02
															Total Non-cancer Hazards for Ingestion and Dermal Exposures				3E-01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (Concentration * 0.05 L/day * 2 hours/day * 13 days/year * 12 years)/(12 years * 365 days/year * 70 kgs)
(3) Exposure Factors: (Concentration * 1 liter/1000 cm2 * 20000 cm2 * dermal permeability constant (cm/hour) * 13 days/year * 12 years)/(12 years *365 days/year * 70 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of
2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

TEF Reference Dose	1,2,3,4,6,7,8-HpCDD	7.00E-10	0.01	7.00E-08
	2,3,7,8-TCDF	7.00E-10	0.1	7.00E-09
	OCDD	7.00E-10	0.0003	2.33E-06

Table B39
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 4-8
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Molecular Weight (MW)	Log Kow log/kow	Permeability Coefficient cm/hr PC	Fraction Absorbed Water FA	Lag Time per event T lag	Time to Reach Steady State t* lag	Permeability coefficient across epidermis B	Dose per event mg/c2 event Daevent	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Hazard Index
Ingestion	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M									1.3E-04	(mg/kg-day)	5.0E-04	(mg/kg-day)	2.6E-01
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M									9.5E-06	(mg/kg-day)	2.0E-02	(mg/kg-day)	4.8E-04
	Dioxin TEQ (4)	2.40E-09	mg/l	2.40E-09	mg/l	M									5.5E-13	(mg/kg-day)	7.0E-10	(mg/kg-day)	7.8E-04
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M													
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M													
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M													
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M									1.1E-01	(mg/kg-day)			
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M									8.6E-04	(mg/kg-day)			
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M									1.3E-03	(mg/kg-day)			
															Total Non-Cancer Hazards - Ingestion				3E-01
Dermal	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	3.2E-07	(mg/kg-day)	5.0E-04	(mg/kg-day)	6.4E-04
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M	391	5.11	2.50E-02	0.8	20	40	0.2	1.00E-05	2.1E-07	(mg/kg-day)	2.0E-02	(mg/kg-day)	1.1E-05
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M	425.2	8	1.30E+00	0.5	7	30	6	2.00E-10	3.20E-12	(mg/kg-day)	7.00E-08	(mg/kg-day)	4.6E-05
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M	306	6.1	3.40E-01	0.5	7	30	6	3.00E-11	5.50E-13	(mg/kg-day)	7.00E-09	(mg/kg-day)	7.9E-05
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M	460	8.2	1.20E+00	0.5	7	30	6	2.00E-09	3.10E-11	(mg/kg-day)	2.33E-06	(mg/kg-day)	1.3E-05
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M			1.00E-03					1.00E+00	1.5E-02	(mg/kg-day)	1.0E+00	(mg/kg-day)	1.5E-02
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M			1.00E-03					8.00E-03	1.2E-04	(mg/kg-day)	6.0E-02	(mg/kg-day)	2.0E-03
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M			1.00E-04					1.00E-03	1.9E-05	(mg/kg-day)			
															Total Non-Cancer Hazards - Dermal				2E-02
															Total Non-Cancer Hazards for Ingestion and Dermal Exposures				3E-01

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (Concentration * 0.05 L/day * 2 hours/day * 39 days/year * 12 years)/(12 years * 365 days/year * 70 kgs)
(3) Exposure Factors: (Concentration * 1 liter/1000 cm2 * 13500 cm2 * dermal permeability constant (cm/hour) * 39 days/year * 12 years)/(12 years *365 days/year * 47 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of
2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

TCDD Reference Dose	1,2,3,4,6,7,8-HpCDD	7.00E-10	0.01	7.00E-08
	2,3,7,8-TCDF	7.00E-10	0.1	7.00E-09
	OCDD	7.00E-10	0.0003	2.33E-06

7.00E-10	0.01
7.00E-10	0.1
7.00E-10	0.0003

Table B40
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 4-8
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Molecular Weight (MW)	Log Kow log/kow	Permeability Coefficient cm/hr PC	Fraction Absorbed Water FA	Lag Time per event T lag	Time to Reach Steady State t* lag	Permeability coefficient across epidermis B	Dose per event mg/c2 event Daevent	Intake (Non-Cancer)	Intake (Non-Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Hazard Index
Ingestion	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M									1.4E-04	(mg/kg-day)	5.0E-04	(mg/kg-day)	2.8E-01
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M									1.0E-05	(mg/kg-day)	2.0E-02	(mg/kg-day)	5.0E-04
	Dioxin TEQ (4)	2.40E-09	mg/l	2.40E-09	mg/l	M									5.7E-13	(mg/kg-day)	7.0E-10	(mg/kg-day)	8.1E-04
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M													
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M													
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M													
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M									1.1E-01	(mg/kg-day)			
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M									9.0E-04	(mg/kg-day)			
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M									1.4E-03	(mg/kg-day)			
															Total Cancer Risks Ingestion				3E-01
Dermal	Trichloroethylene	5.80E-01	mg/l	5.80E-01	mg/l	M	131.4	2.42	1.20E-02	1	0.6	1	1	2.00E-05	3.2E-07	(mg/kg-day)	5.0E-04	(mg/kg-day)	6.4E-04
	Bis(2-ethylhexyl)Phthalate	4.20E-02	mg/l	4.20E-02	mg/l	M	391	5.11	2.50E-02	0.8	20	40	0.2	3.40E-06	2.1E-07	(mg/kg-day)	2.0E-02	(mg/kg-day)	1.1E-05
	1,2,3,4,6,7,8-HPCDD	3.00E-08	mg/l	3.00E-08	mg/l	M	425.2	8	1.30E+00	0.5	7	30	6	2.04E-10	3.2E-12	(mg/kg-day)	7.00E-08	(mg/kg-day)	4.6E-05
	2,4,7,8-TCDF	2.00E-08	mg/l	2.00E-08	mg/l	M	306	6.1	3.40E-01	0.5	7	30	6	3.47E-11	5.5E-13	(mg/kg-day)	7.00E-09	(mg/kg-day)	7.9E-05
	OCDD	3.30E-07	mg/l	3.30E-07	mg/l	M	460	8.2	1.20E+00	0.5	7	30	6	1.95E-09	3.1E-11	(mg/kg-day)	2.33E-06	(mg/kg-day)	1.3E-05
	Aluminum	4.80E+02	mg/l	4.80E+02	mg/l	M			1.00E-03					9.60E-01	1.5E-02	(mg/kg-day)	1.0E+00	(mg/kg-day)	
	Fluoride (Total)	3.80E+00	mg/l	3.80E+00	mg/l	M			1.00E-03					7.60E-03	1.2E-04	(mg/kg-day)	6.0E-02	(mg/kg-day)	
	Lead	5.90E+00	mg/l	5.90E+00	mg/l	M			1.00E-04					1.18E-03	1.9E-05	(mg/kg-day)			
															Total Non-Cancer Hazards - Dermal				8E-04
															Total Non-Cancer Hazards for Ingestion and Dermal Exposures				0.3

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Exposure Factors: (Concentration * 0.05 L/day * 2 hours/day * 13 days/year * 6 years)/(6 years * 365 days/year * 70 kgs)
(3) Exposure Factors: (Concentration * 1 liter/1000 cm2 * 2190 cm2 * dermal permeability constant (cm/hour) * 13 days/year * 6 years)/(6 years *365 days/year * 15 kgs)
(3) Updated TEFs Based on the 2010 document titled "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of
2,3,7,8Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds", (EPA/100/R 10/005, December 2010.

1,2,3,4,6,7,8-HpCDD	7.00E-10	0.01	7.00E-08
2,3,7,8-TCDF	7.00E-10	0.1	7.00E-09
OCDD	7.00E-10	0.0003	2.33E-06

Table B41
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 9 / wading
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Permeability Coefficient (cm/hour)	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Dermal	Aluminum	8.40E+02	mg/l	8.40E+02	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Barium	3.50E+01	mg/l	3.50E+01	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Cyanide	3.00E-02	mg/l	3.00E-02	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Fluoride	3.60E+00	mg/l	3.60E+00	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Lead	5.60E+00	mg/l	5.60E+00	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
											Total Hazard Index Across All Exposure Routes/Pathways	0E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

Table B42
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 9 / wading
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Dermal Permeability Factor	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor	Cancer Slope Factor Units	Cancer Risk
Dermal	Aluminum	8.40E+02	mg/l	8.40E+02	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Barium	3.50E+01	mg/l	3.50E+01	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Cyanide	3.00E-02	mg/l	3.00E-02	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Fluoride	3.60E+00	mg/l	3.60E+00	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
	Lead	5.60E+00	mg/l	5.60E+00	mg/l	M	NA	NA	(mg/kg-day)	NA	(mg/kg-day)	NA
											Total Hazard Index Across All Exposure Routes/Pathways	0E+00

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.

Table B43
Calculation of Cancer Risks
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 9 / wading
Receptor Population:	Recreational User
Receptor Age:	Child

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Dermal Permeability Constant	Intake (Non-Cancer)	Intake (Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Hazard Index
Dermal	Aluminum	8.40E+02	mg/l	8.40E+02	mg/l	M	1.0E-03	2.6E-03	(mg/kg-day)	1.0E+00	(mg/kg-day)	2.6E-03
	Barium	3.50E+01	mg/l	3.50E+01	mg/l	M	1.0E-03	1.1E-04	(mg/kg-day)	2.0E-01	(mg/kg-day)	5.5E-04
	Cyanide	3.00E-02	mg/l	3.00E-02	mg/l	M	1.0E-03	9.3E-08	(mg/kg-day)	2.0E-02	(mg/kg-day)	4.7E-06
	Fluoride	3.60E+00	mg/l	3.60E+00	mg/l	M	1.0E-03	1.1E-05	(mg/kg-day)	6.0E-02	(mg/kg-day)	1.8E-04
	Lead	5.60E+00	mg/l	5.60E+00	mg/l	M	1.0E-04	1.7E-06	(mg/kg-day)	NA	(mg/kg-day)	
											Total Hazard Index Across All Exposure Routes/Pathways	3E-03

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic. Barium corrected for GI Absorption (7%).

Table B44
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 9 / wading
Receptor Population:	Recreational User
Receptor Age:	Adult

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Dermal Permeability Constant	Intake (Non-Cancer)	Intake (Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Hazard Index
Dermal	Aluminum	8.40E+02	mg/l	8.40E+02	mg/l	M	1.0E-03	2.6E-03	(mg/kg-day)	1.0E+00	(mg/kg-day)	2.6E-03
	Barium	3.50E+01	mg/l	3.50E+01	mg/l	M	1.0E-03	1.1E-04	(mg/kg-day)	2.0E-01	(mg/kg-day)	5.5E-04
	Cyanide	3.00E-02	mg/l	3.00E-02	mg/l	M	1.0E-03	9.3E-08	(mg/kg-day)	2.0E-02	(mg/kg-day)	4.7E-06
	Fluoride	3.60E+00	mg/l	3.60E+00	mg/l	M	1.0E-03	1.1E-05	(mg/kg-day)	6.0E-02	(mg/kg-day)	1.8E-04
	Lead	5.60E+00	mg/l	5.60E+00	mg/l	M	1.0E-04	1.7E-06	(mg/kg-day)	NA	(mg/kg-day)	
											Total Hazard Index Across All Exposure Routes/Pathways	3E-03

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic. Barium corrected for GI Absorption (7%).

Table B45
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 9 / wading
Receptor Population:	Recreational User
Receptor Age:	Youth

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Dermal Permeability Constant	Intake (Non-Cancer)	Intake (Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Hazard Index
Dermal	Aluminum	8.40E+02	mg/l	8.40E+02	mg/l	M	1.0E-03	8.2E-03	(mg/kg-day)	1.0E+00	(mg/kg-day)	8.2E-03
	Barium	3.50E+01	mg/l	3.50E+01	mg/l	M	1.0E-03	3.4E-04	(mg/kg-day)	2.0E-01	(mg/kg-day)	1.7E-03
	Cyanide	3.00E-02	mg/l	3.00E-02	mg/l	M	1.0E-03	2.9E-07	(mg/kg-day)	2.0E-02	(mg/kg-day)	1.5E-05
	Fluoride	3.60E+00	mg/l	3.60E+00	mg/l	M	1.0E-03	3.5E-05	(mg/kg-day)	6.0E-02	(mg/kg-day)	5.8E-04
	Lead	5.60E+00	mg/l	5.60E+00	mg/l	M	1.0E-04	5.5E-06	(mg/kg-day)	NA	(mg/kg-day)	
											Total Hazard Index Across All Exposure Routes/Pathways	1E-02

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic. Barium corrected for GI Absorption (7%).

Table B46
Calculation of Non-Cancer Hazards
Reasonable Maximum Exposure
Grasse River Sudy Area, Massena, NY

Scenario Timeframe:	Current/Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Expsoure Point:	Surface Water - Reaches 9 / wading
Receptor Population:	Recreational User
Receptor Age:	Child (1 to 6 years)

Exposure Route	Chemicals of Potential Concern	Medium EPC Value	Medium EPC Units	Route EPC Value	Route EPC Units	EPC Selected for Risk Calculation (1)	Dermal Permeability Constant	Intake (Non-Cancer)	Intake (Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Hazard Index
Dermal	Aluminum	8.40E+02	mg/l	8.40E+02	mg/l	M	1.0E-03	5.6E-03	(mg/kg-day)	1.0E+00	(mg/kg-day)	5.6E-03
	Barium	3.50E+01	mg/l	3.50E+01	mg/l	M	1.0E-03	2.3E-04	(mg/kg-day)	2.0E-01	(mg/kg-day)	1.2E-03
	Cyanide	3.00E-02	mg/l	3.00E-02	mg/l	M	1.0E-03	2.0E-07	(mg/kg-day)	2.0E-02	(mg/kg-day)	1.0E-05
	Fluoride	3.60E+00	mg/l	3.60E+00	mg/l	M	1.0E-03	2.4E-05	(mg/kg-day)	6.0E-02	(mg/kg-day)	4.0E-04
	Lead	5.60E+00	mg/l	5.60E+00	mg/l	M	1.0E-04	3.7E-06	(mg/kg-day)	NA	(mg/kg-day)	
											Total Hazard Index Across All Exposure Routes/Pathways	7E-03

(1) Specify Medium-Specific (M) or Route-Specific (R) EPC selected for hazard calculation.
(2) Specify if subchronic. Barium corrected for GI Absorption (7%).

Appendix G2: Additional Supporting Information – ProUCL Outputs and 1993 Risk Assessment Data

ProUCL Output for the Power Canal Fish Data

General UCL Statistics for Data Sets with Non-Detects

User Selected Options

From File	G:\D_Drive\Projects\Alcoa\Grasse_River\Data Analysis\ProUCL 4.1\Input_Data\ResFish_SMBS_PC_2006to2011.xls.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Tot_PCB_aro

General Statistics

Number of Valid Data	102	Number of Detected Data	82
Number of Distinct Detected Data	81	Number of Non-Detect Data	20
		Percent Non-Detects	19.61%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0514	Minimum Detected	-2.968
Maximum Detected	0.73	Maximum Detected	-0.315
Mean of Detected	0.198	Mean of Detected	-1.837
SD of Detected	0.14	SD of Detected	0.674
Minimum Non-Detect	0.05	Minimum Non-Detect	-2.996
Maximum Non-Detect	0.0541	Maximum Non-Detect	-2.917

Note: Data have multiple DLs - Use of KM Method is recommende		Number treated as Non-Detect	25
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	77
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	24.51%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.147	Lilliefors Test Statistic	0.0893
5% Lilliefors Critical Value	0.0978	5% Lilliefors Critical Value	0.0978
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.165	Mean	-2.195
SD	0.143	SD	0.945
95% DL/2 (t) UCL	0.188	95% H-Stat (DL/2) UCL	0.213

Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.144	Mean in Log Scale	-2.127
SD	0.171	SD in Log Scale	0.85
95% MLE (t) UCL	0.172	Mean in Original Scale	0.167
95% MLE (Tiku) UCL	0.172	SD in Original Scale	0.141
		95% t UCL	0.19
		95% Percentile Bootstrap UCL	0.191
		95% BCA Bootstrap UCL	0.192
		95% H UCL	0.204

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	2.346	Data Follow Appr. Gamma Distribution at 5% Significance Level
Theta Star	0.0846	
nu star	384.8	

A-D Test Statistic	0.841	Nonparametric Statistics	
5% A-D Critical Value	0.762	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.762	Mean	0.17
5% K-S Critical Value	0.0997	SD	0.138
Data follow Appr. Gamma Distribution at 5% Significance Level		SE of Mean	0.0137
		95% KM (t) UCL	0.192
Assuming Gamma Distribution		95% KM (z) UCL	0.192
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	0.192
Minimum	1.00E-06	95% KM (bootstrap t) UCL	0.198
Maximum	0.73	95% KM (BCA) UCL	0.193
Mean	0.16	95% KM (Percentile Bootstrap) UCL	0.192
Median	0.143	95% KM (Chebyshev) UCL	0.229
SD	0.148	97.5% KM (Chebyshev) UCL	0.255
k star	0.292	99% KM (Chebyshev) UCL	0.306
Theta star	0.546		
Nu star	59.61	Potential UCLs to Use	
AppChi2	42.85	95% KM (BCA) UCL	0.193
95% Gamma Approximate UCL (Use when n >= 40)	0.222		
95% Adjusted Gamma UCL (Use when n < 40)	0.223		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006)
For additional insight, the user may want to consult a statistician.

ProUCL Output for the Near Shore Areas Sediment Data

General UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	C:\Jobs\ALCgra\Analysis\Sediment\Near_Shore_all\2010\2010NS.xls.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

TOT_PCB_ARO

General Statistics

Number of Valid Data	245	Number of Detected Data	201
Number of Distinct Detected Data	200	Number of Non-Detect Data	44
		Percent Non-Detects	17.96%

Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0684	Minimum Detected	-2.682
Maximum Detected	281.5	Maximum Detected	5.64
Mean of Detected	5.653	Mean of Detected	0.258
SD of Detected	21.24	SD of Detected	1.626
Minimum Non-Detect	0.0554	Minimum Non-Detect	-2.893
Maximum Non-Detect	0.103	Maximum Non-Detect	-2.273

Note: Data have multiple DLs - Use of KM Method is recommended	Number treated as Non-Detect	54
For all methods (except KM, DL/2, and ROS Methods),	Number treated as Detected	191
Observations < Largest ND are treated as NDs	Single DL Non-Detect Percentage	22.04%

UCL Statistics

Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.396	Lilliefors Test Statistic	0.0427
5% Lilliefors Critical Value	0.0625	5% Lilliefors Critical Value	0.0625
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	

Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	4.644	Mean	-0.383
SD	19.35	SD	2.014
95% DL/2 (t) UCL	6.686	95% H-Stat (DL/2) UCL	7.82

Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.774	Mean in Log Scale	-0.369
SD	22.38	SD in Log Scale	1.995
95% MLE (t) UCL	3.135	Mean in Original Scale	4.645
95% MLE (Tiku) UCL	3.101	SD in Original Scale	19.35
		95% t UCL	6.686
		95% Percentile Bootstrap UCL	6.844
		95% BCA Bootstrap UCL	8.334
		95% H UCL	7.58

Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only
k star (bias corrected)	0.436	Data appear Lognormal at 5% Significance Level
Theta Star	12.95	
nu star	175.4	

A-D Test Statistic	9.772	Nonparametric Statistics	
5% A-D Critical Value	0.835	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.835	Mean	4.65
5% K-S Critical Value	0.0677	SD	19.31
Data not Gamma Distributed at 5% Significance Level		SE of Mean	1.237
		95% KM (t) UCL	6.692
Assuming Gamma Distribution		95% KM (z) UCL	6.684
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	6.691
Minimum	1.00E-06	95% KM (bootstrap t) UCL	9.609
Maximum	281.5	95% KM (BCA) UCL	6.982
Mean	4.638	95% KM (Percentile Bootstrap) UCL	6.913
Median	0.798	95% KM (Chebyshev) UCL	10.04
SD	19.36	97.5% KM (Chebyshev) UCL	12.37
k star	0.195	99% KM (Chebyshev) UCL	16.96
Theta star	23.82		
Nu star	95.39	Potential UCLs to Use	
AppChi2	73.87	97.5% KM (Chebyshev) UCL	12.37
95% Gamma Approximate UCL (Use when n >= 40)	5.989		
95% Adjusted Gamma UCL (Use when n < 40)	5.998		

Note: DL/2 is not a recommended method.

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
For additional insight, the user may want to consult a statistician.

Statistical Summary of Data Used in the 1993 Risk Assessment – Appendix A from the USEPA BLRA (April 1993)

APPENDIX A PART 1: STATISTICAL SUMMARIES OF DATA USED IN THE HUMAN HEALTH RISK ASSESSMENT

- Brown Bullhead and Smallmouth Bass Fillet/Reaches 1 and 2
- Brown Bullhead and Smallmouth Bass Fillet/Reach 3
- Brown Bullhead and Smallmouth Bass Fillet/Reaches 4, 5, 6, 7, and 8
- Brown Bullhead and Smallmouth Bass Fillet/Reaches 7 and 8
- Sediment/Reaches 1 and 2
- Sediment/Reach 3
- Sediment/Reaches 4, 5, and 6
- Sediment/Reaches 7 and 8
- Sediment/Reaches 4, 5, 6, 7, and 8
- Sediment/Reach 9
- Surface Water Filtered/Reaches 1 and 2
- * Surface Water Filtered/Reach 3
- * Surface Water Filtered/Reaches 4, 5, and 6
- * Surface Water Filtered/Reaches 4, 5, 6, 7, and 8
- * Surface Water Filtered/Reaches 7 and 8
- Surface Water Filtered/Reach 9
- Surface Water Unfiltered/Reaches 1 and 2
- Surface Water Unfiltered/Reach 3
- Surface Water Unfiltered/Reaches 4, 5, and 6
- Surface Water Unfiltered/Reaches 4, 5, 6, 7, and 8
- Surface Water Unfiltered/Reaches 7 and 8
- Surface Water Unfiltered/Reach 9

* Missing from original

RECYCLED PAPER

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB & SMB FILLET/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	2	31	60.00	730.00	R1-XF-S46-C-S	44.44	37.87	40.00	50.00
	PCB-1248 (in lipid)	1	14	14600.00	14600.00	R1-XF-S46-C-S	2453.85	3391.96	1428.57	4000.00
	PCB-1254	1	31	160.00	160.00	R2-XF-S19-D-S	27.34	29.79	40.00	200.00
	PCB-1254 (in lipid)	1	14	11428.57	11428.57	R2-XF-S19-D-S	2268.14	3122.53	1428.57	4000.00
	PCB-1260	3	31	40.00	260.00	R1-XF-S46-C-S	29.27	30.57	40.00	50.00
	PCB-1260 (in lipid)	3	17	1428.57	5200.00	R1-XF-S46-C-S	1988.98	2349.00	2222.22	5633.80
	TOTAL PCBs	5	31	40.00	990.00	R1-XF-S46-C-S	58.63	50.59	40.00	50.00
	TOTAL PCBs (in lipid)	4	17	1428.57	19800.00	R1-XF-S46-C-S	3436.04	4694.69	2222.22	5633.80
Inor.	ALUMINUM	3	4	0.69	13.00	R2-XF-S36-C-S	3.77	21941.96	1.00	1.00
	LEAD	2	4	0.05	0.10	R2-XF-S36-C-S	0.05	0.31	0.05	0.05
Other	LIPID CONTENT	29	29	0.05	5.00	R1-XF-S46-C-S	0.99	2.95	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB & SMB FILLET/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
BNAs	DIETHYLPHTHALATE	1	2	4200.00	4200.00	R3-XF-S12-D-S	2182.50	4200.00	330.00	330.00
Pest/PCBs	PCB-1248	7	11	54.00	1200.00	R3-XF-S12-D-S	291.27	2891.26	40.00	40.00
	PCB-1248 (in lipid)	7	7	22222.22	326666.67	R3-XF-S08-D-S	119993.46	378713.10	.	.
	PCB-1260	9	11	84.00	700.00	R3-XF-S12-D-S	174.64	537.87	40.00	40.00
	PCB-1260 (in lipid)	9	9	21818.18	168000.00	R3-XF-S03-D-S	68258.52	124429.38	.	.
	TOTAL PCBs	10	11	86.00	1900.00	R3-XF-S12-D-S	456.82	2424.34	40.00	40.00
	TOTAL PCBs (in lipid)	10	10	21818.18	446666.67	R3-XF-S08-D-S	145428.09	549438.43	.	.
Inor.	ALUMINUM	1	2	3.10	3.10	R3-XF-S23-D-S	1.80	3.10	1.00	1.00
	LEAD	1	2	0.05	0.05	R3-XF-S12-D-S	0.04	0.05	0.05	0.05
Other	LIPID CONTENT	11	11	0.05	0.85	R3-XF-S12-D-S	0.36	0.69	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB & SMB FILLET/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
BNAs	DIETHYLPHTHALATE	1	27	1200.00	1200.00	R6-XF-S17-D-S	536.11	679.49	500.00	3600.00
Dioxins	1,2,3,4,6,7,8-HPCDD	1	1	19.90	19.90	R4-XF-S50-C-S	19.90	19.90	.	.
	1,2,3,4,6,7,8-HPCDF	1	1	20.60	20.60	R4-XF-S50-C-S	20.60	20.60	.	.
	1,2,3,4,7,8-HXCDF	1	1	17.60	17.60	R4-XF-S50-C-S	17.60	17.60	.	.
	1,2,3,6,7,8-HXCDF	1	1	12.60	12.60	R4-XF-S50-C-S	12.60	12.60	.	.
	1,2,3,7,8-PECDF	2	2	18.60	120.00	R4-XF-S10-D-S	69.30	120.00	.	.
	2,3,4,6,7,8-HXCDF	1	1	6.90	6.90	R4-XF-S50-C-S	6.90	6.90	.	.
	2,3,4,7,8-PECDF	1	1	8.40	8.40	R4-XF-S50-C-S	8.40	8.40	.	.
	2,3,7,8-TCDD	1	1	9.10	9.10	R4-XF-S50-C-S	9.10	9.10	.	.
	2,3,7,8-TCDF	1	1	28.30	28.30	R4-XF-S50-C-S	28.30	28.30	.	.
	OCDD	1	2	986.00	986.00	R4-XF-S10-D-S	516.35	986.00	93.40	93.40
	OCDF	2	2	13.30	595.00	R4-XF-S10-D-S	304.15	595.00	.	.
Pest/PCBs	PCB-1248	94	96	100.00	18000.00	R6-XF-S28-D-S	2438.33	3761.91	40.00	40.00
	PCB-1248 (in lipid)	86	87	4000.00	13333333.33	R6-XF-S16-D-S	691023.68	1339650.19	4000.00	4000.00
	PCB-1260	93	96	60.00	4300.00	R6-XF-S16-D-S	794.43	1100.00	40.00	400.00
	PCB-1260 (in lipid)	85	86	2400.00	4777777.78	R6-XF-S16-D-S	242799.18	399478.11	4000.00	4000.00
	TOTAL PCBs	94	96	160.00	21900.00	R6-XF-S28-D-S	3230.26	5063.71	40.00	40.00
	TOTAL PCBs (in lipid)	86	87	6400.00	18111111.11	R6-XF-S16-D-S	931009.07	1762706.42	4000.00	4000.00
Inor.	ALUMINUM	27	28	0.42	1.50	R4-XF-S30-D-S	0.91	1.02	2.00	2.00
	CADMIUM	2	27	0.03	0.03	R6-XF-S11-D-S	0.03	0.03	0.05	0.10
	LEAD	5	28	0.05	0.09	R8-XF-S41-D-S	0.05	0.07	0.01	1.00
Other	LIPID CONTENT	88	89	0.05	5.00	R7-XF-S27-D-S	0.90	1.35	0.05	0.05

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB & SMB FILLET/REACH 7 & 8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	37	39	100.00	3000.00	R7-XF-S50-C-S	1008.46	1998.11	40.00	40.00
	PCB-1248 (in lipid)	32	33	4000.00	4800000.00	R7-XF-S08-D-S	466308.72	2024313.53	4000.00	4000.00
	PCB-1260	37	39	60.00	1100.00	R7-XF-S06-D-S	397.85	646.52	40.00	40.00
	PCB-1260 (in lipid)	32	33	2400.00	1920000.00	R7-XF-S08-D-S	184726.27	617271.50	4000.00	4000.00
	TOTAL PCBs	37	39	160.00	4100.00	R7-XF-S50-C-S	1405.28	3003.35	40.00	40.00
	TOTAL PCBs (in lipid)	32	33	6400.00	6720000.00	R7-XF-S08-D-S	650974.38	2886548.20	4000.00	4000.00
Inor.	ALUMINUM	6	6	0.75	1.50	R7-XF-S50-C-S	1.10	1.45	.	.
	CADMIUM	1	5	0.03	0.03	R7-XF-S02-D-S	0.03	0.03	0.05	0.05
	LEAD	2	6	0.05	0.09	R8-XF-S41-D-S	0.04	0.08	0.05	0.10
Other	LIPID CONTENT	34	34	0.05	5.00	R7-XF-S27-D-S	1.05	2.29	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	ACETONE	13	14	16.00	73.00	R2-B3-D1S	35.75	60.16	10.00	10.00
	CHLOROMETHANE	1	14	33.00	33.00	R2-B3-D1S	7.00	8.71	10.00	10.00
	METHYLENE CHLORIDE	12	14	11.00	37.00	R2-B3-D1S	15.46	21.74	10.00	10.00
	TRICHLOROETHENE	2	14	16.00	53.50	R2-B5-D1S	9.25	12.61	10.00	10.00
BNAs	ACENAPHTHENE	1	13	430.00	430.00	R2-B5-D1S	268.27	331.54	390.00	1500.00
	ANTHRACENE	1	14	760.00	760.00	R2-B5-D1S	504.82	763.46	390.00	6500.00
	BENZO(A)ANTHRACENE	1	14	1600.00	1600.00	R2-B5-D1S	564.82	946.65	390.00	6500.00
	BENZO(A)PYRENE	1	14	1100.00	1100.00	R2-B5-D1S	529.11	840.24	390.00	6500.00
	BENZO(B)FLUORANTHENE	1	14	2000.00	2000.00	R2-B5-D1S	593.39	1027.07	390.00	6500.00
	BENZO(G,H,I)PERYLENE	1	14	640.00	640.00	R2-B5-D1S	496.25	735.65	390.00	6500.00
	BIS(2-ETHYLHEXYL)PHTHALATE	2	14	790.00	1300.00	R2-B2-D1S	474.82	759.23	390.00	4500.00
	CARBAZOLE	1	7	430.00	430.00	R2-B5-D1S	324.29	534.32	390.00	1500.00
	CHRYSENE	1	14	1400.00	1400.00	R2-B5-D1S	550.54	904.96	390.00	6500.00
	DIBENZO(A,H)ANTHRACENE	1	14	490.00	490.00	R2-B5-D1S	485.54	701.01	390.00	6500.00
	FLUORANTHENE	1	14	2300.00	2300.00	R2-B5-D1S	614.82	1085.20	390.00	6500.00
	FLUORENE	1	14	540.00	540.00	R2-B5-D1S	489.11	712.47	390.00	6500.00
	INDENO(1,2,3-CD)PYRENE	1	14	880.00	880.00	R2-B5-D1S	513.39	790.96	390.00	6500.00
	PHENANTHRENE	1	14	2400.00	2400.00	R2-B5-D1S	621.96	1104.22	390.00	6500.00
	PYRENE	2	14	570.00	2800.00	R2-B5-D1S	675.89	1265.17	390.00	6500.00
Dioxins	1,2,3,4,6,7,8-HPCDD	2	6	1.10	28.40	R2-B1-D2S	7.17	109.56	2.80	14.00
	1,2,3,4,6,7,8-HPCDF	1	6	5.60	5.60	R2-B1-D2S	1.52	33.89	0.40	4.00
	OCDD	6	6	3.00	141.00	R2-B1-D2S	31.92	2090.33	.	.
	OCDF	1	6	9.70	9.70	R2-B1-D2S	3.10	14.92	1.80	7.60
Pest/PCBs	PCB-1260	1	36	1200.00	1200.00	R2-B5-D1S	84.65	79.64	84.00	320.00
	TOTAL PCBs	1	36	1200.00	1200.00	R2-B5-D1S	84.65	79.64	84.00	320.00
Inor.	ALUMINUM	14	14	1600.00	7400.00	R2-B2-D1S	2873.57	3746.80	.	.
	ARSENIC	4	14	0.76	0.92	R2-B1-D1S	0.47	0.68	0.48	1.60
	BARIUM	6	6	9.70	15.00	R1-B2-D1S	11.70	13.33	.	.
	CADMIUM	5	14	1.50	4.90	R2-B2-D1S	1.36	2.08	1.20	1.40
	COPPER	1	6	6.30	6.30	R1-B1-D1S	3.11	4.67	4.80	5.10
	FLUORIDE TOTAL	14	14	90.00	300.00	R2-B5-D1S	154.21	187.37	.	.
	LEAD	14	14	1.85	69.50	R2-B5-D1S	15.18	36.03	.	.
Other	ORGANIC MATTER	36	36	0.47	14.00	R2-B2-D1S	2.25	2.92	.	.
	TOTAL ORGANIC CARBON	36	36	1.00	48000.00	R2-B2-D1S	7054.19	38679.76	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	2-BUTANONE	3	11	14.00	40.00	R3-B1-D1S	11.27	20.95	10.00	10.00
	ACETONE	11	11	18.00	230.00	R3-B1-D1S	67.45	136.27	.	.
	CARBON DISULFIDE	1	11	14.00	14.00	R3-B4-D2S	5.82	6.98	10.00	10.00
	METHYLENE CHLORIDE	6	11	11.50	19.00	R3-B5-D2S	10.73	17.03	10.00	10.00
BNAs	BENZO(A)ANTHRACENE	2	11	540.00	1500.00	R3-B4-D2S	471.36	765.45	430.00	1600.00
	BENZO(A)PYRENE	1	11	1100.00	1100.00	R3-B4-D2S	409.09	620.43	430.00	1600.00
	BENZO(B)FLUORANTHENE	3	11	810.00	1300.00	R3-B4-D2S	532.73	926.64	430.00	1600.00
	BENZO(K)FLUORANTHENE	2	11	990.00	1100.00	R3-B4-D2S	475.91	790.38	430.00	1600.00
	CHRYSENE	3	11	710.00	2000.00	R3-B4-D2S	582.73	1065.94	430.00	1600.00
	DIETHYLPHTHALATE	1	11	500.00	500.00	R3-B1-D1S	378.18	516.89	440.00	1600.00
	FLUORANTHENE	2	11	970.00	2800.00	R3-B4-D2S	628.64	1223.71	430.00	1600.00
	PHENANTHRENE	2	11	600.00	1600.00	R3-B4-D2S	485.91	805.40	430.00	1600.00
	PYRENE	2	11	1000.00	2700.00	R3-B4-D2S	622.27	1209.76	430.00	1600.00
Dioxins	1,2,3,4,6,7,8-HPCDD	2	3	12.10	23.30	R3-B4-D1S	12.47	56589217.76	4.00	4.00
	1,2,3,4,6,7,8-HPCDF	2	3	3.70	7.70	R3-B4-D1S	3.88	116279869142057	0.50	0.50
	OCDD	2	3	171.00	179.00	R3-B4-D1S	117.37	1.5892374431E29	4.20	4.20
	OCDF	2	3	12.20	22.60	R3-B4-D1S	11.97	415142423463.69	2.20	2.20
Pest/PCBs	PCB-1248	12	26	160.00	4700.00	R3-T3-L2-D1S	481.15	857.95	100.00	380.00
	PCB-1260	5	26	190.00	940.00	R3-T3-L2-D1S	138.96	202.29	16.00	380.00
	TOTAL PCBs	12	26	160.00	5640.00	R3-T3-L2-D1S	558.85	1061.29	100.00	380.00
Inor.	ALUMINUM	11	11	2900.00	25000.00	R3-B3-D2S	14469.09	27731.46	.	.
	ARSENIC	10	11	0.64	4.40	R3-B1-D1S	1.66	3.27	0.62	0.62
	BARIUM	8	8	25.00	360.00	R3-B3-D2S	134.75	456.53	.	.
	CADMIUM	2	10	3.60	6.30	R3-B3-D2S	1.95	3.85	1.40	4.70
	COPPER	8	8	7.50	39.00	R3-B3-D1S	22.06	39.43	.	.
	FLUORIDE TOTAL	11	11	170.00	490.00	R3-B3-D2S	292.27	372.66	.	.
	LEAD	11	11	4.70	80.50	R3-T3-L2-D1S	20.02	44.36	.	.
Other	ORGANIC MATTER	26	26	1.80	34.00	R3-B1-D1S	6.21	8.00	.	.
	TOTAL ORGANIC CARBON	26	26	3200.00	35000.00	R3-T1-L3-D1S	16453.85	21170.92	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 4-6

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	1,1,2,2-TETRACHLOROETHANE	1	62	69.00	69.00	R4-T2-L3-D2S	6.03	5.95	10.00	10.00
	2-BUTANONE	13	62	10.00	58.00	R6-B1-D2S	9.34	10.05	10.00	10.00
	2-HEXANONE	1	62	10.00	10.00	R6-B2A-D01-D3S	5.08	10.00	10.00	10.00
	4-METHYL-2-PENTANONE	1	62	10.00	10.00	R6-B2A-D01-D3S	5.08	10.00	10.00	10.00
	ACETONE	41	62	12.00	310.00	R6-T3-L2R-D1D	31.89	43.39	10.00	10.00
	CARBON DISULFIDE	2	62	10.00	12.00	R5-T1-L3-D1S	5.19	5.34	10.00	10.00
	METHYLENE CHLORIDE	17	62	10.00	34.00	R6-T3-L2R-D1D	8.85	9.91	10.00	10.00
	TOLUENE	1	62	250.00	250.00	R6-B1-D2S	8.95	6.78	10.00	10.00
	TRICHLOROETHENE	3	62	14.00	68.00	R4-B7-D1S	6.39	6.39	10.00	10.00
BNAs	2,4,5-TRICHLOROPHENOL	1	56	2000.00	2000.00	R5-T1-L3-D1S	1791.07	2160.84	880.00	21000.00
	2,4-DINITROPHENOL	1	56	2000.00	2000.00	R5-T1-L3-D1S	1791.07	2160.84	880.00	21000.00
	4,6-DINITRO-2-METHYLPHENOL	1	56	2000.00	2000.00	R5-T1-L3-D1S	1791.07	2160.84	880.00	21000.00
	4-NITROPHENOL	1	56	2000.00	2000.00	R5-T1-L3-D1S	1791.07	2160.84	880.00	21000.00
	ANTHRACENE	5	61	470.00	4000.00	R4-B1-D1S	2186.68	2275.65	360.00	64000.00
	BENZO(A)ANTHRACENE	38	61	440.00	140000.00	R5-T3-L2-D2S	8065.25	12663.58	360.00	16000.00
	BENZO(A)PYRENE	29	61	780.00	9000.00	R4-B11R-D1S	3259.39	5109.68	360.00	64000.00
	BENZO(B)FLUORANTHENE	40	61	680.00	130000.00	R5-T3-L2-D2S	7453.65	14270.67	360.00	46000.00
	BENZO(G,H,I)PERYLENE	22	61	200.00	4900.00	R4-B1-D1S	2633.32	3469.00	360.00	64000.00
	BENZO(K)FLUORANTHENE	21	61	520.00	9400.00	R4-B8R-D1S	2826.48	3727.69	360.00	64000.00
	BIS(2-ETHYLHEXYL)PHTHALATE	8	61	760.00	50000.00	R4-B9R-D1S	2873.85	2649.86	360.00	64000.00
	CHRYSENE	42	61	480.00	180000.00	R5-T3-L2-D2S	9253.73	17174.95	360.00	46000.00
	DI-N-BUTYLPHTHALATE	5	61	540.00	150000.00	R4-B9R-D1S	5163.52	3310.11	360.00	64000.00
	DIBENZO(A,H)ANTHRACENE	7	61	210.00	2300.00	R4-B1-D1S	2132.75	2144.14	360.00	64000.00
	DIETHYLPHTHALATE	2	59	880.00	1300.00	R6-B4-D1S	1233.43	1389.80	360.00	29000.00
	FLUORANTHENE	41	61	480.00	250000.00	R5-T3-L2-D2S	11037.95	18217.00	360.00	46000.00
	INDENO(1,2,3-CD)PYRENE	20	61	530.00	4600.00	R4-B1-D1S	2538.89	3179.03	360.00	64000.00
	PENTACHLOROPHENOL	1	56	2000.00	2000.00	R5-T1-L3-D1S	1791.07	2160.84	880.00	21000.00
	PHENANTHRENE	22	61	550.00	130000.00	R5-T3-L2-D2S	6103.52	5823.89	360.00	16000.00
	PYRENE	42	61	780.00	230000.00	R5-T3-L2-D2S	10346.07	18018.01	360.00	16000.00
Dioxins	1,2,3,4,6,7,8-HPCDD	4	13	7.60	83.80	R4-B5-D2S	40.83	69.15	30.50	178.00
	1,2,3,4,6,7,8-HPCDF	7	13	16.60	829.00	R4-B4-D2S	154.37	2079.30	8.20	37.50
	1,2,3,4,7,8,9-HPCDF	11	13	1.40	442.00	R4-B4-D2S	78.35	1974.55	1.40	12.50
	1,2,3,4,7,8-HXCDF	9	12	1.90	1310.00	R4-B4-D2S	174.78	5521.17	4.40	134.00
	1,2,3,6,7,8-HXCDF	3	11	45.30	366.00	R4-B4-D2S	45.72	375.06	3.70	18.00
	1,2,3,7,8,9-HXCDD	3	13	26.80	37.20	R4-B4-D2S	12.00	26.37	5.50	27.00
	1,2,3,7,8-PECDF	4	11	23.60	244.00	R4-B4-D2S	40.82	234.16	3.70	52.70
	2,3,4,6,7,8-HXCDF	4	13	23.70	209.00	R4-B4-D2S	37.58	378.91	2.10	185.00
	2,3,4,7,8-PECDF	11	13	8.40	634.00	R4-B4-D2S	104.69	1434.69	3.80	4.30
	2,3,7,8-TCDF	6	7	2.80	525.00	R4-B4-D2S	93.46	76863.38	1.50	1.50
	OCDD	4	13	42.10	310.00	R4-B5-D2S	209.35	320.44	190.00	633.00
	OCDF	10	13	54.30	2240.00	R4-B4-D2S	470.62	4697.99	22.20	100.00
Pest/PCBs	PCB-1248	101	108	240.00	2200000.00	R4-B4-D2S	39741.95	60909.38	88.00	120.00
	PCB-1260	71	108	130.00	44000.00	R4-T2-L3-D1S	5935.44	8578.62	88.00	490000.00
	TOTAL PCBs	101	108	240.00	2200000.00	R4-B4-D2S	42153.94	76230.77	88.00	120.00
Inor.	ALUMINUM	61	61	810.00	34900.00	R6-B2A-D01-D1S	7605.90	9320.93	.	.
	ARSENIC	47	60	0.64	4.50	R6-T3-L2R-D1S	1.20	2.58	0.05	1.00
	CADMIUM	25	59	0.95	6.20	R6-B4-D1S	1.39	1.58	1.00	3.70
	CYANIDE	5	59	1.50	9.60	R6-B2A-D01-D3S	0.77	0.76	1.00	1.00
	FLUORIDE TOTAL	61	61	49.00	825.00	R4-B7-D1S	241.87	269.63	.	.
	LEAD	60	60	3.50	180.00	R4-B2-D2S	31.17	39.82	.	.
Other	ORGANIC MATTER	103	103	0.60	60.00	R4-B4-D2S	9.06	11.17	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 4-6
(continued)

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
	TOTAL ORGANIC CARBON	103	103	590.00	150000.00	R6-B2-D2S	33231.65	55542.12	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 7 & 8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	2-BUTANONE	9	22	17.00	87.00	R7-B4-D2S	24.51	36.47	10.00	37.50
	ACETONE	21	22	28.00	340.00	R7-B4-D2S	120.25	225.87	10.00	10.00
	CARBON DISULFIDE	2	22	17.00	36.00	R8-B3-D2S	12.31	14.98	10.00	37.50
	DIBROMOCHLOROMETHANE	1	22	15.00	15.00	R7-B4-D2S	11.17	13.10	10.00	37.50
	METHYLENE CHLORIDE	10	22	12.00	62.00	R8-B4-D1S	22.07	33.13	10.00	36.00
	TRANS-1,3-DICHLOROPROPENE	1	22	15.00	15.00	R7-B4-D2S	11.17	13.10	10.00	37.50
	XYLENES (TOTAL)	1	20	33.00	33.00	R8-T3-L2-D2S	12.36	14.59	14.00	37.50
BNAs	BENZO(A)ANTHRACENE	7	22	700.00	3000.00	R8-B5R-D2S	786.82	1043.94	480.00	1800.00
	BENZO(A)PYRENE	6	22	650.00	1600.00	R7-B3-D2S	737.27	972.50	480.00	1800.00
	BENZO(B)FLUORANTHENE	13	22	620.00	4400.00	R8-T3-L2-D2S	1627.50	2829.44	480.00	1600.00
	BENZO(G,H,I)PERYLENE	4	22	760.00	1600.00	R8-T3-L2-D2S	607.73	762.86	480.00	1800.00
	BENZO(K)FLUORANTHENE	4	22	840.00	1300.00	R7-B2-D2S	606.14	764.03	480.00	1800.00
	BIS(2-ETHYLHEXYL)PHTHALATE	1	22	1400.00	1400.00	R8-B1-D1S	519.55	645.76	480.00	1800.00
	CHRYSENE	11	22	1400.00	3200.00	R8-B5R-D2S	1257.73	2101.63	480.00	1600.00
	DIBENZO(A,H)ANTHRACENE	1	22	780.00	780.00	R8-B4-D1S	500.91	612.69	480.00	1800.00
	FLUORANTHENE	5	22	550.00	3500.00	R8-B5R-D2S	745.00	976.51	480.00	1800.00
	INDENO(1,2,3-CD)PYRENE	4	22	660.00	1500.00	R8-T3-L2-D2S	586.82	727.36	480.00	1800.00
	PHENANTHRENE	1	22	1000.00	1000.00	R8-B5R-D2S	514.77	632.30	480.00	1800.00
	PYRENE	3	22	710.00	2800.00	R8-B5R-D2S	662.95	857.58	480.00	1800.00
Pest/PCBs	PCB-1248	58	65	100.00	24000.00	R8-T1-L2-D1S	4366.77	9604.65	120.00	16000.00
	PCB-1260	43	65	195.00	6800.00	R7-T4-L2A-D2S	1199.58	2036.12	91.00	6100.00
	TOTAL PCBs	61	65	100.00	24000.00	R8-T1-L2-D1S	5077.85	12119.08	120.00	200.00
Inor.	ALUMINUM	22	22	3900.00	32000.00	R8-B4-D1S	12427.27	15470.51	.	.
	ARSENIC	19	22	0.84	2.20	R8-B5R-D1S	1.22	1.45	0.87	1.50
	CADMIUM	7	22	0.99	4.20	R8-B1-D1S	1.62	1.97	1.40	4.40
	FLUORIDE TOTAL	21	22	140.00	12000.00	R7-B1-D2S	858.43	3923.75	1.00	1.00
	LEAD	21	21	4.90	57.00	R8-B5R-D1S	23.85	34.37	.	.
Other	ORGANIC MATTER	65	65	0.79	65.00	R7-T4-L2A-D2S	22.41	32.61	.	.
	TOTAL ORGANIC CARBON	65	65	1.00	80000.00	R7-T3-L3-D2S	30038.74	7622160412.46	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 9

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	2-BUTANONE	5	20	10.00	30.00	R9-B4-D2S	8.40	10.73	10.00	10.00
	ACETONE	17	20	18.00	150.00	R9-B4-D2S	55.40	121.65	10.00	10.00
	METHYLENE CHLORIDE	11	20	11.00	19.00	R9-B5D-D2S	9.60	12.27	10.00	10.00
	TRICHLOROETHENE	1	20	660.00	660.00	R9-B9D-D2S	37.75	22.87	10.00	10.00
BNAs	BENZO(B)FLUORANTHENE	4	20	440.00	2100.00	R9-B9D-D1S	500.62	637.30	440.00	1000.00
	BENZO(G,H,I)PERYLENE	1	20	640.00	640.00	R9-B10D-D1S	319.87	362.02	420.00	1000.00
	CHRYSENE	3	20	420.00	1200.00	R9-B10D-D1S	382.12	457.42	440.00	1000.00
	FLUORANTHENE	1	20	720.00	720.00	R9-B9D-D2S	326.12	369.57	440.00	1000.00
	INDENO(1,2,3-CD)PYRENE	1	20	540.00	540.00	R9-B10D-D1S	314.87	353.47	420.00	1000.00
	PYRENE	1	20	830.00	830.00	R9-B9D-D2S	331.62	378.61	440.00	1000.00
Dioxins	1,2,3,4,6,7,8-HPCDD	1	1	8.50	8.50	R9-B1-D2S	8.50	8.50	.	.
	1,2,3,4,6,7,8-HPCDF	1	2	3.40	3.40	R9-B1-D1S	2.33	3.40	2.50	2.50
	OCDD	1	2	53.40	53.40	R9-B1-D2S	36.05	53.40	37.40	37.40
Pest/PCBs	PCB-1260	3	20	380.00	780.00	R9-B10D-D1S	154.87	211.91	100.00	260.00
	TOTAL PCBs	3	20	380.00	780.00	R9-B10D-D1S	154.87	211.91	100.00	260.00
Inor.	ALUMINUM	20	20	5500.00	24000.00	R9-B6D-D2S	16205.00	20008.99	.	.
	ARSENIC	19	20	0.90	4.30	R9-B3-D1S	1.95	2.61	0.91	0.91
	CADMIUM	1	20	1.30	1.30	R9-B2-D1S	0.94	1.05	1.30	3.20
	CYANIDE	4	20	1.60	7.60	R9-B9D-D2S	1.36	1.93	1.00	1.00
	FLUORIDE TOTAL	20	20	100.00	1100.00	R9-B9D-D1S	466.00	604.32	.	.
	LEAD	20	20	4.20	29.00	R9-B9D-D1S	12.98	16.14	.	.
Other	ORGANIC MATTER	20	20	1.40	48.00	R9-B8D-D1S	13.76	25.76	.	.
	TOTAL ORGANIC CARBON	20	20	2300.00	85000.00	R9-B8D-D1S	25475.00	41307.54	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	1,1,2,2-TETRACHLOROETHANE	1	84	69.00	69.00	R4-T2-L3-D2S	7.29	7.52	10.00	37.50
	2-BUTANONE	22	84	10.00	87.00	R7-B4-D2S	13.31	14.72	10.00	37.50
	2-HEXANONE	1	84	10.00	10.00	R6-B2A-D01-D3S	6.59	6.98	10.00	37.50
	4-METHYL-2-PENTANONE	1	84	10.00	10.00	R6-B2A-D01-D3S	6.59	6.98	10.00	37.50
	ACETONE	62	84	12.00	340.00	R7-B4-D2S	55.03	83.89	10.00	10.00
	CARBON DISULFIDE	4	84	10.00	36.00	R8-B3-D2S	7.06	7.48	10.00	37.50
	DIBROMOCHLOROMETHANE	1	84	15.00	15.00	R7-B4-D2S	6.62	7.02	10.00	37.50
	METHYLENE CHLORIDE	27	84	10.00	62.00	R8-B4-D1S	12.31	13.83	10.00	36.00
	TOLUENE	1	84	250.00	250.00	R6-B1-D2S	9.44	8.19	10.00	37.50
	TRANS-1,3-DICHLOROPROPENE	1	84	15.00	15.00	R7-B4-D2S	6.62	7.02	10.00	37.50
	TRICHLOROETHENE	3	84	14.00	68.00	R4-B7-D1S	7.55	7.85	10.00	37.50
	XYLENES (TOTAL)	1	20	33.00	33.00	R8-T3-L2-D2S	12.36	14.59	14.00	37.50
BNAs	2,4,5-TRICHLOROPHENOL	1	78	2000.00	2000.00	R5-T1-L3-D1S	1618.59	1830.26	880.00	21000.00
	2,4-DINITROPHENOL	1	78	2000.00	2000.00	R5-T1-L3-D1S	1618.59	1830.26	880.00	21000.00
	4,6-DINITRO-2-METHYLPHENOL	1	78	2000.00	2000.00	R5-T1-L3-D1S	1618.59	1830.26	880.00	21000.00
	4-NITROPHENOL	1	78	2000.00	2000.00	R5-T1-L3-D1S	1618.59	1830.26	880.00	21000.00
	ANTHRACENE	5	83	470.00	4000.00	R4-B1-D1S	1735.15	1575.00	360.00	64000.00
	BENZO(A)ANTHRACENE	45	83	440.00	140000.00	R5-T3-L2-D2S	6136.02	7173.00	360.00	16000.00
	BENZO(A)PYRENE	35	83	650.00	9000.00	R4-B11R-D1S	2590.87	3323.16	360.00	64000.00
	BENZO(B)FLUORANTHENE	53	83	620.00	130000.00	R5-T3-L2-D2S	5909.37	8921.95	360.00	46000.00
	BENZO(G,H,I)PERYLENE	26	83	200.00	4900.00	R4-B1-D1S	2096.42	2319.33	360.00	64000.00
	BENZO(K)FLUORANTHENE	25	83	520.00	9400.00	R4-B8R-D1S	2237.95	2462.36	360.00	64000.00
	BIS(2-ETHYLHEXYL)PHTHALATE	9	83	760.00	50000.00	R4-B9R-D1S	2249.82	1806.98	360.00	64000.00
	CHRYSENE	53	83	480.00	180000.00	R5-T3-L2-D2S	7134.31	10179.05	360.00	46000.00
	DI-N-BUTYLPHTHALATE	5	83	540.00	150000.00	R4-B9R-D1S	3922.95	2087.57	360.00	64000.00
	DIBENZO(A,H)ANTHRACENE	8	83	210.00	2300.00	R4-B1-D1S	1700.21	1513.09	360.00	64000.00
	DIETHYLPHTHALATE	2	81	880.00	1300.00	R6-B4-D1S	1029.66	1050.26	360.00	29000.00
	FLUORANTHENE	46	83	480.00	250000.00	R5-T3-L2-D2S	8309.70	10261.88	360.00	46000.00
	INDENO(1,2,3-CD)PYRENE	24	83	530.00	4600.00	R4-B1-D1S	2021.48	2143.39	360.00	64000.00
	PENTACHLOROPHENOL	1	78	2000.00	2000.00	R5-T1-L3-D1S	1618.59	1830.26	880.00	21000.00
	PHENANTHRENE	23	83	550.00	130000.00	R5-T3-L2-D2S	4622.17	3373.11	360.00	16000.00
	PYRENE	45	83	710.00	230000.00	R5-T3-L2-D2S	7779.46	10085.08	360.00	16000.00
Dioxins	1,2,3,4,6,7,8-HPCDD	4	13	7.60	83.80	R4-B5-D2S	40.83	69.15	30.50	178.00
	1,2,3,4,6,7,8-HPCDF	7	13	16.60	829.00	R4-B4-D2S	154.37	2079.30	8.20	37.50
	1,2,3,4,7,8,9-HPCDF	11	13	1.40	442.00	R4-B4-D2S	78.35	1974.55	1.40	12.50
	1,2,3,4,7,8-HXCDF	9	12	1.90	1310.00	R4-B4-D2S	174.78	5521.17	4.40	134.00
	1,2,3,6,7,8-HXCDF	3	11	45.30	366.00	R4-B4-D2S	45.72	375.06	3.70	18.00
	1,2,3,7,8,9-HXCDD	3	13	26.80	37.20	R4-B4-D2S	12.00	26.37	5.50	27.00
	1,2,3,7,8-PECDF	4	11	23.60	244.00	R4-B4-D2S	40.82	234.16	3.70	52.70
	2,3,4,6,7,8-HXCDF	4	13	23.70	209.00	R4-B4-D2S	37.58	378.91	2.10	185.00
	2,3,4,7,8-PECDF	11	13	8.40	634.00	R4-B4-D2S	104.69	1434.69	3.80	4.30
	2,3,7,8-TCDF	6	7	2.80	525.00	R4-B4-D2S	93.46	76863.38	1.50	1.50
	OCDD	4	13	42.10	310.00	R4-B5-D2S	209.35	320.44	190.00	633.00
	OCDF	10	13	54.30	2240.00	R4-B4-D2S	470.62	4697.99	22.20	100.00
Pest/PCBs	PCB-1248	159	173	100.00	2200000.00	R4-B4-D2S	26450.70	27675.25	88.00	16000.00
	PCB-1260	114	173	130.00	44000.00	R4-T2-L3-D1S	4156.07	4519.48	88.00	490000.00
	TOTAL PCBs	162	173	100.00	2200000.00	R4-B4-D2S	28223.62	34599.44	88.00	200.00
Inor.	ALUMINUM	83	83	810.00	34900.00	R6-B2A-D01-D1S	8883.86	10741.57	.	.
	ARSENIC	66	82	0.64	4.50	R6-T3-L2R-D1S	1.21	2.17	0.05	1.50
	CADMIUM	32	8[illegible]	0.95	6.20	R6-B4-D1S	1.[illegible]	1.61	1.00	4.40
	CYANIDE	5	8[illegible]	1.50	[illegible]	R6-B2A-D01-D3S	[illegible]	0.68	1.00	1.[illegible]

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SEDIMENT/REACH 4-8
(continued)

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
	FLUORIDE TOTAL	82	83	49.00	12000.00	R7-B1-D2S	405.30	449.37	1.00	1.00
	LEAD	81	81	3.50	180.00	R4-B2-D2S	29.28	35.26	.	.
Other	ORGANIC MATTER	168	168	0.60	65.00	R7-T4-L2A-D2S	14.22	18.16	.	.
	TOTAL ORGANIC CARBON	168	168	1.00	150000.00	R6-B2-D2S	31996.30	6078027.07	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=FILTERED SURFACE WATER/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Inor.	ALUMINUM	1	1	36.30	36.30	R2-L4-F-S	36.30	36.30	.	.
	FLUORIDE TOTAL	2	2	0.20	0.54	R2-L4-F-S	0.37	0.54	.	.
	LEAD	1	2	1.50	1.50	R2-L4-F-S	1.00	1.50	1.00	1.00

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=FILTERED SURFACE WATER/REACH 9

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Inor.	FLUORIDE TOTAL	1	1	0.13	0.13	R9-L1-F-S	0.13	0.13	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=UNFILTERED SURFACE WATER/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Inor.	ALUMINUM	1	2	270.00	270.00	R1-L4-U-S	160.00	270.00	100.00	100.00
	FLUORIDE TOTAL	2	2	0.23	11.00	R1-L4-U-S	5.62	11.00	.	.
	LEAD	1	2	1.90	1.90	R2-L4-U-S	1.20	1.90	1.00	1.00
Other	TOTAL HARDNESS	9	9	26.00	44.00	R1-L4-U-S	37.78	42.71	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=UNFILTERED SURFACE WATER/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	ACETONE	1	1	20.00	20.00	R3-L2-U-S	20.00	20.00	.	.
	TRICHLOROETHENE	1	1	1300.00	1300.00	R3-L2-U-S	1300.00	1300.00	.	.
Inor.	ALUMINUM	1	1	120.00	120.00	R3-L2-U-S	120.00	120.00	.	.
	BARIUM	1	1	24.00	24.00	R3-L2-U-S	24.00	24.00	.	.
	FLUORIDE TOTAL	1	1	0.79	0.79	R3-L2-U-S	0.79	0.79	.	.
	LEAD	1	1	1.40	1.40	R3-L2-U-S	1.40	1.40	.	.
Other	TOTAL HARDNESS	5	5	130.00	160.00	R3-L3-U-S	146.00	160.00	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=UNFILT. SURF. WATER/REACH 4-6

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	TRICHLOROETHENE	4	4	13.00	580.00	R4-L2-U-S	176.25	2844688.39	.	.
BNAs	BIS(2-ETHYLHEXYL)PHTHALATE	1	4	11.00	11.00	R4-L2-U-S	6.50	13.48	10.00	10.00
Pest/PCBs	PCB-1248	9	15	0.09	0.50	R6-L4-U-S	0.16	0.38	0.07	0.07
	TOTAL PCBs	9	15	0.09	0.50	R6-L4-U-S	0.16	0.38	0.07	0.07
Inor.	ALUMINUM	4	4	125.00	480.00	R5-L4-U-S	226.25	1081.10	.	.
	FLUORIDE TOTAL	4	4	0.68	3.80	R4-L2-U-S	1.64	21.51	.	.
	LEAD	4	4	1.10	2.30	R4-L4-U-S	1.80	3.26	.	.
Other	TOTAL HARDNESS	15	15	52.00	65.00	R5-L5-U-S	58.03	65.00	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=UNFILTERED SURFACE WATER/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	TRICHLOROETHENE	6	6	10.00	580.00	R4-L2-U-S	127.00	5246.84	.	.
BNAs	BIS(2-ETHYLHEXYL)PHTHALATE	2	6	11.00	42.00	R8-L4-U-S	12.17	48.95	10.00	10.00
Dioxins	1,2,3,4,6,7,8-HPCDD	1	6	0.03	0.03	R8-L4-U-S	0.02	0.03	0.02	0.05
	2,3,7,8-TCDF	1	6	0.02	0.02	R8-L4-U-S	0.01	0.02	0.01	0.01
	OCDD	1	6	0.33	0.33	R8-L4-U-S	0.08	0.49	0.05	0.10
Pest/PCBs	PCB-1248	19	25	0.08	0.50	R6-L4-U-S	0.17	0.28	0.07	0.07
	TOTAL PCBs	19	25	0.08	0.50	R6-L4-U-S	0.17	0.28	0.07	0.07
Inor.	ALUMINUM	6	6	59.10	480.00	R5-L4-U-S	194.02	516.77	.	.
	FLUORIDE TOTAL	6	6	0.44	3.80	R4-L2-U-S	1.28	4.10	.	.
	LEAD	5	6	1.10	5.90	R7-L4-U-S	2.27	8.97	1.00	1.00
Other	TOTAL HARDNESS	24	24	52.00	91.00	R8-L2-U-S	62.23	65.35	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=UNFILTERED SURFACE WATER/REACH 7 & 8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
VOCs	TRICHLOROETHENE	2	2	10.00	47.00	R7-L4-U-S	28.50	47.00	.	.
BNAs	BIS(2-ETHYLHEXYL)PHTHALATE	1	2	42.00	42.00	R8-L4-U-S	23.50	42.00	10.00	10.00
Dioxins	1,2,3,4,6,7,8-HPCDD	1	2	0.03	0.03	R8-L4-U-S	0.02	0.03	0.02	0.02
	2,3,7,8-TCDF	1	2	0.02	0.02	R8-L4-U-S	0.01	0.02	0.01	0.01
	OCDD	1	2	0.33	0.33	R8-L4-U-S	0.18	0.33	0.05	0.05
Pest/PCBs	PCB-1248	10	10	0.08	0.35	R7-L2-U-S	0.19	0.27	.	.
	TOTAL PCBs	10	10	0.08	0.35	R7-L2-U-S	0.19	0.27	.	.
Inor.	ALUMINUM	2	2	59.10	200.00	R7-L4-U-S	129.55	200.00	.	.
	FLUORIDE TOTAL	2	2	0.44	0.66	R7-L4-U-S	0.55	0.66	.	.
	LEAD	1	2	5.90	5.90	R7-L4-U-S	3.20	5.90	1.00	1.00
Other	TOTAL HARDNESS	9	9	59.00	91.00	R8-L2-U-S	69.22	77.55	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=UNFILTERED SURFACE WATER/REACH 9

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Inor.	ALUMINUM	3	3	644.00	840.00	R9-L1-U-S	742.33	978.12	.	.
	BARIUM	2	2	30.00	35.00	R9-L3D-U-S	32.50	35.00	.	.
	CYANIDE	1	3	0.03	0.03	R9-L1-U-S	0.01	976.37	0.01	0.01
	FLUORIDE TOTAL	3	3	0.11	3.60	R9-L3D-U-S	1.32	43768166588784	.	.
	LEAD	2	3	1.10	5.60	R9-L1-U-S	2.40	3815112.47	1.00	1.00
Other	TOTAL HARDNESS	4	4	110.00	130.00	R9-L4D-U-S	118.75	130.00	.	.

APPENDIX A PART 2:
STATISTICAL SUMMARIES OF
DATA USED IN THE ECOLOGICAL RISK ASSESSMENT

- Brown Bullhead Fillet/Reaches 1 and 2
- Brown Bullhead Fillet/Reach 3
- Brown Bullhead Fillet/Reaches 4, 5, 6, 7, and 8
- Brown Bullhead Viscera/Reaches 1 and 2
- Brown Bullhead Viscera/Reach 3
- Brown Bullhead Viscera/Reaches 4, 5, 6, 7, and 8
- Smallmouth Bass Fillet/Reaches 1 and 2
- Smallmouth Bass Fillet/Reach 3
- Smallmouth Bass Fillet/Reaches 4, 5, 6, 7, and 8
- * Smallmouth Bass Viscera/Reaches 1 and 2
- * Smallmouth Bass Viscera/Reach 3
- Smallmouth Bass Viscera/Reaches 4, 5, 6, 7, and 8
- Pumpkinseed Fillet - Reaches 1 and 2
- Pumpkinseed Fillet - Reaches 4 through 8
- Rock Bass Fillet - Reaches 1 and 2
- * Rock Bass Fillet - Reach 3
- * Rock Bass Fillet - Reaches 4 through 8
- Spottail Shiner Whole Body - Reaches 1 and 2
- Spottail Shiner Whole Body - Reaches 4 through 8
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Fillet/Reaches 1 and 2
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Fillet/Reach 3
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Fillet/Reaches 4, 5, 6, 7, and 8
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Fillet/Reaches 7 and 8
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Viscera/Reaches 1 and 2
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Viscera/Reach 3
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Viscera/Reaches 4, 5, 6, 7, and 8
- Brown Bullhead, Smallmouth Bass, Pumpkinseed, and Rock Bass Viscera/Reaches 7 and 8
- Crayfish Whole Body - Reaches 1 and 2
- Crayfish Whole Body - Reaches 4 through 8
- Frog Whole Body - Reaches 1 and 2
- Frog Whole Body - Reaches 4 through 8

RECYCLED PAPER ENFORCEMENT CONFIDENTIAL TRC

* Missing from original

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=UNFILT. SURFACE WATER/UNNAMED TRIBUTARY

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect.	Lowest Observed Limit	Highest Observed Detect.	Highest Observed Limit
Inor.	ALUMINUM	1	1	2400.00	2400.00	UT-L1D-U-S	2400.00	2400.00	.		.	
	ARSENIC	1	1	2.70	2.70	UT-L1D-U-S	2.70	2.70	.		.	
	FLUORIDE TOTAL	1	1	1.40	1.40	UT-L1D-U-S	1.40	1.40	.		.	
	LEAD	1	1	14.00	14.00	UT-L1D-U-S	14.00	14.00	.		.	
Other	TOTAL HARDNESS	1	1	230.00	230.00	UT-L1D-U-S	230.00	230.00	.		.	

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BROWN BULLHEAD FILLET/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	2	21	60.00	730.00	R1-XF-S46-C-S	55.83	52.98	40.00	45.00
	PCB-1248 (in lipid)	1	11	14600.00	14600.00	R1-XF-S46-C-S	2638.24	4384.17	1428.57	4000.00
	PCB-1254	1	21	160.00	160.00	R2-XF-S19-D-S	30.60	36.17	40.00	200.00
	PCB-1254 (in lipid)	1	11	11428.57	11428.57	R2-XF-S19-D-S	2401.88	3882.58	1428.57	4000.00
	PCB-1260	3	21	40.00	260.00	R1-XF-S46-C-S	33.45	37.61	40.00	45.00
	PCB-1260 (in lipid)	3	14	1428.57	5200.00	R1-XF-S46-C-S	2034.24	2502.50	2222.22	5633.80
	TOTAL PCBs	5	21	40.00	990.00	R1-XF-S46-C-S	76.79	80.99	40.00	45.00
	TOTAL PCBs (in lipid)	4	14	1428.57	19800.00	R1-XF-S46-C-S	3791.38	5979.02	2222.22	5633.80
Inor.	ALUMINUM	1	2	13.00	13.00	R2-XF-S36-C-S	6.75	13.00	1.00	1.00
	LEAD	1	2	0.10	0.10	R2-XF-S36-C-S	0.06	0.10	0.05	0.05
Other	LIPID CONTENT	20	20	0.05	5.00	R1-XF-S46-C-S	1.22	4.30	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BROWN BULLHEAD FILLET/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1260	1	1	120.00	120.00	R3-XF-S23-D-S	120.00	120.00	.	.
	PCB-1260 (in lipid)	1	1	21818.18	21818.18	R3-XF-S23-D-S	21818.18	21818.18	.	.
	TOTAL PCBs	1	1	120.00	120.00	R3-XF-S23-D-S	120.00	120.00	.	.
	TOTAL PCBs (in lipid)	1	1	21818.18	21818.18	R3-XF-S23-D-S	21818.18	21818.18	.	.
Inor.	ALUMINUM	1	1	3.10	3.10	R3-XF-S23-D-S	3.10	3.10	.	.
Other	LIPID CONTENT	1	1	0.55	0.55	R3-XF-S23-D-S	0.55	0.55	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BROWN BULLHEAD FILLET/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
BNAs	DIETHYLPHTHALATE	1	14	1200.00	1200.00	R6-XF-S17-D-S	585.71	935.17	550.00	3600.00
Dioxins	1,2,3,4,6,7,8-HPCDD	1	1	19.90	19.90	R4-XF-S50-C-S	19.90	19.90	.	.
	1,2,3,4,6,7,8-HPCDF	1	1	20.60	20.60	R4-XF-S50-C-S	20.60	20.60	.	.
	1,2,3,4,7,8-HXCDF	1	1	17.60	17.60	R4-XF-S50-C-S	17.60	17.60	.	.
	1,2,3,6,7,8-HXCDF	1	1	12.60	12.60	R4-XF-S50-C-S	12.60	12.60	.	.
	1,2,3,7,8-PECDF	1	1	18.60	18.60	R4-XF-S50-C-S	18.60	18.60	.	.
	2,3,4,6,7,8-HXCDF	1	1	6.90	6.90	R4-XF-S50-C-S	6.90	6.90	.	.
	2,3,4,7,8-PECDF	1	1	8.40	8.40	R4-XF-S50-C-S	8.40	8.40	.	.
	2,3,7,8-TCDD	1	1	9.10	9.10	R4-XF-S50-C-S	9.10	9.10	.	.
	2,3,7,8-TCDF	1	1	28.30	28.30	R4-XF-S50-C-S	28.30	28.30	.	.
	OCDF	1	1	13.30	13.30	R4-XF-S50-C-S	13.30	13.30	.	.
Pest/PCBs	PCB-1248	48	48	100.00	18000.00	R6-XF-S28-D-S	3338.33	5603.77	.	.
	PCB-1248 (in lipid)	43	43	4000.00	13333333.33	R6-XF-S16-D-S	746126.82	1675339.76	.	.
	PCB-1260	48	48	60.00	4300.00	R6-XF-S16-D-S	1043.73	1595.09	.	.
	PCB-1260 (in lipid)	43	43	2400.00	4777777.78	R6-XF-S16-D-S	251165.82	464895.05	.	.
	TOTAL PCBs	48	48	160.00	21900.00	R6-XF-S28-D-S	4382.06	7112.02	.	.
	TOTAL PCBs (in lipid)	43	43	6400.00	18111111.11	R6-XF-S16-D-S	997292.64	2103295.67	.	.
Inor.	ALUMINUM	14	15	0.51	1.50	R4-XF-S30-D-S	0.94	1.14	2.00	2.00
	LEAD	2	15	0.05	0.09	R8-XF-S41-D-S	0.03	0.06	0.01	0.10
Other	LIPID CONTENT	43	44	0.05	5.00	R7-XF-S27-D-S	1.20	2.12	0.05	0.05

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BROWN BULLHEAD VICERA/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1254	1	6	280.00	280.00	R2-XF-S25-D-V	66.67	435.10	40.00	70.00
	PCB-1254 (in lipid)	1	3	8235.29	8235.29	R2-XF-S25-D-V	3590.51	1041089173.60	1739.13	3333.33
	TOTAL PCBs	1	6	280.00	280.00	R2-XF-S25-D-V	66.67	435.10	40.00	70.00
	TOTAL PCBs (in lipid)	1	4	8235.29	8235.29	R2-XF-S25-D-V	3239.76	111002.20	1739.13	4375.00
Other	LIPID CONTENT	5	5	0.30	3.40	R2-XF-S25-D-V	1.76	17.51	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BROWN BULLHEAD VICERA/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	1	1	130.00	130.00	R3-XF-S24-D-V	130.00	130.00	.	.
	PCB-1248 (in lipid)	1	1	11818.18	11818.18	R3-XF-S24-D-V	11818.18	11818.18	.	.
	PCB-1260	1	1	180.00	180.00	R3-XF-S24-D-V	180.00	180.00	.	.
	PCB-1260 (in lipid)	1	1	16363.64	16363.64	R3-XF-S24-D-V	16363.64	16363.64	.	.
	TOTAL PCBs	1	1	310.00	310.00	R3-XF-S24-D-V	310.00	310.00	.	.
	TOTAL PCBs (in lipid)	1	1	28181.82	28181.82	R3-XF-S24-D-V	28181.82	28181.82	.	.
Other	LIPID CONTENT	1	1	1.10	1.10	R3-XF-S24-D-V	1.10	1.10	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BROWN BULLHEAD VICERA/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	12	12	1200.00	16000.00	R4-XF-S24-D-V	5000.00	8643.55	.	.
	PCB-1248 (in lipid)	9	9	34285.71	8300000.00	R5-XF-S27-D-V	1245152.30	17710426.81	.	.
	PCB-1260	12	12	290.00	3300.00	R4-XF-S24-D-V	1391.67	2324.69	.	.
	PCB-1260 (in lipid)	9	9	8285.71	2700000.00	R5-XF-S27-D-V	384253.89	6033279.22	.	.
	TOTAL PCBs	12	12	1490.00	19300.00	R4-XF-S24-D-V	6391.67	10781.45	.	.
	TOTAL PCBs (in lipid)	9	9	42571.43	11000000.00	R5-XF-S27-D-V	1629406.19	22949263.92	.	.
Other	LIPID CONTENT	9	9	0.10	7.40	R5-XF-S25-D-V	2.41	15.88	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SMALL-MOUTH BASS FILLET/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Inor.	ALUMINUM	2	2	0.69	0.89	R1-XF-S29-D-S	0.79	0.89	.	.
	LEAD	1	2	0.05	0.05	R1-XF-S29-D-S	0.04	0.05	0.05	0.05
Other	LIPID CONTENT	9	9	0.05	1.50	R1-XF-S20-D-S	0.47	3.52	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SMALL-MOUTH BASS FILLET/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
BNAs	DIETHYLPHTHALATE	1	1	4200.00	4200.00	R3-XF-S12-D-S	4200.00	4200.00	.	.
Pest/PCBs	PCB-1248	7	10	54.00	1200.00	R3-XF-S12-D-S	318.40	3965.91	40.00	40.00
	PCB-1248 (in lipid)	7	7	22222.22	326666.67	R3-XF-S08-D-S	119993.46	378713.10	.	.
	PCB-1260	8	10	84.00	700.00	R3-XF-S12-D-S	180.10	693.27	40.00	40.00
	PCB-1260 (in lipid)	8	8	30666.67	168000.00	R3-XF-S03-D-S	74063.56	130485.43	.	.
	TOTAL PCBs	9	10	86.00	1900.00	R3-XF-S12-D-S	490.50	3712.80	40.00	40.00
	TOTAL PCBs (in lipid)	9	9	22222.22	446666.67	R3-XF-S08-D-S	159162.53	605252.75	.	.
Inor.	LEAD	1	1	0.05	0.05	R3-XF-S12-D-S	0.05	0.05	.	.
Other	LIPID CONTENT	10	10	0.05	0.85	R3-XF-S12-D-S	0.34	0.70	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SMALL-MOUTH BASS FILLET/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Dioxins	1,2,3,7,8-PECDF	1	1	120.00	120.00	R4-XF-S10-D-S	120.00	120.00	.	.
	OCDD	1	1	986.00	986.00	R4-XF-S10-D-S	986.00	986.00	.	.
	OCDF	1	1	595.00	595.00	R4-XF-S10-D-S	595.00	595.00	.	.
Pest/PCBs	PCB-1248	46	48	110.00	4500.00	R4-XF-S21-D-S	1538.33	3170.25	40.00	40.00
	PCB-1248 (in lipid)	43	44	18947.37	4800000.00	R7-XF-S08-D-S	637172.88	1748616.42	4000.00	4000.00
	PCB-1260	45	48	70.00	2000.00	R4-XF-S21-D-S	545.12	893.20	40.00	400.00
	PCB-1260 (in lipid)	42	43	7000.00	1920000.00	R7-XF-S08-D-S	234432.53	528611.41	4000.00	4000.00
	TOTAL PCBs	46	48	220.00	6500.00	R4-XF-S21-D-S	2078.46	4458.61	40.00	40.00
	TOTAL PCBs (in lipid)	43	44	30000.00	6720000.00	R7-XF-S08-D-S	866231.94	2392615.88	4000.00	4000.00
Inor.	ALUMINUM	13	13	0.42	1.20	R5-XF-S01-D-S	0.87	1.00	.	.
	CADMIUM	2	12	0.03	0.03	R6-XF-S11-D-S	0.03	0.03	0.05	0.05
	LEAD	3	13	0.05	0.08	R6-XF-S11-D-S	0.07	0.14	0.01	1.00
Other	LIPID CONTENT	45	45	0.05	2.50	R7-XF-S22-D-S	0.60	0.98	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SMALL-MOUTH BASS VICERA/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	14	14	2400.00	190000.00	R4-XF-S13-D-V	95100.00	331592.80	.	.
	PCB-1248 (in lipid)	14	14	12000.00	1000000.00	R7-XF-S05-D-V	470765.67	1598630.17	.	.
	PCB-1260	14	14	1800.00	64000.00	R7-XF-S05-D-V	38128.57	92783.50	.	.
	PCB-1260 (in lipid)	14	14	9000.00	426666.67	R7-XF-S05-D-V	195447.51	479606.36	.	.
	TOTAL PCBs	14	14	4200.00	242000.00	R4-XF-S13-D-V	133228.57	405350.14	.	.
	TOTAL PCBs (in lipid)	14	14	21000.00	1426666.67	R7-XF-S05-D-V	666213.18	1994543.33	.	.
Other	LIPID CONTENT	14	14	8.50	38.00	R4-XF-S15-D-V	21.61	27.24	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=PUMPKINSEED FISH FILLET/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	1	9	65.00	65.00	R2-XF-S38-C-S	43.89	86.24	40.00	360.00
	PCB-1260	1	9	49.00	49.00	R2-XF-S38-C-S	42.11	78.24	40.00	360.00
	TOTAL PCBs	1	9	114.00	114.00	R2-XF-S38-C-S	49.33	113.06	40.00	360.00
Inor.	ALUMINUM	2	2	1.20	1.30	R1-XF-S39-C-S	1.25	1.30	.	.
	LEAD	2	2	0.05	0.13	R1-XF-S39-C-S	0.09	0.13	.	.
Other	LIPID CONTENT	4	6	0.10	0.58	R1-XF-S39-C-S	0.17	2.06	0.05	0.06

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=PUMPKINSEED FISH FILLET/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	36	41	40.00	1400.00	R6-XF-S26-D-S	255.93	436.65	40.00	40.00
	PCB-1248 (in lipid)	33	36	1600.00	1240000.00	R6-XF-S14-D-S	174020.51	1479506.35	1333.33	4000.00
	PCB-1260	21	41	45.00	530.00	R6-XF-S26-D-S	85.27	120.24	40.00	40.00
	PCB-1260 (in lipid)	19	28	1571.43	520000.00	R6-XF-S14-D-S	70441.94	807075.56	1333.33	4000.00
	TOTAL PCBs	36	41	40.00	1930.00	R6-XF-S26-D-S	331.44	635.71	40.00	40.00
	TOTAL PCBs (in lipid)	33	36	1600.00	1760000.00	R6-XF-S14-D-S	228510.39	2355897.17	1333.33	4000.00
Inor.	ALUMINUM	11	12	0.73	2.90	R5-XF-S49-C-S	1.16	1.44	2.00	2.00
Other	LIPID CONTENT	37	37	0.05	3.50	R7-XF-S35-D-S	0.78	1.56	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=ROCK BASS FILLET/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Inor.	ALUMINUM	2	2	1.20	1.90	R1-XF-S35-C-S	1.55	1.90	.	.
	LEAD	2	2	0.06	0.06	R1-XF-S35-C-S	0.06	0.06	.	.
Other	LIPID CONTENT	8	11	0.05	0.67	R1-XF-S3-D-S	0.14	0.40	0.05	0.05

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SPOT-TAIL SHINER WHOLE/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Other	LIPID CONTENT	1	1	2.00	2.00	R1-XF-S19-C-S	2.00	2.00	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB FILLET/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	3	52	60.00	730.00	R1-XF-S46-C-S	38.99	34.17	40.00	360.00
	PCB-1248 (in lipid)	1	14	14600.00	14600.00	R1-XF-S46-C-S	2453.85	3391.96	1428.57	4000.00
	PCB-1254	1	52	160.00	160.00	R2-XF-S19-D-S	28.03	29.08	40.00	360.00
	PCB-1254 (in lipid)	1	14	11428.57	11428.57	R2-XF-S19-D-S	2268.14	3122.53	1428.57	4000.00
	PCB-1260	4	52	40.00	260.00	R1-XF-S46-C-S	29.64	30.13	40.00	360.00
	PCB-1260 (in lipid)	3	18	1428.57	5200.00	R1-XF-S46-C-S	2044.32	2412.41	2222.22	5970.15
	TOTAL PCBs	6	52	40.00	990.00	R1-XF-S46-C-S	48.39	41.43	40.00	360.00
	TOTAL PCBs (in lipid)	4	18	1428.57	19800.00	R1-XF-S46-C-S	3410.98	4545.88	2222.22	5970.15
Inor.	ALUMINUM	7	8	0.69	13.00	R2-XF-S36-C-S	2.58	8.15	1.00	1.00
	LEAD	6	8	0.05	0.13	R1-XF-S39-C-S	0.06	0.11	0.05	0.05
Other	LIPID CONTENT	41	46	0.05	5.00	R1-XF-S46-C-S	0.68	1.68	0.05	0.06

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=SPOT-TAIL SHINER WHOLE/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	7	7	7500.00	20000.00	R7-XF-S39-C-S	12285.71	17719.28	.	.
	PCB-1248 (in lipid)	7	7	125675.68	316666.67	R7-XF-S38-C-S	217544.17	299862.92	.	.
	PCB-1260	7	7	2900.00	6100.00	R7-XF-S38-C-S	3942.86	4877.46	.	.
	PCB-1260 (in lipid)	7	7	45945.95	101666.67	R7-XF-S38-C-S	71598.85	92365.53	.	.
	TOTAL PCBs	7	7	10600.00	25100.00	R7-XF-S38-C-S	16228.57	22304.84	.	.
	TOTAL PCBs (in lipid)	7	7	179729.73	418333.33	R7-XF-S38-C-S	289143.01	385615.40	.	.
Other	LIPID CONTENT	7	7	3.30	7.50	R7-XF-S39-C-S	5.79	7.78	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB FILLET/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
BNAs	DIETHYLPHTHALATE	1	2	4200.00	4200.00	R3-XF-S12-D-S	2182.50	4200.00	330.00	330.00
Pest/PCBs	PCB-1248	7	18	54.00	1200.00	R3-XF-S12-D-S	193.00	568.82	40.00	300.00
	PCB-1248 (in lipid)	7	7	22222.22	326666.67	R3-XF-S08-D-S	119993.46	378713.10	.	.
	PCB-1260	9	18	84.00	700.00	R3-XF-S12-D-S	121.72	277.24	40.00	300.00
	PCB-1260 (in lipid)	9	9	21818.18	168000.00	R3-XF-S03-D-S	68258.52	124429.38	.	.
	TOTAL PCBs	10	18	86.00	1900.00	R3-XF-S12-D-S	294.17	1078.29	40.00	300.00
	TOTAL PCBs (in lipid)	10	10	21818.18	446666.67	R3-XF-S08-D-S	145428.09	549438.43	.	.
Inor.	ALUMINUM	1	2	3.10	3.10	R3-XF-S23-D-S	1.80	3.10	1.00	1.00
	LEAD	1	2	0.05	0.05	R3-XF-S12-D-S	0.04	0.05	0.05	0.05
Other	LIPID CONTENT	17	17	0.05	0.85	R3-XF-S12-D-S	0.27	0.46	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB FILLET/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
BNAs	DIETHYLPHTHALATE	1	36	1200.00	1200.00	R6-XF-S17-D-S	752.08	969.92	500.00	8200.00
Dioxins	1,2,3,4,6,7,8-HPCDD	1	1	19.90	19.90	R4-XF-S50-C-S	19.90	19.90	.	.
	1,2,3,4,6,7,8-HPCDF	1	1	20.60	20.60	R4-XF-S50-C-S	20.60	20.60	.	.
	1,2,3,4,7,8-HXCDF	1	1	17.60	17.60	R4-XF-S50-C-S	17.60	17.60	.	.
	1,2,3,6,7,8-HXCDF	1	1	12.60	12.60	R4-XF-S50-C-S	12.60	12.60	.	.
	1,2,3,7,8-PECDF	2	2	18.60	120.00	R4-XF-S10-D-S	69.30	120.00	.	.
	2,3,4,6,7,8-HXCDF	1	1	6.90	6.90	R4-XF-S50-C-S	6.90	6.90	.	.
	2,3,4,7,8-PECDF	1	1	8.40	8.40	R4-XF-S50-C-S	8.40	8.40	.	.
	2,3,7,8-TCDD	1	1	9.10	9.10	R4-XF-S50-C-S	9.10	9.10	.	.
	2,3,7,8-TCDF	1	1	28.30	28.30	R4-XF-S50-C-S	28.30	28.30	.	.
	OCDD	1	2	986.00	986.00	R4-XF-S10-D-S	516.35	986.00	93.40	93.40
	OCDF	2	2	13.30	595.00	R4-XF-S10-D-S	304.15	595.00	.	.
Pest/PCBs	PCB-1248	149	157	40.00	18000.00	R6-XF-S28-D-S	1612.62	2914.76	40.00	40.00
	PCB-1248 (in lipid)	134	138	1600.00	13333333.33	R6-XF-S16-D-S	506505.91	1496836.01	1333.33	4000.00
	PCB-1260	128	157	45.00	4300.00	R6-XF-S16-D-S	532.57	899.68	40.00	400.00
	PCB-1260 (in lipid)	114	128	1571.43	4777777.78	R6-XF-S16-D-S	191566.92	564421.20	1000.00	5714.29
	TOTAL PCBs	149	157	40.00	21900.00	R6-XF-S28-D-S	2140.34	4373.95	40.00	40.00
	TOTAL PCBs (in lipid)	134	139	1600.00	18111111.11	R6-XF-S16-D-S	679148.95	2323946.67	1333.33	5714.29
Inor.	ALUMINUM	41	44	0.42	2.90	R5-XF-S49-C-S	1.02	1.12	2.00	2.00
	CADMIUM	2	44	0.03	0.03	R6-XF-S11-D-S	0.08	0.05	0.05	5.00
	LEAD	6	45	0.04	0.09	R8-XF-S41-D-S	0.05	0.06	0.01	1.00
Other	LIPID CONTENT	141	142	0.05	5.00	R7-XF-S27-D-S	0.87	1.25	0.05	0.05

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB FILLET/REACH 7 & 8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	58	66	40.00	3000.00	R7-XF-S50-C-S	643.26	1447.45	40.00	40.00
	PCB-1248 (in lipid)	51	55	1600.00	4800000.00	R7-XF-S08-D-S	296059.57	1375224.06	1333.33	4000.00
	PCB-1260	46	66	45.00	1100.00	R7-XF-S06-D-S	252.42	466.28	40.00	40.00
	PCB-1260 (in lipid)	40	54	1571.43	1920000.00	R7-XF-S08-D-S	117383.71	505822.72	1000.00	5714.29
	TOTAL PCBs	58	66	40.00	4100.00	R7-XF-S50-C-S	889.62	2412.24	40.00	40.00
	TOTAL PCBs (in lipid)	51	56	1600.00	6720000.00	R7-XF-S08-D-S	403666.42	2267032.09	1333.33	5714.29
Inor.	ALUMINUM	11	11	0.75	1.50	R7-XF-S50-C-S	1.11	1.27	.	.
	CADMIUM	1	10	0.03	0.03	R7-XF-S02-D-S	0.03	0.03	0.05	0.05
	LEAD	2	11	0.05	0.09	R8-XF-S41-D-S	0.04	0.05	0.05	0.10
Other	LIPID CONTENT	57	57	0.05	5.00	R7-XF-S27-D-S	1.25	2.16	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB VICERA/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1254	1	8	280.00	280.00	R2-XF-S25-D-V	62.50	189.42	40.00	160.00
	PCB-1254 (in lipid)	1	4	8235.29	8235.29	R2-XF-S25-D-V	2776.21	3580172.39	666.67	3333.33
	PCB-1260	1	8	80.00	80.00	R1-XF-S31-D-V	30.31	45.86	40.00	70.00
	TOTAL PCBs	2	8	80.00	280.00	R2-XF-S25-D-V	62.50	189.42	40.00	70.00
	TOTAL PCBs (in lipid)	1	5	8235.29	8235.29	R2-XF-S25-D-V	2658.47	91349.25	666.67	4375.00
Other	LIPID CONTENT	6	6	0.30	6.00	R1-XF-S23-D-V	2.47	20.56	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB VICERA/REACH 3

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	4	4	130.00	4400.00	R3-XP-S06-D-V	2532.50	121843571.73	.	.
	PCB-1248 (in lipid)	4	4	11818.18	129411.76	R3-XP-S06-D-V	50362.43	2860432.86	.	.
	PCB-1260	4	4	180.00	4500.00	R3-XP-S02-D-V	2695.00	24267732.65	.	.
	PCB-1260 (in lipid)	4	4	16363.64	73529.41	R3-XP-S06-D-V	43984.25	248227.18	.	.
	TOTAL PCBs	4	4	310.00	7500.00	R3-XP-S02-D-V	5227.50	95606822.31	.	.
	TOTAL PCBs (in lipid)	4	4	28181.82	202941.18	R3-XP-S06-D-V	94346.68	1470669.50	.	.
Other	LIPID CONTENT	4	4	1.10	13.00	R3-XP-S02-D-V	6.12	567.00	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB VICERA/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	26	26	1200.00	190000.00	R4-XF-S13-D-V	53515.38	277575.08	.	.
	PCB-1248 (in lipid)	23	23	12000.00	8300000.00	R5-XF-S27-D-V	773786.52	1723357.45	.	.
	PCB-1260	26	26	290.00	64000.00	R7-XF-S05-D-V	21173.08	142206.21	.	.
	PCB-1260 (in lipid)	23	23	8285.71	2700000.00	R5-XF-S27-D-V	269328.27	595285.07	.	.
	TOTAL PCBs	26	26	1490.00	242000.00	R4-XF-S13-D-V	74688.46	406060.14	.	.
	TOTAL PCBs (in lipid)	23	23	21000.00	11000000.00	R5-XF-S27-D-V	1043114.79	2252554.28	.	.
Other	LIPID CONTENT	23	23	0.10	38.00	R4-XF-S15-D-V	14.09	66.29	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=BB,SMB,PS & RB VICERA/REACH 7 & 8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	12	12	1800.00	150000.00	R7-XF-S04-D-V	35583.33	323550.37	.	.
	PCB-1248 (in lipid)	9	9	12000.00	1000000.00	R7-XF-S05-D-V	323664.29	2331933.98	.	.
	PCB-1260	12	12	610.00	64000.00	R7-XF-S05-D-V	14669.17	203979.69	.	.
	PCB-1260 (in lipid)	9	9	9000.00	426666.67	R7-XF-S05-D-V	130184.98	592827.79	.	.
	TOTAL PCBs	12	12	2410.00	214000.00	R7-XF-S05-D-V	50252.50	497451.09	.	.
	TOTAL PCBs (in lipid)	9	9	21000.00	1426666.67	R7-XF-S05-D-V	453849.27	2690186.90	.	.
Other	LIPID CONTENT	9	9	1.00	29.00	R7-XF-S04-D-V	13.19	76.33	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=CRAYFISH WHOLE/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Other	LIPID CONTENT	1	1	1.40	1.40	R2-XI-S35-C-S	1.40	1.40	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE

ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=CRAYFISH WHOLE/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1248	8	10	260.00	3400.00	R4-XI-S46-C-S	1175.50	5707.82	150.00	800.00
	PCB-1248 (in lipid)	8	8	8666.67	200000.00	R4-XI-S46-C-S	70321.35	514020.63	.	.
	PCB-1260	10	10	220.00	1600.00	R6-XI-S30-C-S	742.00	1558.52	.	.
	PCB-1260 (in lipid)	10	10	6000.00	290909.09	R6-XI-S30-C-S	75052.34	632347.68	.	.
	TOTAL PCBs	10	10	420.00	4800.00	R4-XI-S46-C-S	1870.00	4773.82	.	.
	TOTAL PCBs (in lipid)	10	10	16666.67	472727.27	R6-XI-S30-C-S	131309.42	578074.05	.	.
Other	LIPID CONTENT	10	10	0.40	5.70	R5-XI-S40-C-S	2.54	7.89	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=FROG WHOLE/REACH 1 & 2

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Other	LIPID CONTENT	5	5	0.20	1.30	R1-XA-S26-C-S	0.46	1.99	.	.

SUMMARY STATISTICS FOR THE ALCOA SITE
ALL VOC, BNA AND PCB RESULTS IN PPB; DIOXINS RESULTS IN PPT; INORGANICS RESULTS IN PPM

TYPE=FROG WHOLE/REACH 4-8

Class	NAME	Num. Times Detected	Num. Samples Analyzed	Lowest Detected Conc.	Highest Detected Conc.	Highest Conc. Locat.	Arithmetic Mean Conc.	95 Pct. Upp. Conf. Limit	Lowest Observed Detect. Limit	Highest Observed Detect. Limit
Pest/PCBs	PCB-1260	3	3	230.00	2400.00	R6-XA-S22-D-S	1510.00	11602529035.84	.	.
	PCB-1260 (in lipid)	3	3	37704.92	3800000.00	R6-XA-S21-D-S	1359234.97	2.0917105162E28	.	.
	TOTAL PCBs	3	3	230.00	2400.00	R6-XA-S22-D-S	1510.00	11602529035.84	.	.
	TOTAL PCBs (in lipid)	3	3	37704.92	3800000.00	R6-XA-S21-D-S	1359234.97	2.0917105162E28	.	.
Other	LIPID CONTENT	3	3	0.05	1.00	R6-XA-S22-D-S	0.55	25445626498.15	.	.